

The role of subduction erosion in the recycling of continental crust

CHARLES R STERN¹

¹University of Colorado, Department of Geological Sciences,
Boulder, CO 80309-0399 USA, Charles.Stern@colorado.edu

Subduction erosion occurs at all convergent plate boundaries, even if they are also accretionary margins. Frontal subduction erosion results from a combination of erosion and structural collapse of the forearc wedge into the trench, and basal subduction erosion by abrasion and hydrofracturing above the subduction channel. High rates of subduction erosion are associated with relatively high convergence rates (>60 mm/yr) and low rates of sediment supply to the trench (<40 km³/yr), implying a narrow and topographically rough subduction channel which is neither smoothed out nor lubricated by fine-grained water-rich turbidites such as are transported into the mantle below accreting plate boundaries. Rates of subduction erosion, which range up to >440 km³/km/my, vary temporally as a function of these same factors, as well as the subduction of buoyant features such as seamount chains, submarine volcanic plateaus, island arcs and oceanic spreading ridge, due to weakening of the forearc wedge. Globally, subduction erosion is responsible for >1.7 Armstrong Units (1 AU = 1 km³/yr) of crustal loss [1], a significant proportion of the yearly total crustal loss caused by sediment subduction, continental lower crustal delamination, crustal subduction during continental collision, and/or subduction of rock-weathering generated chemical solute that is dissolved in oceanic crust. The paucity of pre-Neoproterozoic blueschists suggests that global rates of subduction erosion were probably greater in the remote past, perhaps due to higher plate convergence rates. Subducted sediments and crust removed from the over-riding forearc wedge by subduction erosion may remain in the crust by being underplated below the wedge, or these crustal debris may be carried deeper into the source region of arc magmatism and incorporated into arc magmas by either dehydration of the subducted slab and the transport of their soluble components into the overlying mantle wedge source of arc basalts, and/or bulk melting of the subducted crust to produce adakites. In selected locations such as in Chile [2,3], Costa Rica, Japan and SW USA, strong cases can be made for the temporal and spatial correlation of distinctive crustal isotopic characteristics of arc magmas and episodes or areas of enhanced subduction erosion. Nevertheless, overall most subducted crust and sediment, >90% (>3.0 AU), is transported deeper into the mantle and neither underplated below the forearc wedge nor incorporated in arc magmas. The total current rate of return of continental crust into the deeper mantle is equal to or greater than the estimates of the rate at which the crust is being replaced by arc and plume magmatic activity, indicating that currently the continental crust is probably slowly shrinking [4,5]. However, rates of crustal growth may have been episodically more rapid in the past, most likely at times of supercontinent breakup, and conversely, rates of crustal destruction may have also been higher during times of supercontinent amalgamation. Thus the supercontinent cycle controls the relative rates of growth and/or destruction of the continental crust. Subduction erosion plays an important role in producing and maintaining this cycle by transporting radioactive elements from the crust into the mantle, perhaps as deep as the core-mantle boundary.

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[2] Stern (1991) *Geology* **19**, 78-81.

[3] Stern et al. (2011) *Andean Geology* **38**, 1-22.

[4] Stern & Scholl (2010) *International Geology Review* **52**, 1-31.

[5] Clift et al. (2009). *Earth Science Reviews* **97**, 80-104.

Stable strontium isotope behaviour in Himalayan river catchments

EMILY I. STEVENSON^{1*}, KEVIN W. BURTON², IAN J. PARKINSON³, CHRISTOPHER R. PEARCE³ FATIMA. MOKADEM¹, AND RACHAEL JAMES⁴

¹Department of Earth Sciences, Oxford University, South Parks Road, Oxford, OX1 3AN, UK. emilys@earth.ox.ac.uk (* presenting author)

²Department of Earth Sciences, Durham University, Durham, DH1 3LE, UK

³Department of Environment, Earth and Ecosystems, The Open University, Milton Keynes, MK7 6AA, UK

⁴National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK

The radiogenic strontium ratio (⁸⁷Sr/⁸⁶Sr) is commonly used as a weathering tracer of continental sources in seawater, with carbonate and silicate based lithologies having different ⁸⁷Sr/⁸⁶Sr ratios. However, ⁸⁷Sr/⁸⁶Sr interpretations can be hindered by the difficulty of distinguishing changes in riverine flux from changes in composition. This is a particular problem for Himalayan rivers as those draining both silicate and carbonate catchments have elevated ⁸⁷Sr/⁸⁶Sr ratios, and there is debate as to how much of the ⁸⁷Sr flux is actually derived from silicate weathering [1].

Recent stable strontium isotope data suggested that carbonate weathering yields a $\delta^{88/86}\text{Sr}$ value distinct from those of both silicate weathering and seawater [2]. This difference in isotopic ratio could resolve whether inputs into rivers, and eventually the oceans, are truly dominated by either silicate or carbonate lithologies and may also be used to distinguish between flux and source.

This study presents high-precision $\delta^{88/86}\text{Sr}$ data and ⁸⁷Sr/⁸⁶Sr data obtained from river waters draining both silicate and carbonate dominated terrains in the Himalaya. Rivers draining carbonate based terrains have an average $\delta^{88/86}\text{Sr}$ value of 0.28±0.08‰ and increase to heavier values downstream (heading towards those of the Ganges, 0.38±0.01‰ [3]), possibly because of continued carbonate precipitation through the catchment. The $\delta^{88/86}\text{Sr}$ of carbonate rivers also correlates with [Si], and other major divalent cations as well as sulphate concentration. [4] Silicate rivers are generally heavier (0.34±0.07‰), but show little systematic behaviour with other elements. These results indicate that the carbonate rivers are generally lighter than those draining silicate terrains, and also suggest that continued secondary mineral precipitation (primarily carbonates) is occurring within those catchments.

[1] Bickle et al. (2005) *GCA* **69**, 2221-2240. [2] Krabbenhöft et al., (2010) *GCA* **74** 4097-4109. [3] Pearce et al., (2011) *AGU, Fall Meet. Abs.* B21D-0342. [4] Kisakürek et al., (2005) *EPSL* **237** 387-401.