OXIDATION DURING METASOMATISM: IMPLICATIONS FOR THE SURVIVAL OF DIAMOND.

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Introduction: Diamonds are formed at conditions of relatively low oxygen fugacity, but may be exposed to oxidising conditions during residence time in the mantle and transport to the surface, leading to their corrosion and eventually to resorption. While some studies conclude that the majority of diamond resorption takes place in the oxidising environment of the kimberlite magma, other studies suggest that some resorption occurs already in the mantle lithosphere prior to entrainment. Such questions are of obvious economic importance since they influence the evaluation of diamond deposits with regard to diamond grade. Zoned garnets from phlogopite-harzburgite xenoliths in the Wesselton kimberlite, Kimberly, South Africa have already been studied using the electron and proton microprobes, and used to infer the history of a multistage metasomatic alteration [1]. In this study we measured $Fe^{3+}/\Sigma Fe$ in the different regions of the zoned garnets, and used the results to determine oxygen fugacities.

Experimental: Mineral fragments of ultramafic xenoliths from the Wesselton kimberlite were mounted in epoxy disks that were ground to thicknesses of 300 µm. Mössbauer spectra were collected using the milliprobe method [2], where beam sizes of 400 µm were used to measure $Fe^{3+}/\Sigma Fe$ in the garnet cores, rims and secondary rims. Temperatures and pressures were determined based on the compositions of co-existing olivine and orthopyroxene, and oxygen fugacities were determined using a garnet-olivine-orthopyroxene oxybarometer [3].

Results and Discussion: $Fe^{3+}/\Sigma Fe$ of the garnets increases from core to secondary rim, which corresponds to an increase in relative oxygen fugacity of approximately one log-bar unit. Combined with reanalysis of literature data from unaltered material from the same locality [4], this implies an increase in relative oxygen fugacity of approximately two log-bar units during the course of metasomatism (Fig. 1). The increase in relative oxygen fugacity during metasomatism has some relevance to diamond preservation. Many garnet peridotites from South Africa show relatively low oxygen fugacities, and many lie within the diamond stability field (Fig. 1). Diamond would hence be preserved during the initial stages of such metasomatism, up to an increase in relative oxygen fugacity of 1-2 log-bar units. Beyond that point, however, the fluid would react with the diamonds, leading to their oxidation and resorption.

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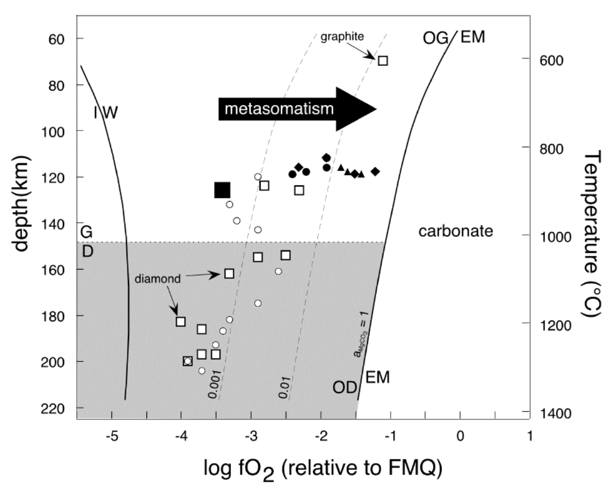

Fig. 1. Oxygen fugacity (relative to FMQ) of garnet peridotites as a function of depth. Zoned garnets from Wesselton (this study) are indicated by solid circles (cores), solid diamonds (rims) and solid triangles (secondary rims), while an unzoned Wesselton sample [4,5] is indicated by the large solid square. Oxygen fugacities calculated from [5] (open squares) and [6] (open circles) are also shown. Assemblages containing graphite and diamond are indicated by arrows. The graphite-diamond transition [7] and the EMOG/EMOD reactions [8] define the maximum stability region of diamond (shaded grey), where dashed lines indicate iso-activity curves for carbonate. The iron-wüstite buffer is indicated for reference, and temperatures are given according to the 43 mW/m^2 model conductive geotherm [9].