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TRANSPORT AND EMPLACEMENT OF IGNIMBRITES AND RESEDIMENTED VOLCANICLASTICS FROM GUTÂI MTS., EASTERN CARPATHIANS, ROMANIA

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ABSTRACT. Gutâi Mts. had started to be built up in Middle Miocene, ca. 15.4 Ma ago. A series of explosive events developed starting with a major magmatic explosion and caldera collapse responsible for large volumes of ignimbrites. Successive explosions followed caldera collapse triggering a series of pyroclastic currents that underwent subsequent reworking. Mass flow has been the main transport mechanism recorded by the sedimentary structures of either ignimbrites or post-ignimbrites volcaniclastics. Multiple ignimbrite units resulted from subaerial mass flows, successively emplaced by progressive aggradation from the basal layer of a density-stratified pyroclastic current. The overlying sequence is composed of different volcaniclastics of pyroclastic origin interlayered with mudstones. They preserve the original composition of ignimbrites, but lack the evidence of hot-state deposition, recording the emplacement from more or less dilute mass flows. A syn-eruptive stage of resedimentation is suggested prior to emplacement in submarine conditions, determined by the transformation of gas-supported pyroclastic currents into water-supported mass flows after transition from subaerial to submarine conditions. The syn-eruptive resedimented volcaniclastics may be correlated with the ignimbrite-type subaerial pyroclastic flows, but they show different degrees of fluidization due to the impact of submarine environment.

Key words: Gutâi Mts., ignimbrites, volcaniclastics, sedimentary structures, submarine.

INTRODUCTION

Gutâi Mts. form with Oas Mts., the Romanian northern segment of Eastern Carpathians volcanic chain (Fig. 1). The Carpathians-associated volcanic chain had been formed by complex processes involving the subduction of the European Plate beneath two continental microplates, Alcapa and Tisza-Dacia, driven to the Carpatho-Pannonian Region (Csontos, 1995). Gutâi Mts. had been built up in Miocene, between 15.4-9.0 Ma (Pecskay et al., 1995). They consist of a lower, mostly burried unit, related to an explosive, felsic volcanism (Fig. 1) and an outcropping upper unit, related to an effusive andesitic volcanism. Co-genetic andesitic intrusions and extrusions pierce the complex volcanic succession.

The felsic volcanism is represented by subaerial ignimbrites and large amounts of resedimented volcaniclastics of pyroclastic origin, emplaced in submarine conditions. A major magmatic explosion and caldera collapse is responsible for the large volumes of ignimbrites emplaced in the southern part of Gutâi Mountains (Fig. 1). The caldera-related ignimbrites of 15.4 Ma have been studied by Fülöp (2000, 2002b). An approach on the transport and emplacement mechanism of ignimbrites has already showed

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the mass flow character and the hot-state progressive aggradational deposition (Fülöp, 2000, 2002b). Successive magmatic explosions followed caldera collapse triggering a series of pyroclastic currents that underwent subsequent reworking. They had built up a thick pile of resedimented volcaniclastics overlying the ignimbrites. The transport and emplacement mechanisms of these volcaniclastics of pyroclastic origin resulted from the complex interaction between subaerial explosion and syn-eruptive reworking in subaqueous environment (Fülöp, 2002a).

This paper represents a synthetic approach of all the types of pyroclast-rich deposits related to the calc-alkaline felsic volcanism, with emphasis on the transport and emplacement mechanisms. It presents new data on volcaniclastic deposits, such as the alternations of fine massive tuffs and stratified pumice lapillistones, getting also into more detail in what concerns the tuffaceous conglomerates. There is a new approach on the genesis of the resedimented volcaniclastic deposits of pyroclastic origin and on their syn-eruptive transformation by submarine reworking, pointing out the lateral correlation of different types of deposits.

Fig. 1. *Position of outcropping ignimbrites and resedimented volcaniclastics in Gutâi Mts.area.*

TYPES OF VOLCANICLASTICS

A wide range of volcaniclastics have been recorded related to the felsic volcanism. The ignimbrites are lapilli tuffs with a heterogeneous composition. They are the only primary pyroclastic deposits and they record hot-state deposition. Ignimbrite genesis is related to the first-stage magmatic explosions, developed ca.15.4 Ma ago, during the inception of volcanism on a pre-existing Paleogene island.

The overlying volcaniclastic sequence is composed of a series of volcaniclastics of pyroclastic origin which cover the whole range of particle sizes, from tuffaceous conglomerates to sandstones and pumice lapillistones interlayered with mudstones. These volcaniclastics lack the evidence of hot-state deposition, but they show a striking compositional similarity with ignimbrites: pumice clasts and glass shards, crystals of plagioclase, quartz, biotite and scarce pyroxene as juvenile pyroclasts;

cognate rhyolitic pyroclasts; sedimentary and metamorphic lithic clasts. However, the ratio of the components is different and determines the grain-size: lithic clasts are predominant in conglomerates and crystals in sandstones; both conglomerates and sandstones contain pumice which is predominant in pumice lapillistones. The sequence developed from Lower-Middle Badenian to Lower Sarmatian, as a result of ongoing subaerial volcanic activity and submarine emplacement of deposits. The pyroclastic debris had been reworked completely by the offset of eruption, in a syn-eruptive stage, preserving the primary components, but sorting them laterally while emplacing (McPhie et al., 1993). It is suggested that more eruptive pulses had developed subaerially, each one followed by submarine resedimentation. Deposits record the impact of submarine environment, which had transformed the gas-supported pyroclastics into resedimented water-supported volcaniclastics (Cas & Wright, 1991; Fischer & Schmincke, 1994).

Large volumes of subaerially emplaced caldera-related ignimbrites had been followed by several smaller volumes of volcaniclastics emplaced under water and related to successive post-caldera subaerial explosive pulses.

TRANSPORT AND EMPLACEMENT MECHANISMS

Fülöp (2002b) has already pointed out the primary and secondary sedimentary structures of ignimbrites reflecting the transport and emplacement mechanisms and helping to reconstruct the source evolution. Multiple units with massive structure, normal coarse-tail grading of lithic clasts and reverse coarse-tail grading of pumice clasts (Fig. 2, Pl. I, Photo 1) are compatible with successive mass flows emplaced by progressive aggradation from a steady, maintained pyroclastic current (Druitt, 1998). This is in accordance with the rheology of the basal layer belonging to a density-stratified suspension current, generated by magmatic explosions (Freundt & Bursik, 1998; Fülöp, 2002b). The eutaxitic texture or welding texture, the cooling textures such as columnar jointings and gas escape pipes reflect a volatile retention regime and/or low cooling rates compatible with hot-state deposition (Fülöp, 2002b).

Facies analysis has been applied to the volcaniclastic sequence overlying the ignimbrites. It suggests a series of mass flows triggered by explosive eruptions and subsequent resedimentation, as well as their transport and emplacement mechanism (Fiske et al., 1998; Fülöp, 2002a).

The coarser and thicker (up to 30 m) terms are matrix-supported tuffaceous conglomerates, sometimes capped by pumice lapillistones or pumice-rich layers. They are unsorted, with massive structure, normal coarse-tail grading of lithic clasts and reverse coarse-tail grading of pumice clasts. The internal organization is similar to ignimbrites but suggesting a stronger fluidization: the larger lithic clasts are concentrated in the basal layer (Pl. I, Photo 2) and the larger pumice clasts in the upper layer (Fig. 3). They seem to be emplaced from subaqueous debris flows derived from subaerial pyroclastic flows which had undergone mixing with water while crossing the shoreline.

The thinner terms of tuffaceous conglomerates suggest a stronger sorting: they are clast-supported, massive deposits with a small amount of pumice (Fig. 4), emplaced “en masse” or by progressive aggradation, from submarine debris flows or hyperconcentrated flows. Tuffaceous sandstones are usually crystal-rich, pumice- and lithic clasts-poor, massive, slightly sorted deposits, suggesting tuffaceous hyperconcentrated flows emplaced “en masse” in submarine conditions. Thicker deposits show multiple units slightly normal graded, with a faint undulated layering suggesting water-escape structures and contain basal loadcast structures (Fig. 5, Pl. II, Photo 1). They seem to be emplaced from fluidized flows, by progressive aggradation processes (Lowe, 1976).

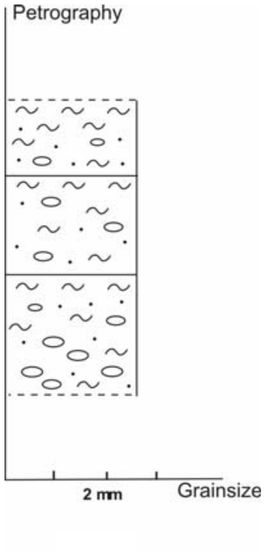


Fig. 2. *Lithological column of multiple units of lapilli tuffs (outcrop on Porcu Valley, Ilba).*

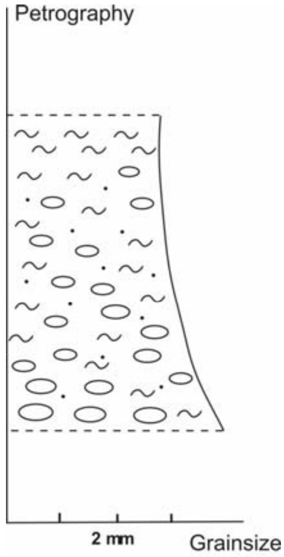


Fig. 3. *Lithological column of thick units of tuffaceous conglomerates (outcrop on Ulmoasa Valley, Băița).*

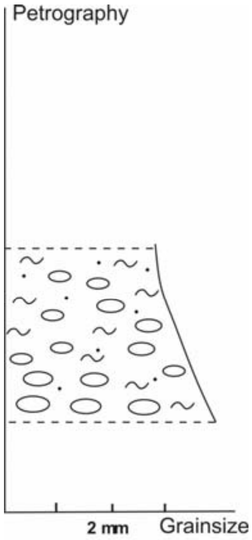


Fig. 4. *Lithological column of thin units of tuffaceous conglomerates (outcrop on Porcu Valley, Ilba).*

Pumice lapillistones or pumice-rich layers form thin sorted deposits showing a crude layering pointed out by aligned flattened pumice clasts (Fig. 6, Pl. II, Photo 2). They had been emplaced from fluidized flows by progressive aggradation (Allen & McPhie, 2000) and underwent strong diagenetic compaction which enhanced the layering.

A different type of deposits has also been identified, with an internal organization suggesting the emplacement of volcaniclastic turbidites from more dilute, turbulent flows. Deposits show a thinning and fining upwards sequence composed of repeated alternations of fine massive tuff and stratified pumice lapillistones (Fig. 7). Such an internal structure corresponds to internal organization of submarine pyroclastic currents undergoing strong fluidization and flow transformation into a dense, basal layer, rich in larger and/or heavier clasts (the lithic clasts) and an upper turbidite current, supporting the lighter components, pumice and glass shards. Only the upper term has been identified in outcrops, the tuffaceous turbidite described by Yamada (1984) and White (2000).

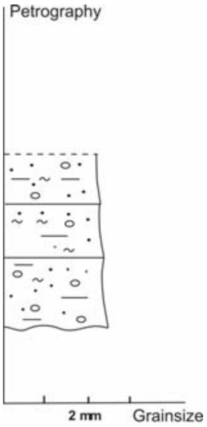


Fig. 5. *Lithological column of multiple units of tuffaceous sandstones (outcrop on Colbu Valley, Ilba).*

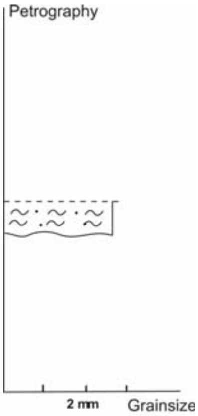


Fig. 6. *Lithological column of pumice lapillistones (outcrop on Porcu Valley, Ilba).*

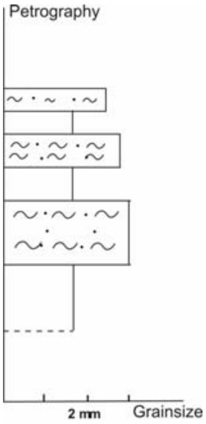
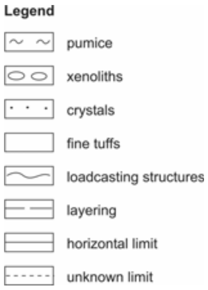


Fig. 7. *Lithological column of the sequence of pumice lapillistones and fine tuffs (outcrop on Toaca Valley, Ilba).*



The thicker tuffaceous conglomerates and the tuffaceous turbidites are deposits which clearly may be correlated with original pyroclastic currents transformed from gas-supported into water-supported resedimented currents upon transition from terrestrial to submarine environment. The lack of the original land-deposited pyroclastic deposits suggests that transformation had taken place short time after explosive eruption, the eruptive centers being located close to the shoreline.

The thinner tuffaceous conglomerates and sandstones are co-genetic with the pumice lapillistones; the overall composition corresponds to pyroclastic debris released by small successive explosions on land, entrained as mass flows and undergoing subsequent fluidization under water. It is therefore a lateral correlation between different sorts of deposits: coarser deposits, tuffaceous conglomerates represent the proximal facies; tuffaceous sandstones represent the medial facies and pumice lapillistones form the distal-most deposits. They have been emplaced from similar water-supported pyroclastic currents related to different sources. Undergoing progressive fluidization, the less fluidized, coarser and heavier components were emplaced in a proximal place, being followed by more fluidized finer components in a median position and ending with the most fluidized, lighter components, in the distal-most facies. The reoccurrence of similar deposits at different levels in the thick post-ignimbrite sequence can be explained by different sources and different explosions separated in time.

CONCLUSIONS

The products of the felsic volcanism that started to build up Gutâi Mts. are 15.4 Ma ignimbrites and different volcaniclastics of pyroclastic origin, interlayered with sedimentary deposits, span in time from Lower-Middle Badenian to Lower Sarmatian.

The ignimbrites are related to a major explosive eruption and caldera collapse. The volcaniclastics have been generated by small successive magmatic explosions from different sources. They show similar pyroclastic composition.

The study of the sedimentary structures provides valuable information in what concerns the transport and emplacement mechanisms. Ignimbrites are emplaced on land from the basal layer of stratified pyroclastic density currents, with minimum fluidization and hot-state deposition.

Post-ignimbrite volcaniclastics show similar mass flow behaviour imprinted by magmatic explosions, but getting the impact of the submarine emplacement. Thick tuffaceous conglomerates and thinning and fining upwards sequence of alternating pumice lapillistones and tuffs represent proximal and distal facies respectively, of lateral submarine syn-eruptive resedimented volcaniclastic currents, transformed from the original pyroclastic ones upon transition from terrestrial to submarine environment. Thin tuffaceous conglomerates, sandstones and pumice lapillistones are corresponding to progressively fluidized tuffaceous mass flows, to debris flows in a proximal facies and more fluidized flows in a median and distal facies respectively, both in submarine environment. The processes repeated several times leading to the thick post-ignimbrite sequence of volcaniclastics, separated by piles of sedimentary deposits.

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REFERENCES

Allen, R., McPhie, J. 2000, Water settling and resedimentation of submarine rhyolitic pumice at Yali, eastern Aegean, Greece. *Jour. of Volcanol. and Geotherm. Res.,* 95: 285-307.

Cas, A. F. R., Wight, J. V. 1991, Subaqueous pyroclastic flows and ignimbrites: an assessement. *Bull. Volcanol.*, 53: 357-380.

Csontos, L. 1995, Tertiary tectonic evolution of the Intra-Carpathian area: a review. *Acta vulcanologica*, 7(2): 1-15.

Druitt, T. H. 1998, Pyroclastic density currents (Gilbert, J. S. O. & Sparks, R. S. J., Eds.) The Physics of Explosive Volcanic Eruptions. *Geol. Soc., Special Publication*, 145: 145-182.

Fisher, R. V., Schmincke, H. U. 1994, Volcaniclastic sediment transport and deposition (Pye, K., Ed.): In *Sediment Transport and Depositional Processes*, Blackwell Scientific Publications.

Fiske, R. S., Cashman, K. V., Shibata, A., Watanabe, K. 1998, Tephra dispersal from Myojinsho, Japan, during its shallow submarine eruption of 1952-1953. *Bull. Volcanol.* 59(4): 262-275.

Freundt, A., Bursik, M. I. 1998, Pyroclastic flow transport mechanisms. In *Developments in volcanology 4: From magma to tephra-modelling physical processes of explosive volcanic eruptions* (Freundt, A. & Rosi, M., Eds.): 173-245.

Fülöp, A. 2000, Morphology of pumice clasts and glass shards of the “Rhyodacitic Formation” in the Gutâi Mountains, Romanian Eastern Carpathians; involved processes. *Rom. J. Mineral.*, 80: 63-68.

Fülöp, A. 2002a, Transport and emplacement of the 15.4 Ma rhyolitic ignimbrites from Gutâi Mts., Eastern Carpathians, Romania. *Studia Universitatis Babeş – Bolyai, (Geol.),* 1: 65-76.

Fülöp, A. 2002b, Facies analysis of volcaniclastic sequence built up above the 15.4 Ma rhyolitic ignimbrites from Gutâi Mts., Eastern Carpathians. *Studia Universitatis Babes-Bolyai, (Geol.)*, Special issue, 1: 199-206.

Fülöp, A. 2002 c, Geometry of 15.4 Ma rhyolitic ignimbrites from Gutâi Mts., Eastern Carpathians, Romania. *Rom. Journal of Mineral Deposits*, 80: 38-40.

Lowe, D.R. 1976, Subaqueous liquefied and fluidized sediment flows and their deposits. *Sedimentology*, 23: 285-308.

McPhie, J., Doyle, M., Allen R. 1993, *Volcanic textures – A guide to the interpretation of textures in volcanic rocks*, Centre for Ore Deposits and Exploration Studies. University of Tasmania, Hobart, 196 pp.

Pécskay, Z., Edelstein, O., Kovacs, M., Bernad, A., Crihan, M. 1994, K-Ar age determination of Neogene volcanic rocks from the Gutâi Mts. (Eastern Carpathians, Romania). *Geologica Carpathica*, 45(6): 357-363.

White, J. D. L. 2000, Subaqueous eruption-fed density currents and their deposits. *Precambrian Research*, 101: 87-109.

Yamada, E. 1984, Subaqueous pyroclastic flows: their development and their deposits: In *Marginal Basin Geology* (Kokelaar, B. P. & Howells, M. F., Eds.), *Geol. Soc. Spec. Pub*. 16: 29-36.

Plate I

Photo 1: Ignimbrites, limit between two flow units (l); Porcu Valley, Ilba (detail in Fig. 2).
Photo 2: Tuffaceous conglomerates; Ulmoasa Valley, Băiţa (detail in Fig. 3).

Plate II

Photo 1: Tuffaceous sandstone with water escape structures (wes); Colbu Valley, Ilba (detail in Fig. 5).
Photo 2: Sequence of pumice lapillistones (pl) and fine tuffs (ft); Toaca Valley, Ilba (detail in Fig. 7).

PLATE I

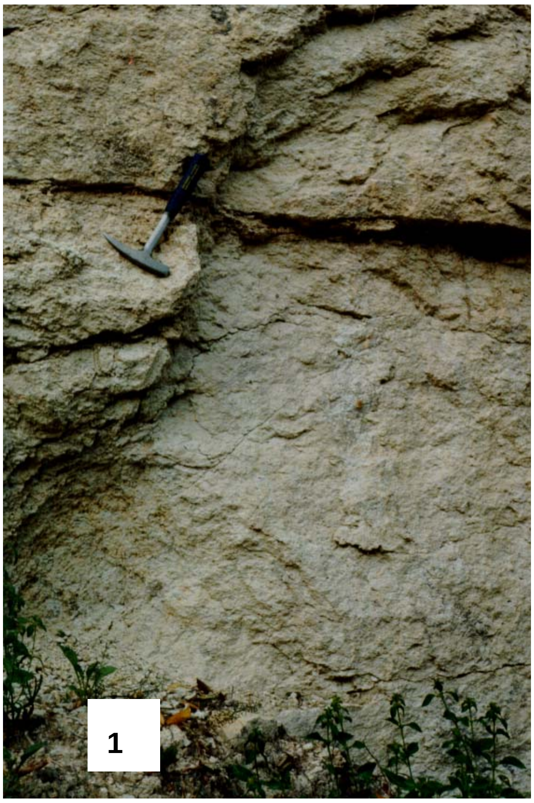

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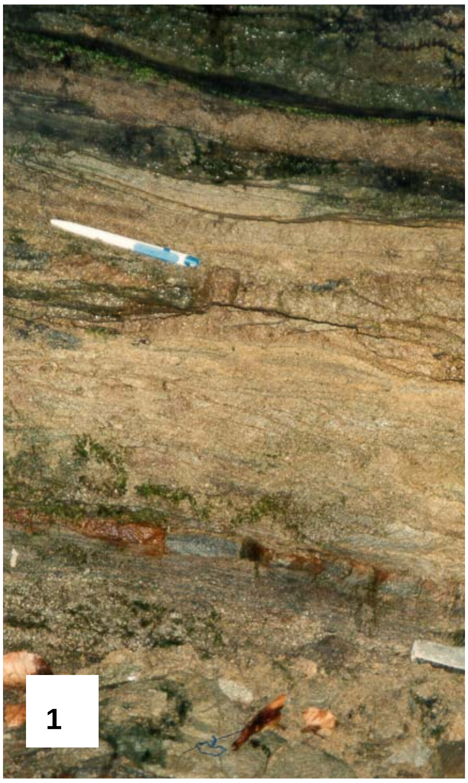
PLATE II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