GROUNDWATER AND GAS RICH MAGMA CONTROLLED PHREATOMAGMATIC (MAAR/DIATREME) VOLCANISM IN THE BALATON HIGHLAND VOLCANIC FIELD, PANNONIAN BASIN, HUNGARY

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Abstract Book, p. 43

INTRODUCTION

Fig. 1

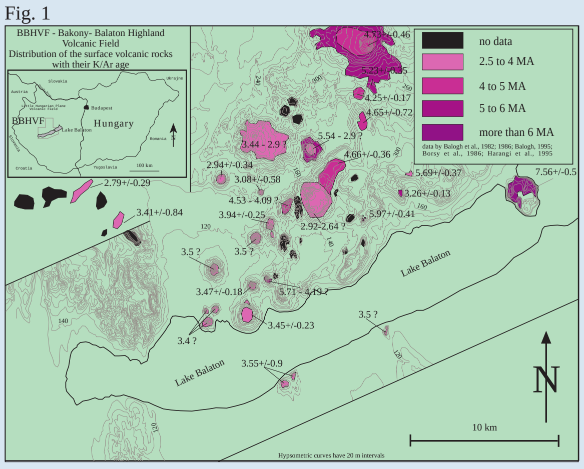
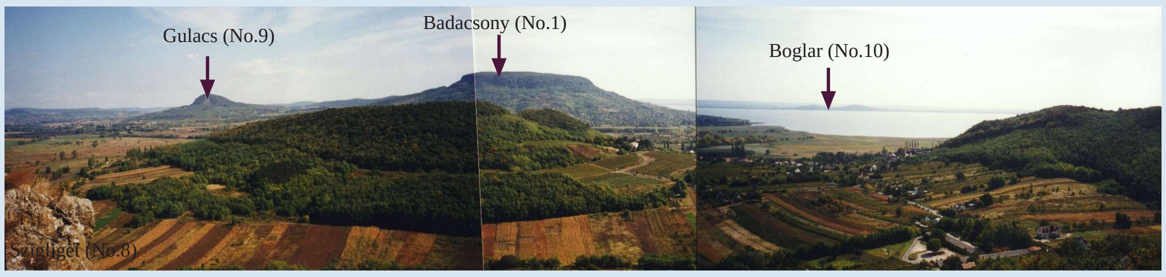


Fig. 2



The Balaton Highland Volcanic Field (BHVF) is located in the Central Pannonian Basin and built up by around 100 alkaline basaltic eruptive centers, which were active during the late Miocene era. The recent topographic highs are usually covered by pyroclastic and lava rock and show strong geophysical anomaly suggesting deep excavated maar/diatreme structures in this regions. The phreatomagmatic volcanoclastic sequences are usually located in the lower basins which are filled by thick late Miocene clastic sediments. The scoria cones and the large lava flows cover the topographic highs or the inner part of the former tuff rings/maar craters, which suggests that the different type of volcanic landforms was strongly controlled by the occurrence of unconsolidated, wet Pannonian sediments and the paleomorphology. The region of maar volcanoes is rich in CO_2 rich mineral water suggesting that the CO_2 could have been separated from the volatile rich parental magma and emplaced into the subsurface region.

PHYSICAL VOLCANOLOGY

Fig. 3 Szigliget (No.8)

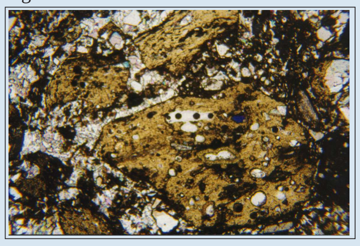


Fig. 5 100 mm Fuzes-to (No.21)

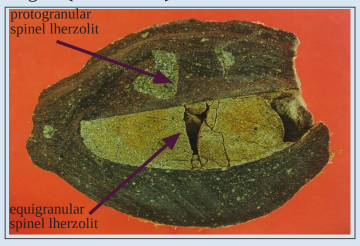


Fig. 7 100 mm Boglar (No.10)

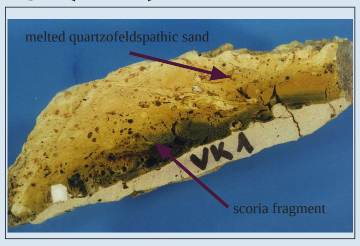


Fig. 9 50 mm Tihany, Peak Hill (No.33)

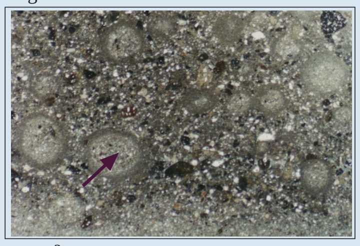
Lava flows filled the maar basins, which usually show north-south elongation. Lava foot breccias,lava channels, tumuli structures are common. Characteristics of the primary volcaniclastics include: chilled juvenile pyroclast (Fig.3),large proportion of wall rock clasts, accretionary lapilli (Fig.4), impact sags, base surge beds, channels, high amount of peridotite lherzolit fragments (Fig.5)

Peperites are related to lava foot or vent zones. Globular peperites are common in the eroded and exposed hydrovolcanic vents (Fig.7. Boglar). Blocky peperite are known next to feeder dyke zones (Fig.6. Hajagos-hegy).

Gilbert-type delta fronts consist of steeply dipping succession of alternating coarse-grained, inverse-to-normal graded reworked tephra beds (Fig.8). The strongly eroded remnants of this deltaic fronts represent the former maar crater rim positions.

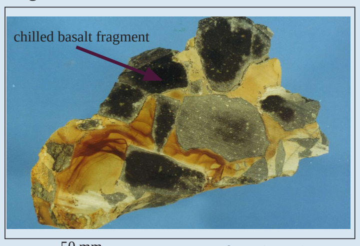
Carbonate lamina succession deposited on the Gilbert-type deltaic front beds.The carbonate beds are cemented by hot spring inducted silicification process (Fig9). The carbonates are microlaminated, varvic structured (fig.10) and large slumped, folded bed.

Fig. 4



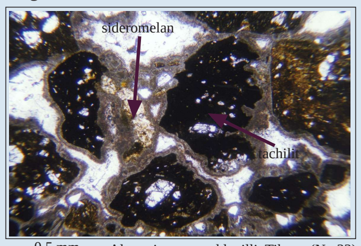
2 mm Tihany, West Coast (No.33)

Fig. 6



50 mm Hajagos-hegy (No.14)

Fig. 8



0.5 mm Algae rims around lapilli, Tihany (No.33)

Fig. 10

1 mm Tihany, Peak Hill (No.33)

tab.1

Locality name and number	Hc	Type	d	D	w	Total ejecta (X106m3)	Calculation of relative elevation	Hp	Erosion	Erosion rate m/Ma
1. Badacsony	420	M/S/Ll	1500	300	50	225	Hc-w	370	270	78
2. Szentgyorgyh.	400	M/S/Ll	1000	200	30	75	Hc-w	370	270	96
3. Gulacs	400	M/S/Ll	800	160	20	50	Hc-w	380	260	75
4. Halap	358	M/S/Ll	1000	200	30	75	Hc-w	328	208	71
5. Fekete-hegy	369	M/S/Ll	1500	200	30	2x225+1X150	Hc-20	350	210	72
6. Bondoro-hegy	370	M/S/Ll	1000	200	30	75	Hc-w	340	180	60
7. Hegyesd	280	P	200?	-	-	-	Hc+20	300	180	58
8. Szigliget	242	M(S)	1200	240	40	2X50+150	Hc+1/3D	322	222	65
9. Fonyod	232	P?	300?	-	-	-	Hc+10	242	142	40
10. Boglar	164	M(S)	500	100	10	2x20	Hc+2/3D	230	130	37
11. Agarteto	511	SV/S/H	-	-	-	-	Hc-lava thickness	400?	150?	44
12. Tagyon	310	P?	200?	-	-	-	Hc+20	330	?	?
13. Csobanc	375	M/S/Ll	1000	200	30	75	Hc-w	345	225	64
14. Hajagos-hegy	330	M/S/Ll	1000	200	30	75	Hc-w	300	180	46
15. Kopasz-hegy	300	M(S)	1000	200	30	75	Hc	300	160	46
16. Pipa-hegy	200	M	1000	200	30	75	Hc+1/2D	300	160	46
17. Kekkuti-hegy	220	M(S)	800	160	20	50	Hc+1/2D	300	160	46
18. Kerekimajor	171	M	800	160	30	50	Hc+2/3D	280	80	23
19. Oreg-hegy	250	M	300	60	8	10	H+2/3D	290	90	26
20. Horog-hegy	266	M	500	100	10	20	H+2/3D	332	192	55
21. Fuzes-to	300	M/S	1000	200	30	75	Hc	300	160	46
22. Kishegyestu	238	M	800	160	20	50	Hc+1/2D	318	178	51
23. Fekete-hegy2	370	M/S/Ll	1500	300	50	225	Hc-w	320	180	39
24. Talodi-erdo	312	M/S/Ll	1500	300	50	225	Hc-w	262	82	18
25. Pula	200	M	1000	200	30	75	Hc+1/2D	300	120	28
26. Kabhegy	599	SV/S/H	-	-	-	-	Pre.Volc.Rec.Elv	400?	250	51
27.Bondoro-hegy	380	M/S/Ll	1000	200	30	75	Hc-w	340	180	32?
28. Hegyestu	336	P?	200?	-	-	-	Hc+30	366	166	28
29. Kabhegy old	as 26.									
30. Toti-hegy	346	P?	200?	-	-	-	Hc+30	376	256	45
31. Tagyon2	399	P?	200?	-	-	-	Hc+30	429?	229?	40
32. Satorma-hegy	354	M/S/H	1000	200	30	75	Hc-w	324	184	41
33. Tihany	232	M(S)	1500	300	50	4X225	Hc+1/3D	332	232	
34. T.dorogd1	320	P?	200	-	-	-	Hc+30	350	150?	27?
35. T.dorogd2	280	M	1000	200	30	2X75	Hc+1/2D	380	180?	33?

2.5 - 4 Ma with data (rows 1–14); 2.5 - 4 Ma pers.com. (rows 15–22); 4 and older with data (rows 23–33); 4 and older pers.com. (rows 34–35)

M-maar, S-scoria cone H-Hawaiian, Ll-lava lake SV-shield volcano, P-plug elevations in meter

Due to the described features, 3 main type of eruptive centers could be identified on the BBHVF. The primary hydrovolcanic sequences are usually related to eroded and recently exposed maar basins. The classification of different eruptive centers using physical volcanology data is shown on Fig. 12.

Porous media aquifer controlled maar volcanoes

This type of volcanic centres is located on thick porous media aquifer covered regions, wich are usually related to the recent low lands. The beds of this centres consist of lapilli tuff with high amount of fine-grained Pannonian Sandstone fragments. In the basal zones large plasticly deformed sandstone fragments are also common. In the stratigraphicly higher levels the beds show drying process of the explosive environment. The transition between phreatomagmatic explosive processes into Strombolian explosive processes was continuous.

Tihany type maar volcanoes

This type of maar volcanic centres occur in those regions where thick porous media aquifer covers fracture controlled aquifer. In the first stage of the eruptive history of this centres , the phreatomagmatic explosions were controlled by the water content of the porous media aquifer. In this stage fine grained lapilli tuff beds deposited from base surges and fall out with high amount of porous media aquifer fragments. With the downmigrating of the explosion locus the porous media dried up. The deeper explosion locus suddenly reached the fracture controlled aquifer, where the abundant karst water became the major control of the phreatomagmatic explosions. In this time highly indurated - “tuff cone kind” - lapilli tuff beds deposited with large, extremely deep excavated country rock content.

Strombolian type eruptive centres

Strombolian scoria cone remnants are widespread in the BBHVF. The high ratio of scoriaceous fragments in redeposited volcaniclastics related to maar crater lake deposition environment suggest that the Strombolian type of activity was very important stage during the eruptive history of BBHVF.

Fig. 11

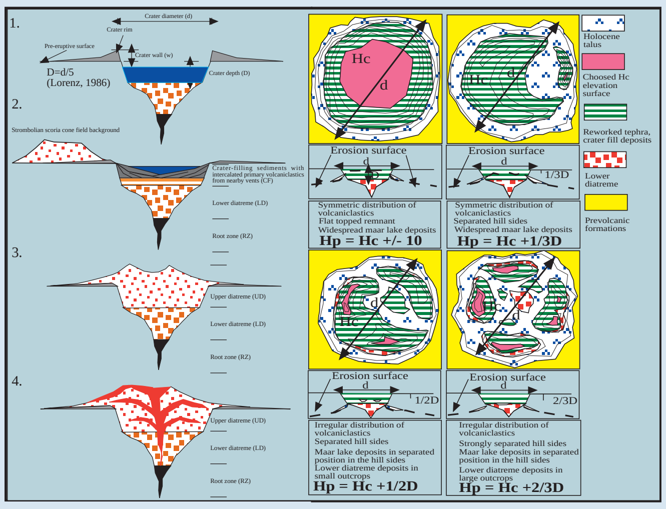
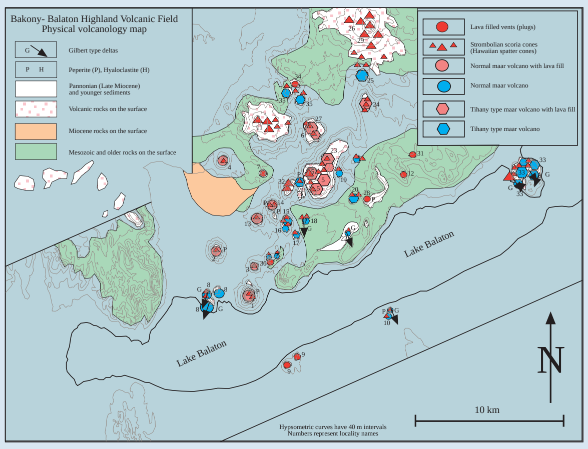


Fig. 11



Using the physical volcanology data of the individual centres we were able to estimate the relative erosion of the volcanic centres. Fig. 10 summarizes the calculation method of the geomorphological parameters of the individual eruptive centres. Estimating the maar crater diameters as input data we used the mappable size of volcanic rocks which belongs to the same vent. The best estimation is given in those areas where the former maar basins were filled by later lava lakes, thus they preserved the original geometry very well. The calculated relative elevations show the pre-volcanic surface elevations. The numbers are not absolute values, they shows differences between the different sites. The absolute elevation are most likely between 0 and 200 meters. Because the two age group are relatively wide in age range, reconstructed paleo-geomorphological maps show most likely trends in the geomorphology rather than absolute (exact) relief.
Fig. 12 shows the paleo- geomorphology during the more than 4 million years old scenario. In the western part of the area, the Pannonian lacustrine sedimentation was still active, while during the same time the eastern part of the region was a slightly elevated area probably with a flat alluvial plain and a small stream system.
Fig. 13 shows the geomorphology during the younger volcanism (2.5-4 Ma). The Pannonian lacustrine sedimentation was most likely already finished in the region. The area was probably not higher than a few hundreds meter (200) above see level and the sedimentation took place in a fluvial environment. The major control of the eruptive style of the individual centres was mainly driven by the occurrence of water saturated Pannonian sediments and the paleo- karst water and its change during the uplift.

Conclusions

1. The distribution of the different type of volcanic centres (maars, scoria cone and lava flows) shows a strong relation with the distribution of
   a., thick porous media aquifer beds (Pannonian Sandstone Formation)
   b., the occurrence of fracture controlled aquifer with karst water system
   c., the recent geomorphology
2. There is a slightly traceable trend of the age distribution of the eruptive centres. The younger eruptive centres are situated on the western side of the region.
3. There is a general trend of north to south elongation of the shape of the individual eruptive centres.
4. There is a general trend of the occurrence of the Gilbert type deltas in the northern side of the eruptive centres showing southward dipping.
5. The distribution of the normal and Tihany type maar volcanoes shows a strong relation between their occurrence and Pannonian or karst water bearing sediments.
6. The paleo- geomorphology of the area was a relatively flat, stream rich, plain, where small basement grabens were elevated above the general topography not more than 100-200 meter.
7. The phreatomagmatic centres erupted in the stream valleys, which were related to paleotectonical lines, structural weakness of the basement rocks. This valleys did most likely not show very characteristic surface evidences of large fault systems. Normal maar forming explosions occurred in those areas where the thick porous media aquifer in the pre- volcanic rock contained enough water to cause phreatomagmatic reactions. The dry explosive or effusive activity occurred where no water rich porous media was available. In those areas where the karst water level was high, and a thin porous media aquifer covered the basement, Tihany type maar volcanism unusual took place.
8. The mechanism of eruptive centres in BBHVF shows strong similarity with the Westeifel Volcanic Field, Germany; Hopi Buttes, Arizona; Fort Rock Valley, Oregon; southeast South Australia, Australia.

PALEOGEOGRAPHY

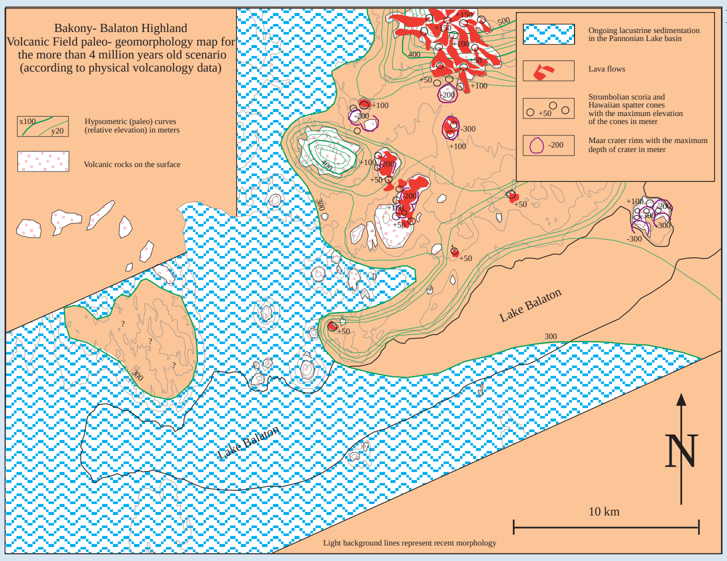
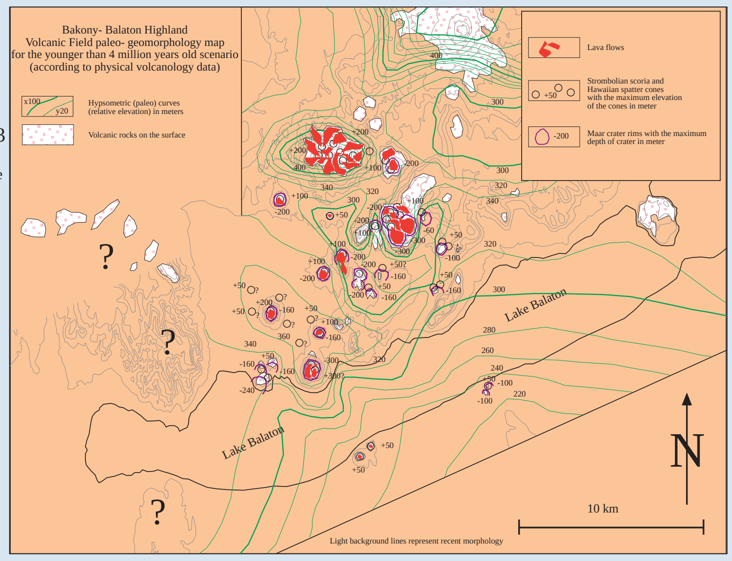


Fig. 12
Palogeographic reconstruction
4m.y. and more before present time

Fig. 13
Palogeographic reconstruction
2.5 to 4 m.y. before present time



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