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Insights into the $^{40}Ar/^{39}Ar$ Geochronology of Pyroxene from Intrusive Mafic Material

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Further insights have been obtained into clinopyroxene $^{40}Ar/^{39}Ar$ geochronology and thermochornology of intrusive mafic material through a large-scale study of dolerites of differing ages (known independently from other geochronometers). Clinopyroxene, an abundant mineral in mafic and intermediate rocks, has a closure temperature of ~700 °C (for cooling rates of 10 °C/Ma[1]). Diffusion studies of Ar in clinopyroxene indicate the ability to retain Ar more efficiently than amphiboles and plagioclase at crustal conditions[1]. Therefore, clinopyroxene $^{40}Ar/^{39}Ar$ geochronology has the potential to bridge a 1000-600 °C gap in closure temperatures for igneous cooling rate and thermochronology studies for rocks devoid of monazite. Robust plateau age spectra are difficult to obtain from material composed of orthopyroxene and clinopyroxene mixtures or two phases of clinopyroxene, resulting instead in sigmoid shape age spectra. However, during routine step-heating experiments of two-phase clinopyroxene populations, two trends can be distinguished within inverse isochron plots[2]. We interpret these trends to represent two thermally distinct domains depicting differing degassing behaviours of low-Ca and high-Ca clinopyroxene. Low-Ca clinopyroxene (pigeonite) degasses during earlier heating steps, whereas high-Ca clinopyroxene (augite) degasses during later heating steps. In contrast, single-phase pyroxenes, such as pyroxene in rapidly cooled volcanic rocks (e.g., [3], [4]), appear to exhibit simple degassing patterns and robust plateaus. The two distinct trends in the $^{36}Ar/^{40}Ar$ vs $^{39}Ar/^{40}Ar$ diagram afford the ability to obtain cooling age information and/or confirm the presence of excess Ar in the system. For each sample, the inverse isochron age calculated from the initial heating steps (directly correlated with the highest K/Ca ratios in the pyroxene mixture, interpreted to represent low-Ca clinopyroxene) are analogous to the known age of the sample. Subsequent degassing steps, when yielding horizontal or positive slopes, produce erroneous inverse isochron ages, suggestive of excess Ar in high-Ca clinopyroxene. This study shows that semi-quantitative ages can be calculated for the low-Ca clinopyroxene portion of the heating schedule when the overall results do not produce robust plateau ages.

(1)Cassata et al. (2011). *EPSL* 304, 407-416
(2)Ware and Jourdan (2018) *GCA* 230, 112-136
(3)Konrad et al. (2019) *GCubed* 20(2), 1041-1053
(4)Jiang et al. (2021) *Geology* 49(2), 206–210