THE SARMATIAN VOLCANIC CLASTS IN SEDIMENTARY SEQUENCES FROM RÂMNICUL SĂRAT BASIN – SOURCES AND DEPOCENTERS

NICOLAE ANASTASIU [1], LUISA MAN [2] and CĂTĂLIN TRIFAN [3]

Bucharest University, Geology and Geophysics Faculty, Mineralogy Department, 1, Nicolae Bălcescu Blvd., Bucharest, Romania
E-mail: nicanastasiu@gmail.com; man_luisa@yahoo.com; trifan.catalin@yahoo.com

Received November 4, 2009

The petrographic diversity of facies in the Sarmatian sequences outcropped in Râmnicul Sărat valley, represents a good opportunity to reconsider the potential connection between the "source area" and the "depositional area". The sedimentary sequences in Râmnicul Sărat valley, dated between 7 and 13 million years (Mațenco *et al.*, 2004, Panaiotu *et al.*, 2007); we applied methods were sequence analysis, grain size and shape analysis following a systematic optical examination of thin sections. The sequences include clastic and biotic facies, from the (predominant) gravely and sandy to the silty-clayish ones, associated in couples (rhythmites) or microsequences (FUS); biotic facies actually represent bivalve storm deposits with various structures.

The *source area* or areas that supplied the basin, starting from the quality of the texture spectrum, from the immaturity of some of the primary sediments (now, *para-gravels* and *graywacks*) into defining petrotypes for the mass flows, must be accepted as having a proximal position, hence close to *depositional areas*.

The abundance of feldspars (plagioclase –An $_{15,25\text{-}45}$ with an evident and recurrent zonality), sometimes more than 50% of the modal spectrum and the diversity of volcanoclast types (from andesites and hornblende andesites, to tuffs (?) and rhyo-dacites) is unequivocally indicating their origin from former volcanic rocks located in the proximity of the sedimentation area; probably related to a volcanic arch with acid and basic events.

Key words: Eastern Carpathians; Sarmatian; Volcanic clasts; Sandstone.

In the bend zone of the Eastern Carpathians, the Sarmatian sedimentary sequences has a well defined coverage and it is delimited by Badenian formations, on the base, and by Meotian formations, on top. Its geotectonic position is double-sided because its northern extremity rests in the Carpathian foredeep area, as a wedge-type complex, distorted by the orogen push towards the foreland basin, and the southern one expands quasi-horizontally in the depozone between in the foreland central and extremely south-eastern column.

The petrographic diversity of facies in the Sarmatian sequences outcropped in Râmnicul Sărat valley, just south of Jitia locality, represents a good opportunity to reconsider the potential connection between the "source area" and the "depositional area".

PREVIOUS RESEARCHES

The sedimentary sequences in Râmnicul Sărat valley, dated between 7 and 13 million years (Mațenco *et al.*, 2004, Panaiotu *et al.*, 2007), in vertical position and in the proximity of Badenian deposits (these being also distorted and lifted vertically) represents a segment of prismatic bodies consisting of "*wedge-top*" deposits (Tărăpoancă *et al.*, 2004, Leveer, 2007). Dating on paleontologic criteria is known for a long time (Tătărâm, 1984, Olteanu, 2006, Stoica 2005).

Proc. Rom. Acad., Series B, **2009**, *2–3*, p. 159–165

The deposit thickness represents variable values from one place to another (400–1000 m, Jipa, 1999), and their lithology is dominated by siliciclastic sequences, with micro-conglomerate, arenaceous, silty and clayish terms (marls, fine sands), associated in couples, predominantly periodical (Jipa, 1999, Negulescu, 2001, Panaiotu, 2004). The described petrotypes include the presence of unaltered volcanic lithoclasts (andesites, andesitic basalts, Panaiotu *et al.*, 2007), textural immaturity and poor sorting and attributed, as primary source, to vulcanites in Calimani Mts. (active 9.4 million years ago, Panaiotu *et al.*, 2004, Pecskay *et al.*, 2006).

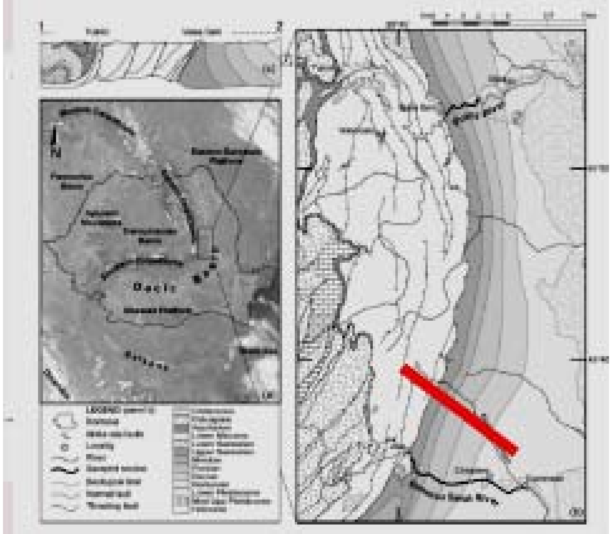

Fig.1. Location of study area; the bend zone of the Eastern Carpathians.

METHODS

The detailed knowledge of the Sarmatian clastic sequences required the deployment of sequence analysis, namely the layer-by-layer mapping of the entire profile, identification of depositional facies by decoding the limits between the layers and sequences, their grain size and shape analysis (with direct measurements and evaluations, macroscopic and microscopic) and, following a systematic and controlled probing, the optical examination of thin sections. The mapped interval developed the shape of a LOG (an expressive lithologic column), which we coded and were able to detect facies associations of various size categories (cycles).

ANALYTICAL DATA – RESULTS

The researched suite is open on a 100 m thickness. Elevated on 1:20 scale, it could outline 4 sequences (mesosequence – facies associations) well delimited and distinctive through their layer particularities (thickness, expansion...), through the facies association type, grainsize and petrographic contents. Specific sedimentary structures, internal or superficial, act as depositional markers in the layer position control.

The ratio between clastic fractions, coarse and medium (R-A) and fine fractions (S-L) are outlined from the first observations as another criterion to separate the mesosequences.

Well delimited sequences through erosion discontinuities or sudden facies changes (unconformity, paraconformity) cumulate metric, variable thicknesses, and represent depositional cycles of the III, IV and V degree (eustatic cycles, paracycles and orbital cycles – Bayer & Seilacher, 1985, Berggen *et al.*, 1995). They include clastic and biotic facies, from the (predominant) gravely and sandy to the silty-clayish ones, associated in couples (rhythmites) or microsequences (FUS), repetitive; biotic facies actually represent bivalve bioaccumulations (especially), with various structures.

Grouping the facies in the geometry of the examined suite allows distinctive, compatible and defining associations for environments and positions (compared to the potential source). Thse associations can be called mesosequences. They alternate from base to the top and indicate transitions from the marine environments (coastline **[A]** – neritic **[B]** and **[C],** to transition environments (most probably, deltaic **[D]**.

The base sequence – **A** – with coastline facies, micro-associations: Am-Amg-Agr-Abi; S-Lpc, S-Lpdic, Rit is delimited in the base by shales/badenian formations and by the first level of bivalves, on top.

The detected petrotypes are: *subquartz sandstones, lithic sandstones* and *subfelspatic sandstones*, often with calcite cement; *sediclasts* are identified in the base terms of the sequence (*cherts, micrites*), *metaclasts* (*quartz, mylonites*) and **volcanoclasts** (*andesites* with fluidal textures). Present feldspars (8–30%) are plagioclase (An_{20-35}), frequently Albit twin crystals (010) with recurrent zoning (!!) and potassium feldspars, microcline with annealing twins in grid.

Medium sequences (average) – **B1, B2 and C**, dominated by the presence of bioaccumulation facies suggest marine environments – coastline and neritic zones; delimited in the base by a plane surface and an almost sudden transition to a fauna “explosion”, has the top part marked by an obvious erosion surface.

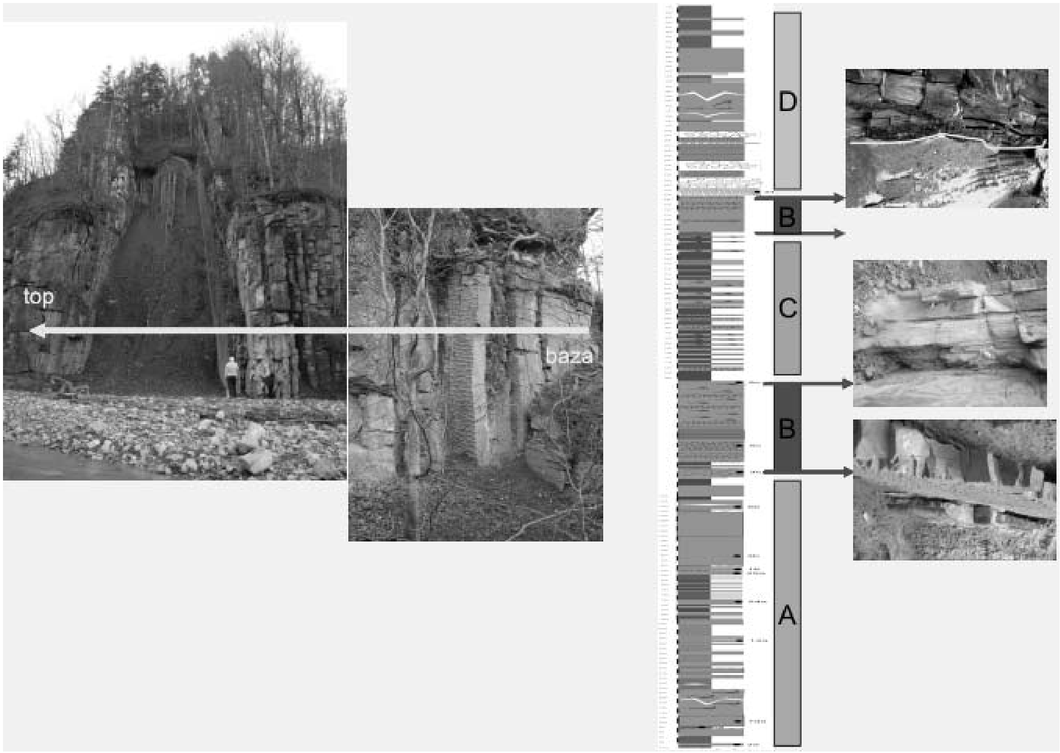

Fig. 2. The outcrop from Ramnicu Sarat Valley, close to Jitia; General log, unconformities and four sequences : A – coastline facies, B – neritic-shelf facies, C – outer shelf facies, D – microdelta facies.

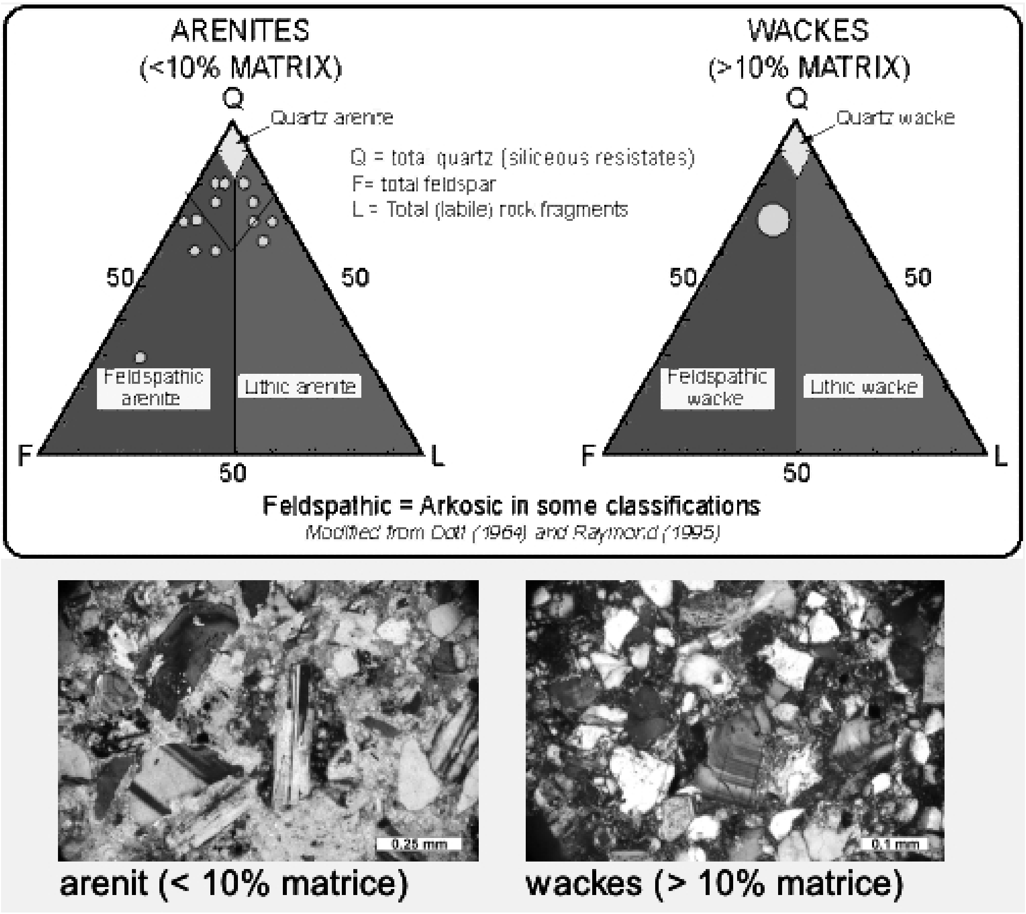

Fig. 3. Plot of sandstone samples on the QFL –Folk diagram.

Petrotypes are dominated by *feldspatic sandstones* (arkoses, subarkoses) and, subordinately, by the *sublithic* ones with low cement and, more frequently, with clayish matrix (?!) (in this case, the terms representing *feldspatic graywacke*). Hybrid petrotypes – *bioclastic sandstones* – occur repetitively and indicate the high frequency of bivalve associations; therein, cement is calcite.

Lithoclasts are extremely varied: frequent *sediclasts* (*cherts, micrites, sparites*) are added with *ooides* of various types (concentric, radial, with bioclastic or volcanoclastic cores); *metaclasts*, subordinated, are represented by *quartz, black quartz, phyllites, mylonites*; **volcanoclasts** are highly diversified and indicate a bimodal characteristic: *andesite with hornblende*, *fluidal andesites*, fresh, but also altered (clay mineral products, oxidation, secondary calcites), together with *rhyolites* with quartz phenocrystals, in a micro and crypto-crystal matrix. Plagioclase feldspars ($An_{22\text{-}40}$) 8–28% in the base sequences and over 50%–60% in those on top of the mesosequence are dominated by the volcanic ones (recurrently zoned crystals) fresh and also altered (secondary calcite, clay mineral products). Microcline, also present, is perthitic.

Bioclasts, represented by bivalves (*Mactra caspia, Mactra bulgarica* – Stoica, 2007), whole or fragmented, partially corroded and dissolved, are included in a feldspars and quartz matrix.

The upper sequence – **D** – is delimited in the base by the above-mentioned erosion surface, has no visible top portion, hence the thickness is not considerable. Component facies – gravely, micro-gravely and sandy, with gradual and skew stratifications, with traces of mud clasts in the base and colophane clasts (bones?) suggest new depositional environments. The channel bodies indicate the penetration into a transition space, probably of deltaic nature.

Petrotypes are *polymictic micro-conglomerates*, from para- to orto-, *lithic* and *sub-lithic sandstones*, with partially calcite cement. The lithoclast group includes, within the *sediclasts*, *quartz sandstones* with glauconite (in sandstone facies in Kliwa or Lucăceşti), *biomicrites* and *carbonatic silts*, micrites with oxidic *stilolites*. *Metaclasts* remain the same (as in B and C sequences), and **volcanoclasts** are diversified: there are *andesites with hornblende*, *microdiorites*, *matrixes,* varied, fresh and altered; we also indicate the presence of *granite with myrmekites*. Plagioclase (30–50%) indicate a more basic trend ($An_{35\text{-}45}$), many of them being recurrently zoned. The microcline is still present and perthitic.

DISCUSSION

In this research point, the detailed mineralogic and petrographic examination of the four sequences representing the medium-upper part of the Sarmatian outlines a few aspects that become significant for the restoration of relations between the “source area” and the “depositional area”.

1. The construction of the examined suite was the result of cyclic, periodical events, under the direct and simultaneous control of eustatic oscillations, degradation and uplifting of the *source area* – extrabasin (when it becomes active) and sinking (when it stops being active) and the intermittent sediment supply (materialized in the micro-sequence quality and facies that define them); thus, the effects can be equivocal.

2. The *source area* or areas that supplied the basin, starting from the quality of the texture spectrum, from the immaturity of some of the primary sediments and from the structures that define them (*i.e.* para-gravels and graywacks) into defining petrotypes for the mass flows, must be accepted as having a proximal position, hence close to *depositional areas*.

3. The abundance of feldspars, sometimes more than 50% of the modal spectrum of mineral associations, the diversity of volcanoclast types (from andesites and hornblende andesites, to tuffs (?) and rhyo-dacites) is unequivocally indicating their origin from former volcanic rocks located in the proximity of the sedimentation area.

4. There are no arguments related to the studied suite to convince us to accept explosive volcanic phenomena of the *pyroclastic fall* type (ashes and tuffs, respectively).

5. The studies interval, as mentioned above, in “prior researches” is situated within the absolute ages 12.5–10.5 million years ago (Maţenco *et al.*, 2004), in the lower and medium Sarmatian ... and represents a part of the “wedge-top" deposits (Tărăpoancă *et al.*, 2004, Leveer, 2007). In this period of time, volcanic occurrences were initiated, but unfinished in Northern Călimani (an area extremely far from the basin considered by us). And, even if we decrease the Sarmatian age to 8.5–7 million years (Panaiotu *et al.*, 2007) only the eruptions in Gurghiu appear on the volcanic occurrences scale (anyway, younger than the interval studied by us).

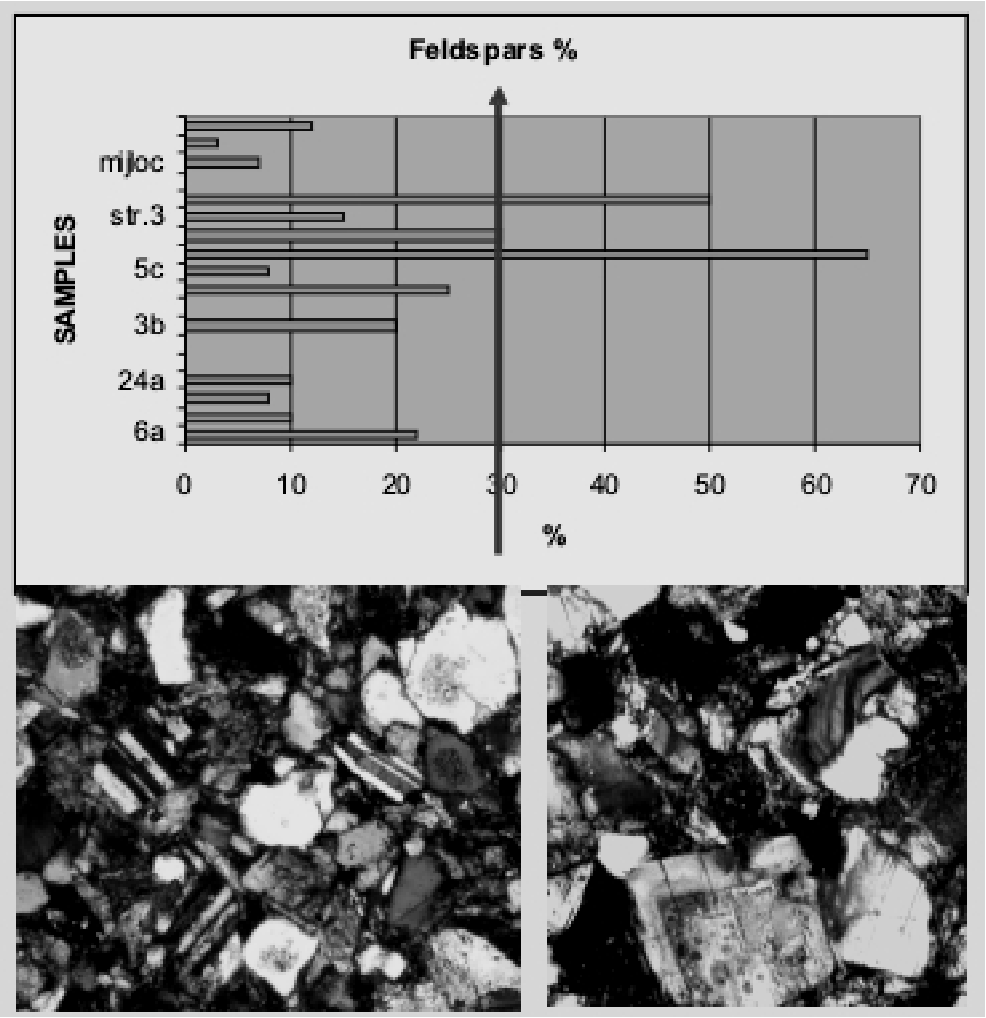

Fig. 4. Feldspars contents variation into sandstone samples (thin sections), and pictures for plagioclase (Albit twins, zoned crystals).

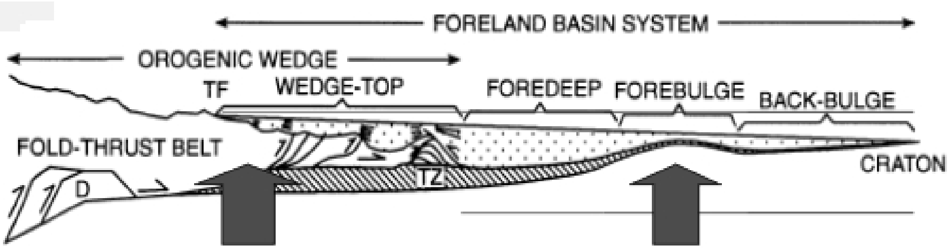

Fig. 5. Possible location for volcanic arc (a part from clast source area).

CONCLUSIONS

C The nature of investigated volcanoclasts (zoned feldspars, corroded quartz, hornblende andesites, rhyo-dacites, etc.), their position in the suite (almost continuous, from the base to the top) and their dual characteristic, both in fresh state, as elements with a high angularity level, but also in an altered state (secondary calcite, clay mineral products, oxidations) come to support the connection with an older source located in the basin proximity. This source was active, but it is no longer active and visible in the present. It must be accepted as of intrusive magmatism (see microdiorite lithoclasts), sub-volcanic and explosively erupted volcanism, bimodal (neutral and acid, the basic one being unconfirmed yet – no pyroxene and olivine found, and the plagioclase are not *labrador*) materialized in lava with fluidal or massive textures, fragmented and redistributed through periodical level oscillations and the active hydrodynamic conditions (ooilites formed in the neighboring aquatic environment).

In this context, however, or in such a background, the age decrease of source magmatites and vulcanites leads us lower, to the Badenian level (12.5–13.5 million years, Mațenco 2003, Vasiliev, 2004, Seghedi, 2005) when explosive phenomena are unanimously and long admitted: quality of products known so far is yet one of rhyodacite ashes (Slănic tuffs, etc.). Hence, the unequivocal expression of an explosive volcanism with *pyroclastic fall* products.

C The water contamination with noxious gases, periodic storms and mechanical destabilization on a gentle slope determined the mass extinction of bivalves (especially) thus facilitating their presservation in three different structural states: rhythmic, structured levels, unstructured populations, incurporation in clay (*mudflows*).

C Following these multiple questions in our attempt to place the volcanic source or sources in its broadest sense, we express two hypotheses:

a) the existence of a volcanic arch with bimodal manifestation in the area located north from the “depositional area” of the lower Sarmatian, triggered by and sunk following the tectonic movements which driven and broke crusts (the foredeep deposits and not only, probably) 11–13 million years ago (see Mațenco, 2003); this could be another magmatic, intrusive and explosively erupted episode, uplifted and turned active, following the Badenian explosive manifestations with *pyroclastic fall*;

b) but, the thinning of the crust and its cracking in the “*fore bulge*” area of foreland basins, on the background of a basin paleomorphology, followed by an uplift (correlated with negative the Neo-Tethys level change (Jipa, Olteanu, 2005) thereof could have driven, from the subjacent asthenosphere, magmatic products and volcanic manifestations; intracratonic rifts are known on the Moesic Platform level).

ACKNOWLEDGEMENTS

Conf. dr. Marius Stoica is acknowledged for discussions regarding molusca biostratigraphy in the study area.

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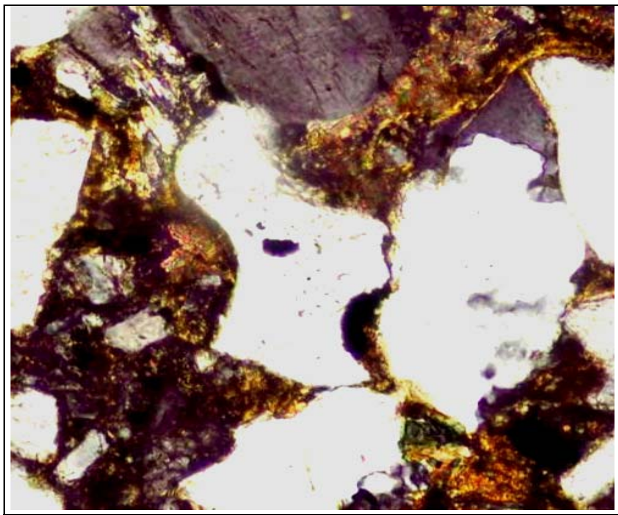
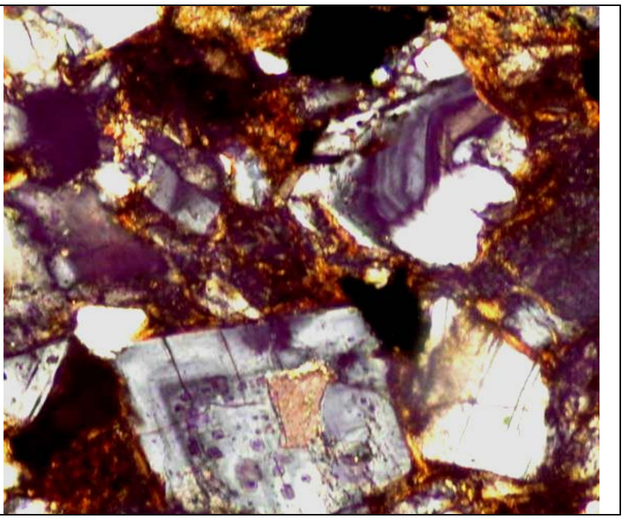
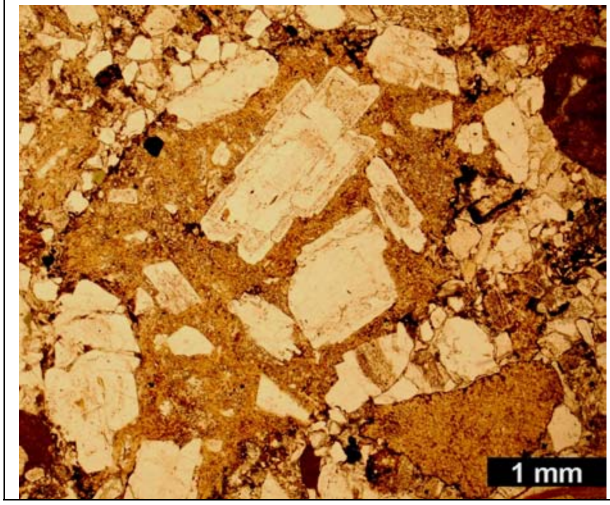
Plate I



1. Coroded quartz into riodacite.
Jitia-RSValley; N+, Ob.10.

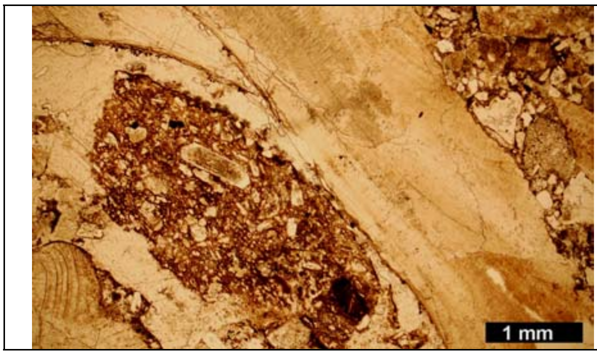


2. Recurrent zoned plagioclase (An$_{25-35}$);
Jitia-RSValley; N+, Ob.10.

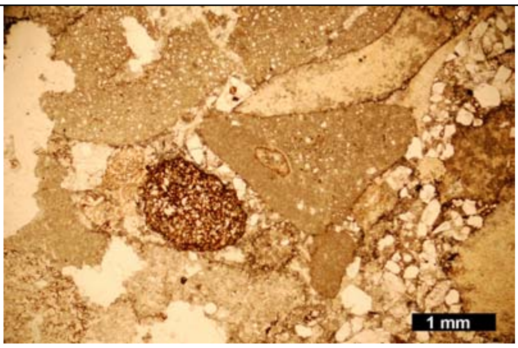


3. Andesite lithoclast with porphyre structures;
Jitia-RSValley; NII, Ob.10.

4. Hornblende phenocrystall into lithic sandstone;
Jitia-RSValley; NII, Ob.20.



5. Andesite lithoclast into bivalve (mollusca) clast;
Jitia-RSValley; NII, Ob.10.



6. Sediclast and andesite matrix lithoclast; Jitia-RSValley;
NII, Ob.10.