Differences between preserved vs. delaminated lower crust: Evidences from the Kohistan arc

OLIVER JAGOUTZ[1], OTHMAR MÜNTENER[2], MAX W. SCHMIDT[3], PETER ULMER[3] AND JEAN-PIERRE BURG[3]

[1]Institute of Geological Sciences, University of Bern (jagoutz@geo.unibe.ch)
[2]Institute of Mineralogy University of Lausanne
[3]Department of Earth Science, ETH Zurich

Delamination and foundering of the lower continental crust (LCC) into the mantle are important crust forming mechanisms However, knowledge of the composition and mineralogy of the preserved and/or delaminated LCC remains scarce. We provide a synopsis of recent research within the Kohistan arc (Pakistan). We show that hydrous and "less-hydrous" liquid lines of descent related to flux and decompression melting, respectively, produced compositionally different lower crustal rocks in the Kohistan arc. These observations allow a new model for CC formation where delaminated and preserved LCC differ in mineralogy and composition.

Within the Kohistan arc two mantle-lower crustal sections are exposed: the older Jijal section and the younger, rifting-related Chilas section. We describe lithologies of these sections and argue that fractionation mechanisms that produced them document two liquid lines of descent with largely differing initial water contents. The Jijal liquid line of descent is typical for a hydrous, high-pressure fractionation sequences (e.g. pyx, grt, Fe/Ti-oxides, amph, An-rich plag). The composition of the Jijal lower-crustal gabbroic rocks differs markedly from bulk lower crust estimates but is complementary to silica-rich rocks (tonalite, granite etc.), exposed within the Jijal section and within the so-called Kohistan Batholith.

The Chilas liquid line of descent is typical for a "less-hydrous" fractionation sequence (e.g. ol, pyx, plag, amph). Gabbro-norite to diorite rocks are dominantly composed of plagioclase, clinopyroxene and orthopyroxene (±quartz, ±amphibole). Despite the similarity of the Chilas gabbroic rocks to typical lower crust compositions, the "less hydrous" fractionation results in massive amounts of gabbroic material and small volume of silica-rich rocks. This mass balance and their mineralogy precludes them to represent the magmatic equivalent of the upper crust.

We propose that the upper, non-sedimentary CC is dominantly formed by hydrous high-pressure fractionation with subsequent delamination of the complementary garnet-pyroxene-amphibole-rich LC cumulates. This LC The delaminated amphibole-rich lower Jijal crust has trace element content and mineralogy adequate to explain certain characteristics of OIB. In contrast, the LCC, which is preserved over geological timescales, is formed by "less-hydrous" parental melts. We suggest that the bulk crustal composition is a mixing between these two compositional end-members.

Plastic deformation of orthoenstatite and the ortho- to high-P clinoenstatite transition studied by atomistic simulation

S. JAHN[1] AND R. MARTOŇÁK[2]

[1]GeoForschungsZentrum Potsdam, Telegrafenberg, 14473 Potsdam, Germany (jahn@gfz-potsdam.de)
[2]Department of Experimental Physics, Comenius University, Mlynská dolina F2, 84248 Bratislava, Slovakia

Atomistic computer simulation techniques are used to study plastic deformations of orthoenstatite, $MgSiO_3$, at high pressure, P, and high temperature, T. The combination of molecular dynamics with metadynamics allows the direct observation of the structural changes at the atomic scale during the creation of stacking faults in the (100) planes. The respective slip deformations consist of at least four partial deformations crossing high energy intermediate structures. Although the low energy structures that may be observable experimentally suggest a dominant (100)[001] single slip system, the partial deformations also have contributions in (100)[010] direction.

Choosing conditions in the stability field of high-P clinoenstatite (T=1000 K, P=15 GPa), one sequence of plastic deformations in orthoenstatite leads to reformation of perfect orthoenstatite, whereas a second sequence results in the formation of the thermodynamically stable high-P clinoenstatite. From experiments (Lin, 2003; Kung *et al.*, 2004) it is known that due to the high kinetic barrier of the partly reconstructive phase transition, the formation of high-P clinoenstatite is prevented at ambient T in a wide pressure range up to at least 22 GPa. We are able to identify some of the possible metastable high-P polymorphs of orthoenstatite, which lead to anomalous behavior of the elastic properties (Kung *et al.,* 2004) and to changes in the Raman spectra (Lin, 2003).

References

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