



PENROSE CONFERENCE REPORT

Secular Variation in Tectonics and Allied Fields

October 22–28, 2004

Conveners:

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A Penrose Conference on secular variation in tectonics and allied fields was held in St. George, Utah, in October 2004. It was jointly sponsored by the Geological Society of America and the U.S. Geological Survey, and was attended by forty people from ten countries. In keeping with the complexity of the earth system, and with the links between tectonics and most other fields, the conference was intentionally broad in scope. The focus was on long time scales, ranging from the entire span of earth history down to a few hundred million years.

The first three days were devoted to talks, posters, and discussions on secular analysis—the tracking of variables as a function of geologic age. Presentations on a wide range of topics were tailored for non-specialists. The keynote speakers were Kevin Burke on tectonics through time and Jan Veizer on evolution of the sedimentary system. We went on to hear about the mantle lithosphere, mantle dynamics, large igneous provinces, ophiolites, supercontinents, continental margins, accretionary orogens, greenstone belts, orogenic gold deposits, orogenic deformation styles, the plate mosaic, Archean continental crust, metamorphic conditions, continental margin magmatism, cyclicity in fossil diversity, tectonics and life, true and apparent polar wander, redox in the oceans, sediment-hosted ores, paleosols, seawater strontium, quartzite-rhyolite association, metallogeny of snowball episodes, and what drives climate.

Earth history has involved a combination of long-term, irreversible changes, catastrophic events, and cycles. As Kevin Burke put it, most processes affecting the lithosphere are cyclical, but some cyclical interactions have led to extraordinary secular changes. The conference served as a reminder of the value of an encyclopedic approach to earth history and earth system evolution. Any viable scenario must account for (1) the exponential decline in global radiogenic heat production; (2) the absence of rocks older than 4.0 Ga; (3) the existence of detrital zircons as old as 4.4 Ga; (4) the scarcity of komatiites younger than Paleoproterozoic; (5)

the decrease in thickness of the thermal continental lithosphere from Archean to present; (6) peaks in the abundance of juvenile continental crust at 2500–2600 and 1800–1900 Ma; (7) peaks in the abundance of orogen gold deposits at 2500–2600 and 100–200 Ma but a complete absence in the Mesoproterozoic; (8) the abundance of massif anorthosites during the Mesoproterozoic; (9) the lack of blueschists before the Neoproterozoic; (10) the long-term increase and shorter-term fluctuations in seawater $^{87}\text{Sr}/^{86}\text{Sr}$; (11) sulfur-isotopic evidence for an oxidizing atmosphere beginning sometime between 2450 and 2090 Ma; (12) the abundance of banded iron ores between ca. 2000 and 2500 Ma; (13) peaks in the abundance of Mississippi Valley type lead-zinc deposits ca. 300 and 100 Ma; and (14) the unchanged state of mantle redox conditions since the Early Archean. Another fifty items could be added to such a list. An encouraging revelation was the diversity of big problems that may be tractable by secular analysis, despite the patchiness of the early rock record. The utility of ore deposits in the study of earth history made itself clear: Each deposit type requires its own unique alignment of controlling variables to form. Probably the biggest controversy to be aired was the long-standing but still anecdotal debate about the Archean tectonic regime: plate tectonics versus something else. Are we mesmerized by modern Earth? Secular analysis has not been widely applied in structural geology, but perhaps such an approach can be devised for the Archean problem.

A two-day field trip followed. We were led through the Phanerozoic stratigraphy of the Colorado Plateau by Ron Blakey of Northern Arizona University. There is no better place to be reminded of the vastness of geologic time. Ron began with a synthesis of the paleogeographic evolution of the Colorado Plateau, beautifully illustrated by maps that can be seen at the Northern Arizona University Web site, <http://jan.ucc.nau.edu/~rcb7/>. Highlights of the trip included stops in Jurassic eolian sandstones of Zion Canyon and in Permian sandstones at Toroweap Point in the western Grand Canyon, just upstream of Volcan's Throne, where the Canyon was once dammed by lava flows.

Conference participants included Walter Alvarez, Irina Artemieva, Ron Blakey, Wouter Bleeker, Dwight Bradley, Mike Brown, Kevin Burke, Kent Condie, John Dewey, Yildirim Dilek, Poul Emsbo, Richard Ernst, Rich Goldfarb, David Huston, Karl Karlstrom, Tim Kusky, Lisa Lamb, Dave Leach, David des Marais, Steve Marshak, Shigenori Maruyama, Joe Meert, Walter Mooney, Rich Muller, Steve Piercey, Tim Raub, Greg Retallack, Doug Reusch, Laurence Robb, Robert Rohde, Alexey Shulgin, Tom Skulski, Phil Thurston, Erkan Toraman, Jan Veizer, Gary Vermeij, Brian Windley, and Mike Zientek. Four graduate students were among the group. It was remarkable how many Red Sox fans happened to be in the same place in late October 2004.

A post-conference volume on *Secular Variation through Earth History* (edited by Dwight Bradley) will follow. It will contain 20–25 chapters and, pending approval, will be published as a Geological Society of America Special Paper. Contributions will be welcomed from those who were unable to attend the conference. Watch for the announcement in a future *GSA Today*.