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Bimodal Miocene volcanism in the Hegau region (SW Germany) produced nosean phonolites by differentiation of primitive melilititic–nephelinitic magmas

In the Hegau region (SW Germany), a type of bimodal alkaline volcanism unique to the southern Central European Volcanic Province (CEVP) occurs. (I) Primitive olivine melilitites and melilite-bearing olivine nephelinites (12-9 Ma) are composed of olivine (Fo_{70-92}), diopsidic clinopyroxene melilite, perovskite, Cr-bearing oxyspinel, F- and Ba-rich phlogopite/kinoshitalite and fluorapatite. (II) In contrast, evolved nosean phonolites contain abundant Ba-bearing alkali feldspar and nosean-haüyne-sodalite$_{ss}$ macrocrysts as well as aegirine augite and accessory apatite, titanite, zircon, and pyrochlore. While the melilititic–nephelinitic rocks are widespread in the southern CEVP and formed by low degrees of partial melting of a carbonated amphibole-bearing garnet wehrlite in the uppermost asthenosphere, the formation of the nosean phonolites remained poorly understood. However, coarse-grained (nepheline) syenitic cumulates, present as enclaves in both rock series, as well as the geochemistry of the phonolites (e.g., negative P and Ti anomalies, trough in the MREE in primitive mantle-normalized trace element patterns), indicate that the evolved magmas may have originated from primitive melts by fractionation of clinopyroxene, mica, alkali feldspar, nepheline, apatite, and titanite. Thermodynamic modelling by MELTS using the whole-rock composition of the melilititic–nephelinitic Hegau rocks as starting composition corroborates that the nosean phonolites were generated by removal of 11–19% oxyspinel, 4–10% olivine, 42–57% clinopyroxene <3% mica, <9% feldspathoids and <8% feldspar at upper crustal pressures (c. 200 MPa), leaving 12–35 mass% of the initial melt. The wide range in composition of the nosean phonolites in the Hegau region can be reproduced by relatively small compositional differences of the primitive parental melts and by variable degrees of fractionation without the necessity for crustal assimilation.

Keywords: bimodal volcanism, Central European Volcanic Province, magmatic differentiation, melilite-bearing olivine nephelinite, MELTS modeling, nosean phonolite

Biography

Thomas Binder studied Economic Geology (Bachelor & Master) at Clausthal University of Technology (Germany) from 2013–2019. He worked on eclogites in the Münchberg gneiss massif (Bavaria) and U-V-bearing five-element vein type deposits in the Harz Mts. (Lower Saxony) and then joined the Petrology and Mineral Resources research group at the University of Tübingen (Germany), where he has just finished his PhD on the petrology and geochronology of alkaline SiO_2-undersaturated rocks in the southern part of the Central European Volcanic Province. He regularly presents his research at international conferences and gives colloquium lectures at various universities.

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