

## The role of chlorite interlayering on $^{40}\text{Ar}$ - $^{39}\text{Ar}$ biotite dating: an $^{40}\text{Ar}$ - $^{39}\text{Ar}$ laserprobe and TEM investigation of variably chloritised biotites

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Biotite is one of the most common minerals dated by the  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  method. It frequently shows K contents below the stoichiometric value, suggesting the presence of low-K impurities. The most common low-K alteration product of biotite is chlorite. This study examines the outcome of the  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  dating method on variably chloritised biotites from intrusive rocks emplaced ~490Ma ago. The infrared (IR) laserprobe technique and different extraction methods were adopted. Incremental laser-heating data on bulk samples yielded hump-shaped age profiles with meaningless young and old age-steps. Both the extent toward anomalous old age-steps and the degree of discordance of the age spectra were much more pronounced in the more chloritised biotite. In contrast, in-situ data on rock chips and total-fusion ages on single biotite grains yielded ages concordant with, or younger than, the inferred emplacement ages. TEM was used to texturally characterise biotite samples at the nanometer scale. It was also used to document the decomposition-transformation process of interlayered biotite-chlorite during in-vacuo IR-laser heating to temperatures ranging from ~600°C to >1000°C. The dramatic transformations imaged for biotite heated above ~600°C prove that the rate of argon release from biotite heated in-vacuo is not simply controlled by a volume diffusion process, thus confirming the conclusions of previous works. TEM results suggest that the development of hump-shaped age profiles results from an interplay between  $^{39}\text{Ar}_{(K)}$  redistribution by recoil during sample irradiation and differential release of argon isotopes hosted in three main reservoirs. These reservoirs are (from least to most retentive): extended defects, chlorite and biotite. The final descending segment is attributed to release of argon with increasing temperature from progressively larger biotite domains for which  $^{39}\text{Ar}_{(K)}$  recoil loss was less important.  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  data support previous findings which suggest that K-Ar ages provide minimum estimates that approach the true biotite age as pristine domains are analysed. The most effective approach for obtaining meaningful  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  ages was individual total-fusion of carefully selected, single flakes previously leafed along the basal cleavage by wet-grinding.

## P-V-T-X properties of two H<sub>2</sub>O-CO<sub>2</sub>-NaCl mixtures up to 850 °C and 500 MPa: synthetic fluid inclusion study

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CO<sub>2</sub>-H<sub>2</sub>O-NaCl solutions are important in many hydrothermal, metamorphic and magmatic processes. Accurate description of the phase state and molar volumes (V) of these fluids is therefore required as a function of pressure (P), temperature (T) and composition (X). Previous experimental studies in this system are in part contradictory, and the contradictions imply alternative interpretations of the geochemical processes in which the fluids are involved. In order to resolve these inconsistencies, the present study uses the synthetic fluid inclusion technique to investigate two ternary mixtures, one with 9.69 mol % CO<sub>2</sub> + 1.74 mol % NaCl and the other with 21.01 mol % CO<sub>2</sub> + 1.52 mol % NaCl (corresponding to a fixed concentration of 6 wt.% NaCl relative to the H<sub>2</sub>O-NaCl binary subsystem). These mixtures were previously investigated, among others, by Gehrig (1980), using a large optical cell, and by Frantz et al. (1992), using synthetic fluid inclusions.

Our main results are: (1) the P-T locus of the bubble curve determined by Gehrig (1980) for the 9.69 mol.% CO<sub>2</sub> isopleth is confirmed, but it appears that the dew-point transitions of Gehrig are inaccurate. Our new dew curves follow a smooth progression in pressure with increasing CO<sub>2</sub> content, as expected from consideration of molecular interactions (Diamond, 1996); (2) Because of these differences, our new molar volumes also deviate from those of Gehrig (1980); (3) In contrast to the results of Frantz et al. (1992), we found no high-temperature field of fluid immiscibility at high pressures. We have identified the probable sources of the systematic errors in the studies of Gehrig (1980) and Frantz et al. (1992).

The investigated isopleth with 9.69 mol % CO<sub>2</sub> corresponds closely to the fluid that forms most orogenic-type gold-lode deposits (Ridley and Diamond, 2000). The absence of immiscibility at high temperatures and pressures therefore releases an important constraint on the possible fluid production mechanisms deep in the crust.

### References

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