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Finite Half Space Model: Implications for the dilemma of the Lithosphere - Asthenosphere Boundary

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Regional variations in heat flow and bathymetry of the oceanic lithosphere provide important constraints on the nature of thermal interactions at the lithosphere – asthenosphere boundary. However, the Boundary Layer models proposed to date have failed to provide a satisfactory account of such variations. In the present work, we point out that this difficulty arises from two basic limitations. First, the integration limit used in the solution of model differential equation for heat diffusion is incompatible with the characteristics of the problem domain. Second, the model does not consider the effects of latent heat in the transformation processes at the asthenosphere-lithosphere boundary. Obviously, the surface heat flux arising from conductive cooling of a semi-infinite half-space cannot approach stable values, since the model formulation imposes a continuous decay of temperature and hence heat flux for all times. In this work we present a new model (designated as the finite half-space model - FHS), that can overcome such limitations. In the FHS model the vertical dimension of the problem domain is set to a value equal to the thickness of the stable lithosphere. FHS model assumes that the formation of lithosphere arise from cooling and solidification of the magma rich mantle (MRM) layer on top of the asthenosphere of finite thickness. Results of numerical simulations reveal that theoretical values derived from FHS model provide vastly improved fits to observational data for heat flow and bathymetry for the entire age range of the oceanic lithosphere, when compared with those that can be achieved using the infinite half space and Plate models. More importantly, the improvements in model fits have been achieved without the need to invoke the ad-hoc hypothesis of large-scale hydrothermal circulation in the stable ocean basins. The relevance of the new model results in providing new insights into the nature of thermal interactions at the lithosphere – asthenosphere boundary is discussed and implications for understanding regional scale variations in global heat flow emphasized.