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Deformation of Lake Shorelines and Mid Crustal Flow in Tibet

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The mid crust beneath Tibet is generally thought to be highly mobile low viscosity material. A low viscosity layer of mid crustal material can account for the relatively flat nature of the high plateau?high elevation but low relief?and injection of mid crust into low lying regions around the Tibetan Plateau is thought to be one of the main processes involved in the expansion of the Plateau. Mechanical modeling shows that many of the first order features of the Tibetan Topography can be explained by the presence of a mid crust with a viscosity of 10^19 Pa s or less. However, there has been no independent quantitative estimate of the effective viscosity of the mid crust. Lake shorelines offer a way to achieve this.

Despite its low rainfall, Tibet contains a large number of lakes due to the lack of water outlets from the central plateau. Many of these lakes are surrounded by well-preserved paleo shorelines. The presence of these shorelines shows that the lakes were once much larger than they are now. One of the largest lakes in Tibet is Lake Nam Co, which lies 150 km to the north of Lhasa. This lake shows good development of plaeo-shorelines and is of a suitable size to investigate properties of the mid crust. When there is a drop in the water level of a lake, it reduces the weight on the underlying crust and resulting in a buoyancy force that tends to uplift the substrate. The maximum uplift possible is determined by the ratio of the densities of water to rock: approximately 1 m of uplift for every 3 m decrease in the water level. The reason for the uplift is the inflow of mobile rock at depth. Re-equilibration will not be instantaneous?it will take time for crustal flow to occur. The time scale for this crustal flow depends mainly the geometry of the lake basin and the viscosity of the crust. The geometry is well-known and viscosity can then be estimated from measurements of the amount of uplift and the time that it took for the uplift to occur. Shorelines are palaeo-horizontal markers and, therefore, any uplift can be recognized by careful measurement that reveals present day deviations from horizontal. Preliminary results of age dating and surveys of shorelines using kinematic GPS show the potential of this methodology for obtaining good first order estimates of the mid crustal viscosity.

Keywords: Tibet, Lake shorelines, Crustal Flow, Mid crustal viscosity