A Petrotectonic Model for Formation of Hadean Zircons

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Detrital zircons as old as nearly 4.4 Ga offer insights into the earliest moments of Earth history. We interpret results of geochemical investigations of these zircons to indicate their formation in near-H_2O saturated meta- and peraluminous magmas under a low (~25°C/km) geotherm beginning by ca. 4.4 Ga. Alternate views, such as their growth in melts derived from mafic crust, invariably focus on the subset of geochemical constraints that are consistent with that interpretation while ignoring those that are contradictory (e.g., inclusion assemblages, T^{xlln}). In pursuing a petrotectonic model that explains the full spectrum of Hadean zircon features, it is important to note that they are unlike typical Phanerozoic magmatic zircons (e.g., in their low T^{xlln} and inclusion assemblages. However, the 20 Ma Arunachal leucogranites (AL) of the eastern Himalaya are a rare exception to this generality. They show LILE covariance trends indicative of wet basement melting together with a normal distribution of magmatic zircon crystallization temperatures about an average of 660±25°C. In the same fashion as Hadean zircons, AL zircon rims and inherited cores are dominated by an inclusion assemblage of muscovite + quartz and yield formation pressures ranging from 7-14 kbars. Their seemingly unique character may reflect an origin more akin to that of the Hadean zircons. Geochemical data coupled with geologic mapping indicates the source of the AL to be in the hangingwall of a megathrust that rapidly carried undehydrated foreland sediments (i.e., a source of H_2O to flux hangingwall anatexis) to depths of ~25 km. Modeling shows the thermal structure of this continental collision environment to be broadly similar to the temperature distribution predicted for a Hadean ocean-continent subduction zone. The similarity of these two environments, separated by over 4 Ga, suggests a broadly comparable plate boundary setting for formation of both the Hadean and AL zircons. A key difference is the absence of metaluminous magmas in the Himalayan case, due to intercontinental convergence. Thus Hadean underthrusting may have brought a co-equal mixture of continental-derived sediment and oceanic crust to the melting zone, producing both S- and I-type magmas directly from the interface between subducting sediment and mantle wedge. This environmental explains each of the myriad characteristics thus far winnowed from these ancient grains.