Geophysical Research Abstracts
Vol. 15, EGU2013-7658-1, 2013
EGU General Assembly 2013

The Siberian Traps and the end-Permian event: Geology, geochemistry and atmospheric modeling of gas release

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The Siberian Traps were emplaces through sedimentary basins covering the Siberian Craton, passing thick accumulations of carbonates and evaporites. Contact metamorphism of the sedimentary rocks around dolerite sills and dikes generated greenhouse gases and halocarbons to such an extent that the process could be responsible for both the end-Permian carbon isotope excursion and the mass extinction. The key processes are suggested to be 1) metamorphism of oil-saturated rock salt sequences (halocarbon production), 2) methane generation from metamorphism of organic-rich shales (methane production), and 3) decarbonation of dolostones (carbon dioxide production). We have analyzed the petrography and geochemistry (including carbon isotopes) of contact metamorphic carbonates from outcrops, and can document the devolatilization processes. In addition, we have explored the potential global warming effects of CO_2 and CH4 emissions to the end-Permian atmosphere from the volatile generation. We have constrained the effect of century scale degassing events using the atmospheric lifetime of CH4 and CO_2, the pre-event atmospheric composition in terms of methane and carbon-dioxide as well as H2S, the gas flux to the atmosphere, the IR absorption efficiency, the radiative forcing and the climate sensitivity. Assuming rapid emplacement of one single major sill intrusion into the Tunguska Basin, and 100 year gas release with 60% CH4 and 40% CO_2, the global annual mean temperature could rise by 2-5°C (best estimate ∼3.5°C). In contrast, degassing from subaerial lava flows with the same magma volume as a sill has one order of magnitude lower influence on the global climate, resulting in a warming of about 0.1°C. Per molecule CH4 is much more efficient in absorbing and re-emitting IR radiation than CO_2, yielding a much stronger greenhouse effect in the Earth's atmosphere. Considering that the heat trapped in the atmosphere over a 100 year period resulting from an emission of CH4 is, under current conditions, about 25 times larger than from a similar mass of CO_2, i.e. the Global Warming Potential (GWP) is ∼25, the climate impact of a mixture containing 60% CH4 is strongly dominated by this compound. This effect increases with the amount of available H2S as it strongly influences the lifetime of CH4 in the atmosphere by reducing the oxidation potential. The method and geological model can be applied to other boundary events with LIPs, such as the Triassic-Jurassic boundary (∼3.1°C), the Toarcian event (∼2.9°C), and the Palaeocene-Eocene Thermal Maximum (∼3.5°C).