Sturm, A., Schmitt, A.K., Cionoiu, K., Danišík, M. (2023)

Crystallization timescales for the Wehr complex (East Eifel Volcanic Field): Insights from zircon geochronology and glass geochemistry

The Quaternary East Eifel volcanic field (EEVF) comprises three major evolved, phonolitic to trachytic centers (from old to young: Rieden, Wehr, and Laacher See) in addition to ~80 scoria cones. The prominent Laacher See eruption ca.13.000 years ago ranks among the largest Quaternary volcanic events in Europe, with the phonolitic Laacher See tephra (LST) being widely dispersed and of great relevance as a tephrochronological marker horizon[1]. Magmatic activity as recorded by zircon indicates that evolved magma was present underneath Laacher See at least 50 ka prior to its eruption. Continuous degassing and deep low-frequency earthquakes presumably related to fluid migration in the crust hint at ongoing magmatic activity.

Multiple eruptive phases characterize the older volcanic complexes of Rieden and Wehr, and it is therefore relevant to compare them to Laacher See center with presently only one eruption. Here, we focus on three eruptions that are associated with the Wehr depression or nearby centers, and where existing eruptive geochronology based on $^{40}Ar/^{39}Ar$ suggest eruptions <116 ka, bridging the transition of activity from Wehr to Laacher See. Three composite pumice samples were collected from previously established type localities (Dachsbusch, Herchenberg) comprising the Hüttenberg Tephra (HT), Glees Tephra (GT), and Dümpelmaar Tephra (DT). Whereas HT and GT are generally attributed to the Wehr depression, DT is presumably sourced from a small vent west of the Herchenberg scoria cone[2].These trachytic-phonolitic magmas evolved from parental basanite, similar to LST, although there are major and trace element as well as isotopic differences[3].

SIMS U-Th zircon crystallization ages for HT (230^{+28}_{-23} ka; MSWD= 0.83; n=27, uncertainties 1σ) and GT (154^{+18}_{-15} ka, MSWD= 1.71; n=32) are nominally older than published $^{40}Ar/^{39}Ar$ eruption ages[2] by at most 15 ka, but zircon crystallization and eruption ages overlap within uncertainty. The U-Th zircon age for DT of 120^{+5}_{-5} ka (MSWD= 1.02; n=33) also overlaps with the published $^{40}Ar/^{39}Ar$ age (116 ±16 ka), but this is only based on two sanidine analyses with the lowest ages that were interpreted as maximum eruption age[2]. Crustal zircon xenocrysts are common in all pumices, but morphologically distinguishable from the juvenile zircon population dominated by dipyramidal morphology. Glass geochemistry indicates high abundances of Zr, which is a pre-requisite for zircon saturation in highly alkaline melts.

In contrast to $^{40}Ar/^{39}Ar$ ages for individual K-feldspar crystals that display significant age heterogeneity[2], in part exceeding the onset of volcanism in the EEVF, juvenile zircon crystals from HT, GT, and DT define a single population based on their individual isochrons. No carry-over of older zircon crystals into younger eruptions was detected, suggesting either eruption from distinct magma reservoirs, or complete resorption of pre-existing crystals between eruptive pulses. Future (U-Th)/He zircon geochronology will further constrain the temporal evolution of the evolved EEVF complexes.

[1]Bogaard, v. d. P., Schmincke, H.-U., 1985. Geol. Soc. Am. Bull. 96, 1554–1571.

[2]Bogaard, v.d. P., Hall, C.M., Schmincke, H.-U., York, D., 1989. Nature 342, 523–525.

[3]Wörner, G. et al., 1988. N Jb Miner Abh, 159, 73–99.