Evaluating the role of arc volcanism on Neoproterozoic to Early Paleozoic climate

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Identifying the driving mechanisms for major climatic shifts deep in Earth history is challenging. Here we use a global compilation of detrital zircon age data to evaluate spatiotemporal variation in continental arc volcanism and tectonic outgassing of CO_2 to the atmosphere during the Neoproterozoic and Early Paleozoic. This data set reveals a direct link between tectonically driven CO_2 emissions and the dramatic episodes of climate change observed in this interval: the Cryogenian "Snowball Earth" and the "hothouse" world of the Cambrian. Importantly, these climatic events had profound affects on early animal evolution. Specifically, our data show the following trends: (1) a global reduction in continental arc volcanism occurred around the transition into the "Snowball Earth" whereas widespread arc systems initiated near the terminal Cryogenian and its glacial interval; (2) Continental arc systems stayed active and further expanded dramatically during the Ediacaran and into the Cambrian. This corresponding to an extreme greenhouse climate and protracted interval of global environmental stress; and (3) A global reduction in arc volcanism during the early Ordovician is associated with a period of global cooling and the onset of the Great Ordovician Biodiversification Event (GOBE). These data demonstrate that global variation in plate tectonic regimes plays a major role in steering Earth's climate and evolutionary patterns on million year time scales.

Initiation and 35 Myr duration of S-type granitic magmatism in an accretionary orogen

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Granites in circum-pacific igneous provinces can often be divided into 'S-' and 'I'-types on the basis of elemental and isotopic characteristics [e.g. 1]. This division reflects a dominance of sedimentary or igneous source components, and dating of granites allows tracking of the relative contributions to growing batholiths in accretionary orogens. In the Lachlan and New England Orogens of Eastern Australia, a progression from S-type through I-type to A-type granites occurs repeatedly over ~100 Myr periods. S-type intrusion occurs during the first major extensional event following major compression, while later I-type intrusion reflects a diminished sedimentary source and increasing mantle contribution. The timing of S- and I-type granites is therefore related to the tectonic evolution of orogens [2].

The S-type phase of intrusion in the New England accretionary orogen (~300-280 Ma) records an environment switching from compression to extension and back to compression as part of this process. We have undertaken U-Pb dating of zircons extracted from small (~backarc) gabbroic and dioritic bodies (Bakers Creek Supersuite), recalculated the ages of S-type granites (Hillgrove Supersuite), and compiled chronological data for the New England Orogen in order to investigate the establishment of magmatism in this area. We find a progression through: (1) diverse magmatism involving gabbroic, dioritic, S- and I-type during establishment of magmatism (305-295 Ma); (2) a major pulse of S-type magmatism (295-285 Ma), ending with; (3) I-type and HREE-depleted (deep crustal) magmatism around the time of the Hunter-Bowen orogenic event (~285-266 Ma).

Magmatism occurs over a ~35 Myr period in the region of most voluminous intrusion, but timing varies along-strike and may reflect assymetric rifting of the orogen. Together, these data time the heating, melting, depletion, and exhaustion of the S-type magma source.

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