PALEOCLIMATE - HADEAN TO RECENT

John W. Valley

Charles R. Van Hise Professor, Dept. of Geology and Geophysics, University of Wisconsin, 1215 W. Dayton St., Madison, WI 53706

Rocks have recorded Earth's climate for 4.5 billion years. The geochemistry of well-constrained samples restricts surface temperatures, ocean conditions, precipitation, seasonality, and weather. Such data contribute to modeling past, and future changes, cyclicity, forcing mechanisms, and tipping points. These proxies are critical to understand events ranging from the early climate that permitted emergence of life, to recent climate that helps predict its future. In spite of profound intellectual and societal importance, only a fraction of this record has been identified and deciphered.

The Wisc-SIMS Ion Microprobe Lab at UW-Madison makes *in situ* stable isotope measurements, permitting study of previously inaccessible climate proxies. In Phanerozoic carbonates, high precision $\delta^{18}O$ can now be measured in time series at the scale of a day in otoliths (Weidel et al. 2008) and mollusks, and less than a month in speleothems. A stalagmite from Soreq Cave, Israel reveals that annual precipitation decreased 50% from ca. 1 m/y at 100 AD to 0.5 m/y by 700 AD correlating to the decline of Roman/Byzantine rule in the Levant (Orland et al. 2009). Growth zoning of $\delta^{18}O$ and bimodal vital effects can be analyzed in forams with a 3μm spot (Kozdon et al. 2009). In Archean zircons, 10-20μm growth domains within zircons can be dated and analyzed for $\delta^{7}Li$ and trace elements (Cavosie et al. 2006, Ushikubo et al. 2008), and $\delta^{18}O$ can be measured at sub-μm-scale (Page et al. 2007). Early Archean (i.e., Hadean, pre-4 Ga) detrital zircons have elevated $\delta^{18}O$ from 6.3 to 7.5‰, high [Li] of 10-70ppm, and low $\delta^{7}Li$ of 0 to -10‰ that indicate the existence of weathered protoliths and oceans. The presence of liquid water (vs. steam) as early as 4.3 Ga suggests that habitats were hospitable for life 800 myr earlier than the first known fossil evidence or low $\delta^{13}C$ kerogen.