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Intracrystalline geothermometers validated on synthetic clino and orthopyroxenes and applied to a terrestrial analogue

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Abstract

This Ongoing discussion on the application of intracrystalline "geothermometers" to Martian nakhlite samples indicates that the available calibration equations that express the lnk_D as a function of $1/T$(K) for clino- and ortho-pyroxenes (cpxs and opxs) require further validation. This can only be done using crystals grown in rock analogues synthesized under controlled temperature conditions. With these samples, it is possible to compare the closure temperature (T_C) of the intracrystalline $Fe^{2+}Mg$ ordering process for each of both phases (cpx and opx), with the quenching temperature (T_Q) of the synthesis experiments.

1. Introduction

Intracrystalline thermometry records the last thermal event experienced by a single mineral phase if the system remains closed for the entire cooling process, as expected for our synthesized samples, which are subjected to a rapid quenching.

2. Method

For this purpose, we measured by single crystal Xray diffraction the Fe^{2+}-Mg order degree, expressed as the intracrystalline distribution coefficient k_D, on three pairs of synthetic samples containing both clinopyroxene and orthopyroxene as separated crystals. Each of these synthetic samples was experimentally grown from a hydrous nepheline basanite under conditions that ranged from 1050°C at 2.0 GPa to 1170 °C at 3.0 GPa.

3. Results

Our results, obtained by applying for cpx and opx the calibration equations by [1] and that by [2], respectively, demonstrate for the first time the quite remarkable agreement between calculated closure temperatures (T_C) and actual quenching temperatures (T_Q) for synthesis products over which we have complete control. The smallest discrepancy between calculated and actual temperature is of the order of degrees (e.g.12 °C and 4 °C for clinopyroxenes and orthopyroxenes respectively), whereas the largest is of the order of tens of degrees (e.g. 22 °C and 55 °C for clinopyroxenes and orthopyroxenes respectively). These values are well within the intrinsic estimated standard deviations (e.s.d.'s) that arise from the structural refinement (e.g. about 28 °C for the sample with the highest e.s.d. on the Fe site occupancy).

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