Continental reactivation and reworking: an introduction

R. E. HOLDSWORTH[1], M. HAND[2], J. A. MILLER[3] & I. S. BUICK[4]

[1] *Reactivation Research Group, Department of Geological Sciences, Durham University, Durham DH1 3LE, UK*

[2] *Department of Geology and Geophysics, Adelaide University, Adelaide, SA 5005, Australia*

[3] *Department of Geological Sciences, The University of Cape Town, Rondebosch 7700, Republic of South Africa*

[4] *Department of Earth Sciences, La Trobe University, Bundoora, VIC 3083, Australia*

In contrast to oceanic lithosphere, the continents are manifestly composed of the products of tectonic processes whose cumulative duration spans much of the Earths history. Most continents contain Archaean nuclei that are enclosed by Proterozoic and Phanerozoic tectonic domains. The evolution of post-Archaean continental volumes has included additions of new continental material, but it has also involved repeated modification of parts of the existing continental lithosphere during periods of *tectonic rejuvenation*. This generally involves processes such as the formation of new structural fabrics, the overprinting of metamorphic assemblages and the generation and emplacement of magmas. Such behaviour can occur repeatedly throughout the geological record because the quartzofeldspathic continental crust cannot be subducted due to its relative buoyancy and weakness compared with its oceanic counterpart and the underlying lithospheric mantle. Thus, the character of the continents is significantly influenced by the way in which the existing lithosphere responds to new tectonothermal events that follow geologically significant cessations of activity for millions to hundreds of millions of years (Sutton & Watson 1986).

Existing continental lithosphere may be modified during its incorporation into new collisional systems, for example the involvement of the Hercynian 'basement' in the Alpine collision. However, the most dramatic manifestations of continental tectonic rejuvenation occur during intraplate orogeny, where a coherent pre-existing lithospheric volume undergoes large-scale failure. Notable modern examples of intraplate orogeny are the Cenozoic Tien Shan and the Mongolian Alti in north Asia, which are forming in response to the Himalayan collision (e.g. Hendrix *et al.* 1992; Dickson Cunningham *et al.* 1996), and also the Atlas Mountains of Morocco, which are linked to the on-going Alpine collision (e.g. Ramandi 1998). In the ancient geological record, two of the best examples are the mid-Palaeozoic Alice Springs Orogeny and the Neoproterozoic to Palaeozoic Petermann Orogeny in central Australia (e.g. Sandiford & Hand 1998; Hand & Sandiford 1999). In recognition of the importance of intraplate orogeny as an expression of continental rejuvenation, a large amount of work has focused on the mechanisms leading to large-scale intraplate failure (e.g. Vilotte *et al.* 1982; England & Houseman 1985; Kuzsnir & Park 1987; England & Jackson 1989; Platt & England 1994; Tommasi *et al.* 1995; Ziegler *et al.* 1995, 1998; Avouac & Burov 1996; Neil & Houseman 1997; Sandiford & Hand 1998; Hand & Sandiford 1999; Pysklywec *et al.* 2000). A number of factors are likely to control the locus of tectonic activity, but there appear to be two first order controls: (1) temporal and spatial variations in the thermal state of the lithosphere (e.g. Sonder & England 1986; England 1987; Neil & Houseman 1997); and (2) the presence of pre-existing mechanical defects such as faults, shear zones or major compositional boundaries (e.g. Ziegler *et al.* 1995; Butler *et al.* 1997; Holdsworth *et al.* 1997).

The rejuvenation of pre-existing crust and lithosphere occurs largely via two related processes. *Reactivation* is normally considered to involve the rejuvenation of discrete structures (e.g. Holdsworth *et al.* 1997), whilst *reworking* involves the repeated focusing of metamorphism, deformation and magmatism into the same crustal- or lithospheric-scale volume. These are considered to be useful end-member definitions that describe the way in which continental lithosphere is modified. However, there is some ambiguity firstly because reworking and reactivation may represent broadly the same process operating at different scales and/or depths (see below),

From: MILLER, J. A., HOLDSWORTH, R. E., BUICK, I. S. & HAND, M. (eds) *Continental Reactivation and Reworking*. Geological Society, London, Special Publications, **184**, 1–12. 1-86239-080-0/01/$15.00