Mixture of phases "phlogopite-talc" in the emerald deposit of Santa Terezinha de Goiás, Brazil.

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Introduction – General Geology

The emerald deposits in Brazil represent a particular type of mineralization hosted mainly Proterozoic volcano-sedimentary sequences. The K-Ar and Ar/Ar geochronology of emerald mineralization from Santa Teresinha of Goias resulted in very disturbed spectra with significant variations in age values. This work deals with the different factors that may have caused the observed perturbations.

The emerald deposit of Santa Teresinha is the result of two processes (Giuliani et al., 1990): the first is the regional metamorphism responsible for the formation of carbonated talc-schists; the second is the infiltration of hydrothermal fluids that originated the phlogopite-schists hosting the emeralds (650-600 Ma, Brasiliano Orogeny).

Characterization of the phlogopite-talc mixture

The petrographic and X-ray diffraction examination of samples of phlogopite-talc-schists showed a great heterogeneity in the distribution of the association phlogopite + talc (+ chlorite). This heterogeneity was also observed in ^{40}Ar/^{39}Ar analysis: the age spectra of the three grains of phlogopite presented very different results.

Two single grains Sta11g provided upward-convex spectra with ages ranging from 530-635Ma (Sta11g-a) and 530-545Ma (Sta11g-b) while Sta11a provided a plateau age of 520 + 2Ma with 97% of ^{39}Ar released.

Excess argon in the talc

The presence of talc could explain the observed perturbations in the age spectra. As theoretically potassium is not part of talc composition, it is believed that the residual ^{40}Ar found in talc is a consequence of diffusion from neighboring minerals during a Proterozoic thermal event.

^{40}Ar degasing in talc was studied in a quadrupole spectrometer by continuous heating and temperature steps: maximum degasing occurs close to 1000°C (with H_2O and CO_2).

To evaluate the effects of the mixing on the K-Ar age, a mixing-model from degasing curves with the integrated K-Ar age was established. In this way it was possible to determine the age range based on the mixture (Ribeiro-Althoff, 1997).

Conclusion

The irregular shape of the age spectra obtained for the phlogopite could be explained by the mixing of varying proportions of two ^{40}Ar components: a radiogenic component (phlogopite) and an inherited component (talc), with different degasing curves. The apparent-age difference between the single grains indicates that the excess Ar varies from one grain to another.

[1] Giuliani et al. (1990) *Miner. Depos.*, **25**, 57-64.
[2] Ribeiro-Althoff (1997) *Thesis INPL/CNRS*, 214 pp.

The origin of mineralising brines in unconformity-related U deposits: Insights from noble gases and halogens in fluid inclusions

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In the Proterozoic Athabasca Basin (Canada) unconformity-related UO_2-ores are associated with U-rich fluid inclusions (FIs) that are either NaCl-rich or $CaCl_2$-rich, and are hosted by quartz and dolomite [1, 2]. In order to constrain the origin of these brines we analysed the naturally occurring isotopes of Ar, Kr and Xe, together with halogens (Cl, Br and I), K, Ca and U in samples containing representative FIs. This was achieved by in vacuo crushing of irradiated samples using extended ^{40}Ar-^{39}Ar methodology [3].

The FIs have molar Br/Cl ratios from 7×10^{-3} to 13×10^{-3}, and I/Cl ratios from 2×10^{-6} to 12×10^{-6}. These compositions are consistent with the fluids deriving the bulk of their salinity by sub-aerial evaporation of seawater, beyond the point of halite saturation. The low I/Cl ratios do not favour fluid interaction with organic matter, or hydrocarbons, as a reductant for localizing U mineralisation.

One sample collected adjacent to high-grade U ore (~40 wt % U) has a less than atmospheric ^{40}Ar/^{36}Ar ratio of 180-220. This is ascribed to nucleogenic production of ^{36}Ar from ^{35}Cl in the FIs, due to an exceptionally high neutron fluence in the immediate (<1m) vicinity of the high-grade ores.

The majority of samples contain FIs with age-corrected ^{40}Ar/^{36}Ar of between the modern atmospheric value of ~300 and 450. These values are considered representative of the fluids initial composition and are typical of upper crustal sedimentary formation waters. The ^{40}Ar/^{36}Ar ratio is correlated with Cl/^{36}Ar in several of the samples and defines ^{40}Ar$_E$/Cl values of between 6×10^{-5} and 10^{-7}. Combined with the salinities (25-35 wt.% salts), the ^{40}Ar$_E$/Cl values, indicate fluid ^{40}Ar$_E$ concentrations of 7×10^{-10} to 200×10^{-10} mol.g^{-1} (^{40}Ar$_E$ denotes crustally-derived excess ^{40}Ar).

The FIs non-radiogenic ^{84}Kr/^{36}Ar and ^{129}Xe/^{36}Ar ratios are intermediate of air and air-saturated brines. The fluids have elevated ^{36}Ar concentrations of up to twenty times air-saturated seawater. The data are interpreted to reflect preferential acquisition of ^{36}Ar>^{84}Kr>^{129}Xe from sedimentary rocks. The lack of a strong enrichment in radiogenic ^{40}Ar and preservation of low ^{40}Ar/^{36}Ar ratios, suggests interaction of the brines with basement rocks occurred at high water-rock ratios or low temperatures (<200 °C).

[1] Richard (2010) *Terra Nova* **22**, 303-308.
[2] Richard (2011) *Geochim. Cosmochim Ac.* **75**, 2792-2810.
[3] Kendrick (2012) *Chem. Geol*. **292-293**, 116-126.