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MICROFACIES DU JURASSIQUE DES DINARIDES EXTERNES DE LA YOUGOSLAVIE

Rajka Radoičić

Introduction

La stratigraphie du Jurassique des Dinarides externes se basait jusqu'aux jours plus récents sur les découvertes des macrofossiles. Sur les cartes géologiques on a distingué soit le Jurassique non différencié, soit certaines parties du Jurassique abondantes en macrofossiles: principalement le Liassique (couches à *Lithiotis* et calcaires variés à Brachiopodes) et le Malm (calcaires à *Cladocoropsis* et calcaires dits tithon-valanginiens à *Ellipsactinia*, Polypiers, *Diceras et Nerinea*). La faune de Céphalopodes n'était connue que d'un petit nombre de localités: quelques affleurements des couches liassiques à Céphalopodes au Monténégro du Nord et à l'Herzégovine et couches de Lemeš jurassiques supérieures de la Dalmatie moyenne. Les travaux pour la carte géologique des Dinarides externes au 1 : 25 000^e que l'on exécute dans ces derniers temps avaient démontré qu'il faudrait disposer des données stratigraphiques détaillées et beaucoup plus nombreuses obtenues uniquement par les études biostratigraphiques complexes. Les premiers essais des études micropaléontologiques avaient déjà offert de très importants résultats en découvrant les nombreux microfossiles même dans les sédiments qui étaient tenus stériles. Il n'était pas rare que ces sédiments jurassiques fussent rangé jusqu'à ce moment dans le Triassique ou dans le Crétacé supérieur. Les études micropaléontologiques et surtout les études des microfaciès avaient sans doute grandement éclairci les problèmes du Jurassique des Dinarides externes — les résultats des travaux exécutés jusqu'à présent dans ce domaine sont l'objet de cet aperçu.

Etant donné que les microfaciès jurassiques, préparés pour être imprimés en 1961, n'étaient pas publiés à temps utile, on a fait un complément le plus nécessaire en tenant grand compte de la bibliographie apparue sur ces entre-temps. En plus, la présentation de certaines séries est complétée de quelques données plus intéressantes obtenues après 1961. Il est à souligner qu'aujourd'hui on dispose de très intéressants matériaux micropaléontologiques d'un grand nombre de colonnes jurassiques détaillement levées, non seulement à l'Institut de recherches géologiques et géophysiques à Belgrade, mais aussi aux autres centres géologiques à Ljubljana. Zagreb, Sarajevo et Titograd. Cela veut dire, qu'aujourd'hui au moment de la publication des microfaciès jurassiques, la série jurassique des Dinarides externes de Yougoslavie est étudiée beaucoup plus largement et plus minutieusement que ce que l'on pourrait conclure de ce travail.

Au cours de l'étude des microfaciès jurassiques des Dinarides externes ma collègue Aleksandra Danilova, qui travaille également sur l'étude des microfaciès jurassiques et crétacés d'une partie des Dinarides internes et des montagnes carpatho-balkaniques, n'a pas hésité à m'apporter son concours dans une collaboration utile. Je voudrais à cette occasion la remercier chaleureusement pour cette collaboration de longues années. Je remercie également M. le Professeur Zarija Bešić et ma collègue Smiljka Pantić avec lesquels je travaillais plusieurs années sur les terrains monténégrins, ainsi que le collègue Djordje Cekić pour les photos réussies des lames minces micropaléontologiques.

Belgrade, novembre 1964.

NOTE STRATIGRAPHIQUE

Les microfaciès jurassiques des Dinarides externes sont exposés suivant les régions respectivement suivant les colonnes stratigraphiques particulières (fig. 1). La majeure partie de colonnes stratigraphiques tirent leur origine des Dinarides monténégrines. Pour ce domaine on présente, dans le but de compléter l'image sur les conditions paléogéographiques, à côté des séries jurassiques des zones variées des Dinarides externes également les microfaciès d'une partie des Dinarides internes (zone externe des Dinarides internes: le Jurassique des environs de Pljevlje).

Sur le développement de la majorité des séries en question on avait déjà écrit (R. Radoičić, 1963/64); c'est pourquoi on ne présente que les aperçus stratigraphiques tabellaires avec remarque qu'ils sont plus ou moins schématisés en fonction du degré de leur connaissance. Il ne serait pas superflu de répéter la conclusion relative aux caractères de la série jurassique des Dinarides externes, à savoir:

«— la variabilité prononcée de l'épaisseur (de quelques dizaines à plus de 1 200 m);

— la sédimentation de l'eau peu profonde, de l'infranéritique à celle de l'eau peu profonde littorale finale y inclus le régime laguno-lacustre dans le Kimméridgien et le Portlandien intimement lié avec les bauxites et dans certaines régions également grandes lacunes dans la colonne stratigraphique, et

— la variété des faciès du caractère zoné, quoique dans certaines zones se sentît une différenciation plus importante dans la direction longitudinale. Temporairement, les différenciations faciales s'observent *pro parte* au Liassique, et surtout dans le Dogger et le Malm inférieur, tandis que l'homogénéité des faciès d'une vaste étendue des Dinarides externes de Yougoslavie caractérise la période après le Kimméridgien (série à *Clypeina jurassica*, série à Tintinnines aberrantes,* etc. . . .)».

L'importance des microfaciès en question n'est pas toujours la même — je considère qu'il est nécessaire, pour connaître le développement d'une série, de connaître non seulement les microfaciès caractéristiques mais aussi ceux de l'importance stratigraphique secondaire ou même ceux stratigraphiquement indifférents (en titre d'exemples, calcaires variés à Ostracodes, Thaumatoporelles, certaines Codiacées, Cyanophytes, etc. . . .), mais qui dans une région restreinte ou dans une zone paléogéographique déterminée peuvent être les «marquers» stratigraphiques très importants (par ex., calcaires microoolithiques, certains calcaires oolithiques-détritiques et oolithiques à Echinodermes, calcaires organogènes-détritiques à Echinodermes, Cristellaria et autres Lagénidés du Jurassique inférieur c'est-à-dire du Liassique et du Liassique-Dogger).

Les microfaciès qui suivent sont très répandus et très caractéristiques pour certaines périodes du Jurassique des Dinarides externes:

LIASSIQUE

Les microfaciès à

— *Triassina hantkeni, Aulotortus, Sestrosphaera*
— *Palaeodasycladus mediterraneus*
— *Orbitopsella praecursor*
— *Lituosepta recoarensis*
— *Spirillina liassica. Trocholina* sp. nov. et Lagénidés
— *Vidalina martana, Glomospira* sp., etc. . . .

DOGGER

Les microfaciès à

— *Globigerina helveto-jurassica*
— *Dictyoconus cayeuxi*
— *Selliporella donzellii, Teutloporella gallaeformis*
— *Nerinella*
— *Trochamminidae, Textulariidae, Verneuilinidae* (fréquentes) et *Endothyra* sp.

DOGGER SUPÉRIEUR ET MALM INFÉRIEUR

Les microfaciès à

— *Protopeneroplis striata* et *Trocholina*
— *Pfenederinidae*

* Les microfossiles considérés dans cet essai de synthèse comme Tintinnines aberrantes appartiennent selon A. Farinacci (1963) à une seule espèce des Teredinides dénommée *Bankia striata* (Carozzi).

MALM

Les microfaciès à

— microfossiles problématiques Pr 3 et Pr 6, Bryozoaires (?) Br 1, Codiacea C 1, etc.
— *Labyrinthina mirabilis*
— *Cladocoropsis mirabilis* et Kurnubies
— *Kurnubia palastiniensis* et *Kurnubia wellingsi*
— *Conicospirillina*
— *Saccocoma*
— *Pianella grudii* et Charophytes
— «*Macroporella*» *sellii*
— «*Lituonella*» sp.
— *Clypeina jurassica*, et
— Calpionelles.

COUCHES INTERMÉDIAIRES: JURASSIQUE-CRÉTACÉ (INFRAVALANGINIEN)*

Les microfaciès à

— *Clypeina jurassica* et Tintinnines aberrantes, et
— *Calpionellopsis*, Tintinnopselles et Calpionelles peu fréquentes.

A côté des microfaciès cités on a observé que les microfaciès à *Pseudocodium convolvens* (pl. 9/2, pl. 10/1, *Bullopora* sp. (pl. 104) et *Clypeina* spp. (pl. 35 et 36) ont également une extension stratigraphique très restreinte. Leur valeur stratigraphique ne pouvait pas être vérifiée étant donné qu'ils ne sont pas constatés, dans le cadre des études faites jusqu'à présent, que dans les séries ici présentées.

En terminant il faudrait souligner que l'étude des microfaciès jurassiques est faite grâce à nombreuses observations sur le terrain. C'est ce qui a permis d'observer beaucoup plus facile la migration des faciès dans le temps et espace dont il faudrait tenir grand compte à l'occasion de l'interprétation stratigraphique. Je citerais un exemple: les calcaires à *Ellipsactinia* des zones paléogéographiques déterminées des Dinarides externes apparaissent dans le Malm inférieur, tandis que les calcaires à *Ellipsactinia* d'autres zones ayant la position des falaises par rapport aux sillons de ce miogéosynclinal (par rapport au sillon de Budva-Boka ou celui au Nord: la falaise à peu près de la ligne Vjetarnik-Durmitor-Nevesinje) sont sans doute plus jeunes — ils se trouvent dans le Malm supérieur.

*

Les lames minces micropaléontologiques appartiennent à la Collection des lames minces micropaléontologiques de l'Institut de recherches géologiques et géophysiques à Belgrade.

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* Etant donné qu'aux domaines examinés après le Jurassique sup. s'étaient continûment déposées les couches crétacées inférieures, à côte des microfaciès jurassiques de certaines séries on présente également le microfaciès infravalanginiens et valanginiens inférieurs.

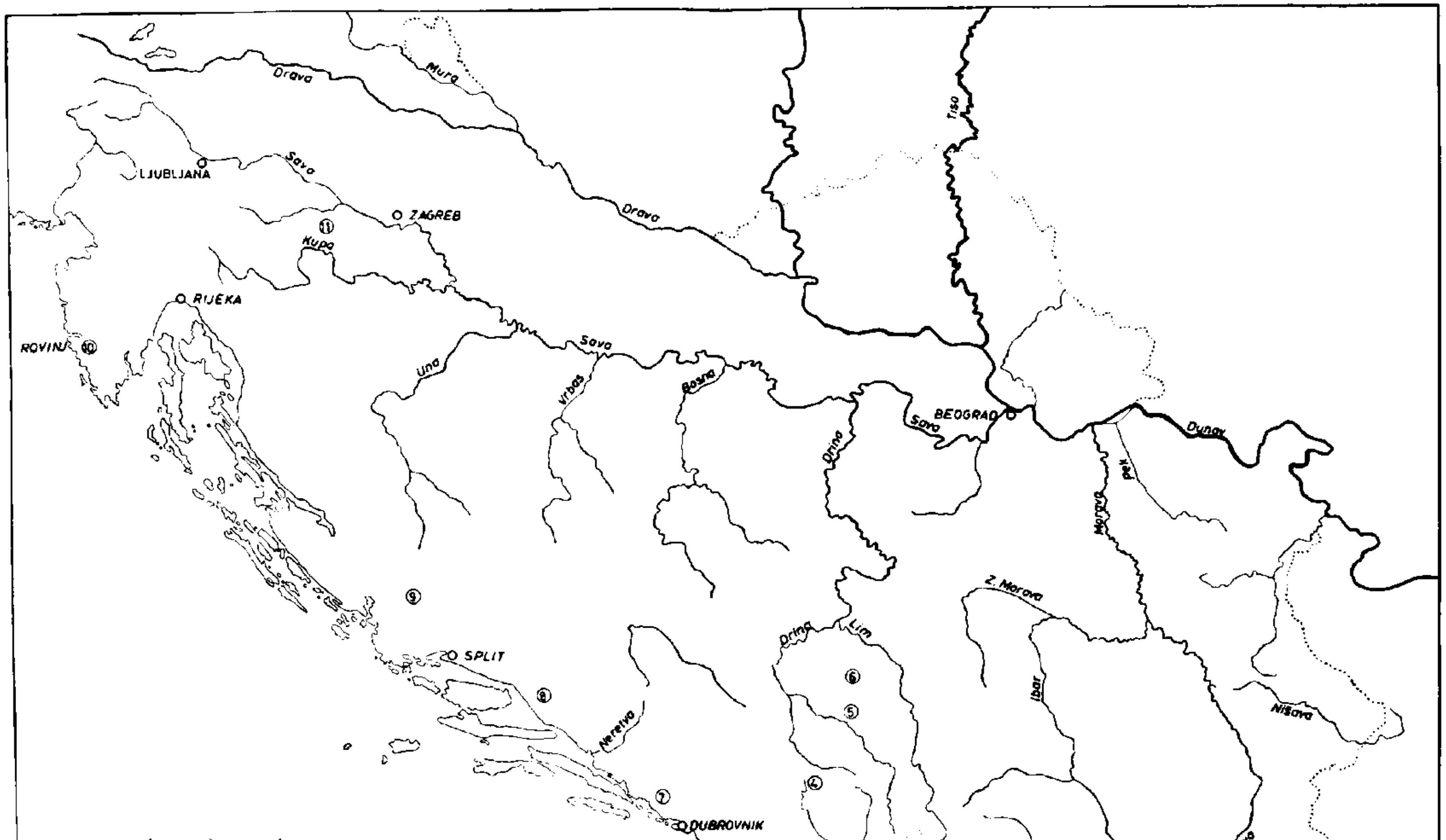


Fig 1 1 à 11 RÉGIONS OÙ LES SÉRIES JURASSIQUES ONT ÉTÉ ETUDIÉES

11 La série jurassique des environs de Sošice (Žumberak)
10 La série jurassique des environs de Rovinj
9 La série jurassique de Lemeš et ses environs
8 La série jurassique de la région Mosor - Biokova - Bačine
7 La série jurassique de Herzégovine du sud - région entre Dubrovačko primorje et Trebinje - Popovo polje
6 La série jurassique des environs de Pljevlja - Dinarides internes
5 La série jurassique de Kosanica et de Kraljevo gora
4 La série jurassique de la montagne Vojnik
3 La série jurassique de la bordure nord de la Zetska ravnica - région de Dečić et de Cijevna
2 La série jurassique de la bordure ouest de la Zetska ravnica et région vers le Vieux Montenegro
1 La série jurassique des versants nords de la montagne Rumija

Tableau № 1

LA SÉRIE JURASSIQUE DES VERSANTS NORD DE LA MONTAGNE RUMIJA

Âge	Faciès		Planche №
	Krsajina de l'Est	Krajina de l'Ouest	
Néocomien		Calcaires à Tintinnines aberrantes et autres microfossiles. Dolomies.	
Malm supérieur	(Jurassique supérieur de la Krajina de l'Est n'est pas étudié.)	Calcaire à *Clypeina jurassica*, autres Dasycladacées et Foraminifères. Dolomies.	16 à 18 13 à 15
Malm supérieur		Calcaires à Cyanophytes, *Conicospirillina, Pseudocyclammina,* Diceras, Nerinéidés et rares *Cladocoropsis.*	11, 12 10/2
Malm inférieur	Calcaires organogènes et organogènes-detritiques à Hydrozoaires, Polypiers, etc. Calcaire organogène-détritique avec petits morceaux de jaspes. ↓	Calcaires massifs biohermes à Polypiers coloniaux; *Ellipsactinia,* autres Hydrozoaires, *Diceras* et Nerinéidés.	
Malm inférieur		Calcaires organogènes-detritiques à Gastéropodes, Polypiers solitaires, Hydrozoaires, *Pseudocodium convolvens*, autres Algues et *Protopeneroplis striata*	10/1 8, 9 7/2
Dogger	Brèche hétérogène (les composantes: calcaires liasiques variés et jaspes).	Calcaires oolithiques à Trocholines, *Protopeneroplis striata,* rares Dasycladacées et autres Algues.	6, 7/1 5/2
Lias	↑ Calcaires à jaspes (Brachiopodes) et zones à jaspes.	Calcaires oolithiques et oolithiques-détritiques à Echinodermes, Lagénidés, *Vidalina* et autres Foraminifères.	5/1 4
Lias	↓	Calcaire à *Orbitopsella* et autres Foraminifères, calcaire à *Palaeodasycladus mediterraneus.*	3 2 1
Trias supérieur	Dolomies et calcaires à Megalodontidés.		

Tableau № 2

LA SÉRIE JURASSIQUE DE LA BORDURE OUEST DE LA ZETSKA RAVNICA ET DU DISTRICT VERS L'ANCIEN MONTENEGRO

Âge		Faciès	Planche №
Néocomien		Calcaires à Tintinnines aberrantes; calcaires à Coprolithes, Dasycladacées, etc.; calcaires dolomitiques et dolomies.	41
Néocomien		Calcaire à Tintinnines aberrantes et *Clypeina jurassica*. — Dolomies.	
Malm	supérieur	Dolomies, calcaires dolomitiques et calcaires à *Clypeina jurassica* (*pro parte*, dans la partie inférieure: calcaire à Charophytes).	39, 40 38
Malm	supérieur	Calcaire à Kurnubies, Cyanophytes, Hydrozoaires, etc.; dolomies. — Calcaire à *Clypeina* spp., Kurnubies, etc.	35 á 37 34/2
Malm	inférieur	Calcaires à *Cladocoropsis mirabilis*, Kurnubies, *Pseudocyclammina*, Cyanophytes et Dasycladacées. *Pro parte*, dans la partie inférieure: calcaire oolithique à Trocholines.	34/1 33
Malm	inférieur	Calcaire divers, grumeleux et organogène-détritique à Pfenderinidés, Trochamminidés, Textularidés, Verneuilinidés et Dasycladacée *Teutloporella gallaeformis*. Calcaire oolithique à *Protopeneroplis striata*.	32 31 30
Dogger		Calcaires à *Selliporella donzellii*, *Teutloporella gallaeformis* et autres Dasycladacées, puis Trochamminidés, Textularidés, Verneuilinidés, etc. Calcaire oolithique à *Protopeneroplis striata*.	29 28 27
Dogger		Calcaire à *Dictyoconus cayeuxi*. — Calcaires à Trochamminidés, Textularidés, etc. Calcaire grumeleux à *Thaumatoporella*.	26 25
Lias		Calcaires oolithiques; calcaire à *Glomospira* et Codiacées; calcaires à *Lithiotis*, *Pseudocyclammina*, *Lituosepta*, *Orbitopsella* et *Palaeodasycladus*.	24 23 20 á 22
Lias		Calcaire à *Palaeodasycladus mediterraneus*. — Dolomies.	19
Trias	supérieur	Dolomies et calcaires à Megalodontidés.	

Tableau № 3

LA SÉRIE JURASSIQUE DE LA BORDURE NORD DE LA ZETSKA RAVNICA
DISTRICT DE DEČIĆ ET DE CIJEVNA

Âge		Faciès			Planche №
Néocomien		Calcaire peu bitumineux à Tintinnines aberrantes, Coprolithes, *Salpingoporella annulata*, Gastéropodes, etc.			55
Néocomien		Calcaire peu bitumineux à *Clypeina jurassica*, Tintinnines aberrantes et *Salpingoporella annulata*.			54/2
Malm	supérieur	Dolomies, calcaire dolomitiques et bitumineux et calcaire à *Clypeina jurassica*.			54/1
Malm	supérieur	Calcaire à Charophytes, Ostracodes, *Pianella grudii* et Ostréidés.	Calcaire à rares Clypeines, «*Macroporella*» *sellii* et Cyanophytes, «*Lituonella*», *Kurnubia*, etc.	↑ Calcaires organogènes et organogènes-détritiques à Hydrozoaires, Polypiers, Brachiopodes, Nérinées et *Diceras*.	49 á 53 46 á 48 45/2
Malm	inférieur	Calcaire à *Cladocoropsis mirabilis*, Cyanophytes, «*Macroporella*» *sellii*, Kurnubies et autres Foraminifères.		Calcaires oolithiques et oolithiques-détritiques à *Protopeneroplis striata* et rares *Cladocoropsis*, calcaire à Codiacées. ↓	45/1 44 42, 43

Tableau № 4

LA SÉRIE JURASSIQUE DE LA MONTAGNE VOJNIK

Âge		Faciès		Planche №
Néocomien		Calcaires à Tintinnines aberrantes, Coprolithes, Dasycladacées, Nérinées, etc.		
Néocomien / Malm supérieur		Calcaire à *Clypeina jurassica* et Tintinnines aberrantes. Dolomies.		
Malm supérieur		Calcaire à *Clypeina jurassica*. Dolomies.		72
Malm supérieur	Calcaires organogènes et organogèno-détritiques à Hydrozoaires, Polypiers, *Diceras*, Nerinéidés, etc.	Calcaire marneux à Ostracodes, Charophytes et *Pianella grudii*.		71 70/2
Malm inférieur	↓	Niveau du calcaire conglomératique et de celui d'aspect conglomératique et traces de bauxite.	↑ Bauxite	70/1 69/2
Malm inférieur	↓	Calcaire organogéno-détritique à Hydrozoaires, Polypiers, etc.	↓	
Dogger	Calcaires organogèno-détritiques à Trocholines et *Protopeneroplis striata*. Dolomies.			69/1 68/2 67, 68/1
Dogger	Calcaire à Lamellibranches pélagiques, calcaire à Globigérines. Microbrèche.			66 64/2, 65
Lias		Calcaire marneux rougeâtre et calcaire à Lagénidés, *Spirillina liassica* et Céphalopodes.		60 á 64/1
Lias		Marno-calcaire et calcaire marneux à Lagénidés et *Spirillina liassica*. Dans la partie inférieure: calcaire à *Triassina hantkeni*.		59 57, 58 56
Trias supérieur		Dolomies et calcaires à Megalodontidés.		

Tableau № 5

LA SÉRIE JURASSIQUE DE KOSANICA ET DE KRALJEVA GORA

Âge	Faciès	Planche №
Néocomien	Calcaire marneux et marno-calcaire à *Calpionella*, *Calpionellopsis* et *Tintinnopsella*.	79
Malm supér.	La série clastique — calcaire marneaux à *Calpionella* et Radiolaires, marne, calcarenites, calcaires bréchiques, etc.	78 77
Malm infér.	Calcaires organogènes et organogènes-détritiques à Mollusques, Polypiers, Hydrozoaires et Codiacées.	76 75/2
Dogger	Calcaires divers à petits Foraminifères et *Aeolisaccus*.	75/1
Lias	Calcaires rougeâtres et grisâtres à *Globochaete*, Lagénidés, Lamellibranches pélagiques, etc.	74/2
Lias	Calcaire rouge à Lagénidés, *Vidalina martana*, *Spirillina liassica* et Céphalopodes.	74/1
Lias	Calcaires grisâtres à *Thaumatoporella* et *Aulotortus*.	73
Trias supérieur	Calcaire à Megalodontidés.	

Tableau № 6

LA SÉRIE JURASSIQUE DES ENVIRONS DE PLJEVLJA DINARIDES INTERNES

Âge		Faciès au Sud	Faciès au Nord	Planche №
Néocomien		Marne et calcaire marneux à *Calpionella, Calpionellopsis* et *Tintinnopsella*.		88
Malm	supér.	Calcaire marneux à *Calpionella*.	Calcaire à *Calpionella* et Ammonites (d'après les matériaux de l'Institut Géol. — Titograd).	
Malm	infér.			
Dogger		La série des calcaires et jaspes (calcaire marneux, calcaires silifiés à Radiolaires et Lamellibranches pélagiques, calcaires détritiques-oolithiques, détritiques et bréchiques, jaspes).	La «Diabase -Hornstein Formation».	87 86
Dogger			Calcaire rougeâtre-grisâtre, marneux, à Lamellibranches pélagiques et rares Globigérines.	85/2
Lias		Calcaire rouge à microfossiles peu abonndants (Lagénidés, Spirillina *liassica*, etc.).	Calcaire rouge à Céphalopodes Lagénidés, *Spirillina liassica*, Brachiopodes, etc.	85/1 84
Lias			Calcaire rougeâtre à Lagénidés, *Spirillina liassica* et autres, Foraminifères.	83 82 81
Lias			Calcaire grisâtre et brunâtre à rares microfossiles (Ostracodes et *Thaumatoporella*).	80
Trias supérieur		Calcaires à Megalodontidés et Dasycladacées.		

LA SÉRIE JURASSIQUE DE L'HERZÉGOVINE DU SUD
DISTRICT ENTRE DUBROVACKO PRIMORJE ET TREBINJE-POPOVO POLJE

Âge	Faciès		Planche №
Néocomien	Dolomies.	Calcaires différents à Tintinnines aberrantes; calcaires à Coprolithes, *Salpingoporella annulata* et Nerinéidés.	
Néocomien	Dolomies.	Calcaires à *Clypeina jurassica*, *Pianella gigantea* et Tintinnines aberrantes, calcaire à Coprolithes.	109 108
Malm supérieur	Dolomies et calcaires dolomitiques à *Clypeina jurassica.*	Calcaire à *Clypeina jurassica* et niveau de calcaire à Charophytes.	107 106 105/2
Malm inférieur	Calcaires organogènes-détritiques à Hydrozoaires, Polypiers et Nerinéidés.	Calcaires à *Cladocoropsis mirabilis*, Kurnubies, *Bullopora*, «*Macroporella*» *sellii*, etc. Dolomies.	105/1 102 à 104
Malm inférieur	Calcaire à Pfenderinidés.	Calcaire à petirs Foraminifères.	101 100
Dogger	Calcaires organogènes-détritiques à *Selliporella donzellii; Endothyra* sp. et autres Foraminifères (Textularidés, Trochamminidés, Verneuilinidés), Microgastéropodes (*Nerinella* et aut.), etc.; dolomies.		96 à 99
Dogger	Calcaires oolithiques et calcaire à Coprolithes. Dolomies.		95 94/2
	Dolomies, calcaires oolithiques et calcaires à Echinodermes, *Glomospira*, etc.		94/1 93/2
Lias	Calcaires à *Lithiotis, Orbitopsella, Lituosepta* et *Palaeodasycladus mediterraneus.*		93/1 91, 92/2 89/2,90
Lias	Dolomies.	Calcaire à *Palaeodasycladus.*	89/1
Trias supérieur	Dolomies et calcaires à Megalodontidés.		

Tableau № 8

LA SÉRIE JURASSIQUE DE LA RÉGION MOSOR-BIOKOVO-BAČINE

Âge		Mosor	Biokovo	Bačine	Planche №
Néocomien		Calcaires variés à Tintinnines aberrantes, Coprolithes, Dasycladacées, Nerinéidés, etc.			120, 121
		Calcaire à *Clypeina jurassica* et Tintinnidés aberrantes.			119/2
Malm	supérieur	Calcaires organogènes-détritiques, marneux, grumeleux et dolomitiques à *Clypeina jurassica*			119/1
		Dolomies et calcaire brèchique.			118
	inférieur	Calcaire à *Labyrinthina mirabilis, Pseudocyclammina, Cladocoropsis.* Calcaire dolomitique et parties inconsidérables de dolomies.	Calcaire à *Cladocoropsis mirabilis,* Kurnubies, Cianophytes, etc.	Calcaire organogène-détritique et aut. à Codiacées, *Pseudocyclammina,* Kurnubies, Hydrozoaires, Polypiers et Nerinéidés.	117
					116/2
			Calcaire à Pfenderinidés et *Pseudocyclammina;* calcaire dolomitique et dolomie.		116/1
Dogger			Calcaire organogène-détritique à *Seliporella donzellii;*	↑	115
			calcaire oolithique à *Protopeneroplis striata* et Trocholines. Dolomie et calcaire brèchique.	Calcaires organogènes-détritiques, détritiques-oolithiques et calcaire oolithique.	114
			Calcaire oolithique à *Dictyoconus cayeuxi.* Calcaire brèchique. Dolomie.	↓	112, 113
Lias			Calcaire grumeleux, calcaires oolitithiques variés et parties inconsidérables de dolomie.		
			Calcaire à *Lithiotis,* Lituolidés, *Orbitopsella, Palaeodasycladus,* etc.		110, 111
Trias	supérieur		Dolomies.		
			Dolomies à Megalodontidés.		

LA SÉRIE JURASSIQUE DE LEMEŠ ET DE SES ENVIRONS

Âge	Faciès: Lemeš	Faciès: Environs plus large de Lemeš	Planche №
Néocomien	Calcaires à Dasycladacées rares Foraminifères et Gastéropodes.		133/2
Malm supérieur	Dolomies avec intercalations de calcaire organogène-détritique à petits morceaux de jaspes et Codiacées, *Teutloporella* cf. *obsoleta*, *Conicospirillina*, *Aptichus*.	Calcaire à fossiles fort rares (*Conicospirillina* et autres). ↓	133/1 132
Malm inférieur	La série des calcaires et jaspes à Céphalopodes, Radiolaires, etc. Dans la partie supérieure: calcaire tacheté à nombreux Ammonites et *Saccocoma;* dans la partie la plus ancienne: calcaire à rares Miliolidés, calcaire à Globigérines et Radiolaires.	Dolomies.	130, 131
Dogger		Calcaire à Pfenderinidés, dolomie stérile.	129 127, 128
Dogger		Calcaire grumeleux, oolithique et dolomitique à fossiles fort rares. Dolomies.	
Lias		Calcaire oolithique sterile, calcaires oolithiques variés à *Glomospira* et autres Foraminifères. Dolomies.	126 125
Lias		Calcaire à *Lithiotis*, *Orbitopsella*, *Glomospira*, etc.	124 122, 123

Tableau № 10

LA SÉRIE JURASSIQUE DES ENVIRONS DE ROVINJ

Âge		Faciès		Planche №
Néocomien		Calcaire à Tintinnines aberrantes, calcaire à *Salpingoporella annulata*, Coprolithes, rares Foraminifères, etc. Dolomie et calcaire dolomitique.		141 140/2
Malm	supérieur	Calcaires criptocristallins, calcaire grumeleux à *Clypeina jurassica* (dans la partie supérieure: niveau à Charophytes. Dolomies.	Calcaires organogènes détritiques, subcristallins, à Hydrozoaires, autres macrofossiles, Coprolithes et nombreux Foraminifères (*«Endothyra»)* Pfenderinidés. Verneuilinidés, Textularidés, *Pseudocyclammina*).	140/1 137 à 139 136/2
			Calcaire organogène-détritique et autres à Trocholines, autres Foraminifères et *Bačinella*.	136/1 135
	inférieur	Calcaire à *Cladocoropsis mirabilis*, *Thaumatoporella parvovesiculifera* et Foraminifères.		
		Calcaire grumeleux, calcaires criptocristalins variés à Pfenderinidés, *Thaumatoporella parvovesiculifera*, Brachiopodes, etc.		134

Tableau № 11

LA SÉRIE JURASSIQUE DES ENVIRONS DE SOŠICE (ŽUMBERAK)

Âge	Faciès		Planche №
Sénonien	La série clastique du Sénonien supérieur (brèche hétérogène avec débris de tous les calcaires jurassiques cités).		
Malm	Calcaire marneux et calcarénite à Calpionelles.		148
Malm	Calcaire à fins débris organogènes, calcaire à Radiolaires et Lamellibranches pélagiques.	Calcaire organogèno-détritique à Dasycladacées, Codiacées, Polypiers, etc.	147/2 147/1
Dogger	Calcaires à fossiles fort rares — Lamellibranches peu abondantes, Radiolaires, Echinodermes, etc. Calcaires oolithiques et pseudo-oolitiques. (Couches peu étudiées du point de vue paléontologique).		
Dogger	Calcaire organogèno-détritique à Lagénidés, *Spirillina liassica*, débris d'Echinodermes, etc.		146/2 146/1 145/2
Lias	Calcaire à *Lituosepta recoarensis*, calcaire oolithique-détritique.	Calcaire organogèno-détritique à *Palaeodasycladus mediterraneus* et petits Foraminifères.	145/1 144 143
Lias	Calcaire microcristallin, cryptocristallin et oolithique (en majorité stérile).		142
Trias supérieur	Dolomies et calcaires à Megalodontidés.		

BIBLIOGRAPHIE

Agip mineraria, 1959, Microfacie italiane (dal Carbonifero al Miocene medio). S. Donato Milanese.

Anić D., 1962, Prilog poznavanju jure i krede istočnog dijela Biokova. Geološki vjesnik Instituta za geol. istraživanja u Zagrebu za 1961. godinu, sv. 15, br. 1. Zagreb.

Aurouze G., Bellon J., Bizon J. J., Journel C., 1956, Sur la présence du genre Kilianina dans le bassin de Paris. Bull. Soc. Géol. France, ser. 6, T. 6. Paris.

Aurouze G., Bizon J. J., 1958, Rapports et différences des deux genres de Foraminifères: Kilianina (Pfender) et Meyerdorffina n. gen. Rev. de Micropaléontologie, vol. 1, n. 2. Paris.

Bešić Z., 1953, Gornja jura u oblasti Durmitora i Sinjajevine. Vesnik Zavoda za geol. i geof. istraživanja u Beogradu, tom. X. Beograd.

Carozzi A., 1946, Sur quelques Desycladacées du Purbeckien du Jura. C. R. Sc. Phys. Hist. nat., Genève, Vol. 63. Genève.

Carozzi A., 1948, Étude stratigraphique et micrographique du Purbeckien du Jura suisse. Arch. sc. Genève, Vol. 1, fasc. 2. Genève.

Carozzi A., 1955, Dasycladacées du Jurassique supérieur du bassin de Genève. Ecl. Geol. Helv., Vol. 48, no 1. Basel.

Cati F., 1959, Nuovo Lituolide nei calcari grigi liassici del Vincentino Giorn. di Geol., ser. 2°. Vol. 27 (1956-57). Bologna.

Catenaci E., De Castro P., Sgrosso I., 1963, Complessi-guida del mesozoico calcareo-dolomitico nella zona orientale del Massiccio del Matese. Mem. della Soc. Geol. Italiana, Vol. 4. Bologna.

Colom G., 1947, Estudios sobre la sedimentación profunda de las Baleares desde al Lias superior al Cenomanense-Turonense. Madrid.

Colom G., 1955, Jurassic-Cretaceous pelagic sediments of the Western-Mediterranean zone and the Atlantic area. Micropaleontology, vol. 1, n. 2. New York.

Crescenti U., 1959, Sopra una nuova Macroporella (Alga calcarea), nel Malm dell'Italia meridionale. Giorn. di geol., ser. 2°, vol. 27 (1956-57). Bologna.

Cuvillier J., Sacal V., 1951, Corrélations stratigraphiques par microfaciès en Aquitaine Occidentale. Third World Petr. Congr. Leiden.

Cuvillier J., Dufaure Ph., 1963, Position stratigraphique de la zone à «Palaeodasycladus» dans le Lias des Corbièrs des Pyrénées et du bassin d'Aquitaine en général. C. R. Acad. des Sciences, t. 257. Paris.

Čanović M., 1959, Prilog mikropaleontološkom proučavanju sedimenata jure na graničnom terenu Crne Gore, Hercegovine i Dubrovačkog Primorja. Geol. glasnik Geološkog zavoda NRCG, knj. 3. Titograd.

De Castro P., 1962, Il Giura-Lias dei Monti Mattari e dei rilievi ad ovest della valle dell'Irno e della Piana di Montoro. Boll. Soc. Nat. in Napoli, vol. 71. Napoli.

De Castro P., 1962, Sulla presenza del Giura (Dogger e Malm) nei Monti Aurunci. Boll. Soc. Nat, in Napoli, vol. 71. Napoli.

De Castro P., 1963, Kilianina Pfender et Orbitammina Berthelin (?) (Foraminifera) nella zona a Pfenderina (Batoniano) dell'Appennino meridionale. Boll. Soc. Nat. in Napoli, vol. 73. Napoli.

Dufaure Ph., 1958, Contribution a l'étude stratigraphique et micropaléontologique du Jurassique et du Néocomien de l'Aquitaine à la Provence. Revue de Micropaléontologie, vol. 1, no. 2. Paris.

Elliott G. F., 1955, Fossil calcareous algae from the Middle East. Micropaleontology, vol. 1, n. 2. New York.

Elliott G. F., 1956, Further records of fossil calcareous algae from the Middle East. Micropaleontology, vol. 2, n. 4. New York.

Elliott G. F., 1958, Fossil microproblematica from the Middle East. Micropaleontology, vol. 4, n. 4. New York.

Elliott G. F., 1960, Fossil calcareous algal floras of the Middle East with a note on a cretaceous problematicum Hensonella cyllindrica gen. nov. et sp. nov. Quat. Jour. Geol. Soc., vol. 115. London.

Emberger J., 1955, Les Clypéines (Algues siphonées verticillées) des Monts des Ouland-Näil, Atlas saharien, Algérie. Bul. Soc. Géol. France, ser. 6, t. 5, Paris.

Emberger J., 1957, Aperçu sur la répartition stratigraphique du genre Clypeina Michelin. C. R. somm. Soc. Géol. France, n. 3, Paris.

Farinacci A., 1959, Le microbiofacies giurassiche dei Monti Martani (Umbria). Ist. di Geol. e Paleont. Univ. Roma, A-VIII, n. 41. Roma.

Farinacci A., Sirna G., 1960, Livelli a Saccocoma nel Malm dell'Umbria e della Sicilia. Boll. Soc. Geol. Ital., vol. 79, fasc. 1. Roma.

Farinacci. A., 1963, «L'Organismo C» Favre 1927 appartienne alle Teredinidae ?, Geol. Romana, Vol. II. Roma.

Gignoux M., Moret L., 1920, Le genre Orbitopsella Mun. Chal. et ses relations avec Orbitolina. Bull. Soc. Géol. France, ser. 4, t. 20. Paris.

Hagn H., 1955, Facies und Mikrofauna der Gesteine der Bayerischen Alpen. Brill, Leiden.

Henson F. R. S., 1948, Larger imperforate Foraminifera of South-Western Asia. Brit. Mus. (Nat. Hist.). London.

Henson F. R. S., 1948, New Trochamminidae and Verneuilinidae from the Middle East. Ann. Mag. Nat. Hist., ser. 11, vol. 14 (1947), n. 117, London.

Herak M., Kochansky-Devidé V., 1959, Jurassic calcareous algae in some new localities in the Dinaric Mountains. Bull. sc. Cons. Acad. Zagreb, 4, no. 4. Zagreb.

Herak M., 1960, Calcareous algae of the young Paleozoic and Mesozoic of Yugoslavia, and their application in the stratigraphy. Repport of the Int. Geol. Cong., XXI S. Norden; Part VI — Pre-Quater. Microp. Copenhagen.

Herak M., Bahun S., 1963, Prilog stratigrafskoj analizi naslaga u području Slunj-Komesarac-Rakovica (Hrvatska). Geol. vjesnik Ins. za geol. istraž. u Zagrebu za 1962. g., sv. 16. Zagreb.

Johnson J. H., 1954, An introduction to the study of rock building algae and algal limestones. Quart. of the Colorado school of Mines, vol. 49, n. 2. Colorado.

Kochansky-Devidé V., 1958, Izmjena generacija vrste Orbitopsella praecursor u lijasu Plitvica. Geol. vjesnik Ins. za geol. istraživanja u Zagrebu, sv. 11 za god. 1957. Zagreb.

Lefeld J., Radwanski A., 1960, Planktoniczne liliowce Saccocoma Agassiz w malmie i neokomie wierchowym Tatr Polskich. Acta geol. Polonica, vol. 10, n. 4, Warszawa.

Maync W., 1959, On some larger arenaceous Foraminifera from the Liassic limestones section of Monte Baldo, east of Lago di Garda, Italy. Riv. Ital. Pal. Strat., vol. 65, n. 4. Milano.

Maync W., 1960, Morphology and occurence of the foraminiferal genus Orbitopsella. Riv. Ital. Pal. Strat., vol. 66, n. 4. Milano.

Maync W., 1961, Note sur le genre Orbitammina (Foraminifère) et sa répartition stratigraphique. Revue de Micropaléontologie, vol. 4, n. 1. Paris.

Misik M., 1959, »Lombardiová« mikrofacia — vedúci horizont v malme západných Karpát. Geologicky sbornik 10, 1. Bratislava.

Morellet J., 1950, Contribution à l'étude de Clypeina jurassica Favre d'après remarquables échantillons du Jurassique d'Algérie. Bull. Soc. Géol. France, ser. 5, 20, Paris.

Oberhauser, R., 1964, Zur Kenntnis der Foraminiferengattungen Permodiscus, Trocholina und Triasina in der alpinen Trias und ihre Einordnung zu den Archaedisciden. Sonderabdruck aus den Verhandlungen Geol. B. A., Heft 2, Wien.

Peck R. E., 1957, North American Mesozoik Charophyta. Geol. Sur. Prof. Paper 294 — A. Washington.

Petković K., Veselinović D., 1958, Développement biostratigraphique et répartition paléogeographique des faciès jurassiques sur le territoire de la Yougoslavie. Bull. t. 21 de l'Acad. ser. des sc., Classe math. et nat., n. 6. Beograd.

Pia J., 1920, Die Siphoneae verticillatae von Karbon bis zur Kreide. Abh. zool. botan. Gesel. Wien, 11, 2. Wien.

Pia J., 1924, Einige neue oder ungenügend bekannte Siphoneae verticillatae aus dem mitteleuropäischen Malm. Ann. d. Naturhist. Museums in Wien, Bd. 38. Wien.

Polšak A., Milan A., 1961, Naslage lijasa na području Bukovače kod Bijelog polja u Lici. Geol. vjesnik Inst. za geol. istr. u Zagrebu, sv. 14 za 1960. g. Zagreb.

Polšak A., Milan A., 1962, Facijelni i tektonski odnosi sjeveroistočnog područja Like. V savjetovanje geologa Jugoslavije. Beograd.

Praturlon A., 1964, Calcareous algae from jurassic-cretaceous limestone of central Apennins (Southern Latium-Abruzzi). Geologica Romana, vol. 8. Roma.

Radoičić R., 1956, Nove lokalnosti starije jure u sjeverozapadnoj Crnoj Gori. Geol. glasnik Zavoda za geol. istraživanja NRCG, knj. 1. Cetinje.

Radoičić R., 1957, Nalazak krečnjačkih algi u sedimentima gornje jure okoline Lastve (Trebinje). Zapisnici SGD za 1957 i Geol. glasnik Zavoda za geol. istraživanja u Titogradu. Titograd.

Radoičić R., 1957, Nove lokalnosti sedimenata sa Clypeina jurassica Favre u Crnoj Gori. Vesnik Zavoda za geol. i geof. istraživanja u Beogradu, knj. XIII. Beograd.

Radoičić R., 1957, Slojevi sa Cladocoropsis mirabilis Felix u oblasti Zetske Ravnice. Vesnik Zavoda za geol. i geof. istraživanja u Beogradu, t. XIII. Beograd.

Radoičić R., 1959, Rezultati mikropaleontološkog ispitivanja sedimenata okoline Bačinskog jezera. Geol. glasnik Zavoda za geol. istraživanja NRCG, knj. 3. Titograd.

Radoičić R., 1959, Krupne tintinine Campbelliella nov. gen. i Daturellina nov. gen. — preliminarna beleška. Vesnik Zavoda za geol. i geof. istraživanja. Beograd.

Radoičić R., 1961, Flišolika serija gornje jure u sjeverozapadnoj Crnoj Gori. Vesnik Zavoda za geol. i geof. istraživanja, knj. 19. Beograd.

Radoičić R., 1961, Bilješka o rasprostranjenju gornjojurskih facija u Crnoj Gori i Primorju. Zapisnici SGD za 1961. Beograd 1963.

Radoičić R., 1962, Bilješka o dogeru spoljašnjih Dinarida. Zapisnici SGD za 1962. Beograd.

Radoičić R., 1962, Gornja jura sjeverne Hercegovine. Zapisnici SGD za 1962. Beograd.

Radoičić R., 1962, Hadžiella zetae gen. nov. sp. nov. aberantnih tintinina. Zapisnici Srp. geol. društva za 1962. g. Beograd.

Radoičić R., 1962, Paleoekologija i biostratigrafija aberantnih tintinina Jugoslavije. Disertacija, Ljubljana 1962.

Radoičić R., 1963, Mikrofauna gornjolijaskih krečnjaka Crne Gore, Stare Raške i Rožaja. Vesnik Zavoda za geol. i geof. istraživanja u Beogradu, knj. 20. Beograd.

Radoičić R., 1963, O jednoj novoj gornjojurskoj dazikladacei Pianella grudii gen. nov., spec. nov. Vesnik Zavoda za geol. i geof. istraživanja u Beogradu, knj. 20. Beograd.

Radoičić R., 1964, Mikropaleontološke odlike i stratigrafska korelacija nekih jurskih stubova spoljašnjih Dinarida. Referat na Simpozijumu za naftu, maja 1963. u Hercegnovom. Nafta, br. 10.

Radoičić R., 1964, Teutloporella gallaeformis spec. nov. iz jure spoljašnjih Dinarida. Geološki glasnik Zavoda za geol. istraživanja u Titogradu, knj. IV (u štampi).

Raffi G., Forti A., 1959, Micropaleontological and stratigraphical investigations in «Montagna del Morone» (Abruzzi — Italy). Revue de Micropaléontologie, vol. 2, n. 1. Paris.

Remane J., 1958, Quelques observations sur la passage des faciès subalpins a la limite jurassique-crétacé dans les environs de Grenoble. Trav. du Lab. Géol., Fac. Sc. Univ. Grenoble, t. 34, Grenoble.

Remane J., 1964, Révision paléontologique de Tintinnopsella oblonga (C a d.) et des espèces avoisinantes (Note préliminaire). Revue de Micropaléontologie, vol. 7, n. 1. Paris.

Rutgers A. Th. C., 1942, Geologie und Paleontologie des südöstliche en Teiles des Biokovo und seines Hinterlandes (Dalmatien). Geogr. en Geol. Mededeelingen, ser. 2, n. 4, Utrecht.

Sartoni S., Crescenti U., 1959, La Zona a Palaeodasycladus mediterraneus (P i a) nel Lias dell'Appennino meridionale. Giorn. di Geol., ser. 2, vol. 27 (1956-57). Bologna.

Sartoni S., Crescenti U., 1962, Ricerche biostratigrafiche nel mesozcièo dell'Appennino meridionale. Giorn. di Geol., ser. 2, vol. 29 (1960-61). Bologna.

Sigal J., 1952, Ordre des Foraminifera in: Pivetau: Traité de Paléontologie, vol. 1. Paris.

Smout A. H., Sugden W., 1962, New information on the foraminiferal genus Pfenderina. Paleontology, vo. 4, n. 4. London.

Sirna G., 1962, Stratigrafie e microfacies dei lembi mesozoici della valle di Galati Mamertino (Sicilia nord-orientale). Geologica Romana, vol. 1. Roma.

Yabe H., Toyama S., 1949, New Dasycladaceae from the Jurassic Torinosu Limestone of the Sakawa Basin II. — Proceed. of the Japon Acd., vol. 25, 7.

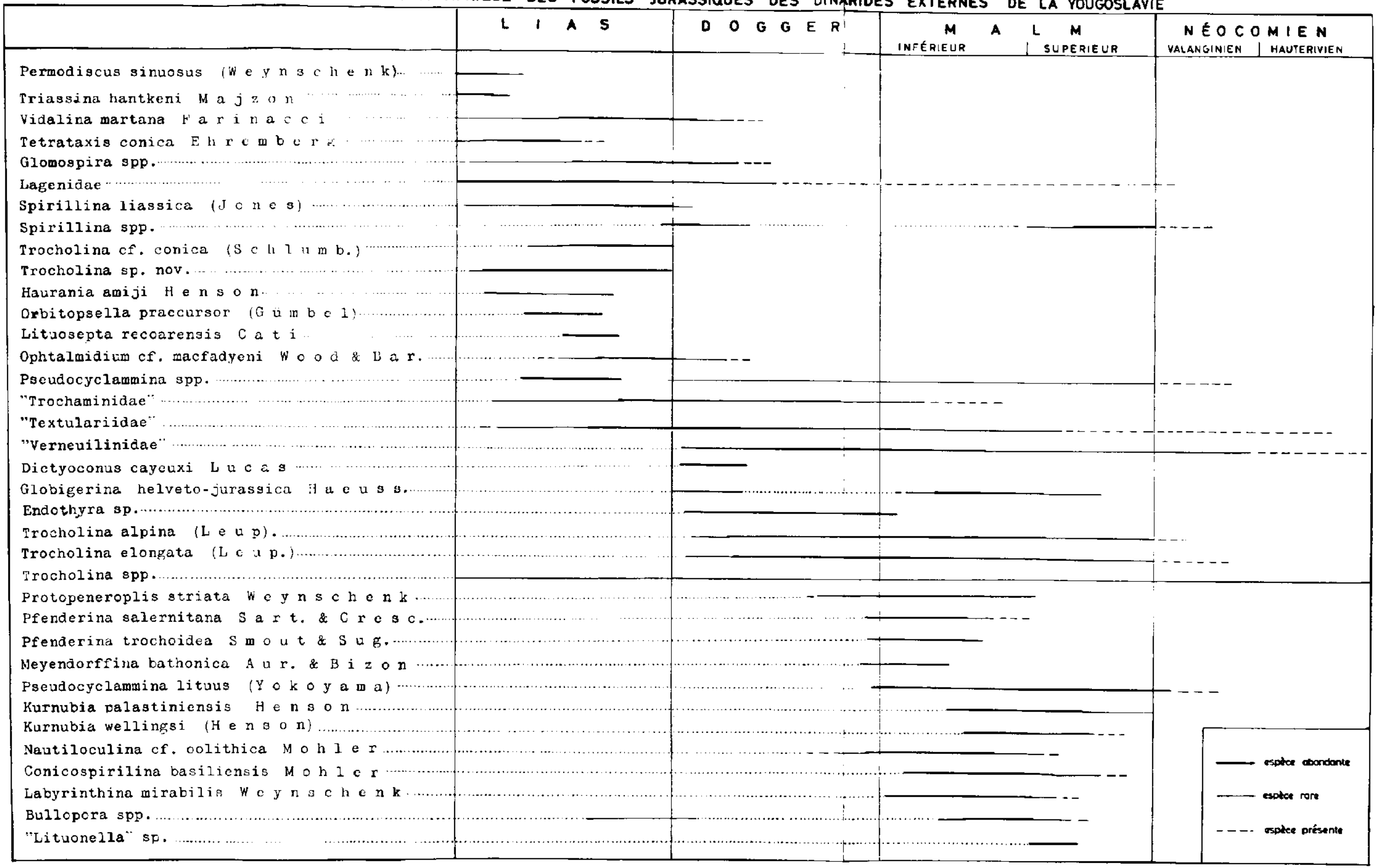
Weynschenk R., 1951, Two new Foraminifera from the Dogger and Upper Triassic of Sonnwend Mountains of Tyrol. Jour. Pal. vol. 25, n. 6. Tulsa.

Weynschenk R., 1956, Some rare Jurassic index Foraminifera. Micropaleontology, vol. 2, n. 3. New York.

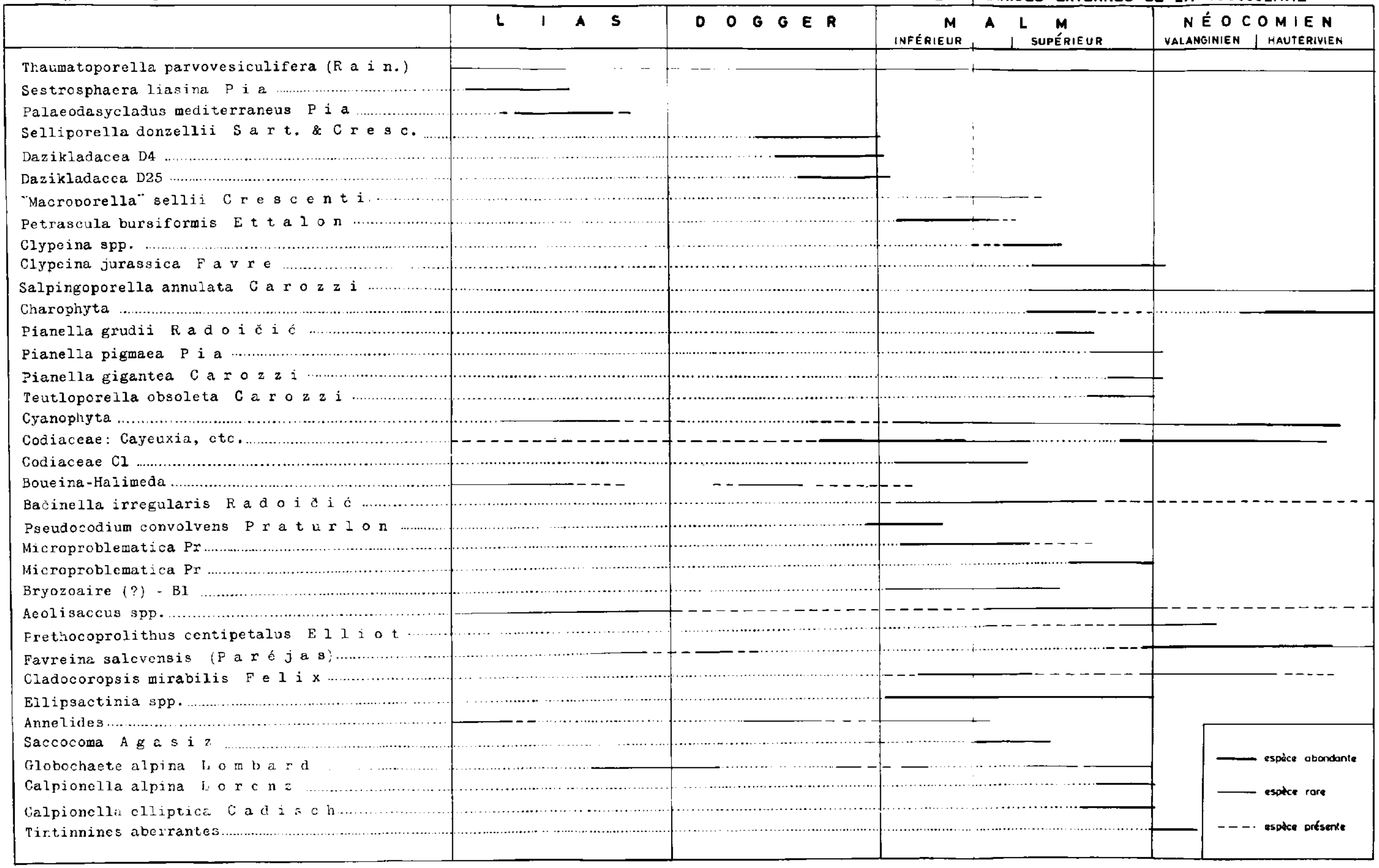
LISTE DES PLANCHES

1. Foraminifera

EXTENSION STRATIGRAPHIQUE DES FOSSILS JURASSIQUES DES DINARIDES EXTERNES DE LA YOUGOSLAVIE



2. Algae, Microproblematica, Tintinnina, etc. **EXTENSION STRATIGRAPHIQUE DES FOSSILS JURASSIQUES DES DINARIDES EXTERNES DE LA YOUGOSLAVIE**



LA SÉRIE JURASSIQUE DES VERSANTS NORD DE LA MONTAGNE RUMIJA

(Tableau № 1)

Planches: I à XVIII

PLANCHE I

Fig. 1 et 2

Calcaire grumeleux, en partie subcristallin, à *Palaeodasycladus mediterraneus* Pia (×17). Pl. mince 3069—60. Dans l'association: petits Foraminifères peu abondants

Montagne Rumija, versants nord, Krajina de l'Ouest

LIAS INFÉRIEUR

Les calcaires à *Palaeodasycladus* sont souvent tachetés quoique ce ne soit pas ici le cas. Ces taches grandes de 0,5 à 1,5 mm sont de fait les Cyanophytes dont le noyau renferme d'ordinaire des *Palaeodasycladus*. Dans ces cas ils sont tellement mal préservés («dissolus») que leur construction à peine s'aperçoit dans la lame mince

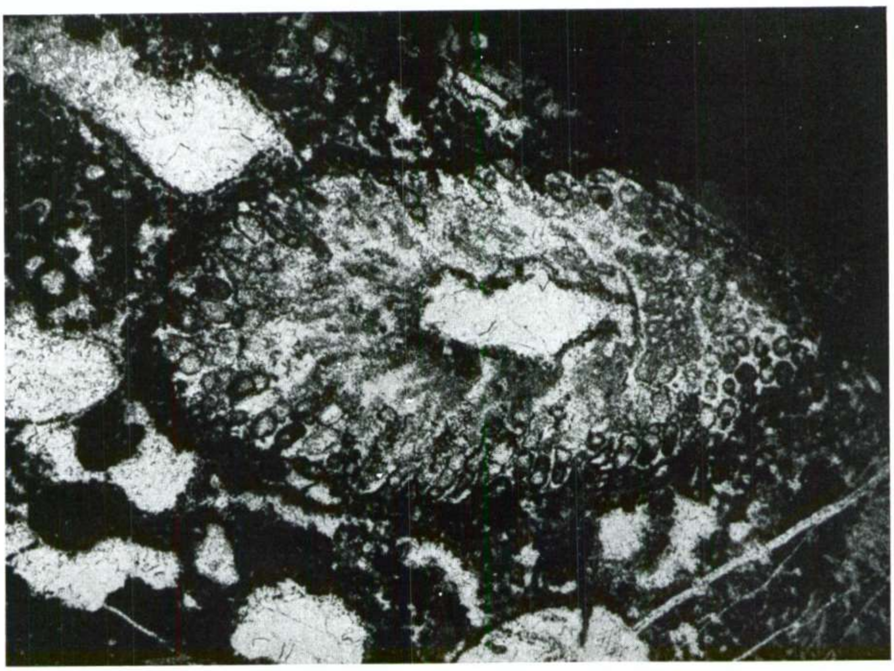


PLANCHE II

Fig. 1

Calcaire à *Frondicularia* sp. et Radiolaires (× 37,5). Pl. mince 3070-60
Versants nords de la montagne Rumija, Krajina de l'est
LIAS INFÉRIEUR-MOYEN (série des calcaires et jaspes)

Fig. 2

Calcaire légèrement marneux à *Frondicularia* sp. (× 37,5). Pl. mince 3071-60
Versants nords de la montagne Rumija, Krajina de l'est
LIAS INFÉRIEUR-MOYEN (série des calcaires et jaspes)

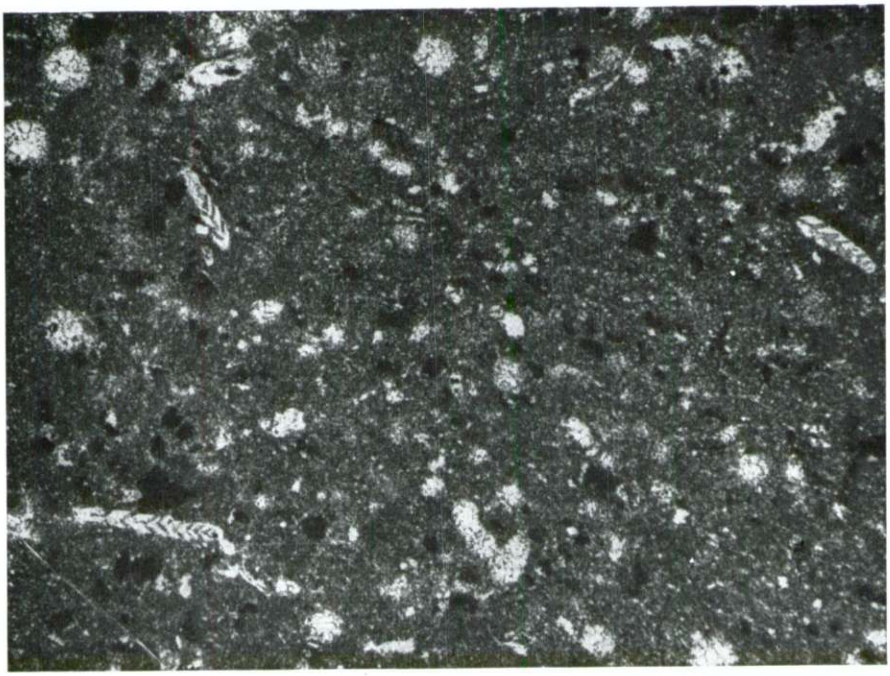


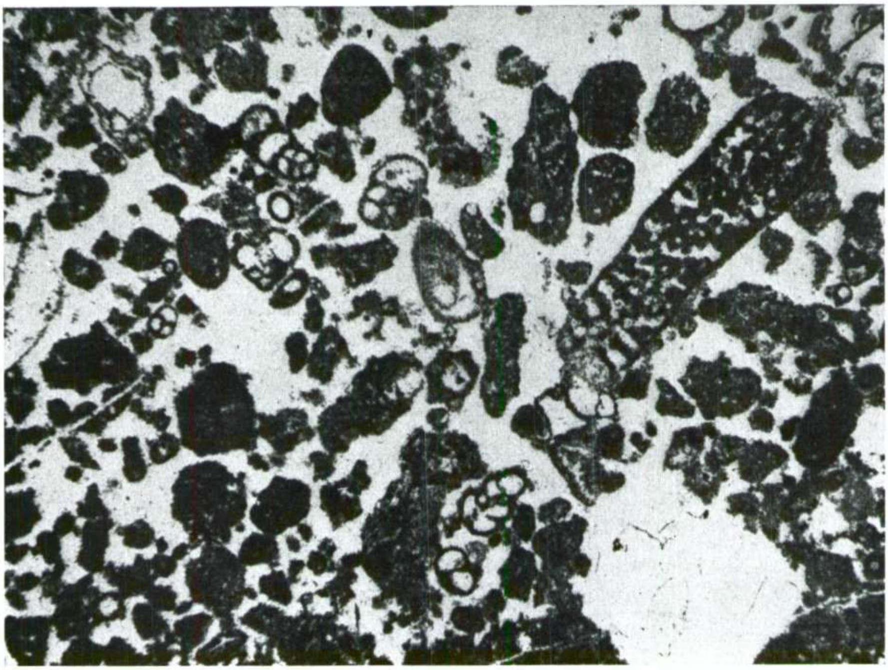
PLANCHE III

Fig. 1 et 2

Calcaire grumeleux à *Orbitopsella*, petits Foraminifères, *Thaumatoporella* et fins débris organogènes (× 27,5). Pl. mince 3072-60

Versants nords de la montagne Rumija, Krajina de l'ouest

LIAS MOYEN



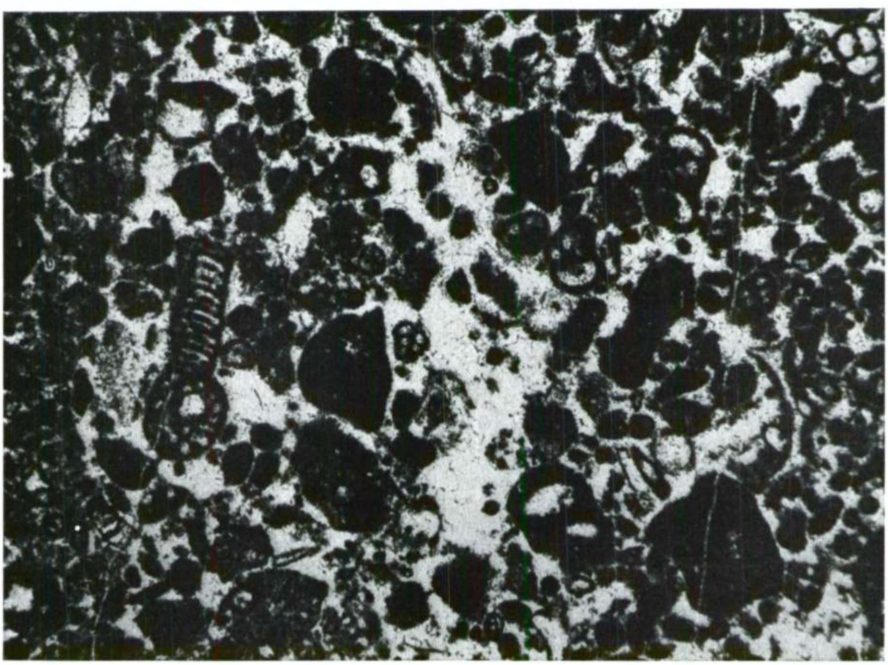


PLANCHE IV

Fig. 1

Calcaire oolithique à débris d'Echinodermes (× 27). Pl. mince 3074-60
Versants nords de la montagne Rumija, Krajina de l'ouest
LIAS SUPÉRIEUR

Fig. 2

Calcaire organogène-détritique à Lagénidés (*Cristellaria* sp. et autres), *Vidalina martana* Farinacci, Microgastéropodes et débris d'Echinodermes (× 27,5). Pl. mince 3077-60

Versants nords de la montagne Rumija, Krajina de l'ouest
LIAS SUPÉRIEUR (LIAS SUPÉRIEUR-DOGGER INFÉRIEUR)

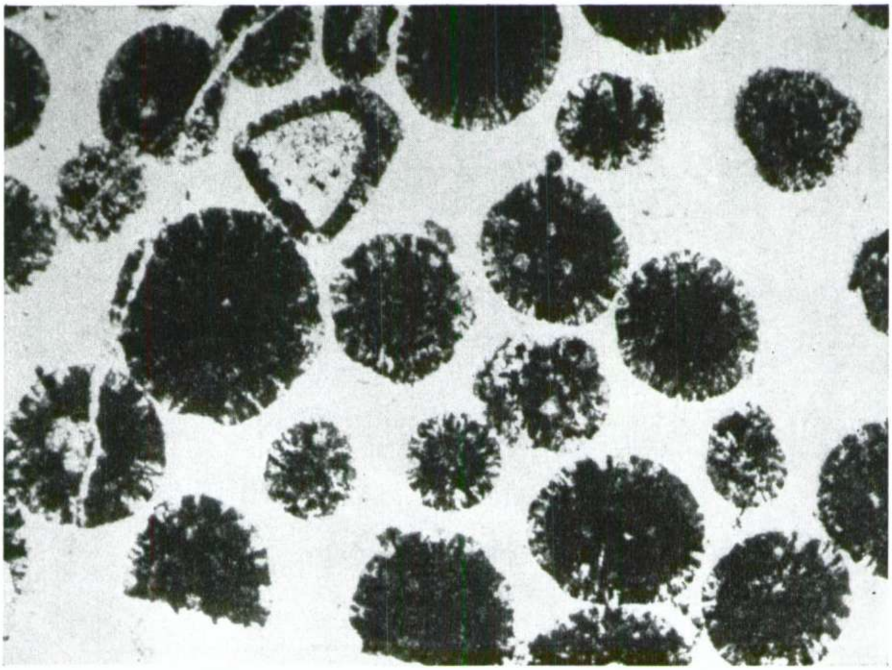


PLANCHE V

Fig. 1

Calcaire microgrumeleux à *Ophtalmidium* sp. et fins débris organogènes (× 27,5). Pl. mince 3077-60; le même plaque mince: pl. IV, fig. 2

Versants nords de la montagne Rumija, Krajina de l'ouest

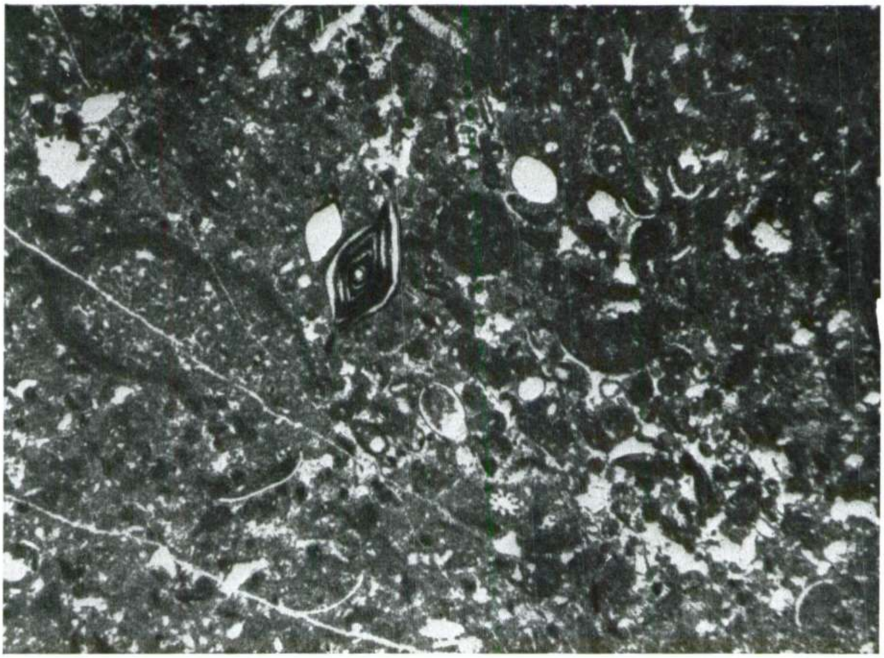
LIAS SUPÉRIEUR (ou LIAS SUPÉRIEUR-DOGGER INFÉRIEUR)

Fig. 2

Calcaire grumeleux, organogène-détritique, à Trocholines, Lituolidés et autres Foraminifères (× 35). Pl. mince 03460

Versants nords de la montagne Rumija, Krajina de l'ouest

DOGGER INFÉRIEUR



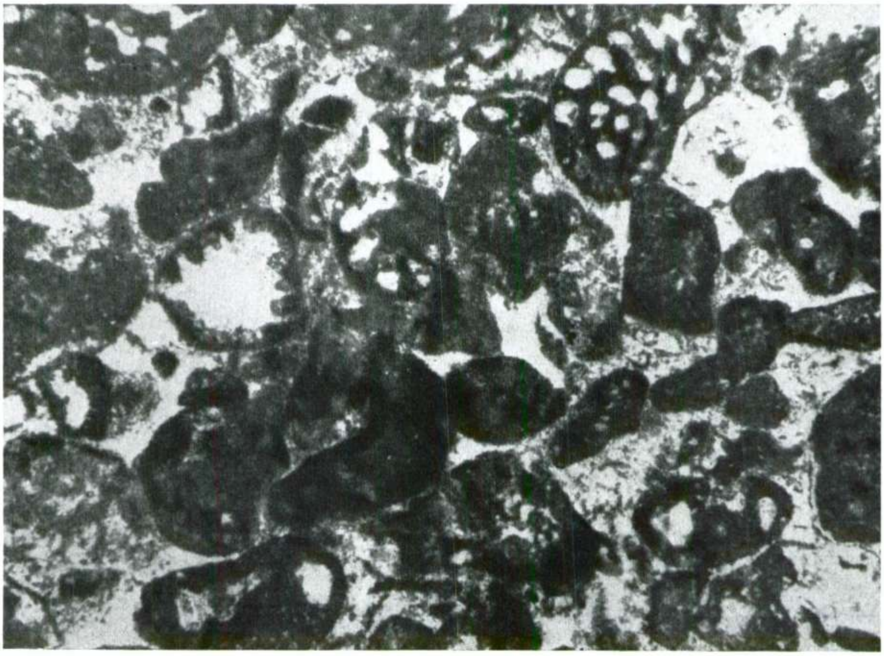


PLANCHE VI

Fig. 1

Calcaire à Codiacées et rares Foraminifères (× 17,5). Pl. mince 3078-60
Versants nords de la montagne Rumija, Krajina de l'ouest
DOGGER

Fig. 2

Calcaire oolithique à débris de Dasycladacée *Selliporella donzellii* Sartoni & Crescenti (× 30). Pl. mince 3079-60. Dans l'association: *Trocholina*, *Endothyra* et autres Foraminifères
Versants nords de la montagne Rumija, Krajina de l'ouest
DOGGER SUPÉRIEUR

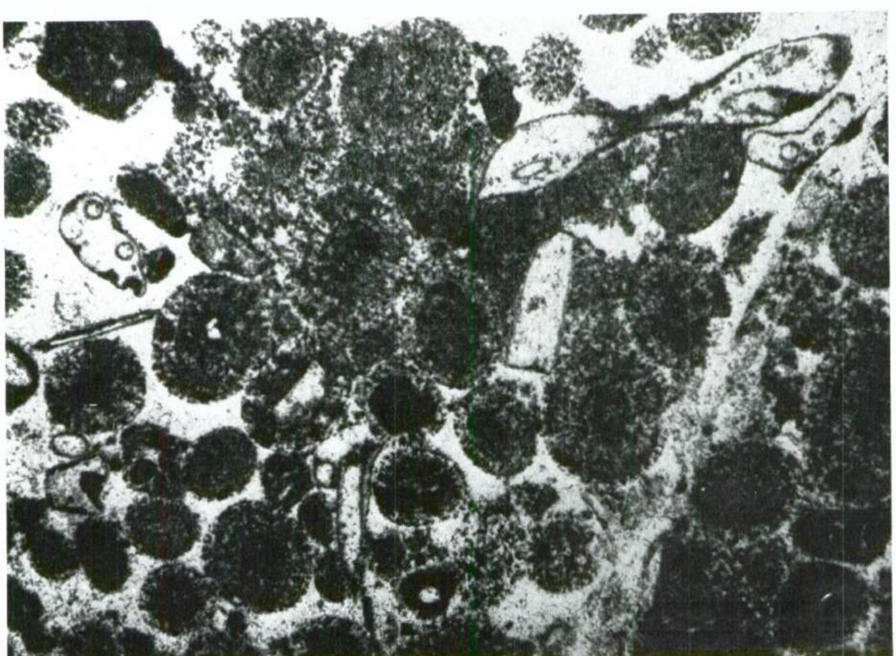


PLANCHE VII

Fig. 1

Calcaire oolithique à *Protopeneroplis striata* Weynschenk et Trocholines (× 40). Pl. mince 3083-60

Versants nords de la montagne Rumija, Krajina de l'ouest

DOGGER SUPÉRIEUR

Fig. 2

Calcaire à Nerinéidés (× 15). Pl. mince 3084-60

Versants nords de la montagne Rumija, Krajina de l'ouest

DOGGER SUPÉRIEUR — MALM INFÉRIEUR

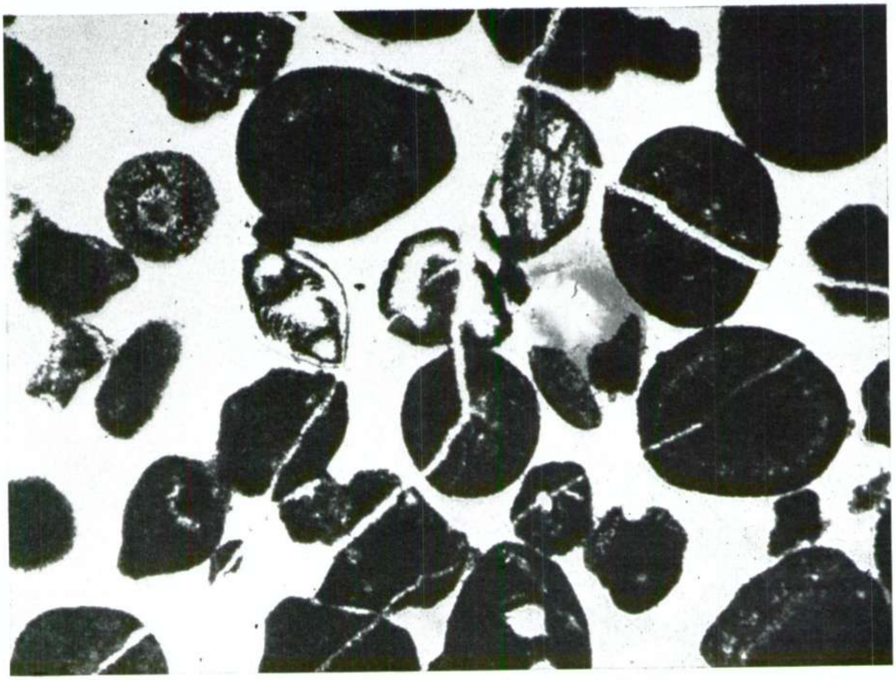


PLANCHE VIII

Fig. 1

Calcaire à *Thaumatoporella parvovesiculifera* (Rain.) (× 27,5). Pl. mince 3085-60. Dans l'association: *Bačinella*, rares Trocholines et mal conservés et «dissolus» *Cladocorpsis*

Versants nords de la montagne Rumija, Krajina de l'ouest

MALM INFERIEUR (les couches les plus anciennes)

Fig. 2

Calcaire organogène-détritique à *Pseudocodium convolvens* Praturlon et petits Foraminifères (× 27,5). Pl. mince 3089-60. Dans l'association: *Bačinella irregularis* Radoičić et autres Codiacées, *Pseudocyclammina*, Polypiers, Hydrozoaires et débris d'Echinodermes

Versants nords de la montagne Rumija, Krajina de l'ouest

MALM INFERIEUR (les couches les plus anciennes)

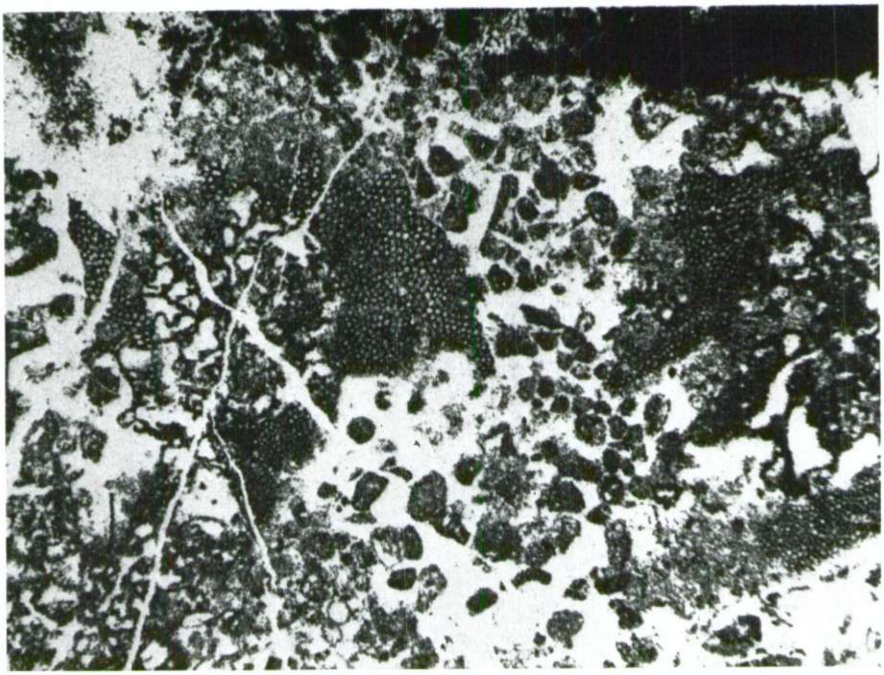


PLANCHE IX

Fig. 1

Calcaire pseudooolithique-détritique à Polypiers; Trocholines et autres Foraminifères (× 17,5). Pl. mince 3088-60. Dans l'association: ***Protopeneroplis striata*** Weynschenk, ***Pseudocodium convolvens*** Praturlon, etc.

Versants nords de la montagne Rumija, Krajina de l'ouest

MALM INFÉRIEUR (les couches les plus anciennes)

Fig. 2

Calcaire organogène-détritique à ***Pseudocyclammina lituus*** (Yokoyama), ***Pseudocodium convolvens*** Praturlon, etc. (× 27,5). Pl. mince 3090-60

Versants nords de la montagne Rumija, Krajina de l'ouest

MALM INFÉRIEUR (les couches les plus anciennes)

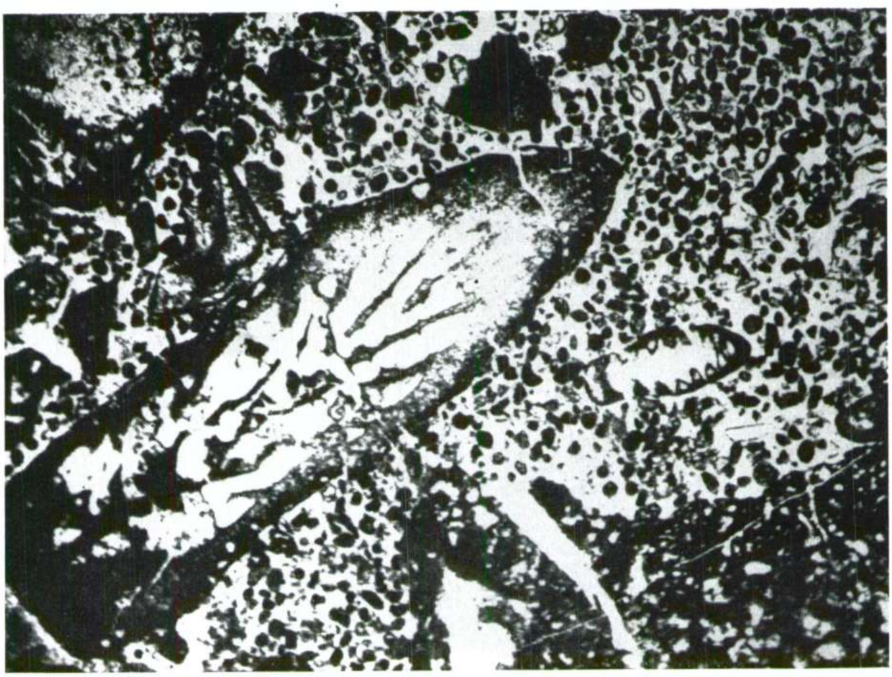


PLANCHE X

Fig. 1

Calcaire organogène-détritique à *Pseudocodium convolvens* Praturlon (× 27,5). Pl. mince 3090-60

Versants nords de la montagne Rumija, Krajina de l'ouest

MALM INFÉRIEUR (les couches les plus anciennes)

Fig. 2

Calcaire à Foraminifères peu nombreux (Miliolidés et autres), débris de Mollusques, d'Echinodermes et d'Algues (× 27,5). Pl. mince 3092-60

Versants nords de la montagne Rumija, Krajina de l'ouest

MALM INFÉRIEUR (probablement OXFORDIEN)

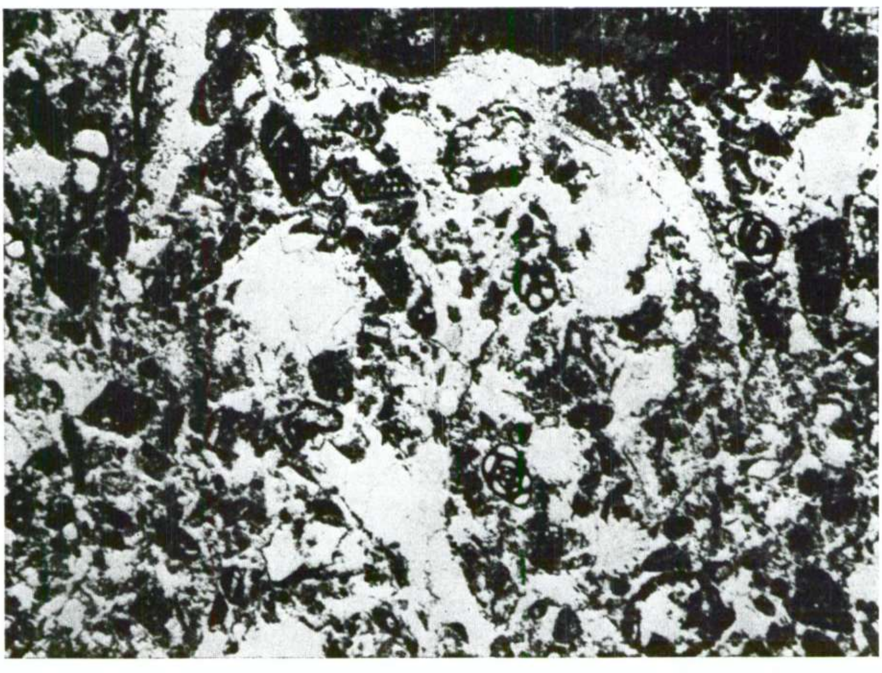


PLANCHE XI

Fig. 1 et 2

Calcaire légèrement marneux à Cyanophytes (*Girvanella* ?), (× 17,5). Pl. minces 2312a et 2312b-60

Versants nords de la montagne Rumija; Krajina, Murići

MALM (OXFORDIEN-KIMMÉRIDGIEN)

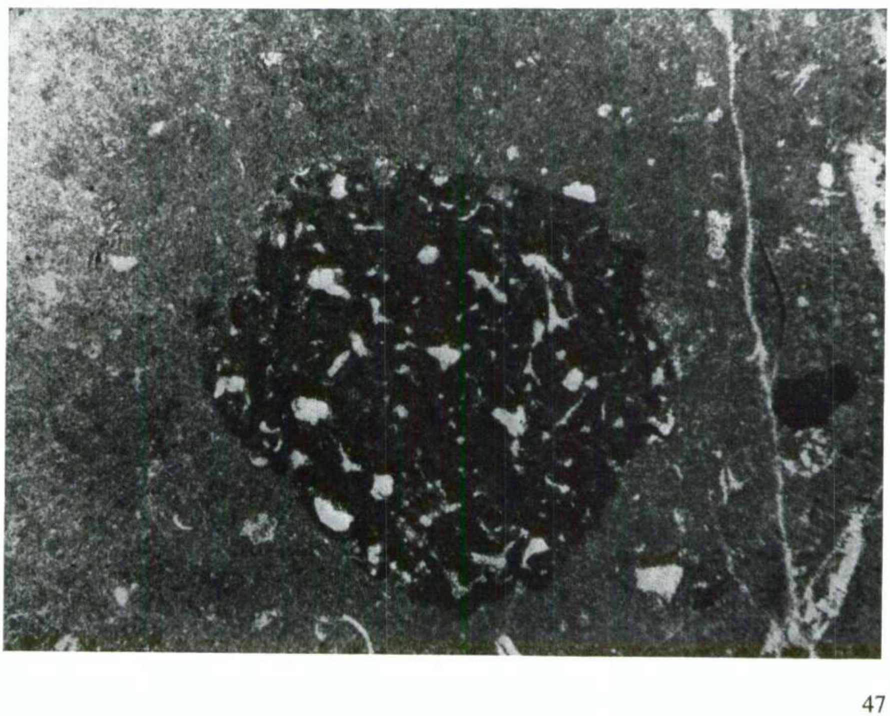


PLANCHE XII

Fig. 1 et 2

Calcaire fin microgrumeleux à *Conicospirillina basiliensis* Möhler, *Pseudocyclammina* sp. et autres rares Foraminifères; *Prethocoprolithus centripetalus* Elliott, Cyanophytes, etc. (× 27). Pl. mince 2321-60

Versants nords de la montagne Rumija, Krajina, environs de Murići

MALM (KIMMÉRIDGIEN INFÉRIEUR)

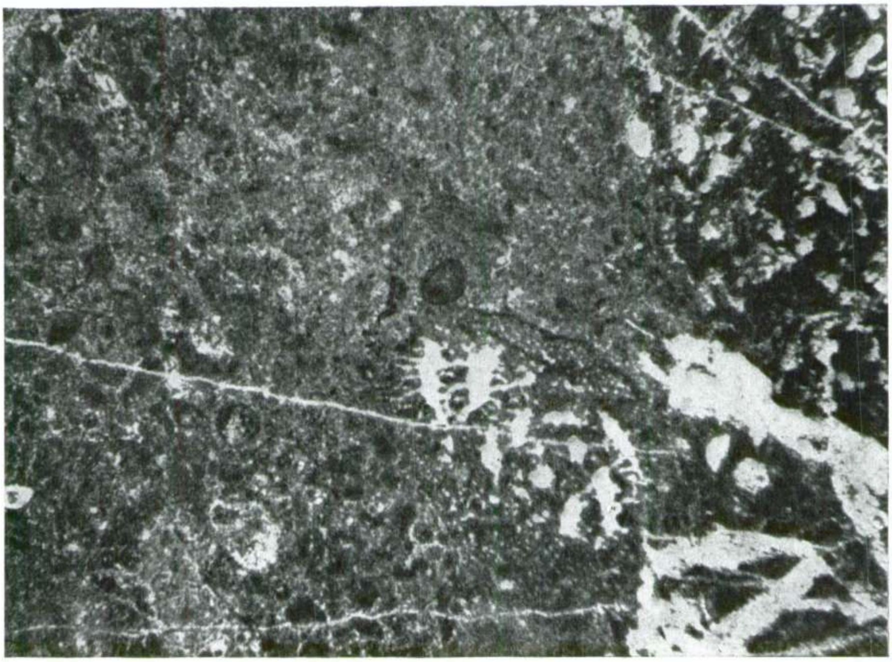


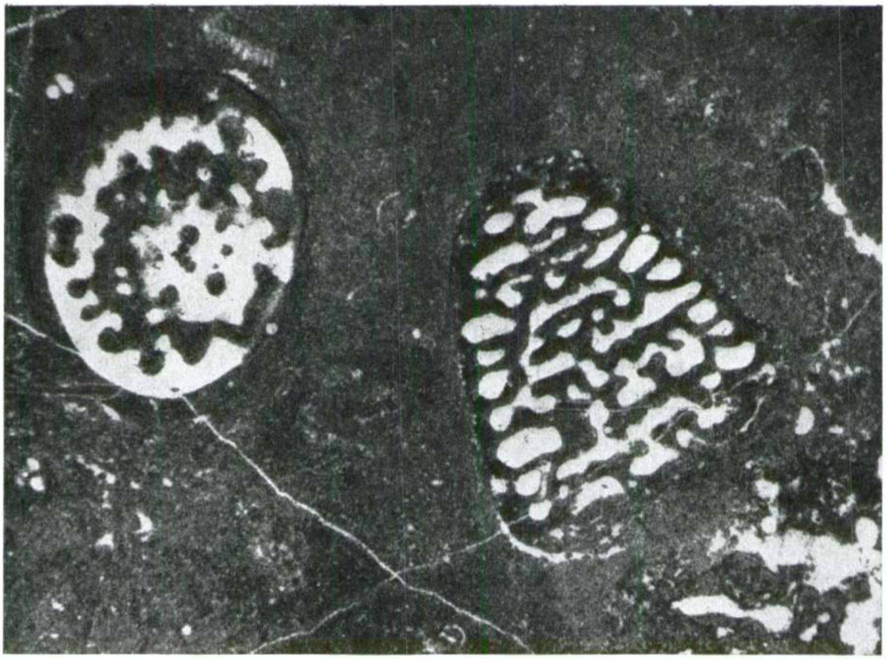
PLANCHE XIII

Fig. 1 et 2

Calcaire légèrement marneux à «*Lituonella*» et Cyanophytes (× 27,5 — fig. 1; × 17,5 — fig. 2). Pl. minces 2316 et 2315-60. Dans l'association: très rare *Clypeina jurassica* Favre, *Thaumatoporella parvovesiculifera* (Rain.) et Codiacées (= pl. XIV)

Versants nords de la montagne Rumija, Krajina, environs de Murići

MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR)



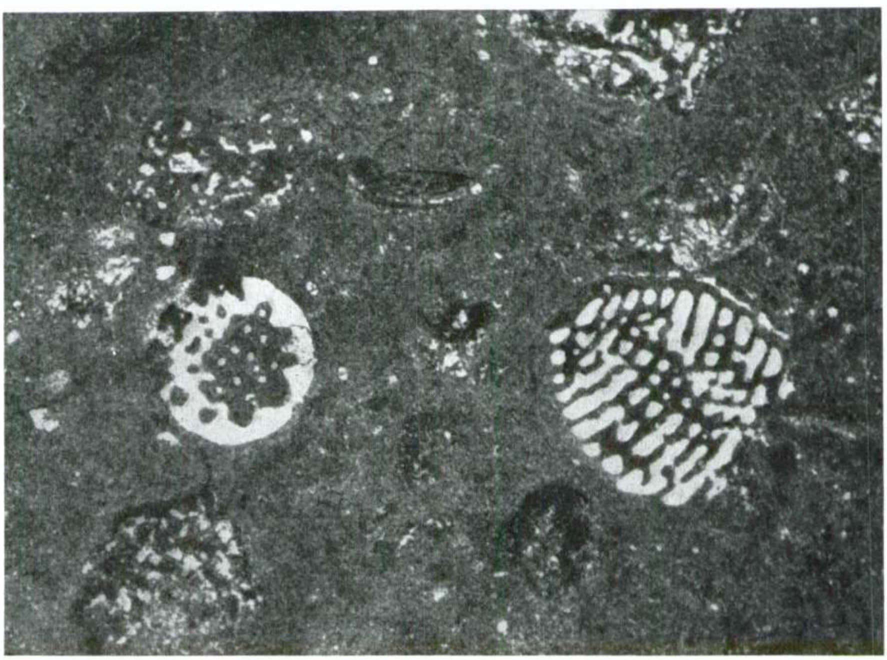


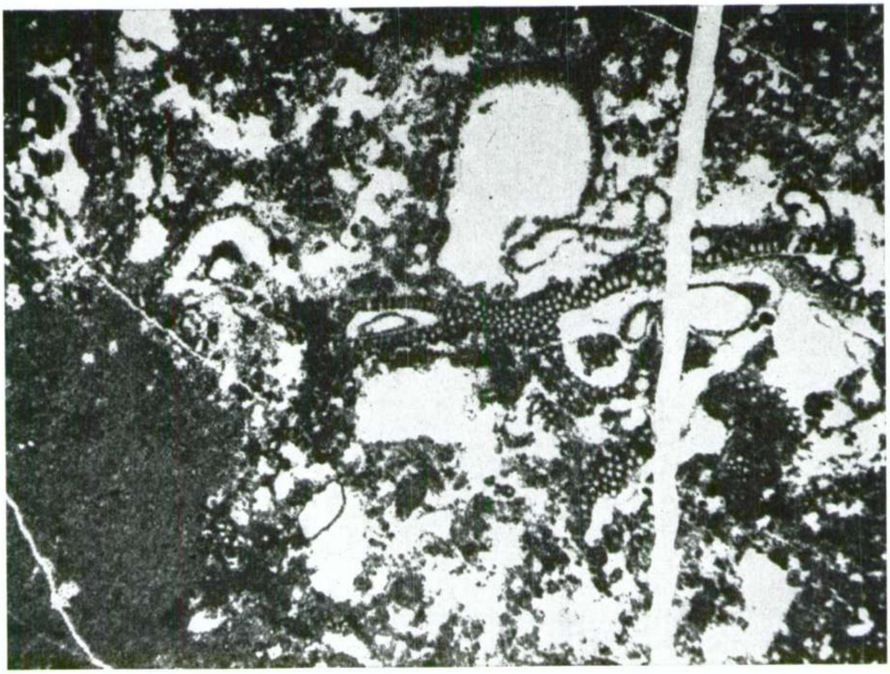
PLANCHE XIV

Fig. 1 et 2

Calcaire à *Thaumatoporella parvovesiculifera* (Rain.), Codiacées et «*Lituonella*» (× 27). Pl. mince 2315-60

Versants nords de la montagne Rumija; Krajina, Murići

MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR)



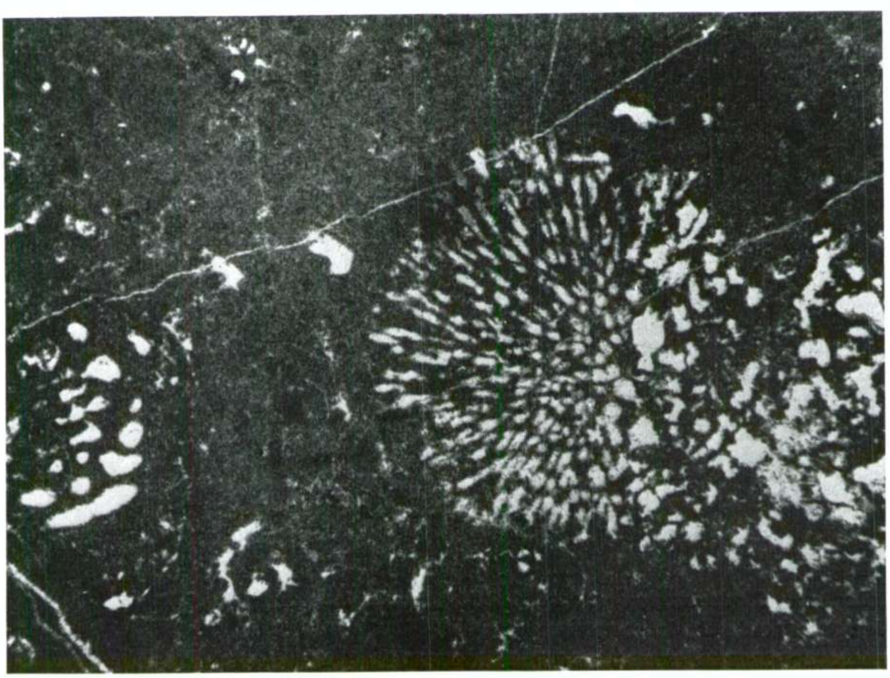


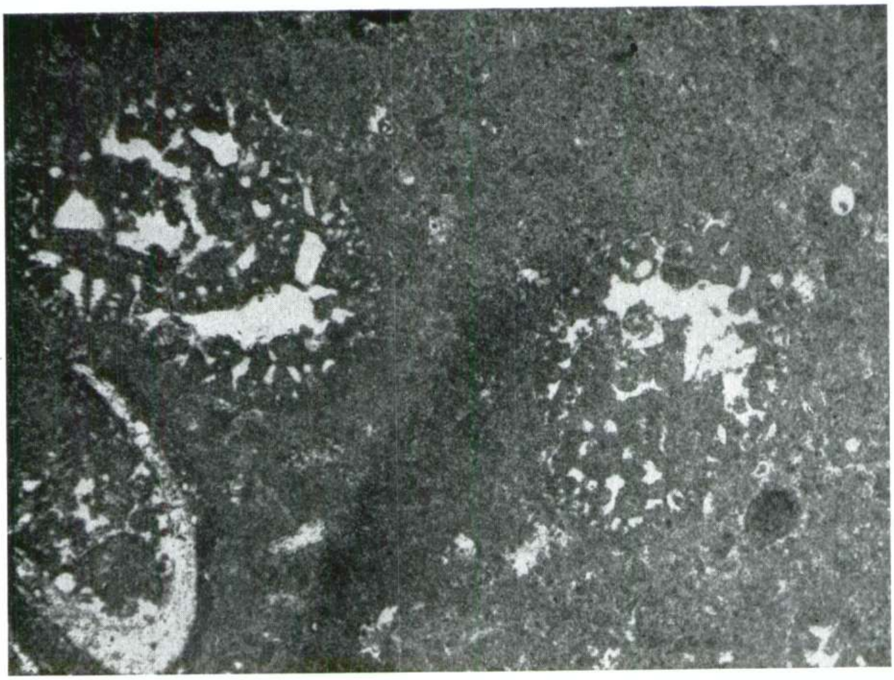
PLANCHE XV

Fig. 1

Calcaire à *Pseudocyclammina* cf. *lituus* (Yokoyama), (× 27,5). Pl. mince 2314-60. Dans l'association: *Cladocoropsis mirabilis* Felix.
Versants nords de la montagne Rumija; Krajina, Murići
MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR)

Fig. 2

Calcaire à *Cladocoropsis mirabilis* Felix (× 27). Pl. mince 2314-60
Versants nords de la montagne Rumija; Krajina, Murići
MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR)



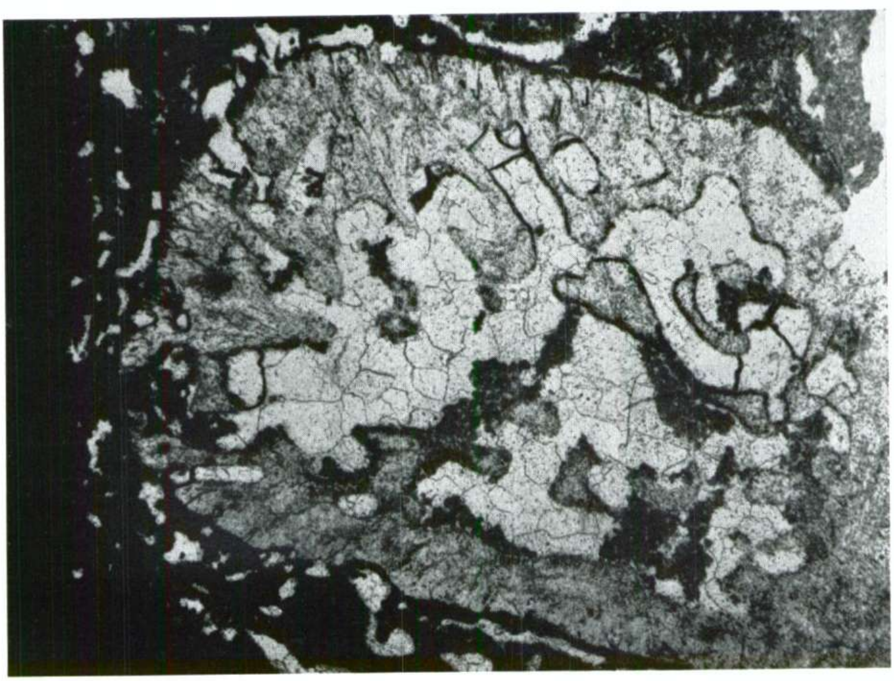


PLANCHE XVI

Fig. 1

Calcaire à *Clypeina jurassica* Favre (× 27,5). Pl. mince 2312-60. Dans l'association: Cyanophytes, Ostracodes et très rares petits Foraminifères

Versants nords de la montagne Rumija; Krajina, Murići

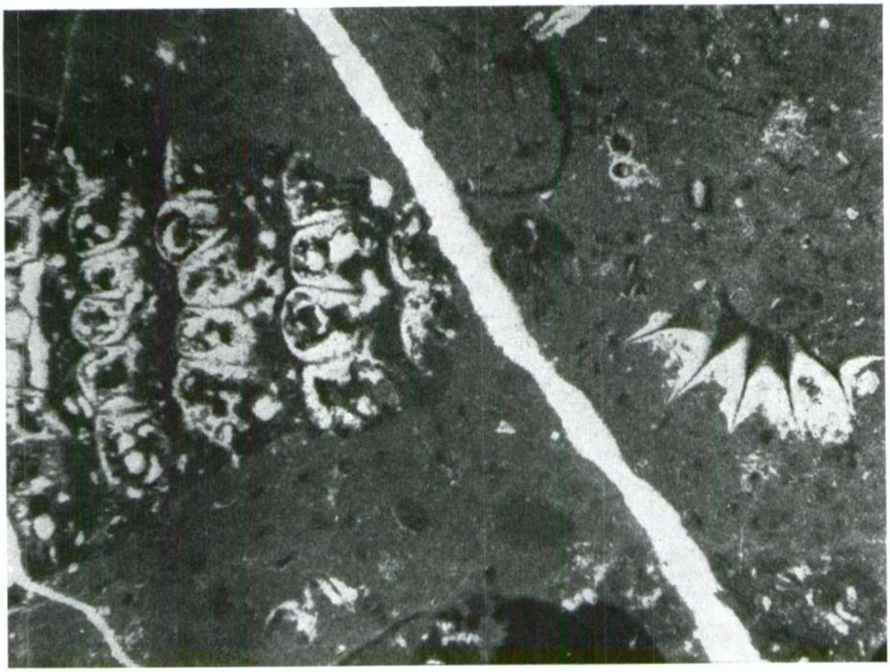
MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR-PORTLANDIEN)

Fig. 2

Calcaire à Charophytes (× 27,5). Pl. mince 2311-60. Dans l'association: Ostracodes

Versants nords de la montagne Rumija; Krajina, Murići

MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR-PORTLANDIEN)



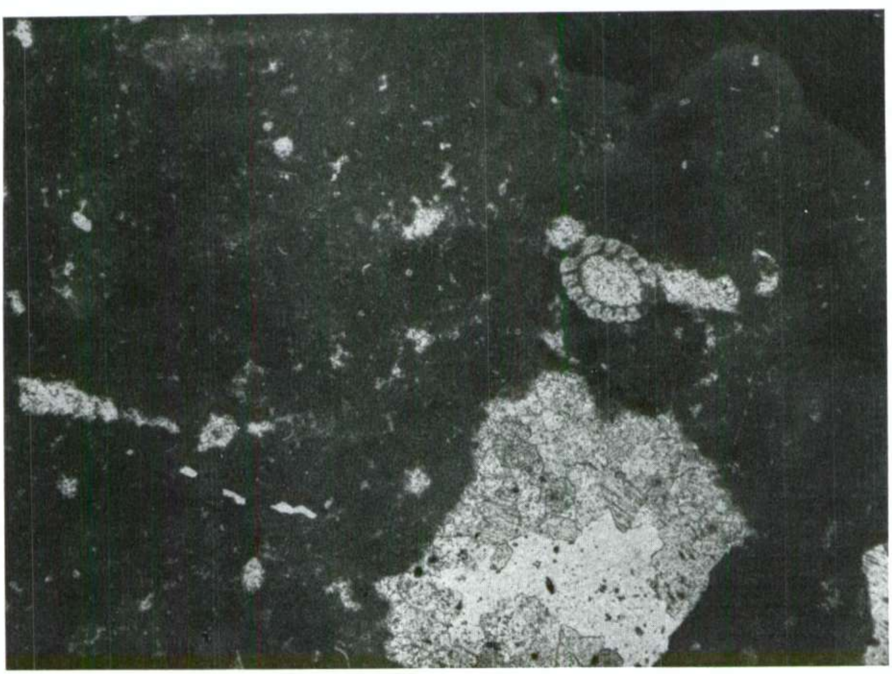


PLANCHE XVII

Fig. 1 et 2

Calcaire oolithique-détritique à *Nerinea* cf. *suessi* Peters* et Codiacées (× 15). Pl. mince 2310-60

Versants nords de la montagne Rumija; Krajina, Murići

MALM SUPÉRIEUR (PORTLANDIEN)

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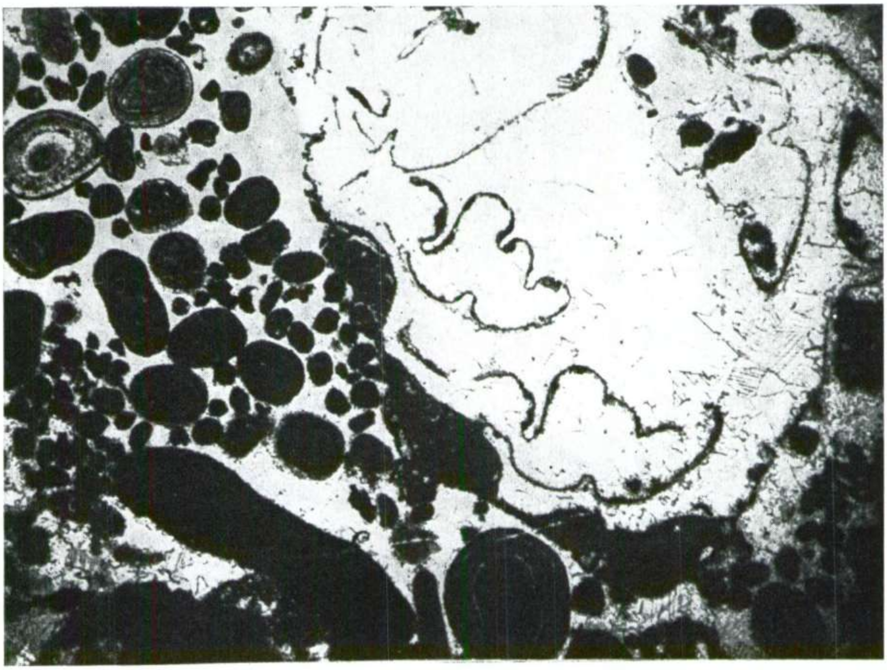
* Détermination de Mme. O. Marković.



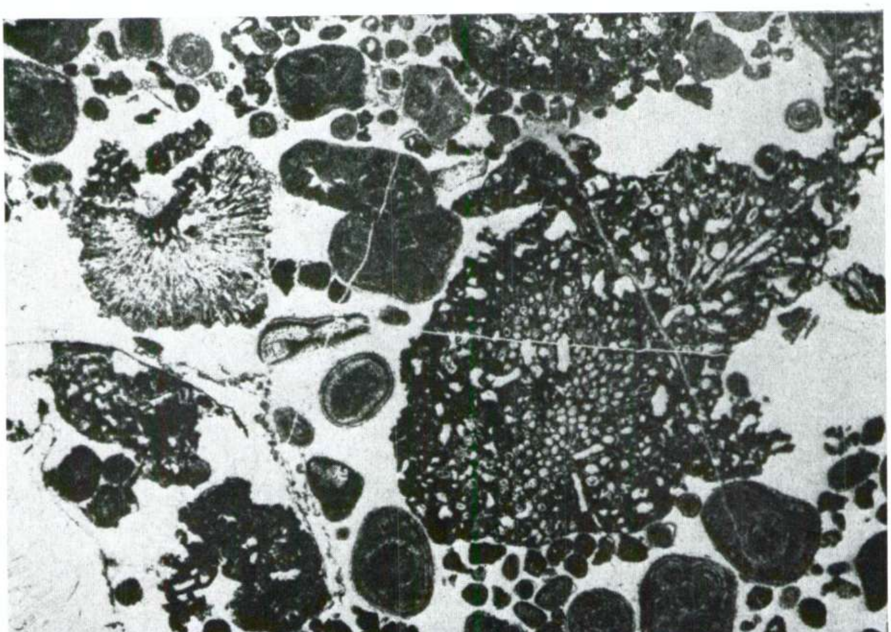


PLANCHE XVIII

Fig. 1 et 2

Calcaire légèrement marneux à *Salpingoporella annulata* Carozzi, une Dasycladacée inconnue (D27) et Mollusques (× 27,5). Pl. mince 2309-60. Dans l'association: *Clypeina jurassica* Favre, autres Dasycladacées, Kurnubia et rares Polypiers solitaires

Versants nords de la montagne Rumija; Krajina, Murići

MALM SUPÉRIEUR (PORTLANDIEN)

LA SÉRIE JURASSIQUE DE LA BORDURE OUEST DE LA ZETSKA RAVNICA ET DU DISTRICT VERS L'ANCIEN MONTÉNÉGRO

(Tableau № 2)

Planches: XIX à XLI

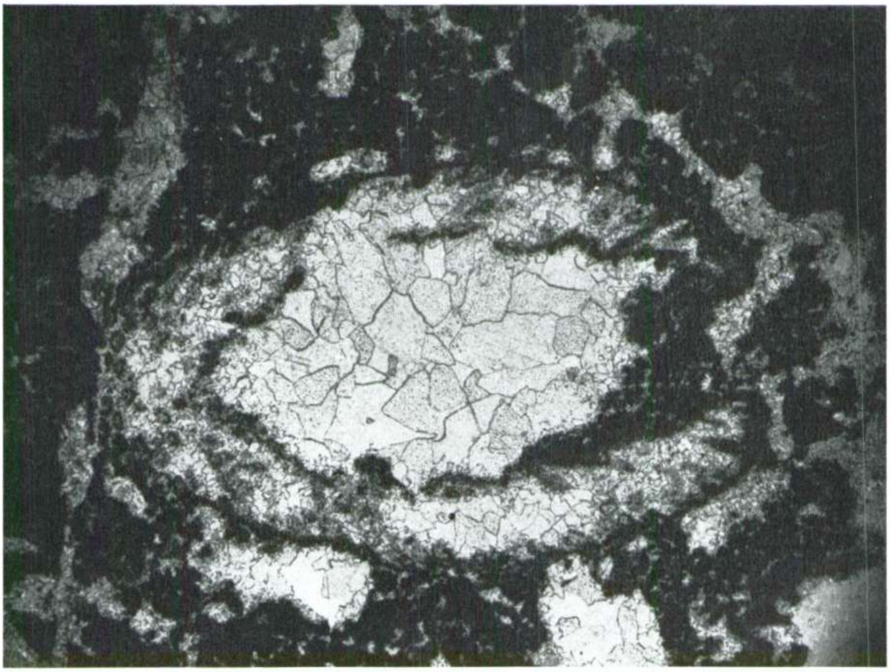
PLANCHE XIX

Fig. 1 et 2

Calcaire à *Palaeodasycladus mediterraneus* Pia et petits Foraminifères (× 17). Pl. mince 1229-57

Odrinska gora (l'île dans le lac Skadarsko jezero)

LIAS INFÉRIEUR



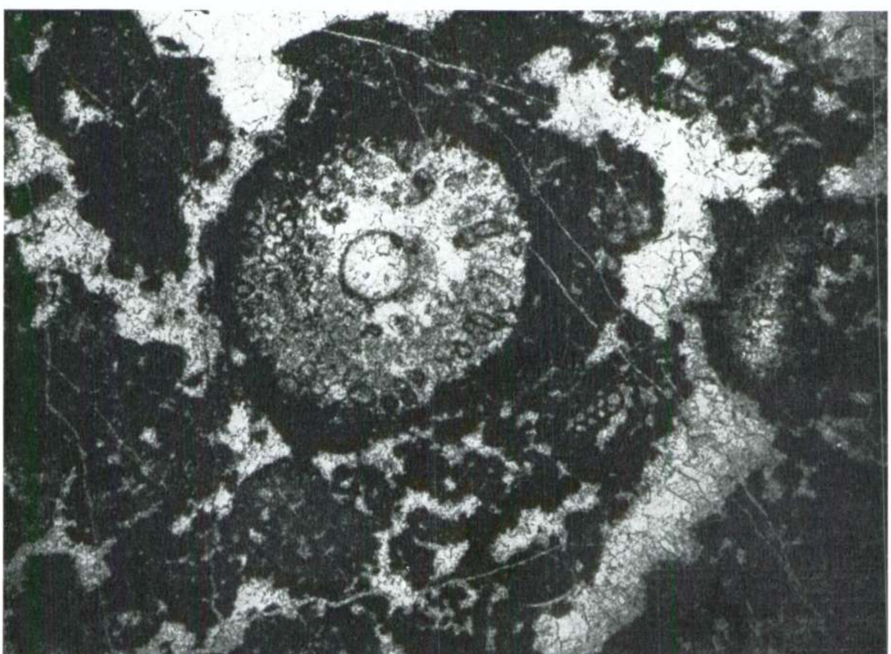


PLANCHE XX

Fig. 1 et 2

Calcaire microgrumeleux à *Orbitopsella praecursor* (Gümbel), (× 17,5). Pl. minces 1815 et 1816-60

Bordure ouest de la Zetska ravnica, Dodoši

LIAS MOYEN

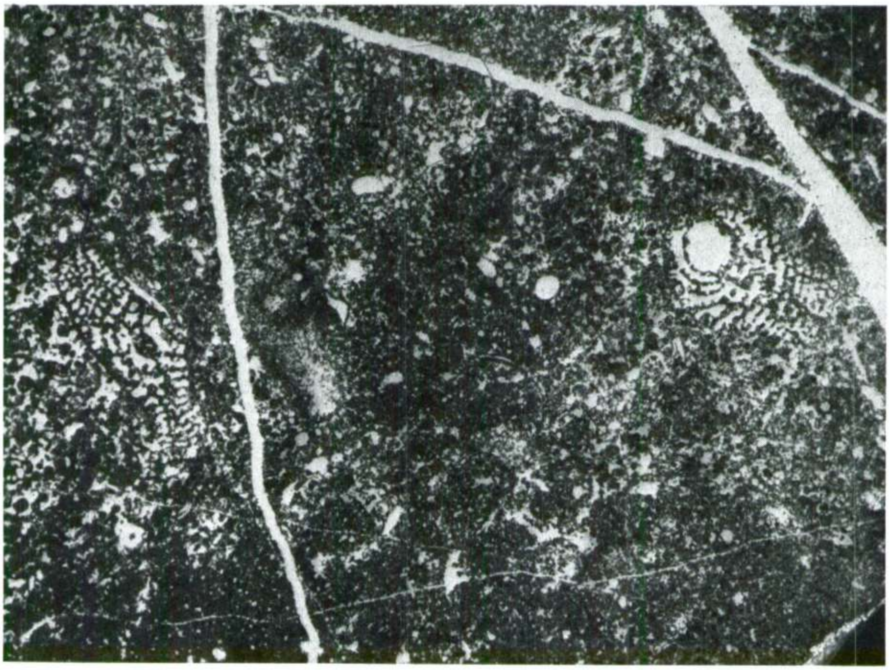


PLANCHE XXI

Fig. 1 et 2

Calcaire légèrement marneux à «*Aeolisaccus*» (débris de Bryozoaires?), Bryozoaires et très transformées Dasycladacées-*Palaeodasycladus mediterraneus* Pia (× 40). Pl. mince 353-55

Bordure ouest de la Zetska ravnica, Dodoši

LIAS MOYEN

PLANCHE XXII

Fig. 1

Calcaire légèrement bitumineux à *Pseudocyclammina* sp., autres Foraminifères et débris de Mollusques (× 40). Pl. mince 197-55

Bordure ouest de la Zetska ravnica, Dodoši

LIAS MOYEN

Fig. 2

Calcaire bitumineux à *Pseudocyclammina* sp. et les coques des petites Lamellibranches (× 40). P. mince 351-55

Bordure ouest de la Zetska ravnica, Dodoši

LIAS MOYEN

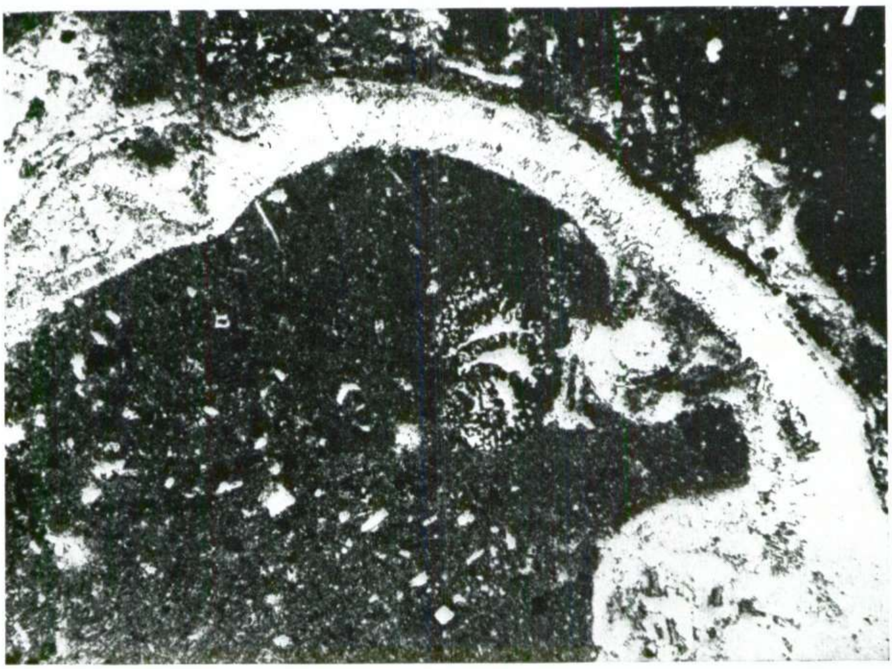


PLANCHE XXIII

Fig. 1

Calcaire marneux, peu bitumineux, à Lituolidés et autres Foraminifères, Micro-gastéropodes et débris de Mollusques (× 17,5). Pl. mince 354-55

Bordure ouest de la Zetska ravnica, Dodoši

LIAS MOYEN

Fig. 2

Calcaire à Codiacées (× 17,5). Pl. mince CG-1106. Dans l'association: *Thaumatoporella parvovesiculifera* (Rain.) et petits Foraminifères

L'Ancien Monténégro, Topsude

LIAS MOYEN-SUPÉRIEUR

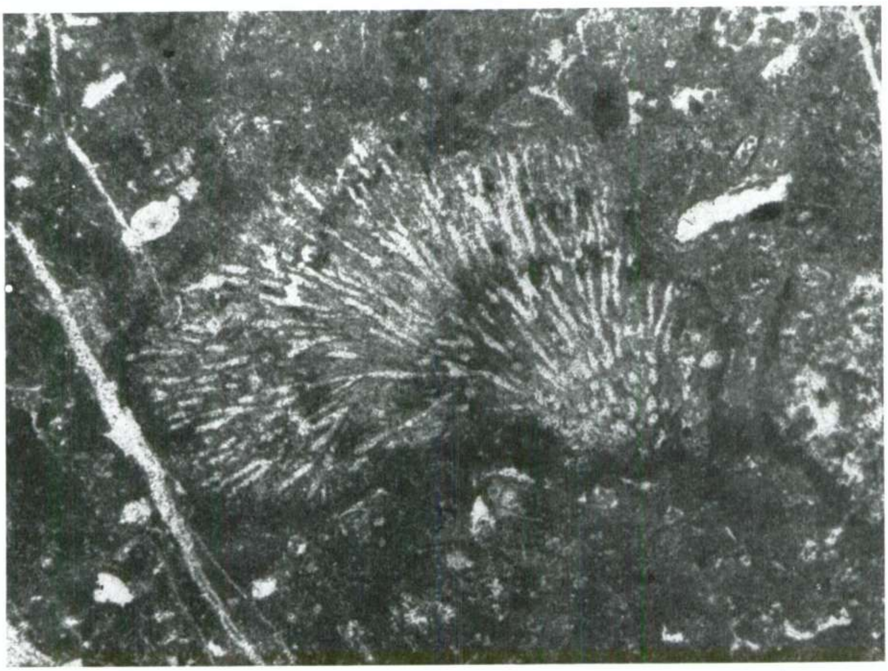


PLANCHE XXIV

Fig. 1

Calcaire microgrumeleux à *Thaumatoporella parvovesiculifera* (Rain.) et rares petits Foraminifères (× 29). Pl. mince 1819-59

Bordure ouest de la Zetska ravnica, Buza-Bobija

LIAS SUPÉRIEUR-DOGGER INFÉRIEUR

Fig. 2

Calcaire grumeleux à Trochamminidés et Textularidés (× 29). Pl. mince 1820-60. Dans l'association: rares Codiacées et Microgastéropodes

Bordure ouest de la Zetska ravnica, Buza-Bobija

LIAS SUPÉRIEUR-DOGGER INFÉRIEUR

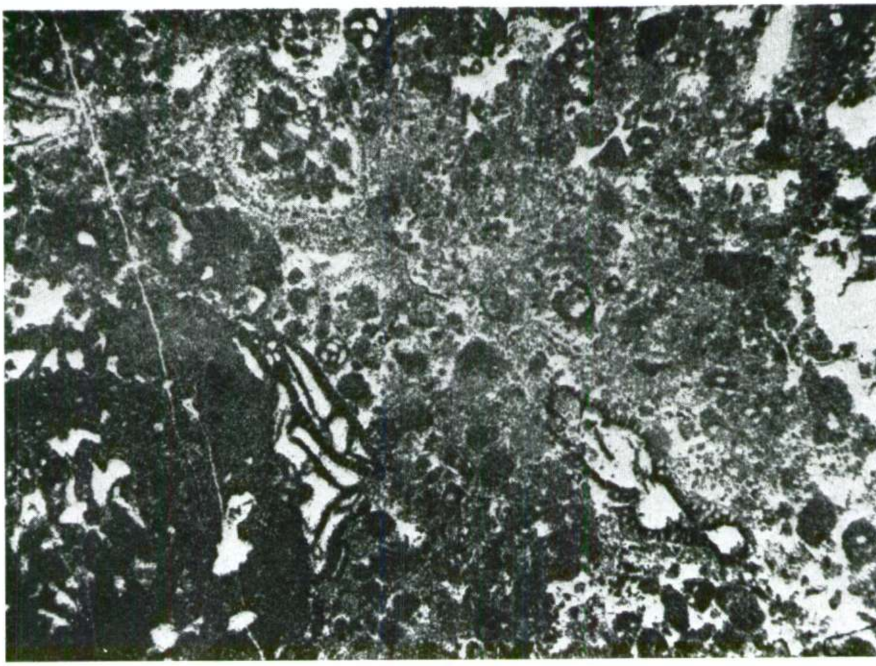


PLANCHE XXV

Fig. 1

Calcaire peu détritique, subcristallin, à Trochamminidés, Verneuilinidés, Textularidés et très rares Miliolidés (× 28). Pl. mince 1822-60. Dans l'association: *Thaumatoporella parvovesiculifera* (Rain.) et rares petits Trocholines

Bordure ouest de la Zetska ravnica, Buza-Bobija

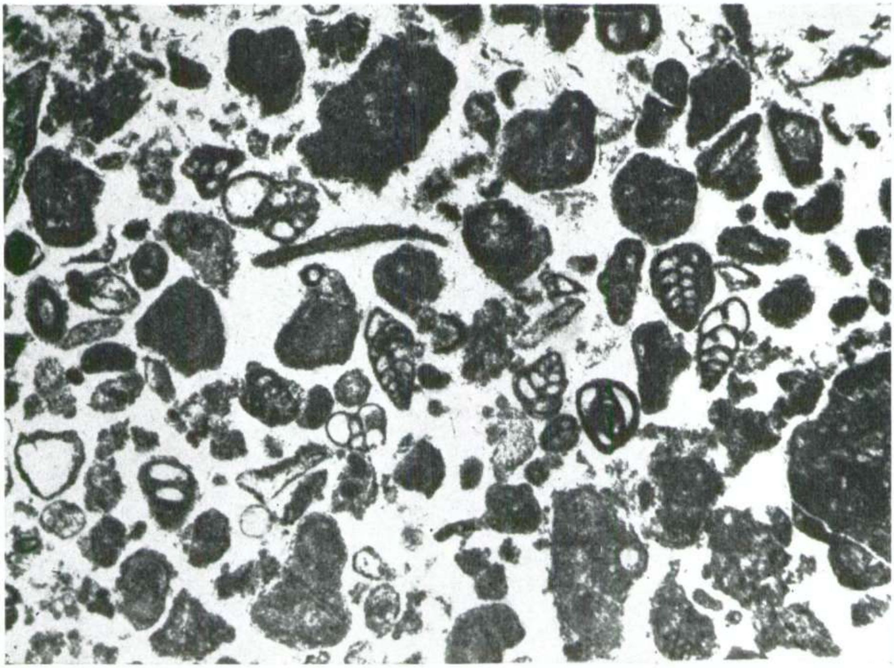
DOGGER INFÉRIEUR

Fig. 2

Calcaire à Foraminifères peu abondants, *Aeolisaccus* sp. et Microgastéropodes (× 28). Pl. mince 1823-60. Dans l'association: *Thaumatoporella parvovesiculifera* (Rain.)

Bordure ouest de la Zetska ravnica, Buza-Bobija

DOGGER INFÉRIEUR



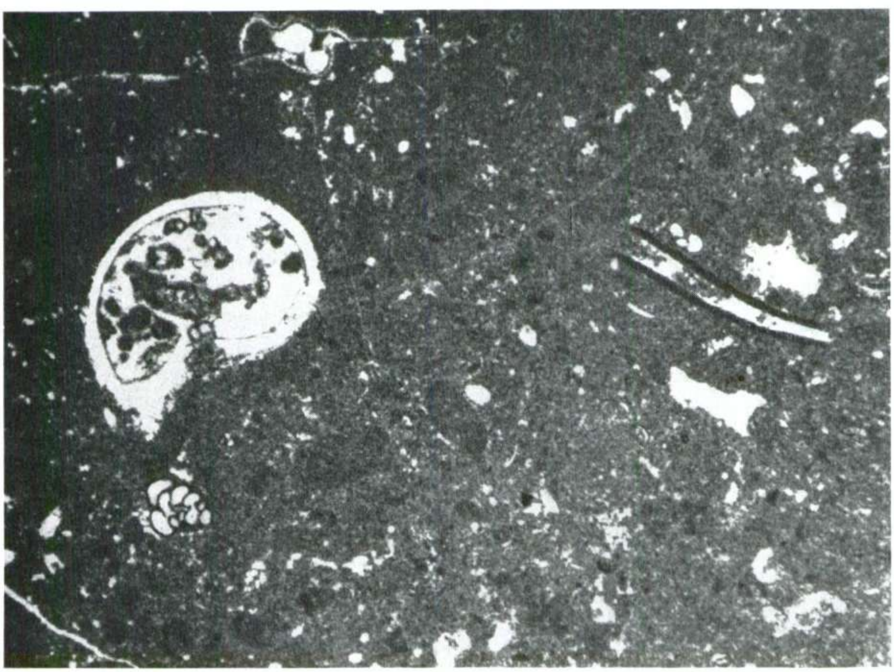


PLANCHE XXVI

Fig. 1

Calcaire grumeleux, en partie oolithique, à *Dictyoconus cayeuxi* (Lucas), (× 37,5). Pl. mince 615-61

L'Ancien Monténégro, environs de Grkavac

DOGGER INFÉRIEUR

Fig. 2

Calcaire oolithique-détritique à *Dictyoconus cayeuxi* (Lukas), (× 37,5). Pl. mince 621-61

L'Ancien Monténégro, environs de Resna

DOGGER INFÉRIEUR

PLANCHE XXVII

Fig. 1

Calcaire organogène à Textularidés, Trochamminidés, Verneuilinidés, puis *Thaumatoporella parvovesiculifera* (Rain.), Dasycladacées et débris divers (× 17,5). Pl. mince 1824-59

Bordure ouest de la Zetska ravnica, Buza-Bobija

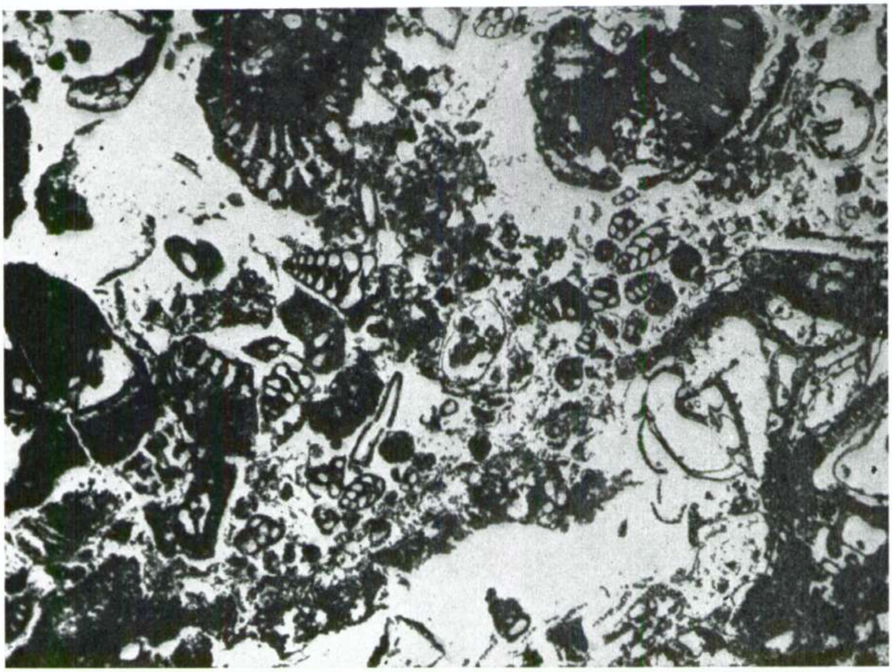
DOGGER INFÉRIEUR

Fig. 2

Calcaire organogène à nombreux Foraminifères (Textularidés, Trochamminidés, Verneuilinidés, Miliolidés, etc.), et débris de Mollusques (× 28,5). Pl. mince 1827-59. Dans l'association: Dasycladacées et petites *Nerinella*

Bordure ouest de la Zetska ravnica, Buza-Bobija

DOGGER SUPÉRIEUR



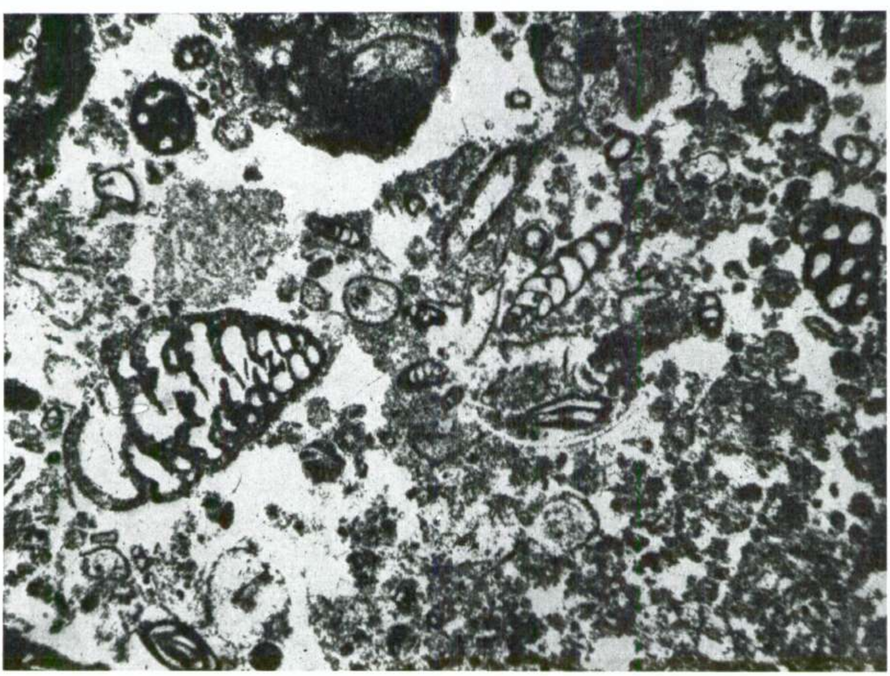


PLANCHE XXVIII

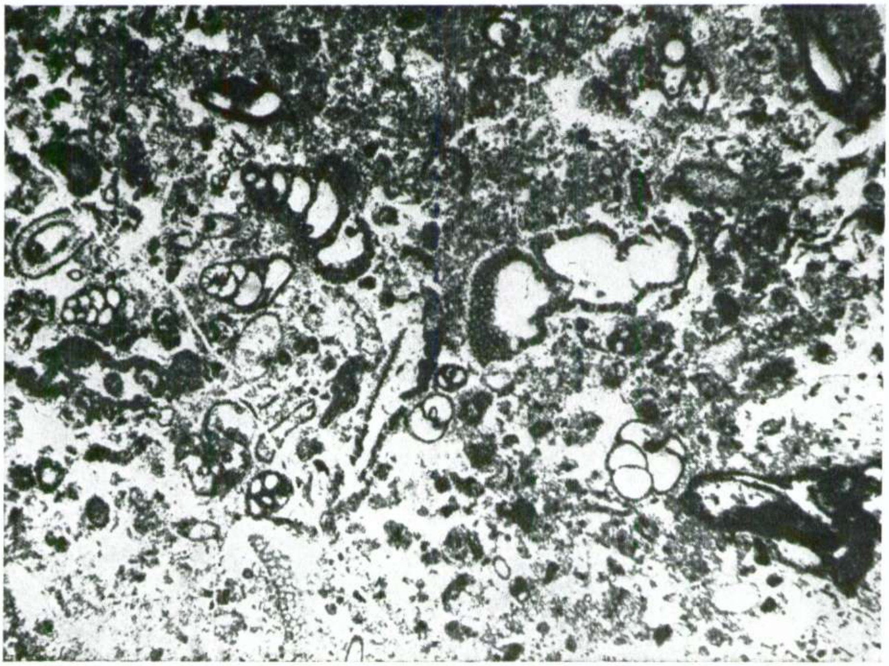
Fig. 1 et 2

Calcaire organogène à *Thaumatoporella parvovesiculifera* (Rain.), nombreux Foraminifères (Trochamminidés, Textularidés, Verneuilinidés et aut.) et débris très abondants de Dasycladacées (*Selliporella*) et de Mollusques (× 28,5). Pl. mince 1827-59

Bordure ouest de la Zetska ravnica, Buza-Bobija

DOGGER SUPÉRIEUR

Protopeneroplis striata apparaissant généralement dans les calcaires oolithiques et oolithiques-détritiques est peu fréquente dans les sédiments de la bordure ouest de la plaine Zetska ravnica où les calcaires oolithiques apparaissent secondairement dans le Dogger et Malm. Dans la colonne examinée les *Protopeneroplis* sont observés dans une couche des calcaires oolithiques détritiques se trouvant à quelques mètres au-dessus du calcaire présenté sur cette planche.



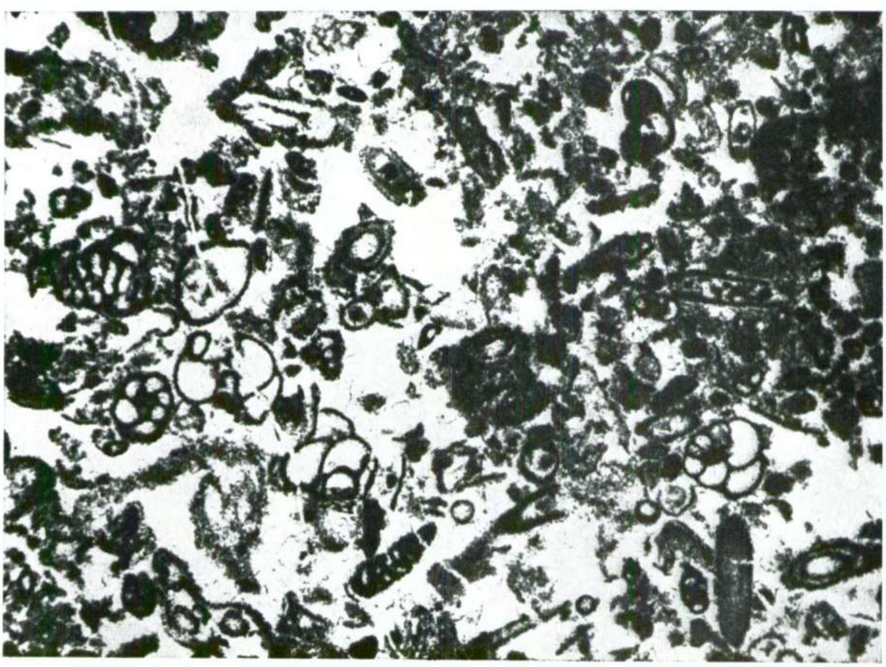


PLANCHE XXIX

Fig. 1

Calcaire phytogène à *Selliporella donzellii* Sartoni & Crescenti et Foraminifères très rares (× 40). Pl. mince 167-57

Bordure ouest de la Zetska ravnica, au nord de Ponar

DOGGER SUPÉRIEUR

Les microfaciès des calcaires à *Selliporella donzellii* ou leurs débris et autres microfossiles peu fréquents, représentent, ayant en vue leur large extension géographique, les microfaciès du Dogger les plus importants dans les Dinarides externes. A côté de l'espèce *Selliporela donzellii* se trouvent de plus deux Dasycladacées: *Tevtloporella gallaeformis* Rad. et la D4.

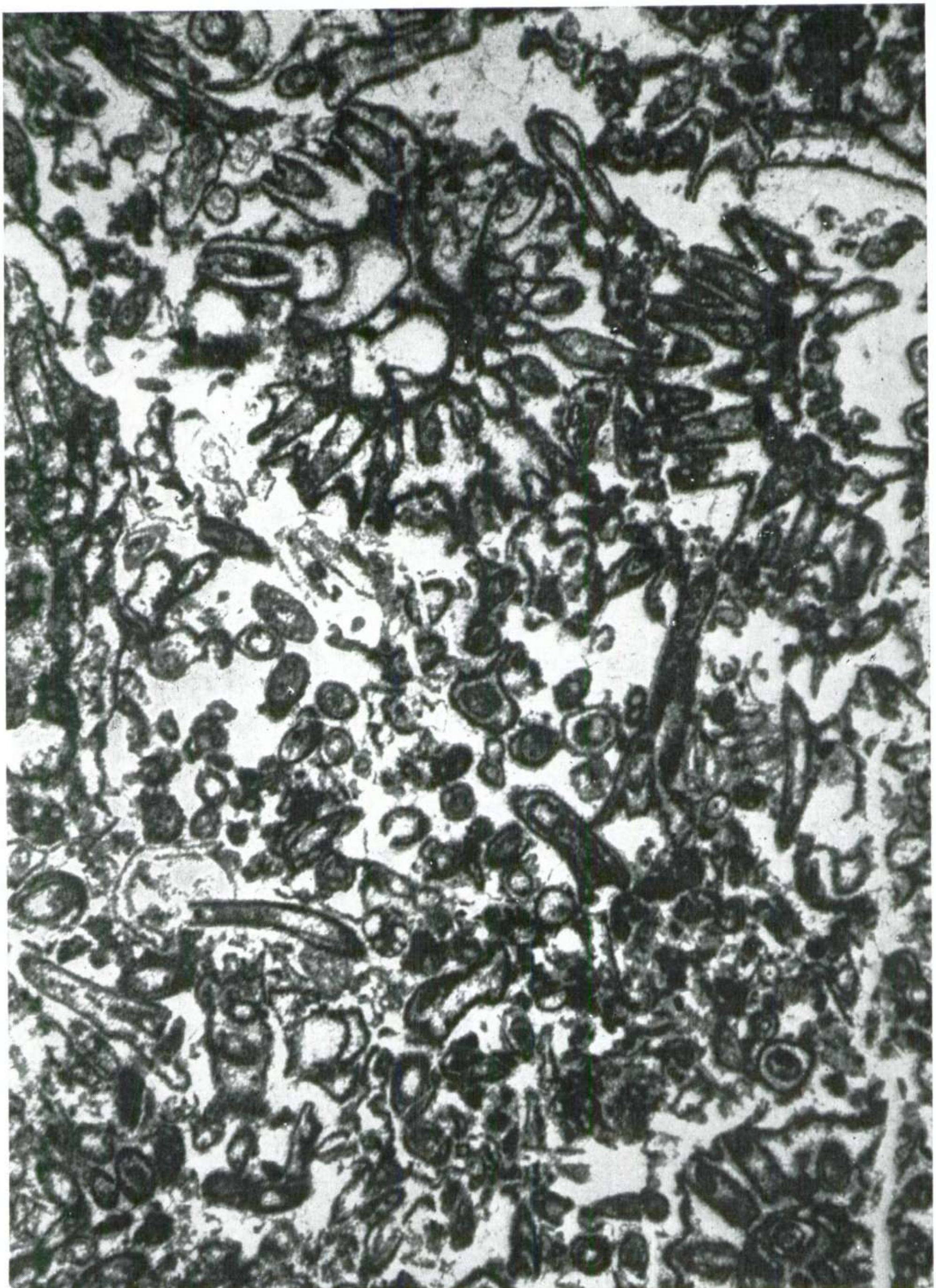


PLANCHE XXX

Fig. 1

Calcaire grumeleux à *Thaumatoporella parvovesiculifera* (Rain.) et Foraminifères (× 28,5). Pl. mince 1828-59. Dans l'association: débris de Dasycladacées, rares Microgastéropodes et Polypiers

Bordure ouest de la Zetska ravnica, Buza-Bobija

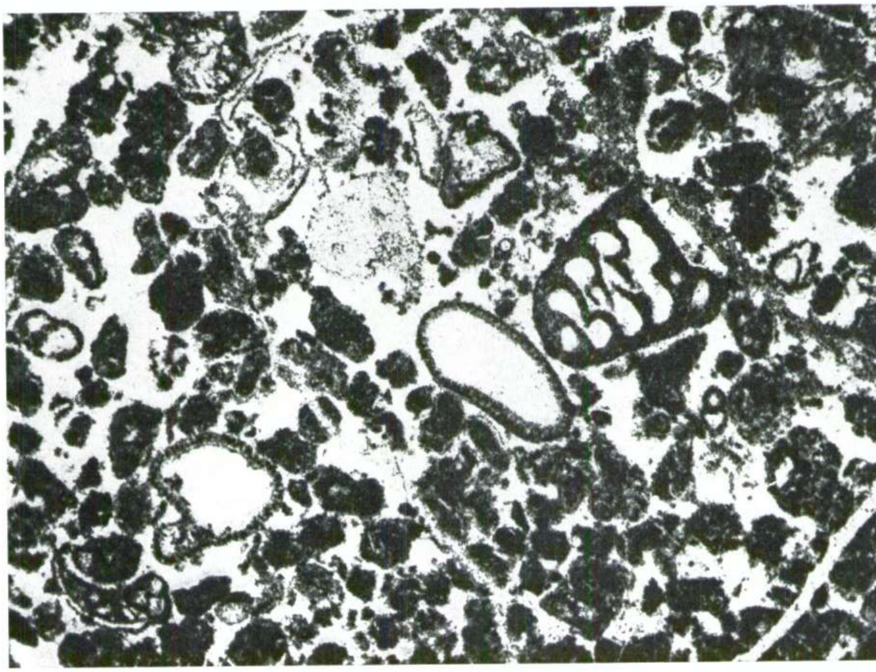
DOGGER SUPÉRIEUR

Fig. 2

Calcaire grumeleux à *Pfenderina salernitana* Sartoni & Crescenti (× 30). Pl. mince 1834-59. Dans l'association: autres Foraminifères peu abondants et débris de Dasycladacées

Bordure ouest de la Zetska ravnica, Buza-Bobija

DOGGER SUPÉRIEUR-MALM INFÉRIEUR



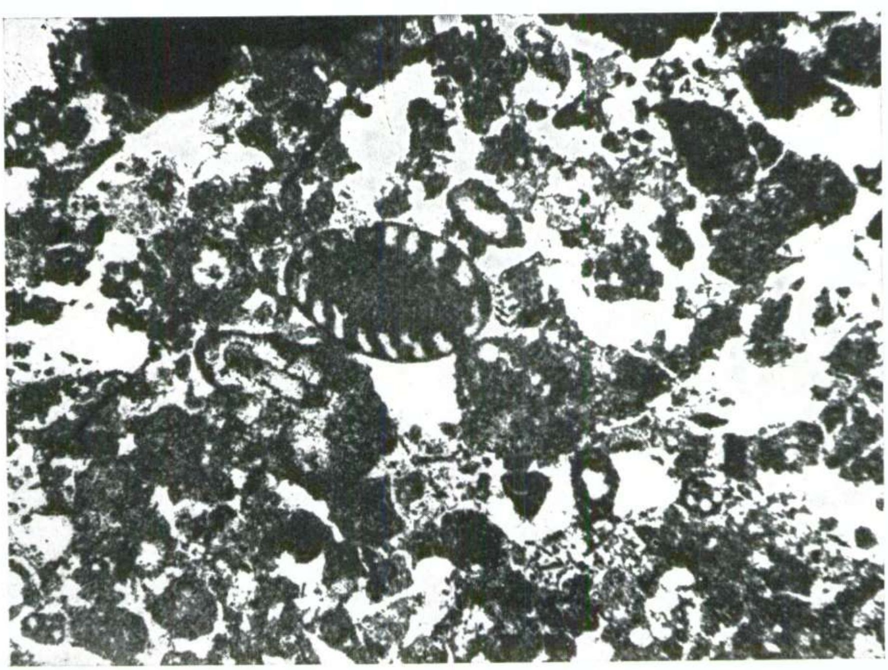


PLANCHE XXXI

Fig. 1 et 2

Calcaire à *Pfenderina* cf. *trochoidea* Smout & Sugden, *Meyendorffina bathonica* Aurouze & Bizon et autres Foraminifères (× 28,5). Pl. mince 1834-59

Bordure ouest de la Zetska ravnica, Buza-Bobija

DOGGER SUPÉRIEUR-MALM INFÉRIEUR

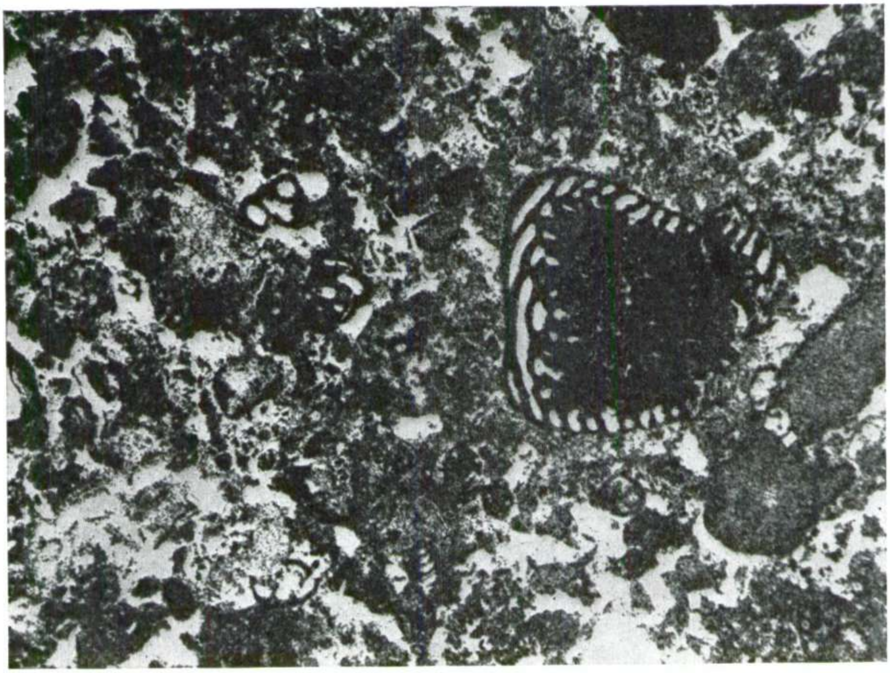


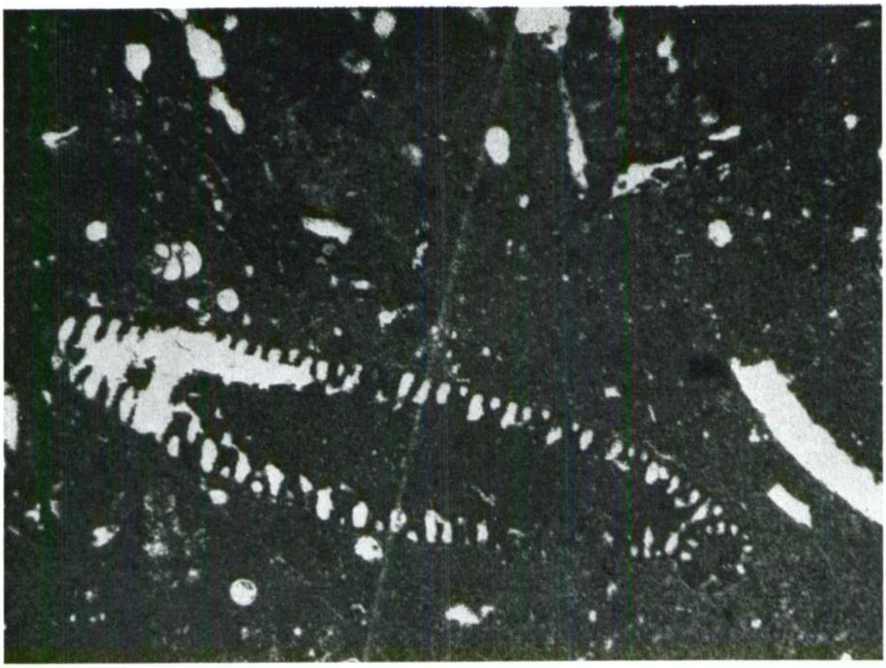
PLANCHE XXXII

Fig. 1 et 2

Calcaire à Pfenderines (*Pfenderina* sp.), Verneuilinidés, Textularidés et autres Foraminifères (× 30). Pl. mince 1841-59. Dans l'associations: *Thaumatoporella parvovesiculifera* (Rain.), *Teutloporella gallaeformis* Radoičić, Microgastéropodes et débris de Mollusques

Bordure ouest de la Zetska ravnica, près de Ponar

DOGGER SUPÉRIEUR-MALM INFÉRIEUR



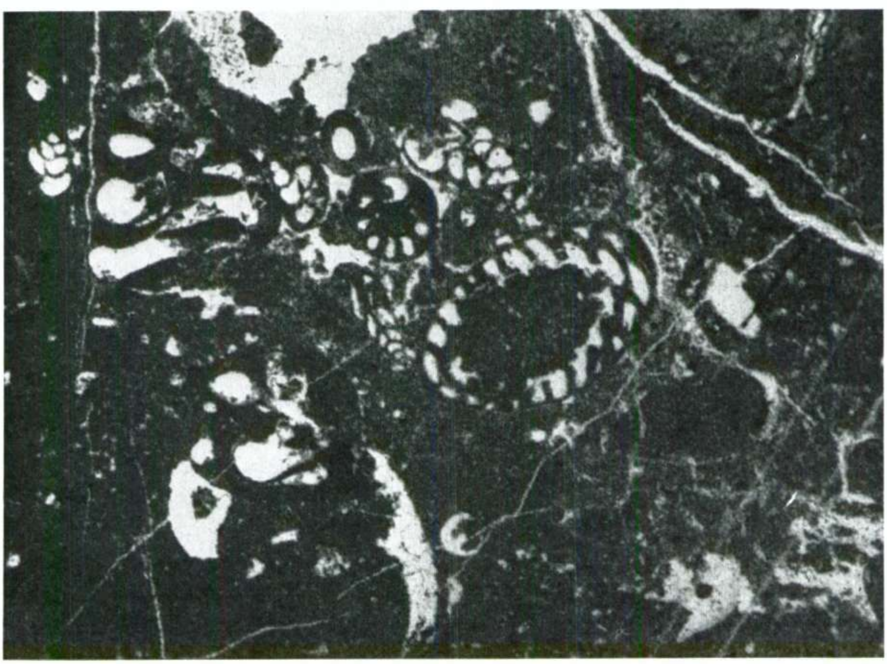


PLANCHE XXXIII

Fig. 1

Calcaire oolithique-détritique à Trocholines, *Labyrinthina mirabilis* Weynschenk et autres Foraminifères (× 17). Pl. mince 44-57

Bordure ouest de la Zetska ravnica, Kurioci-Vukovci

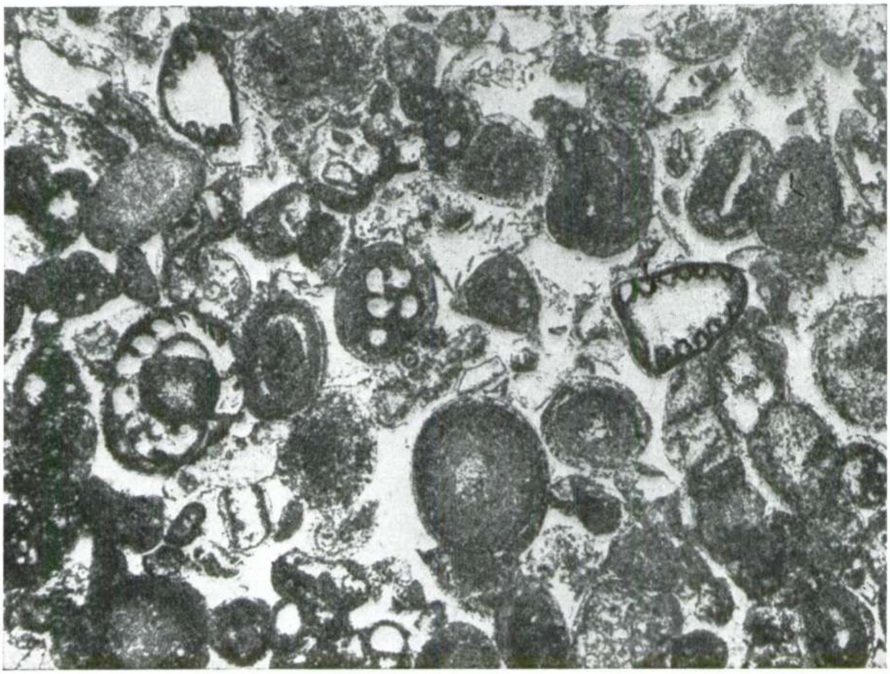
MALM INFÉRIEUR (partie inférieure des couches à *Cladocoropsis mirabilis*)

Fig. 2

Calcaire oolithique-détritique à Trocholines (× 17). Pl. mince 133 a-57

Bordure ouest de la Zetska ravnica, Kurioci-Vukovci

MALM INFÉRIEUR



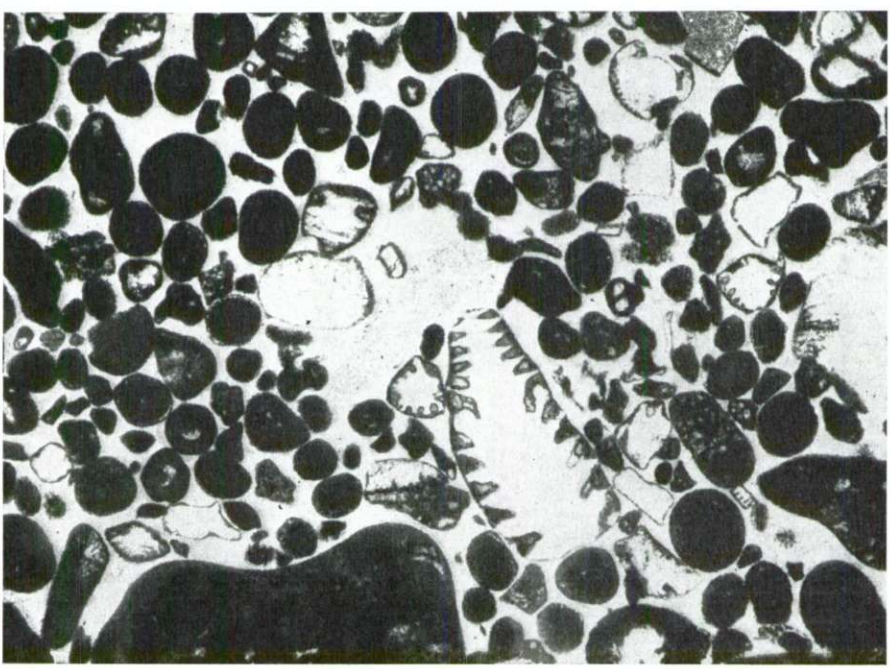


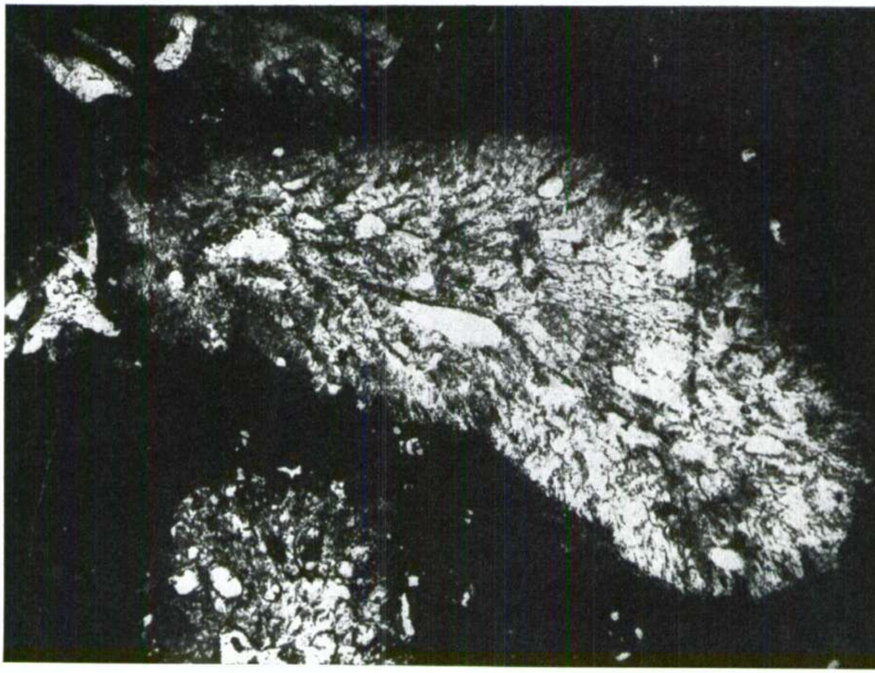
PLANCHE XXXIV

Fig. 1

Calcaire à *Cladocoropsis mirabilis* Felix (× 10). Pl. mince 137-57
Bordure ouest de la Zetska ravnica, au sud de Vukovci
MALM INFÉRIEUR (KIMMÉRIDGIEN INFÉRIEUR)

Fig. 2

Calcaire à *Kurnubia palastiniensis* Henson, autres Foraminifères et Dasycladacées (*Clypeina* spp. et autres), (× 30). Pl. mince 1095-57
Bordure ouest de la Zetska ravnica, Rvaši
MALM SUPÉRIEUR (partie inférieure des couches à *Clypeina jurassica*)



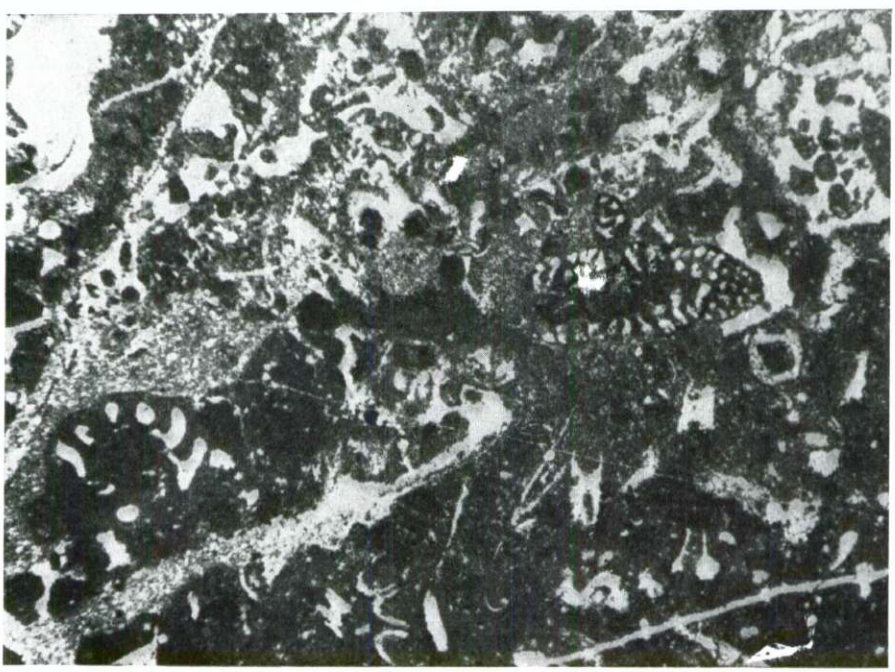
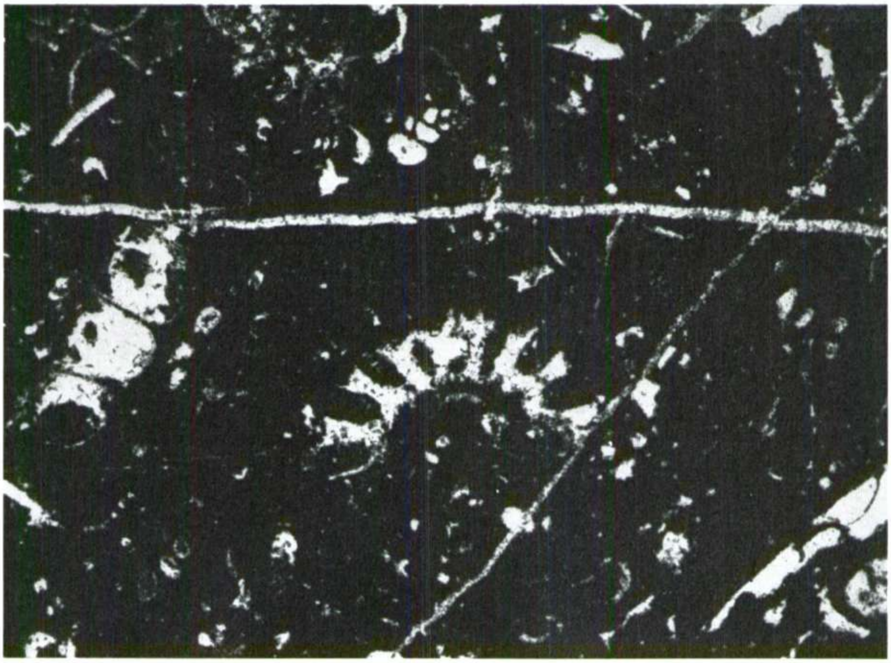


PLANCHE XXXV

Fig. 1 et 2

Calcaire à Dasycladacées (*Clypeina* spp. et autres), (× 30). Pl. mince 1095-57
Bordure ouest de la Zetska ravnica, Rvaši
MALM SUPÉRIEUR (partie inférieure des couches à *Clypeina jurassica*)



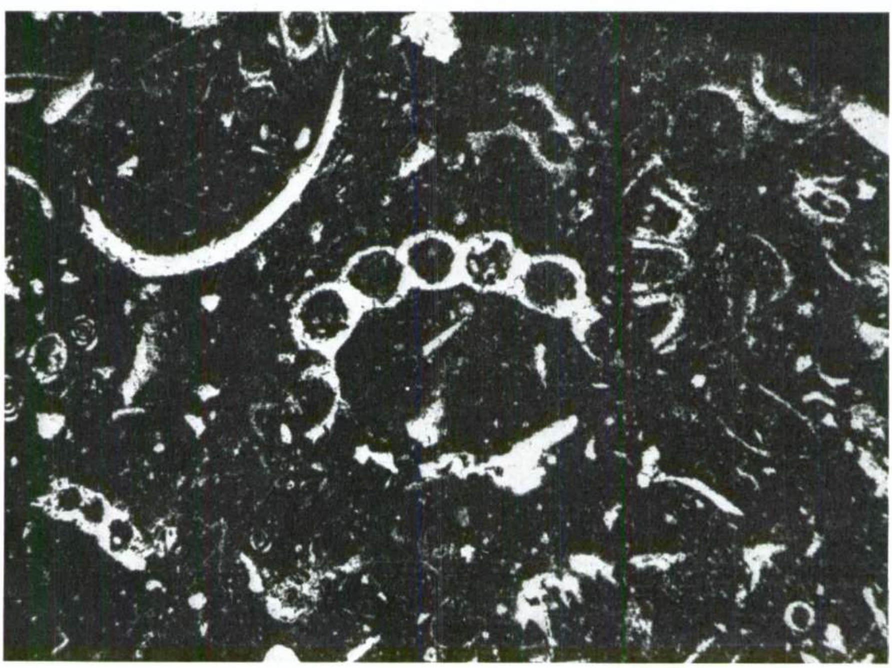


PLANCHE XXXVI

Fig. 1 et 2

Calcaire à Dasycladacées (*Clypeina* spp. et autres) et Foraminifères peu abondants (× 30). Pl. mince 1095-57

Bordure ouest de la Zetska ravnica, Rvaši

MALM SUPÉRIEUR (partie inférieure des couches à *Clypeina jurassica*)

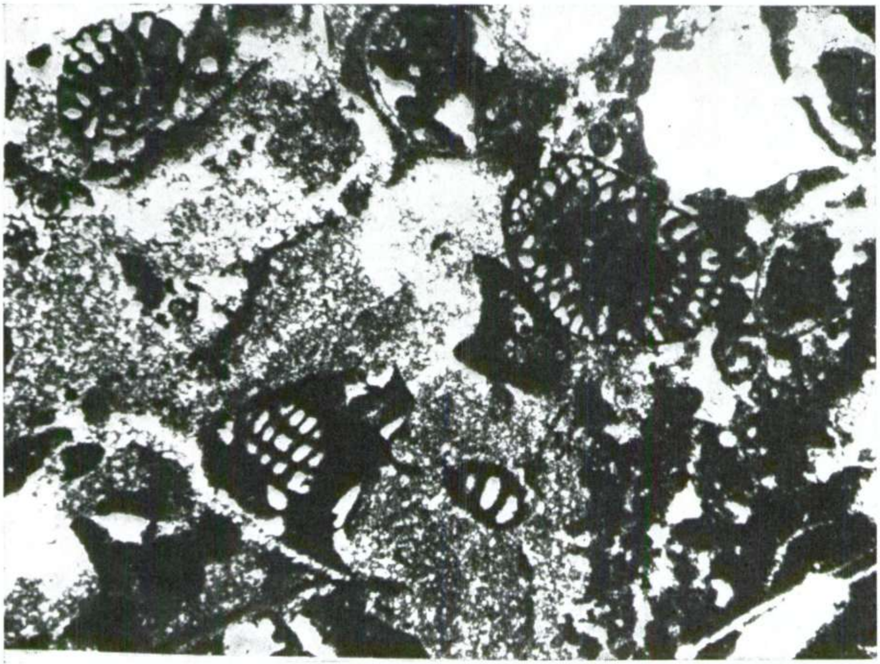
PLANCHE XXXVII

Fig. 1

Calcaire à *Kurnubia* sp. et Dasycladacées (× 35). Pl. mince 1096-57
Bordure ouest de la Zetska ravnica, Rvaši
MALM SUPÉRIEUR (partie inférieure des couches à *Clypeina jurassica*)

Fig. 2

Calcaire à *Kurnubia wellingsi* (Henson), *Kurnubia* sp. et autres Foraminifères (× 30). Pl. mince 1097-57
Bordure ouest de la Zetska ravnica, Rvaši
MALM SUPÉRIEUR (partie inférieure des couches à *Clypeina jurassica*)



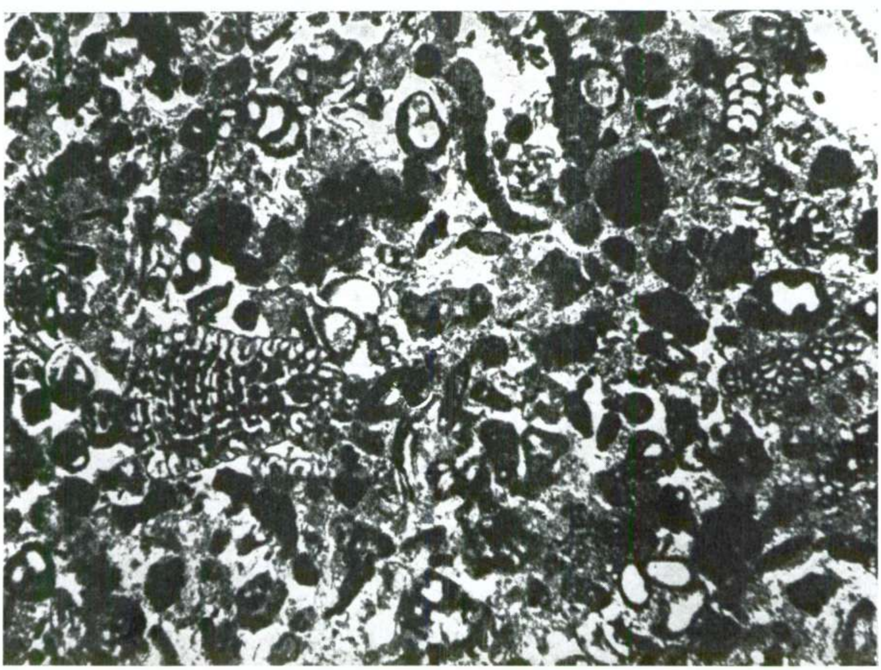


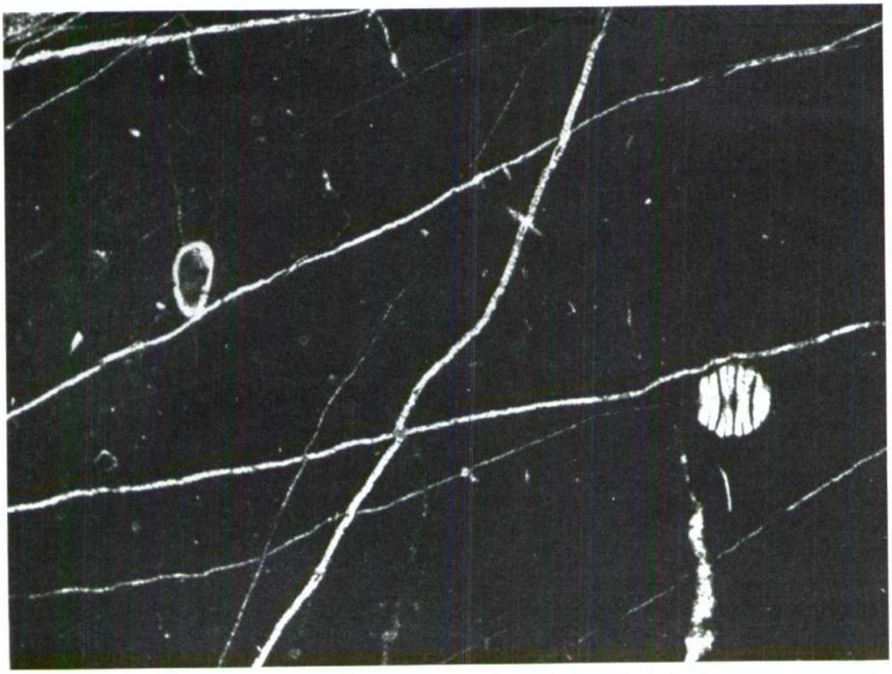
PLANCHE XXXVIII

Fig. 1

Calcaire marneux, peu bitumineux, à Charophytes (× 28,5). Pl. mince 1851-59
Bordure ouest de la Zetska Ravnica, Bobija
MALM SUPERIEUR (partie inférieure des couches à *Clypeina jurassica*)

Fig. 2

Calcaire marneux à Ostracodes (× 70). Pl. mince 1099-57
Bordure ouest de la Zetska ravnica, Rvaši
MALM SUPÉRIEUR (partie inférieure des couches à *Clypeina jurassica*)



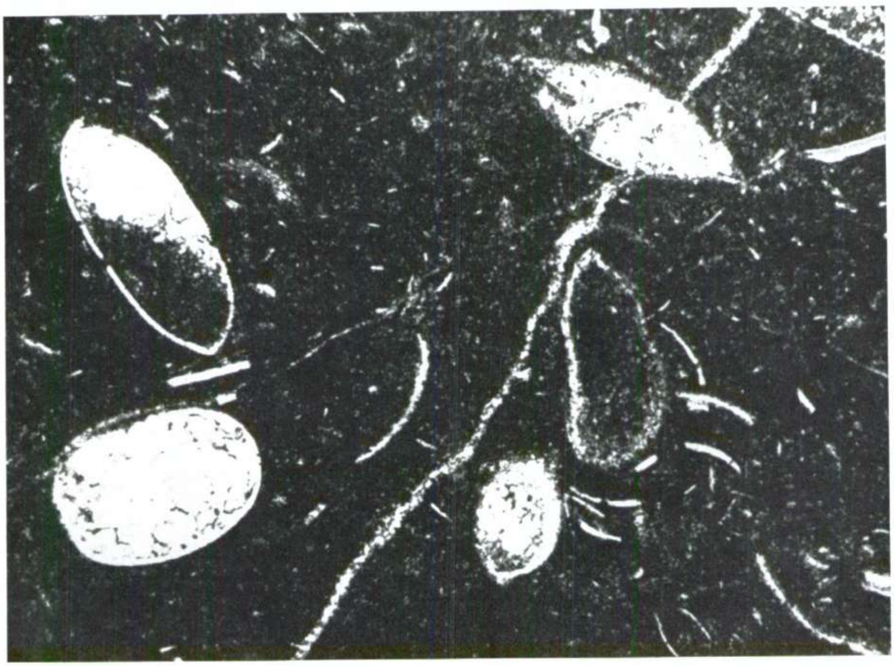


PLANCHE XXXIX

Fig. 1

Calcaire à rhomboèdres de dolomie, *Clypeina jurassica* Favre et *Kurnubia palastiniensis* Henson (× 30). Pl. mince 55-57

Bordure ouest de la Zetska ravnica, Vukovci

MALM SUPÉRIEUR (PORTLANDIEN)

Fig. 2

Calcaire à *Pianella* cf. *gigantea* Carozzi, *Salpingoporella annulata* Carozzi et *Clypeina jurassica* Favre (× 30). Pl. mince 139-57

Bordure ouest de la Zetska ravnica, Vukovci

MALM SUPÉRIEUR (PORTLANDIEN)

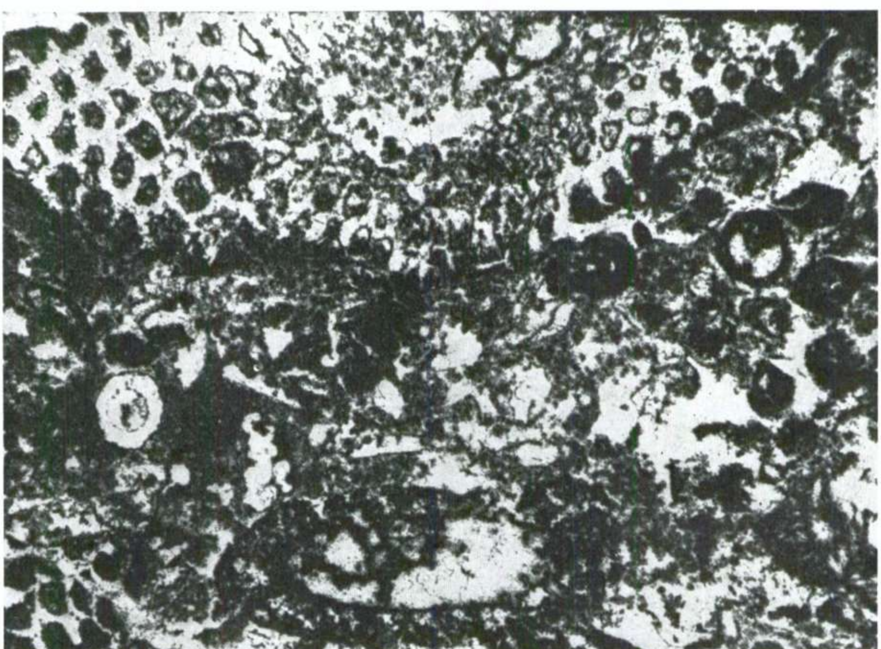


PLANCHE XI

Fig. 1

Calcaire marneux à *Clypeina jurassica* Favre et *Teutloporella obsoleta* Carozzi (× 17,5). Pl. mince 159-57

Bordure ouest de la Zetska ravnica, Vukovci

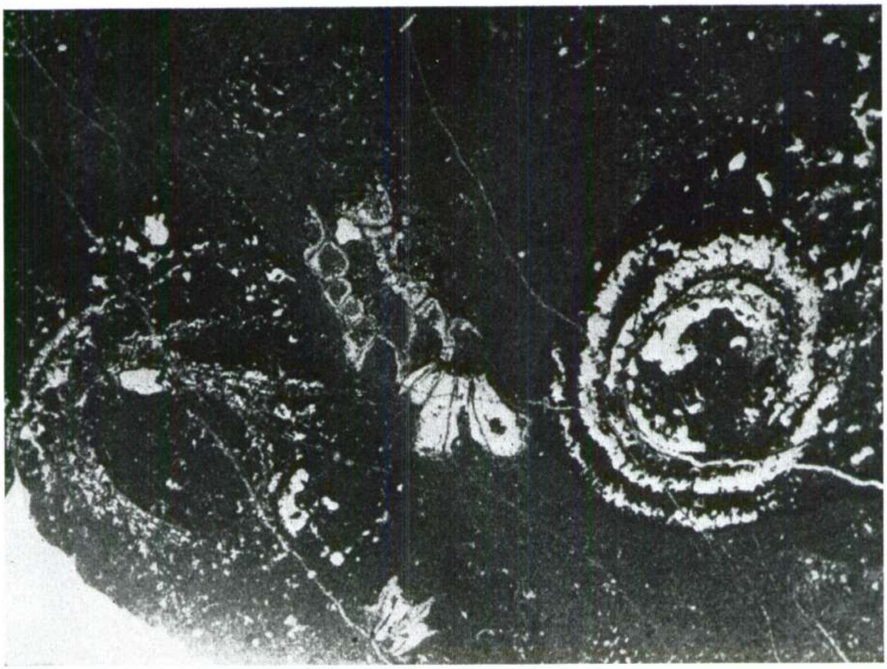
MALM SUPÉRIEUR (PORTLANDIEN)

Fig. 2

Calcaire légèrement marneux et dolomitique à *Clypeina jurassica* Favre (× 17,5). Pl. mince 160-57

Bordure ouest de la Zetska ravnica, Vukovci

MALM SUPÉRIEUR (PORTLANDIEN)



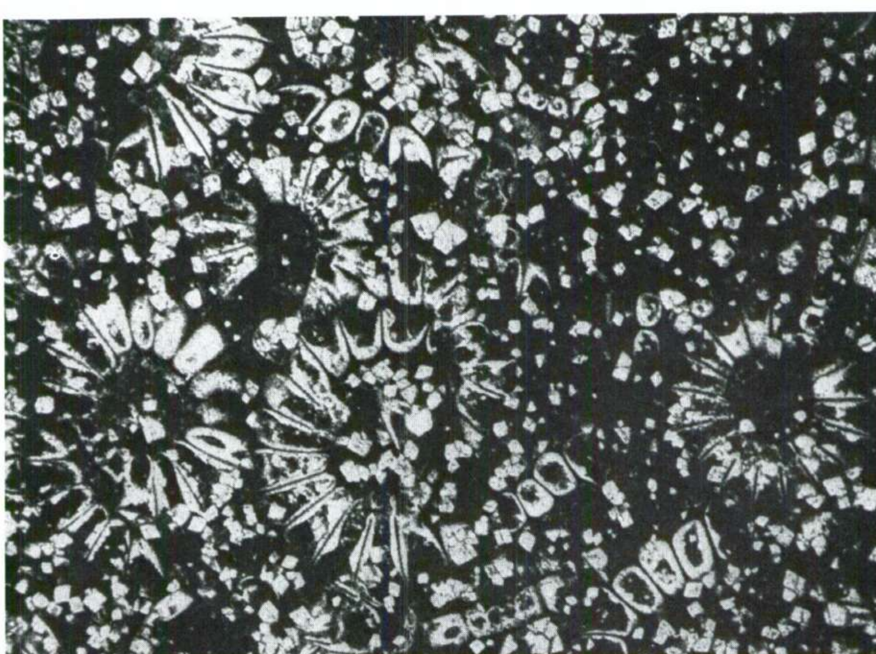


PLANCHE XLI

Fig. 1

Calcaire à Tintinnines aberrantes — (*Daturellina costata* Rad.) — et *Salpingoporella annulata* Carozzi (× 27,5). Pl. mince 289-55

Bordure ouest de la Zetska ravnica, Trštenik

VALANGINIEN INFÉRIEUR

LA SÉRIE JURASSIQUE DE LA BORDURE NORD DE LA ZETSKA RAVNICA DISTRICT DE DEČIĆ ET DE CIJEVNA

(Tableau № 3)

Planches: XLII à LV

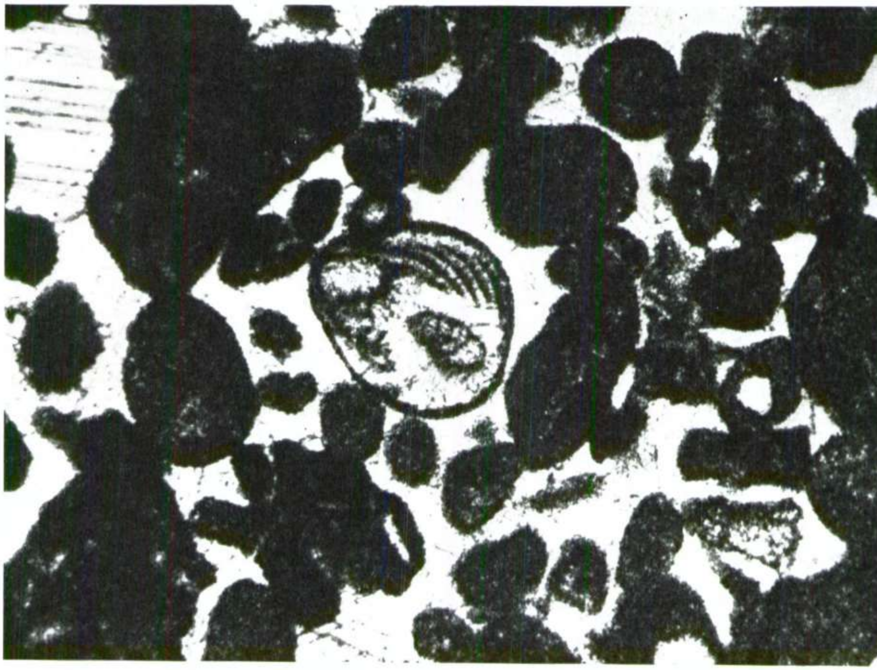
PLANCHE XLII

Fig. 1 et 2

Calcaire oolithique-détritique à *Protopeneroplis striata* Weynschenk et Codiacée Cl (fig. 1 — × 82; fig. 2 — × 32). Pl. mince 1197-57. Dans l'association: Trocholines, rares Miliolidés et autres Foraminifères, *Cladocoropsis mirabilis* Felix.

Bordure nord de la Zetska ravnica — cañon de la rivière Cijevna, au sud de Stepovo.

MALM INFÉRIEUR



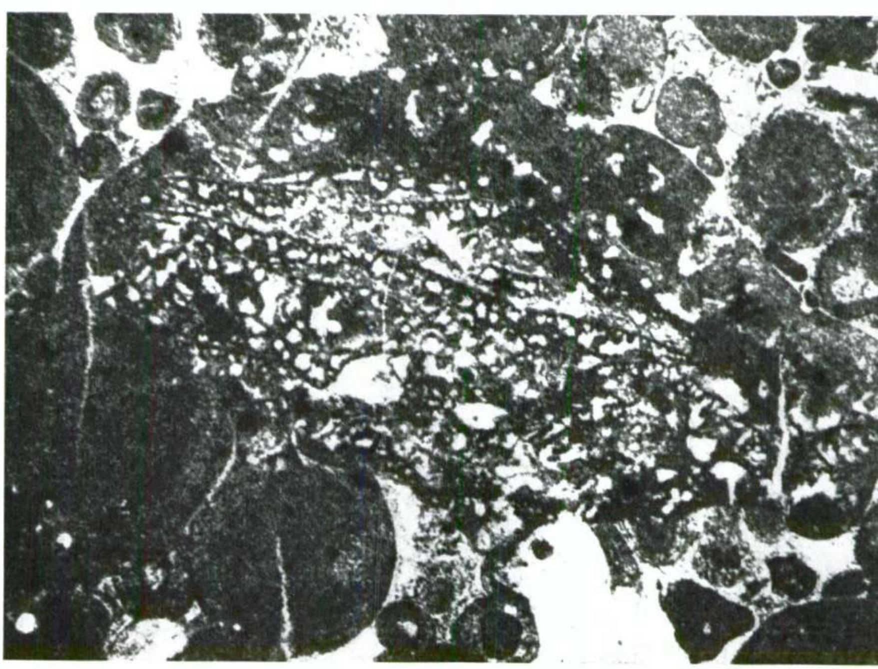


PLANCHE XLIII

Fig. 1

Calcaire oolithique-détritique à ***Protopeneroplis*** *striata* Weynschenk et *Nautiloculina* sp. (J. Speck: «***Nautiloculina*** n. sp. aff. *oolithica* Möhler»), (× 60). Pl. mince 1198 a-57

Bordure nord de la Zetska ravnica — cañon de la rivière Cijevna

MALM INFÉRIEUR (OXFORDIEN)

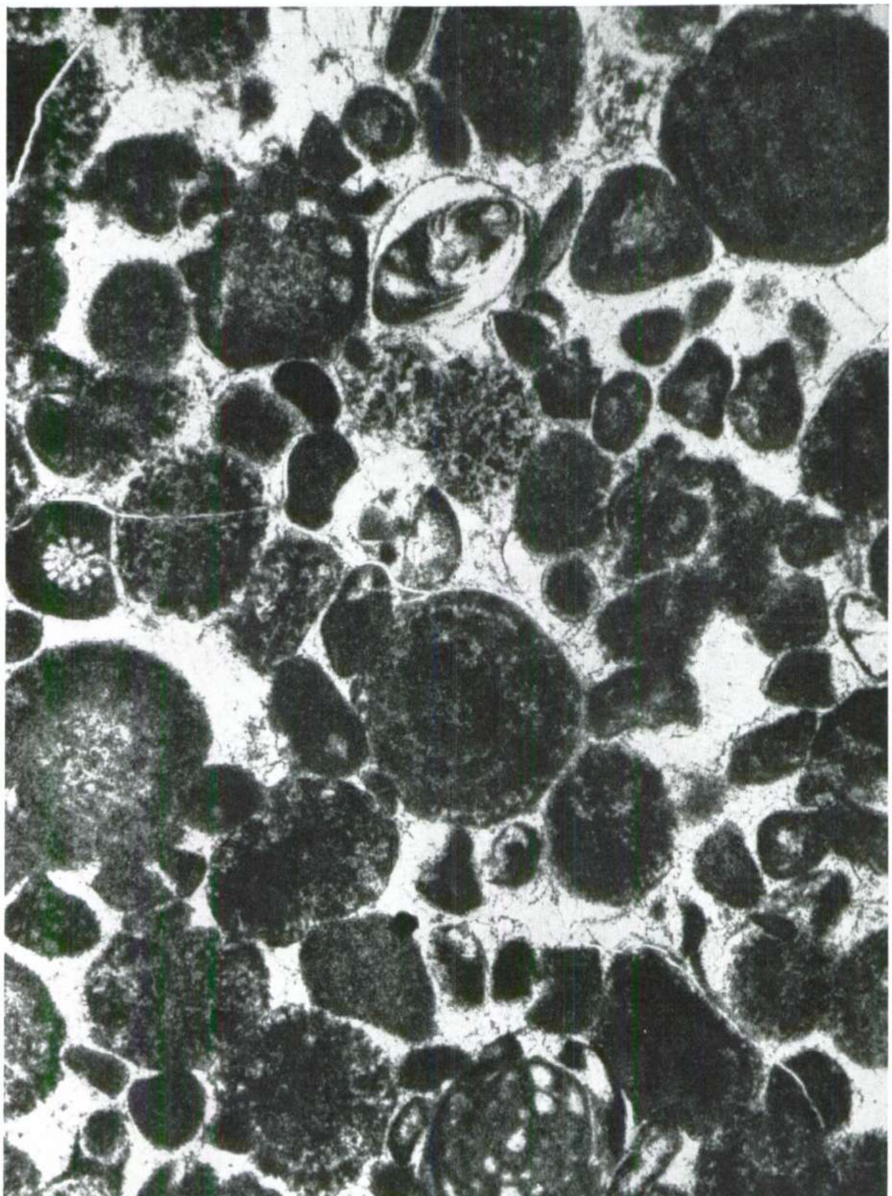


PLANCHE XLIV

Fig. 1

Calcaire grumeleux à Codiacées (× 17,5). Pl. mince 1198-57. Dans l'association: *Thaumatoporella parvovesiculifera* (Rain.) et Foraminifères peu abondants

Bordure nord de la Zetska ravnica — cañon de la rivière Cijevna

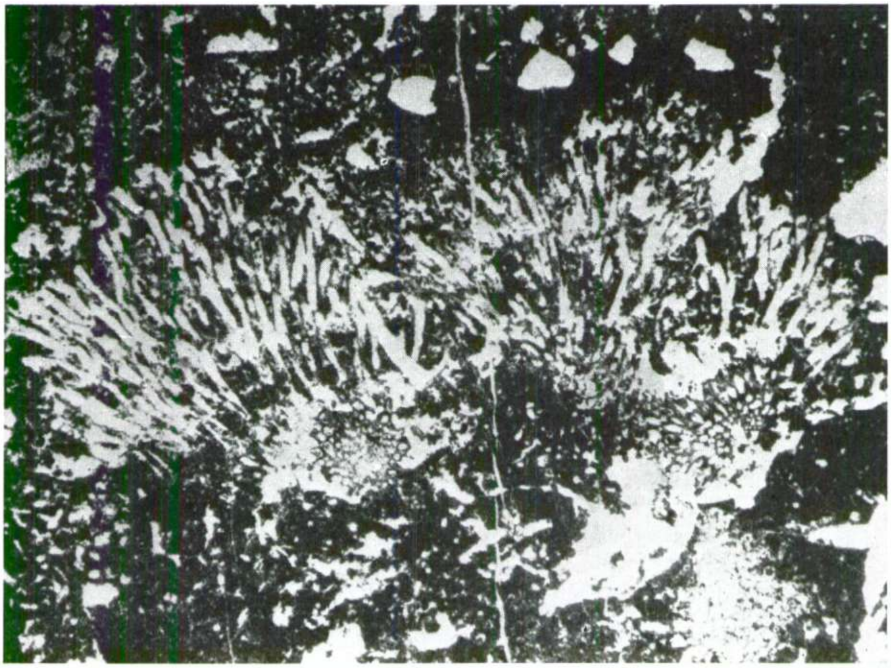
MALM INFÉRIEUR

Fig. 2

Calcaire grumeleux à Codiacéss (× 17,5). Pl. mince 1199-57. Dans l'association: *Protopeneroplis striata* Weynschenk

Bordure nord de la Zetska ravnica — cañon de la rivière Cijevna

MALM INFÉRIEUR



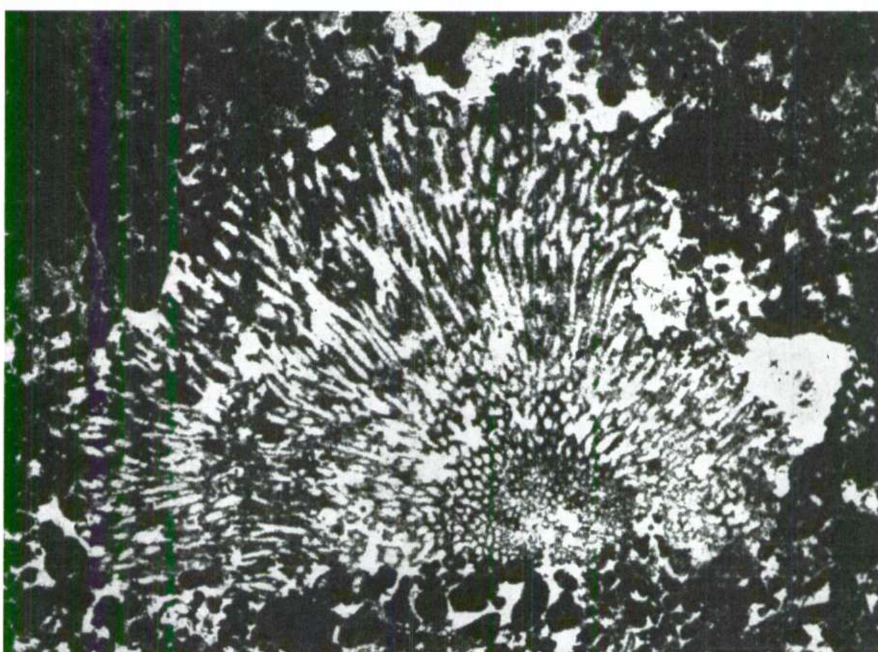


PLANCHE XLV

Fig. 1

Calcaire peu bitumineux à *Cladocoropsis mirabilis* Felix (× 16). Pl. mince 1152-57. Dans l'association: *Thaumatoporella parvovesiculifera* (Rain.), Cyanophytes, Codiacées; puis Kurnubies et autres Foraminifères

Bordure nord de la Zetska ravnica—Spilja

MALM INFÉRIEUR (probablement KIMMÉRIDGIEN INFÉRIEUR)

Fig. 2

Calcaire grumeleux à *Pseudocyclammina* sp. (× 35). Pl. mince 1124 a-57. Dans l'association: rares «*Lituonella*» et autres Foraminifères, rare *Clypeina jurassica* Favre

Bordure nord de la Zetska ravnica—Spilja

MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR)

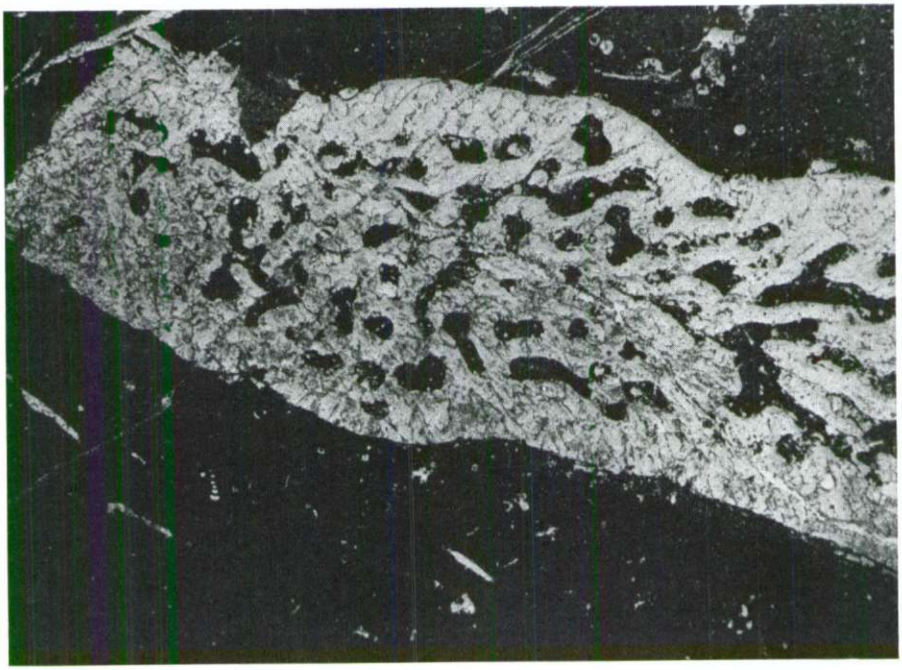


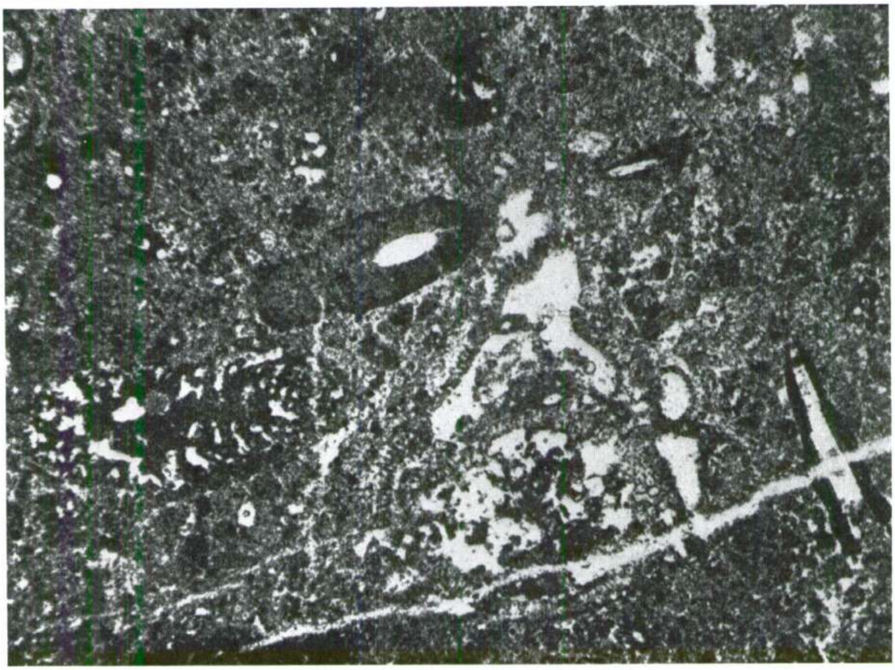
PLANCHE XLVI

Fig. 1 et 2

Calcaire peu bitumineux à Microproblematica, ***Thaumatoporella parvovesiculifera*** (Rain.), ***«Macroporella» sellii*** Crescenti, *Kurnubia palastiniensis* Henson, etc. (fig. 1 — × 30, **fig. 2 — × 70). Pl. mince 1071-57**

Bordure nord de la Zetska ravnica — environs de Spilja

MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR)



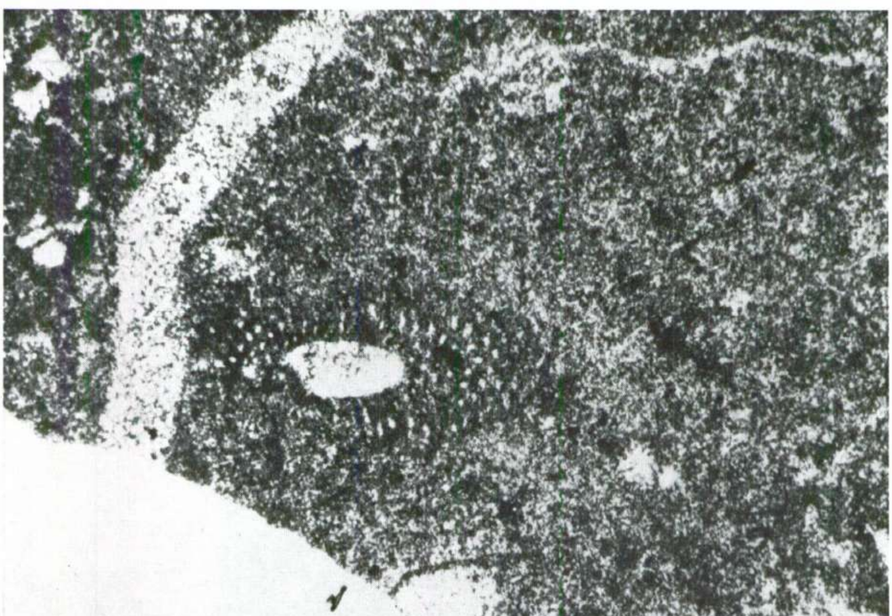


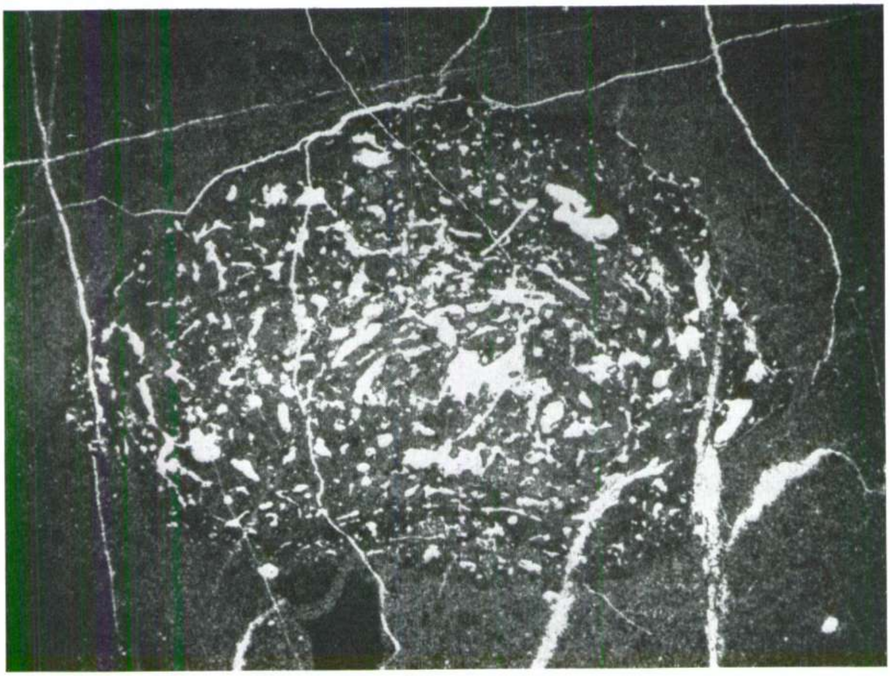
PLANCHE XLVII

Fig. 1

Calcaire peu bitumineux à Cyanophytes (× 30). Pl. mince 833-57
Bordure nord de la Zetska ravnica, Dečić
MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR)

Fig. 2

Calcaire peu bitumineux à Cyanophytes et «Lituonella» (× 26). Pl. mince 842-57
Bordure nord de la Zetska ravnica, Dečić
MALM SUPÉRIEUR (KIMMERIDGIEN SUPÉRIEUR)



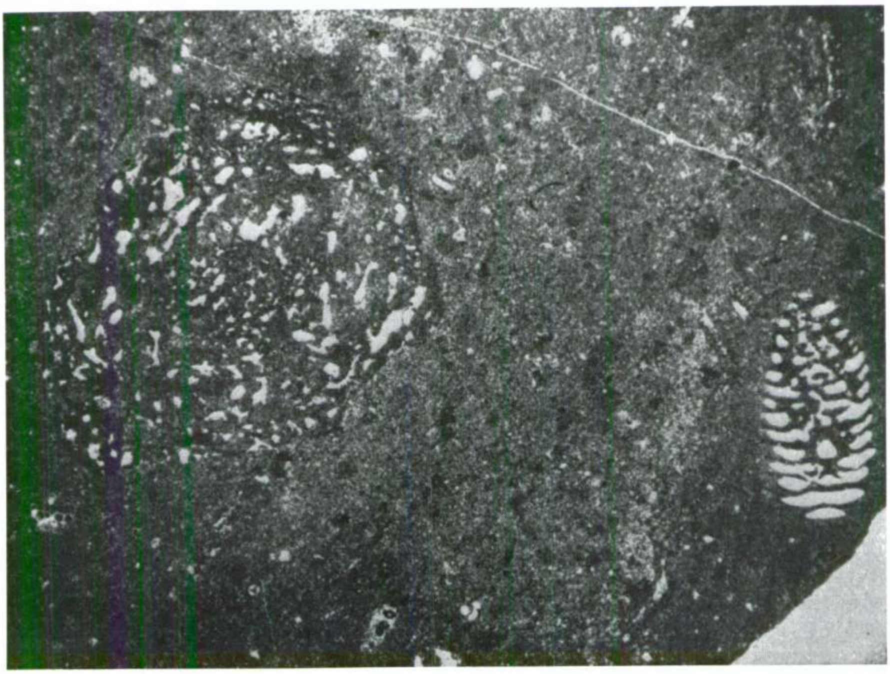


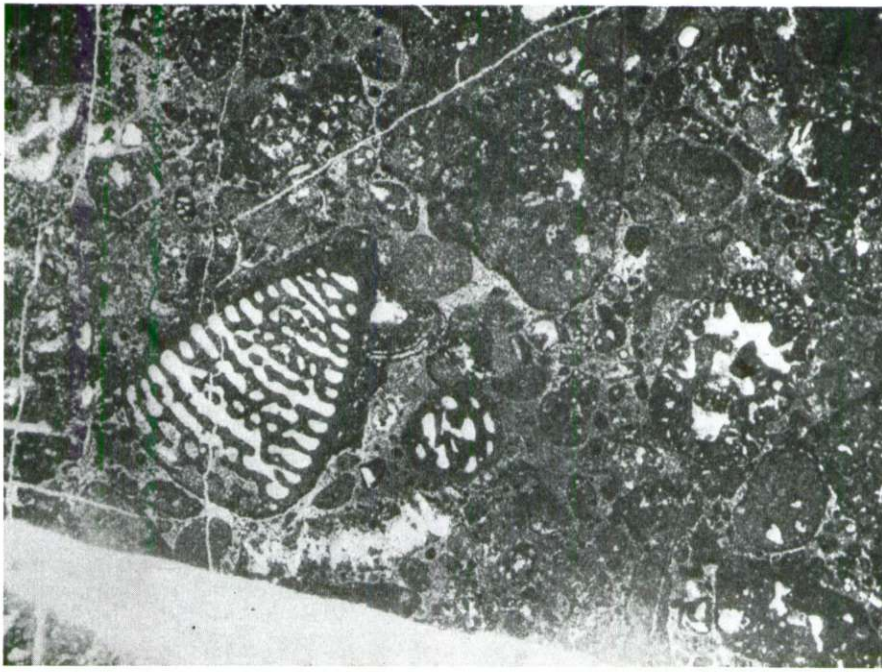
PLANCHE XLVIII

Fig. 1 et 2

Calcaire peu bitumineux à «*Lituonella*», *Pseudocyclammina*, *Kurnubia palastiniensis* Henson, autres Foraminifères et Algues: Cyanophytes et *Clypeina jurassica* Favre (× 17). Pl. mince 1124 et 1124 a-57

Bordure nord de la Zetska ravnica, environs de Skorać

MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR)



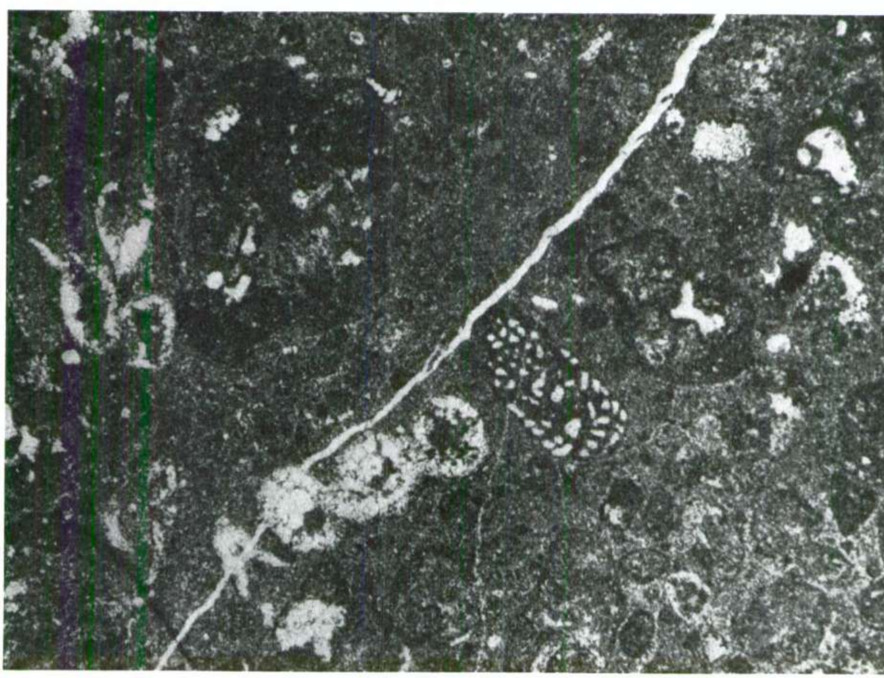


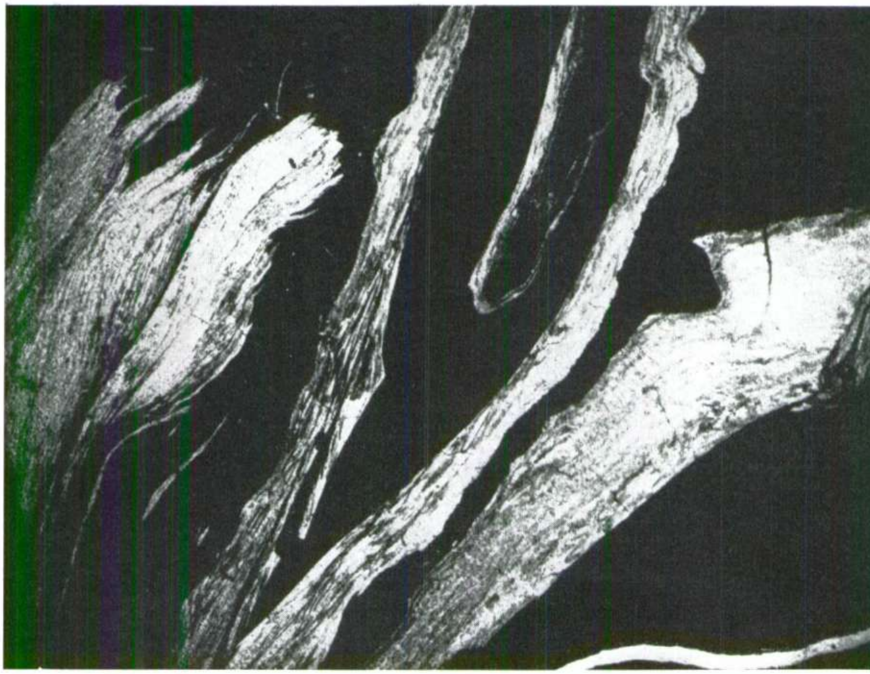
PLANCHE XLIX

Fig. 1

Calcaire bitumineux à Ostréidés (× 17,5). Pl. mince 1181-57
Bordure nord de la Zetska ravnica — Mileš, Kećeva
MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR-PORTLANDIEN)

Fig. 2

Calcaire légèrement bitumineux à Charophytes et Ostracodes (× 25,5). Pl. mince 313-57
Bordure nord de la Zetska ravnica, Mileš
MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR-PORTLANDIEN)



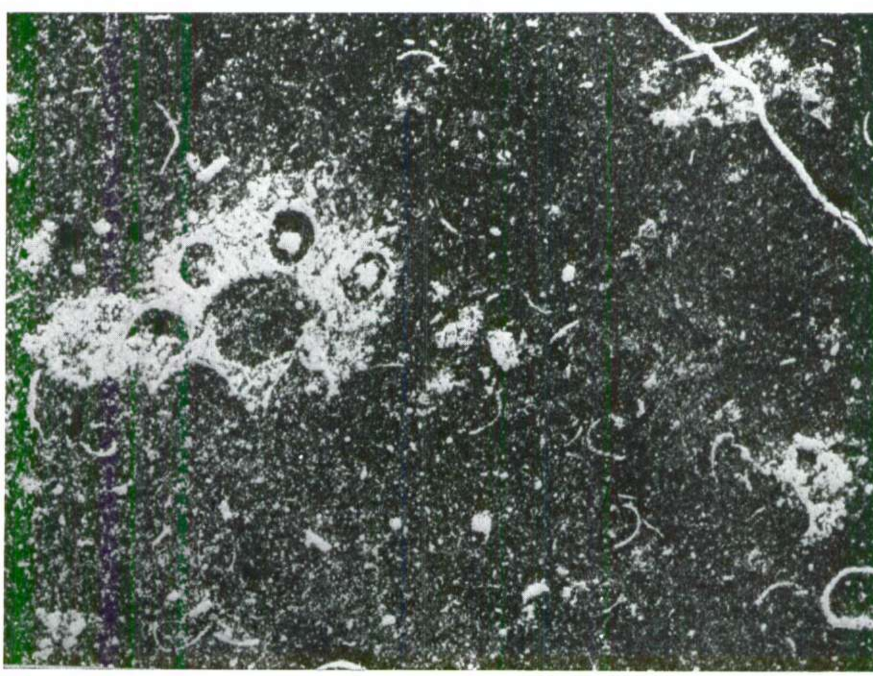


PLANCHE L

Fig. 1

Calcaire légèrement bitumineux à *Pianella grudii* Radoičić et Ostracodes (× 30).
Pl. mince 340 a-57. Dans l'association: Charophytes

Bordure nord de la Zetska ravnica, Dečić

MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR-PORTLANDIEN)

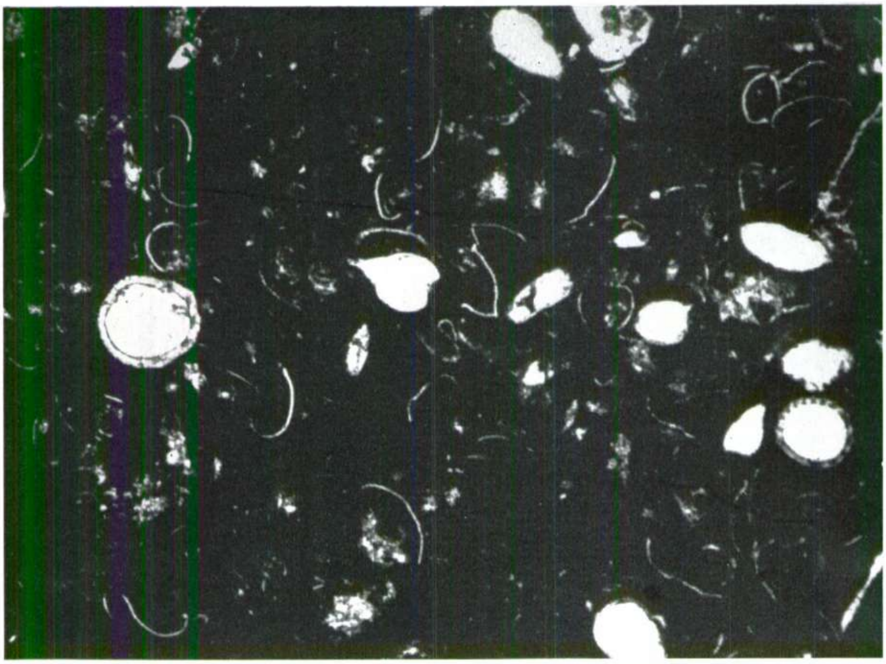
PLANCHE LI

Fig. 1

Calcaire bitumineux à Ostracodes et Charophytes (× 18). Pl. mince 1182-57
Bordure nord de la Zetska ravnica, Mileš
MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR-PORTLANDIEN)

Fig. 2

Calcaire peu bitumineux à rares oolithes (× 27,5). Pl. mince 1188-57
Bordure nord de la Zetska ravnica, Mileš
MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR-PORTLANDIEN)



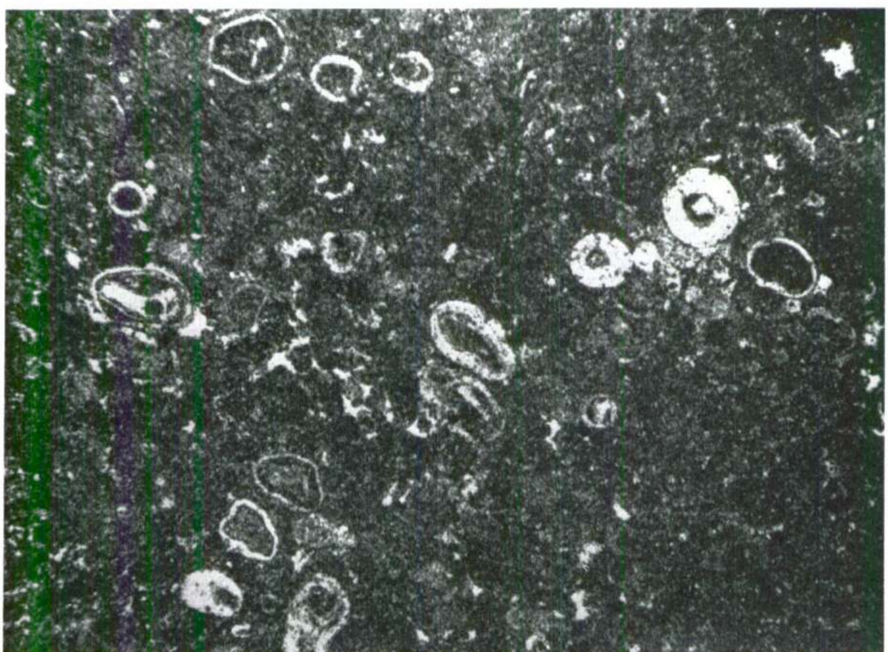


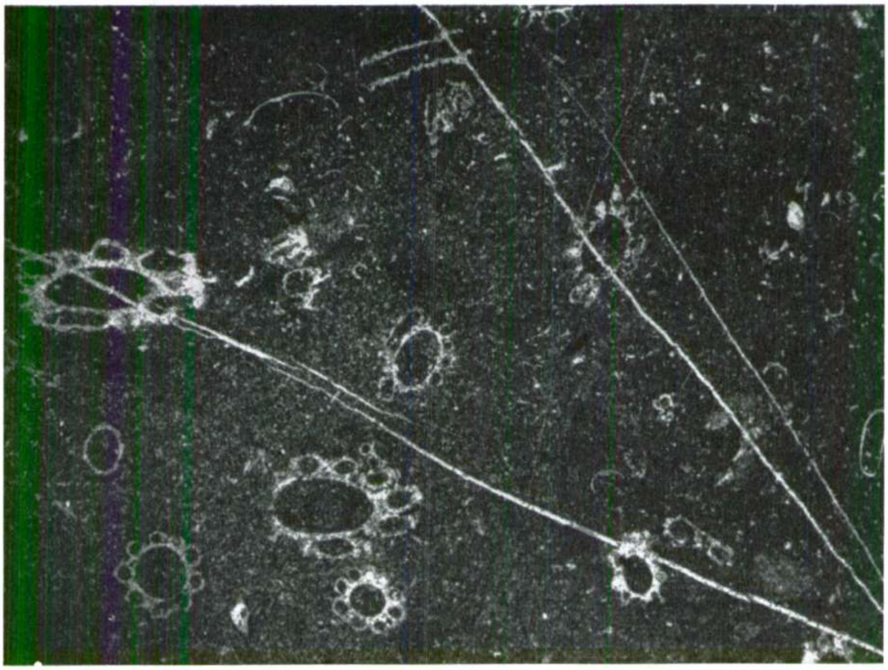
PLANCHE LII

Fig. 1 et 2

Calcaire peu bitumineux à Charophytes (fig. 1: × 21, fig. 2: × 18). Pl. minces 866 et 867-57

Bordure nord de la Zetska ravnica, Mileš

MALM SUPÉRIEUR (PORTLANDIEN)



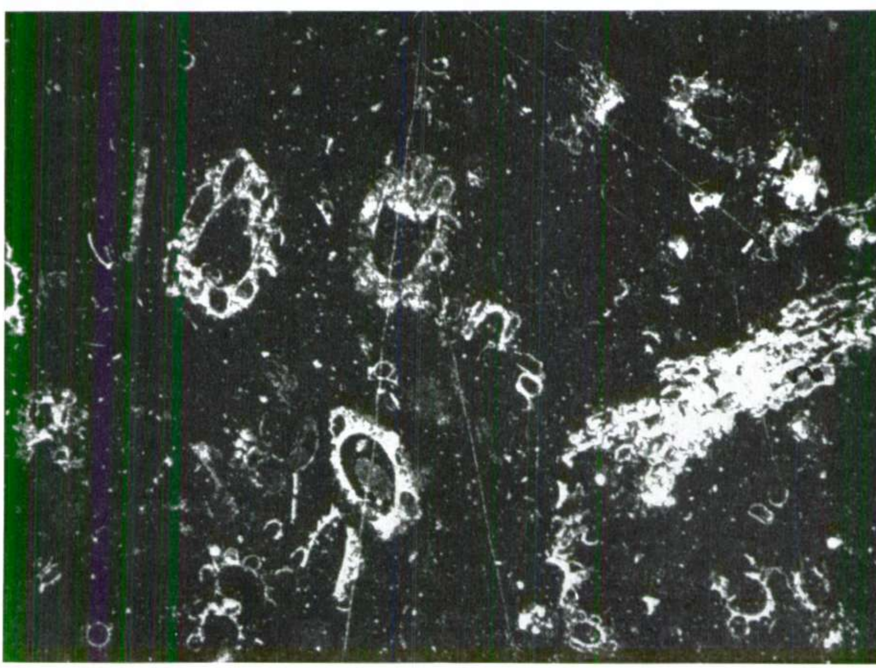


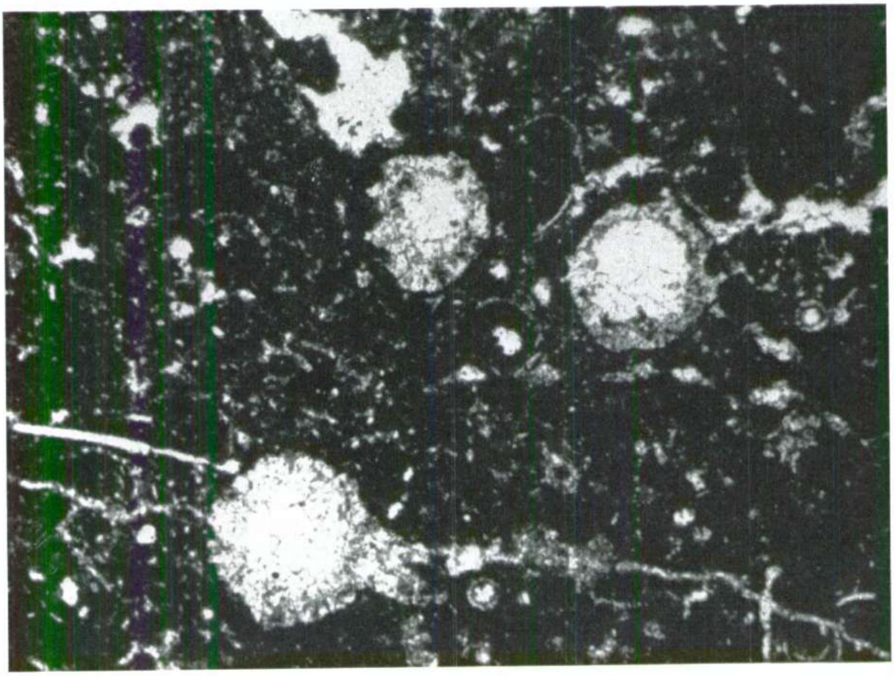
PLANCHE LIII

Fig. 1

Calcaire microgrumeleux à Charophytes (× 48). Pl. mince 186a-57
Bordure nord de la Zetska ravnica, Mileš
MALM SUPÉRIEUR (PORTLANDIEN)

Fig. 2

Calcaire dolomitique à *Clypeina jurassica* Favre (× 27,5). Pl. mince 1191-57
Bordure nord de la Zetska ravnica, Mileš
MALM SUPÉRIEUR (PORTLANDIEN)



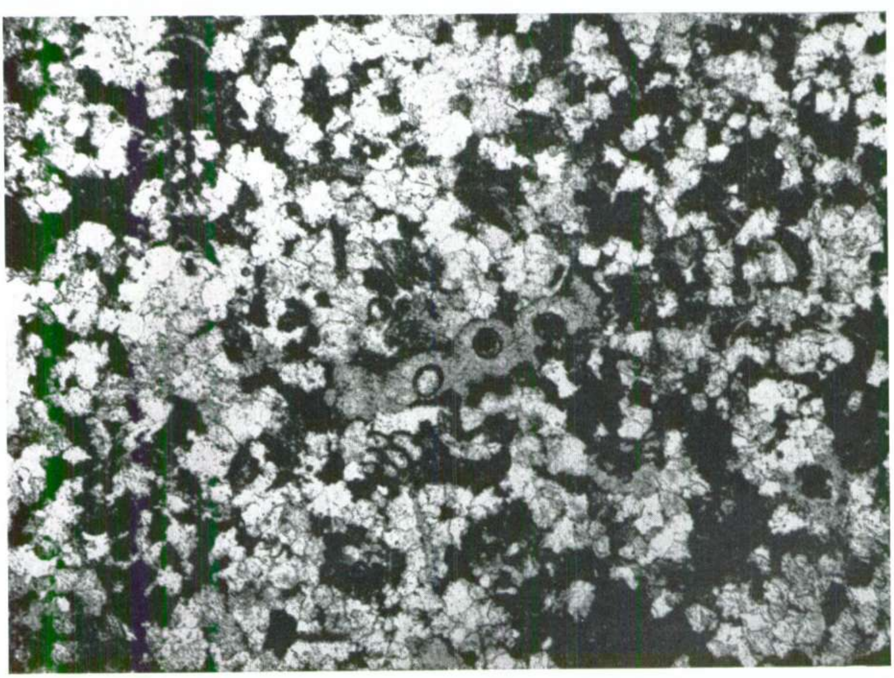


PLANCHE LIV

Fig. 1

Calcaire bitumineux à *Clypeina jurassica* Favre et rares Foraminifères (× 15). Pl. mince 245-57

Bordure nord de la Zetska ravnica, Dečić

MALM SUPÉRIEUR (PORTLANDIEN)

Fig. 2

Calcaire peu bitumineux à *Salpingoporella annulata* Carozzi (× 27,5). Pl. mince 1192-57. Dans l'association: Tintinnines aberrantes

Bordure nord de la Zetska ravnica, Mileš

VALANGINIEN

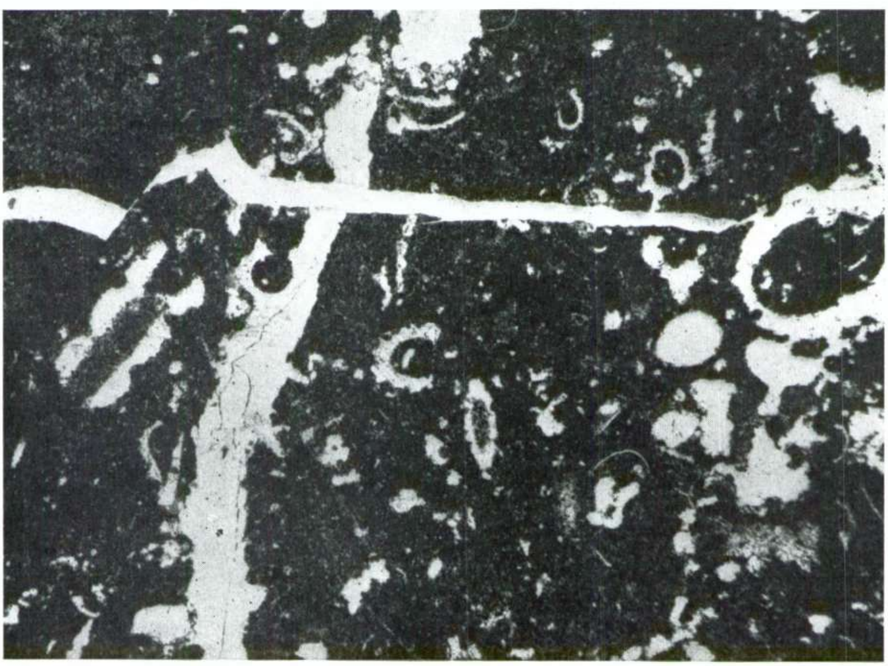


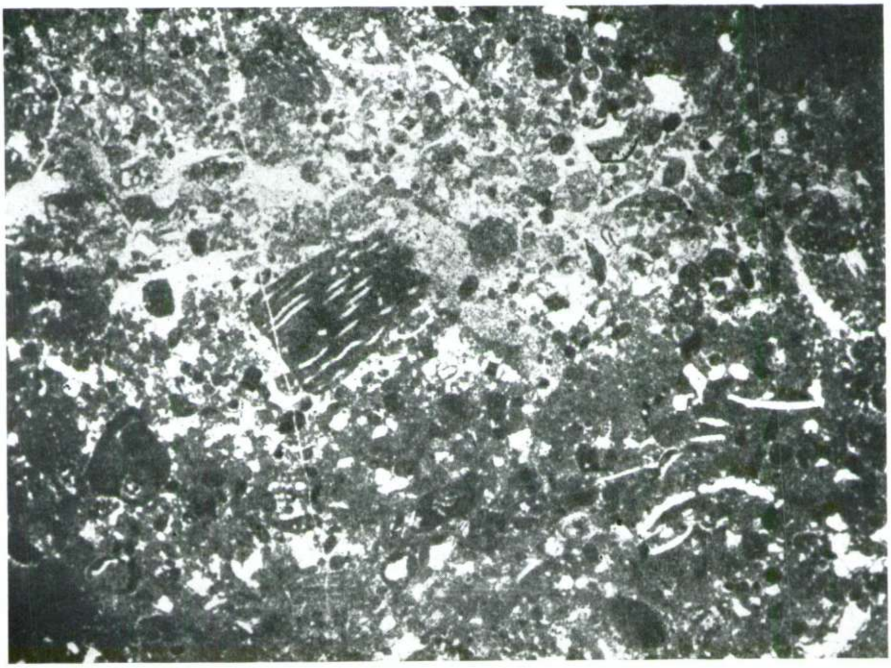
PLANCHE LV

Fig. 1 et 2

Calcaire grumeleux, peu bitumineux, à *Favreina salevensis* (Paréjas), Tintinnines aberrantes, etc. (× 26). Pl. mince 8-57

Bordure nord de la Zetska ravnica, Dečić

VALANGINIEN



LA SÉRIE JURASSIQUE DE LA MONTAGNE VOJNIK

(Tableau № 4)

Planches: LVI à LXXII

PLANCHE LVI

Fig. 1

Calcaire organogène à petits Brachiopodes, débris d'Echinodermes et de Mollusques, et Foraminifères: *Spirillina liassica* (Jones), *Trocholina* sp. nov. et Lagénidés (× 45). Pl. mince 785-62

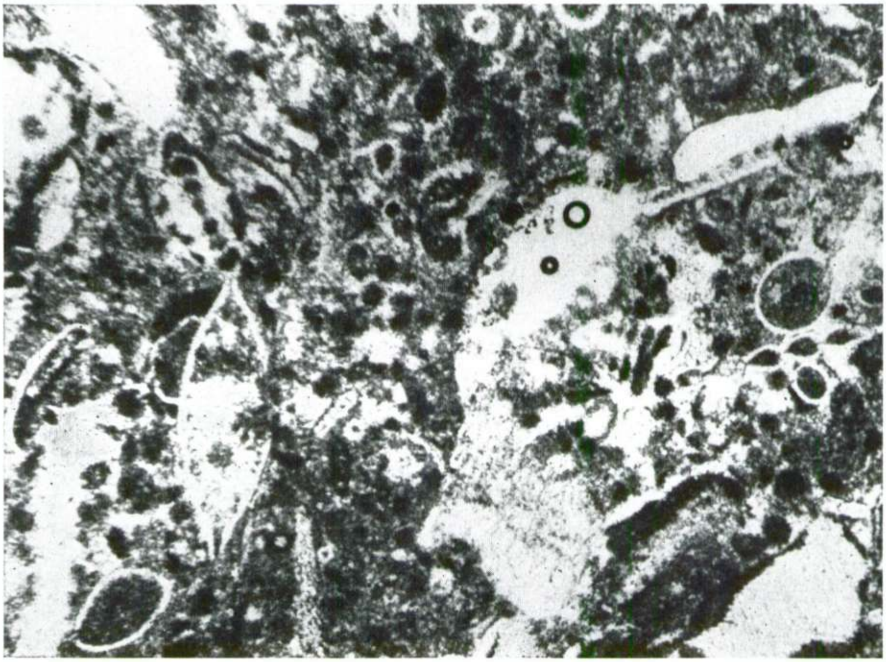
Montagne Vojnik, environs de Lipova Ravan

LIAS INFÉRIEUR

Fig. 2

Calcaire à *Permodiscus sinuosus* (Weynschenk) (× 32). Pl. mince 787-62
Montagne Vojnik, environs de Lipova Ravan

LIAS INFÉRIEUR



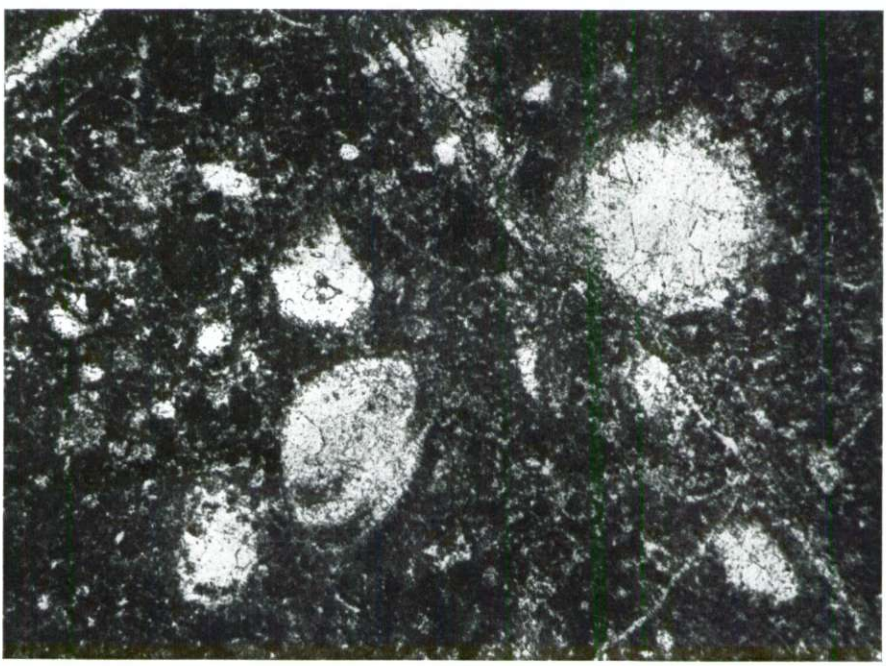


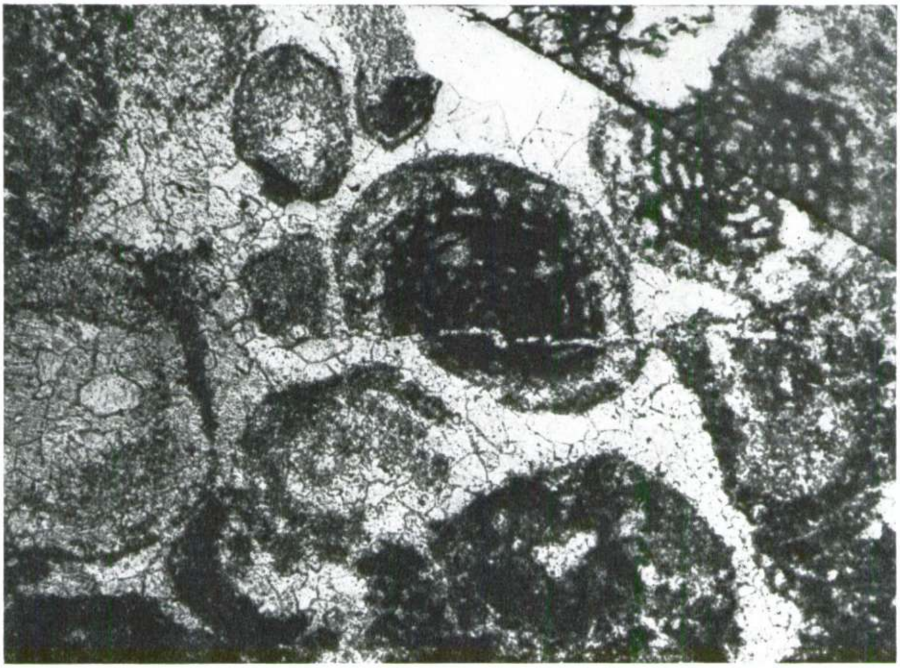
PLANCHE LVII

Fig. 1 et 2

Calcaire microgrumeleux, en partie subcristallin à *Triassina hantkeni* Majzon, *Permodiscus sinuosus* (Weynschenk) et autres Foraminifères peu abondants (× 32). Pl. minces 788 et 788 a-62. Dans l'association: Dasycladacées (*Sestrosphaera*)

Montagne Vojnik, environs de Lipova Ravan

LIAS INFÉRIEUR



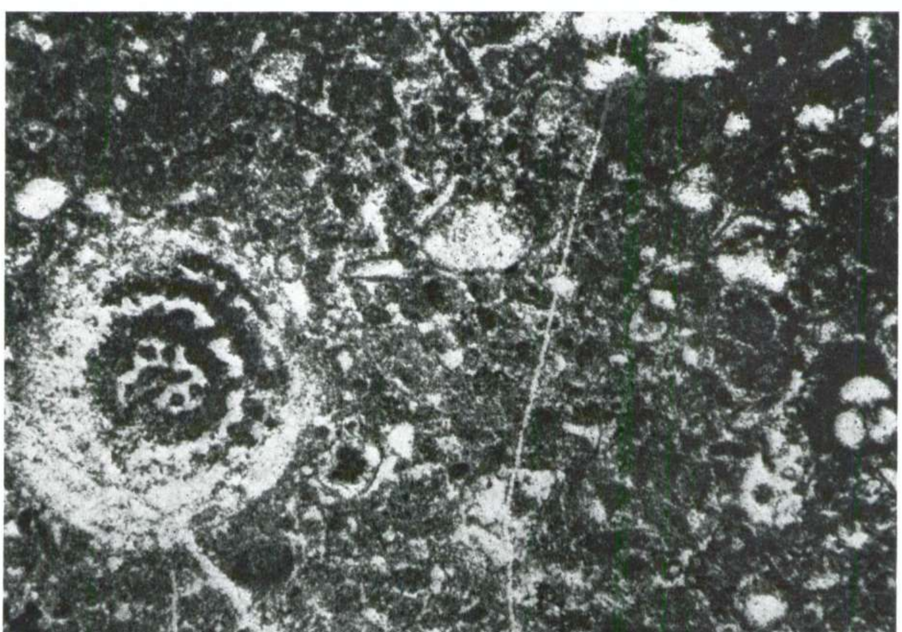


PLANCHE LVIII

Fig. 1 et 2

Calcaire microgrumeleux à ***Sestrophaera liasina*** Pia, *Permodiscus sinuosus* (Weynschenk) (trés recristallisé), etc. (× 32). Pl. mince 788 a et 788 b-62

Montagne Vojnik, environs de Lipova Ravan

LIAS INFÉRIEUR

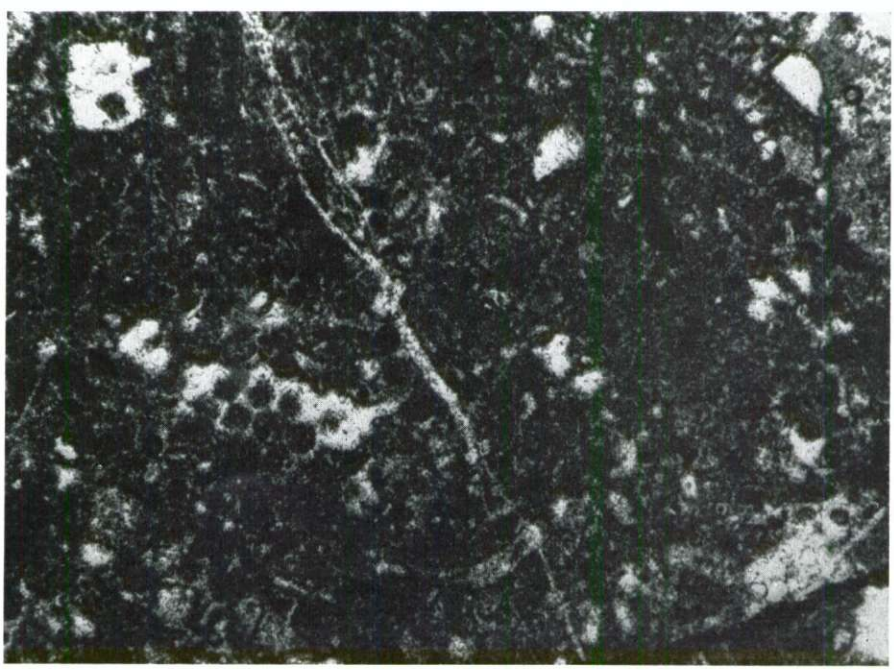


PLANCHE LIX

Fig. 1

Calcaire détritique, subcristallin, à *Trocholina* spec. nov., *Vidalina martana* Farinacci, Lagénidés et débris d'Echinodermes (× 32). Pl. mince 789-62

Montagne Vojnik, environs de Lipova Ravan

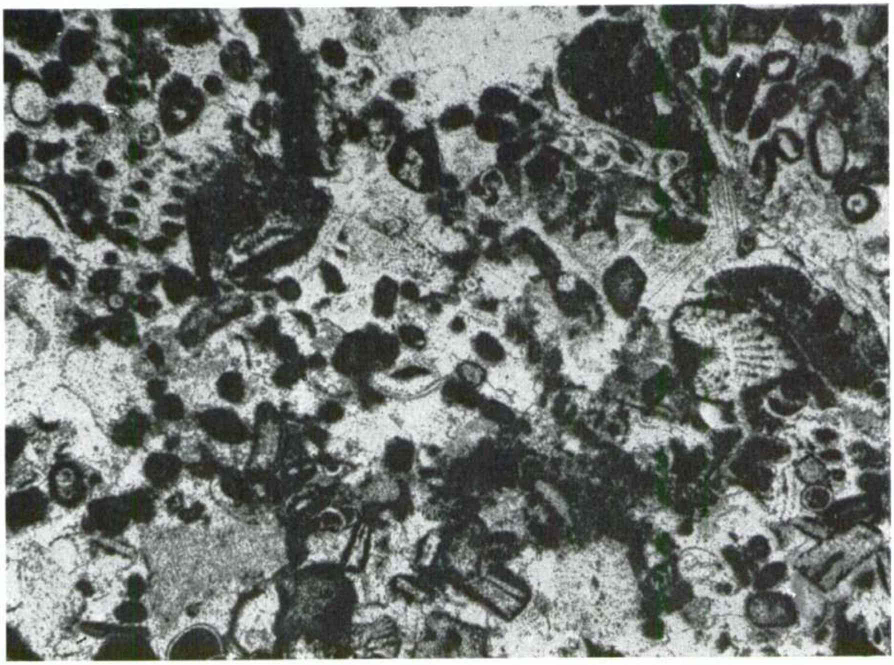
LIAS (partie moyenne de la série liasique)

Fig. 2

Calcaire légèrement marneux à Lagénidés (*Cristellaria* sp. et autres), débris d'Echinodermes, etc. (× 35). Pl. mince 791-62

Montagne Vojnik, environs de Lipova Ravan

LIAS (partie moyenne de la série liasique)



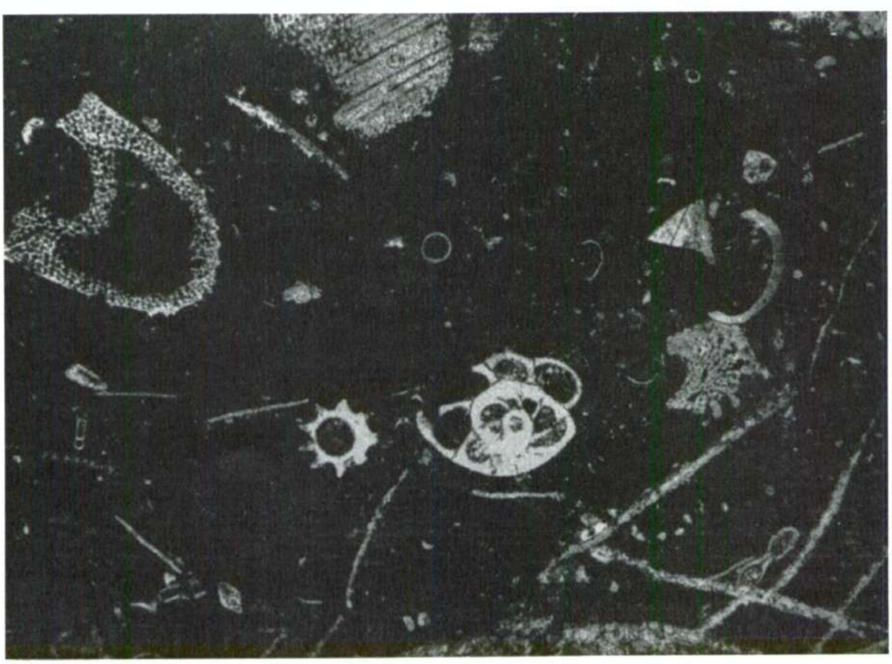


PLANCHE LX

Fig. 1 et 2

Calcaire finement organogène-détritique à débris d'Echinodermes et de Mollusques, petits Brachiopodes et Foraminifères: *Vidalina martana* Farinacci et nombreuses Lagénidés (fig. 1 — × 21, fig. 2 — × 45). Pl. mince 88-54. Dans l'association: *Spirillina liassica* (Jones)

Montagne Vojnik, environs de Lipova Ravan

LIAS SUPÉRIEUR («Ammonitico rosso inferiore»)

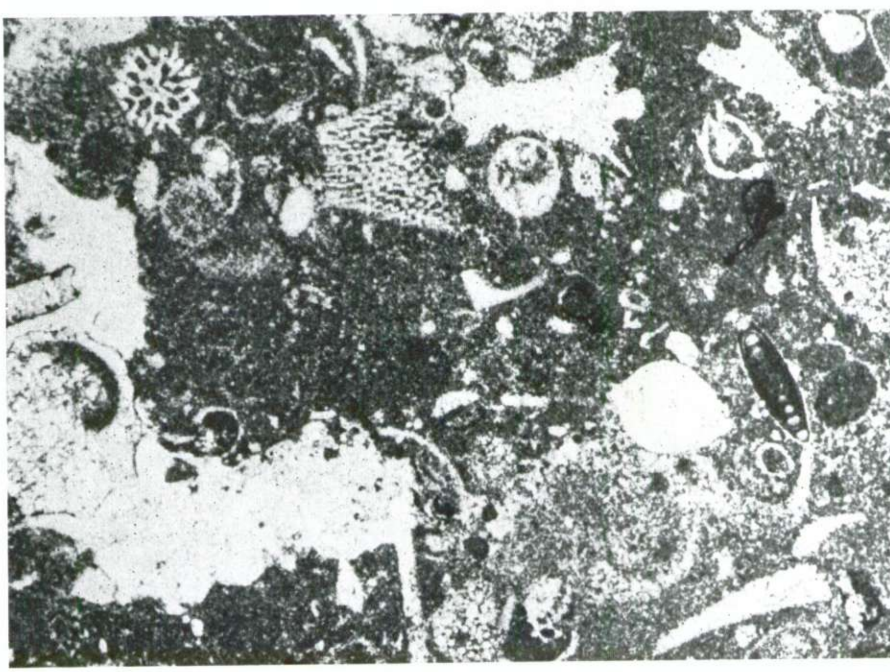


PLANCHE LXI

Fig. 1

Calcaire finement organogène-détritique à Lagénidés, loges initiales d'Ammonites et petits Ammonites, Brachiopodes, spicules de Spongiaires et débris de Mollusques et d'Echinodermes (× 32). Pl. mince 90-54. Dans l'association: *Spirillina liassica* (Jones) et *Vidalina martana* Farinacci

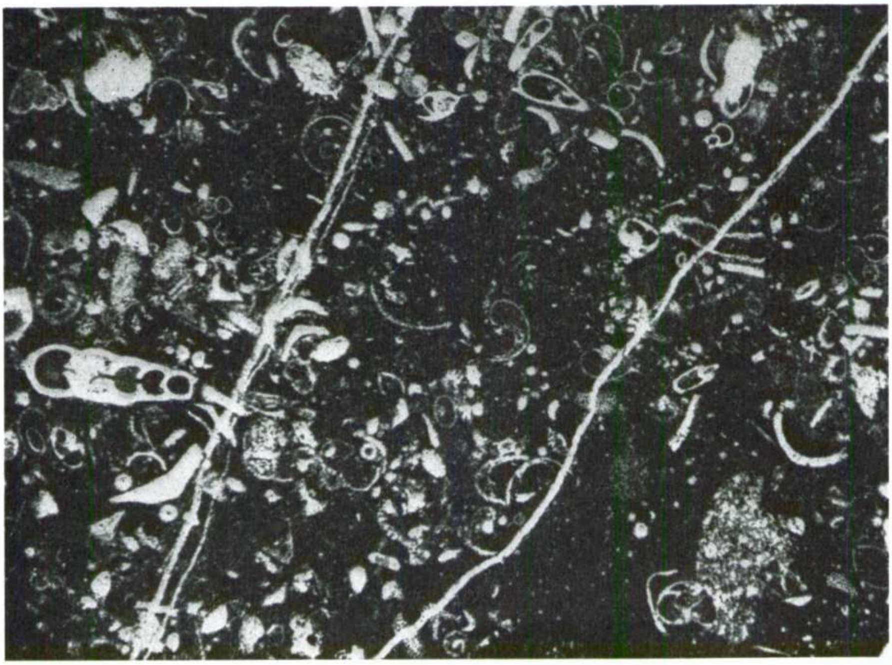
Montagne Vojnik, environs de Lipova Ravan

LIAS SUPÉRIEUR

Fig. 2

Calcaire organogène-détritique à débris de Mollusques et d'Echinodermes, petits Ammonites, spicules de Spongiaires et Foraminifères: *Vidalina martana* Farinacci, *Trocholina* cf. *conica* (Schlumb.), Lagénidés, etc. (× 35). Pl .mince 794-62
Montagne Vojnik, environs de Lipova Ravan

LIAS SUPÉRIEUR



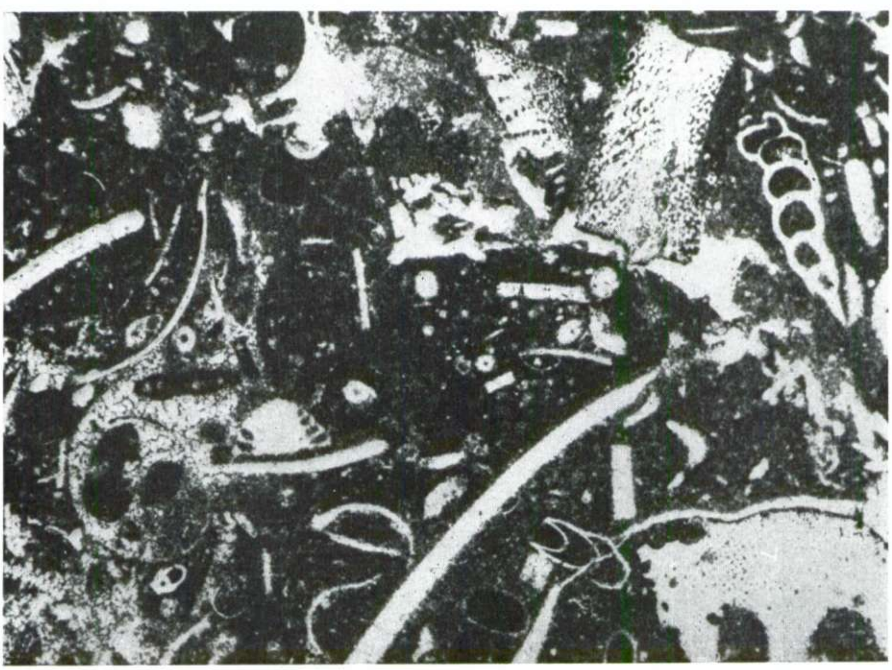


PLANCHE LXII

Fig. 1 et 2

Calcaire légèrement marneux à loges initiales d'Ammonites et petits Ammonites, Microgastéropodes, Spongiaires, débris d'Echinodermes et Foraminifères: *Spirillina liassica* (Jones), *Trocholina* spec. nov., Lagénidés (fig. 1 — × 32, fig. 2 — × 35). Pl. mince 96-54 (différemment vue la même plaque mince: sur la fig. 1 — essaim d'Ammonites)

Montagne Vojnik, environs de Lipova Ravan

LIAS SUPÉRIEUR

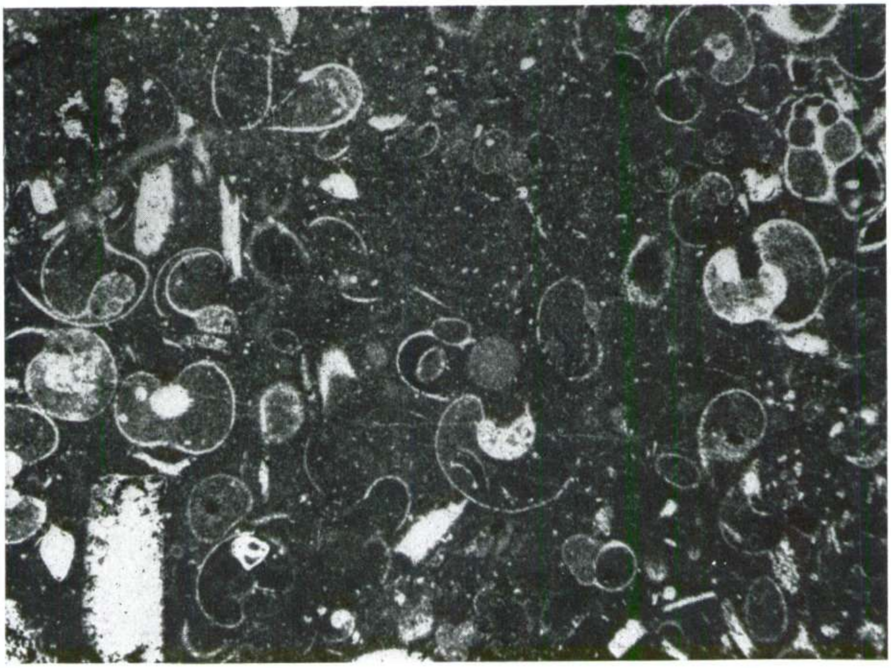


PLANCHE LXIII

Fig. 1

Calcaire marneux, finement organogène-détritique, à débris d'Echinodermes et de Mollusques, petits Ammonites, spicules de Spongiaires et Foraminifères: *Spirillina liassica* (Jones) et aut. (× 50). Pl. mince 794 a-62

Montagne Vojnik, environs de Lipova Ravan

LIAS SUPÉRIEUR

Le faciès des calcaires rougeâtres aux Cephalopodes est très répandu dans la région de la montagne Vojnik et renferme la faune abondante: *Hildoceras bifrons* Brug., *Hildoceras comensis* Buch., *Hildoceras laevisoni* Sim., *Phylloceras nilssoni* Héb., *Phylloceras gardanum* Vacek, *Phylloceras heterophyllum* Sow., *Lythoceras velifer* Men., *Lythoceras francisci* Opp., *Nautilus* spp., *Atractites* spp., etc.

PLANCHE LXIV

Fig. 1

Calcaire légèrement marneux à débris d'Echinodermes, Microgastéropodes, *Spirillina liassica* (Jones), etc. (× 45). Pl. mince 94-54

Montagne Vojnik, environs de Lipova Ravan

LIAS SUPÉRIEUR (couches les plus jeunes)

Fig. 2

Calcaire finement organogène-détritique à débris d'Echinodermes et de Mollusques et rares Lagénidés (× 19). Pl. mince 2301-60

Montagne Vojnik, environs de Lipova Ravan

LIAS SUPÉRIEUR-DOGGER INFÉRIEUR

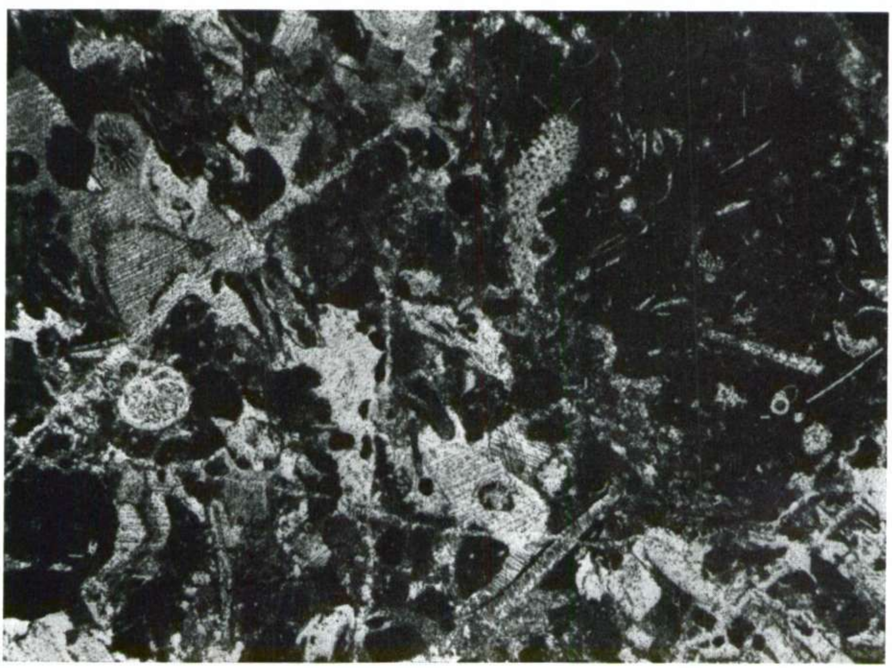


PLANCHE LXV

Fig. 1

Calcaire à *Globigerina helveto-jurassica* Haeussler et débris de Lamellibranches (× 100). Pl. mince 2303-60. Dans l'association: *Spirillina* sp.

Montagne Vojnik, environs de Lipova Ravan

DOGGER INFERIEUR (BAJOCIEN)

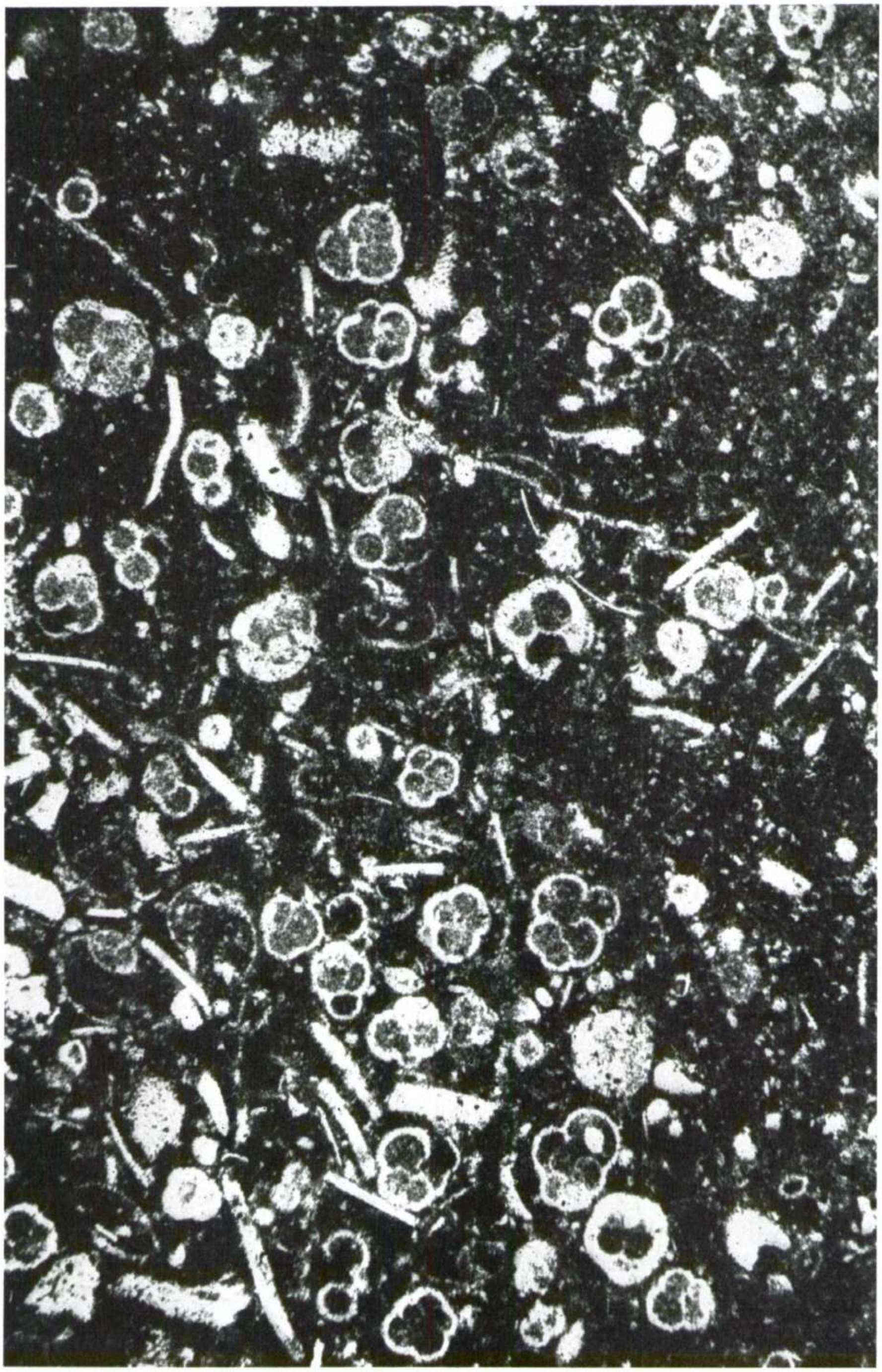


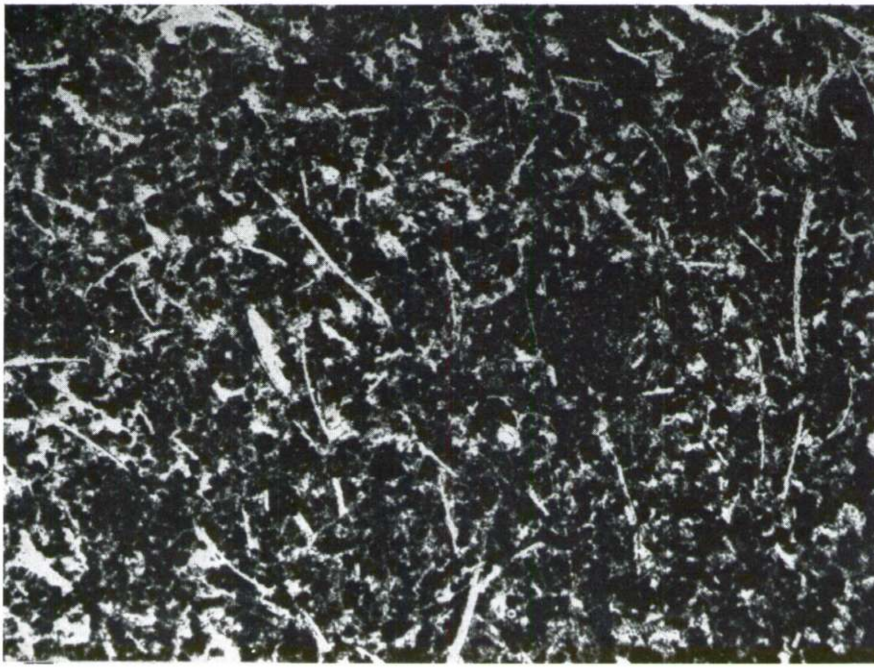
PLANCHE LXVI

Fig. 1

Calcaire microgrumeleux à Lamellibranches pélagiques (× 30). Pl. mince 795-62
Montagne Vojnik, environs de Lipova Ravan
DOGGER INFÉRIEUR

Fig. 2

Microbrèches à *Pseudocyclammina* sp. (× 19). Pl. mince 797-62. Les composantes: calcaire à Lamellibranches pélagiques et calcaire à Globigérines — rares oolithes dans le ciment
Montagne Vojnik, environs de Lipova Ravan
DOGGER INFÉRIEUR



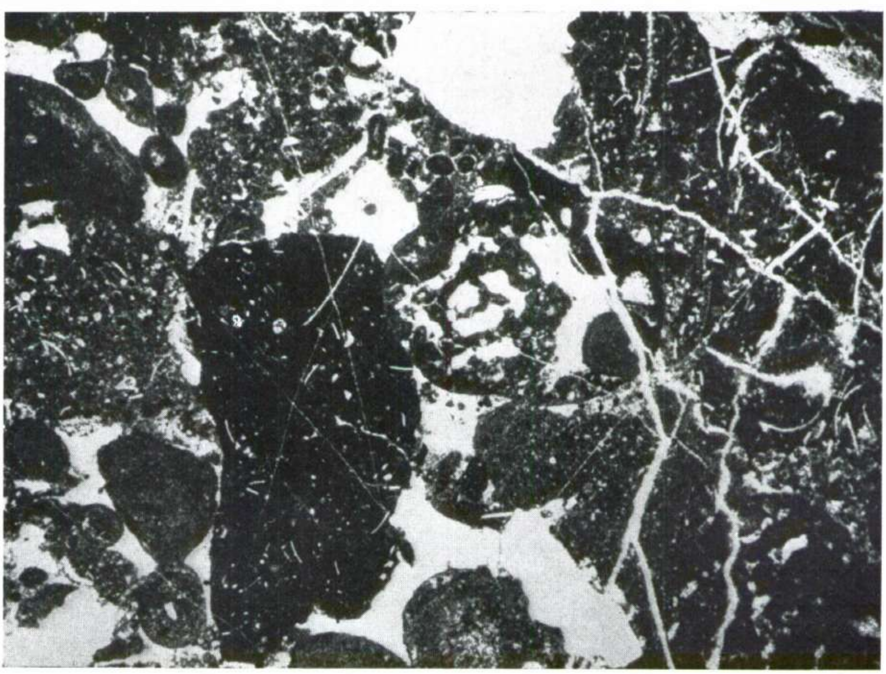


PLANCHE LXVII

Fig. 1 et 2

Calcaire oolithique-détritique à **Trocholines** (× 45). Pl. minces 796 et 801-62
Montagne Vojnik, environs de Lipova Ravan
DOGGER SUPÉRIEUR

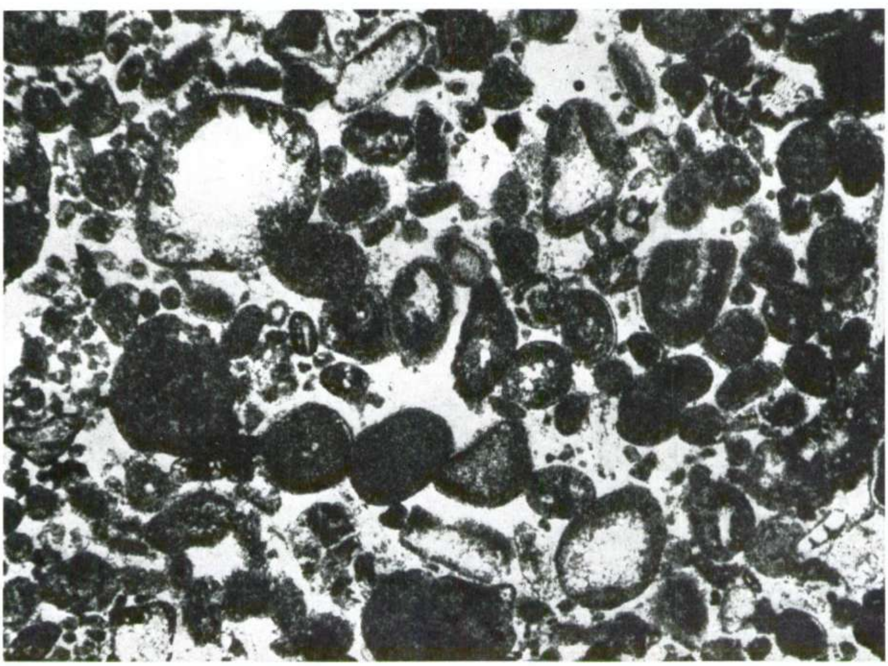


PLANCHE LXVIII

Fig. 1

Calcaire oolithique à *Protopeneroplis striata* Weynschenk (× 72). Pl. mince 2306-60

Montagne Vojnik, environs de Lipova Ravan

DOGGER SUPÉRIEUR

Fig. 2

Calcaire grumeleux, subcristallin, à fin débris divers et *Aeolisaccus* sp. (× 30). Pl. mince 2307-60

Montagne Vojnik, environs de Lipova Ravan

DOGGER SUPÉRIEUR-MALM INFÉRIEUR

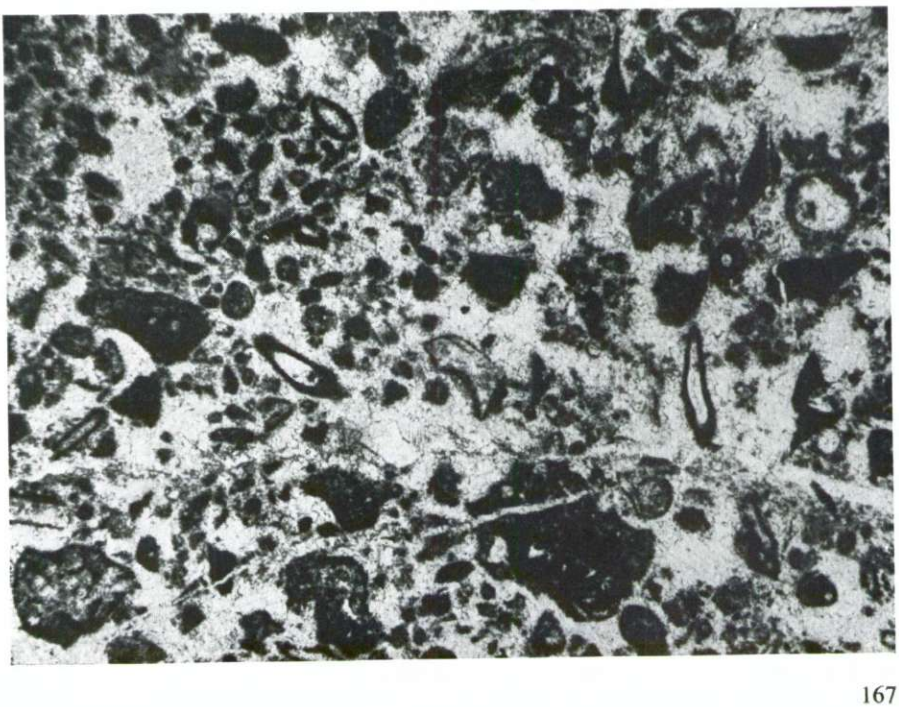


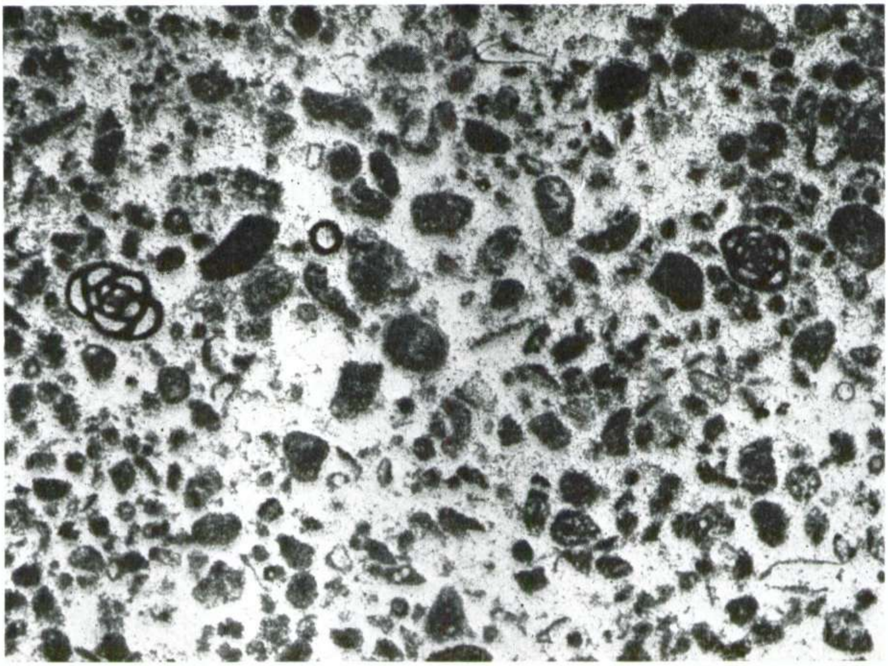
PLANCHE LXIX

Fig. 1

Calcaire grumeleux, subcristallin, à rares Foraminifères (Miliolidés et autres), (× 60). Pl. mince 2307 a-62
Montagne Vojnik, environs de Lipova Ravan
DOGGER SUPÉRIEUR-MALM INFÉRIEUR

Fig. 2

Calcaire à Microproblematica Br 1 (Briozoaires?), (× 30). Pl. mince 2307 b-60
Montagne Vojnik, environs de Lipova Ravan
MALM INFÉRIEUR (OXFORDIEN-KIMMÉRIDGIEN)



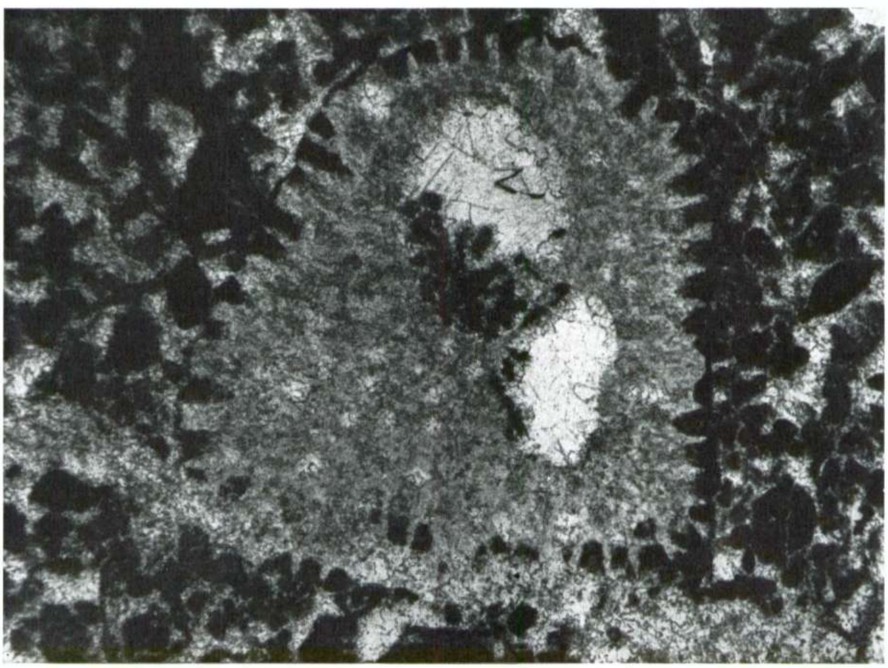


PLANCHE LXX

Fig. 1

Calcaire organogène à Polypiers, Codiacés et Foraminifères. Codiacée croûteuse renferme le Polypies et partiellement une Conicospirillina (C), (× 35). Pl. mince 813-62

Montagne Vojnik, environs de Lipova Ravan

MALM INFERIEUR (OXFORDIEN-KIMMÉRIDGIEN)

Fig. 2

Calcaire marneux à rares Ostracodes, Microgastéropodes et Charophytes (× 35). Pl. mince 814-62

Montagne Vojnik, environs de Lipova Ravan

MALM SUPÉRIEUR (la série du toit des bauxites)

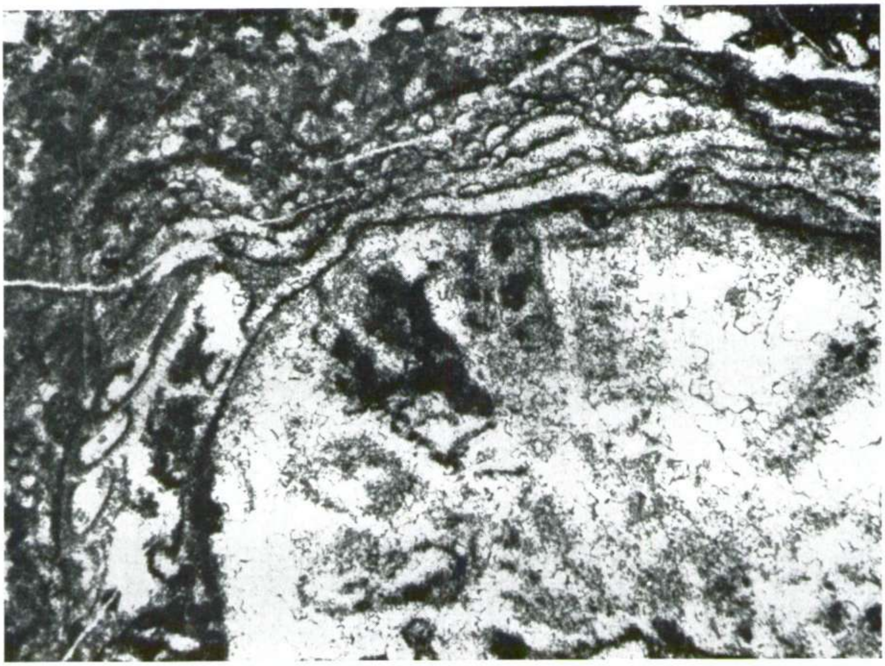


PLANCHE LXXI

Fig. 1

Calcaire marneux à Ostracodes (× 30). Pl. mince 801-62
Montagne Vojnik, environs de Lipova Ravan
MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR-PORTLANDIEN)

Fig. 2

Calcaire marneux à *Pianella grudii* Radoičić et rares Ostracodes (× 32). Pl. mince 806-62
Montagne Vojnik, environs de Lipova Ravan
MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR-PORTLANDIEN)

PLANCHE LXXII

Fig. 1

Calcaire marneux à *Pianella grudii* Radoičić et Ostracodes (× 32). Pl. mince 806-62

Montagne Vojnik, environs de Lipova Ravan

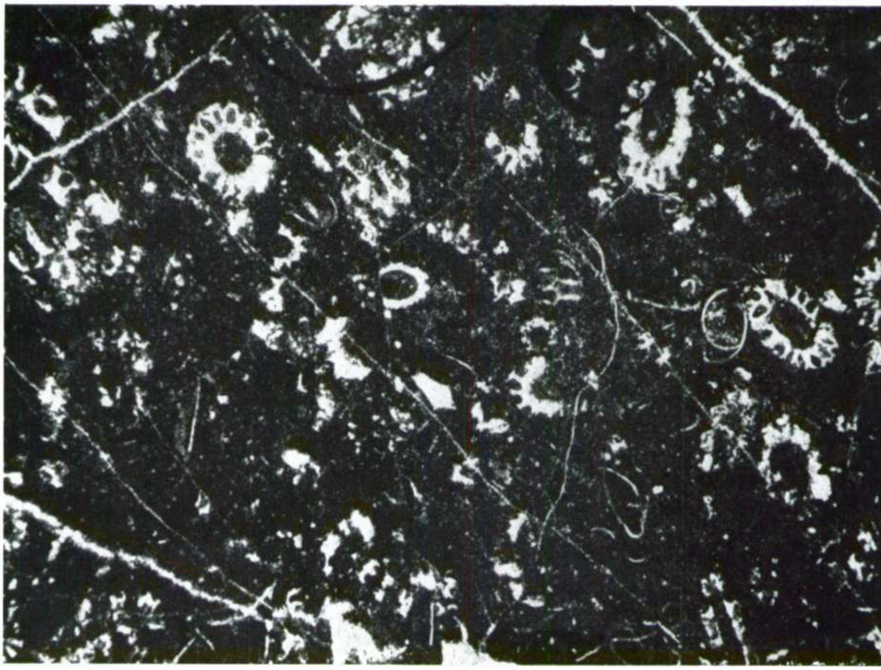
MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR-PORTLANDIEN)

Fig. 2

Calcaire marneux à *Clypeina jurassica* Favre (× 32). Pl. mince 809-62

Montagne Vojnik, environs de Lipova Ravan

MALM SUPÉRIEUR (PORTLANDIEN)



LA SÉRIE JURASSIQUE DE KOSANICA ET DE KRALJEVA GORA

(Tableau № 5)

Planches: LXXIII à LXXIX

PLANCHE LXXIII

Fig. 1

Calcaire détritique, subcristallin, à *Permodiscus sinuosus* (Weynschenk)* (× 45). Pl. mince 2160-60

Kraljeva gora, contreforts sud-est vers Kosanica

LIAS INFÉRIEUR

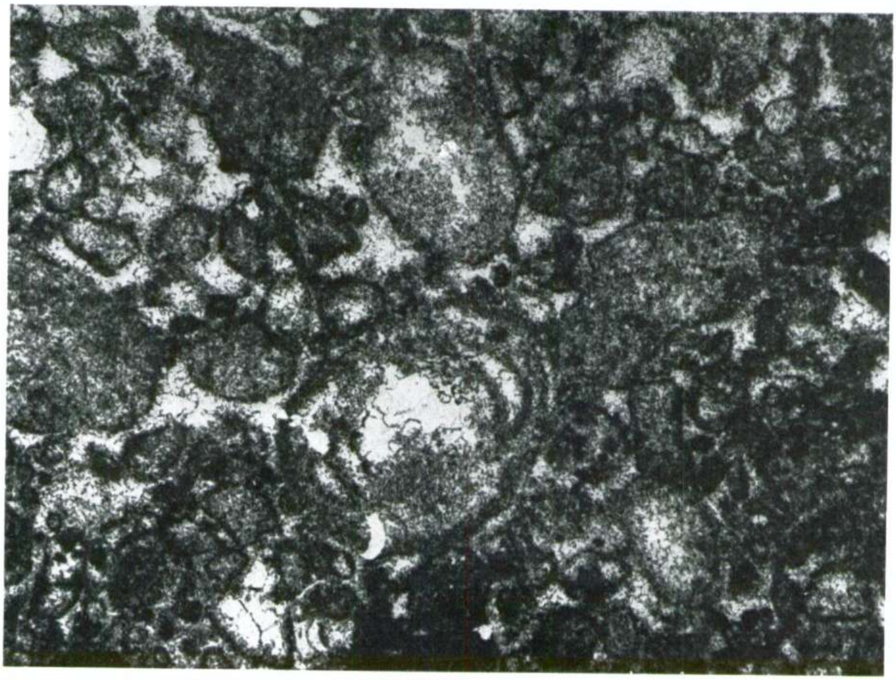
* Quoique la structure de la paroi de ces formes ne soit pas visible à cause de la récristallisation, il semble qu'il est mieux de les traiter comme les représentants du genre *Permodiscus* que de l'*Aulotortus* comme l'avait proposé R. Oberhauser (1964).

Fig. 2

Calcaire à *Thaumatoporella parvovesiculifera* (Rain.), rares Lagénidés et Spirillines (× 45). Pl. mince 2161 a-60

Kraljeva gora, contreforts sud-est vers Kosanica

LIAS



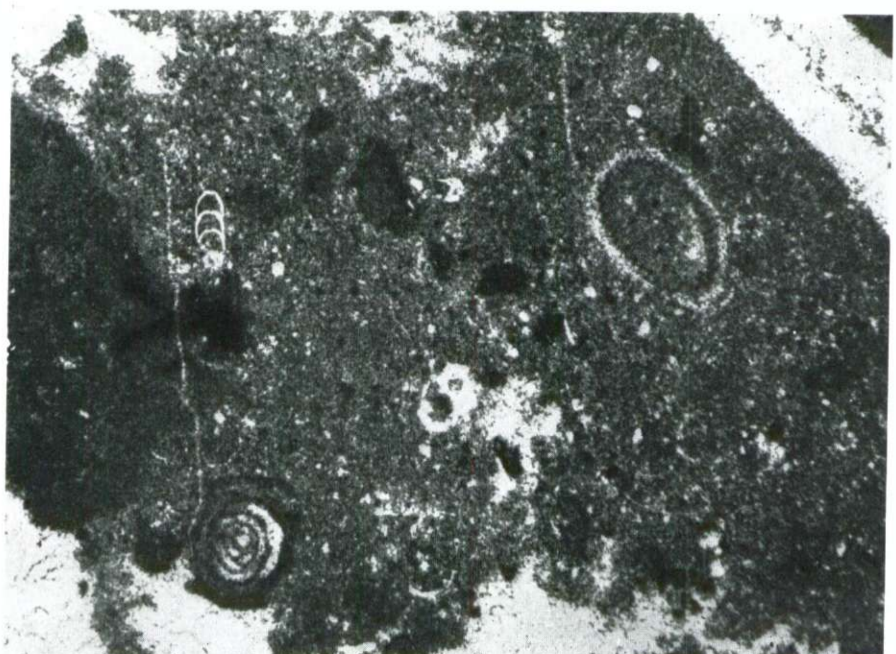


PLANCHE LXXIV

Fig. 1

Calcaire à *Spirillina liassica* (Jones), petits Brachiopodes et débris d'Echinodermes (× 40). Prep. 2164-60. Dans l'association: *Hildoceras bifrons* Brug. et autres Ammonites

Kraljeva gora, contreforts sud-est vers Kosanica

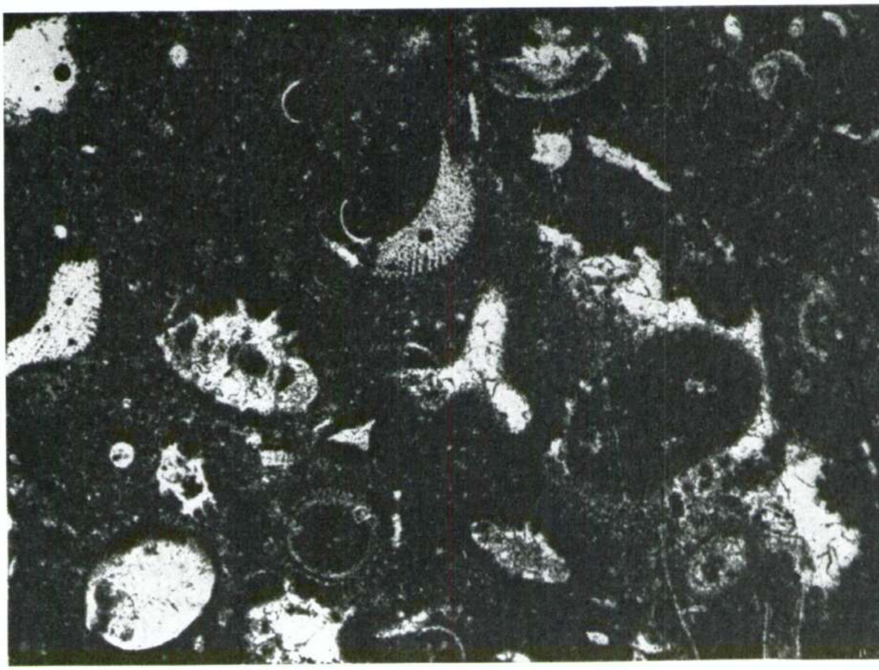
LIAS SUPÉRIEUR

Fig. 2

Calcaire pseudo-oolithique à petits Lamellibranches, débris d'Echinodermes, Lagénidés et *Vidalina martana* Farinacci (× 28). Pl. mince 2166-60

Kraljeva gora, contreforts sud-est vers Kosanica

LIAS SUPÉRIEUR-DOGGER



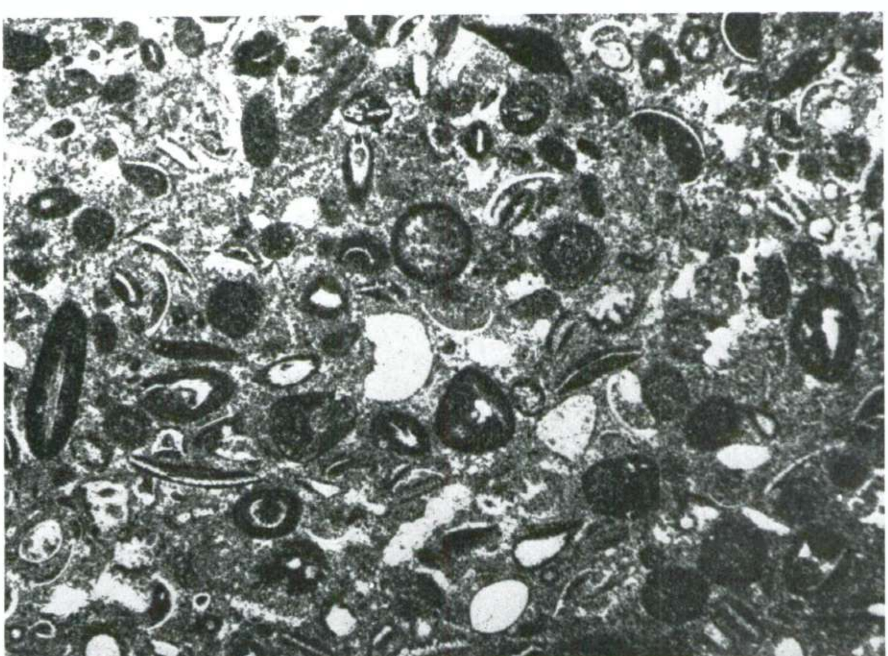


PLANCHE LXXV

Fig. 1

Calcaire microgrumeleux-subcristallin à rares Foraminifères et *Aeolisaccus* sp. (× 37,5). Pl. mince 2169-60

Kraljeva gora, contreforts sud-est vers Kosanica

DOGGER

Fig. 2

Calcaire organogène-détritique à Codiacées et débris de Mollusques (× 30), Pl. mince 2175-60. Dans l'association: Codiacées C1 et C2, Bryozoaires? — Br1, Annélides, débris de Dasycladacées, etc. — planche LXXVI

Kraljeva gora, contreforts sud-est vers Kosanica

MALM INFERIEUR

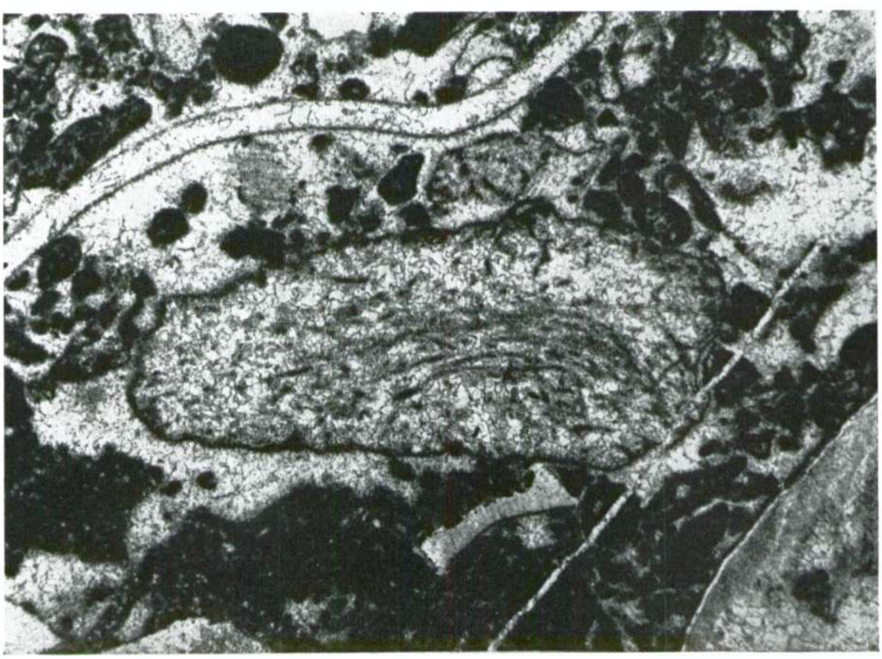


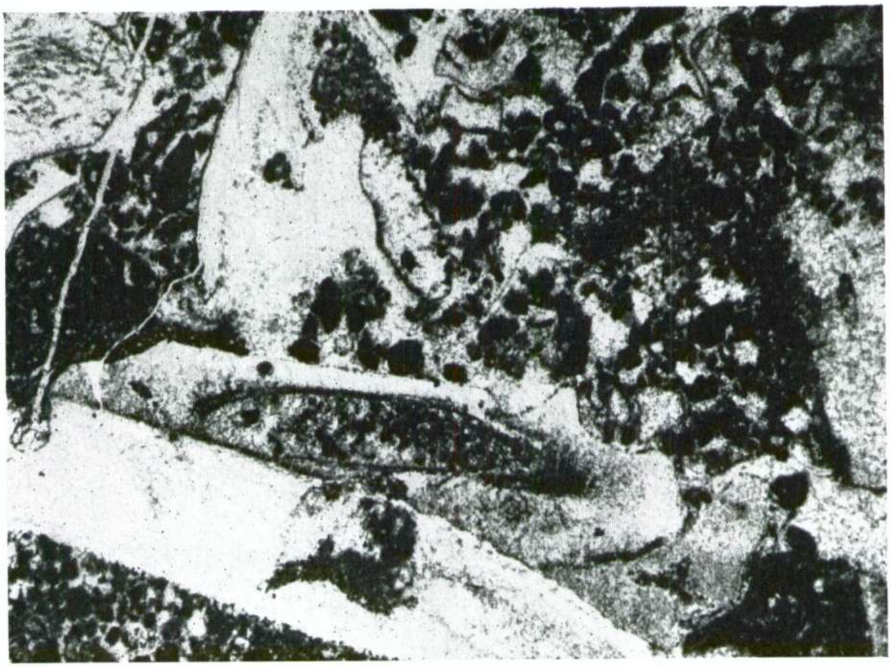
PLANCHE LXXVI

Fig. 1 et 2

Calcaire organogène-détritique à Codiacées C1 et C2, Annélides, Bryozoaires? — Br1, débris de Mollusques, etc. (× 30). Pl. mince 2175-60

Kraljeva gora, contreforts sud-est vers Kosanica

MALM INFÉRIEUR



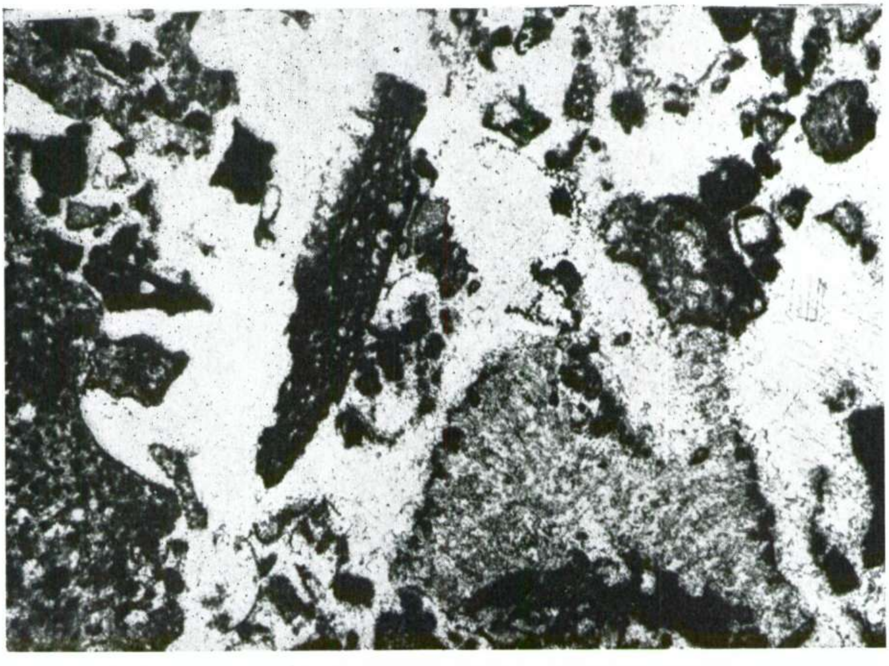


PLANCHE LXXVII

Fig. 1 et 2

Calcaire à Radiolaires (*Cenosphaera* sp., *Lithostrobus* sp. et aut.), (× cca 200). Pl. minces 819 et 820-58

Kraljeva gora, contreforts sud-est vers Kosanica

MALM SUPÉRIEUR

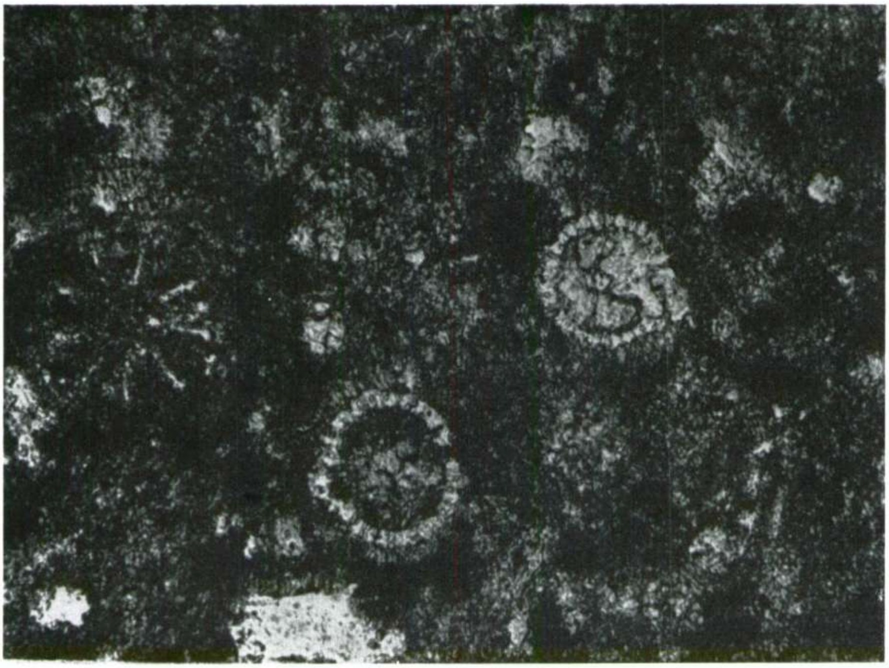


PLANCHE LXXVIII

Fig. 1

Calcarénite à fragment de Dasycladacée *Clypeina jurassica* Favre (× 43). Pl. mince 2183-60. Dans l'association: rares Calpionelles. Dans ce sédiment les Clypeines sont les fossiles alochtones apportés de régions voisines meridionalles Kraljeva gora, contreforts sud-est — Kosanica

MALM SUPÉRIEUR (PORTLANDIEN)

Fig. 2

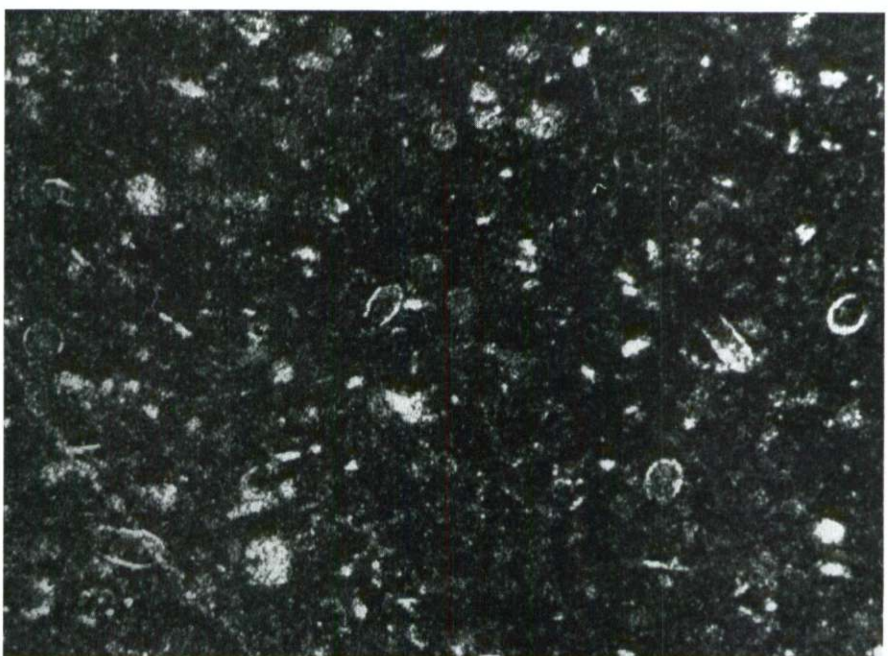
Calcaire à *Calpionella alpina* Lorenz (× 210). Pl. mince 821-58
Kraljeva gora, contreforts sud-est — Kosanica

MALM SUPÉRIEUR (PORTLANDIEN)

PLANCHE LXXIX

Fig. 1 et 2

Calcaire à *Calpionella alpina* Lorenz, *Calpionella elliptica* Cadisch et *Calpionellopsis oblonga* (Cadisch), (× 140 — fig. 1; × 95 — fig. 2). Pl. mince 3116-60
Kraljeva gora, contreforts sud-est vers Kosanica
BERRIASIEN



LA SÉRIE JURASSIQUE DES ENVIRONS DE PLJEVLJA DINARIDES INTERNES

(Tableau № 6)

Planches: LXXX à LXXXVIII

PLANCHE LXXX

Fig. 1

Calcaire marneux à Ostracodes (× 72,5). Pl. mince 2188-60
Environs de Pljevlja, près de Mihajlovići
LIAS INFÉRIEUR

Fig. 2

Calcaire à Thaumatoporelles transformées (× 72,5). Pl. mince 2189-60
Environs de Pljevlja, près de Mihajlovići
LIAS INFÉRIEUR

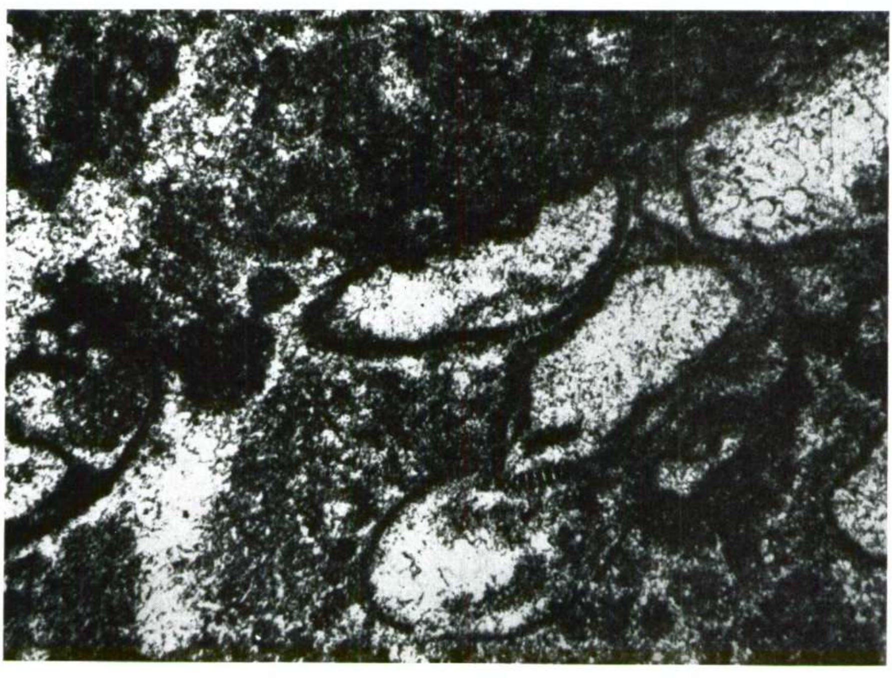


PLANCHE LXXXI

Fig. 1

Calcaire à Lagénidés, autres Foraminifères et débris d'Echinodermes (× 72). Pl. mince 2191-60

Environs de Pljevlja, près de Mihajlovići

LIAS

Fig. 2

Calcaire pseudo-oolithique à *Spirillina liassica* (Jones), *Globochaete* et débris de Mollusques (× 72). Pl. mince 2192-60

Environs de Pljevlja, près de Mihajlovići

LIAS (MOYEN-SUPERIEUR)

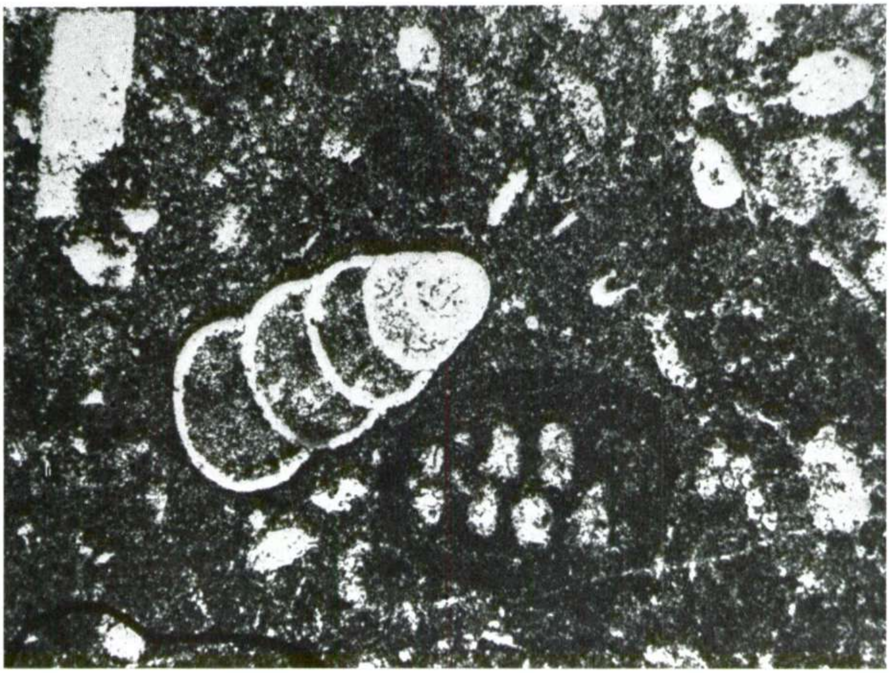


PLANCHE LXXXII

Fig. 1

Calcaire à Lamellibranches pélagiques et Lagénidés peu abondants (× 72). Pl. mince 2193-60

Environs de Pljevlja, près de Mihajlovići

LIAS (MOYEN-SUPÉRIEUR)

Fig. 2

Calcaire organogène-détritique jusqu'à pseudo-oolithique à *Globochaete alpina* Lombard, rares Lagénidés et débris de Mollusques et Brachiopodes (× 72). Pl. mince 2195-60

Environs de Pljevlja, près de Mihajlovići

LIAS (MOYEN-SUPÉRIEUR)

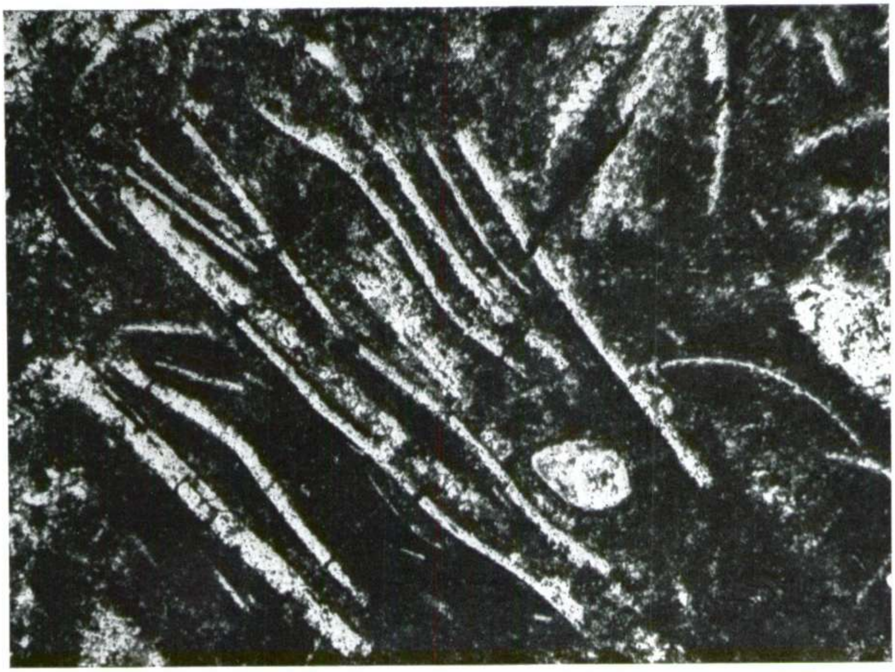


PLANCHE LXXXIII

Fig. 1

Calcaire organogène-détritique à pseudo-oolitique à Lagénidés, petits Brachiopodes, débris d'Echinodermes et de Mollusques (× 72). Pl. mince 2195-60

Environs de Pljevlja, Mihajlovići

LIAS (MOYEN-SUPÉRIEUR)

Fig. 2

Calcaire à Globochaete, puis Lagénidés et autres Foraminifères et débris d'Echinodermes et de Mollusques (× 72). Pl. mince 2196-60

Environs de Pljevlja, près de Mihajlovići

LIAS (MOYEN-SUPÉRIEUR)

PLANCHE LXXXIV

Fig. 1

Calcaire à Lagénidés et débris d'Echinodermes (× 72). Pl. mince 2198-60. Dans l'association: Ammonites et Brachiopodes

Environs de Pljevlja, près de Mihajlovići

LIAS SUPÉRIEUR

La faune d'Ammonites est composée des espèces: ***Phylloceras nilssoni*** Heb., ***Phylloceras heterophyllum*** Sow., *Lythoceras francisci* Opp., *Lythoceras velifer* Men. et autres

Fig. 2

Calcaire à débris d'Echinodermes et de Mollusques, petits Ammonites et rares Foraminifères (*Trocholina* sp. et aut.) (× 72). Pl. mince 2199-60

Environs de Pljevlja, près de Mihajlovići

LIAS SUPÉRIEUR

PLANCHE LXXXV

Fig. 1

Calcaire à *Globochaete alpina* Lombard et débris divers peu abondant (× 72). Pl. mince 2199-60

Environs de Pljevlja, près de Mihajlovići

LIAS SUPÉRIEUR

Fig. 2

Calcaire à rares Globigérines, *Globochaete alpina* Lombard et coquilles écrasées de Lamellibranches pelagiques (× 72). Pl. mince 2201-60

Environs de Pljevlja, près de Mihajlovići

DOGGER INFÉRIEUR

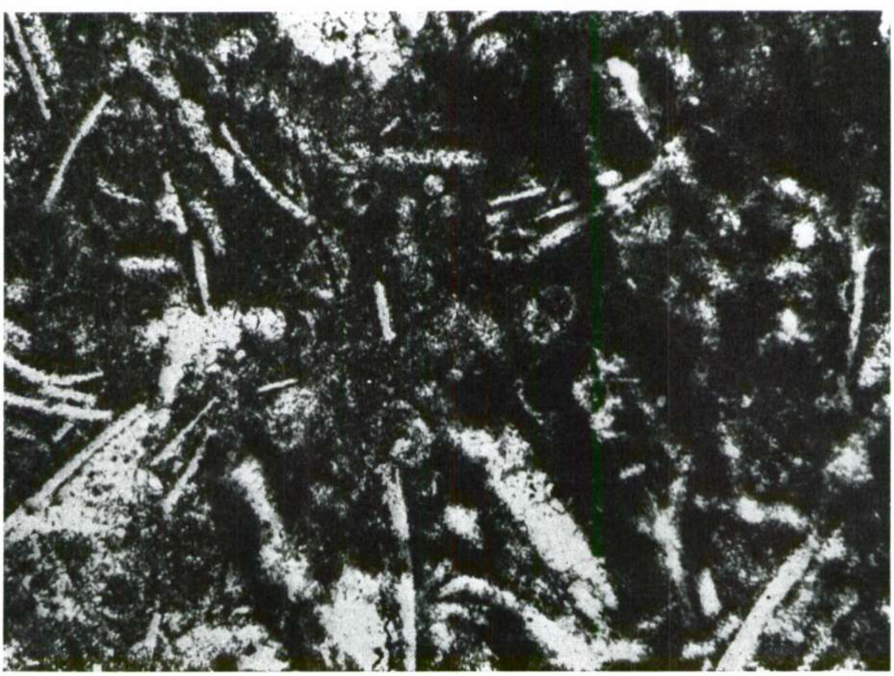


PLANCHE LXXXVI

Fig. 1

Calcaire avec écrasées coquilles de Lamellibranches pélagiques (× 72). Pl. mince 2202-60

Environs de Pljevlja, près de Vlahovići

DOGGER-MALM

Fig. 2

Calcaire à Lamellibranches pélagiques et Radiolaires (× 30). Pl. mince 3104-60

Environs de Pljevlja, Vlahovići

DOGGER-MALM

PLANCHE LXXXVII

Fig. 1

Calcaire à Radiolaires (× 30). Pl. mince 3105-60
Environs de Pljevlja, Vlahovići
DOGGER-MALM

Fig. 2

Calcaire à Radiolaires et les parties du calcaire fort silifié
Environs de Pljevlja, Vlahovići
DOGGER-MALM

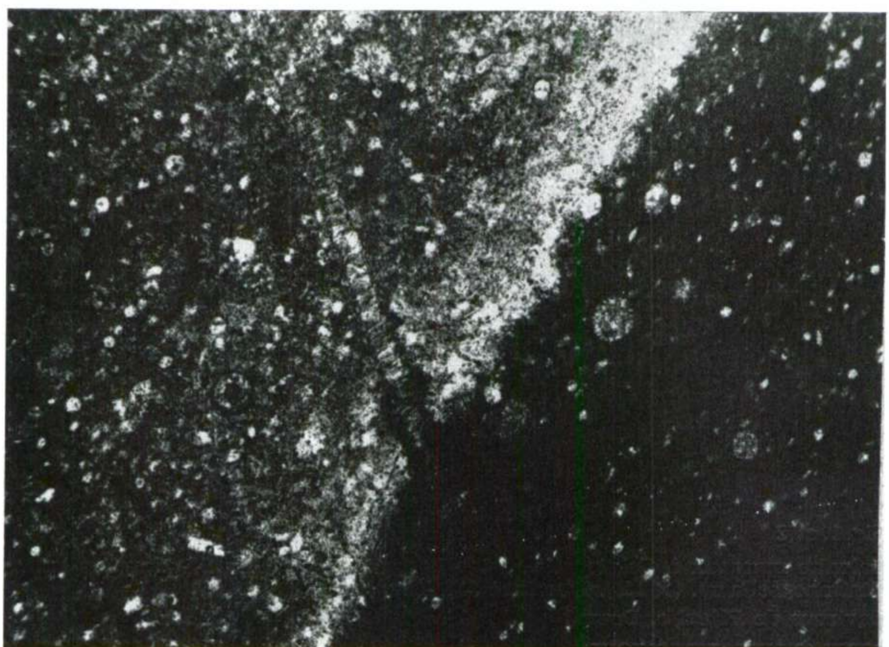


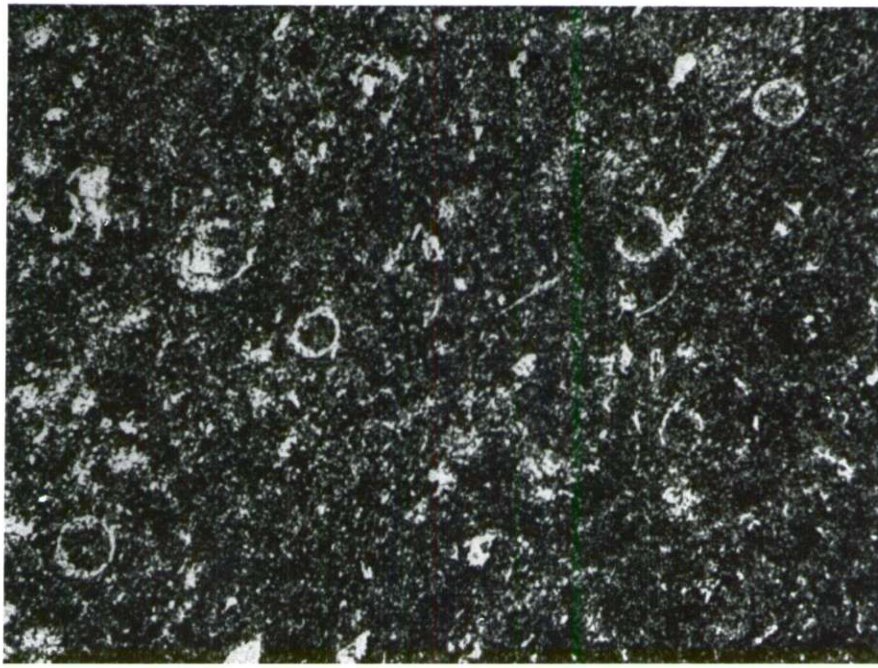
PLANCHE LXXXVIII

Fig. 1 et 2

Calcaire marneux à Calpionella alpina Lorenz, Calpionella elliptica Cadisch et Tintinnopsella sp. (× 120). Pl. mince 3111-60

Environs de Pljevlja, Dragaš

PORTLANDIEN (TITHONIQUE)



LA SÉRIE JURASSIQUE DE L'HERZÉGOVINE DU SUD
DISTRICT ENTRE DUBROVAČKO PRIMORJE ET TREBINJE-POPOVO POLJE

(Tableau № 7)

Planches: LXXXIX — CIX

PLANCHE LXXXIX

Fig. 1

Calcaire à *Palaeodasycladus mediterraneus* Pia et Foraminifères peu abondants (× 35). Pl. mince 377-61

Herzégovine du sud, environs d'Ivanica

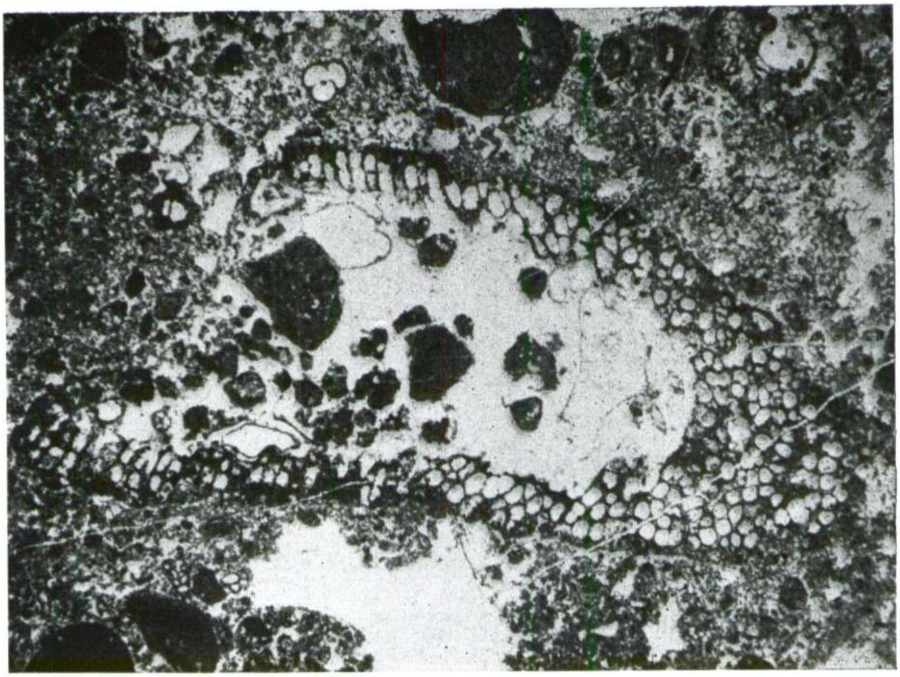
LIAS INFÉRIEUR

Fig. 2

Calcaire à *Pseudocyclammina* sp. et rares autres Foraminifères (× 15). Pl. mince 416-61. Dans l'association: *Thaumatoporella parvovesiculifera* (Rain.), *Sestrosphaera liasina* Pia et Microgaséropodes (= pl. XC)

Domaine limitrophe entre l'Herzégovine du sud et Dubrovačko primorje, environs de Gromača

LIAS MOYEN (couches à *Lithiotis*)



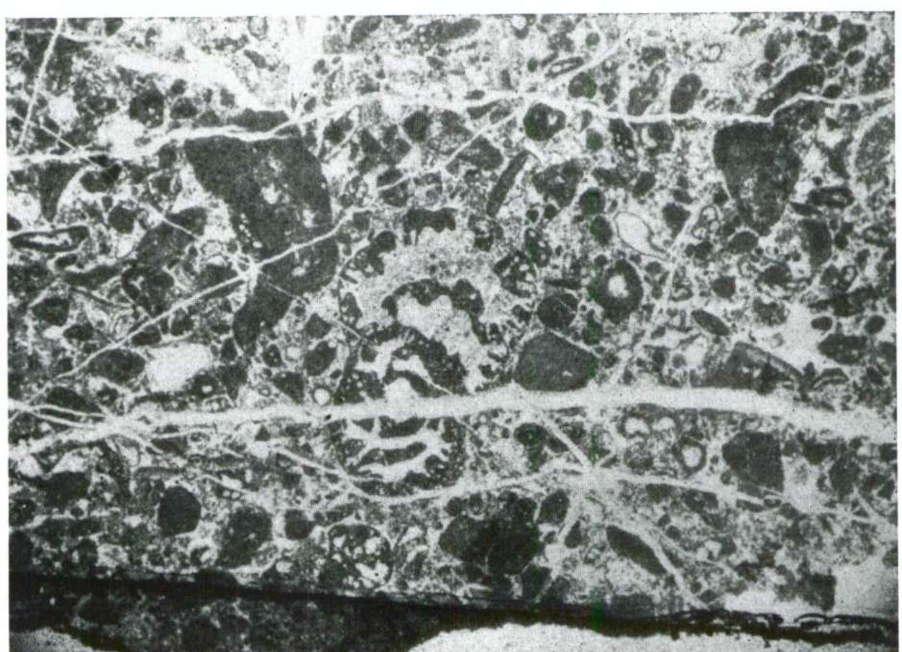


PLANCHE XC

Fig. 1

Calcaire organogène-détritique à *Sestrosphaera liasina* Pia, autres Algues, Foraminifères et Microgastéropodes (× 15). Pl. mince 416-61

Domaine limitrophe entre l'Herzégovine du sud et Dubrovačko primorje, environs de Gromača

LIAS MOYEN (couches à *Lithiotis*)

Fig. 2

Calcaire à débris de Dasycladacée *Sestrosphaera liasina* Pia et débris divers peu abondants (× 15). Pl. mince 417-61

Domaine limitrophe entre l'Herzégovine du sud et Dubrovačko primorje, environs de Gromača

LIAS MOYEN (couches à *Lithiotis*)

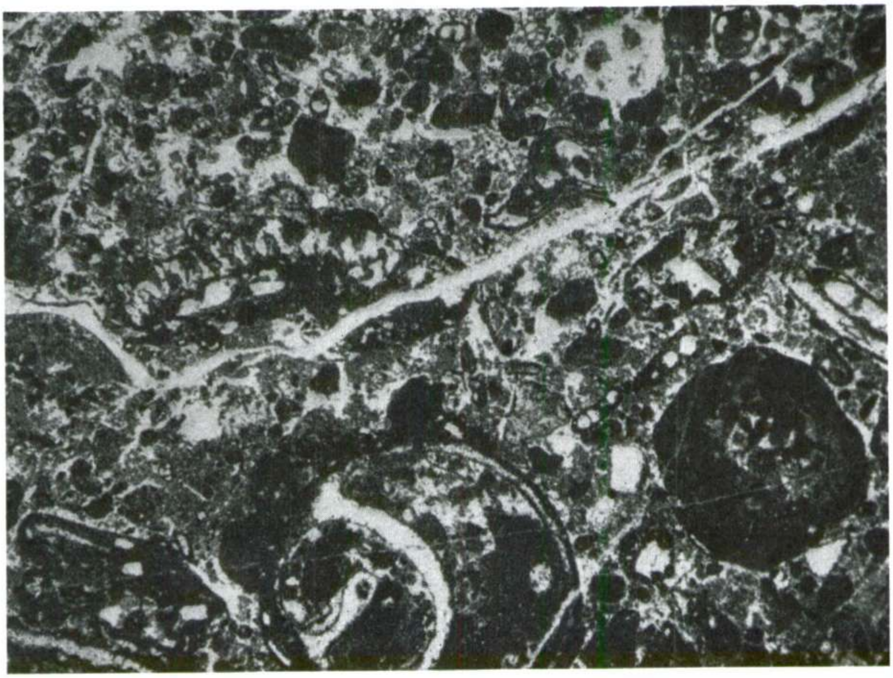


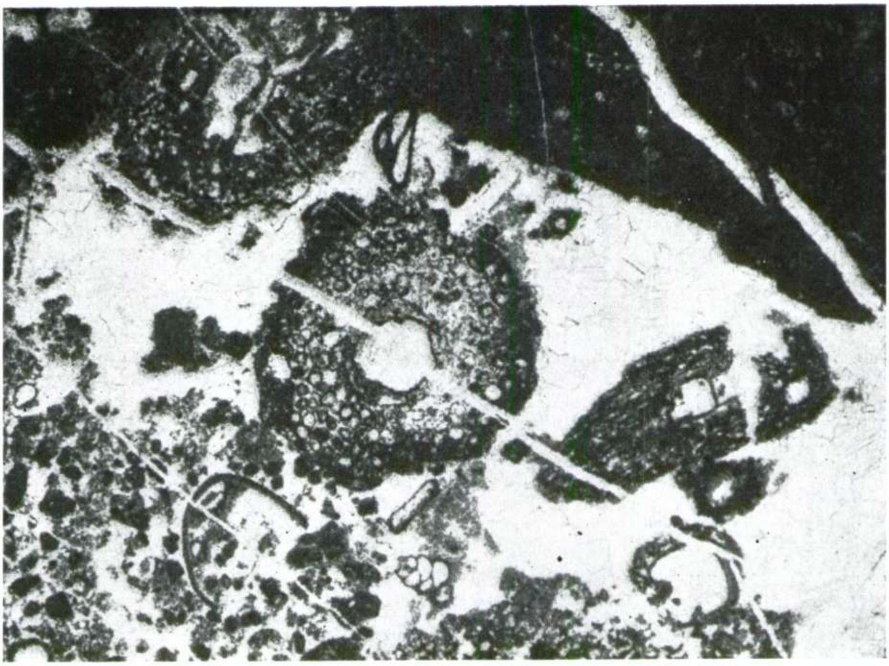
PLANCHE XCI

Fig. 1 et 2

Calcaire grumeleux, en partie subcristallin, à *Palaeodasycladus mediterraneus* Pia, *Thaumatoporella parvovesiculifera* (Rain.) et petits Foraminifères (× 30). Pl. mince 418-61

Domaine limitrophe entre l'Herzégovine du sud et Dubrovačko primorje, environs de Gromača

LIAS MOYEN (couches à *Lithiotis*, *Orbitopsella*, etc.)



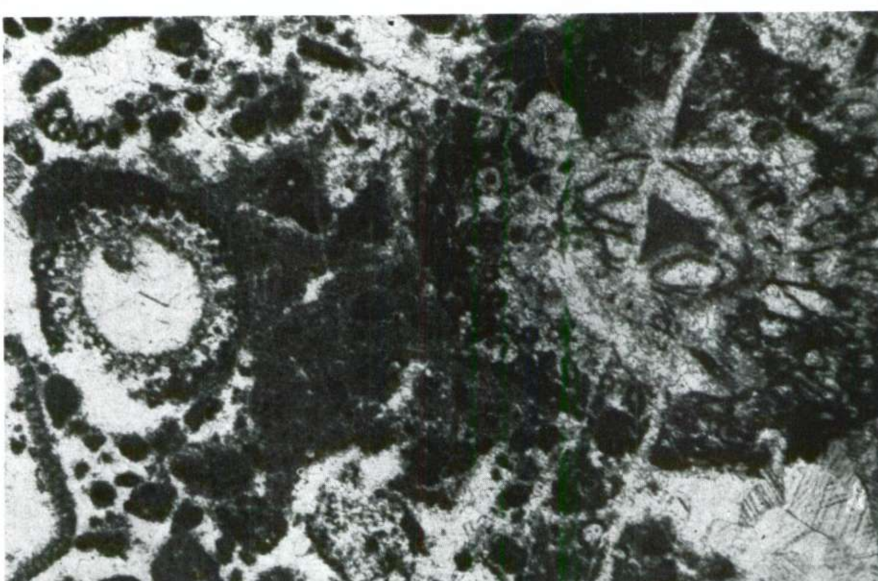


PLANCHE XCII

Fig. 1

Calcaire à débris de coquilles de Lamellibranches (*Lithiotis*, *Durga*), (× 15). Pl. mince 419 a-61

Domaine limitrophe entre l'Herzégovine du sud et Dubrovačko primorje, environs de Gromača

LIAS MOYEN

Fig. 2

Calcaire grumeleux à *Glomospira* (× 70). Pl. mince 420-61

Domaine limitrophe entre l'Herzégovine du sud et Dubrovačko primorje, environs de Gromača

LIAS MOYEN-SUPÉRIEUR

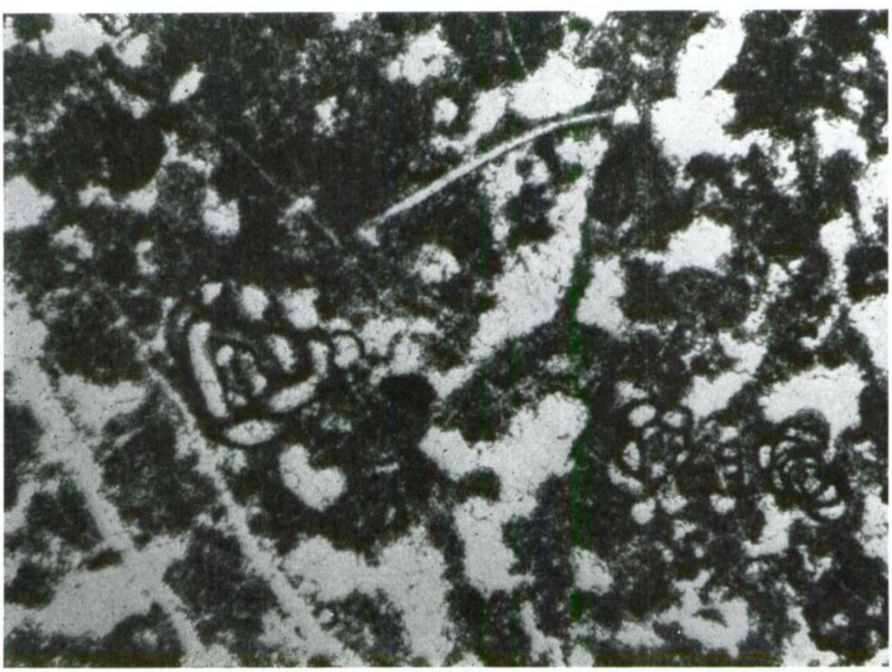


PLANCHE XCIII

Fig. 1

Calcaire pseudo-oolithique à débris de Mollusques et de Dasycladacées et petits Foraminifères peu nombreux (× 15). Pl. mince 421-61

Herzégovine du sud, environs de Gromača

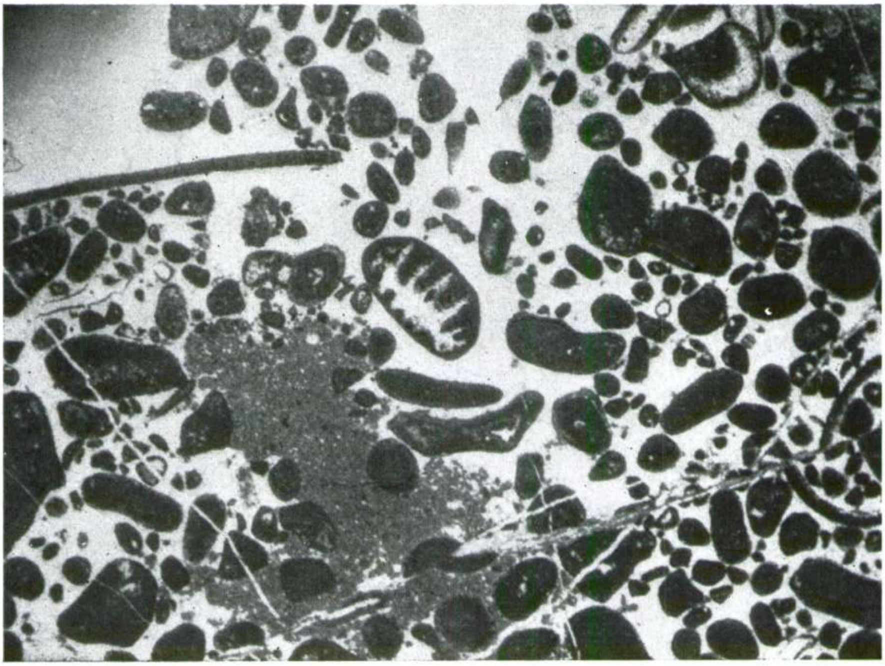
LIAS MOYEN-SUPÉRIEUR

Fig. 2

Dolomie stérile (intercalation dans les calcaires oolithiques), (× 30). Pl. mince 1745-62

Au nord de Župa dubrovačka

LIAS SUPÉRIEUR



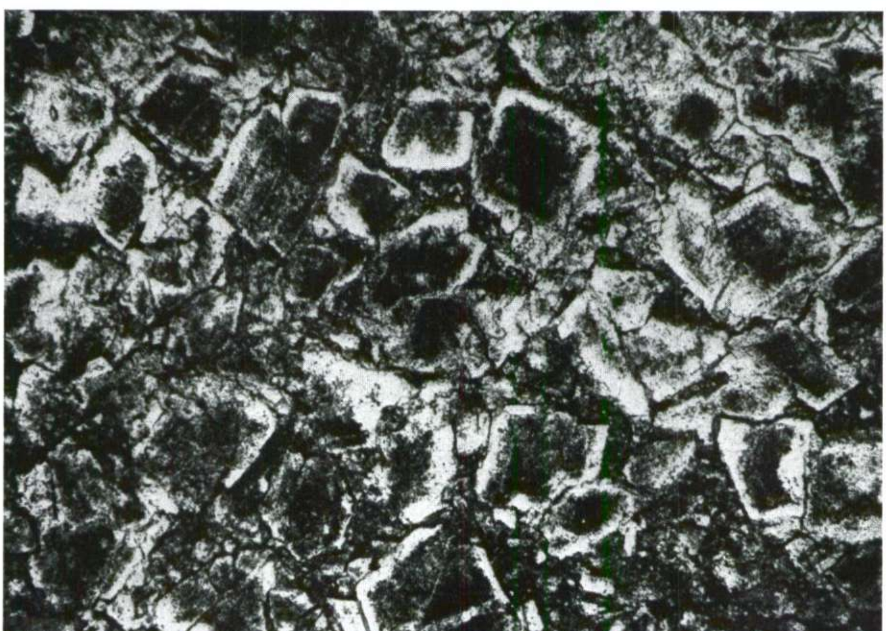


PLANCHE XCIV

Fig. 1

Calcaire finement oolithique azoïque (× 32). Pl. mince 337-61
Herzégovine du sud, environs d'Uskoplje
LIAS SUPÉRIEUR-DOGGER INFÉRIEUR

Fig. 2

Calcaire organogène, subcristallin à Microgastéropodes (*Nerinella* et aut.), (× 15). Pl. mince 338-61. Dans l'association: Foraminifères peu abondants
Herzégovine du sud, environs d'Uskoplje
DOGGER INFÉRIEUR

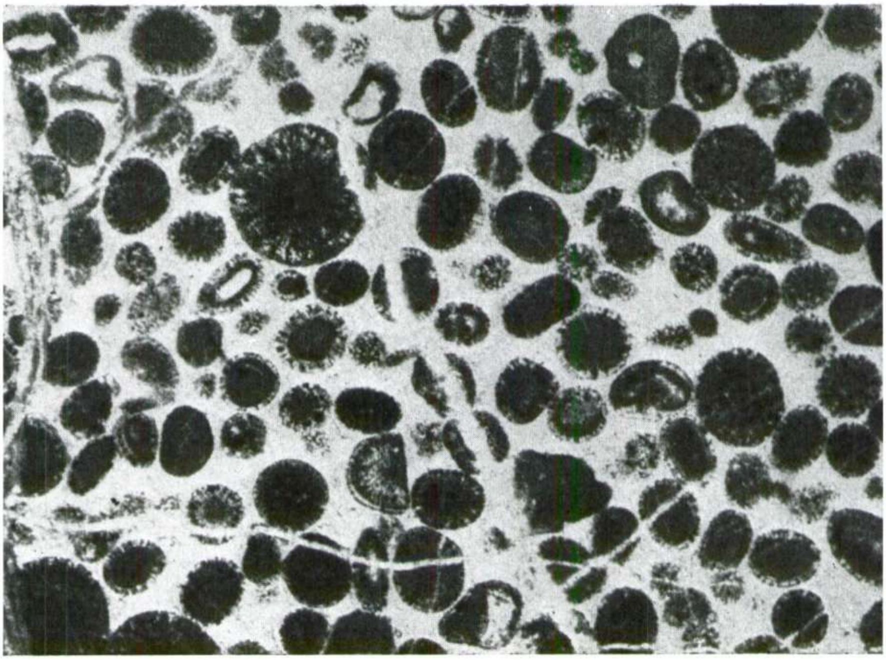


PLANCHE XCV

Fig. 1

Calcaire grumeleux à Coprolithes et petits Foraminifères peu abondants (× 28). Pl. mince 431-61

Herzégovine du sud, entre Gromača et Šćenica

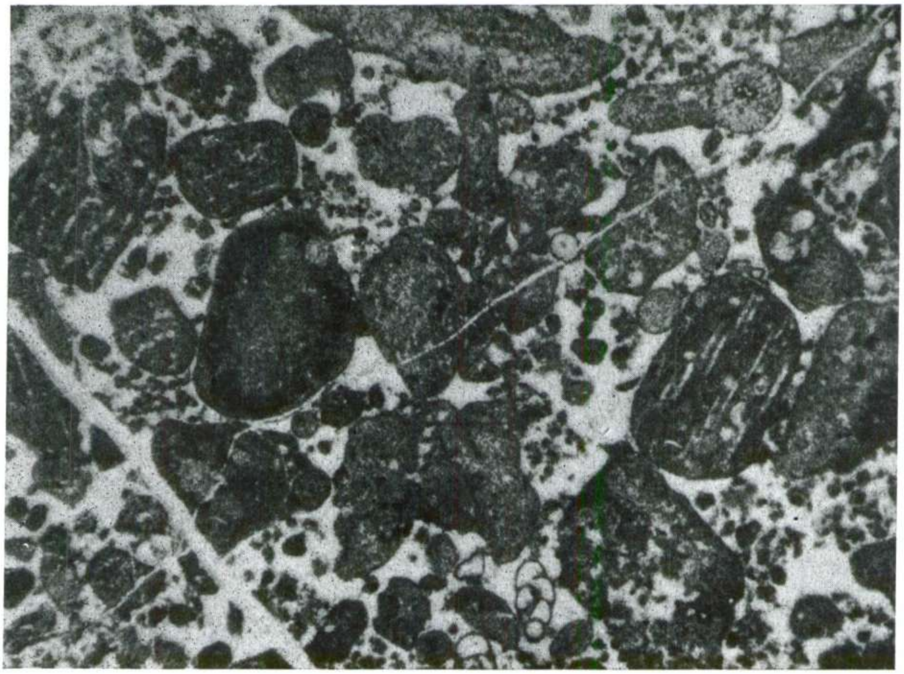
DOGGER INFÉRIEUR

Fig. 2

Calcaire organogène-détritique, subcristallin, à débris de Mollusques et de Dasycladacées et à Foraminifères (*Endothyra* sp. et autres), (× 28). Pl. mince 432-61

Herzégovine du sud, entre Gromača et Šćenica

DOGGER



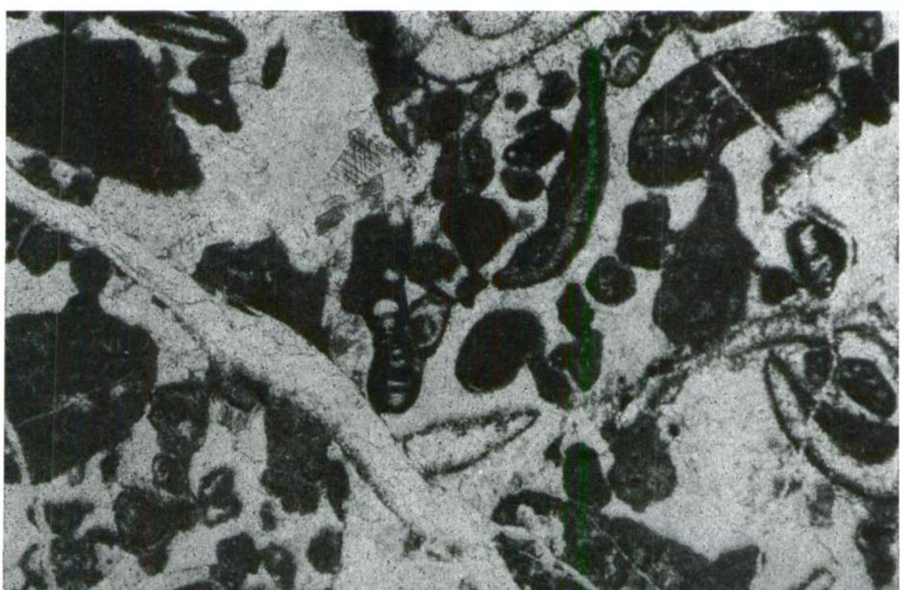


PLANCHE XCVI

Fig. 1

Calcaire organogène-détritique, subcristallin, à débris de Dasycladacée *Selliporella donzellii* Sartoni & Crescenti et Foraminifères — *Endothyra* sp. — (× 28).
Pl. mince 433-61

Herzégovine du sud, entre Gromača et Šćenica

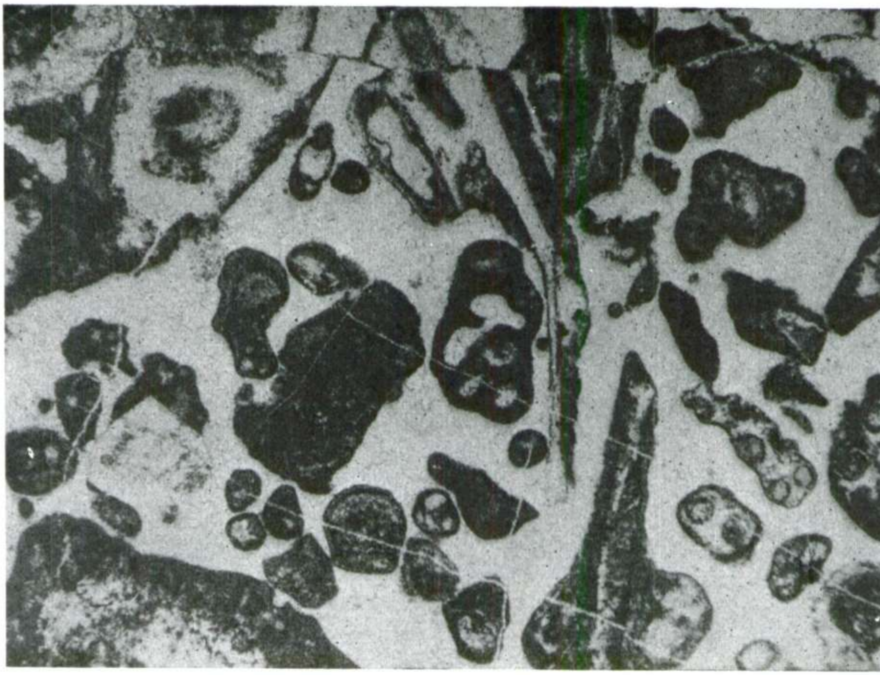
DOGGER SUPÉRIEUR

Fig. 2

Calcaire organogène-détritique à débris de Dasycladacées et de Mollusques et nombreux Foraminifères (Textularidés, Trochamminidés, Verneuilinidés), (× 28).
Pl. mince 436-61

Herzégovine du sud, entre Gromača et Šćenica

DOGGER SUPÉRIEUR



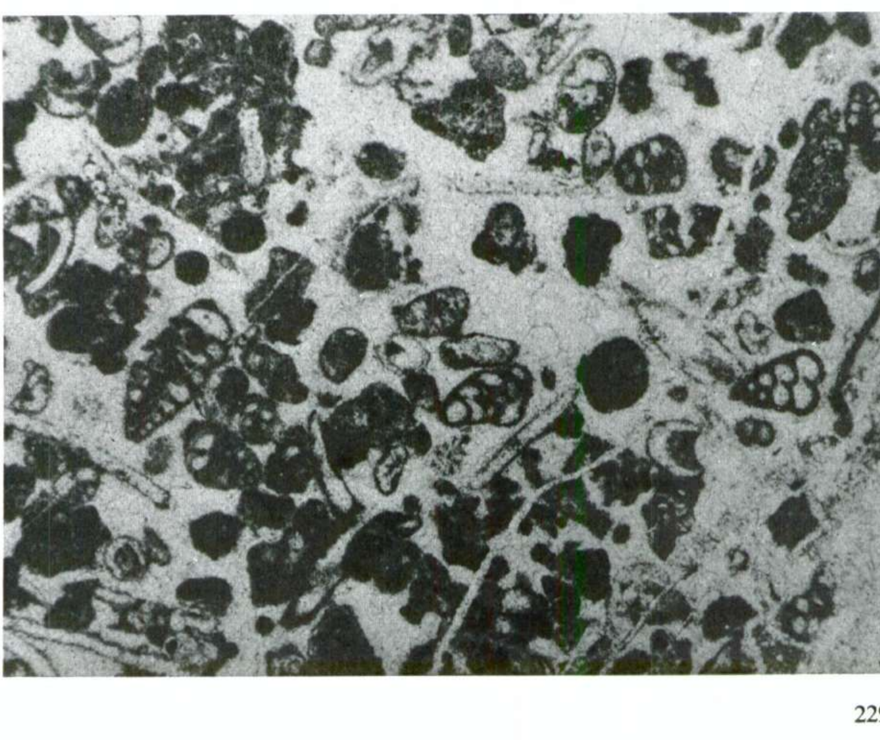


PLANCHE XCVII

Fig. 1

Calcaire organogène-détritique à ***Selliporella donzellii*** Sartoni & Crescenti et Foraminifères peu abondants (× 17). Pl. mince 433 a-61

Herzégovine du sud, entre Gromača et Šćenica

DOGGER SUPÉRIEUR

Fig. 2

Calcaire organogène-détritique à ***Selliporella donzellii*** Sartoni & Crescenti, Foraminifères et Microgastéropodes (× 17). Pl. mince 560-61

Herzégovine du sud, Čovine-Vlaka

DOGGER SUPÉRIEUR

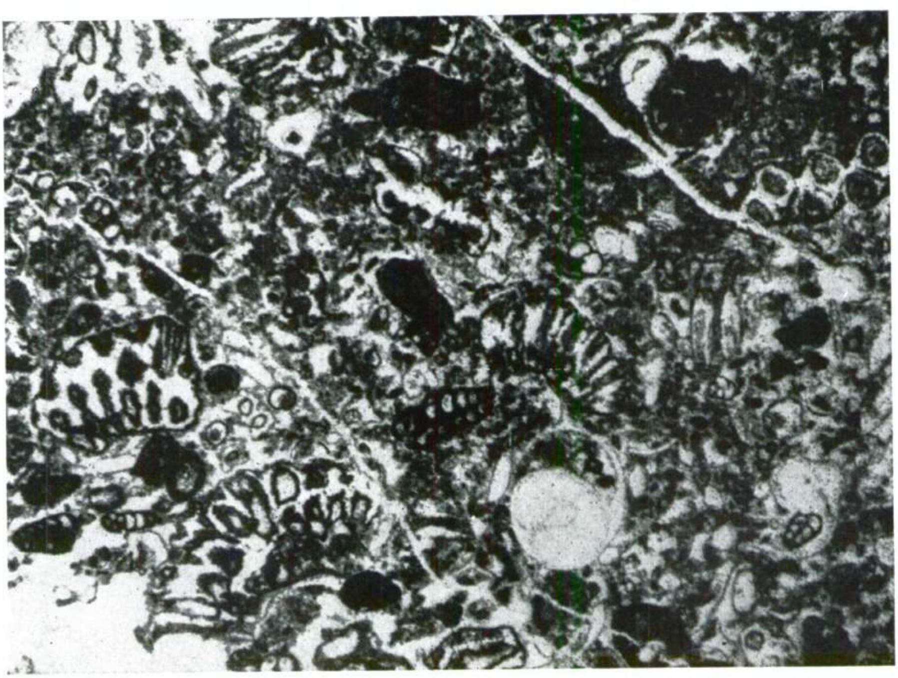


PLANCHE XCVIII

Fig. 1

Calcaire à *Selliporella donzellii* Sartoni & Crescenti et Foraminifères (× 27). Pl. mince 560-61

Herzégovine du sud, Čovine-Vlaka

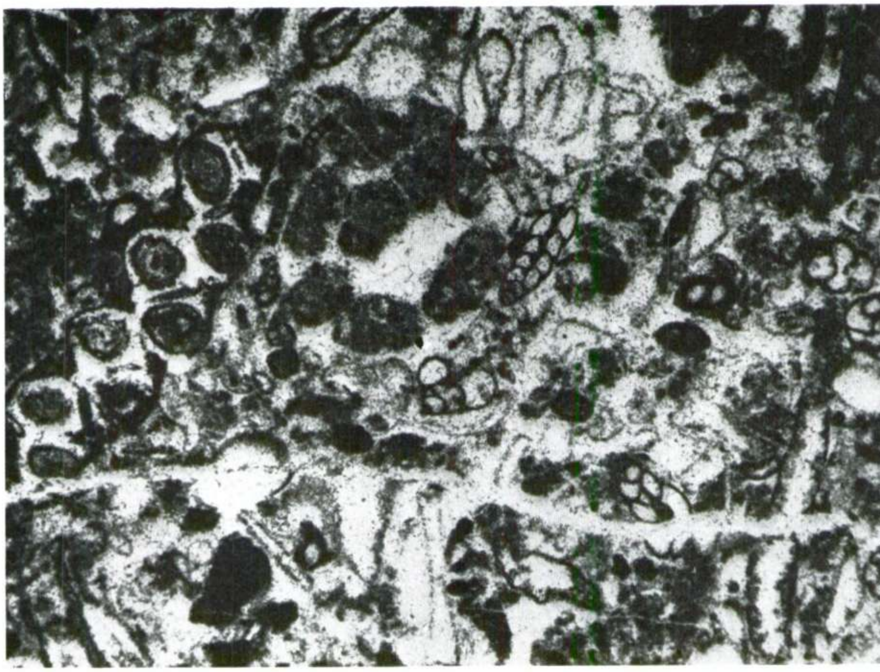
DOGGER SUPÉRIEUR

Fig. 2

Calcaire à Trochamminidés, Textularidés et Verneuilinidés (× 15). Pl. mince 561-61. Dans l'association: *Selliporella donzellii* Sartoni & Crescenti

Herzégovine du sud, Čovine-Vlaka

DOGGER SUPÉRIEUR



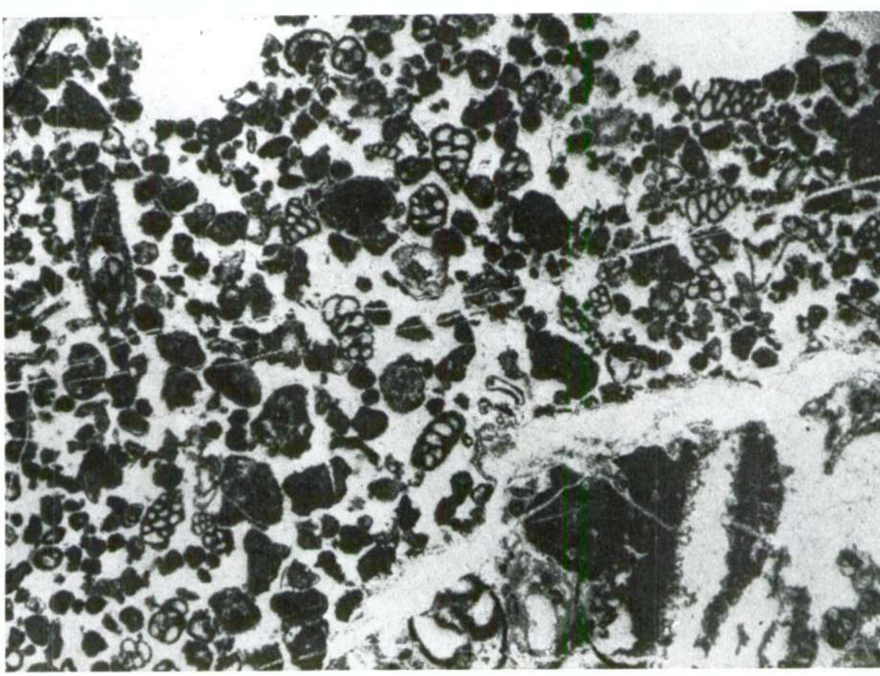


PLANCHE XCIX

Fig. 1 et 2

Calcaire subcristallin à ***Selliporella donzellii*** Sartoni & Crescenti et Foraminifères peu abondants (× 15). Pl. mince 388-63

Herzégovine du sud, entre Visočnik et Radovan ždrijelo

DOGGER SUPÉRIEUR

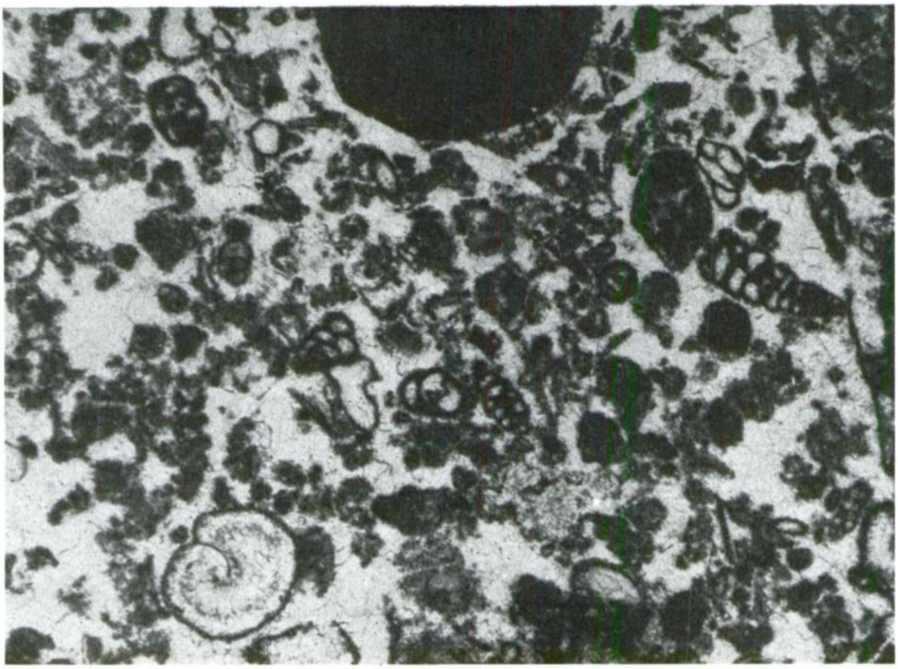
PLANCHE C

Fig. 1 et 2

Calcaire à Textularidés, Trochamminidés, Verneuilinidés, Microgastéropodes, *Aeolisaccus* sp., etc. (× 28). Pl. mince 437-61

Herzégovine du sud, au sud de Šćenica

DOGGER SUPÉRIEUR-MALM INFÉRIEUR



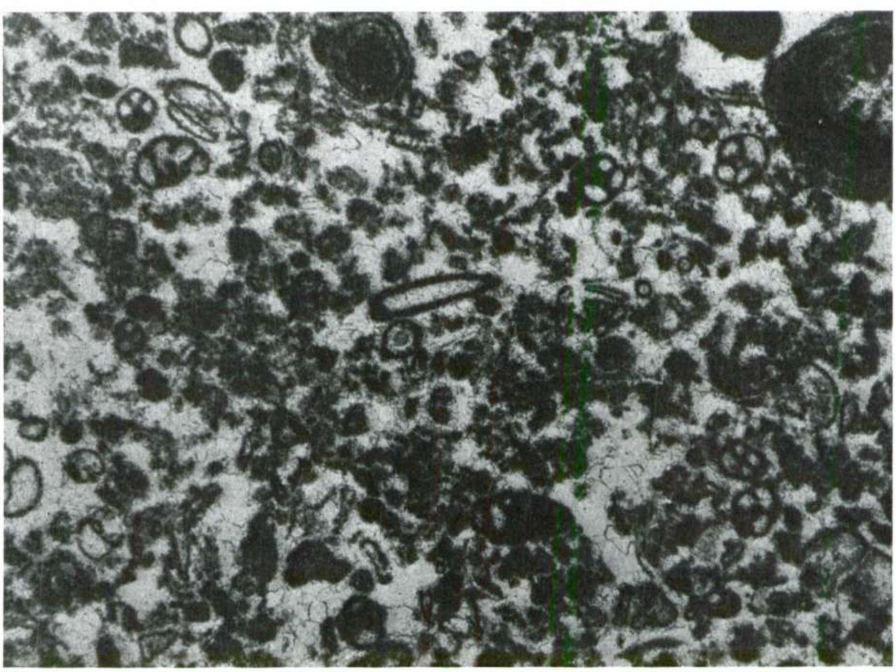


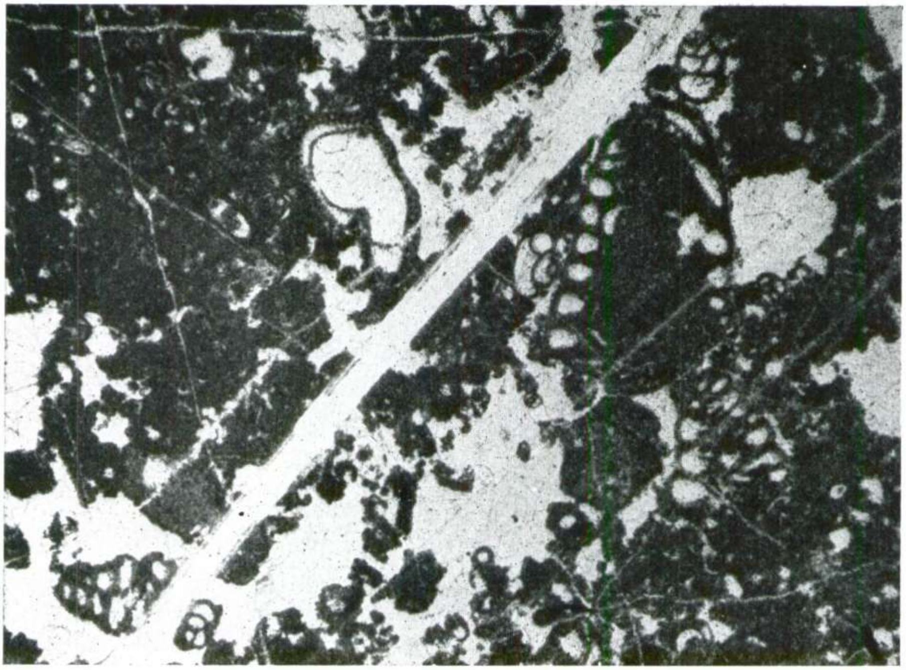
PLANCHE CI

Fig. 1 et 2

Calcaire grumeleux à Pfenderinidés et autres Foraminifères et *Thaumatoporella parvovesiculifera* (Rain.), (× 30). Pl. mince 1779-62

Herzégovine du sud, au nord de Plat

MALM INFÉRIEUR (couches les plus anciennes)



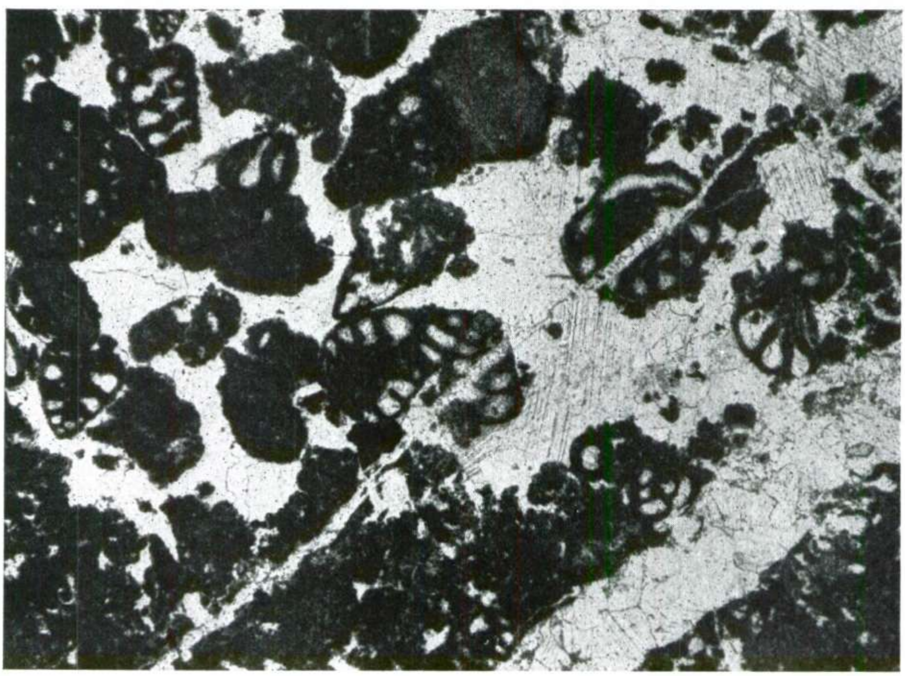


PLANCHE CII

Fig. 1 et 2

Calcaire grumeleux à *Pfenderina salernitana* Sartoni & Crescenti, rares Trochamminidés et Verneuilinidés et *Thaumatoporella parvovesiculifera* (Rain.). (× 32). Pl. minces 1779 a et 1779 b-62

Herzégovine du sud, entre Plat et Glavska

MALM INFÉRIEUR (couches les plus anciennes)

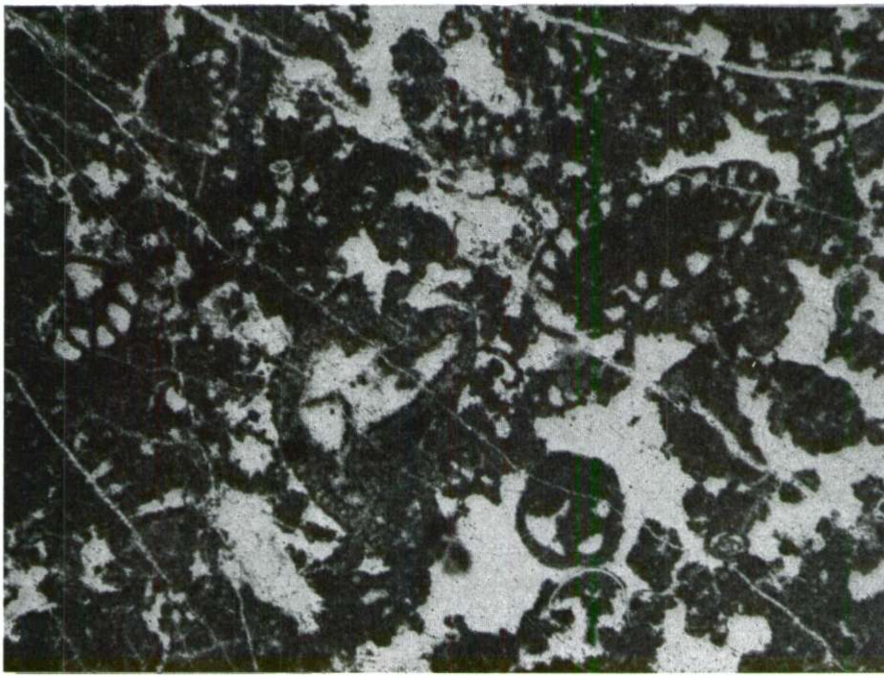


PLANCHE CIII

Fig. 1

Calcaire organogène-détritique, subcristallin, à *Clypeina* (?) sp. (× 28). Pl. mince 344-61. Dans l'association: Foraminifères, Microproblematica, Microgastéropodes

Herzégovine du sud, Uskoplje-Orah

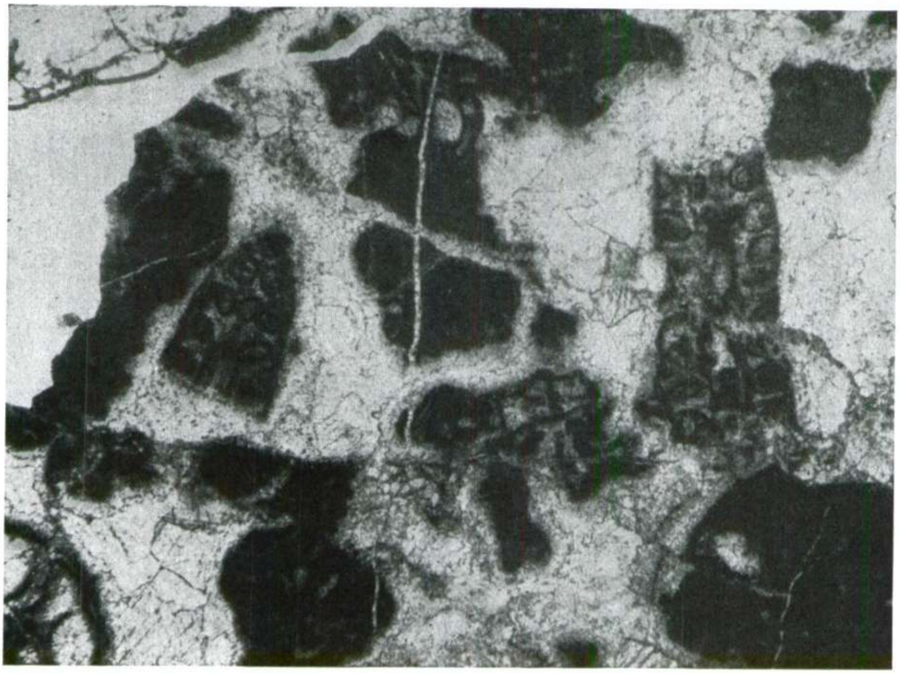
MALM (couches à *Cladocoropsis mirabilis*)

Fig. 2

Calcaire à «*Macroporella*» *sellii* Crescenti, *Thaumatoporella parvovesiculifera* (Rain.) etc. (× 28). Pl. mince 354-61. Dans l'association: Kurnubies, Lituolidés, *Labyrinthina*

Herzégovine du sud, Uskoplje-Orah

MALM (couches à *Cladocoropsis mirabilis*)



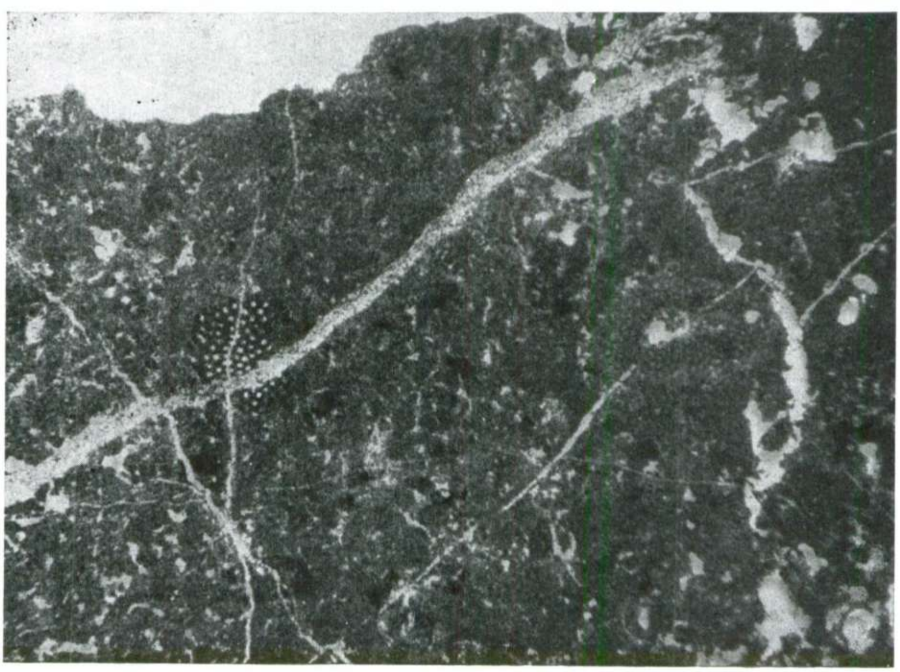


PLANCHE CIV

Fig. 1 et 2

Calcaire à *Bullopora* sp., Kurnubies, autres Foraminifères et Dasycladacées (fig. 1 — × 50, fig. 2 — × 28). Pl. minces 566 et 567-61

Herzégovine du sud, Čovine-Vlaka

MALM (couches à *Cladocoropsis mirabilis*)

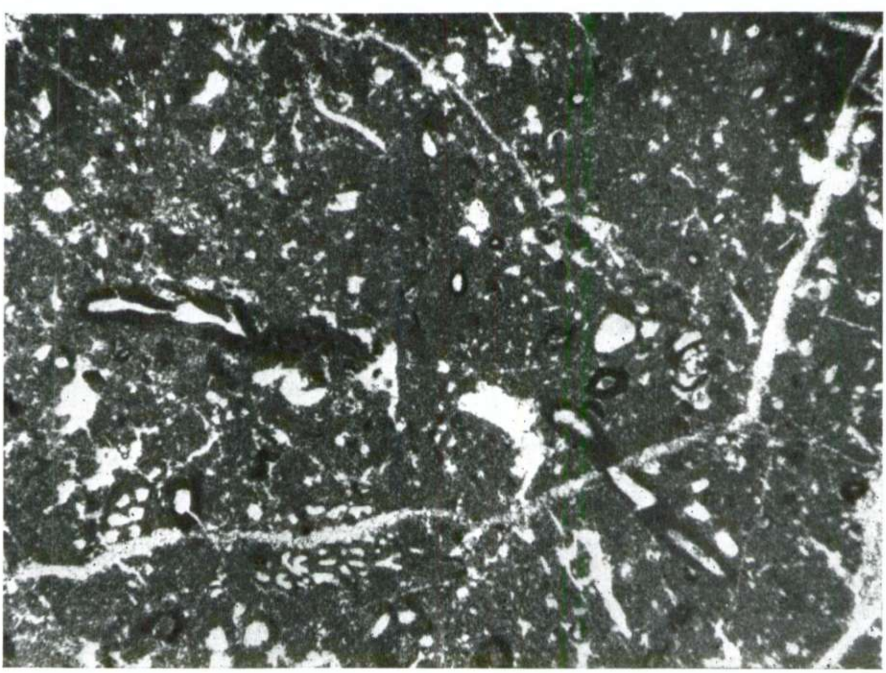


PLANCHE CV

Fig. 1

Calcaire à Foraminifères (× 28). Pl. mince 346-61. Dans l'association: rares *Kurnubia* et *Thaumatoporella*

Herzégovine du sud, Uskoplje-Orah

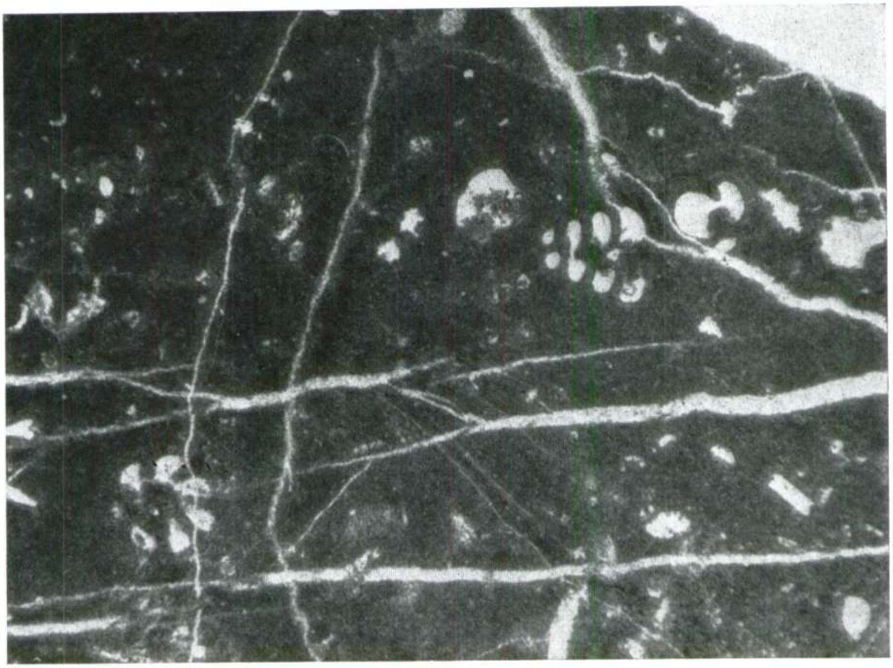
MALM (KIMMÉRIDGIEN)

Fig. 2

Calcaire à Cyanophytes (× 15). Pl. mince 348-61. Dans l'association: rares Ostracodes et Foraminifères

Herzégovine du sud, Uskoplje-Orah

MALM SUPÉRIEUR (couches à *Clypeina jurassica*)



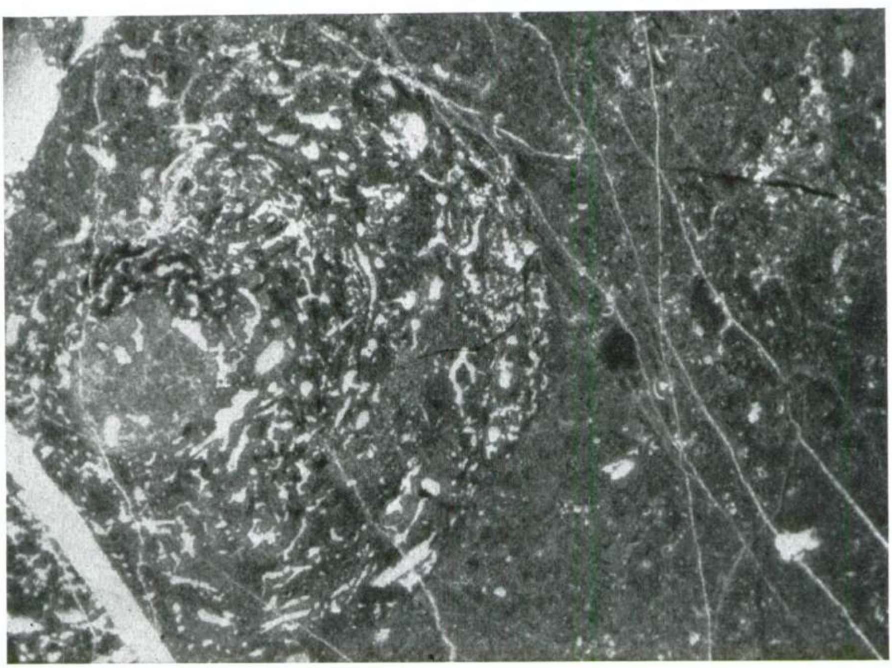


PLANCHE CVI

Fig. 1

Calcaire à *Kurnubia palastiniensis* Henson et *Pfenderina* sp. (× 28). Pl. mince 512-61. Dans l'association: *Thaumatoporella parvovesiculifera* (Rain.)

Herzégovine du sud, environs de Radovan ždrijelo

MALM SUPÉRIEUR

Fig. 2

Calcaire à Charophytes (× 28). Pl. mince 444-61

Herzégovine du sud, Šćenica

MALM SUPÉRIEUR (couches à *Clypeina jurassica*)

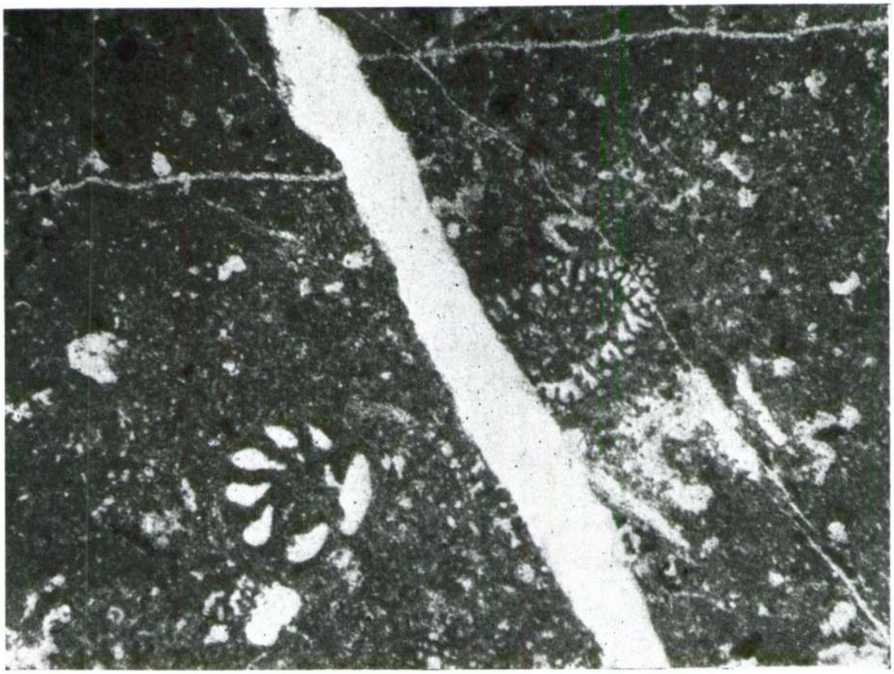


PLANCHE CVII

Fig. 1

Calcaire marneux à Ostracodes (× 28). Pl. mince 360-61
Herzégovine du sud, au sud d'Orah
MALM SUPÉRIEUR (PORTLANDIEN, couches à *Clypeina jurassica*)

Fig. 2

Calcaire dolomitique à *Clypeina jurassica* Favre (× 28). Pl. mince 349-61
Herzégovine du sud, au sud d'Orah
MALM SUPÉRIEUR (PORTLANDIEN)

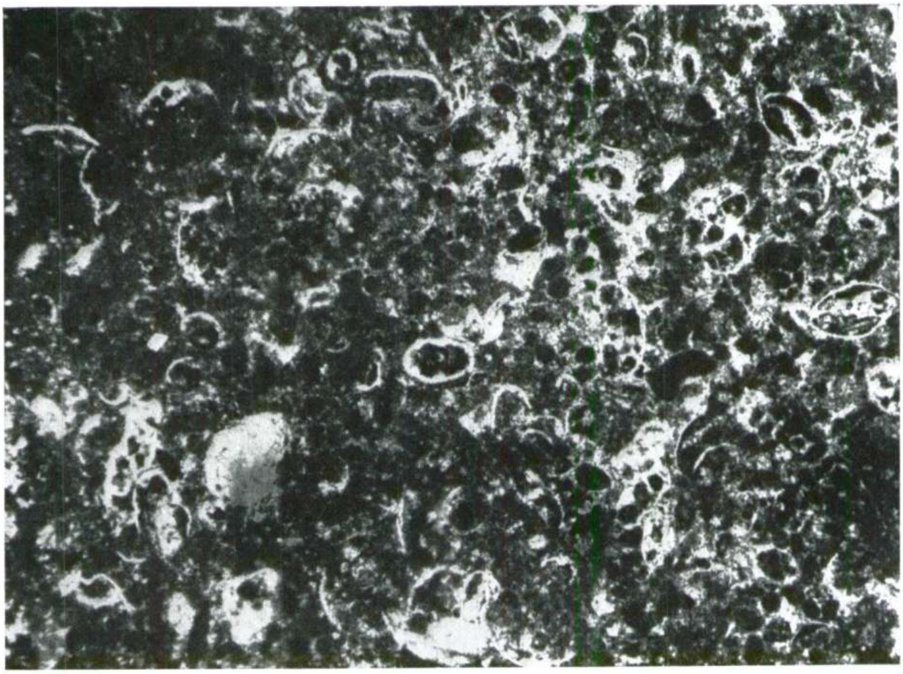


PLANCHE CVIII

Fig. 1

Calcaire organogène à *Clypeina jurassica* Favre, *Pianella gigantea* (Carozzi), Tintinnines aberrantes et Foraminifères peu abondants (× 28). Pl. mince 521-61
Herzégovine du sud, Radovan ždrijelo

INFRAVALANGINIEN

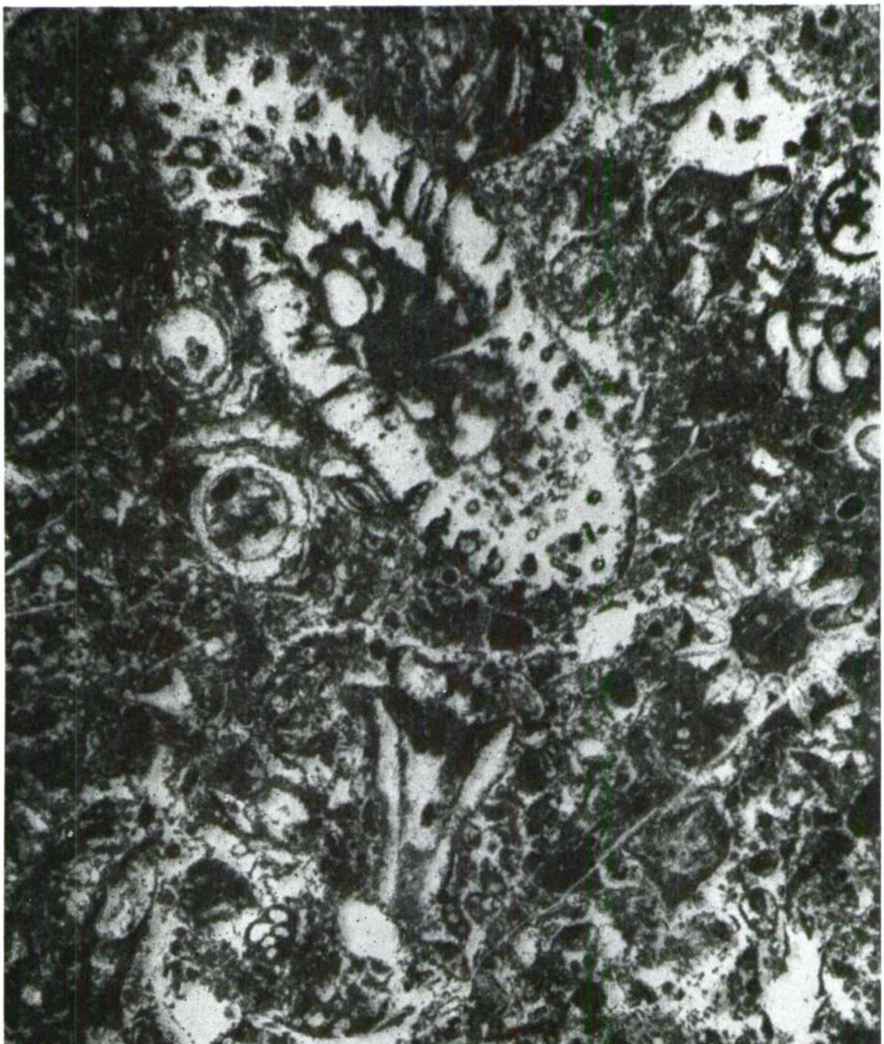
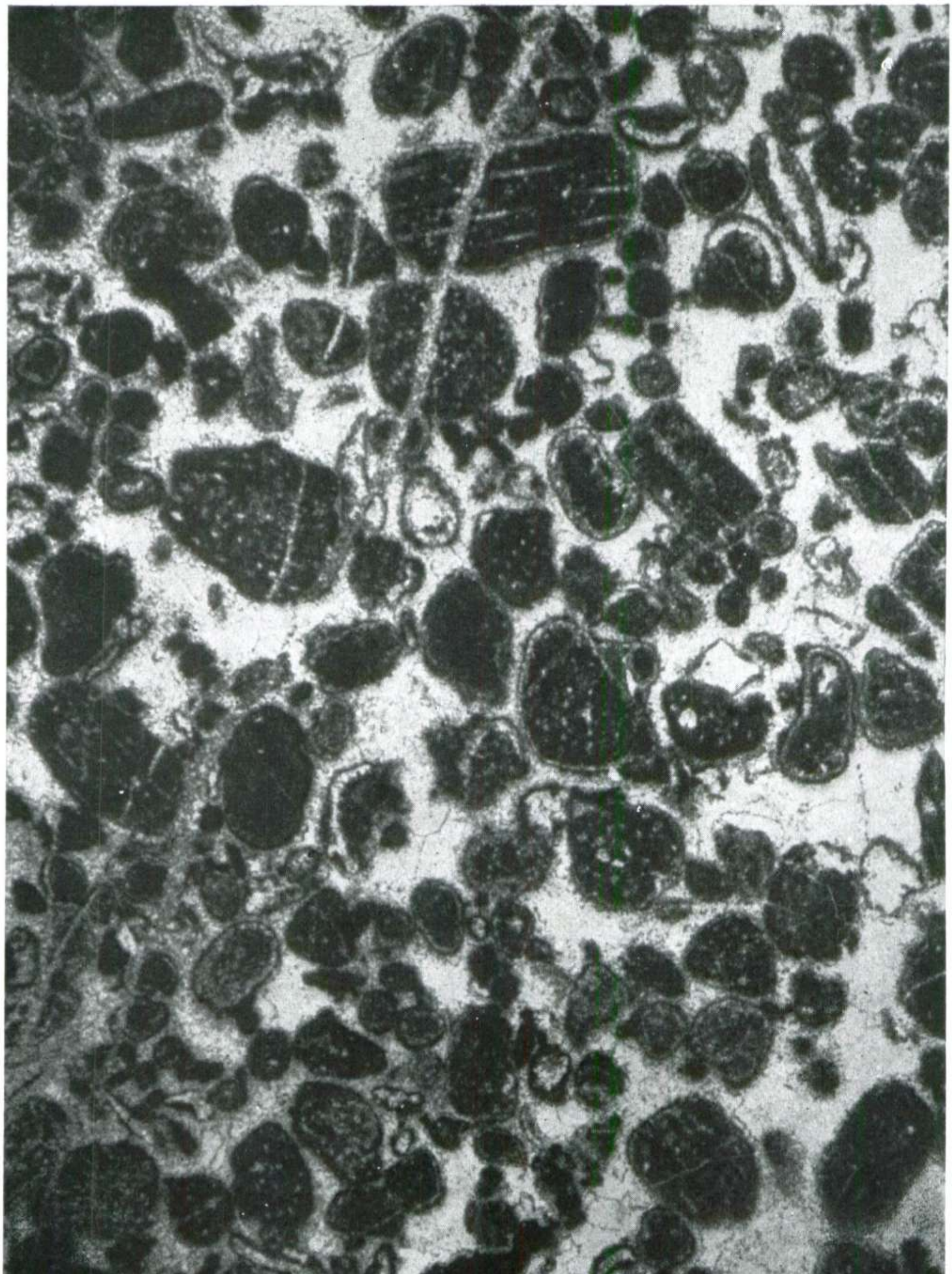


PLANCHE CIX

Fig. 1

Calcaire à Coprolithes — ***Favreina salevensis*** (Paréjas) (× 35). Pl. mince 362-61
Herzégovine du sud, Zaplanik
INFRAVALANGINIEN (couches à ***Clypeina jurassica*** et Tintinnines aberrantes)



LA SÉRIE JURASSIQUE DE LA RÉGION MOSOR—BIOKOVO—BAČINE

(Tableau № 8)

Planches: CX à CXXI

PLANCHE CX

Fig. 1

Calcaire à *Palaeodasycladus mediterraneus* Pia (× 18). Pl. mince 1000-61. Dans l'association: *Thaumatoporella parvovesiculifera* (Rain.) et Foraminifères peu nombreux

Montagne Biokovo, versants suds

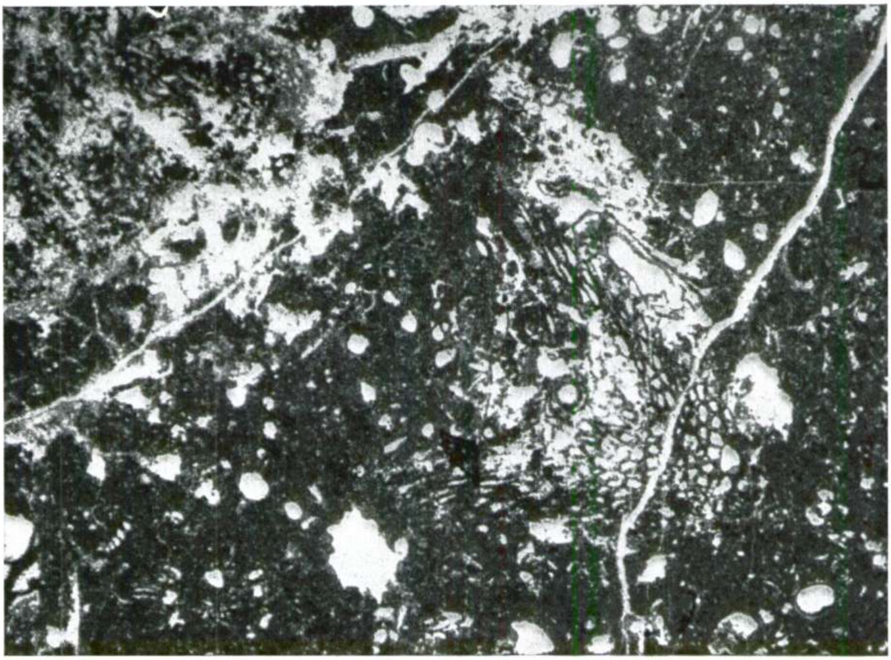
LIAS (partie moyenne de la série liasique)

Fig. 2

Calcaire à Thaumatoporella parvovesiculifera (Rain.), (× 27,5). Pl. mince 1001-61

Montagne Biokovo, versants suds

LIAS (partie moyenne de la série liasique)



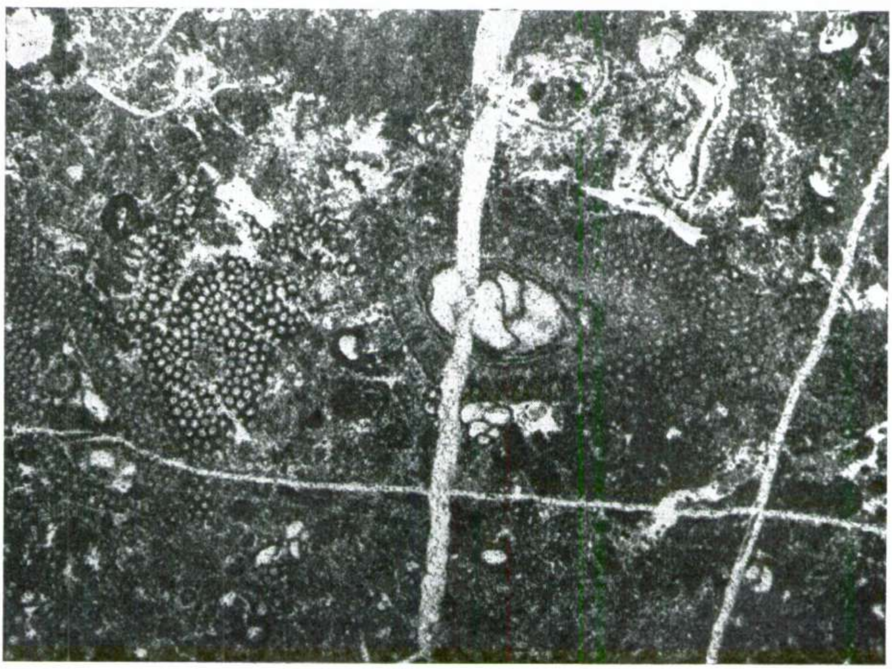


PLANCHE CXI

Fig. 1 et 2

Calcaire à *Orbitopsella* sp., *Glomospira* sp., Lituolidés, Trocholines et débris divers peu abondants (fig. 1 — × 27, fig. 2 — × 60). Pl. mince 1061-61. Dans l'association: rares Codiacées

Montagne Biokovo, versants suds

LIAS (partie moyenne de la série liasique)

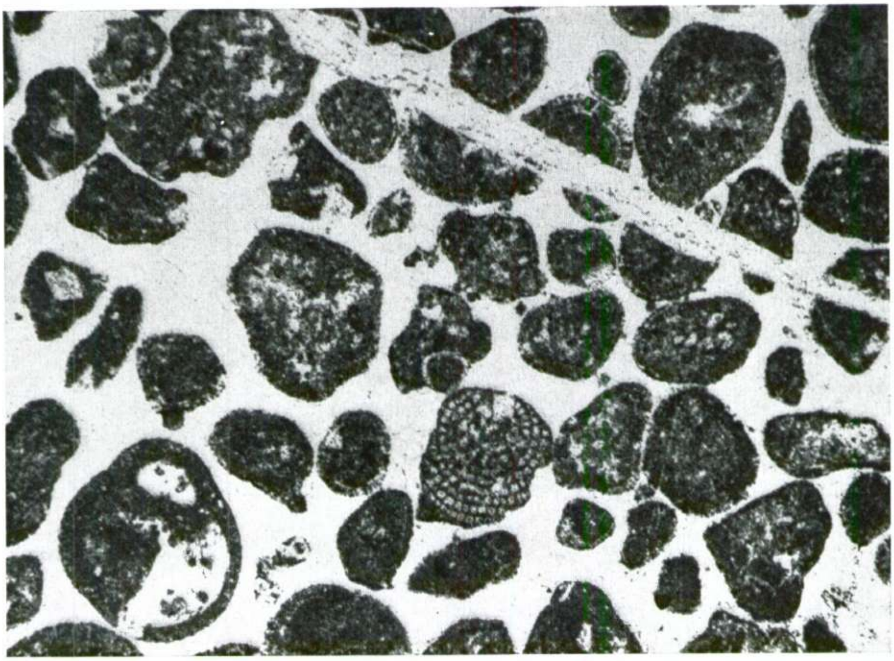
PLANCHE CXII

Fig. 1 et 2

Calcaire oolithique-détritique à *Dictyoconus cayeuxi* (Lucas), *Endothyra*, etc. (× 37). Pl. mince 1005 a-61

Montagne Biokovo, versants suds

DOGGER INFÉRIEUR



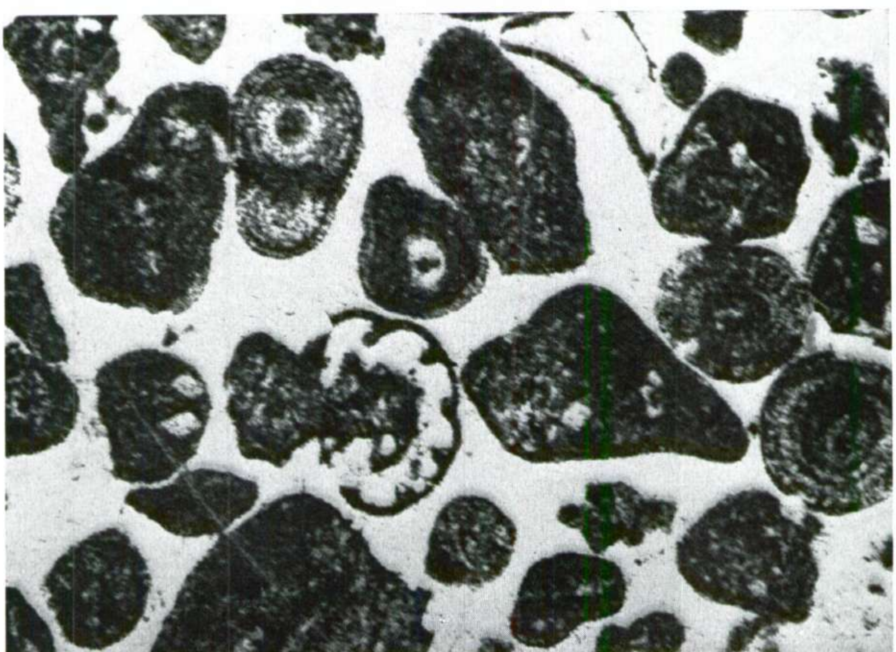


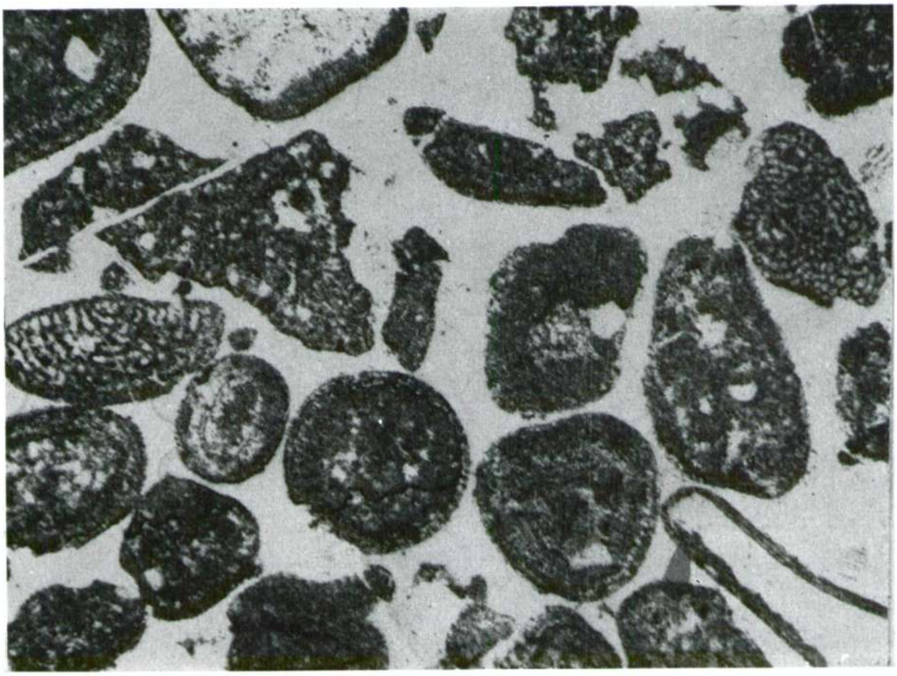
PLANCHE CXIII

Fig. 1 et 2

Calcaire oolithique-détritique à *Dictyoconus cayeuxi* (Lucas), (× 37). Pl. mince 1005 a-61

Montagne Biokovo, versants suds

DOGGER INFÉRIEUR



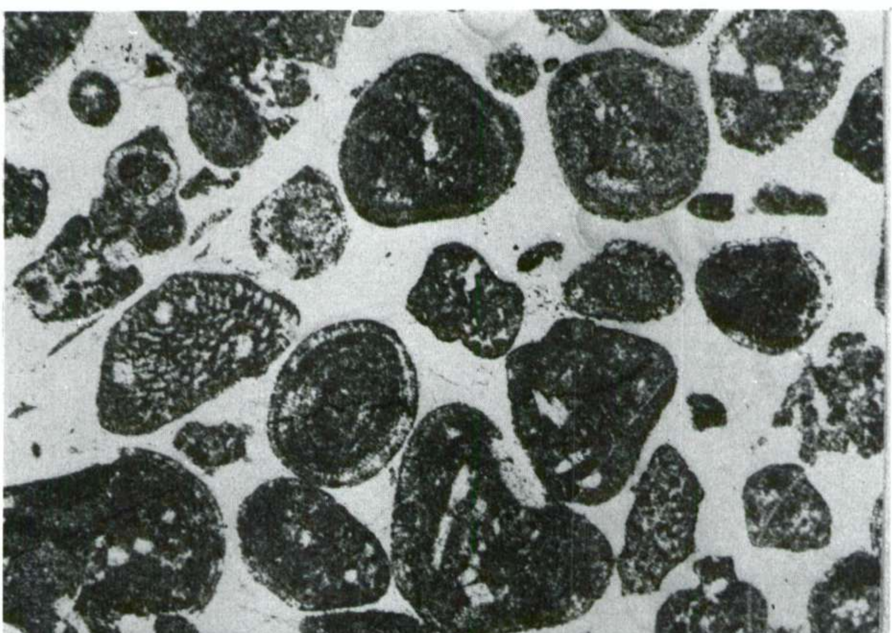


PLANCHE CXIV

Fig. 1

Calcaire oolithique-détritique à *Protopeneroplis striata* Weynschenk (× 65). Pl. mince 1012-61

Biokovo de l'ouest, environs de Zadvarje

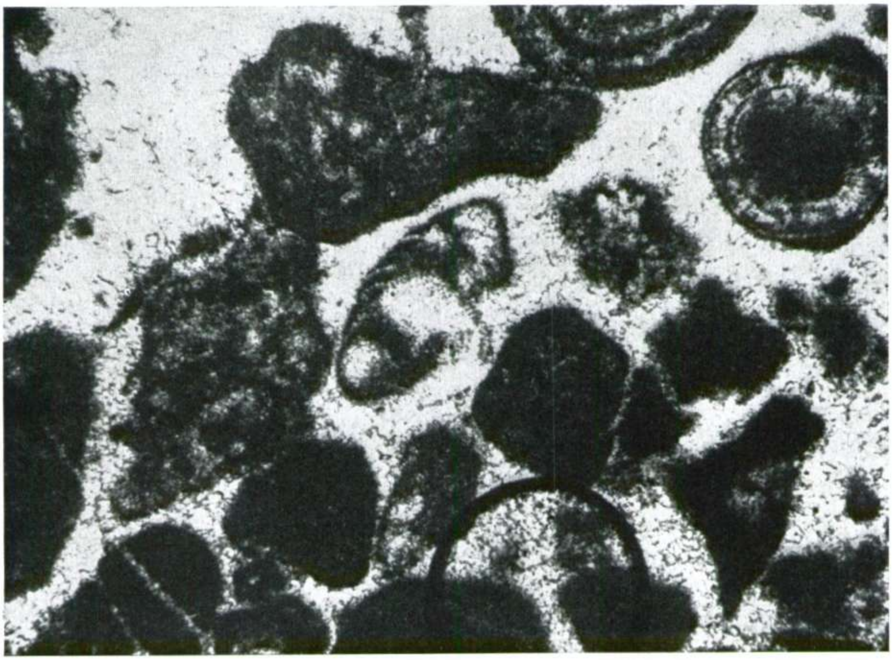
DOGGER SUPÉRIEUR

Fig. 2

Calcaire oolithique-détritique à Trocholines (× 65). Pl. mince 1013-61. Dans l'association: *Protopeneroplis striata* Weynschenk, petits Foraminifères, débris de Mollusques, d'Echinodermes et de Dasycladacées

Biokovo de l'ouest, environs de Zadvarje

DOGGER SUPÉRIEUR



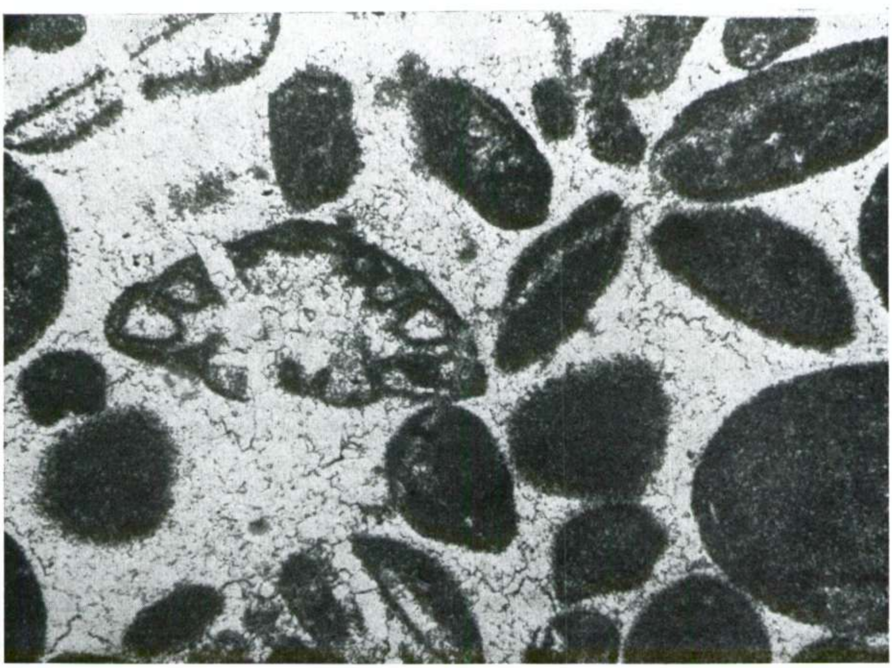


PLANCHE CXV

Fig. 1 et 2

Calcaire organogène-détritique, subcristallin, à *Selliporella donzellii* Sartoni & Crescenti et débris de Mollusques (× 17,5). Pl. mince 994-61

Montagne Biokovo, versants suds du S^{t} Ilija

DOGGER SUPÉRIEUR

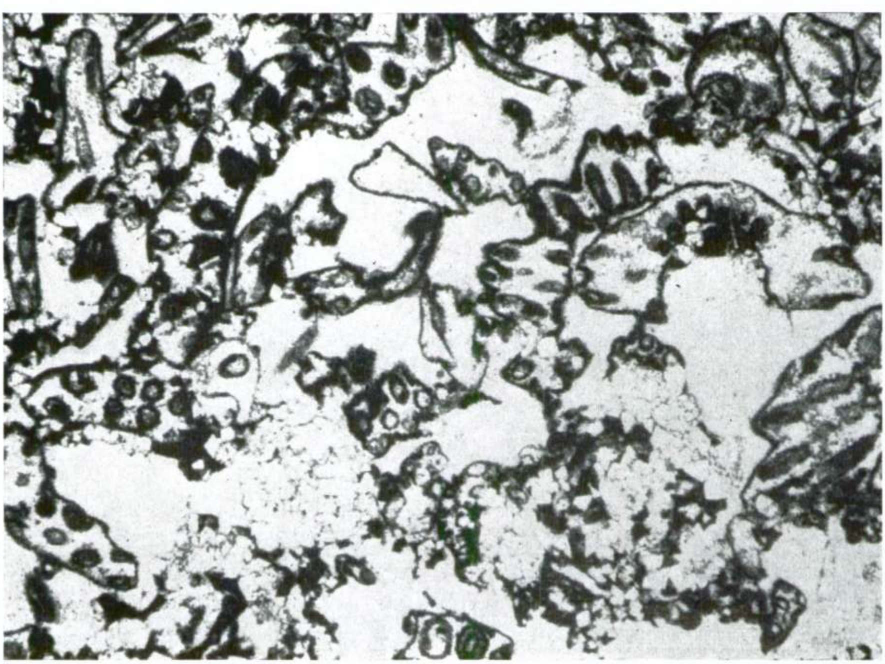


PLANCHE CXVI

Fig. 1

Calcaire grumeleux à Pfenderines, autres Foraminifères et débris divers peu abondants (× 27,5). Pl. mince 1071-61

Biokovo de l'ouest, Kolibret-Čikeš

MALM INFÉRIEUR (couches les plus anciennes)

Fig. 2

Calcaire légèrement marneux à *Pseudocyclammina lituus* (Yocoyama), (× 27,5). Pl. mince 1123-61. Dans l'association: *Thaumatoporella parvovesiculifera* (Rain.), *Cladocoropsis mirabilis* Felix et *Kurnubia*

Montagne Biokovo, Babinjača

MALM (OXFORDIEN-KIMMÉRIDGIEN)

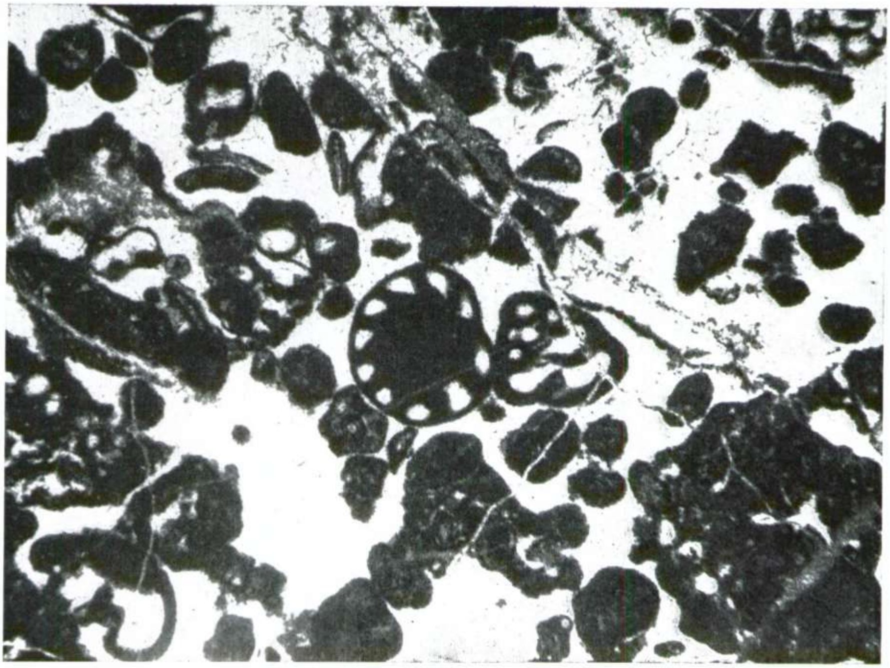


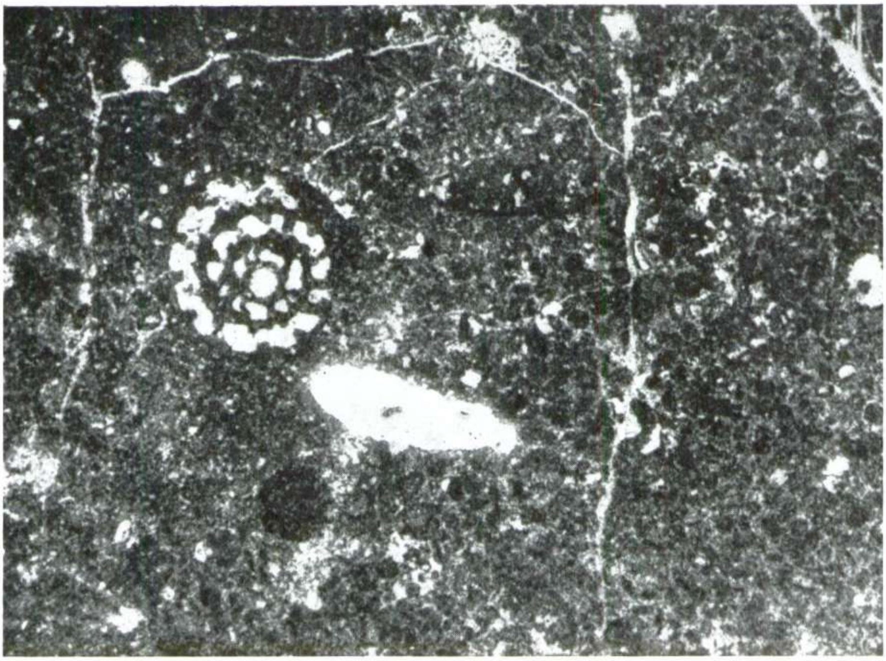
PLANCHE CXVII

Fig. 1 et 2

Calcaire à *Labyrinthina mirabilis* Weynschenk (× 27,5). Pl. mince 703-60. Dans l'association: *Conicospirillina*, *Pseudocyclammina* et autres Foraminifères

Montagne Mosor, sud-ouest de Ljubljen

MALM (KIMMÉRIDGIEN)



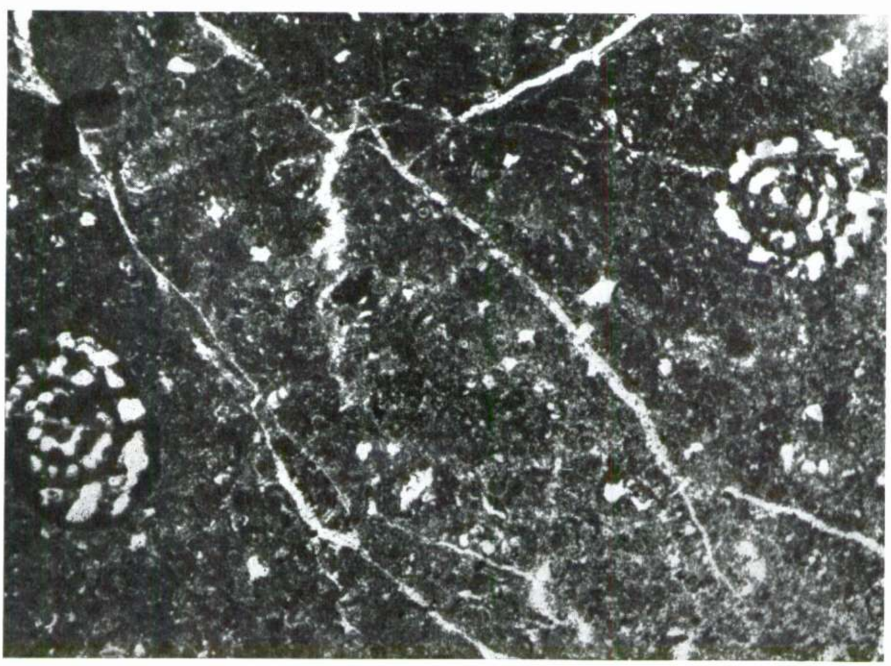


PLANCHE CXVIII

Fig. 1 et 2

Calcaire grumeleux à *Clypeina jurassica* Favre, *Pianella* cf. *gigantea* Carozzi et Foraminifères peu nombreux (× 27,5). Pl. mince 1126-60

Montagne Mosor, Ljubljen de l'ouest

MALM SUPÉRIEUR (PORTLANDIEN)

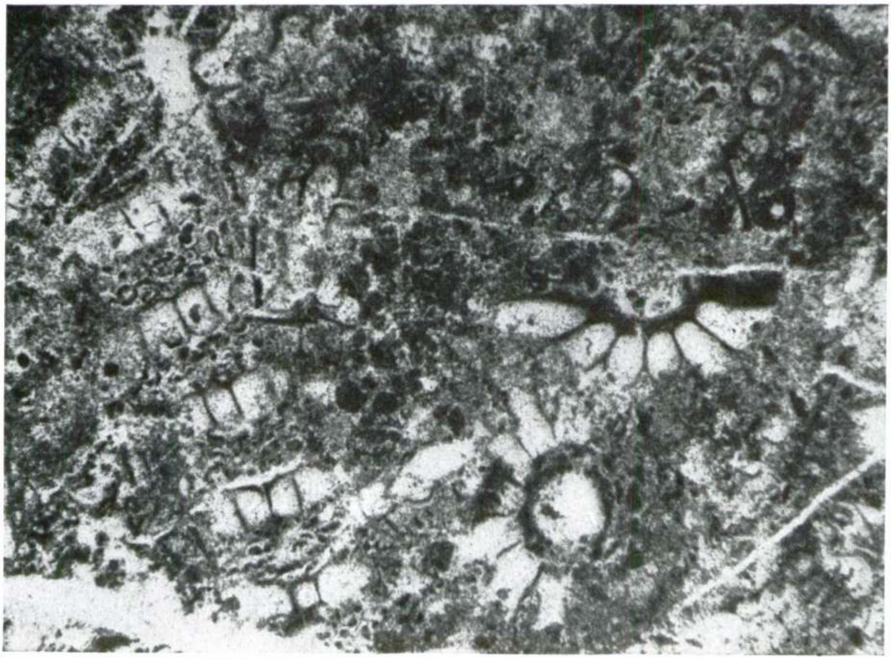


PLANCHE CXIX

Fig. 1

Calcaire grumeleux, en partie oolithique, à *Clypeina jurassica* Favre et Codiacées (× 27,5). Pl. mince 713-60

Montagne Mosor, versant sud-est

MALM SUPÉRIEUR (PORTLANDIEN)

Fig. 2

Calcaire cristallin à *Clypeina jurassica* Favre et Tintinnines aberrantes — *Campbelliella mileši* Radoičić et aut. (× 17,5). Pl. mince 2297-60

Environs du lac Bačinsko jezero

INFRAVALANGINIEN

PLANCHE CXX

Fig. 1

Calcaire grumeleux à Tintinnines aberrantes — *Campbelliella mileši* Radoičić (× 40). Pl. mince 1074-61. Dans l'association: *Salpingoporella annulata* Carozzi et petits Foraminifères peu nombreux

Biokovo de l'ouest, Kolibret-Čikeš

VALANGINIEN

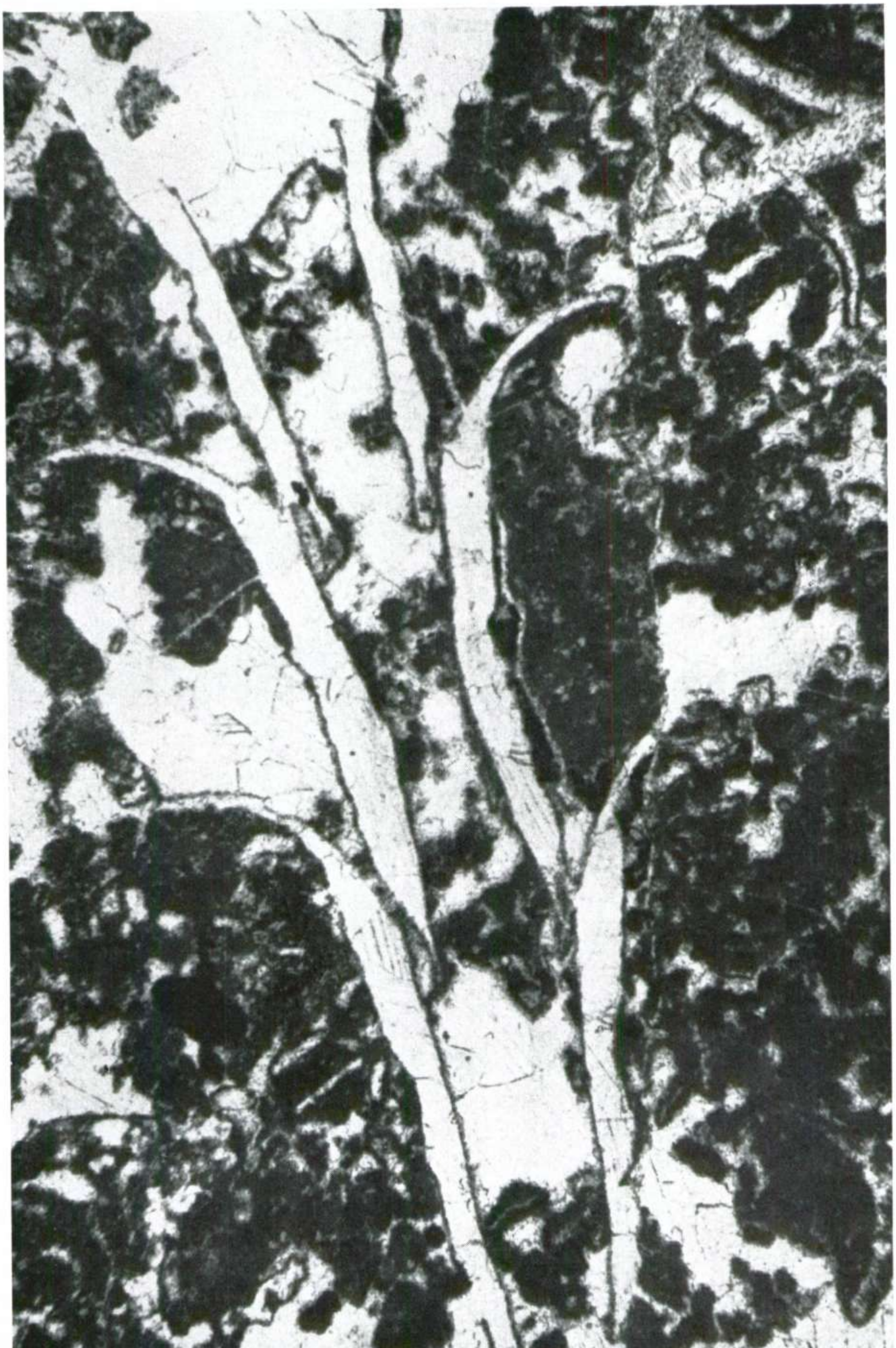


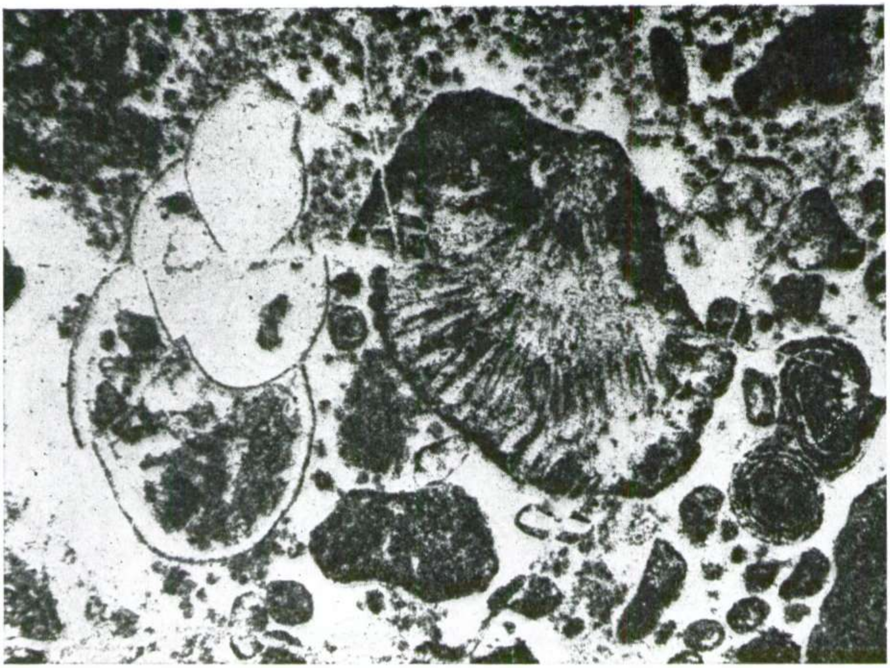
PLANCHE CXXI

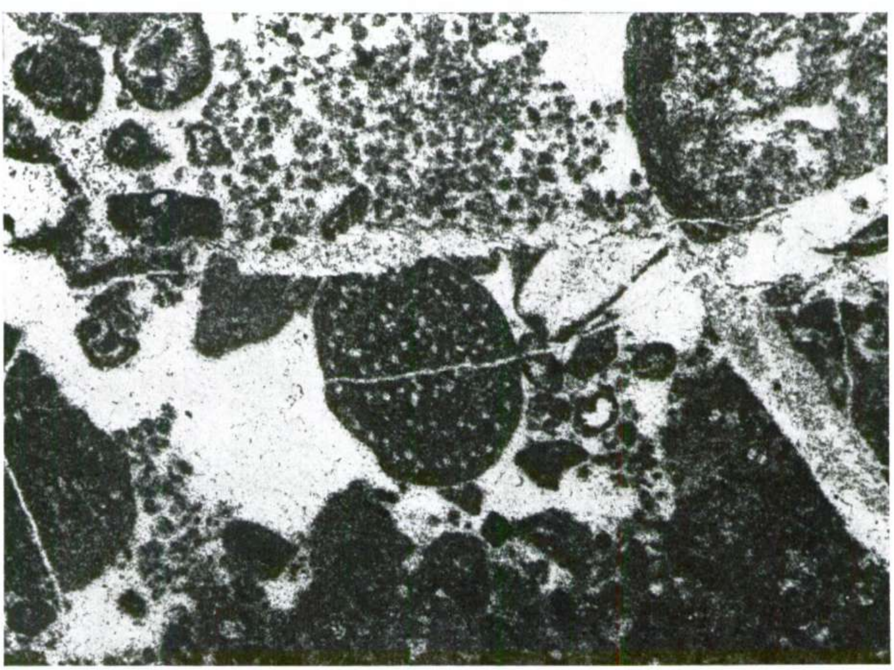
Fig. 1 et 2

Calcaire, en partie oolithique jusqu'à grumeleux, à *Favreina salevensis* (Paréjas), Codiacées, Microgastéropodes, etc. (× 50). Pl. mince 2298-60

Environs du lac Bačinsko jezero

VALANGINIEN





LA SÉRIE JURASSIQUE DE LEMEŠ ET DE SES ENVIRONS

(Tableau № 9)

Planches: CXXII à CXXXIII

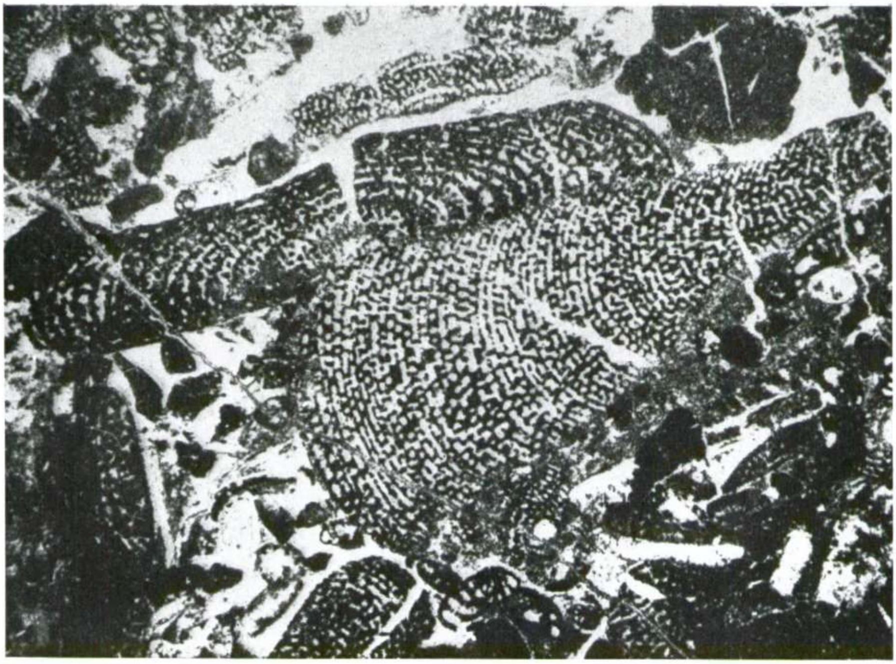
PLANCHE CXXII

Fig. 1 et 2

Calcaire à *Orbitopsella praecursor* (Gümbel), (× 17,5). Pl. mince 2420-60. Dans l'association: *Glomospira* sp. et autres Foraminifères

Lemeš, environs de Vinica

LIAS



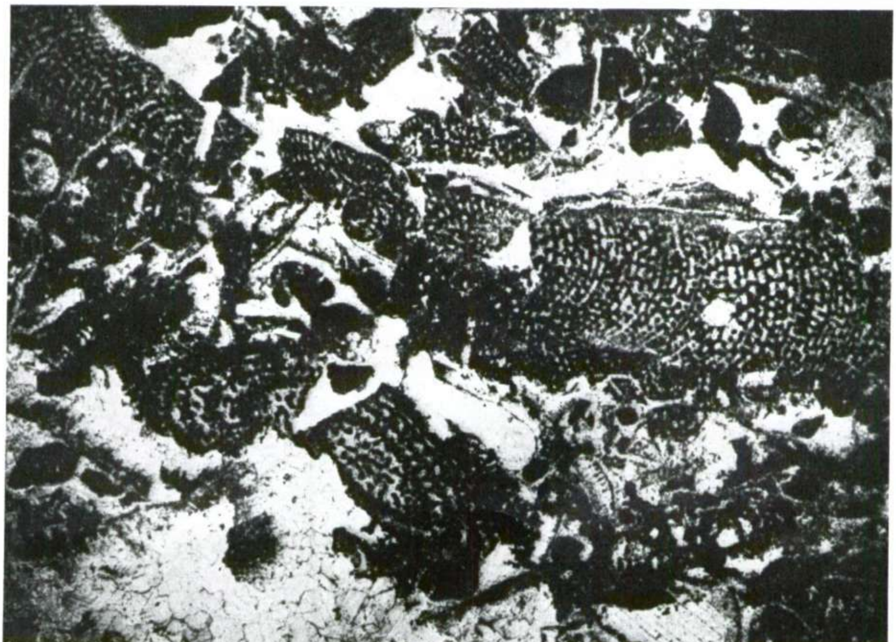


PLANCHE CXXIII

Fig. 1 et 2

Calcaire à Ostracodes et Foraminifères peu abondants (fig. 1 — × 20; fig. 2 — × 27,5). Pl. mince 2423-60

Lemeš, environs de Vinica

LIAS (couches à *Lithiotis*)

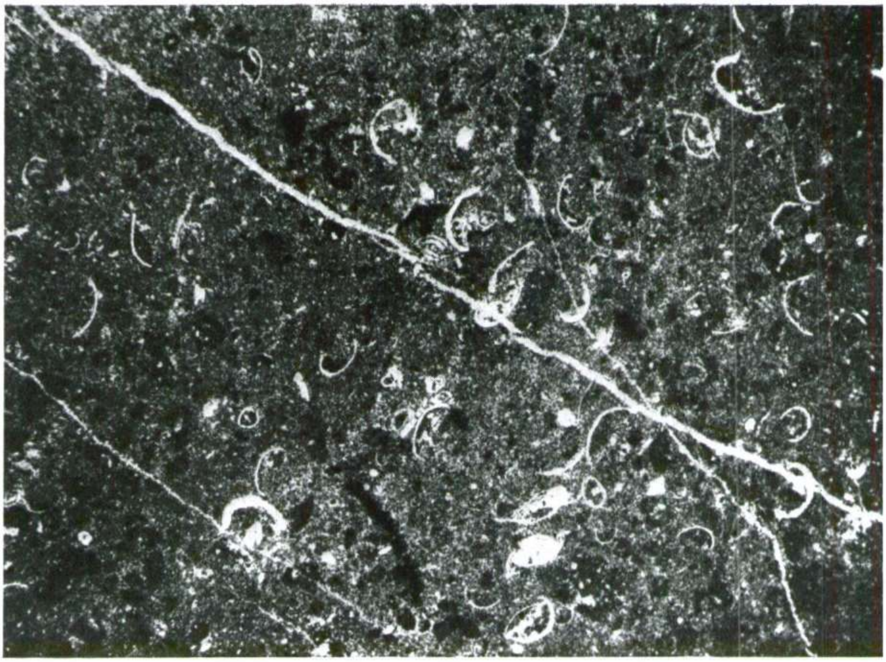


PLANCHE CXXIV

Fig. 1 et 2

Calcaire à Foraminifères (Lituolidés, *Glomospira* et autres), débris de Mollusques etc. (fig. 1 — × 30; fig. 2 — × 72). Pl. mince 2412. Dans l'association: ***Palaeodasycladus mediterraneus*** Pia.

Lemeš, environs de Vinica

LIAS (couches à *Lithiotis*)

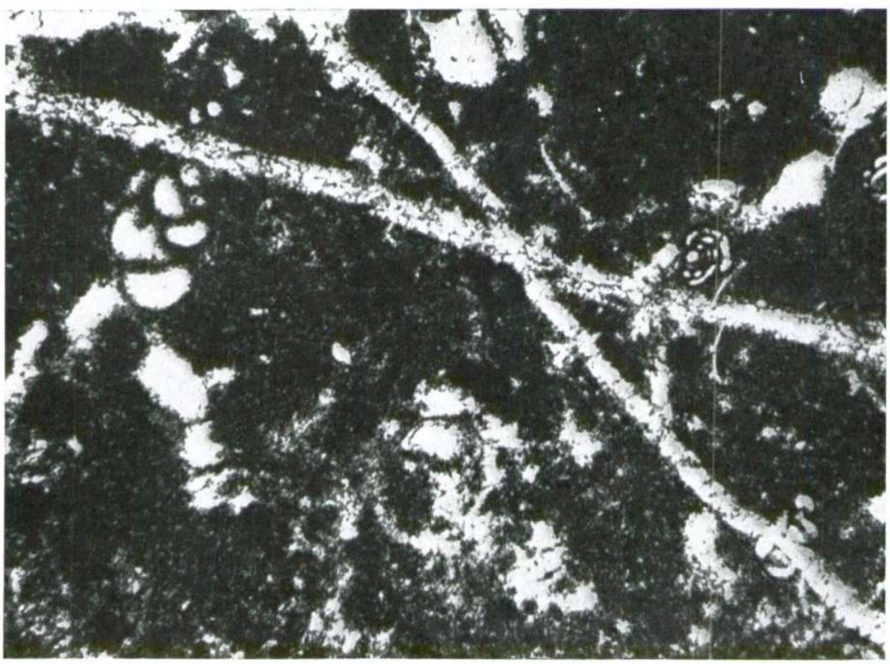


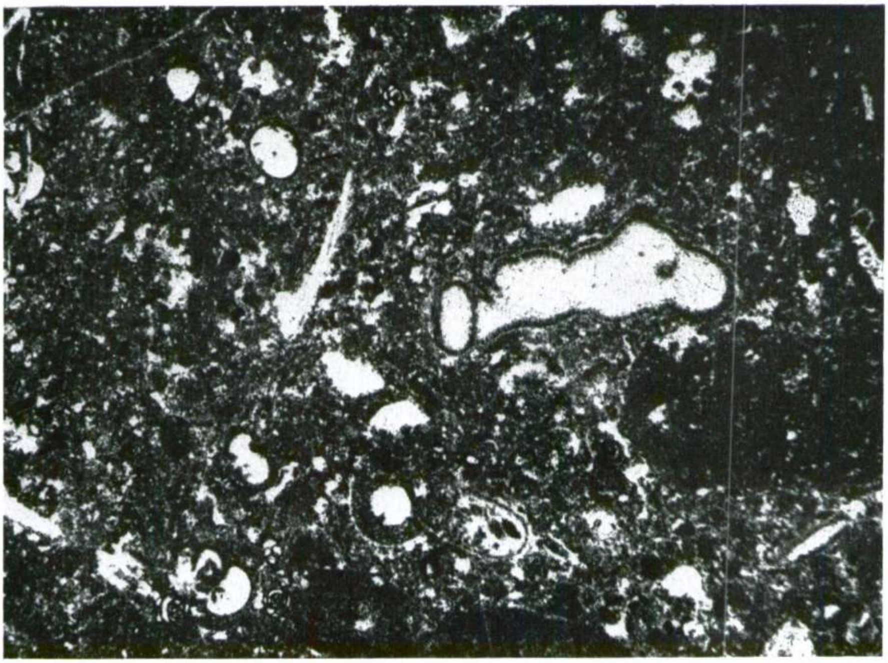
PLANCHE CXXV

Fig. 1 et 2

Calcaire à *Glomospira* sp., Trochamminidés, Verneuilinidés, autres Foraminifères et *Thaumatoporella parvovesiculifera* (Rain.)

Lemeš, environs de Vinica

LIAS MOYEN-SUPÉRIEUR



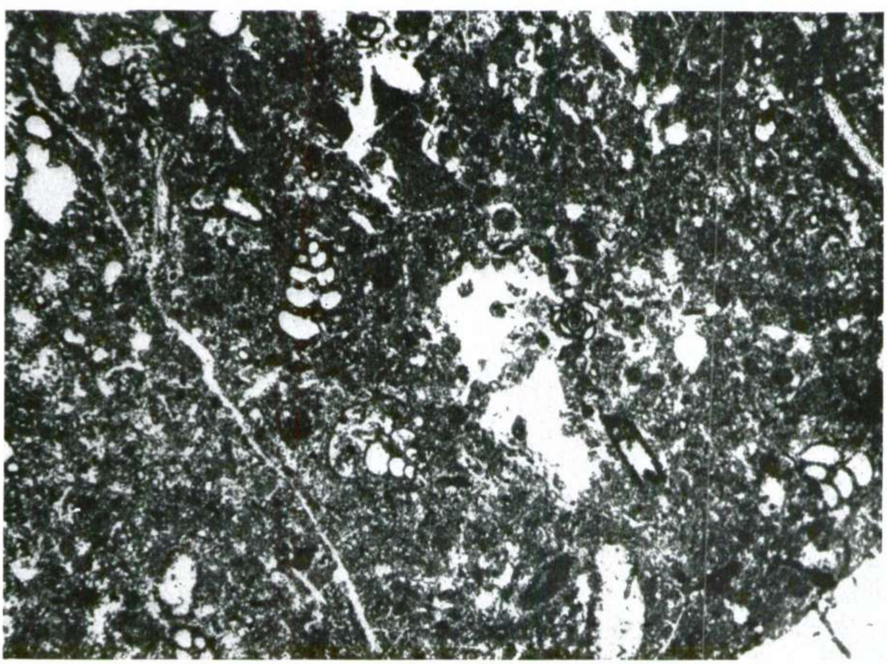


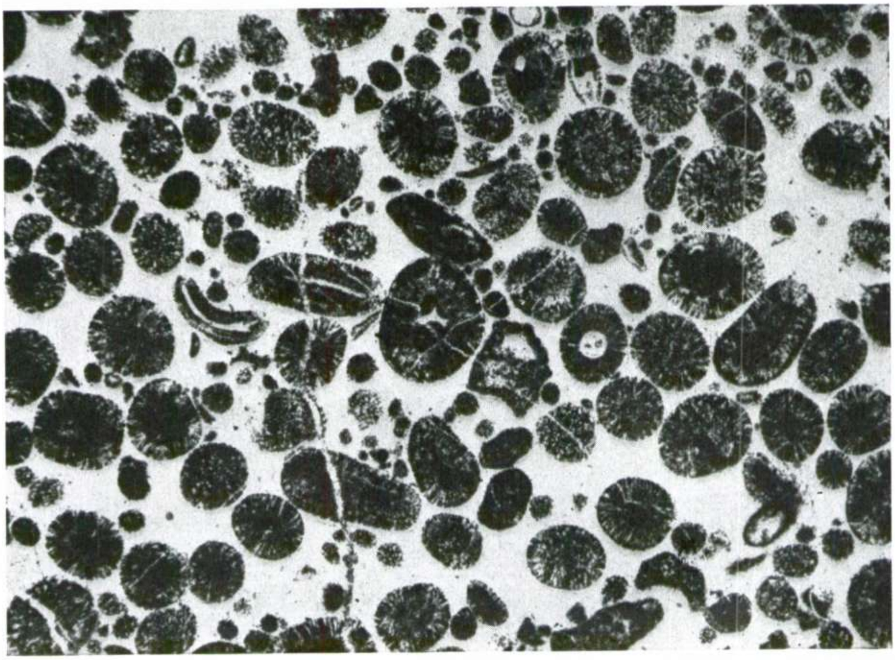
PLANCHE CXXVI

Fig. 1

Calcaire oolithique à rares débris organogène (× 27,5). Pl. mince 2416-60
Lemeš, environs de Vinica
LIAS MOYEN-SUPÉRIEUR

Fig. 2

Calcaire micro-oolithique à *Glomospira* sp., etc. (× 27,5). Pl. mince 2417-60
Lemeš, environs de Vinica
LIAS MOYEN-SUPÉRIEUR



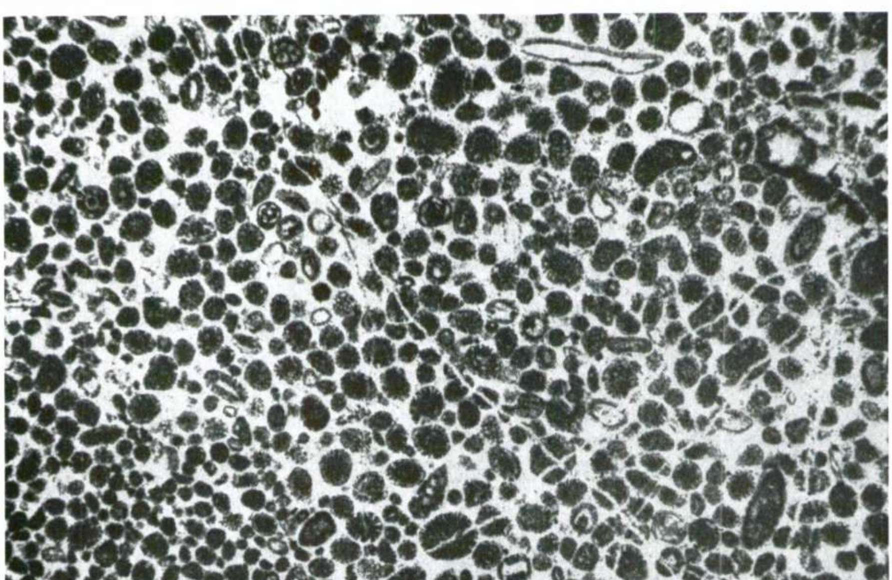


PLANCHE CXXVII

Fig. 1 et 2

Calcaire à Pfenderines (× 72). Pl. mince 2400-60. Dans l'association: *Thaumatoporella parvovesiculifera* (Rain.)

Lemeš, environs de Kuk

DOGGER SUPÉRIEUR-MALM INFÉRIEUR

PLANCHE CXXVIII

Fig. 1

Calcaire à *Thaumatoporella parvovesiculifera* (Rain.) et Foraminifères (Pfenderines et autres), (× 72). Pl. mince 2402-60

Lemeš, environs de Kuk

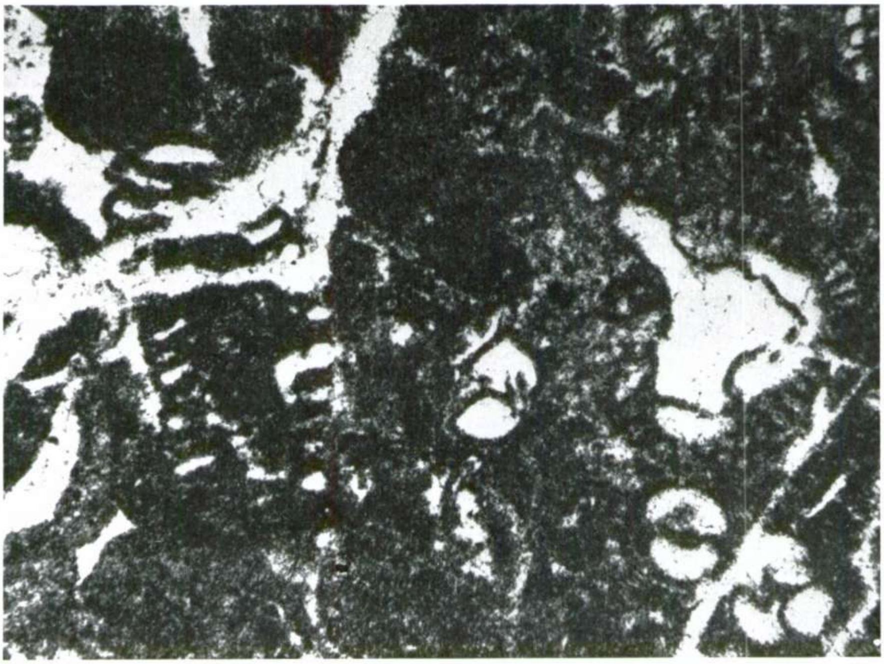
DOGGER SUPÉRIEUR-MALM INFÉRIEUR

Fig. 2

Calcaire subcristallin à rares Foraminifères (Miliolidés et autres) etc. (× 75). Pl. mince 2338-60

Lemeš

DOGGER SUPÉRIEUR (?)—MALM INFÉRIEUR



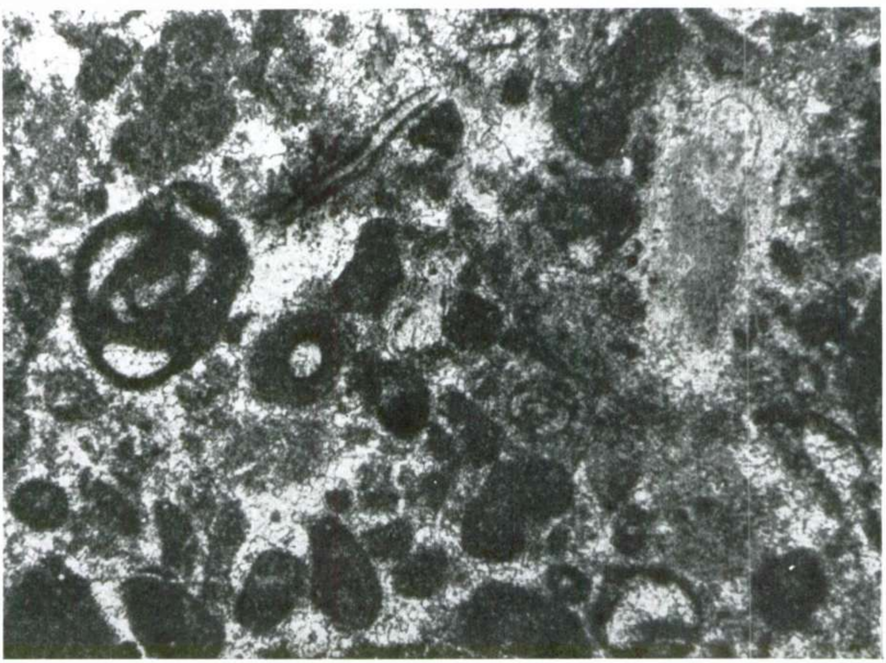


PLANCHE CXXIX

Fig. 1

Calcaire à Radiolaires (× 80). Pl. mince 2340-60

Lemeš

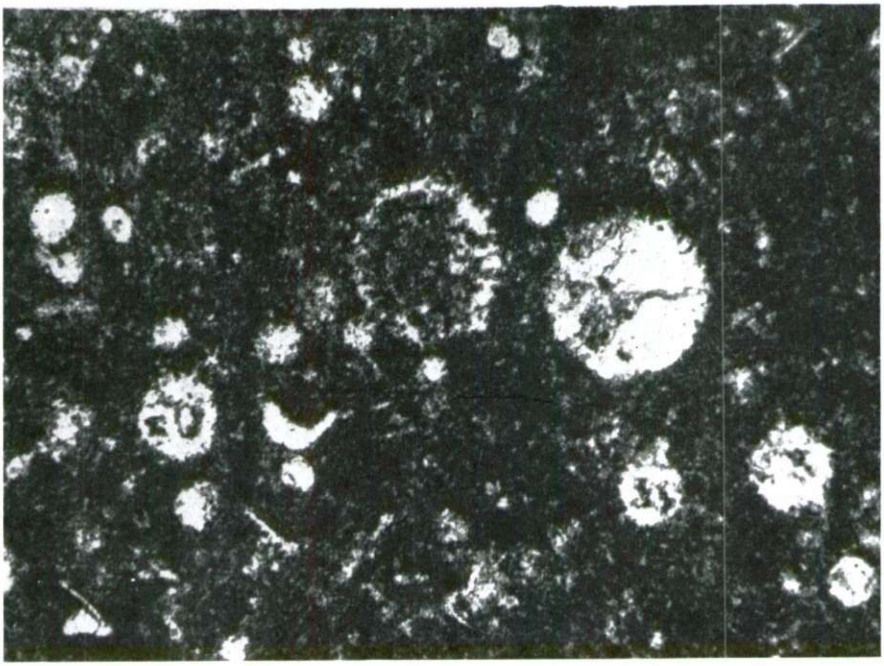
MALM INFÉRIEUR

Fig. 2

Calcaire à Globigérines peu abondantes (× 100). Pl. mince 2341-60. Dans l'association: Radiolaires et Lamellibranches pélagiques

Lemeš

MALM INFÉRIEUR



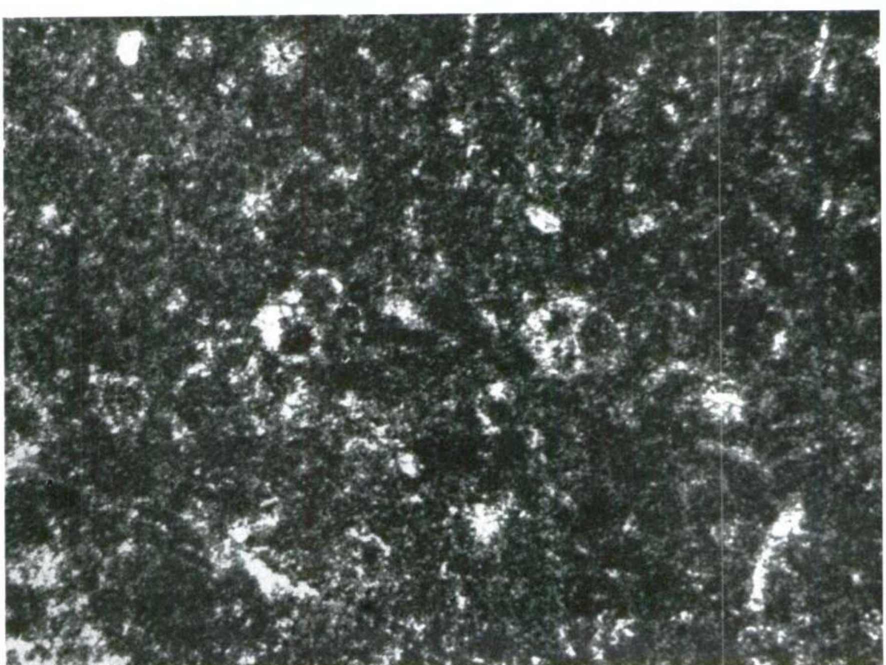


PLANCHE CXXX

Fig. 1 et 2

Calcaire à *Saccocoma* Agassiz (× 28). Pl. mince 2344-60
Lemeš

MALM (KIMMÉRIDGIEN — calcaire à nombreux Ammonites)

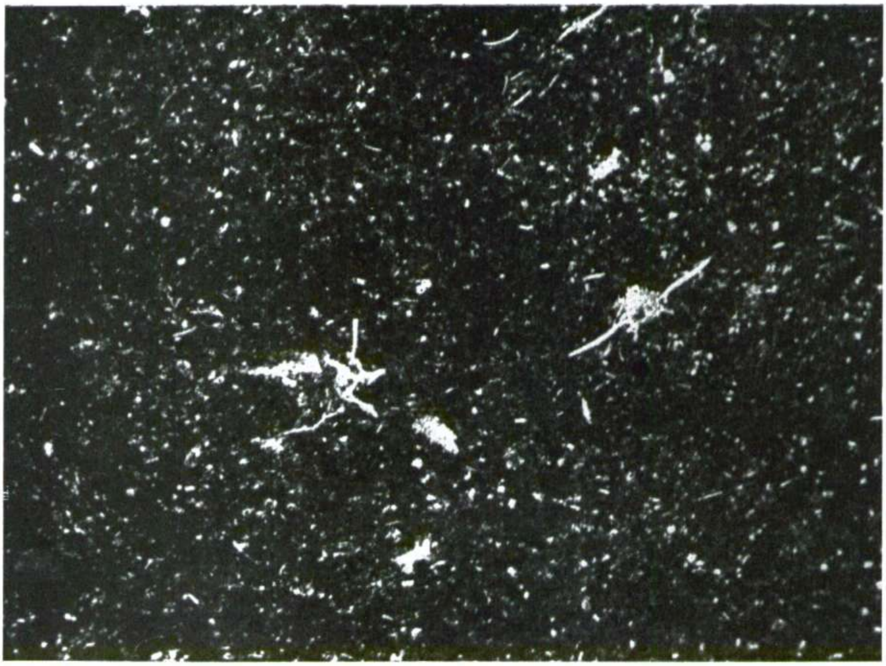


PLANCHE CXXXI

Fig. 1

Calcaire à *Saccocoma* Agassiz (× 28). Pl. mince **2346-60**. Dans l'association: *Globochaete alpina* Lombard.

Lemeš

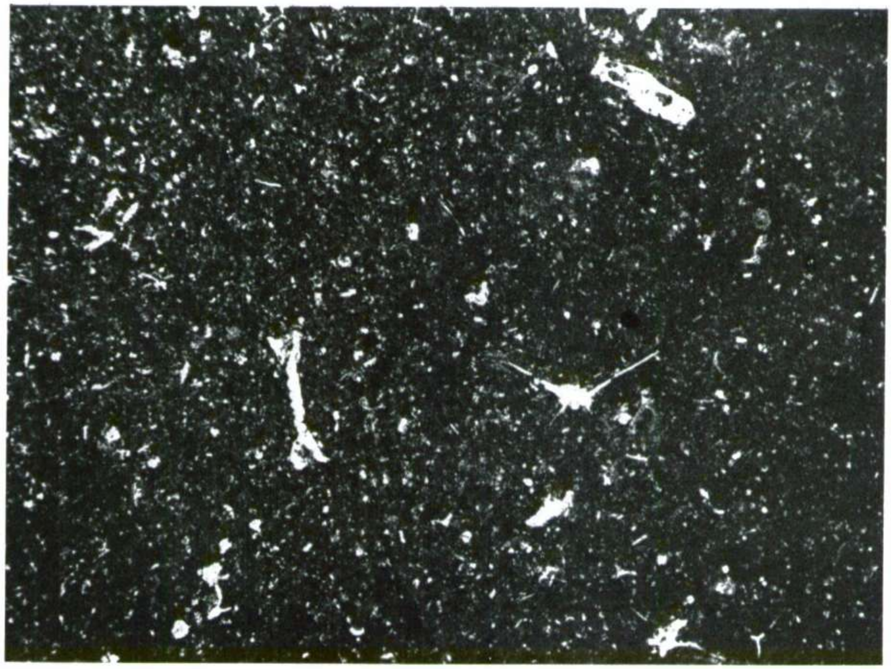
MALM (KIMMÉRIDGIEN)

Fig. 2

Calcaire à Radiolaires (× 28). Pl. mince **2350-60**

Lemeš

MALM (KIMMÉRIDGIEN)



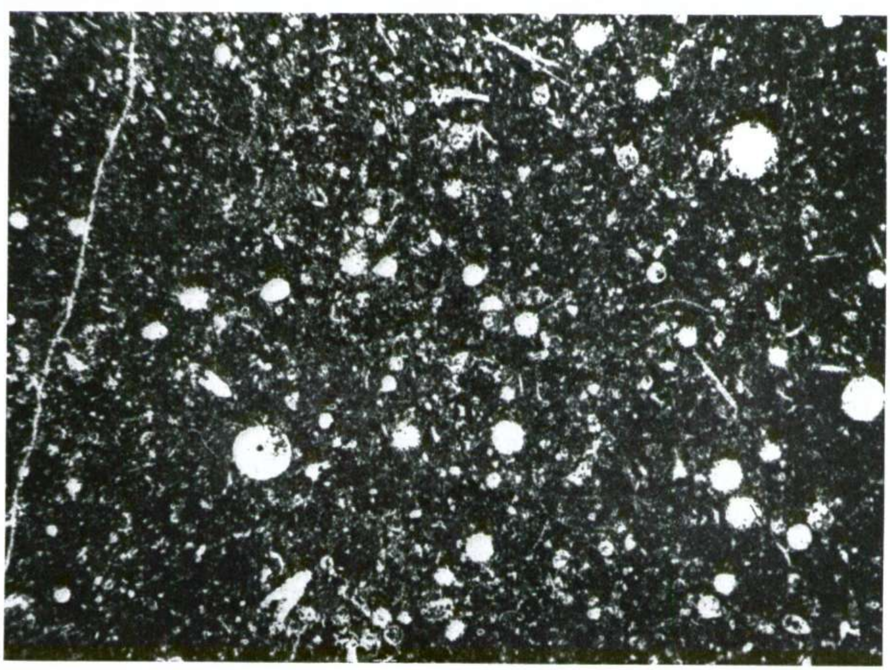


PLANCHE CXXXII

Fig. 1

Calcaire à *Conicospirillina* cf. *basiliensis* Möhler (× 72). Pl. mince 2365-60
Lemeš, au nord d'Orlovača
MALM SUPÉRIEUR (PORTLANDIEN)

Fig. 2

Calcaire à Aptychus, petits Cyanophytes etc. (× 17). Pl. mince 2367-60
Environs de Lemeš, au nord d'Orlovača
MALM SUPÉRIEUR (PORTLANDIEN)

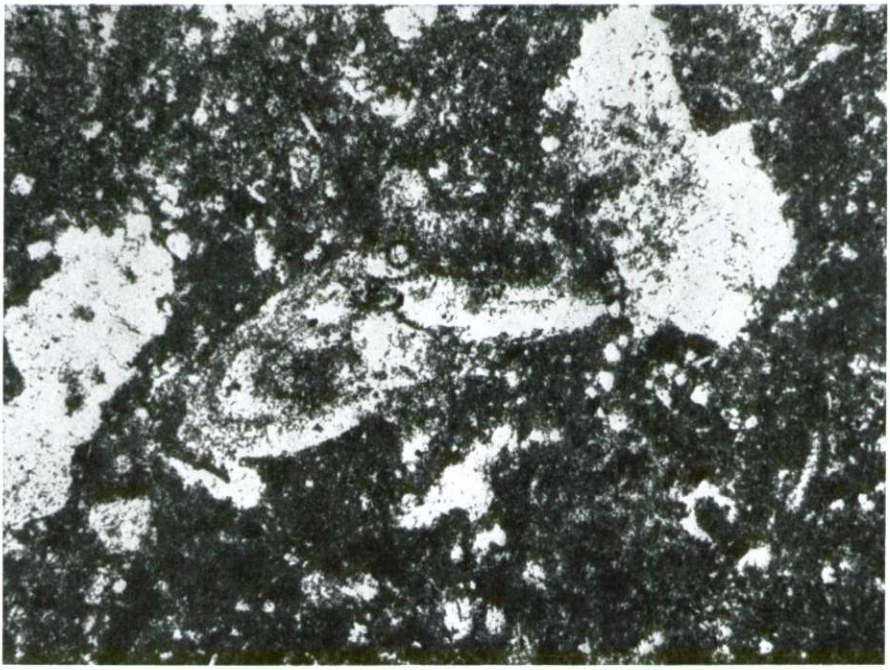


PLANCHE CXXXIII

Fig. 1

Calcaire organogène-détritique à Codiacées (× 27,5). Pl. mince 2368-60. Dans l'association: *Teutloporella* cf. *obsoleta* Carozzi

Environs de Lemeš, au nord d'Orlovača

MALM SUPÉRIEUR (PORTLANDIEN)

Fig. 2

Calcaire à *Salpingoporella annulata* Carozzi (× 27). Pl. mince 2375-60. Dans l'association: Foraminifères peu abondants

Environs de Lemeš, Orlovača

NÉOCOMIEN

LA SÉRIE JURASSIQUE DES ENVIRONS DE ROVINJ

(Tableau № 10)

Planches: CXXXIV à CXLI

PLANCHE CXXXIV

Fig. 1

Calcaire à Pfenderinidés (× 27,5). Pl. mince 1837-60. Dans l'association: petits Foraminifères peu abondants et *Thaumatoporella parvovesiculifera* (Rain.)
Environs de Rovinj, S^{t} Eufimija-Križ-Figarola
MALM INFÉRIEUR (ou DOGGER-MALM)

Fig. 2

Calcaire à Pfenderinidés et autres rares Foraminifères (× 70). Pl. mince 1840-60
Environs de Rovinj, S^{t} Eufimija-Križ-Figarola
MALM INFÉRIEUR (ou DOGGER-MALM)

PLANCHE CXXXV

Fig. 1 et 2

Calcaire organogène à ***Bačinella irregularis*** Rad. et nombreuses Trocholines (× 30). Pl. mince 1865-60. Dans l'association: autres rares Foraminifères et *Thaumatoporella parvovesiculifera* (Rain.)

Environs de Rovinj, Figarola

MALM SUPÉRIEUR (KIMMÉRIDGIEN, probablement SUPÉRIEUR)

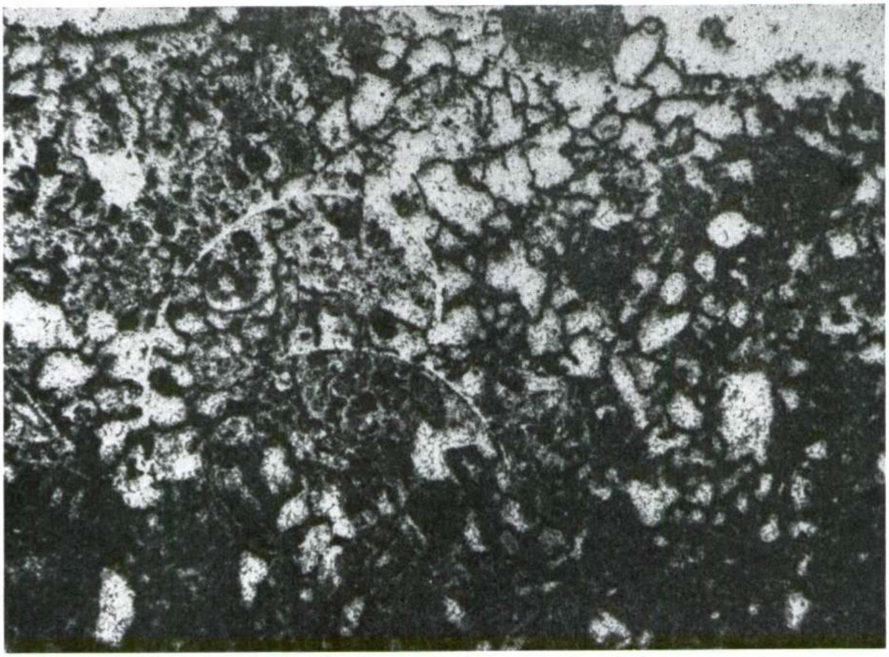


PLANCHE CXXXVI

Fig. 1

Calcaire à Trocholines et autres Foraminifères (× 30). Pl. mince 1866-60
Rovinj, Figarola
MALM SUPÉRIEUR (probablement KIMMÉRIDGIEN SUPÉRIEUR)

Fig. 2

Calcaire à *Aeolisaccus* sp., Ostracodes et Foraminifères peu nombreux (× 30).
Pl. mince 1873-60
Rovinj
MALM SUPÉRIEUR (PORTLANDIEN)

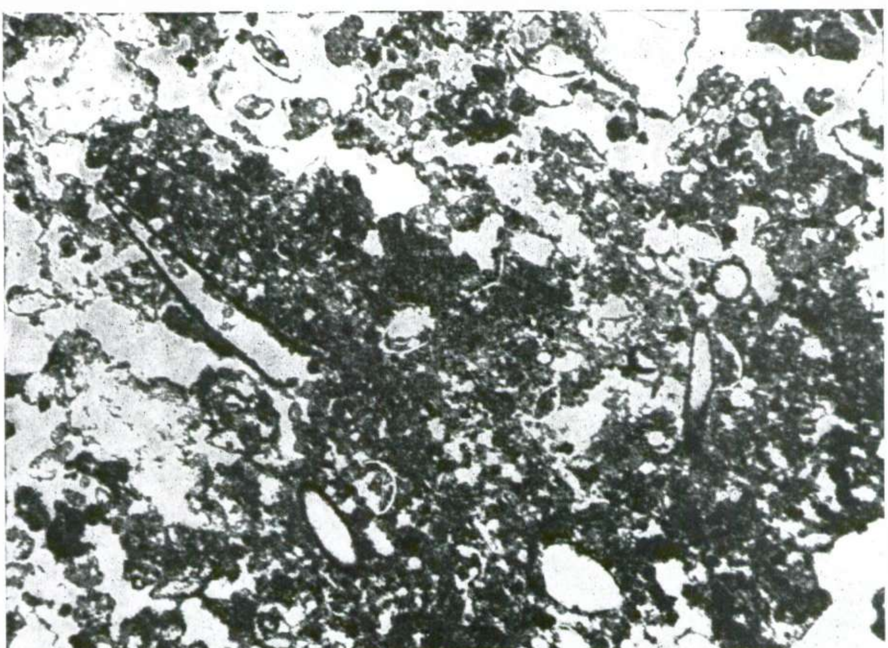


PLANCHE CXXXVII

Fig. 1

Calcaire organogène à *Thaumatoporella parvovesiculifera* (Rain.) et nombreux Foraminifères (*Pseudocyclammina*, Textularidés, Verneuilinidés et *Endothyra* ?), (× 30). Pl. mince 1904-60

Rovinj, Zlatni rt

MALM SUPÉRIEUR (PORTLANDIEN)

Fig. 2

Calcaire à *Favreina salevensis* Paréjas (× 30). Pl. mince 1906-60

Rovinj, Zlatni rt

MALM SUPÉRIEUR (PORTLANDIEN)

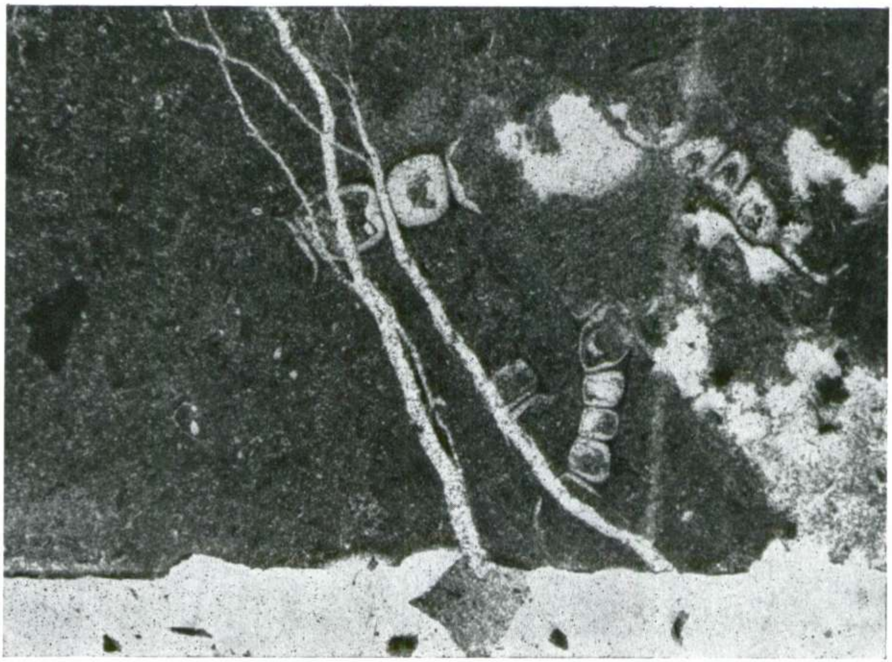
PLANCHE CXXXVIII

Fig. 1 et 2

Calcaire criptocristallin et grumeleux à *Clypeina jurassica* Favre (× 30). Pl. minces 1884 et 1885-60. Dans l'association: Ostracodes et Foraminifères peu abondants

Rovinj

MALM SUPÉRIEUR (PORTLANDIEN)



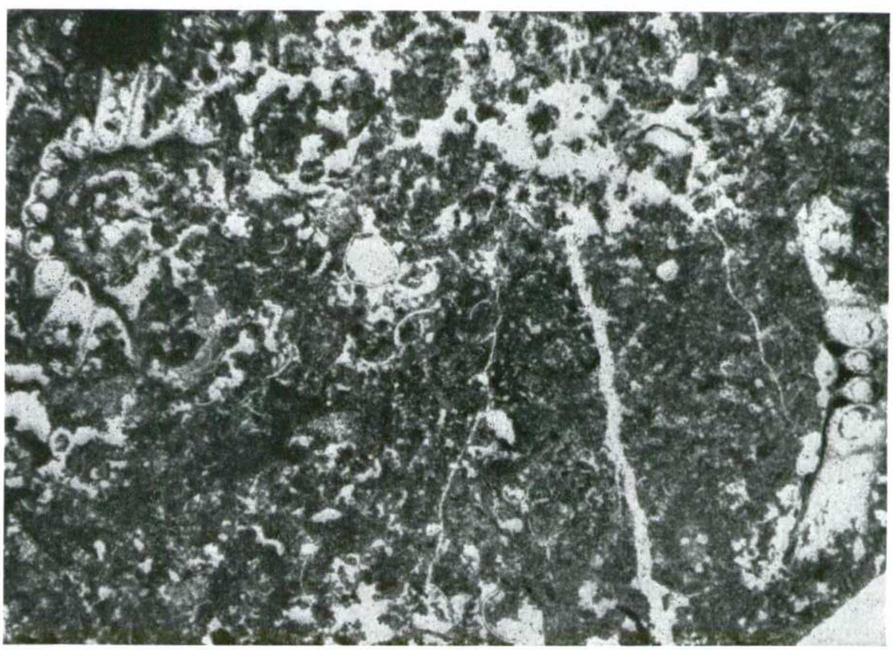


PLANCHE CXXXIX

Fig. 1 et 2

Calcaire finement détritique à Foraminifères (*Pseudocyclammina*, *Endothyra* ? et autres), (fig. 1 — × 15, fig. 2 — × 30). Pl. minces 1908 et 1908 a-60. Dans l'association: rares Trocholines et *Bačinella irregularis* Rad.

Rovinj, Zlatni rt

MALM SUPÉRIEUR (PORTLANDIEN)

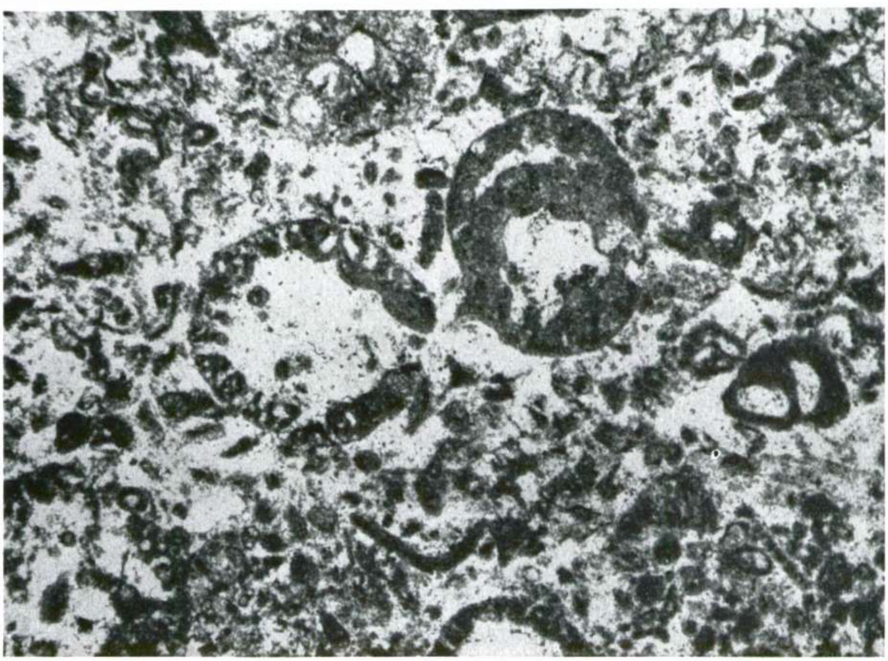


PLANCHE CXL

Fig. 1

Calcaire criptocristallin à Calpionelles fort rares (× 200). Pl. mince 1875-60
Rovinj
MALM SUPÉRIEUR (PORTLANDIEN)

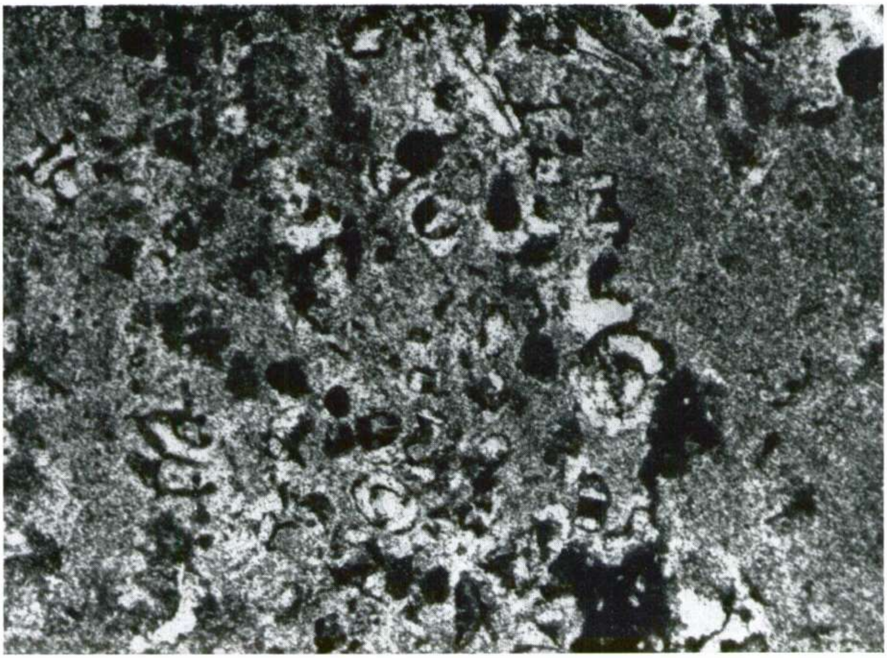
Fig. 2

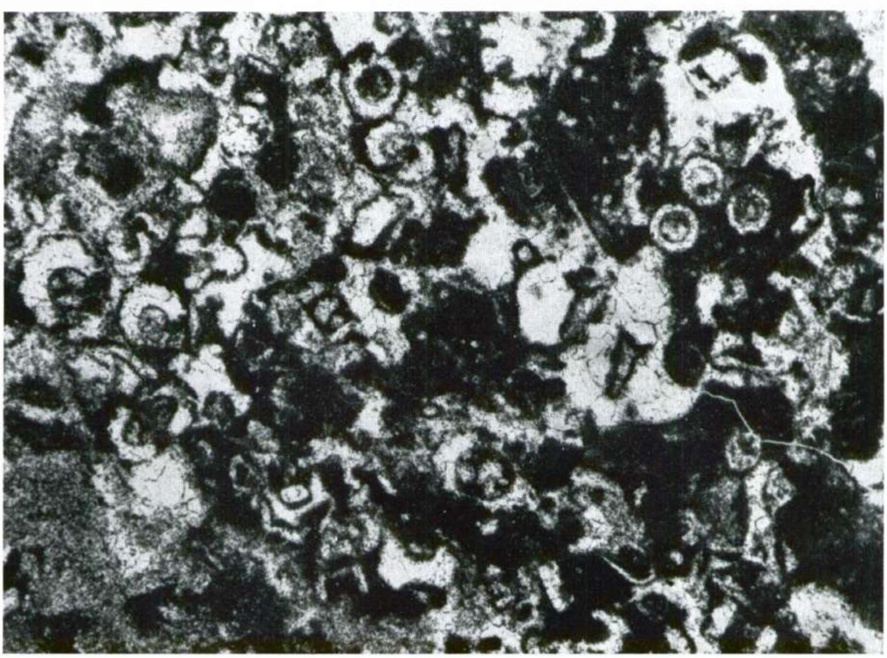
Calcaire à Tintinnines aberrantes: *Campbelliella mileši* Rad. et *Tintinnopsella* sp. (× 20). Pl. mince 1924-60
Rovinj, Zlatni rt
VALANGINIEN

PLANCHE CXLI

Fig. 1 et 2

Calcaire à *Salpingoporella annulata* Carozzi (×.30). Pl. mince 1920-60
Rovinj, Zlatni rt
VALANGINIEN





LA SÉRIE JURASSIQUE DES ENVIRONS DE SOŠICE (ŽUMBERAK)

(Tableau № 11)

Planches: CXLII—CXLVIII

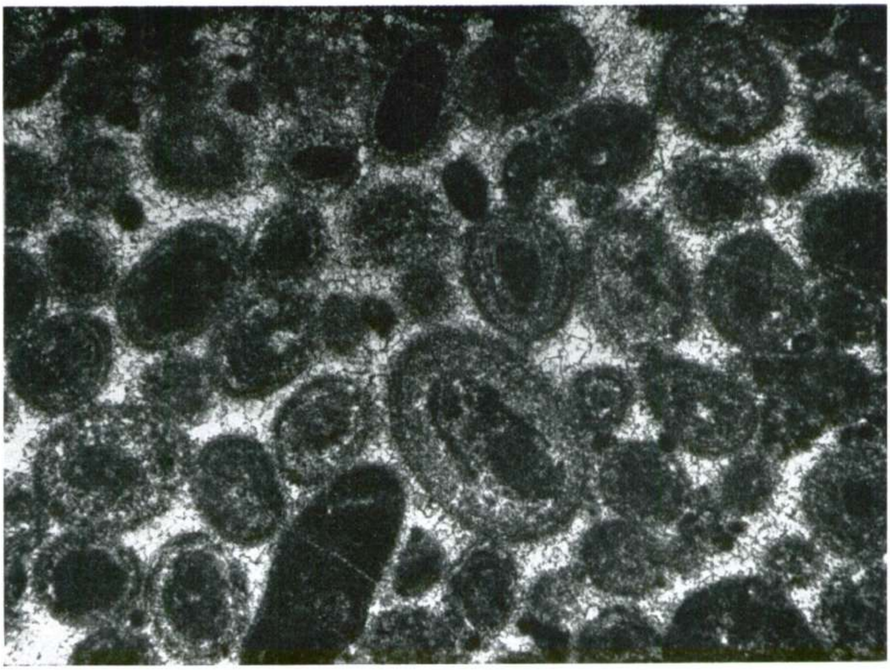
PLANCHE CXLII

Fig. 1

Calcaire oolithique, azoïque (× 27). Pl. mince 96-61
Žumberak, environs de Sošice
LIAS INFÉRIEUR

Fig. 2

Calcaire organogène-détritique — débris de Dasycladacées, d'Echinodermes et de Mollusques; Microgastéropodes (× 27). Pl. mince 98-61
Žumberak, environs de Sošice
LIAS INFÉRIEUR



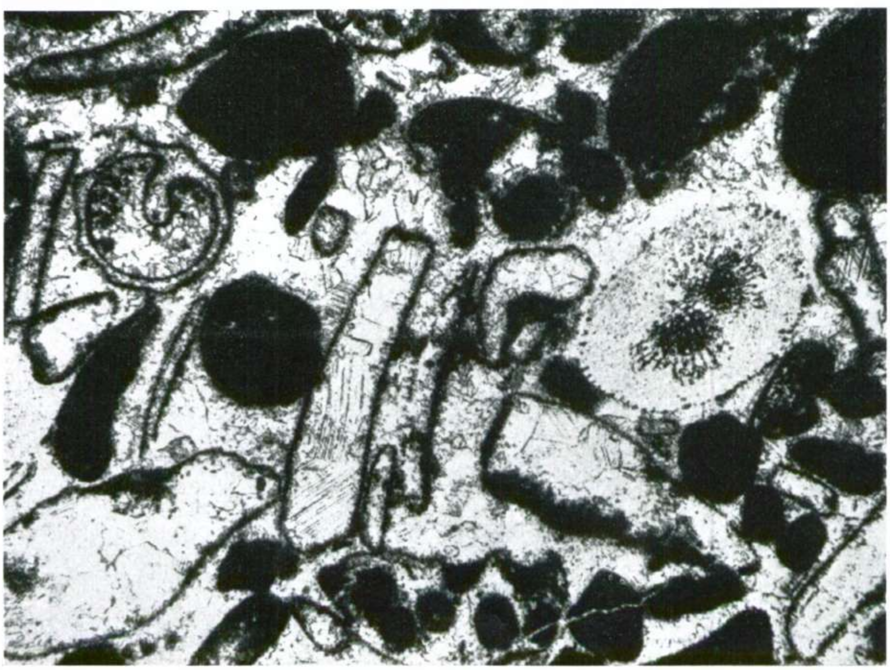


PLANCHE CXLIII

Fig. 1 et 2

Calcaire organogène, subcristallin, à ***Palaeodasycladus mediterraneus*** Pia, rares Foraminifères et débris de Mollusques (× 15). Pl. mince 119 et 120-61

Žumberak, environs de Pogana jama

LIAS INFÉRIEUR-MOYEN

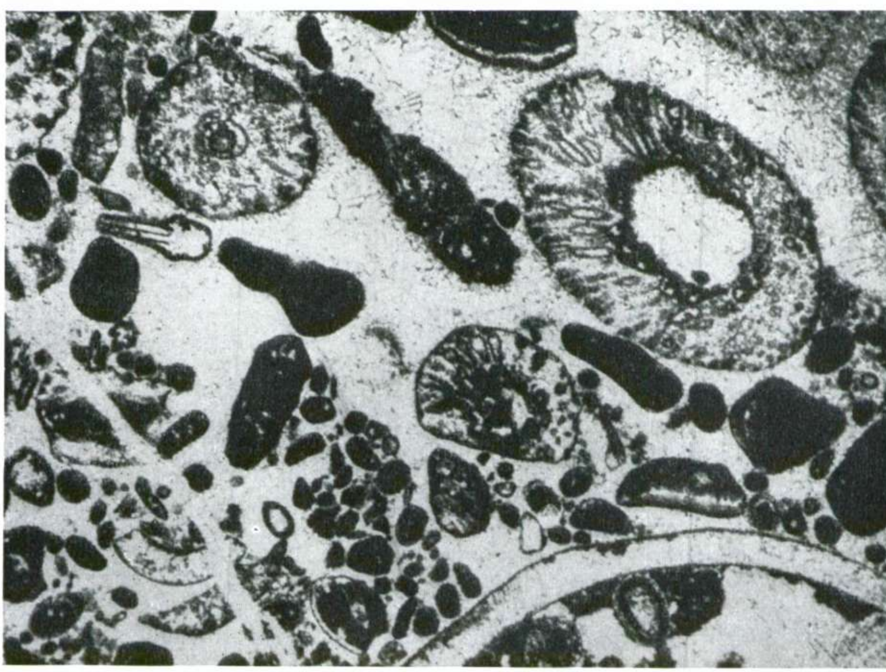


PLANCHE CXLIV

Fig. 1

Calcaire oolithique à petits Foraminifères peu nombreux et fin débris divers (× 27). Pl. mince 99-61

Žumberak, environs de Sošice

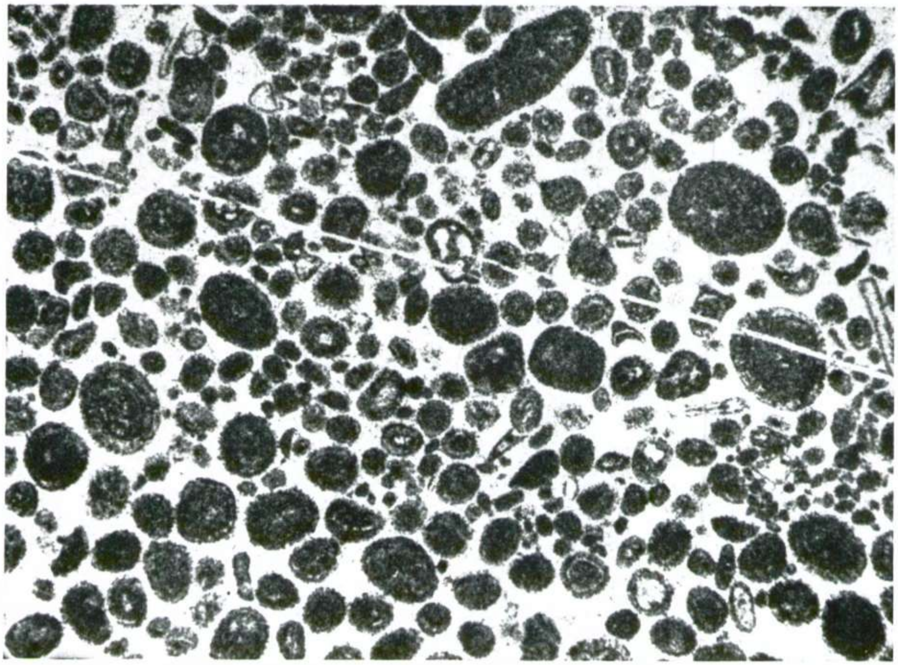
LIAS MOYEN

Fig. 2

Calcaire microgrumeleux à *Lituosepta recoarensis* Cati (× 27). Pl. mince 102-61. Dans l'association: très rares petits Foraminifères et Thaumatoporelles transformées

Žumberak, environs de Sošice

LIAS MOYEN



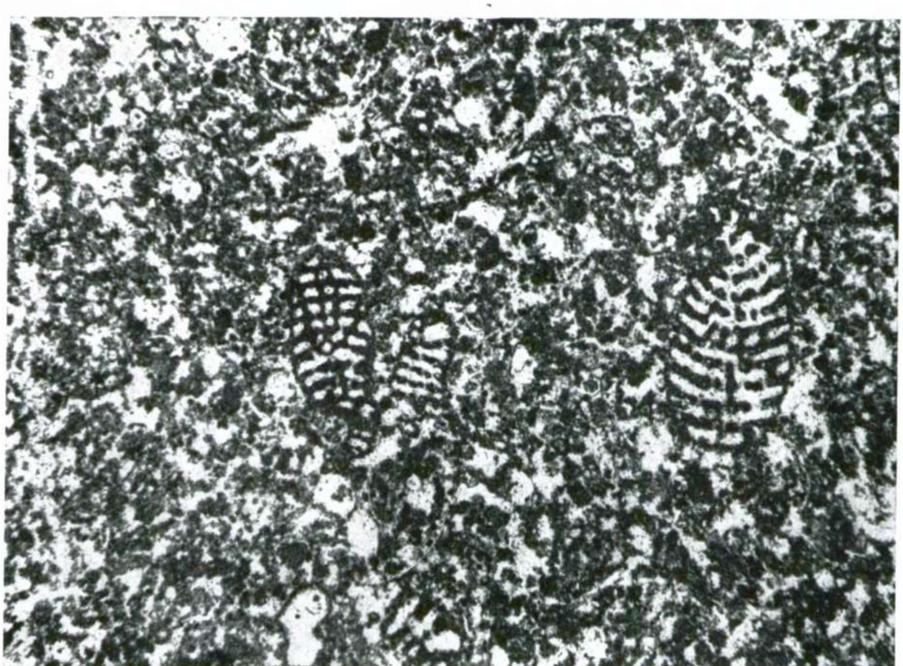


PLANCHE CXLV

Fig. 1

Calcaire microgrumeleux à *Lituosepta recoarensis* Cati, petits Foraminifères peu nombreux et Thaumatoporelles transformées (× 30). Pl. mince 102-61

Žumberak, environs de Sošice

LIAS MOYEN-SUPÉRIEUR

Fig. 2

Calcaire organogène-détritique à *Spirillina liassica* (Jones) et débris d'Echinodermes (× 40). Pl. mince 78-61. Dans l'association: *Vidalina martana* Farinacci et Lagénidés

Žumberak, environs de Sošice

LIAS SUPÉRIEUR

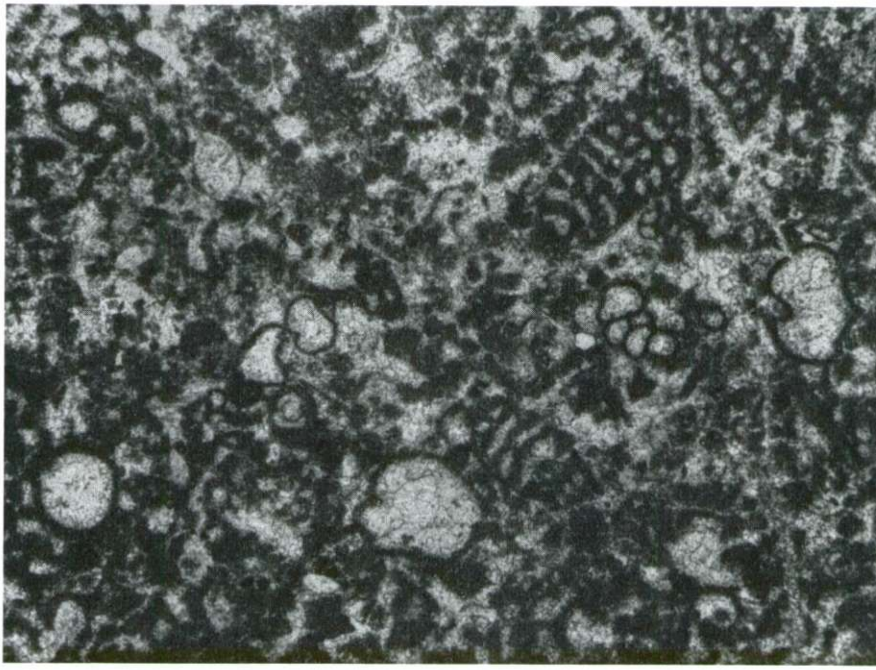
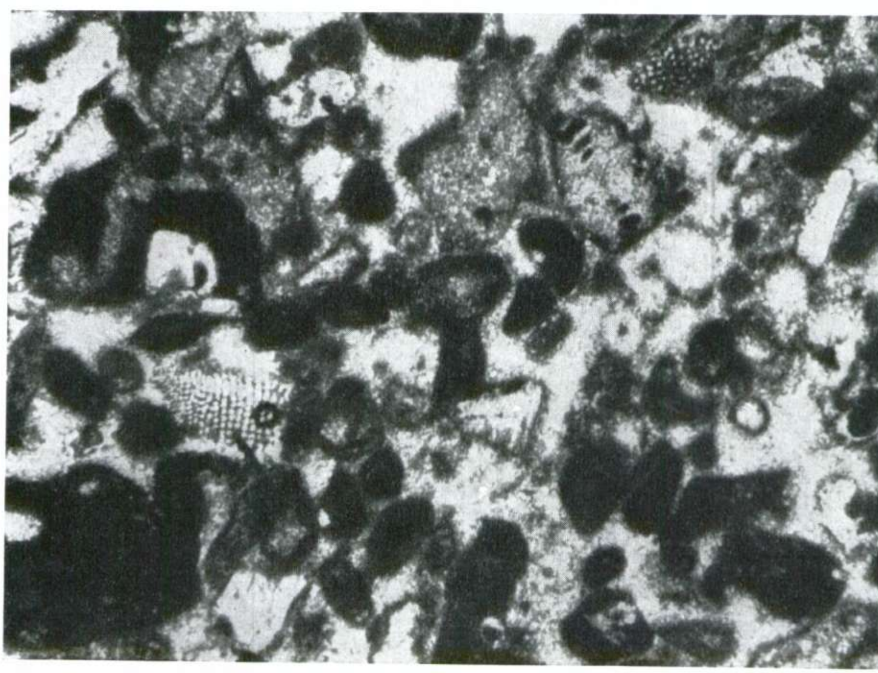



PLANCHE CXLVI

Fig. 1

Calcaire organogène-détritique à *Cristellaria* et autres Lagénidés et débris abondants d'Echinodermes et de Mollusques (× 30). Pl. mince 105-61. Dans l'association: *Spirillina liassica* (Jones), *Vidalina martana* Farinacci et Ophtalmidiidés

Žumberak, environs de Sošice

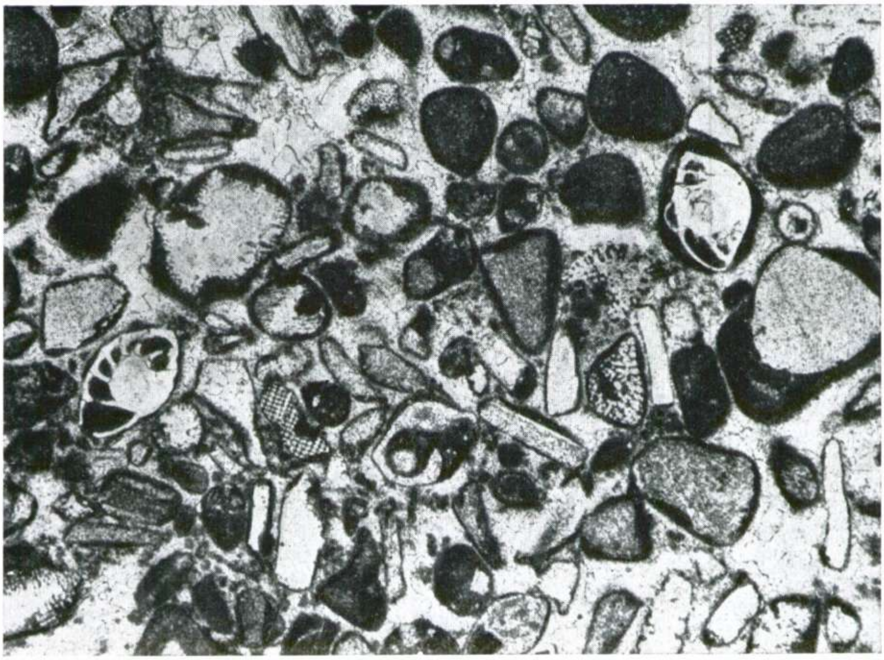
LIAS SUPERIEUR

Fig. 2

Calcaire organogène-détritique — débris d'Echinodermes et de Mollusques (fragments de *Saccocoma*), (× 30). Pl. mince 108-61. Dans l'association: *Vidalina, Spirillina* etc.

Žumberak, environs de Sošice

LIAS SUPÉRIEUR ou LIAS-DOGGER



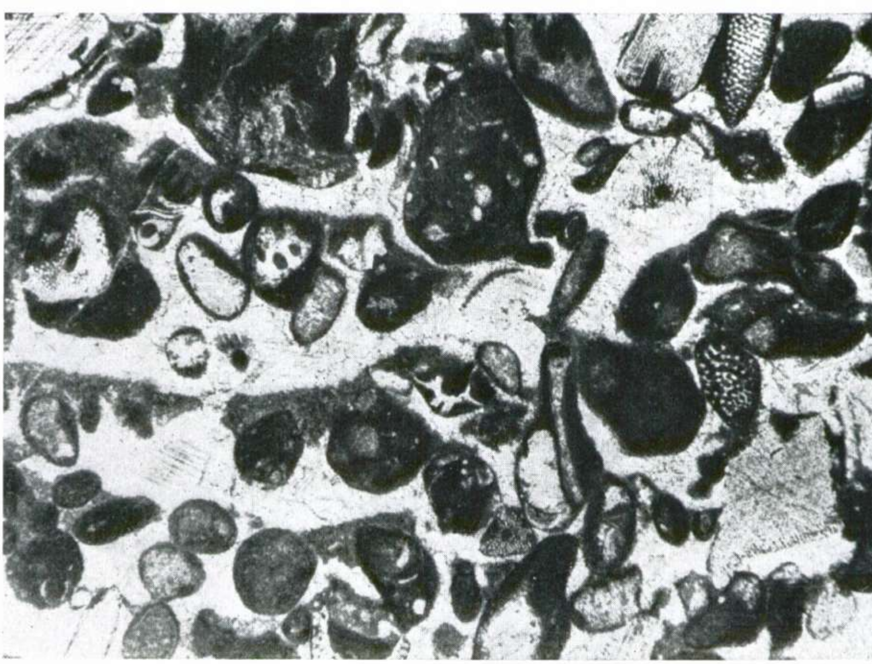


PLANCHE CXLVII

Fig. 1

Calcaire organogène-détritique à *Petrascula bursiformis* Ettalon (× 30). Pl. mince 91-61. Dans l'association: *Bačinella irregularis* Radoičić et Codiacées apparentées

Žumberak, environs plus large de Sošice

MALM INFÉRIEUR

Fig. 2

Calcaire à rares Radiolaires calcifiés et Lamellibranches pélagiques (× 43). Pl. mince 109-61

Žumberak, environs de Sošice

MALM SUPÉRIEUR (KIMMÉRIDGIEN-PORTLANDIEN)

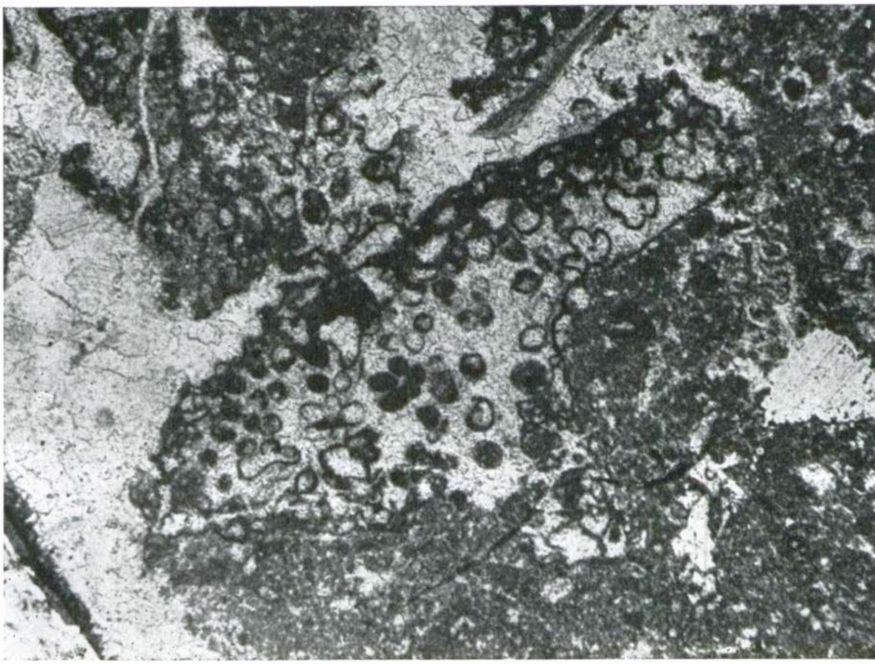


PLANCHE CXLVIII

Fig. 1

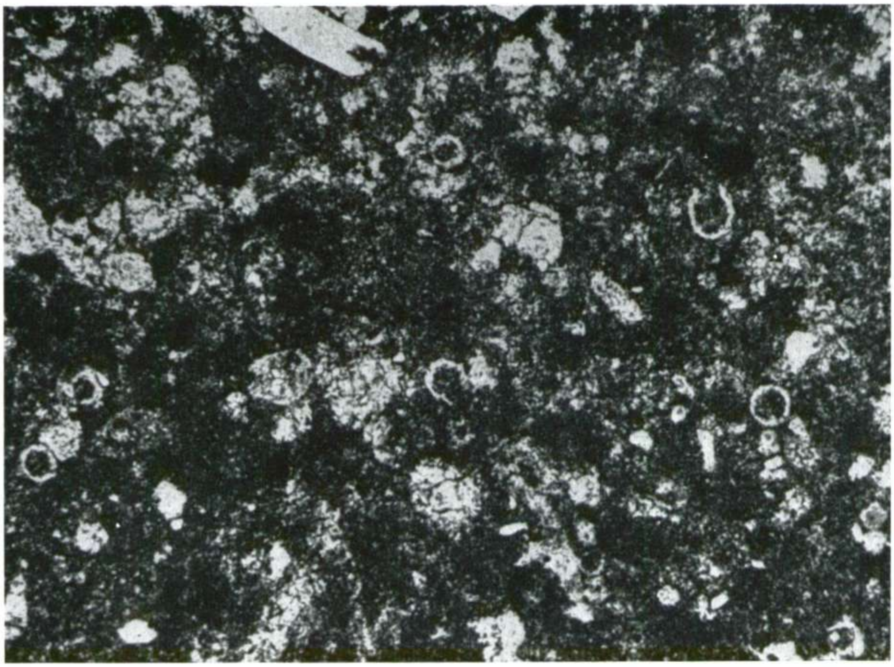
Calcaire à *Calpionella alpina* Lorenz et *Calpionella elliptica* Cadisch (× 100).
Pl. mince 110-61
Žumberak, Sošice

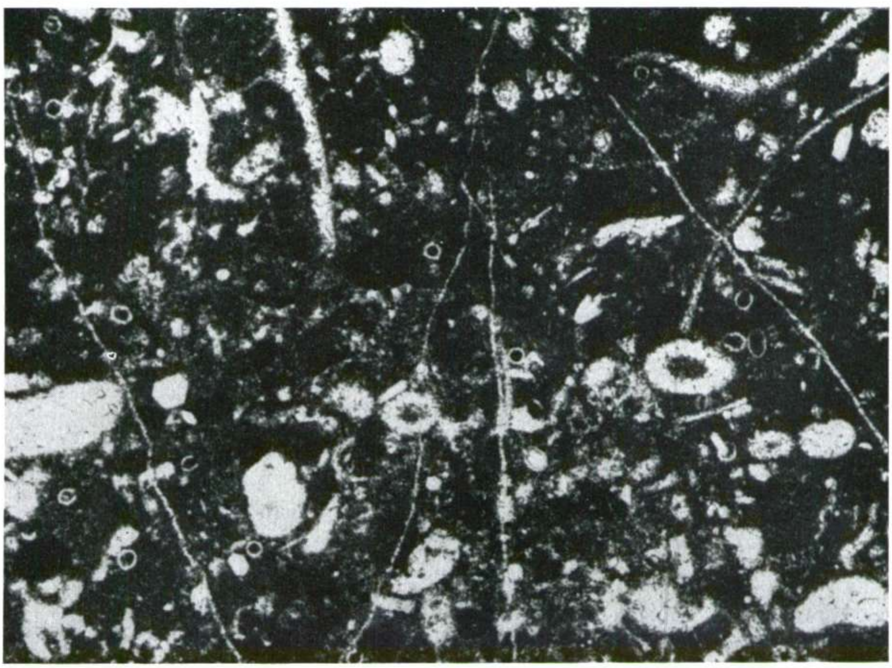
MALM SUPERIEUR (PORTLANDIEN)

Fig. 2

Calcaire à *Calpionella alpina* Lorenz et *Calpionella elliptica* Cadisch (× 43).
Pl. mince 111-61. Dans l'association: *Globochaete alpina* Lombard, spicules de Spongiaires, puis rares Ophtalmidiidés et autres Foraminifères
Žumberak, Sošice

MALM SUPÉRIEUR (PORTLANDIEN)





LES AUTRES MICROFACIÈS JURASSIQUES

Planches: CXLIX à CLXV

PLANCHE CXLIX

Fig. 1 et 2

Calcaire à Annelides, Microgastéropodes et petits Foraminifères peu abondants (× 30). Pl. mince 906-63

Environs d'Osječenica, près de Grahovo; Monténégro

LIAS INFÉRIEUR (couches les plus anciennes)

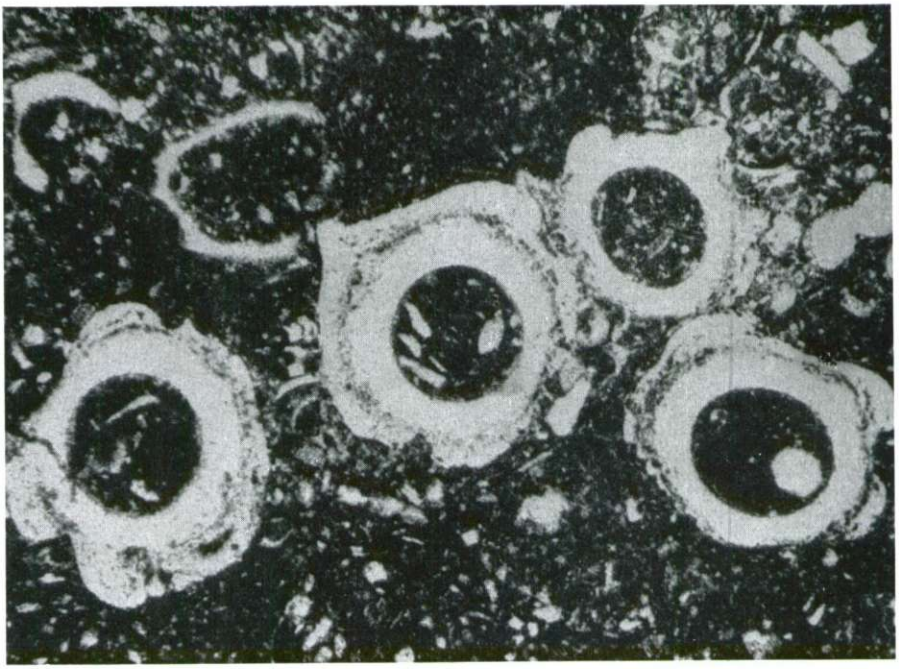


PLANCHE CL

Fig. 1 et 2

Calcaire pseudo-oolithique à *Pelleria bonomii** (Vialli) Grubić (fig. 1, négatif — × 7,5; fig. 2, détail — × 17,5). Pl. mince 1397-64. Dans l'association: autres Hydrozoaires, débris d'Echinodermes et petits Foraminifères; ***Vidalina martana*** Farinacci, ***Spirillina liassica*** (Jones) et autres. (= pl. CLI)

Montagne Lovćen, Bukovica

LIAS INFÉRIEUR

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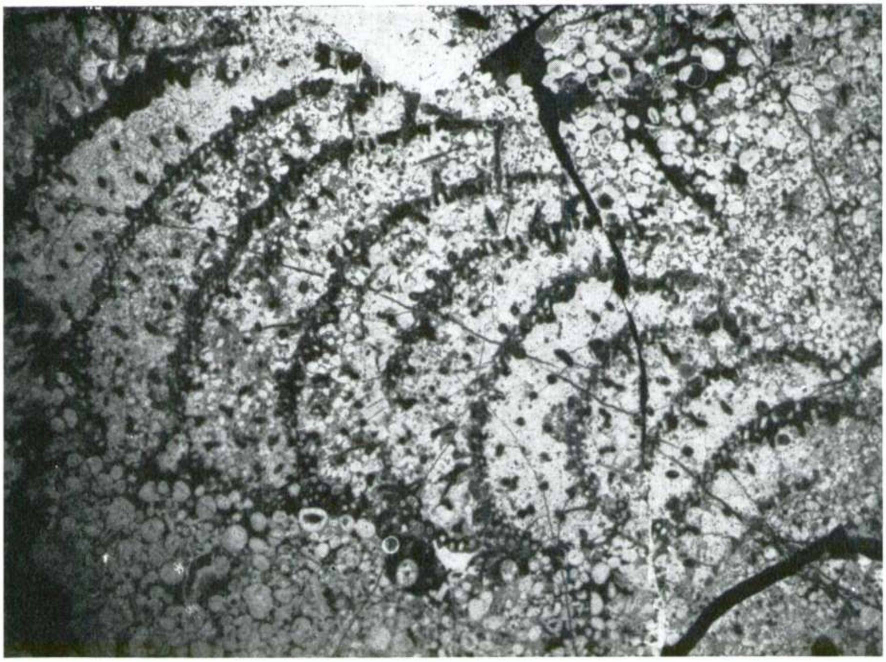
* Détermination: A. GRUBIĆ



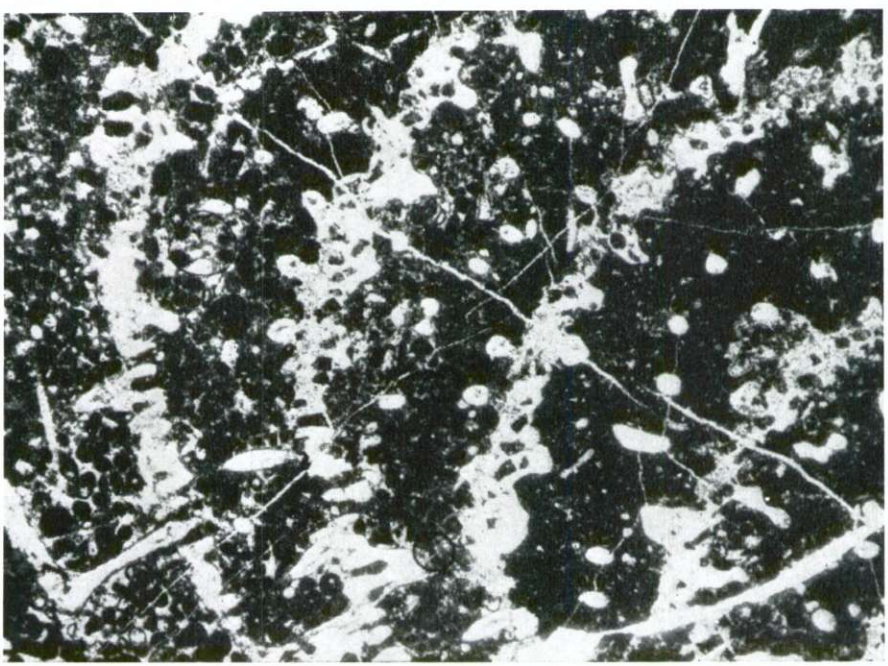


PLANCHE CLI

Fig. 1 et 2

Calcaire pseudo-oolithique à Hydrozoaires (fig. 1, négatif — × 7,5; fig. 2, détail — × 17,5). Pl. mince 1396-64. Dans l'association: *Pelleria bonomii* (Vialli) Grubić, débris d'Echinodermes et petits Foraminifères: *Vidalina martana* Farinacci, *Spirillina liassica* (Jones) et autres

Montagne Lovćen, Bukovica

LIAS INFÉRIEUR

PLANCHE CLII

Fig. 1

Calcaire oolithique à débris divers peu abondant (× 35). Pl. mince 556-62
Environs de Blizna dans la vallée de Morača, Monténégro
LIAS INFÉRIEUR (couches les plus anciennes)

Fig. 2

Calcaire à *Lituosepta recoarensis* Cati (× 17,5). Pl. mince 529-62
Martinićko Gostlje, Javorak; Monténégro
LIAS

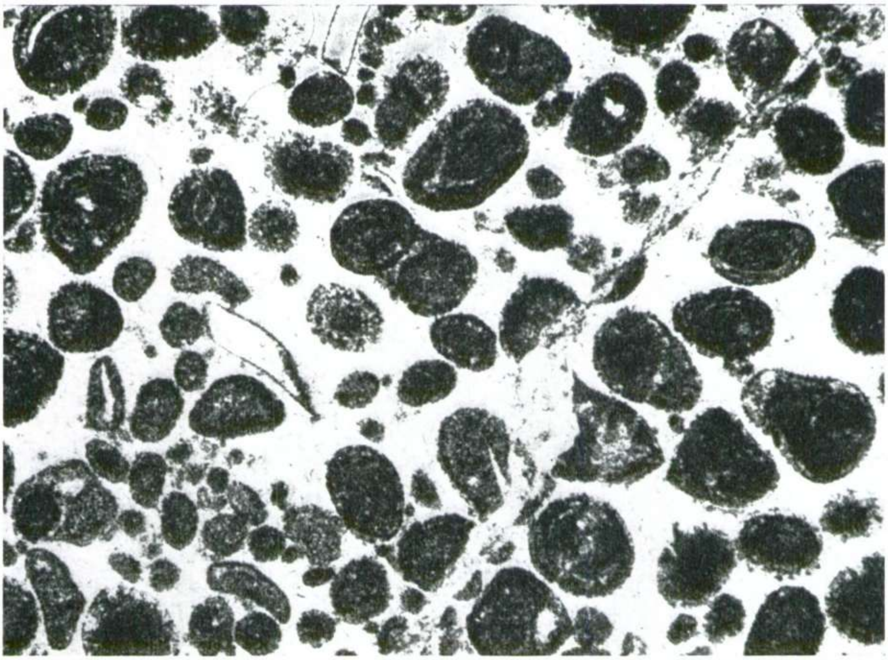


PLANCHE CLIII

Fig. 1

Calcaire à débris d'Echinodermes (× 17). Pl. mince 248-57
Environs plus large de Kopilje, près de Seoca, Monténégro
LIAS (partie moyenne de la série liasique)

Fig. 2

Calcaire oolithique à débris d'Echinodermes (× 17). Pl. mince 250-57
Environs plus large de Kopilje, près de Seoca, Monténégro
LIAS (partie moyenne de la série liasique)

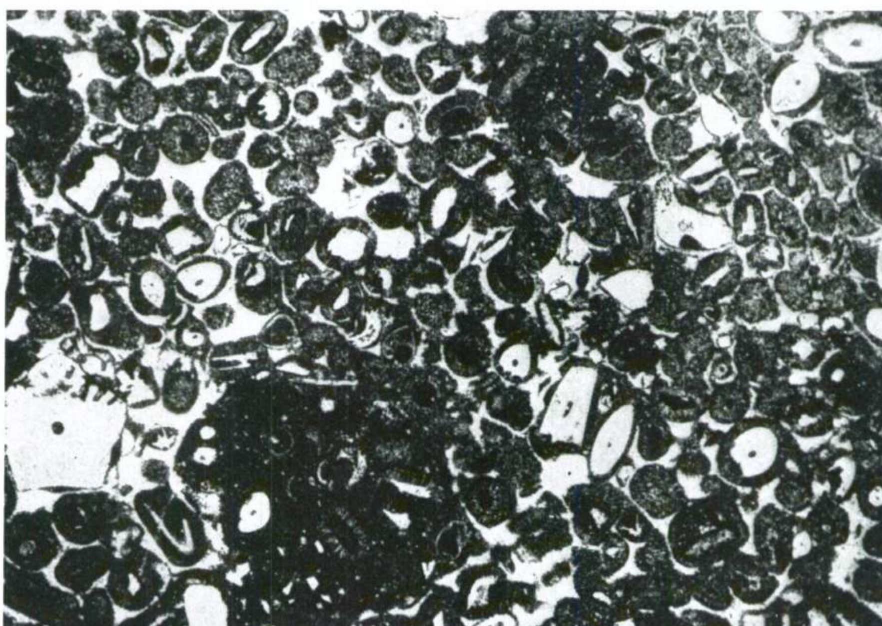


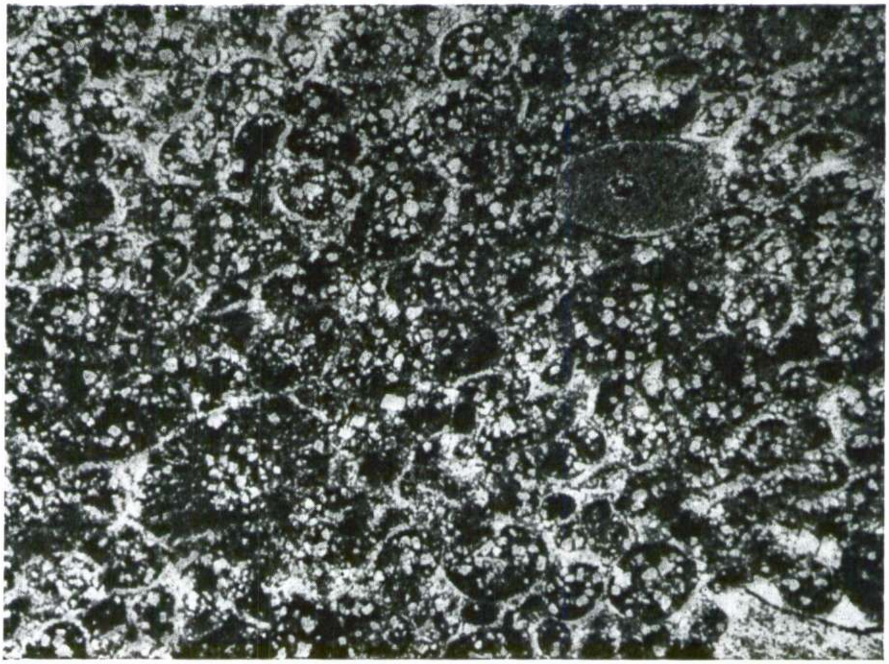
PLANCHE CLIV

Fig. 1 et 2

Calcaire oolithique à Echinodermes, pris de la dolomitisation (× 33). Pl. mince 67-63

Environs plus large de Nikšić, près de Broćanac, Monténégro

LIAS (MOYEN-SUPÉRIEUR)



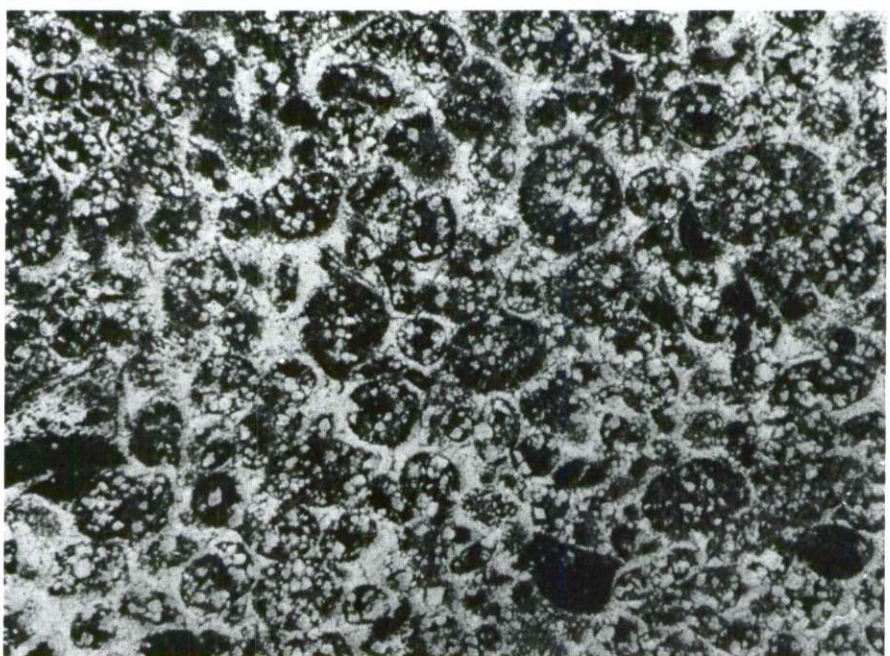


PLANCHE CLV

Fig. 1 et 2

Calcaire organogène, cristallin, à ***Spirillina liassica*** (Jones), Lagénidés, débris d'Echinodermes et Mollusques (× 35). Pl. mince 1875-64. Dans l'association: petits Ammonites, Trocholines et rares Vidalines (= pl. CLVI)

Boka Kotorska, Vrmac

LIAS SUPÉRIEUR

PLANCHE CLVI

Fig. 1 et 2

Calcaire organogène, cristallin, à Lagénidés, Trocholines et débris d'Echinodermes et de Mollusques (× 35). Pl. mince 1876-64. Dans l'association: petits Ammonites *Spirillina liassica* (Jones) et rares Vidalines (= pl. CLV)

Boka Kotorska, Vrmac

LIAS SUPÉRIEUR

PLANCHE CLVII

Fig. 1

Calcaire organogène à *Teutloporella gallaeformis* Radoičić (× 17,5). Pl. mince **1685-64**

Domaine entre Grab et Konavli, environs de Veliki Oro

DOGGER SUPÉRIEUR

PLANCHE CLVIII

Fig. 1

Calcaire organogène-détritique à Codiacées C1 (× 75). Pl. mince 554-62. Dans l'association: *Conicospirillina basiliensis* Möhler

Šujaci — dans la vallée de Morača, Monténégro

MALM INFÉRIEUR

Fig. 2

Calcaire organogène à *Bačinella irregularis* Radoičić (× 27). Pl. mince 01803

Au nord de Nikšić, vers Vojnik, Gvozd

MALM INFÉRIEUR

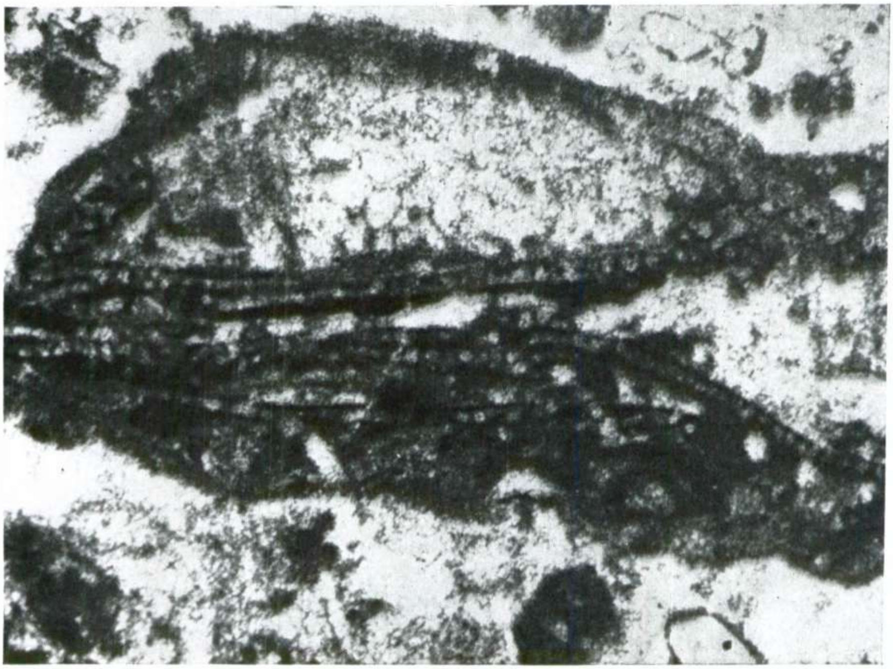


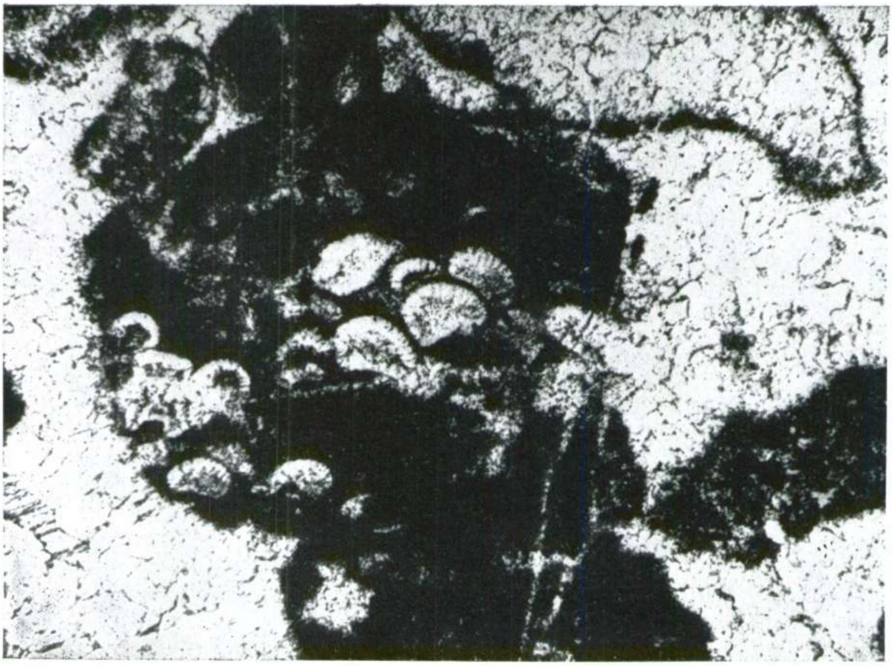
PLANCHE CLIX

Fig. 1 et 2

Calcaire organogène-détritique, subcristallin, à Microproblematica Pr6 (× 50). Pl. mince 01707. Dans l'association: Codiacées, Hydrozoaires, etc.

Domaine de la montagne Durmitor, Klještine

MALM INFÉRIEUR



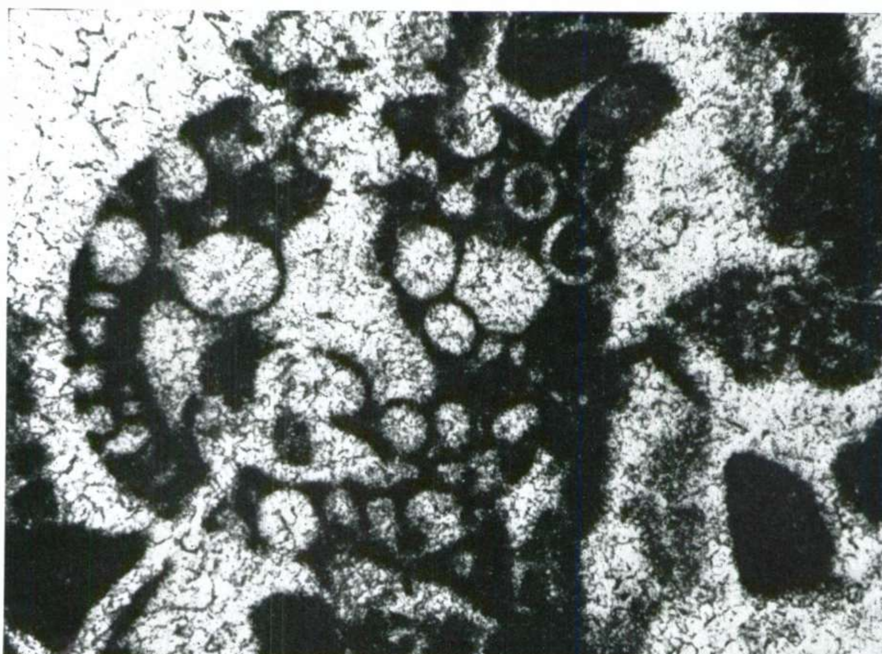


PLANCHE CLX

Fig. 1

Calcaire à Sphaeractinidés (× 17). Pl. mince 01720. Dans l'association: *Aeolisaccus* sp.

Montagne Durmitor

MALM (KIMMÉRIDGIEN)

Fig. 2

Calcaire à *Pianella grudii* Radoičić et Ostracodes (× 45). Pl. mince 1889-63

Environs de Milovići, Banjani; Monténégro

MALM SUPÉRIEUR (KIMMÉRIDGIEN SUPÉRIEUR-PORTLANDIEN)

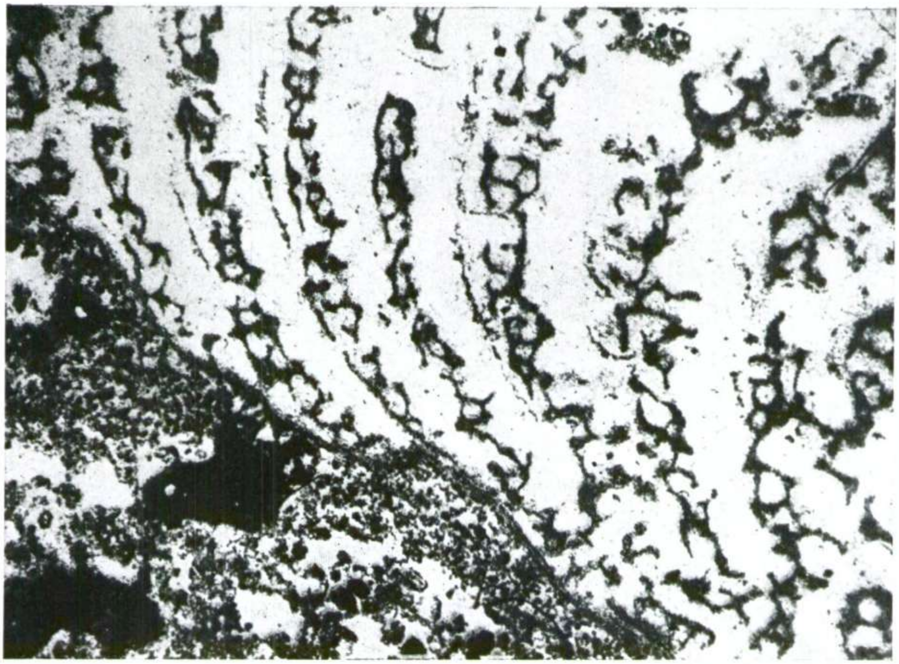


PLANCHE CLXI

Fig. 1 et 2

Calcaire peu bitumineux à *Aeolisaccus* sp., Ostracodes, petits Foraminifères peu nombreux et débris de Dasycladacées (fig. 1 — × 95, fig. 2 — × 17). Pl. minces 248 et 246-62

Biočki stan, environs de Nikšićka Župa

MALM SUPÉRIEUR (KIMMERIDGIEN SUPÉRIEUR-PORTLANDIEN)

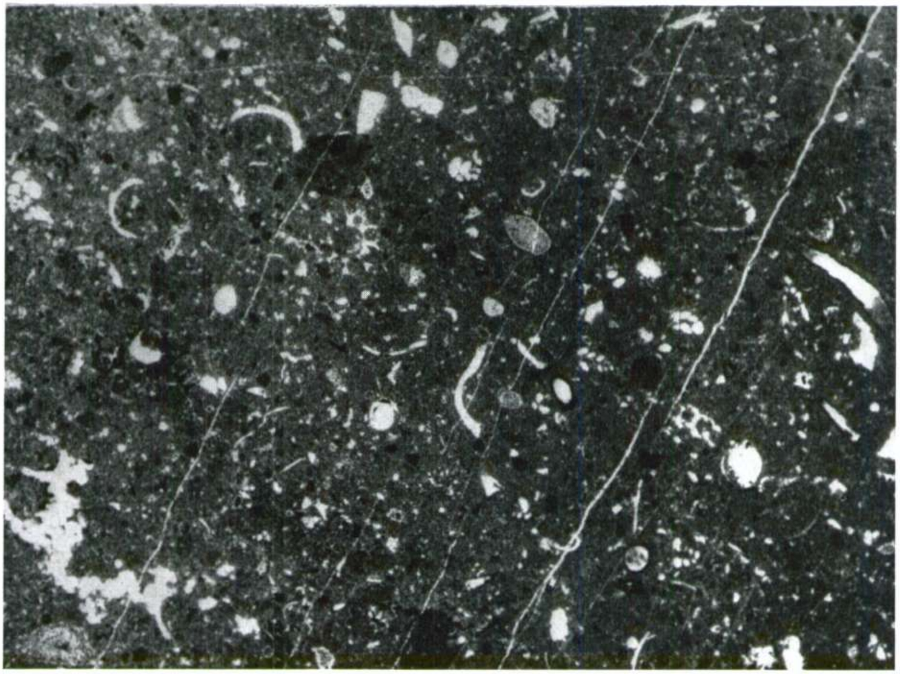


PLANCHE CLXII

Fig. 1 et 2

Calcaire organogène-détritique à *Nipponophycus* cf. *ramosus* Yabe & Toyama, (× 27,5). Pl. mince 1280-63

Domaine de la montagne Orjen, Ubli

MALM SUPÉRIEUR (PORTLANDIEN)

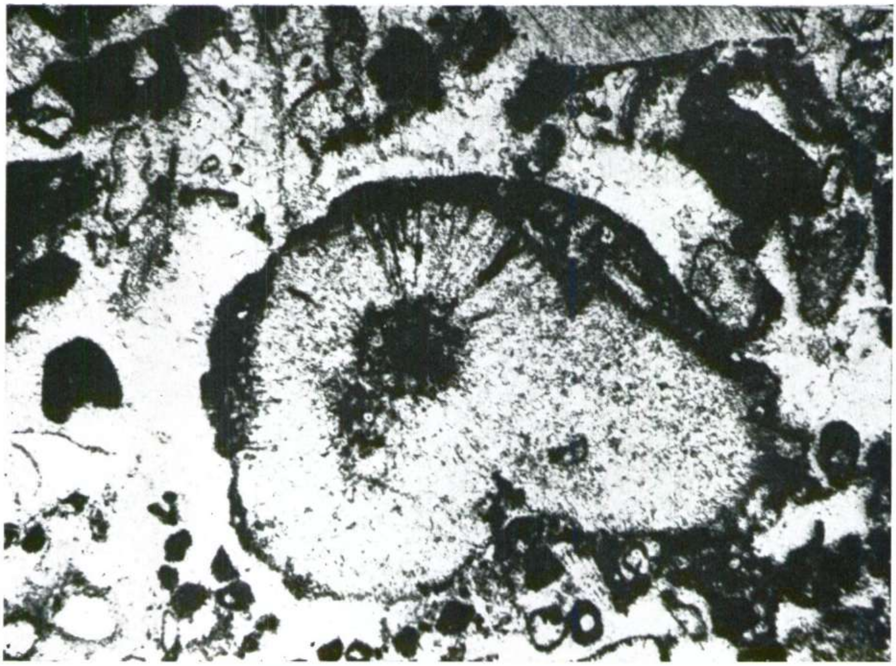


PLANCHE CLXIII

Fig. 1

Calcaire à Dasycladacées recristallisées — le plus vraisemblablement il est question de l'espèce *Pianella gigantea* Carozzi (× 27,5). Pl. mince 1278-63

Domaine de la montagne Orjen, Ubli

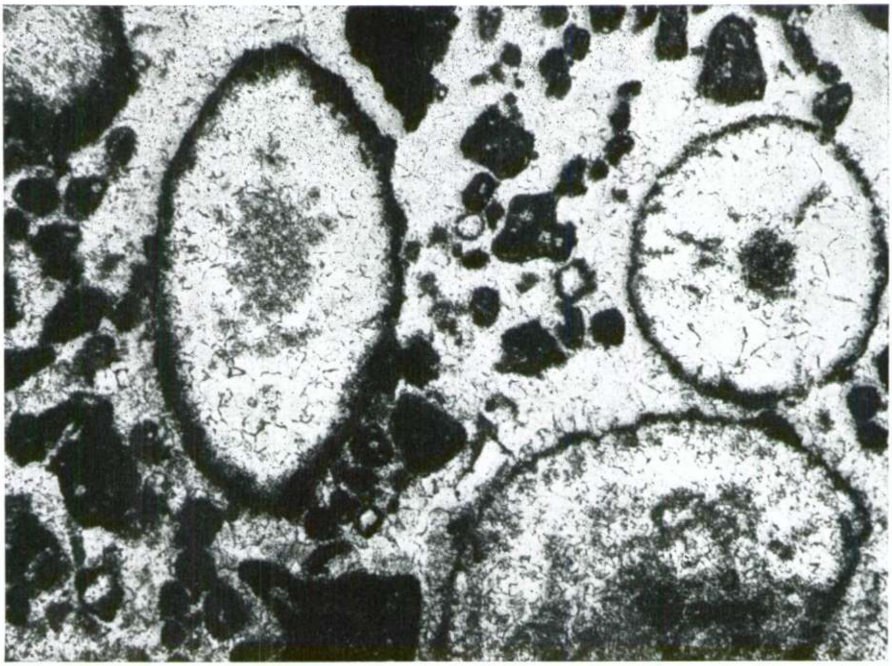
MALM SUPÉRIEUR

Fig. 2

Calcaire organogène-détritique à Dasycladacées et Codiacées (× 27,5). Pl. mince 1274-63

Domaine de la montagne Orjen, Ubli

MALM SUPÉRIEUR



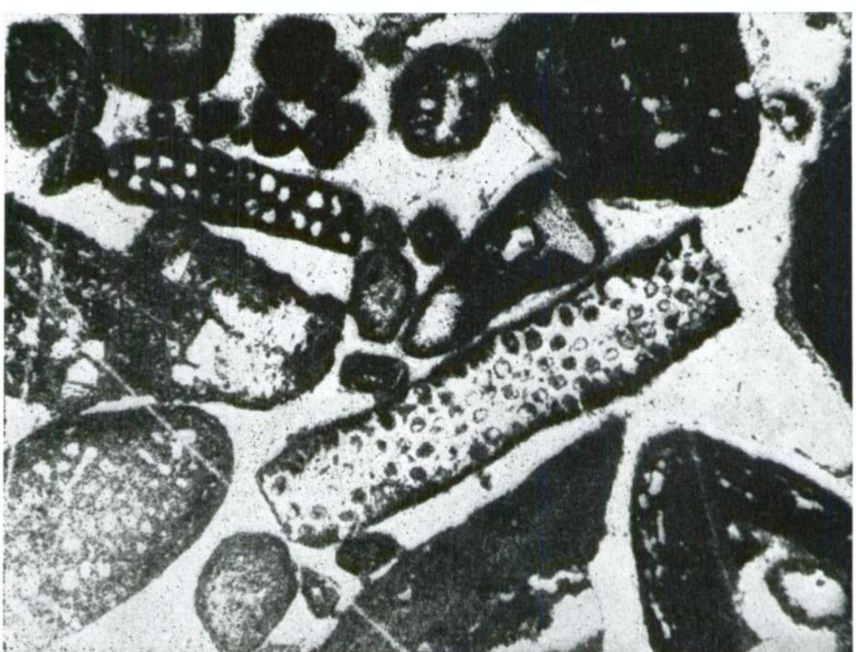


PLANCHE CLXIV

Fig. 1

Calcaire à *Spirillina* sp. et Radiolaires (× 90). Pl. mince 3148-60
Herzégovine du nord, Tjentište-Suha
MALM SUPÉRIEUR (PORTLANDIEN — couches à Calpionelles)

Fig. 2

Calcaire à débris de Lamellibranches pélagiques et *Globochaete alpina* Lombard (× 95). Pl. mince 3151-60
Herzégovine du nord, Tjentište-Suha
MALM SUPÉRIEUR (PORTLANDIEN — couches à Calpionelles)

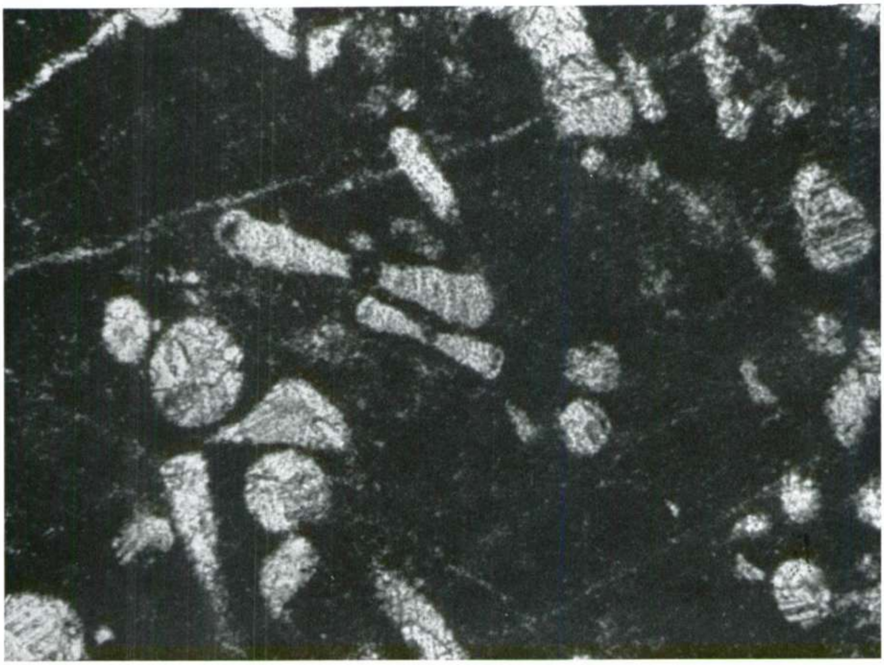


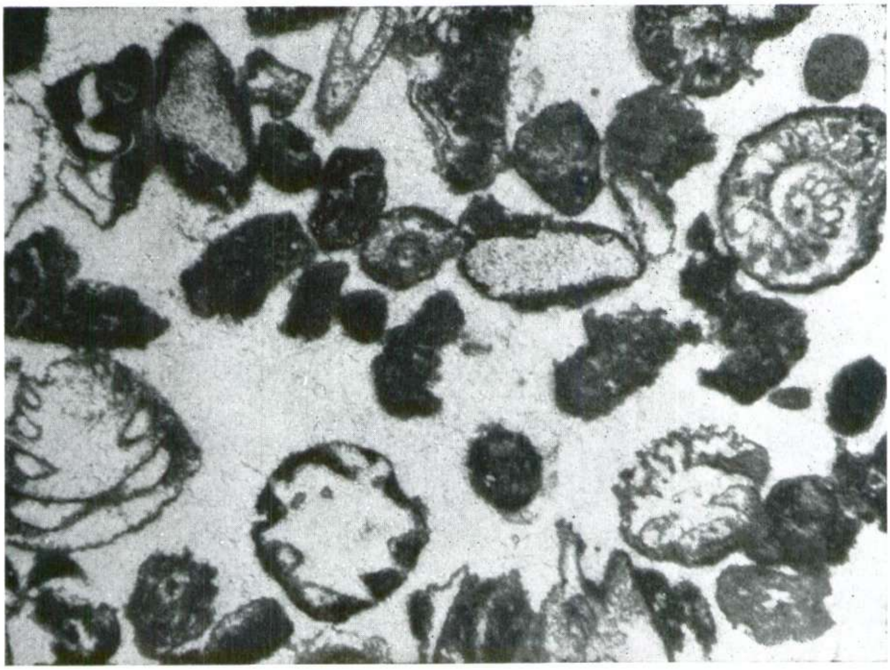
PLANCHE CLXV

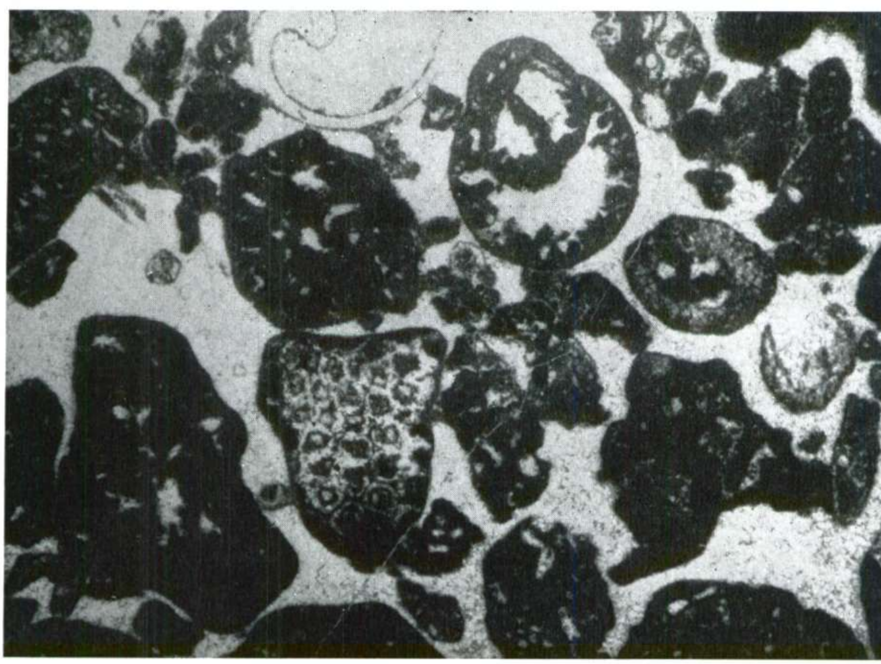
Fig. 1 et 2

Calcaire organogène à Trocholines, *Pseudocyclammina, Protopeneroplis ?*, Dasycladacées (Macroporelles, Acicularia et autres), Codiacées, Microgastéropodes, etc. (× 18,5). Pl. mince 1990-62

Boka Kotorska, Ljuta

MALM SUPÉRIEUR?





JURSKI SEDIMENTI MED ZAGRADCEM IN RANDOLOM V DOLINI KRKE

Ljudmila Šribar

S 7 slikami v prilogi

Uvod

Leta 1961 smo na Dolenjskem kartirali območje lista Ribnica 52/3. Geološko skupino je vodila Lija Rijavec, sodeloval pa je poleg mene še Zvonko Mencej. Med študijem literature za pripravo terenskega dela smo dobili uporaben podatek pri Germovšku (1950), ki omenja pri izviru Globočca, jugozahodno od Zagradca, najdbe litiotid in drugih školjk ter koral v srednjeliadnem apnencu.

Kartiranje smo pričeli pri Zagradcu in ugotovili, da so od tu do Randola nad Krko razviti vsi sedimenti jure od liade do malma. Pri Zagradcu in Randolu so jurske plasti ločene od ostalih s prelomoma, ki potekata od jugozahoda proti severovzhodu. Na tem območju smo našli tudi številne vodilne jurske fosile, zlasti mikrofosile, ki so nam v glavnem omogočili stratigrafsko razčlenitev skladov, delno pa smo plasti horizontirali po njihovi medsebojni legi.

Biostratigrafski opis

Po fosilnih in mikrofosilnih ostankih ter stratigrafski legi smo jurske plasti med Zagradcem in Randolom razdelili takole: spodnja liada, srednja liada, zgornja liada in dogger, spodnji malm in zgornji malm.

Spodnja liada

Spodnjeliadne plasti leže na zgornjetriadnem dolomitu noriške in retske stopnje. Te plasti vsebujejo ostanke alg *Sphaerocodium bornemanni* Rothpl. in megalodontide. Glavni dolomit je v glavnem razvit v dolini Krke; najjužneje sega na pobočje Šiškega vrha (516 m). Za zgornji del glavnega dolomita v bližini postopnega prehoda triada—jura je zelo značilna pasovitost, ki smo jo opazovali tudi pod mikroskopom. V kamenini se menjavajo temnejši in svetlejši različno široki pasovi, kar je posledica različne zrnavosti dolomita ter primesi drobnega organskega detritusa in gline. Mikrokristalni pasovi s primesjo gline in drobnega organskega detritusa so temnejši, svetlejši pasovi pa so sestavljeni iz drobnozrnatega dolomita. Pasovit dolomit postopno prehaja v dolomitiziran apnenec. Više postaja apnenec vedno bolj čist in kompakten ter je pogosto preprežen s kalcitnimi žilicami. Vsebuje ostanke brahiopodnih in gastropodnih lupinic in je pogosto marogast, ponekod pa kaže oolitno strukturo.

Med Zagradcem in Randolom smo mejo med triado in juro potegnili tam, kjer zgornjetriadni glavni dolomit postopno preide v siv gost apnenec, oolitni apnenec in apnenec z lupinicami brahiopodov in gastropodov. V manjši količini dobimo tudi temno siv zrnat dolomit.

Spodnjeliadnih plasti na opisanem območju nismo mogli dokazati s fosili, na njihovo starost sklepamo le po legi med zgornjetriadnim glavnim dolomitom in srednjeliadnimi skladi z litiotidami. Severozahodno od Šiškega vrha smo v spodnjeliadnem apnencu našli algo *Palaeodasycladus mediterraneus* (Pia) (1. sl.), ki je pa ne moremo imeti za vodilni fosil spodnje liade. V profilu jurskih skladov na Mali gori smo našli to algo v srednji liadi v horizontu z litiotidami in s foraminifero *Orbitopsella praecursor* (Šribar, 1965). Tudi v vzorcih apnenca, ki jih je Grad nabral pri kartiranju v kamnolomu pri Podutiku, smo našli ostanke alge *Palaeodasycladus mediterraneus*. Vendar liadnih plasti na območju Podutika nismo mogli podrobno horizontirati, ker litiotidni horizont ni izrazit. Mejo med triado in juro pa smo tu potegnili med plastmi z megalodontidami in sivim apnencem, ki ponekod vsebuje oolite.

Po Farinaccijevi in Radoičićevi (1964) je alga *Palaeodasycladus mediterraneus* razširjena v zgornjem delu spodnje liade, v srednji liadi in delno v zgornji liadi. Njena razmejitev navzgor in navzdol ni jasno označena. Po Sartoniju in Crescentiju (1962) pa nastopa tudi v plasteh retske stopnje. Enak podatek smo našli tudi v mikropaleontološkem atlasu Agip Mineraria, 1959.

Srednja liada

Tudi srednja liada je na območju med Zagradcem in Randolom razvita apneno. Apnenec je temno siv in vsebuje lepo vidne bele lupine litiotid. Horizont z litiotidami smo sledili neprekinjeno od izvira Globočca pri Zagradcu, kjer jih je omenil že Germovšek (1950), do Randola pri Krki. Horizont z litiotidami vsebuje tudi vodilno srednjeliadno foraminifero *Orbitopsella praecursor* (Gümb.), ki smo jo našli v oolitnem apnencu (2. sl.). Plasti z litiotidami so debele prek 50 m.

Zgornja liada-dogger

V sedimentih med srednjeliadnimi plastmi, dokazanimi s fosili, in spodnjemalmskimi skladi z vodilno mikrofloro, nismo našli fosilnih ostankov. Po legi smo te vmesne sedimente prišteli zgornji liadi in doggerju. Med njimi nismo nikjer zasledili diskordance. Sestavljajo jih v glavnem oolitni apnenec z različno velikimi ooliti, nadalje siv gost apnenec in marogast apnenec. V tem delu jure nismo dobili mikrofosilov, ki bi imeli večji pomen za določitev starosti plasti. Našli smo sicer nekatere foraminifere, med njimi za dogger najbolj značilne primerke iz družine Valvulinidae in Textulariidae (3. sl.), vendar vrst nismo mogli določiti. Te foraminifere nastopajo često v vzorcih iz srednjega dela jure. Dobili smo jih tudi pri mikropaleontološki obdelavi jurskega profila na Mali gori (Š r i b a r , 1965).

Spodnji malm

Malm smo s pomočjo mikrofosilnih ostankov razdelili v spodnji malm (oxfordij-spodnji kimmeridgij) in zgornji malm (zgornji kimmeridgij-portlandij).

Spodnji malm (oxfordij-spodnji kimmeridgij). Plasti spodnjega malma ležijo konkordantno na doggerskih skladih. Sestavljata jih svetlo do temno siv gost apnenec in oolitni apnenec. Njihova starost je dokazana s fosili. Najpomembnejši so spodnjemalmski hidrozoji. Spodnjemalmski oolitni apnenec vsebuje ostanek foraminifere *Protopeneroplis striata* Weynschenk (4a in 4b sl.), ki je vodilna za zgornji del doggerja in spodnji malm.

Kaže, da je ta foraminifera pri nas redka, kajti kljub velikemu številu pregledanih vzorcev iz jurskih sedimentov je bila ta najdba dolgo osamljena. Šele pozneje, pri kartiranju lista Ilirska Bistrica 65 in Kranj 65, smo v spodnjemalmskih plasteh ponovno našli foraminifero *Protopeneroplis striata* Weynschenk. Po literaturnih podatkih (W e y n s c h e n k , 1950) nastopa ta foraminifera v zgornjem doggerju in spodnjem malmu. V naših najdiščih pa smo jo vedno našli le v spodnjemalmskem apnencu.

Med Zagradcem in Randolom so v spodnjem malmu zelo pogostne alge iz rodu *Coscinoconus* sp. (5. sl.). Te alge so številne tudi v drugih območjih Slovenije v spodnjemalmskih plasteh.

Zgornji malm (zgornji kimmeridgij-portlandij)

Zgornjemalmske plasti leže konkordantno na spodnjemalmskih. Sestavlja jih povečini svetlo siv apnenec, ki kaže ponekod oolitno ali psevdooolitno strukturo. Apnenec se menjava s svetlim zrnatim dolomitom. Med Zagradcem in Randolom smo našli v številnih vzorcih zgornjemalmskega apnenca vodilno algo *Clypeina jurassica* Favre (6. sl.).

V zgornjem delu zgornjega malma nastopajo skupno s klipeinami tudi velike tintinine = *Bankia striata* (Carozzi).

Na zgornjemalmskih plasteh leži spodnjekredni apnenec. Tudi starost tega apnenca smo dokazali z mikrofosili.

JURASSIC SEDIMENTS BETWEEN THE VILLAGES ZAGRADEC AND RANDOL IN KRKA VALLEY

In the course of geological mapping on the sheet Ribnica 52/3 between the villages Zagradec and Randol fairly complete stratigraphic section of Jurassic sediments ranging from Liassic to Malm has been encountered. In this region some Jurassic guide fossils and microfossils have been found. This first and the stratigraphical position of the strata enabled the division of Jurassic sediments into Lower and Middle Liassic, Upper Liassic-Dogger, Lower Malm and Upper Malm.

Lower Liassic. The Lower Liassic strata are conformably underlain by the Upper Triassic dolomit of the Noric and Rhaetic stage. The Triassic dolomite grades into dolomitized limestone and gray limestone containing localy oolites and relics of brachiopods and gastropods.

In the described region the Lower Liassic strata couldn't be identified by means of the fossils; conjectures about their age hawe been possible only on the basis of their position between the Upper Triassic dolomite and Middle Liassic strata with lithiotides. In the north western part of the "Šiški vrh" *Palaeodasycladus mediterranues* (Pia) (Fig. 1) has been fund. This alga is widespread from the upper part of Lower Liassic to the lower part of the Upper Liassic but is not considered to be the guide fossil of the Lower Liassic.

Middle Liassic. The Middle Liassic limestone is predominantly dark gray in colour and contains relics of white shells of lithiotides. The horizon with lithiotides has been traced without interruption from Globočec near Zagradec, where it has been already mentioned by Germovšek (1950) to Randol near the Krka river. In the strata with lithiotides the guide Middle Liassic foraminifer *Orbitopsella praecursor* (Gümbel), (Fig. 2) has been identified.

Upper Liassic-Dogger. In the sediments occurring between the Middle Liassic strata proved by the presence of fossils, and the Lower Malmian strata containing the guide microflora, there were no determinable fossils, by which the age of these interbedded strata could be identified.

These sediments have been ranged in the Upper Liassic and Dogger only owing to their position. They are composed of oölitic limestone, gray and dense limestone and mottled limestone. In general some small foraminifers belonging to the family of Valvulinidae and Textulariidae. (Fig. 3) have been found in this part of the Jurassic.

Lower Malm (Oxfordien-Lower Kimmeridgien)

The age of the Lower Malmian strata conformably overlying the Doggerian beds is established by the presence of the hydrozoan fauna. The foraminifer *Protopeneroplis striata* Weynschenk (Figs 4a and 4b), which is the guide fossil for the upper part of Dogger and for the Lower Malm, has been identified in the Lower Malmian oölitic limestone.

In the Lower Malmian limestone between Zagradec and Randol, the algal remnants of *Coscinoconus* (Fig. 5) are very abundant.

Upper Malm (Upper Kimmeridgien-Portlandien). The Upper Malmian strata overlying conformably the Lower Malmian strata are mostly represented by light gray limestone of oölitic and pseudooölitic texture. The limestone alternates with granular dolomite. Here the guide fossil is *Clypeina jurassica* Favre (Fig. 6), occurring in the upper part of the Upper Malm together with Tintinnides aberrantes — *Bankia striata* (Carozzi). The Upper Malmian strata are overlain by Lower Cretaceous limestone.

LITERATURA

Agip Mineraria, 1959, Microfaciės italiane (dal Carbonifero al Miocene medio). 35 pp., T-CXLV tt., S. Donato Milanese.

Elis, B. et Messina, A. R., 1940, Catalogue of Foraminifera. Special Publ. Am. Mus. of Nat. Hist. New York.

Farinacci, A., 1963, L'«Organismo C» Favre 1927 appartiene alle Teredinidae? Geologica Romana, vol. II., Roma,

Farinacci, A., 1964, Sulla posizione sistematica e stratigrafica di Protopeneroplis striata Weynschenk, 1950. Geologica Romana, vol. III, Roma.

Farinacci, A. & Radoičić, R., 1964, Correlazione fra serie giuresi e cretacee dell"Appennino centrale e delle Dinaridi Esterne. La ricerca scientifica,. anno 34, serie 2, II-A. Roma.

Germovšek, C., 1950, Hidrogeološki pregled Krke in njenih pritokov od izvira do izliva Radulje. Arhiv Geološkega zavoda v Ljubljani.

Nikler, L., Sokač, B. et Ivanović, A., 1964, Die Gesellschaften der Mikrofossilien der Jura und Kreide des südöstlichen Velebit. Bull. Sci., Cons. Acad. RSF Yougosl., T. 9, No. 3, Zagreb.

Kerčmar, D., 1962. Prve najdbe zgornjejurskih apnenih alg v Sloveniji. Geologija 7, Ljubljana.

Radoičić, R., 1964, Mikropaleontološke odlike i stratigrafska korelacija nekih jurskih stubova spoljašnih Dinarida. Nafta 15, Zagreb.

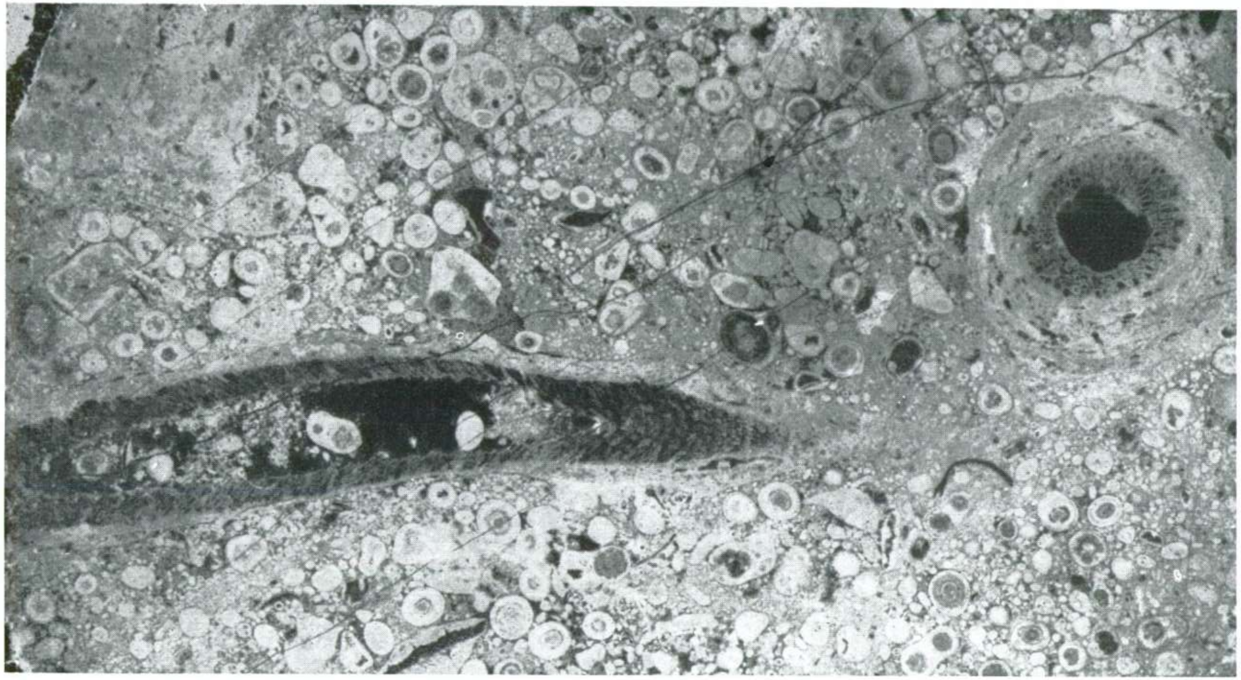
Sartoni, S. et Crescenti, U., 1962, Ricerche biostratigrafiche nel Mesozoico dell'Appennino Meridionale. Giorn. Geol., 29, Bologna.

Šribar, L., 1962, Mikropaleontološki pregled vzorcev z lista Ribnica 52. Arhiv Geološkega zavoda v Ljubljani.

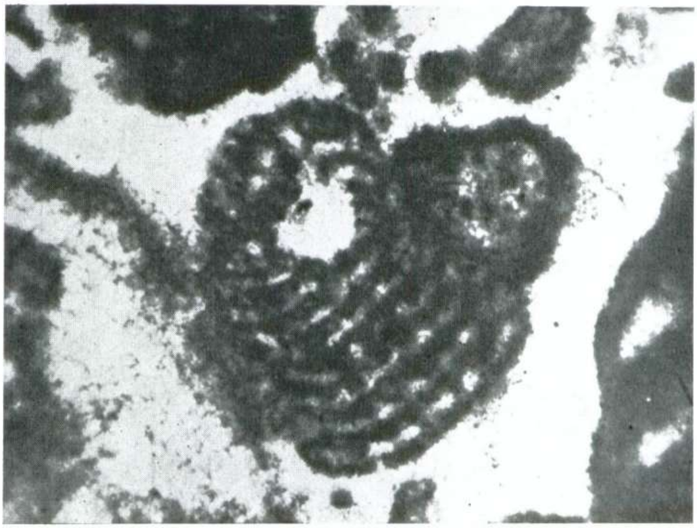
Šribar, L., 1964, Mikrofacies mezozojskih skladov Slovenije, I. faza. Arhiv Geološkega zavoda v Ljubljani.

Šribar, L., 1965, Mikrofacies mezozojskih skladov Slovenije, II. faza. Arhiv Geološkega zavoda v Ljubljani.

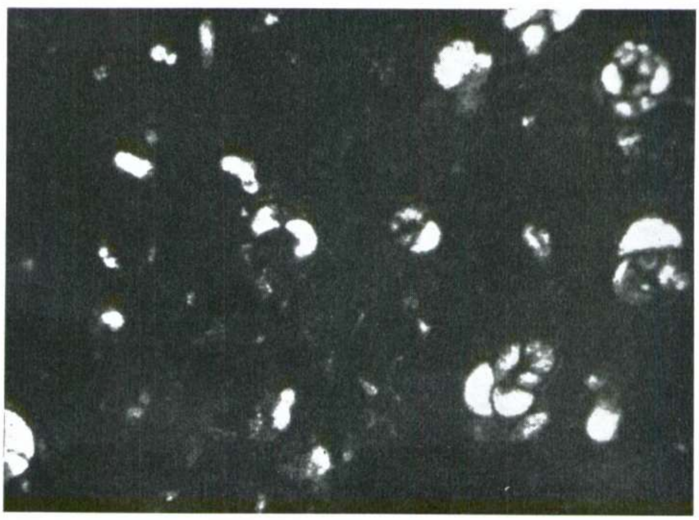
Weynschenk, R., 1950, Die Jura-Mikrofauna und Flora des Sonnwendgebirges (Tirol). Innsbruck.



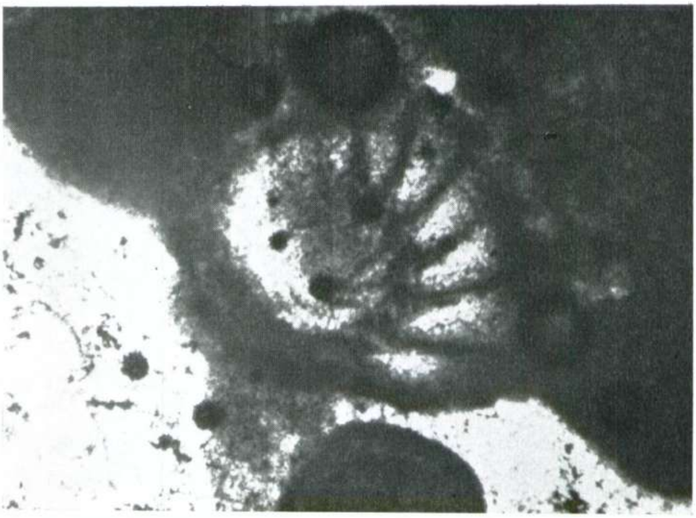
Sl. 1. *Palaeodasycladus mediterraneus* (Pia), 8×, spodnja liada, Zagradec—Randol, št. zb. 1144—6912



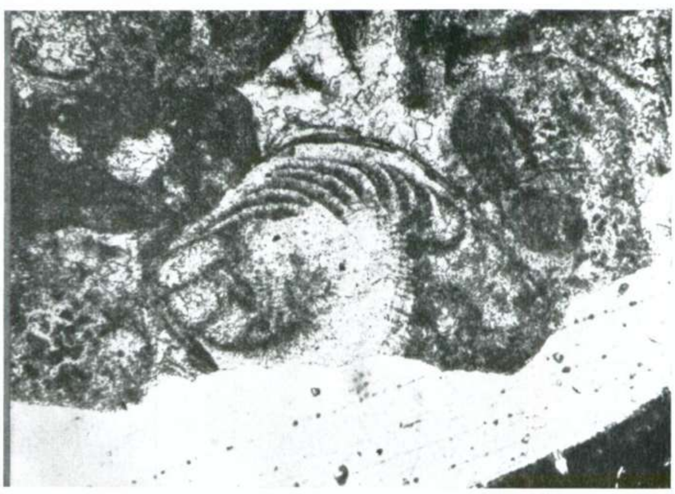
Sl. 2. *Orbitopsella praecursor* (Gümbel) 32×, srednja liada, Zagradec-Randol št. zb. 766 a—6737



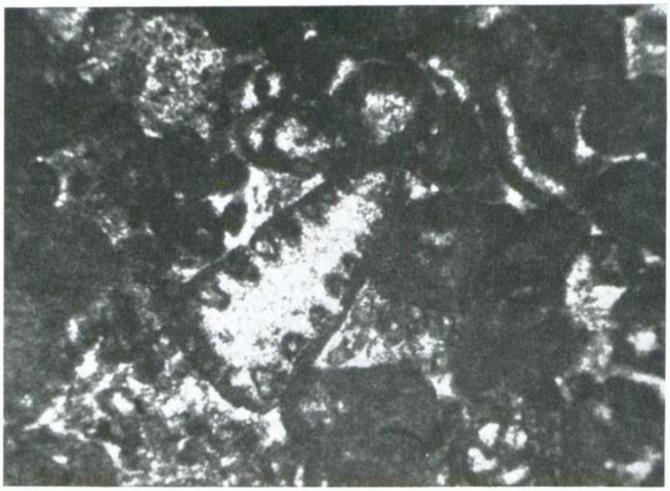
Sl. 3. *Textulariidae,* 35×, zgornja liada-dogger, Zagradec-Randol št. zb. 568—5741



Sl. 4 a. *Protopeneroplis striata* Weynschenk, 75×, spodnji malm, Zagradec-Randol, št. zb. 773—6776

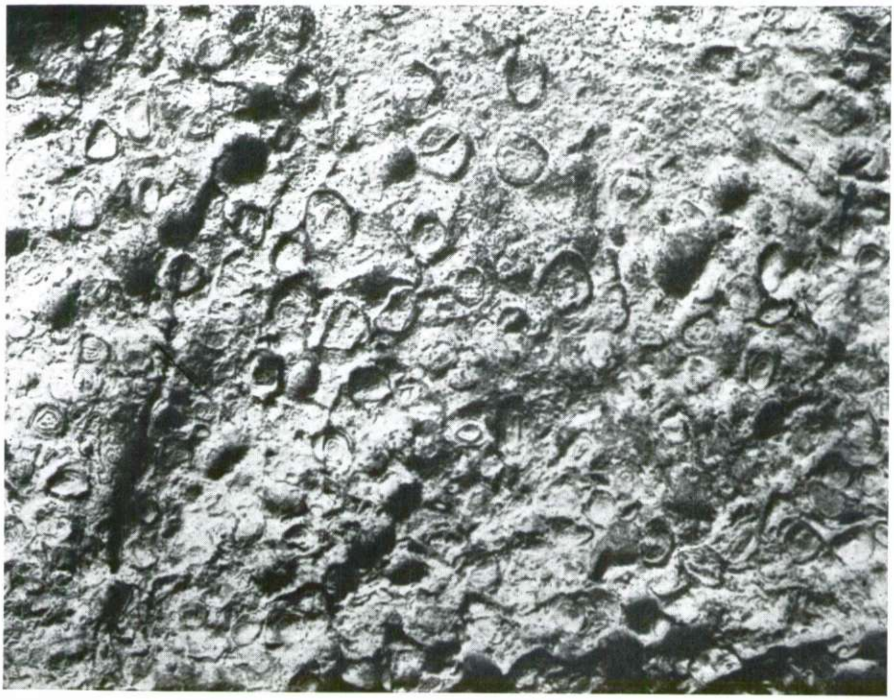


Sl. 4 b. *Protopeneroplis striata* Weynschenk, 75×, spodnji malm, Zagradec-Randol št. zb. 23—12434



Sl. 5. *Coscinoconus* sp., 35 ×, spodnji malm, Zagradec-Randol, št. zb. 711—6761

Sl. 6. *Clypeina jurassica* Favre, 32×, zgornji malm, Zagradec-Randol, št. zb. 503—5635



Sl. 1. *Sphaerocodium bornemanni* na površini glavnega dolomita. Staro Apno pri Turjaku. Naravna velikost

Fig. 1. *Sphaerocodium bornemanni* naturally washed out on the surface of upper dolomite. Staro Apno at Turjak. Natural size

Sl. 2. Zbrusek dolomita z algo *Sphaerocodium bornemanni*. Povečano 4,5-krat

Fig. 2. Thin section of dolomite including alga *Sphaerocodium bornemanni*. Enlarged 4,5×

STAROST PLASTI Z ALGO SPHAEROCODIUM BORNEMANNI ROTHPLETZ V SLOVENSKIH ZUNANJIH DINARIDIH

Stanko Buser

Z 1 skico med tekstom in 2 slikama v prilogi

Plasti z algo *Sphaerocodium bornemanni* Rothpletz so bile v Jugoslaviji prvič odkrite leta 1945. Opisal jih je leta 1952 Herak. Iz Slovenije je isti avtor določil prve sferokodije šele leta 1957.

Po podatkih geološke literature se sferokodiji v alpskem razvoju triade pojavljajo od zgornjega dela ladinske stopnje (kasian-cordevol) in segajo v zgornjo triado. Rothpletz (1891, 299) in Leuchs (1925, 7) pravita, da so te alge najbolj razširjene v kasianskih (cordevol) in posebno še v karnijskih plasteh. Herak (1952, 190) je prvi izrazil mišljenje, da so sferokodiji razširjeni tudi v plasteh noriške stopnje. Rothpletz (1891, 299 in 300) pa jih je našel tudi v plasteh retske stopnje.

Sphaerocodium bornemanni ima kroglast talus s koncentrično zgradbo, podobno oolitni. Na prerezih so lepo vidne posamezne plasti, ki jih predstavljajo enocelična vlakna individuov. Med plastmi, oziroma kroglastimi talusi, so tanki pasovi prikamenine, navadno temnejši kot talusi, ki jih na terenu zato lahko opazimo. Kroglaste plasti talusov povečini obdajajo drobec kamenine ali majhen odlomek lupine. Prve notranje plasti imajo zato več ali manj obliko tujega vključenega telesa, medtem ko so zunanje plasti lepo okrogle, oziroma grudaste. Velikost kroglastih alg je od 1 do 16 milimetrov. Na raznih lokalitetah se dobe tudi različno velike alge. Povečini nastopajo alge tesno druga ob drugi in so kamenotvorne; zato kažejo plasti videz oolitne zgradbe (1. in 2. sl.).

Pri geološkem kartiranju smo dognali, da se pojavlja horizont s *Sphaerocodium bornemanni* v slovenskih zunanjih Dinaridih v srednjem delu glavnega dolomita, ki pripada noriški in retski stopnji zgornje triade. Ta dolomit je litološko skoraj povsod enako razvit od spodnjega do zgornjega dela.

Na doslej kartiranem ozemlju slovenskih zunanjih Dinaridov so pod glavnim dolomitom povsod plasti karnijske stopnje, ki jih predstavljajo rdečkast peščenjak, argilit, lapor, breča, konglomerat in tufi. Ponekod je razvit v spodnjem delu klastičnih karnijskih sedimentov črn apnenec z vmesnimi glinastimi in lapornatimi plastmi. V teh glinenolapornih plasteh se dobe značilni fosili *Pachycardia rugosa* Hauer, *Trigonodus carniolicus*

Bitt., *Myophoria kefersteini* Mün. V zgornjem delu dolomit noriško-retske stopnje postopno prehaja v spodnjejurske plasti. Noriško-retski dolomit je v slovenskih zunanjih Dinaridih tipično skladovit in pasovit ter vsebuje vložke belega zrnatega nepasovitega dolomita. Debelina noriško-retskega dolomita je 1000 do 1500 metrov.

Sphaerocodium bornemanni in drugi fosili se navadno pojavljajo v zrnatem dolomitu. Horizont z algami je debel 25 centimetrov do 2 metra. Pri Gornjih Otavah severovzhodno od Cerknice smo poleg alge *Sphaerocodium bornemanni* našli še školjko *Conchodus infraliasicus* (Wulf.) in polža *Worthenia solitaria* Benn. Severno od Dol (zahodno od Radeč) pa leži horizont s *Conchodus infraliasicus* tik pod horizontom z algami, medtem ko nahajamo plasti z megalodontidami in polži drugod nekaj metrov nad horizontom z algami. S tem je dokazano, da pripada horizont z algo *Sphaerocodium bornemanni* v slovenskih zunanjih Dinaridih povsod noriški stopnji.

Algo *Sphaerocodium bornemanni* smo dobili tudi v spodnjem delu karnijskega črnega lapornatega apnenca na hribu Zaplaz pri Čatežu. To najdišče leži na meji Posavskih gub. Karnijske plasti leže tukaj na belem zrnatem cordevolskem dolomitu. S tem je v Sloveniji sedaj prvikrat najdena ta alga tudi pod noriško-retskim dolomitom. Vendar s tem ni izgubila stratigrafskega pomena za slovenske zunanje Dinaride, kjer jo dobimo samo v glavnem dolomitu. Imeti moramo vedno pred očmi, da je lahko isti fosil, ki za določeno območje ni vodilen, drugod vodilen, ker se pojavlja v stalnem horizontu.

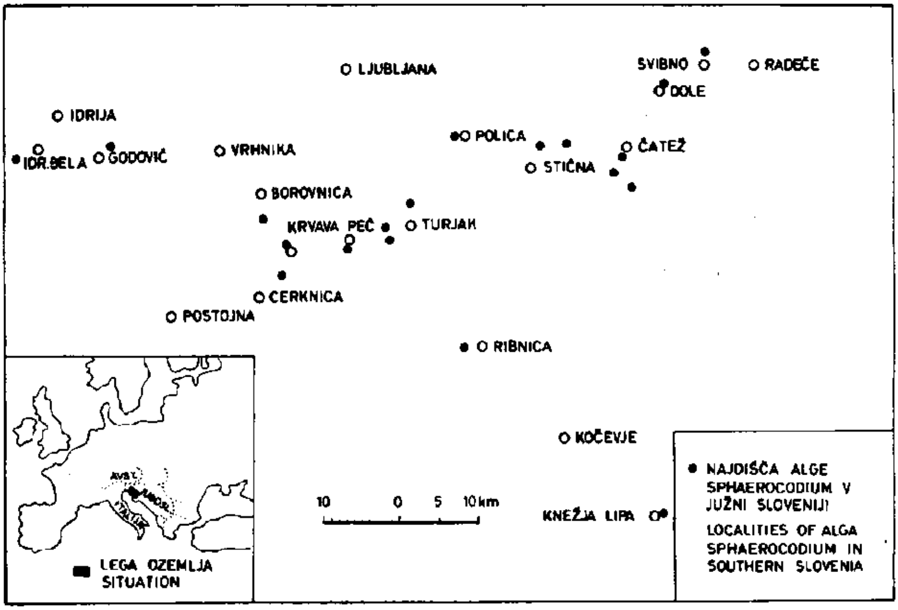
Nad horizontom z algami leži v slovenskih zunanjih Dinaridih še v znatni debelini litološko popolnoma enak dolomit, ki pripada delno še noriški delno pa že retski stopnji. Po postopnem prehodu glavnega dolomita v plasti spodnje jure sklepamo, da je povsod razvita tudi retska stopnja, ki je pa zaradi pomanjkanja fosilnih ostankov in litološko enako razvitega dolomita ne moremo ločiti od noriške stopnje.

Opis važnejših najdišč sferokodijev

3. sl.

Dolina Bele pri Idriji. V zgornjem delu kanjonske doline, vrezane v glavni dolomit, nastopa v zrnatem dolomitu med pasovitim dolomitom okoli 2 metra debela plast, ki je vsa polna alg *Sphaerocodium bornemanni*. Ta plast leži okoli 600 metrov nad plastmi karnijske stopnje dokazanimi s fosili. Tik nad horizontom s sferokodiji slede skladi s školjkami *Conchodus infraliasicus*. Plast z algami se da več ali manj kontinuirno slediti na dolžini okoli dva kilometra. Nad horizontom s sferokodiji leže še okoli 500 metrov debele plasti glavnega dolomita, ki na severnem pobočju Trnovskega gozda prehajajo v spodnjeliadne plasti.

Godovič. Ob cesti Godovič—Zavratec je v peskolomu zdrobljenega pasovitega dolomita okoli 2,5 metra debel horizont s sferokodiji, ki so zelo lepo ohranjeni. Tudi tukaj leže pod tem dolomitom klastični skladi karnijske stopnje.



Sl. 3. Najdišča alge Sphaerocodium v južni Sloveniji

Fig. 3. Localities of alga Sphaerocodium in southern Slovenia

Vrhnika. Na južnem pobočju hriba Planina zahodno od Vrhnike je v zrnatem dolomitu, ki nastopa v pasovitem glavnem dolomitu, 1 meter debel horizont s sferokodiji. Tudi tukaj leži dolomit, ki pripada noriško-retski stopnji, na karnijskih plasteh.

Borovnica. Ob stezi, ki se vzpenja po strmi grapi Pekel južno od Borovnice, vsebuje pasoviti dolomit okoli 1,75 metra debelo plast s sferokodiji. Ta plast leži okoli 400 metrov nad klastičnimi sedimenti karnijske stopnje. Precej visoko nad plastjo s sferokodiji sledi bel zrnat dolomit z megalodontidami.

Cerknica. Pri vasi Selšček severovzhodno od Cerknice, kjer se odcepi cesta proti Rakitni, sta v pasovitem noriško-retskem dolomitu dve po en meter debeli plasti s sferokodiji. Ob isti cesti, ki pelje od vasi Gornje Otave proti Rakitni, smo našli tik nad horizontom s sferokodiji tudi školjko *Conchodus infraliasicus* in polža *Worthenia solitaria*. Tu je nesporno dokazano, da pripada horizont s sferokodiji noriški stopnji zgornje triade.

Turjak. Pri vaseh Četež, Visoko in Staro apno v okolici Turjaka je največ najdišč sferokodijev na vsem raziskanem ozemlju. Tudi tukaj nastopa v glavnem dolomitu od 1 do 2 metra debel horizont s sferokodiji, ki se da slediti, delno prekinjeno, na več kilometrov. V vsej dolžini leži dolomit konkordantno nad plastmi karnijske stopnje. Tukaj lahko omenimo tudi več najdišč sferokodijev v glavnem dolomitu južno od vasi Krvava peč, kjer gradi ta dolomit večji del strmih sten Iškega Vintgarja.

Knežja lipa. Z območja Kočevske je že Herak opisal plasti s sferokodiji; primerke mu je poslal pokojni Germošek (Herak 1957, 31 in 33). Tudi v okolici Knežje lipe na Kočevskem so sferokodiji v glavnem dolomitu, ki leži na klastičnih sedimentih karnijske stopnje in torej pripada noriško-retski stopnji. *Sphaerocodium bornemanni* se pojavlja v srednjem delu glavnega dolomita, ki vsekakor pripada še noriški stopnji.

Najdišča sferokodijev na Kočevskem so naravno nadaljevanje najdišč v okolici Ribnice, Turjaka in Krvave peči. Proti jugovzhodu se nadaljujejo skladi glavnega dolomita s Kočevskega v sosednjo Hrvatsko, kjer dolomit s sferokodiji prav gotovo tudi pripada noriški stopnji.

Polica. Ob cesti v strmem vseku na zahodni strani vasi Polica smo našli sferokodije v temno sivem pasovitem glavnem dolomitu. Plast z algami je debela okoli 30 centimetrov. Zanimivo je to, da se dobi ob isti cesti, že zgoraj na ravnini, še več plasti s sferokodiji, ki so med seboj ločene s plastmi brez alg. Vendar so v teh višjih plasteh, ki leže okoli 55 metrov nad spodnjo plastjo z algami, primerki sferokodijev bolj zakrneli in niso tako številni. V vmesnih plasteh med spodnjim in zgornjim horizontom s sferokodiji se dobe v belem zrnatem dolomitu primerki školjke *Conchodus* cf. *infraliasicus*.

Dole. V vseku nove ceste severno od Dol je najden v pasovitem dolomitu okoli 2 metra debel horizont s sferokodiji. Zanimivo je, da leži tukaj plast z megalodontom *Conchodus infraliasicus* 35 metrov pod horizontom s sferokodiji.

Svibno. Na strmem južnem pobočju od Svibnega so sferokodiji v belem zrnatem glavnem dolomitu, ki je litološko zelo podoben kasianskemu (cordevol) dolomitu zgornjega dela ladinske stopnje.

Dve zadnji najdišči ležita v Posavskih gubah in kažeta, da se *Sphaerocodium bornemanni* pojavlja tudi zunaj območja zunanjih Dinaridov.

Julijske Alpe. Na območju Mangarta leži glavni dolomit s sferokodiji, o katerih je poročal že Herak (1957, 35), na klastičnih sedimentih karnijske stopnje in verjetno pripada noriški stopnji zgornje triade. V zadnjem času pa na tem območju nismo raziskovali in zato nimamo novih podakov o starosti plasti s sferokodiji v Julijskih Alpah.

THE AGE OF THE STRATA WITH THE ALGA SPHAEROCODIUM BORNEMANNI ROTHPLETZ IN THE SLOVENE EXTERNAL DINARIDS

During the geological mapping of the Slovene external Dinarids we succeeded in getting many particulars about the age of that strata containing the Alga *Sphaerocodium bornemanni* Rothpletz. The algal remnants appear in the 25 cm to 2 m thick horizon in the dolomite of the Noric stage. At Gornja Otava NE of Cerknica besides *Sphaerocodium bornemanni* also the shell *Conchodus infraliasicus* (Wulf.) and the snail

Worthenia solitaria Benn. have been discovered. North of Dole (West of Radeče) the horizon with the *Conchodus infraliasicus* appears just under the horizon of sphaerocodiums. In the most localities the stratum with megalodontids and snails lies some metres above the algal horizon. It is proved that the strata with *Sphaerocodium bornemanni* of the Slovene external Dinarids belong to the Noric stage of the Upper Triassic.

Above the horizon with sphaerocodium a thick series of dolomites lies, which is lithologically completely the same and belongs partly to the Noric and partly already to the Rhaetic stage.

On the southern border of Sava folds, and that at Čatež village alga *Sphaerocodium bornemanni* Rothpletz occur also in black marly limestone of lower part of Carnic stage.

LITERATURA

Herak, M., 1952, Značenje alge Sphaerocodium Bornemanni Rothpletz za interpretaciju gornjeg triasa u području Zagorske Mrežnice. Rad Jugosl. Akad. 289, p. 187—195. Zagreb.

Herak, M., 1956, O mezozoiku područja Korane između Barilovića i Poloja. Geol. vjesnik 8-9, p. 53—66. Zagreb.

Herak, M., 1957, Novi nalazi sferokodija u Hrvatskoj i Sloveniji. Geol. vjesnik 10, p. 31—38. Zagreb.

Herak, M., 1960, Trias de la Yougoslavie. Geol., vjesnik, 15, p. 301—310. Zagreb.

Herak, M., 1963, Prilog stratigrafskoj analizi naslaga u području Slunj—Komesarac—Rakovica (Hrvatska). Geol. vjesnik 16, p. 33—44. Zagreb.

Leuchs, K., 1925, Sphaerocodium in nordalpinen Plattenkalk. Centralbl. f. Min., Geol. u. Pal., Abt. B., p. 5—8. Stuttgart.

Ogilvie Gordon, M., 1927, Das Grödener-, Fassa- und Enneberggebiet in den Südtiroler Dolomiten, III. Teil: Paläontologie. Abhandl. d. Geol. Bundesanst. 24, H. 2, p. 76—77. Wien.

Rothpletz, 1891, Fossile Kalkalgen aus den Familien der Codiaceen und der Corallineen. Zeitschr. d. Deutsch. geol. Ges. Bd. 43, H. 2, p. 295—322. Berlin.

IGNIMBRITNI TUFI PRI PODLJUBELJU

Ančka Hinterlechner-Ravnik

S 14 slikami v prilogi

Kratka vsebina. Na območju Podljubelja pri Tržiču smo v izdankih plasti, ki so jih doslej kartirali kot werfenske in anizične, z mikroskopsko raziskavo določili ignimbritne tufe v dveh horizontih. Ignimbritni tufi pod rudonosnim apnencem so v glavnem rdeči in beli. Vsebujejo vtrošnike prvotnega kalijevega glinenca nižetemperaturnega sanidina in ortoklaz. Nad rudonosnim apnencem pa najdemo poleg rdečih tudi zelene in sive različke, nikdar pa izrazito belih. Ti različki so pogosto spremenjeni. Značilno zanje je tudi, da so sestavljeni v glavnem iz kristalov sekundarnega albita in fragmentov plovca. Za oba horizonta pa velja, da so značilnosti ignimbritnih tufov v nekaterih vzorcih lepo ohranjene, v drugih pa zaradi devitrifikacije zabrisane. Kemično analizirani vzorec pripada ignimbritnemu tufu biotitnega porfirja.

Uvod

Jeseni leta 1965 so S. Buser, S. Dozet in J. Cajhen geološko kartirali ožjo okolico Podljubelja. V plasteh, ki so jih imeli za werfenske in anizične, so bili pozorni zlasti na izdanke kamenin, ki so jih geologi prištevali h kremenovemu porfiritu. Raznobarvne vzorce teh izdankov, ki so jih vzeli pod rudonosnim apnencem in nad njim, smo podrobno petrografsko analizirali. Nismo pa raziskali tufskih vzorcev iz tistega dela profila, ki so ga geologi že doslej šteli v wengen.

Doslej so geologi imeli orudenenje v Podljubelju za wengensko. Če je razdelitev celotnega zaporedja na werfenski, anizični in wengenski del točna, je orudenenje werfenske starosti. Vendar pa je za tak sklep treba prej ponovno preveriti celotno zaporedje plasti na podlagi paleontoloških dokazov.

O werfenskih sedimentih, podobnih tufom, je pisal Germovšek (1955, 117), o verjetni sedimentaciji produktov tedanjega vulkanizma Zorc (1955, 29), o tufih v plasteh skitske stopnje na območju Ljubeljskega prelaza pa Kahler (1959, 146).

O nastanku ignimbritnih tufov in njihovi terminologiji

Ignimbritni tufi so nastali tako, da je zelo viskozna steklasta magmatska masa zaradi velike vsebnosti plinov eksplodirala, preden se je razlila čez žrelo vulkana. Oblak eksplodiranega materiala, tako imenovani »nuée ardente«, sestavljen iz pepela plovca in značilnih konkavnih fragmentov sten prejšnjih votlinic, ki so bile zapolnjene s plini, je padel še vroč na zemljo, kjer se je začel zaradi lastne teže premikati kot lavina. Od tod izvira psevdofluidalna struktura kamenine. Zaradi visoke temperature je bil ves material še plastičen, zato so se konkavni steklasti drobci in plovec, obteženi z maso premikajočega se materiala, povečini sploščili in razpotegnili. Deformacije so različne glede na lego drobcev v tufskem materialu, najmočnejše so v sredini. Najmanjši steklasti drobci in pepel so se plastično ovili okrog vtrošnikov in večjih kosov plovca, ki so predstavljali oviro za premikajoči se material.

Za ignimbritne tufe je tudi značilno, da so se lahko posamezni steklasti drobci med seboj zvarili, kar je posledica visoke temperature in njihovega neposrednega medsebojnega stika. Visoka temperatura, počasno ohlajanje in prisotnost plinov pa so navadno povzročili tudi devitrifikacijo steklastih komponent. Devitrifikacija je pogosto popolnoma zabrisala značilne strukture, zlasti vitroklastično, ki pa se je ohranila, če so drobci kristalizirali z aksiolitno strukturo. Zaradi limonitizacije pa značilne strukture kljub devitrifikaciji pogosto vidimo brez analizatorja. Strukturne razlićke tufov je laže ločiti v mlajših kameninah kot v starejših. Produkte devitrifikacije stekla predstavljajo po literaturnih podatkih ortoklaz, tridimit in kristobalit. V starejših vulkanskih kameninah preideta tridimit in kristobalit v kremen. Te zelo drobno zrnate agregate so analizirali po rentgenski difrakcijski metodi.

Vtrošniki, ki so za ignimbritne tufe tudi značilni, so idiomorfni, hipidiomorfni in pogosto nalomljeni. Nastajali so že v intratelurni fazi, ko so bili tudi magmatsko korodirani. Vtrošniki pripadajo večinoma kremenu in kislim plagioklazom.

Ignimbritni tufi nastajajo predvsem iz zelo viskoznih, kislih in srednjekislih magem.

Raziskovalci si danes glede pomena izraza ignimbrit niso enotni. Neenotnost izvira od tod, ker ga uporabljajo za različne pojme. Vulkanologi označujejo z njim vrsto erupcije, medtem ko ga nekateri geologi uporabljajo kot ime določene skupine kamenin, drugi pa celo kot vrsto kamenin.

Vulkanologi so prvotno razlikovali dve glavni vrsti eruptivnih produktov: lavo in tefro, oziroma tuf. Sčasoma se je pokazala potreba, da se za vmesne člene najdejo novi izrazi; Lewinson-Lessing (Armenskoje vulkaničeskoje negorje. Prir. 5, 1928), je vpeljal tufolave kot tretji tip efuzivov, Marshall pa leta 1932 pojem ignimbritov. Nekatere vrste kamenin obeh skupin so si zelo podobne. Vendar izraza tufolava in ignimbrit nista identična in ju mnogi avtorji nedosledno uporabljajo. Strukture tufolav in ignimbritov, ki jih opazujemo pod mikroskopom, pa so lahko enake (Pichler, 1963).

Tufolava je po **V l o d a v c u** (1953) avtobrečasta lava; nastaja v notranjosti lavinih potokov, če razpoke v manj viskoznih delih lave zapolnijo drobci iz njenega bolj viskoznega toka. Pod nadaljnjimi mehaničnimi vplivi se zvišujeta pritisk in temperatura, tako pride do plastičnih deformacij in s tem v zvezi do podobnih struktur kot so ignimbritne. Vendar so tako nastale strukture redke. Po **P i c h l e r j u** razlikujemo tufolave od ignimbritov po tem, da so plasti tufolave tanjše in manj razsežne.

Izraz ignimbrit bi bilo možno opustiti. Ker pa je v literaturi tako zelo razširjen, ga bi bilo težko odpraviti. Vendar ga v petrografskem pomenu ne smemo več uporabljati v samostalniški obliki, temveč le v pridevniški. »Ignimbritni riolit« je petrografski izraz, medtem ko je »riolitni ignimbrit« vulkanološki pojem (**V l o d a v e c**, 1964). »Ignimbritni izbruh« je poseben tip vulkanskega izbruha. Njegovi produkti imajo obliko pokrova, sestavljenega v prerezu iz različnih kamenin: vulkanskega pepela, (nezvarjenega) tufa, delno zvarjenega tufa, zvarjenega tufa in rahlega plovca, ki kažejo posebne strukture. Za petrografsko vrednotenje je potrebno raziskati celoten profil, medtem ko na stratigrafski pomen kažejo tudi posamezni kosi tufolav oziroma ignimbritnih tufov. Ignimbritne usedline moramo petrografsko še posebej določiti kot npr. ignimbritni riolitni tuf. V tem smislu smo izraz ignimbriten v tem članku tudi uporabljali.

Petrografska raziskava podljubeljskih ignimbritnih tufov

Podrobno smo petrografsko analizirali vzorce ignimbritnih tufov iz izdankov v skitskih in anizičnih sedimentih. Tudi tufski različki v wengenskih skladih tega območja kažejo vitroklastično strukturo, natančneje pa njihovih vzorcev še nismo raziskali.

Analizirani različki se med seboj ločijo po barvi in po sestavi. Za ignimbritne tufe pod rudonosnim apnencem sta značilni predvsem rdeča in bela barva, medtem ko nad rudonosnim apnencem najdemo poleg rdečih različkov tudi več zelenih in sivih, nikdar pa izrazito belih. Zaradi različnih odtenkov barv vidimo pogosto že megaskopsko, zlasti na rdečih različkih, da so sestavljeni iz fragmentov različne velikosti od enega milimetra do nekaj centimetrov, s čimer prehajajo že v breče.

Bistvena značilnost ignimbritnih tufov pod rudonosnim apnencem je, da vsebujejo kot vtrošnik prvotni kalijev glinenec, nižetemperaturni sanidin kriptopertit, ki včasih prehaja v ortoklaz. Nižetemperaturni sanidin dokazuje počasno hlajenje tufske mase. Vtrošniki in osnova ignimbritnih tufov, ki leže nad rudonosnim apnencem, pa so spremenjeni. Plagioklaz je zastopan v vseh pregledanih vzorcih s sekundarnim albitom, ki je pogosto že tudi kalcificiran in sericitiziran. V laboratorijski zbirki pa imamo tudi vzorce, ki jih je v zgornjem horizontu nabral **B e r c e** leta 1953; ti vsebujejo svež sanidin. Vtrošniki glinencev v starejših ignimbritnih tufih so redki (do 15 %), medtem ko kristali glinencev v mlajših ignimbritnih tufih včasih v kamenini prevladujejo.

Iz izdankov pod rudonosnim apnencem smo petrografsko raziskali vzorce št. 701, 1173 (štirje različki), 1216, 1259, 1381, 1454, ki so vijoličasto rdeči, sivi, beli in zeleni. Zaradi različnih odtenkov vidimo pogosto že megaskopsko, zlasti na rdečih različkih, da so sestavljeni iz fragmentov različne velikosti od enega mm do nekaj cm.

Strukture teh vzorcev smo pod mikroskopom zlasti lepo opazovali brez analizatorja v zbruskih rdečih različkov. Vulkanski fragmenti so včasih precej močno deformirani (sl. 1a in 1b). Plovec je pogosto popolnoma stisnjen ali (v belih različkih) zelo razpotegnjen ter žarkovito kristaliziran. Redki fragmenti, predvsem večji, ki imajo jasno laminacijo in včasih drobne spremenjene vtrošnike plagioklaza, pa niso deformirani (sl. 2). Take fragmente smo našli tudi v ignimbritnih tufih v krovnini rudonosnega apnenca.

Osnovo pregledanih ignimbritnih tufov sestavljajo steklasti drobci značilnih oblik (sl. 1a in 2a) in najfinejši vulkanski pepel. Redko smo opazovali skoraj popolnoma ohranjene podolgovate votlinice nekdanjih plinskih mehurčkov (sl. 1a). Steklo je mikro do zelo drobno devitrificirano in ga pod mikroskopom ni mogoče natančneje določiti. Značilna je aksiolitna struktura devitrificiranih drobcev (sl. 1a in 1b). Beckejeva črta osnove je glede na vtrošnike sanidina pozitivna, glede na kanadski balzam pa negativna. V enem samem zelo silificiranem vzorcu pa smo ugotovili pozitivno Beckejevo črto. V tem vzorcu (št. 1 454) je tudi vtrošnik sanidina včasih nadomeščen z drobnozrnatim kremenom in albitom (sl. 3). V osnovi rdečih različkov sta drobno dispergirana magnetit in hematit, osnova belih različkov pa je kalna. V rdečih vzorcih ni samo osnova obarvana z železovimi oksidi, temveč tudi litoidni fragmenti, ki se pa zaradi različne koncentracije oksidov jasno odražajo od osnove kamenine. V osnovi zelenkastih različkov je drobno dispergiran klorit; večje luske smo opazovali le redko. Včasih je osnova delno sericitizirana. Akcesorna so posamezna nekoliko večja zrna železovih oksidov in apatit.

Kot vtrošniki nastopajo kalijevi glinenci. V belih različkih so pogosto popolnoma kaolinizirani, v rdečih pa smo našli kristalno čist sanidin kriptopertit (sl. 1a, 1b, 2a in 2b). Skoraj pri vseh meritvah sanidina po metodi Fedorova smo ugotovili rahla odstopanja od monoklinske mreže, ker ta metoda za določanje kalijevih glinencev ni najbolj natančna. Kot optičnih osi, kemična analiza kamenine, steklast lesk in prosojnost kristala pa jasno govore za sanidin. Njegovi kristali so hipidiomorfni, včasih nalomljeni, z lepimi sledovi magmatske resorbcije. Navadno so poedinci, redko dvojčični, predvsem po bavenskem zakonu, a tudi po karlovarskem in manebaškem ter tvorijo lepe kombinacije. Sliki 1a in 1b kažeta magmatsko korodiran sanidinov vtrošnik, zraščen po levem in desnem bavenskem ter po manebaškem zakonu. Na dveh rahlo conarnih zrnih (sl. 2a in 2b) smo lahko neposredno zmerili spremembo kota optičnih osi od jedra proti ovoju; vrednosti $2V_x$ so se spreminjale pri prvem zrnu od 24° do 36,5°, pri drugem pa od 17,5° do 28,5°. Na drugih zrnih se je neposredno izmerjen kot optičnih osi $2V_x$ spreminjal od 14° do 40°, povprečje znaša 26,7° (merjenih 35 zrn). Ravnina optičnih osi je pravokotna na ploskev (010), kar dokazuje nižetemperaturno obliko sanidina in počasno hlajenje tufske mase. Variaciji kota optičnih osi ustreza do 62 % albita in anortita, glede na povprečni kot $2 V_x$ pa je 23 % te komponente v seriji sanidin-anortoklaz kriptopertit (D e e r, H o w i e, Z u s s m a n, 1963, 58).

V belih različkih nastopajo predvsem vtrošniki ortoklaza. V nekaterih različno obarvanih vzorcih opazujemo posamezna zrna s prehodi sanidina v ortoklaz, pri tem je del zrna, ki pripada ortoklazu, kalen. Na sl. 4 tega karlovarskega dvojčka pripada na temnem zrnu svetlejši del ortoklazu, temnejši sanidinu; na svetlem zrnu dvojčka pa je obratno.

Vtrošniki ortoklaza so idiomorfni in hipidiomorfni, včasih nalomljeni, le redko magmatsko korodirani. Večini so poedinci, redkeje dvojčični, zraščeni po karlovarskem, manebaškem in tudi bavenskem zakonu. Vedno so rahlo kalni. Neposredno merjen kot optičnih osi $2 V_x$ variira od 52° do 72° in znaša povprečno 61,5° (merjeno na 12 zrnih). Območje vrednosti kota optičnih osi ustreza ortoklaz kriptopertitu z 22 do 43 % albita in anortita, povprečna vrednost kota optičnih osi pa ustreza 33 % te komponente (D e e r, H o w i e, Z u s s m a n, 1963, 58).

Za ignimbritne tufe nad rudonosnim apnencem je značilno, da so sestavljeni v glavnem iz kristalov in drobcev plovca [vzorci št. 514 (dva različka), 515, 516 (dva različka) in 1116 (štirje različki); sl. 5a, 5b, 6a, 6b in 7]. Relativna količina obeh komponent se zelo spreminja. Vzorec pravega kristalastega tufa kaže sl. 8; takšni tufi so na območju Podljubelja redki. Velika nehomogenost teh vzorcev je vidna že megaskopsko. Litoidni fragmenti sami lahko tudi vsebujejo posamezne manjše vtrošnike. Deli, kjer opazujemo v zbrusku najfinejši vulkanski pepel, so pogosto še skoraj izotropni (sl. 6b). Kristali mlajših ignimbritnih tufov pripadajo sekundarnemu albitu, ki je zelo neenoten (sl. 5b in 6b). Prvotna oblika kristalov pa je ohranjena; zrna so hipidiomorfna in pogosto magmatsko korodirana. V rdečkastih različkih so plagioklazi rahlo limonitizirani. Pogosto so kalcificirani in sericitizirani. V zrnih, merjenih po metodi Fedorova, znaša količina anortita nekaj procentov, redko do 10 % an, v enem samem zrnu pa 20 % an. Kot optičnih osi $2 V_x$, merjen neposredno, variira od 84° do 88°, povprečni kot optičnih osi je 87,7° (merjenih 9 zrn). Pri meritvi ene same optične osi pa variira kot $2 V_x$ od 84° do 92° in znaša povprečno 89° (merjenih 15 zrn). Glede na povprečni kot optičnih osi ustreza sestava plagioklaza nizkotemperaturnemu oligoklazu s 16 % an (D e e r, H o w i e, Z u s s m a n, 1963, 134). Na fragmentih plovca in ob zrnih plagioklaza kamenin tega horizonta opazujemo pogosto zelo lepe plastične deformacije. Prav tako so ohranjeni lepi steklasti fragmenti z aksiolitno strukturo in s sledovi sintranja (sl. 6a in 7). Fragmenti plovca so pogosto žarkovito kristalizirani. Redki fragmenti kažejo tudi koncentrične zunanje robove okrog radialno kristaliziranih sferulitov (sl. 5b in 6b). Zanimivi so fragmenti plovca s scefranimi robovi, ki so nastali ob eksplozijah plinskih mehurčkov in so zelo lepo ohranjeni (sl. 7) ter le delno deformirani. Posamezni večji litoidni in majhni steklasti fragmenti nekaterih vzorcev so močno kalcificirani.

Značilni vtrošnik, zastopan skoraj v vsakem vzorcu s posameznimi luskami, je biotit. Pogosto je svež, včasih pa limonitiziran. Luske svežega biotita kažejo pleohroizem svetlo zelene do temno rjave, skoraj črne barve. Včasih so le rjavo pleohroične. Luske so navadno nalomljene. Zanimivi so redki, a lepi pojavi magmatske korozije tudi na tem kristalu (sl. 9). Zelenkaste rogovače, ki po literaturnih podatkih nastopa v magmatskih kameninah Podljubelja (B e r c e, 1954), v naših vzorcih nismo našli. Isto velja za vtrošnik kremena (sl. 8).

Pregledani vzorci imajo psevdofluidalno (sl. 2 in 2b, 5a in 5b, 6a in 6b, 7), in eutaksitsko (sl. 1a in b) strukturo, poudarjeno s subparalelno ali paralelno orientacijo litoidnih fragmentov in vtrošnikov. Ta struktura ignimbritnih tufov je tem bolj izrazita, čim večje so bile obtežitve med konsolidacijo kamenine. Steklasti drobci so pod velikimi pritiski izgubili svoje značilne konkavne oblike in so zelo sploščeni. Opazujemo različne stopnje plastičnih defomacij; nedeformirani drobci so redki (sl. 1a in 7). Tuji fragmenti, naknadno vključeni v tufsko maso, niso plastično deformirani.

Pregledani vzorci pripadajo ignimbritnemu tufu biotitnega porfirja oziroma trahita. Kamenine mlajših izbruhov, nad rudonosnim apnencem, so albitizirane in predstavljajo ignimbritni tuf biotitnega keratofirja.

Vtrošniki vulkanske kamenine lahko dajo nepravilno indikacijo o njeni sestavi. Zato smo en vzorec tudi kemično analizirali. Ker beli različki vsebujejo delno spremenjene plagioklaze, smo za analizo izbrali rdeč različek s svežimi vtrošniki sanidina. Povprečni neposredno merjeni kot optičnih osi $2\,V_x$ sanidina tega vzorca, merjen na 9 zrnih, je $26{,}9^0$. Podatki kemične analize se skladajo z opazovanji pod mikroskopom. V 1. tabeli je podana kemična analiza, preračunana na CIPW formulo in na Nigglijeve parametre. Nigglijevi parametri nam povedo, da pripada analizirana kamenina kalijevi (mediteranski) provinci, natančneje leukosienitskemu-granitskemu rapakiwitskemu tipu magme in je salična, kisla, bogata z alkalijami in siromašna s c (B u r r i, 1959). Vzorec spada med redke različke triadnih vulkanskih kamenin pri nas, ker je zelo bogat s kalijem in skoraj ne vsebuje natrija in kalcija.

Kamenine, ki smo jih določili kot ignimbritne tufe biotitnega porfirja in biotitnega keratofirja, je B e r c e imenoval kremenov porfirit in pripomnil, da kemične analize govore bolj za kremenov keratofir. Našel ga je samo v werfenskih plasteh in ga je imel za produkt wengenskega vulkanizma (B e r c e, 1954).

Ob vulkanskih eksplozijah na območju Podljubelja so drobci padali delno tudi v morje. Tam so se relativno hitro ohladili in pomešali z večjimi količinami drugega sedimentacijskega materiala. Taka kamenina lahko nakazuje, kako daleč je prišel pepel ob določenem vulkanskem izbruhu. V teh vzorcih ne opazujemo struktur, značilnih za ignimbritne tufe. Pregledali smo en sam tak različek (vz. 701), sestavljen pretežno iz steklastih drobcev značilnih konkavnih oblik, ki pa vsebuje tudi rekristalizirane, s kloritom zapolnjene mikrofosile. Na steklastih fragmentih smo opazovali sicer določeno orientacijo, vendar kot posledico sedimentacije.

Povzetek

V okolici Podljubelja smo ugotovili ignimbritne tufe. Nahajajo se pod rudonosnim apnencem in nad njim v plasteh, ki so jih do sedaj kartirali kot werfenske in anizične. Značilnosti ignimbritnih tufov so v nekaterih vzorcih lepo ohranjene, v drugih pa zaradi devitrifikacije zabrisane. Ignimbritni tufi pod rudonosnim apnencem so ohranjeni sveži in vsebujejo vtrošnike nižetemperaturnega sanidina in ortoklaza, nad rudonosnim apnencem pa so včasih še delno steklasti, albitizirani, kalcificirani in sericitizirani. Kemično analiziran vzorec pripada ignimbritnemu tufu biotitnega porfirja.

IGNIMBRITNI TUF BIOTITNEGA PORFIRJA — IGNIMBRITE TUFF OF BIOTITE PORPHYRY

1 173 b/11 474

1. tabela — Table 1

a) Kemična analiza / Chemical analysis

SiO_2	70,72	71,17
TiO_2	0,17	0,17
Al_2O_3	13,24	13,32
Fe_2O_3	1,87	1,88
FeO	0,63	0,64
MgO	0,94	0,95
CaO	0,30	0,30
Na_2O	0,70	0,71
K_2O	10,40	10,46
P_2O_5	0,07	0,07
H_2O^+	0,37	—
H_2O^-	0,21	—
CO_2	0,07	0,07
S	0,26	0,26
Vsota / Total	99,95	100,00

b) Normativni mineralni sestav / CIPW norms

q	25,44
c	0,82
or	61,72
ab	6,29
hy_{Mg}	2,4
mt	0,70
hm	1,44
il	0,31
ap	0,31
cc	0,2
pr	0,48
	100,11

$\frac{Sal}{Fem}$	16,14
$\frac{Q}{F}$	0,37
$\frac{K_2O' + Na_2O'}{CaO'}$	∞
$\frac{K_2O'}{Na_2O'}$	9,25
Formula CIPW	I,4,1,1

c) Nigglijevi parametri / The Niggli-parameters

al	41,46
fm	18,04
c	1,58
alk	38,92
si	378
k	0,9
mg	0,42

Analiziral:
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IGNIMBRITE TUFFS AT PODLJUBELJ (SLOVENIA)

Abstract. In the region of Podljubelj in Karavanke mountains by petrographical analyses ignimbrite tuffs in two distinct horizons mapped up to now as Werfenian and Anisian were determined. The ignimbrite tuffs laying under the mineralized limestone generally are red or white in colour, and characterized by phenocrysts of low-sanidine and orthoclase. The ignimbrite tuffs occuring over the mineralized limestone are of green and gray colour too, but never distinctly white, often composed essentially of crystals and pumice fragments. Phenocrysts are albitized, samples in the whole rather altered. The ignimbrite tuffs characteristics in some samples of both horizons are good conserved, in others due to devitrification obliterated. The chemically analyzed sample belongs to biotite-porphyry ignimbrite tuff.

Introduction

In the year 1965 the near vicinity of Podljubelj was mapped geologically by S. Busser, S. Dozet, and J. Cajhen. Examining the strata considered as Werfenian and Anisian, they paid especially attention on rock outcrops, which were determined by geologists as quartz porphyrite. Variegated samples of those outcrops occuring under and over the mineralized limestone were petrographically examined, while tuff intercalations in Wengenian sediments, which follow in the section, are not closely determined.

The mineralization with cinnabar at Podljubelj has been considered to be of Wengenian age. If the stratification of the geological sequence of strata in Werfenian, Anisian and Wengenian is correct, the mineralization is of Werfenian age. But for this conclusion the stratigraphical sequence is to be proved again paleontologically.

Germovšek for the first time (1955, 17) wrote about Werfenian sediments like tuffs, Zorc (1955, 29), supposed the sedimentation of products of Werfenian volcanism, while Kahler (1959, 146) stated tuffs in the beds of Scytian stage in the region of Ljubelj pass.

Petrographic characteristics of ignimbrite tuffs at Podljubelj

Ignimbrite tuffs petrographically analyzed occur in two distinct horizons varying in colour and in composition. For ignimbrite tuffs overlain by the mineralized limestone red and white colour are characteristic, while the tuffs underlain by the mineralized limestone are of green and gray colour too, but never distinctly white. Owing to different colour shades especially in red samples, we see often megascopically that ignimbrite tuffs are composed of fragments of different size, varying from one milimeter to some centimeters, thereby, grading over into breccias.

The ignimbrite tuffs overlain by mineralized limestone are characterized by phenocrysts of low-sanidine, which sometimes passes over into orthoclase. But phenocrysts and matrix of ignimbrite tuffs occurring over the mineralized limestone are altered. Plagioclase phenocrysts belong to secondary low-albite and are often calcitized and sericitized. In our laboratory collection there are also some samples from the upper horizon collected by Berce (1954), which contain low-sanidine phenocrysts too. In tuffs of lower horizon phenocrysts of alkali felspar are scarce (to 15 %), while plagioclases in younger ones sometimes prevail.

From the lower horizon lying under the mineralized limestone nine samples were analyzed (No. 701, 1173 four varieties, 1216, 1259, 1381, 1454). The original structures have been in a great extent destroyed. But the characteristics indicating the origin of rocks are distinct, especially on limonitized samples, observed under the microscope with parallel polars. Glass shards are sometimes highly deformed (Fig. 1a and 1b). Pumice fragments are compressed or rather flattened showing development of spherulites with radial aggregates. Some larger volcanic fragments, probably alien material, showing distinct lamination, and sometimes including small altered phenocrysts of plagioclase, have not been deformed at all (Fig. 9). Similar fragments are found in the ignimbrite tuffs overlying the mineralized limestone too.

The matrix is composed of glass shards (Fig. 1 and 2a) and finest volcanic dust. Seldom circular glass-bubble walls, only slightly flattened are preserved (Fig. 1a). The devitrificated glass products are too fine grained to be identifiable under the microscope. Axiolitic structure of shards is often developed (Fig. 1a and 1b). The refraction index of the matrix is higher to sanidine phenocrysts and lower to Canada balsam. Only one sample (No. 1454) is very silicified, and even its sanidine phenocrysts are sometimes replaced with fine grained quartz and albite (Fig. 3). The magnetite and hematite microlites in the matrix, as well as in the lithic fragments give the red colour of samples. Different concentration of iron oxides makes possible megascopic distinction of tuff components. The matrix of green specimens contains microlites, and seldom fine chlorite scales.

In red ignimbrite tuffs sanidine cryptoperthite with vitreous luster occurs (Fig. 1a and 1b, 2a and 2b). Felspar phenocrysts are generally subhedral, some edges are irregular or fractured, some are rounded or irregularly embayed. Twinning is seldom absent, principal observed twin laws are Carlsbad, Baveno (left and right), and Manebach (Fig. 1a and 1b). Directly determined values of $2V_x$ for 35 sanidine phenocrysts are ranging from 14^0 to 40^0, averaging $26{,}7^0$. The average optic axial angle corresponds in composition to sanidine cryptoperthite with 23 % of albite-anorthite (Deer, Howie, Zussman, 1963, 58). In two slightly zoned sanidine phenocrysts the variation of the optic axial angles from the core to the rim has been determined. In the first grain the $2V_x$ ranges from 24^0 to $36{,}5^0$, in the second grain it ranges from $17{,}5^0$ to $28{,}5^0$. The optic axial plane is always normal to the plain (010). This orientation is characteristic for low-sanidine.

Phenocrysts of alkali felspar in samples of white colour belong to orthoclase and are often rather turbid due to alteration, caused by development of kaolinite and sericite. In some samples of different colour, there are crystals of sanidine passing to orthoclase as shown in Fig. 4. In the dark individual of this Carlsbad twin the lighter part belongs to orthoclase and the darker one to sanidine. In the lighter individual the relation is opposite.

Orthoclase phenocrysts are euhedral or subhedral, sometimes fractured, rarely rounded or embayed. Twinning, not always present, is on the Carlsbad, Manebach, seldom Baveno laws. The range of directly measured optic axial angles $2\,V_x$ in twelve orthoclase grains changes from 52^0 to 72^0, averaging $61{,}5^0$.

The ignimbrite tuffs occurring over the mineralized limestone are often composed essentially of crystals and pumice fragments [samples No 514 (two varieties), 515, 516 (two varieties and 1116 (two varieties); Fig. 5 a, 5 b, 6 a, 6 b, and 7]. Relative proportion of both components varies even in individual sections of the same sample. A crystal tuff is shown in Fig. 8, but such samples in the region of Podljubelj are scarce. Matrix composed of glass shards and finest volcanic dust is often preserved glassy (Fig. 6 b). Felspar phenocrysts of the upper ignimbritic horizon are characterized by albitization. The primary crystal shapes are preserved: they are subhedral, and often embayed and rounded. Albite is generally partly or completly replaced by calcite and sericite. In red coloured varieties albite shows slight turbidity due to limonitization. Twinning on albite law is generally present. The Fedorow-Nikitin method gives the anorthite content of some per cent, seldom about 10 %. The range of directly measured optic axial angles $2\,V_x$ in nine grains changes from 84^0 to 88^0, averaging $87{,}7^0$. The optic axial angle corresponds to low-temperature oligoclase. Pumice fragments and the matrix around the phenocrysts often show plasticity, molding and distortion. Highly flattened and unflattened characteristically shaped shards, sometimes welded (Fig. 6 a and 7), with axiolitic structure, are observable.

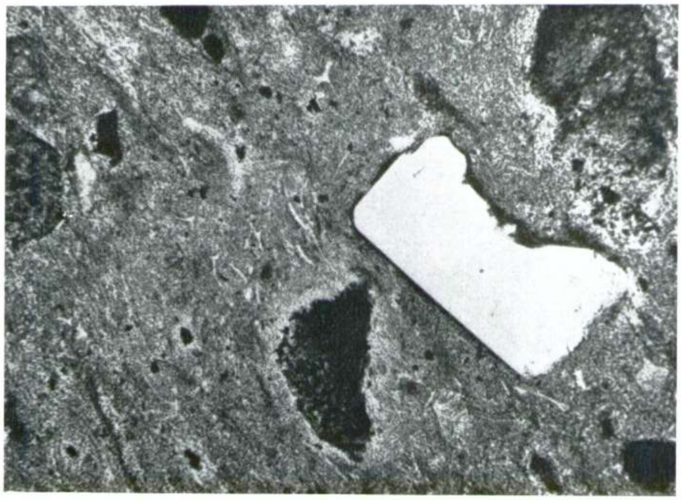
The pumice structure of larger pumice fragments is because of devitrification eliminated or hardly preserved. Some pumice fragments show development of spherulites with radial aggregates and one concentric outer rim (Fig. 5 b and 6 b). Two pumice fragments with characteristic rims showing remnants of exploded vesicle walls are shown in Fig. 7. Pumice fragments alone are devitrified. Some of them are calcitized.

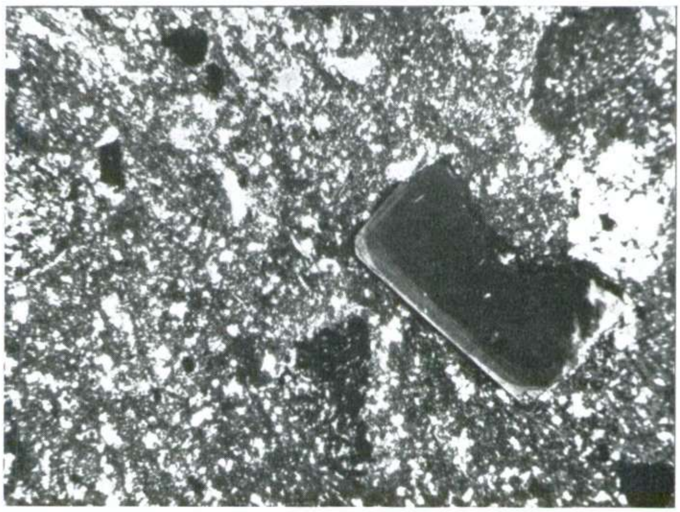
Characteristic phenocryst, present in nearly every section with single flake is biotite. It is often unaltered showing pleochroism from light green to very dark brown colour, but is often limonitized too. Its flakes are usually broken. Interesting are rare deeply embayed phenocrysts of biotite (Fig. 9).

Examined samples have for ignimbrite tuffs characteristic pseudofluidal (Fig. 2 a and 2 b, 5 a and 5 b, 6 a and 6 b, and 7) and eutaxitic texture (Fig. 1 a and 1 b), stressed with subparallel or parallel orientation of lithic fragments and phenocrysts.

Sl. 1 a in 1 b, vz. 1 173 b/11 747, nikola ‖ in +, 35×, Tominčev graben. Rdeč ignimbritni tuf z eutaksitsko teksturo. Magmatsko korodiran vtrošnik sanidina, delno razpočen mehurček z aksiolitno strukturo

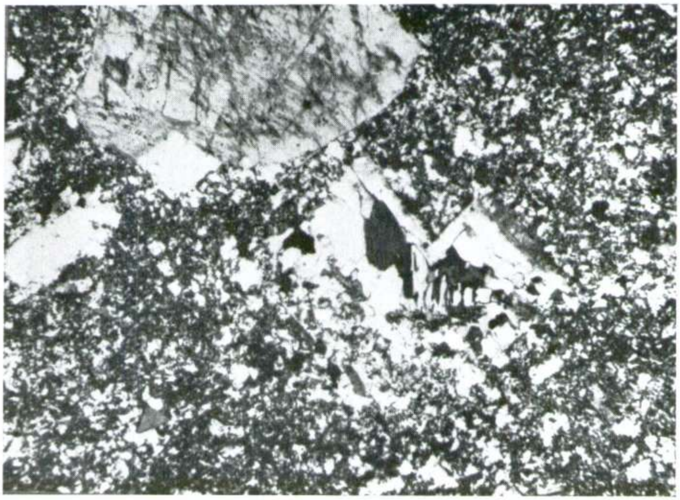
Fig. 1 a and 1 b, sam. 1 173 b/11 747, polars ‖ and +, 35×, Tominčev graben. Red ignimbrite tuff with eutaxitic texture. Resorbed phenocryst of sanidine, axiolitic structure in a partly broken bubble





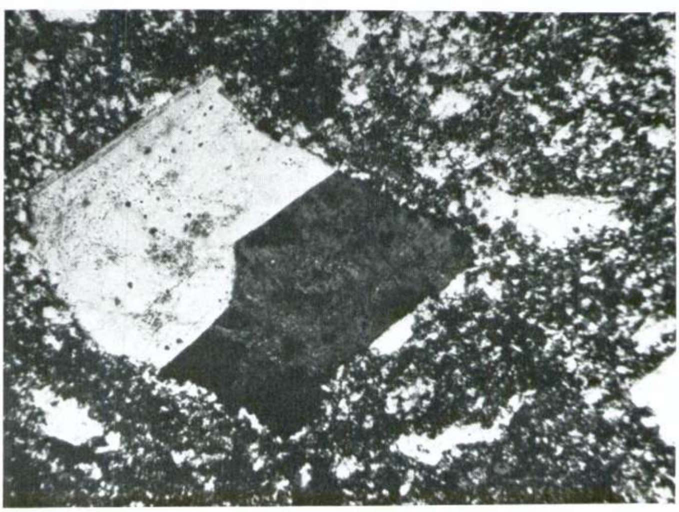
Sl. 2a in 2b, vz. 1 173 b/11 747, nikola || in +, 35×, Tominčev graben. Rdeč ignimbritni tuf. Idiomorfen in magmatsko korodiran vtrošnik sanidina, ki je rahlo conaren. Devitrificirana osnova iz zelo drobnega vulkanskega pepela in steklastih drobcev

Fig. 2a and 2b, sam. 1 173 b/11 747, polars || and +, 35×, Tominčev graben. Red ignimbrite tuff. In the middle of the figure a sharply euhedral irregularly embayed slightly zoned sanidine phenocryst. The devitrified matrix is composed of glass shards and volcanic dust



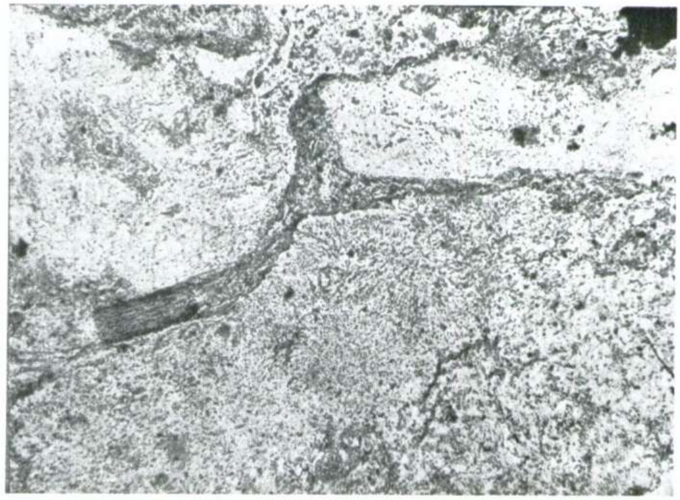
Sl. 3, vz. 1 454/11 748, nikola +, 35×, Tominčev graben. Rdeč ignimbritni tuf, devitrificiran, silificiran; plagioklaz, nadomeščen s kremenom in lamelicami kislega plagioklaza

Fig. 3, sam. 1 454/11 748, polars +, 35×, Tominčev graben. Red ignimbrite tuff, devitrified, rather silicified. The euhedral felspar replaced with fine grained quartz and sodic plagioclase



Sl. 4, vz. 1 454/11 748, nikola +, 35×, Tominčev graben. Rdeč ignimbritni tuf s psevdofluidalno teksturo. Sanidinov vtrošnik prehaja v ortoklaz. Drobnozrnata devitrificirana osnova

Fig. 4, sam. 1 454/11 748, polars +, 35×, Tominčev graben. Red ignimbrite tuff with pseudo-fluidal texture. Sharply euhedral sanidine phenocryst, passing to orthoclase. In the fine grained devitrified matrix all structures are obliterated

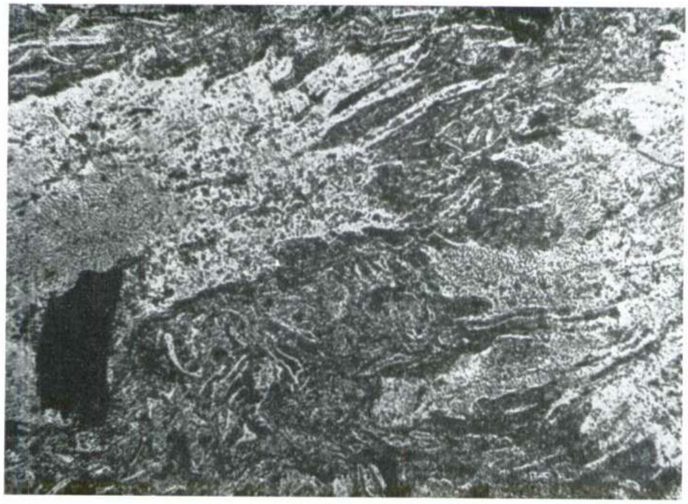


Sl. 5a in 5b, vz. 1 116 c/12 185, nikola || in +, 85×, Drmalka. Rdeč ignimbritni tuf. Sferuliti v fragmentu plovca. Dva velika, delno kalcificirana vtrošnika albita. V osnovi večinoma šibka kompresija

Fig. 5a and 5b, sam. 1 116 c/12 185, polars || and +, 85×, Drmalka. Red ignimbrite tuff. The pumice fragment is showing development of spherulites. Two large partly calcitized phenocrysts of albite. In the matrix slight compression and distortion

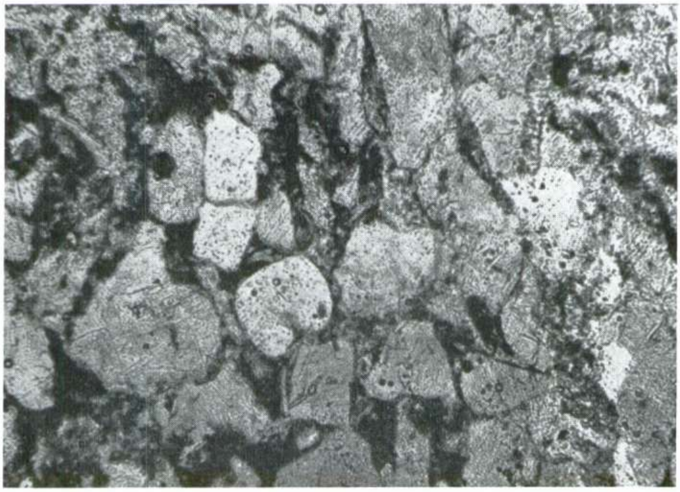
Sl. 6a in 6b, vz. 1 116 c/12 185, nikola ∥ in +, 35×, Drmalka. Rdeč ignimbritni tuf z vitroklastično strukturo, Vtrošniki albitiziranega plagioklaza, velik s sferuliti kristaliziran fragment plovca. Na različnih mestih različno deformirani in sintrani drobci stekla

Fig. 6a and 6b, sam. 1 116 c/12 185, polars ∥ and +, 35×, Drmalka. Red ignimbrite tuff with vitroclastic structure. Phenocrysts of albitized plagioclase, a large pumice fragment, showing development of spherulites. Shards thorough welded and differently compressed and distorted



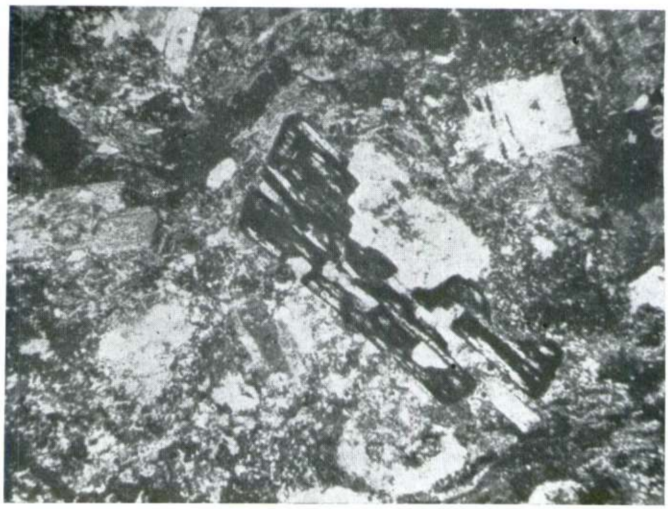
Sl. 7, vz. 1 116 c/12 185, nikola ||, 85×, Drmalka. Rdeč ignimbritni tuf. Dva fragmenta plovca z značilnimi scefranimi robovi, nastalimi ob eksplozijah plinskih mehurčkov. Steklasti fragmenti osnove so sintrani, deformacije niso najbolj močne

Fig. 7, sam. 1 116 c/12 185, polars ||, 85×, Drmalka. Red ignimbrite tuff. Two pumice fragments with characteristic rims showing remanent junctions of exploded vesicles walls. Matrix is composed of recrystallized welded shards and glass dust. Compression slightly expressed



Sl. 8a in 8b, vz. 1 883/9, nikola ‖ in +, 35×, Potočnikov graben. Rdeč kristalast tuf. Kristali albitiziranega plagioklaza, zrno kremena

Fig. 8a and 8b, sam. 1 883/9, polars ‖ and +, 35×, Potočnikov graben. Red crystal tuff. Crystals belong to albitized plagioclase, a single grain of quartz



Sl. 9. vz. 1 116 b_1/12—189, nikola +, 35 ×, Drmalka. Zelenkast ignimbritni tuf, sestavljen iz plovčevih fragmentov ter vtrošnikov albitiziranega in kalcificiranega plagioklaza. Vidimo tudi vtrošnik magmatsko korodiranega biotita. Osnova je sestavljena iz steklastih fragmentov in vulkanskega prahu, ki so delno kristalizirani in kalcificirani

Fig. 9, sam. 1 116 b_1/12 189, polars +, 35×, Drmalka, Greenish ignimbrite tuff, composed of pumice fragments and albite phenocrysts. In the middle of the figure an embayed biotite grain. Matrix shards and dust partly devitrified and calcitized

According to the petrographic description the discussed specimens belong to biotite-porphyry ignimbrite tuff or trachytic ignimbrite tuff. Younger ones, when albitized belong to biotite-keratophyre ignimbrite tuff.

Because phenocrysts of a volcanic rock may give an incorrect indication of its chemical composition, a red specimen with unaltered sanidine phenocrysts has been analyzed. The data of chemical analyses are in agreement with petrographical observation, and are given in table 1. The Niggli parameters are showing potassium province, leucosyenitic-granitic rapakiwitic magma type, which is salic, acid, rich in alkalies and scarce in c (Burri, 1959). The analyzed sample has among Triassic volcanic rocks in Slovenia an exceptional composition, being rich in potassium and scarce in sodium and calcium.

Rock determined now as biotite-porphyry ignimbrite tuff and biotite keratophyre ignimbrite tuff, considered Berce (1954) as quartz porphyrite noting already, the chemical analyses correspond better to quartz keratophyre. He found these magmatic rocks only in Werfenian strata considering them to be of Wengenian age.

About the meaning of the term "ignimbrite" different authors have not been in agreement. Confusion results from different application of the term ignimbrite. Volcanologists use it for a special kind of eruption, while geologists for special deposition or group of rocks, some even for a special kind of rock. It were possible to discard the term ignimbrite. But owing to its extended use, we have to except it. It is suggested to use this term for petrographical determinations in the adjective form only. The term "ignimbritic rhyolite" has a petrographical meaning, while the term "rhyolitic ignimbrite" has a volcanologic meaning (Vlodavec, 1964). "Ignimbritic eruption" represents a special kind of volcanic eruption named "nuée ardente", resulting in the form of a sheet, giving in the section different rocks: volcanic ash, (nonwelded) tuff, partly welded tuff, welded tuff, and a loose pumice deposition with great porosity, each of them showing special structures. Ignimbritic depositions have to be petrographically specified in addition, i. e. rhyolite ignimbrite tuff. In this manner the author used the term of such a kind of tuffs.

LITERATURA

Berce, B., 1953, Rudnik živega srebra Sv. Ana nad Tržičem, Arhiv Geološkega zavoda Ljubljana.

Berce, B., 1954, Kremenov porfirit v ožji okolici rudnika Sv. Ana nad Tržičem, Geologija 2, Ljubljana.

Burri, C., 1959, Petrochemische Berechnungsmethoden auf äquivalenter Grundlage, Basel.

Buser, S., 1966, Poročilo o geološkem kartiranju ozemlja bližnje okolice živosrebrnega rudnika v Podljubelju, Arhiv Geološkega zavoda Ljubljana.

Buser, S., Hinterlechner-Ravnik, A., 1966, Preliminary communication about the outcrops of ignimbrites in the Scytian and Anisian layers northwest of Tržič (Slovenija), Bull. Sci., Zagreb.

Carozzi, A. V., 1960, Microscopic Sedimentary Petrography, London.

Deer, W. A., Howie, R. A., Zussman, J., 1963, Rock-forming Minerals. Vol. 4, London.

Germovšek, C., 1955, O geoloških razmerah na prehodu Posavskih gub v Dolenjski kras med Stično in Šentrupertom, Geologija 3, Ljubljana.
Grad, K., 1957, Geologija Litije in okolice, Arhiv Geološkega zavoda Ljubljana.
Grad, K., 1960, Tolmač h geološki karti FLRJ — list Polšnik, Arhiv Geološkega zavoda Ljubljana.
Heinrich, E. W. M., 1956, Microscopic Petrography, London.
Hinterlechner-Ravnik, A., 1965, Magmatske kamenine v grödenskih skladih v Sloveniji, Geologija 8, Ljubljana.
Hjelmqvist, S., 1956, On the occurrence of ignimbrite in the pre-Cambrian, Sveriges Geologiska Undersökning, Ser. C. No. 542, Arsbok 49 (1955), No. 2, Stockholm.
Kahler, F., 1959, Sedimentation und Vulkanismus im Perm Kärntens und seiner Nachbarräume, Geologische Rundschau 48/1959, Stuttgart.
Karamata, S., 1959, Alkalni feldspati u našim intruzivima, Glasnik Prirod. muzeja u Beogradu, Serija A, knj. 11, Beograd.
Kropač, J., 1925, Rudnik živega srebra v Sv. Ani, Arhiv Geološkega zavoda Ljubljana.
Lewinson-Lessing, F. Ju., 1928, Armenskoje vulkaničeskoje negorje. Prir. 5.
Maucher, A., 1960, Der permische Vulkanismus in Südtirol und das Problem der Ignimbrite, Geol. Rundschau, 49/2, Stuttgart.
Pichler, H., 1963, Zur Problematik der Ignimbrit-Diagnose, N. Jb. Geol. Paläont., Abh., Bd. 118, 3, Stuttgart.
Poulieff, C. N., Rainoff, N. Iw., 1965, Sanidin in grobporphyrischen Rhyodazit aus Spahievo, Bez. Haskovo — nordöstliche Rhodopen (Bulgarien), Chemie der Erde, 24. Bd., H. 3/4.
Rittmann, A., 1952, Nomenclature of Volcanic Rocks, Bull. Volcanol., Ser. II, 12, 75—102, Napoli.
Rittmann, A., 1960, Vulkane und ihre Tätigkeit, Stuttgart.
Roberts, R. J., Peterson, D. W., 1961, Suggested magmatic differences between welded ash tuffs and welded crystal tuffs, Arizona and Nevada (Art. 320), Geol. Survey Research, Geol. Survey Prof. Paper 424-D, Washington.
Ross, C. S., Smith, R. L., 1961, Ash-Flow Tuffs: Their Origin, Geologic Relations and Identification, Geol. Survey Prof. Paper 36, Washington.
Šantar, A. A., 1966, Permske ignimbritovie otloženija južnogo sklona čatkaljskogo hrebta Tjanj-Šanja, Litologija i poleznie iskopaemie, 2.
Teller, F., Manuskriptna geološka karta 1:75.000, Radovljica.
Vlodavec, V. I., 1964, O termine »ignimbrit«, Izv. Akad. Nauk SSSR, Ser. geol., 6, Moskva.
Weyl, R., 1961, Mittelamerikanische Ignimbrite, N. Jb. Geol. Paläont., Abh., Bd. 113, H. 1, Stuttgart.
Zorc, A., 1955, Rudarsko geološka karakteristika rudnika Mežica, Geologija 3, Ljubljana.

ADOLA GOLD PLACERS AND NICKEL-CHROMIUM ORE DEPOSITS

Danilo Jelenc

With 17 photographs, 2 sketch maps, and 9 tables

Introduction

The gold-bearing area of Adola is located in a triangle bounded by the towns of Neghelli, Dilla, and Yavello in Sidamo Province (Ethiopia), and it is situated between the altitudes of 1000 and 2000 meters. The Adola district is a part of Dawa and Ganale rivers drainage system. The territory between the Awata and Mormora rivers has been the most worked, although a few areas on the left bank of the Awata river and on the right bank of the Mormora river, as well as at Dawa, Dawa Cursu, Ujima, and Aflata rivers, are partially worked.

The Adola gold-bearing area, whose center is the town Kebre Mengist (before Adola), is situated 470 km south of Addis Ababa. The road passes through Modjo, Adamitullu, Shashemene, and Wondo towns, and it is an all-weather road. From Kebre Mengist, the road extends for about 720 km to the southeast through Neghelli and Somaliland to Mogadishu. Thirty kilometers of the road to Neghelli are bad; the road then become better, and from Neghelli to Mogadishu it is good and passable throughout the year. The road leaves Dollo, the last town in Ethiopia, and continues to the border between Somalia and Ethiopia. Thus, the mining area is connected with three ports: Djibouti through Addis Ababa by railroad, Mogadishu through Somalia, and Assab through Addis Ababa by road.

The southern part of the gold-bearing area is covered partly by savanna land, and the northern part of it by forest. The climate of the area now being explored is very good. Day temperatures average about 30° C, while night temperatures are usually low.

The nickel-chromium ore deposits are situated along pre-Cambrian schists in alignment striking NNE—SSW. The western alignment strikes through Tulla and Ula Ulu mountains, and the eastern alignment through Budussa, Kenticha and Dubicha mountains.

The nickel-chromium ore deposits have been discovered 1959, most of them during the systematic geological mapping, although the green garnierite staining rock of the Kajimiti area has long been known to the local inhabitants.

Maps of the area available include one on a scale of 1 : 750 000 made by Italians, and another one of 1 : 1 000 000 made by British experts and intended mainly for flight purposes. In 1952 an aerial survey was carried out by the Ethiopian Air Force at the request of the Ministry of Mines. This surface covers about 5000 sq. km. Unfortunately, it remained in the form of photo-mosaic, and it was never transferred into a contour map. The aerophotographs have been the main basis for geological mapping, photogeological interpretation, topography of the area, and geological mapping.

From June 16—July 16, 1956, a map of the area between the Wollabo Dam-Awata pump station and Dembi valley was made by the author's prospecting group. It indicates water drainage system and roads on a scale of 1:5000 for the area being exploited at that time. The survey was based on six triangulation points and a net of polygons. All important altitudes were already leveled.

Geology of the area

The oldest rocks, the proper basement, of the region are gneiss, actinolite schist and mica schist for which the name Gari Boro series is proposed. In the northern part of the area, the gneiss is intersected by many pegmatite, aplite, and quartz veins; in the south near the junctions of the Aflata, Ujima, and Dawa rivers, the gneiss is mostly intersected by pegmatite veins. The grey gneiss grading into mica schist occurs in the form of an elongated block striking north-south.

The pegmatite, aplite, and quartz veins are essentially younger than the gneiss. Their origin is assumed to be due to a recrystallization process in tectonic lines.

Occuring in slight disconformity with highly crystallized Gari Boro series, The Adola series is composed of following rocks:

1. Amphibole schist
2. Conglomerate and sandstone
3. Chlorite-talc-tremolite schist
4. Serpentinite
5. Graphitic quartzite and white quartzite
6. Phyllitic slate
7. Sericite schist.

The mineral composition of amphibole rocks varies widely (Figs 1, 2, 3). The first type comprises hornblende, quartz, and plagioclases, and it belongs to plagioclase amphibolite; it occurs near Chembi in the Ganale river drainage area.

Another association, found further south near Bedakessa, is composed of quartz, zoisite, hornblende and epidote and belongs to zoisite-amphibole schist (Hinterlechner, 1956) (Fig. 1). The most common rock of the area is the amphibolite from Gayo composed of hornblende in a matrix of salic minerals (Fig. 3).

Conglomerate and sandstone are widely developed, and they strike north-south following a line westward from Shakisso. On both sides of this alignment other schist types of the Adola series have been indicated. The alignment predominates in this part of the country, as it is more resistant to erosion than other schists of the Adola series. These rocks form lenses in chlorite and talc schists, building the ridge between Demi Danissa and Kajimiti valley. The conglomerate is composed of quartz and feldspar in a zoisite epidote matrix. The sandstone contains quartz, biotite, and shlorite.

Fig. 1. Zoisite-amphibole schist (quartz, zoisite, hornblende, epidote), × 35. Bedakessa, Adola district. Determination A. Hinterlechner

Fig. 2. Amphibole schist, × 35. Borę basin, upper terrace. Determination D. Jelenc

Fig. 3. Amphibolite (grains of hornblende in groundmass of salic minerals) × 35. Gayo Camp. Determination A. Hinterlechner

Chlorite-talc-tremolite schist forms the next zone of Ula Ulo and farther south in the Ujima area. The rock is composed of an association of talc, chlorite, and tremolite. The size of mineral grains is less than 0,1 mm. Magnetite is accessory only; its crystals range in size from 0,03 to 20 mm. A parallel structure of bands of chlorite and talc could be observed. The rock is a product of the regional metamorphism of the sediments.

Some specimens reflect the transition between amphibole schist and chlorite schist. Tremolite could usually be observed as a constituent of

Fig. 4. Serpentinite (serpentine, talc, magnesite, accessory magnetite), × 35. Kajimiti bore hole I, Adola district. Determination D. Jelenc

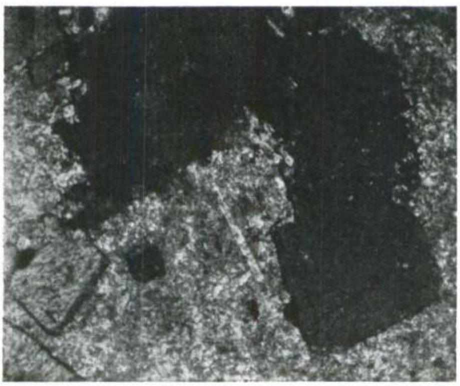


Fig. 5. Serpentinite (the idioblastic mineral grains belong to magnesite), × 35. Ula-Ulo, Adola district. Determination D. Jelenc

this rock type, and the zone has therefore been called the zone of chlorite-talc-tremolite schist.

The next zone belongs to rock types composed of peridotite, and serpentinite (Figs 4 and 5).

Finally, the above-described rocks contain intercalations of graphitic quartzite and white quartzite. They occur near Budussa mountain in Gudba valley and other places. The quartzite of Gudba valley is composed of quartz grains and muscovite.

These rocks occur as isolated dikes in amphibole and chlorite schists. The conglomerate, composed of a zoisite epidote matrix and gneiss pebbles up to 5 cm long and 1,5 cm wide derived from the gneiss of the Gari Boro series. Their position in conformity with the Adola series, forming a part of it, as well as the pebbles of Gari Boro gneiss included in them, prove the conglomerate to be younger than the Gari Boro series.

The less metamorphosed rocks compared with all other above described rocks belonging to pre-Cambrian occuring within Adola series are besides the conglomerate, sandstone, phyllitic slate, graphitic schist, sericite schist, and graphitic quartzite.

Phyllitic slate, graphitic schist, and graphitic quartzite occur in the former Imperial Highway Authority quarry near Kebre Mengist, graphitic schist and graphitic quartzite could be observed on the road between Kebre Mengist-Neghelli some kilometers from Kebre Mengist and near Adadicoto air field some kilometers from Shakisso village. Sericite schist was found near Shakisso village on the new road Shakisso — Kebre Mengist.

A series of conglomerate in disconformity, thus younger than the above-mentioned Adola series, has probably covered larger areas, but is mostly eroded. Only partial remnants have been preserved in the lower part of the Ujima river near its confluence with the Dawa river and in the Anfarara area off the Shashemene-Kebre Mengist main road. Their age could not be determined but they most probably belong to Cenozoic.

Basic and acid rocks intruded into the metamorphosed sediments could be found near Shakisso between the Awata and Mormora rivers. At Laga Dembi, according to Doorninck (1950), the following rocks have been found: diorite, gabbro, pyroxenite, and peridotite. Peridotite rocks were found also at Kenticha, Monissa, Dubicha and Lolotu mountains.

Near Kojowa river an diopside peridotite outcrop has been indicated. Another specimen, containing olivine remnants, has been observed near Ula-Ulo.

It is supposed that the above-mentioned zones of serpentinite are metamorphosed ultrabasic rocks. This may also be confirmed by nickel and chromium contained in those rocks. However, the chlorite-talc-tremolite schist represents the former sediments metamorphosed by regional metamorphism.

The amphibolites also represent products of regional metamorphism of sediments. At the Upper Falls of Mormora river has been indicated an intrusion of grey granitic rock, characterized by the presence of biotite. This intrusion zone has been followed northward, where the same intrusive body occurs west of the road near Anfarara. The Imperial Highway Authority has used this granite for road construction, so an abandoned quarry is to be observed at the spot. Southwards, in the gorge of the Ujima river, another granite outcrop occurs. The name Sawana granite is proposed for this granite occurrence, as it was first known near the Sawana valley, a left tributary of the Mormora river near the Upper Falls (Fig. 6). Pegmatite, aplite, and quartz veins occur in granite. The granite specimens are very similar in their mineral composition, but vary widely regarding the grain size. Feldspars belong to microcline, anorthoclase, and rarely orthoclase. A spectrographical analysis of this granite has shown the presence of Mn, Pb, Sn, Cr, V, and Zn*, and traces of Ba, Sr, and Ni.

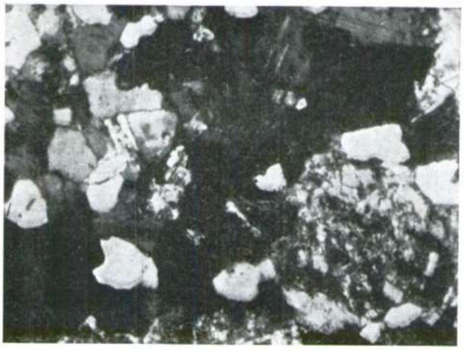


Fig. 6. Sawana granite (microcline, quartz, microcline perthite), × 35. Ujima, Adola district. Determination D. Jelenc

As the granite is overlain by Jurassic sediments, it is assumed to be older than Jurassic. This has also been proved by age determinations by the radiogenic method**. The basis for determination has been biotite, and the results obtained are given in table I.

Table I

THE AGE DETERMINATION OF SAWANA GRANITE

Locality	K %	Radiogenic. 40 Ar.	Age, millions of years	Color
Upper Falls at Mormora river	4,98	0,2013 ppm	495 ± 20	Grey
Ujima gorge near Dawa river	5,07	0,1990 ppm	482 ± 20	Pink

Bearing in mind the experimental errors, there is no significant difference between these two results. They are within the usual 400—650 million years range, which is a characteristic of all micas so far dated from basement rocks along the eastern side of Africa as well as those from Aden, Somalia, and Egypt. The age of biotite is an indication of the last change imposed on the rock, which cannot be younger than the biotite itself.

* The spectrographical analysis was made by A. Kandare in Geološki zavod (Geological Survey) in Ljubljana.

** The age determination was made by Overseas Geological Survey laboratories, London.

The above mentioned age, which ranges from 482 ($\pm$20) to 495 ($\pm$20) million years, corresponds to the period of the late Cambrian or early Ordovician. Thus, the age of Sawana granite is pre-Cambrian, taking into consideration only the last cycle of metamorphism indicated by the biotite. The age is not Mesozoic, as has been assumed by some authors.

Gold Placers

The distribution of gold-bearing placers has proved that the primary deposit extends generally from south to north along the strike of the basement rocks.

The degree of gold content depends on the following characteristics of the geological environment:

1. The Adola series is, as a rule, the bedrock of the commercially important placers.
2. The gold content is proportionate to the percentage of amphibole schist in gravel.
3. The gold content is proportionate to the size of the gravel. Gold-bearing placers occur usually in the areas where the bedrock is composed of chlorite-talc-tremolite schist mainly altered to a type of greenish yellowish clay. Selective erosion caused depressions in chlorite-talc-tremolite schist and elevations in conglomerate, amphibole schist, and serpentinite. In addition, the soft talc-chlorite-tremolite schist has been an excellent trap for gold nuggets, grains and specks.

This distribution of the gold along the north-south trending valleys which intersect the talc-chlorite-tremolite schist, conglomerate, quartz veins, and amphibole schist, renders possible the conclusion that the gold originates from these rocks. The quartz veins and pegmatites genetically connected with Sawana granite, diorite, or other basic rocks intruded in the Adola series may be another possible source of gold mineralization.

The following arguments exist for the theory that the gold is associated with amphibole schist and chlorite-talc-tremolite schist.

1. Gold has been indicated in inclusions of quartz in amphibole schist of Gayo walley.*
2. Gold distribution show no detectable relation to the granitic intrusions.
3. The general distribution of gold entirely follows the north-south strike of the talc-chlorite-tremolite schist and amphibole schist.

The gold might be derived from conglomerate with which the gold could be syngenetically associated. This explanation is however not feasible for the time being as the gold was not found in conglomerate.

As the gold was found only in the quartz inclusions of amphibolite, the explanation might be correct, that the gold originates from this

* Chemical analysis was carried out by A. Kandare in Geološki zavod (Geological Survey) in Ljubljana in the year 1956.

quartz. The quartz inclusions in amphibolite seem to represent the product of lateral secretion. It is supposed that during the same secretion gold was concentrated in these quartz inclusions.

The existence of conglomerate and quartzite in less metamorphosed Adola series and recrystallized quartz deposits in high crystallized Gari Boro series might be the second proof for the gradual metamorphism of psammitic and pelitic layers essentially composed of quartz grains. Only smaller bodies in the Adola series are found completely recrystallized in form of quartz inclusions. However, the higher stage of metamorphism of Gari Boro series leads to a complete recrystallization.

The other possible derivation of the gold-bearing quartz in Adola series from the granitic, dioritic or other intrusive rocks seems to be less probable as the placers gold distribution follows the metasediments of Adola series and as quartz as possible gold source represents isolated lenses and inclusions in the Adola series. The association of gold placers over large areas with Adola series could be explained due to the angular appearance of gold and therefore its short transportation distance only by syngenetic process and lateral (metamorphic) secretion of quartz and ore minerals.

According to some authors (Kossmat), the amphibole schist represents a product of differentiation of an initially granitic-dioritic magma separated into dioritic and granitic portions, as suggested for the Sokota Island granite-amphibolite succession. The essentially older amphibole schist (compared with granite) does not permit this conclusion for the Adola area, where an extrusive origine of a part of amphibolites is assumed.

The same conclusion could be drawn for Bedakessa, Shanka, Hidi Dimma, Wollena, and Laga Dembi areas, where similar geological conditions have been found.

Economic deposits of gold occur in placers of the second erosion cycle. Detailed investigations have been carried out in Upper Bore basin to find out the relationship between the primary rocks and the distribution of the gold placers. The corresponding geological cross section indicate that the richest deposits follow the areas composed of the chlorite-talc-tremolite schist associated with amphibole schist. Alluvial deposits have been found only in those valleys where the rocks of these groups occur.

The oldest erosion cycle could be recognized in the remnants of the former rivers of the Shakisso, Reji, Megado, and Sillu saddles. The following erosion cycle comprises former rivers with relatively large placers forming meanders of which only a part of the extension is proved by prospecting. The further lowering of the erosion basis created conditions for the third erosion cycle, which is represented by the present erosion systems of the Mormora, Awata, Dawa and other rivers.

The discovery of the economic gold placers was possible since in a portion of the placers, owing to the activity of the third cycle, the overburden has been removed completely (at the Dawa Cursu placer), or partly (at the Bore basin placers). The deposits became thus economically more interesting, as the overburden was thinned considerably or even completely removed.

The thickness of the overburden varies between 1 and 20 meters depending on the distance of placers from the recent local base level of erosion. Generally the placers near river systems have a thin overburden, provided that the creeks carry surface water, and in areas where the placers lack moving surface water and are far from the present rivers, the overburden is thick. Another influence has been the structural movements, which have changed the course of the placers, as well as moved parts of the placers of the second erosion cycle. This is reflected in the strange forms of the creecks, which sometimes have a length of only 1—2 km and a width 0,1—0,5 km, making difficult the identification of the former drainage system. The study of structural movements and geomorphology has cleared up some of the problems in Bore basin; however, further study should elucidate the palaeogeography of the river drainage system of the second cycle.

The age of the first and second erosion cycles could not be established, although the third cycle is certainly younger than the Rift valley volcanism. The essentialy older age of the second and first cycles is supported by the following data:

1. Basalt and volcanic glass gravels have been found only in rivers of the third erosion cycle, i. e., the Awata, Dawa, and Mormora. However, the gold placers of the second erosion cycle do not contain fragments of volcanic rocks.

2. The placers of the second cycle are often disturbed by movements which could be assumed to be associated with the youngest Rift valley structural movements.

The post-volcanic age of the second erosion cycle is supported by explanation that the absence of the gravel originated of volcanic rocks could be explained by a shorter river bed which did not reach volcanics. The absence of volcanic rocks in placers of the second erosion cycle might indicate the older age of these placers, particularly as they are found in abundant quantities in the Awata, Mormora, and Dawa rivers, so in the youngest erosion cycle.

The gold placers associated with the above-mentioned basement rocks occur in the area of the well-known basis of the Ethiopian and Somali plateau. They are situated in the western part of the Somali plateau, which is bounded by the Rift walley in the northwest. The depression of the Rift valley is built of basalt and other volcanic rocks. The gold-bearing area is situated in similar depressions striking northeast-southwest.

The gravels in gold placers are composed of sterile quartz, hydrothermal quartz with gold, quartzite, amphibole schist, and, rarely, of granite which are usually decomposed to clay and sand. The amount of gold is entirely proportionate to the amount of amphibole schist gravel in the placer.

The gold originates from the quartz inclusions occurring in amphibole- and talc-chlorite-tremolite schists.

Prospecting in the new placer areas is based on the experiences in the more or less known area of Adola. A study has been made to determine if there are analogous geological structures in other part of the Sidamo-Borana basement in order to find new gold placers. Systematic geological mapping has been carried out in order to determine favourable structures.

Bore Basin

In the second part of 1955, prospecting and exploration was started in Bore basin. Bore placer, which was first explored, is located on the right bank of the Mormora river. It begins on the other side of Megado mountain at an altitude of about 1730 meters. The Bore placer stretches 10 km downstream in the northwest-southeast direction, and then turns east-west. The last part again turns northeast-southwest. The whole placer has a length of about 36 km and an average width of 80 m. The placer in the first part downstream up to the old waterfall (gorge) has an average depth of 3 m; below the waterfall its depth presumably increases to over 10 m in average.

The Bore basin is now dry and represents the bed of an old river drainage system which existed during the second erosion cycle foregoing the present erosion cycle. Bore valley in the east meets the Mormora river as an elevated terrace. The elevation of the junction is about 1320 meters. The whole Bore basin covering an area of about 200 sq. km,

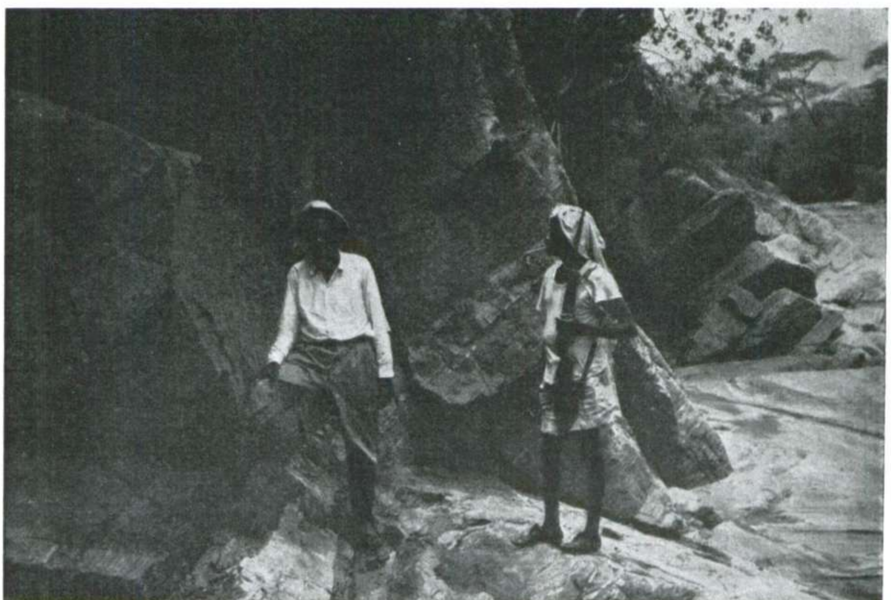


Fig. 7. Gari boro gneiss with aplitic veins. Ujima, Adola district

Table II

PROSPECTING AND EXPLORATION AT THE LOWER BORE TERRACE

Placer	Line	Pit	Average depth in meters	Gold content g/cu. m.	Remarks
Tulla (Burri)	10	P	11,7	0,58	
		I		0,12	
		G		0	
		J		1,19	
		N		0,25	
		K		0,30	
Tayisso (Ababido)					The whole creek is gold-bearing, but the gold content is low
Lower Bore	300	M	9,7	1,5	
		N		1,5	
		O		2,8	
		P		3,05	
		Q		2,50	
		R		2,10	
	302	M	10,5	2,15	
		N		1,30	
		O		0,40	
		P		0,40	
		Q		1,50	
		R		2,60	
		S		nil	
	304	G	11,2	1,76	
		H		1,50	
		I		0,35	
		J		0,30	
		K		4,80	
		L		4,85	
		M		0,60	
	500	O	11,6	0,8	
		Q		0,57	
		R		0,30	
		S		0,65	
	560	M	12,7	0,97	
Gudba	20		16,6	—	Bedrock was not reached
	24		13,0	—	Location at the Gudba gorge
	60		2,2	0,102	

is built by upper and lower terraces divided by amphibolite. The alternating streams of the Upper Bore placer are the Kajimiti and Demi Danissa placers, which are probably older than the Lower Bore placer. There are also some smaller feeder placers adjoining the Upper Bore placer. Parallel to the Upper Bore placer is the Gagama placer. Gudba valley is also formed of two terraces. The basis of the upper terrace at one of its ends is built by Gari Boro gneiss (Fig. 7), and it is found to be sterile in its lower part. The placers joining the Bore are Tayisso (Ababido), Tulla (Burri), and some smaller placers in the Daba area. To summarize, gold placers have been indicated in the following areas:

Upper Terrace includes:

1. Upper Bore placer
2. Smaller feeder placers of Upper Bore
3. Gagama placer
4. Demi Danissa placer
5. Kajimiti placer.

Lower Terrace includes:

1. Tulla (Burri) placer
2. Tayisso (Ababido) placer
3. Lower Bore placer
4. Smaller feeder placers.

Previous prospecting and exploration gave the following successful results in various areas of the Upper Bore terrace:

Kajimiti placer is about 8 km long, and it contains gold-bearing gravels along the whole length. The end of the placer toward the Bore basin watershed is particularly rich in gold.

Demi Danissa placer with its two main affluent placers has a gold content along the whole length.

Gagama placer has been proved as gold-bearing in a length of 2,5 km.

Many feeder placers are formed in normal position to the main Bore placer, where gold reserves have been proved suitable for handwork operation.

The results of prospecting and exploration works in various placers of the Lower Bore terrace are shown in Table II.

Table III

PROSPECTING AND EXPLORATION OF BORE BASIN TILL THE END OF SEPTEMBER 1962

Location	Number of lines	Number of pits
Upper Basin		
Bore placer	249	1149
Gagama placers	29	210
Demi Danissa placer	105	372
Kajimiti placer	44	864
Lower Basin		
Tulla (Burri) placer	33 (planned)	132 (planned)
Tayisso (Ababido) placer	8	38
Gudba placer	30 (planned)	240 (planned)
Other placers	60 (planned)	360 (planned)

The richest placers are located along upper Bore valley, where the gold occurs continuously. The distribution of gold in Kajimiti, Demi Danissa, and Gagama valley is different as the gold occurs in many paystreaks which are not continuous, but limited to certain areas.

Lower Mormora Basin

Mormora meanders near Lower Bore

Placer examinations were made by the Natomas Co. (1956) from July 27 to October 15, 1956, in connection with geological field work being carried out by a joint prospecting team made up of personnel representing Goldfield Consolidated Mines Co., Newmont Exploration, Ltd., and Natomas.

The primary target in the exploration area was a meander area occupying a narrow flat valley along the Mormora river 60 km air distance south of Kebre Mengist. The area was believed to be physically suitable for dredge prospecting.

In May 1956, three shafts were dug and 0,03, 0,09, and 0,06 g/cu. m of gold were indicated (Table IV).

The deposit would be a potential source of gold if proper prospecting by drilling were to be carried out.

Table IV

EXPLORATION IN MORMORA MEANDER

Shaft no.	Bedrock depth in meters	Overburden thickness in meters	Gravel thickness in meters	Gold content	
				Gravel g/cu. m	Top to bottom g/cu. m
1	7,1	6,3	0,8	0,25	0,03
2	7,7	7,1	0,6	1,10	0,09
3	6,6	6,3	0,3	1,55	0,06

The overburden is stiff red clay containing fine sand locally. The gravel bed is composed of loose quartz sand with well-rounded pebbles up to 70 mm in size mixed with pebbles of amphibole schist and other metamorphic basement rocks. The bedrock is soft micaceous schist.

Lower Mormora basin is located mainly on gneiss and mica schist of the high crystalline Gari Boro series, and it is influenced by the youngest erosion cycle. Thus, the possibility of finding commercial gold placer deposits is very slight. Only the meanders of the Mormora river indicate some gold content which probably originates in the eroded portions of Bore basin and in the Adola series of the Budussa alignment.

Lower Mormora basin could be considered as suitable for the gold placer along the Budussa talc-chlorite-tremolite alignment with serpentinite and amphibolite.

Upper Mormora Basin

The basin, located in the Adola series, is intruded by Sawana granite near Upper Falls of Mormora river. Many placers belonging to this basin have been exploited by handworkers as they are located near the Mormora river for water supply. The main placers are Laga Gesho, Sawana, Hiddi Dimma, and other placers, all left hand side affluents of the Mormora river.

Feeder placers of the Mormora river include Laga Dembi, Reji, Wollena, Lago Gesho, Laga Adunia, Hiddi Dimma, and Alona placers.

Wollena placer is 11 km long, and has been partly exploited by handworkers. The placer is now being prospected, and it has been found to be commercially interesting.

Reji and Laga Dembi placers together have a length of 16 km. These creeks have been already exploited by handwork.

Systematic prospecting has indicated gold reserves in the placers large enough to justify dredging.

Upper Mormora basin is located in a similar geological structure as the Bore basin, but in the youngest erosion cycle.

Table V

PROSPECTING AND EXPLORATION OF THE UPPER MORMORA BASIN

Location	Number of lines	Number of pits
Feeder placers	111 (planned)	666 (planned)
Mormora river	50 (planned)	50 (planned)
Wollena placer	24	220
Reji placer	48	288
Laga Dembi placer	166	341

Shakisso Basin

Kalacha placer is 10 km long. Drilling carried out some years ago did not indicate attractive results. Efforts are now being made to find the eventual connection between Shanka placer and Kalacha placer.

Kalacha placer according to Astrup (1948) is a horseshoe-shaped, fairly broad that occurs at the foot of the low hills where Shakisso and Wodo villages are situated. The entire length might be about 9,5 km including only the lower part from the Awata junction and Shakisso. The upper part of the placer is called Laga Gora. The upper and lower ends of the placer are covered with thick forest, but the central part of some 4 km is fairly free from trees and therefore suitable for mining operations. This is where drilling operations were carried out in 1948.

The width of the placer is, on the average, 150 m, but it becomes narrower towards the upper and lower ends. The Kalacha placer has only two principal feeder placers 3 km apart. One comes down from the mountains near Laga Reji and the other from the airfield at Adadikotto.

Fig. 8. Prospecting for gold in Adola district

Prospecting by pits in these valleys allegedly yielded traces of gold. The upper end of the Kalacha valley continues through a narrov gold field. The length of the prospected area was 3650 m (the distance between the prospecting lines A and E). The drilling showed 162 000 cu. m. of gravel with 50 kg gold reserves. Line E near Shakisso has been found to be the richest one.

Shanka-Wollabo placer is about 23 km long. One hundred forty-seven pits have already been dug to prove the presence of gold in upper and lower Shanka creek with favourable results. Dredging vas introduced in 1956 and is still in operation.

Table VI

PROSPECTING AND EXPLORATION OF THE SHAKISSO BASIN

Location	Number of lines	Number of pits
Kalacha creek	20	80
Shanka-Wollabo creek	46	421

Bedakessa placer explorations with drilling equipment have been carried out in lower Bedakessa valley. Fifty-one bore holes were made, three lines by two "Banca" hand drills. Ground water was met at about 3,5 m below the surface. The direction of the lines was 24° northeast and the distance between bore holes 25 m. The explorations started in February 1956. The results of drilling show an average tenor of gold of 0,7 g/cu. m.

The basin is built by the same type of rocks as the Bore basin. A gneiss alignment belonging to the Adola series dominates the basin from Shakisso to the Reji area. Other rocks occurring in the basin are amphibole- und talc-chlorite-tremolite schists of the Adola series with intrusive rocks as pyroxenite, diorite, and serpentinite.

The basin belongs to the second erosion cycle. Many commercially important gold placers have been found in this basin, which has been also the main supplier of the gold in the past from manual operations as well as from the former mechanized project at Bedakessa and the present mechanized project at Shanka placer.

Dawa Basin

The discovery of the Dawa-Cursu gold-bearing area not only made possible to increase gold exploitation in the years 1958—1959, but also increased the possibility of finding gold in southern areas. To prove the reserves in these areas, it is necessary to carry out a systematic prospecting program.

The longest valley is Gambela, which is 22 km long. It is situated on Gari Boro series, and the content of gold found there during reconnaissance prospecting is discouraging.

The Dawa river alluvial deposit near junction of the Cursu and the Dawa rivers was found to be very rich. The area is located geologically in the Adola series, and it is particularly rich in amphibole schist. About 9,5 km from the Cursu junction at Dawa is the junction of a 10 km long valley which seems to be located in Adola series. All the above-mentioned placers belong to the youngest erosion cycle.

Aflata Basin

The main creek of the Aflata basin, which is situated southwest of the Dawa basin, is about 100 km long. This stream has been found to be gold-bearing, and manual operations have taken place in the area (Fig. 9). The basin is located in Adola series, and it belongs to the youngest erosion cycle.

Ujima Basin

A similar erosion basin with a relatively large surface is developed south of the Aflata basin. The length of the main placer, including feeder placers, amounts to 47 km taking into consideration only the area included in the existing aerial photographs. Only a small part of this drainage basin (that belonging to the Adola series) has been found to be gold-bearing. However, in the portion of the placer located on gneiss no gold has been found.

Fig. 9. Hand panning for gold in Aflata placer. Adola district

Makanissa Basin

The Makanissa basin is situated as a peneplained area belonging to the second erosion cycle between the Awata and Mormora rivers east of Ula-Ulo mountain. Large valleys were formed during this erosion cycle. Prospecting for gold in this area started in 1963. The basin is built up of talc-chlorite-tremolite schist on the boundary with gneiss.

Lower Awata Basin

The Awata river flows in its lower course (before its junction with the Mormora) on gneiss. Gold placers have not been reported from this area. The area belongs to the youngest erosion cycle.

Kojowa River Basin

The Kojowa river is flowing in the course included in available topographical base on gneiss. Commercial deposits have not been reported from this area belonging to the youngest erosion cycle.

Placer Mining

Past methods (J e l e n c, 1956) of working in this area include mainly (about 6/7 of the production) the digging of a large number of pits by handwork (Fig. 10). After the pit reaches bedrock, gold-bearing gravel is excavated in all directions as much as the primitive means permit. The distance between the pits is about 5—10 meters. The gold-bearing gravels are handed up from the pits and are carried for washing to the nearest small rivers or water basins which are dug on the surface. Water is transported to the washing basins from the nearest river by

Fig. 10. Hand panning for gold in Dawa placer. Adola district

Fig. 11. Clearing operation for transmission line of Shanka gold operation in forest area in Adola district

trucks or by workers. Some short canals were also constructed to supply water to working places in the valleys wherever convenient.

Dredge-dragline equipment was first installed in Bedakessa creek and later in Shanka creek (Figs. 12, 13, 14). This equipment has a washing capacity of 90 cu. m gravel per hour.

A water-supply system was built to supply water to the dredge and for ground sluicing in Bedakessa, as well as in neighboring valleys. An earthen dam was also built at Wolabo to accumulate water. The dam has a capacity of about 30.000 cu. m. From Wolabo dam, the water is conveyed to another reservoir located some 10 m above the upper Bedakessa valley.

The output of the gold by handwork operations decreased from initial 7395 kg during the 1944-48 period to 5299 kg during the following 1948-1952 period, and to 3023,3 kg during the 1952-56 period mainly due to the exhaustion of gold placers in the affluents of the Awata and the left bank of the Mormora river, as these placers are situated near water suitable for the handwork. The placers situated far from water have remained out of operation as the exploitation of those placers required larger investments for water supply and therefore for prospecting and exploration to find out the reserves. In order to prevent a further decrease in gold output, mechanization has been planned for the Shanka and Bore basin placers. These projects are based on proved reserves of

Fig 12. New power plant 500 kW for Shanka gold dragline-dredge operation

gold, which have been increased from 2000 kg in 1958 to about 11 000 k. in 1963. These reserves represent a sound basis for further mine development and gold output, which has already increased owing to the discovery of Dawa Cursu placer and the introduction of a mechanized project at Shanka. Both projects are based on dragline stripping of the overburden of the gold placers, and on dragline dredging of gravel.

A further increase in the gold output is expected with reconstruction of the Shanka and Bore projects. Two pover stations have been built to supply these two projects with power. One Diesel power station of 500 kW is supplying the Shanka mechanization project. A second 1500 kW water power station is under construction at the Mormora river (Figs. 15 a, b). It will supply power to the Bore basin placers mechanization projects.

At the Shanka placer, the mechanization project represents merely a reconstruction project with the main aim of increasing the gold output. The text below describes the main features of the Bore mining project.

Fig. 13. Mechanization project Shanka. Two draglines of the Dragline-dredging operation. Adola district

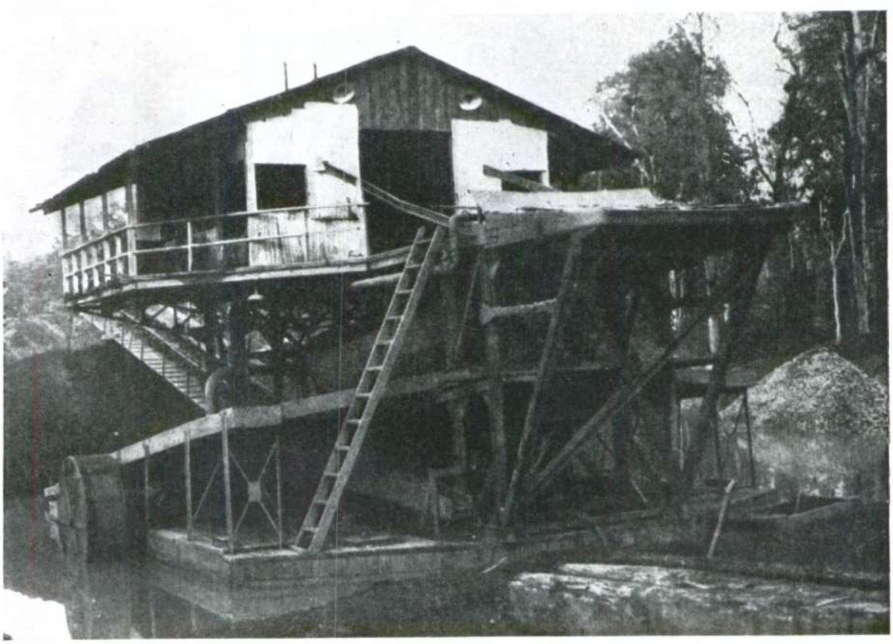


Fig. 14. Mechanization project Shanka. Washing plant for gold of the Dragline-dredge operation. Adola district

Bore Placer Project

It has been proved (J e l e n c, 1956) that the handwork method of mining is not profitable from a national economic point of view. Therefore mechanization of work and treatment is needed. The large investment could only decrease the cost and increase profits and the repayment of invested capital.

An additional motive for the mechanization of projects is stabilization of production. The gold production from manual labor in the

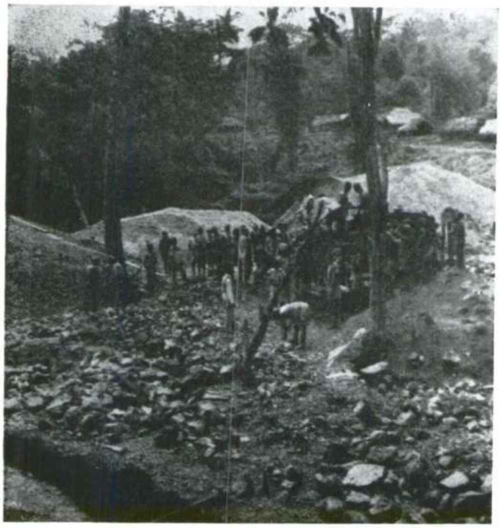


Fig. 15. Construction of the power plant 1500 kW at Mormora river for Bore Dragline-dredge operation

last ten years has varied from 1662 to 310 kg annually. A constant production is possible only if it is based on reserves which would assure a more or less constant output for many years in advance. Certainty as to proved reserves of gold is the only way of making the investment possible and enabling the repayment of capital on equipment and machinery.

The renewed efforts at surveying in 1959 and at prospecting in 1960 were some of the most important prerequisites for starting the Bore placer project.

Intensified work has been started 1959 to prepare all requirements and preparations for the mechanization project started. The main features of the work were:

1. Surveying and prospecting in 1959-1961.
2. The approval of the investment program of 1959, which included a power station, workshop, mining equipment, water supply, and mining camp and subsequent elaboration of Bore placer project.
3. Selection of electricity as the source of power and the starting of the constructing for a power plant and pumping station workshop in 1962 and 1963 respectively.

The above-mentioned basic data enabled the starting of the placer project, which was completed during the second part of 1960 and in the first part of 1961.

The area in which the traces of gold occur covers about 10 000 sq. km while the drainage basin of the Upper Bore, on which the project is based, covers a surface of only about 100 sq. km.

The present project represents the first attempt to exploit the virgin gold gravel without foregoing handwork operation on the basis of proved gold reserves. Observations of water losses from the exploration pits organized by the author have made possible an estimate of leakage during exploitation as the dredging has been selected from among many alternatives as the cheapest one.

In order to determine the upper limit of possible losses of water from the pond, Kleindienst (1960) considered the specific discharge of pit No. 28/K with a 7 cm decrease in water level during 10 minutes of observation after getting the stabilization of water losses to 0,0136 lit./min. $\times$ sq. cm.

Applying the results of the above experiment to the actual case of the possible leakage in the widest cross section of the exploitation area without regard to different conditions leads to the following result: discharge of 367,5 liters per minute.

This result is based on the highest observed discharge from the pits during the experiments. The major portion of the results showed only one-third to a maximum of one-half of the value taken into account above.

On the basis of the results in test pits and theoretical considerations, it can be concluded that the expected leakage from the pond for the dredging does not represent any problem, and for this reason it presents no hindrance to the proposed dredge project.

Nickel-Chromium Deposits

The nickel-chromium primary deposits are confined in general to magma of basic and ultrabasic provenience. Basic magma which generally displays pronounced differentiation was intruded into the metasediments of Adola series, and it has split into peridotite, pyroxenite, and diorite. The serpentinite which predominates is derived from ultrabasic rocks of an originally peridotitic composition. Less altered specimens still show some relic cores of the earlier mafic minerals, mainly olivine. Serpentinite is composed of lizardite, a serpentine-type mineral (Baines and Duesing, 1963).* Metamorphic equivalents of the ultrabasic rocks and their altered products as they occur in the Adola series have shown traces of nickel and chromium minerals both in primary and secondary mineral occurrences.

Chromite is found as an accessory mineral of the serpentinite, and due to magmatic segregation it seems to be concentrated in lens-shaped bodies, whose existence is proved by eluvial chromite, a product of erosion of the former primary chromite deposit mostly near or on the surface of the serpentinite. As large serpentinite bodies are found, there exist a fair possibility of finding chromite deposits in this type of rock. The content of chromium in the serpentinite amounts to 0,01—0,03 %.

In one case at Budussa (Fig. 16), eluvial chromite was found associated with anthophyllite schist some kilometers from serpentinite. This could be explained by postmagmatic injections into intrusive rock surrounding metasediments, or by complete erosion of serpentinite body. In Dubicha Gudda the chromite was found as primary constituent of serpentinite, however, in antophyllite coating in lenses 3 m long and maximum 20 cm thick striking EW and here and there NE—SW.

Chromite deposits associated with talc-carbonate and talc schists are known from South Africa and southern Rhodesia respectively. In the future prospecting both possibilities of primary chromite deposit shall be considered.

In general, some nickel- bearing rocks contain considerable quantities of sulphur which gives rise to nickel sulphides deposits. As the occurrences of Sidamo do not contain sulphur, the nickel was originally combined with silica, and when it congealed a rock containing nickeliferous silicate (olivine) was formed. Laboratory experiments show according to Kitaisky (?) that a molten mass consisting of various metals, sulphur and silica constitues not one, but two hot liquids. These liquids are as immiscible as water and oil. When the magma chamber cools, the molten sulphide mass begins to crystallize later than the molten silicate. As the sulphur did not exist in the ultrabasic and basic magma of Sidamo Province, nickel deposits are of silicate type. There were no indications of sulphidic nickel minerals in this province. Therefore it is hard to

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* I am thankfull to Baines T. V. of International Nickel Comp. Ontario for friendly communication about petrographic determination made by Duesing C. M. in 1963.

expect that sulphidic nickel minerals will be found as the sulphur content was determined to be very low (less than 0,01 %) in the serpentinite cf this area. The ultrabasic and basic magma which has given rise to nickel deposits was therefore a nickeliferous silicatic magma

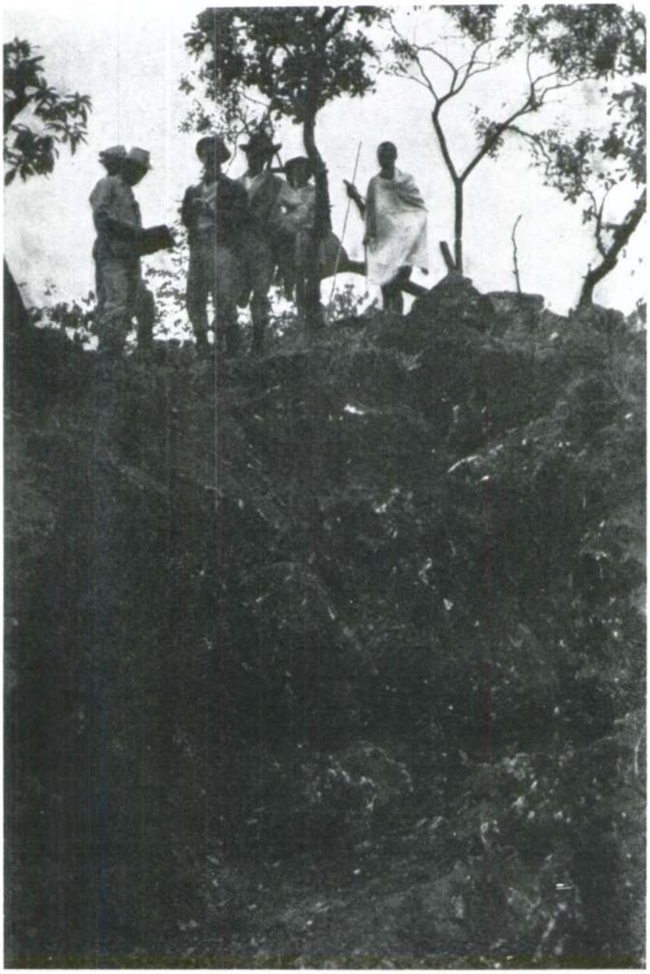


Fig. 16. Eluvial chromite deposit at Budussa. Adola district

Thus, nickel is genetically probable assocciated originally with olivine and other silicates whose lattices were altered during the process of metamorphism. Nickel compounds of unknown chemical structure were formed together with serpentinite.

The main accessory mineral of the compact rock zone is crystalline magnetite, which is partly replaced by amorphous magnetite. The amorphous magnetite is younger than the crystalline magnetite, and it seems to be replaced partly by trevorite (?), as the analysis of amorphous magnetite has indicated a content of 0,96 % of Ni and 0,44 % of Cr.

The magnetite occurs in veins 2—5 mm thick as well as in the form of grains dispersed in the primary rock, i. e. in the serpentinite.

Serpentinite forms lens-shaped and irregular bodies of various sizes in the talc-chlorite-tremolite schist. The Tulla serpentinite body is about 800 m long and about 100 m wide on the average. The Dubicha Gudda and Mika serpentinites have a total length of a few kilometers and a width of several hundred meters. The serpentinites of Burjiji and of Budussa are a few hundred m long and about 50 m wide. The Kenticha serpentinite, which is composed of many bodies, indicates various sizes. The serpentinite of Ula-Ulo is round with a diameter of 300 m. The T'Allo serpentinite is similar to a layer parallel with the Adola series.

Monissa serpentinite which strikes north-south is composed of three bodies cut by erosion of two brooks flowing in east-west direction. The total length of serpentinite is about 7000 m being 200—500 m wide. Lolotu serpentinite is about 1000 m long, being about 300 m wide. Near Budussa there occur two serpentinite bodies Tulan Chebi being about 20 m long and 10 m wide and Aragessa, being composed of four separated bodies covering totally about 400 sq. m of surface. Chabessa serpentinite is situated between Monissa and Dubicha Gudda serpentinites being about 1000 m long and about 250 m wide.

Morphologically the serpentinite builds elevated, round, elliptical, or irregular bodies which can be easily recognized in the field. The serpentinitic mountains dominate over wide areas, i. e. Ula-Ulo extends over the Bore drainage basin, as do the Dubicha Gudda and Dubicha Mika mountain ridges over the Kebre Mengist plane. They are mostly devoid of forest.

According to the assumed primary content of chromium and nickel minerals in the serpentinite, the above areas may be divided into two groups. The first group comprises serpentinite bodies where eluvial chromite was not found. The second group comprises serpentinite where eluvial chromite was found to be either associated with the serpentinite or near it.

In the first group are Burjiji, Ula-Ulo, and Tulla. They are barren of eluvial chromite, but they contain, however, small amounts of chromite as accessory mineral, as indicated by chemical analysis. Owing to the small content of nickel (0,2—0,5 %), the serpentinites have no commercial value as mineral deposits, as the nickel was not found in sulfidic form.

The second group of primary occurrences of chromite has been indicated by eluvial chromite debris at Budussa, Kenticha, Dubicha Gudda, Dubicha Mika, and the Wollabo area (where chromite debris were found, but no serpentinite). The commercial value of these deposits can be determined only by extensive prospecting and exploration.

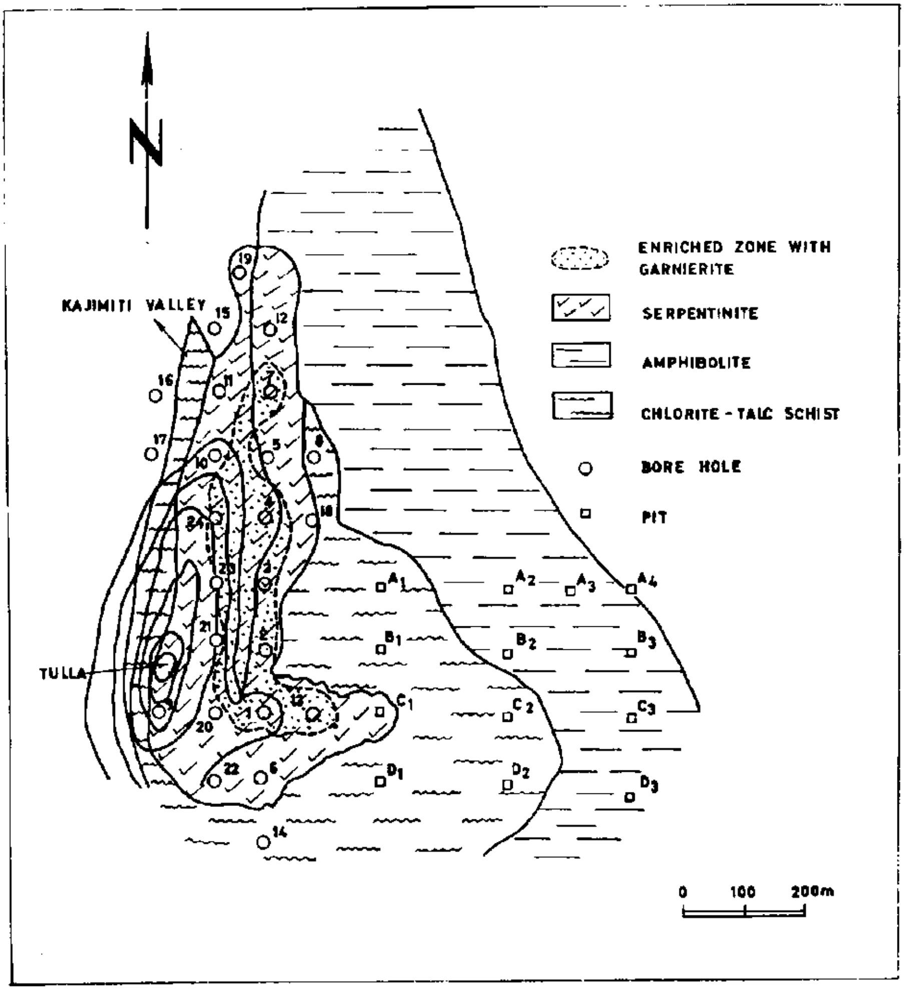


Fig. 17. Geologic sketch map at Tulla

Stronger indications of the eluvial chromite were found at Budussa, associated with talc-chlorite-tremolite schist; smaller indications associated with serpentinite, however, were found at Dubicha Gudda and T'Allo valley. At Wollabo valley, only a few pieces of chromite were found.

Nickel mineralization

The decomposed zone has been enriched in nickel in the altered zone of serpentinite of Tulla, Ula-Ulo, Ketta, Kenticha, Dubicha Gudda, Dubicha Mika and other deposits of this area. The nickel content in the zone of the compact, fresh rock amounts to less than 0,5 % and chromium to about one tenth of this percentage, which corresponds to the normal geochemical content of these metals in the family of the ultrabasic rocks.

Nickel deposits of Tulla, Ula-Ulo, and others as well as the deposits along the Mormora—Awata watershed at Kenticha are associated with residual soil of altered serpentinite. Residual soil of the upper zone of the formation is enriched in garnierite and probably in other nickel compounds.

Tulla

The numerous garnierite veins dip 20—30° E. They follow the fissures of the altered serpentinite, which are parallel to the slope of the Tulla Saddle.

Residual nickel deposit in Tulla has been drilled systematically. Table VII shows the depth and Table VIII the petrographical and chemical section of residual soils. The situation of the holes drilled and pits dug is given in the **Fig.** 17.

The highest content of nickel follows the line 13 — 1 — 2 — 3 — 4 — 24 — 7; however, the volumes do not show commercial quantities.

These petrographical and chemical characteristics indicate that the nickel deposit is associated with residual soils. The constituents such as magnesium salts and silica are washed out of the serpentinite. The decomposed superficial zone in the Tulla deposit has been enriched in various nickel compounds.

Prospecting based on the above chemical analysis has proved around 6500 tons of nickel in 583 000 tons of nickel ore with 1,14 % of nickel, considering only that part of the cores of the bore holes with nickel content higher than 1 %.

The average depth of the deposit was found to be 6,57 m. The deepest mineralization with nickel content above 1 % is found in the bore hole 1.

Table VII

THE DEPTH OF RESIDUAL NICKEL DEPOSITS IN THE TULLA AREA AS DETERMINED BY DRILLING

Number of the hole	Depth of the hole m	Depth considered for reserves m	Residual soil with serpentinite m	Serpentinite m	Average nickel content %
1	79,60	18	24,70	54,90	1,14
2	6,50	1	1,00	5,50	1,03
3	4,00	1,2	2,20	1,80	0,92
4	13,00	9,0	10,10	2,90	1,45
7	6,00	5,00	6,00	—	1,14
24	3,0	3,0	—	—	1,18
13	8,80	8,8	8,80	—	0,89

Table VIII
SECTION OF THE BORE HOLE № 1 AT TULLA

Bore hole 1 Depth in meters	Petrographical composition of core	Nickel content %
0,0— 0,7	Brown, argillaceous, decomposed serpentinite with white spots	1,58
0,7— 1,4	Pink, decomposed serpentinite	0,98
1,4— 3,0	Pink, sandy, decomposed serpentinite	1,80
3,0— 3,5	Pink, argillaceous, decomposed serpentinite	1,42
3,5— 6,5	Pink, argillaceous, decomposed serpentinite	0,84
6,5— 8,0	The same as 3,5—6,5	1,58
8,0— 9,5	Pink, sandy, argillaceous, decomposed serpentinite	1,58
9,5—10,0	The same as 8—9,5	1,10
10,0—12,5	The same as 9,5—10,0	0,70
12,5—13,0	The same as 10,0—12,5	1,07
13,0—13,8	The same as 12,5—13,0	1,01
13,8—15,6	Brown, sandy, argillaceous, decomposed serpentinite	
15,6—18,0	The same as 13,8—15,6, but at the lower portion with transition to compact, fresh serpentinite	0,73
18,0—21,0	Sandy, pinkish, argillaceous, decomposed serpentinite in the upper part; green spots in the lower layers of compact rock	0,44
21,0—24,0	Pink, sandy, argillaceous, decomposed serpentinite	0,56
24,0—24,7	Shaly, sandy, grey to reddish layer of decomposed serpentinite	0,64
24,7—79,6	Compact, fresh rock with yellow and green veins impregnating the rock, but with intercalations of grey sandy layers; weak reaction to HCl.	Less than 0,5

Ula-Ulo

The numerous gernierite veins occur in the western slope of the Ula-Ulo hill, discovered along the road cut in the slopes. They dip 30° W and are mostly parallel to the western slope of the hill, filling fissures of the altered serpentinite.

The Ula-Ulo zone was drilled in 1963 (May—December). About 1500 m of shallow bore holes were spotted. Some of them are shown in Table IX. Chemical analyses have been carried out for each meter of the core in the laboratory of the Ministry of Mines. Considering only those portions with nickel contents over 1 %, the average content of this deposit was found to be 1,5 %. Taking into consideration only the contents over 0,8 %, the average nickel content was found to be 1,35 %. The tonnage of nickel ore was about 2 000 000 tons at the end of 1963.

This deposit contains an enriched ore zone with the highest grade of nickel (4,53 %) indicated by garnierite.

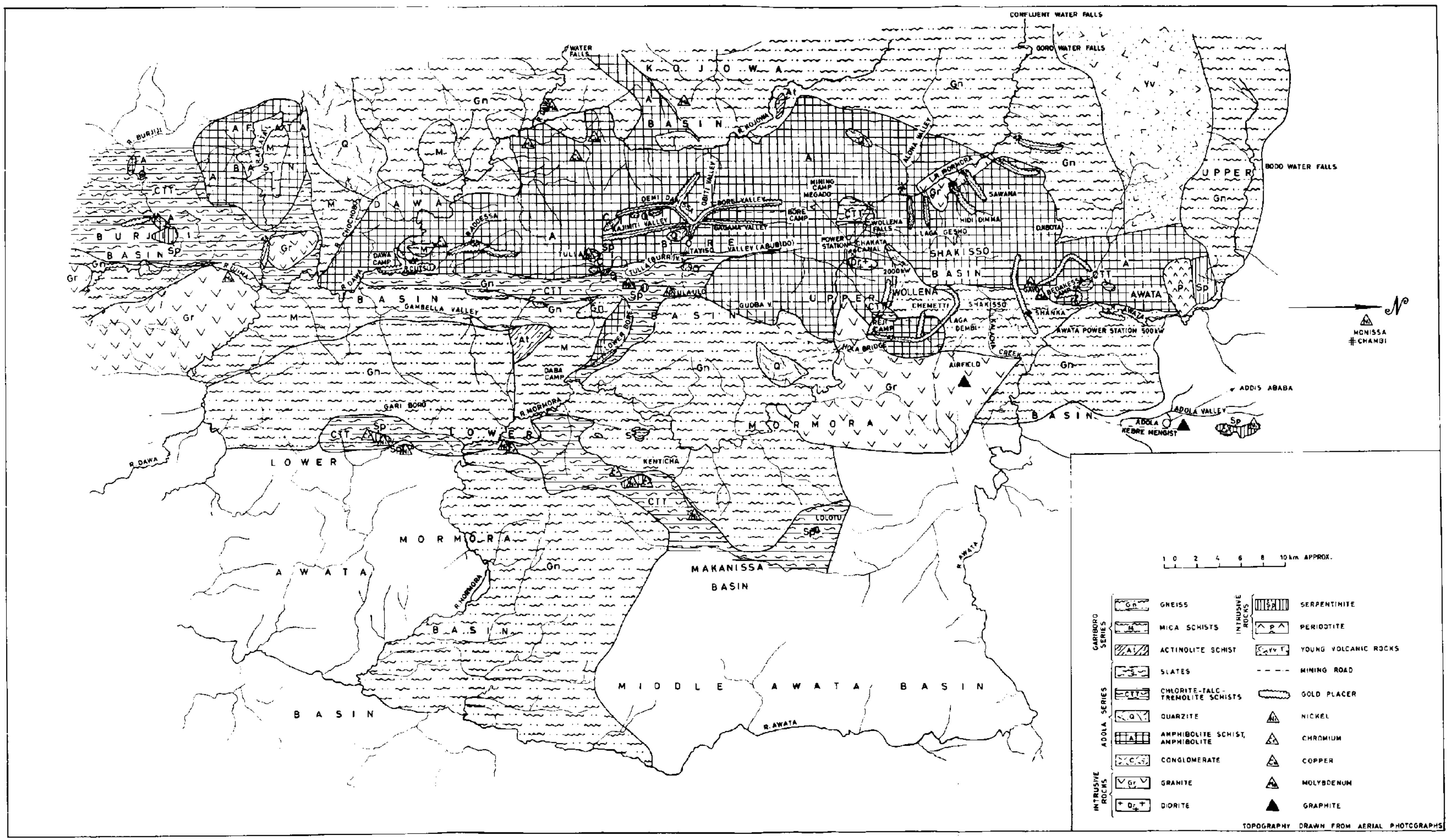
Table IX

SOME OF THE ULA-ULO NICKEL CONTENTS

Number of the hole	Depth of the hole, m	Average nickel content, %
36	6,7	1,22
59	3,0	1,27
0/F	6,5	1,77
0/B	9,5	1,76
0/E	6,0	1,39
1/B	3,3	3,70
2/B	13,0	1,40
2/A	11,5	1,09
0/C	0,3	1,69
1/A	20,4	1,95
2/C	3,0	1,08
3/B	6,3	1,41
4/A	12,0	1,88
4/B	5,0	1,77
5/A	5,0	2,31
5/B	10,8	1,90
5/C	4,0	1,35
12	9,6	0,96
13	8,9	0,92
14	8,8	1,45
15	4,2	1,06
16	7,5	1,38
17	5,0	1,13
18	12,0	0,84
19	8,3	1,43
20	6,0	1,54
21	2,0	1,06
22	4,7	1,39
23	4,0	0,93
26	4,5	1,15
27	8,7	1,11
40	11,2	1,54
41	6,6	2,23
43	3,0	1,05
45	2,0	1,30
47	2,3	1,45
62	5,0	1,12
72	3,4	0,95
95	5,0	1,21
97	5,4	1,98
Average depth	6,61	1,35

Kilta

Another deposit of the same type is found 2 km to the south of Ula-Ulo. This serpentinite also shows enrichment of nickel in residual soil of the alteration zone.



GEOLOGIC SKETCH MAP SHOWING THE ADOLA GOLD PLACERS AND SOME OTHER ORE DEPOSITS

Dubicha Gudda and Mika

This serpentinite residual soil shows enrichments of nickel. The prospecting in this area is carried out at present on a large scale.

Monissa

Monissa weathered serpentinite and subordinate lateritic soil with nickel contents within 0,5 and 1,1 % is situated in extreme north of the Sidamo-Province pre-Cambrian rocks area situated about 16 km west of Meleka village, which is in turn about 35 km from Kebre Mengist village at the road to Addis Ababa. It could be visited also from Chambi village along the path about 7 km long in northern direction. Chambi village could be reached from Kebre Mengist by road constructed for the gold-bearing areas of Ababa river drainage basin.

The nickel-bearing area which is more or less identical with the serpentinite is about 5000 m long and 100—500 m wide. The serpentinite is embedded in talc-chlorite-tremolite schist bounded mostly by gneiss.

Lolotu

Lolotu is located about 32 km south-eastwards of the Adadicotu airfield. The nickel-bearing area is associated with weathered serpentinite and subordinate lateritic soil. The nickel content of samples got by preliminary prospection gave similar results as the samples collected in Monissa.

Chabessa

Chabessa serpentinite body is similar to Dubicha Gudda serpentinite and is situated between Monissa and Dubicha Gudda about 3 km to the north from Dubicha.

The available surface of serpentinite is smaller than in Monissa and Dubicha mountains. Its nickel content in weathered serpentinite is similar to that of Monissa.

Tulan Chebi and Aragessa

In extreme south of the serpentinite outcrops south of Kenticha the nickel content in weathered serpentinite of two samples amount to 1,5 %.

*

The above described nickel ores of Sidamo have been discovered by nickel bloom. The rock outcrops were attacked by meteoric water, oxidized by air, and decomposed by organic acid deriving from the metabolic activity of plants and animals, a process which may be compared with the oxydation of metals. Prolonged oxidation of nickeliferous minerals on the earth surface, particularly at Tulla, produced nickel green, which could be a hydrous oxide or a hydrosilicate. The apple green tint stain is in contrast against the pink-grey background of serpentinite. Particularly at Tulla serpentinite outcrops nickel green occurs on the surface of serpentinite as sinters, incrustations, coatings, also as small veins or network of veinlets extending some distance into the serpentinite from its surface. The typical apple green tint staining gave rise to inhabitants of this region to pay attention to the occurrence on which samples have been sent to the Ministry of Mines.

Based on favourable result of analysis, prospecting started in the year 1963 at Tulla. The first structural bore hole proved the distribution of nickel in the depth (Table VIII). This hole show that the highest concentration of nickel was found in the depth of 1,4 m — 3,0 m with 1,8 % of nickel. In the depth the content of nickel decreases up to 18 m. Small variations within 0,44 and 0,64 % have been found in content of nickel in deeper parts of the core, but the content was less than 0,5 % of nickel below 24,7 m. The drilling proceeded up to 79,6 m in serpentinite and proved that any concentration of nickel could be expected in the depth. Based on this bore hole, a large drilling program was set up and carried out in Tulla area, partly with mechanized drilling, partly with pitting and hand boring as the small depths requested to reach serpentinite with less content than 0,5 % of nickel vary within 3 m and 13 m.

At Ula-Ulo and other serpentinite nickel staining was hidden until the prospecting started. It appeared along the road to the top of Ula-Ulo mountain which cuts the slopes of this mountain.

It was mentioned in the primary nickel deposit chapter that the nickel compound originates from the disintegration of the olivine lattice during the process of metamorphism and concentration of nickel in the product of metamorphism. Serpentinite is an alteration product of olivine and pyroxene. The serpentinite is chemically composed of metals (magnesium, iron, nickel) linked with silica in a definite order. Serpentinite contains a very minute amount of nickel which replaces a part of magnesium and iron, and which is probably uniformly distributed throughout the mineral. It represents the initial material from which silicate nickel ore was derived.

In order to get the nickel deposits of higher concentration (over 1 % of nickel) compared with the average content of serpentinite (less than 0,5 %) of nickel, process of weathering must take place.

During the process of weathering the first element leached out was magnesium, followed by more magnesium together with iron and nickel. The last to be weathered was the silica matrix. All these elements were dissolved by water, which infiltrated underlying rocks through cracks and pores.

First precipitated at the very surface of the earth was iron which accumulated in the upper crust between 0 m and 1 m forming a type of brown laterite, being loose if dry, and argillaceous if wet. A part of the iron went farther down to be deposited in the fissures of the rock

Veins of crystalline magnetite and amorphous magnetite occur within this layer. These veins usually limit the second layer and introduce the third layer which consists of light partly weathered serpentinite of lower density than fresh serpentinite which has not been decomposed into clay. A characteristic of this zone is the magnesite occurring as white veins in fissures, and minute grains of calcite, as this layer shows weak reaction of hydrochloric acid. The leached serpentinite is nickeliferous only at the upper part near to the second layer where increased contents have been noticed compared with the lower parts of the layer. Farther down, as the above mentioned carbonates begin to appear, the amount of nickel decreases until it reaches the unaltered serpentinite.

The Tulla deposit represents a transition type to the fissure type of nickel deposit, where the zoning is not so clearly expressed. However, deposits as Ula-Ulo, Dubicha Mika and Gudda belong to the clearly zoned types of weathered nickeliferous deposits.

The subsequent erosion influenced the entire nickeliferous deposit, as it is composed of comparatively loose and easily erodable argillaceous material. Therefore, at some places (Dubicha Mika and partly Dubicha Gudda) the upper layer and a part of second layer were eroded, as the serpentinite with magnetite veins appeared at the surface. In some places only the upper layer is eroded (part of Tulla and Ula-Ulo), as the highest contents of nickel have been found at the surface or near of it.

After weathering of serpentinite nickel in the solution was carried deeper compared with iron to be precipitated in the depth of 0,7—1,3 m.

Magnesium, however, infiltrated deeper layers of the rock, and it deposited after iron and nickel. Therefore, fissures filled with magnesite were observed. This layer represents the root of the weathering process.

Silica began to dissolve only when the serpentinite was completely free of above mentioned metals. While a part of silica remained in situ, the leached parts were gradually deposited in the pores and fissures.

The above process gave rise to the following sedimentation characteristics, which are found in all deposits prospected and explored in details (Tulla, Ula-Ulo, Dubicha Mika and Gudda) in more or less clear forms.

The lateritic iron layer with transition to ochre occurs in the upper part of the weathered zone. This zone is mostly eroded and only partly preserved. The middle part of the weathered zone is mainly composed of pink, sometimes sandy argillaceous material (clay) with remnants of original serpentinite.

This clay is of low plasticity, it is waxlike and greasy if touched. Minute inclusions of octahedra of magnetite and probably of other spinels with traces of platinum could be detected in it, if the material was panned as at Tulla and Ula-Ulo in form of fine black sand (clay which originates from other rocks usually does not yield black sand). By means of the microscopic analysis of Ula-Ulo material veins and stringers of chalcedony were determined in this layer. These veins result from silica deposited in cracks by descending solutions.

Secondary (eluvial) chromite deposits

The largest residual deposit of chromite was found in Budussa 100 km south of Kebre Mengist. The serpentinite in this area occurs in the environment of the chlorite-tremolite schist and antophyllite rocks (with asbestos) in form of two bodies. Chromite boulders occur in blocks up to 0,5 cu. m in size.

Trenching carried out in the year 1960-61 has proved that the eluvial chromite blocks are isolated from mother rock. They have been brought to the surface by gradual erosion of the mother rock which could be talc, as relics of this rock have been found associated with chromite boulders.

The reserves of residual chromite amount to maximum 2000 metric tons. The relation between iron and chromium is very favourable and could be considered as a high-grade chromite in respect of its low iron content. As the reserves are too small, the residual deposit has no commercial value.

According to Bentor (1963) who visited in the year 1963 the Budussa chromite occurrence, the chromite boulders could not have been transported from afar, as evidenced by their very large size and by the fact that on the highest part of the trench chromite pebbles occur without any admixture of other materials. According to this visitor, there are three possibilities of the origin of the chromite blocks. The first one explains the boulders being formed from at a present eroded primary chromite deposit near the present eluvial deposit. The second possibility assumes the boulders having rolled down from the higher part of Budussa mountain, what seems to be remote, as a survey showed that neither rocks usually associated with chromite nor chromite occur on this hill. The third possibility assumes the chromite blocks derived from an exposure of ultrabasic rocks occurring about 4 km to the NNE.

A very small number of chromite pieces occurs at Dubicha Gudda and Dubicha Mika; therefore, the residual chromite deposit has no commercial value. The same may be concluded for Wollabo Valley chromite occurrences.

Genesis of nickel-chromium deposits

Taking in consideration the above mentioned field data and laboratory investigation, the chromium and nickel are derived from peridotitic magma. The forming of the deposit was as follows:

Peridotitic magma

Peridotite-magmatic concentration
(Olivine with nickel and chromite was formed)

Metamorphism
(Nickel went into solution and formed various compounds)

Serpentinite
(Concentration of nickel as well as chromite in serpentinite)

Alteration and erosion

(A residual clay with garnierite and other nickel compounds is formed. Eluvial chromite deposits near serpentinite were formed by erosion of serpentinite).

Summary

To improve the mine development and increase the gold production in Ethiopia, in Sidamo province a complex geological-mining development project is being carried out by the Ministry of Mines of the Imperial Ethiopian Government. The main method used was a systematic prospecting in order to increase the gold reserves, planning of mine development, construction of water supply and power supply system, and acquisition of new mining equipment.

During geological mapping metamorphosed ultrabasic rocks have been found, and a systematic prospecting and exploration for nickel and chromium minerals is actually carried out.

The result will be the increase of gold production by mechanized projects and the limiting of handwork production on placers unsuitable for mine development.

REFERENCES

Astrup, J., 1948, Inedited report on exploration by drilling of the alluvial gold in Kebre Mengist Valley.

Bentor, Y. K., 1963, Ethiopia Preliminary Report, July 20 — August 19.

Doorninck, N. H., 1950, Inedited Reports, Addis Ababa.

Hinterlechner, A., 1956, Petrografsko poročilo o vzorcih iz Adole in okolice, Ljubljana.

Jelenc, D., 1956, Inedited Report on Mining problems of Ethiopia, Addis Ababa.

Jelenc, D., 1956, Inedited Report on Kebre Mengist goldfields, Addis Ababa.

Jelenc, D., 1965, Mineral Occurences of Ethiopia, Edited by Ministry of Mines, Addis Ababa.

Krenkel, 1925, Geologie Afrikas, in Geologie der Erde, Berlin.

Kitaisky, Prospecting for nickel, Moscow.

Kleindienst, M., 1960, Inedited report on review of Bore Project, Addis Ababa.

Natomas Co., 1956, Inedited report on placer gold of Ethiopia, Addis Ababa.

THE IRON AND MANGANESE ORE DEPOSITS IN ETHIOPIA

Milan Hamrla

With 18 photographs, 9 sketch maps and 6 tables

Introduction

Ethiopia is still one of the few African countries without a well active Public Geological survey (D i x e y , 1960). Accordingly, the mineral potential of the country is known only partly, and the activity in mineral exploration develops still on occurrences and deposits known for a long time ago. The prospection from the ancient times revealed many of the existing deposits, especially those visible at the surface. Besides gold which was the primary target of the ancient prospector, also iron ore deserved special attention by the native people in its struggle to get provided with weapons and utensils. The native people exploited and smelted iron ore at numerous localities for centuries and still nowadays the primitive technique of smelting by use of charcoal can be seen.

With the beginning of modern time the new-comers became interested in searching for iron and other mineral raw-materials in the country. During the Italian occupation serious efforts have been made to assess and to develop iron ore deposits, but without practical success. No new large and economically important deposit has been discovered and developed.

Also in the post-war time no additional iron ore deposit was found and the assessment of the known deposits was directed to the idea of errection a modern steel-mill industry. Presently, there is only one small steel foundry and rolling mill operating from 1962 at Akaki near Addis Ababa, and having a capacity of 50 tons per day only. Scrap iron is used prevailingly with a small amount of limonite ore from Entoto hill.

Following the suggestions of the Second five year Plan on the urgent priority and special significance for iron prospecting, extensive exploration was undertaken in the last two years by the Ministry of mines, and directed toward verifying the reserves of iron ore in the known deposits. In the Plan, however, the construction of a steel and metal industry based on domestic ore is planned for the end of 1967. The first step of renewed reconnaissance and exploration of the main part of known deposits is in general finished. Further exploration, being in course now, is carried out by specialised groups of foreign contractors and is directed toward the assessment of the eventual economic reserves by means of geophysical and drilling techniques.

The iron and manganese ores hitherto known in Ethiopia are oxidic only. The deposits belong to different types as it will be described in the following.

This article presents a brief summary of essential data on the principal iron and manganese ore occurrences in Ethiopia known till the beginning of 1964. The description of individual deposits is given mainly on the basis of personal field observation as well as own sampling and microscopic examination, supplemented by additional data from published literature and other sources. For each deposit a very short history of exploration is mentioned. The geological mode of occurrences is described and the deposits are classified regarding the origin. The reserves are estimated regarding the type of deposit and the degree of exploration. The measured tonnages have been calculated for some of the deposits. Three of the occurrences treated have not been visited and verified by the author in the field. Several new chemical analyses hav been made in the Chemical laboratory of the Ministry of mines. The other analyses and data used in preparing this article were derived from the listed references.

The author's personal view regarding the economic appraisal of the deposits is not necessarily the opinion of any other person.

GENERAL DATA ON THE IRON AND MANGANESE OCCURRENCES IN ETHIOPIA

Geological setting of the country

About one quarter of Ethiopia's surface consists of pre-Cambrian crystalline rocks of sedimentary and igneous origin. Different lithological types can be distinguished. A highly metamorphosed series, having resulted from high-grade regional metamorphism, is composed of gneisses, mica-shists and amphibolites. An apparently less metamorphosed para-series is composed of different schistose rocks including quartzites and crystalline limestones. Both series are intruded by acid and basic igneous masses. The whole crystalline basement is strongly folded and faulted with the general N—S trend of foliation. Stratigraphically, no exact differentiation has been performed till today, and the correlation of the rocks with metamorphic facies of other parts of Africa is not yet solved (Furon, 1960).

In Africa the metalliferous mineral occurrences are almost all associated with the metamorphic rocks of pre-Cambrian. The same can be expected for Ethiopia. The relatively most important primary iron ore deposits hitherto known in the country are bound to the metamorphic complex.

The pre-Cambrian basement was erroded to a peneplain and overlain unconformably by the sediments of Mesozoic and volcanic rocks of

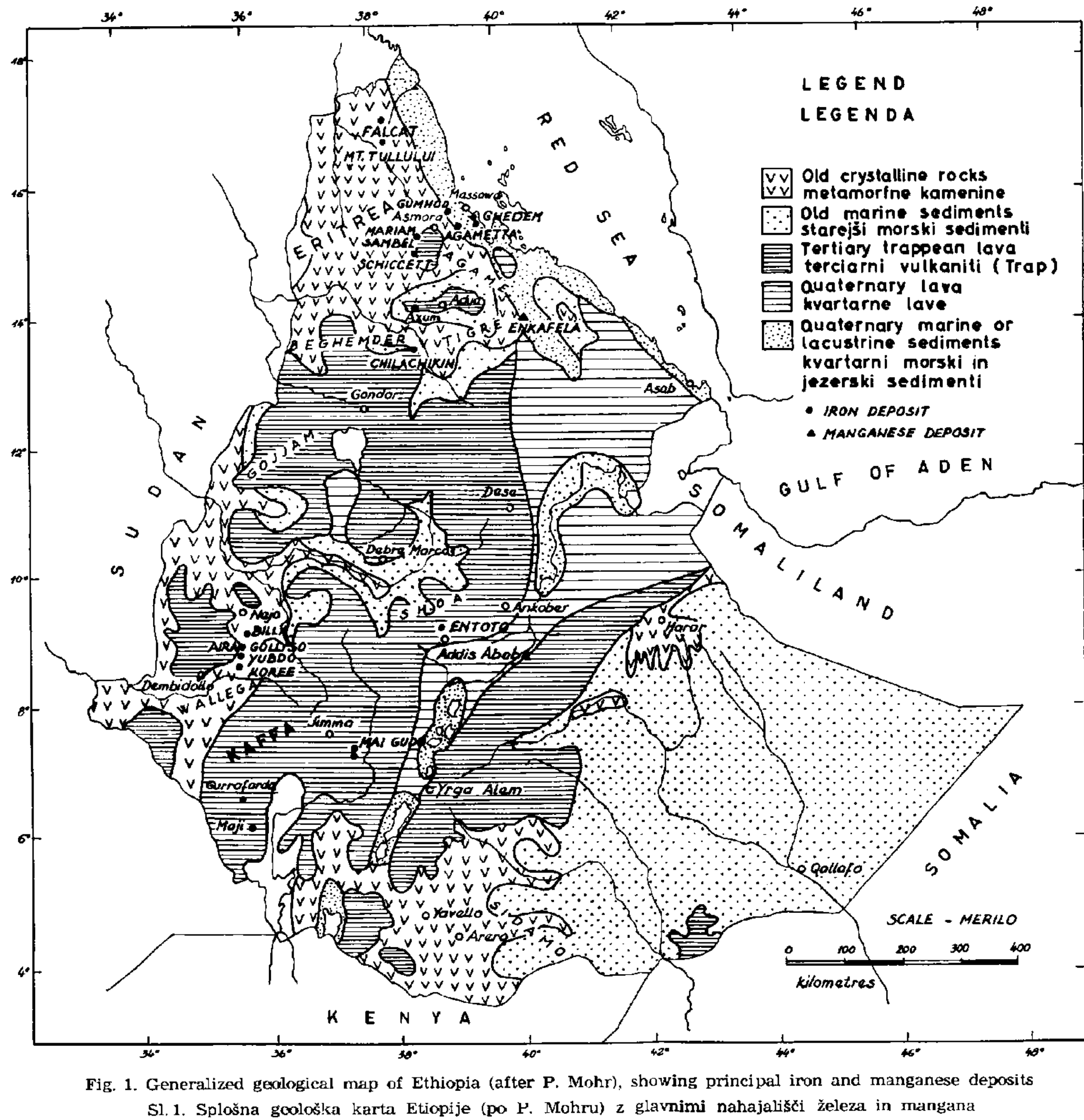


Fig. 1. Generalized geological map of Ethiopia (after P. Mohr), showing principal iron and manganese deposits

Sl. 1. Splošna geološka karta Etiopije (po P. Mohru) z glavnimi nahajališči železa in mangana

Tertiary. Mesozoic sediments spread in general in the eastern part of the country and cover a good another quarter of the country's surface. They are composed of marine sandstones, limestones and evaporitic sediments prevailingly.

Cainozoic is represented by sedimentary rocks of Tertiary which are confined to the extreme east of the country and are of marine origin prevailingly. The most extensive Tertiary formation is represented by extrusive volcanic rocks of Trap series which extend over the Mesozoic and pre-Cambrian formations. Nearly half of the country's surface is covered by thick layers of volcanic rocks of Trap series consisting of basalts prevailingly with some more acid rocks and pyroclastics. These rocks build up the high plateau in the central part of the country. In Tertiary age the upwarping and sinking movements started and shaped the present forms of mountains and rifts.

The volcanism continued during Quaternary in which period also marine, lacustrine and fluviatile depositions were sedimented in local areas and basins. Recent volcanic activity is known in this part of Africa and the youngest volcanic rocks are named Aden series.

During the emersion periods the process of weathering alteration, known as lateritization, took place over the pre-Cambrian complex as well as Mesozoic sedimentary and Cainozoic volcanic formations. The alteration processes played an important part in the formation of secondary iron and manganese accumulations.

Distribution and kinds of deposits

The existing deposits are primary and secondary in origin. As to the geological mode of the occurrences the relatively most promissing and high-grade ores are confined to the pre-Cambrian metamorphic rocks. The primary deposits are known to exist in Eritrea and Wollega provinces. The pre-Cambrian basement complex must be considered as the potentially most favourable environment to contain primary high-grade ore, but also secondary low-grade ore.

The next favourable environment is represented by the volcanic rocks of Trap series. The existing low-grade iron ores are an alteration product and resulted from weathering and leaching under the influence of the descending meteoric waters. In the same way the secondary iron concentrations formed in the clastic Mesozoic sediments cemented by ferruginous cement.

Hydrothermal iron mineralizations in pre-Cmabrian rocks do exist too, being of ascendent katathermal and telethermal or rather hot-spring character.

The depositions of manganese have much less extent in comparison with iron. Only one primary deposit is known to exist in marine sediments of young geologic age. Other manganese occurrences are connected with the secondary iron depositions. Iron and manganese behave in a similar manner in the exogenic cycle and concentrations of both metals in residual deposits are frequent.

The distribution of deposits and occurrences treated is given in the generalized geological map of Ethiopia (Fig. 1.).

The deposits of iron and manganese belong to the varied types of genesis. The iron ores are magnetitic, hematitic and limonitic and the manganese ores are oxidic too, being more or less ferruginous. The following genetical types of deposits have been found in Ethiopia.

Iron

1. Metamorphic type is of primary sedimentary origin and subsequently mineralogically and texturally altered by regional metamorphism.
2. Combined metamorphic-contact metasomatic type was formed by a combination of sedimentation, metamorphism and metasomatism.
3. Residual concentration type, having resulted from decomposition and leaching of extrusive or other ferruginous siliceous rocks.
4. Hydrothermal type is of katathermal and telethermal (hot-spring) character.
5. Magmatic type is inferred only and not cleared enough.

Manganese

1. Residual concentration type is closestly connected with secondary iron accumulations.
2. Hydrothermal type is closestly connected with telethermal iron.
3. Sedimentary type is of marine origin.

DESCRIPTION OF DEPOSITS AND OCCURRENCES

IRON

1. Metamorphic type

Koree — Gollisso — Nejo zone

General. Regarding the possible reserves of high-grade iron ore this zone in Wollega province seems to be one of the relatively most promissing areas in the country. Its center is in the Aira area north of Yubdo. A small primitive smelting activity is reported to have existed there from the former time and exists still nowadays. No published data are available on these occurrences except Murdock (1960), who dropped some lines on these deposits, having considered them as small and irregular replacements in dunite and not persistent at depth. His opinion was that none of the occurrences in Wollega are of any importance except for strictly local use for primitive smelting, such as was formerly carried out there.

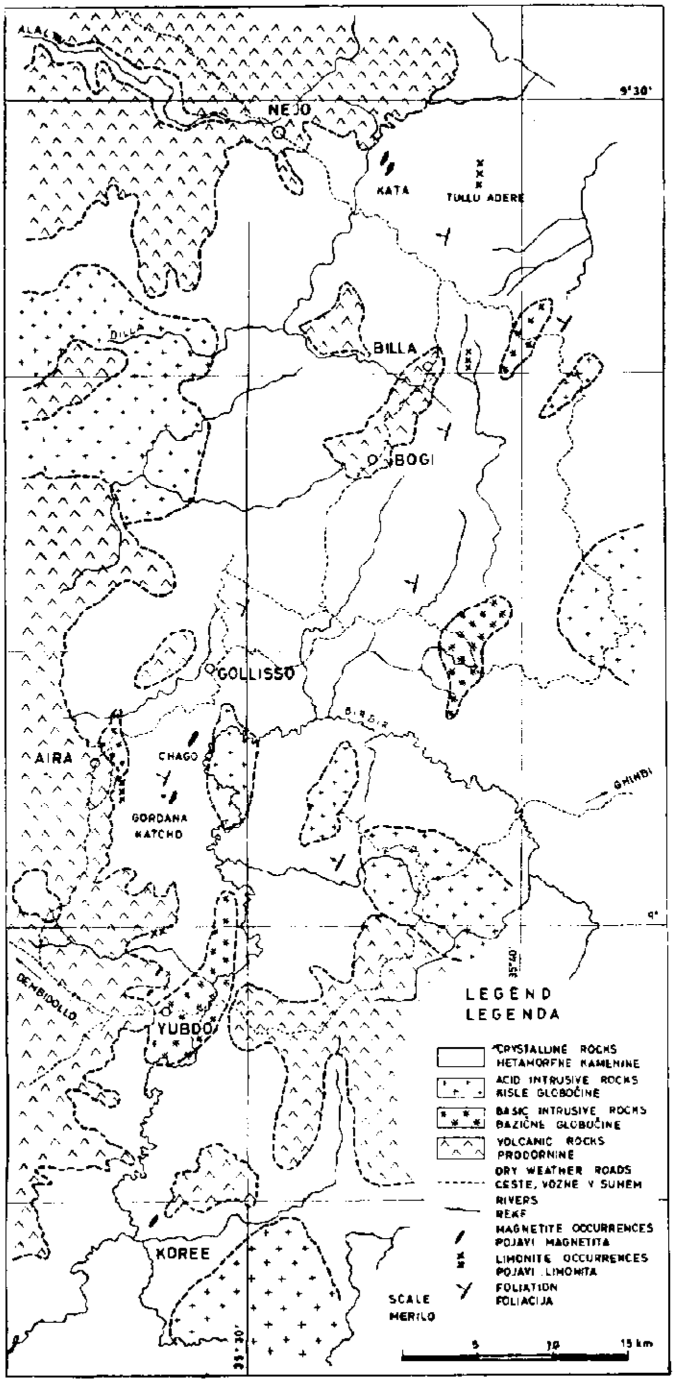


Fig. 2. Geological sketch map of the iron ore-bearing zone Koree-Gollisso-Nejo in Wollega

Sl. 2. Geološka skica nahajališč železove rude v coni Koree-Gollisso-Nejo v Wollegi

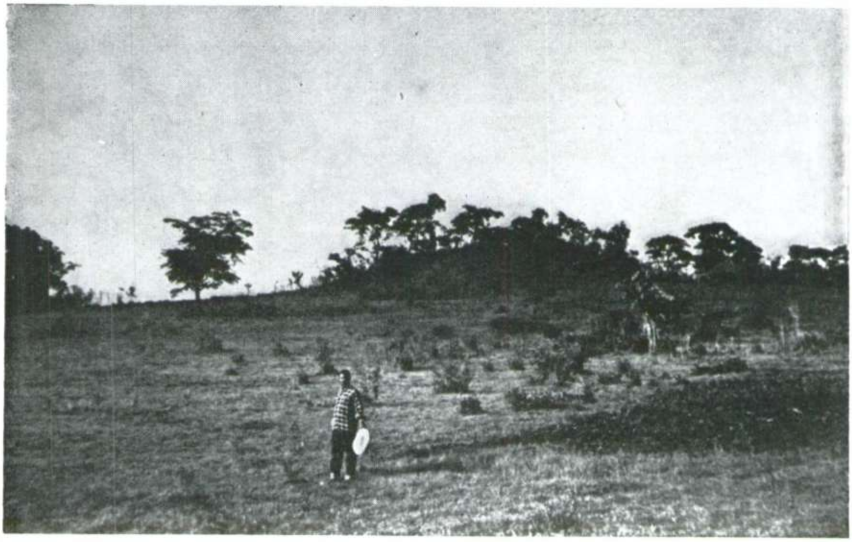


Fig. 3. View of Koree outcrop on the top of hill
Sl. 3. Pogled na izdanek Koree vrh griča

The zone was not searched in the past due to the lack of suitable communications and thus little prospects of economic exploitation. In the season 1963 extensive prospection was carried out by the Ministry of mines. Recently (spring 1964) detailed geological and geophysical (magnetometer survey) exploration started with the aim to assess more exactly the deposits, and to provide the basis for an eventual further drilling program. It was carried out by the Yugoslav RUDIS company.

Geologically the region is built up by pre-Cambrian rocks of apparently younger less metamorphosed series and overlain by basaltic cover. Petrographically para-rocks as mica-schist, chlorite-schist, amphibole-schist, phyllites and quartzites prevail, having a constant foliation of abcut 15° and dipping steeply west. Igneous rocks of ultrabasic, basic and acid types are included as well as some gneisses. The general situation of the zone is given in the enclosed map (Fig. 2.).

Ore outcrops are known to extend in a zone of several tens of kilometers in lenght. Lenslike ore bodies occur included in the crystalline rocks. Besides outcrops in situ also secondary ore can be found as large boulders. The possibility exists that the zone continues southwards as well as northwards from the prospected and reconnoitred area. No doubt a mineralized zone following the general NNE—SSW trend of foliation in the basement complex is in question.

The magnetitic-martitic ore is coarse crystalline, bluish-black in colour but the strike is reddish due to the high grade of martitization. On the surface rare incrustations with limonite occur sometimes.

D e s c r i p t i o n. The most southern outcrop of ore at Koree some 16 km south of Yubdo is the biggest in dimensions from all existing in the discussed zone. It consists of a lens of about 200 m of visible lenght, having a thickness of several meters. The outcrop forms a well pronounced topographic ridge, striking 35^0 and dipping nearly vertically (Fig. 3.). The prolongation of the ore body for some additional 100 m is assumed, the outcrop being hidden under the thick cover of residual soil. The ore consists of magnetite and martite and appears in big angular blocks with quartzite banding, being more or less impure and limonitized.

About 500 m southeast from the outcrop large boulders of magnetite are scattered on a pretty great surface, several of them of considerable size. The boulders are not in situ. They form secondary deposit derived either from the existing Koree outcrop or another one burried under the soil in the vicinity. Anyhow, the boulders could not have been transported from afar.

The existing reserves at Koree can be estimated to some 150 000 to 200 000 tons of ore, provided the depth of the lens is about one half of the lenght and a lenslike body is supposed. Additionally, several thousands tons of ore are deposited as boulders on secondary place.

The next known outcrop of ore exists about 1,5 to 2 km northwest of Yubdo. On a hill slope just beneath the volcanic cover scattered boulders and pieces of ore can be found on a surface 300 m by 60 m approximately. Some of them are very large in size, weighing several tons each (Fig. 4.). It looks very probable that at least a part of ore is not in situ there,

Fig. 4. Boulders of magnetite at Yubdo outcrop
Sl. 4. Magnetitni bloki na izdanku Yubdo

but due to the very large size of the blocks they could not have been transported from afar. The primary deposit has to be somewhere very near, burried under the residual soil or even basaltic capping. The coarse-grained ore seems to be clean with some inclusions of quartz.

About 650 m northwards from this place iron ore in situ crops out in a trench made by natives, which exploited the ore. The ore body here might be about 30 m in lenght and several meters thick, judging on the dimensions of the trench. Its strike might be about 45° and dip nearly vertical. The ore consists of impure limonitized magnetite intermingled with banded quartzite. It is possible that the lens continues southwards under the volcanic cover, which begins just at the end of the trench.

The form as well as the character of the deposit could not be definitely established by surface examination only. The existing reserves at Yubdo locality might not exceed the general estimate of several hundreds of thousand tons at maximum, taking into consideration the assumption the ore is in situ prevailingly. If this is not the fact the reserves are much smaller.

Several kilometers east from Aira Mission and some 16 km north of Yubdo the Gordana Katcho hill is built up of quartzite, chlorite-schist and mica-schist. On the hill the traces of former exploitation can be seen in form of a trench, striking conformably with the foliation of the metamorphic complex. The trench is about 100 m long and variable in width with several meters on average. Although it is filled up with earth and grown over by vegetation, the blocks and pieces of magnetite can be seen. Bands of magnetite are included in white quartzite indicating the genetic connection of both rocks and minerals. The traces of an exploitation in limited extent can be found also on the western slope of the hill perpendicular to the trend of the mineralized zone.

The exposition of the outcrop is bad and an estimation of probable reserves difficult. It could be assumed that several tens of thousand tons of ore might exist there, depending on the not clear dimensions of the ore body.

The next outcrop at the locality Chago some 5 km south of Gollisso has a lenght of about 300 m and a width of several meters. Former exploitation by natives is evident and remnants of smelting-furnace can be seen too. The area is strongly covered by residual soil and on some places magnetite ore is to be seen in large block, being very compact and of the same appearance as on the other spots described as above. The trench follows the foliation of the metamorphic rocks, being in general 15° to 20°.

The preliminary tonnage estimate of reserves might be analogous to that of Koree, amounting from 100 000 to 200 000 tons of ore.

In the area east of Nejo magnetite boulders can be found at several localities (Gambo, Kata valley, Tullu Adere), but there is also ore in situ in form of smaller lenslike outcrops. The ore is of the same appearance and composition as in the other localities described above. The geological environment is more or less the same and the quartzitic and schistose rocks of the basement prevail. A prospection is in course to establish the position and the dimensions of the existing outcrops. For the time being a very rough tonnage estimate of several tens of thousand tons of inferred ore can be assumed for this area.

Analyses. Several samples of magnetitic-martitic ore from Wollega have been analysed in 1962 (analyst A. Regan). Table 1. gives the composition of the chip samples of selected clean ore from different localities.

Table 1 — 1. tabela

Locality	Fe	TiO_2	SiO_2	P_2O_5	S	MnO
Koree	71,6	0,0	0,82	0,06	0,09	0,09
Yubdo	70,9	tr.	1,2	0,08	tr.	0,12
Gordana Katcho	70,8	tr.	3,1	0,03	0,05	0,23
Chago	68,8	tr.	1,8	0,14	tr.	0,12
Nejo (Kata)	65,2	tr.	8,7			

Several additional chip samples have been analysed in the laboratory, giving the same size-order in the quantity of the components.

In Wollega a rich magnetitic-hematitic ore is in question, very low in sulphur and in phosphorus. The percentage of silica is low in samples of clean ore, but on average it can be expected higher owing to the variable inclusions of quartz and quartzitic mother rock to which the ore is bound.

Polished sections of ore have been examined under the microscope in order to provide additional information about the processes of its formation. The microscope reveals a rather porous coarsegrained ore of largely martitized magnetite (Pl. 1, Fig. 1.). The magnetite is almost completely oxidized to hematite in form of lamellae, following the (111) planes of magnetite. The alteration is more pronounced at margins of magnetite crystals and martite extends irregularly along cracks into magnetite. With progressive martitization the lamellae broaden and very often only residual areas of magnetite remain.

Limonite replaces martitized magnetite here and there, forming rims and irregular bodies .Quartz grains can be found in the ore, concentrated in bands sometimes. An important feature is the exceptional appearance of small roundish inclusions of pyrite and chalcopyrite in the middle of unaltered magnetite grains.

Origin. The intimate connection of ore to the parametamorphic rocks consisting of white quartzite and other schistose rocks is evident at all find-spots where magnetitic ore occurs. The ore zone and the ore bodies run parallel with the foliation of the metamorphic complex. The outcroping portion of the ore lenses is extremely altered to martite due to the supergene oxidation of magnetite.

There is no doubt that the ore is singenetic with the adjacent rocks of originally sedimentary series. This has been strongly folded and metamorphosed by regional and dynamic metamorphism, accompanied by granitic and other intrusions. Metamorphism entailed mineralogical and textural changes of the primary sediments the "bedding" of which is still discernible in metamorphosed rocks. The paragenesis of the present ore is simple and the magnetite as well as the quartz waste is recrystallized. The sulphides might be primary in origin, and the presence of rare small grains of pyrite and chalcopyrite in the ore could be due to the conditions of primary sedimentation rather than having been introduced later by thermal solutions. There is no other evidence of any hydrothermal activity. Accordingly, the iron ore occurrences in this part of Wollega belong to the metamorphic type of deposits, being derived from a former sedimentary accumulation and subsequent concentration of iron.

The question about the primary sedimentary environment and the form in which iron was present originally is difficult to explain. The idea that the original beds of iron formation could belong to epicontinental sediments seems the most probable. Iron may have precipitated and concentrated either as sedimentary oxides or even iron silicates. The attribution of iron to a magmatic source as for instance exhalative activity on the sea floor is less probable. Since the formation the iron-bearing sediments were subjected to extensive metamorphism and recrystallisation, having converted the primary iron concentration into magnetite. The uncertainity as to the details of origin of this ancient deposit is a direct consequence of its long and complex geological history and this shall be kept in mind when considering the genesis of pre-Cambrian deposits.

Reserves. No accurate tonnage estimate of the whole zone is possible before the full program of detailed survey, including drilling, will be carried out. For the time being the presence of ore is known on the above described localities only. The estimated reserves are given as approximate figures in the Table 2.

Table 2 — 2. tabela

Locality	Estimated reserves (tons) Measured	Inferred (min.)	(max.)
Koree	50 000	100 000	150 000
Yubdo	20 000	50 000	300 000
Gordana Katcho	10 000	40 000	100 000
Chago	80 000	100 000	200 000
Nejo (east)	—	—	50 000
Total	160 000	290 000	800 000

The quantity of existing reserves for single locality can not be expected more than several hundreds of thousand tons at maximum. The whole zone must be ranged accordingly to small-size iron deposit with a total tonnage of about half a million or so tons of high-grade iron ore. The lenght of the zone is about 70 km and the total lenght of the visible outcrops 750 m only.

Billa

Approximately 2 to 3 km east of the village Billa in Bogi district in Wollega a pronounced barren mountainous ridge extends (Fig. 5). It is composed of compact light grey quartzite, having a strike of about 10° and dipping apparently very steep west. On the western slope of the ridge several more or less limonitized quartzitic and schistose rocks can be found in a 100 to 200 m wide zone, containing even pure limonitic

Fig. 5. View of Billa ridge with scattered pebbles of limonite

Sl. 5. Pogled na greben Billa z razmetanimi kosi limonita

pieces and debris. A banding in the metamorphic strata can be seen and the schistose rocks alternate with layers richer in iron oxide. The lenght of this zone is about 1,5 km. The average iron content is relatively low. It is possible that in the series of alternating strata some of them contain a higher content of iron.

Genetically the iron concentrations at this locality are in general bound to the zone of metamorphic rocks as described above. The ferruginous quartzite and schist are of sedimentary origin and subsequently recrystallized by regional metamorphism. The quartzite might be metamorphosed originally arenaceous sediment. The local concentration of limonite found in this place is secondary in origin and has formed by leaching and precipitation of iron out of the primary mother rocks. Chip samples of ore have been analysed, containing even 56 % of iron and 3 to 5 % of silica, but these figures can not be regarded as average. The iron content varies from place to place, being in average very low.

For the time being it is believed that the iron ore occurrence at Billa is of no economical value due to the low iron percentage.

The existence of sedimentary-metamorphic iron occurrences in Wollega is, however, an interesting phenomenon due to the fact that many of the significant world's iron deposits belong to this type, which usually contains high-grade iron ore. In South Africa and especially in recent time in West Africa enormous deposits of this type have been discovered (Finn, 1964).

In the northern prolongation of Billa ridge some 12 km away of it an analogous iron concentration was found at Tullu Bollale, having the same appearance as that of Billa ridge. Hematitic schist was observed also along the main road to Nejo several kilometers before the town. The iron contents is low. The rocks are reddish-brown and well schistose. Ferruginous schist does exist also in the vicinity of Gollisso.

The conclusion can be made that in this part of Wollega several ferruginous schistose horizons appear the iron contents of which is disseminated very irregularly, and here and there concentrated to rich but rather small lenslike ore bodies.

2. Metamorphic — contact metasomatic type

Falcat — Agametta zone

General. Regarding the geological information available for the time being the most interesting and potentially important might be the iron ore occurrences in Eritrea. Lenslike ore bodies of high-grade magnetitic ore were known for many years to extend at several localities, especially in the area Sabub-Agametta about 40 km east of Asmara, and in the extreme northern part of Eritrea in the Falcat area. Several new ore occurrences have been found in the Gumhod area during the prospecting campaign carried out in 1963 by the Ministry of mines. It looks very probable that additional ore bodies could be found by systematic work in the mountainous and partly extremely hard accessible parts of this province.

The data on investigations carried out formerly on these iron ore-bearing areas (Fig. 6.) are summarized by Usoni (1952). In 1919/20 several pits and trenches were dug in Agametta area. Extensive exploration was carried out immediately before War II, applying magnetometer survey too. The reserves were estimated to 2,5 million tons.

In 1956 the German KRUPP company assesed the reserves to be probably beyond the 2,5 million tons. In 1963 the Ministry of mines engaged the Yugoslav RUDIS company to explore definitely the 100 sq. km large area between Sabub and Agametta in the most southern part of the ore-bearing zone. At the same time the reconnaissance, prospecting and preliminary studies in the adjacent areas covering totally over 1800 sq. km were carried out by the Ministry of mines. The aim of this

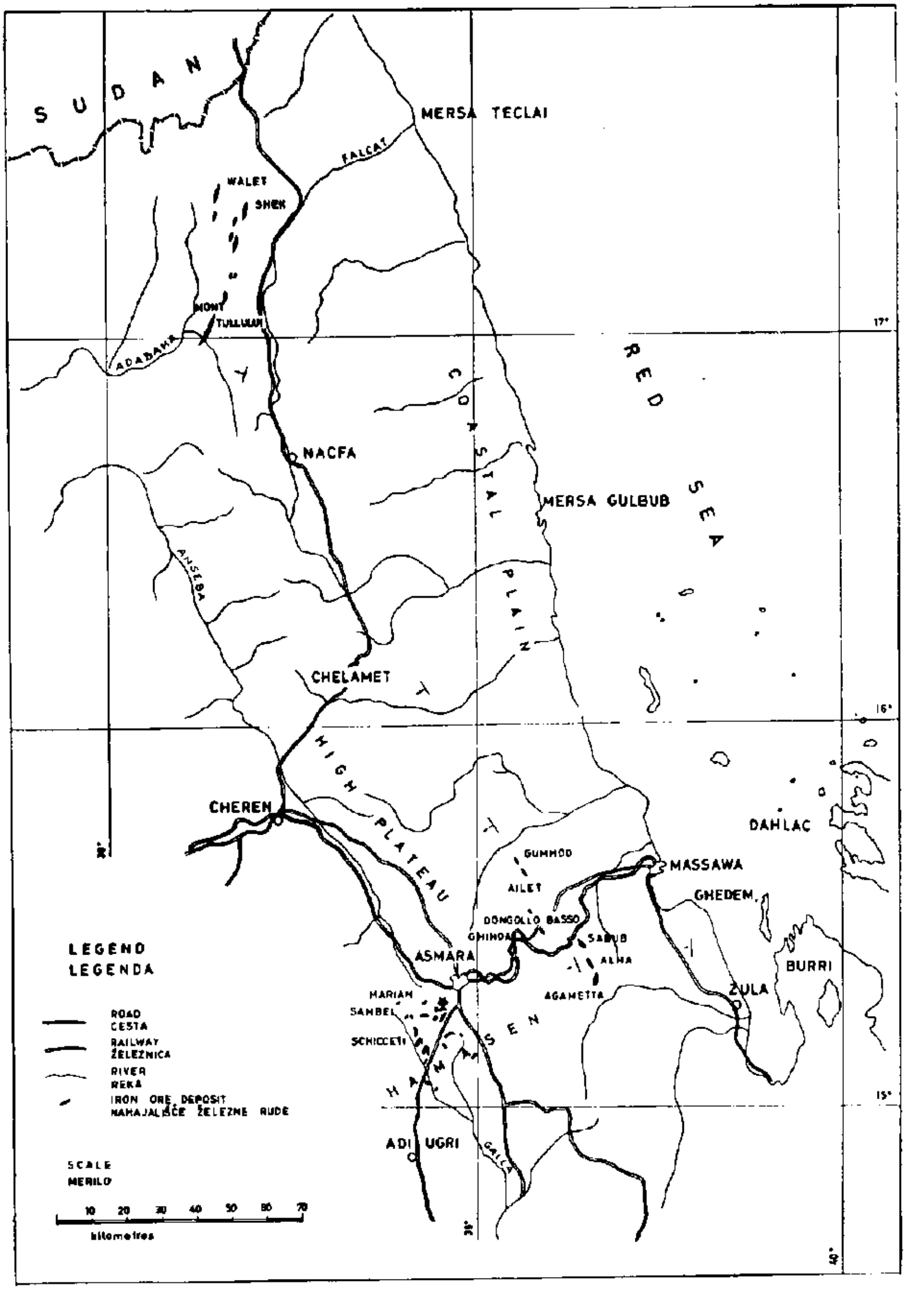


Fig. 6. Sketch map of iron ore-bearing areas in north eastern Eritrea
Sl. 6. Karta območij železovih nahajališč v severovzhodni Eritreji

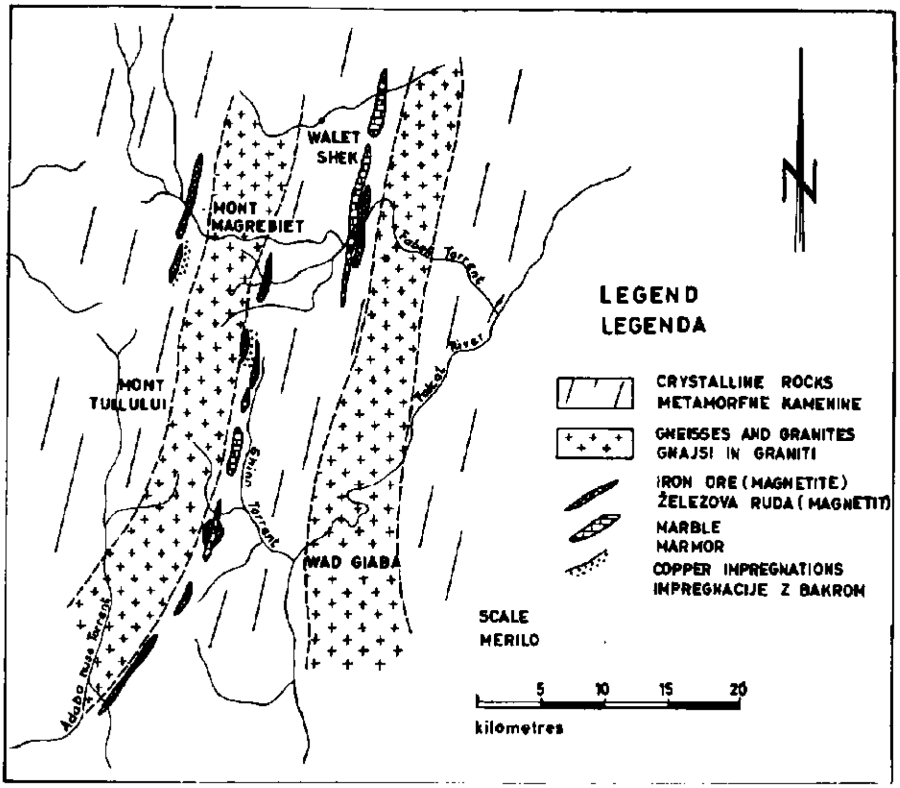


Fig. 7. Provisional geological sketch map of the Falcat area. (After A. Cavagnari, 1919)

Sl. 7. Približna geološka skica območja Falcat. (Po A. Cavagnariju, 1919)

activity was to provide the preliminary basis for the eventual further investigations.

The northern ore deposits in the Falcat region could not be visited by the author in 1963. The deposits were studied in the past mainly by Bibollini (Usoni, 1952). The general geological situation is evident from an unreliable sketch by Cavagnari (Fig. 7.). In 1940/41 the Italian RIMIFER company explored the deposits geologically and geophysically without having discovered new ore bodies. No definite view can be deduced from Usoni's data regarding the economic importance of these deposits, and the reserves were estimated to 200 000 to 300.000 tons only.

In judging the potential possibility of the whole ore-bearing zone the deposits in the Falcat area must be explored and studied definitely in the shortest possible time.

According to the Italian geologists the iron ores of Agametta as well as of the northern deposits in the Falcat area are pyrometasomatic in origin and related to silicic intrusions. KRUPP found obvious indications of the sedimentary character of the ore in Agametta area. RUDIS (1963) interpreted the origin of the ore in connection with the exhalative volcanic processes in the shallow sea. Subsequently hematite was transformed into magnetite by regional metamorphic and contact metamorphic processes.

Description. Geologically the Gumhod-Agametta area in the eastern part of the central Eritrea consists of pre-Cambrian rocks of presumably low-grade metamorphism similar to those in Wollega. The most important rock-types are parametamorphic schistose rocks varying from almost unaltered arenaceous sedimentary rocks to high-grade metamorphosed gneiss facies. The inclusions of calcareous lenses occur often in the basement complex, the foliation of which is in general NNW—SSE in this part of Eritrea. Granitic, pegmatitic and differentiated intrusive rocks are included. On the plateau south of Asmara basalt capping covers the basement rocks, and in the coastal part of Eritrea young Tertiary sediments and basaltic lavas spread locally over them.

The existing magnetitic ore is prevailingly massive and occurs in big angular blocks (Fig. 8.). Texturally it is coarse-grained but also fine-grained or in the form of banded ferruginous quartzite and schist. The latest shows here and there also a well defined banding with quartz-rich layers alternating with iron oxide-rich layers. Also the alternation of magnetite layers with schistose chlorite-schist and other schists is not

Fig. 8. Outcrop of magnetite ore at Agametta
Sl. 8. Izdanek magnetitne rude v Agametti

Fig. 9. Outcrop of sehistose magnetite ore at Dongollo basso
Sl. 9. Izdanek skrilave magnetitne rude v Dongollo bassu

seldom to be seen. This banding is without doubt an original sedimentary layering, accentuated perhaps by metamorphic recrystallization. Also the fine-grained magnetite ore shows a very fine banding parallel to the folliation of the sedimentary complex (Fig. 9.). The coarse-grained ore is more clean and the banding seems to be less pronounced. In the northern part of the zone near Gumhod the ore layers consist of alternating bands of magnetite and schistose rocks. The schistose textured ore is intermingled with green chlorite-schist and quartz layers.

The southern part of the ore-bearing zone between Sabub and Agametta is built up by different low-grade metamorphic rocks, which contain several lenslike iron ore bodies, following the general foliation in the metamorphic series. In general some ten groups of ore lenses exist there, occurring in different levels in the ore-bearing horizon. According to RUDIS (1963) the ore bodies have the predominant lenghts between 5 and 25 m and the thicknesses exceed exceptionally more than 1 m. Schistose metamorphic rocks contact larger bosses of granodiorite and granite porphyry. A narrow zone of older basic extrusive rocks occurs in the basement complex and RUDIS believes these rocks might be genetically related to the granodiorite as well as to the iron ore. An important feature is the presence of skarns, which are not always connected to the calcareous lenses occurring within the metamorphic series. Besides the locally abundant quartz, garnet, epidote and other silicates also grains of sulphides and patches of copper carbonates occur in this type of ore mineralization. Malachite was found also in small quartz veinlets crossing the metamorphic rocks.

Near Dongollo basso a completely isolated lens of banded magnetite ore was found on the Gahar hill, having a lenght of 15 m and a maximal width of 1,5 m. Several kilometers to the north another small outcrop of ore exists near Ailet. Both are included in the foliated schistose rocks.

In the Gumhod area several new magnetite occurrences have been found during prospection. They have the same morphological features as those in Sabub-Agametta area, being characterised by scarse small-

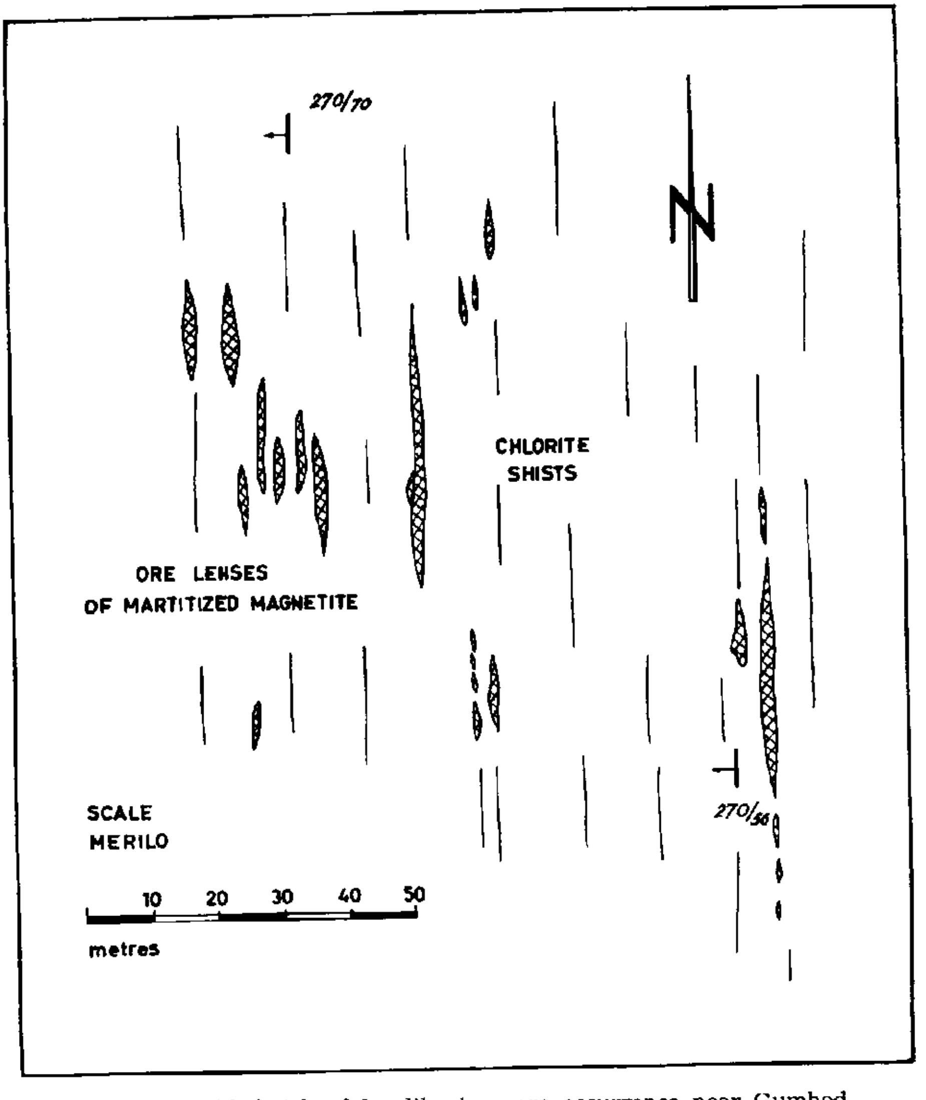


Fig. 10. Field-sketch of lenslike iron ore occurrence near Gumhod

Sl. 10. Terenska skica lečastih teles železove rude pri Gumhodu

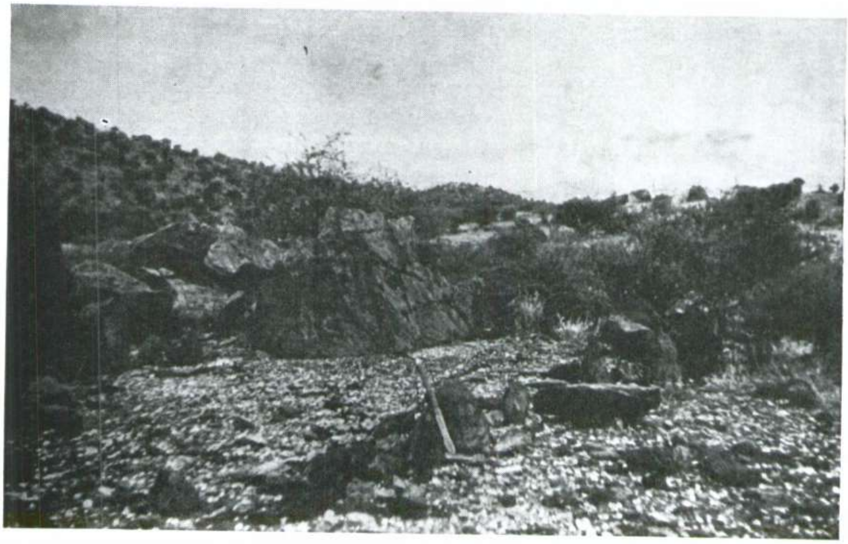


Fig. 11. Outcropping small lenslike ore bodies near Gumhod
Sl. 11. Izdanek majhnih lečastih rudnih teles pri Gumhodu

sized lenslike ore bodies lying in the strike of the metamorphic complex. There is no doubt the occurrences belong to the same ore-bearing zone. Three groups of ore lenses have been found there and the group Gumhod I is shown in the sketch (Fig. 10.) as well as in the photo (Fig. 11.).

The area between Sabub and Gumhod is represented by a plain covered by sands and torrential piedmont gravels. The thickness of this cover can be estimated to several meters on average. The continuation of the ore-bearing zone along this 20 km long area between the northern and southern outcrops is very probable, however, composed of the eventual small groups of ore lenses. The possible existence of ore under this alluvial cover might be partly proved by a 600 m long magnetic anomaly discovered by RUDIS's magnetometer survey near Fort Ambatocan (RUDIS, 1964).

This ore-bearing zone continues in all probability further to the NNW following the general trend of the basement complex. Magnetite sands are known along the sea-shore at Mersa Gulbub in the Northern desert. Future efforts shall be directed towards possible new discoveries of ore in this area. Owing to the fact that this region is far and very hard to access only a well organized and equiped terrestrial prospection could bring results.

In the northern part of Eritrea, about 180 km north of Asmara similar magnetite deposits occur at Walet Shek and Mont Tullului in the region of Falcat river. The iron ore occurrences of Falcat-Mont Tullului area and others are described by Usoni (1952), following mainly Bibolini's data. Considering also additional data on these areas the conclusion can be made, that the geological situation in general does not differ from that in the Gumhod-Agametta area, except perhaps more accentuated skarn character of the deposits. Magnetite lenses occur everywhere in the closest contact with marble, having both the forms of elongate lenslike bodies. The strike of the basement complex might be there NE—SW and the zone of interest several tens of kilometers in lenght. The deposits are described to be typical contact-metasomatic in type with large formation of epidote, garnet and perhaps ilvaite, the minerals replacing calcite. The mineralization is thought to be due to hydrothermal solutions derived from porphyric extrusions as well as granodiorite or other igneous masses in depth in the vicinity. The lenght of lenslike iron ore bodies may vary between 100 m and 300 m, having the thicknesses of about 10 m as maximum. The presence of iron and copper sulphides is indicated (Usoni, 1952). From Cavagnari's sketch (Fig. 7.) the copper mineralizations look to be well delimited. Specular hematite may occur in the Falcat ore too.

Analyses. KRUPP analysed in 1956 seven grab samples of iron ore from Agametta area. The results would give an average composition of ore as follows (in percent):

Fe	58
SiO_2 . . .	14
P	0,047
O	0,018

Additionally, three chip samples of good ore from Sabub-Agametta area have been analysed in the Chemical laboratory of the Ministry of mines. The results are given in the Table 3 (in percent):

Table 3 — 3. tabela

No.	Fe	SiO_2	Ca	Mg	Al_2O_3	P	Ti	MnO	Cu	SO_4
250	47,04	22,82	0,00	0,00	0,53	0,02	0,00	0,54	tr.	tr.
251	47,50	30,70	0,00	0,00	0,23	0,044	0,00	0,40	tr.	tr.
253	68,13	2,30	0,00	0,00	0,20	0,017	0,00	0,35	tr.	tr.

The percentages of iron and silica are variable and depend on picked samples. It could be estimated that an average contents of iron would vary between 50 and 65 % and that of silica between 10 and 20 % respectively in the representative samples, which, however, have not yet been systematically taken and examined. Small contents of phosphorus, sulphur and other admixtures make the composition of ore excellent.

Many samples of ore as well as other rocks were examined under the microscope as polished and thin sections. As to the ore there are two types to be distinguished: banded magnetite-martite ore and magnetite with skarns. It can be said, in general, that the banded ore consists of granoblastic recrystallized agregate of magnetite and quartz prevailingly. Magnetite in form of allotriomorphic fine grains is concentrated in bands but also dispersed in quartz matrix (Pl. 1, Fig. 2.). Magnetite is always martitized, and martite spreads along the grain boundaries and fissures or follows the planes (111) of magnetite in form of lamellae. Some rare inclusions of chlorite, mica, amphibole, epidote and calcite are present. The blastic grain structure of the rocks, which vary from magnetite-bearing quartzite on one side to dense granular magnetite on the other, is due to the metamorphic recrystallization.

Big crystalls of epidote occur in the banded rocks sometimes and later quartz fills the cracks and fissures, proving additional hydrothermal processes in the ore. Besides very advanced martitization of magnetitic grains distinct lamellar hematite occur too and can be seen even by unaided eye. The impression is got the lamellar hematite might be due to a special crystallization phenomenon undipendent from that of martitization of magnetite. Lamellar hematite is distinguished by very porous texture.

The presence of sulphides in banded ore is another important feature. Rare isometric crystals of pyrite are spread allong banding in quartz matrix. They are much bigger than the average size of magnetite crystals. The great part of these grains appear already completely altered to zoned limonite which spreads also along fine fissures in the ore. Homeoblastic fine-grained quartz matrix gets disturbed along the margins of these crystals and longish quartz grains are oriented perpendicularly to the margins of sulphide grains. Pyrite crystals, having more than 1 mm in size, occur in the bordering zones with marble too. Normally they are pseudomorphoses after pyrite which can be found within limonite in form of small relicts only. It looks that the sulphides have been introduced with a later generation of quartz due to the hydrothermal processes which produced skarns.

On the other side small roundish and elongate grains of chalcopyrite occur in the magnetite grains as well as in the martitized parts of it (Pl. II, Fig. 1.). The small gold-yellow bodies are distributed very scarcely and irregularly. Their direction seems to be here and there parallel to that of the martite lamellae. The size of these grains which are well delimited from the surronding magnetite, is generally less than 0,01 mm, and the maximum not more than 0,03 mm.

Malachite is concentrated as secondary filling in fissures and cracks together with the supergene iron oxides.

There is no certainity regarding the textural relation of copper and iron minerals. The intimate relation of both minerals could point out that copper might be primary in origin and syngenetic with iron. This relation is not yet studied in details and sufficiently explained for the time being.

The skarn type of ore consists of garnet, epidote, amphibol, prevailing quartz and magnetite (Pl. II, Fig. 2.). The microscope reveals the idiomorphic garnet and epidote cemented by magnetite and a later quartz.

The idiomorphic garnet crystals show often skeletonlike forms with oriented bandsgrowth in quartz. This is a proof of more or less simultaneous crystallization whereupon magnetite crystallized apparently as the last of the components. Magnetite is always allotriomorphic. It can be found also in the center of garnet crystals.

O r i g i n. The information gathered hitherto points out to the explanation of the origin of deposits in the following way. The main part of iron in the existing ore bodies is of primary sedimentary origin. It was deposited in the ancient marine basin where the metasediments of the present pre-Cambrian complex originated. A small amount of copper might have been deposited simoultaneously with iron. The original form in which these two metals might have been precipitated is unknown. According to RUDIS (1963) some indications for an exhalative iron origin might exist.

Regarding sedimentary copper minerals there are occurrences in the world known where this metal is associated with sedimentary rocks, having originated in the conditions of shallow-water sedimentation. In general there iz much uncertainity as to the sedimentary environment in which the sediments were deposited. The copper mineralization of apparent sedimentary origin seems to be present in Eritrea also at the new discovered occurrence Mont Sacar in the vicinity of Gumhod.

The primary depositions containing iron were subsequently subjected to several periods of metamorphism and deformation. They were extensively metamorphosed and recrystalized and iron concentrated to lenslike ore bodies of granoblastic texture.

The next hydrothermal replacement mineralization followed, the result of which was the formation of skarns. The mechanism of these events as well as the origin of solutions is not cleared. The components could be either newly brought from magmatic sources or may be simply a remobilization of elements from sedimentary sources already present, without introduction of new material. The solutions may have been derived from the batholitic activity, connected to granodioritic intrusions, younger than the metasediments.

The process of martitization is believed to be of supergene origin. As already pointed out a part of hematite is possibly due to hydrothermal activity too.

R e s e r v e s. The reserves for the most southern part of the iron-bearing zone between Sabub and Agametta have been calculated by RUDIS (1963), and summarized to a global sum of 425 000 tons. Some nine groups of ore lenses in the zone of about 15 km lenght may contain about 124 000 tons of visible and probable ore, and several hundreds of thousand tons of potential possible ore. The enlargement of reserves on account of inferred ore in the depth is not hopeful due to small dimensions of the ore lenses and their scarce displacement in the terrain.

As to the visible and probable reserves in the Gumhod area they are calculated to 8530 tons only. The inferred tonnages can be estimated to several tens of thousand tons (H a m r l a, 1964).

On the basis of the known geological situation in both areas, and on the assumption that the ore might be present in the plain area covered by alluvial sands the tonnage estimate is possible by statistical method. Hence, the reserves of the whole 40 km long zone might amount to about 1 million tons, related to twelve known occurrences and additional nine supposed to exist under the alluvial cover. A depth to 60 m under the surface was considered and the actual relation between the proven and inferred reserves is about 1 : 7 (Hamrla, 1964).

More promising in reserves might be the Falcat region. The Italian sources report much greater dimensions of the ore bodies from those established in the Gumhod-Agametta area. On the other hand these data seem to be doubtful if compared with the Italian data for Agametta. Additionally the great distance from potential industrial centres as well as from the shore (60 km air-line to Red-sea port Mersa Teclai) makes the immediate economic proficiency of these deposits doubtful even if larger reserves exist. The deposits should be, however, reconnoitred and well assessed in light of experiences gained through detailed geological and geophysical examination of Gumhod-Agametta area. Moreover the whole 180 km long zone between Gumhod and Falcat valley should be prospected and assessed.

Other deposits

Similar iron ore deposits are reported to exist in Sidamo province in the area of Yavello and Irbi as well as in the zone of Arero and Metacapersa (Murdock, 1960). Magnetitic and hematitic ore is reported to contain 60 to 68 % of iron. These localities would be worth to be explored to such an extent that the eventual significance could be assessed.

3. Residual concentration type

The occurrences of residual ores are due to the decomposition of silicate rocks in the process of weathering. During the decomposition some leached components go into solution and are carried away, others remain and precipitate in convenient environment. Under conditions characterised by alternating dry and wet seasons, the decomposition is more complete and results in a lateritic soil composed of limonitic and bauxitic components, meanwhile silica is extensively removed.

Under favourable climatic and other conditions iron and also manganese may accumulate in this way to form even economic deposits. The concentration of iron in lateritic residue forms residual — lateritic deposit. If the leached components precipitate in open spaces residual — infiltration type originates.

Regarding the nature of mother-rock the iron has been leached from the extrusive volcanic rocks and ferruginous siliceous rocks can be distinguished.

Extrusive rocks as source of iron

Mai Gudo

G e n e r a l. The Mai Gudo area is situated about 60 km to SSE from Jimma in the upper drainage pattern of the Odonitta river. The mountainous area is difficult to access. A 65 km long old road in very bad condition presently connects the locality with the highway some 30 km before Jimma.

The deposit consists of many small iron ore occurrences, the most important of which are shown in the enclosed map (Fig. 12.). There is no persistency among the isolated accumulations.

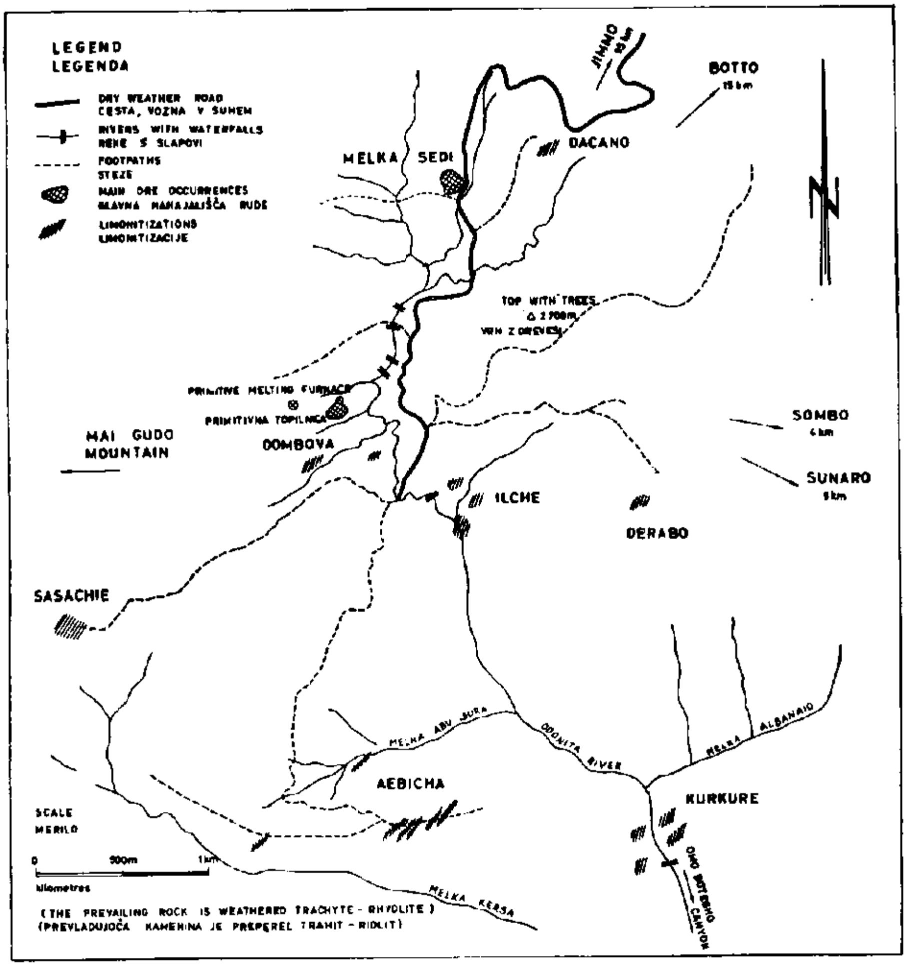


Fig. 12. Sketch map of Mai Gudo iron (and manganese) ore occurrences

Sl. 12. Skica nahajališč železove (in manganove) rude Mai Gudo

The ore has been exploited by natives and smelted in a primitive way for a long time ago for the manufacture of tools and weapons. During the Italian occupation considerable mining activity has been carried out and about 20 000 tons of ore were mined. In that time Villaminar estimated the ore reserves, which are cited by Usoni (1952) to amount to 1,2 million tons totally.

In 1945 Murdock visited the area and estimated the reserves to 120 000 tons (Murdock, 1960). He pointed out the guess has been made without any real basis. In 1956 an expert of the German KRUPP company reconnoitred the area and found it not worth of any further exploration.

At the end of 1962 the Ministry of mines explored the area by pitting and trenching. The occurrences have been found practically without economic importance, being very small in size and insignificant in reserves of ore of medium and low quality (Hamrla, 1963). Additionally, the position of the area is very unfavourable regarding transportation facilities.

Description. The large region of Mai Gudo is built up of volcanic rocks of Trap series. Dolerite and olivine-basalt are reported to build the highest parts of the mountains. The prevailing rocks are trachyte-rhyolite. The rocks are extremely weathered and characteristically violet-reddish coloured. Residual soil covers the surface and locally accumulates in considerable thickness. Yellowish-brownish bands and crack-fillings by compact ore could be stated everywhere in the soft weathered country rocks which contain often yellow ochreous and black manganiferous inclusions. The traces of former exploitation in limited extend can be locally found.

Melka Sedi is the most important locality among all occurring in this region. Supergene iron ore occurs in the lowest part of a pretty steep slope. Old ditches and trenches are evident in the outcropping area which may have a surface of about 120 m by 100 m. Residual soil covers the weathered rocks, being ferruginous and intensively yellowish-reddish-brown coloured. Thin veins and bulby inclusions of compact ore are frequent. Small bodies of compact limonite are included in yellow earthy ochre containing bluish-black manganese hydroxides as well as layers of grayish-black earthy wad. The structure of ore is breccious and it passes here and there to the residue. It looks that the more compact ore is concentrated in the lowest part of the mineralized zone near the bottom of the slope. The quantitative relation between the compact ore and the waste is in general unfavourable.

At Dacano ferriferous concentrations occur in weathered rocks accompanied by manganese oxides. They are quantitatively unsignificant.

The outcroping area at Dombova extends on a roughly estimated area 100 m by 80 m. The ore occurrence is similar to Melka Sedi in appearance but smaller and poorer in degree of mineralization. An old trench reveals the prevailing yellowish weathered rocks and banded soil with irregularly concentrated limonite in form of small bulbs and veinlets other than greater blocks and lenses.

At Ilche only scarce traces of mineralization exist in residual soil as proved by several pits.

At Sassachie weathered yellowish-brown rocks prevail, containing small crack-fillings of iron and manganese oxides.

No remarkable ore concentrations exist also at the localities Kurkure, Derabo, Sunaro and Botto, where unimportant local concentrations of compact ore are accumulated in cracked weathered country rock.

Veinlike iron ore occurrences were signaled from the locality Aebicha. Iron and manganese oxides are concentrated in tectonically crushed zones, striking 200° to 250° and dipping vertically. They have 10 cm to 40 cm in width. The breccious weathered rocks are cemented with iron oxides as well as with silica, indicating in this way the forms of apparent veins.

At the locality Sombo a several centimeters thick lenslike seam of manganese ore was found underlying the clayey overburden. This residual manganese concentration is of theoretical interest only.

In general the Mai Gudo ore can be described as mostly unclean and more or less breccious with admixtures of weathered rocks. It consists of hydrated oxides of iron in all varieties from brown hydrohematite on one side to high porous ochre of earthy nature on the other side. The same passes for manganese ore which exhibits stalactitic and spongy masses, but also earthy wad of high porosity can be often observed.

A n a l y s e s. For Melka Sedi and Dombova ore twelve chip and channel samples have been analysed by KRUPP (1956), indicating the average iron content about 40 %. The average manganese contents for Melka Sedi iz 8,6 % and for Dombova 3,8 %. Phosphorus and sulphur range about 0.03 % and silica between 6 and 17 %.

Several chip samples from different localities were analysed also in the Chemical laboratory of the Ministry of mines. The samples did not represent the average of the existing ore but rather relatively rich ore was taken. The results are shown in Table 4 (in percent):

Table 4 4. tabela

Locality	Fe	Mn	SiO_2	Al_2O_3	Remarque
Ilche	37,9	0,3	36,0	4,7	Siliceous ore
Kurkure	45,0	1,64	20,0	3,15	Rich compact ore
Aebicha I	45,6	tr.	21,9	1,0	Siliceous breccious ore
Aebicha II	34,8	0,1	41,0	0,0	Unclean breccious ore
Sunaro	58,8	0,3	3,5	0,0	Clean compact ore
Sombo	7,7	44,5	5,4	2,7	Rich manganese ore

The microscopic examination of polished sections of ore specimens reveals the porous texture of limonitic ore composed of goethite prevailingly. The admixtures of impurities are often (Pl. III, Fig. 1.). Psilomelane occurs intimately intergrown with iron oxide but also in form of fine banding.

Microscopic examination of the country rock reveals no mafic phenocrysts in hollocrystalline porphyritic rock. Minute mafic components are disseminated in the matrix only. Decomposition begins in the matrix which get to be impregnated by yellowish pigment. The limonitic products fill up also the cleavages in sanidine phenocrysts, which get to change to products of kaolinization.

Origin. Genetically the accumulation of iron and manganese can be explained through principles of supergene mineralogy of both elements. The mineralization is the result of chemical weathering of the country rock. Iron and manganese have been leached out of mafic minerals in the fine-grained matrix and precipitated more of less in situ, having accumulated in residuals and different openings in the rock where iron and manganese-bearing solutions have penetrated. Silica, alkalies and alkaline earths have been removed in solution and carried away. There is no doubt on the descending origin of the solutions. Also the morphology and the superficial character of the occurrences reveal a secondary enrichment only.

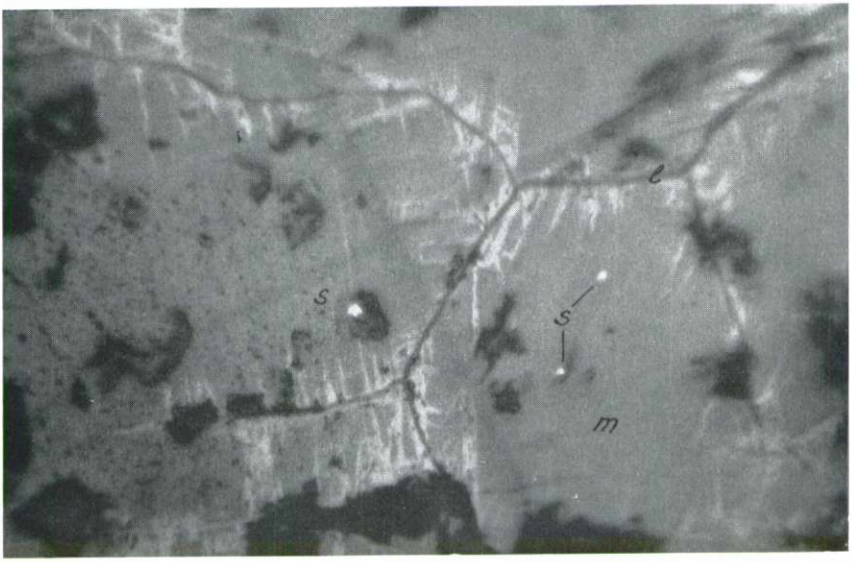
Iron and manganese might have originated partly perhaps also from more basic rocks the presence of which is indicated in the area. However, the percentage of iron and manganese in acid rocks is low. Economically important iron ores of this genetical type are normally bound to more basic rocks.

Reserves. Regarding the reserves Melka Sedi and Dombova deserve limited attention only. At both localities the quantity of useful compact ore does not exceed 20 % of the volume of the layers of altered ochreous decomposed rocks prevailingly. Hence the measured reserves of compact ore have been calculated to 65 000 tons for Melka Sedi and 12 000 tons for Dombova, having an average of about 40 % of iron and several percents of manganese. The additional inferred tonnages could be estimated to 25 000 tons only. From the point of view of smelting industry the reserves as indicated above have a very limited significance. An additional unfavourable factor regarding the mining is high compact ore — to — waste ratio, ranging about 1 : 5.

For all other localities the conclusion is due, that no reserves of economic importance were detected and can also not be expected. Taking into consideration also the transportation difficulties the reserves of Mai Gudo have very small economic importance for the time being.

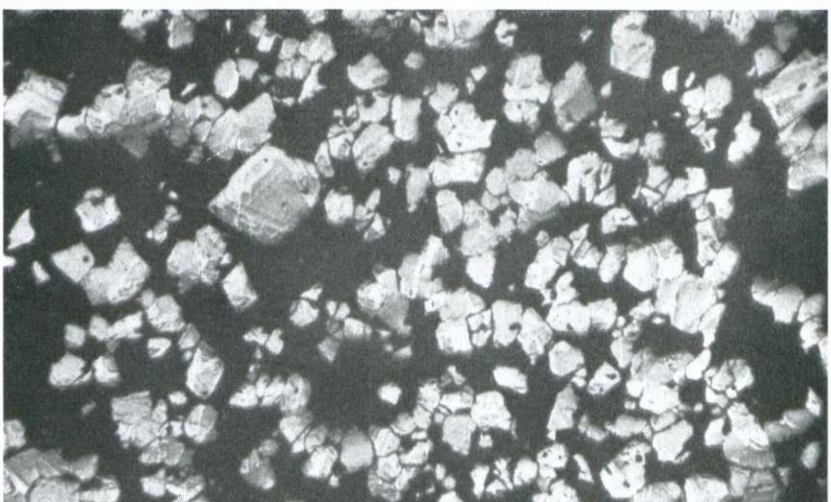
Entoto

Entoto hill several kilometers north of Addis Ababa is known for a long time to yield iron ore. Old trenches and overgrown pits give evidence of former mining activity. Small isolate lenses and veinlike accumulations of hard limonitic ore are exploited in very reduced scale presently to meet local requirement of the Akaki smelting factory. The ore is used as extra-charge to the scrap iron.



Pl. I, Fig. 1. Koree ore; — oil immersion, 600 ×. Martitized magnetite (m), limonite (l) in cracks and small grains of sulphide (s)

I. tab., 1. sl. Ruda Korree; — oljna imerz., 600 ×. Martitiziran magnetit (m) z limonitom (l) v razpokah in drobnimi zrni sulfida (s)

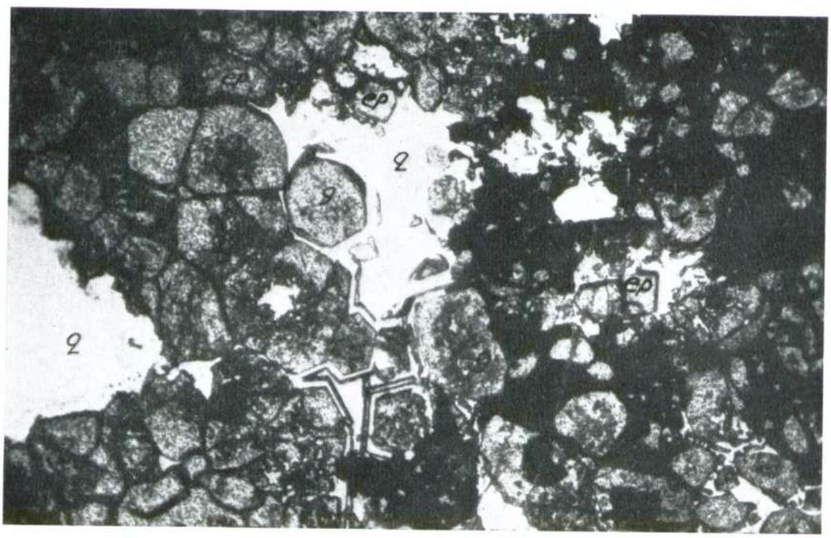


Pl. I, Fig. 2. Dongollo basso ore; — oil immersion, 135 ×. Granoblastic agregate of partly martitized magnetite in quartz matrix

I. tab., 2. sl. Ruda Dongollo basso; — oljna imerz., 135 ×. Granoblastičen agregat delno martitiziranega magnetita v osnovi kremena

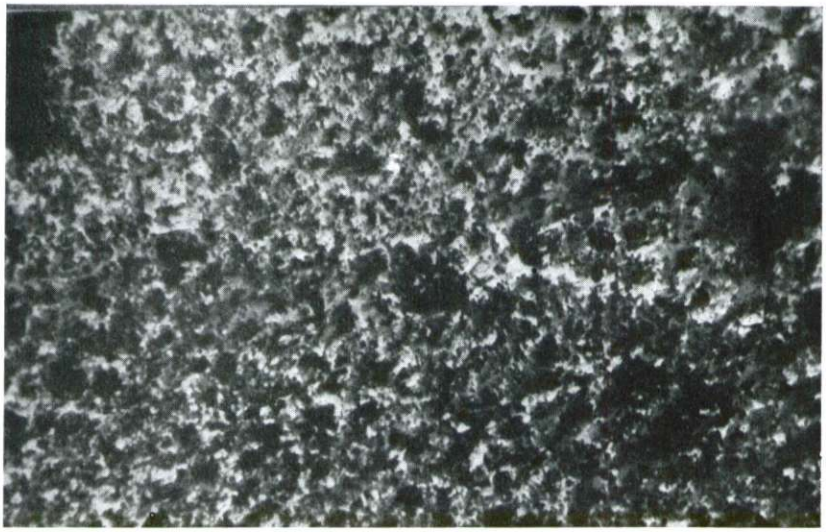
Pl. II, Fig. 1. Gumhod ore; — oil immersion, 600 ×. Martitized magnetite (m) with small grains of chalcopyrite (ch) and malachite (ml)

II. tab., 1. sl. Ruda Gumhod; — oljna imerz., 600 ×. Martitiziran magnetit (m) z drobnimi zrni halkopirita (ch) ter malahitom (ml)



Pl. II., Fig. 2. Agametta ore; — thin section, 40 ×. Skarn ore: magnetite (m), garnet (g), epidote (ep) and quartz (q)

II. tab., 2. sl. Ruda Agametta; — zbrusek, 40 ×. Skarnova ruda: magnetit (m), granat (g), epidot (ep) in kremen (q)



Pl. III., Fig. 1. Mai Gudo ore; — oil immersion, 135 ×. Porous impure limonitic ore

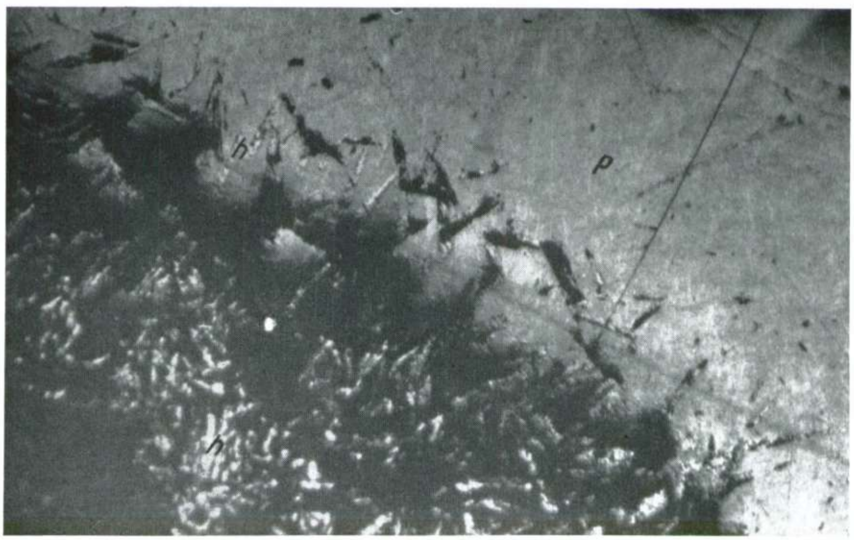
III. tab., 1. sl. Ruda Mai Gudo; — oljna imerz., 135 ×. Porozna nečista limonitna ruda

Pl. III., Fig. 2. Ghedem ore; — oil immersion, 135 ×. Zonal texture of ore, consisting of alternating bands of iron oxide (g), manganese oxide (m), silica (s) and calcite (c)

III. tab., 2. sl. Ruda Ghedem; — oljna imerz., 135 ×. Conarno strukturirana ruda sestoji iz izmeničnih pasov železovega oksida (g), manganovega oksida (m), kremenice (s) in kalcita (c)

Pl. IV., Fig. 1. Ghedem ore; — oil immersion, crossed nicols, 135 ×. Fine-crystalline agregate of pyrolusite

IV. tab., 1. sl. Ruda Ghedem; — oljna imerz., navzkrižni nikoli, 135 ×. Drobno kristalast agregat piroluzita



Pl. IV., Fig. 2. Enkafela ore; — oil immersion, 135 ×. Psilomelane (p) and needleshaped hollandite (h)

IV. tab., 2. sl. Ruda Enkafela; — oljna imerz., 135 ×. Psilomelan (p) in igličast holandit (h)

The Entoto mountain is built up of trachytic-rhyolitic rocks prevailingly. The ore occurrences are known on the southern slope of St. Raquel church's hill. The rocks are altered and decomposed on the surface and residual soil is accumulated in thick cover locally. The limonitic ore is found as fillings of fractures and cracks in the weathered rocks or as small isolated inclusions in decomposed rock. The ore is compact, glassy limonite prevailingly but sometimes soft and banded ochreous parts can be found too. The width of "veins" is several decimeters at the maximum.

The origin of the ore is due to the leaching of iron by rain water during the weathering of country rock. Other leached components were carried away but iron precipitated in fractures and other openings in the rock. The colloidal ferric hydroxide hardens subsequently into amorphous glassy limonite with more or less obviously banded texture.

The estimation of reserves is difficult. The quantity, however, can be expected very small and no economic importance might be attributed to the locality for the time being. On the other hand an accurate search of the whole mountainous complex would possibly reveal several new ore concentrations, however, of limited dimensions. The reserves of inferred ore can be estimated not exceeding several thousands of tons only. Nevertheless, the tranportation situation of this area is favourable and a smelter is near.

Aira — Yubdo

In the Aira-Yubdo area in Wollega volcanic Trap series overlays the pre-Cambrian metamorphic rocks. The volcanic cover is relatively thin and reduced partly only to the tops of the hills. The rocks are largely composed of olivine-basalt. Along the border of the Trap capping the presence of thin layers of ferriferous rocks of oölitic and spongy texture is evident on many places in the volcanics' marginal zone. Near Aira Mission the ferriferous rocks are composed of quartz sandstone and conglomerate witch limonitic cement. At the magnetite occurrence near Yubdo an oölitic limonitic layer can be observed in the basis of the basaltic cover overlying the metamorphic schists.

Genetically the mineralization is a residual concentration of supergene iron oxides. The pre-Trapean residue, having resulted from the weathering of the basemnt rocks, was hardened by limonitic cement. The iron was dissolved by meteoric waters out of the basaltic rocks during the decomposition. The solutions percolated down and infiltrated the underlying residuals or other clastic rocks, having found a favourable place for the precipitation and deposition of dissolved minerals, and transforming them in oölitic and spongy ferruginous rocks. It is obvious that silica was leached and transported too due to the ferric-siliceous character of the existing ore.

In this way also the long discussed "birbirite", a special spongy ferric-siliceous rock known from Yubdo platinum deposit, might be explained as limonitized and silicified former lateritic crust of ultrabasic rocks which, however, contain platinum too. An additionnal proof for this explanation is the fact that "birbirite" can be found prevailingly along the western border of ultrabasic mass where it is still more or less in contact with basaltic cover.

Sands and gravel near Aira Mission may have originated as young lacustrine sediments deposited before the extrusions took place. Porous clastic sediments were cemented subsequently by ferric oxides transported in solutions from the overlying volcanic rocks (Hamrla, 1963).

The observed phenomenon of iron accumulation in the marginal zone along the volcanic capping occurs surely also on other places, where the geological conditions are favourable. The residual limonitic concentrations occurring in this way may be of theoretical interest only. At least in the Aira-Yubdo area the conditions as observed do not allow any hope for depositions of commercial value.

Ferruginous siliceous rocks as source of iron

Hamasen

General. The large occurrences of low-grade iron ore of residual type exist in Eritrea in the waste area south of Asmara, known by regional names Hamasen and Serae. Also there the natives smelted the ore to prepare the utensils and weapons. There is some descriptive information about the deposits of "nodular limonite" scattered in the waste area south of Asmara and also on other places in Tigre province. Dainelli (1943) described the phenomenon and later Usoni (1952) gave detailed information on the results of explorations carried out particularly during 1930/31. According to the Italian investigator Tissi the ore might extend on a large surface, and the thicknesses of layer are reported between 0,15 m and 0,6 m only.

Geologically this part of Eritrean high plateau is built up by schistose rocks of pre-Cambrian age overlain by volcanic capping. The pre-Cambrian surface was erroded to a peneplain before the Triassic transgression took place. The subsequent denudation removed the greatest part of the uncomformably overlying Triassic and Jurassic sediments before the Tertiary volcanic cover spread over the weathered surface of the basement complex.

The pre-Cambrian rocks of this area are predominantly phyllites, chlorite-schist and sericite-mica-schist streaking generally NNE—SSW, and containing gold-bearing quartz reefs. Granite bosses crop out at several places. The volcanics are built up by basalts, trachytes and rhyolites.

Description. The concentration of iron oxides is connected to the zone of alteration on the old levelled surface of the schistose pre-Cambrian rocks. The reddish layers of ferriferous rocks are to be seen everywhere, where the errosion removed or cut the basaltic covering. The largest areas of exposed reddish ferriferous rocks extend in the surroundings of Mariam Sambel just westwards of the new airport of

Fig. 13. Scattered pebbles of low-grade iron ore at Mariam Sambel
Sl. 13. Razmetani kosi nizkoprocentne železove rude pri Mariam Sambel

Asmara (Fig. 13.), and westwards of Schicceti on the Asmara-Adi Ugri road. There are many additional more or less exposed occurrences along the whole margin of volcanic capping, and isolated islands occur on the basement where the volcanic cover was already removed.

The approximate situation of the iron-bearing localities is given in the enclosed sketch (Fig. 14.).

At Mariam Sambel low-grade iron ore can be found on a surface of about 3 sq. km. It is compact with a nodular and breccious appearance. The thickness of existing layer is difficult to estimate but it is thought to reach several meters at maximum. The limonitic-hematitic ore is low-grade by appearance and should contain a relatively great percentage of silica.

Near Schicceti between the highway and the river Mareb there are large surfaces covered by reddish ferruginous products confined to the contact zone between the basement complex and overlying volcanics. The oxidized and secondary enriched ferruginous zone shows an obvious schistosity and represents the upper weathered part of the basement rocks, consisting locally of ferruginous and other schists (Fig. 15.). Irregular or lenslike inclusions of white siliceous staff are not seldom and might result from the precipitation of leached silica. The highest part of the secondary enriched zone is a breccious brownish-reddish rock of nodular and spongy appearance, similar to ferruginous concentrations observed by the author in Wollega and described above.

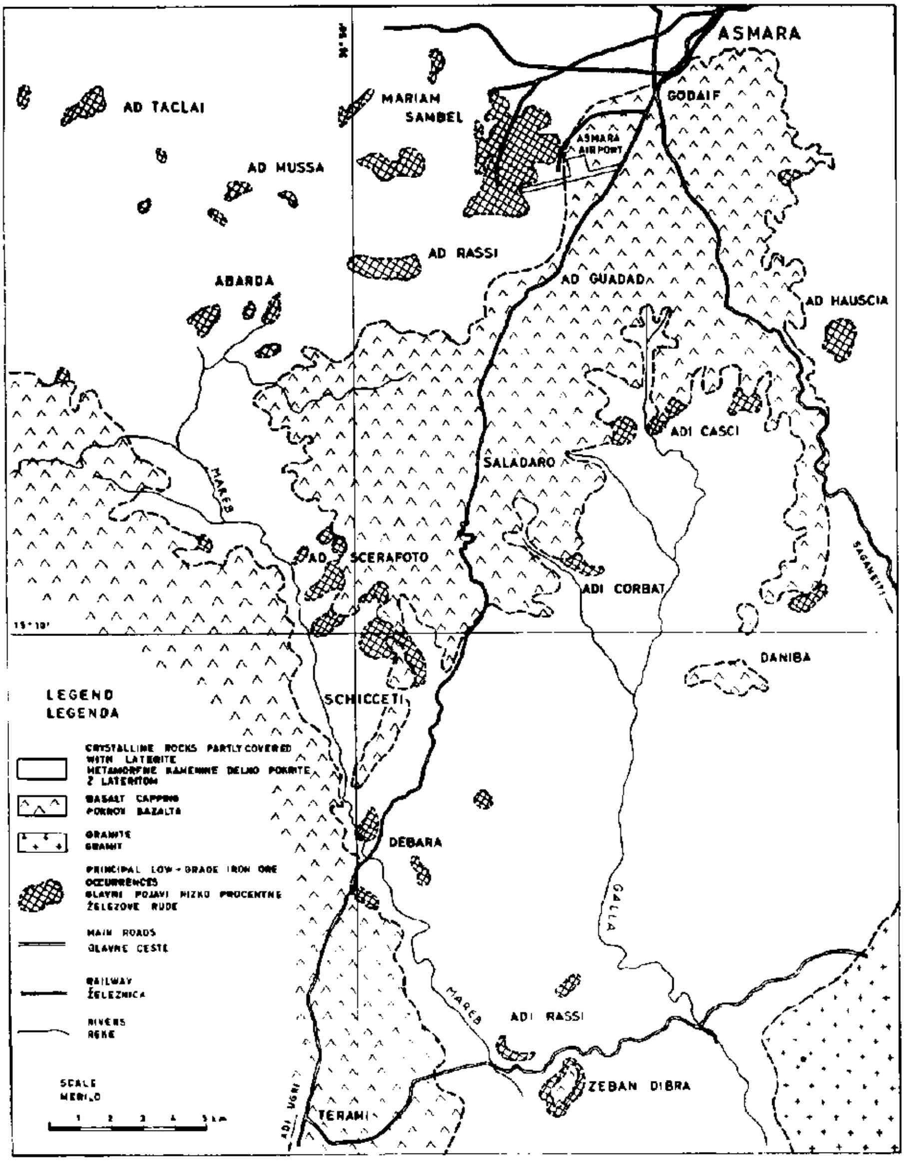


Fig. 14. Provisional geological sketch map of Hamasen. (After L. Usoni)
Sl. 14. Približna geološka skica Hamasena. (Po L. Usoniju)

There are many other localities in this region where the occurrences of iron oxides appear in the altered weathering zone immediately on the surface of crystalline basement rocks.

In general, the ore appears mostly unclean, breccious and schistose textured, cemented with reddish cement. It consists of weathered rock and iron oxides and hydroxides. The passages from ferriferous concentrations to the schistose basement rocks can be observed especially in the lowest part of the layer.

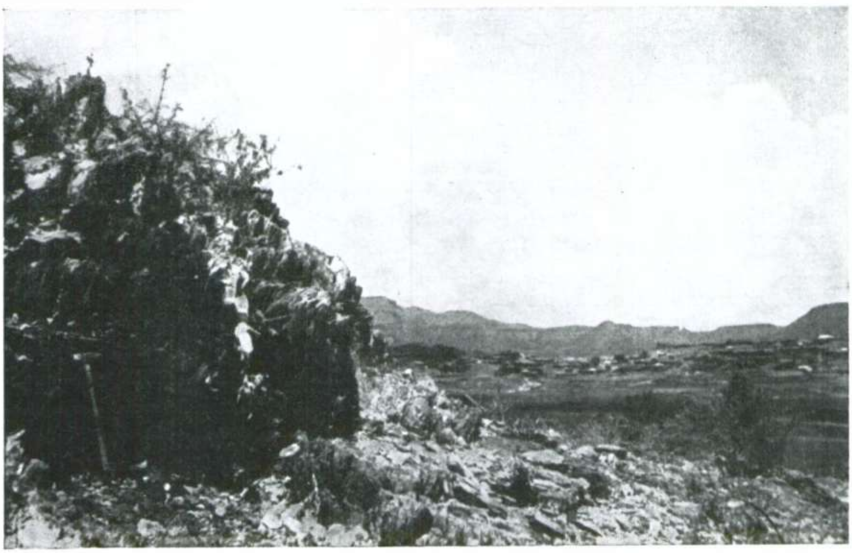


Fig. 15. Schistose low-grade iron ore with quartz inclusions near Schicceti

Sl. 15. Skrilava nizkoprocentna železova ruda z vključki kremena blizu Schiccetija

Analyses. As to the percentage of iron the low-grade ore contains there are large variations estimated visually to range between 5 and 6 % but averaging rather low. For the time being the data of several chemical analyses given by Usoni (1952) are available only. The iron contents is reported to vary between 30 and 56 % and silica 13 to 18 %, averaging accordingly to 40 % of iron and 16 % of silica. The contents of other admixtures like phosphorus and sulphur is very low. These values can be accepted as a rough orientation only because no garanty exists on the correctness and precision of sampling and analysing performed. The visual estimation of an average percentage of metal in the ore is much lower. It is possible, however, that parts in the mineralized zone exist which might yield a higher average in iron.

Origin. The supergene enrichment of iron is due to the weathering of the pre-Cambrian basement rocks in the period of emersion before the lawa flows dispersed over the peneplained and levelled surface. According to Mohr (1961) the age of weathering and decomposition can be dated as belonging to the Portlandien-Eocene interval. The basement rocks were oxidated and leached during that interval and the rain-water removed different constituents of the rocks other than iron which remained and enriched in situ. The aspect of the mineralized layers is thus an argilaceous and breccious. A part of supergene iron could be leached also out of the overlying basaltic capping and after percolating the fractures and cracks it precipitated and accumulated in the upper part of the weathered and decomposed basement rock.

Reserves. According Usoni (1952) Tissi examined the deposits in 1931 by 219 shallow pits and trenches. He estimated the total reserve of low-grade iron ore might be about 15 million tons, a half of this tonnage being situated in the immediate surroundings of Asmara. Supposing the continuity of the ferriferous deposit under the volcanics, Tissi estimated the inferred reserves to 200 million tons.

Nothing more definite is possible to say about the reserves existing in this area as well as the quantity of ore with a satisfactory chemical composition for the time being. It could be expected that several tens of million tons of ore might be potentially important regarding the quality as well as other factors influencing the eventual exploitation. Anyhow, the deposits must be regarded as a potential second- or third-order source due to the low contents of metal. Regarding the transportation facilities their situation is good. The future of these deposits might be perhaps in blending with high-grade ores.

To asses the existing ore detailed exploration is necessary. It is being carried out by the Ministry of mines for the time being in order to detect richer and thicker parts of the layers.

Tigre

Many explorers observed the ferriferous lateritic formations in Tigre province and reported upon the existence of iron deposits. An old primitive exploitation on a small scale as well as smelting for local requirements is known in different parts of the province. Quite exhaustive description of these and Eritrean deposits is summarized by Dainelli (1943). Usoni gives some general information concerning the most important localities between Adua, Axum and Enticcio (Usoni, 1952). The iron occurrences are reported to be "ferriferous laterites" similar to those in Eritrea, and connected to the basement rocks as well as to the Mesozoic formations of Adigrat and Upper sandstones. The interesting appearance of nodular and pisolitic limonite concentrations is known to exist at many of those places where clastic sandstones crop out. Merla and Minucci give some detail on mineralization indicating that the prevailing limonitic "lateritic crust" has a thickness of 5 to 6 m at maximum, but the weathered zone of the sandstones is much thicker (Merla, Minucci, 1938). According to Villaminar the grade of metal averages about 45 % (Murdock, 1960).

As to the genesis of iron accumulation Merla and Minucci considered it as a result of lateritization of sandstones during the peneplaination which preceeded the Trappean eruptions (Merla, Minucci, 1938). The ferruginous cement of sandstones might be of primary authigene origin. On the other hand, Dainelli considered the presence of the opaline-limonitic sediments as to have been transported in the Uper Jurassic or Cretaceous period from the lateritized emerged basement rocks and sedimented in the sea (Dainelli, 1943).

According to Mohr (1961) there is obvious evidence of the lateritic weathering on the top of Upper sandstone. The lateritic crust found in Eritrea upon the basement complex passes further south into the sandstone formations. The alteration takes the form of a limonitic enrichment of the topmost strata to a depth of some ten meters.

It is probable that the enrichment of iron might be locally sufficient to form an economic iron-ore deposit. No figures for the reserves are known, but it can be expected that perhaps several million tons of low-grade ore might be available.

Other residual occurrences

The phenomenon of iron concentration as described above for different more known localities occurs in the whole region of the Ethiopian plateau where similar petrographic, morphologic and climatic conditions exist, being in general convenient for leaching and transportation of iron and its accumulation either in residual lateritic soil or other favourable environment.

There is some information on local iron ore occurrences at different localities of Ethiopia, but the details are rather limited and up to now no one of them deserved larger interest regarding the economic importance. Dainelli (1943) gives an overlook of find-spots of ore and these localities are indicated or described many times in several other reports.

Residual deposits are known from Beghemder west of Tana lake and north of Gondar as well as near the town itself. The occurrences are reported from Gojjam some 100 km north of Debra Marcos, and from Ankober in Shoa. A small lateritic-infiltration type occurrence is reported to exist near Yavello in Sidamo province (Murdock, 1960).

To the same type belong probably the occurrences reported to exist at Maji and Gurrafarda in Kaffa province.

4. **Hydrothermal type**

Ghedem

General. The sole more important known deposit of hydrothermal origin is situated some 7 km southeast of Massaua, occupying the extreme northern part of the Ghedem mountain. The deposit was visited and explored many times in the past as described by Usoni (1952), who summarized all what was knovn about it. The main exploration and exploitation of the ore took place immediately before the War II. Several trenches, pits and bore-holes were executed and a limited tonnage of ore was exported to Italy.

There was no certainity about the origin of this iron and also manganese accumulation and M o h r even in 1961 ranged the deposit as a probably pre-Cambian sedimentary one. In 1963 preliminary prospection and studies were carried out by the Ministry of mines (H a m r l a , 1963). Early in 1964 the deposit was searched geologically and geophysically by the Yugoslav RUDIS company on behalf of the Ministry of mines in order to establish definitely its eventual economic signification.

The mineralizations are located on a hill confined on three sides by dislocations and surrounded by alluvial sands and gravels. The prevailing direction of the faults is about 30° and the dip is more or less vertical but dislocations run also about 150°. Here and there along the borders of the hill the slickenside fault surfaces can be clearly seen with traces of oblique movements. The faults are accompanied by tectonic breccias. The main ore bodies are bound to these dislocation (Fig. 16.).

The area is built by metamorphic crystalline rocks. Micaceous and gneissic schistose rocks prevail, dipping generally 75° to 80° west. Pegmatitic veins and dikes in various directions are often. Greenish porphyry rocks appear at some parts of the hill. Gray-black crystalline carbonate rock appears along the borders of the hill following the main tectonic directions. It forms elongated ridges like dikes on the hill and it fills the cracks and fissures in pegmatites and other rocks, being directly

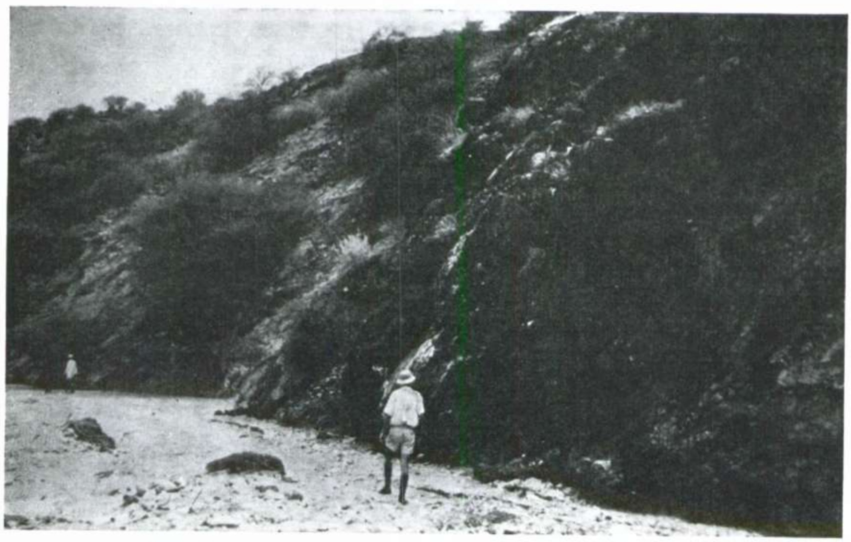


Fig. 16. Ore body No. 3 along the torrent Ghedem

Sl. 16. Rudno telo št. 3 vzdolž hudournika Ghedem

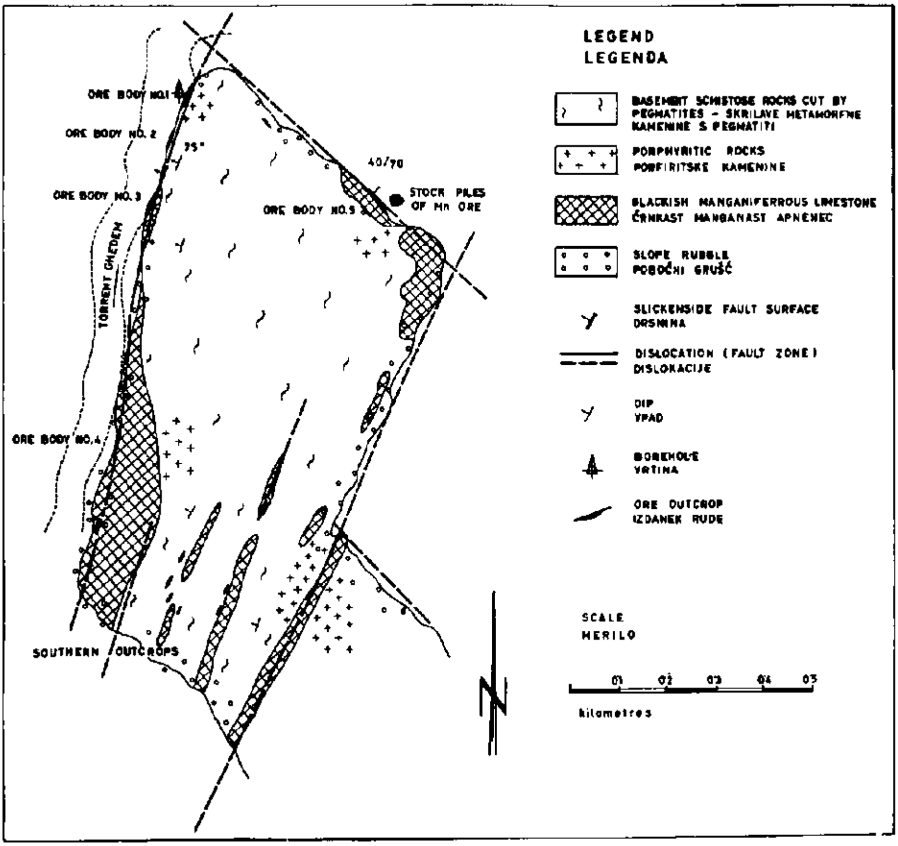


Fig. 17. Provisional geological sketch map of Ghedem deposit
Sl. 17. Približna geološka skica nahajališča Ghedem

connected with iron and manganese mineralization (Fig. 17.). Carbonate gangue alternate with iron and manganese oxides in bands, indicating in this way the obvious genetic connection.

Description. The main ore bodies appear allong the borders of the hill in form of lenslike outcrops, having an average lenght of several ten meters and thickness of several meters only. The best exposed outcrops are situated along the torrent Ghedem due to its errosive activity. Many smaller ore outcrops are occurring in the southern part of the hill, accompanied by calcareous gangue which includes more or less of metal oxides as incrustations or inclusions.

Iron ore is limonite prevailingly, having a porous and spongy texture. The breccious ore is composed of particles of country rock, cemented by iron and manganese oxides. Manganese ore appears generally fine-banded mammillary or as crusts, being intimately mixed and intergrown with iron oxide. The ore is generally composed of both iron and manganese oxides.

The main ore body, a part of which is already removed by excavations, shows visible dimensions 75 m by 15 m by 5 m approximately. The porous limonitic ore seems to be crushed and mylonitized and subsequently cemented again with iron oxides. In the vicinity of the ore body many thin veins of ore intersect the adjacent country rocks.

The visible dimensions of the other ore outcrops are smaller. The ore is in general more breccious and impure with increased contents of manganese. The breccious texture gives obvious evidence of a tectonically effected mineralized zone. Blackish manganiferous limestone everywhere accompanies the ore. The separation of the ore outcrops on the western side of the hill along the torrent Ghedem was thought to be due to errosion, but this hope was disproved by RUDIS' survey in 1964.

On the southern part of the hill several mineralized limonitic zones and small ore outcrops can be observed at many places. No traces of exploitation can be seen there.

On the north-eastern border of the hill there are two outcrops of ore which have been mined in the past. The ore is breccious and manganese oxides prevail. Also this border is obviously tectonically effected and fragments of ore can be found intermingled with slope-rubble.

Analyses. All transitions between calcareous waste and rich either iron or manganese ore can be observed in the field. The results of analyses of several chip samples of ore and of two average samples of ore shipped in 1940 to Italy are given by Usoni (1952). The chemical composition of Ghedem ore might result accordingly as follows (in percent):

Fe	about 54	S	0,055 to 0,13
SiO_2	about 12	P	0,027 to 0,04
Mn	0,2 to 0,45		

This quality, however, can not be expected as an average one because the ore from diverse outcrops differs in great extent due to the varying mineralogical composition and admixtures of impurities. The iron ore — to — manganese ore ratio might be in general about 18 : 1 relating to the Italian sources (Usoni, 1952).

No new chemical analyses of ore are available presently. The carbonate gangue was chemically examined only in order to clear its composition which is the following (in percent):

$CaCO_3$	94,0	SiO_2	0,3
Fe_2O_3	1,86	S	0,00
Al_2O_3	1,64	Mg	0,00
MnO	3,1		

The admixtures of manganese oxides cause the black colour of the carbonate rock. Besides the calcite the elongate shaped crystals would point to aragonite.

Microscopic examination of the ore reveals the prevailing concentric texture of oxidic minerals in form of fine curved bands and zones (Pl. III, Fig. 2.). Radial crystallization is common, and the fibrous radially arranged agregates with long axes normal to the bands show continuous transition through bands and zones with fine needle-shaped free surfaces.

Goethite is the prevailing iron mineral. Bandlike ochreous inclusions seems to be replaced by goethite. Manganese oxides are represented by fine-grained psilomelane and fine fibrous pyrolusite (Pl. IV, Fig. 1.). Some yellow bands might belong to hollandite. Small flaky inclusions of pyrolusite are found in goethite. Silica occurs in form of irregular cryptocrystalline masses and alternates in bands with other oxides. It contains more or less fine dispersed oxides and forms a jasper-like cherty rock. Calcite is present in relatively big crystals and never as fine banding. Small irregular inclusions of manganese oxides are always present in it. More "generations" of iron and manganese oxides are evident.

Origin. The accumulations of iron and manganese oxides, accompanied by gell quartz and carbonate gangue, have originated from thermal solutions. The mineralization might be classified as epithermal or rather hot-spring deposition and was caused by a relative young thermal cycle. The deposition took place as filling of holes and cavities along the dislocations, cementing the tectonically crushed zones under the formation of breccious ore. There is no doubt of an ascendent character of the solutions which must have been loaded with CO_2. About the origin of these acid solutions nothing can be said with certainty. They were very probably bound to the young (Pliocene or Pleistocene) volcanic activity in the region, being either of juvenile or surface provenience as ascending heated meteoric waters.

The alternating bands of different oxides were caused by variations of physico-chemical conditions during the precipitation. The fine banding is, however, normally the proof of deposition in a colloidal state. The zonal structures observed develop mostly by minerals of supergene origin which are deposited as alteration products from cold aqueous solutions. Such textures, however, are found also in hypogene minerals and iron and manganese oxides are known to originate also as hydrothermal low-temperature products.

As to the mechanism of precipitation the constituents might have been transported in molecular solutions as bicarbonates, and after oxidation transformed partly to more stable colloidal state and precipitated as gels. Carbonate crystallized probably from bicarbonate solution. Other components precipitated subsequently as gels and acquired later more or less expressed crystallinity.

It can be assumed that the acid solutions percolated the deeper parts of the earth's crust, having leached iron, manganese, silica and calcium out of different rocks of metamorphic basement series. Another possibility is the solutions are derivatives of a magmatic source.

Reserves. According to Usoni the reserves of ore were estimated in the years before the War II by Tazzer who calculated the visible part to 80 000 tons, the probable one to 32 000 tons, and the possible one to 540 000 tons. Minucci estimated the visible tonnage to 85 000 tons, and the possible one to 265 000 tons (Usoni, 1952).

On the basis of recalculation of reserves in the field the conclusion can be made that the visible part of the outcrops amounts to about 36 000 tons. Some additional 40 000 tons of possible ore may exist in the immediate prolongation of the outcrops to the depth. According to the type and form of the deposit some hundreds of thousand tons might be additionally considered as inferred possible tonnage (Hamrla, 1963). These figures practically coincide with those given by Italians. The deposit has to be classified accordingly as a very small one. Altogether about 30 000 tons of ore have been excavated only (Usoni, 1952).

The RUDIS' estimate of the total quantity of ore is about 650 000 tons, and it should be considered as possible reserve only.

The prospection of the surroundings of Ghedem, carried out in the season 1963 by the Ministry of mines, did not find any additional mineralizations of the same type.

Chilachikin

According to KRUPP's report (1964) the Chilachikin iron ore occurrence is situated near the Asmara-Gondar road, about 30 km southeast of Enda Selassie and some 270 km from Asmara. The area is composed of pre-Cambrian phyllites and sericite-schists, traversed by numerous young quartz veins which in a few cases show marginal iron mineralizations. Mesosoic sandstones form isolate cappings on the tops of hills and mountains.

No information is available of any former investigation in this area. KRUPP executed several trenches which exposed quartz veins in schistose rocks. The thicknesses of the veins are between 0,1 m and 0,5 m, but in many cases under 0,1 m. The 1,5 m thick quartz vein is marginally mineralized with coarse-grained hematite, the width of mineralized band being 5 cm or about 5 % of volume only.

The iron mineral is specular hematite. Its connection to quartz veins can be interpreted as apparently katathermal derivative of a magmatic source. Veins of this kind are rarely of economic importance, and also this occurrence is interesting from a mineralogical point of view only.

As much as it is known until now there are very few iron ore occurences in the country formed by ascending solutions. Usoni guesses some iron ores connected to quartz gangue at Agame region could be of hydrothermal origin (Usoni, 1952). There are no other data available on the existence of other hydrothermal iron ore occurrences in Ethiopia and this genetical type is unimportant as potential source of iron ore.

5. **Magmatic type**

There are no precise data available refering to the iron ore occurrences of magmatic origin. The suspection that iron ores of magmatic origin might exist in the country is due to a sample of granular magnetitic ore gathered during the prospecting campaign in 1963 in the area north of Nejo in Wollega (Hamrla, 1963).

The microscopic examination of ore specimen revealed a granular intergrowth of allotriomorphic magnetite and ilmenite with an idiomorphic axial mineral, belonging probably to the group of orthopyroxenes, and amounting to about 50 % by volume. Magnetite shows the initial martitization. The composition of ore sample is 39 % of iron, 5,9 % of titanium beside silica and a small percentage of magnesia.

This ore might be a product of magmatic crystallization differentiation. No other data are available for the time being. The find-spot was not yet examined and the geologic feature of the occurrence is not yet known.

MANGANESE

1. **Residual concentration type**

All known residual occurrences of manganese are bound to the concentrations of supergene iron oxides described above. It is well known that manganese is very similar in behaviour of transportation and precipitation to iron. In supergene deposits they are normally both found together. Manganese can be easier removed in solution in comparison with iron, but it does not precipitate as easy as iron. The manganese hydroxides are normally deposited as gels from colloidal solutions and solidify as psilomelane. They undergo subsequently further dehydration and crystallize as pyrolusite which acquires more or less expressed crystallinity and exhibits radial texture.

The accumulations of manganese oxides in described residual iron deposits have no economic importance. In Mai Gudo area manganese oxides are closestly connected to iron oxides as inclusions or intergrowings. Local concentration of manganese ore was found at the locality Sombo in form of several centimeters thick lenticular ore seam, the composition of which is given in Table 4.

Mineralogically, psilomelane in colloform banding and zoning prevails and earthy wad is common too.

In general, the contents of manganese in Mai Gudo iron ore ranges from 4 to 12 %. The conditions for formation of richer and larger depositions were not favourable in this area, because the content of manganese in trachytic-rhyolitic rocks is to small to give rise to more important residual manganese concentrations.

Similar small and scarce accumulations of supergene manganese minerals are known from different other places, and their formation is due to the weathering phenomenon of volcanic rocks.

2. Hydrothermal type

The only occurrence of manganese ore of hydrothermal origin is known at Ghedem. The geological side of the deposit is described above. Manganese oxides in form of psilomelane and pyrolusite occour in general closestly connected to iron oxides, forming colloform textured ore of alternating bands and zones or as incrustations within breccias and carbonate waste. Manganese oxides are fine-crystalline prevailingly (Pl. IV, Fig. 1.). The black colour of the accompanying manganiferous calcstone is due to the fine admixtures of manganese oxides which are displaced in calcite crystals following the rhomboeder directions, but also among calcite grains.

The prevailing manganese ore occurs along the north-eastern border of the hill, as evidenced in several outcrops or trenches. The contents of manganese in this ore might be about 40 %. The rich manganese ore was exploited separately in the past, and there is still a quantity of about 800 tons stored in piles near the working places for the time being.

The mineralization can be explained by a young thermal cycle, having originated either from leaching of deep-lying rocks or from solutions of magmatic origin. There are outcrops of more of less manganiferous ore or ferruginous manganese ore or even pure manganese ore. This very pronounced and quick change in the composition of ore regarding the contents of oxides as well as carbonate gangue could be explained by very unstable physico-chemical conditions of deposit's formation.

The reserves of manganese ore from Ghedem can be estimated to about 4000 tons of visible and probable ore. The inferred tonnage could be expected to reach some tens of thousand tons at maximum.

3. Sedimentary type

Enkafela

General. Enkafela is the only known manganese ore deposit of sedimentary origin. The locality is situated about 20 km southwest of Dallol on the border of the Salt plain in the Danakil depression, and was discovered incidentally several years ago. A prospection licence and lease for exploitation was given in 1955 covering an area 300 m by 350 m only, and in 1958 primitive mining started under a private licence. The ore is transported by truck to the port of Mersa Fatma on the Red sea coast, and exported via Massaua to USA. The production is small and altogether not more than 40 000 tons of ore have been exploited and shipped to Massaua till the end of 1963.

The geology of the Salt plain depression is characterized by an early Pliocene sea ingression which deposited during Plio-Pleistocene marine beds composed of conglomerates, sands, clays and evaporites. All around the Salt plain conglomeratic and gypseous sediments occur which were formed in the shallow sea along the former coastline. Along the whole western margin of the Salt plain thick layers of terrassed pluvial torren-

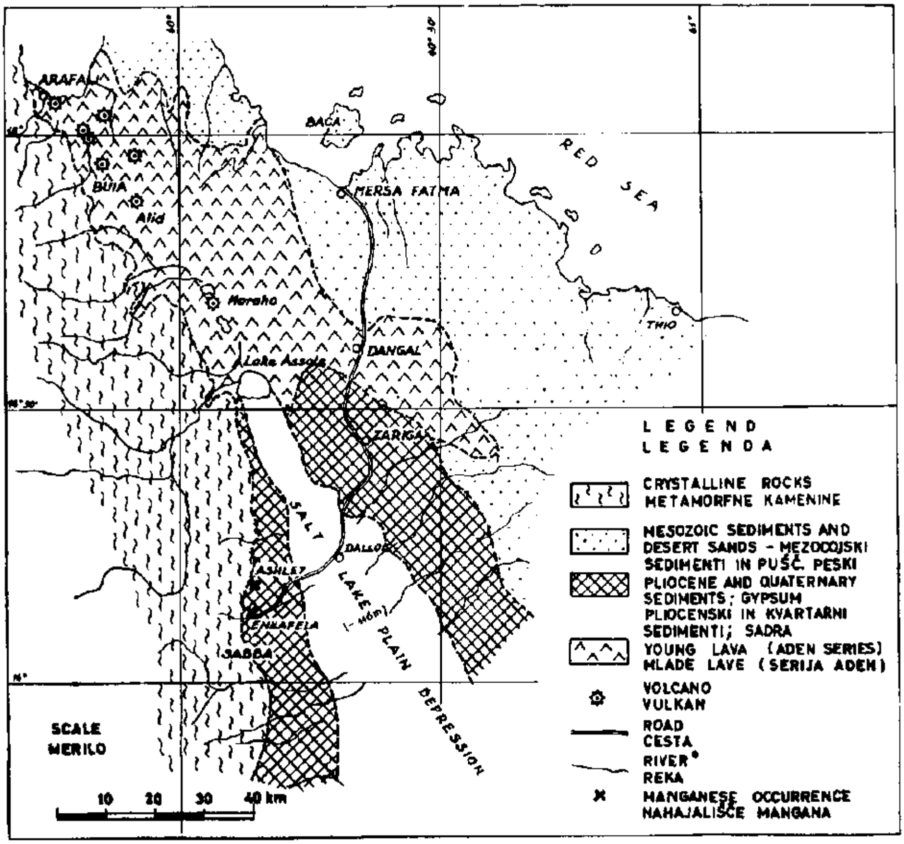


Fig. 18. Provisional geological sketch map of the northern Salt plain depression. (After various sources)

Sl. 18. Približna geološka skica severnega dela depresije »Salt plain«. (Po raznih virih)

tial gravel rest unconformably on marine sediments which are well exposed only in young wadi-cut valleys. In such a valley of the Handeda river the manganese ore became erroded and the layer exposed. The manganese ore is interstratified in the clastic marine succession, and its sedimentary nature is evident.

The mountains bordering the Enkafela area to the west are composed of volcanics, meanwhile to the east huge deposition of piedmont gravels form the passage to the Salt plain (Fig. 18.).

D e s c r i p t i o n. The Enkafela mining area covers a surface of about 250 m by 300 m for the time being. Several lenslike ore outcrops can be observed in the wadis. The layer exploited has a maximal thickness of 1,4 m in center and decreases to 0,1 m towards margins. The total volume of the known ore might be thus not more than 10 000 cubic meters only. Marginal passages of ore to the waste can be observed. The greyish black cavernous ore is pure and occurs as botryoidal and spongy mass composed of hard oxides. A very fine crystalline texture can be seen along the cavities. The ore bed is overlain by thin irregular ferriferous breccious layer. The footwall of the ore body consists of coarse clastic sediments containing sands and gravels, and cemented in the upper part with manganese oxides. The hanging wall consists of tuffic aglomerates with corals and other marine fossils.

Fig. 19. Interstratified layer of manganese ore at Enkafela
Sl. 19. Med plasti vključen sloj manganove rude v Enkafela

The following succession of the ore-bearing marine sediments was observed in the eastern part of the open pit (Fig. 19.), from bottom up:

0,5 to 0,8 m	Middle-grained sandy breccia, including small nodules and vertical thin veinlets of manganese oxides;
0,1 to 1 m	Coarse gravel and sand, cemented with manganese oxides (pebbles and grains of volcanic origin prevailingly);
0,5 to 0,8 m	Banded manganiferous impure sandy bed of loose consistence;
0,5 to 0,9 m	Compact manganese ore;
5 to 6 m	Tuffic aglomerates with corals and other marine fossils;
8 to 10 m	Marly sandstones, well banded;
10 to 15 m	Torrential gravel.

Another outcrop of manganese ore was found at the locality Ashley some 7 km north of Enkafela. Several thin earthy layers of manganese ore can be observed, having a thickness not more than 0,3 m totally. The geological environment corresponds entirely to that described for Enkafela. Thin-bedded marine sediments prevail, being covered by a thick layer of torrential gravel.

Analyses. The average chemical composition of the Enkafela ore which was shipped from Massaua to USA between 1960 and 1964 is as follows* (in percent):

Mn (dry basis)	51,26
Moisture	0,68
SiO_2	1,81
Al_2O_3	0,80
Fe_2O_3	1,50
BaO	7,70
S	0,029
P	0,021
Pb	0,000
Cu	0,000
As	traces

The quality of ore is good although the admixture of barium is significant.

Under the microscope manganese minerals can be seen only. The ore show mild zoning. Microcrystalline agregate of psilomelane in mixture with some pyrolusite prevails. Hollandite occurs too and yellow relatively bigger prismatic crystals are concentrated in thin zones (Pl. IV, Fig. 2.).

Origin. The deposit of relatively recent geologic age is of sedimentary origin and was formed in the shallow sea-shore zone rich in oxigen. The manganese might originate from the decomposition of different volcanic rocks in the western hinterland of the Salt plain, and was transported by flowing waters into the littoral sea. It precipitated as manganese hydroxide and was diagenetically transformed to psilomelane-pyrolusite compounds. Iron oxides are normally admixtured to the primary oxidic ore and they are found in Enkafela immediately on the top of the manganese bed. It is believed for the time being that in sedimentary deposits manganese was precipitated directly from sea-water by the activity of microorganisms. Another possibility about the source of manganese could be the connection with hot-spring volcanic activity of that time. More detailed investigation of facial environment as well as the mechanism of precipitation of ore could provide useful hints for the eventual further finding of new accumulations in the vicinity.

Reserves. The total amount of ore which was yielded from the deposit hitherto ranges not more than several tens of thousand tons totally. At the end of 1963 the still existing visible reserves have been estimated not more than about 5000 tons only. Due to the sedimentary

* Personal communication by Mr. L. Zingoni (Technical Officer of the Mining Office in Asmara).

character of the deposition in the former littoral zone, the further economic findings in the immediate vicinity are possible. The known and exploited lenslike ore bodies pass laterally to the sterile or low-grade mineralized clastic rocks. In the case the source of manganese were the volcanic or other rocks of the hinterland, the western border of the Salt plain's sedimentation basin could be a large geological environment which might have favorized the deposition of manganese, and the lateral persistency of the ore-bearing horizon is probable. This assumption is supported by the appearance of the ore at Ashley. Hence, it would be advisable to explore the marginal part of the western piedmont area of the Salt plain depression in order to find out the eventual new manganese ore concentrations.

IRON AND MANGANESE DEPOSITS IN THE NEIGHBOURING COUNTRIES

For the reason of comparison, and following the available sources, the iron and manganese deposits of the neighbouring East African countries are described in the shortest way.

There are several iron deposits existing in Sudan. The country's geological setting is similar to that of Ethiopia, being composed of pre-Cambrian rocks and Mesozoic and younger sediments.

In the Red-Sea zone north of Port Sudan the Sufaya and Fodikwan deposists consist of massive magnetite-hematite ore. The ore bodies extend in conformity with the folliation of the metamorphic rocks dipping steeply east. The layered deposits might seem to be genetically similar to those of Eritrea, or might even belong to the same ore-bearing zone which extend between Falcat and Agametta. More accurate data point to the genetic interpretation of deposits by magmatic differentiation.* Accordingly, the ore bodies originated as ore injections bound to diorite-lamprophyres at Sufaya and porphyrites at Fodikwan. The reserves of high-grade ore are reported to range over 10 million tons for each of the deposits, and there is a large quantity of low-grade ore in addition. The position close to the Red-Sea coast is favourable, and plans have been prepared to exploit the ore at a rate of several hundreds of thousand tons yearly.

At Abu Tulu in Northern Sudan a similar deposit consists of high-grade magnetite-hematite ore. It extends in the nort-eastern strike of the metamorphic complex. The reserves are reported to amount to 36 million tons.

A deposit of resigual type exists at Kutum in Western Sudan. It might be bound to the process of weathering of Nubian sandstone. The ore is concretionary hematite and the reserves total 2 million tons.

A small deposit of probable hydrothermal origin at Fadlab north-east of Khartoum originated as replacement of marbles by hematite. The reserves are several hundreds of tons only.

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* Personal communication by Mr. M. Dolenc, Chief geologist of the Geological Survey of Slovenia, Yugoslavia.

Manganese ore is reported to occur at two localities in the northern part of Sudan near the sea shore. Smaller sedimentary deposits of relatively young geologic age might be in question.

In general the Sudanese iron and manganese deposits look to be genetically very close to the deposits in Ethiopia expect the larger dimensions and the reserves reported to exist. It seems that these occurrences, while interesting, offer little chance of a commercial development for the time being.

In Somalia iron deposits exist between the rivers Shebeli and Giuba westward of Mogadisco and 200 to 300 km from the shore. This large ore-bearing Bur region is described in short by Usoni (1952). In a large area of about 200 by 50 km many important outcrops of rich iron ore occur. The area is built up by crystalline schistose rocks which are intruded by numerous granite bosses and basic differentiates. The ore consists of magnetite, ilmenite and quartz waste. The contents of iron in the ore is not less than 55 % in average.

The Bur deposits are considered to be magmatic in origin and might have formed by segregation. The visible reserves are estimated over 200 million tons. Provided this estimation is not far from the truth the Bur deposits may be the most important potential sources of iron in East Africa.

Small and unimportant deposits are known to exist in Somaliland. A limonite occurrence of very restricted dimensions is known at Galan Galo near Candala on the northern coast. It is a residual deposit in calcareous strata of Lower Eocene, formed by action of meteoric water (Usoni, 1952). A similar very small residual occurrence of limonitic crustifications exist at Timassoh south of Candala. There are also reports on the veinlets of siderite included in phyllitic schists of pre-Cambrian.

According to the data available no important deposits exist in Kenya (Pulfrey, 1960).

Metamorphic and residual lateritic iron ore deposits are explored in Malagasy,- totaling in 170 million tons of 28 to 62 % ore (Murdock, 1963). Only a small part of these reserves belong to high-grade ore.

ECONOMIC APPRAISAL OF THE TREATED ETHIOPIAN DEPOSITS

There is large interest in Ethiopia to find out reserves of iron ore for establishment of metalurgical industry. The errection of national mining and stell-mill industry is suggested in the Second five year Plan of overall country's development. It depends on different factors of economics influencing the final price of hot metal, but the quantity and quality of ore available is of primary importance.

The estimated reserves of iron ore, referring to the principal to-day known and above treated deposits, are summarized in the Table 5.

Table 5 5. tabela

Locality	Average ore-grade estimate (% Fe)	Measured	Category of reserves (tons) Inferred (min.)	(max.)
Koree-Gollisso-Nejo	60	160 000	290 000	800 000
Agametta-Gumhod	58	132 000	....	500 000
Falcat-Tullului	55	—	300 000	1 000 000
Mai Gudo	40	77 000	—	25 000
Entoto	40	—	—	10 000
Aira-Yubdo	25	—	—	100 000
Hamasen	35	—	5 000 000	50 000 000
Tigre	30	—	—	5 000 000
Ghedem	54	36 000	40 000	500 000

Taking into consideration that an economic iron ore deposit of to-day shall contain at least several million tons of high-grade (over 60 %) ore. the conclusion may be made that there is little chance of economic development of known iron ore deposits for the time being even if the maximum of inferred reserves do exist. It is a well known fact that an up-to-date mining production requests large capacities and big reserves, particularly if there are cheap raw-matters in question like iron ore.

From the point of view of establishing big industry the reserves of high-grade iron ore from Eritrea as well as from Wollega are not sufficient. For a planned production of 300 000 tons of pig iron annually the proved reserves should amount to 15 million tons of 60 % ore to guarantee the raw-matter for 30 years. Also the fuel should be in all probability imported. The searching for coal carried out in the country and aimed to find out the eventual adequate fuel for metallurgic industry does not show much prospects.

Regarding the development of export markets small tonnages known for the time being and high transportation costs do not give much prospect. However, world market is governed today by cheap high-grade iron ore, and it would be difficult to find ready markets.

It shall be pointed out, that the degree of geological information for the iron ore potential is far from being satisfactory, and also the known deposits have been explored only partly as this can be seen from the ratio of categories of reserves. However, new discoveries are possible although there is little probability that large and rich deposits exist in the country still undetected. But the possibility of finding new smaller high-grade or middle-grade deposits still exists in the unexplored and remote parts of the country.

On the other hand it looks possible that low-grade iron ore could be found in larger quantities. Its value should be measured in terms of proved quantity and quality as well as technology of mining, beneficiation and metallurgy. There is not much prospect to make from these deposits any larger profit presently, provided the exploration now in course will be negative.

At this time the known iron ore reserves of the country are such that a very modest development could be realized only. Local small-scale exploitation of ore connected with smelting and manufacturing in situ might prove perhaps economically feasible. First of all the sources in Eritrea and Wollega could make a contribution to the local economy.

The Eritrean deposits deserve priority due to favourable communications. The endeavour to appraise the feasibility to use the ore of several existing deposits in Eritrea for the eventual errection of a single plant might be perhaps useful. For this reason the exploration of the known and potential iron ore deposits in Eritrea shall continue in order to clear definitely the tonnages available.

As to the manganese deposits known at present the reserve estimate is given in the Table 6.

Table 6 — 6. tabela

Locality	Average ore-grade estimate (% Mn)	Category of reserves (tons)		
		Measured	Inferred (min.)	Inferred (max.)
Mai Gudo	40	—	—	—
Ghedem	35	1000	3000	30 000
Enkafela	50	5000	—	200 000

The Enkafela deposit is the single one which deserves attention and its ore could be placed successfully to world market. Small proved reserves are unsignificant. The finding of eventual new reserves in the Salt plain's marginal areas is due to systematic geological exploration.

In Ethiopia today the contribution of the mineral industry to the national economy shall be enlarged. To reveal the mineral potential of the country, including the final appraisal of the iron and manganese ore deposists, a well organized and equiped governmental Geological Survey shall perform well programmed and supported field campaigns in large scale. The comparatively modest economic mineralizations in the light of discoveries up to this time should not discourage the starting of intensive efforts to asses and develop mineral resources. There can be little doubt that the potential possibilities of finding mineral raw-materials well exist in the country.

REFERENCES

Commission d'expertes Yougoslaves; 1955, Géologie et ressources minières de l'Ethiopie. Addis Ababa.
Dainelli, G., 1943, Geologia dell'Africa Orientale. Roma.
Dixey, F., 1960, Survey of the natural resources of the African continent. UNESCO-ECA report (provisional reproduction).
Finn, W. K., 1964, LAMCO-Liberia's new iron mine. World Mining, May 1964.
Furon, R., 1960, Géologie de l'Afrique. Paris.
Geol. Survey Dept. of the Republic of Sudan, 1963, Data on mineral occurrences in Sudan (Communication to ECA, Addis Ababa). Archives of the Ministry of mines.
Hamrla, M., 1963, Report on Ghedem iron and manganese deposit. Addis Ababa. Archives of the Ministry of mines.
Hamrla, M., 1963, Report on iron ore occurrences in Mai Gudo region (Nadda district, Kaffa province). Addis Ababa. Archives of the Ministry of mines.
Hamrla, M., 1963, Reports (2) on journeys to Wollega. Addis Ababa. Archives of the Ministry of mines.
Hamrla, M., 1964, Report on the state of exploratory activity in Eritrea at the end of 1963. Addis Ababa. Archives of the Ministry of mines.
Imperial Ethiopian Government, 1962, Second five year development Plan. Addis Ababa.
Imperial Ethiopian Government, 1963. Annual development program 1955 E. C. Addis Ababa.
KRUPP Co., 1956, Ethiopia report. Essen, Archives of the Ministry of mines.
Merla, G., Minucci, E., 1938, Missione geologica nel Tigrai. Vol. I. Roma.
Mohr, P., 1961, The geology of Ethiopia. Addis Ababa.
Murdock, T. G., 1960, Geology and mineral resources of Ethiopia (U. S. Dept. of Interior, Working paper 10). Addis Ababa.
Murdock, T. G., 1963, Mineral resource of the Malagasy republic (U. S. Dept. of Interior, Inform, circ. 8196). Washington.
Pulfrey, W., 1960, The geology and mineral resources of Kenya. Nairobi.
RUDIS Co., 1963, Preliminary report on geological and geophysical exploration of Agametta iron ore deposit area. Ljubljana. Archives of the Ministry of mines.
RUDIS Co., 1964, Iron ore deposit at Agametta and Ghedem hill in Eritrea province. Ljubljana. Archives of the Ministry of mines.
Usoni, L., 1952, Risorse minerarie dell'Africa Orientale. Roma.

NAHAJALIŠČA ŽELEZOVE IN MANGANOVE RUDE V ETIOPIJI

Milan Hamrla

z 18 slikami, 9 skicami in 6 tabelami

Doslej poznana nahajališča železove in manganove rude v Etiopiji so razvrščena po nastanku v 5 tipov oziroma v 3 tipe. Vsako nahajališče je kratko opisano, upoštevaje poleg prevladujočih avtorjevih podatkov tudi druge vire, zlasti za lokalnosti, ki niso bile preverjene na terenu. Naveden je večinoma le grobo ocenjen velikostni red rezerv. Kjer pa so bile rezerve določene podrobneje, so poleg možnih rezerv podane tudi ostale kategorije (5. in 6. tabela). Stopnja raziskanosti nahajališč je močno različna. Analizni podatki so vzeti iz razpoložljivih virov, novejše analize pa so bile izvedene v kemičnem laboratoriju Ministrstva rudarstva v Addis Ababi.

Relativno najbolj pomembna so metamorfna in metamorfno-metasomatska nahajališča bogate rude v provincah Eritreji in Wollegi. Gre za metamorfozirana prekambrijska prvotno sedimentarna ležišča. Dimenzije rudnih teles so skromne in zaloge relativno majhne.

Številčno prevladujoči tip predstavljajo nahajališča nastala z delovanjem meteorskih voda, ki so izluževale vulkanske ali druge železo vsebujoče kamenine. Železo se je v glavnem koncentriralo v lateritskih preperinah ali v drugem primernem okolju. Najbolj obsežna nahajališča tega tipa so v Eritreji ter utegnejo biti zaloge nizkoprocentne rude znatne.

Zanimivo nahajališče železove in manganove rude Ghedem je nastalo z delovanjem vročega vrelca v bližnji geološki preteklosti. Zaloge so majhne.

Visokotemperaturna nahajališča so brez vsakega pomena, pojav rude domnevno magmatskega izvora pa je še nepreverjen.

Visokoprocentna ruda je magnetitno-hematitna, sicer pa prevladuje bolj ali manj onečiščen limonit.

Manganovo rudo najdemo povsod v zvezi z eksogenimi železovimi rudami pa tudi na Ghedemu. Vsi ti pojavi so ekonomsko zelo malo pomembni. Doslej je znano le eno nahajališče morskega sedimentarnega nastanka, vendar zelo skromnih dimenzij in rezerv. Ni izključeno, da je rude več.

Za primerjavo je nanizanih nekaj podatkov o analognih nahajališčih železove in manganove rude v sosednjih deželah.

Zaradi majhnih količin zalog in drugih neugodnih faktorjev je na podlagi sedaj znanih podatkov le malo možnosti za ekonomsko upravičen razvoj železarstva v Etiopiji v obsegu, predvidenem v drugem 5-letnem planu dežele. Razvoj majhnih lokalnih rudarskih in topilniških obratov, predvsem privatnih, pa je možen.

V splošnem pa je Etiopija geološko malo raziskana ter je njen pravi mineralni potencial še precej neznan. Dokončna ocena tudi železovih in manganovih nahajališč bo možna šele, ko bodo izvedene vse potrebne geološke in druge raziskave.

HIDROGEOLOŠKE RAZMERE NA OBMOČJU STROJNICE ELEKTRARNE SREDNJA DRAVA 1. STOPNJA

Ljubo Žlebnik

S 6 risbami med tekstom in 2 fotografijama v prilogi

Uvod

Hidroelektrarna Srednja Drava je kanalskega tipa z jezom v Melju in s strojnico pri Zlatoličju. Jez in strojnica bosta povezana z 17,2 km dolgim dovodnim kanalom. Iz strojnice bo odtekala voda po 6 km dolgem odvodnem kanalu v Dravo nekoliko nad Ptujem.

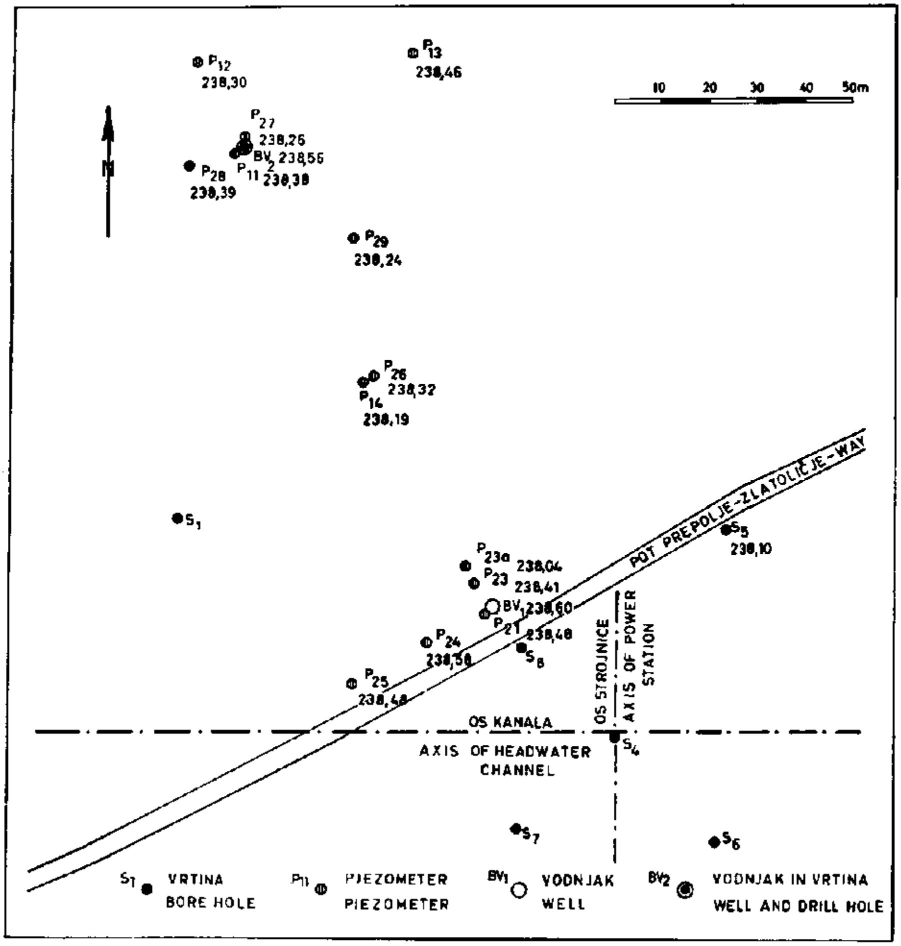
Strojnica je projektirana na pleistocenski terasi v bližini glavne ceste Maribor—Ptuj pri vasi Zlatoličje. Površina terase je na nadmorski višini 237,8 m do 238,4 m. Temelji strojnice leže po projektu na koti 201 m v globini 37,5 m pod površino.

Gladina podtalne vode je pri srednjem stanju vode na koti 230 m; to kaže, da bo gradbena jama za strojnico izkopana 29 m globoko pod gladino podtalne vode, kar je doslej edinstven primer v Sloveniji. Za izdelavo projekta te zahtevne gradnje je bilo potrebno ugotoviti sestavo tal ne le zaradi pogojev temeljenja, temveč tudi zaradi ocene dotoka podtalne vode v gradbeno jamo. V ta namen je bilo na območju strojnice v Zlatoličju izvrtanih 7 vrtin; vrtina S_2 je bila globoka 60 m, vrtina S_4 celo 68,5 m, medtem ko so druge vrtine segale le do kote 200 m (1. sl.).

Geološki opis

Podatki vrtin so pokazali, da sestavlja teraso zgoraj 24,2 do 26 m debela plast debelega peščenega proda z vložki in lečami peska. Spodaj leži bolj droben gosto odložen peščen kremenov prod, ki vsebuje vložke konglomerata, zbitega peska in trde peščene gline. Vložki peska in peščene gline, debeli 0,5 do 4 m, ne sestavljajo zveznih plasti, temveč se horizontalno izklinjajo.

Po podatkih kartiranja v širši okolici je bilo mogoče sklepati, da je vrhnja prodna plast pleistocenska, medtem ko je spodnja prodna plast pliocenske starosti. Pliocenske plasti so razkrite v gričevju na levem bregu Drave med Vurbergom in Ptujem, kjer jih sestavljajo droben peščen kremenov prod, konglomerat, zbit pesek in glina. Po litološki sestavi



Sl. 1. Situacija raziskovalnih vodnjakov, vrtin in piezometrov na območju strojnice v Zlatoličju

Fig. 1. Situation of the exploration wells, drill holes and piezometers in the powerhouse site at Zlatoličje village

so te plasti enake kot na območju strojnice v Zlatoličju. V zgornji prodni plasti so kasneje med kopanjem gradbene jame našli kosti mamuta, kar dokazuje, da je vrhnja prodna plast pleistocenska.

Raziskave zrnavosti proda so pokazale, da je v zgornji, pleistocenski prodni plasti primes melja neznatna, največ 6 %, peska pa je 35 do 57 %. Spodnji, pliocenski prod je drobnejši ter vsebuje veliko melja, od 11 do 35 %, peska pa je 20 do 62 %.

Tudi po litološki sestavi se pliocenski prod močno razlikuje od pleistocenskega. Pleistocenski prod vsebuje poleg kremenovih tudi prodnike amfibolita, tonalita, gnajsa in redko apnenca, medtem ko v pliocenskem produ prevladujejo dobro zaobljeni drobni kremenovi prodniki. Tako sestavo pliocenskega proda je mogoče razložiti z večjo transportno razdaljo v pliocenu, medtem ko je bila ta razdalja v pleistocenu zaradi ledenikov mnogo krajša in so se poleg prodnikov kremena ohranili tudi prodniki manj odpornih metamorfnih hribin.

Med vrtanjem smo pliocenske plasti raziskali tudi po standardni metodi penetracije. V pleistocenskem produ te raziskave niso uspele zaradi debelih oblic, ki prevladujejo v produ. V pliocenskem produ, pesku in peščeni glini so penetracijski preizkusi povečini uspeli in so pokazali, da so pliocenske plasti dobro konsolidirane; penetracijska konica je prodrla v globino 1 čevlja (30,5 cm) šele po 100 do 250 udarcih.

Zaradi velike razlike hidrostatičnih pritiskov v vrtini in zunaj obložne kolone je pleistocenski prod ob izvlačenju jedrne cevi prodiral navzgor v obložno kolono. Med vrtanjem v pliocenskem produ tega pojava ni bilo. V pleistocenskih plasteh je bilo treba obložno kolono zabiti do dna vrtine po vsakem izvlačenju jedrne cevi, ker so se sicer stene rušile. V pliocenskem produ pa je bilo možno vrtati brez cevitve do 10 m globoko.

Ta pojav je nastal zato, ker je bil ob spodnjem koncu obložne kolone strujni pritisk v pleistocenskem produ večji od njegove prostorninske teže, zmanjšane za vzgon. V pliocenskem produ pa ta pojav ni možen, ker ima večjo prostorninsko težo in poleg tega določeno kohezijo.

Raziskave vzorcev nekoliko sprijetega pliocenskega proda iz vodnjaka BV_1 so pokazale, da je njegova prostorninska teža pri naravni vlagi = 2,06 do 2,3 t/m^3. Prostorninska teža pleistocenskega proda pa doseže največ 2,04 t/m^3.

Dopustna obremenitev pliocenskega proda v globini 2 m pod površino je po predpisih PTP 5 kp/cm^2, v globini 37,5 m pod površino, pod temelji strojnice, je znatno večja. Temeljna tla bodo po izkopu gradbene jame razbremenjena za celotno težo izkopanega materiala. Razbremenitev bo dosegla vrednost 52,5 t/m^2, računano po obrazcu

$$\sigma_z = \gamma \, . \, h + (\gamma_s - \gamma \quad) \, . \, (1 - n) \, . \, (z - h)$$

σ_z = normalna napetost v navpični smeri
γ_s = 2,7 t/m^3 (specifična teža trdne snovi)
γ_w ~ 1 (specifična teža vode)
z = 37,5 m (globina izkopa)
n = 0,25 (poroznost)
γ = 2,025 t/m^3 (povprečna suha prostorninska teža pleistocenskega in pliocenskega proda)
h = 8 m (globina izkopa nad vodo)

Izkop gradbene jame bo do globine 8 m v suhem peščenem produ, niže bo pod gladino podtalne vode. Ker je izkop z mehanizacijo mogoč le do določene globine, je projektant predvidel črpanje vode iz gradbene jame, da bi bil izkop na suhem.

Temeljna tla bodo po izkopu gradbene jame razbremenjena in se bodo zato dvignila. Ker ni znan deformacijski modul E pliocenskega proda, ne moremo povsem točno izračunati, za koliko se bodo tla dvignila. Po podatkih laboratorija za mehaniko tal univerze v Ljubljani (K e r i n , 1965) bo dvig znašal 19,5 do 28 cm.

Ko bo strojnica zgrajena, se bodo tla ponovno posedla. Posedanje bo manjše od dviga, ker je predvidena teža zgradbe manjša od teže izkopanega materiala. Del zgradbe s turbinama, obrnjen proti toku, je težji od nasprotnega dela, obrnjenega v smeri toka. Bolj obtežen del temeljnih tal se bo tudi bolj posedel, in sicer za 19 do 21 cm, medtem ko se bo manj obtežen del posedel za 16 do 19 cm. Razlika v posedanju je torej 3 do 5 cm. Vendar so te številke le približne, ker je bila pri izračunavanju privzeta za deformacijski modul E pliocenskega proda zelo nizka vrednost (670 kp/cm^2). Zato bosta dejansko posedanje in razlika v posedanju obeh delov strojnice manjša. Med gradnjo bo potrebno opazovati posedanje strojnice, da bi preprečili morebitne okvare turbin po pričetku obratovanja elektrarne, ki bi nastale zaradi nagibanja strojnice.

Hidrogeologija

Za izračunanje dotoka vode v gradbeno jamo je bilo potrebno čim točneje ugotoviti vrednost koeficienta prepustnosti pleistocenskega in pliocenskega proda. V ta namen smo raziskali prepustnosti prodov laboratorijsko ter s črpalnimi poizkusi v vodnjakih in vrtinah. Za ta članek smo podrobneje vrednotili samo rezultate raziskav v pliocenskem produ. medtem ko bodo podatki o pleistocenskem produ obdelani v posebni razpravi.

S poizkusnim črpanjem v vodnjaku BV_2 je bilo ugotovljeno, da je srednja vrednost koeficienta prepustnosti *k* pleistocenskega proda 4,1 do $4{,}63.10^{-1}$ cm/sek (2. sl.).

Podatkov za vrednost koeficienta prepustnosti pliocenskega proda je bilo znatno več. Že leta 1959 smo s črpalnim poizkusom v vrtini C_2

LEGENDA K 2. SLIKI
ELPLANATIONS TO FIG. 2

P29 22998 ● — PIEZOMETER Z GLADINO VODNEGA HORIZONTA V PLIOCENSKEM PRODU / PIEZOMETER SHOWING THE WATER TABLE IN PLIOCENE GRAVEL

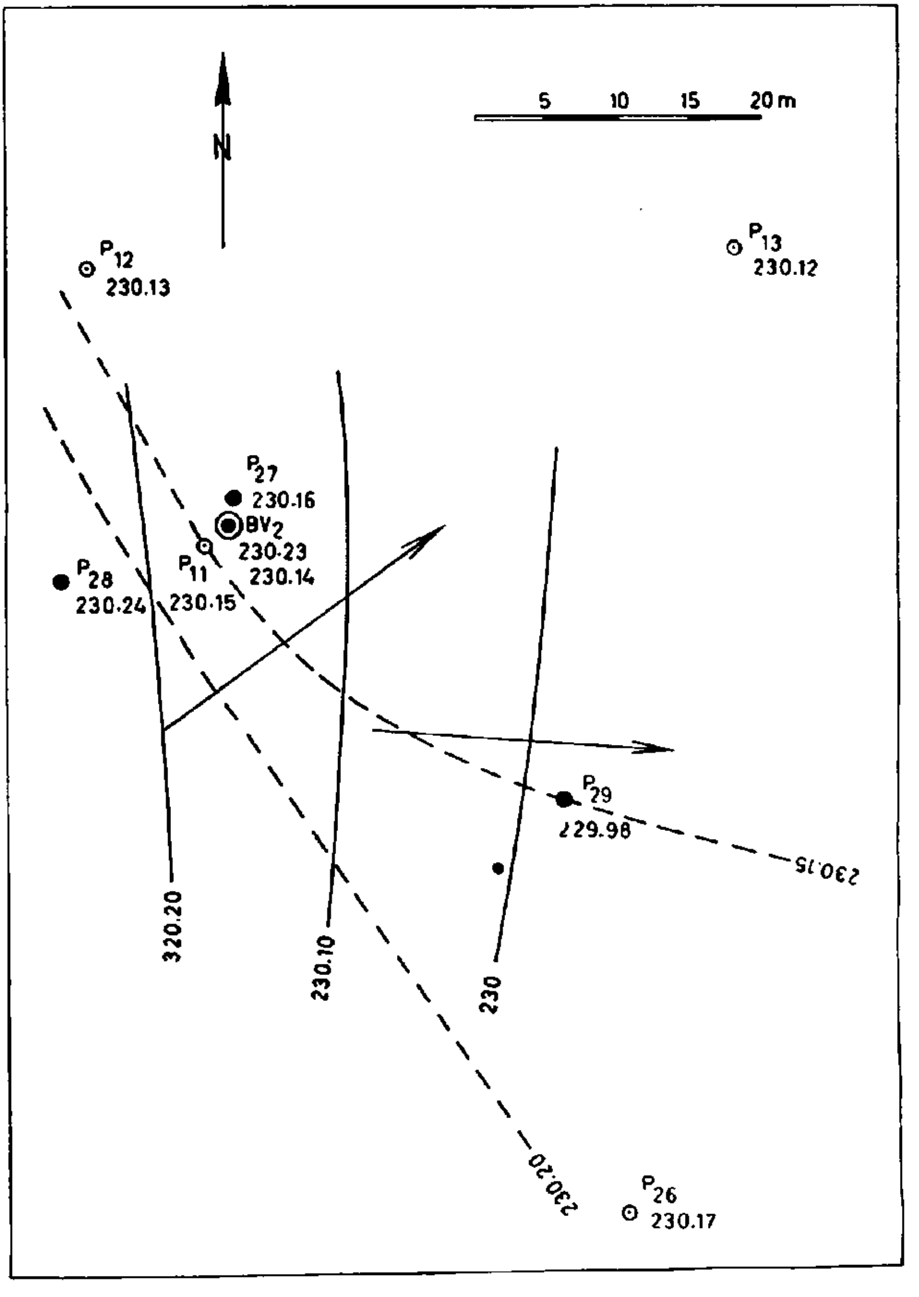
P13 23012 ⊙ — PIEZOMETER Z GLADINO VODNEGA HORIZONTA V PLEISTOCENSKEM PRODU / PIEZOMETER SHOWING THE WATER TABLE IN PLEISTOCENE GRAVEL

◉ — VODNJAK BV_2 TER VRTINA Z GLADINAMA VODNIH HORIZONTOV V PLEISTOCENSKEM IN PLIOCENSKEM PRODU / WELL BV_2 AND DRILL HOLE SHOWING THE WATER TABLES IN PLEISTOCENE AND PLIOCENE GRAVELS

—— HIDROIZOHIPSE VODNEGA HORIZONTA V PLIOCENSKEM PRODU DNE 27.4.1964 / CONTOURS OF THE GROUND WATER TABLE ON APRIL 27, 1964

- - - HIDROIZOHIPSE VODNEGA HORIZONTA V PLEISTOCENSKEM PRODU DNE 27.4.1964 / CONTOURS OF THE GROUND WATER TABLE ON APRIL 27, 1964

→ SMER TOKA PODTALNE VODE / FLOW DIRECTION OF THE GROUND WATER



N
5
10
15
20 m
P12
230.13
P13
230.12
P27
230.16
BV2
230.23
230.14
P28
230.24
P11
230.15
P29
229.98
320.20
230.10
230
230.15
230.20
P26
230.17

Sl. 2. — Fig. 2

v Hajdošah ugotovili, da v pliocenski prodni plasti, izolirani v krovnini in talnini z glino, niha vrednost koeficienta prepustnosti med $5{,}05.10^{-2}$ in $5{,}14.10^{-3}$ cm/sek. Na območju strojnice v Zlatoličju smo prepustnost pliocenskega proda preizkusili s tlačenjem vode v vrtine S_1, S_2, S_4, S_5, S_6, S_7 in S_8.

Prepustnost smo v vrtinah raziskovali po odsekih 2 do 8 m, ker smo se morali ravnati po tehničnih možnostih zatesnitve vrtine z obturatorjem. V prodnih plasteh obturator ni povsod tesnil, zato smo ga morali pomikati navzgor in navzdol, dokler nismo dosegli zadovoljive tesnitve. Merili smo povečini le pri dveh različnih pritiskih; ko je pritisk vode narasel prek 5 kp/cm², je voda pogosto predrla stene vrtine ob obturatorju, kar se je pokazalo v nenadnem padcu pritiska.

Za izračunanje Darcyjevega koeficienta k po podatkih merjenja prepustnosti je mogoče upoštevati le pritiske na stene vrtine v merjenih odsekih, zato je bilo treba odšteti tlačne izgube, ki nastanejo pri pretakanju vode skozi drogovje, prišteti pa pritisk vodnega stebra od manometra do gladine podtalne vode.

Vodne izgube pri raziskavah prepustnosti so nihale od 8,5 do 52 l/m/min pri pritiskih 3,5 do 4,5 kp/cm² v določenih odsekih.

Koeficient prepustnosti »k« smo izračunali po Dupuitovi enačbi za dotok vode iz horizonta pod pritiskom:

$$k = \frac{0{,}366 . Q . \log \frac{R}{r}}{M . H}$$

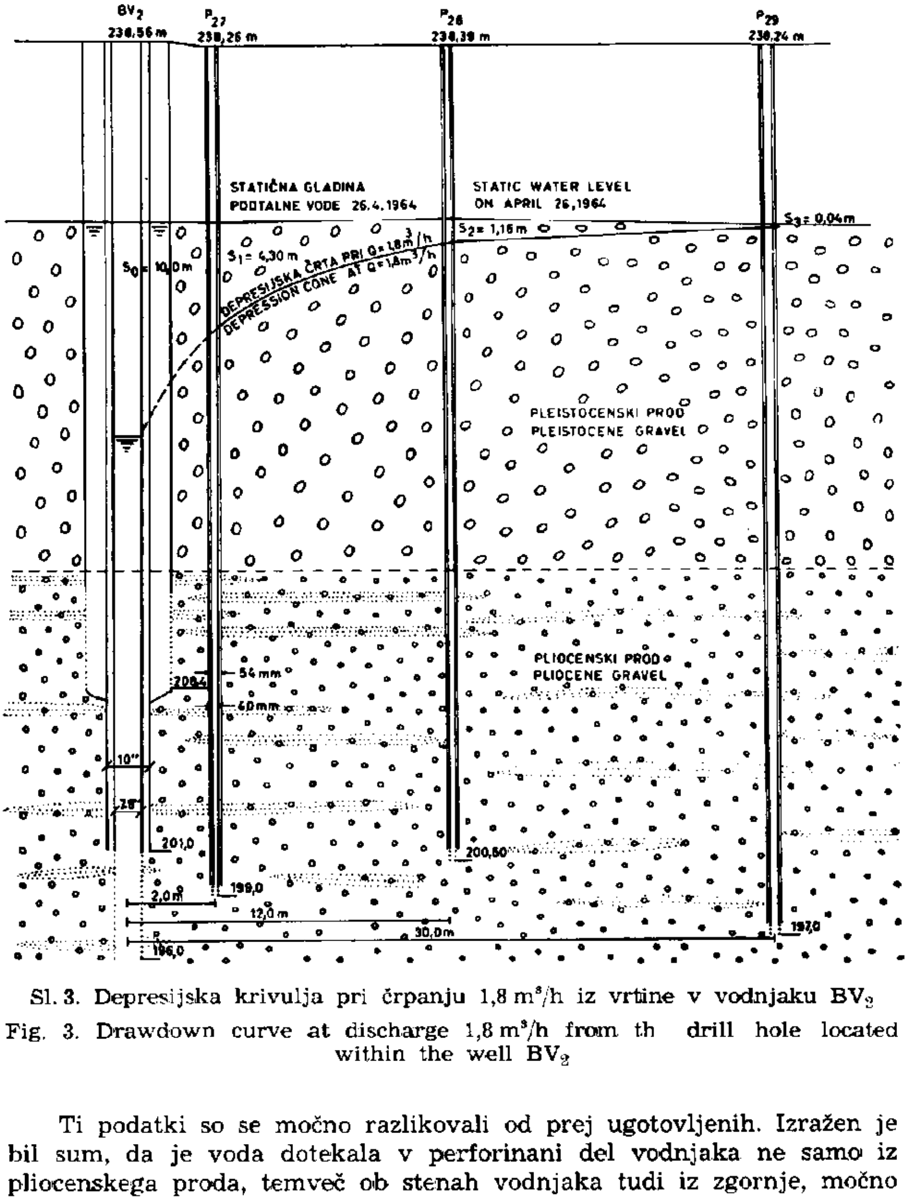
M = dolžina raziskanega odseka vrtine v m
r = polmer vrtine v m
Q = vodne izgube med preizkusom VDP v m³/sek
H = pritisk vode na stene vrtine, izražen v m vodnega stebra
R = polmer vpliva v m ~ 100 m.

Izračunane vrednosti k so približne, ker dejanske razmere niso ustrezale v celoti pogojem enačbe, vendar so za oceno prepustnosti uporabne.

Tako izračunane vrednosti koeficienta k nihajo od $3{,}76.10^{-4}$ do 3.10^{-3} cm/sek.

V geomehanskem laboratoriju univerze v Ljubljani so v permeametru raziskali vzorce pliocenskega proda iz vodnjaka BV_1, zbite na isto prostorninsko težo, kot je bila ugotovljena pri neporušenih vzorcih proda. Ugotovljeno je bilo, da niha koeficient prepustnosti k od $1{,}2.10^{-4}$ do $5{,}3.10^{-5}$ cm/sek.

Vse navedene raziskave so kazale, da je pliocenski prod vsaj stokrat manj prepusten kot pleistocenski prod. Da bi potrdili rezultate raziskav, so izkopali vodnjak BV_1 do kote 197,5 m, ki je bil perforiran v pliocenskem produ le od kote 206 m navzdol. Po podatkih poizkusnega črpanja je bil koeficient »k« pliocenskega proda 3.10^{-2} cm/sek, kar je le desetkrat manj kot prepustnost pleistocenskega proda.



Sl. 3. Depresijska krivulja pri črpanju 1,8 m^3/h iz vrtine v vodnjaku BV_2

Fig. 3. Drawdown curve at discharge 1,8 m^3/h from th drill hole located within the well BV_2

Ti podatki so se močno razlikovali od prej ugotovljenih. Izražen je bil sum, da je voda dotekala v perforinani del vodnjaka ne samo iz pliocenskega proda, temveč ob stenah vodnjaka tudi iz zgornje, močno prepustne pleistocenske prodne plasti.

Posebno pozornost so vzbudili podatki kemičnih analiz vode, ki je bila vzeta med črpanjem iz vodnjakov BV_1 in BV_2. Po kemični sestavi sta bila oba vzorca vode skoraj enaka, čeprav je bil vodnjak BV_2 perforiran v pleistocenskih plasteh, vodnjak BV_1 pa le v pliocenskih plasteh. Trdota je bila pri obeh vzorcih 14,6° dH. V nasprotju z dobljenimi rezultati analiz smo pričakovali, da se bosta vodi razlikovali med seboj, ker je litološka sestava pleistocenskega in pliocenskega proda precej različna.

Za projekt izkopa gradbene jame in gradnje strojnice je bilo treba poznati čim točnejšo vrednost koeficienta k pliocenskega proda. Zato je Geološki zavod po naročilu Dravskih elektrarn ponovno izvedel poizkusno črpanje v pliocenskem produ. V ta namen je leta 1964 izvrtal z dna vodnjaka BV_2 vrtino premera 7,5 colov do kote 196 m. Obložna cev vrtine je bila spodaj perforirana na dolžini 5 m. Da bi preprečili pretakanje vode iz zgornje, bolj prepustne plasti ob ceveh vodnjaka navzdol v perforirani del vrtine, je bila do kote 201 m zabita še neperforirana cev premera 20 colov. Enako so bile izvedene tudi piezometrske vrtine. P_{27}, P_{28} in P_{29} (3. sl.).

Že prvi podatki črpanja so pokazali, da je izolacija pliocenskega proda od pleistocenskega popolnoma uspela; že pri $Q = 0{,}205$ l/sek je znašala depresija v vrtini 3,6 m, v piezometrskih ceveh pa nekoliko manj. Poizkusno črpanje je trajalo 10 dni pri 6 različnih količinah Q od 0,205 do 1,7 l/sek (4. sl.). Pri vseh poizkusih smo črpali tako dolgo, da smo dosegli stacionarno stanje, razen pri $Q = 1{,}7$ l/sek, ko je gladina vode v vodnjaku padla pod spodnji rob črpalke in je bilo črpanje prekinjeno.

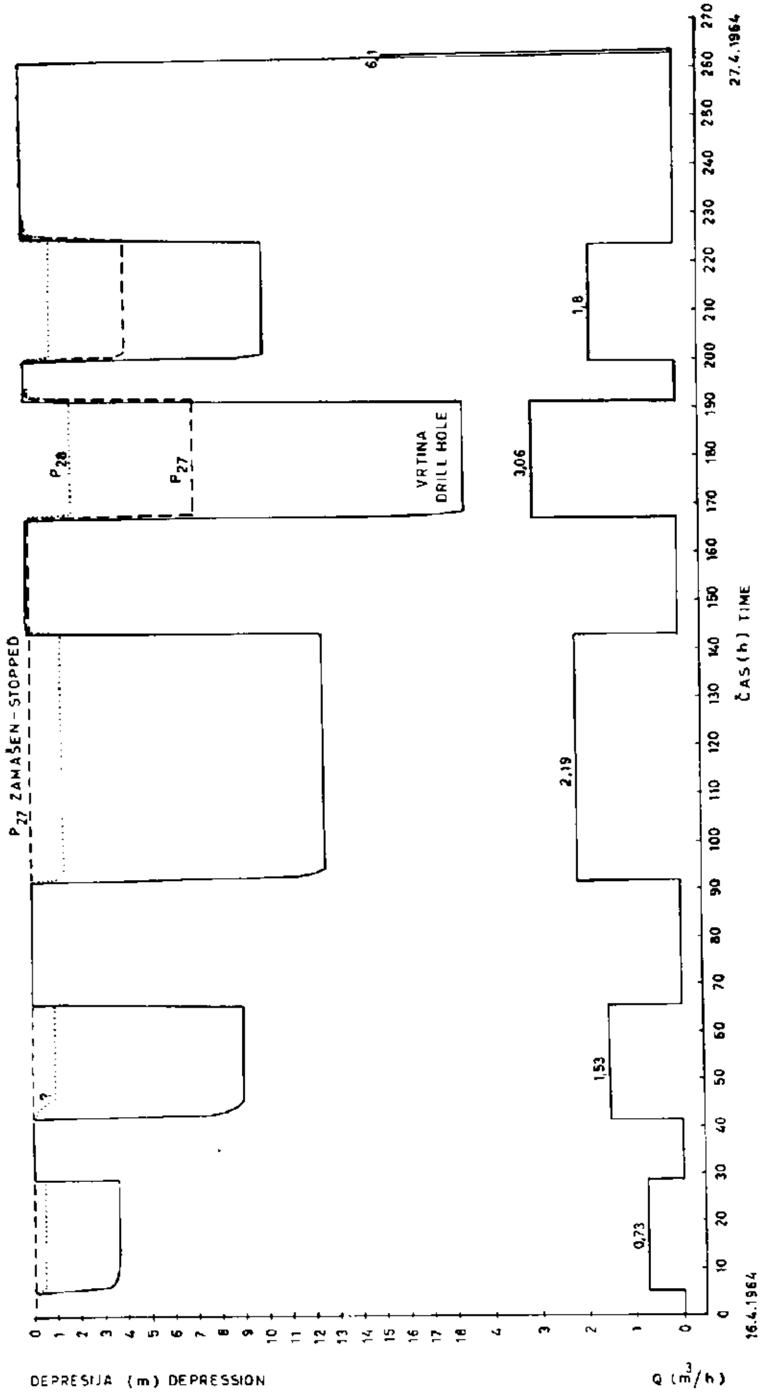
Za izračunanje vrednosti k iz črpalnih poizkusov, pri katerih je bilo doseženo stacionarno stanje, smo uporabili Thiemovo enačbo za dotok vode k vodnjaku iz vodnega horizonta pod pritiskom:

$$k = 0{,}366\, Q\, \frac{\log . r_2 - \log . r_1}{M (s_1 - s_2)}$$

r_2 = razdalja piezometra P_{28} od središča vrtine
r_1 = razdalja piezometra P_{27} od središča vrtine
s_1 = znižanje gladine vode v piezometru P_{27} med črpanjem
s_2 = znižanje gladine vode v piezometru P_{28} med črpanjem
M – debelina vodnega horizonta — dolžina perforiranega dela črpalne vrtine.

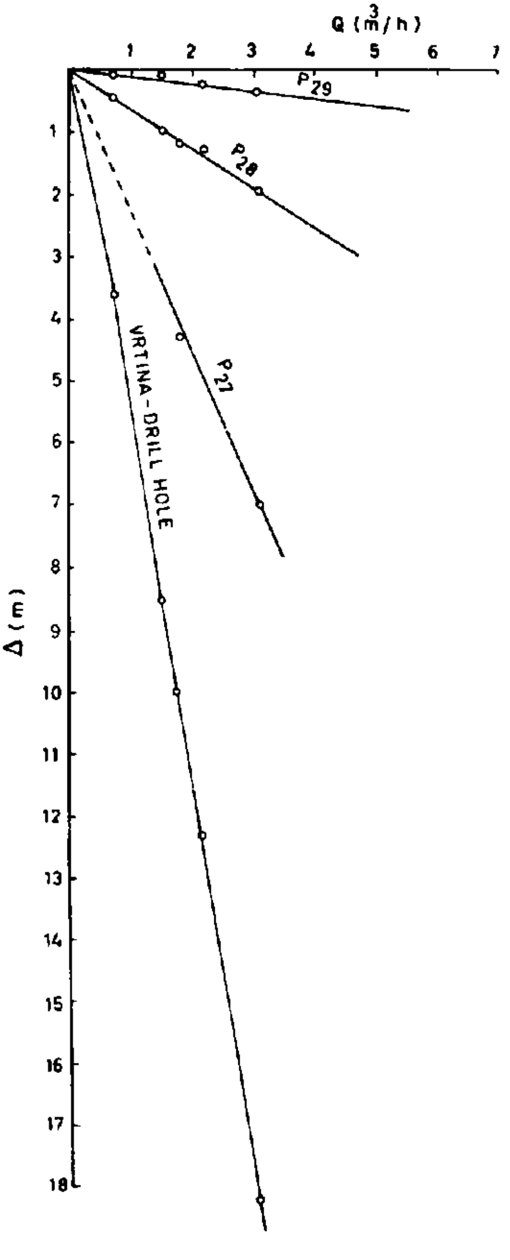
Razmere med črpalnim poizkusom so približno ustrezale pogojem Thiemove enačbe. Pri računanju smo privzeli, da je plast pliocenskega proda in peska nad perforacijo v vrtini do kote 214 m, kjer je meja med pliocenskim in pleistocenskim prodom, nepropustna. Ta predpostavka ni povsem točna, vendar lahko z gotovostjo trdimo, da je prepustnost pliocenskih plasti v navpični smeri neznatna. Med vrtanjem je namreč voda dotekala v vrtine le na odsekih čistega peščenega proda. Na odsekih vrtine v meljastem produ, glini in konsolidiranem pesku ni bilo znatnejšega dotoka vode, kar smo ugotovili po znatnem upadanju vodne gladine v vrtini, potem ko smo izolirali čiste peščene prodne plasti z obložno cevjo. Vrtali smo brez izplake, zato se voda v vrtini ni tako hitro dvignila do prvotne višine, ko smo izvlekli jedrno cev.

Enake pliocenske plasti nastopajo tudi pod dnom vrtine, tj. pod koto 196 m. Zato smo privzeli, da so tudi te plasti v navpični smeri nepropustne in da iz njih med poizkusnim črpanjem voda ni dotekala v vodnjak.



Sl. 4. Diagram črpanja iz vrtine v vodnjaku BV_2

Fig. 4. Diagram of the pumping test with the drill hole located within the well BV_2



Sl. 5. Diagram odvisnosti depresije Δ od količine črpane vode Q v vrtini in piezometrskih ceveh

Fig. 5. Diagram showing the relations between drawdown Δ and drill hole discharge Q

Opazovanja so potrdila našo domnevo, da je depresija v vodnjaku in piezometrskih ceveh sorazmerna količini črpane vode, kar je značilno za vodne horizonte pod pritiskom (5. sl.).

Vrednost koeficienta prepustnosti k je:

za $Q = 0{,}5$ l/sek
$k = 9{,}04.10^{-6}$ m/sek

za $Q = 0{,}85$ l/sek
$k = 9{,}48.10^{-6}$ m/sek

V obeh primerih smo uporabili podatke iz piezometrskih cevi P_{27} in P_{28}, ki so najbolj zanesljivi. Med črpanjem so bile v piezometrski cevi P_{29} malenkostne depresije, v vrtini pa je bila depresija večja, kot bi ustrezalo Thiemovi depresijski črti, in sicer zaradi izgub pritiska pri pretakanju vode skozi perforirano cev (6. sl.). Kot debelino vodnega horizonta M smo privzeli dolžino perforiranega dela vodnjaka. Vodni horizont M vsebuje več plasti prepustnega peščenega proda, vloženih v zelo malo prepusten pesek in meljast prod. Izračunana vrednost koeficienta k je srednja vrednost prepustnosti močno prepustnih in zelo malo prepustnih pliocenskih plasti.

Vrednost koeficienta k smo zaradi kontrole računali tudi po grafični metodi, ki jo je predložil Castany (1963).

Po tej metodi računamo k po enačbi

$$T = \frac{0{,}366 . Q}{c}$$

$$T - k . M$$

$$c = \frac{\delta \Delta}{\delta (\log x)}$$; vrednost c odčitamo neposredno z grafičnega prikaza

depresije in logaritma razdalje; na ordinato nanašamo vrednosti depresije v navadnem merilu, vrednosti razdalj piezometrov od središča vrtine pa v logaritmičnem merilu. Pri dveh različnih vrednostih Q smo dobili naslednji vrednosti za k: Pri $Q - 1{,}8$ m³/h

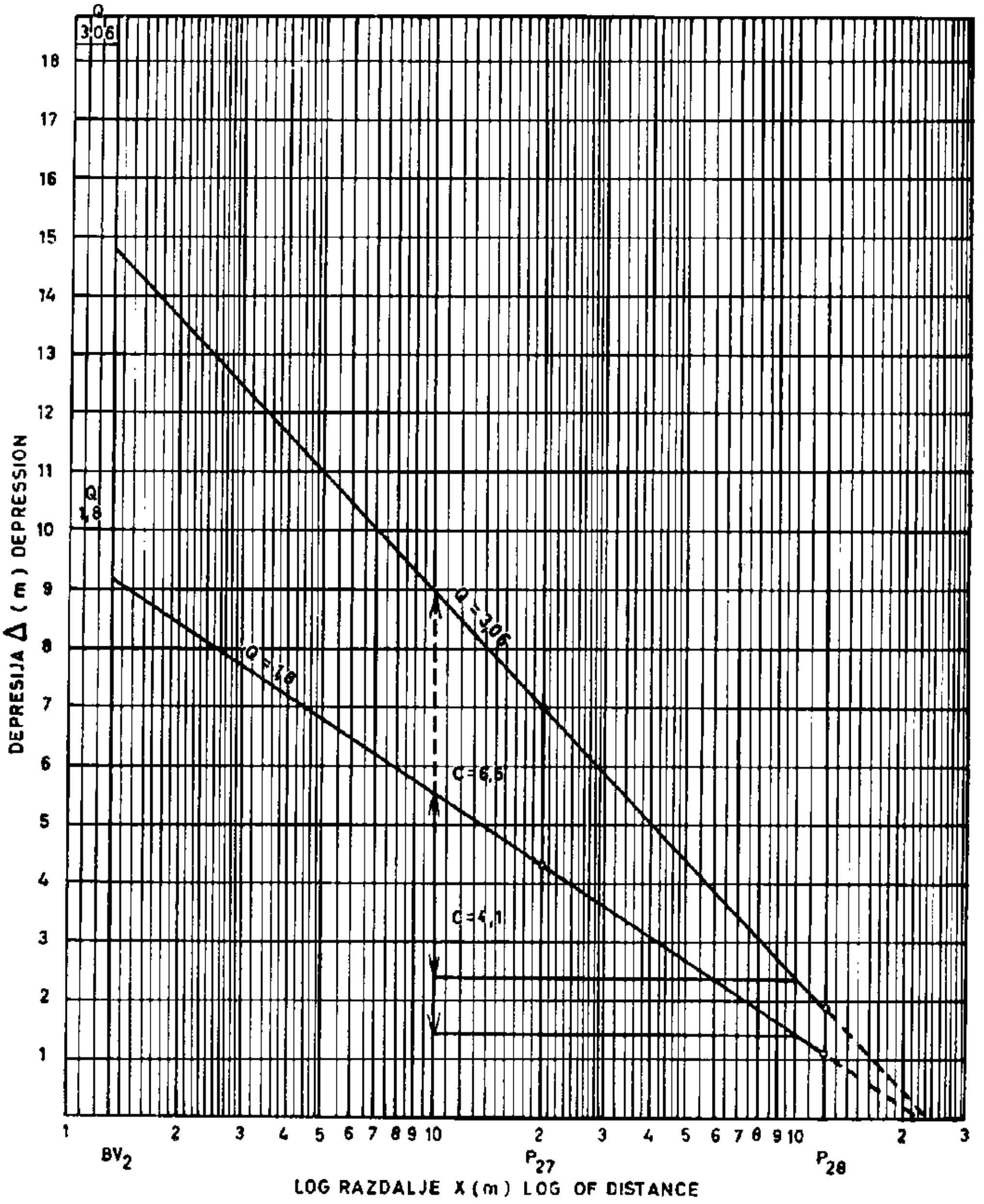
$$T = \frac{0{,}366 . 0{,}0005}{4{,}1} = 4{,}47 . 10^{-5} \text{m}^2/\text{sek}$$

$$k = \frac{T}{M} = \frac{4{,}47 . 10^{-5}}{5} = 8{,}93 . 10^{-6} \text{m/sek}$$

Pri $Q = 3{,}06 \text{m}^3/\text{h}$

$$T = \frac{0{,}366 . 0{,}00085}{6{,}5} = 4{,}78 . 10^{-5} \text{m}^2/\text{sek}$$

$$k = 9{,}57 . 10^{-6} \text{m/sek}$$



Sl. 6. Depresija v vrtini in piezometrih pri črpanju 1,8 m^3/h in 3,06 m^3/h

Fig. 6. Depression of the water table in the drill hole located within the well BV_2 and piezometers at discharges 1,8 m^3/h and 3,06 m^3/h

Rezultati, ki smo jih dobili z računanjem na oba načina, so skoraj enaki. Izračunana vrednost koeficienta *k* je srednja vrednost prepustnosti 5 m debele plasti pliocenskega proda, iz katere je med črpanjem dotekala voda v vrtino. Pliocenski prod sestoji iz plasti manj prepustnega meljastega proda in iz plasti bolj prepustnega čistega peščenega proda. To velja za celotno območje, zato lahko privzamemo izračunano vrednost koeficienta *k* za ves pliocenski prod.

Kemična analiza vode, ki je tekla med črpanjem iz vrtine, je pokazala, da se njena sestava močno razlikuje od sestave vode iz zgornjega vodnega horizonta. Trdota vode v spodnjem horizontu je le 11,55° dH, v zgornjem pa 14,6° dH.

Po podatkih poizkusnega črpanja iz vrtine v vodnjaku BV_2 je bil izdelan glavni projekt. Projektant je predvidel kopanje gradbene jame brez zagatnih sten s črpanjem vode, ki bo dotekala iz pleistocenskega proda. Dotoka vode iz pliocenskega proda ni upošteval, ker vrednost koeficienta *k* kaže, da bo zelo majhen. Prav tako je bilo mogoče po podatkih vrtanja sklepati, da v pliocenskem produ ne bo pojavov tekočega peska.

Po končanem izkopu gradbene jame so opazovanja potrdila pričakovanje, da bo dotok vode iz pliocenskih plasti le neznaten. Točnih podatkov o količini vode ni bilo mogoče zbrati, ker zid, temeljen v pliocenskih plasteh, ki brani prelivanje vode, dotekajoče iz pleistocenskega proda v gradbeno jamo, ni popolnoma vodotesen. Po približni oceni dotok iz pliocenskega proda ni presegal 10 l/sek.

GEOLOGIC AND HYDROGEOLOGIC CONDITIONS IN THE POWERHOUSE SITE OF THE SREDNJA DRAVA I POWER PLANT

Abstract

The powerhouse of the Srednja Drava I power plant is projected on the Pleistocene terrace of Drava river near the main road Maribor—Ptuj at the village Zlatoličje. The foundations of the powerhouse are proposed on the plus 201 m level in the depth of 37,5 meters and 29 meters below the ground water table. In the powerhouse area extensive geologic and hydrogeologic researches have been carried out (Fig. 1). According to data obtained by bore holes, the terrace is composed to the depth of approximately 25 meters by loosely packed Pleistocene gravel; below it is a layer of densely packed Pliocene gravel with intercalations of sand, conglomerate and indurated clay. These intercalations horizontally thin out at a short distance.

From the grading analysis of the Pleistocene and Pliocene gravels emerged that the Pleistocene gravel contains only an inisignificant admixture of silt and from 35 % to 57 % sand. The particle seize of Pliocene gravel is mostly very thin, containing from 11 % to 35 % silt and 20 % to 62 % sand.

Standard penetration tests carried out in the Pliocene gravel showed that it is much consolidated. On account of coarse particles the results of the same tests in the Pleistocene gravel are not reliable. The Pleistocene and the Pliocene gravel differ from one another very much as to the value of volume weight. This comes up at the former at most to 2,04 t/cu. m and at the latter from 2,06 to 2,3 t/cu. m.

From drilling examinations emerged that Pleistocene gravel at corresponding conditions turns into running sand, whereas this is not the case with Pliocene gravel.

All these investigations show that the Pliocene gravel under the foundations of the powerhouse can be loaded with more than 5 kp/sq. cm.

The additional intensity of loading soil will not be significant because unloading due to excavations will reach the value of 52,5 t/sq. m. The conditions of the powerhouse foundations are therefore favourable. Excavations will mostly take place under the ground water table. The Pleistocene gravel could be partly excavated by means of power equipment. Before the excavation of dense packed Pliocene gravel, however, water will have to be removed from the building ground by pumping.

For the excavation project the quantity of water inflow from Pleistocene and Pliocene gravels had to be evaluated. For this purpose permeability tests of Pleistocene and Pliocene gravels were carried out and that in laboratory and under field conditions with bore holes and pumping tests. At the village Zlatoličje two wells were dug out, BV-1 and BV-2. The screen of the shallow well BV-2 was sunk and perforated only within the section of Pleistocene gravel. The same operation was performed at the deeper well BV-1 only in the lower part of the Pliocene gravel. Pumping test showed the value of permeability coefficient k of the Pleistocene gravel from 4,1 to $4{,}63.10^{-1}$ cm/sec and of the Pliocene gravel 3.10^{-2} cm/sec (Fig. 2). Laboratory investigations of Pliocene gravel, pumping tests and permeability measurements at drilling gave much lower values of the permeability coefficient k and that from $5{,}05.10^{-2}$ to $5{,}3.10^{-5}$ cm/sec. A particular attention raised the chemical analyses of water from both wells because they showed nearly the same quality of water. Owing to a different gravel composition a corresponding difference in the chemical composition of water should be expected. The suspicion gained ground that during the pumping test water penetrated in the perforated portion of the well BV-1 not only from the Pliocene gravel, but also along the casing exterior from the overlaying, very permeable Pleistocene gravel. In any case in the Pliocene gravel on account of the different lithologic composition a somewhat different quality of water could be expected.

By ordre of the Dravske Elektrarne another pumping test had to be carried out. Consequently the Geological Survey of Ljubljana made a drilling hole in the Pliocene gravel within the shallow well BV-2 (Fig. 3). The pumping test proved to be successful. Measurements of the water table in the test hole as well as in the piezometers showed a great depression and that already at $Q = 0{,}205$ litre/sec (Fig. 4). Chemical analyses of water, flowing from the well during the pumping test, showed that its composition greatly differs from the one of the upper water horizon. Whereas the water hardness from the Pleistocene gravel reaches 14,6^0 dH, the one from the Pliocene gravel comes up only to 11,5^0 dH.

At the stabilized water level the value of k was evaluated from pumping test data- applying the same equation as for the flow to a well, penetrating a confined aquifer (Fig. 5). Observations during the pumping test showed that the drawdown in the testhole and in the piezometers was proportionate to the discharge rate. This is a characteristic for the confined aquifers. The calculated value of k oscillates between 9,06 to $9{,}48.10^{-4}$ cm/sec. On the basis of these data the main project provided an excavation without sheet pile courtains and without grouting but pumping of water flowing from the Pleistocene gravel. The discharge from the Pliocene gravel has not been taken into account owing to the very low value of k. According to drilling data no running sand could be expected in the Pliocene gravel. For this reason the foundations of the powerhouse have been projected directly on the Pliocene gravel without any consolidation works.

Later observations during the excavation entirely confirmed all the foreseeings regarding the discharge of water from the Pleistocene and Pliocene gravels and the possibility of foundations on the Pliocene gravel (Figs. 7 A and 7 B).

LITERATURA

Bogomolov, G. V., in Silin-Bekčurin, A. I., 1959, Specijalna hidrogeologija. »Gradjevinska knjiga«, Beograd.

Castany, G., 1963, Traité pratique des eaux souterraines. Dunod, Paris.

Kerin, A., 1965, Diplomska naloga št. 453/65. Arhiv Fakultete za arhitekturo, gradbeništvo in geodezijo v Ljubljani.

Todd, D. K., 1964, Ground water hydrology. John Wiley & Sons, Inc., Publishers.

Žlebnik, L., 1963, Pregledno geološko poročilo k projektu elektrarne prve stopnje Srednje Drave. Poročilo v arhivu Geološkega zavoda v Ljubljani.

A

B

Sl. 7. — Fig. 7

A. Pogled na zahodni del gradbene jame

A. View of the western part of excavation

B. Pogled na severni in vzhodni del gradbene jame

B. View of the northern and eastern part of excavation

p = pleistocenski prod — Pleistocene gravel
pl = pliocenski prod — Pliocene gravel
i = izvir v pleistocenskem produ — Flow of water from Pleistocene gravel
v = voda, ki teče proti črpališču — Water flowing to pumping station
č = črpališče — Pumping station
z = Betonski zid, ki preprečuje prelivanje vode v gradbeno jamo — Concrete wall protecting the excavation from water

O BARITU NA SLOVENSKEM

Milan Fabjančič

Uporaba barita

Uporabnost barita je zelo mnogostranska. Največ ga porabijo za težke izplake pri globinskem vrtanju, za proizvodnjo litopona in barv, v kemični industriji in za proizvodnjo baritnega cementa.

V ZDA je leta 1959 od celotne potrošnje barita odpadlo 95 % na globinsko vrtanje, na industrijo gumija 2 %, na industrijo stekla 1 %, na industrijo barv 1 % in na druge potrošnike 1 %. Struktura potrošnje barita se v tej državi zelo počasi spreminja in ostaja po več let skoraj enaka. Isto velja tudi za druge industrijske države.

Za posamezne namene postavljajo za kvaliteto barita različne zahteve, ki jih je možno izpolniti z manj ali bolj zapletenimi proizvodnimi operacijami. Zahteve se nanašajo na kemično čistost (maksimum škodljivih primesi, minimum koristnih snovi), specifično težo, beloto, konsistenco, vsebino vlage in na druge lastnosti surovine. Za vsako vrsto uporabe barita postavljajo posebno strukturo pogojev, z drugimi besedami, pri določeni uporabi barita so važne samo določene lastnosti. Seveda pa se tudi pri enaki uporabi često razlikujejo pogoji različnih potrošnikov, zlasti če so iz različnih držav. Zato se mora proizvajalec tehnično prilagoditi vsaj glavnim zahtevam tržišča, oziroma tistemu krogu kupcev, kjer doseže najugodnejše poslovne rezultate. Barit je potrebno prebirati, prati, drobiti, mleti, flotirati, žariti, beliti, elektromagnetno čistiti od železa, kemično predelovati in pakirati.

Tako imenovani petrolejski barit primešajo izplakam za vrtanje globinskih vrtin. S težkimi izplakami obvladujejo ogromne pritiske v globinah, pa tudi pritiske plinov v ležiščih nafte in tako preprečujejo erupcije. Pri petrolejskem baritu je važna specifična teža 4,2 do 4,3, takšna granulacija, da gre 95 % barita skozi sito z luknjicami premera 42 mikronov (325 mesh) in vsebina $BaSO_4$ do 94 %. Poleg tega ne sme vsebovati v vodi topnih soli.

Za izdelavo litopona zahtevajo običajno kosovni barit s 93 % do 96 % $BaSO_4$, ki lahko vsebuje največ 1 % Fe_2O_3 in 1,5 % SiO_2; Al_2O_3, CaO in MgO pa največ 0,5 %. Ne sme vsebovati F, Zn in Pb. Litopon je pigment, ki vsebuje 70 % $BaSO_4$ in 30 % ZnS; uporabljajo ga za proizvodnjo oljnih in slikarskih barv ter emajlnih premazov.

Podobni so pogoji za barite, ki jih uporablja kemična industrija za proizvodnjo barijevega sulfata, karbonata, klorida, oksida, hidroksida, nitrata in še mnogih drugih spojin.

Kot polnilo uporabljajo bel prirodni barit, kemično zelo čist, ter drobno in precizno mlet, tako da imajo zrnca premer pod 42 mikronov. Dodajajo ga barvam, lakom in finejšim vrstam papirja. Kot polnilo uporabljajo barit tudi pri proizvodnji gumija, impregniranju tkanin, linoleja in insekticidov. V ta namen mora barit vsebovati vsaj 96 % barijevega sulfata in manj kot 0,2 do 1 % Fe_2O_3.

Steklu dodajajo barit kot talilo in bistrilo. Potrebne učinke dosežejo z njegovim oksidacijskim delovanjem. Steklarski barit ne sme vsebovati težkih kovin, kot npr. Fe, Cu, Co, Cr, Ni, ker njihovi oksidi barvajo steklo. Zn in Pb ne motita, Fe_2O_3 pa sme vsebovati le 0,1 %. Zrnca morajo imeti premer 0,08 mm ali manj.

Za cementni barit je dovolj, če vsebuje 80 % do 92 % $BaSO_4$, mora pa imeti specifično težo 4,15 in ne sme vsebovati snovi, ki škodljivo vplivajo na cement ali armaturo. Pb je škodljiva komponenta, koristna pa je, če barit vsebuje do 8 ali največ do 10 % SiO_2, 2,5 do 3 % Al_2O_3 in toliko železa, da je utežno razmerje $FeO_3 : Al_2O_3 = 1 : 2$. Če vsebuje barit malo železa in aluminija, mu dodajajo boksit, če pa vsebuje mnogo železa, mu je treba dodajati glinico, ki pa je precej draga. Barit naj bo mlet do takšne granulacije, da ima 90 % zrnc premer manjši od 90 mikronov. Uporabljajo ga za izdelovanje cementa za zaščitne zidove proti radioaktivnemu sevanju, pa tudi kot dodatek k hladno mešanim asfaltom pri gradnji kvalitetnih cest in pist, za obloge cevovodov, položenih prek rek in močvirij in za podobne namene.

Problem proizvodnje barijevih cementov je bil že tudi pri nas postavljen zaradi izrednih lastnosti teh veziv, ki se kažejo:

1. v obstojnosti pri visokih temperaturah do 1730° C in z dodatki še pri višjih,

2. v izredni odpornosti proti delovanju morskih in drugih sulfatnih vod,

3. v visoki stopnji nepropustnosti za rentgenske in gama žarke.

Z lastnostmi baritnih cementov se je ukvarjal Broniski; 15 let je izpostavljal prizme iz različnih cementov morski vodi v Črnem morju in je ugotovil, da so baritni cementi proti njej mnogo odpornejši kot drugi, klasični cementi. Zanimiv je Sanielevicijev poskus; z emitiranjem mehkih žarkov gama skozi ovire različnih debelin in materialov je z Geiger-Müllerjevim števcem ugotovil njihovo varovalno debelino pri določenih napetostih rentgenskega sevanja. Rezultate kaže 1. tabela.

1. tabela

DEBELINA VAROVALNIH OBLOG PRED RENTGENSKIMI ŽARKI

Snov	Najmanjša varovalna debelina pred rentgenskimi žarki v mm pri napetosti 60 kV	200 kV
Valjana svinčeva pločevina	0,9	4
Barijev zaščitni beton	7	29
Svinčevo steklo	8	34
Kalcijev zaščitni beton z dodatki Ba	14	60
Zaščitni betoni z običajnim cementom	65	270

Iz tabele vidimo, da je zaščitni učinek barijevega betona pred rentgenskimi žarki pri napetosti 60 kV in 200 kV blizu zaščitnemu učinku svinčevega stekla. Pri navedenih napetostih rentgenskih žarkov je potrebna dvojna debelina kalcijevega zaščitnega betona, da dosežemo učinek, ki ga ima barijev beton. Zaščitni učinek enako debele valjane svinčeve pločevine je osemkrat večji kot pri barijevem betonu, material za postavitev svinčeve zaščitne membrane pa je približno trikrat dražji kot material za postavitev enakovrednega zidu iz barijevega betona.

Že uporabnost barita kaže, da so njegovi veliki potrošniki države z visoko razvito proizvodnjo nafte in sploh dežele z razvito industrijo. Potrošnja barita se namreč razvija vzporedno z razširjanjem njegove uporabe v novih industrijskih panogah in sorazmerno z razvojem industrije, v kateri ga že uporabljajo. Potrošnja barita v industrijsko razvitih državah je skoraj povsod precej večja od njihove lastne proizvodnje. Zato so te države veliki uvozniki barita. To pospešuje proizvodnjo v drugih državah, ki imajo možnosti za proizvodnjo te surovine in je same ne uporabljajo v tolikšni meri, kot jo proizvajajo. Med izvozniki barita so zato povečini industrijsko manj razvite države. Proizvajalci barita pa so razvite in manj razvite države, kar kaže 2. tabela.

2. tabela

PROIZVODNJA BARITA V LETU 1962*

Dežela	V tonah	Dežela	V tonah
Alžirija	19 958	Kanada	207 991
Argentina	18 144	Kitajska	81 647
Avstralija	9 979	Kolumbija	9 979
Avstrija	1 081	Koreja, južna	920
Brazilija	51 002	Maroko	89 793
Burma	4 048	Mehika	318 135
Čile	1 397	Nemčija — zahodna	426 377
Egipt	2 722	Pakistan	2 870
Filipini	416	Peru	95 000
Francija	70 035	Poljska	45 215
Grčija	79 832	Portugalska	2 087
Indija	24 476	Španija	34 019
Iran	15 000	Švica	62
Irska	343	Turčija	1 900
Italija	121 915	ZDA	804 640
Japonska	35 048	Združeno kraljestvo	76 896
Jugoslavija	130 000	ZSSR	181 437
Južnoafriška unija	1 699		

Iz Bolgarije, Češkoslovaške, Vzhodne Nemčije in Severne Koreje, kjer tudi pridobivajo barit, nimamo podatkov.

Iz tabele vidimo, da so bili v letu 1962 največji proizvajalci barita ZDA, Zahodna Nemčija, Mehika, Kanada, ZSSR, Jugoslavija, Italija, Peru, Maroko in Kitajska. Svetovno proizvodnjo barita v letih 1950 do 1962 kaže 3. tabela.

* Preračunani podatki iz Minerals Yearbook 1962; US Department of the Interior, Bureau of Mines.

3. tabela

SVETOVNA PROIZVODNJA BARITA V LETIH 1950 DO 1962*

Leto	V tonah	Leto	V tonah
1950 do 1954 povprečno	1 823 000	1959	2 722 000
1955	2 450 000	1960	2 767 000
1956	2 812 000	1961	2 685 000
1957	3 175 000	1962	3 003 000
1958	2 359 000		

Jugoslavija proizvaja kosovni in mleti barit. Proizvodnja se je začela razvijati že med obema svetovnima vojnama, vendar v majhnih količinah. V svetovnega proizvajalca barita se je naša država razvila po drugi svetovni vojni.

Po približnih podatkih je v Jugoslaviji naraščala proizvodnja barita kot kaže 4. tabela.

4. tabela

PROIZVODNJA BARITA V JUGOSLAVIJI

Leto	V tonah	Leto	V tonah
1939	5 000	1955	88 123
1951	24 447	1956	93 918
1952	34 819	1957	120 780
1953	81 114	1962	130 000
1954	95 046		

V ZDA krijejo z lastno proizvodnjo le približno polovico barita za domačo potrošnjo in so zato največji uvoznik kosovnega barita na svetu. Ameriški rudniki v notranjosti kontinenta so precej oddaljeni od velikega dela predelovalne industrije, ki je koncentrirana v bližini atlantskih pristanišč. Zato sorazmerno majhni stroški ladijskega transporta omogočajo sosednjim državam (Kanada, Mehika), pa tudi bolj oddaljenim, izvoz barita v ZDA. Mehika in Kanada sta glavna dobavitelja barita ZDA, v zadnjih letih pa se jima je pridružil še Peru. Poleg teh držav se na tem tržišču pojavljajo še Grčija, Španija in Maroko. Ker so jugoslovanski bariti kvalitetnejši od mnogih drugih, so ZDA za nas pomembno tržišče. Povpraševanje po naših baritih je tu vedno večje od možnosti naših dobav. Zahteve glede kvalitete niso stroge, vendar so cene v tem času nizke in se gibljejo okoli 10 $ za tono kosovnega barita. Avstrija je naše baritno tržišče zaradi ugodnega transporta. Uvaža 3500 do 5000 ton barita letno.

Zahodna Nemčija je drugi največji proizvajalec barita na svetu. Kljub temu uvaža okoli 20 000 ton barita letno. Postavlja pa zelo stroge pogoje glede kvalitete. Sedaj v to državo ne izvažamo, ker močno konkurirata Španija in Maroko, ki imata ugodnejše transportne možnosti.

Velika Britanija postavlja ugodnejše cene za barit kot nemško tržišče.

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* Preračunani in zaokroženi podatki iz Minerals Yearbook 1959, 1962; US Department of the Interior, Bureau of Mines.

Francosko tržišče ima za naš barit podobne pogoje kot angleško. ZSSR uvaža predvsem kosovni barit in postavlja sorazmerno stroge zahteve glede hvalitete. Vendar izvažamo na to tržišče tudi precejšnje količine mletega barita. Madžarska uvaža predvsem kosovni beli barit, z njim pa še nekaj sivega kosovnega in mletega. Kupca našega barita sta lahko tudi Češkoslovaška in Poljska.

Kot konkurent se na vzhodnem tržišču pojavlja Bolgarija, vendar ima majhno proizvodnjo in slabo kvaliteto.

Za jugoslovanske barite pridejo v poštev tudi tržišča bližnjega in srednjega vzhoda, kamor do sedaj še nismo izvažali večjih količin.

Tako v zahodnih kot v vzhodnih deželah je povpraševanje po naših baritih večje kot naša ponudba.

Iz zgodovine proizvodnje barita v Sloveniji

V Sloveniji sta doslej obratovala dva baritna rudnika Pleše pri Škofljici in Litija. V obeh so prvotno pridobivali druge mineralne surovine; pred prvo svetovno vojno so v Plešah odkopavali le svinčevo rudo, v Litiji pa poleg svinčeve še živosrebrno, cinkovo, železovo in tudi srebrovo. Barit so začeli pridobivati šele po prvi svetovni vojni.

Kvaliteto barita iz Pleš in Litije kaže 5. tabela.

5. tabela

KEMIČNA SESTAVA BARITA IZ PLEŠ IN LITIJE

Sestavina	Pleše %	Litija %
$BaSO_4$	93 do 99	88 do 95
SiO_2	0,1 do 4,8	3 do 6
Fe	0,07 do 0,12	0 do 2,93
Al_2O_3	0,11 do 0,95	
$CaCO_3$	0,07 do 1,05	1,05 do 1.26
$MgCO_3$	0,0 do 0,90	do 0,35

Vidimo, da je barit iz Pleš precej boljši, ker vsebuje skoraj 5 % več $BaSO_4$ ter manj SiO_2 in Fe. Zanimivo je, da je v litijskem baritu tudi več kalcita kot v baritu iz Pleš.

Takšne prednosti surovine so vplivale, da so v Plešah začeli pridobivati barit prej in v večjem obsegu kot v Litiji. Leta 1919 je prvič financirala organizacijo proizvodnje barita Jadranska banka s sedežem v Ljubljani. Z delom so začeli na zahodni strani hriba Čelo, nad vasjo Dule.

Na vzhodni strani istega hriba pa je začela v obdobju med prvo in drugo svetovno vojno z eksploatacijo barita Tehniška komercialna družba, ki je tudi imela svoj sedež v Ljubljani. Proizvodnja je bila majhna, v letih 1934 do 1945 je znašala približno 6000 ton barita.

Tudi iz litijske jame, kjer je po prvi svetovni vojni odkopavala svinčevo rudo rudarska družba Litija, so že od časa do časa prebrali kakšno tono barita. Belega so prodajali po 4000 din za 10 ton, rjavega pa po 1500 din za enako količino.

Med okupacijo so Nemci poskusili organizirati pridobivanje barita v Litiji, čeprav zaradi velikega odstotka SiO_2, ki je znašal 8 % do 10 %, z litijsko surovino niso bili zadovoljni. Zaradi primesi železa so jo ocenili kot neprimerno za industrijo barv. Kljub tem neugodnim lastnostim so v Litiji leta 1943 nakopali 2056 ton barita, leta 1944 pa še 243 ton. Vseboval je 88.1 % $BaSO_4$ in 9,2 % SiO_2. Obogatili so ga na kraju samem in pošiljali v Celje, kjer so ga uporabljali za izdelavo litopona.

Po vojni so v Plešah takoj obnovili proizvodnjo barita na hribu Čelo. Temu revirju se je leta 1954 pridružil še revir Vrhovka. V Litiji se je začela proizvodnja barita šele leta 1952, ko sta se rudnika Pleše in Litija združila pod imenom Posavski rudniki. V letu 1956 so na obeh rudnikih zgradili mokromehanični separaciji. Zato se je v letih 1956 in 1957 proizvodnja barita močno povečala. Istočasno pa so začeli v Litiji, prvič po drugi svetovni vojni, ponovno pridobivati svinčev koncentrat. Po letu 1957 se je proizvodnja barita v Litiji zaradi poslabšanja konjunkture zopet zmanjšala, konec leta 1959 pa je bila ustavljena. Med tem časom je naraščala proizvodnja svinčevega koncentrata. V rudniku Pleše pa so kontinuirano odkopavali barit do leta 1963, ko so morali prenehati, ker so zaradi mnogo preskromnih raziskovalnih del izčrpali zaloge.

Proizvodnjo v rudnikih Pleše in Litija nam kaže 6. tabela.

6. tabela

PROIZVODNJA RUDNIH KONCENTRATOV V LITIJI IN PLEŠAH

Leto	Proizvodnja v tonah						
	Sitarjevec Litija			Pleše	Skupaj		
	PbS	$BaSO_4$	ZnS	$BaSO_4$	PbS	$BaSO_4$	ZnS
1946	—	—	—	591	—	591	—
1947	—	—	—	6005	—	6005	—
1948	—	—	—	7543	—	7543	—
1949	—	—	—	5368	—	5368	—
1950	—	—	—	2647	—	2647	—
1951	—	—	—	1870	—	1870	—
1952	—	473	—	4070	—	4543	—
1953	—	5933	—	5100	—	11033	—
1954	—	3548	—	4523	—	8071	—
1955	—	2887	—	5575	—	8462	—
1956	118	4200	—	6415	118	10615	—
1957	50	6600	—	6635	50	13235	—
1958	650	1243	—	5775	650	7018	—
1959	620	910	—	5260	620	6170	—
1960	724	247	—	5290	724	5537	—
1961	735	—	—	6425	735	6425	—
1962	939	—	—	6000	939	6000	—
1963	952	155	—	5079	952	5234	—
1964	512	1782	259	—	512	1782	259
1965	388	1729	—	—	—	—	—

Z novim letom 1961 je bil litijski rudnik priključen k rudniku Mežici kot poslovna enota.

Novo matično podjetje je zgradilo flotacijo s kapaciteto 100 t rude/24^h, ki je začela obratovati poleti istega leta. S tem je bila povečana proizvodnja galenitnega koncentrata. Nekaj let pozneje so uredili tudi pridobivanje baritnega in sfaleritnega koncentrata. Izkoristki so znašali okoli 90 % Pb za svinčevo rudo, 92 % do 93 % Zn za cinkovo rudo in 60 % do 70 % za baritno rudo. Z izboljšanim tehnološkim postopkom bi mogli predelati stare odvale, ki vsebujejo 1,83 % Pb, 0,47 % Zn in 30 % $BaSO_4$. Z rekonstrukcijo izbiralnice bi povečali njeno predelovalno zmogljivost za 50 %, obenem pa bi jo usposobili za pridobivanje barita iz starega flotacijskega odvala z zadovoljivim izkoristkom. Redna proizvodnja baritnega in cinkovega koncentrata se je začela šele v letu 1964. Rekonstrukcija izbiralnice pa v tem času še ni bilo opravljena.

Nahajališča barita v Sloveniji

Proizvodnja barita v Sloveniji se je razmahnila do pomembnejšega obsega šele po drugi svetovni vojni. Ta mineral so imeli prej za spremljajočo jalovino svinčeve in tudi cinkove rude. Zato ga stara poročila poredko omenjajo in še to le mimogrede. Ves barit, ki so ga odkopali obenem s svinčevo rudo pred prvo svetovno vojno, in večji del barita, odkopanega med obema vojnama, leži na odvalih.

Tudi po drugi svetovni vojni je zanimanje za svinčevo in cinkovo rudo često puščalo barit v senci. Zato so doslej zbrani podatki nepopolni.

Študij nahajališč, kjer so bili registrirani pojavi barita ter svinčeve in cinkove rude, bi nam dal nove podatke o njihovem gospodarskem pomenu. Vendar nam rudišča, kjer so doslej že odkopavali galenit, sfalerit ali celo barit, kažejo, s kakšnimi baritnimi pojavi lahko računamo v Sloveniji.

Doslej smo po literaturi in lastnih zapiskih ugotovili naslednja nahajališča s podatki o baritnih pojavih:

Arhov graben nad Zavrstnikom pri Litiji
Belščica v Karavankah na območju Jesenic
Brezno pri Laškem
Budna vas pri Radečah
Dobrava pri Litiji
Dule pri Škofljici
Hrastarija vzhodno od Litije
Lokavec pri Rimskih Toplicah
Maljek vzhodno od Litije
Mamolj vzhodno od Litije
Marija Reka pod Mrzlico
Na Jezeh vzhodno od Litije
Odanče južno od Golice nad Jesenicami
Pasjek pod Polšnikom
Ples pri Kozjem
Pleše vzhodno od Škofljice
Počivalnik severozahodno od Tržiča
Podčešje vzhodno od Litije
Podkraj pri Hrastniku
Probsov kamnolom zahodno od Zavrstnika
Sitarjevec pri Litiji
Šancetova ruda blizu Loga pod Mangartom
Šmarje pri Grosupljem
Štriglavi jarek pod Mamoljem
Volčja jama pri Zavrstniku
Vrbetov jarek vzhodno od Litije
Vrhovka pri Škofljici
Zagorica pri Litiji
Zavrstnik pri Litiji

Posamezna od teh nahajališč so v severozahodni Sloveniji, v Karavankah in pod Mangartom, vsa druga pa v trikotniku Škofljica—Celje—Št. Janž v osrednji Sloveniji na območju Posavskih gub.

A. *Barit v Karavankah in pod Mangartom*

Na tem območju so doslej znani le štirje pojavi barita, in sicer:

Šancetova ruda v bližini Loga pod Mangartom. Barit se tu pojavlja kot spremljevalec galenitne rude v plasteh srednje triade. Poleg barita in galenita najdemo še pirit, limonit in sadro. Vsi ti minerali zapolnjujejo prelome s smerjo SSW—NNE ali pa jih spremljajo. Na tem območju je obratoval rudnik svinca.

Belščica v Karavankah na območju Jesenic. Tudi tu se barit pojavlja v kompleksni mineralizaciji s sideritom, piritom, galenitom in sfaleritom v bližini rova Urbas.

Odanče nad Jesenicami južno od Golice. Barit spremlja galenitno-sfaleritno rudo.

Počivalnik severozahodno od Tržiča. Tu so našli barit z malahitom, azuritom in tenantitom.

O ekonomski vrednosti teh pojavov ni podatkov.

B. *Barit v Posavskih gubah*

Večina nahajališč barita v Posavskih gubah je v ožjem območju litijske antiklinale, kjer so najzahodnejši izdanki okoli Pleš, najvzhodnejši pa, z izjemo Plesa, pri Budni vasi, na poti od Radeč pri Zidanem mostu proti Št. Janžu. Tudi v teh mejah izdanki ne kažejo kontinuitete, ampak so razbiti na posamezna območja, kjer so bolj strnjeni.

Največje je centralno območje širše okolice Litije. Tu so baritni pojavi razvrščeni južno od Save, od Volčje jame na zahodu, do Pasjeka in Štriglavega jarka na vzhodu; razdalja med krajnimi pojavi znaša okoli 12 km. Izdanki svinčeve rude pa to območje še nekoliko razširjajo.

Tu so znana od zahoda proti vzhodu naslednja nahajališča barita: Volčja jama, Probsov kamnolom, Arhov graben, Zavrstnik, Sitarjevec, Dobrava, Zagorica, Na jezeh, Maljek, Podčešje, Vrbetov jarek, Hrastarija, Mamolj, Štriglavec.

Jugovzhodno od Ljubljane so znani pojavi barita v okolici Škofljice: Pleše, Dule, Vrhovka, Šmarje.

Redko razporejena so nahajališča barita na območju Št. Janž—Laško—Trbovlje: Budna vas, Podkraj, Lokavec, Brezno in Marija Reka.

Od vseh teh nahajališč sta zunaj litijske antiklinale le Brezno in Marija Reka, ki je hkrati najsevernejši znani pojav barita na območju Posavskih gub.

Osnovni podatki o najdiščih so naslednji:

a) Območje Št. Janž—Laško—Trbovlje

Budna vas. Tu prevladujejo paleozojske plasti s kremenovim peščenjakom in konglomeratom ter glinastim skrilavcem. Pojavljajo se tudi werfenski skrilavec in peščenjak ter triadni apnenec. Baritno-galenitno-cinabaritna ruda zapolnjuje prelome. Takšne pojave moremo opazovati v več krajih. Tu je obratoval do začetka našega stoletja rudnik svinca v dolini potoka Knapovka.

Podkraj. Na desnem bregu Save med Hrastnikom in Zidanim mostom je bil v prejšnjem stoletju rudnik svinca. Poleg PbS se tod pojavljata še barit in cinabarit.

Lokavec. Osnovo terena sestavljajo plasti paleozojskega kremenovega peščenjaka in konglomerata, ki jih delno pokrivajo werfenski skladi in ponekod školjkoviti apnenec. Rudni minerali, med njimi prevladuje galenit, zapolnjujejo prelome in razpoke v peščenjaku in konglomeratu. Barit nahajamo tu le v redkih kristalih. Lokavec je bil rudnik svinca, kjer so zadnjikrat rudarili med prvo svetovno vojno.

Brezno pri Laškem. Barit v tej lokalnosti omenja Jelenc (1953).

Marija Reka. Star rudnik svinca in živega srebra. Zadnja poskusna proizvodnja živega srebra je bila leta 1958. Na mladopaleozojskem temnem glinastem sljudnatem skrilavcu leži werfenski bel in rdeč sljudnat peščenjak,. ki vsebuje manjše leče apnenca in dolomita. Plasti vpadajo proti jugu pod koti 30° do 60°.

Samorodno živo srebro in cinabarit se pojavljata v nepravilnih majhnih lečah. Razpoke z vpadom 150/50° so zapolnjene s kremenom, baritom in cinabaritom. Sedlar (1950) navaja, da so baritne žile debele do 40 cm. Tudi Makuc omenja barit in kremen kot spremljevalca cinabarita. Po njegovih poročilih so posebno bogate s cinabaritom prav baritne žile.

Ples pri Kozjem. Iz te lokalnosti omenja baritni pojav Jelenc (1953).

V opisanih nahajališčih barita so v kompleksnih rudah tudi pojavi sorodnih rud, in sicer:

1. V širši okolici Budne vasi so znana nahajališča svinčevo-živosrebrovih rud v krajih Trebeljno-Srednik (Pb, Zn), Log (Pb), Kompolje (Pb, Zn), Brunska gora (Pb). To območje prehaja v okolici Radeč v območje bakrovih rud z najdišči Močilno (Cu), Sv. Križ (Cu) in Laški potok (Pb).

Zahodneje najdemo svinčevo rudo v Padežu in Št. Jurju pod Kumom. V okolici Radeč je še več izdankov bakrove rude.

2. Na območju Podkraja in Lokavca se pojavlja mineralizacija s svincem v Velikih Širjah pri Zidanem mostu, Loki in Rudi, medtem ko tvorijo pojavi v Dobravi (Pb), Stranju (Pb, Zn), Zabukovju (Pb), Ledini (Pb, Zn), Tržišču (Pb, Zn) in Mokronogu (Pb, Zn) zunanjo cono rudnih pojavov baritnega območja.

3. V okolici Brezna pri Laškem in Marije Reke ni drugih znanih baritnih pojavov, pač pa so vzhodno od tod še nahajališča sorodnih rud: Žikovica pri Laškem (Pb), Padež (Pb), Svetina (Pb), Celje-Stari grad (Hg).

b) Okolica Škofljice

Pleše. Jedro doslej znanih pojavov barita na tem območju je v hribu Čelo (421 m) nad vasjo Dule.

Osnovo rudišča sestavlja karbonski kremenov peščenjak, ki tu in tam prehaja v kremenov konglomerat. Ti kamenini često prekriva temen glinasti skrilavec, ki delno tvori talnino triadnega dolomita. Ekonomsko najpomembnejša orudenenja so na kontaktu glinastoskrilave krovnine mladopaleozojskega peščenjaka s triadnim dolomitom v obliki leč, ki dosegajo debelino 0,3 do 4 m, horizontalno dolžino 50 do 100 m in širino 50 m. Leče so s kontaktom paleozoik-triada vred nagnjene pod približno 40° proti severovzhodu. Manjše leče barita imajo smer tudi pravokotno na smer večjih.

Barit se, razen v kompaktnih telesih, više pojavlja tudi v samem dolomitu, in sicer kot vezivo v ožjih razpokanih in zdrobljenih dolomitnih conah, redko debelejših od 1 m. Prav tako sega barit v tanjših žilicah v globino, kjer često spremlja galenit v poroznem peščenjaku. Globlje se pojavlja tudi sfalerit. Mejni nivo med zgornjim, baritnim delom rudišča in spodnjim, baritno-galenitno-sfaleritnim delom je približno na višini izvoznega rova Čelo (+320 m).

Kaže, da so rudonosne raztopine prihajale v to območje po prelomih smeri NW—SE. Posebno ugodni pogoji za koncentracijo orudenenj so obstajali na krajih, kjer so raztopine po razpokah naletele na karbonatne kamenine, to je na kontaktu triadnega dolomita in plasti mlajšega paleozoika.

V prejšnjem stoletju so v tem rudišču odkopavali svinčevo rudo. Barit so začeli izkoriščati po prvi svetovni vojni.

Vrhovka. Tu so nekoč izkoriščali svinčevo rudo, ki je poleg barita v podobnem geološkem položaju kot v drugih delih rudišča Pleše.

Dule. Tudi tu so v preteklem stoletju odkopavali svinčevo rudo.

Šmarje pri Grosupljem. Izdanek barita z galenitom po Jelencu (1953). V širši okolici so znani še naslednji sorodni rudni pojavi:

Molnik (Pb, Zn), Podlipoglav (Pb) in Sostro (Pb).

c) Širša okolica Litije

Volčja jama. Stara dela pod Ščitom in Jastrebnikom. Tu je bil rudnik s topilnico. Pri Andrejčku pri mlinu so sledovi starih rovov in žlindre. Omenjajo izdanke svinčeve rude in izdanke barita.

Probsov kamnolom zahodno od Zavrstnika. Ob cesti Zavrstnik—Ljubljana, med Olbanom in Mlavčarjem, so v Probsovem kamnolomu sledovi galenita in barita.

Arhov graben. Ob poti od Potočnika proti Zavrstniku je žila barita z limonitom in goethitom, debela 50 cm. Ob isti poti je izdanek barita ob vznožju pobočja nad kmetijo Arh. Žila je debela 60 cm.

Zavrstnik. To rudišče je pod južnimi obronki hriba Sitarjevec na območju naselja Zavrstnik. Od Sitarjevca je ločeno z nad 300 m široko cono, v kateri doslej nismo našli pomembnejših rudnih pojavov. Osnova rudišča je zgrajena iz mladopaleozojskega kremenovega peščenjaka in konglomerata ter glinastega skrilavca. Na tem območju so jamska dela starega rudnika, ki je nehal obratovati l. 1855 in ga je zalila voda.

L. 1959 sta si po predhodnem izčrpavanju vode in raziskovalnih delih na nivojih +212 m in +185 m ogledala dostopni del rudišča Jože Duhovnik in Franc Drovenik. Obstajajo pa tudi dobre stare jamske karte. Rudišče tvori v glavnem galenitno-sfaleritno-baritna žila s smerjo WNW—ESE in strmim vpadom proti NNE. Debelina te žile, ki vsebuje tudi kremen in kalcit, redko pa še pirit in halkopirit, znaša 10 do 30 cm, povprečno pa 15 cm. Zunanji, sfaleritni deli žil kažejo na največjo relativno starost tega minerala. Proti globini se sfalerit razpršuje, mineralizacija izgublja značaj žile in dobiva obliko impregnacij. Na nekaterih krajih doseže debelina orudene cone z impregnacijami vred tudi do 5 m. Vsebina Pb se z globino zmanjšuje, barit in kalcit pa se izgubljata.

Rudišče je nad nivojem +212 m v glavnem odkopano. S svincem bogati deli so verjetno odkopani tudi niže, do nivoja +193,5 m. Ostala ruda je relativno siromašna s Pb in vsebuje več Zn, po oceni Duhovnika in Drovenika povprečno 0,7 % Pb in 3 % Zn v odkopnih blokih debeline 1 m.

Štriglavec. Med znanimi nahajališči barita v širši okolici Litije so pojavi v dolini potoka Štriglavec med najvzhodnejšimi. Osnovo tega območja tvori mladopaleozojski kremenov peščenjak. Vmes so ponekod tudi plasti temnega glinastega skrilavca.

Na območju Štriglavca je več starih rudarskih del in odvalov. Na nekaterih najdemo kose rude, ki vsebuje sfalerit, galenit in barit. Barit se pojavlja le v severnem delu območja Štriglavca. Velike kose barita najdemo na odvalu rova, zgrajenega v kremenovem peščenjaku na višini približno +350 m desno od potoka. Vmes najdemo tudi galenit in sfalerit. Proti vzhodu spremljamo baritne pojave na severnem pobočju Velike njive, kjer je Ciglar (1962) našel v potokih kose barita z galenitom. Baritna cona se vleče tudi proti zahodu, kjer je izdanek barita severozahodno od Ognjičarja. Ta izdanek so leta 1959 podkopali z rovom. Njegov odval vsebuje kose kremenovega peščenjaka, vmes pa tudi precej barita z galenitnimi impregnacijami.

Hrastarija. Več rovov z baritom in galenitom na odvalih je v jarku Popilovna in ob potoku Hrastarija. Ti pojavi so verjetno podaljški baritno-galenitnih rudnih žil, znanih iz Štriglavca in Pasjeka na vzhodu.

Mamolj, Pasjek. Večina doslej opisanih del in izdankov vzhodno od Litije je razporejenih po severnih pobočjih Mamolja. Sem spadajo dela pod Sv. Janezom, v Štriglavem jarku, Hrastariji in ob zahodnem delu Polšenskega potoka. Pojavi rude na območju zadnjih dveh potokov so često opisani tudi pod imenom Pasjek.

Vrbetov jarek. Med Spodnjim logom in Maljekom je baritni izdanek ob poti v Vrbetovem jarku.

Maljek. Na območju potoka Maljek so sledovi zelo intenzivnega rudarjenja. Rovi so bili usmerjeni iz doline potoka pod hribe Špilj, Gradišče, Srednji hrib in Tri hraste. Ta rudarska dela so sekala in spremljala pretežno svinčeve in cinkove rudne žile.

T o r n q u i s t (1929) je zapisal, da plasti peščenjaka in skrilavca vpadajo proti severu, žile pa imajo smer NW—SE. Rudni pojavi nastopajo približno 1 km od Maljeka. Na tem območju je po T o r n q u i s t u 12 rudnih žil; severnejše so bogatejše kot južnejše. S starimi deli so izkoriščali le sorazmerno plitva območja nad okolnimi dolinami. Globlji deli so verjetno nedotaknjeni. Leta 1930 so 300 m vzhodno od ustja potoka Maljek na višini 8 m nad Savo začeli kopati rov v smeri 165° 30′ z namenom, da podkopljejo vse rudne žile tega rudonosnega pasu do Jablanice. Na 50 m rova so naleteli na 20 cm debelo žilo sfalerita, kmalu nato so prišli do prelomne cone s smerjo 65° in vpadom proti SE. Baritno žilo, debelo 15 cm, so našli v zgornjem, Svetlinovem rovu na drugem križišču. Koščke barita, galenita in sfalerita pa najdemo razen v Hrastovem potoku po vsej poti skozi Bukov graben. Baritna žila, ki prihaja na površino na vrhu hriba Špilje, ima smer SE—NW, vpada proti NE pod kotom 60° in je po P a s t o r j u (1953) debela 80 cm.

Na jezeh. Stari rovi in nasipi z galenitom in baritom na območju vzhodno od Samčeve žage pričajo o intenzivnem rudarjenju v preteklosti. Na grebenu, ki vodi proti SE, nastopa mineralizacija z galenitom in baritom v karbonskem peščenjaku in konglomeratu vzdolž prelomov povečini s smerjo 20 do 30°. Po D u h o v n i k u (1947) znaša debelina rudnih žil, glede na kose v potoku, največ 90 cm. V njih je 2 do 3 %, največ 5 % Pb. Avtor pa ne omenja, ali je v rudnih žilah poleg galenita samo barit ali nastopajo v večjih količinah še drugi minerali.

Zagorica. V Zagorici so stara rudarska dela razporejena na pobočjih štirih dolin: Velika dolina nad Kokolom, Šimenčkova dolina nad Planinškom, Slatenska dolina nad Žago in Ojstermanova dolina nad Jezom. Na odvalih najdemo barit in galenit. Na robu pobočja med Šimenčkovim in Slatenskim potokom je v zrušenem rovu izdanek barita. Obstajajo podatki o 4 rudnih žilah s smerjo 273° do 310° in z vpadi 28° do 80° proti NE. Le ena vpada pod 50° proti SW.

Sitarjevec. Gozdnat hrib Sitarjevec južno od Litije je zgrajen iz mlajšepaleozojskega sljudnatega kremenovega peščenjaka, temnega glinastega skrilavca in bolj redko iz kremenovega konglomerata. Skrilavci in peščenjaki se pogosto pojavljajo izmenoma v tanjših ali debelejših plasteh. Na območju jamskih del Sitarjevca vpadajo plasti generalno proti W pod koti 25° do 45°, rudne žile pa imajo smer NW—SE in vpadajo v glavnem proti NE.

Rudne žile so zapolnitve predrudnih razpok. Postrudna tektonika je intenzivnejša. Izraziti so postrudni prelomi smeri SW—NE. Rudišče je snop več kot 40 rudnih žil in žilic, od katerih pa je le okoli 30 % rentabilnih za odkopavanje. Žile so najčešče nagnjene pod kotom 40° do 50° proti NE; vsebujejo galenit in barit in imajo v sedaj znanih delih do 60 cm $BaSO_4$ in do 10 cm PbS. V prejšnjih časih pa so odkopavali tudi žile debeline nad 2 m, npr. žilo Alma. Če spremljamo parageneze najvidnejših mineralov od zgoraj navzdol, vidimo, da je v zgornjih delih cinabarit, ki običajno spremlja barit, z baritom pa nastopa tudi galenit. Niže se najprej počasi umika barit, nato pa še galenit. Še preden se barit popolnoma umakne, nastopi sfalerit. Njegova koncentracija z globino narašča in preide v telesa, kjer popolnoma prevladuje. Z njim nastopa kremen, ki ga končno v globini zamenja, tako da rudišče preide v jalove kremenove korene.

Večje žile so v Sitarjevcu sledili z rudarskimi deli po vpadu 100 m do 150 m v višinskih intervalih 50 m do 100 m, vendar v teh intervalih v nobeni žili nismo mogli spremljati vsega prehoda od najplitvejših do najglobljih paragenez po podani shemi, ampak smo si lahko sliko o zaporedju paragenez ustvarili po opazovanjih posameznih delov rudnih žil v različnih lokalnostih. Proti jugovzhodu je sistem rudnih žil prekinjen s cono glinastega skrilavca. Sistem orudenelih razpok se ponovno pojavi na jugovzhodni strani te cone.

To so v letu 1962 in 1963 pokazale tri globinske vrtine na območju Dobrave. S temi vrtinami smo presekali na 18 mestih rudne pojave, in sicer v intervalu +235,60 m do +111,00 m; imajo torej višinsko amplitudo 174,60 m in so razporejena na razdalji prek 300 m. Kako daleč sega orudenenje iz opisanega smernega in globinskega intervala, bo treba še ugotoviti z nadaljnjimi raziskavami.

Poleg opisanih nahajališč barita najdemo na istem območju od vzhoda proti zahodu še naslednje sorodne rudne pojave brez barita: Preska (Pb), Polšnik (Pb), Pusti malen (Pb), Grmada (Pb, Zn), Jablanske Laze, (Pb, Zn), Jablanica (Pb, Zn), Tenetiše (Pb), Breg (Pb), Grmača (Pb), Štangarska Poljana (Pb), Kresniški vrh (Pb), Štanga (Pb), Gozd Reka (Pb, Hg), Jevnica (Pb, Zn), Prežganje (Pb) in Andrejevec (Pb).

Ni podatkov o baritu severno od Save v širši okolici Litije, verjetno se tam ne pojavlja.

Zaloge barita v Sloveniji

Razlikujemo dva glavna tipa baritnih orudenenj, in sicer tip Pleše in litijski tip.

Tip Pleše nastopa lečasto in je relativno čist, litijski tip pa ima žilne oblike z manj čistim baritom in s primesmi galenita in drugih mineralov. Litijski tip baritnih teles je bolj razširjen kot tip Pleše in je verjetno zastopan tudi na območju rudišča Pleše v karbonskem peščenjaku. Zato je litijski žilni baritno-galenitni tip rudnih teles za pridobivanje barita bolj pomemben kot tip Pleše.

Nimamo še podatkov o ekonomski vrednosti barita v Karavankah in pod Mangartom. Tudi pomena baritnih nahajališč na območju Št. Janž—Laško—Trbovlje sedaj še ne moremo oceniti. Seveda velja to prav tako za okolico Pleš in Litije, čeprav imamo o tem območju največ podatkov.

Za zdaj smo ocenili zaloge barita le na območje Pleš in Litije; prikazali smo jih na 7. tabeli. Skoraj vse zaloge kategorije A so na starih baritnih odvalih na jugovzhodnem pobočju Sitarjevca, kjer so jih odlagali, ko so odkopavali svinčevo rudo, barita pa še niso izkoriščali. Skupne zaloge barita vseh kategorij znašajo sedaj v Litiji in Plešah 217 000 ton. Ta količina ni tako neznatna, kajti znaša skoraj 8 % zalog sedanjih rudnikov barita v Jugoslaviji. Zanimiva je primerjava slovenskih zalog barita z zalogami proizvajalcev te surovine v Jugoslaviji (8. tabela).

ZALOGE BARITA V PLEŠAH IN LITIJI V ZAČETKU LETA 1964

7. tabela

Ležišče	Kategorija zalog (v tonah)							Stopnja raziskanosti
	A	B	A+B	C_1	$A+B+C_1$	C_2	$A+B+C_1+C_2$	$(A+B):(C_1+C_2)$
Pleše	—	710	710	—	710	16000	16710	0,04
Litija ležišče	1511	2094	3605	16841	20446	50000	70446	0,05
halde	30000	—	30000	—	30000	—	30000	—
Nahajališča v širši okolici Litije	—	—	—	—	—	100000	100000	0,00
Skupaj ležišča	1511	2804	4315	16841	21156	166000	187156	0,02
Skupaj halde	30000	—	30000	—	30000	—	30000	
Ležišča + halde	31511	2804	34315	16841	51156	166000	217000	

Opomba: Zaloge v Plešah ocenil Ciril Janželj.
Zaloge v Litiji ocenil ing. Milan Fabjančič.
Zaloge v širši okolici Litije ocenila ing. Jože Tiringer in ing. Boris Berce v začetku leta 1956. Pri teh zalogah se stanje od 1. 1956 do 1. 1964 ni bistveno spremenilo.

ZALOGE BARITA V JUGOSLAVIJI

8. tabela

Ležišče	Kategorija zalog (ton)							Stopnja raziskanosti
	A	B	A+B	C_1	C_2	C_1+C_2	$A+B+C_1+C_2$	$(A+B):(C_1+C_2)$
Lokve	—	79000	79000	30000	8000	38000	117000	2,08
Ričice	—	90000	90000	91000	—	91000	181000	0,99
Topusko	30000	28000	58000	56000	400000	456000	514000	0,13
Ljubovija	—	300000	300000	150000	150000	300000	600000	1,00
Velika Kladuša	51000	29000	80000	221000	—	221000	301000	0,36
Gornji Vakuf	—	21000	21000	—	100000	100000	121000	0,21
Kreševo	—	375000	375000	—	400000	400000	775000	0,93
Skupaj	81000	922000	1003000	548000	1058000	1606000	2609000	0,62
Slovenija (brez odvalov)	1511	2804	4315	16841	166000	182841	187156	0,02

Kljub znatnim zalogam barita nižjih kategorij v Sloveniji, vidimo po primerjavi stopnje raziskanosti, da so slovenska najdišča barita mnogo slabše raziskana kot je povprečje v Jugoslaviji in da je ta surovina v Sloveniji popolnoma zanemarjena. Zato so potrebna izdatna vlaganja v raziskave rudišč, ki vsebujejo tudi barit, da bi tako ustvarili možnosti za normalno proizvodnjo barita v Sloveniji. To tudi zato, ker je proizvodnja barita v osnovi tehnološko že organizirana v Litiji. Predvsem je potrebno prekategorizirati zaloge C_2 v zaloge višjih kategorij. Čeprav litijski barit ni tako kvaliteten kot barit iz Pleš, za proizvodnjo baritnih cementov vendar ustreza brez flotacijske predelave. Tipični vzorec litijskega barita vsebuje:

$BaSO_4$	90,46 %
SiO_2	5,28 %
$MgCO_3$	2,55 %
$CaCO_3$	1,10 %
$SrSO_4$	0,52 %
Al_2O_3	0,16 %
PbS	0,15 %
Fe	0,08 %
F	0,05 %
	100,35 %

Takšna kemična sestava pa ne ustreza pogojem, ki jih postavljajo glavni porabniki barita pri nas in na zunanjem tržišču. Zato so v Litiji uvedli flotacijsko pridobivanje barita. Na ta način so zboljšali njegovo kakovost. Flotacijsko pridobljen barit je že v začetku proizvodnje vseboval:

$BaSO_4$	95 % do 98 %
SiO_2	3 % do 0,2 %
CaO+MgO	0,5 % do 0,1 %
Pb	0,5 % do 0,1 %
Fe	0,3 % do 0,01 % (povprečno 0,15)
Mn	0,003 %
H_2O	6 % do 8 %

Granulametrijsko sestavo flotacijskega barita kaže 9. tabela.

GRANULAMETRIJSKA SESTAVA FLOTACIJSKEGA BARITA

9. tabela

Frakcija s premerom zrnc (v mikronih)	Utežni odstotek
120 in več	0,0 do 1,3
90 do 120	0,5 do 10,0
60 do 90	4,7 do 16,5
40 do 60	10,5 do 19,0
40 in manj	44,0 do 80,0

Tudi ta barit še nima vseh lastnosti visokokvalitetnega barita, vendar ga je možno z nadaljnjimi postopki zboljšati. V ta namen ga je treba beliti, mleti do granulacije 40 mikronov, pa tudi 15 do 20 mikronov, izžgati flotacijski film, ki obdaja zrnca flotacijsko pridobljenega barita, odstraniti okside železa in druge škodljive primesi ter ga ustrezno pakirati. Te postopke bo treba v Litiji uvajati zaradi rentabilnosti obratovanja, kajti litijski rudnik bo lahko obstajal in proizvajal visokokvalitetni barit le v primeru, če bo proizvajal tudi cenejše barite, uporabne za barijeve cemente in za druge potrebe. Po podatkih o dosedanji proizvodnji svinca v Litiji sklepamo, da mora izkopnina pri sedanjih prodajnih in proizvodnih pogojih za svinec* vsebovati 4,2 % Pb, da bi bilo obratovanje ob izključnem izkoriščanju svinčeve rude rentabilno. Za rentabilno pridobivanje barita brez svinca pa je za cenejše vrste barita potrebna izkopnina s 50 % $BaSO_4$, za dražje pa s 40 % $BaSO_4$. Ti podatki kažejo, da proizvodnja posamezne mineralne surovine v Litiji, pa naj gre za svinec ali barit, pri sedanjih zalogah v jami ne bi bila rentabilna. Tudi če bi poleg svinca proizvajali še nizkokvalitetni barit, ne bi dosegli rentabilnosti. Le skupna proizvodnja svinca in visokokvalitetnega barita bi bila rentabilna; pri tem bi bilo možno proizvajati vzporedno tudi cenejši barit za cementno industrijo.

Po kratkem pregledu o stanju surovinske osnove lahko rečemo, da je iz kompleksne litijske rude možno rentabilno pridobivati barit, ker je med rudnimi zalogami 100 000 ton rudnih odvalov, pri katerih jamski stroški odpadejo. Vendar je osnovna proizvodnja rude v jami; tu pa so rudne zaloge višjih kategorij skoraj izčrpane. Do nedavnega tudi zaloge nižjih kategorij niso bile znane. Z raziskavami geološkega oddelka rudnika Mežica po letu 1963 pa so se zaloge nižjih kategorij povečale. Vendar zaradi pomanjkanja sredstev in težav pri izboljševanju tehnološkega postopka pri proizvodnji raziskovalna dela le počasi napredujejo. Da bi povečali proizvodnjo barita in svinca v Litiji, bi morali predvsem vlagati več sredstev v raziskovalna dela.

Problematika geoloških raziskovanj baritnih nahajališč

Čeprav lahko računamo v Sloveniji še z določenimi zalogami barita brez znatnejših primesi drugih mineralov, je glavni del zalog barita v kompleksnih rudah, ki vsebujejo poleg barita tudi galenit, cinabarit in cinkovo svetlico. Vsi ti minerali dosežejo na posameznih območjih pomembno koncentracijo tudi kot posamezne rudne komponente. Med nahajališči baritno-svinčevo-cinkovih in sorodnih rud v Sloveniji so rudišča, v katerih se pojavlja barit v pomembnejših količinah, v manjšini. Vendar nam izkušnje kažejo, da so rudne žile, ki vsebujejo tudi barit, med vsemi rudnimi pojavi v Posavskih gubah

* Cena 250 000,00 S-din/t rafiniranega svinca, 4000,00 S-din/t rude, 3000,00 S-din stroškov za predelavo 1 t rude v izbiralnici, izkoristek v izbiralnici 90 %, v topilnici 95 %, topilniški stroški 30 000,00 S-din na 1 t koncentrata z vsebino 65 % Pb. Letni obseg proizvodnje 20 000 ton rude.

najbolj stalne in zato najpomembnejše. Zato je smotrno, da damo pri bodočih raziskovalnih delih na tem območju prednost prav galenitno-baritnim orudenenjem v predrudnih, morda ponekod tudi medrudnih razpokah s prevladujočo smerjo NW—SE. Po Tornquistovi teoriji naj bi bila najbogatejša rudna telesa v Posavskih gubah interstratificirane rudne plasti, podobno kot pri Pb-Zn ležiščih v Karavankah. Novejše raziskave pa so pokazale, da gre v Posavskih gubah za diskordantna rudna telesa, kar postavlja raziskovalna dela na bistveno drugačno osnovo. Dokaz za to nam nudijo zlasti opazovanja v Litiji. Osnovni kriterij pri usmerjevanju raziskovalnih del torej ni ožja stratigrafska opredelitev rudonosnega horizonta, ampak predvsem smer predrudne disjunktivne tektonike na območju nekdanjih emanacijskih centrov rudonosnih raztopin.

Kljub temu pa imajo z baritom orudeneli prostori v Posavskih gubah tudi svoje stratigrafske meje. Na Slovenskem ni bil doslej v terciarnih sedimentih najden noben pojav niti baritne rude niti drugih rud z baritnega kompleksa. V triadnih plasteh v Posavskih gubah se pojavljajo svinčevo-cinkove rude (Stranje, Ledina, Mokronog), medtem ko se baritna orudenenja ne oddaljujejo od kontakta mlajši paleozoik-triada v smeri stratigrafsko mlajših plasti. V glavnem pa se telesa svinčevih, cinkovih, bakrovih, antimonovih, živosrebrovih rud in barita pojavljajo v paleozojskih plasteh. To kaže na mladopaleozojsko in delno še starotriadno starost rudotvornih procesov na tem območju. Sklepamo, da je spodnji del werfena zgornja meja kompleksnih rudišč s pomembnejšo koncentracijo barita na območju Posavskih gub.

Razen diskordantnega položaja rudnih žil baritnega kompleksa, kaže na hitrotermalni nastanek še conarna tekstura rudnih žil, pri čemer so vsokotemperaturni minerali (npr. ZnS) koncentrirani ob mejnih površinah in spodnjih delih žil, nizkotemperaturni minerali pa v srednjih in zgornjih delih žil (HgS). Barit in galenit sestavljata zgornje in osrednje dele rudnih žil. Zato je raziskovanje na območju baritnih in baritno-galenitnih izdankov ugodno, ker lahko pod njimi pričakujemo še obsežne dele rudnih žil, ki se raztezajo v globino. Upoštevati pa je treba, da so rudne žile pogosto prekinjene s prelomi, kar otežuje raziskovalno delo in odkopavanje.

Ob nastajanju baritnih ležišč verjetno ni bil povsod prisoten triadni pokrov, ki je, kot kaže, imel s svojimi karbonatnimi plastmi določen vpliv na rudotvorni proces. Kjer so rudonosne hidrotermalne vode dosegle karbonatne kamenine, je prišlo v njih do intenzivnejšega odlaganja $BaSO_4$ ob delnem razvoju metasomatskega procesa. Takšen primer imamo v Plešah. Nadaljnje raziskave bodo morale pokazati, će je to povzročilo dekoncentracijo barita v nižjih paleozojskih klastičnih kameninah, kjer so se v razpokah usedali galenit, sfalerit in drugi minerali. Na območjih, kjer ni bilo triadnega pokrova, je barit v paleozojskih kameninah izdatno zastopan. Do podobnih ugotovitev je namreč prišel tudi Jeremić v Veliki Kladuši in drugod, da se barit pojavlja v glavnem v karbonatnih kameninah in le v primerih, če teh ni, je koncentriran v grobo klastičnih sedimentih. Med bosanskimi paleozojskimi baritnimi ležišči jih je 60 %

v karbonatnih kameninah (apnenec, dolomit, marmor), 30 % v grobo klastičnih sedimentih (peščenjak, konglomerat, breča) in 10 % v glinastem skrilavcu. V Bosni so torej karbonatne kamenine imele pri rudotvornih procesih vlogo koncentratorjev rudnih substanc in zato tam nastopajo relativno bogatejša baritna rudna telesa. Na območju Posavskih gub pa so med mladopaleozojskimi plastmi karbonatne kamenine samo izjemno zastopane. Zato pri nas v paleozoiku ni prišlo do nastanka velikih metasomatskih rudnih teles. Na karbonatne kamenine so baritonosne terme naletele le v spodnjem delu werfena, kjer je obstajal. Zadnja baritna telesa so nastajala v spodnjem delu triade, na kar kaže položaj baritnih leč v Plešah. Zato pozneje ni moglo priti do metasomatskih koncentracij barita v mlajših karbonatnih kameninah. V naših rudnih žilah v paleozojskih plasteh pa so se koncentrirali poleg barita tudi drugi koristni minerali, zlasti galenit in sfalerit, kar povečuje vrednost teh rudišč. Orudenenja v triadnih plasteh, med katerimi ni več barita, so le rudne tvorbe posthumnih triadnih emanacij.

Vprašanje raztezanja baritno-galenitno-sfaleritnih žil v globino za sedaj še ni rešeno. Vsekakor pa lahko pričakujemo, da dosegajo večje globine, kot so običajno smatrali nekateri geologi in rudarji, ki so razpravljali, ali je verjetno, da segajo v Litiji rudna telesa pod savsko obzorje (+248) ali ne.

Danes vemo, da tudi baritna rudna telesa segajo pod današnje najnižje obzorje +192 m, kar govori še za znatne globine baritno-svinčevega, svinčevo-cinkovega in cinkovega globinskega intervala. Z globinsko vrtino št. 5 v Dobravi smo na sledove PbS in $BaSO_4$ naleteli še na nadmorski višini +111 m.

Metoda raziskovanj z globinskim vrtanjem se je pokazala pri raziskovanju kompleksnih rudnih žil v okolici Litije kot zelo uspešna. Dala je hitre in zanesljive rezultate o orudenih območjih. Zato bi jo morali tudi v bodoče uporabljati. Geološke raziskave naj bi bile usmerjene k določanju ožjih orudenih območij za raziskovanje z globinskim vrtanjem. Pri tem delu bi uporabljali tudi pomožne raziskovalne metode geofizike, geokemije in druge. Prednost bi bilo treba dati tistim območjem, v katerih bi mogli zaradi ugodnih pogojev novoodkrite zaloge kmalu odkopavati. Takšni pogoji so predvsem v okolici Litije. S tem bi omogočili, da bi rudnik Litija postopno povečal proizvodnjo barita in svinca, pa tudi cinka.

Pri jamski rudarski eksploataciji so ob zadovoljivih hidrogeoloških pogojih najboljše možnosti za doseganje dobrih ekonomskih rezultatov do globin 300 ali 400 m pod površino (Janković, 1960). Zato je treba raziskave z globinskim vrtanjem omejiti na globino do 300 m. Večji del tega območja je v Posavskih gubah čista celina, v kateri ni bilo še niti raziskav niti eksploatacije, kljub geološkim pogojem za odkrivanje novih, predvsem baritno-svinčevo-cinkovih orudenenj. Zato bi bilo treba vlagati v te raziskave znatna sredstva ob sodelovanju podjetij, ki so zainteresirana za barit ter svinčev in cinkov koncentrat.

ABOUT BARITE OCCURRENCES IN SLOVENIA

This assay gives a survey of barite occurrences in Slovenia and adds them their economic dimension from the aspect of production and uses of barite in technic and industry as well as the turnover of this mineral matter to the world extent. Thus proportions for valuation of the significance of production, domestic consumption and export of Yugoslave barites are created and a statement is made that Yugoslavia is one of the ten greatest world producers of barite.

The author deals with the possibilities of discovering new barite ore reserves in Slovenia. On this area two barite mines, Pleše and Litija have been active. The concentration of $BaSO_4$ in Pleše barite (93 % to 99 %) was higher than in that of Litija (88 % to 95 %) and therefore the quality of the first one is considerably better. By processing and other improving operations also from the Litija lead-zinc-barite complex ores barite products of high grade quality can be gained. On such principles the new introduced production of barite is developing in Litija, which is by now the single active barite mine in Slovenia.

However, the assurance of exploatable barite containing ores becomes a burning question.

In Slovenia the following barite occurences are known: Šancetova ruda, Odanče, Belščica, Počivalnik, Dule, Pleše, Vrhovka, Šmarje, Volčja jama, Probsov kamnolom, Arhov graben, Zavrstnik, Sitarjevec (the mine Litija), Dobrava, Zagorica, Na jezeh, Maljek, Vrbetov jarek, Podčešje, Hrastarija, Mamolj, Pasjek, Štriglavec, Marija Reka, Podkraj, Brezno, Budna vas, Lokavec, and Ples.

Most of these locations are scattered in tectonic unity of Sava folds on the area of the Litija anticline.

There are two main types of barite deposits in Slovenia: the Pleše- and the Litija-type. The significance of the first of them is more or less regular lense form of ore bodies and relative purity of barite substance. The widely prevailing Litija-type appears in the form of veins containing chiefly galena, sphalerite, and barite.

Total reserves of barite in Slovenia amount for the time being to 217 000 tons. The major part of them are complex galena-sphalerite-barite ores. In the lead, zinc, and barite concentrates, which can be produced by mines on the area of Slovene barite deposites, many enterprises are interested. By this proceedings preferance should be given to the exploration works with the purpose of increasing of ore reserves.

In complex ore bodies containing barite, galena, sphalerite, cinnabar, and copper ores, also single of these minerals attain economic concentrations on particular locations, but the veins with presence of barite show the greatest permanence and owing to a usually considerable content of galena they are the most important kind of ore types appearing on the area of Sava folds.

Although barite-galena veins are joined on preore fissures, the spaces containing ore appearances also have their stratigraphic limits. In any

case the upper stratigraphic limit of barite appearances on the area of Sava folds is not removed far from the contact Younger Paleozoic-Triassic in the direction to stratigraphicaly younger strata. This is evident by geological situation of the Pleše barite deposit. In the majority barite-galena deposits appear in Paleozoic strata, accompanied by other mineralisations. They are doubtless of hydrothermal origin and surely of Younger Paleozoic till Lower Triassic age.

During formation of barite deposits the Triassic cover was probably not present in all the parts where they arose. Where it was, the cover had a certain modifying influence on ore-forming processes, owing to its carbonate strata (limestones, dolomits). Where the ore-bearing hydrothermal solutions arrived to carbonate rocks, an intensive deposition of $BaSO_4$ and the simultaneous partial replacement took place. Such a case is observed in Pleše. On the places where Triassic cover was absent during the ore-forming process, barite was deposited in Paleozoic rocks.

In Paleozoic of Sava folds the carbonate rocks occur only exeptionally. For that reason in Slovenia opulent metasomatic barite bodies appear rarely. Instead of this in ore-veins in Paleozoic rocks next to barite particularly galena and sphalerite were concentrated, which increases the walue of these barite deposits.

The problem of continuation of barite-galena-sphalerite veins into the depth has not been solved yet. By the drill-holes in Dobrava near Litija the traces of PbS and $BaSO_4$ were found still on the plus 111 m level.

Future geological explorations should be directed to limiting of ore bearing zones interesting for further exploration by drilling and mining works. By previous drillig in Dobrava good results were obtained. Priority should be given to those locations, where the technical conditions allow prompt beginning of exploitation of new ore reserves. Such conditions are realized in the surroundings of Litija. By explorations on this area the increase of output of barite, lead and zinc in Litija mine should be made possible, while in perspective in the wide region of Sava folds new mining centres for production of these raw materials should be organized. Finally, the exploration as well as the exploitation would not be performed without difficulties, due to contorted ore- bearing strata and interrupted ore veins.

LITERATURA

Dammer, B. in Tietze, O., 1914, Die nutzbare Mineralien, Band II, Stuttgart.

Tornquist, A., 1929, Die Blei- Zinkerzlagerstätte der Savefalten vom Typus Litija, Wien.

Tilli, H. J., 1951, Scraper Assembly Cuts Costs at Open-Pit Barite Mine. Engeneering and Mining Journal, vol. 152, Number 3, New York.

Jelenc, D., 1953, O raziskovanju mineralnih surovin v LR Sloveniji. Geologija, 1. knjiga, Ljubljana.

Johnstone, S. J., 1954, Minerals for the Chemical and Alied Industries, London.

Žebre, S., 1955, Rudarska dejavnost v območju posavskih gub. Rudarsko-metalurški zbornik, št. 4, Ljubljana.
Broniski, A., 1957, Barium- und Strontium- Zemente. Zement — Kalk — Gips, Heft 5, Wiesbaden.
Gomišček, S., 1957, Prispevek k polarografskemu določevanju svinca v baritnih rudah in njih flotacijskih produktih. Rudarsko-metalurški zbornik, št. 2, Ljubljana.
Jurković, I., 1957, Metalogenija Petrove gore u jugozapadnoj Hrvatskoj (Habilitacijona radnja). Geološki vjesnik XI, Zagreb.
Čičić, S., 1957, Geologija ležišta barita na Podkovaču severna Crna Gora. Geološki glasnik, Sarajevo.
Jeremić, M., 1958, Baritska ležišta Jugoslavije i mogućnosti njihovog razvoja. Tehnika br. 3, Beograd.
Onić, D., 1958, Eksploatacija barita na području Lokve—Mrzle vodice. Nemetali 1, Zagreb.
Jeremić, M., 1958, Baritno-fluoritno ležište »Žune« kot Ljubije. Rudarsko-metalurški zbornik, št. 4, Ljubljana.
Peters, W. C., 1958, Economic position of Western Barite Deposits. Mining engineering, vol. 10, No. 9, New York.
Jurković, I., 1958. Pojave barita u Hrvatskoj. Geološki vjesnik XII, Zagreb,
Jakžin, A. A., 1959, Poiski i razvedka mestoroždenij poleznyh iskopaemyh, Moskva.
U. S. Department of the interior, Bureau of mines, Minerals Yearbook 1959.
Jeremić, M., 1960, Intenzitet i ekstenzitet bosanske hidrotermalne baritizacije. Rudarsko-metalurški zbornik, št. 2, Ljubljana.
Jeremić, M., 1960, Baritonosno područje Une i Sane u sjeverozapadnoj Bosni. Tehnika br. 2, Beograd.
Broniski, A. in Ionescu, 1960, Bariumoxydhaltige feuerfeste Tonerdezemente. Zement-Kalk-Gips, Heft 3, Weisbaden.
Janković, S., 1960, Ekonomska geologija, Beograd.
Jurković, I., 1961, Istraživanja rudnih ležišta u N. R. Hrvatskoj. Geološki vjesnik 15, Zagreb.
Broniski, A., 1961, Ähnlichkeiten und Verschiedenheiten der Calcium-, Strontium- und Barium-Zemente. Zement-Kalk-Gips, Heft 1, Wiesbaden.
Jeremić, M., 1962, Pojava barita kod Jerme u Istočnoj Srbiji. Rudarsko-metalurški zbornik, št. 1, Ljubljana.
Jeremić, M., 1962, Mogućnost korišćenja barita iz olovo-cinkanih ležišta Zletovo u Makedoniji. Tehnika, br. 11, Beograd.
Grafenauer, S., 1963, O mineralnih paragenezah Litije in drugih polimetalnih nahajališč v posavskih gubah. Rudarsko-metalurški zbornik, št. 3, Ljubljana.
Jeremić, M., 1963, Koeficient zaobljenosti baritnih valutica kao mjerilo rastojanja od primarnih do predeponovanih baritnih ležišta, Tehnika 5, Beograd.
Jeremić, M., 1963, Metalogenija paleozojskih ležišta barita Bosne. Arhiv za tehnologiju, 1-2, Tuzla.
Arhiv Geološkega zavoda v Ljubljani, rudnika Litija in bivše uprave Posavskih rudnikov svinca in barita v Ljubljani.

RAZVOJ SPODNJEKREDNIH SKLADOV TER MEJA MED JURO IN KREDO V ZAHODNEM DELU TRNOVSKEGA GOZDA

Dragica Turnšek in *Stanko Buser*

Z 1 sliko med tekstom in s 3 tablami slik v prilogi

Uvod

Na podlagi mikropaleontoloških raziskav nam je na Trnovskem gozdu uspelo razčleniti zgornjejurske in spodnjekredne sklade na več horizontov. Zato v tem članku uvajamo v slovensko geološko literaturo nova imena za posamezne geološke stopnje. Da bi poenotili slovensko stratigrafsko nomenklaturo, smo nekoliko spremenili tudi dosedanje nazive posameznih stopenj.

Podobno kot je P a v l o v e c za paleogenske stopnje uvedel izraze z enotnimi končnicami na *ij*, bomo imenovali tudi stopnje jurskih in spodnjekrednih skladov enotno.

V 1. tabeli podajamo imena stopenj za zgornjo juro in spodnjo kredo, za primerjavo pa še angleške, francoske in italijanske izraze.

ZGORNJEJURSKE IN SPODNJEKREDNE STOPNJE
UPPER JURASSIC AND LOWER CRETACEOUS STAGES

1. tabela — Table 1

		Slovensko	Angleško	Francosko	Italijansko
Lower Cretaceous	Spodnja kreda	albij	Albian	albien	albiano
		aptij	Aptian	aptien	aptiano
		barremij	Barremian	barremien	barremiano
		hauterivij	Hauterivian	hauterivien	hauteriviano
		valanginij	Valanginian	valanginien	valanginiano
Upper Jurassic	Zgornja jura	portlandij	Portlandian	portlandien	portlandiano
		kimmeridgij	Kimmeridgian	kimmeridgien	kimmeridgiano
		oxfordij	Oxfordian	oxfordien	oxfordiano

Terenske raziskave

V zadnjih letih smo kartirali območje osnovne geološke karte lista Gorica. Pri kartiranju nam je uspelo rešiti nekatere zanimive probleme, med drugim tudi vprašanje o meji med jurskimi in krednimi plastmi na zahodnem delu Trnovskega gozda.

Jurske in kredne plasti na Trnovskem gozdu so znane že prek sto let. Precej podrobno jih je opisal Stur (1858). Kasnejši raziskovalci, posebno Hauer (1868), Kossmat (1905, 1906 in 1909), Winkler (1924), Stache (1885 in 1920) in Wiontzek (1934) so se držali v glavnem njegovega mišljenja o starosti teh plasti. Na geoloških kartah (Kossmat, 1905 in Stache, 1920) so na območju Trnovskega gozda zgornjejurski skladi razdeljeni na sferaktinijski in koralni apnenec ter nerinejski apnenec titonske stopnje. K spodnji kredi pa je prištet ozek pas ploščastega trnovskega apnenca na zahodnem delu Trnovskega gozda.

Na podlagi mikropaleontoloških raziskav smo dognali, da pripada večji del nerinejskega apnenca, ki so ga doslej prištevali izključno zgornji juri, spodnjemu delu krede, tj. valanginiju in hauteriviju.

Skladi, ki pripadajo vrhnjemu delu malma, tj. zgornjemu kimmeridgiju in portlandiju, se vlečejo v dveh ozkih pasovih vzhodno od Trnovega. Prvi pas poteka od južnega strmega roba Trnovskega gozda prek Krnice in naprej proti severu ter se zaključi ob prelomu južno od vasi Nemci. Drugi pas malmskih plasti poteka južno od vasi Rijavci proti severu in severovzhodno od vasi Voglarji preide na ozemlje sosednje, tolminske karte.

Starost zgornjemalmskih plasti je dokazana predvsem na podlagi mikroflorističnih ostankov. Da bi določili točno starost teh plasti, smo nabrali v vzporednih prečnih profilih precej vzorcev za mikropaleontološke raziskave (1. sl.). V zbruskih apnenca smo našli številne primerke alge *Clypeina jurassica* Favre, ki jasno kažejo, da pripadajo ti skladi zgornjemu malmu. S tem je tudi dokazano, da so koralni in hidrozojski apnenci, ki leže pod skladi z algo *Clypeina jurassica*, starejši. Kossmat (1909, 91) jih je namreč primerjal s titonijskim štramberškim horizontom.

V zgornjem delu zgornjemalmskih plasti se pojavljajo skupaj z algo *Clypeina jurassica* tudi velike tintinine. Debelina tega horizonta znaša 10 metrov. Ponekod postavljajo mejo med zgornjo juro in spodnjo kredo tam, kjer se pojavijo prvi primerki velikih tintinin. Na Trnovskem gozdu smo prišteli horizont, v katerem se pojavljajo *Clypeina jurassica* in tintinine skupaj, še titonu, in mejo med juro in valanginijem postavili tam, kjer alga *Clypeina jurassica* izumre. Upoštevamo namreč ugotovitve in mnenja večine raziskovalcev, da je ta alga vodilna za zgornji del malma in sega do meje jura-kreda. Po našem mnenju so se velike tintinine pojavile že proti koncu portlandija in niso vezane izključno na valanginij. Vsekakor pa je meja med portlandijem in valanginijem na Trnovskem gozdu postopna.

V zgornjem delu zgornjega malma se pojavljajo tudi številne nerineje, po katerih je dobil ime nerinejski apnenec. Pri zadnjih raziskavah se je pokazalo, da segajo nerineje v zahodnem delu Trnovskega gozda še

RAZLAGA TABEL — EXPLANATION OF PLATES

1. tabla — Plate 1

1. Odlomki alge *Clypeina jurassica* Favre, × 10. Zg. kimmeridgij-portlandij, zbrusek št. 3 b.

The fragments of *Clypeina jurassica* Favre, × 10. U. Kimmeridgian-Portlandian, thin section No. 3 b.

2. Odlomki velikih tintinin, × 10, valanginij, zbrusek št. 18 b.

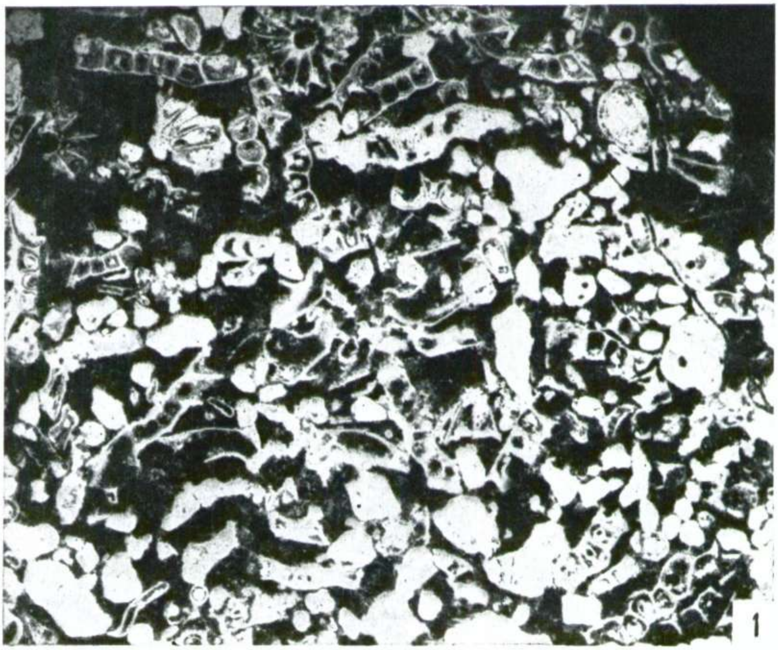
The fragments of large tintinins, × 10, Valanginian, thin section No. 18 b.

2. tabla — Plate 2

1. *Cuneolina laurentii* Sartoni e Crescenti, × 35, aptij (Aptian), zbrusek (thin section) 25 d.
2. *Choffatella* sp., × 35, valanginij (Valanginian), zbrusek 7.
3. *Salpingoporella apenninica* Sartoni e Crescenti, × 35, hauterivij (Hauterivian), zbrusek 22 c.
4. *Favreina salevensis* (Paréjas), × 35, hauterivij (Hauterivian), zbrusek 8 a.
5. *Haplophragmoides* sp., × 35, barremij (Barremian), zbrusek 23 c.
6. *Salpingoporella dinarica* Radoičić, × 35, aptij (Aptian), zbrusek 28 c.
7. *Solenopora* sp., × 35, valanginij (Valanginian), zbrusek 6 c.

3. tabla — Plate 3

1. *Orbitolina* sp., × 19, aptij (Aptian), zbrusek (thin section) 30 b.
2. *Trochamminoides* sp., × 35, barremij (Barremian), zbrusek 23 c.
3. *Bačinella irregularis* Radoičić, × 35, barremij (Barremian), zbrusek 23 b.
4. *Salpingoporella dinarica* Radoičić, *Cuneolina* sp., × 35, aptij (Aptian), zbrusek 28 c.



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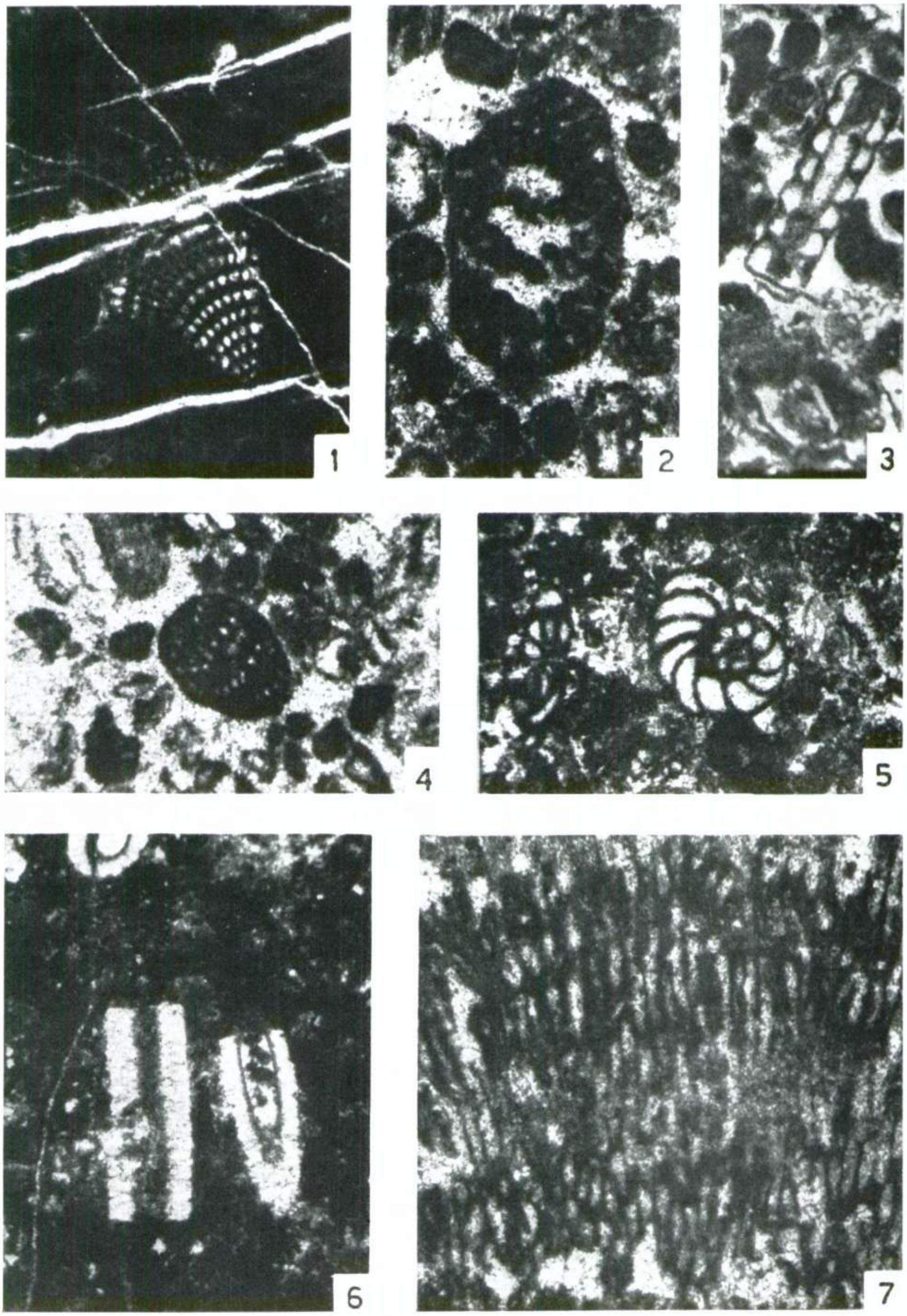
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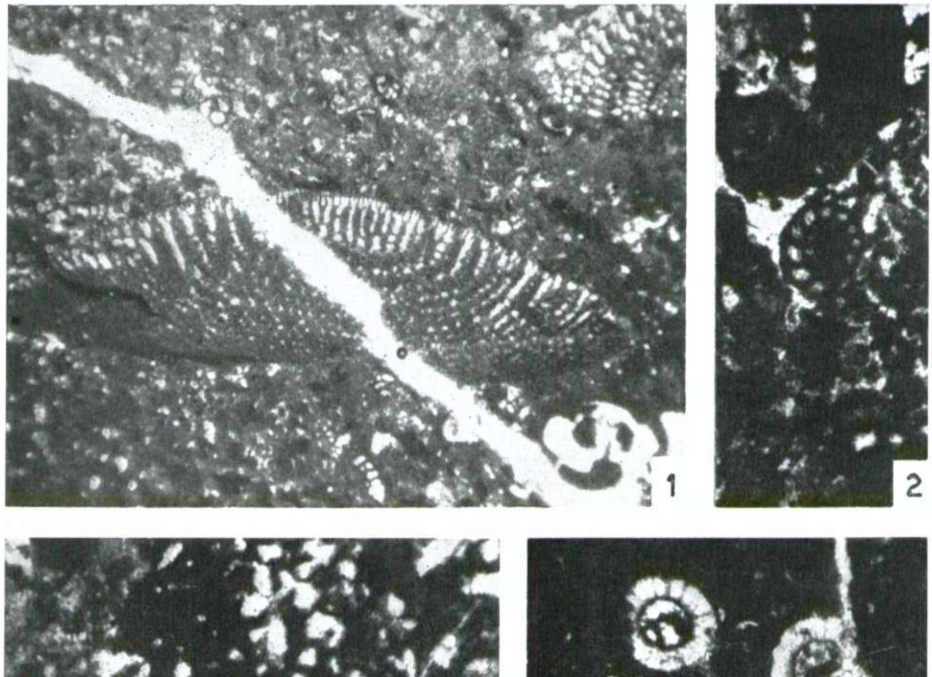
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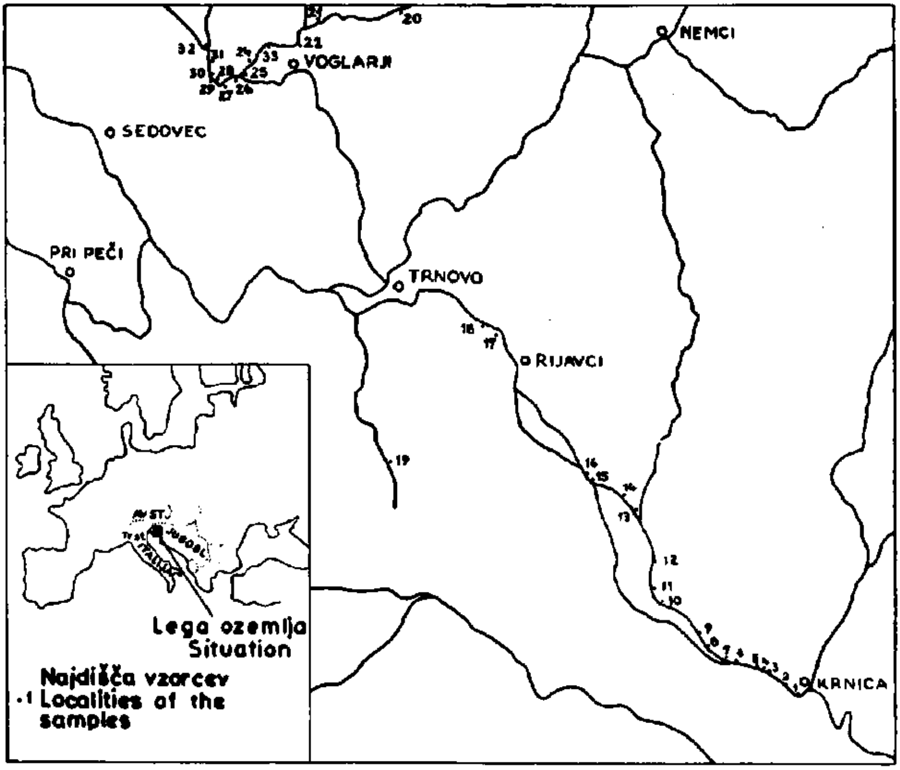


Sl. 1. Najdišča vzorcev apnenca z mikrofosili v zahodnem delu Trnovskega gozda
Fig. 1. Localities of the limestone samples with microfossils taken in the western part of Trnovski gozd

v plasti, ki vsebujejo samo velike tintinine, in že nesporno pripadajo valanginiju. Nerineje paleontološko še niso raziskane.

Zgornji del malmskih plasti je v zahodnem delu Trnovskega gozda razvit kot bel do rjavkasto siv in svetlo rjav gost skladovit apnenec. Med gostim apnencem se pojavljajo pole oolitnega apnenca. V spodnjem delu tega kompleksa leži pri Krnici in v okolici Rijavcev neskladovit bel zrnat dolomit, ki se bočno izklinjuje in zato ponekod sploh ni razvit. *Clypeina jurassica* se pojavlja v gostem in oolitnem apnencu, nerineje pa so številnejše v oolitnem apnencu.

Zanimivo je, da je v vzhodnem delu Trnovskega gozda razvit v zgornjem delu malma bel zrnat dolomit, ki se horizontalno menjava s svetlim apnencem. Prav takšen je razvoj teh plasti na Hrušici ter na Logaški planoti in na Dolenjskem. Apnenec vsebuje klipeine, nikjer pa ne dobimo za zahodni del Trnovskega gozda tako značilnih nerinej. Na Trnovskem gozdu imamo torej dva razvoja zgornjemalmskih skladov, ki se ločita med seboj po litoloških in delno tudi po biostratigrafskih značilnostih.

Ta razlika se ne kaže samo v zgornjemalmskih skladih, ampak v celotnem razvoju jurskih plasti.

Valanginijske plasti so litološko razvite popolnoma enako kot zgornjemalmske. Toda v njih nastopajo velike tintinine brez alge *Clypeina jurassica*, dobimo pa številne druge alge. Celotna združba mikrofavne in mikroflore je vidna v paleontološkem delu iz posameznih profilov.

Plasti hauterivijske stopnje zavzemajo večjo površino kot valanginijski in zgornjemalmski skladi. V njih nastopajo v glavnem iste vrste alg kot v valanginijskih plasteh, toda velikih tintinin ni več. Značilne za hauterivij so zelo pogostne favreine, ki sicer za stratigrafijo niso toliko uporabne. Važno pa je v tej spodnjekredni stopnji njihovo masovno pojavljanje. V hauterivijskih plasteh tudi ni več nerinej, ki so v valanginiju še zelo pogostne. Velike tintinine in nerineje so izginile istočasno.

Hauterivijske plasti so razvite v obliki belega gostega skladovitega apnenca. Le poredko se med gostim apnencem pojavijo do en meter debele pole oolitnega apnenca. Pri Trnovem in Voglarjih je razvit v zgornjem delu hauterivijske stopnje temno siv in črn ploščast apnenec, ki vsebuje gomolje roženca. Ne predstavlja sklenjenega horizonta, temveč se bočno izklinja. Šele ta apnenec, ki so ga prejšnji raziskovalci imenovali trnovski ploščasti apnenec, so prištevali v spodnjo kredo. Celoten kompleks skladov pod tem ploščastim apnencem, tj. ves valanginij in spodnji hauterivij, pa so uvrščali v zgornjo juro.

Barremijskih in aptijskih skladov na terenu nismo ločili, ker so litološko enaki. Zavzemajo precej velik obseg med Trnovim in Podgozdom. Razviti so kot rjavkasto siv do temno siv precej bituminozen apnenec, ki se menjava z gostim belim apnencem. Pri Podgozdu nastopa v zgornjem delu teh skladov temno siv apnenčev skrilavec, ki je precej bituminozen ter vsebuje pole in gomolje roženca. Tudi horizont apnenčevega skrilavca se proti jugu izklini.

Starost barremijsko-aptijskih skladov je določena z makrofavno in mikrofosili. Od makrofosilov vsebujejo *Toucasia* cf. *carinata* Math., *Requienia ammonia* Goldf. in *Nerinea* sp. Zahodno od Voglarjev dobimo tudi kaprinide in radiolite. Nekatere horizonte sestavljajo same zaobljene lupine omenjenih fosilov. Mikrofosili, ki se pojavljajo v teh plasteh, so navedeni v poglavju o mikropaleontoloških raziskavah (5. in 6. tabela).

Albijsko stopnjo smo združili s cenomansko, ker v plasteh teh dveh stopenj nismo našli značilnih fosilov, da bi ju lahko ločili. Plasti teh dveh stopenj se razprostirajo na velikem območju zahodno od Trnovega in Podgozda. Enake plasti so razvite tudi na območju gora Sv. Gabrijel in Skalnica (Sv. gora) ter severnega dela Sabotina, kjer sestavljajo prevrnjeno antiklinalo.

Starost teh plasti smo določili delno po fosilnih ostankih delno pa po njihovem stratigrafskem položaju. V njih se dobe številne lupine rekvienij in nerinej. V zbruskih smo dobili tudi orbitoline. Pri Mrzleku v dolini Soče ter na sedlu med Skalnico in Sv. Gabrijelom so bile najdene fosilne ribe, ki jih je zelo natančno obdelal Gorjanović-Kramberger (1895). V albijskih in cenomanskih plasteh nastopajo pogostni primerki velikih radiolitov.

Albijski in cenomanski skladi so razviti v obliki temno sivega do rjavkasto sivega skladovitega apnenca, ki je navadno precej bituminozen. Ploščast apnenčev skrilavec z ostanki rib nastopa v srednjem delu teh skladov.

Nad cenomanskimi skladi leži konkordantno bel zrnat radiolitni turonski apnenec, ki vsebuje v spodnjem delu zelo značilen in stalen horizont s kaprinidami.

Mikropaleontološki del

Spodnjekredne kamenine so v Sloveniji mikropaleontološko še zelo malo raziskane. Doslej je bil z mikrofavno dokazan le valanginij na nekaterih krajih Dolenjske in Notranjske (Turnšek, 1964). Pleničar (1960) se je pri svojem obsežnem študiju kredne dobe posvetil predvsem zgornji kredi in raziskovanju rudistne favne.

Mikropaleontološke raziskave spodnjekrednih skladov so dale v sosednjih republikah, pa tudi drugod po svetu, že lepe rezultate. Zato smo izdelali na Trnovskem gozdu natančen profil skozi zgornjemalmske in spodnjekredne sklade. Mikropaleontološke analize so omogočile, da smo v spodnji kredi lahko ločili več stratigrafskih stopenj: valanginij, hauterivij, barremij, aptij ter albij. Naše delo je bilo toliko zanimivejše, ker smo rezultate lahko primerjali z razvojem v Dalmaciji, Črni gori in v južnih Apeninih.

Algae

Družina: DIPLOPORIDAE

Rod: *Salpingoporella* Pia 1918

Salpingoporella annulata Carozzi

V najdiščih na Trnovskem gozdu je ta vrsta sorazmerno redka in slabo ohranjena. V zbruskih dobimo le odlomke stebelc. Našli smo jo v zgornjeportlandijskih in spodnjevalanginijskih plasteh v vzorcih 3, 4, 10, 18, 20 in 22.

Salpingoporella apenninica Sartoni e Crescenti

2. tab., 3. sl.

1962, S. *apenninica*, Sartoni e Crescenti, pp. 266—268, Tav. 20, fig. 2, Tav. 23, fig. 1, Tav. 44, fig. 1, 2, 4, 5, 6, 8

Talus ali osrednja cevka je valjast, v prečnem preseku okrogel, z gladko steno. Verticili so pogostni in prekrivajo vso osrednjo cev. Vrsta *S. apenninica* je podobna vrsti *S. annulata*, le manjša je od nje in med posameznimi vretenci ima brazde.

Dimenzije naših primerkov		po Crescentiju
največja dolžina steljke	0,8 mm	1,39 mm
premer osrednje cevi	0,09 do 0,12 mm	0,097 do 0,22 mm
premer steljke	0,25 do 0,30 mm	0,19 do 0,32 mm

Stratigrafska in regionalna razširjenost: Sartoni in Crescenti sta prvič opisala to vrsto iz južnih Apeninov iz okolice Salerna. Plasti s to algo sta imenovala »cona s *Salpingoporella apenninica*«. Dobila sta jo nad horizontom s tintininami, ki sta jih prištela med pteropode in jih po Carozziju imenovala *Vaginella striata*. Cono s *Salpingoporella apenninica* sta uvrstila v zgornji titonij, v spodnji titonij pa cono s *Clypeina jurassica* in *Vaginella striata*. Toda če upoštevamo ugotovitve večine mikropaleontologov, da je *Clypeina jurassica* značilna za ves zgornji malm (= zgornji kimmerdgij in portlandij), in da so velike tintinine značilne za valanginij (Radoičić, 1963), potem je cona s *Salpingoporella apenninica* mlajša od plasti z velikimi tintininami, vsekakor pa mlajša od zgornjega portlandija. Rod *Salpingoporella* se z nekaterimi vrstami res pojavlja v zgornji juri, ne more nam pa rabiti pri razmejevanju jure in krede, ker se iste vrste pojavljajo še v spodnji kredi.

Na Trnovskem gozdu smo dobili vrsto *S. apenninica* skupaj z velikimi tintininami in v plasteh nad njimi, tj. v valanginiju in hauteriviju. V Sloveniji je znana le s Trnovskega gozda, verjetno pa se pojavlja povsod, kjer poznamo podoben razvoj skladov, le da smo jo zaradi izredne podobnosti z vrsto *S. annulata* prezrli ali uvrščali k tej vrsti. Vrsto *S. apenninica* smo dobili v vzorcih 10, 20 in 22.

Salpingoporella dinarica Radoičić
2. tab., 6. sl., 3. tab., 4. sl.

1959, *S. dinarica*, Radoičić, pp. 33, Tab. 3-4
1959, *S. dinarica*, Radoičić, Tab. 8, sl. 2
1960, *S. dinarica*, Radoičić, Tab. 15, sl. 1, 2, tab. 16, sl. 3, tab. 17, sl. 2
1962, *S. dinarica*, Sartoni e Crescenti, pp. 268, Tav. 27-28, Tav. 45, fig. 1-3

Steljka je cilindrična. Osrednja cev je sorazmerno velika. Obdajajo jo majhni gosti izrastki, ki so v dveh sosednjih vretencih razporejeni diagonalno. Naši primerki popolnoma ustrezajo opisom Radoičićeve, samo da so nekateri manjši.

	Dimenzije naših primerkov	po Radoičićevi
premer steljke	0,13 do 0,49 mm	0,24 do 0,56 mm
premer osrednje cevi	0,07 do 0,26 mm	0,128 do 0,40 mm

Razširjenost: Vrsto *S. dinarica* je prvič opisala Radoičićeva (1959) iz okolice Titograda in iz raznih krajev južne Dalmacije. Našla jo je v barremijsko-aptijskih skladih. Danes je ista avtorica mnenja, da je vrsta *S. dinarica* vodilna za aptijsko stopnjo. Italijanska raziskovalca Sartoni in Crescenti sta vrsto *S. dinarica* dobila v zgornjem delu cone s *Cuneolina composaurii* (valanginij—aptij) torej približno v istem horizontu kot v Dalmaciji in v Črni gori. K tej vrsti sta prištela tudi primerek, ki ga je Elliott opisal pod imenom *Hensonella cylindrica* n. gen. n. sp. iz barremijsko-aptijskih plasti v Iraku (Sartoni e Crescenti, 1962).

V Sloveniji smo vrsto *S. dinarica* našli doslej le v vzorcih 28, 30 in 31 s Trnovskega gozda in smo sklade s to algo uvrstili v aptij.

Rod: *Clypeina* Michelin
Clypeina jurassica Favre
1. tab., 1. sl.

Alga *C. jurassica* je bila podrobno opisana že iz raznih krajev Notranjske in Dolenjske (Kerčmar, 1962). Na Trnovskem gozdu jo nahajamo v skladih zgornjekimmeridgijske in portlandijske starosti nad apnenci s hidrozoji. Dobili smo jo v vzorcih 1 do 5 in 17.

? **Tintinnina**
Velike tintinine
1. tab., 2. sl.

Fosilne oblike, ki jih je Favre označil kot organizem »C«, in ki jih je Carozzi pozneje imel za pteropode ter jih imenoval *Vaginella striata* n. sp. (Carozzi, 1954), je **Radoičićeva** uvrstila med ciliata k tintininam (Radoičić, 1959, 1963). Farinacci pa jih je določila za školjke skupine Teredinidae. Vse primerke je dala v eno vrsto *Bankia striata* (Carozzi). Pri tem je opozorila, da reduplikacija, ki se pojavlja pri tem organizmu, pri ciliatih doslej ni znana. Poleg tega je ugotovila, da imajo stene teh fosilnih fragmentov dve plasti, sestavljeni iz sorazmerno velikih nepravilnih kalcitnih kristalov, medtem ko imajo fosilne tintinine mikrokristalne kalcitne stene (Farinacci, 1963).

Od številnih primerkov, ki smo jih opazovali, imajo dvojne stene samo tiste oblike, pri katerih nastopa reduplikacija. Pri številnih enojnih oblikah so tudi stene enojne in pri teh ne moremo govoriti o stenah iz več plasti. Reduplikacija pa je pri školjkah ravno tako posebnost kot pri tintininah. Zato še naprej upoštevamo mišljenje Radoičićeve in problematične oblike uvrščamo k tintininam, dokler njihov sistematski položaj ne bo preučen.

Na Trnovskem gozdu so velike tintinine slabše ohranjene kot v nekaterih najdiščih Dolenjske in Notranjske. Določili smo lahko naslednje vrste:

Campbelliella mileši Radoičić
Campbelliella sp.
Daturellina costata Radoičić
Zetella sp.

Vse te vrste so opisane že iz najdišč na Dolenjskem (Turnšek, 1964), zato jih s Trnovskega gozda omenjamo samo kot novo najdišče.

Velike tintinine tudi na Trnovskem gozdu nastopajo v zgornjem portlandiju skupaj z algo *Clypeina jurassica*, številnejše pa so v valanginiju, kjer jih spremljajo redke salpingoporele. Velike tintinine smo našli v vzorcih 4 in 5, 6 in 7, ter 17. do 20.

Foraminifera

Družina: VERNEUILINIDAE

Verneuilina sp.

Hišica je triserialna, navadno trioglata. V zbruskih dobimo številne preseke, značilne za rod *Verneuilina*. Nekateri primerki so tudi izredno lepo ohranjeni, toda zaradi pomanjkanja literature vrste nismo mogli determinirati.

Različne verneuiline smo našli v hauterivijskih, barremijskih in aptijskih skladih v vzorcih 21, 23, 28 in 29,

Cuneolina laurentii Sartoni e Crescenti

2. tab., 1. sl.

1962, *C. laurentii*, Sartoni e Crescenti, pp. 277-278, Tav. 48. fig. 7-9, tav. 49. fig. 1

V zbruskih dobimo longitudinalne aksialne preseke, ki ustrezajo prvim opisom te vrste. Hišica je koničasta, nekoliko stisnjena. Kamrice se večajo od baze proti vrhu.

Razširjenost: Holotip je opisan iz Monte Alburno v južnih Apeninih. Več primerkov je najdenih še v raznih drugih okoliških krajih. Sartoni in Crescenti ga omenjata v coni s *Cuneolina composaurii* (valanginij-aptij).

Na Trnovskem gozdu nastopa ta vrsta v spodnjem delu aptija skupaj z algo *Salpingoporella dinarica*. Dobili smo jo v zbruskih 25 d in 28 c.

Cuneolina sp.

3. tab., 4. sl.

Nekateri primerki so slabo ohranjeni ali pa je v zbrusku tako slab presek, da vrste ne moremo določiti. Razne oblike kuneolin se pojavljajo v plasteh barremija in aptija skupaj z *Bačinella irregularis* in *Salpingoporella dinarica*. Dobili smo jih v zbruskih 25 d, 28 b, 28 c, 28 d.

Družina: LITUOLIDAE

Haplophragmoides sp.

2. tab., 5. sl.

Hišica je planspiralna. Kamrice in stene so enostavne. Začetna kamrica je majhna, okrogla, okrog nje so v krogu nanizane mlajše kamrice, ki se postopno večajo in podaljšujejo. Spiralna linija se počasi odvija in postane pri mlajših kamricah bolj ravna. Mlajše kamrice so torej podolgovate in ozke. Vseh kamric je navadno 9 do 13 ali 14. Druga kamrica je zelo majhna, tretja in četrta pa sta navadno združeni v eno široko.

Naši primerki so podobni vrsti *H. scitulum*, vendar so kamrice manj involutne. Tudi zavojna linija mlajših kamric je nekoliko bolj ravna kot pri vrsti *H. scitulum*.

Velikost hišice je 0,4 mm do 0,65 mm. Dobili smo jih v plasteh barremija in aptija v zbruskih 23, 28 in 29.

Primerki so zelo lepo ohranjeni. Opisali bi lahko novo vrsto, vendar imamo za foraminifere premalo sodobne literature na voljo.

Trochamminoides sp.
3. tab., 2. sl.

Hišica je okrogla s številnimi kamricami. Vse kamrice so približno enake velikosti in se zelo malo prekrivajo ali pa sploh ne. Zavojna linija je enakomerno okrogla. Zavoji so 3 do 4.

Primerki rodu *Trochamminoides* nastopajo v skladih barremija in aptija skupaj s *Haplophragmoides* sp., *Bačinella* sp. in *Salpingoporella dinarica*.

Zaradi pomanjkanja literature tudi pri teh primerkih nismo mogli določiti vrste.

Družina: ORBITOLINIDAE

Najnovejša študija in revizija orbitolinid je Douglassova razprava iz leta 1960. Med orbitolinide je prištel rodove *Orbitolina, Dictyoconus, Coskinolinoides, Simplorbitolina* in Iraqia.

Orbitolinide so značilne za dobo od barremija do cenomana. Douglass pravi, da so se razvijale iz rodu *Coskinolinoides* prek rodu *Simplorbitolina* in da je za razvoj značilna delitev prekatov oziroma kamric. Za vrsto *Orbitolina discoidea* Gras je mnenja, da je bolj primitivna oblika orbitolin, ker ima zunanje kamrice deljene samo na dva dela.

Orbitolinide iz najdišč na Trnovskem gozdu so različnih oblik. Hišice imajo obliko ozkega ali širokega stožca, z deljenimi majhnimi ali velikimi zunanjimi kamricami. Nekatere oblike so bolj primitivne, druge bolj komplicirane. Zgradba se lepo vidi zlasti na zunanjih kamricah. Starejše so razcepljene navadno na dva dela, pri mlajših pa opazujemo že delitev na tri dele ali na dvakrat po dva dela. Opis vseh primerkov zahteva globljo samostojno študijo in jih bomo podrobneje obdelali mogoče kdaj v bodoče. V tem članku naj navedemo dve najbolj pogostni vrsti: *Orbitolina conoidea* Gras in *Orbitolina discoidea* Gras.

Orbitolina conoidea ima visoko stožčasto hišico. Največja višina hišice je 0,36 do 1,32 mm, največja širina hišice pa 1,35 do 1,88 mm.

Orbitolina discoidea pa ima naslednje dimenzije: največja višina hišice meri 0,79 do 1,12 mm, največja širina hišice pa 2,67 do 4,29 mm.

Orbitoline smo dobili v skladih barremija in aptija v vzorcih 27, 30 in 32 (3. tab., 1. sl.).

Pregledno stratigrafsko razpredelnico orbitolinid sta podala Bassoullet in Moullade (1962) iz barremijsko-aptijskih skladov Sierra du Montsech v Španiji. Rod *Orbitolinopsis* se po njunih ugotovitvah pojavlja v barremiju, *Iraqia* v spodnjem aptiju, *Orbitolina* pa v vsem aptiju. Vidimo torej, da so orbitolinide značilne za dobo od barremija do aptija ali še mlajše. V naših nahajališčih smo jih dobili skupaj z *Bačinella irregularis* in algo *Salpingoporella dinarica*, ki to starost potrjujeta.

Crustacea

Rod: *Favreina* Brönnimann 1955

Favre in Youkovsky sta neke fosilne oblike iz portlandija v Švici imenovala kot organizme »B«. Cuvillier je pozneje podobne oblike našel v spodnji kredi Akvitanije in jih prištel k haracejam. Paréjas je te ostanke spoznal za izločbe nekaterih rakov. Dal jim je ime *Coprolithus*. Za holotip je določil Favrejevo obliko »B« in jo imenoval *Coprolithus salevensis* (po Brönnimannu, 1955).

Brönnimann (1955) je opisal te iste oblike in jim po prvem najditelju dal ime *Favreina*. Za holotip je določil prav tako obliko »B« in jo imenoval *Favreina youkovskyi*. Enako vrsto je našel tudi na Kubi. Takrat še ni vedel, da je Paréjas opisal isto obliko pod drugim imenom.

Brönnimann in Norton (1961) sta ponovno pregledala omenjene fosilne ostanke in ugotovila, da se Paréjas pri svojem opisu novega rodu ni držal vseh nomenklaturnih pravil. Med drugim mu ni določil položaja v sistemu. Zato naziv *Coprolithus* ni veljaven. Omenjena avtorja sta ga ukinila in uveljavila ime *Favreina*. Rod *Favreina* sta uvrstila v Crustacea. Ta naziv upoštevajo danes paleontologi. Edino holotip, ki ga je Brönnimann prvič imenoval *Favreina youkovskyi*, Paréjas pa isto obliko že prej *Coprolithus salevensis*, se preimenuje v *Favreina salevensis* (Paréjas).

Favreina salevensis (Paréjas)

2. tab., 4. sl.

1955, *Favreina youkovskyi*, Brönnimann, pp. 40, Pl. 2, fig. 11, text fig. 5 e—5 n.

1960, *Coprolithus salevensis*, Radoičić, pp. 48, Tab. 7.

1961, *Favreina salevensis*, Brönnimann e Norton, pp. 835—838, fig. 1—3.

To so organski ostanki nepravilne okroglaste ali podolgovate oblike. V podolžnem preseku vidimo v njih ozke paralelne kanale, brez kakršnekoli pravilne razporeditve. V prečnem preseku so ti kanali okrogli.

Doslej je bila ta vrsta najdena v portlandiju v Švici, v zgornji juri Arabije, v spodnji kredi Francije in Kube ter v zgornji juri in spodnji kredi južnih Dinaridov.

V Sloveniji je zelo pogostna. Na Trnovskem gozdu smo jo našli v skladih spodnje krede, v hauteriviju. Bogatejša najdišča so na Notranjskem in Dolenjskem. Nastopa v zgornjejurskih in spodnjekrednih skladih od zgornjega kimmeridgija do konca barremija.

Favreina kurdistanensis Elliott

1962, *F. kurdistanensis*, Elliott, pp. 36, Pl. 3. fig. 1—3, 6.

Primerek je nepravilne oblike. Sosednji kanali so za razliko od vrste *F. salevensis* spojeni. V prečnem preseku ne dobimo posameznih okroglih cevčic, ampak sta po dve navadno spojeni, zato je videti, kot da so cevčice ali kanali v parih.

Elliott je našel to vrsto v plasteh barremija v severnem Iraku. Pri nas na Trnovskem gozdu ni bila najdena, pač pa je zelo pogostna v Loškem potoku na Dolenjskem. Pojavlja se v skladih hauterivijske starosti.

Incerte sedis

Bačinella irregularis Radoičić

3. tab., 3. sl.

1959, *B. irregularis,* Radoičić, pp. 89, Tab. 3. sl. 1-2.
1960, *B. irregularis,* Radoičič, Tab. 17. sl.1.
1962, *B. irregularis,* Sartoni e Crescenti, pp. 271, Tav. 26. fig. 2, Tav. 29.

Radoičićeva (1959) je *B. irregularis* opisala kot organizem, katerega celice so različne velikosti in nepravilne oblike. Razporejene so v skupine ali v neke vrste nepravilnih nizov, ki se med seboj prepletajo. Nov rod je uvrstila k algam z nejasnim sistematskim položajem. Njeno domnevo sta potrdila Sartoni in Crescenti (1962), ki sta enako obliko našla v spodnjekrednih skladih južnih Apeninov. Menita, da gre za posebne vrste apneno algo.

Doslej ne poznamo nobene alge s podobno strukturo, niti pri algah ne moremo govoriti o kakršnih koli celicah, zato je uvrstitev rodu *Bačinella* med alge še nezanesljiva. Nekoliko se nagibamo k mnenju, da pripada posebni skupini hidrozojev, podobno kot *Cladocoropsis.* Različno oblikovane »celice« spominjajo na cenostilne cevi s tabulami. Tudi mikrostruktura skeletnih elementov je podobna hidrozojski. Ponekod zelo jasno vidimo temno osrednjo črto, okoli katere so radialno razvrščena vlakna. Podobne oblike kot je *Bačinella* smo dobili v vzorcih z Nanosa skupaj s hidrozojem *Cladocoropsis,* zato je primerjava toliko bolj verjetna.

Vrsta *Bačinella irregularis* je znana iz raznih krajev južne Dalmacije in Črne gore ter iz okolice Salerna v južni Italiji. Vedno se pojavlja v barremijskih skladih. Pri nas smo jo našli na Trnovskem gozdu pod skladi z algo *Salpingoporella dinarica* in ustreza barremijski stopnji spodnje krede. Dobili smo jo v vzorcih 23 in 27.

Aeolisacus sp.

Za majhne apnene cevčice, na obeh straneh odprte, je Elliott (1958) osnoval nov rod *Aeolisacus* z neznanim sistematskim položajem. Podolžna os je rahlo zakrivljena, stene so nepravilno okrogle. Ta avtor je opisal novo vrsto *Aeolisacus dunningtoni* iz permskih, zgornjetriadnih ter spodnje- in srednjejurskih skladov Bližnjega vzhoda.

Radoičićeva je našla novo vrsto istega rodu v senonskih skladih Dugega otoka. Njena vrsta *Aeolisacus kotori* se razlikuje od vrste *A. dunningtoni* po večji debelini sten.

Na Trnovskem gozdu so podobne oblike v aptijskih skladih skupaj z algo *Salpingoporella dinarica*. Naši primerki so povečini okrogli. Le redki so nekoliko ovalni. Mogoče so to samo prečni preseki daljših cevčic, ali pa le majhne kroglice, ki bi lahko predstavljale novo vrsto rodu *Aeolisacus*. Zaradi prekristaliziranosti in premajhnega števila primerkov nismo mogli določiti vrste.

Stratigrafski del

Italijanska raziskovalca Sartoni in Crescenti (1962) sta na podlagi mikropaleontoloških raziskav razčlenila sklade južnih Apeninov na več con ali horizontov. Imenovala sta jih po najznačilnejših fosilnih vrstah. Njuno razpredelnico za zgornjo juro in spodnjo kredo kaže 2. tabela.

RAZDELITEV SKLADOV NA CONE PO SARTONIJU IN CRESCENTIJU
THE DIVISION OF STRATA AFTER SARTONI AND CRESCENTI

2. tabela — Table 2

aptij—valanginij	cona s *Cuneolina composaurii*
zg. titonij	cona s *Salpingoporella apenninica*
sp. titonij—kimmeridgij	cona s *Clypeina jurassica* in *Vaginella striata*
lusitanij—callovij	cona s *Kurnubia palastiniensis*

Radoičićeva je stratigrafsko razdelilla južne Dinaride. Plasti ni imenovala po mikrofavni, pač pa je na podlagi mikrofavne določila vse stratigrafske člene zgornje jure in spodnje krede. Najznačilnejšo favno, ki jo je dobila v posameznih horizontih, kaže 3. tabela.

STRATIGRAFSKA RAZDELITEV PLASTI PO RADOIČIĆEVI
THE STRATIGRAPHIC DEVISION OF THE STRATA AFTER RADOIČIĆ

3. tabela — Table 3

aptij—barremij	*Salpingoporella dinarica* — *Bačinella irregularis*
hauterivij	brez značilne mikrofavne
valanginij	velike tintinine
infravalanginij	*Clypeina jurassica* in velike tintinine
portlandij—zg. kimmeridgij	*Clypeina jurassica*
sp. kimmeridgij—oxfordij	*Cladocoropsis mirabilis*

Do enakih ali podobnih rezultatov so prišli tudi drugi raziskovalci, vendar omenjamo samo ta dva razvoja, ker sta najpopolnejša, in ker je zanimiva primerjava z našimi nahajališči.

S a r t o n i in C r e s c e n t i sta vso dobo od valanginija do aptija združila v eno samo cono s *Cuneolina composaurii*. Ta foraminifera je najznačilnejša. Poleg nje pa sta navedla še algo *Salpingoporella dinarica, Bačinella irregularis* in druge. Zapovrstnost mikrofavne v južnih Apeninih in v južnih Dinaridih je skoraj enaka. Razlika je le v nekaterih stratigrafskih razmejitvah, zlasti med portlandijem in valanginijem. S a r t o n i in C r e s c e n t i sta postavila mejo jura-kreda glede na mikrofavno mnogo više kot je postavljena v Dinaridih in drugod v Evropi in na Bližnjem vzhodu. Velike tintinine, ki sta jih italijanska avtorja imenovala *Vaginella striata*, sta uvrstila v spodnji titonij. Nista jih ločila od horizonta z algo *Clypeina jurassica*, v naših nahajališčih pa je ta razdelitev izrazita. Še celo cona s *Salpingoporella apenninica*, ki leži nad horizontom z velikimi tintininami, spada po njunem mnenju še v zgornji titonij. Kuneoline, orbitoline, *Salpingoporella dinarica, Bačinella irregularis* in druga mikrofavna, značilna za barremijsko-aptijske sklade, je v južnih Apeninih postavljena v dobo od valanginija do aptija, torej tudi že v najnižji del spodnje krede. Na ta način spodnja kreda v Apeninih sploh ni razčlenjena in je doba valanginija in hauterivija mikropaleontološko zelo pomanjkljivo raziskana.

Na Trnovskem gozdu smo razčlenili sklade na podlagi mikrofavne podobno kot v južnih Dinaridih. Razlika je le v razmejitvi jure in krede.

RAZDELITEV SKLADOV NA TRNOVSKEM GOZDU
THE DIVISION OF STRATA IN TRNOVSKI GOZD

4. tabela — Table 4

aptij	*Salpingoporella dinarica*
barremij	*Bačinella irregularis*
hauterivij	favreine, *Salpingoporella apenninica*
valanginij	velike tintinine
portlandij zg. kimmeridgij	*Clypeina jurassica* in velike tintinine *Clypeina jurassica*
sp. kimmeridgij—oxfordij	hidrozoji, korale, hetetide

Poleg značilnih fosilov, omenjenih v razpredelnici, najdemo v posameznih horizontih še drugo mikrofavno in mikrofloro:

Zgornji malm: *Clypeina jurassica, Salpingoporella annulata*, redke solenopore, *Cayeuxia* sp., redke tekstularije, v zgornjem portlandiju se pojavijo še velike tintinine.

Valanginij: velike tintinine *Campbelliella mileši, Daturellina costata, Zetella* sp. in drugi nedoločljivi odlomki tintinin, *Salpingoporella annulata, S. apenninica*, zelo pogostna je *Cayeuxia* sp. Dobimo še foraminifero *Choffatella* sp., miliolide, tekstularije in solenopore.

Hauterivij: *Favreina salevensis*, redke miliolide, tekstularije in verneuilinide. Redki sta algi *Salpingoporella annulata* in *S. apenninica*.

V hauterivijskem horizontu nismo dobili nobene značilne favne. Določeno oporo nam lahko nudijo vrste rodu *Favreina*. Papeš (1963) je v Livnem ugotovil najštevilnejše favreine v hauteriviju. Tudi na Dolenjskem, zahodno od Loškega potoka, smo dobili najštevilnejše vrste rodu *Favreina* v skladih nad velikimi tintininami in smo jih uvrstili v hauterivij. Mogoče bomo z nadaljnjim raziskovanjem lahko pripisali nekaterim vrstam rodu *Favreina* večji stratigrafski pomen.

Barremij: *Bačinella irregularis, Haplophragmoides* sp. *Trochamminoides* sp., orbitolinide, *Cuneolina* sp., miliolide, tekstularije.

Aptij: *Salpingoporella dinarica, Cuneolina laurentii, Cuneolina* sp., orbitolinide, miliolide.

Stratigrafska razširjenost mikrofosilov je podana na 5. tabeli. Za točno zapovrstnost mikrofosilov po plasteh pa navajamo še mikropaleontološke analize vseh vzorcev iz profila pri Voglarjih (št. 17 do 32) od zgornjeportlandijskih do spodnjealbijskih skladov (6. tabela).

Zaključki

1. Na ozemlju Trnovskega gozda je bila sedimentacija na prehodu iz zgornje jure v spodnjo kredo neprekinjena. V zg. malmu nastopa značilna alga *Clypeina jurassica*. Mejo med juro in kredo postavljamo tam, kjer ta alga izumre.

2. Velike tintinine se pojavijo že v zgornjem portlandiju, najštevilnejše so v valanginiju in konec valanginija skupaj z nerinejami izginejo. Nerineje so zelo pogostne že v zgornjem malmu, nadaljujejo pa se še v spodnjo kredo.

3. Hauterivijske plasti vsebujejo redko mikrofavno. Najznačilnejše so favreine (*F. salevensis*), ki jih spremljajo redke alge iz rodu *Salpingoporella*.

4. Prvi pojavi orbitolinid in kuneolin ter vrsta *Bačinella irregularis* označujejo barremijsko stopnjo spodnje krede.

5. Starost aptijskih skladov je določena z algo *Salpingoporella dinarica*, ki je vodilna za ta horizont in je na Trnovskem gozdu zelo pogostna. Spremljajo jo orbitolinide, kuneoline ter redkejše druge foraminifere.

6. V albijsko-cenomanijskih skladih se pojavljajo rekvienije, nerineje in orbitolinide. Albij in cenomanij se ne razlikujeta niti litološko niti po makrofavni. Mikrofavnistično tega horizonta nismo raziskali.

STRATIGRAFSKA RAZŠIRJENOST MIKROFOSILOV NA TRNOVSKEM GOZDU

STRATIGRAPHICAL DISTRIBUTION OF MICROFOSILS IN TRNOVSKI GOZD

5. tabela — Table 5

	Zg. malm Upp. Malm	Valanginij Valanginian	Hauterivij Hauterivian	Barremij Barremian	Aptij Aptian	Albij Albian
Clypeina jurassica	××××××					
Salpingoporella annulata	×××××	××××××	××××××			
Salpingoporella apenninica		×××××	××××××			
Campbelliella mileši	××××	××××××				
Daturellina costata	××××	××××××				
Zetella sp.	××	××××××				
Verneuilina sp.		×××	××		×××××	
miliolide			×× ××××	×× ××××	×××× ××	×××
tekstularije	×× ×××	×××	××× ×	× × ×	× ×	×
Trochamminoides sp.				×××××	××××××	×
Haplophragmoides sp.				×××××	××××	
Bačinella irregularis				××××××		
Cuneolina sp.				××××	×××××	
Cuneolina laurentii					××××	
Orbitolinidae				×××××	××××××	×××
Salpingoporella dinarica					××××××	
Aeolisacus sp.					××	
Favreina salevensis			×××× ×			

MIKROPALEONTOLOŠKE ANALIZE IZ PROFILA PRI VOGLARJIH
MICROPALAEONTOLOGICAL ANALYSES OF SAMPLES FROM SECTION AT VOGLARJI

6. tabela — Table 6

Stratigr. horizont stratigr. Horizon	Številka vzorca Number of samples	Mikrofavna Microfauna
Albij? Albian?	32	*Orbitolina conoidea*, *O. discoidea*, Miliolidae
	31	*Salpingoporella dinarica*, Miliolidae
Aptij Aptian	30	*Salpingoporella dinarica*, Orbitolinidae, Miliolidae, Textularidae
	29	*Haplophragmoides* sp., *Verneuilina* sp., Miliolidae
	28	*Cuneolina laurentii*, *Salpingoporella dinarica*, *Haplophragmoides* sp., *Trochamminoides* sp., Verneuilinidae, *Aeolisacus* sp.
Barremij Barremian	27	*Bačinella irregularis*, Orbitolinidae
	26	Miliolidae, Textularidae
	25	*Cuneolina laurentii*, Miliolidae
	24	brez mikrofavne — without microfauna
	23	*Bačinella irregularis*, *Haplophragmoides* sp., *Trochamminoides* sp., Orbitolinidae, Verneuilinidae, Miliolidae, Textularidae
Hauterivij Hauterivian	22	*Salpingoporella annulata*, *S. apenninica*, *Favreina* sp., Miliolidae
	21	*Verneuilina* sp., *Textularidae*, Miliolidae
Valanginij Valanginian	20	*Cayeuxia* sp., *Salpingoporella apenninica*, *S. annulata*, *Daturellina costata*
	19	brez mikrofavne — without microfauna
	18	*Campbelliella mileši*,. *Daturellina* sp., *Zetella* sp., *Salpingoporella annulata*
Zg. portlandij Up. Portlandian	17	*Clypeina jurassica*, Tintinnina, *Cayeuxia* sp.
Sp. portlandij Zg. kimmeridgij L. Portlandian U. Kimmeridgian	*Clypeina jurassica*	
Sp. kimmeridgij —oxfordij L. Kimmeridgian —Oxfordian	Hydrozoa, Anthozoa, Chaetetidae	

THE DEVELOPMENT OF THE LOWER CRETACEOUS BEDS AND THE BOUNDARY BETWEEN JURASSIC AND CRETACEOUS FORMATIONS IN THE WESTERN PART OF TRNOVSKI GOZD

The micropalaeontological analyses of samples from several localities of Trnovski gozd (Southwestern Slovenia), have enabled us to distinguish some stratigraphical horizons of the Lower Cretaceous. There have been established: Valanginian, Hauterivian, Barremian, Aptian and Lower Albian. The stratigraphic sequence of Trnovski gozd can be compared with the same horizons in Dalmatia and in Southern Italy. Similar relations occur also in some places of Lowland and Inland Slovenia.

The former investigators distinguished in the Upper Jurassic of Trnovski gozd the sphaeractinian and the coral limestones, and in the uppermost part the nerinean limestone, which was ranged as a whole into the Tithonian stage. The coral and sphaeractinian limestones up to now have been compared with the Štramberk horizon.

On the basis of the micropalaentological evidence the authors succeeded to demonstrate that the greater part of the nerinean limestone, till now placed in the Upper Jurassic, belongs to the Lower Cretaceous, namely to Valanginian and Hauterivian.

The Upper Malmian strata are developed especially well at Krnica east of Trnovo, and near the village Rijavci. These strata occur as white to brownish grey compact and well stratified limestone alternating with brown oölitic limestone.

From the Upper Malmian to Albian strata the following microfossils have been determined:

Algae: *Clypeina jurassica* Favre
Salpingoporella annulata Carozzi
Salpingoporella apenninica Sartoni e Crescenti
Salpingoporella dinarica Radoičić

Foraminifera: *Verneuilina* sp.
Cuneolina laurenti Sartoni e Crescenti
Cuneolina sp.
Haplophragmoides sp.
Trochamminoides sp.
Choffatella sp.
Orbitolinidae
Miliolidae
Textularidae

Tintinninae: *Campbelliella mileši* Radoičić
Campbelliella sp.
Daturellina costata Radoičić
Daturellina sp.
Zetella sp.

Crustacea: *Favreina salevensis* (Paréjas)
Favreina kurdistanensis Elliott
Favreina sp.

Incertae sedis: *Bačinella irregularis* Radoičić
Aeolisacus sp.

Clypeina jurassica Favre is well exposed in the area of Trnovski gozd, but the beds of this leading alga are in some localities thinner in comparison with finding places of Notranjska and Dolenjska.

Salpingoporella apenninica Sartoni e Crescenti. This alga is similar to *S. annulata,* but it is smaller and has among particular verticils the furrows which are easily seen. *S. apenninica* was found by Sartoni and Crescenti (1960) in the "Cone with *S. apenninica*", and allocated to the Upper Tithonian in South Appennins. It lies above the horizon with Large Tintinninae, which are characteristic for Valanginian, therefore we suppose that "cone with *S. apenninica*" is younger than Valanginian, and anyhow younger than the Upper Portlandian. In our country alga *S. apenninica* has been found together with Large Tintinninae in Valanginian and together with favreins in Hauterivian beds.

Salpingoporella dinarica Radoičić has been described for the first time in Slovenia. It is abundant in the Aptian horizon and is one of the leading fossil of this period. Our specimens correspond with the description of Radoičić, but some of them are smaller than up to this time known forms. The measurements of alga *S. dinarica* from Trnovski gozd are as follow:

		after Radoičić:
diameter of alga	0,13—0,49 mm	(0,24—0,56 mm)
diameter of axial tube	0,07—0,26 mm	(0,128—0,400 mm)

At the first time Radoičić allocated *Salpingoporella dinarica* and *Bačinella irregularis* to one horizon of the Barremian-Aptian age. They were also ranged in the same period by Italian investigators Sartoni and Crescenti, and by Elliott, who described *S. dinarica* as *Hensonella cylindrica* from Iraq (Sartoni e Crescenti, 1962). Now-a-days predominates the opinion that *S. dinarica* belongs to the upper part of the Barremian-Aptian strata; consequently *S. dinarica* is characteristical for the Aptian horizon.

? Large Tintinninae. The fossil forms which were denoted by Favre as organism "C", and later Carozzi determined them for pteropods and named them *Vaginella striata* (Carozzi, 1954), Radoičić allocated to Ciliata to the group of Tintinnina, and erected new independent genera with many species. (Radoičić, 1959, 1963). Farinacci has all the above mentioned fossils combined into one species *Bankia striata* (Carozzi), and allocated them to the Lamellibranchiata of the family Teredinidae. The same author says that the reduplication, which appears at this organism, is so far not known at Ciliata.

Besides she points out that the wall of well preserved examples consists of a thin internal layer and an external one (Farinacci, 1963).

We have examined a lot of material and discovered the "double walls" only at reduplicated specimens. The reduplication is, however, particularity so for the mussels as for the tintinnins. We appreciate the opinion and the statements of Radoičić, and place the problematic fossils among the Tintinninae, until their systematical position is not finally solved.

On the territory of Trnovski gozd the Large Tintinninae are not so good preserved as in some localities of Lowland Slovenia. All the species, we have established (*Campbelliella mileši, Daturellina costata, Zetella* sp.) were already described in our country (Turnšek, 1964). According to that we mention them only as a new finding place in Trnovski gozd.

The Large Tintinninae appear already in the Upper Portlandian together with *Clypeina jurassica,* but there are more numerous in Valanginian beds, where they appear like stonebuilders.

Foraminifera. The various forms of miliolids, textularids, and verneuilinids occur in all the layers from the Upper Jurassic to Albian. Their existence is not of considerable importance for the stratigraphy of the Lower Cretaceaous beds. There have been found *Cuneolina laurentii* Sartoni e Crescenti, *Haplophragmoides* sp., *Trochamminoides* sp. and Orbitolinidae.

Favreinae. The rests of favreins are rarely found in Trnovski gozd. Only one species *F. salevensis* (Paréjas) has been determined. It occurs in the beds of the Hauterivian age.

Bačinella irregularis Radoičić. Radoičić (1959) has the new genus *Bačinella* described as fossil organism, which is consisted of cells of different size and irregular forms. These are arranged into the groups or series, which are irregularly interlaced. Genus has been allocated to Algae, its systematic position has not been obvious. Sartoni and Crescenti have found *Bačinella* in the beds of Lower Cretaceous in South Appennins, and they suppose to deal with a special form of calcareous Algae.

So far we do not know any alga with similar structure. The tubes at solenopors are parallel. We consider, that *Bačinella* belongs to the special group of hydrozoans, like *Cladocoropsis*. Different forms of "cells" with partings in *Bačinella* remind us of coenosteal tubes and interspaces with tabulae in hydrozoans. Also the microstructure of skeletal elements in *Bačinella* resembles to that of hydrozoans. In some elements of *Bačinella* we can obviously notice the medial dark line with radial fibrous.

In the area of Trnovski gozd *Bačinella* has been found under the strata with *Salpingoporella dinarica,* and corresponds to the Barremian stage of the Lower Cretaceous.

Conclusions

The micropalaeontological analyses of samples from Trnovski gozd show the following results:

1. Sedimentation from the Upper Jurassic to Lower Cretaceous evolved uninterruptedly. The boundary between the Portlandian and the Valanginian is erected there, where *Clypeina jurassica* became extinct.

2. The Large Tintinninae appear already in the Upper Portlandian, more frequent they are in the Valanginian. At the end of Valanginian the Large Tintinninae together with Nerineae became extinct.

3. The Hauterivian strata seldom contain microfauna. The most common are favreins (*Favreina salevensis*), accompanied by rare *Salpingoporella annulata* and *S. apenninica*.

4. *Bačinella irregularis* and the first appearance of cuneolins and orbitolinids characterize the Barremian stage of the Lower Cretaceous.

5. The age of Aptian beds is determined by the alga *Salpingoporella dinarica* which is often found on Trnovski gozd.

6. The strata with *Salpingoporella dinarica* are overlain by the Albian-Cenomanian beds, containing the fragments of Requieniae, and Radiolites together with Orbitolinidae.

A precise succession of microfauna in Upper Malmian and Lower Cretaceous and the division on the individual stratigraphic horizons is given in the Slovenian texte on the tables 5 and 6.

LITERATURA

Bassoullet, J. P. & Moullade, M., 1962, Les Orbitolinidae du çrétacé inférieur de la Sierra du Montsech, Province de Lerida (Espagne). Rev. Micropaléont., 5, 2; 104—114, Paris.

Bronnimann, P., 1955, Microfossils incertae sedis from the Upper Jurassic and Lower Cretaceous of Cuba. Micropaleontology, 1, 1; 28—51, New York.

Brönnimann, P. & Norton P., 1960, On the classification of fossil fecal pellets and description of new forms from Cuba, Guatemala and Libya. Eclogae Geol. Helv., 53, 2; 832—842, Basel.

Buser, S., 1961, Geološke razmere na Hrušici, Nanosu in vzhodnem delu Trnovskega gozda. Manuskript, Geološki zavod, Ljubljana.

Buser, S., 1962, Geološke razmere na Trnovskem gozdu in Vipavski dolini. Manuskript, Geološki zavod, Ljubljana.

Buser, S., 1962, Razvoj jurskih slojev v slovenskem Dinarskem gorovju. Report of 5. Meeting Geol. Yugoslavia, 163—167, Beograd.

Buser, S., 1963, Razvoj jurskih skladov v slovenskih Dinaridih (Trnovski gozd, Nanos, Snežnik) .Manuskript, Geološki zavod, Ljubljana.

Buser, S., 1964, Tolmač k osnovni geološki karti SFRJ lista Gorica in Palmanova 1 : 100.000. Manuskript, Geološki zavod, Ljubljana.

Cushmann, J., 1955, Foraminifera. Their Classification and Economic Use. Lituolidae. 4. Edition. pp. 99—112, Pl. 10. Cambridge.

Čanović, M., 1959, Neki mikropaleontološki podaci za izdvajanje sedimenata donje krede na terenu Trebinje (Hercegovina). Geol. glasnik, 3, 23—27, Tab. 1-2, Titograd.

Čanović, M., 1959, Prilog mikropaleontološkom proučavanju sedimenata gornje jure na graničnom terenu Crne gore, Hercegovine i dubrovačkog Primorja. Geol. glasnik, 3, 71—78, Tab. 10—13, Titograd.

Douglass, R. C., 1960, Revision of the family Orbitolinidae. Micropaleontology, 6, 3; 249—264, Pl. 1, New York.

Elliott, G. F., 1962, More microproblematica from the Middle East. Micropaleontology, 8, 1; 29—44, Pl. 1—6, New York.

Farinacci, A., 1963, L'«Organismo C» Favre 1927 appartiene alle Teredinidae. Geologica Romana, 2, 151—178, Tav. 1—5, Roma.

Gorjanović-Kramberger, C., 1895, Fosilne ribe Komena, Mrzleka, Hvara i M. Libanona Jugosl. akad. znanosti i umjetnosti. Zagreb.

Hauer, F., 1868, Geologische Übersichtskarte der österreichischen Monarchie, Blatt VI, Oestliche Alpenländer. Jahrb. k. k. geol. R. A., Wien.

Kerčmar, D., 1962, Prve najdbe zgornjejurskih apnenih alg v Sloveniji. Geologija, 7, 9—24, Tab. 1—4, Ljubljana.

Kossmat, F., 1905, Erläuterungen zur geologischen Karte der Österr.-ungar. Monarchie, SW Gruppe, Nr. 98, Haidenschaft und Adelsberg. Wien.

Kossmat, C., 1906, Das Gebiet zwischen dem Karst und dem Zuge der Julischen Alpen. Jahrb. k. k. geol. R. A., Wien.

Kossmat, C., 1909, Der küstenländische Hochkarst und seine tektonische Stellung. Verh. geol. R. A., Wien.

Kossmat, F., 1910, Erläuterungen zur geol. Karte SW Gruppe, Nr. 91, Bischoflack und Idria. Wien.

Maync, W., 1960, Biocaractères et analyse morphométrique des espèces jurassiques du genre. Pseudocyclammina (Foraminifère). II. Pseudocyclammina jaccardi (Schrodt). Rev. Micropoléont., 3, 2; 103—118, Paris.

Moullade, M., 1960, Les Orbitolinidae des microfaciès barrémiens de la Drôme. Rev. Micropaléont., 3, 3; 188—198, Pl. 1—2, Paris.

Papeš, J., 1963, O razvoju i mogućnosti raščlanjivanja donje krede u području Livna. Geol. glasnik, 7, 33—38, Sarajevo.

Pleničar, M., 1960, Stratigrafski razvoj krednih plasti na južnem Primorskem in Notranjskem. Geologija, 6, 22—145, Ljubljana.

Pleničar, M., 1963, Tolmač k osnovni geološki karti FLRJ, list Postojna. Manuskript, Geološki zavod, Ljubljana.

Pokorný, V., 1958, Grundzüge der zoologischen Micropaläontologie. Lituolidae, pp. 186—189, Berlin.

Radoičić, R., 1959, Salpingoporella dinarica nov. spec. u donjokrednim sedimentima Dinarida. Geol. glasnik, 3, 33—42, Tab. 3—5, Titograd.

Radoičić, R., 1959, Paleontološke odlike sedimenata okoline Bačinskog jezera (Gradac—Ploče). Geol. glasnik, 3, 55—63, Tab. 7—9, Titograd.

Radoičić, R., 1959, Krupne tintinine Campbelliella nov. gen. i Daturellina nov. gen. Vestnik Zavoda za geol. i geofiz. istraž. Srbije, 17, 79—86, Tab. 1—2, Beograd.

Radoičić, R., 1959, Nekoliko problematičkih mikrofosila iz dinarske krede. Vesnik Zavoda za geol. i geofiz. istraž. Srbije, 17, 87—92, Tab. 1—2, Beograd.

Radoičić, R., 1960, Mikrofacije krede i starijeg tercijara spoljnih Dinarida Jugoslavije. Paleontologija Jugosl. Dinarida. Ser. A, Mikropaleontologija, 4, 1; Titograd.

Radoičić, R., 1962, Paleoekologija i biostratigrafija aberantnih tintinina Jugoslavije. Doktorska disertacija, manuskript, Beograd in Ljubljana.

Sartoni, S. & Crescenti U., 1962, Ricerche biostratigrafiche nel Mesozoico dell'Appennino meridionale. Giornale di Geologia. Ann. Mus. Geol. Bologna, Ser. 2, Vol. 29 (1960—1961), 161—304, Tav. 11—42, Bologna.

Stache, G., 1889, Die Liburnische Stufe und deren Grenz-Horizonte. Abh. geol. R. A., Wien.

S t u r , D., 1858, Das Isonzo-Thal von Flitsch abwärts bis Görz, die Umgebungen von Wippach, Adelsberg, Planina und Wochein. Jahrb. k. k. geol. R. A., Wien.

T u r n š e k , D., 1965, Velike tintinine iz titonskih in valangijskih skladov severozahodne Dolenjske. Geologija 8, 102 do 112, Ljubljana.

V e t t e r s , H., 1947, Erläuterungen zur geologischen Karte der Republik Österreich und seinen Nachbargebieten. Wien.

W i n k l e r , A., 1924, Ueber den Bau der östlichen Südalpen. Mitt. Geol. Ges., Wien.

W i o n t z e k , H., 1934, Rudisten aus der oberen Kreide des mittleren Isonzogebietes. Palaeontographica, Stuttgart.

HIPERSTENOV ANDEZIT PRI SV. ROKU OB SOTLI

Ernest Faninger

Z 1 sliko med tekstom

V terciarju je bilo na Slovenskem močno vulkansko delovanje. Večina izbruhov je bila v spodnjem miocenu, vendar pa se je vulkanizem ponekod pojavil že v oligocenu (Hamrla, 1955). Terciarni vulkanizem se je končal v pliocenu z izlivi bazaltne lave; sledove te zadnje faze najdemo le v skrajnem severovzhodnem delu Slovenije.

Za oligocensko-miocenski vulkanizem na slovenskem ozemlju so značilni predvsem andeziti in daciti ter njihovi grohi. Andeziti so povečini avgitni, redkeje hiperstenovi, daciti pa rogovačni ali biotitni, oziroma hloritni, kadar hlorit nadomešča biotit. Avgitni andezit je razširjen predvsem okoli Šaleške doline; najdemo ga na Smrekovcu, pri Belih vodah in drugod. Kot nahajališče hiperstenovega andezita navaja Teller (1898) Št. Ilj pri Dramljah. Daciti so v zahodnem delu Pohorja ter v bližnji dolini reke Drave in v Šaleški dolini.

Andezite na Slovenskem omenjajo številni avtorji v geoloških (Teller, 1898) in petrografskih razpravah (Graber, 1929), njihovega popolnega petrografskega opisa pa doslej še ni nihče objavil.

V našem članku bomo obdelali le predornino od Sv. Roka ob Sotli, ki jo je Hatle (1881) označil kot avgitni andezit in kasneje še Dreger (1920) kot roženast trahit.

Temno siva do črna predornina pri Sv. Roku ob Sotli je spodnje miocenske starosti in kaže porfirsko strukturo. Njene glavne sestavine so vtrošniki plagioklazov (12 vol. %) in rombičnih piroksenov (5 vol. %), ostalo, razen drobnih zrnc magnetita, pripada temni amorfni osnovi, ki pa ima tudi tanjše svetlejše pasove.

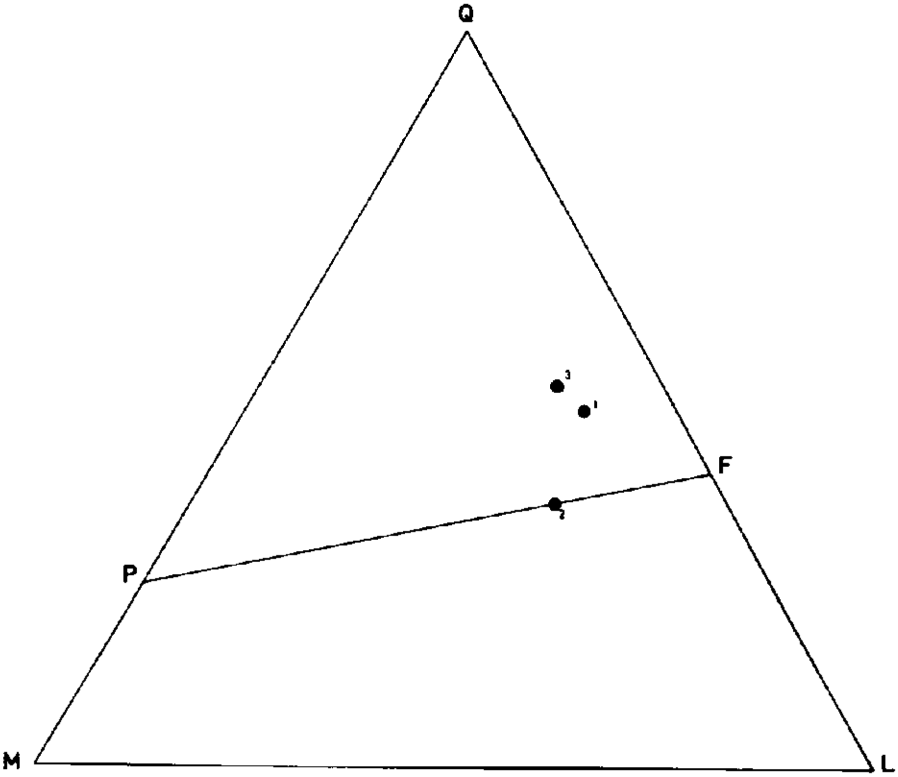
Plagioklazovi vtrošniki ustrezajo po optičnih lastnostih visokotemperaturnim modifikacijam. Njihova sestava niha med 60 % in 71 % an — srednja vrednost sedmih meritev ustreza labradoritu s 65 % anortitne komponente (Zavarickij, 1958). Pri rombičnih piroksenih pa opazimo nihanje kota optičnih osi med -53^0 in -63^0; kot srednjo vrednost pri štirih meritvah dobimo $2V = -59^0$, kar ustreza hiperstenu s 37 % ferosilitne komponente (Tröger, 1956).

Kamenino pri Sv. Roku ob Sotli moramo torej po njeni modalni sestavi, strukturi in starosti imenovati andezit, točneje hiperstenov labradoritov andezit.

Oglejmo si še kemično sestavo kamenine in klasifikacijo na kemični podlagi; analizo in ustrezne magmatske parametre vidimo v 1. tabeli.

Za predornino pri Sv. Roku ob Sotli je predvsem značilna visoka količina proste kremenice v normativni sestavi; zato se tudi Nigglijevi parametri ujemajo z normalno kremenovo dioritsko magmo in ne z dioritsko, kot bi pričakovali glede na njeno modalno sestavo, ki nima kremena v vtrošnikih. Toda visoka količina proste kremenice v normativni sestavi nam da slutiti, da je tudi kremen bistvena sestavina amorfne osnove. Rombični pirokseni v modalni sestavi so v popolnem soglasju z normativno sestavo, saj je pri njej wolastonitna komponenta tako majhna, da je ni treba upoštevati in tako pripadajo tudi v normativni sestavi praktično vsi pirokseni rombični vrsti.

Naša kamenina ustreza torej po Nigglijevih parametrih normalnemu kremenovemu dioritskemu tipu magme in ne dioritskemu (Burri,



Sl. 1. — Abb. 1

Primerjava magmatske kamenine od Sv. Roka ob Sotli z andezitom in dacitom
Vergleich des Eruptivgesteines von V. Rok ob Sotli mit Andesit und Dacit

Označba Bezeichnung	Kamenina Gestein	Q	L	M
1	Andezit od Sv. Roka ob Sotli	49,2	39,7	11,1
2	Andezit (Tröger, 1935)	35,8	43,3	20,9
3	Dacit (Tröger, 1935)	52,0	35,5	12,5

1959), kot bi pri andezitih v splošnem pričakovali. Zato nastane vprašanje, ali smo s kemičnega vidika sploh upravičeni, da imenujemo našo kamenino andezit. Tudi primerjava vrednosti QLM (Burri, 1959) s tipičnim andezitom in dacitom, ki ju navaja Tröger (1935), nam pokaže, da zavzema sicer naš vzorec neko vmesno lego med obema kameninama, vendar je njegova projekcijska točka mnogo bliže dacitu kot andezitu (1. slika). Tudi primerjava istih kamenin s pomočjo parametrov Zavarickega nam pove, da se po kemičnih lastnostih naša kamenina mnogo bolj približuje dacitu kot andezitu, saj je vrednost *d* proti dacitu 3,1, proti andezitu pa 9,5 (Sawarizki, 1954). Po kemičnih lastnostih gre torej prej za dacit kot za andezit. Toda za klasifikacijo magmatskih kamenin je merodajnejša modalna sestava, ki kaže, da je naš vzorec tipični andezit. Kemična sestava pa nam je le važno dopolnilo, ki kaže, da je predornina od Sv. Roka bolj kisla, kot bi pri andezitih pričakovali.

HYPERSTHENANDESIT BEI SV. ROK OB SOTLI

Im Terziär hat es in Slowenien eine starke vulkanische Tätigkeit gegeben. Der größte Teil der Ergüsse fand im unteren Miozän stat, doch es gibt auch Anzeichen dafür, daß einzelne Ausbrüche schon im Oligozän statgefunden haben (Hamrla, 1955). Die terziäre vulkanische Tätigkeit fand im Pliozän mit Basaltergüssen ihren Abschluß, doch ist diese letzte Phase nur an das äußerste nordöstliche Gebiet Sloweniens beschränkt.

Die Spuren des oligozän-miozänen Vulkanismus sind in Slowenien sehr häufig. Es handelt sich vorwiegend um Andesite und Dacite, die häufig von Tuffen begleitet werden. Bei den Andesiten unterscheidet man Augit- und Hypersthenandesite, bei den Daciten treten aber als femische Einsprenglinge gewöhnlich Hornblende und Biotit bzw. Chlorit auf.

Die Aufgabe unserer Abhandlung ist die petrographische Beschreibung des aus unterem Miozän stammenden Ergußgesteines, das bei Sv. Rok ob Sotli — einer Ortschaft östlich von Rogatec — auftrit. Das Gestein wurde erstmals von Hatle (1881) als Augit-Andesit beschrieben und später von Dreger (1920) als Hornfelstrachyt bezeichnet.

Das dunkle Ergußgestein von Sv. Rok ob Sotli weist eine porphyrische Struktur auf. Als Einsprenglinge treten Plagioklase (12 Vol. %) und rhombische Pyroxene (5 Vol. %) auf, den Rest, außer überall im Gestein auftretenden winzigen Magnetitkörnchen, bildet eine dunkle Grundmasse, die auch schmälere lichtere Bänder aufweist.

Die Plagioklaseinsprenglinge entsprechen der optischen Eigenschaften nach den Hochtemperaturformen (Zavarickij, 1958). Ihre Zusammensetzung schwankt zwischen 60 % und 71 % An — der Mittelwert von sieben Messungen weist einen Gehalt von 65 % An auf und entspricht sonach einem Labradorit. Bei den rhombischen Pyroxenen aber schwankt der Winkel der optischen Achsen zwischen —53° und —63° — und der Mittelwert von vier Messungen ergab 2 V = —59°; auf Grund dessen entscprechen die rhombischen Pyroxenen einem Hypersthen mit 37 %

Ferosilitkomponente. Der mineralogischen Zusammensetzung, Struktur und Alters nach muß das Gestein von Sv. Rok ob Sotli als Andesit, genauer gesagt als Hypersthenlabradoritandesit, klassifiziert werden.

Die chemische Zusammensetzung ist in der Tabelle 1 ersichtlich. Es ist zunächst darin eine für die Andesite ungewöhnlich große frei Quarzmenge auffallend. Auch die Niggli-Werte entsprechen nicht einem dioritischen sondern einem normalen quarzdioritischen Magma (B u r r i, 1959), obwohl man bei den Andesiten in allgemeinen ein dioritisches Magma erwarten sollte. Auch der Vergleich der QLM-Werte mit einem typischen Andesit und Dacit, die von T r ö g e r (1935) angegeben werden, zeigt uns, daß das Gestein von Sv. Rok ob Sotli zwar eine Zwischenstellung zwischen beiden Gesteinstypen einnimmt, doch es kommt an der Zeichnung (Abb. 1) viel näher an den Dacit als an den Andesit zu liegen. Auch der Vergleich des Chemismus derselben Gesteinen mittels der Zavarickij-Parameter (S a w a r i z k i, 1954) zeigt uns eine viel größere Annäherung an den Dacit als an den Andesit, denn *d* gegenüber Dacit hat den Wert 3,1, gegenüber Andesit aber 9,5. Nach der chemischen Zusammensetzung müßte das Gestein von Sv. Rok ob Sotli eher Dacit als Andesit angesprochen werden. Doch weil für die Klassification der Eruptivgesteinen die modale Zusammensetzung maßgebender ist, und nach dieser wird unser Gestein als Andesit betrachtet, muß dieser Name beibehalten werden. Doch die chemische Zusammensetzung gibt uns Auskunft, daß das Gestein von Sv. Rok ob Sotli saurer ist als nach der mikroskopischen Untersuchung zu erwarten wäre. Da als Eindsprengling kein Quarz vorhanden ist, muß der normative Quarzüberschuß in der amorphen Grundmasse enthalten sein. Durch die niedere Wollastonitmenge in der normativen Zusammensetzung ist das Auftreten der rhombischen Pyroxenen in der modalen Zusammensetzung vollkommen erklärlich.

LITERATURA

B u r r i, C., 1959, Petrochemische Berechnungsmethoden auf äquivalenter Grundlage, Basel.

D r e g e r, J., 1920, Erläuterung zur geologischen Karte SW-Gruppe Nr. 94. Rohitsch und Drachenburg, Wien.

G r a b e r, H. V., 1929, Neue Beiträge zur Petrographie und Tektonik des Kristallins von Eisenkappel in Südkärnten, Mitt. d. Geol. Ges. in Wien, XXII. Band.

H a m r l a, M., 1955, Poročilo o geologiji zahodnega dela in obrobja Šaleške doline, Arhiv geološkega zavoda v Ljubljani.

H a t t l e, E., 1881, Zur Kenntniss der petrographischen Beschaffenheit der südsteirischen Eruptivgesteine. Mitt. naturw. Vereins für Steiermark, Jg. 1880, 17, 22 do 500, Graz.

S a w a r i z k i, A. N., 1954, Einführung in die Petrochemie der Eruptivgesteine, Berlin.

S t r m o l e, D., 1960, Odnosi med magmatskimi kameninami okolice Belih vod, Velenja in Dobrne, njihova starost in geneza (naloga za strokovni izpit, Univerza v Ljubljani).

T e l l e r, F., 1898, Erläuterung zur geologischen Karte SW — Gruppe Nr. 84, Prassberg, Wien, 1898.

T o v š a k, R., 1959, Andeziti in tufi iz Smrekovca (naloga za strokovni izpit, Geološki zavod v Ljubljani).

Tröger, W. E., 1935, Spezielle Petrographie der Eruptivgesteine, Berlin.
Tröger, W. E., 1956 Optische Bestimmung der gesteinsbildenden Minerale, Teil 1, Stuttgart.
Zavarickij A. N., Sobolev V. S., Kvaša L. G., Kostjuk V. P. i Bobrievič A. P., 1958, Novye diagrammy dlja opredelenija sostava vysokotemperaturnyh plagioklazov. — Zapiski min. obšč. 87, vyp. 5, 529—541.

1. tabela — Tabelle 1.

HIPERSTENOV ANDEZIT PRI SV. ROKU OB SOTLI
HYPERSTHENANDESIT VON SV. ROK OB SOTLI

a) Kemična analiza in sistem CIPW

Analitik: Max Weibel, Zürich — Sistem CIPW

Utež. %		Sistem CIPW	
SiO_2	63,6	Q	21,90
TiO_2	0,51	or	6,40
Al_2O_3	15,5	ab	33,82
Fe_2O_3	1,4	an	21,14
FeO	3,8	di wo	0,03
MnO	0,10	di en	0,02
MgO	1,9	di fs	0,01
CaO	4,5	hy en	4,70
Na_2O	4,0	hy fs	5,13
K_2O	1,1	mt	2,08
P_2O_5	0,16	il	0,91
H_2O^+	3,0	ap	0,36
H_2O^-	0,6		
	100,17	Sal	83,26
		Fem	13,24
		H_2O	3,6
			100,10

$$\frac{Sal}{Fem} = \frac{83,26}{13,24} = 6,3$$

$$\frac{Q}{F} = \frac{21,90}{61,36} = 0,36$$

$$\frac{Na_2O' + K_2O'}{CaO'} = \frac{760}{760} = 1,00$$

$$\frac{K_2O'}{Na_2O'} = \frac{115}{645} = 0,18$$

CIPW (I) II. 4. 3. 4 (5).

b) Nigglijevi magmatski parametri in ekvivalentna norma (Burri, 1959)

Nigglijevi parametri		baza		dopolnilni parametri		katanorma	
si	248,0	Q	49,19	π	0,35	Q	20,83
ti	1,41	Kp	4,00	γ	0,01	Or	6,67
p	0,23	Ne	22,47	μ	0,45	Ab	37,45
al	35,6	Cal	13,24	k'	0,15	An	22,07
fm	27,9	Cs	0,05	mg'	0,45	Wo	0,06
c	18,7	Fs	1,57			En	5,45
alk	17,8	Fo	4,09			Hy	5,21
		Fa	4,70	Q	49,19	Mt	1,57
k	0,15	Ru	0,35	L	4,70	Ru	0,35
mg	0,40	Cp	0,34	M	11,10	Cp	0,34
qz	+76,8		100,00				100,00

Magma: normalna kremenovo dioritska — Sestava plagioklazov: 37,1 % An

c) parametri Zavarickega

a	10,8	f'	58,5	n	84,9
c	5,4	m'	38,2	t	0,6
b	8,7	c'	3,3	φ	14,6
s	75,1			Q	+23,2

POROČILO O DELU SLOVENSKEGA GEOLOŠKEGA DRUŠTVA V LETIH 1963 DO 1965

Mario Pleničar

V tem času je društvo iskalo stikov s slovenskimi in drugimi jugoslovanskimi ter inozemskimi geologi. Tesneje se je povezalo tudi s predavatelji geologije na srednjih šolah.

Jeseni 1963 je organiziralo skupno z zavodom za napredek šolstva tečaj geologije za srednješolske predavatelje. Geološko društvo je preskrbelo predavatelje, ki so tečaj vodili. Na tečaju so obravnavali predvsem teoretična vprašanja. Podobni prihodnji tečaji naj bi zajeli praktično uporabo geoloških izsledkov in metod v gospodarstvu.

Malo pred tem časom je bil tudi dokončno izdelan diafilm kot učni pripomoček za pouk geologije.

Društvo je povabilo v Ljubljano več tujih geologov, ki so imeli pri nas predavanja in so se udeležili z nekaterimi člani društva geoloških obhodov. V tem času je bil dvakrat v Ljubljani dunajski paleontolog dr. Othmar Kühn, častni član Slovenskega geološkega društva in dopisni član SAZU, dalje sta nas obiskala znani poljski sedimentolog dr. Stanislav Djułiński in sovjetski tektonik dr. Adran Sorskij.

Jeseni 1964 je društvo sodelovalo pri organizaciji geološke ekskurzije avstrijskega in nemškega geološkega društva po Sloveniji ob priliki geološkega posvetovanja na Dunaju. Društvo je za to ekskurzijo izdalo poseben vodič. Ekskurzijo so vodili trije naši člani (dr. Dušan Kuščer, dr. Anton Ramovš in Ančka Ravnik-Hinterlechner).

Prek Zveze geoloških društev je naše društvo poslalo dva člana na geološko posvetovanje o terciarju v Pečuh na Madžarskem. Kot gosta Madžarskega geološkega društva so ju peljali še v Budimpešto, ter jima omogočili stike z raznimi geološkimi strokovnjaki.

Razen v poletnih mesecih je društvo organiziralo vsakih 14 dni strokovno predavanje ali diskusijski večer. Od 25. 1. 1963 do 20. 3. 1965 so bila naslednja javna predavanja:

25. 1. 1963	S. Gadžić, Hidrogeologija izvirnega območja Pive
1. 2.	F. Habe, Geološko-morfološki paberki s poti po norveških ledenikih in fjordih
22. 2.	T. S. Lowering, The search for blind ore-bodies in the East Tintic district, Utah

15. 3.	D. Kuščer, Geološki vtisi s potovanja v Romunijo
8. 3.	M. Dolenc, Stanje železovih, svinčevih in cinkovih rudnikov v Alžiriji
5. 4.	R. Gospodarič, Geološki izlet v Poljske Tatre in predgorje
25. 4.	H. Usova, Prikaz serije diapozitivov za pouk geologije na srednjih šolah
16. 5.	skupno z Geografskim društvom: M. Šifrer, O historičnih gibanjih ledenikov v Ötztalskih in naših Alpah
12. 6.	skupno z Geografskim društvom: N. Čadeževa, Povojna barvanja ponikalnic v Sloveniji
25. 10.	O. Kühn, Geološko potovanje v Etiopijo
8. 1. 1964	Diskusijski večer o hidrogeološkem standardu; vodil ga je dr. Dušan Kuščer
22. 1.	Napovedano predavanje S. Božičevića o krasu v Liki je odpadlo, ker se referent ni javil. Namesto predavanja smo predvajali diapozitive o podmorskem svetu. Tolmačil je D. Kuščer
19. 2.	M. Pleničar, O geoloških raziskovanjih v Alžiriji
11. 3.	S. Buser, Geologija Trnovskega gozda
25. 3.	S. Buser, Geologija Vipavske doline
8. 4.	M. Iskra, Geologija Savskih jam
22. 4.	V. Bohinc, Vtisi s poti po Grčiji
28. 10.	J. Perkavac, Metode sledenja kraških vod
18. 11.	F. Habe, Etna in Vezuv
9. 12.	S. Janežič, Odvodnjavanje zgornjerenskega premogovnega bazena
23. 12.	R. Pavlovec, Geološki vtisi s Kephallenie in Ithake
13. 1. 1965	D. Ravnik, O geoloških raziskovanjih v Etiopiji in Eritreji
27. 1.	Diskusija o standardu inženirsko-geološke karte. Vodil jo je F. Drobne
17. 2.	M. Breznik, Hidrogeološke razmere pokrajine Jezire v Siriji
3. 2.	J. Duhovnik, Ogled rudišč in organizacija raziskovalnega dela v Bolgariji
20. 3. 1965	Za občni zbor smo pripravili naslednje kratke referate: M. Dolenc, Geološke raziskave v tujini in perspektive E. Faninger, Magmatske kamenine v severni Sloveniji F. Drobne, Geologija Ljubljane T. Nosan, Hidrogeološke in inženirsko-geološke raziskave v Sloveniji

Dolgoletni društveni referent za šolstvo prof. Usova je napisala v tem času že drugi učbenik za pouk geologije na srednjih šolah. Prednost tega učbenika je predvsem v tem, da navaja primere za razne geološke značilnosti in pojave na slovenskem ozemlju in v mejah Jugoslavije. Drugi člani so priobčevali svoje izsledke v domačih in tujih strokovnih revijah.

RIHARDU ŠIMNOVCU V SPOMIN

Šestega maja 1966 zvečer je ugasnilo življenje Riharda Šimnovca, moža, ki je 45 let svojega življenja posvetil slovenskim geologom in slovenski geologiji.

Rodil se je 3. aprila 1891 v ljubljanskem Trnovem. Po končani štirirazredni ljudski šoli na Grabnu in petih letnikih umetnoobrtne strokovne šole je delal kot pohištveni mizar in strokovni risar pri raznih podjetjih doma in v inozemstvu. Kot je bila takrat navada, je po končanem uku odšel z doma, da bi se izpopolnil v stroki in si nabral življenjskih izkušenj. Prva svetovna vojna mu je v Tirolah prekrižala načrte, moral je na fronto. Kmalu po ustanovitvi ljubljanske univerze je bil imenovan za provizornega uslužbenca in bil 22. februarja 1921 dodeljen geološko-paleontološkemu inštitutu. Prof. M. Salopek je v njem spoznal sposobnega in vestnega delavca in že 6. junija 1924 je bil postavljen za laboranta. Na tem mestu je ostal kot aktivni delavec do 1. aprila 1956, odtlej naprej pa kot honorarni delavec vse do konca prejšnjega leta, ko mu je neozdravljiva bolezen načela še poslednje moči.

Šimnovčeve velike sposobnosti, njegova delavnost in njegova velika ljubezen do dela v službi geologije so mu naklonile, da je dal v svojem poklicu veliko več, kot je od njega terjala laborantska služba. Poleg običajnih del se je lotil še študija osnovne določevalne paleontološke literature in s profesorjevimi nasveti uredil paleontološko zbirko in še dve manjši zbirki za študentske vaje in jih nenehno spopolnjeval. S pomočjo literature se je lotil določevanja različnih fosilnih ostankov iz naših krajev, nabranih na geoloških ekskurzijah. Veliko zanimanje in izreden spomin sta mu pomagala, da je kmalu poznal vse okamenine v obsežni zbirki in vedel zanje tudi potrebno literaturo. To pa je bilo neprecenljive vrednosti za študente, ki jim je znal vselej svetovati in pomagati, kolikor je mogel. Med službovanjem je prepariral nešteto najrazličnejših okamenin od vsepovsod; svoje bogate izkušnje pa je rad posredoval vsem, ki so ga prosili za pomoč.

V njegovi skrbi je bila skozi štiri desetletja tudi obsežna inštitutska knjižnica in vzorne kartoteke so njegovo delo. Poznal je domala vso domačo in tujo strokovno literaturo in ni ga bilo boljšega svetovalca študentom, kot je bil naš Šimnovec. Številni geologi in drugi strokovnjaki so še po končanem študiju prihajali k njemu po literaturo in nasvete.

S svojim tehničnim znanjem in natančnostjo je v inštitutu v celoti nadomestil še tehničnega risarja. Izdelal je več zahtevnih rokopisnih geoloških kart slovenskih specialk, mnoge geološke skice in številne študijske pripomočke za predavanja. Seveda so tudi sposobnosti njegovega prvotnega poklica prišle vsepovsod do veljave. Vselej in povsod se je zavzemal za ugled inštituta, najbolj pa je to dokazal s svojim vestnim in natančnim ter predanim delom slovenski geologiji.

Skoraj vse generacije slovenskih geologov je spremljal od začetka študija do diplome, pomagal pa je še številnim študentom biologije, geografije, gradbeništva in rudarstva. In prav vsem je ostala globoka hvaležnost za njegovo nesebično pomoč, ki jo je delil na vse strani.

Ob intimni slovesnosti njegovega 45-letnega laborantskega dela je bil otroško vesel, da ga imajo njegovi študentje tako radi in so se ga tako prisrčno spomnili. S svojim delom pa je zaslužil, da se ga s hvaležnostjo spominjamo tudi sedaj, ko ga ne bo več med nami.

A. Ramovš

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