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A new clinopyroxene thermobarometer for mafic to intermediate magmatic systems

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Temperature and pressure are key factors dictating magmatic evolution in-depth and types of volcanic eruptions. However, accurately estimating the storage temperatures and pressures of magmas is always challenging. Clinopyroxene-only thermobarometer is one of the most practical and widely used tools to unravel magma plumbing systems and pre-eruptive temperatures of magmas. Although several clinopyroxene-only thermometers and barometers have rigorously been calibrated, they display low accuracy and precision when being applied to mafic and intermediate systems at crustal depth. Hence, we present new empirical nonlinear barometric and thermometric models, which were formulated to improve the performance of clinopyroxene-only thermobarometry based on 559 experimental runs conducted with pressure ranging from 1bar to 12kbar. Particularly, a total of 559 experimental runs conducted in the pressure range of 1 bar to 12 kbar have been used for calibration and validation of the new barometric and thermometric formulation. The superiority of our new models with respect to previous ones was confirmed by comparing their performance on 100 replications of calibration and validation, and the standard error of estimate (SEE) of the new barometer and thermometer are 1.66 kbar and 36.6 ℃, respectively. Although our new barometer and thermometer fail to reproduce the entire test dataset, which has not been used for calibration and validation, they still perform well on clinopyroxenes crystallized from subalkaline basic to intermediate magmas (i.e., basaltic, basalt-andesitic, dacitic magma systems). Thus, their applicability should be limited to basaltic, basalt-andesitic and dacitic magma systems. In last step, we applied the new thermobarometer to several tholeiitic Icelandic eruptions. The estimated storage conditions are in the range of 1100–1200°C and 0–4kbar for the evolved volcanoes, while of 1244±19°C and 6.0±1.1kbar for the highly primitive ones and the established magma storage conditions exhibiting a general consistency with phase equilibria experiments. Therefore, we propose that our new thermobarometer represents a powerful tool to reveal the crystallization conditions of clinopyroxene in mafic to intermediate magmas.