Constraining rates of crustal recycling using geophysical and geochemical methods

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Whatever its origin the continental crust has been maintained by growth via arc magmatism during the Phanerozoic [1]. This gain is balanced by large volumes of continental crust that are reworked back into the upper mantle via subduction zones. Whether a particular margin is in long-term accretion or is the location of net tectonic erosion crustal materials are delivered to depth beneath the arcs via the subduction channel, which is fed by material removed from both the toe of the forearc and its under surface [2]. Globally we estimate that around 3 Armstrong Units (1 AU = 1 km^3/yr) are subducted to depth, of which 1.65 AU comprises subducted sediments and 1.33 AU tectonically eroded forearc crust. Estimates of crustal subduction by the loss of passive margin crust during continental collision events indicate around rates of 0.4 AU for the Cenozoic, suggesting this is not the dominant process in crustal recycling. Geochemical data can be used to estimate how much of the subducted sediment is returned to the crust via arc magmatism. Rates vary widely between arcs, with as much as 80% recycling in Costa Rica, but <5% for the Kamchatka and Lesser Antilles Arcs. Globally around 23% of the subducted material is reworked into arc magmatism. The remaining 77% is subducted deeper in the upper mantle. Erosional flux from the continents to the trenches is the primary control on margin tectonic character [3] and in turn this is linked to climate. Faster erosion during glacial-interglacial cycles means that the margins are more accretionary at the present time than is typical in the past. Erosion is generally able to remove excess crustal thicknesses generated by orogeny within 200 m.y. As such it is the key control on crustal thicknesses and is itself governed by sealevel and the volume of water in the global ocean.

[1] Rudnick (1995) *Nature* **378**, 573–578. [2] Vannucchi *et al.* (2008) *Nature* **451**, 699-704. [3] Clift & Vannucchi (2004) *Rev. Geophys.* 42, RG2001.

$^{40}Ar/^{39}Ar$ dating in Thor-Odin dome, British Columbia, Canada: Excess Ar in high-grade migmatitic rocks

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$^{40}Ar/^{39}Ar$ hornblende and biotite dating was carried out in the core of the southern Canadian Cordillera to investigate the significance and behaviour of excess argon in migmatites, and to place constraints on tectonic models. High-grade rocks of the Thor-Odin dome, in the Monashee Mountains, were deformed and underwent anatexis at mid-crustal levels during Late Cretaceous to Eocene orogenesis ([1] and references therein). The cause of Eocene denudation is controversial (e.g. extension, extrusion or diapirism). $^{40}Ar/^{39}Ar$ samples from an ~12 km thick structural section of cord-sil-kf-melt, sil-kf-melt and sil-st grade rocks coincide with U-Pb geochronology sample sites.

As is the case in Thor-Odin dome, $^{40}Ar/^{39}Ar$ cooling dates from migmatitic rocks may be unreliable indicators of cooling history because excess argon may cause cooling dates to be significantly older than is geologically reasonable. In the sampling transect, hornblende yields $^{40}Ar/^{39}Ar$ plateau ages ranging from 88 to 52 Ma. In most samples, the release spectra show components of excess argon. There is an apparent correlation between increasing hornblende dates, an increasing component of excess argon and structural position of the samples, and the Late Cretaceous dates in the core of the dome are "too old" relative to the ca. 56-54 Ma timing of anatexis based on U-Pb geochronology studies from the same rocks [1]. Excess argon may have originated within basement rocks and may be a consequence of short residence time of the rocks at high temperatures; this is under investigation. In contrast to the hornblende data set, the biotite cooling dates show little variation with respect to structural level, and their release spectra show no observable excess argon.

Interpretation of robust $^{40}Ar/^{39}Ar$ data, in conjunction with other data sets and geological observations, do not support detachment faulting on the southwest flank of the dome and support models whereby the domal geometry had formed prior to exhumation on bounding extensional fault systems.

[1] Hinchey *et al.* (2006) *Can. J. Earth Sci.* **43**, 1341-1365.