Subsidence Mechanism of Australian Intracratonic Basins

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Abstract

Globally, intra-cratonic sedimentary basins overlie regions of thick lithosphere (>170 km) with stratigraphic records typically spanning ~500 Myrs. Despite four decades of research into these basins, a consensus on a common subsidence mechanism has not yet emerged, thereby casting doubt that one even exists.

Over the last ten years, shear and body wave tomographic studies of the Australian continent have established that the gross lithospheric thickness doubles from ~120 km in the east to >200 km in central and western Australia (Fishwick et al., 2005). The Canning Basin and Centralian Superbasin are the largest basins overlying thick lithosphere that exhibit a prolonged history of subsidence. These basins are some of the best studied intracratonic basins in the world and therefore are an excellent natural laboratory for elucidating first order basin subsidence mechanisms. In order to achieve this goal we have analysed the architecture, water-loaded subsidence and magmatic history of these basins.

The onset of subsidence in both basins was accompanied by normal faulting, although evidence in central Australia is sparse. This early subsidence follows the characteristic exponential rift-sag form (McKenzie, 1978). In the 350 km wide central and south-western Canning Basin, the subsidence trend is so simple that it can be inverted for lithospheric thickness following the method outline by Crosby et al. (2010). Such analysis constrains the basin to have formed and now overlie standard thickness lithosphere (100-120 km) implying short wavelength (<400 km) variations in lithospheric thickness are poorly constrained by shear wave tomography. In contrast, the north-eastern Canning Basin displays a more complex subsidence history driven by temporal variations in active faulting followed by minimal post-rift thermal subsidence. The relatively recent intrusion of 18-22 Ma diamondiferous lamproites into the basin indicates it overlies >150 km thick lithosphere (Jaques et al., 1986). The variations in Canning Basin subsidence and associated lithospheric thickness indicates the lithospheric template fundamentally controls basin dynamics and thereby the resulting basin architecture.

The Centralian Superbasin records an even more complicated subsidence history than the north-eastern Canning Basin, with multiple phases of anomalous subsidence, inversely related to major intracratonic orogenic events. The most significant anomalous phases of subsidence occurred between 480-510 Ma, unaccompanied by active faulting yet immediately postdating the ~510 Ma Kalkarindji large igneous province (Evins et al, 2009). The lack of normal faulting precludes a basin-wide rifting model as the main cause of subsidence. The temporal association of subsidence with a large igneous province precludes a dynamic downwelling model as proposed for North-American intra-cratonic basins (Burgess, 2008). This permanent subsidence is more likely to be the isostatic response to erosion of the crust and/or lithospheric mantle above the transient Kalkarindji plume head.

The analysis of basin subsidence overlying regions of thick lithosphere in central and western Australia indicate there appear to be multiple subsidence drivers. Further global analysis relating basin architecture, subsidence and magmatism is required in order to establish the veracity of intracratonic basin classifications and the validity of seeking a common intra-cratonic basin subsidence mechanism.

References:

Crosby, A. G., Fishwick, S. & White, N. (2010), 'Structure and evolution of the intracratonic Congo Basin', Geochemistry Geophysics Geosystems 11, 1–20.

Evins, L. Z., F. Jourdan, and D. Phillips (2009), The Cambrian Kalkarindji Large Igneous Province: Extent and characteristics based on new 40Ar/39Ar and geochemical data, Lithos, 110(1-4), 294-304.

Fishwick, S., Kennett, B. L. N. & Reading, A. M. (2005), 'Contrasts in lithospheric structure within the australian craton–insights from surface wave tomography', Earth and Planetary Science Letters 231(3-4), 163–176.

McKenzie, D. (1978), 'Some remarks on development of sedimentary basins', Earth and Planetary Science Letters 40(1), 25–32.

Jaques, A. L., Lewis, J. D. & Smith, C. B. (1986), The Kimberlites and Lamproites of Western Australia, Geological Survey of Western Australia Bulletin, 132.

Burgess, P. M. (2008), Chapter 2 phanerozoic evolution of the sedimentary cover of the North American craton, in D. M. Andrew, ed., 'Sedimentary Basins of the World', Volume 5, Elsevier, pp. 31–63.

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