Forum Reply

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Mercury anomaly, Deccan volcanism and the end-Cretaceous Mass Extinction

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We thank Jan Smit and colleagues (Smit et al., 2016) for giving us the opportunity to clarify some important points in our original manuscript (Font et al., 2016a) and to discuss the issues raised in their Comment. Their main critique centers on the origin of the mercury anomalies, which they argue are post-depositional and cannot be assigned to Deccan Traps activity. Their arguments center on the hypothesis of Lowrie et al. (1990) who invoked a process of downward infiltration by reducing waters to explain the origin of the white beds below the Cretaceous-Paleogene (KPg) boundary at Gubbio, Italy. Apparently Smit et al. are not aware of the work by Abrajevitch et al. (2015) or that this issue was addressed in our *Geology* paper. Here we provide more detailed explanations of why the comments by Smit et al. are out of date.

(1) Smit et al. argue: "Deccan Traps Phase 2 should begin >370 k.y…below the KPg boundary...As a consequence, the Hg concentrations…should not be restricted to the top 50–60 cm". In addition, they argue that "Phase 2 of the Deccan traps begins somewhere in the top of MagnetoChron 30N". However, Smit et al. are not aware that high-precision U-Pb dating of Deccan phase 2 accurately places the onset ~250 k.y. before the KPg boundary (Schoene et al., 2015) and correlative with the base of magnetochron C29r (Chenet et al., 2007). The mass extinction was documented within the inter-trappean sediments (Keller et al., 2012). Second, Smit et al. assume that any volcanic eruption results in global anomalous Hg concentrations. However, geochemical anomalies are not expected to precisely coincide with the beginning of volcanic activity, but depend on the volcanic emission rate, composition of the aerosols and the residence times in the atmosphere that determine whether and when concentration of toxic agents reach critical threshold conditions tipping the environment into crisis mode (Font et al., 2016b; Schmidt et al., 2016). We consider that the interval of increased Hg values of ~1 m spanning the KPg at Bidart reflects the peak emission rate of the Deccan phase 2, rather than total duration of the eruptions.

(2) The second argument put forward by Smit et al. invokes diagenetic modification of sediments below the KPg boundary. Specifically, they refer to Lowrie et al. (1990) who attributed low values of magnetic susceptibility and remanent magnetization in the white beds at Gubbio to reductive dissolution of iron oxides by downward infiltration of reducing waters resulting from rapid accumulation of organic matter produced by the mass extinction. However, a recent study by Abrajevitch et al. (2015) refutes this interpretation. Abundant magnetite particles of biogenic origin (fossil magnetosomes of magnetotactic bacteria known to be particularly sensitive to reductive dissolution because of their small size and large surface to volume ratio) have been detected within and below the KPg boundary clay at Bidart (see Abrajevitch et al., 2015, their figure 8). The presence of dissolution-sensitive magnetofossils in the interval between the boundary clay and the bleached sediments below strongly argues against downward percolation. Rather, the low-susceptibility layer marks a different environmental event that preceded the KPg mass extinction.

If we assume a post-depositional origin due to downward fluid percolation for the Hg anomalies found at Bidart, the latter should be solely located below the KPg boundary. However, our figure 2 shows that Hg anomalies are also observed above the KPg boundary (in biozones P0 and P1a), which contradicts Smit et al.'s argument. In addition, their anoxia interpretation is not compatible with the low total organic carbon (TOC) values observed across the KPg boundary at Bidart, nor with the suboxic to oxic conditions indicated by widespread colonization of *Thalassinoides* during the KPg boundary event at Agost and Caracava (Spain) (Rodriguez-Tovar, 2005). We conclude that Smit et al.'s arguments for post-depositional alteration to explain the newly found Hg anomalies are not sustainable. These Hg anomalies mark the time when Deccan volcanism reached paroxysmal eruptions and adds to unraveling the true nature of the KPg mass extinction, which needs to be highlighted rather than obscured.

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