Multi-stage hydrothermal alteration of accessory minerals from an alkali pegmatite from Zomba-Malosa (Malawi)

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The alkali pegmatites from the Chilwa Alkaline Province (CAP) of Malawi have experienced at least two events of fluid interactions, as texturally evidenced by the occurrence of two distinct alteration zones in pyrochlore. The oldest alteration zones (Stage I) are characterised by the occurrence of numerous pores and lower U concentrations than unaltered, pristine areas. These zones are often cross-cut by irregular, ramified or finger-like zones (Stage II), which are composed of concentric rings of different backscattered electron (BSE) intensity and are chemically characterised by lower Ca and Na concentrations than the Stage I and pristine zones. Pyrochlore is closely associated with zircon. The zircon crystals are also severely altered. The alteration zones are characterised by microporosity and numerous, < 10 μm large thorite inclusions as well as by lower Th concentrations than the pristine zircon. Some thorite inclusions are also altered as revealed by a lowered BSE intensity and high concentrations of Ca, Al, and Fe in some thorite areas.

Laser ablation inductively-coupled plasma mass spectrometric (LA-ICPMS) analyses of altered and unaltered zircon as well as unaltered pyrochlore and its Stage I alteration zones yielded statistically indistinguishable U-Pb ages of c. 118 Ma, which suggests that the Stage I alteration zones in pyrochlore and the porous zircon alteration zones formed during a single event soon after the crystallisation of both minerals from the pegmatite magma. Th-(U)-total Pb dating of the unaltered thorite by electron microprobe yielded a well-defined age of 122 ± 5 (2σ) Ma, whereas the data of the altered areas suggest a Pb-loss event at < c. 9 Ma. This suggests that the thorite inclusions are formed during the alteration of zircon as part of a replacement process and that they were later altered by probably low-temperature fluids once they have become severely self-irradiation-damaged. It is likely that the Stage II alteration zones in pyrochlore were also formed during this recent fluid event.

Rapid uplift of the Jwangeng kimberlite, South Botswana: Caused by mantle metasomatism and documented by OH-diffusion profiles in garnet from eclogitic xenoliths (UNESCO IGCP 557)

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The mechanism of kimberlite eruption plays a significant role in diamond exploration, thus this study is a good example how the society benefits from science. One major physical aspect in understanding the eruption dynamics of kimberlites is the ascent rate of the kimberlitic melt. Water is commonly dissolved in nominally water free minerals (NAMS) as OH by mantle metasomatism. Due to eruption of the kimberlite, water partitions prefentially into the kimberlitic melt, because due to the higher solubility of water in the melt compared to NAMS. The decrease of OH content in NAMS can thus be used, to quantify the ascent rates of the kimberlite. We present for the first time high resolution FT-IR based synchrotron measurements of OH in eclogitic garnets from the Jwangeng Diamond Mine in south Botswana. We measured hydrogen profiles from core to the rim and towards totally embedded microcracks in eclogitic garnet crystals. The measurements in the studied garnets shows a strong variation in OH concentration and demonstrate that the amount of water stored in diamond bearing layers has been underestimated for a long time due to the loss of water during the uplift of the kimberlite. We used experimental diffusion data for hydrogen and the calculated average ascent rate ranges between 3.2 and 6.7 m/s. By using the calculated ascent rates and the results from the geothermobarometry, the studied xenoliths reached the surface within a few days.