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THERMAL-MECHANICAL RESPONSE TO SIMPLE SHEAR EXTENSION; K.P. Furlong, Department of Geosciences, Pennsylvania State University, University Park, PA 16802

The mechanism of extension in the continental crust is apparently much more complex than that acting in the oceanic lithosphere. Recently, Wernicke (1,2) has proposed that a significant fraction of extension in the continental lithosphere may occur by a simple shear mechanism along discrete fault/shear zones which cut the crust, and perhaps extend into the uppermost mantle. Clearly much of the surface evidence for extension supports this concept, but the depth extent of simple shear extension in the continental crust is unclear. In this study I have determined, using numerical simulations, the thermal and associated mechanical behavior of the continental lithosphere in response to lithosphere extension along a low-angle simple shear zone which cuts through the lithospheric plate (Figure 1), in order to evaluate the resolving ability of thermal (heat flow and metamorphic P-T-time paths) and elevation observations in constraining the mode of continental extension. The general gometry of the region is shown in Figure 1 at a time after extention has ceased (points x and x' were initially adjacent). The initial crustal thickness across the region was assumed to be constant. The surface heat flow and elevation response to this extension for the region between A and C is given in Figures 2a and 2b. Extension was assumed to have occurred over a 15 Ma period with a net vertical motion of 20 km. During the period of active extension, the heat flow response is dominated by the effects of (vertically) advected heat causing a strong anomaly in the vicinity of the thinnest upper plate. After the cessation of extension (time > 15 Ma) the heat flow anomaly decrease and the location of the maximum migrates to the regions of thicker upper plate as a function of the conductive time lag. In the regions of thinnest crust, the heat flow decays to values below those assumed initially as a consequence of removal of (assumed) radiogenically enriched upper and middle crust. The width of the heat flow anomaly varies in time, but for an assumed dip for the shear zone of 20°, the anomaly is approximately 75-100 km wide. By 25 Ma (time = 40 Ma) after the cessation of extension, however, the heat flow anomaly has decayed to a point where it is likely to be difficult to resolve. The elevation response to this extension is dominated by the effects of crustal thinning (and hence the specifics of the geometry of the shear zone) with only a small transient effect from the thermal perturbations. For the rates of extension used here, the maximum average temperature increase in the lithospheric plate (during extension) is $<200^{\circ}C$ restricting the effects of thermal/density effects in elevation to <600 meters. Clearly the dominant effect (approximately 3 km of subsidence) is related to crustal thinning, and thus also dependent on the initial crustal structure.

The thermal and associated mechanical (elevation) response of the continental lithosphere to simple shear extension is greatest during the period of active extension. The 'relaxation' of the thermal field occurs over a time scale of 10's of millions of years, while the elevation response is virtually complete by the end of the extension. The ability to constrain this extension mechanism requires either detailed control on the subsidence/uplift history of the region and some control over the patterns of the perturbations in the thermal field. The utilization of metamorphic pressure-temperature-time trajectories (3) may provide a means to constrain the thermal history and consequently constrain the extension mechanism. Without such constraints, it is unlikely that present day thermal and elevation measurements will provide adequate information to discern the mechanism of extension in continental regions.

(1) Wernicke, B., (1981) Low-angle normal faults in the Basin and Range province--Nappe tectonics in an extending orogen. Nature, 291, p. 645-648.

(2) Wernicke, B., (1985) Uniform-sense normal simple shear of the continental lithosphere. Can. J. Earth Sci., 22, p. 108-125.

(3) Spear, F.S., Selverstone, J., Hickmott, D., Crowley, P. and Hodges, K.V., (1984) P-T paths from garnet zoning: A new technique for deciphering tectonic processes in crystalline terrances. Geology, 12, p. 87-90.

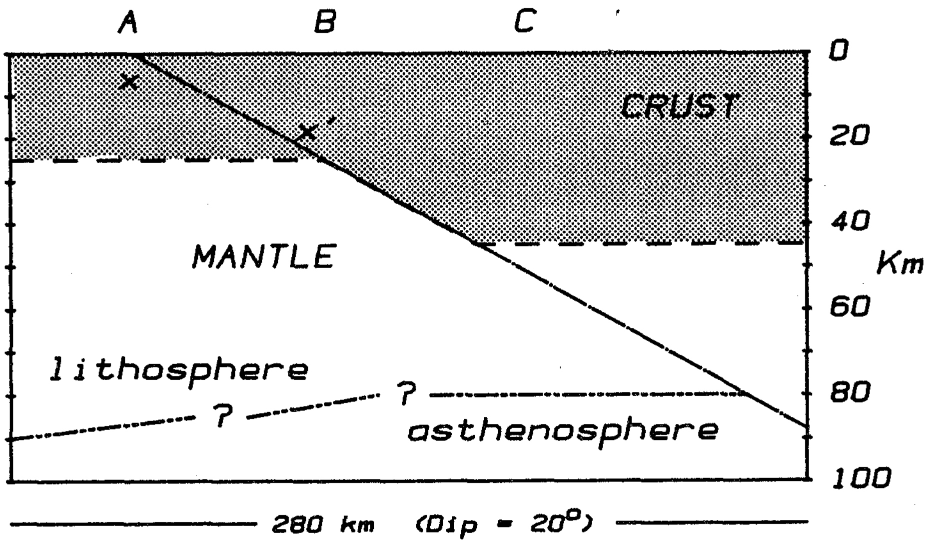

Figure 1. Schematic of model domain and geometry for simple shear model. Shaded region represents crust. A, B, and C mark locations referred to by Wernicke (2) as extensional allocthons (or "core complexes"), limit of significant upper crustal extension, and Moho "hinge" respectively. Positions labeled x and x' were adjacent prior to extension. For a shear zone dipping at 20, the region between A and C is approximately 140 km wide.

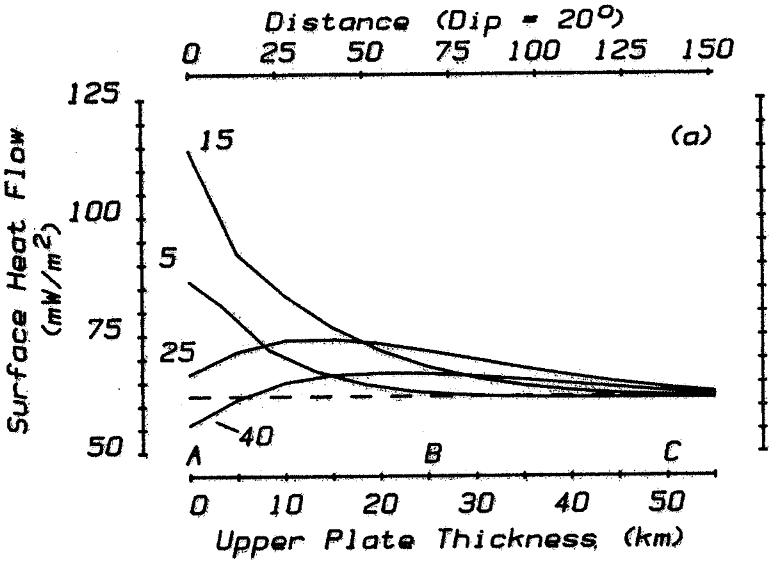

Figure 2a. Predicted surface heat flow response during (0-15 Ma) and after (> 15 Ma) simple shear extension along finite width shear zone. Dashed line is assumed intial heat flow regime.

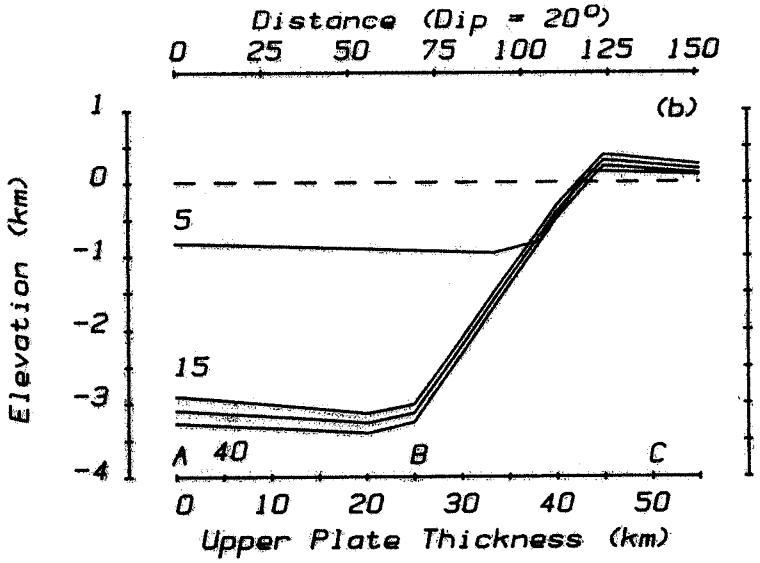

Figure 2b. Predicted elevation response during and after simple shear extension. Dashed line is initial datum surface.