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Lower continental crust formation through focused flow in km-scale melt conduits: The zoned ultramafic bodies of the Chilas Complex in the Kohistan Island arc (NW Pakistan)

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Continental crust (CC) is generally believed to be formed at convergent plate boundaries. However, a major problem of this model is that mantle derived melts forming Island arcshave a high Mg# (>0.7) in equilibration with a mantle assemblage. The bulk CC, estimated largely based on seismic properties and xenolith composition, has a low Mg# of ˜0.5-0.56. To counterbalance this "Mg#-gap" massive amounts of high Mg# cumulates should be present in the lower crust of Island arcs. However, in exposed Island arc sections (e.g. Kohistan Arc and Talkeetna Arc) such high Mg# cumulates are volumetrically minor. Various mechanisms have been proposed to overcome this paradox including the presently most widely accepted one of delamination of the high Mg# cumulates, which sink back into the mantle. In this study we examined zoned ultramafic bodies of the Chilas complex in the Kohistan island arc (Pakistan), one of the largest (250*40 km) mafic lower crustal intrusions worldwide. Associated with the dominantly gabbronoritic mafic sequence are zoned ultramafic complexes composed of a dunitic core and subsequent 'shells' of lherzolite and pyroxenite towards the contact with the surrounding mafic sequence. Based on field observations, whole-rock and mineral major and trace elements and Sm-Nd isotopic data of the main units within the Chilas Complex, we propose that the zoned ultramafic bodies are essentially vertically continuous feeding channels, probably reaching into the upper mantle. The high and low Mg# of olivine in the dunitic core of the ultramafic bodies indicate that the melt evolved during ascend in the melt channels. We estimated the composition of

the flux in and out of those melt channels: Based on primitive olivine chemistry the primary melt entering the melt channels and forming the entire Chilas complex was a high Mg# olivine tholeiite in equilibrium with a mantle assemblage. The bulk composition of the mafic sequence essentially represents the melt composition of the melt getting out of the melt channels. Estimates indicate a basaltic-andesitic bulk composition of the mafic Chilas gabbronorite sequence. The low Mg# bulk composition of the gabbronorite sequence closely matches estimates of lower crustal compositions. Accordingly, fractionation of mantle derived melts within melt channels in the upper mantle could be an additional possibility to explain the “Mg#-gap”.