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Dacite – siltstone peperite from Trlično at Rogatec, Eastern Slovenia

Peperit dacita in meljevca iz Trličnega pri Rogatcu

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Ključne besede: terciarni vulkaniti, peperit, dacit, zeoliti, analcim, Slovenija

Abstract

Dacitic glassy lava flow at Trlično is surrounded by a dacite – siltstone peperite and peperitic breccia that underwent alteration, recognised in two, only a few metres thick zones. In the higher-temperature alteration zone, albite extensively replaces volcanic glass and primary plagioclases. The siltstone components are altered to microcrystalline quartz, iron oxides and interlayered illite/smectite clay minerals. This zone developed upon thermal metamorphosis related to the transfer of heat from the cooling lava. In the lower temperature alteration zone, analcime occurs as the replacement of volcanic glass and pore- and fissure-filling, while the primary plagioclases and poorly lithified siltstone remained fairly unchanged. This zone developed under hydrothermal conditions related to the heating, circulation and reactions of pore waters in the sediment surrounding the lava flow.

Kratka vsebina

Dacitno steklasto lavo pri Trličnem obkrožata peperit dacita in meljevca in peperitna breča, ki sta spremenjena v dveh, le nekaj metrov širokih conah. V višjetemperaturni coni albit močno nadomešča vulkansko steklo in primarne plagioklaze. Meljasta sestavina je spremenjena v mikrokristalni kremen, železove okside in glinene minerale z zmesno strukturo vrste illit-montmorillonit. Ta cona je nastala s kontaktno, termično metamorfozo vezano na toplotni tok, ki je izvirala iz ohlajajoče se lave. V nižjetemperaturni coni pa se pojavlja analcim, ki nadomešča vulkansko steklo in zapolnjuje pore in manjše razpoke v kamnini. Primarni plagioklazi in meljasta sestavina sta skoraj nespremenjeni. Ta cona je nastala pod hidrotermalnimi pogoji zaradi pregrevanja, kroženja in reaktivnosti pornih raztopin v okolnem sedimentu lavinega toka.

Introduction

Peperites are volcaniclastic rocks developed by mixing of lava or magma and the enclosing soft sediment (Cas & Wright, 1987; Fisher & Schmincke, 1985; McPhie et al., 1993). They are characterised by interesting fluidal textures and distinct globular clast forms, and also, by alteration and authigenic mineralisation related to intensive heat transfer from the cooling lava or magma to the enclosing sediment.

In Slovenia, peperites and peperitic or intrusive hyaloclastites were recognised in the Tertiary volcanic complex of Smrekovec (Kralj, 1996). While the identification of andesite – siltstone peperites is relatively easy, andesite – tuff, and particularly andesite – resedimented tuff peperites commonly involve many ambiguities. Alteration and the formation of zeolites and other authigenic minerals additionally complicate their recognition (Kralj, 1998).

A thin layer of peperite occurs in the Trobni Dol area in the marine siltstone termed “sivica” that overlies an over 100 m thick horizon of pyroclastic flow deposits (Kralj, 1999). The terminating stage of volcanic activity was non-explosive and produced a thin glassy lava flow which underwent entirely autoclastic fragmentation and mixing with the underlaying marine silt. Silt fluidisation is well seen by redistribution of organic matter from a dispersed form into layers and elongate lenses oriented parallel to the flow direction.

Peperites and other autoclastic rocks in the Rogaška Slatina and Rogatec volcanic areas (Fig. 1) are poorly studied. Their recognition is very difficult owing to the impact of intensive tectonic activity and alteration. At Trlično, the process of mixing of dacite and siltstone can be traced from the parts of the lava flow with almost completely assimilated silt, to the peperite zone and the lava flow margins with dacite hyaloclasts dispersed in the surrounding sediment forming peperitic breccias. This contribution deals with the rock petrography, their mode of formation and alteration accompanying the interaction of hot lava and the enclosing water-saturated sediment.

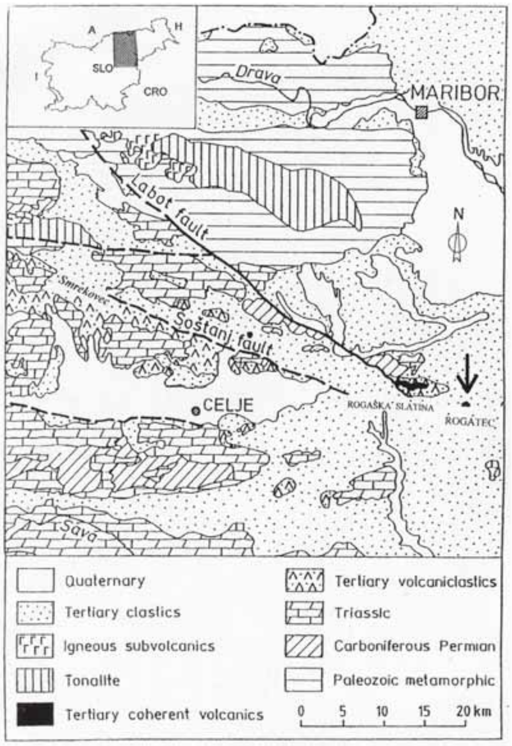


Fig. 1. Simplified geological map of the eastern Slovenia (modified after Aničić, B. & Juriša, M. 1985; Buser, S. 1978), and detailed geographic position of Trlično.

Brief outline of geological setting

The Rogaška Slatina and Rogatec area belongs to the south-western margins of the Pannonian Basin. Pre-Tertiary basement mainly consists of Mesozoic carbonates and interstratified volcanic rocks. The oldest Tertiary deposits are Eocene limestone and calcarenites. Their erosional remains outcrop north of Rogaška Slatina. Oligocene deposits are developed as marine silts, siltstones, and subordinate fine-grained sandstones, marls and claystones. Volcanic activity seemingly started in Upper Oligocene, and persisted discontinuously until Eggenburgian. The magma composition varied in time from andesitic to dacitic and rhyodacitic. During the Eggenburgian time, some hundred metres thick sandstone deposits accumulated at Macelj and Log (up to about 500 m), and Plešivec (up to 300 m), along with marine siltstone (Aničić & Juriša, 1985). Karpatian and Ottnangian sediments are missing in the area. The Badenian sequence is characterised by some ten metres thick basal layer of lithothamnium limestone and calcareous conglomerate, and it is overlain by several hundred metres thick silt and marl deposits, locally interstratified with sandstone and calcarenite. During Sarmatian, the environment changed from marine and brackish to continental. Silts and siltstones dominate, and in the upper part of the sequence, sandstones and conglomerates locally occur. South of Rogaška Slatina, Pannonian marls outcrop and they are the youngest Tertiary sediments in the area.

In the Rogaška Slatina and Rogatec area, three regional faults meet – the NW-SE trending Labot Fault from which the Donat Fault splits, the ENE- WSW trending Šoštanj Fault and the Celje Fault (Aničić & Juri-

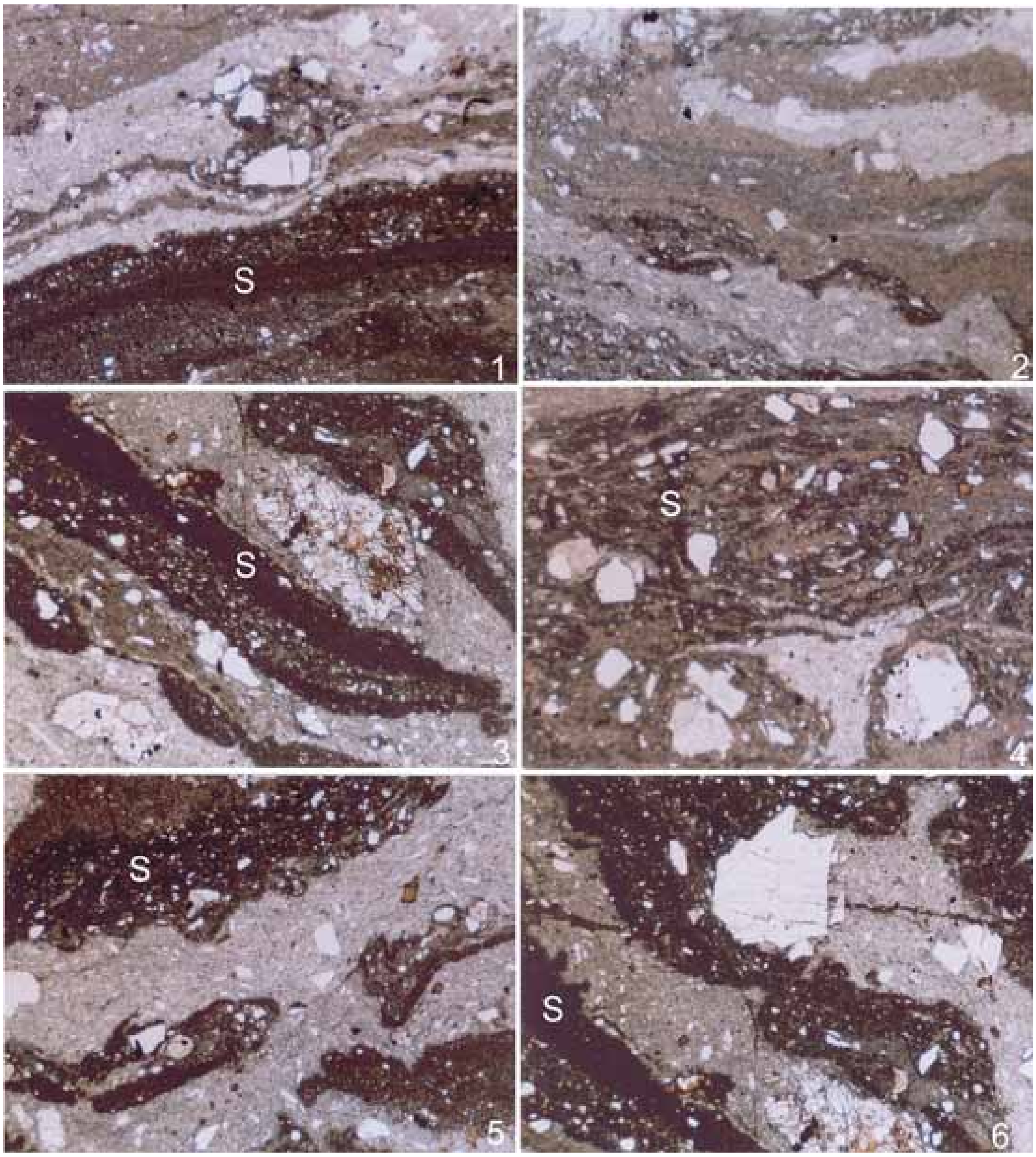


Plate 1

Fig. 1. Bands in a laminar lava flow with different degree of crystallinity and composition, PPL 27x

Fig. 2. The bands ending in more turbulent parts of the lava flow, PPL 27x

Fig. 3. Entrapped sediment (S) rich in organic matter, PPL 27x

Fig. 4. Peperite developed in a lateral part of the lava flow, PPL 27x. Blackish areas belong to the enclosed sediment (S)

Fig. 5. Wavy boundaries between the bands of lava and the sediment (S) possibly developed by the boiling of pore water in the sediment and assimilation reactions. PPL 27x

Fig. 6. Lava bands (lighter areas) mixing with the sediment (dark areas, S), PPL 27x

ša, 1985; Buser, 1978). The Šoštanj Fault and the Celje Fault join at Rogatec, and continue on the territory of Croatia north of Trlično (Aničić & Juriša, 1985; Aničić et al., 2002). South of the joined Celje Fault and Šoštanj Fault, effusive and explosive volcanic rocks outcrop at Trlično and Sv. Rok. Their assumed age is Egerian as indicated by the surrounding silts and siltstones (Aničić & Juriša, 1985).

Volcanic rocks at Trlično

Lava flow from Trlično is a plagioclase-augite-magnetite-phyric dacite. Groundmass consists of brownish glass in which microlites – mainly plagioclases - are set. The texture and composition are not homogenous throughout the rock (Plate 1 - Fig. 1), and indicate that magma developed by a mixing process which was not thoroughly completed by the time of extrusion to the surface (Kralj, 2002). Some lava parts, subordinate in occurrence, are more rich in groundmass microlites and contain up to 0,5 mm sized olivine microphenocrysts. The other parts of the lava flow are essentially glassy and contain less phenocrysts and much smaller microlites. By magma mixing, banding parallel to the flow direction developed. The bands can be fairly irregular, convoluted and some mm thick or regularly layered and much thinner attaining some tenths of mm. The bands may just simply end, or gradually become more and more thin, and finally mix and assimilate with another layer (Plate 1 - Fig. 2). Some plagioclases were broken during the flow, seemingly owing to the collision with other grains and/or friction related to the increase in viscosity caused by the cooling of still moving lava flow.

When magma extruded in the surrounding soft silty sediment and later moved on its surface as a lava flow, mixing and partial assimilation occurred mainly along the lava flow margins characterised by a laminar flow and very high shear between the coherent plug and the channel walls. Irregularly shaped pieces of the sediment were incorporated in the laminar part of the lava flow (Plate 1 - Figs. 3, 4), and changed their shapes into bands during the flow advance (Plate 2 – Fig. 1). These bands locally show wavy upper and lower boundaries with the enclosing lava (Plate 1 – Figs. 5, 6), and they probably originate from sediment fluidisation developed by pore water boiling. The sediment shows varying degree of alteration: in general, clayey and fine-grained silty matrix was altered preferentially with respect to the quartz grains that have commonly preserved their original crystal structure and the grain shape (Plate 2 - Fig. 1).

Outermost shells of the laminar lava flow underwent autobrecciation and the formation of hyaloclastites and peperitic breccias (Plate 2 – Figs. 2). Due to proximity to the lava flow, they underwent extensive alteration reflected in the formation of illite/sericite interlayered filosilicate minerals, albite and quartz. Authigenic minerals replace the primary constituents – plagioclases and volcanic glass, and fill the voids forming interstitial cement and veinlets. This alteration shell developed mainly by thermal metamorphosis related to the heat release form the lava flow.

Some metres away from the contact with the lava flow, the intensity of hyaloclastite alteration decreases and and authigenic mineral assemblage changes into analcime – illite – microcrystalline quartz (Plate 2 – Figs. 3, 4). Analcime replaces volcanic glass and plagioclases and fills the voids. The ve-

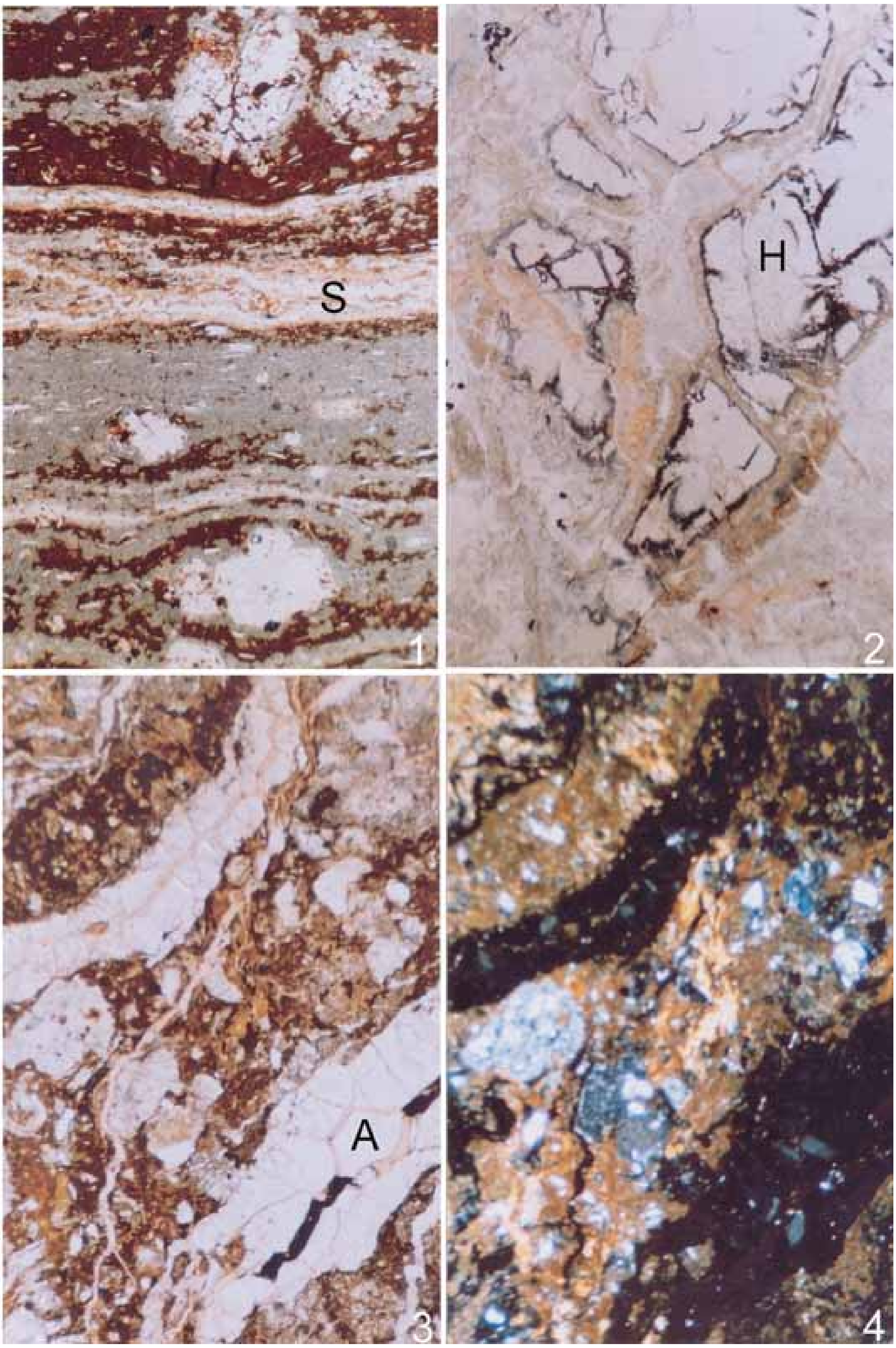
Plate 2

Fig. 1. Banded lava: the sediment is aligned in thin bands (white areas, S) and is extensively altered into quartz, albite and iron oxides (band margins). PPL 27x

Fig. 2. Peperitic breccia: lava hyaloclasts (H) and sedimentary matrix are extensively altered into quartz, albite, illite/sericite and iron oxides, PPL 27x

Fig. 3. Analcime (A)veinlets, PPL 27x

Fig. 4. The same as Fig. 3, XP


S
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ins are some tenth of mm thick and are up to 1 mm sized. Analcime is mainly isotropic although very weak birefringence occurs in some larger crystals (Plate 2 – Fig.4). This alteration shell developed under hydrothermal conditions by the release of deuteric fluids from the lava flow, and heating and circulation of pore fluids from the surrounding sediment. The pore fluids consisted essentially of entrapped marine water. Similar geochemical conditions of analcime development were observed in volcaniclastic rocks of Mt. Smrekovec (Kralj, 1998).

Conclusions

Dacitic lava from Trlično extruded into soft, silty, marine sediment. During the flow, some mixing occurred producing dacite – siltstone peperite and peperitic breccias. Sediment incorporated in the laminar lava flow commonly followed the flow planes becoming thinner and thinner with the flow advance. Incorporated in the laminar flow, the sediment underwent alteration into quartz, albite, sericite and iron oxides. Peperitic breccias consist of hyaloclasts and sedimentary matrix. Along the contacts with the lava flow, peperitic breccias are extensively altered into albite – quartz – interlayered illite/sericite, and some metres away into analcime, quartz and illite. The former authigenic mineral assemblage is mainly related to thermal metamorphic conditions related to the transfer of heat from the cooling lava flow. Analcime possibly developed under hydrothermal conditions generated by heating, circulation and reactivity of pore fluids – essentially marine water entrapped in the surrounding sediments, and by eventual mixing of pore waters with deuteric fluids released from the cooling lava flow.

Acknowledgements

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