Geophysical Research Abstracts
Vol. 17, EGU2015-8614, 2015
EGU General Assembly 2015

Timing and mechanisms of mafic magma ascent/emplacement in the continental middle crust: an example from the Permian Sondalo gabbroic complex (Alps, N-Italy)

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We explore the mechanisms of mafic magma ascent and emplacement in the continental crust by studying the mid-crustal Permian Sondalo gabbroic complex (Campo unit, Eastern Central Alps, N-Italy). We characterized the structure and anisotropy of magnetic susceptibility (AMS) fabric of the concentric gabbroic to dioritic intrusions. We used Laser Ablation ICP-MS U–Pb zircon dating on magmatic and metamorphic rock samples, zircon trace element geochemistry and existing P−T estimates to constrain the timing and depth of magma emplacement. Petrological and geochemical observations provide insights on the crystallization sequence in the magmatic rocks and facilitate the interpretation of the AMS record.

The magmatic and magnetic fabrics (foliations and lineations) of the pluton reflect their original orientations and are essentially vertical, indicating vertical magma transfer through the crust. The intrusion was emplaced in two phases. (1) The concordant orientation between the main magmatic foliation and the host-rock xenoliths elongation and foliation in the centre of the pluton suggest that the first magma ascent phase occurred through fracture opening parallel to the vertical fabric of the host metasedimentary rocks. Trace element analyses point to late-magmatic zircon crystallization, which enable to interpret the associated U–Pb results of 289−288 Ma as the age of this initial emplacement stage. (2) The second magma ascent phase is marked by a rheological change in the host-rock. The temperature increase in the contact aureole induced partial melting and decreasing mechanical strength in the metasediments. This resulted in the formation of a vertical foliation in the metamorphic aureole and a weaker but concordant magmatic foliation at the rim of the pluton. This ascent phase occurred at 288−285 Ma and accounts for the contrasted P−T evolution of metasedimentary rocks in the contact aureole. Thermal models of the intrusion indicate that the contact aureole thickness cannot be explained by a single pulse, but was either thinned by shearing during the second magma ascent period, or magmas were emplaced in several smaller pulses. Our results provide new insights into a crustal-scale mafic plumbing system.