Facies analysis of a Late Miocene lava dome field in the Tokaj Mts. (Carpathian-Pannonian Region): Implication for a silicic caldera structure?

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Subaerial silicic effusive volcanism commonly form high viscosity, thick (up to 100 m), short (less than a few kilometres), small- to medium volume (< 1 km3) lava flows and domes. Their emplacements are often connected to silicic calderas, although they could form also lava dome fields. The Miocene (from ca. 15 Ma to 10 Ma) volcanic activity of the Tokaj-Slanske Mountains in the northeast segment of the Pannonian Basin was characterized by intense silicic volcanism in addition to eruption of andesitic magmas. The subsequent tectonic events and erosion exposed uniquely the inner structure of the rhyolitic lava domes enabling the reconstruction of their evolution. A comparison of the palaeovolcanic features with those of the characteristics of young lava domes provide a challenging way to understand better the emplacement mechanism of silicic effusive products and also to conduct the volcano geology methodology in a palaeovolcanic area.

The Telkibánya Lava Dome Field (TLDF) was formed in the northern part of the Tokaj Mts. at around 13 Ma (Fig. 1). It extends over 30 km2 and the volcanic formations have a maximum thickness of over 300 m. The spatial distribution of the eroded silicic extrusions and the covering andesite flows (Fig.1) shows strong structural alignment which is controlled by the regional NW-SE (and perpendicular) striking fault system in accordance to the stress field of Late Miocene regional extension. We performed a detailed field work accompanied with petrologic and geochemical study in order to map the lava dome structures. As a result, we concluded that the extrusive event could have occurred after a major explosive event. The pyroclastic series conformably deposited on shallow marine sediments, however, developments of the lava domes were taken place in subaerial environment at least in two phases.

Lithofacies associations

The surface outcrops and the revised borehole database offer a good opportunity to obtain detailed records of silicic lava dome/flow stratigraphy. The substantial textural heterogeneity and zonation were interpreted as a result of changing temperature (cooling rate), mechanical stress, and vesiculation processes within the subaerial cooling lava bodies. The mapped lithofacies units can be subdivided into five main lithofacies associations based on their specific textural-structural features developed during their emplacements: volcaniclastic deposits, coherent rhyolite, rhyolite-perlite transition zone, coherent glass (perlite) and fragmented carapace.

Volcaniclastic deposits: The silicic lavas extruded on extended pyroclastic deposits (up to 50m). The typical massive lapilli tuffs (mLT) are followed by stratified (sLT) and usually reversely graded, lithoclast-rich pumiceous, perlitic lapilli tuff (mlLT) units. In addition, we could recognize clast-supported lithic breccia layers (mlBr).

Coherent rhyolite

The coherent rhyolite (CR) is the most common lithofacies within the TLDF units. The groundmass is usually devitrified in variable scales and involves high temperature crystallization domains (HTCDs) in macro (lithophysae, spherulite) and micro scale (axiolith, felsite). Based on the inner structure of the CR, three sub-facies zones can be distinguished: massive, flow-banded and vesicular subunits.

Rhyolite-glass (perlite) transition zone

A transition between the crystallized and glassy lava dome parts was developed in variable thicknesses (m-10m's). Based on the textural characteristics perlitic rhyolite (usually devitrified) and rhyolitic perlite zones were distinguished. The transition occurs in two main types: a, alternation of decimetre thick rhyolite and perlite bands in a usually strongly foliated texture, b, lithophysae and "megaspherulites" (up to 50 cm in diameter, Fig.2) in perlite. The lithophysae show more-or-less equidimensional or slightly elongated shape with coalescence in the direction of flow layering. Cavities are filled with by vapour phase crystallization products as tridymite and opal varieties.

Coherent perlite

The coherent glass (now perlite) unit is subdivided into two subzones: the inner, mostly vesicle free, typical perlite and the marginal vesiculated, pumiceous lithofacies. This pumiceous perlite usually grades into clast-rotated breccias of the fragmented carapace. The thickness of this lithofacies is in the range from a few metres up to 40 metres. The common banding is by typical fluidal texture and/or vesicle elongation. The colour of the hydrated glass is vary from black (obsidian-like perlite) to grey (typical perlite) as a result of H2O diffusion rate. The porosity ratio of pumiceous perlite ranges from 60 % (like common pumice) to 5% toward the perlite zone.

Fragmented carapace

The monolithological, matrix-poor (<20%), clast-supported breccias contain mainly subangular to very well rounded pumiceous perlite. Red and black coloured breccias are embedded between the pumiceous perlite breccia and coherent perlite zone and include fragments (mm-cm sized) of both lithology units. This facies has a lenticular shape with a sharp upper contact towards the covering breccia and grading down to the coherent glass.

Interpretation of the TLDF volcano stratigraphy

a. Within the TLDF succession lava dominated dome/flow complexes and surrounding pyroclastic apron are distinguished. They were formed during major explosive volcanic events followed by intense lava dome extrusion activity and epithermal mineralization.
b. A large negative gravity anomaly (-24 mGal) was recognized under the TLDF in a sharp contrast of local maxima (-7 mGal) of subvolcanic intrusion and low sulphidation type alteration area (Fig.1).

c. Occurrence of the silicic lithofacies units and the geophysical data suggest an approximately 20 km wide caldera formed by collapse event after the initial explosive volcanism. The subsequent post-caldera resurgence was characterized by lava dome activity.
d. The massive lapilli tuffs are interpreted as typical ignimbrites with gas segregation pipes and charcoal, whereas the bedded, well-sorted lithofacies has a pyroclastic fall origin. The reversely graded perlitic lapilli and block-rich facies could have probably derived from lava dome-related pyroclastic density currents.
e. Erosion exposed all the main lithological units of an idealized lava dome-flow complex at different levels. The thickness/surface ratio varied in the function of the erosion rate. The coherent rhyolite zones are interpreted as the core facies of eroded lava domes and flows. The textural heterogeneity of transition zone reflects variations in cooling rate with development of HTCDs (lithophysae and spherulite). The “megaspherulites” described here are rare worldwide. The coherent glass developed by enhanced cooling and later underwent strong devitrification. The pumiceous perlite could represent the finely vesicular pumice units of recent lava domes. The fragmented carapace in a complex architecture surrounds the coherent lava flow/dome units. The clast distribution refers to mechanical disruption during extrusion. The texture of red and black breccias implies secondary vesiculation event releasing volatile phases.
f. The present day morphology reflects the preservation potential of the lithological units rather than the original depositional geometry. The erosional volume (8.5 km3) are quite similar to other moderate to large volume lavas (Mono-Inyo Chain-California, Badlands Rhyolite-Idaho,) The estimated volume of the silicic lavas could have been certainly more than 10 km3.

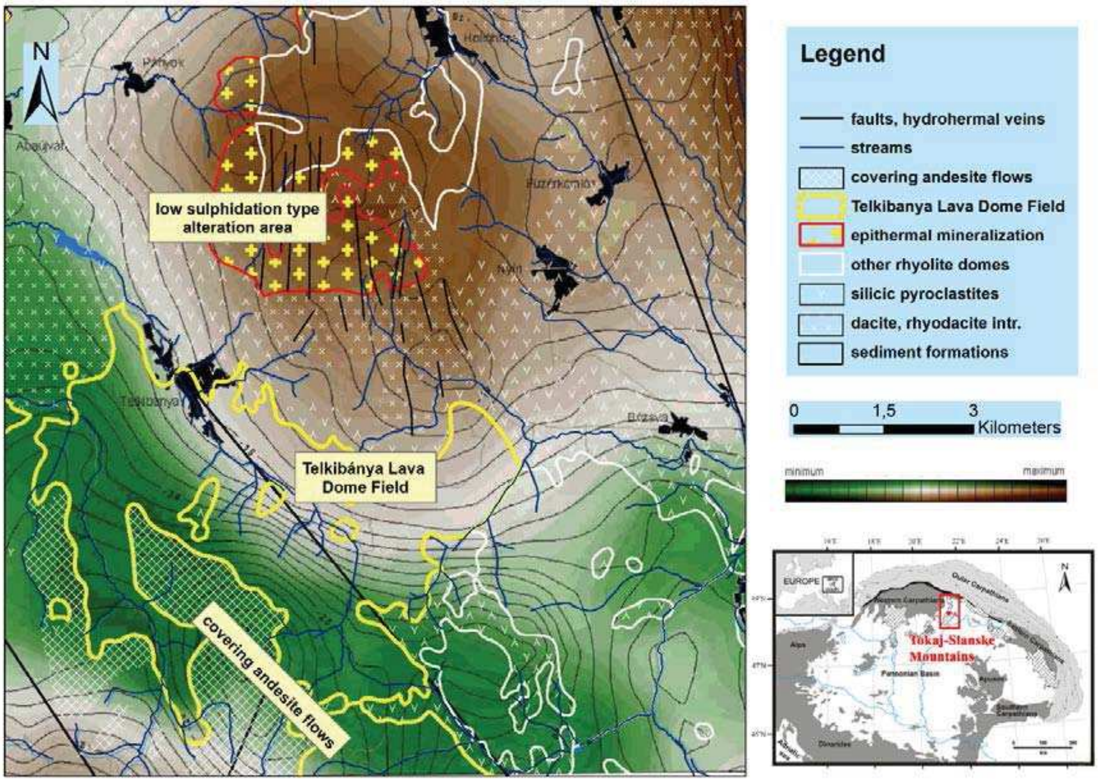

Fig. 1 - *Gravity Bouguer-anomaly map of Kiss and Zelenka (2009) with the geological-volcanological interpretation of Telkibánya Lava Dome Field. Colours from calculation by □=2.0 g/cm3, isolines from □=2.67 g/cm3. Reference: Telkibánya Geology Publ. Univ. Miskolc, Series A, Mining 78, 97-115.*

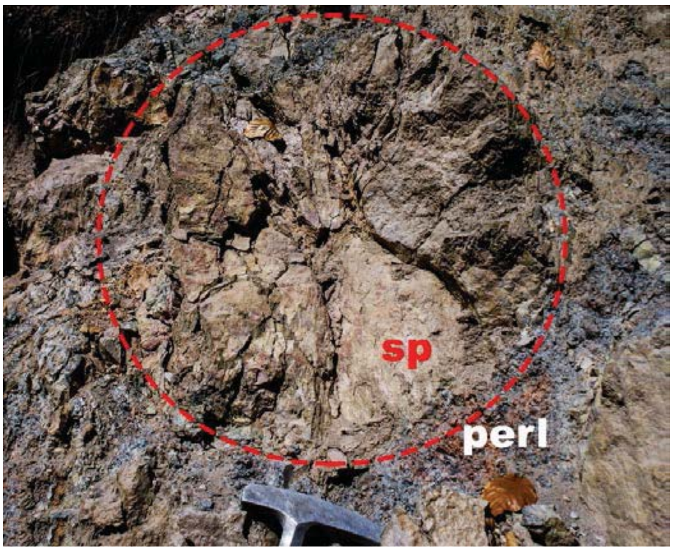

Fig. 2 - *The largest high temperature crystallization domain "megaspherulite" 0.5 m <) with radial jointing in perlite from perlite–rhyolite transition at the base of Cser Hill dome.*