FLUID INCLUSIONS IN XENOLITH GLASS: DIRECT EVIDENCE FOR FLUID OVERPRESSURE UNDER AN EXPLOSIVE VOLCANO (SZIGLIGET, W-HUNGARY)

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Aqueous fluid inclusions were studied in the melted glass phase of some quartz-rich xenoliths hosted by alkaline basalt and lamprophyre lapillis and blocks in Szigliget volcano (Bakony-Balaton Highland Volcanic Field, W-Hungary). The Szigliget volcano consists of pyroclastic rocks deposited from relatively low concentration pyroclastic currents and phreatomagmatic fallout tephra which are the products of a phreatomagmatic explosive activity (Németh et al 2000). This volcanic activity belongs to the Pliocene alkaline basaltic volcanism of the Pannonian Basin.

The xenoliths consist mainly of quartz with glassy zones or melt pockets occasionally with additional plagioclase, K-feldspar, biotite, cordierite, calcite and garnet. The melt zones and pockets contain different mineral assemblages such as Al-rich orthopyroxene + spinel ± plagioclase and/or ternary feldspar, Al-rich orthopyroxene + K-feldspar, spinel + quartz, garnet± plagioclase ± Al-rich orthopyroxene ± spinel, mullite ± corundum ± spinel, corundum ± spinel ± plagioclase and/or ternary feldspar.
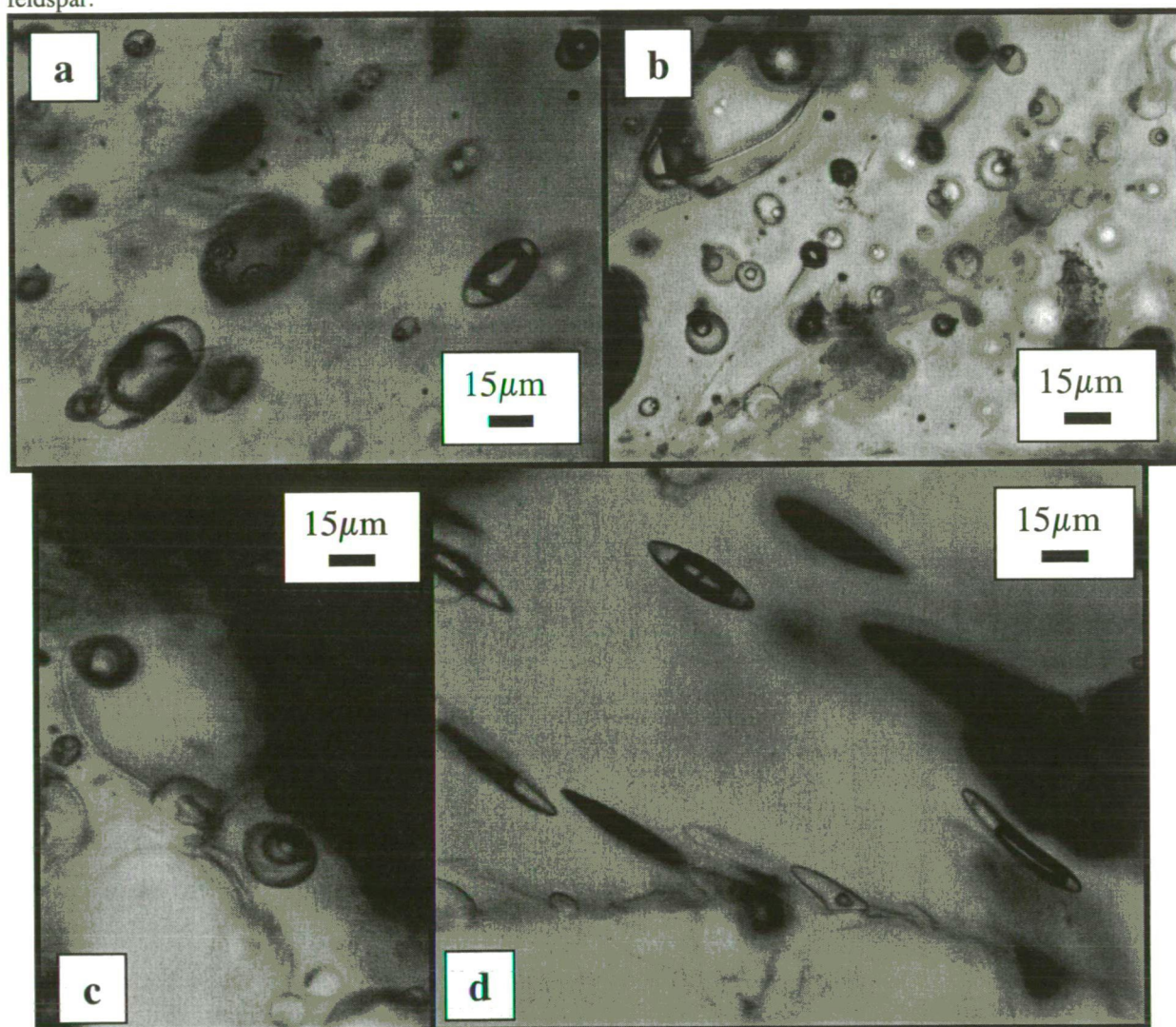

Figure 1. **a:** Ellipsoidal two phase (L+V) aqueous inclusions (Type 3) in glass with variable liquid/vapour ratio. **b** Spherical single phase vapour (Type 1) and two phase (L+V) inclusions (Type 3) in glass. **c** Three phase H_2O-$NaCl$-CO_2 inclusion (Type 4) in the glass. **d** Elongated aqueous inclusions showing fluidal texture.

Melt zones are originated mostly from preexisting mica-rich layers. The melt has in most cases a peraluminous rhyolitic composition with A/CNK between 0.99 and 3.22 and normative corundum between 1.3 and 11.4.

Five types of fluid inclusions were observed at room temperature in the glass phase and in the matrix quartz:

1. Single phase vapour in the glass (Fig 1b),
2. Single phase liquid brine in the glass,
3. Two phase (L+V) aqueous, H_2O-NaCl inclusions in the glass (Fig 1a, b, d)
4. Three phase ($L_W+L_{CO2}+G_{CO2}$) H_2O-NaCl-CO_2 inclusions in the glass (Fig. 1c).
5. Two phase (L+G) CO_2 inclusions in the matrix quartz (Török, 2002).

All inclusions in the glass occur as solitarily inclusions or more often in clusters or dispersed throughout the glass phase without visible cracks or healed fractures. The inclusions are sometimes attached to minerals in the glass. The shape of the inclusions tends to be ellipsoidal (Fig. 1a) or spherical (Fig. 1b). Sometimes elongated inclusions are also observed following the fluidal texture of the glass and enclosed minerals (Fig. 1d). The liquid/vapor ratio in the inclusions usually varies within wide range, but sometimes it may be constant in some melt pockets. These textural features refer to the primary nature of the aqueous fluid inclusions in the glass.

CO_2 inclusions in the matrix quartz are also occur as solitary ones or in small groups or clusters. Secondary single phase inclusions are also exist, but these ones were not measured.

Measurements were made on the type 3 and 5 inclusions. Ice melting temperatures in the aqueous fluid inclusions of type 3 in the glass range from -2.9 to -4.6°C which means salinity between 4.8 and 7.3 NaCl equiv.wt% (Bodnar, 1992). Homogenisation temperatures range from 99 to 160°C. Above this temperature the aqueous inclusions begin to stretch and decrepitate. The calculated density of the aqueous inclusions is between 0.94 and 0.99 g/cm^3.

Type 5 CO_2 inclusions in the matrix quartz have melting points between -56.7 and -57.4°C and homogenisation temperature between +26.5 and +29.7°C (Török, 2002).

Presence of mullite, the Al-rich orthopyroxene (with Al_2O_3 content up to 15wt%) and the ternary feldspar thermometry shows the ultrahigh-temperature conditions where the temperature exceeded 1100°C in the xenoliths. The stability of spinel+quartz and spinel+Al-orthopyroxene+quartz, and the isochores of the CO_2 inclusions show pressures about 300-350 MPa which means depth of origin of about 12-15km for the xenoliths. This is just above the present day boundary between the mafic lower crust and the felsic upper crust. The isochores of the two phase aqueous inclusions with the measured homogenisation temperature range show 1.8-2.1 GPa pressure at 1100°C, which means a very high fluid overpressure as compared to the pressures estimated for the xenoliths. The calculated pressure for the aqueous inclusions would correspond to mantle depths down in the garnet lherzolite stability field. In some places where single phase liquid aqueous inclusions (type 2 inclusions) exist this overpressure is even higher.

The aqueous fluid inclusions in the glass mean that the system was oversaturated in respect of water and that the free aqueous phase coexisted with the melt. The single phase vapour inclusions may represent later shrinkage bubbles or vesiculation during uplift. The variable liquid/vapor ratios observed in several places mean inhomogeneous trapping and/or inequilibrium between the melt and fluid and/or density changes during uplift in the still melted glass. The constant liquid/vapour ratios observed locally may represent local equilibrium between the aqueous fluid and the melt. The estimated depth of the explosion center of the volcano was estimated to have been down to 1000 m from the surface by Németh et al (2000). This is much less than the estimated depth of origin of the xenoliths which means that either the fluid overpressure recorded by the aqueous fluid inclusions is a local feature which did not serve as cause for the eruptive nature of the volcano or alternatively the eruptive center lies much deeper than it is thought before.

Acknowledgements

References

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