Geophysical Research Abstracts,
Vol. 10, EGU2008-A-03050, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-03050
EGU General Assembly 2008

Lower crustal magma conduits in the Kohistan island arc: Role in melt transfer and differentiation

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Understanding the formation of magmatic arcs requires not only to understand the formation of primitive arc melts but also their evolution during transfer from the mantle wedge source to the arc. Indeed, the chemical characteristics of arc-melts are acquired during a complex process involving the fluid/melt slab input, the mantle wedge, and transfer, fractionation, and assimilation of the mantle melt at the base of and in the crust.

The Sapat complex (Kohistan-Pakistan) exposes a lower crust section of the Kohistan Paleo-Island Arc. The section is composed of predominantly fine grained meta-gabbros with some trondhjemites hosting kilometer-scale pyroxenite-wehrlite-dunite bodies which show intrusive contacts. These bodies have oval cross sections and sub-vertical contacts with the host meta-gabbros showing normal (top-side-up) magmatic way-up criteria. The very limited, max. 50 cm wide contacts show the pyroxenites or wherlites to pervade the meta-gabbros, hence documenting intrusion of a magma that resulted in the pyroxenite-dunite bodies into the meta-plutonics. As there is no large scale deformation in the host meta-gabbro outside the narrow contact zone, the km-sized conduits must have formed through thermal erosion of the host-gabbro.

Various petrological compositions characterize the different ultramafic bodies. The largest body is composed of hornblende-bearing wherlite, clinopyroxenite, and dunite. These lithologies provide evidence for melts intruding and reacting with their own

previous cumulates, which are magmatically eroded or cut and are represented by layers and subvertical dykes of olivine-bearing-clinopyroxenites and dunites. Another ultramafic body is composed of homogeneous websterite with, in places, sub-vertical layers. Within this body, sub-vertical zones where plagioclase has crystallized denote impregnation by a later reactive percolating melt (olivine decomposed in symplectite, pyroxene dissolved in the melt). Cumulative dunite is the single lithology of other small bodies.

The petrological differences may reflect differences in melt composition and in the pressure, temperature and H_2O-concentration during crystallization, as e.g. suggested by the presence of garnet in the websteritic body. Mineral analyses coupled with structural interpretations lead to the conclusion that these bodies represent magma conduits that acted as feeder pipes of basaltic melt to mid-crustal to surface levels of the growing Kohistan arc. The arc magmas already evolved in these conduits and acquired at least part of their chemical signature. Such magmatic bodies are analogues to deep-seated “magmatic chambers”, but more importantly locate and elucidate the mode of magma transfer from the base of the crust (or deeper) to upper crustal or shallower levels within the arc.