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Volcaniclastic Rocks in Borehole Tdp-1/84 Trobni Dol, Eastern Slovenia

Vulkanoklastične kamnine v vrtini Tdp-1/84 Trobni Dol, vzhodna Slovenija

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Ključne besede: vulkanoklastične kamenine, piroklastične kamenine, sedimenti podmorskega piroklastičnega toka, riolitni tufi, zeoliti, Slovenija

Abstract

Uppermost 160 metres in the cored borehole Tdp-1/84 Trobni Dol, mainly consist of volcaniclastic sediments, deposited entirely in a marine environment. Two phases of volcanic activity were recognised, the second one producing huge amounts of pyroclastic material of rhyolitic composition, transported in a submarine pyroclastic flow and settled as an over 107 m thick ignimbrite deposit. After termination of explosive volcanic activity, sedimentation of fossiliferous marine mudstone Sivica continued, and immediately above the ignimbrite it contains a few cm thick layer of rhyolite-mudstone peperite. Peperite formed when magma intruded into a water-saturated muddy sediment, desintegrated into hyaloclasts owing to chill-and-quench processes, and finally, intermixed with the sediment. Overlying syn-eruptive resedimented volcaniclastics were deposited after ceassation of volcanic activity, with normal marine transport and sedimentation agents.

Kratka vsebina

Gornjih 160 metrov jedrovane vrtine Tdp-1/84 Trobni Dol povečini sestoji iz vulkanoklastičnih sedimentov, ki so bili v celoti odloženi v morskem okolju. Prepoznali smo dve fazi vulkanskega delovanja, od katerih je bila druga še posebno močna. Ob eksplozijah riolitne magme so nastale ogromne količine vulkanskega pepela, ki so se transportirale s podmorskim piroklastičnim tokom in se sedimentirale kot preko 107 metrov debel horizont ignimbrita. Ko je vulkanizem prenehal delovati, se je nadaljevala morska sedimentacija sivice, ki vsebuje nekaj cm debel sloj peperita iz riolita in sivice. Peperit je nastal ob intruziji magme v vlažen sediment. Zaradi hitrega ohlajanja se je magma pričela drobiti v hialoklaste in se nato mešala s sedimentom. Nad peperitom se nahajajo sin-eruptivno presedimentirani vulkanoklastiti, ki predstavljajo piroklastični material, sedimentiran in transportiran z normalnimi dejavniki v morskem okolju potem, ko je vulkanizem že ugasnil.

Introduction

The village Trobni Dol is located in Eastern Slovenia (Fig. 1), in the Tertiary Laško basin. Volcaniclastic rocks crop out on the crest of the Rudnica anticlyne, in the form of triangular, fault-bounded area of less than 120 km^2. The Laško basin is characterised by the occurrence of coal, which is the main reason for geological exploration of the area in the past, and also in the last decades.

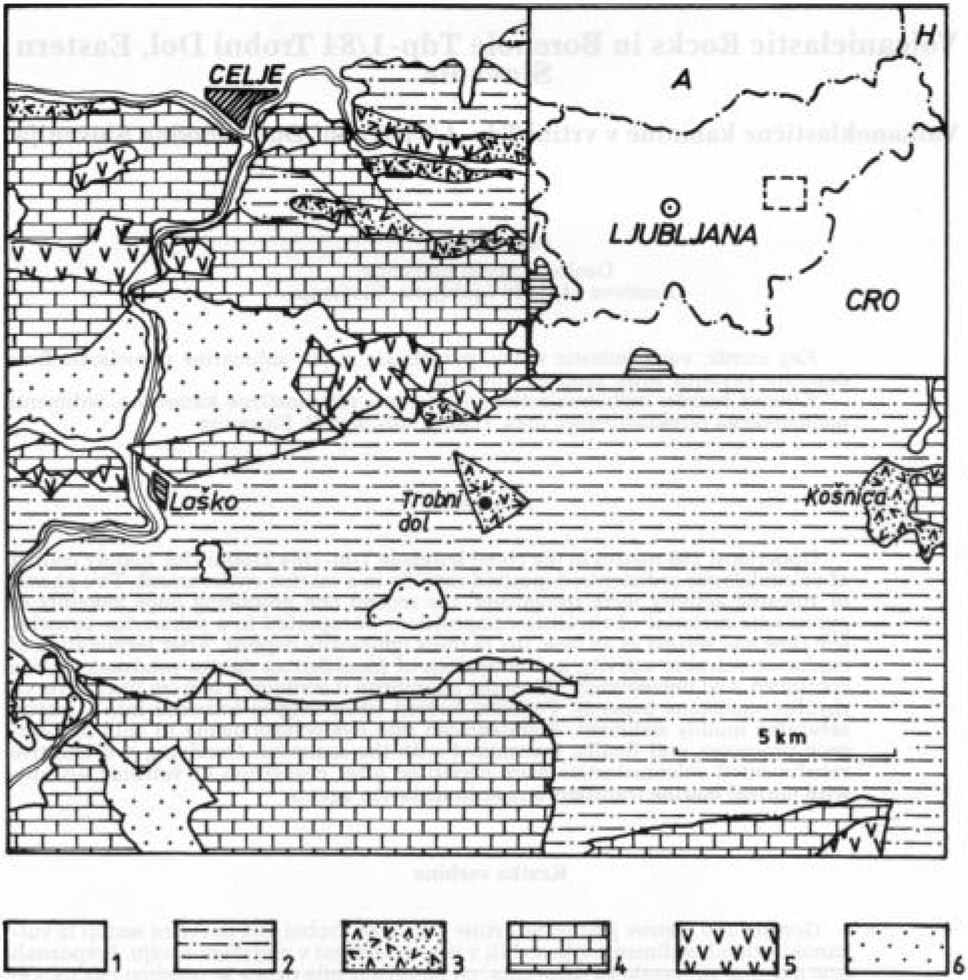

Fig. 1. Simplified geologic map of the Trobni Dol area (modified after Buser, 1977). 1, Quaternary; 2, Mio-Pliocene clay, silt, sand and gravel; 3, Oligocene volcaniclastics; 4, Mesozoic carbonates; 5, Triassic keratophyre and tuffs; 6, Permian and Carboniferous clastic rocks

Sl. 1. Shematska geološka karta območja Trobnega Dola (prirejeno po Buserju, 1977). 1, kvartar; 2, mio-pliocenski sedimenti - glina, melj, pesek in prod; 3, oligocenski vulkanoklastiti; 4, mezozojski karbonati; 5, triasni keratofir in njegov tuf; 6, permijski in karbonski klastiti

Early works date in the previous century (Zollikofer, 1861; Stur, 1871; Bittner, 1884), and they were followed in the period between both wars (Munda, 1939). The most extensive exploration of the area started after the Second World War. It was dominantly related to elaboration of the Basic Geological Map of Slovenia, sheet Celje (Buser, 1977; 1979), but also, to coal prospection (Hamrla, 1987). Recent works of Dozet and Rijavec (1994), Petrica et al. (1995), and Grad et al. (1996) deal with biostratigraphic division of Tertiary beds in the area, as well as with occurrence and chemical composition of the Trobni Dol coal seams.

In the year 1984, two cored boreholes have been drilled in the vicinity of Trobni Dol (Petrica, 1983). Their purpose was to find any new resources of coal in the area. The first one, Tdp-1/84 penetrated 360 metres of the Tertiary sediments and sedimentary rocks, and terminated in the basement, composed of Triassic dolomite. The second borehole Tdp-2/84 is 400 metres deep, but owing to the complex tectonic setting of the area, it did not reach the basement. The upper 160 metres of the drilled section in Tdp-1/84 mainly consist of volcaniclastic rocks, deposited in a shallow-marine environment. The present contribution deals with lithofacieses of volcaniclastic rocks, recognised in the Tdp-1/84 borehole core, their depositional sedimentary environment and diagenetic alteration.

Geological setting of the Trobni Dol area

Trobni Dol area forms a part of the Laško basin. The basement consists of Permo-Carboniferous shales, quartzarenites and conglomerates, Permian sandstones and Triassic dolomite, shales and volcanic rocks. The basin is infilled with Tertiary successions ranging in age from Upper Oligocene to Badenian. Upper Oligocene beds in the area comprise Pseudosocka beds, grayish green marine mudstone named Sivica (Grad et al., 1996), and volcaniclastics of rhyolitic composition. Oligo-Miocene and Miocene beds are subdivided only on the basis of lithology - owing to the lack of fossils - into sandy clays and sands of the Upper Egerian age, Eggenburgian marine marly clay and silt, named the upper Govce beds, Badenian calcarenites (the Laško beds), and Sarmatian silts and sands.

Basement in the Tdp-1/84 borehole consists of Triassic dolomite, which is overlain discordantly by the lower Pseudosocka beds at 383.6 m. The lower Pseudosocka beds are composed of massive clay with some up to 40 cm thick coal seams. At 368.3 metre, the upper Pseudosocka beds occur being developed as finely laminated limestone, marly limestone and calcareous marl. At 341.5 metre, the sediments grade upwards into interstratified claystones, sandstones and siltstones. The Pseudosocka beds indicate intermixing fresh-water, brakish and shallow-marine environment. At 299.5 m, they are overlain by a 140 m thick succession of bluish gray marine mudstone Sivica. Foraminifera fauna indicates Lower Egerian age (Grad et al., 1996). At 159.4 m, pyroclastic rocks occur, and they fairly predominate up to the depth of 12.5 m, where a thin layer of eluvium is encountered.

Volcaniclastic succession

Volcaniclastic succession encountered in borehole Tdp-1/84, Trobni Dol, was compared with the models described by Wright & Mutti (1981), Yamada (1973),

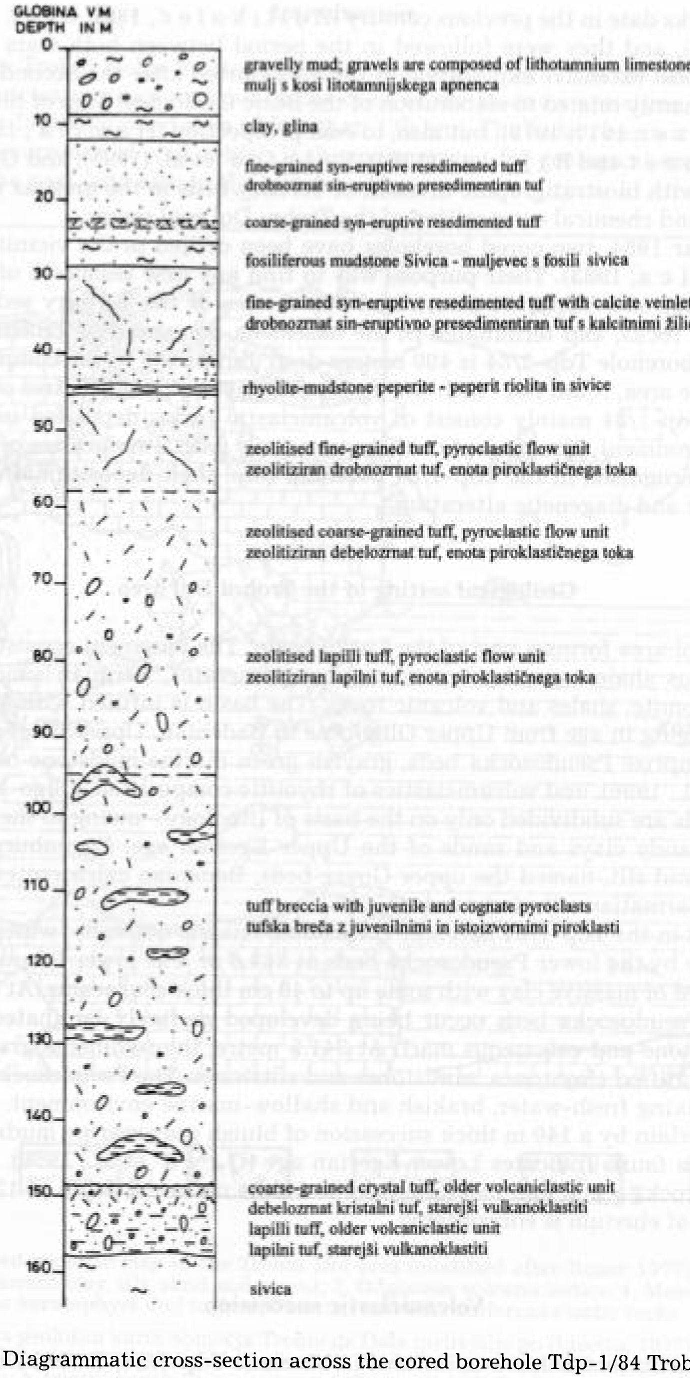

Fig. 2. Diagrammatic cross-section across the cored borehole Tdp-1/84 Trobni Dol
Sl.2. Shematski prikaz profila jedrovane vrtine Tdp-1/84 Trobni Dol

Table 1. Bulk chemical composition of volcaniclastic rocks from the Tdp-1/84 borehole, Trobni Dol in wt.%. Analyst Vida Hudnik, Kemijski inštitut Slovenije
Tabela 1. Glavne prvine vulkanoklastičnih kamnin iz vrtine Tdp-1/84 Trobni Dol, v masnih %. Analitik Vida Hudnik, Kemijski inštitut Slovenije

Sample / Element	1	2	3
SiO_2	69.1	69.8	65.9
Al_2O_3	11.1	12.9	11.6
Fe_2O_3	2.6	1.0	1.0
FeO	0.39	0.65	0.5
MnO	0.02	0.04	0.02
MgO	0.4	0.6	1.1
CaO	1.1	0.9	3.1
Na_2O	2.9	3.4	0.5
K_2O	2.3	2.8	3.0
TiO_2	0.2	0.2	0.2
P_2O	0.009	0.04	0.01
S	1.4	0.03	0.01
CO_2	2.3	0.4	0.1
L.O.I.	10.1	7.4	8.4

1: sample from the pyroclastic flow unit, a depth of 83.05 m
2: peperite sample, a depth of 44.5 m
3: surface sample from resedimented unit

Table 2. Microprobe analyses in wt.% of the matrix (sample 1), transitional area (sample 2) and a glass shard altered to clinoptilolite and cristobalite (sample 3). Analyst Peter Pavli, IEVT Ljubljana
Tabela 2. Mikroanaliza v masnih % osnove (vzorec 1), prehoda (vzorec 2) in črepinjice vulkanskega stekla, spremenjene v klinoptilolit in kristobalit (vzorec 3). Analitik Peter Pavli, IEVT Ljubljana

Sample / Element	1	2	3
SiO_2	53.04	71.12	70.30
Al_2O_3	23.81	11.22	13.25
Fe_2O_3	1.51	1.40	0.16
MgO	1.68	0.68	0.34
CaO	2.02	0.52	0.74
Na_2O	0.85	1.36	2.54
K_2O	8.48	2.81	3.14
Sum	91.42	89.13	90.49

Fe_2O_3 is total Fe recalculated as Fe_2O_3

F i s k e & M a t s u d a (1964), and C a r e y & S i g u r d s s o n (1980). Diagenetic alteration of rocks is described already by K o v i č & M i š i č (1989).

The succession lies conformably on the fossiliferous marine mudstone Sivica, and consists of an older, partially eroded volcaniclastic unit, pyroclastic flow unit, rhyolite mudstone (Sivica), peperite unit and resedimented unit (Fig. 2). Pyroclastic flow unit is ideally developed submarine pyroclastic flow deposit. It is relatively thick amounting to 107 m. Pyroclastic flow unit terminates with a 3 decimetre thick layer of the marine mudstone Sivica with autobrecciated rhyolite flow intermixed with the sediment, and forming a peperite. Resedimented unit is about 19 metres thick and comprises two horizons of fainty laminated syn-eruptive resedimented fine-grained tuff, interlayered with Sivica.

Classification of volcaniclastic rocks from the Tdp-1/84 borehole is by no means simple. According to the silica and alkali content (Table 1) the rocks can be classified as dacites or rhyolites. However, bulk chemical composition, recalculated to the anhydrous base and compared with the data of Ewart (1979) indicates the tuffs developed from a rhyolitic magma. The main problem concerning reliability of this chemical composition is in diagenetic alteration of the rocks which involves redistribution of many elements on a small-scale, and maybe also their enrichment or loss owing to the mobility on a larger-scale. A small scale redistribution is reflected in a different diagenetic alteration pattern of lapilli and glass shards which are replaced by the zeolite clinoptilolite, and the fine-grained matrix which is replaced by clay minerals. Microprobe analyses have shown rather diverse chemical composition of matrix, zeolitised volcanic glass, and the transitional area between them (Table 2). Chemical composition of the matrix indicates the loss of silica and sodium, and the gain of magnesium, aluminium, potassium and iron. The released silica and sodium were, at least partially, incorporated in clinoptilolite, which replaces volcanic glass. Both diagenetic reactions, from matrix to clay, and from glass to clinoptilolite involve hydration process and partial redistribution of alkaline and alkaline earth elements.

Older volcaniclastic unit

Older volcaniclastic unit is 8.9 m thick, and consists of extensively altered pumice lapilli tuff (Plate 1 - Fig. 1) overlain by a 12 cm thick layer of resedimented crystal tuff (Plate 1 - Fig. 2). Plagioclases are still relatively fresh, but the texure of fine-grained matrix can not be recognised any more owing to alteration. Volcanic glass in pumice lapilli is also completely replaced by illite and a random mixed layer clay mineral beidellite/montmorillonite/illite with B/M/I=50/40/10 (Plate 1 - Fig. 3; K o v i č & M i š i č, 1986). Overlain plagioclase-rich coarse-grained tuff is resedimented, and contains detritial admixture, mainly quartz and chert. Fine-grained matrix is subordinate in occurrence as calcite and pyrite cement predominate. Both rock types of the older volcaniclastic unit contain glauconite.

Pyroclastic flow unit

Pyroclastic flow unit consists of massive tuff breccia in the lower part, massive, normally graded pumice lapilli tuff or ignimbrite in the central part, and massive coarse-grained tuff with dominating glass shards and pumice in the top. The whole pyroclastic flow unit comprises dispersed foraminifers, commonly replaced by pyrite, and fragments of coal. The temperature of this submarine pyroclastic flow was hardly high enough for charring of plant material to occur. The fragments originate from underlying coal seams destructed during volcanic explosions. Their distribution is rather uniform throughout the unit and may indicate intensive turbulence, which is a general characteristic of transport in a pyroclastic flow (Cas & Wright, 1987; Fisher & Schmincke, 1984).

Tuff breccia occurs between 149 m and 95 m of depth. The largest clasts are cognate in origin. Most commonly, they have lensoid forms and are up to 30 cm long. They represent the fragments of the older unit, which was disturbed during the new eruption, and admixed to juvenile material transported by the pyroclastic flow. Juvenile material forms the matrix of tuff breccia, and consists of pumice lapilli tuff with abundant glass shards. While cognate fragments are altered to clay minerals, juvenile material is extensively replaced by clinoptilolite.

Above a depth of 95 metres, cognate fragments dissapear, and juvenile material prevails. Between 95 m and 58 m, normal gradation of lapilli can be recognised, although fine-grained matrix remains completely unsorted. The largest lapilli attain the sizes up to 7 cm, and their shape is commoly fluidal (Plate 2 - Fig. 1, Fig. 2). The deformation occurred during their deposition in the pyroclastic flow, when they have been still hot enough to be partially in a fluidal condition. Most commonly, they are elongated in the flow direction, but sometimes more extraordinary Z-forms occur. Internal texture of such lapilli is collapsed, and much alike to welded tuffs (Plate 2 - Fig. 3). Phenocrysts of plagioclase feldspars can be aligned in the flow direction (Plate 5 - Fig. 3), but they can also be broken „in situ“ (Plate 3 - Fig. 1). Such desintegration of plagioclases possibly occurred during cooling and deformation of lapilli.

Very rarely, some extraordinary lapilli occur, being peperite fragments in origin (Plate 3 - Fig. 2, Plate 5 - Fig. 2). Peperite fragments are composed of intimate mixtures of magma and a sediment, and they are characterised by banded structure. They probably formed prior to explosive eruption, when ascending magma came in a contact with the wall sediments causing minor intermixing with, and assimilation of them.

Matrix of lapilli tuffs is a coarse- and fine-grained vitric tuff. Its main constituents are glass shards, many of them having typical Y-forms. Glass shards show no sign of

Table 3. Microprobe analyses of some plagioclase grains, borehole Tdp-1/84, in a depth of 96.4 m. Analyst Peter Pavli, IEVT Ljubljana

Tabela 3. Mikroanaliza nekaterih zrn plagioklazov, vrtina Tdp-1/84, globina 96.4 m. Analitik Peter Pavli, IEVT Ljubljana

Sample/ Element	1	2	3	4
SiO_2	51.6	53.2	56.8	61.3
Al_2O_3	32.7	32.1	34.0	33.2
Fe_2O_3	0.03	0.03	0.96	0.45
CaO	13.3	13.6	15.4	11.4
Na_2O	2.2	2.1	1.7	2.8
K_2O	0.2	0.2	1.2	0.7

welding. Plagioclase grains are subordinate in occurrence. They are commonly encountered as twinned and zoned crystals. Fedorov's optical determination of composition indicates that oligoclase and andesine prevail. Microprobe analyses show even higher amounts of calcium (Table 3), and recalculated formula on the basis of 8 oxygen atoms indicate average bytownitic composition $(Na_{0.2}K_{0.1}Ca_{0.7}\ Fe_{0.001})[Al_{1.7}\ Si_{2.3}]$.

Among mafic minerals encountered in the tuff, biotite prevails, but somewhat rarely, hornblende also occurs. Both minerals indicate the magma was not dry and contained enough water for hydrous phases to form (G i l l, 1981). Among accessory minerals, apatite and Fe-Ti oxydes were determined by microprobe analysis. Quartz grains are rare in occurrence, and the majority of them are of detritial origin.

Peperite unit

Pyroclastic flow unit terminates with fossiliferous marine mudstone Sivica which contains up to 5 cm thick layer of peperite (Plate 4 - Fig. 1, Fig. 2, Fig. 3; Plate 5 - Fig. 1). Peperite formed during the intrusion of magma into a wet, water-saturated sediment and indicates relative proximity to the vent. Superheating of water in the sediment commonly causes fluidisation effects (M c P h e e et al., 1993), and owing to abundant organic matter, they can be well observed in the peperite from borehole Tdp-1/84 (Plate 4 - Fig. 1, Fig. 2, Fig. 3; Plate 5 - Fig. 1). Magma is desintegrated into irregularly shaped fragments having up to 2 cm in diameter. Some of the fragments have round forms, and the others are elongated along the flow direction. The edges are jagged. Glassy groundmass is altered to clinoptilolite, calcite and cristobalite. Organic matter is pyritised, and commonly wrapped around the fragment surfaces causing flow foliation.

Syn-eruptive resedimented volcaniclastics

Above the peperite layer, syn-eruptive volcaniclastic rocks occur, and they are interlayered with two thin layers of Sivica. Syn-eruptive volcaniclastics were resedimented after volcanic eruption with normal marine transporting agents, and not with the energy of volcanism. Fine-grained tuffs predominate (Plate 3 - Fig. 3). Their sorting is still poor, but nevertheless, better than in the tuffs of the pyroclastic flow unit. Rare, up to some cm thick layers of coarse-grained tuffs consist of plagioclase-feldspar grains and pumice with subordinate fine-grained matrix. Volcaniclastic rocks are extensively altered to Ca-beidellite, randomly mixed layer clay mineral beidellite/montmorillonite, clinoptilolite and cristobalite (K o v i č & M i š i č, 1989).

Conclusions

Volcaniclastic succession encountered in the borehole Tdp-1/84 Trobni Dol was entirely deposited in a marine environment in two stages of volcanic activity:

1. older eruption which can be recognised in an 8.9 m thick layer of pumice lapilli tuff, extensively altered into Ca-Na montmorillonite and illite. It is overlain by resedimented crystal-rich tuff with calcite and pyrite cement.

2. younger eruption partially disrupted older volcaniclastics, and produced huge amounts of pyroclastic material, transported in a submarine pyroclastic flow, and settled as an over 107 m thick ignimbrite deposit. Diagenetic alteration is reflected in the development of clinoptilolite and mixed layer clay minerals beidellite/montmorillonite/illite.

Whether the second, vigorous eruption terminated with non-explosive magma eruption is not known. Outcrops of lava flows were not found in the broader Trobni Dol area, and for this reason it is very likely, that peperite developed during the termination of explosive volcanic activity when magma infilled the conduit. In the contact with water-saturated sediments it desintegrated into hyaloclasts owing to chill-and-quench processes. Sudden temperature rise related to the magma intrusion caused matrix fluidisation which enabled dispersion of hyaloclasts away from the contact of magma and the sediment.

After the termination of volcanic activity, local resedimentation of deposited pyroclastic material started, with normal transporting agents related to a marine environment.

Vulkanoklastične kamnine v vrtini Tdp-1/84 Trobni Dol, vzhodna Slovenija

Raziskovalna vrtina Tdp-1/84 je bila namenjena odkrivanju novih nahajališč premoga na območju Laške sinklinale. Locirana je bila pri vasi Trobni Dol in je prevrtala 360 metrov terciarnih plasti, vse do predterciarne podlage triasnega dolomita. Zgornjih 160 metrov so prevladovale vulkanoklastične kamnine, ki so v tem prispevku podrobneje obravnavane.

V zaporedju vulkanoklastičnih kamnin iz vrtine Tdp-1/84 smo ločili štiri glavne enote:

1. starejše vulkanoklastite,
2. mlajše piroklastite, sedimentirane s podmorskim piroklastičnim tokom,
3. peperit, in
4. sin-eruptivno presedimentirane vulkanoklastite

Sedimentacijska enota starejših vulkanoklastitov se nahaja v najglobljih delih vulkanoklastičnega zaporedja in je debela le 8.9 m. Sestoji iz lapilnega tufa, ki v najzgornejšem delu prehaja v kristaloklastični tuf s kalcitnim in piritnim cementom, ki predstavlja že nekoliko presedimentirano vulkanoklastično kamnino. Lapilni tuf je močno spremenjen v illit in glinen mineral z zmesno strukturo vrste beidellit/montmorillonit/illit.

Nad starejšimi vulkanoklastiti se nahaja 107 metrov debela enota piroklastičnih kamnin, ki so nastale ob močni vulkanski eksploziji riolitne magme. Eksplozija je porušila del starejših vulkanoklastičnih sedimentov in jih skupaj z juvenilnim materialom transportirala s podmorskim piroklastičnim tokom. Tako se v spodnjem delu nahaja tufska breča, ki prehaja navzgor v normalno gradiran lapilni, in nato v debelozrnat in drobnozrnat vitroklastični tuf. Največji lapili so bili v času transporta še dovolj vroči, da so se plastično deformirali. Najpogosteje so razpotegnjeni v smeri toka, najti pa je mogoče tudi bolj nenavadne oblike, podobne črki Z (Plate 2 - Slika 1). V piroklastičnem horizontu je značilen diagenetski mineral klinoptilolit.

Piroklastični horizont se konča s slojem sivice, v kateri je peperit. Peperit nastane tedaj, ko magma prodre v vlažen sediment in se zaradi nenadnega ohlajanja razdrobi ter pomeša s sedimentom. Zaradi intruzije se porna voda v sedimentu vpari in sediment postane podoben visokoviskozni tekočini. Proces imenujemo fluidizacija (M c P h e e et al., 1993). Fluidizacija je v peperitu iz vrtine Tdp-1/84 še posebej lepo vidna zaradi obilice organske snovi v sivici (Plate 5 - Slike 1, 2, 3).

Nad peperitom se nahajajo sin-eruptivno presedimentirani vulkanoklastiti. Predstavljajo piroklastični material, ki se je presedimentiral z običajnimi dejavniki transporta v morskem okolju potem, ko je vulkanizem že prenehal delovati.

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Plate 1 - Tabla 1

1 Lapilli tuff from the older volcaniclastic unit, borehole depth 155.6 m. Volcanic glass in pumice lapilli (L) is extensively replaced by clay minerals. Plane polarised light, magnification 23 ×

Lapilni tuf, starejši vulkanoklastiti iz globine 155.6 m. Vulkansko steklo v plovčevih lapilih (L) je močno nadomeščeno z minerali glin. Presevna polarizirana svetloba, povečava 23 ×

2 Crystal tuff with calcite and pyrite cement, older volcaniclastic unit, borehole depth 149.0 m. Plane polarised light, crossed nicols, magnification 23 ×

Kristaloklastični tuf, starejši vulkanoklastiti iz globine 149.0 m. Presevna polarizirana svetloba med navzkrižnimi nikoli, povečava 23 ×

3 Another view to a pumice lapillus (L), replaced by clay minerals. Borehole depth 120.3 m. Plane polarised light, magnification 63 ×

Še en pogled na plovčev lapil (L), nadomeščen z minerali glin. Plane polarised light, magnification 23 ×

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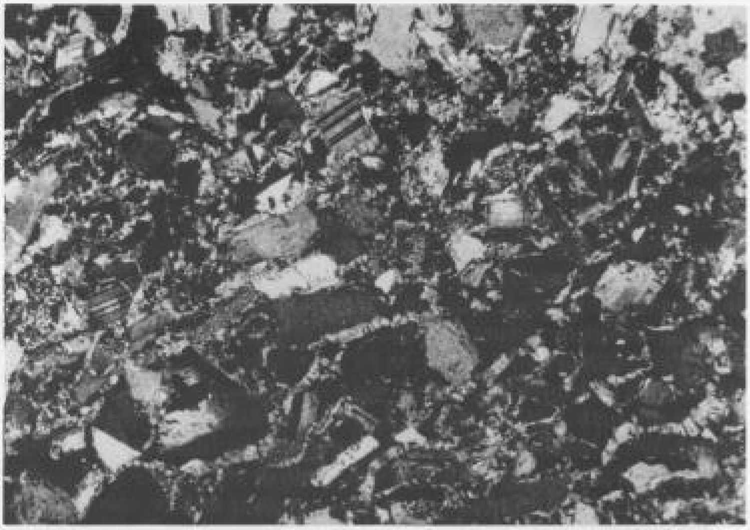

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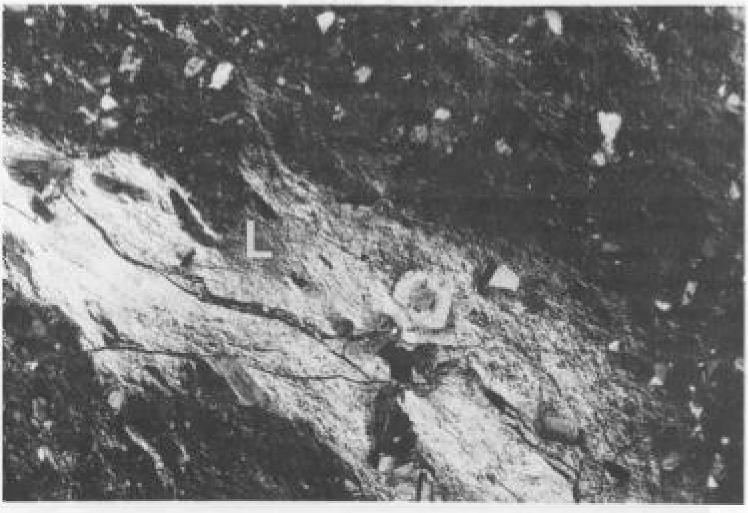

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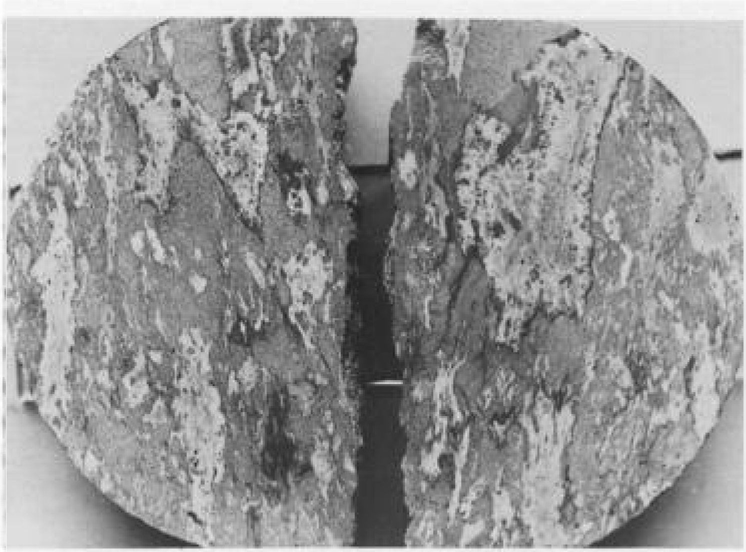
Plate 2 - Tabla 2

1 Polished core surface from the borehole at a depth of 83.2 m. Many lapilli have flame-like endings, and some of them have extraordinary Z-shape. Core diameter is 9 cm
Polirana površina jedra vrtine iz globine 83.2 m. Številni lapili imajo na konceh oblike, ki so podobne ognjenim zubljem, maloštevilni med njimi po obliki spominjajo na črko Z. Premer jedra je 9 cm

2 Lapilli endings under the microscope, borehole depth 83.2 m. Plane polarised light, magnification 23 ×
Robni deli lapilov pod mikroskopom, globina 83.2 m. Presevna polarizirana svetloba, povečava 23 ×

3 A detail of a deformed lapillus (L), borehole depth 83.5 m. Glassy groundmass resembles to a welded tuff. Plane polarised light, magnification 23 ×
Detajl deformiranega plovčevega lapila (L) iz globine 83. 5 m. Steklasta osnovna masa spominja na nataljene tufe. Presevna polarizirana svetloba, povečava 23 ×



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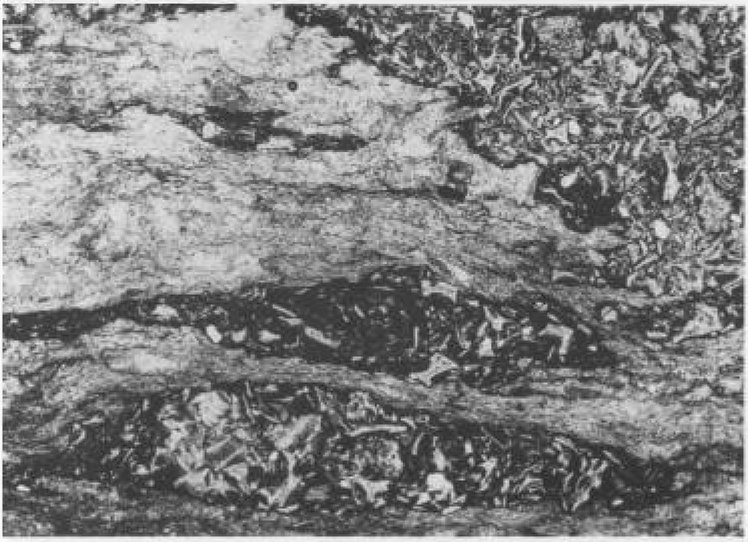

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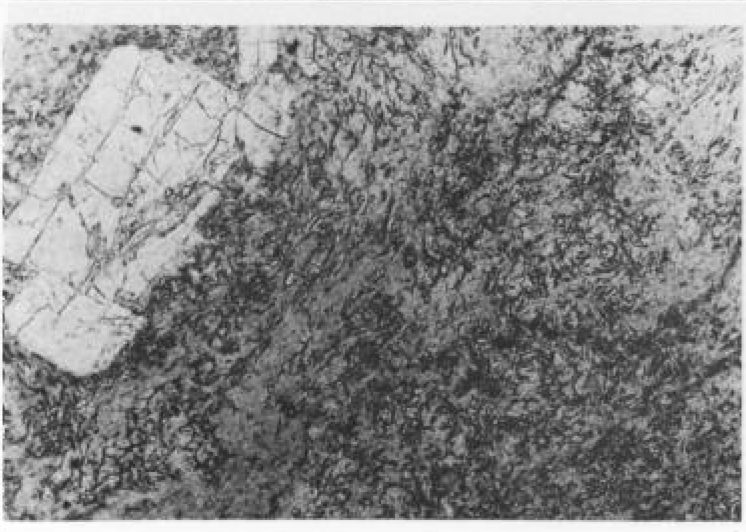

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Plate 3 - Tabla 3

1 During the lapilli deformation, vesicles collapsed into glass shards and the plagioclase phenocryst was broken „in situ“. Borehole depth 95.0 m. Plane polarised light, magnification 63 ×

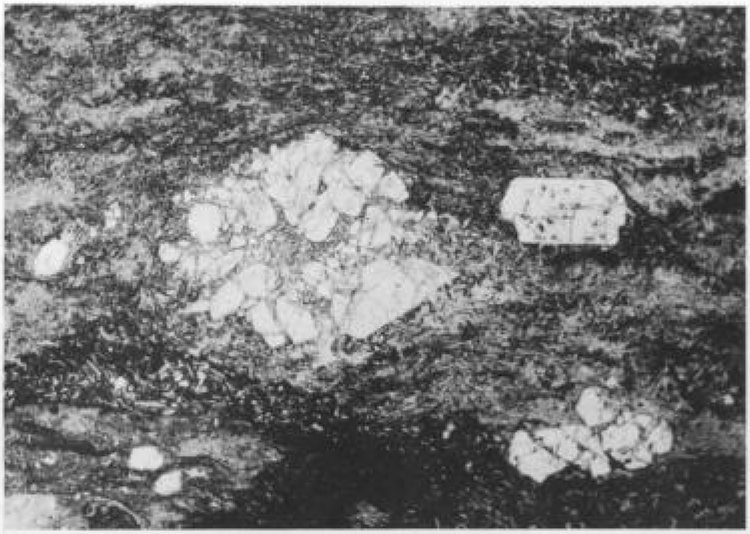
Med deformacijo lapila so se votlinice plinskih mehurčkov porušile in nastale so črepinjice vulkanskega stekla, vtrošnik plagioklaza pa se je tudi zdrobil na mestu. Presevna polarizirana svetloba, povečava 63×

2 A clast of peperite in the lapilli tuff from a borehole depth of 83.5 m. Plane polarised light, magnification 63 ×

Klast peperita v lapilnem tufu z globine 83.5 m. Presevna polarizirana svetloba, povečava 63 ×

3 Fine-grained vitric tuff from the syn-eruptive resedimented unit, at a depth of 13.4 m. Plane polarised light, magnification 63 ×

Drobnozrnat vitrični tuf iz enote sin-eruptivno presedimentiranih vulkanoklastitov. Globina 13.4 m, presevna polarizirana svetloba, povečava 63 ×



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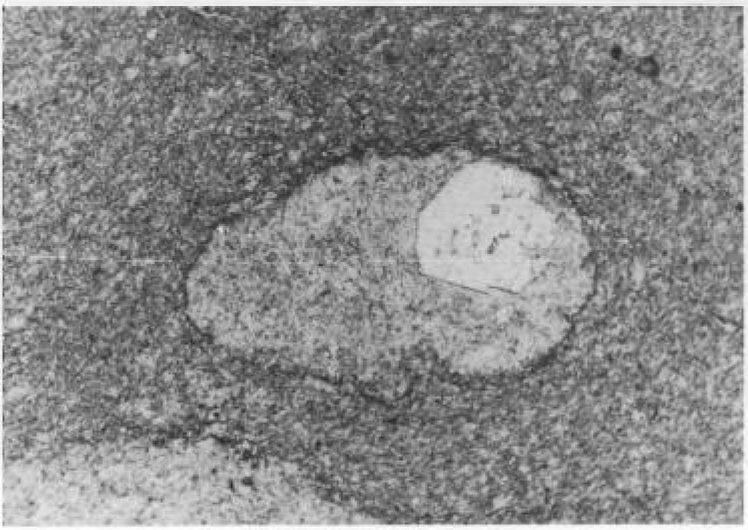

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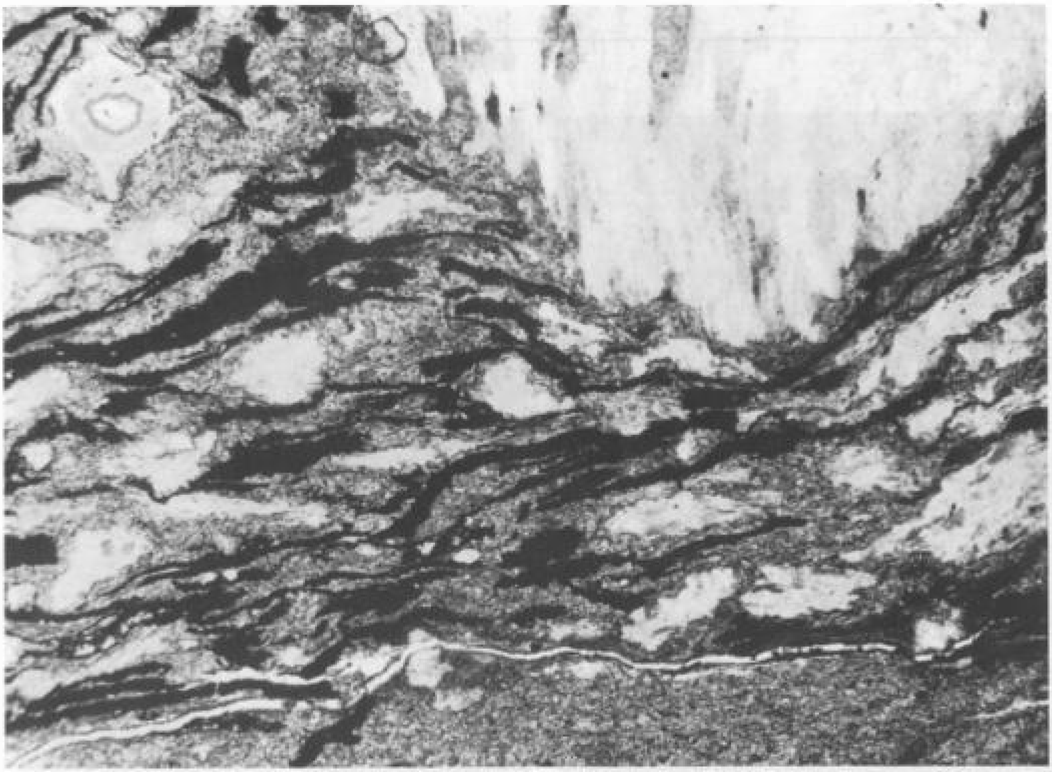
Plate 4 - Tabla 4

1 Rhyolite - mudstone peperite, borehole depth 44.3 m. Irregular hyaloclasts (light areas) are dispersed in the mudstone Sivica (gray areas). Fluidal structure is indicated by pyritised organic matter (dark areas). Plane polarised light, magnification 45 ×

Peperit riolita in sivice iz globine 44.3 m. Nepravilni hialoklasti (svetla polja) so razpršeni v sivici (siva polja). Fluidalno teksturo nakazuje piritizirana organska snov (temna polja). Presevna polarizirana svetloba, povečava 45 ×

2 Same as Fig. 1, another view
Enako kot sl.1, še en pogled na peperit

3 Same as Fig. 1, another view
Enako kot sl.1, še en pogled na peperit



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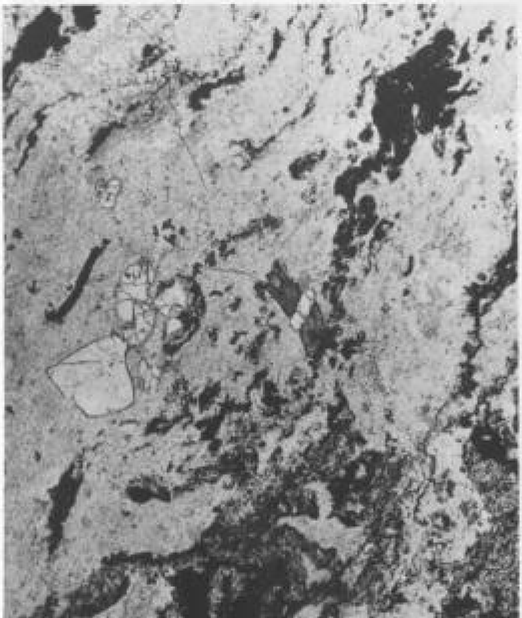

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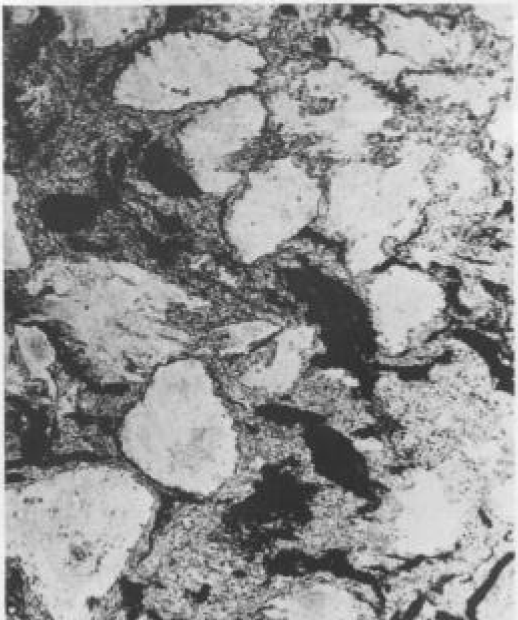

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Plate 5 - Tabla 5

1 Rhyolite - mudstone peperite, borehole depth 44.3 m. Irregular hyaloclasts of rhyolite (light areas) are dispersed in the mudstone Sivica (gray areas). Pyritised organic matter shows the flow directon (dark areas). Plane polarised light, scale bar 0.1 mm

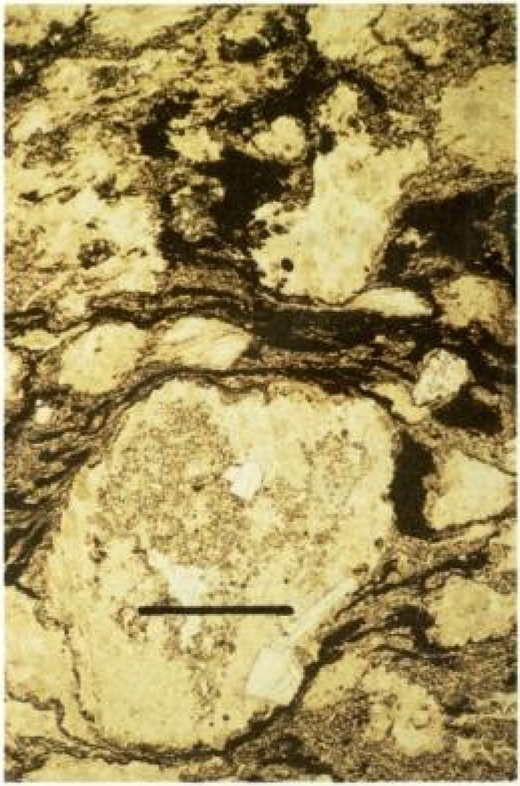
Peperit riolita in sivice iz globine 44.3 m. Nepravilni hialoklasti riolita (svetla polja) so razpršeni v sivici (siva polja). Organska snov je razporejena v smeri tečenja (temna polja). Presevna polarizirana svetloba, merilo 0.1 mm

2 A clast of peperite in the lapilli tuff from a borehole depth of 83.5 m. Plane polarised light, magnification 23×

Klast peperita v lapilnem tufu z globine 83.5 m. Presevna polarizirana svetloba, povečava 23 ×

3 A narrow belt of fine-grained matrix with oriented plagioclases indicating dynamical fow-conditions. Borehole depth 83.0 m. Plane polarised light, scale bar 0.1 mm

Ozek pas razpotegnjene drobnozrnate tufske osnove z orientiranimi plagioklazi, ki kaže na dinamične pogoje tečenja. Globina 83.0 m. Presevna polarizirana svetloba, merilo 0.1 mm



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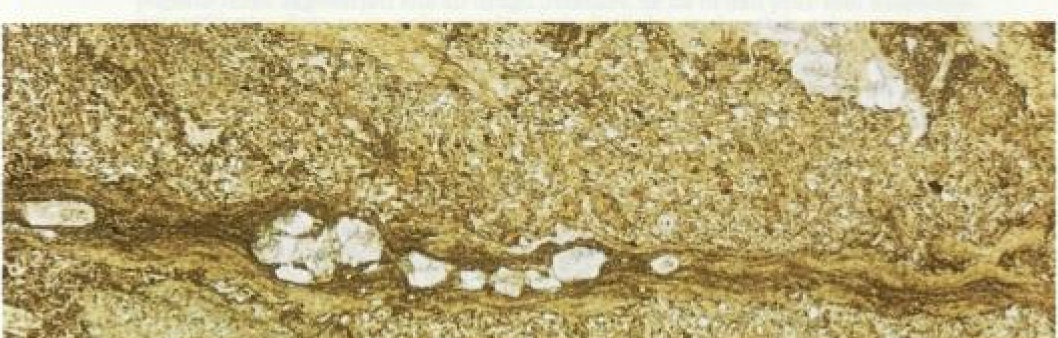

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