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A crystal/melt partitioning study for sulfur and halogens: pyroxenes as probes for assessing gas loads in LIP magmas

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A link between magmatism from Large Igneous Provinces (LIPs) and mass extinctions has been observed at least in five occasions in the Phanerozoic. Volatile species such as S, C and halogen compounds severely impacted the global environment, released both from melts and thermal metamorphism of volatile-rich sediments. It is still challenging to obtain quantitative estimates of the degassed volatiles for ancient magmatic systems, particularly in the absence of melt inclusions. We propose to fill the gap of knowledge on sulfur partitioning between minerals and melts, at the aim of using phenocrysts as probes of volatile contents in the melts from which they crystallized. Measuring a volatile concentration in natural minerals (chiefly clinopyroxene) and combining it with an experimentally determined partition coefficient (KD), the volatile load in basaltic equilibrium melts can be calculated. We measured a clinopyroxene/melt sulfur KD of 0.0009 ± 0.0001 for basaltic experiments performed at conditions typical of LIP basalts (FMQ-2; 800-1000 MPa; 1000°-1350°C), through ion microprobe (Nordsim). Basaltic experiments were also simultaneously analyzed for Cl and F. For these elements the measured clinopyroxene/melt KDs were more variable, 0.0071 ± 0.0052 and 0.1985 ± 0.087 , respectively. Compatibility of sulfur, chlorine and fluorine in clinopyroxene from basaltic systems is markedly different ($F > Cl > S$), in agreement with what observed by previous studies, and the partition coefficient is well constrained around 0.001 for S. Application of the newly measured sulfur KD to samples from thoroughly-dated lava piles from the Deccan Traps and from the Siberian Traps sills reveal that most of the basalts were at or near sulfide saturation (up to ca. 2000 ppm for low fO_2 melts).