Annual Convention & Exhibit, American Association of Petroleum Geologists
May 19-22, 2019 San Antonio, Texas

Theme 11: SEPM Research Symposium – A look into the future of Energy and sustainability using the sedimentary record.

How Major, Explosive, Subduction-Related, Andesitic Volcanic Eruptions Cause Slow, Incremental, Global Cooling While Extensive, Rift-Related, Basaltic Lava Flows Cause Sudden Warmings That Form Most of the Boundaries Within the Geologic Time Scale

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Throughout Earth history, major rapid warming has been contemporaneous with extensive effusive eruption of flood basalts. The greater the area covered, the greater the warming, the longer the warming lasts, the greater associated ocean acidity, and the greater the level of mass extinction. These events range from late Triassic rifting of North America from Africa, to late Permian attempted rifting of Siberia, to late Paleocene rifting of Norway from Greenland. The largest basalt flows typically occur at the end of geologic Periods, Epochs, and even Ages. Lava flows covering hundreds of square kilometers were contemporaneous with the Medieval Warm Period, the Roman Warm Period, the Mycenean-Shang Warm Period, etc. Warming is caused by chlorine and bromine rising from hot lava, depleting the ozone layer, which allows more very hot ultraviolet-B solar radiation to reach Earth's surface.

Major explosive volcanic eruptions are also observed to deplete the ozone layer, causing short-term warming, but form aerosols in the lower stratosphere that reflect and scatter sunlight, causing net global cooling of ~0.5ºC for 2 to 4 years. Modeling shows that cooling the whole ocean surface for only a few years affects ocean temperatures for nearly a century. In this way, several large explosive eruptions each century are observed to cool oceans incrementally over tens of thousands of years down into ice-age conditions.

During the past 120,000 years, oxygen isotopes in Greenland ice cores document 25 highly erratic sequences of rapid warming of air out of ice-age conditions within a few years followed by slow, incremental cooling over millennia back into ice-age conditions. Fine layers of trona, oil shale, and dolostone in the Eocene Green River Formation show similar rapid erratic cycling from temperate to very hot environments in sequences averaging a few thousand years. Paleozoic brachiopod habitat temperatures also vary rapidly. When high densities of oxygen isotope proxies for air and water temperature can be determined, preferably in the field, fine-scale changes in climate can be observed and cross-correlated globally at a more-detailed resolution than magnetic anomalies.

When subduction dominates, Earth is cooled into ice ages and even Snowball Earth. When sub-aerial rifting dominates, oceans can be warmed to hot tub temperatures with high rates of mass extinction.

Observed changes in climate correlate very poorly with observed changes in greenhouse gas concentrations.