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Self-consistent thermo-chemical modelling of the lithosphere beneath the West African Craton

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The lithosphere beneath the West African craton is thermo-chemically modelled using a self-consistent petrological-geophysical approach [1,2] ensuring that elevation, geoid, surface heat flow (SHG), surface wave dispersion and magnetotelluric data are all honoured. These five data types are all different, and differently sensitive to lithospheric chemical and physical parameters.

For the West African Craton, as expressed in central southern Burkina Faso, an elevation of 316 ±25 m, a reduced geoid (removing long wavelength contributions) of -0.30 ±0.80 m and a relatively low SHF of 42 ±10 mW/m^2, coupled with a defined crustal structure (Moho at 40 ±2 km) and constrained by permissible ranges of CFMAS mantle oxides based on Archean-aged lithosphere [3] and Primitive Upper Mantle oxide compositions [4, 5] for sub-lithospheric mantle, yields acceptable models for a single-layered lithosphere with a posterior distribution for the LAB in the extremal range of 140-260 km, with a mean and median of 215 km. The posterior distributions for Mg# peak at 90.75 for the lithospheric mantle, and 88.5 for the sub-lithospheric mantle.

Including Rayleigh wave phase velocity dispersion curve for the region, derived from Fishwick's [6] Africa model (with 1% errors assumed), in the inversion increased the minimum depth for the LAB to 160 km, but otherwise has little effect on constraining subsurface parameters. When the MT data [7] are included, no single-layered lithosphere models are found that fit, and accordingly a multi-layered lithosphere has to be adopted. This is primarily to allow variations in water content with depth. Acceptable models exhibit a posterior distribution with a somewhat tighter range of LAB depth of 180-220 km.

Depth variation of CFMAS oxide composition cannot be defined from these surface observations, only their depth-averages, and the three lithospheric layers are essentially similar in their oxide chemistry. Imposing a requirement for models with a layered oxide composition similar to that found for the Kaapvaal Craton (Low-T somewhat depleted Lherzolitic top layer, highly-depleted Harzburghitic middle layer, High-T somewhat fertile lower layer) yields acceptable models with somewhat deeper LABs.
These models will be shown and discussed, and compared with models found for northern Ghana. Implications will be drawn regarding the constraints that are found from joint inversion of all five data types.

References:

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