## 5.4.45

# Does zircon trace element chemistry monitor magmatic-to-hydrothermal crystallization history?

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The Sn-W mineralized Mole Granite in Eastern Australia crystallized at 247.7 ±0.5 Ma (zircon U/Pb age). Zircon populations crystallized throughout the magmatic to hydrothermal evolution of this intrusion. These populations possess highly variable trace element signatures. In magmatic zircon, a conspicuous depletion in trace element contents, e.g., the REE, is documented with progressive crystallization of the magma. This evolution reflects progressive saturation of REE accepting minerals such as monazite, thorite and xenotime. Zircon that precipitated from an exsolved magmatic volatile phase in Sn-W-bearing ore quartz veins shows chondrite-normalized REE patterns almost identical to those of late magmatic zircon. Therefore, element distribution coefficients between zircon and the granitic melt or the magmatic-hydrothermal fluid that separated from it are closely comparable to each other. Lead and Cs are strongly incompatible in hydrothermal zircon, with measured zircon-fluid distribution coefficients of $\leq 0.001$, Li and Sn are moderately incompatible in zircon (D ~ 0.1-0.6) and Ce is strongly compatible (D ~14). Hydrothermal zircon has higher Ta/Nb and U/Th ratios than the magmatic populations.

The second example of hydrothermal zircon crystallized at 243.8 +0.5 Ma (monazite U/Pb age), some 3 Myrs after the solidification of the host granite. These crystals reveal increasing trace element concentrations from core to rim, opposite to trends observed for the older generation of hydrothermal zircon. The protracted evolution of this intrusion thus tapped different fluid sources. Comparison with literature data confirms that the diversity of trace element characteristics of genetically similar zircon populations from different localities may exceed that observed between genetically different types of zircon from one locality. This is exceptionally well illustrated here for zircon precipitated from hydrothermal fluids. Therefore, trace element abundances and chondrite-normalized REE patterns, by themselves, are not indicative of the geological environment in which zircon crystallized. Nevertheless, variations in zircon trace element contents that relate to the chemistry of the melt or fluid from which it crystallized are promising for future petrogenetic modelling notably because zircon is often a liquidus phase and can crystallize throughout the magmatic to hydrothermal evolution of an intrusion.

## 5.4.46

# Mount Etna: Dynamics of magma degassing and ascent towards the shallow levels of the feeding system

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Since 1996, peripheral gas emissions of Mt Etna volcano have been sampled and analyzed for chemical composition and helium isotopic ratios, with the aim of investigating fluid origin. Helium isotopes showed values in the range of 6.5±1Ra at all sampled sites [1], matching those previously measured in the fluid inclusions of primitive olivine phenocrysts of the Etnean historical lavas[3]. Similar findings have been seen in gases trapped in the olivine phenocrysts of lavas of the last two eruptions (2001 and 2002-2003). In view of that, such results highlight the magmatic origin of the released gases from the local sub-continental mantle. The chemical composition of the sampled gases showed selective dissolution in shallow hot aquifers according to gas solubility. In fact, they showed a $CO_2$-dominated mixture with variable percentage of $CH_4$ except at Fondachello where gases were methane-dominated. Such a process has been recognized and modelled [2], allowing determination of the pristine composition of the magmatic gas mixtures. Therefore, in accordance with magma degassing processes, the variation of restored He/Ne and He/$CO_2$ chemical ratios have been interpreted by using the numerical model of Nuccio & Paonita [5] to estimate initial and final magma pressures within the feeding system. The results, in agreement with geophysical investigations [4], defined two levels of magma storage in the Etnean feeding system, at pressures in the order of 360 and 160 MPa respectively, which correspond to depths of about 10 and 3 km below sea level. Significant pulses, related to the ascending magma in the plumbing system, were detected at Mt Etna just before the onset of the 17 July 2001 eruption and some months before the eruption 2002-2003, suggesting injection of deep volatile-rich magma in the shallow reservoir. This geochemical approach can be applied to all volcanic systems, and gives a new tool to better understand dynamics.

**References**
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