Geophysical Research Abstracts
Vol. 16, EGU2014-5783, 2014
EGU General Assembly 2014

3D cone-sheet and crystal-settling models reveal magma-reservoir structure of the Carlingford central complex, Ireland

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The Palaeogene Carlingford central complex, northeast Ireland, hosts a swarm of mostly basaltic cone-sheets with several lithological subsets (Halsall, 1974). The two most abundant sets are aphyric and highly porphyritic cone-sheets with up to 80% of cm-sized plagioclase phenocrysts. The abundance of highly porphyritic cone-sheets seems to systematically increase with altitude compared to the aphyric type (Meade, 2008). We hypothesised that this observation might be explained by the zonation of the source magma reservoir. In order to test this hypothesis, we modelled the 3D cone-sheet structure at depth and the settling of plagioclase phenocrysts. The 3D model of the Carlingford cone-sheet swarm reveals that lithological types of Carlingford cone-sheets are not systematically distributed in space. Using the method proposed by Burchardt et al. (2013), we constructed the likely source reservoir of the cone-sheets, which is saucer-shaped, elongated in NW direction, 7 km long and 3 km wide, and located at a depth of 1 km below the present-day land surface. Our calculation of the terminal velocity of the plagioclase phenocrysts shows that the large phenocrysts in the porphyritic cone-sheets were too big to float at the conditions present in the Carlingford magma reservoir. We can therefore exclude vertical magma-chamber stratification as an explanation for the formation and distribution of porphyritic and aphyric cone-sheets. Instead, we envisage the formation of a crystal mush at the base and sides of the Carlingford magma reservoir. Cone-sheet injection and magma-cha,ber replenishments have remobilised plagioclase cumulates, which may explain the occurrence and distribution of aphyric and highly porphyritic cone-sheets.

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