

The carbonatite-alkaline silicate rock association from the Eifel Volcanic Province (Germany)

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The igneous activity of the Eifel Volcanic Field (Germany) is part of the diffuse magmatism developed from Cenozoic to recent times in France, Germany, Poland and Czech Republic, mostly along the European Cenozoic Rift System. The Eifel Volcanic Field is characterised by the presence of abundant evolved compositions (such as phonolites and syenites), with minor basic/ultrabasic lithologies (e.g., olivine-bearing nephelinites and basanites), occasionally associated to coarse-grained carbonatites. The Quaternary (<0.7 Ma) igneous activity of this area occurred contemporaneously in the West and the East Eifel fields. The strongly explosive activity of the Laacher See volcano is the largest and the youngest (~12.9 ka) of the East Eifel, which emplaced essentially phonolitic magma and much rarer ultrabasic lavas with potassic affinity. The main peculiarity of the Laacher See volcano is the occurrence of tephra deposits characterised by the presence of abundant plutonic ejecta (up to 20 cm in size) from the disrupted chamber walls, with mafic, intermediate, and felsic composition, plus low amounts of carbonate-rich lithologies (5%).

In this study, we present the results of a detailed petrographic investigation coupled with mineral chemical, whole-rock geochemical and isotopic (Sr-Nd-Pb) analyses on lavas, scoriae and plutonic ejecta with a wide compositional ranging from leucitites and basanites to sövites and syenite-carbonatite hybrid rocks. For the origin of the carbonatitic and silico-carbonatitic rocks, we propose a two-step model in which a CO₂-bearing parental leucitite magma evolved towards CO₂-enriched phonolite compositions after prolonged fractionation of olivine + clinopyroxene + Fe-Ti oxides ± melilite. Once it reached this point, magma unmixing led to the separation of a SiO₂-rich and CaO-CO₂-poor melt (which later crystallised to form syenites) from a SiO₂-poor and CaO-CO₂-rich aliquot (which led to the formation of Ca-carbonatites). The syenite-carbonatite lithologies can, thus, be considered the result of the unmixing process, with small blobs of carbonatite magma entrapped by a silicate magma and the composite samples resulting from the juxtaposition of lithologically different domains crystallized from the two unmixed magma batches along the magma chamber walls.