Geophysical Research Abstracts
Vol. 12, EGU2010-10171, 2010
EGU General Assembly 2010


# The association of cone sheets and regional dykes: data from the Isle of Skye (UK), numerical modeling, and applications to terrestrial planets

Andrea Bistacchi (1), Matteo Massironi (2), and Riccardo Pozzobon (2)

(1) Dipartimento di Scienze Geologiche e Geotecnologie, Università di Milano Bicocca, Milano, Italy (andrea.bistacchi@unimib.it), (2) Dipartimento di Geoscienze, Università degli Studi di Padova, Padova, Italy.

The spatial distribution and orientation of dykes propagating from a shallow magma chamber is a key element in understanding the stress field and internal growth of volcanoes on terrestrial planets, with consequences on eruptive processes and stability of volcanic edifices.
In order to contribute to these topics, we went back to the classical Cuillins cone sheet complex on the Isle of Skye, where the roots of a Tertiary basaltic volcano are exposed (Anderson, 1936, Proceedings of the Royal Society of Edinburgh, 56, 128-157), and performed a detailed field study. In the Cuillins complex, inward dipping cone sheets, developed under magma inflation conditions, show either pure dilational or hybrid shear kinematics. Cone sheets disappear after a critical distance and are substituted by a set of parallel subvertical dykes perpendicular to the regional least compressive stress axis.
The results of this study are consistent with both structural patterns reported on some Terrestrial and Martian volcanoes and scale models where the same association of cone-sheets and "regional" dykes can be found or inferred.
To explain these data, we developed a set of finite element models, which for the first time include an elasto-plastic rheology and consider the total stress field deriving from gravity, tectonics and magma chamber overpressure. Numerical modeling shows that only in the case of a shallow oblate magma chamber cone sheets may be predicted for realistic magma overpressure values (ca. 10-20 MPa). In contrast they should not develop with sub-spherical or prolate magma chambers. In any case, cone sheets appear to be confined within a distance from the central axis of about 1-1.2 diameters of the magma chamber and in the volume immediately above it, whilst radial dikes dominate beyond the 1-1.2 diameter limit. When a realistic regional stress field is considered, the radial dikes progressively merge into a regional swarm of parallel dikes, oriented perpendicular to the least compressive stress axis. The cone-sheets/radial dykes association is not consistent with conditions leading to caldera collapse (deflation), and it is noteworthy that cone sheet emplacement is likely to contribute significantly to internal growth of volcanoes.
This model can be applied to the activity of volcanoes on terrestrial planets to infer: (i) the presence of a relatively shallow, oblate magma chamber; (ii) its dimensions; (iii) the tensional state of the system and particularly an overpressure condition in the magma chamber.