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F, Cl, and S contents of olivine-hosted melt inclusions in mafic dikes and the environmental impact of flood volcanism in the Paraná-Etendeka LIP

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Large Igneous Provinces (LIPs) have been proposed to trigger mass-extinction events by the release of large quantities of volcanic gases which results in major climatic perturbations causing worldwide ecological stress and collapse. A prerequisite for understanding the proposed link between LIP volcanism and biological crisis is reliable information about the total gas emissions during these events. We present the first estimations of total F, Cl and S emissions from the Paraná-Etendeka LIP in the South Atlantic. Data from this province are of special interest because it is among the world's largest LIPs but is not associated to a mass extinction event. We have determined pre-eruption concentrations of F, Cl and S by in-situ analysis of melt inclusions preserved in olivine phenocrysts from basaltic dikes in the Etendeka province of NW Namibia. The melt inclusions have Mg-rich basaltic bulk compositions with about 8 to 18 wt.% MgO, overlapping the compositional range of the host rocks. A major feature of the melt inclusions is their wide variation in major and minor element concentrations, including F, Cl and S. This is attributed to trapping of variably-mixed melt fractions during crystallization of olivine in the roots of the dike system. Fluorine concentrations vary from about 190 to 450 ppm, Cl from <10 to 125 ppm and S from <30 to 1100 ppm. All inclusions were rehomogenized in heating experiments and the lowest concentrations may be due to partial leakage of S and halogens. Therefore, the maximum values are considered best estimates of the true melt concentrations.

These melt inclusion data are combined with the volume of extruded magma in the province (2.2 to 2.35 million cubic km) and with published degassing efficiencies to calculate total emissions from the Paraná-Etendeka LIP of 600-1200 Gt fluorine, 200-500 Gt chlorine and 3100-5400 Gt sulfur. The estimated sulfur emissions are similar to those from the similar-sized Deccan and Siberian LIPs, both of which are related to mass extinctions, but the Paraná-Etendeka LIP produced much lower emission of halogens. This may help explain the smaller ecological impact of the Paraná-Etendeka magmatism. These results support the proposal that massive halogen emissions related to LIP volcanism may be an important factor for extinction scenarios because of global destruction of the ozone layer.