N.F. 20

Origin of Mantle-Xenoliths in the Phonolith of the Heldburg

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Abstract

Magmatic differentiates such as trachyte and phonolite are volumetrically subordinate to mafic rocks within the Cenozoic Central European Volcanic Province (with the exception of the East Eifel volcanic field). Within the volcanic field of the Heldburg dike swarm area the phonolite of the Heldburg castle hill ("Burgberg") represents the only known occurrence of differentiated magmatic rocks. However, the Heldburg phonolite is internationally famous foremost for containing mantle xenoliths (spinel lherzolite). Former studies proposing a cogenetic relationship between the phonolite and the peridotites, concluded that the phonolite magma must have evolved under upper mantle conditions. In the current study we present petrographic evidence for magma mixing and mingling in the Heldburg phonolite melt due to the intrusion of mantle derived basanitic magma which is exposed today as dike at the foot of the Heldburg Burgberg. During this process the mantle xenoliths were introduced into the phonolite melt as they all contain a rim of basanitic magma. We identified three major lithologic units in the area of the Heldburg castle, ranging in composition from basanite over tephrite to phonolite. Extensive mingling features (e.g., schlieren layers, load casts, flame structures, mafic enclaves) are developed between these units, indicating that all of them were melts at the time of mixing. The petrographic indications are evidence for at least two coexisting melts of different degrees of differentiation.