CRUSTAL GROWTH MECHANISMS: THE ROLE OF TRANSFORM CONTINENTAL MARGINS. P. J. Patchett and C. G. Chase, Department of Geosciences, University of Arizona, Tucson AZ 85721, USA (patchett@geo.arizona.edu; chase@geo.arizona.edu)

Introduction: There has been much discussion of juvenile arc versus oceanic plateau initiation for crustal growth. Both in the case of growth by creation and addition of arcs [e.g. 1,2], and by addition of plume-related plateau structures [e.g. 3-6], it is observed that most mid-upper crustal rocks eventually preserved in orogenic belts are subduction-related magmatic products or derived sediments. To first order, the rate of production of subduction-zone magmas from any protolith must be a function of subduction rate, but also of the water content of subducted rocks. Considering also factors that inhibited long-term stabilization of continents in the pre-3.5 Ga Earth, no close relationship between the heat budget and continent generation is expected.

Rates of Growth: Perceived need for plume-driven crust generation comes from apparent growth rates that locally exceed those of present-day arcs by large amounts [e.g. 7,8]. This problem can be partly explained away by serial accretion of arc structures [1,9], but assemblages of crust such as northern hemisphere 1.9-1.7 Ga [1] and 0.9-0.6 Ga Arabia [9] still seem to require very large growth rates. It is assumed that an oceanic plateau, with a thick section of wetted basaltic protolith, whether obducted, accreted or subducted, would provide a large amount of “fuel” for a major crust generation episode [e.g. 6].

Episodicity: Episodicity of crust generation in individual continents has long been known. Episodicity on a global scale is not expected [10], as corroborated by important generation periods showing up in lesser-known continents [e.g. 4], to fill the “gaps” seen in North America and Europe. Any apparent global episodicity that remains is probably an artifact of poorly-known continents, and cannot be used, in our view, to constrain mechanisms [cf. 11].

Transform Continental Margins: Both the problems of high local growth rates and apparent episodicity are explained if mechanisms exist to pile up juvenile crust into one or more restricted zones of orogenic belts. This could be through serial arc accretion [e.g. 9,12], or by transform faulting along the continental margin [12]. All that is needed in Proterozoic time is more intense development of the accretion and transform faulting seen in the Canadian Cordillera [12]. Here, after subduction of the Mid-Ocean Ridge, the Pacific margins of Canada and of California have become transform margins, with transport of accreted terranes to the North. Large strike faults are visible and in part active, but can become nondescript shear zones in ancient terranes [e.g. 13, and cf. 2].

Modeling of Transform Margins: We have constructed models of the development, frequency and duration of transform margins to continents. The critical factor is a large continental margin re-entrant (“arm pit”) established either at time of rifting, or by subsequent accretion patterns. If a large re-entrant exists, then one of its sides must become either a transform margin, or at least have a large component of transpressive convergence. The larger the continental re-entrant, and the longer-lived the ocean basin, the greater the pile-up of juvenile arc material into the re-entrant area. The Monte Carlo models compare successfully to paleogeography (C. Scotese, website) for Phanerozoic time. Geographic comparisons are close to impossible in Precambrian time. Nevertheless, to qualitatively explain episodes like the 1.9-1.7 Ga crust or the Arabian-Nubian Shield, we show that major transform margins are expected whenever large ocean basins had a protracted history of convergence at their margins. Models indicate that a major transform margin has a high probability of existing somewhere on the globe at all times. A major transform margin is expected to continue to operate, continuously or intermittently, for the lifetime of the ocean basin, hence for 150-300 m.y. This explains apparent rapid growth and episodicity without resort to extraordinary mechanisms.