INTERACTION BETWEEN LAVA LAKES AND PYROCLASTIC SEQUENCES IN PHREATOMAGMATIC VOLCANOES: HALÁP AND BADACSONY, WESTERN HUNGARY

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Abstract: The most prominent geomorphological features of the eroded Mio/Pliocene Bakony-Balaton Highland intraplate alkaline basaltic volcanic field are the semi-circular, lava capped buttes. The semi-circular distribution of lava flows indicates strong geomorphological control on lava flow emplacement and suggests that lava flows accumulated behind geographical barriers, such as a former tuff ring around the phreatomagmatic volcanoes. This is supported by the fact that often the large buttes, capped with thick lava flows, are accompanied by a strong negative Boguer-anomaly indicating mass deficit characteristic for country rock excavation and vent zone subsidence. The presence of pyroclastic rocks overlain by circular shaped lava flows resembles a pyroclastic facies that commonly fill phreatomagmatic volcanic craters, vents and conduits. At two locations (Badacsony and Haláp) in the Bakony- Balaton Highland Volcanic Field good exposures allow the examination of the relationships between lava lakes and the former tuff ring deposits, producing peperitic lava lake margins.

Keywords: phreatomagmatic, peperite, tuff ring, lava lake, basalt

Introduction

The Bakony- Balaton Volcanic Field (BBHVF) is a Mio/Pliocene alkaline basaltic intraplate volcanic field and is located in the western part of the Pannonian Basin, Hungary, 150 km away south-west from Budapest (Fig. 1). From Late Miocene to Pleistocene, alkaline basaltic volcanism characterised the region in form of eruption of small volume intraplate volcanoes (Szabó et al. 1992). The volcanic landforms of the volcanic fields of the western Pannonian basin predominantly consist of eroded remnants of scoria cones, tuff rings, and maars (Jugovics 1968; Németh & Martin 1999). The eruption of this vents were predominantly subaerial, however there are growing evidences that volcanism may have started shallow sublacustrine environment in places where valleys were preoccupied by lakes (Martin & Németh 2002). However, the idea of subaqueous volcanism in the history of research at BBHVF is not new (Lóczy 1913; Jámbor & Solti 1976; Bence et al. 1979), but the presented interpretations commonly lack of convincing field evidences, satisfactory models with good concert with volcanic facies analysis of volcaniclastic rock units as well as distinguishing intravent and extravent volcaniclastic deposits. In this paper we give a short description of two eroded phreatomagmatic volcanoes preserved by thick, semicircular lava lakes. Both presented sites give evidences of active intravent interaction between emplacing and growing lava bodies and tephra rims in a wet vent zone. To our knowledge such settings have not been documented yet.

Badacsony diatreme

At Badacsony, one of the largest lava capped butte of the BBHVF is formed by a thick (> 50 m) black, strongly chilled, affanitic basanite overlying a coarse grained, unsorted yellow lapilli tuff. Regardless that Badacsony is volumetrically among the largest volcanic remnants of the BBHVF with a current elevation of 437 m absl and 1 km, slightly north-south aligned lava capped plateau, little has been published of its geological framework (Cserny et al. 1981) or reconstruction of its eruptive history (Hofmann 1875; Lóczy 1913). Pyroclastic rocks have been sparsely reported from the region earlier, and mainly focused on an elongate shape lapilli tuff occurrence in the northern margin of the area (Hármas-hegy) (Hofmann 1875; Németh et al. 2002). The lapilli tuff (Fig. 2) from Badacsony consists of finely dispersed quartz or quartzofeldspathic sandstone accidental lithic fragments, xenocrystals of olivine and pyroxene as well as blocky, weakly to highly vesicular, microlite poor sideromelane glass shards (tephrite, phonotephrite). These are indicative of phreatomagmatic origin (Heiken 1972), near surface vesiculation (Houghton & Wilson 1989) and possible excavation of pre-volcanic country rocks (Lorenz 1986). The lava lake at Badacsony exhibits irregular lower contact to the pyroclastic units, commonly showing tumuli structures (Fig. 3). The tumulis enclose highly vesicular scoriaceous lava spatter clasts, with vesicles filled by clay, calcite or quartzofeldspatic fragments, as well as strongly palagonitized, often red blocky volcanic glass shards (Fig. 4). The irregular shape of the tumuli features and their irregular geographical distribution indicate that they formed rather accidentaly upon the contact between wet unconsolidated tephra and basanite lava. Between lava units a thin sedimentary veneer and their associated tumulis indicate short interuption of lava emplacement into a wet, water-filled Badacsony crater.

Haláp diatreme

At the other location, at Haláp, quarrying removed the central lava lake facies of the volcano, leaving behind a „castle-like" pyroclastic rim and thin lava layers, which allows to study the contact zone of the lava lake and the former crater filling and/or tuff ring (Fig. 1). The pyroclastic units (Fig. 5) at Haláp are yellow, brown, sideromelane volcanic glass shard-rich bedded, structureless or inverse graded lapilli tuffs containing large volume (~ 25 vol%) of accidental lithic clasts predominantly derived from the immediate pre-volcanic fluvio-lacustrine sedimentary units (Late Miocene, Pannonian) and interpreted to have been deposted by primary pyroclastic processes and occasional reworking of already deposited volcanic material into the crater. The lava in contact to the pyroclastic units show a peperitic contact. The affanitic, dark basanite columnar jointed lava lake gradually destroyed the sedimentary structures of the pyroclastic units, by developing peperites in a zone of metres thickness. Along the peperitic zone of the solidified lava lake, there are dispersed, highly vesicular, irregular shape coherent basanite fragments (dm-sclae size) infiltrated with clay. The clay in these fragments is inferred to have been derived from the tuff ring-forming tephra and/or the underlying pre-volcanic silicilcastic units due to fluidisation caused by the emplacement of the hot lava into a dish-shape vent. The presence of these peperites at Haláp suggests a wet and unconsolidated state of the tephra prior and during emplacement of the lava lake.

Conclusion

On the basis of the field description of two studied sites in the BBHVF, it has been concluded that both volcanoes were phreatomagmatic tuff rings (possible maar) with wide craters (vent zone) in which subsequent lava was emplaced. The lava flow emplacement was confined by the rim of the wet tephra (Fig. 6). The presence of peperite, and/or tumuli filled with „clay-soaked" spattery, highly vesicular scoriaceous fragments are evidences that the emplacement of the lava lakes occured in a wet environment. However, at Badacsony, the presence of irregular bubble-shaped, clay-rich vesicuar zones in the dense, coherent lava body of the lava lake give evidence that lava emplacement may have occured in time delay relative to the formation of the tuff ring of Badacsony. This happened presumably after the partial fulfilment of the crater by water due to water inflow from the ground-water table.

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Fig. 1.

Overview maps of the studied erosional remnants. A) overview of the BBHVF, B) Badacsony and C) Haláp diatreme

Fig. 2

Photomicrograph from a yellow lapilli tuff from the southern flank of the Badacsony. Note the abundance of angular quartz grains (white clasts) derived from Neogene silicilcastic units as well as the streched sideromelane tephrite glass shards (yellow grains) indicative of phreatomagmatic explosive eruption.

Fig. 3
Overview of the quarry wall exposing the interiour of the Badacsony lava lake. Note the irregular distribution of the vesicular scoriaceous zone in the coherent lava body, indicative of magma water interaction in the lava lake.

Fig. 4
Close up view of the scoriaceous zone of the agglomerate and/or tuff breccia. Note the whitish intergranular zone composed of clay likely to have been derived and infiltrated from loose tephra and/or siliciclastic pre-volcanic sedimentary units due to fluidisation caused by the heat of the emplaced lava body.

Fig. 5
Outcrop view of the pyroclastic lapilli tuff units build up the tuff ring, which confined the movement of the lava lake at Haláp.

Fig. 6
Interpretative cross sections of the studied diatremes exhibiting complex crater lake processes responsible for development of peperitic zones and/or tumuli structures in wet, phreatomagmatic craters of Badacsony and Haláp-

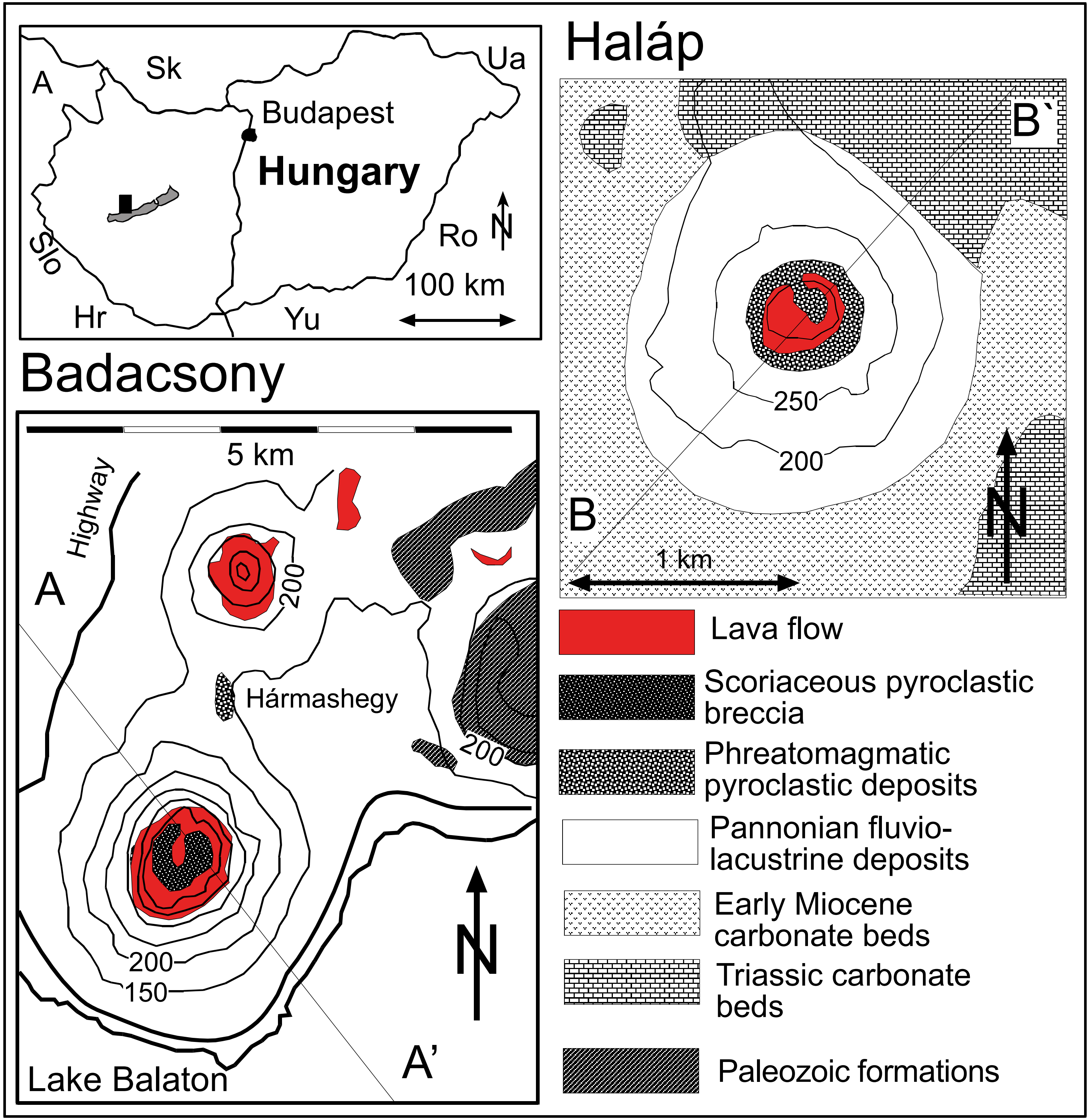
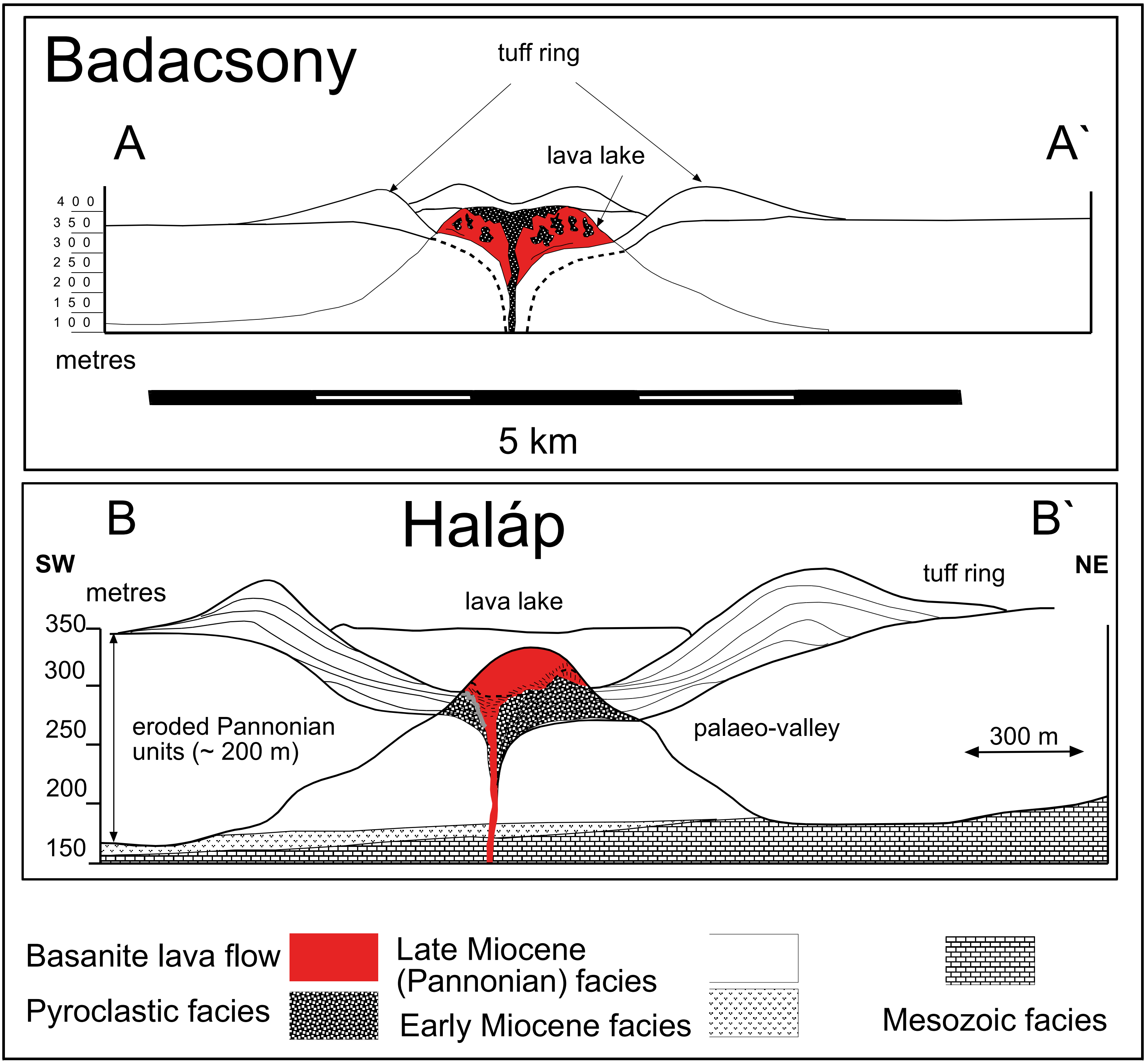

Sk
A
Ua
Budapest
Hungary
Slo
Ro
100 km
Hr
Yu
Badacsony
5 km
Highway
A
200
Hármashegy
200
200
150
Lake Balaton
A'
Haláp
B`
250
200
B
1 km
Lava flow
Scoriaceous pyroclastic breccia
Phreatomagmatic pyroclastic deposits
Pannonian fluvio-lacustrine deposits
Early Miocene carbonate beds
Triassic carbonate beds
Paleozoic formations

Fig. 1



Badacsony
tuff ring
A
A`
lava lake
4 0 0
3 5 0
3 0 0
2 5 0
2 0 0
1 5 0
1 0 0
metres
5 km
B
Haláp
B`
SW
NE
tuff ring
metres
lava lake
350
300
250
200
150
eroded Pannonian
units (~ 200 m)
palaeo-valley
300 m
Basanite lava flow
Pyroclastic facies
Late Miocene
(Pannonian) facies
Early Miocene facies
Mesozoic facies

Fig. 6