Petrology of the melilititic and nephelinitic rock suites in the Lake Natron-Engaruka monogenetic volcanic field, northern Tanzania

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The Lake Natron - Engaruka Monogenetic Volcanic Field (LNE-MVF) in northern Tanzania consists of more than 150 vents of Upper Pleistocene to Holocene age that are scattered over an area of 2500 km^2. Here we describe the petrological characteristics of these eruptions in detail and link the magma chemistry to eruptive behaviour when the magmas reach the surface. Erupted magmas are predominantly of melilititic or nephelinitic compositions (70 and 25%, respectively), together with minor amounts of basanites (5%). The melilititic magmas form by small degrees (1-2%) of partial melting of a metasomatized upper mantle source (containing 1-4% garnet together with both amphibole and phlogopite). The melilitites ascend very rapidly through the lithosphere prior to eruption minimizing the effect of fractional crystallization and/or crustal contamination. These eruptions also frequently carry relatively large amounts of mantle debris to the surface. The nephelinitic rock suite, on the other hand, form by larger degrees of melting (2-4%) at higher levels of the sub-continental lithosphere containing less garnet (<1%). The scarcity of mantle debris in the nephelinitic eruption deposits, combined with the more evolved magma chemistry indicates ponding in crustal reservoirs en-route to the surface. For many of the nephelinitic magmas this ponding resulted in fractional crystallization of predominantly olivine, which is also one of the main phenocryst phases in these rocks. However, these periods of ponding in the crust must have been short as none of the investigated rocks show any clear evidence of being affected by crustal contamination.

Within the LNE-MVF there is a rough correlation between magma chemistry and the resulting volcanic landforms. Large maar volcanoes and tuff cones/rings are predominantly of melilititic composition, whereas the nephelinites typically form scoria cones. This is attributed to the fact that melilititic magmas can hold more CO_2 dissolved in the melt structure compared to nephelinites, in combination with a rapid ascent from the upper mantle to the surface for the melilitites (<1-2 days). We interpret violent exsolution of CO_2 (in response to rapid decompression) to be responsible for the higher explosivity of the melilititic eruptions compared to the nephelinitic magmas within the LNE-MVF.