Complex flow in granite crystal mush evidenced by AMS, rock magnetism and microstructure (Castle Crags pluton, California)

Matěj Machek[1], Prokop Závada[1], Eduard Petrovský[1], Aleš Špičák[1]

[1] Institute of Geophysics AS CR, v.v.i., Boční II/1401, 141 31 Prague 4, Czech Republic

Corresponding author: mates@ig.cas.cz

Abstract: The Castle Crags pluton (CCG) (167 Ma) belongs to the Wooley Creek suite of plutons (152-170 Ma that intruded the Klamath Mountains province in northern California. This province represents accretional mountain belt developed at active continental margin and composed of rock assemblage of oceanic affinity (Snoke and Barnes, 2006) accreted during Late Paleozoic through Middle Mesozoic by westward thrusting (Irwin, 1981; Snoke and Barnes, 2006). The pluton itself intruded Ordovician Trinity peridotite of Trinity subterrane and consists of three concentrically arranged rock types. Based on petrography, geochemistry, and gradational textural changes, Vennum (1980) interpreted the pluton intrusion as a single batch of magma differentiated by fractional crystallization inward from margins. The internal magmatic fabric of the CCG shows concentric pattern of margin-parallel vertical magmatic and magnetic foliations. The magnetic lineations reveal plunge trends parallel to the margins of the pluton and continuously increasing plunge angles from the margin to the core of the pluton. The concentric zonality of the pluton is documented also in distribution of magnetic susceptibility, degree of AMS (parameter P) and AMS shape (parameter T). The central part of CCG pluton displays the lowest magnetic susceptibility accompanied by the lowest AMS degree and strongly oblate AMS elipsoid shapes. The susceptibility (92e-06 to 2e-02 (SI)) and AMS degree (1.013 to 1.713) increase towards pluton margins. Very high values of AMS degree cannot be explained by alignment of non-interacting magnetite particles during the magma flow, as the maximum P value for ferromagnetic granites in which magnetite carries the AMS was estimated at 1.18 (Tarling and Hrouda, 1993). The observed lack of subsolidus deformation in the samples that show high AMS degree led us to perform detailed magnetic study to find the source of unusually high values of P parameter. The thermomagnetic curves, hysteresis loops, isothermal remanent magnetization acquisition (IRM) curves and DC demagnetization (DCD) curves were measured to explain high values of AMS degree that could have resulted from hematite and/or magnetostatic interactions in the rock. However, the detailed analysis of magnetic properties didn't reveal the source of the high P parameter values. Therefore, we

conducted a microstuctural analysis comprising measurements of crystalographic preferred orientation (CPO) of feldspar phenocrysts and a quantitative analysis of microstructure. The analysis revealed phenocryst preferred orientation parallel but also symmetrically oblique to AMS foliation, microstructural features documenting interstitial melt and dilatancy textures. The observed CPO and microstructural features correspond to the shear thickening rheology of highly crystallized magma (Smith, 1997; 2002, Park and Means, 1996). This leads us to the conclusion that the crystalline mush was actively deforming during magma emplacement or at least at its final stage.

Keywords: AMS, rock magnetism, granite, pluton emplacement, magma flow

References :

Irwin, W.P., 1981: Tectonic accretion of the Klamath Mountains, in Ernst, W.G., ed., The geotectonic development of California. Rubey Volume I: Prentice-Hall, Inc., Englewood Cliffs, New Jersey, p. 29-49.

Park, Y., Means, W.D., 1996: Direct observation of deformation processes in crystal mushes. J. Struct. Geo. 18 (6), 847–858.

Smith, J.V., 1997: Shear thickening dilatancy in crystal-rich flows. J. Volcanol. Geotherm. Res. 79 (1–2), 1–8.

Smith, J.V., 2002: Structural analysis of flow-related textures in lavas. Earth-Sci. Rev. 57 (3–4), 279–297.

Snoke, A.W., and Barnes, C.G., 2006: The development of tectonic concepts for the Klamath Mountains province, California and Oregon, in Snoke, A.W., and Barnes, C.G., eds., Geological studies in the Klamath Mountains province, California and Oregon: A volume in honor of William P. Irwin. Geological Society of America Special Paper 410, p. 1–29.

Tarling, D.H., Hrouda, F., 1993: The Magnetic Anisotropy of Rocks. Chapman and Hall, London, U.K.

Vennum, W.R., 1980: Petrology of the Castle Crags Pluton, Klamath Mountains, California. Geological Society of America, Bulleti,n 91(5), p. I 255-I 258, II 1332-II 1393.