# The Late Tectonic Evolution of the Slave Craton and Formation of its Tectosphere

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An outstanding question in Archean tectonics is the relationship between thick, depleted lithospheric keels that presently underlie the cratons and the overlying crustal section. Evidence for Archean diamonds and Re-Os model ages of cratonic peridotites argue for the development of stable lithospheric mantle early in a cratons history, at least in part synchronous with crust formation or stabilisation (Pearson 1999). The late tectonic evolution of cratons is complex and involves extensive magmatism, deformation, and metamorphism that significantly post-date the timing of crust formation. Many of these tectonic events are difficult to reconcile with early development of thick tectosphere and suggest that crust-mantle coupling and stabilization occurred late in the orogenic development of cratons.

Over the past decade the Slave craton in northwestern Laurentia, has emerged as a major diamondiferous craton. The extensive and well documented geological record of the Slave craton, provides a new crustal perspective on the development of diamond-bearing tectosphere. In this contribution we describe the late tectonic evolution of the Slave craton based on field and geochronological studies, supplemented by geochronological data from lower crustal xenoliths to argue that stabilisation of the cratonic root, certainly to depths of 200 km, was most likely a late feature of the craton.

## Geological Background

The Slave is a small craton bounded by Paleoproterozic orogenic belts on its east and west. The craton is characterized throughout its central and western part by a Mesoarchean basement (4.0 -2.9Ga) referred to as the Central Slave Basement Complex (CSBC; Bleeker et al 1999), and its cover sequence, with isotopically juvenile (<2.85 Ga?) but undefined basement in the east (Thorpe et al 1992; Davis& Hegner, 1992; Davis et al. 1996). Isotopic data from granites and lower crustal xenoliths suggest that Mesoarchaen basement dips to the east and underlies the central part of the craton at depth, although its eastern extent remains poorly defined. Thick, tholeiitic volcanic sequences developed on the CSBC between 2.73 and 2.70 Ga, with no correlative volcanic sequences as yet documented in the eastern Slave Bleeker et al., this volume). This was followed by widespread calc-alkaline volcanism between 2.69-2.66 Ga in both the eastern and western Slave, and culminated in deposition of thick turbidite sequences over the entire exposed craton at 2.66 Ga.

The dominant tectono-metamorphic structures recorded in exposed crustal rocks developed between 2.64 and 2.58 Ga, 20-80 m.y. after deposition of the principal volcanic sequences, and several 100 m.y after development of the Mesoarchean basement complex. Post-2.64 Ga structures are dominated by at least three regional folding events (D1, D2, D3), accompanied by systematic temporal variation in plutonic rock composition. These events record large horizontal shortening and show little or no apparent spatial correlation with the location of known or inferred Mesoarchean basement. Folding cannot be related to events internal to the craton, such as previously inferred in arc/microcontinent collision models (e.g. Kusky 1989; Davis and Hegner 1992), and is interpreted to reflect boundary conditions outside the preserved area of the craton. The present distribution of crustal age domains as mapped by isotopic methods (e.g. Thorpe et al. 1992; Davis et al. 1996) is considered an earlier (pre-2.69 Ga) feature, overprinted by the post-2.64 Ga deformation.

## D1 Deformation and Diorite-Granodiorite Plutonism

The orientation of the earliest D1 fold structures define an approximately NE-SW trending fold belt, after taking into account the effects of D2 folding, at relatively high angle to the inferred N-S trending boundary between contrasting basement domains. D1 shortening pre-dates intrusion of ca. 2.63-2.61 Ga diorite to granodiorite plutons in the south-western and central parts of the craton (Davis and Bleeker 1999). Early diorite-granodiorite plutonism is regional diachronous, with older >2.62 Ga plutonic rocks occurring in the south and south eastern parts of the craton, roughly parallelling the trend of the D1 fold belt, and younger, <2.615 Ga plutons to the north and northwest. Although the tectonic origin of this event remains uncertain it represents a major melting event in the mantle beneath the Slave craton Geochrmical signatures of these plutons are consistent with a signature of 'subduction-modified' mantle (Davis et al. 1994). Griffin et al 1999 proposed a plume model to drive this event, however, the temporal and spatial relationships between folding and plutonism are more consistent with a collisional origin of some description perhaps involving subduction.

## D2 Deformation and Late Granites

Major regional shortening occurred through the interval 2610 to 2685 Ma and was accompanied by voluminous two mica and K-feldspar granite plutonism throughout the craton. The granite plutonism in this interval shows no regional diachroneity, regardless of the timing of the earlier plutonism (van breemen et al. 1992; Davis and Bleeker 1999). The intense craton-wide "granite bloom" argues for a major thermal disturbance, the cause of which remains speculative (lithospheric delamination, post-collisional extension, crustal thickening/relaxation).

### Lower Crustal Xenoliths

Geochronological studies of lower crustal granulite xenoliths recovered from kimberlites document metamorphic zircon growth that correlates with the timing of plutonism and metamorphism in the upper crust. In addition, discrete periods of younger zircon growth (2.56, 2.51 Ga) continued at least 20 to 70 m.y. after the regional low P-high T metamorphism and granitic magmatism in the upper crust. This pattern of younger metamorphic events in the deep crust is characteristic of other Archean cratons (e.g. Superior; Kaapvaal) and has been attributed to tectonic imbrication (Krogh 1993), or repeated imbrication and delamination events (Moser et al. 1996). The high temperature of the lower crust immediately following amalgamation of the craton, coupled with evidence for continued metamorphic zircon growth for >50 m.y.. after stabilization of the upper crust is difficult to reconcile with a thick (200 km), cool, lithospheric mantle root capable of stabilizing diamond remaining coupled beneath the craton. If diamond-bearing mantle existed at that time, its Late Archean thermal evolution must be in part decoupled from that of the overlying crustal section.

### Crust-Mantle Relationships

Studies of lithospheric samples and geophysical data have documented regional variations in the composition and structure of the Slave lithospheric mantle (Grutter et al 1999; Griffin et al 1999; Kopylova &Russel 2000; Jones et al 2001). Grutter et al (1999) proposed a compositional division of the Slave lithosphere into three approximately E-NE oriented zones, each defined by distinct garnet chemistry, and linked these to the late structural grain of the Slave Province. One possible interpretation would be that the domains are related to imbrication or modificatoin of mantle by NW or SE vergent subduction beneath the Slave craton during D1 shortening and 2.63-2.61 Ga plutonism. This would impart a NE-SW structural grain in the lithosphere and would imply decoupling of the earlier Mesoarchean-Neoarchean crustal boundaries from the underlying mantle (Grutter et al 1999). Subsequent collision (external to the present craton boundaries) would then lead to widespread deformation and granite plutonism throughout the province at 2.58 Ga, with continued metamorphism (extension?) in the lower crust to 2.56 Ga. In detail, the orientation and location of mantle domains may prove to be more complex, with both laterally and vertically layered mantle (Griffin et al 1999; Kopylova et al 2000; Jones et al 2001). Reconciling the geometry of different mantle domains with crustal structures is essential to develop more refined models of tectosphere formation.

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