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Effects of crustal heat source redistribution on the strength envelopes

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The paper focuses on how some tectonic processes lead to crust strengthening. In particular, it is concerned with the long-term thermal and mechanical effects of the redistribution of the heat producing radioactive elements in extensional areas. The analysis is performed with simple physical models of stretching and magma extraction from the deep-middle crust. Deformations given by a combination of frictional sliding and ductile creep are used to describe the strength of the crust. Implicit in this problem is the recognition that materials are characterised by rheological properties which vary as a function of both temperature and pressure. The heat source distribution within the continental crust is described by means of the parameters qc and dc. The former represents the contribution of the heat sources to the terrestrial heat flux and the latter is the length scale over which these sources are distributed. This parameterization provides a useful tool for illustrating the thermal response of the crust to the changes in radiogenic heat production resulting from thinning and formation of felsic magmas. During extension, the radiogenic heat sources decrease and become less deeply buried; the generation and segregation of magmas transport the incompatible elements, U and Th, to higher crustal levels. Variations in thermal state of the deep crust resulting from extension are relevant. The thermal effects accompanying magma extraction are strongly dependent on the initial distribution of U, Th and K. The largest long-term cooling effect in thinning processes results for heat source distributions with high qc and dc. Deep crustal melting has little impact on long-term cooling for initial distributions characterized by low values of dc. Since the rheological behaviour is considered to be temperature-dependent, changes in the deep crustal thermal regime following the redistribution of heat sources affect the long-term mechanical state of the crust and the lithospheric mantle. Increases in strength occur as the parameters of the heat source

distribution are reduced. The configurations characterized by low dc and qc are more stable and less sensitive to small changes in these parameters. The long-term mechanical consequences accompanying extension are more significant for crust characterized by low initial length scale of the heat-production distribution. Magmatism leads to a lower increase in strength and the largest relative change is seen in crust characterized by high heat production. A 50% reduction in the crustal heat contribution will result in an increase in strength by a factor of 1.7 if the tectonic regime is compressive. Such an increase is lower for transcurrent and extensional regimes, reducing to 1.5. These considerations suggest that crustal scale differentiation of heat sources is a necessary precursor to cratonization.