Deficient electron microprobe totals: Discussion of potential causes

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Radiation-damaged minerals, including zircon, coffinite, thorite and monazite, are occasionally found to yield electron microprobe results whose totals (oxide sums) are deficient, i.e. appreciably below 100 wt%. Causes of the apparently too low totals are controversial; most authors have assigned the phenomenon to enhanced contents of hydrous species, other non-analyzed elements, textural peculiarities such as voids, or instability and degradation under the electron beam. It has also been observed that micro-areas yielding low totals are typically recognized from very low BSE intensities (Kempe *et al.*, 2000), which is in apparent contradiction to their usually high degree of radiation damage and the positive correlation between radiation damage and BSE intensiy (Nasdala *et al.*, 2006).

We have studied low-totals zircon from three localities. Deficient totals and accompanying very low BSE intensities are only detected in areas affected by secondary alteration whereas primary zircon never shows these phenomena. The alteration has often, but not always, led to enhanced actinide content, which is why low-totals areas are mostly radiation-damaged. Low-totals areas were found to contain up to 5 wt% hydrous species, which explains both the deficient analysis sums and the low BSE intensity (due to decrease of the average atomic number). In the TEM, low-totals areas show a sponge-like texture with numerous sub-micron sized voids, as it was suggested by Pointer *et al.* (1988). We explain the formation of this texture and the water uptake by secondary, fluid-driven alteration of previously radiation-damaged and thus volume-expanded zircon.

References

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The first record of allochthonous kimberlite within the Batain Nappes, Eastern Oman

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Kimberlites, carbonatites, alkaline and ultramafic lamprophyres and other alkalic ultrabasic rocks have been recently discovered within the Batain Nappes in the eastern Oman Mountains. The kimberlite area comprises several allochthonous bodies. Most of these are carbonatite and carbonate kimberlite which contains mantle derived (altered peridotitic) xenoliths and xenocrysts. The kimberlite occurs either as breccia pipes and/or as long dykes ~ 6 km long. The kimberlites contain abundaunt macrocrysts of mica (phlogopite and/or biotite), chromite, chrome diopside, pelletal lapilli and autolithic fragments in a calcite + serpentine matrix. The kimberlites are dominantly composed of 'hapabyssal and diatreme facies' volcaniclastic rocks. These include pyroclastic lapilli-, carbonate-dominated tuffs, and volcaniclastic kimberlite, all of which intruding late Jurassic to Lower Cretaceous marine sedimentary rocks (cherts and shales) of the Wahra Formation, within the Allochthonous Batain Mel'ange. Major and trace elements and isotopic composition indicate that the Omani kimberlites in this study form a compositionally cohesive group of rocks more akin geochemically to the Koidu type kimberlites of West Africa than the Group I kimberlites from South Africa. The kimberlite contained zircon, G9 garnet and chromite grains with typical kimberlitic morphologies and chemical properties similar to diamond inclusion chromite. However, there were no micro-diamonds observed.

Fifteen pinkish ('kimberlitic') zircon grains, 0.5 to 1.5 mm in size, were picked from the kimberlite tuff and were analyzed at GEMOC. Trace-element patterns are typical of kimberlitic to carbonatitic zircons. Their mean age of 137.5 ± 1 Ma (95 % confidence,MSWD = 0.49) is consistent with intrusion into Lower Cretaceous rocks . Their $^{176}Hf/^{177}Hf$ (0.28286±1, ε_{Hf} = 6.2) is typical of kimberlitic zircons of this age, and may represent the subcontinental lithospheric mantle.