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UPPER PLIOCENE TO QUATERNARY BASALTIC VOLCANISM IN THE PERŞANI MOUNTAINS

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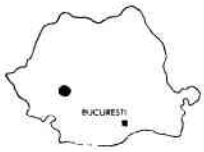

Key words: Volcanic features. Trachybasalts. Xenoliths. Lava flows. Base surges. Fallout. Perşani Mountains. East Carpathians.

Abstract: Upper Pliocene-Pleistocene (2.25-0.5 Ma) small-sized volcanic edifices are aligned on a NE-SW trend over 22 km in the western part of the Perşani Mts (East Carpathians). From north to south, three isolated volcanic centers occur (Sărata, Racoş and Mateiaş), then a larger volcanic area develops - probably initially caldera type - with a lot of eruptive centers (Hoghiz-Bogata Valley) and some isolated occurrences at Comana. The volcanics consist of trachybasalts with abundant lherzolite xenoliths. Volcanic structures are complex, witnessing several superimposed eruptive phases: an initial phreatomagmatic phase caused ejection of juvenile material and great quantities of fragmented bed-rock material, with formation of initial maars; in the second phase lava flows and possible ephemeral lava lakes were generated; the third phase - again phreatomagmatic - with mostly volcanian base surge (with low angle cross bedding) deposits and plinian fallout deposits (proximal with bomb sags), rich in mantle xenoliths; the fourth phase produced strombolian scoria and spatter cones, consisting of agglutinates, agglomerates and lapilli deposits.

Introduction

In the Perşani Mts (Southeastern Transylvania), an intracontinental basaltic volcanic area, representing the youngest volcanic activity in the Eastern Europe, occurs. This north-northeast to south-southeast trending area, including several simple and complex volcanic edifices, is about 22 km long and 8 km wide. It lies between the Sărata Valley to the north and Comana to the south.

Due to its unique spectacular features, the basaltic volcanics were intensely studied by many workers in the past. The first descriptions belong to Hauer and Stache (1863), Herbich (1878), Koch (1900), Wachner (1915) and the earliest petrographic study was done by Laţiu (1928).

As the earliest volcanological approach, Preda (1940) firstly established the succession of volcanic products, the following four sequences being distinguished: (1) lower tuffs, (2) lava flows, (3) upper tuffs and (4) scoria deposits. The volcanic structure and the volcanic history of the Racoş-Hoghiz area have more recently been presented by Mihăilă et al.(1972) and Mihăilă , Peltz (1977). Rădulescu (1969), Rădulescu et al. (1981) and Rădulescu, Săndulescu (1980) suggested an intraplate geotectonic setting for the basaltic volcanism in the Perşani Mts. Other papers were focused on age (Tövissi, 1972; Tövissi, Chintăuan, 1972; Casta, 1980; Mihăilă, Kreutzer, 1981; Ghenea et al., 1981), mantle xenoliths (Măldărescu et al., 1982, 1983), petrology (Peltz, Bratosin, 1971, 1986; Peltz et al., 1972; Peltz, Peltz, 1983; Peltz, Stoian, 1985; Peltz et al., 1985).

Following recent geological investigation based on lithological and petrographical observations, a more detailed picture of the eruptive history in the Perşani Mts has been obtained.

The petrographical and petrochemical investigations highlight the mineralogical and chemical homogeneity of the alkali-basaltic volcanics, disregarding their position in the lithological columns and occurrence areas. According to these data, they are mainly of trachybasaltic composition (Peltz, Bratosin, 1986).

Volcanic sequences

Explosive and effusive basaltic volcanic products occur in four areas: Sărata Valley, Racoş-Mateiaş, Hoghiz-Bogata-Trestia Valley and Comana de Sus (Fig. 1). The northernmost area is located along the

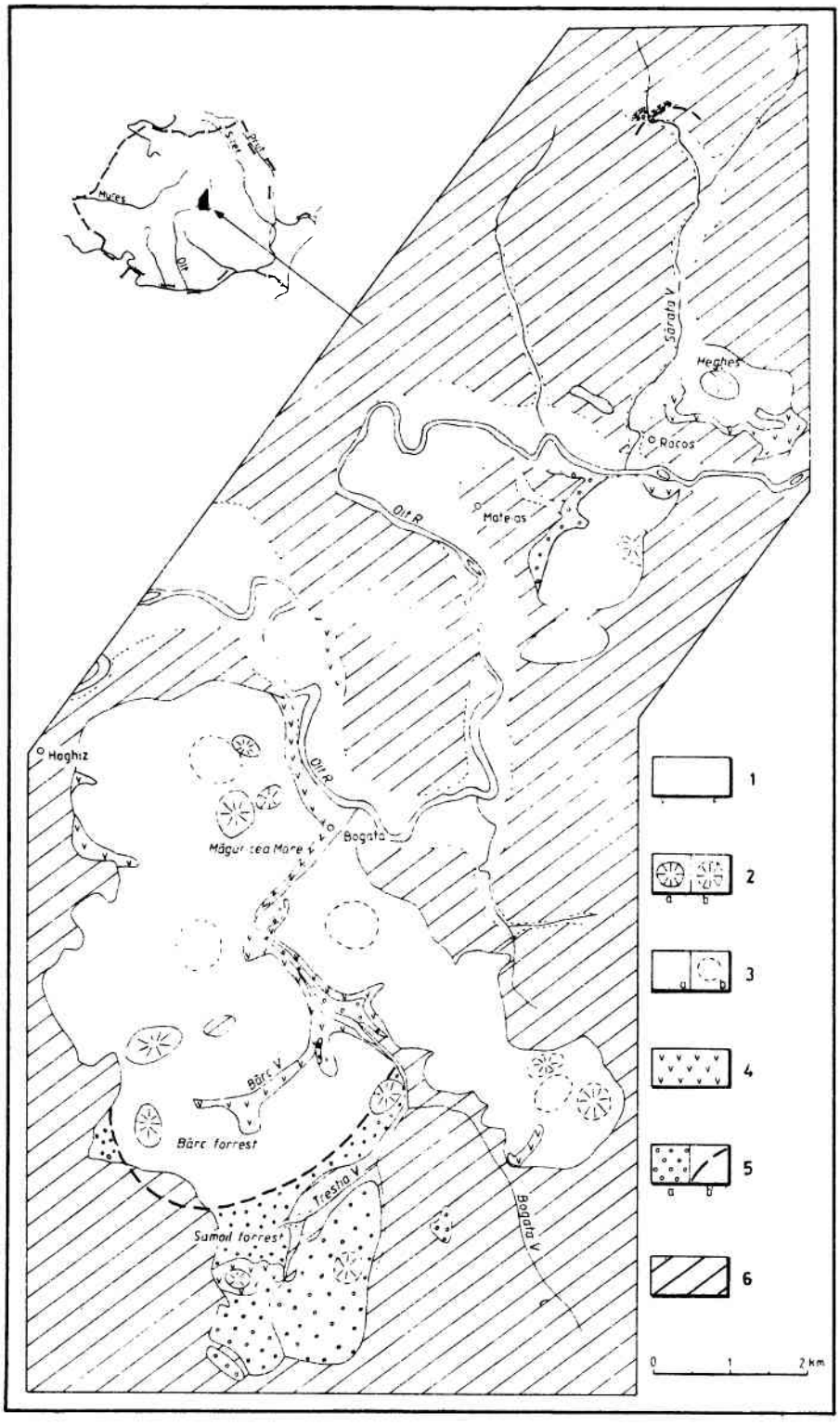

Fig. 1 Geological sketch of the area with Quaternary basaltic volcanism in the Perşani Mts (Romania). 1, Holocene alluvia; 2, Fourth stage: scoria cones: a)mapped; b) presumed; 3, Third stage pyroclastics: a) fallout and base surge deposits, b) presumed tuff-rings features; 4, Second stage: lava flows; 5, First stage pyroclastics: a) base surge, fallout and flow deposits; b) presumed outline of tuff-ring border; 6, Prebasaltic Mesozoic and Cainozoic sedimentary and volcanic formations.

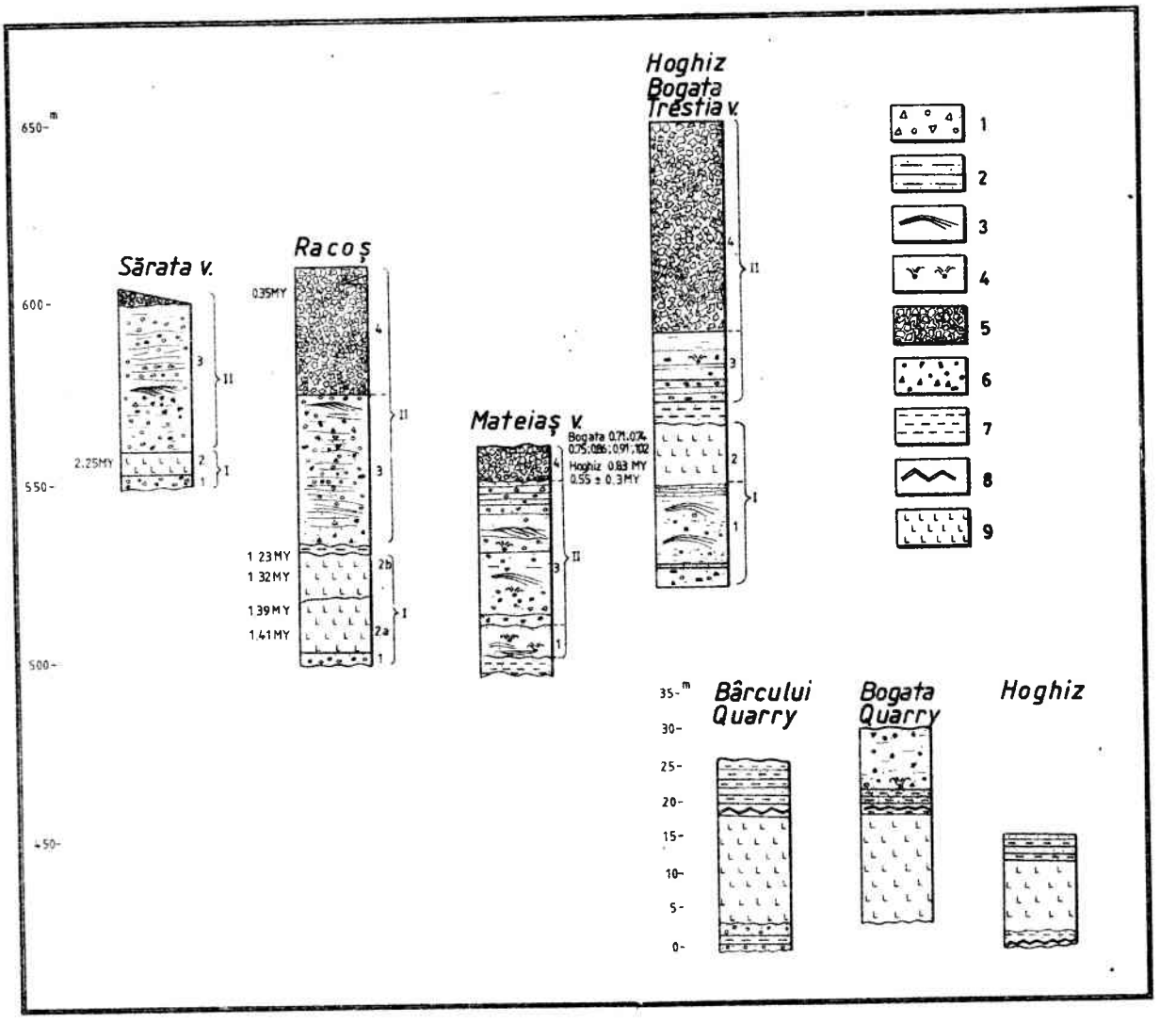

Fig. 2 Synthetic lithological columns in basaltic sequence in Perşani Mts. 1, lapillistone, lapilli tuffs; 2, tuffs; 3, dunes; 4, ballistic blocks; 5, agglutinates and scoria tuffs; 6, accidental fragments; 7, clays; 8, paleosoils; 9, lava flows.

Sărata Valley, 5 km north of Racoşul de Jos village, covering about ca. 0.3 sqkm. The second area, of about 3.5 sqkm, occurs at both sides of Olt River near Racoşul de Jos and Mateiaş villages. The third and most extensive occurrence covers almost 40 sqkm, between Hoghiz and Bogata to the north and the waterheads of the Trestia Brook to the south. The southernmost area is situated at the Comana Valley covering 1.5 sqkm; however, it is not included in our following considerations. All these occurrence areas are distributed along NNE-SSW trending tectonic line.

The succession of volcanic sequences is presented in four generalised lithological columns, corresponding to the mentioned occurrence areas. K-Ar ages are displayed too, according to Casta (1980), Mihăilă, Kreutzer, 1981, Ghenea et al. (1981) (Fig. 2).

1. In the east-side bank of the Sărata Valley, an about 60 m long outcrop occurs. In its lowermost part a 2.5 m thick sequence of pyroclastic deposits, consisting of alternating poorly stratified and poorly sorted lapillistones and lapilli tuffs, can be seen. They display in places crossbedding laminae and lenticular features. Essential pyroclasts include porous or scoriaceous lapilli embedded in a poorly welded ashy matrix. Typical lapillistones tend to occur as lenticular beds. Occasionally larger fragments appear as scoria and as cauliflower-type bombs. The pyroclastic deposit is rich in accidental material represented by lithic fragments disrupted from the prevolcanic basement (Myocene rhyolitic tuffs and quartz pebbles).

At the upper part of the sequence, well-bedded lapillistones, containing fewer accidental fragments, prevail. The observed features suggest phreatomagmatic eruptions with pyroclastic surge and fallout emplace-

ment mecanism.

The described deposits are topped by a lava flow with variable thickness (7–10 m) and with a blocky-jointed basal part. At the top of the lava flow, a transition to lapilli tuffs and lapillistones showing distinct bedding planes can be observed. At the upper part of this 5–10 m thick sequence, well-stratified pyroclastics, almost lacking essential components, crop out. Fine and coarse accessory basaltic lapilli, with a compact structure and accidental material (Mesozoic limestones, diatomites, quartz pebbles and Miocene tuffs) are the major components. Lherzolitic mantle xenoliths are also present. This sequence displays base surge depositional features originating in a phreatic eruption.

Some isolated basaltic scoria blocks have been found near the outcrop area, suggesting the possible presence of the strombolian fallout deposits, too.

2. In the Racoş-Mateiaş area, two lithological columns corresponding to two different volcanic structures will be described. At Racoş, plan-parallel layered lappilli tuffs occur in the lowermost part. Their essential components consist of dense or porous basalt fragments. The sequence is 2–2.5 m thick, poorly sorted and normally graded. It contains abundant accidental fragments, represented by quartz pebbles, Miocene tuffs and older limestones from the basement (Pl. I, Fig. 1).

In the main quarry of Racoş, at the base of the outcrop, the transition from first-phase pyroclastics to lava flow can be well noticed. Various developments of the cooling-generated joint pattern across the flow can also be studied. The thin (0.3–1 m) vesicular blocky-jointed basal part turns upwards into a thick (5–10 m) collonade in the middle of the flow and then into platty-jointing (1–2 m) at its uppermost part. In the western corner of the quarry, a vertical contact between lava and former pyroclastics marks the margin of a lava pond. The lava itself locally displays curved columns and two superposed collonades, separated by a thin platty-jointed zone suggesting two superposed flow units in the pond. Locally, some interesting structural features, mainly in the upper flow units, can be observed here in some blocky-jointed rocks. Chilled borders and grey or pinkish-brown core, showing granulated structures are obvious. Hit with a hammer, these rocks are disaggregate in small irregular, polyhedral, more or less equant, fragments (Pl. I, Fig. 2). These features were previously described as "cucuruz basalts" by quarry workers. Their average grain-size is similar to that of lapilli from almost all lapilli tuff deposits.

In the eastern part of the main quarry a lava tunnel with elliptical section has been found in the lower part of the lava flow. It is now partially filled by with an argillaceous material containing basalt blocks. Peridotitic xenoliths showing a rounded shape and 15–35 cm in diameter are frequently enclosed in the lava flows. Joint-plane fissures and larger vesicles contain in places incrustations and druses of well-crystallized calcite, generated from post-volcanic solutions.

In the main quarry a well-bedded lacustrine sedimentary sequence (argillaceous sand) with a thin discontinuous limestone level at the base is exposed on top of the lava flows.

In the eastern quarry of Racoş, thick sequences (tens of meters) of well-bedded pyroclastics overlie the lava flows, as a second pyroclastic level in the lithological column. A succession of finely bedded (cm, dm) poorly sorted lapilli tuffs, enclosing scoria and abundant accidental material, is well exposed. At the lava flow-pyroclastics boundary, a phreatic deposit made exclusively of accidental fragments is present. The patchy appearance of this sequence is a consequence of different abundance of light-coloured accidental fragments contrasting with dark essential material (Pl.II, Fig. 1). Locally, the deposits are updomed and cut by numerous normal faults, likely due to shallow intrusions accompanying the last phase activity (Pl. II, Fig. 1).

In the upper part of the quarry, unconformably overlying reddish scoria lapilli, layers of the neighbouring Hegyes scoria cone can be seen.

The Hegyes scoria cone is well exposed, due to its long-time excavation, now displaying only its remnants - a central pillar and surrounding lowered border. Repeated unconformities are visible in the walls of the central pillar, suggesting a complicated inner structure and significant changes of the summit area during the building up of the cone. Cone-building material mainly consists of coarse scoria fragments, bombs and spatter including tiny lava tongues in the central part and of finer unconsolidated scoria ash and lapilli layers at the periphery. Grain-size variation in the latter reflects pulsating intensity during the eruption.

At Mateiaş, near the Mateiaş Brook mouth, fine sand deposits with few coarse sand interlayers, several meters thick, occur. The deposit consists of basaltic component with frequent admixture of Miocene Perşani tuff fragments. Several thin mica-sand interbeds also occur. It displays plane-parallel and in places sandwave laminations with bedding set thicknesses of 0.05–0.5 cm. The bedding sets locally show some grading and sorting. Backset lamination in dune-like structures dips 15–30^0 towards SW, suggesting an origin in a NE situated volcanic source.

Upstream, along the Mateiaş Valley, a sequence of pyroclastic deposits is exposed. They consist of plane-parallel bedded tuffs (centimeter to decimeter thick) displaying multiple normal grading (Pl. II, Fig. 2), rarely reverse grading and in places dune-like cross-

bedding (Pl. II, Fig. 2), and fine tuffs showing mantle bedding and a network of fine polygonal cracks. Compositionally, they are characterized by the variable abundance of essential and accidental fragments.

Another important feature of this sequence is the presence of numerous bomb-sags formed by the impact of accidental ballistic blocks that fell in the soft moistened fine ash layers (Pl. III, Fig. 1). Bomb sags are obviously symmetrical and only a few assymetrical ones have been found, suggesting their source towards east. Impacting blocks are lacking from certain sags. These small impact depressions favoured coarse-fraction accumulation from the base of the next deposit (Pl. III, Fig. 1). The features of the sequence are characteristic of subaerial fallout and surge mechanisms.

At the bottom of the sequence a 0.5 m thick bed of clay is exposed.

The next sequence is 2-3 m thick and consists of massive unsorted lapilli tuff, showing local concentrations of accessory basaltic blocks (0.5–1 m in diameter) or Miocene Perşani tuff accidental fragments (0.3–0.7 m in diameter). Its features are consistent with the pyroclastic flow origin of the sequence.

Another bedded sequence (10 meters thick), showing a slightly coarser grain-size, follows. It is represented by lapillistones and some fine and coarser tuff interlayers, within which the essential component prevails. Accidental Perşani tuff fragments enclosed in this sequence - and in the previously described one as well - are well rounded and display desiccation cracks (Pl. III, Fig. 2). Planar and wavy bedding with internal cross-lamination in places, normal grading and the presence of bomb sags are the main structural features of the sequence, suggesting subaerial fallout and base surge emplacement processes.

In the Mateiaş Valley area, the uppermost sequence is a 10-15 m thick massive to poorly bedded deposit, consisting of more or less welded ash and basaltic scoria, agglutinated spatter in places, typical of strombolian explosive activity.

In the Mateiaş quarry, on the left side of the Olt River, a lava flow sequence more than 50 m thick crops out. A giant inclusion of bedded tuffs (10/7 m) engulfed in the lava flow can be seen in the quarry, suggesting former explosive activity. Another sequence of bedded tuffs is present at its top. It is not very clear whether the lava flow is confined to a local vent, or its eruption center is situated somewhere within the Racoş area, where the effusive activity was important.

The generalised lithologic column for the Hoghiz-Bogata-Trestia Valley area is shown in Figure 2.

Like in all other areas, the first-phase volcanic activity displays an explosive character, during which thick sequences (tens of meters) of bedded pyroclastics accumulated. They are well exposed on the left side of the Trestia Brook (Pl. IV, Fig. 1) and in La Gruiu area. These deposits consist of various grain-sized pyroclastic rocks, ranging from blocks to fine ash-sized fragments. They are typically composed of coarse accidental clasts (Mesozoic limestone, conglomerate pebble and gravel, Miocene rhyodacitic tuffs, disrupted from the basement) of more or less porous essential basaltic lapilli, and of an abundant basaltic ash matrix. Locally, abundant mantle xenoliths and loose amphybole and pyroxene megacrysts are included.

In the northern and eastern part of the area, the sequence is thinner (1–5 m) and in places it overlies a clay deposit displaying paleosol features at its top (Pl. IV, Fig. 2). In the Bogata area, this sequence has not been found. Depositional features suggest subaerial fallout and surge deposits.

Initial explosive activity was followed by massive lava outpourings. Lava flow sections are well exposed in several quarries along the Bârc and Bogata valleys and in natural outcrops along the Hoghiz and Trestia valleys, and in the left bank of the Olt River, near Bogata. The lava flow thickness is relatively constant (10–15 m). The basal part is vesicular, displaying horizontal platy jointing, which turns upwards into vertical columns (Pl. V, Fig. 1). The upper part occasionally presents blocky fragmentation similar to that of Racoş lava flows, showing inhomogeneous and granulated structure. At Hoghiz this kind of structures seems to be generalised for the entire lava pond.

On top of the lava flow, an argillaceous sequence has accumulated, as it was observed in the Bârc and Bogata quarries. This lacustrine deposit contains several tiny intercalations of fine airfall tuff.

The next sequence is well exposed in the Bogata quarry, being represented by well-bedded pyroclastic deposits (7–10 m thick). In their lower part accidental fragments prevail, represented by limestone, Perşani tuff (most of them rounded with desiccation cracks), quartz pebble and gravel. Some bomb sags have been observed too. In the upper part of the sequence, cross-bedding lamination typical of base surge depositional processes can be seen, whereas in the lower part of the sequence fallout deposition prevails.

As in the whole Perşani basaltic province, volcanic activity finished with scoria cone building strombolian eruptions (Pl. V, Fig. 2). Seven cones displaying well preserved morphology have been recognised; among them Măguricea Mare, Măguricea Mică, Gruiu and Trestia are best exposed. Local presence of scoria blocks and bombs (Pl. VI, Fig. 1) in some other areas, without associated relevant morphology, has also been found. Strombolian fallout deposits exposed in the quarry north of Măguricea Mare are similar or identical to those described at Racoş (Hegyes Hill) (Pl. VI, Fig. 2).

Volcanological interpretations

Despite of some differences in their K-Ar ages (Casta, 1980; Mihăilă, Kreutzer, 1981), the various occurrence display similar sequence successions of the explosive and effusive products. First phase activity was explosive everywhere. Large-scale phreatic and phreatomagmatic explosive activity occurred, during which a complex sequence of subaerial fallout and base surge deposits accumulated. Phreatic and phreatomagmatic eruptive centers were likely of maar and/or tuff-ring type. Their initial features were not preserved, due to the subsequent volcanic activity. Based on bedding plane position measurements and using overall deposit geometry and some morphological criteria, some of them have tentatively been identified, the largest one in the Barc-Trestia valleys area.

Initial explosive activity was followed by massive lava outpourings, probably in the craterial areas of the former maar structures. The observed lava flow sections suggest an unique flow unit, except for Racoş area, covering land surfaces around effusive vents. The source areas were located at Sărata, Racoş, Bogata-Hoghiz and Barc-Trestia valleys. The source of the Mateiaş lava flow could be either from a local vent, or from the Racoş center.

The two initial (explosive and then effusive) phases could be interpreted as a first-stage volcanic activity all over the area. Geological observations suggest a longer repose time following this first stage during which local lacustrine environments developed and argillaceous sequences accumulated at the top of the lava flows. Thin intercalations in some clay deposits (Barc Valley) suggest intermittent small-scale explosive activity occurring at this time.

The second-stage activity started again with phreatic and phreatomagmatic explosive eruptions. The resulted deposits show similar features to those of their first-stage counterparts, including prevailing fallout and surge deposition. Volcanic activity was not synchronous at different eruptive centers, since overlapping spatial relationships between the same-stage pyroclastics belonging to different vents have been encountered, such as along Mateiaş Valley, where phreatomagmatic deposits from a local vent overlie distal phreatomagmatic tuffs belonging to an eruptive vent in the Racoş area. Vent locations during this stage were partly the same as for the first stage activity, but new vents have likely been added. They were recognised as circular depressions, well expressed morphologically in the Hoghiz-Bogata-Trestia Valley area. Their initial features likely were of tuff-ring type.

Volcanic activity ended in the Perşani Mts with scoria cone building strombolian eruptions, as a consequence of the decreasing magmatic volatile content and /or external water availability to trigger explosive magma-water interaction.

The occurrence of the two main eruptive stages is interpreted as a result of two magma pulses, each of them starting with violent explosive eruptions, followed by less energetic eruptive events.

The best preserved volcanic features are the scoria cones. They are superimposed upon first-stage volcanic edifices partially destroyed by second-stage phreatic and phreatomagmatic eruptions. Of all, the Hoghiz-Bogata-Trestia Valley occurrence area displays the most complex structure, including several adjoining and/or coalescing tuff-ring type edifices, partially invaded by ponded lava flows during the first stage, and superimposed second stage scoria cones or their remnants.

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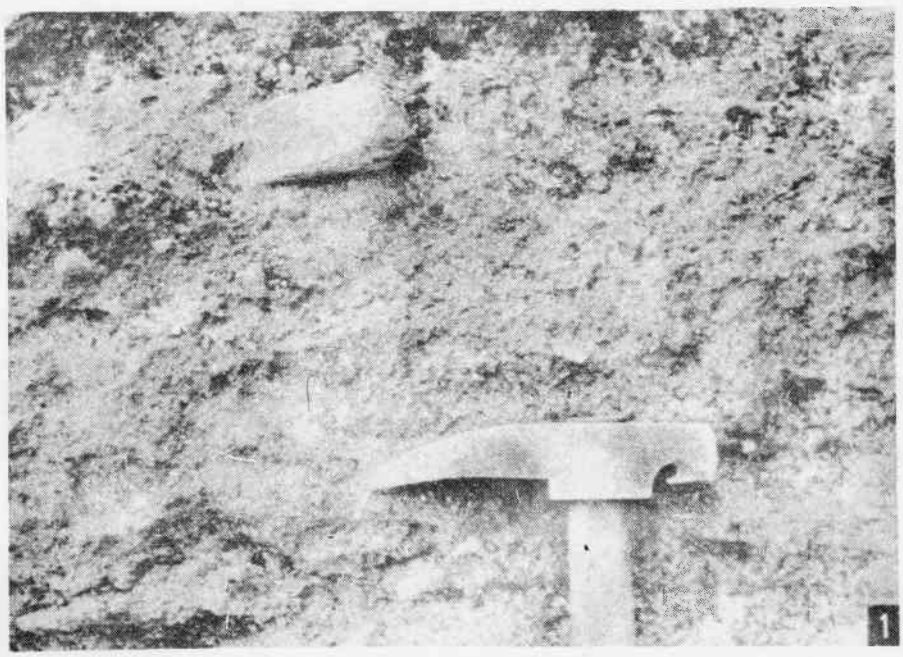

Fig. 1 – Accidental fragments of Miocene rhyolitic Perşani tuff (1) and Mesozoic limestone (smaller, light-coloured) in first-stage phreatomagmatic deposit; Racoş quarry.

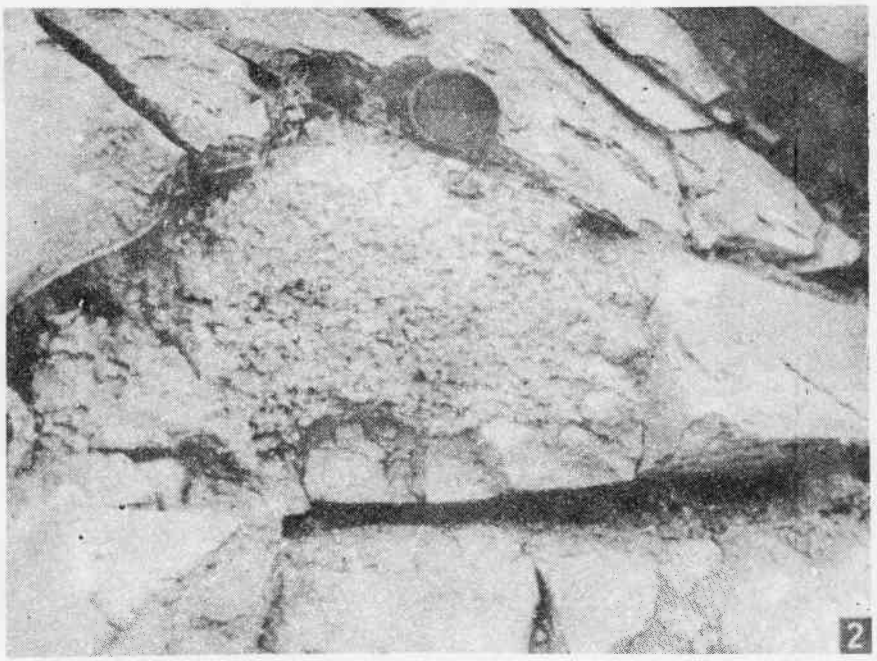

Fig. 2 – Detail in blocky jointed lava flow with granulated core ("cucuruz basalt") and massive crust within a polyhedral block; Racoş quarry.

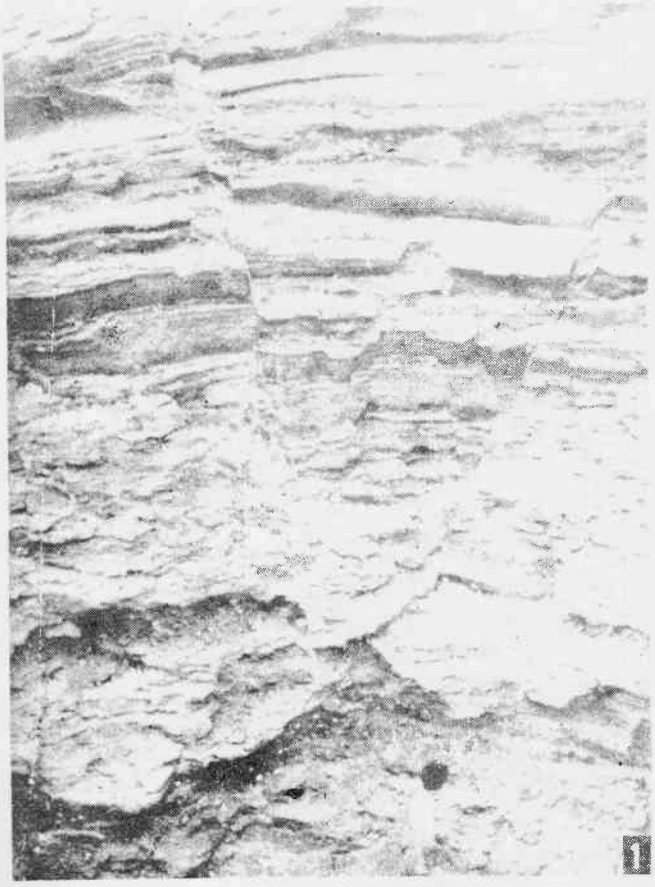

Fig. 1 – Layered third-stage phreatomagmatic deposits showing postdepositional uplift and normal faulting in the north-eastern quarry at Racoş. Small light-coloured fragments represent accidental material.

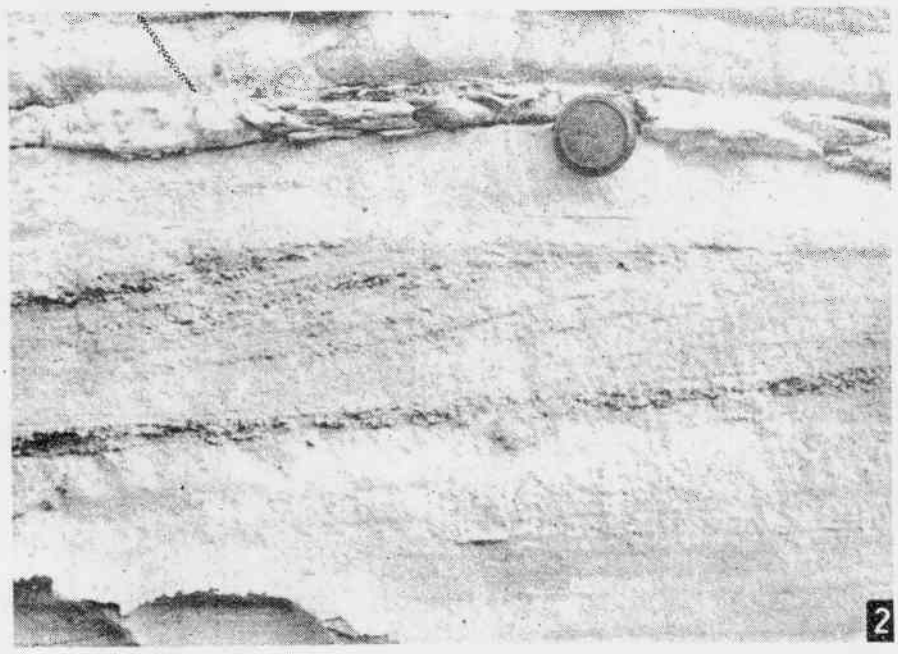

Fig. 2 – Horizontally layered phreatomagmatic ashfall and cross-bedded base surge deposits; first-stage pyroclastics; Mateiaş Valley.

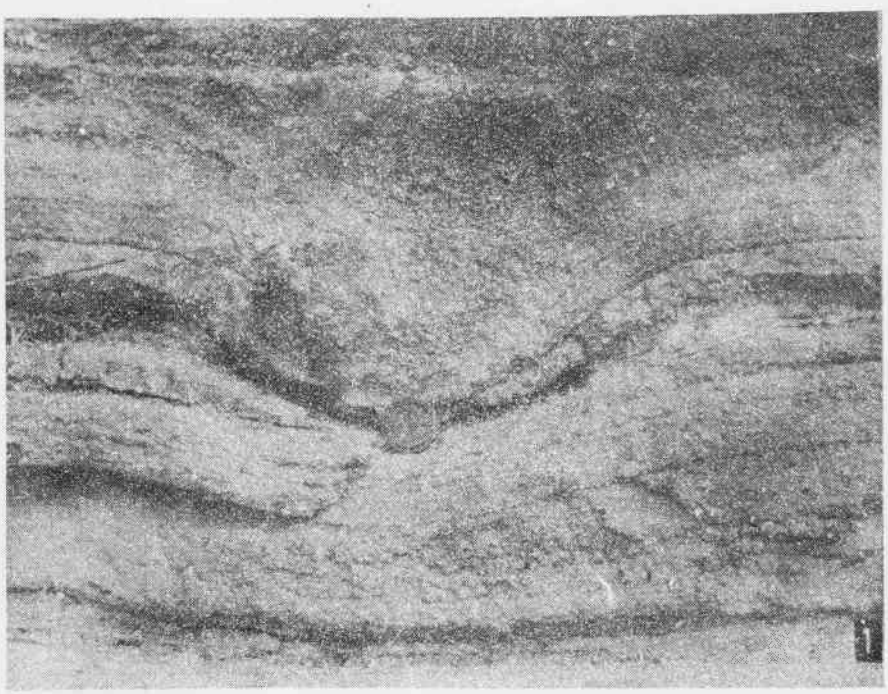

Fig. 1 – Bomb-sag in horizontally layered phreatomagmatic ashfall tuffs; Mateiaş Valley. Note the coarse-grained filling in the sag from the overlying bed. Polygonal desiccation crack network in the light-coloured fine fallout ash at the bottom of the picture is an evidence for wet-ash deposition.

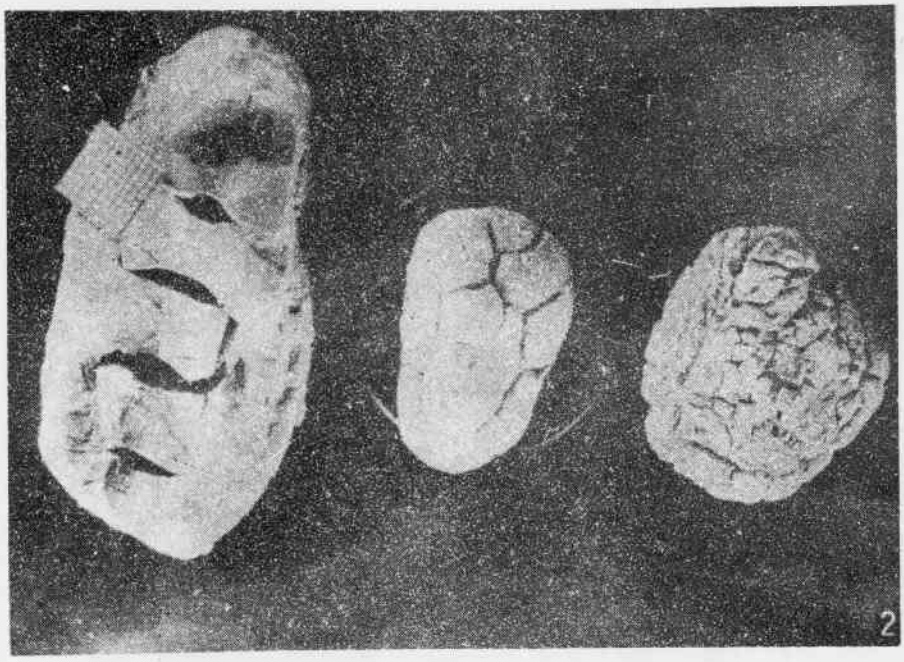

Fig. 2 – Rounded accidental Miocene tuff fragments with desiccation cracks in base surge deposits; Mateiaş Valley.

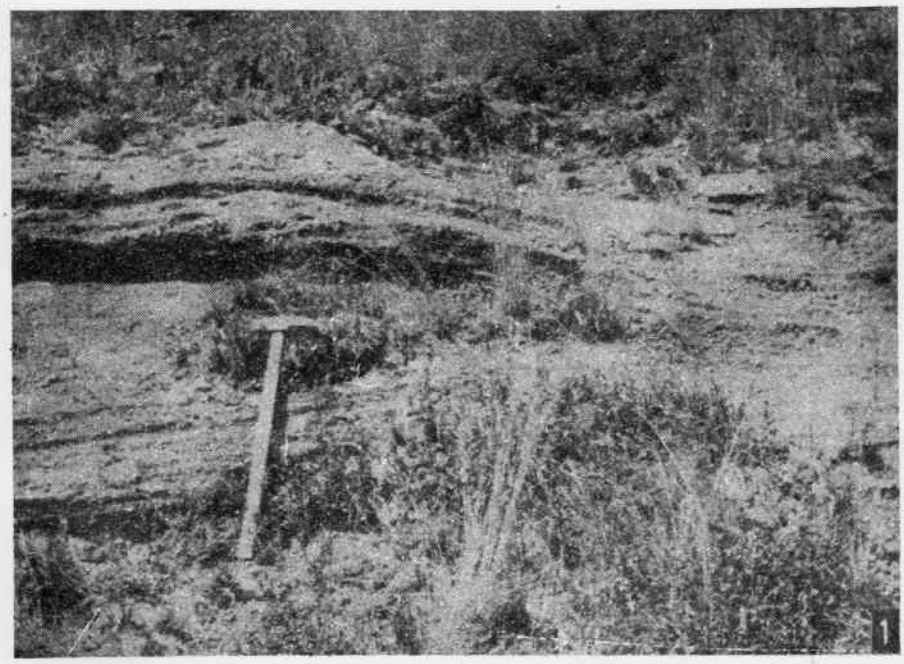

Fig. 1 – Cross-bedded base surge deposits within first-stage pyroclastic sequence croping out in the northern side of the Trestia Valley.

Fig. 2 – Unconformable boundary between Quaternary argillaceous deposits – solidificated in its uppe part – and layered pyroclastic fall deposits. Note mantle bedding at the base of pyroclastics Bârc Valley.

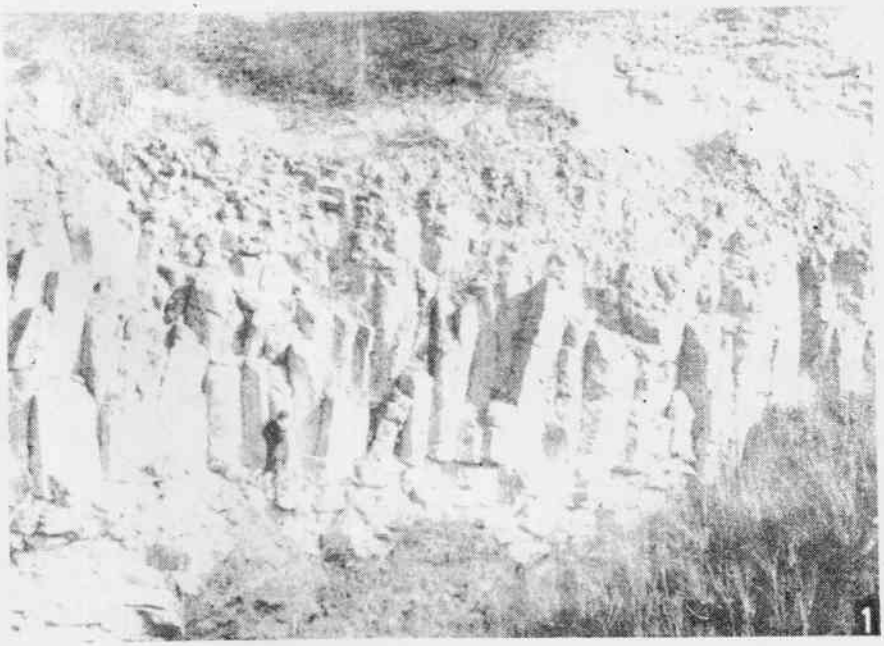

Fig. 1 – Lava flow displaying basal platty jointing (a), vertical columns in the middle part (b) and blocky fragmentation at the top (c). It is covered by third-stage pyroclastics. Bogata quarry.

Fig. 2 – Typical scoria cone morphology slightly modified by subsequent erosion. Gruiu cone.

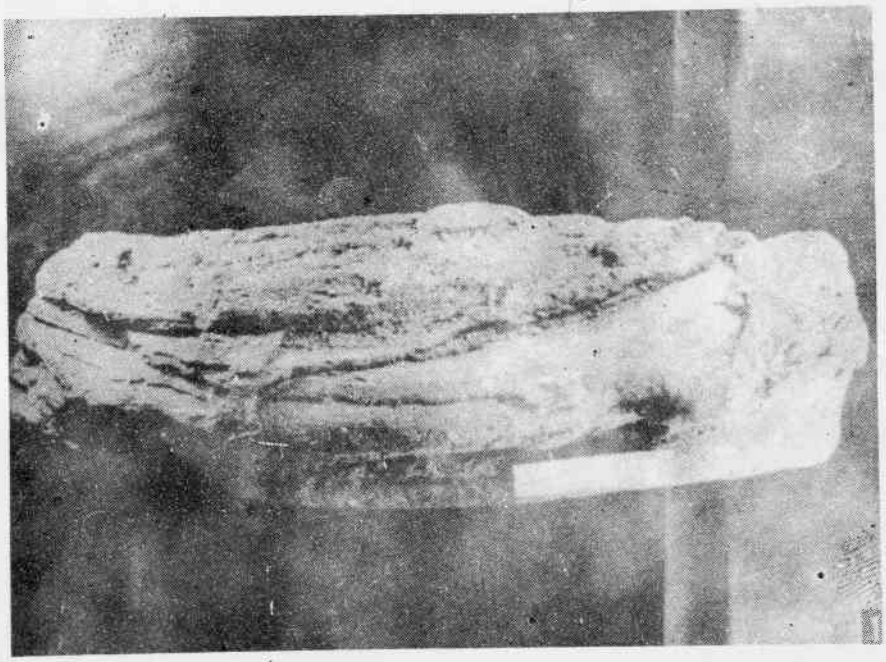

Fig. 1 – Slightly contorted ribbon bomb from one of the scoria cones west of Trestia Valley.

Fig. 2 – Agglutinate (spatter deposit) in the central part of the Măguricea III scoria cone. Note bread-crust cracking on the surface of some scoria fragments (right bottom) and highly vesicular interiors of many scoria.