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Minor and trace element partitioning between pyroxene and melt in rapidly cooled chondrules

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ABSTRACT

We present minor and trace element (REE, Sr, Y, and Zr) data for pyroxenes and mesostases in four porphyritic chondrules from the Semarkona ordinary chondrite. Apparent partition coefficients for clinoenstatite, orthoenstatite, pigeonite, and augite are compared with experimental and petrologic data from the literature, and the effects on apparent partition coefficients of the rapid cooling rates at which chondrules crystallized are evaluated. For most elements, the effects of cooling at rates of hundreds of degrees per hour cannot be distinguished from variations in equilibrium data resulting from differences in temperature or composition. However, for LREE apparent partition coefficients are significantly higher than comparable equilibrium data, and the ratio of HREE/LREE partition coefficients is lower, particularly for Ca-poor pyroxene. We attribute this flattening of REE patterns to the effect of rapid cooling. Apparent partition coefficients of all REE and Y in augite are higher than equilibrium data, particularly in one chondrule with a high Al_2O_3 content. We suggest that this may be attributed to an increase in the uptake of trivalent trace element cations in the pyroxene crystal structure as a result of charge-balanced substitutions with Al^{3+} cations.