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Weakness underneath the Altiplano: observations, causes and tectonic implications

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The formation of high, wide and thick continental plateaus seems to be associated to an intrinsic weakness of the crust and/or mantle lithosphere, as suggested by thermo-mechanical models and geological evidences. Two observations confirm this suggestion along the Altiplano Plateau: 1) elastic thickness estimates are lower than 10 km, implying a very low flexural rigidity, 2) viscosities estimated from surface deformation patterns are lower than 10^{21} Pa s. Both quantities strongly increase toward the flanks of the plateau. Geophysical observations impose constraints on the causes behind this weak rheological state. P-wave seismic velocities (Vp), throughout the entire crustal column (thickness $\approx$70 km), are of the order of 6 km/s. Some authors interpret such low Vp values as the expression of a whole felsic crustal composition under dry conditions and no partial melting. This interpretation implies a low density for the lower crust (2700 Kg/m^3), that after being allocated in a 3D density model (see Tassara et al., session GD8 of this assembly) generates a Bouguer anomaly 400 mGal lower than the observed anomaly. A lower crustal density of 3100 Kg/m3 fits the observed gravity field much better. Low Vp values and high densities can be reconciled assuming substantial degrees of partial melting (20-25%) of a dominantly mafic lower crust, since this process strongly reduces the seismic velocities without major effects on the density. High degrees of partial melting below the Altiplano are suggested by extremely low values of electrical resistivity (1 Omh/m) and are also expected from measurements of surface heat flow higher than 80 mW/m^2 implying Moho temperatures as high as 1300˚C. All these observations favor the idea that the weak rheology underneath the Altiplano Plateau is primary caused by the presence of high amounts of partially molten mafic material.

The current rheological state and its relationship to the presence of lower crustal melts

cannot be used straight backward to deduce the reason why the plateau began to form. However this model suggests that after that, temporally related phases of volcanic activity and crustal deformation should have a common origin in the lower crust. The huge Upper Miocene ignimbritic flare-up occurred along the plateau could be associated to an enhanced lower crustal fusing due to either an increase in the mantle-derived basaltic input and/or the exposure of the lower crust to high temperatures via crustal thickening. The subsequent evolution of the Altiplano seems to be dominated by the weakness of its partially molten mafic lower crust, which is compressed between the rigid forearc and foreland regions. The injection of new crust of the Brazilian shield (mafic at the surface) by underthrusting below the Subandean fold-thrust belt increases the crustal thickness without surface deformation of the plateau and is probably accommodated by a lateral lower crustal flow.