

Controls on the magnitude of Ce anomalies in zircons and implications for T-X- fO_2 evolution of magmatic systems

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Increases in the magnitude of positive Ce anomalies in zircons from igneous rocks are often interpreted to be controlled by progressive melt oxidation and have been used to provide evidence for the elevated redox state of magmas associated with magmatic-hydrothermal ore deposits. In this study, we test this idea by comparing trace element compositions of zircons from the Resolution porphyry Cu-Mo deposit, Arizona, with numerical models of melt Ce systematics and zircon-melt trace element partitioning. We show that although Ce anomalies in Resolution zircons (estimated by the chondrite-normalised ratio of Ce and Nd) may increase by over an order of magnitude throughout the period of zircon crystallisation, oxybarometric estimates in fact indicate a constant melt redox during this time. We employ a Monte Carlo approach to model the evolution of the Ce anomaly in zircon as a function of temperature, fO_2 , and melt composition, and compare our model against literature zircon data from chemically well-constrained volcanic rocks. We find that large increases in the magnitude of the Ce anomaly can be reproduced by cooling at fixed oxidation state and that this effect is magnified by increasing the melt Ce/Nd ratio, which can be driven by the co-crystallisation of amphibole, apatite and especially titanite. Increases in melt oxidation state are not sufficient to explain high positive Ce anomalies in zircons from some hydrous, oxidised volcanic and hypabyssal rocks, which additionally require a combination of titanite co-crystallisation and low crystallisation temperature. We therefore caution against the interpretation of zircon Ce anomalies solely in the context of melt fO_2 variation.