Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

SCG087-05 Room: 302 Time: May 27 10:13-10:30

Climate change, surface erosion, and topographic growth: Periodic instability in compressional stress field

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By altering the vertical normal stress in deforming regions, erosion and sedimentation affect that deformation. In particular, where anticlines and synclines are growing, both erosion and sedimentation reduce resistance imposed by gravity to growth and enable folds to grow more rapidly than where neither occurs. To assess these effects quantitatively, we treat the crust as a two-layered medium consisting of a high-viscosity surface layer and a low-viscosity lower layer over a stiff substratum. Using linear stability analysis, we examined effects of surface erosion on growth rates of periodic instabilities as the layers undergo regional compression. As erosion rates increase, in most cases the dominant growth rate factor and the dominant wavelength also increase (dominant wavenumber decreases). The ratio of thicknesses of the lower to upper layer dH, is the most important structural parameter influences how erosion affects growth: (1) for a thick viscous channel beneath a thin top layer, large dH, the growth rate factor is independent of both dH and the viscosity ratio (lower to upper layer) , but is sensitive to the ratio, L, of stresses that balance gravity acting on topography to the viscous resistance of the surface layer. Conversely, (2) when dH is small (thick top layer over a thin channel), the channel flow in the lower layer dictates the system behavior and hence the dominant growth rate factor. An increase in surface erosion and sedimentation accelerates growth for (1) but not for (2), because the essential role of erosion and sedimentation is to modify the effect of gravity acting on topography. Thus, surface erosion becomes effective when gravitational effects overwhelm viscous resistance applied from the bottom layer. When the bottom layer is less dense than the surface layer, erosion and sedimentation affect the system most when L takes a transition value between the channel flow mode and gravity resisting mode. Based on these insights, we suggest that the transition from open folding across most of the Zagros to tight folding in a narrow belt results from an increased erosion, possibly in response to global climate change. In this talk, we focus on the linkage between the global climate change, rates of sedimentation and erosion, and mountain building process in Zagros.

Keywords: Erosion, Sedimentation, Folding, Topography