A 3D snapshot from granitic system: Tourmaline nodules and their bearing on the granite evolution

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Peraluminous granites generated during the Late Cretaceous evolution of the LP-HT zone in the Adria-Europe plate boundary setting host tourmaline nodules. These tourmaline-bearing bodies from the Moslavačka Gora (MG), Croatia show great similarity with leucogranitic veins and can be described as compact spherical to ovoid aggregates (cm to dm in diameter) with a fine-grained (grain size 1-2 mm) core (slightly alkali-deficient dravite to schorl tourmaline (#Fe 0.40-0.66) + quartz + albite + K-feldspar ± muscovite) enveloped by a leucocratic halo (quartz + K-feldspar + oligoclase An_{11-21} ± muscovite). When observed in 2D sections solely, the isolated nature of tourmaline nodules can be easily mistaken with similar 2D cross-section of a leucogranitic vein. For that reason tourmaline nodules' spatial distribution inside the host, shape and internal structure of individual bodies have been reconstructed and visualized through destructive serial sectioning tomography with physical resolution of 3.5 mm (serial cutting) or 0.35 mm (serial lapping) between individual planes. Obtained 3D reconstructions of rock volumes containing tourmaline nodules showed that they are indeed isolated spherical bodies dispersed inside the granitic host and not vein formations. The two structural units of a nodule, core and halo, are clearly distinguishable in 3D and show sharp contacts to each other but also to the granitic host.

The morphology, peculiar texture, distribution and origin of tourmaline nodules inside granite can be most suitably explained through the emplacement mechanism and crystallization setting of the host granite at upper crustal level (at MG locality calculated approx. depth of 5-6 km, T=720 °C). During emplacement, decompression and arising immiscibility leads to melt unmixing and production of two different melt phases: "normal" granitic and B-rich one. Prominent depolymerization of B-rich melt, followed by density and viscosity decrease together with lowering of liquidus and solidus temperatures, leads to physical separation of a buoyant B- and fluid-rich phase in form of distinct B-rich bubbles or pockets, which coalesce in order to decrease surface tension. Such isolated volumes now contain necessary concentration of boron and other elements needed for tourmaline growth and become precursors for the future solidified tourmaline nodules.

Noble gases and halogens in the MORB-source mantle: Recycled?

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Powerful information from the extinct ^{129}I and ^{244}Pu systems is derived from the distribution of the daughter ^{129}Xe and ^{136}Xe between terrestrial reservoirs. Because of its simplicity, the conclusion that the Earth was open to Xe loss until ~80Ma after the Earth accreted, for example, is unequivocal. The $^{129}Xe/^{130}Xe$ ratio in the atmosphere, mantle and any primordial volatile rich mantle reservoir will then be determined by the ^{129}I (and ^{244}Pu)/Xe ratio in that reservoir and any subsequent interactions between reservoirs. The Earth's atmosphere, for example, has a lower $^{129}Xe/^{130}Xe$ than the convecting mantle. While there has been an exceptional concentration of the halogens at the Earth's surface compared to other incompatible elements (>90% BSE) [1], this is balanced by the atmosphere's high relative Xe concentration.

In the simplest (reference) model we can make the key assumption that the closure of the respective mantle reservoirs is the same as the atmosphere closure time of 80Ma. In the case where 80% of the convecting mantle Xe is recycled air [2], we calculate the iodine concentration, required to provide the convecting mantle ^{129}Xe excess caused by ^{129}I decay to be $[I]_{model}$ ~0.14ppb I. We then predict one of three cases when comparing $[I]_{observed}$ with $[I]_{model}$: 1) They will be in close agreement, in which case we can consider the convecting mantle to be closed with respect to the I/Xe system; 2) $[I]_{observed}$ will be lower than $[I]_{model}$, which then requires either an earlier closure age of the reservoir or significant net loss of I from the system after ^{129}I has ceased to be active; or 3) $[I]_{observed}$ will be greater than $[I]_{model}$ due to a net excess of dead iodine being added to the system. Current convecting mantle I concentration estimates, based on MORB, range from <0.7 ppb to orders of magnitude higher [3] and point towards the latter, consistent with recent observation of noble gas and halogen subduction to at least 100km depth [4]. Iodine determination of the MORB (and OIB) source remains a critical objective for future work.

[1] Burgess *et al*., (2002) *EPSL* **197**, 193-203. [2] Holland & Ballentine (2006) *Nature* **441**, 186-191. [3] Aiuppa *et al*., (2009) *Chemical Geology* **263,** 1-18. [4] Sumino *et al*. (2010) *EPSL* **294**, 163-172