Evolution of monogenetic rhyolite volcanoes: Viničky, Eastern Slovakia

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Abstract

Four essential volcanic units have been recognized in the late Middle Miocene rhyolite complex at the southern side of the Zemplín horst next to the village Viničky. A succession of ash/pumice flow, surge and fall deposits separated by horizons of eolian dust and paleosoil in total thickness >15 m forms the lower unit. It represents distal facies deposits of subplinian/plinian/phreatoplinian type eruptions at unidentified centers. The second unit rests upon the lower one with unconformity marking a period of erosion. It consists of coarse phreatic/phreatomagmatic pyroclastic rocks with fragments of basement rocks and glassy dacite/rhyodacite. They represent proximal facies of a phreatomagmatic pyroclastic ring. Both units are truncated by a rhyolite extrusive dome, formed of perlite and perlitic breccias at its margin. Emplacement of the dome concluded activity of local centers northwest of Viničky. An extensive rhyolite coulee represents the fourth, uppermost volcanic unit. It is 40 – 70 m thick, formed of felsitic rhyolite with perlite and perlitic breccia at the base. Orientation of flow banding implies that the Borsuk extrusive dome 1 km northeast of Viničky was a source of the coulee. The dome and coulee form together one rhyolite body of the dome-flow type. With exception of the distal facies tuffs at the base the rhyolite complex represents most probably products of three overlapping monogenetic volcanoes.

Keywords: *phreatomagmatic eruption, cryptodome, dome-flow, coulée, rhyolite tuffs, perlite*

Introduction

Rhyolite volcanic fields are often monogenetic as their basaltic counterparts. They are composed of many individual volcanoes, each one having its own specific form, lithology and history. While a given rhyolite volcanic field may cover a quite short time interval, individual volcanoes are not strictly contemporaneous and their products mutually overlap. One of such fields of rhyolite monogenetic volcanoes of the Middle Miocene to early Late Miocene (Late Badenian to Early Pannonian) age extends in the area of highlands Tokaj, Zemplín, Beregovo, Oas in northeastern Hungary, eastern Slovakia, Transcarpathia of SW Ukraine and northern Romania. It includes a complex of rhyolites and related volcanoclastic rocks in surroundings of the village Viničky in eastern Slovakia (Fig. 1) that represents remnants of three overlapping monogenetic volcanoes. Natural outcrops, several abandoned quarries and excellent outcrops in walls of a wine cellar (830 m of galleries) excavated in a succession of phreatomagmatic pyroclastic rocks allow for a paleovolcanic reconstruction of events that created the volcanoes.

Geological setting

The Middle Miocene Tokaj-Zemplín-Beregovo-Oas field of monogenetic rhyolite volcanoes is an integral part of the Middle/Late Miocene bimodal andesite-rhyolite volcanics associated with a system of horsts and grabens south of the Transcarpathian Basin – a segment in the Carpathian volcanic arc (Lexa et al. 2010). Episodes of rhyolite volcanic activity alternated with activity of andesites and dacites that have given rise to mostly solitary small stratovolcanoes, effusive complexes and extrusive domes. K/Ar ages of andesites, dacites and rhyolites overlap in the interval 13.8-9.5 Ma (Pécskay et al. 2006; Pécskay unpublished data). The formation of the horst and grabens, as well as the volcanism were related to the interplay of subduction, delamination and back-arc extension (Seghedi and Downes 2011). The bimodal andesite-rhyolite volcanic association is interpreted as contemporaneous partial melting of metasomatized lithospheric mantle and crustal source materials as a result of the related tectono-thermal reactivation. Peraluminous rhyolites are of anatectic origin, later affected to various extent by mixing with mafic mantle source magmas and lower pressure AFC processes (Konečný et al. 2010).

Rhyolites of the volcanic field appear as clusters or solitary extrusive domes, dome-flows/coulées and related pyroclastic and epiclastic volcanic rocks that evolved in terrestrial and/or shallow marine environment (Lexa et al. 2010). In the area of the Zemplín horst (southern part of Eastern Slovakia) rhyodacite/rhyolite extrusive domes/coulées and related volcanoclastic rocks occur along marginal faults of the horst. The horst represents an uplifted block of basement rocks including Late Paleozoic conglomerates, sandstones and shales and Triassic sandstones, limestones and dolomites. Rhyodacites/rhyolites belong to two episodes of volcanic activity. Solitary rhyodacite/rhyolite extrusive domes along the northeastern and eastern sides of the horst and reworked rhyolite pumice tuffs interbedded with the Late Badenian sedimentary rocks at the southwestern side of the horst belong to the first stage age in the interval 13.2-12.2 Ma (Pécskay, unpublished data). Rhyolite extrusive dome/coulée (dome-flow) and underlying breccias and tuffs around the village Viničky at the southern side of the horst (the Viničky volcanoes) represent the younger second stage of the Sarmatian age. The age is not well constrained K-Ar dating of felsitic rhyolite, obsidian and perlite whole rock samples provided results in a broad interval 13.3 – 9.7 Ma (Bagdasarjan et al. 1971; Merlich and Spitkovskaya 1974; Uhlík et al. 2002; Pécskay unpublished data). Apparently the results on whole rock samples are variably affected by the presence of tiny basement inclusions, excess argon in plagioclase phenocrysts and/or loss of radiogenic argon by unstable glass.

Geology and lithology of the volcanoes

Rhyolites, breccias and tuffs of the Viničky volcanoes rest mostly on rocks of the pre-Tertiary basement. Permian conglomerates, sandstones and shales extend bellow most of the volcanoes, while overlying Triassic sandstones and dolomites occur underneath their northern and south-eastern parts (Bačo et al. 2012). It is probable that locally there are bellow the volcanoes preserved also remnants of Upper Badenian tuffaceous sedimentary rocks. Four essential units are distinguished in the overlying complex of rhyolitic rocks. At its base there is a succession of distal facies rhyolite tuffs in thickness >15 m, well-exposed in walls of the wine cellar. The Viničky volcanoes itself are represented by overlapping products of three volcanic centers. Early phreatic/ phreatomagmatic activity created a pyroclastic ring with a center northwest of Viničky. Subsequently an extrusion of glassy rhyolite took place at the center closer to the village. Corresponding proximal facies pyroclastic rocks and glassy rhyolites are exposed in the vine cellar above the tuffs. Both units exposed in the wine cellar are covered by extensive rhyolite coulee (dome-flow) with extrusive center about 1 km northeastward in the area of the hill Borsuk (Fig. 1).

The lower unit of tuffs is exposed in the thickness 15 m. Their extent bellow the lowermost horizon of the cellar is not known. Exposed succession starts with unsorted ash-flow tuff horizon grading upward into 1.5 m thick brownish paleosoil horizon with variable eolian dust admixture. The succession continues by three eruption cycles of total thickness 4.5 m, each starting with sorted crystal-rich fall tuff or less sorted coarser fall/ surge pumice tuffs followed by unsorted ash-flow tuffs and concluded by ochre to brown color poorly developed dusty paleosoil horizons of smaller thickness. Next 3.5 m is dominated by thick layers of sorted (fall) and poorly sorted (surge/flow) coarse pumice tuffs interbedded with horizons of sorted fine to medium grained tuffs and ochre to brown fine dusty horizons. Lamination and normal or reversed grading has been observed in fall type deposits. Following a period of erosion the succession continues with poorly sorted ochre to brown color pumice tuffs with substantial dust component in fine matrix that grade upward into fine tuffaceous paleosoil of reddish-brown color with variable eolian dust admixture. Paleosoil is enriched in smectite and iron hydroxides and contains tiny remnants of plant roots. The described succession of tuffs was affected by normal faulting and once more eroded before the deposition of phreatic/phreatomagmatic pyroclastic rocks of the middle unit.

Succession of poorly to well-sorted pyroclastic breccias, lapilli tuffs and tuffs of the middle unit with overall thickness >15 m starts with sorted tuffaceous sandy deposits rich in nonvolcanic

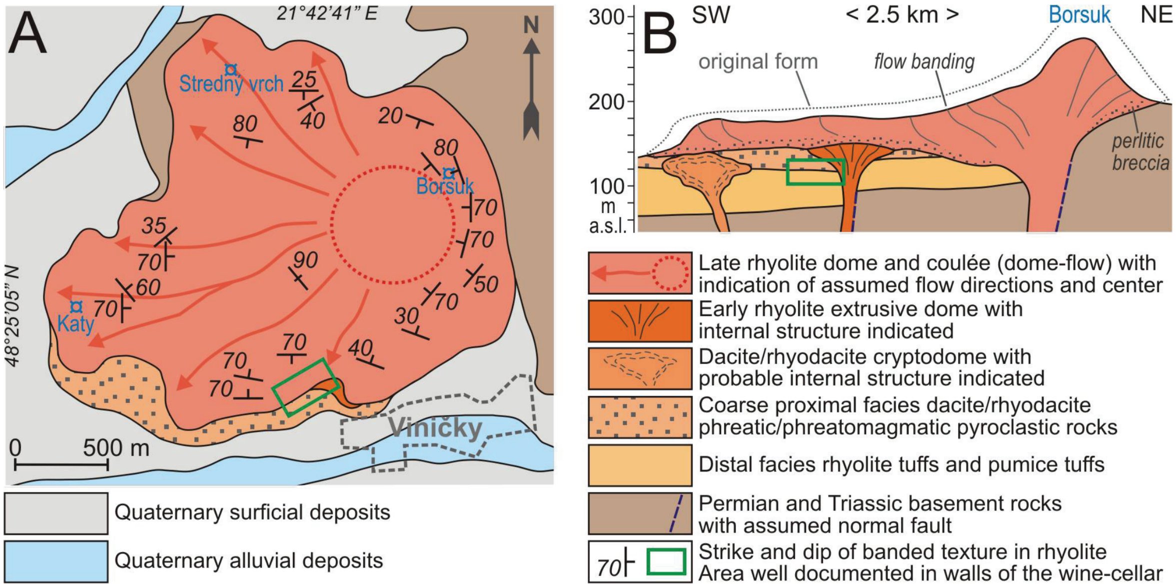

Figure 1. Structural scheme of the Viničky rhyolite volcanoes.

components of quartz and mica grains and clay minerals. Characteristic are also plant remnants and leaf imprints. Contact with underlying fine tuffs is sharp, paleosoil is missing. Most of the succession is formed of alternating beds of variable grain-size from fine tuffs to coarse lapilli tuffs. Only few beds are coarse enough to be classified as pyroclastic breccia. Especially in coarse beds there are frequent blocks, rarely up to 1 m diameter. Some blocks created impact structures. Basement rocks dominate among angular blocks and lapilli, juvenile dark glassy dacites/ rhyodacites are less frequent. Rare deformed fragments of underlying tuffs have also been observed. Tuffaceous matrix, as well as fine to coarse tuff beds, is rich in nonvolcanic material too. At the top of the exposed succession beds of lapilli tuffs are thinner, better sorted and of finer grain-size. Juvenile fragments are less frequent. Lapilli tuffs here alternate with horizons of brown fine dusty tuffs, often with numerous accretionary lapilli.

Drilling 800 m west of the wine cellar evidenced a dacite intrusive body emplaced in rhyolite pyroclastic rocks (Bačo et al. 2012). The margin of the dacite body is glassy and brecciated. Apparently it can be interpreted as a cryptodome.

At the eastern side of the wine cellar the successions of tuffs and phreatic/phreatomagmatic pyroclastic rocks is truncated by marginal parts of rhyolite extrusive dome. Rhyolite is glassy, perlitic, locally with small remnants of obsidian as cores of perlite blocks (marekanite). Its color varies from almost black to pale gray, often in alternating bands of pronounced flow bending dipping 40°-50° eastward. Perlitic breccias occur locally close to the contact with tuffs.

The three units exposed in walls of galleries in the wine cellar are buried by extensive rhyolite coulee passing northeastward into the source extrusive dome forming together a dome-flow (Fig. 1). Its primary morphology is still preserved in the morphology of the ridge north and northwest of Viničky. Rhyolite is felsitic, pale and slightly porous. It shows blocky to platy jointing, locally with well pronounced flow banding expressed as alternation of dark massive bands and pale porous bands. Figure 1, shows orientation of flow banding that fits well the assumption of the dome passing westward and northwestward into coulee. Thickness of the coulee is 40-70 m, originally perhaps up to 100 m. At the base and margins felsitic rhyolite grades into perlitic rhyolite and perlitic breccias. Basal perlitic breccias of the coulee are well exposed in the northern part of the wine cellar, where they rest on eroded surface of tuffs and phreatic/phreatomagmatic pyroclastic rocks. Breccias are formed of angular blocks of dark to pale perlites up to 3 m in diameter, often with pronounced flow banding, in pinkish matrix of grounded perlitic material. Underlying tuffs are locally deformed and mixed with perlite blocks into peperitic breccia.

Discussion and conclusions

A detail lithological analysis of natural outcrops and walls of the wine cellar has brought evidence that what appeared before as a single rhyolite volcano in reality represents four overlapping essential volcanic units inferred to be parts of monogenetic rhyolite volcanoes with different volcanic centers. Lower unit of alternating ash and pumice flow and fall tuffs with eolian dust and paleosoil horizons implies intermittent plinian type eruptions at distal volcanic centers. Such centers, represented by rhyolite domes of roughly the same age, are known from the northern part of the Tokaj mountain range 15-20 km west and northwest of Viničky. Erosion and thick soil horizon at the top of the lower unit correspond to a longer lasting break in volcanic activity.

The overlying unit of dacite/rhyodacite phreatic/phreatomagmatic pyroclastic rocks shows many aspects characteristic of the proximal deposits forming a pyroclastic ring, including ballistic block impacts and coarse pyroclastic surge/fall deposits. Locally low proportion of juvenile glassy fragments implies transition among phreatomagmatic and phreatic types of eruptions. Such eruptions are usually initiated by rising magma coming close to the surface and subsequently forming a dome in the crater (e.g. Panum dome in Mono Craters, California). We have no evidence of the exact position of the crater and hypothetical dome. However, the same type of magma appears close by as the cryptodome (Fig. 1).

Despite a petrographic similarity the steep intrusive contact of perlitic rhyolite in the eastern part of the wine cellar with older pyroclastic rocks rules out a possibility, that it represents a part of the overlying rhyolite coulee. Instead we assume the form of a small extrusive dome (Fig. 1).

Morphology and orientation of flow banding in the youngest rhyolite coulee unquestionably point to the source dome in the area of the hill Borsuk 1 km northeast of Viničky, with dome root situated on one of the Zemplín horst marginal faults indicated by basement displacement (Fig. 1).

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