Zircon growth and recycling during the assembly of the Tuolumne Batholith, Sierra Nevada, California

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The Cretaceous Tuolumne Batholith represents a classic example of a large (~1200 km^2), compositionally zoned pluton and provides a natural laboratory for the study of magmatic processes. Eruptions of large volumes of felsic magma demonstrate that large magma bodies exist in Earth's crust, but the geochemical and geophysical path that links these large magma volumes to the frozen remnants of magma input (plutons) is still obscure. Deciphering the intrusive record of magma systems is essential to understanding the relationship between surface volcanism and the long-term storage and evolution of magma reservoirs. U-Pb zircon TIMS analyses from several locations in the batholith exhibit appreciable dispersion of single crystal or crystal fragment ages (several 10^5 yrs to $1x10^6$ yrs) and, in addition, display distinctly older ages that likely represent zircon crystals entrained from older parts of the Tuolumne magmatic system. Since techniques aimed at eliminating Pb loss (and thus age scatter) have been employed prior to analysis, we interpret the age dispersion to reflect real variation in the timing of zircon crystallization. Two samples that show a high degree of age dispersion (> 1 Myr) were selected for trace element analysis and Ti-in zircon geothermometry by SHRIMP-RG. Crystallization temperatures ranged from 780-640°C and averaged 695°C (a_{TiO2} ~ 0.75 based on presence of titanite). No clear correlation exists between crystal age and temperature. In most cases, the temperatures from crystal centers were within uncertainty of the temperatures at the rims or show a slight core to rim decrease in temperature. Trace element ratios vary systematically with temperature (e.g. decreasing Th/U ratio with decreasing T) and are attributed to fractionation, although neither sample represents strongly fractionated melt. Low total Zr indicates that the magmas were initially undersaturated in zircon when emplaced, which is also consistent with late zircon crystallization. Entrainment of zircon from older parts of the magmatic system occurred late in the history of the batholith, and recycling of zircon crystals during successive magmatic injections is compatible with progressive growth of a large, long-lived, crystal mush body. Similar studies, applied to magmatic systems where both the plutonic sources as well as the volcanic products can be studied, are expected to shed further light on linking the former with the latter.

On the primitivity of the Wild 2 cometary dust

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We were impressed by the analytical results obtained by 183 scientists on a 0.2 µg of dust from the Wild 2 comet (W2-dust) returned by Stardust [1]. What is less impressive is the way the data are interpreted and sold as a "big surprise".

We already argued that the unmelted chondritic dust recovered from the stratosphere and polar ices and snows (micrometeorites or MMs) that we and many other analyzed are cometary dust particles. In 1998, we thus pointed out that cometary dust particles would be similar to MMs, being made of a material related to the CM-type hydrous-carbonaceous chondrites containing refractory phases, kerogen, and being depleted in chondrules [2]. This "ordinary" dust was formed in the inner solar system and then forwarded to the outer solar system by huge surges of nebular gas [3].

The W2-dust analyses confirm these earlier deductions because they establish strong similarities with MMs for: (i) the abundance of Ca-Al-rich inclusions and pre-solar grains: (ii) the H, C, N, and O isotopic compositions; (iii) the chemical composition of the refractory magnesian silicates and of Fe sulfides. These similarities imply that hydrous silicates must also be present in the W2-dust, and that they should be dominated by saponites, which are the major hydrous silicates of unmelted MMs. However, the Stardust team repeatedly emphasized that "hydrous silicates are missing" in the W2-dust. The fate of these missing silicates, which is not discussed, is just pictured in the bulb-shaped aerogel track reported on the cover page of Science [1]. It documents the microscopic explosion of a dust particle containing saponite during its µs deceleration in the aerogel. Only the most massive and refractory particles can be found at the termini of the tracks.

Indeed, saponite contains both OH groups and very labile H_2O, which starts to be released at about 100°C. Consequently, it should be "instantaneously" released during the pulse heating of the particles and form an explosion bulb in the aerogel – with the result that saponite is now missing. In contrast, "dry" crystalline particles produced "carrot"-shaped tracks.

References

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