Acta Mineralogica-Petrographica, Szeged, XXIX, 81—93, 1987—1988

REDEPOSITED VOLCANOCLASTIC LIMESTONE IN THE EASTERN MECSEK MTS., SOUTHERN HUNGARY

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ABSTRACT

In the eastern Mecsek Mts. of Southern Hungary, various volcano-sedimentary mixed rocks have been recognized: redeposited volcanoclastic limestone, intrusive breccia?, and local mixing at the contacts between limestone and magmatites. The redeposited volcanoclastic limestone described in detail in this paper, consists of volcanogenic and sedimentary clasts and limestone matrix. The rock is underlain by Oxfordian limestone and overlain by Lower Cretaceous basaltic lava breccia. The volcanic fragments exhibit different petrographic features (various texture, vesicularity, alteration and composition) indicating that they were derived from different lava flows. The rock formed by debris flow in a rough basin topography, associated with a continental rift-type basaltic volcanism.

INTRODUCTION

The Mesozoic sequence of the eastern Mecsek Mts., Southern Hungary is known from the Lower Triassic. During the Middle and Upper Jurassic pelagic sediments (limestone, calcareous marl) were deposited dominantly; the Oxfordian cherty limestone and radiolarite indicate the greatest depth of the sea. The paroxysm of the submarine basaltic volcanism was reached during Valanginian and Hauterivian time. Various mixed rocks composed of volcanogenic and sedimentary components formed due to the volcanic activity and the accompanying tectonic movements. Based on their origin 3 groups can be separated:

1. Upper Jurassic-Berriasian redeposited volcanoclastic limestone. It is composed of volcanogenic and sedimentary clasts and limestone matrix. This rock appears in the area of the Kisújbánya basin *(Fig. 1)*, in the middle of the Márévár valley, one of the left tributaries of Singödör valley and in the borehole Hosszúhetény XX.

2. Contact between sediments and volcanics, as local mixing occurs frequently. Calcareous sediments were penetrated by volcanic fragments, while lava flows incorporated limestone clasts. The original texture was preserved in some of these sedimentary fragments. At the Márévár valley small (2—3 mm) limestone amygdales can be found in the basalt. Such a local mixed rock appears especially in the vicinity of the Singödör valley, in the Hidas valley and Márévár valley.

3. Volcanoclastic mixed rock. It may be intrusive breccia in the area of Máza and Váralja-South (NE-Mecsek). Two boreholes (Váralja-11, BÓNA *et al.*, 1983; and Váralja-29) display this rock composed of volcanic and sedimentary (mainly siltstone and sandstone) clasts embedded in a fine grained matrix. The position in the sequence and its petrographical features indicate intrusive breccia origin. Investigation of this rock is in progress.

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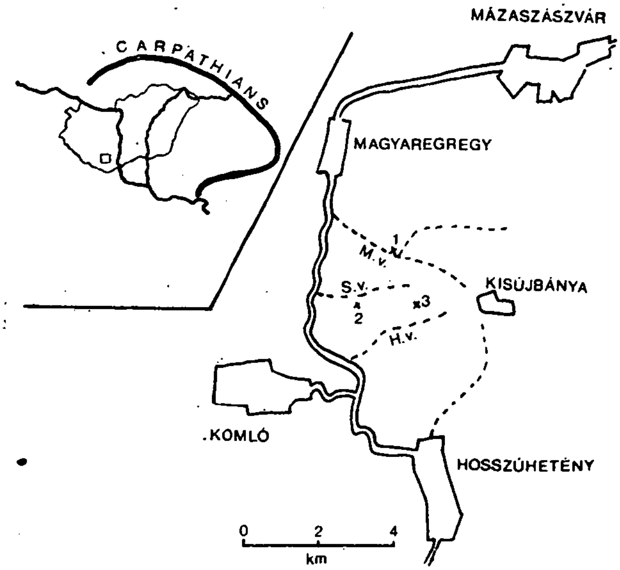


Fig. 1. Localities of redeposited volcanoclastic limestone: 1. Márévár valley, at the mouth of Somosi csörge 2. Left tributary of the Síngödör valley 3. Borehole Husszúhetény XX. (M. v. = Márévár valley, S. v. = Síngödör valley, H. v. = Hidas valley)

In this paper the redeposited volcanoclastic limestone is described only from the aspect of petrography and origin.

The first description of the Mecsek mixed rocks was made by NAGY, (1967), concentrating on the contact effects of the volcanic material in the limestone. He supposed that the volcanic clasts had got through joints into the limestone. Based on textural features BILIK, (1979) divided the volcanic clasts into three groups in the borehole Hosszúhetény XX. NAGY, (1986) investigated the mixed rocks in a new aspect. After describing the resedimentation features in thin sections he set up a model. He supposed a long time preserving of calcareous mud in unconsolidated state. Based on his micropaleontological and sedimentological investigations he explained the formation of mixed rocks with submarine resedimentation.

KOVÁCS, (1988) described olistostromes composed of volcanic and sedimentary components in the Uppony Mts., Northeastern Hungary, which may be similar genetically to the Mecsek redeposited mixed rock.

In the Lahn Dill area (FRG) and Eastern Thüringia (GDR) volcano-sedimentary mixed rocks have been reported under various name (Schalstein s. l., Dillenburger Schichten, Langenaubacher Breccia). Although they underwent low-grade metamorphism, on the basis of the microscopic features (LEHMANN, 1941) and petrographical descriptions (LIPPERT *et al.*, 1970; RÖSLER, 1960) the similarity to the Mecsek mixed rocks is conspicuous. In the Black Flysch and Rarau-Haghimas Syncline of the Eastern Carpathians similar rocks occur as well (SANDULESCU *et al.*, 1981; RUSSO—SANDULESCU *et al.*, 1979).

FIELD DESCRIPTION

The redeposited volcanoclastic mixed rock is underlain by Oxfordian siliceous limestone and overlain by Valanginian (?) lavabreccia and hyaloclastite.

At the Singödör locality a long sequence from the Bajocian marl to the Lower Cretaceous volcanics is exposed in a small tributary. The 4.5 m thick mixed volcanic-limestone unit is situated in the middle of the valley, underlain by vertical cherty limestone layers. Within this unit Upper Jurassic and Berriasian volcanic-free limestone boulders (up to 1.5 m in diameter) are embedded in a soft volcano-sedimentary material *(Fig. 2.A)*.

The Márévár valley locality exposes a ca. 20 m long green, greyish green and in some places brown, friable to hard mixed sequence. Its real thickness can be up to 5—6 m only — the rock dip to the SE *(Fig. 2.B)*. The varying hardness of the rock is due to its variable proportions of volcanic material content. Numerous rounded,

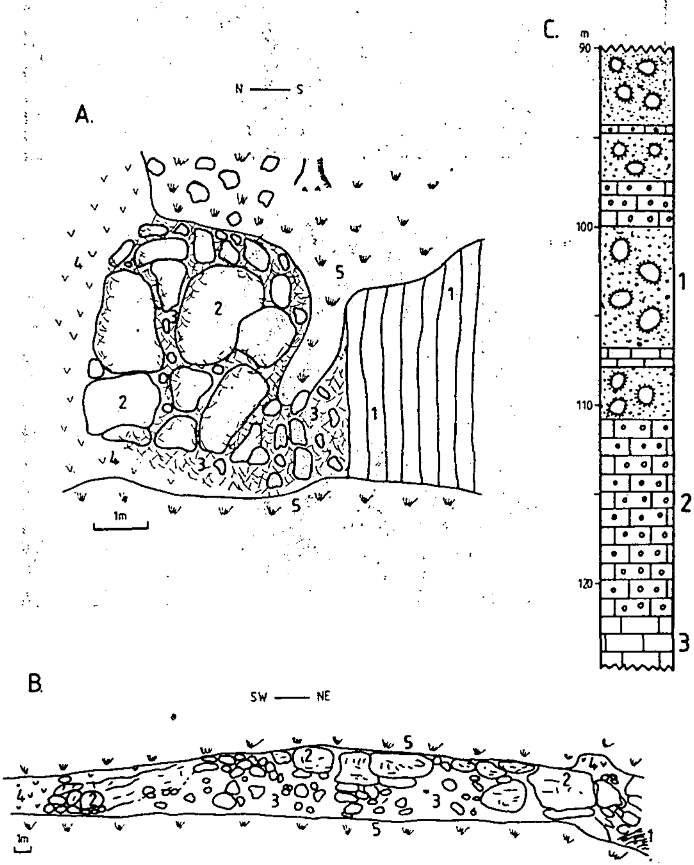


Fig. 2. Sketch of the outcrops of redeposited volcanoclastic limestone: A.) Síngödör tributary; B.) Márévár valley (1. Oxfordian siliceous limestone; 2. limestone boulders embedded in volcanoclastic mixed rock; 3. Volcanoclastic mixed rock with fine grained clasts; 4. Weathered lava breccia, hyaloclastite; 5. Soil and debris.) (after HARANGI, 1987, modified) C.) Borehole Hosszúhetény XX. between 90 m and 125 m. (1. lava breccia; 2. redeposited volcanoclastic limestone; 3. limestone) (after BILIK, 1979, modified).

hard fist-sized limestone blocks with low volcanogenic content are enclosed by a frequently exfoliated, friable — weathered — carbonate material with high volcanogenic content. In the inner part of the limestones no volcanic material can be observed, but in its marginal parts volcanic clasts appear. The contact between these two field is indistinct *(Figs. 3, 4, 5)*.

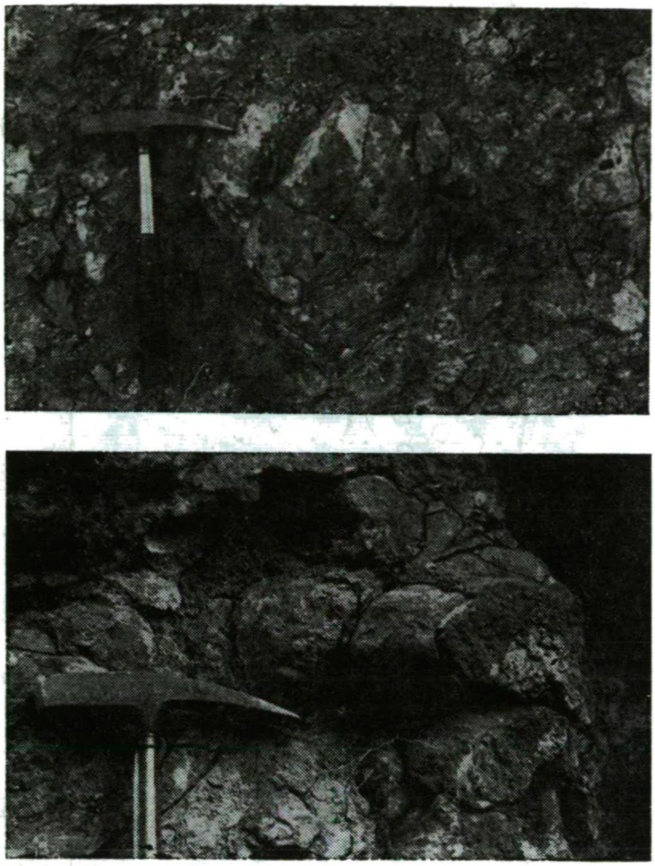
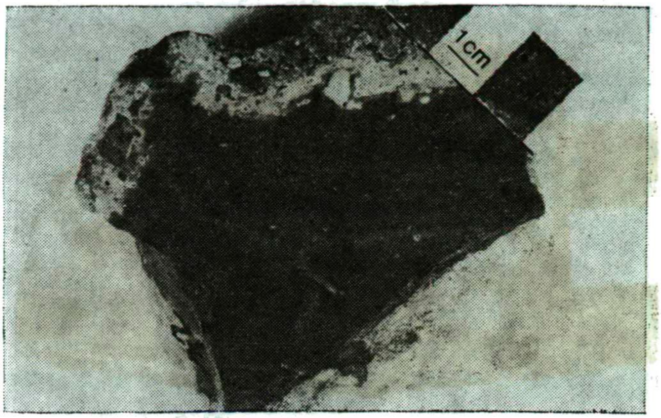


Fig. 3—4. Rounded hard siliceous limestone clasts are surrounded by soft vocanoclastic mixed material (Márévár valley).

The borehole Hosszúhetény XX. between 90 m and 125 m exposes alternating volcano-carbonate mixed rock and basaltic lavabreccia units *(Fig. 2.C)*. These are underlain by Upper Jurassic limestone (Bilik, 1979).

In this paper the first two localities are described in detail.

In both outcrops we can often find some slickensides and shear surfaces due to the post-consolidation movement of the rocks. The volcano-carbonate mixed rock can be crumbled in some places, where most of the volcanic clasts are weathered to clay-minerals and limonite, but generally it is medium hard. The harder limestone fragments have predominantly green-greenish blue colour. Especially in the Márévár valley the rock often diplays oriented texture with alternating bands of limestone



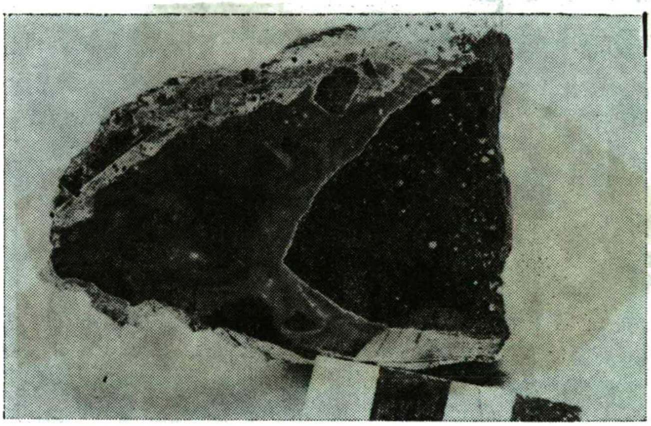
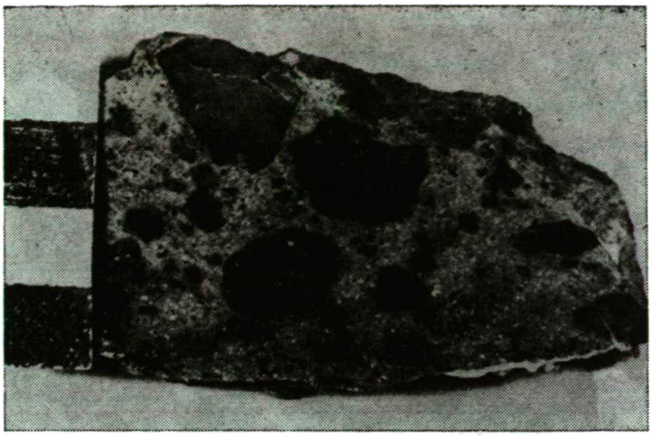


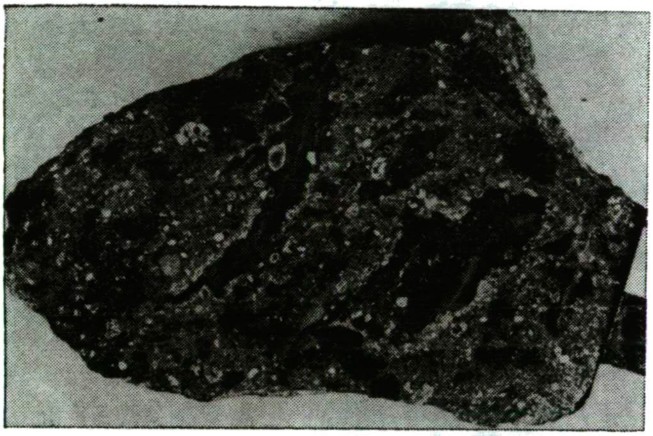
Fig. 5—6. Volcanoclastic mixed material appear in the marginal part of siliceous limestone core, which may contain larger (up to 8 cm diameter) volcanic clast.

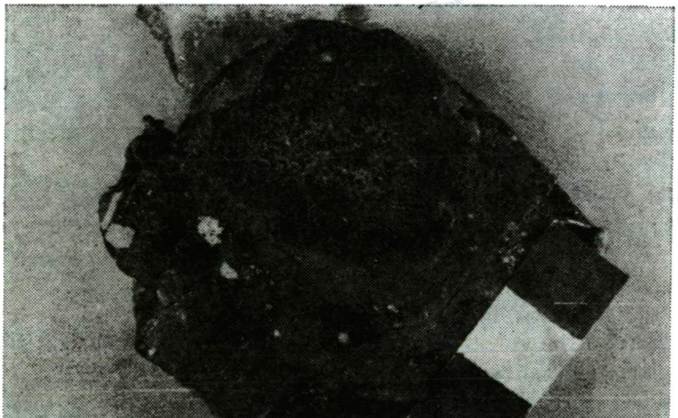
matrix rich in volcanic clasts and dark green radiolarian limestone schliers and lenses poor in clasts *(Fig. 8)*.

The larger (5—15 cm) clasts are generally more or less rounded *(Fig. 7, 9, 10)*, but the cherts and radiolarites fragments are angular. The green clast-poor siliceous limestone frequently shows a banded, flow structure, which can be observed to the naked eye too, but in some parts the deep and light green bands blend chaotically.

The volcanic clasts are up to 15 cm, however, most of them are less than 1 cm in diameter. Most of the volcanic fragments are brown or grey, with carbonate and chlorite amygdales. The unweathered fragments are larger, they fall into the range of 5—15 cm in size, containing often fresh pyroxene phenocrysts. Numerous clasts are surrounded by a thin (up to 0.05 mm) light-coloured rim.







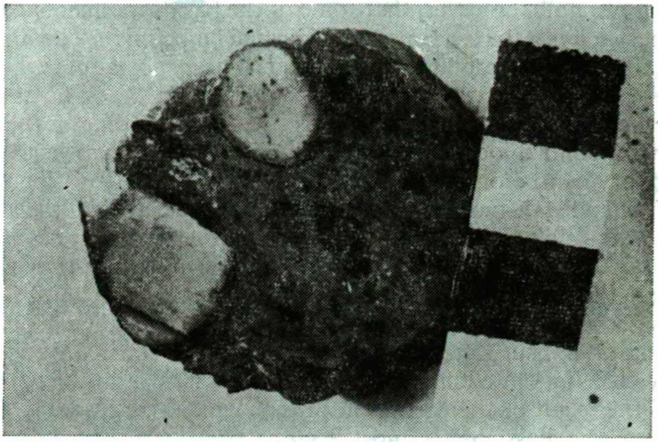


Fig. 7—10. Characteristic polished surfaces of the redeposited volcanoclastic limestone. There are more or less rounded clasts in the limestone matrix. Oriented radiolarian limestone lensens poor in clasts appear in the mixed rock frequently

PETROGRAPHY

The volcano-carbonate mixed rock consists of the matrix and the clasts:

Matrix: limestone, clayey limestone — the volcanoclastic parts are coloured by limonite.

Clasts: (1) Volcanic clasts: totally altered glass shards, amygdaloidal alkaline carbo-chloro basalt, alkaline chloro-nontro basalt, carbobasalt, basalt, trachytoid feldspar basalt, spilitic basalt. (2) Sedimentary clasts: calpionellid limestone, radiolarian siliceous limestone, radiolarite, chert. (3) Crystal clasts: plagioclase, pyroxene, pseudomorphs after mafic minerals, calcite, quartz.

The greatest part of the clasts are volcanogenic (ca. 75%), the sedimentary portion amounts to 20% (in vol% it is greater) and the crystal clasts are present in minor proportions (5%).

We could obtain information about the composition of the redeposited volcanoclastic limestone mainly on the basis of microscopic study considering the small sizes of the clasts.

The banded character of the rock can be recognized in thin section samples, too. Grey micritic-, brown clayey-limonitic-, radiolarian siliceous limestone bands and bands with coarse calcite crystal clasts alternate, interfinger with each other or chaotically blend one another in the volcanic clast-free limestone parts. The calcite crystals frequently appear oriented within the bands. The limestone parts with clasts coloured by limonite are not bordered sharply by the clast-free parts, there is a continuous transition between them. Compaction features occur and the calcite crystals are oriented around some clasts showing the direction of the embedding.

The shape of the clasts are variable, there are perfectly rounded, but amoeba-like irregular and angular forms, too. According to Floyd, (1986) the degree of angularity attained by volcanic clasts is the function of both cooling fracture brecciation and submarine erosion. The highly vesicular glassy clasts are irregular shard-like fragments, the larger, glassy or holocrystalline basalt clasts have more rounded margins. We have to note, however, that some of the basalt fragments have irregular, branching shape, wich may be explained by semisolid embedding. The limestone clasts are predominantly rounded produced by submarine transportation.

The contact between the carbonate matrix and the clasts can be „static" or „dynamic". In the first case the boundary is sharp, rectilinear, while in the other case a more complicated contact occurs, they interfinger with each other or sometimes indistinct boundary can be observed between them. NAGY. (1986) separated strong, distinct, indistinct and statistical boundary relating to the nature of the accumulation. Around most of the volcanic fragments a dark limonitic rim appear with various width (0.01—0.04 mm) *(Fig. 11, 12)*. LEHMANN, (1941) explained the dark rim at the contact between the „weilburgit" and the carbonate wall-rock in the Lahn-Dill area (FRG), with physical and chemical influences of the magma penetrating the sediments. BILIK, (1979) suggested that the limonitic rim-zones around the volcanic fragments prove the hot-state embedding of the volcanics. I am of the opinion that the dark rim is the result of the migration of the elements released by the alteration (devitrification) of the glass shards and the glassy groundmass of the volcanic clasts. The water diffusing to the volcanic glass can remove some cations — especially Fe, Mg, Ti and Ca (PESTY, 1985). The Fe and Ti as magnetite and ilmenite may have accumulated at the rim of the volcanic clasts and other boundary of inhomogeneous fields (eg. at the margin of the amygdales). Later these rims were oxidized to limonite. HENTSCHEL and THEWS (1979) stressed that the half-opaque rim appearing at the margin of the vesicles and fragments and composed of Ti-minerals is characteristic to palagonite tuffs.

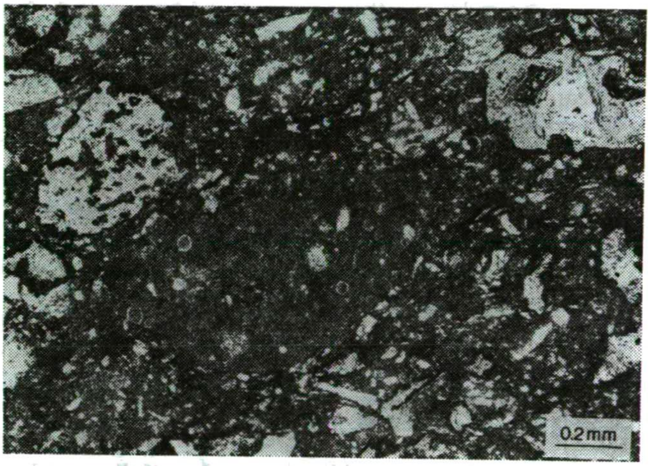


Fig. 11. Clast-free calpionellid limestone clast with indistinct boundary (in the middle of the picture.) The volcanoclastic limestone matrix encloses originally glass shards altered to carbonate minerals, with dark rim around them (Síngödör tributary).

(1) *Volcanic clasts*

According to the embedding state of the volcanics, two groups can be separated (I have to note that this embedding does not mean here only getting into the present matrix, but into a previous carbonate matrix as well.):

(1.1) Volcanic clasts embedded into the sediments in cold, solid-state: they can be characterized by predominantly rounded margin, compaction feature in the car-

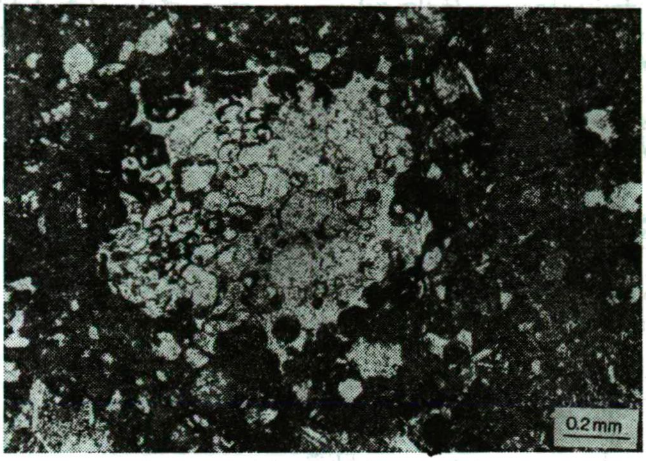


Fig. 12. Originally vesicular glass shard altered to calcite with dark rim around it embedded in limestone matrix (Márévár valley).

bonate matrix near their edges and the oriented calcite crystals around them. Dark rim zone appears rarely.

(1.2) Volcanic fragments embedded into the sediment in semisolid-state: amoeba-like, irregular shape and the „dynamic“ contact are characteristic of this type of clasts. Incorporation of carbonate material by the volcanics is common. Dark rim-zone frequently occur (the chemical interaction may have been stronger in this case), but it can be absent, as well.

The volcanic fragments exhibit different petrographic features (various texture, vesicularity, alteration and composition) indicating that they derived from different lava flows. The majority of the volcanogenic clasts are the irregular, highly vesicular altered glass shards showing strongly cuspate margins formed by the curved interior surfaces of the vesicles. The alteration products are mostly carbonate minerals and limonite, and less chlorite-nontronite. The presence of preserved opaque rims within the clasts indicate the originally vesicular structure *(Fig. 11, 12)*. Alteration of volcanogenic clasts may have taken place in two stages: soon after the initial eruption on the submarine surface and after transportation in the calcareous sediments. The chlorite, chlorite-nontronite and limonite assemblages may indicate the first phase of alteration, while the second stage is represented by carbonate minerals (FLOYD, 1986).

Most of the volcanic fragments being larger than 1 cm in diameter are volcanics with higher crystallization degree. They are characterized by various textures and more or less alteration degree. Olivin and pyroxene are present only occasionally, but generally in the form of carbonate or chlorite pseudomorph. Pyroxene phenocrysts are more common than olivine and in some parts they occur with plagioclase phenocrysts forming cummuloporphyritic groups. Fresh pyroxene are common in the larger (ranging from 5 to 15cm) clasts only. Their optical characters suggest augitic composition.

Plagioclase phenocrysts (0.5—20 mm) are more common than the mafic constituents. They are fresh or medium altered. In the limestone matrix some calcite clasts can be observed, which enclose fresh plagioclase phenocrysts *(Fig. 13)*. Their origin cannot be explained unambiguously because of their small sizes (max. 3 mm) and the lack of similar samples in the volcanic sequence of the Mecsek Mts. The composition of plagioclase phenocrysts was determined by using an universal stage. On the basis of their optical characters they have a composition of An_{50-60}. Plagioclase laths in the groundmass are more acidic, they are andesine-oligoclase, in some part albite in composition.

The originally glassy groundmass altered to chlorite-nontronite or montmorillonite, limonite or carbonate minerals. Tiny magnetite grains and ilmenite-leucoxene needles are very common in it, in some parts they appear densely. In the spilitic basalt clasts fine grained quartz occur quite often.

The great proportion of amygdales in the volcanic clasts are remarkable. Genetically two types of amygdales can be separated: vesicles infilled subsequently by secondary minerals and so-called pseudo-amygdales (Rösler, 1960; Bilik, 1979). These latter are remains of the magmatic incorporation of carbonate material. Steps of the incorporation of carbonate mud can be seen in the mixed rock too, suggested that some of the volcanic clasts were semi-solid in the time of embedding into the calcareous sediment. Some volcanic fragments enclose unaltered calpionellid limestone „amygdales" *(Fig. 14)*, bag-like swallowing of the carbonate matrix is also common at the margin of the volcanics.

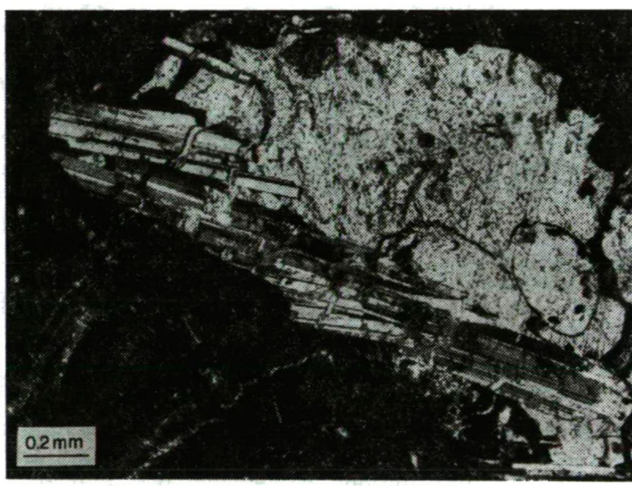


Fig. 13. Clacite clast encloses fresh plagioclase phenocrysts embedded in limestone matrix (Síngödör tributary).

(2) Sedimentary clasts

The two outcrops are different to one another considering the sedimentary clasts. At Singödör side-valley locality younger — Tithonian and Berriasian — rocks dominated (calpionellid limestone), while in the Márévár valley the age of the rocks is predominantly Kimmeridgian and Oxfordian (siliceous limestone) (Nagy pers, comm.). On the basis of embedding, the sedimentary fragments can be divided into two groups: (a) lithified and (b) semi-lithified clasts and fragments embedded in mud-state (see also Nagy, 1986). The contact between the latter ones and the carbonate matrix is indistinct *(Fig. 11)*. The clasts are more or less rounded, some of them

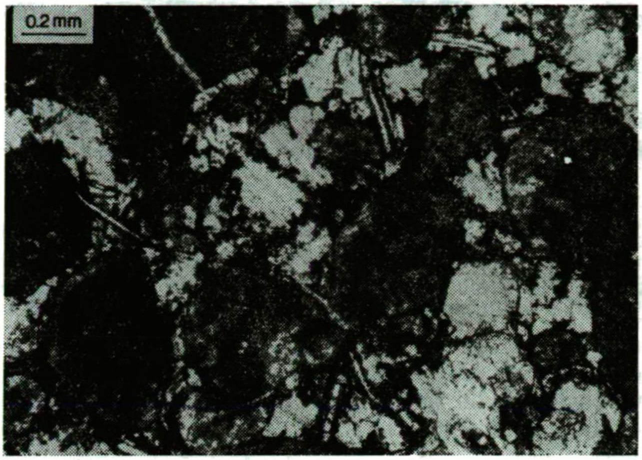


Fig. 14. Calpionellid limestone amygdales in basalt clast embedded in limestone matrix (Márévár valley).

lenticular, but the strongly siliceous limestone, chert and radiolarite fragments are angular. They are free of volcanic material and the limonitic impregnation characteristic for the the matrix, cannot be observable in them.

(3) Crystal clasts

Crystal fragments amount to the minor part of the volcanoclastic mixed rock. In the Singödör tributary the majority of them are plagioclase phenocrysts while in the Márévár valley pyroxene crystals dominate. The plagioclase crystal clasts are predominantly fresh, ranging from 0.02 to 0.5 mm. Their composition is similar to the phenocrysts of volcanic clasts, they are andesine-labradorite. Around some pyroxene crystal fragments compaction features can be observed. They are more or less altered, ranging from 0.5 to 4.5 mm and based on their optical properties their compositions are augitic. In the limestone matrix calcite and chlorite pseudomorphs appear frequently as well. Rounded quartz crystal clasts occur rarely.

(4) Matrix

The matrix of the redeposited volcanoclastic mixed rock is limestone, clayey limestone being coloured by limonite in the parts of the volcanoclastic field. The limestone is micritic, but calcite crystal clasts (0.01—1.3 mm) frequently appear. Generally the matrix itself is mixed, fossils and calcareous materials of different ages build it up mixing chaotically or arranged in bands (NAGY, 1986). The microfossils were identified by NAGY, according to him the matrix of the rock in the Márévár valley is predominantly Lower Kimmeridgian, partly enclosing Upper Oxfordian fossils. Some younger (Tithonian-Berriasian) microfossils can be found in uncertain preservation in the amygdales of a volcanic fragment. At the Singödör tributary and the borehole Hosszúhetény XX. the rock can be characterized by more mixed microfossil assemblage (Lower Kimmeridgian-Berriasian).

FORMATION OF THE REDEPOSITED VOLCANOCLASTIC LIMESTONE

According to the deep sea researches (Deep Sea Drilling Project) it is obvious that in marine environment where volcanic activity occurs, volcanic clasts can be embedded in sediments due to transportation by mass flows (at the flanks of seamounts and at the deep-sea trenches; LONSDALE and SPIESS, 1979; MURDMAA and AVDEIKO, 1980; MOBERLY and SCHLANGER *et al.*, 1986) or pyroclastic eruptions (VALLIER *et al.*, 1977; ROETHE and KOCH, 1976).

The volcano-sedimentary mixed rocks of the Dillenburger Schichten and Langenaubacher Breccia in Lahn-Dill area (FRG) were formed by reef-splitting due to the volcanic activity and the accompanying tectonic movements. Mixed sediments composed of volcanic and sedimentary clasts were accumulated at the flanks of the reef in the basin (LIPPERT *et al.*, 1970).

KOVÁCS, (1988) explained the origin of olistostromes of Uppony Mts., NE-Hungary by earthquakes accompanied by subaqueous basic volcanic activity, which resulted incorporation of the underlying carbonate sediments into the downslope moving lava flow.

A common feature of the Mecsek redeposited mixed rock and the other similar formation (Uppony Mts., Lahn-Dill, Eastern Carpathians) is their connections with submarine continental rift-type basaltic volcanism. The tectonic movements initiated by the rifting made a rough basin topography, smaller and larger seamounts were formed and the differences of bottom levels made possible resedimentation processes.

The age of the redeposited volcanoclastic limestone is not clear. According to the micropalaeontological investigations of NAGY, the oldest constituents of the rock are Upper Oxfordian, the youngest are Berriasian. NAGY, (1986) established a mixing of materials of different ages in Upper Jurassic-Lower Cretaceous limestones and stressed that the lime-mud may have been preserved as long as 30 Ma in unconsolidated state. The lasting lime-mud state is not rare in the recent marine environment: the DSDP Sites-sections expose even Eocene and Cretaceous — mud-state sediments, composed of mixed microfossil assemblages in some parts (eg. Eocene to recent; MURDMAA and AVDEIKO, 1980).

The resedimentation model (NAGY, 1986) can be applied to the interpretation of the formation of the redeposited volcanoclastic limestone. The Late Jurassic-Berriasian sequence of Mecsek Mts. was deposited in a bathyal environment (rich plankton, absence of benthos), but rarely neritic facies occured as well. The complex basin topography and the delayed lithification of carbonate sediments after Oxfordian age made possible the resedimentation and mixing of lime muds of different ages. Initiation of the basaltic volcanism associated with earthquakes and submarine eruptions (formation of pillow lava, lava breccia and hyaloclastite) accelerated this process. Solid and semi-solid volcanic clasts formed large slumps together with limestone blocks, soft carbonate mud and were embedded in carbonate mud in the deepest parts of the basin. Later these local mixed debris flow-sediments were covered by basaltic lava-breccia and hyaloclastite produced by the paroxysm of the volcanic activity.

ACKNOWLEDGEMENTS

Thanks are due to I. NAGY, CS. SZABÓ and I. BILIK for the discussions of the Upper Jurassic-Lower Cretaceous sedimentation and volcanism of Mecsek. I would like to thank I. NAGY for the identification of microfossiles of the mixed rock. I appreciate the helpful comments on our manuscript offered by I. BILIK, CS. SZABÓ, M. KÁZMÉR and S. KOVÁCS.

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Manuscript received, 27 May, 1988