during winter, and surface ozone at high northern latitudes during the onset of spring, has long been recognized; whether heterogeneous reactions are also important in the production of ozone during winter at mid-latitudes is less clear. Although the haze suggests that the photochemistry might result in the formation of secondary organic aerosols in the smog.

Of course, the high levels of ozone measured by Schnell and colleagues[2] could be specific to the local environment, given the restrictions in our understanding of the processes responsible for the findings. Nevertheless, the number of wells in the Wyoming gas field measured by Schnell and colleagues[2] are expected to triple by 2010 with respect to their number in 2008, with unknown consequences for the future probability of local ozone pollution. ❐

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MASS EXTINCTIONS

Noxious traps

ELSEVIER

The most profound mass extinction in Earth's history occurred 250 million years ago, at the end of the Permian period, when a vast number of species were wiped off the surface of the planet. Among the possible causes of this catastrophe is the magmatic episode associated with the immense Siberian Traps large igneous province: changes in climate triggered by gases released during this event, particularly when hot magma intruded thick piles of organic-rich sediments and salt, could have fatally destabilized delicate ecosystems.

However, could the right types of gases have been released in sufficient quantities to force climate change? To find out, Henrik Svensen from the University of Oslo, Norway, and his colleagues studied large, pipe-like features that are abundant throughout the province and investigated the field relationships between the sediments and the intruded magma (*Earth Planet. Sci. Lett.* **277,** 490–500; 2008).

They tested the potential of magmatic heating of salt deposits to produce gases, such as methyl chloride — with the capacity to damage the ozone layer — by heating representative rock samples in the laboratory. Their experiments did indeed result in the production of methyl chloride, as well aws sulphur dioxide. It is already known that greenhouse gases such as carbon dioxide and methane are readily released when organic matter, coal and oil are heated by magma.

Using estimates for the volumes of magma and metamorphosed contact material from the Siberian Traps, Svensen and colleagues quantified the amount of greenhouse gases — as well as methyl chloride and similar gases — that could have been produced during the magmatic episode. They estimate that over a hundred thousand gigatons of carbon dioxide could have been generated. Thousands of gigatons of methyl chloride and related gases could also have been released, sufficient to damage the ozone layer. This finding is important in light of recent work that shows that the release of high quantities of hydrogen sulphide and methane during the end-Permian would have done little to deplete atmospheric ozone.

The organic-rich sediments and salt occur at a depth of one kilometre or more beneath the surface. The researchers suggest that it is at this level that the gases must have been generated in response to heating by intruding magma. The highly pressurized gases then drilled their way through the large pipe-like structures and escaped into the atmosphere. Hundreds of such pipes have been identified in the province, and must have acted as an efficient system to bring the gases up to the surface.

Although some other large igneous provinces are believed to have led to the release of greenhouse gases and to have modified Earth's climate, they did not lead to mass extinctions. The particularly deleterious effects of the Siberian Traps could have resulted from the combined impact of global warming due to greenhouse gases and the destruction of the ozone layer due to gases such as methyl chloride. Perhaps the extensive and thick salt deposits that happened to be heated by rising magma proved fatal for the biosphere at the end of the Permian wperiod.

NINAD BONDRE