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Radio-induced alteration in cordierite – Implications for petrology, gemmology and materials science

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Cordierite is a common metamorphic and magmatic mineral, which is used as petrologic tool for reconstructing the history of its host rock. Further applications include cordierite gemstones and the use of synthetic analogs in ceramics. Cordierite is stable over a wide temperature and pressure range and relatively resistant to chemical alteration; however, its properties can be significantly changed upon the impact of external irradiation.
In the course of a comprehensive study, natural radiohaloes in cordierite (a widespread feature caused by the impact of alpha-particles originating from radioactive inclusions) as well as artificial analogs produced by implantation of 8.8 MeV He^{2+} ions were investigated using modern micro-techniques. Additional irradiation experiments were performed using O^{6+} ions, electrons and gamma-rays.
Ion irradiation causes yellow colouration that is strongly pleochroic, and fades at higher doses. The possibility of radiation-treatment for enhancing the quality of gem-cordierite is discussed. While samples remain crystalline up to doses of 10^{16} He^{2+}/cm^2, the same material is fully amorphised when irradiated with the same dose of 30 MeV O^{6+} ions. These different observations may help to estimate the performance assessment of cordierite-ceramics in radiated environments.
A very important result concerning the petrological use of cordierite is the radio-induced transformation of channel constituents: Inside the irradiated areas the vibrational bands of CO_2 decrease in intensity, whereas two new bands appear at 2135 cm^{-1} (both IR- and Raman-active; cf. Nasdala et al., 2006) and 1550 cm^{-1} (only Raman-activ). They are assigned to stretching vibrations of carbon monoxide and molecular oxygen, respectively, thus indicating a radio-chemical transformation $2CO_2 \rightarrow 2CO + O_2$ in alpha-irradiated cordierite. This study yields the first spectroscopic evidence for the irradiation-induced formation of molecular oxygen in cordierite. Polarised vibrational spectra of oriented samples give evidence that not only CO_2 but also CO and O_2 are preferentially oriented parallel [100], most probably being located at the Ch¼ position in the large channel cavities. Carbon monoxide and O_2 molecules seem to coexist in artificially irradiated cordierite without any sign of back reaction. Investigations on natural CO_2-bearing cordierite from different localities show that the $2CO_2 \rightarrow 2CO + O_2$ transformation is ubiquitous in radiohaloes.
Up to date, the detection of CO in cordierite has solely been ascribed to a reducing environment during crystal formation (Khomeko & Langer, 2005). In contrast, this present study shows that CO can also be produced by radioactivity. This, as well as the production of radiogenic O_2, has to be taken into account in reconstructing palaeofluid compositions from molecules trapped in the structural channels of cordierite.

References:
Khomenko VM, Langer K (2005): Carbon oxides in cordierite channels: Determination of CO_2 isotopic species and CO by single crystal IR spectroscopy. Am Mineral 90: 1913-1917
Nasdala L, Wildner M, Wirth R, Groschopf N, Pal DC, Möller A (2006): Alpha particle haloes in chlorite and cordierite. Mineral Petrol 86: 1-27