An improved iterative technique to determine the volume and composition of NaCl-H_2O-CO_2 fluid inclusion

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Parry (1986) established an iterative technique to determine the molar volume and composition (V_m-X) of NaCl-CO_2-H_2O (NHC) fluid inclusions. Using this technique, the determination of the V_m-X is only needed to measure CO_2 liquid-vapor homogenization temperature ($T_{h,CO2}$), salinity and total homogenization temperature (T_h). However, the technique is cumbersome to use and inaccurate to calculate the CO_2 mole fractions (X_{CO2}). The inaccuracy may attribute to ignoring the content of CO_2 dissolved in salt aqueous solutions when constructing the mathematic expression of X_{CO2} at 40°C.

In this study, an improved iterative technique is proposed. There are four formulations from f_1, f_2, f_3 to f_4 to carry out the iterative calculation. The former three are the mathematic expressions of V_m, X_{CO2} and *NaCl*, respectively. They are related to $T_{h,CO2}$, salinity where the content of CO_2 dissolved in salt aqueous solutions is included. In addition, parameter F is introduced into these formulations which represents CO_2 phase volume fractions when CO_2 liquid-vapor is homogenized. Formulation f_4 denotes equation of state or phase diagrams related toT_h of the NHC system. Given an NHC inclusion with known $T_{h,CO2}$, salinity and T_h, the iterative calculation can be carried out. Initially, freely input one F value to f_1 to obtain the molar volume V_{m1}. Then, the F value is inputted to f_2 and f_3 to obtain X_{CO2} and X_{NaCl}. Finally, through the X_{CO2} and X_{NaCl} values, the other molar volume value V_{m2} is determined by f_4. If V_{m1} is unequal to V_{m2}, the F value should be changed and the calculating process should be repeated. Only when V_{m1} is equal to V_{m2}, the iterative calculation is ended and the V_{m1} (V_{m2}), X_{CO2} and X_{NaCl} of the NHC inclusion are determined.

Compared to Parry's technique (1986), the improved iterative technique is more convenient to use, and more accurate for X_{CO2}, which is verified by experimental and theoretical calculation.

References

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Gas geochemistry of ore-forming solution in the Xiazhuang U-ore-field, North Guangdong, China

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The Xiazhuang uranium ore-field is located in the north of Guangdong province, south China and contains one of the largest granite-type uranium deposits in the country. In the field, the only primary uranium mineral found is pitchblende associated with minerals as quartz, fluorite, hematite, pyrite and calcite. The age of uranium mineralizations in the area is predominately from 86 Ma to 59 Ma, and the age of host rocks (granites) mainly ranges from 194 Ma to 134 Ma.

Studies of mineral gas-liquid inclusions indicated that the uranium concentration of the ore-forming solution in the field varied from 0.7 g/L to 4.0 X 10^{-6} g/L, and that uranium migrated in form of $UO_2(CO_3)_2^{2-}$ and $UO_2CO_3^0$ in the HCO_3 - Ca and HCO_3·F - Ca type solution for the pre-metallogenic epoch, and in form of $UO_2\ F_3^-$ and $UO_2F_4^{2-}$ in the SO_4·F - Ca·K·Na, HCO_3 - Ca·Na and F - Ca types solution for the metallogenic epoch respectively.

The gas chemistry of inclusions revealed that the predominate gas component is CO_2 and the other important gases are CH_4 and H_2 of the solution. The gas concentrations of inclusions in quartz associated with pitchblende are reported in g/L in the Table below.

Sample No.	H_2	CH_4	CO_2
XZ1-2	0.836	0.022	37.300
XZ-6	0.117	0.193	32.600
XW-014	1.195	3.922	8.008
ZSX-010	1.005	2.758	8.085
ZSX-020	0.565	1.075	27.078

Uranium mineralizatiions resulted from rapid change of physicochemical conditions. As the solution flowed upward into the discharge areas of the ore-forming hydrothermal system, the confining pressure for the solution declined so greatly that boiling took place, and large amounts of carbon dioxide escaped from the solution. As a result, $UO_2(CO_3)_n^{2(1-n)}$ and $UO_2F_n^{n-2}$, stable in CO_2 -rich solutions, could be decomposed into UO_2^{2+}, then easily reduced into pitchblende.

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