Geophysical Research Abstracts
Vol. 13, EGU2011-5892, 2011
EGU General Assembly 2011

The influence of inefficient erosion on orogen structure

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Deciphering orogenic history is of crucial importance to understanding past global climates, sediment budgets and ocean chemistry, however reading the record of surface processes in the exposed roots of ancient orogens is extremely difficult (Whipple 2009). The structural evolution of the Betic orogen is strongly linked to surface processes during the emergence of the Sierra Nevada during the Miocene (Reinhardt et al. 2007). The generation of relief at the mountain margins appears to generate a characteristic geometry of structures during tectonic denudation. We present a model of the emergence of a young mountain block, based on the early unroofing history of the Sierra Nevada, southern Spain. Inefficient erosion in headwater areas due to lack of water generates a plateau-like morphology with zones of marginal high relief formed by a combination of efficient fluvial incision and normal faulting at the mountain front. This geomorphology triggers tectonic denudation on a series of weak mylonite and evaporite horizons. Distinctive "flat topped" profiles of mountains are preserved in many non-glaciated mountain belts suggesting that inefficient erosion is a common feature elsewhere. The consequence of building high elevation "plateaus" is that tectonic denudation rather than erosion may be the dominant early exhumation mechanism of young mountains. The influence of differential unroofing at depth in the orogen generates a distinctive scale of structure that can be recognised not only in the brittle deformation in young orogens but in the ductile roots of exhumed ancient orogens. We suggest that the gneiss domes and metamorphic core-complexes of ancient orogens are features that may form in response to differential erosion and hence have the potential to record details of climatic conditions during their formation. Although many recent studies have focussed on the influence of enhanced erosion at mountain fronts on the structural history of orogens (Finlayson et al. 2002; Wobus et al. 2003), we highlight the important influence of tectonic denudation and the key role of inefficient erosion in orogenic history.

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