Field evidence for coal combustion links the 252 Ma Siberian Traps with global carbon disruption

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We welcome the opportunity to discuss the geochronologic constraints on organic matter combustion during Siberian Traps magmatism in further detail, and to clarify several key misunderstandings by Davydov et al. (2021) regarding our model (Elkins-Tanton et al., 2020). While we agree with Davydov et al. that constraining the timing of organic matter combustion, recorded in our samples from the Siberian Traps, is critical to testing linkage with end-Permainian environmental disruption, we disagree with their suggestion that our samples span 9 m.y. (from 253 to 244 Ma).

We do not argue, though, that the samples described by us, which are distributed across a broad area of the Siberian Traps (thousands of kilometers), are synchronous.

Rather, we interpret these field observations as evidence for widespread organic matter carbonization and combustion, at multiple intervals during Siberian Traps magmatism, suggesting this was an important province-scale process.

Data from Burgess and Bowring (2015) provide a precise timeline of Siberian Traps magmatism. Burgess and Bowring (2015) obtained an age of 252.27 ± 0.11 Ma (2σ uncertainties) for perovskite from an Arydzhangsky suite alkali lava intercalated with volcanoclastic rocks from the Maymecha-Kotuy region, slightly older than the end-Permainian mass extinction at 251.94 ± 0.037 Ma (Burgess et al., 2014). The Angara River tuffs are part of the Kapaevsky Formation (Naumov and Ankudimova, 1995). Zircons from sills in this region yield ages from 251.681 ± 0.063 Ma to 251.46 ± 0.051 Ma (Burgess and Bowring, 2015). These data support coal- and organic matter-magma interactions bracketing the mass extinction interval.

Ultimately, the tempo of magmatism and the distribution of intrusive magmas are likely to determine the rates of light carbon release from disrupted sedimentary rocks, including coal- and organic matter-bearing strata.

Contrary to the assertion of Davydov et al., we did not state that there was “massive coal combustion on the surface”, and this appears to reflect a fundamental misunderstanding of our model. Instead, we stated “Siberian Traps magmas incorporated and combusted coal and organic-rich material”. We clarify the model in here Figure 1, showing ascending magmas entraining xenoliths of coal and carbonaceous sediments that are carbonized in the subsurface and also combusted either through reduction of magmas (Iacono-Marziano et al., 2012) or exposed to the atmosphere. This model is based on direct evidence we showed of coal and combusted organic matter entrained within samples of Siberian Traps rocks.

Reference to lack of, or limited, coal layers within the Siberian Traps basalts appears to be based on the misunderstanding that the model was focused instead on burning of coal beds/swamps deposited during the Siberian Trap eruptions. The model only considers underlying coal and organic-rich shale of deeper sediments of the Tunguska Basin (Fig. 1). We also reported the occurrence of char and inertinite particles that were interpreted as evidence for forest fires also occurring at time of eruption. The carbon isotope budget, however, was focused on the combustion of deeper coal and organic-rich shales.

Finally, smaller points: (1) The unsubstantiated claim that the high moisture content of Tunguska Basin coal would be too high to allow combustion ignores the evidence presented of combustion having occurred. (2) In response to Davydov et al.’s final comments, our figure 1 and figure S7 are drawn based on two different sources: the first (“stratigraphic log”) is re-drawn from Permyakov et al. (2012), whereas figure S7 is based on the older Malich et al. (1974) geological map at 1:200 000. We preferred not to change the original maps. (3) Finally, yes, the location of the Kaerkan open-pit mine could have been described more accurately: it is located 30 km southwest of Talnakh and 15 km west of Norilsk.

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