Climate changes caused by degassing of sediments during the emplacement of large igneous provinces: COMMENT

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Many mass extinctions and biotic crises coincide with eruptions of large igneous provinces (LIPs), but a causal link remains disputed because many LIPs apparently had no severe deleterious impact on the biosphere (Wignall, 2005). Ganino and Arndt (2009) presented exciting data showing that intensity of global climate changes is linked to the substratum rock types heated by the igneous activity because “contact metamorphism around intrusions in dolomite, evaporite, coal, or organic-rich shale generates large quantities of greenhouse and toxic gases (CO₂, CH₄, SO₂), which subsequently vent to the atmosphere and cause global warming and mass extinctions.” (p. 323). This is a quantitatively reasoned claim that “release of sediment-derived gases had a far greater impact on the environment than the emission of magmatic gases” (p. 323). Accordingly, this venting mechanism is indirectly designated as the major control on the extinction magnitude (Ganino and Arndt, 2009, their figure 1).

The hypothesis, based on impressive data from the Permian Emei Shan LIP, has implications for the volcanic greenhouse scenario of Wignall (2005). My principal reservation refers, however, to Ganino and Arndt’s oversimplification of the diversity of volcanism-related disastrous factors and consequent feedbacks. For example, gas-poor basalt is the dominant wall rock in the giant Ontong-Java oceanic province, not associated with a large biotic crisis. Consequences of continental and oceanic LIPs are quite different because of the “buffering” effect of sea-water cover (Coffin, 1994). In fact, a positive biotic response may be linked with volcanogenic warming and fertilization in oceanic domains, as modeled for the Cenomanian-Turonian anoxic event (Sinton and Duncan, 1997; see Racki and Wignall, 2005).

Listed below are some other significant aspects of the volcanic hazard, at most minimally discussed by Ganino and Arndt:

1. Eruptive gas content in basaltic magma. As measured by Self et al. (2008), sulfur and chlorine contents in glass inclusions within Cretaceous–Paleogene Deccan lavas show conclusively that huge amounts of lethal volatiles were expelled (i.e., 3.5 teragrams of SO₂ and 1 teragram of HCl for every 1 km³ of lava erupted). The perturbation from even individual eruptive spasms, such as short-term climate oscillations due to volcanic winter effect, as well as damage to the ozone layer, was probably far more severe than usually assumed.

2. LIP-associated explosive volcanism. Ray and Pande (1999) revealed that carbonate magmatism, associated with the Deccan Traps volcanism, was responsible for injection of a substantial amount of CO₂ and SO₂, comparable to that of the Chicxulub impact scenario. Isozaki (2009) in his double-phased “plume winter” scenario focused on large-scale alkaline volcanoclastic eruptions during the Late Permian extinction events. Coupled ultra-Plinian–type explosions of felsic and kimbervitic volcanoes may have driven calamitous ecosystem changes, in particular reducing sunlight and temperature owing to stratospheric dust/aerosol screens. This cooling prior to the long-term greenhouse period might be generated in an additional way, especially by silicic pyroclastic eruptions: iron fertilization by great volumes of pyrolytic carbon (Gröcke et al., 2009). This strongly suggests only limited thermogenic emission, even from heated coals and organic-rich shales in some geological circumstances, i.e., where lava loses most of its energy when heating and evaporating water. Such case histories demonstrate that LIPs should be comprehensively examined on a case-by-case basis.

REFERENCES CITED


