

# Two different types of hydrothermal fluids related with talc mineralization in Poongjeon deposits; microthermometric and stable isotopic characteristics

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## 1. Introduction

Microthermometric and stable isotope studies of fluid inclusions were conducted about the Poongjeon talc deposits that are embedded in dolomitic marble near the contact of the Cretaceous Muamsa Granite of the Ogcheon Metamorphic Belt. Talc was produced as an alteration product of tremolite during the retrograde stage of contact metamorphism related to the igneous intrusion. Spatially separated two quartz vein groups, vein I from the marble or the marble-amphibolite contact and vein II from amphibolite-metapelite contact, were investigated to reveal the fluid composition and its evolutionary history during the mineralization process.

## 2. Analytical Methods

Microthermometric determinations on fluid inclusions were carried out on vein quartz samples included in talc ore bodies. The measurements were focused on primary and pseudosecondary inclusions using a U.S.G.S.-type gas flow heating-freezing stage at Seoul National University.

Twenty samples of vein quartz (13 for vein I and 7 for vein II) were selected for oxygen isotope compositions of vein quartz, hydrogen isotope compositions of inclusion water, and carbon isotope compositions of CO<sub>2</sub> gas extracted from the fluid inclusions. For oxygen isotope analysis vein quartz samples were treated with HCl to dissolve carbonate fractions and were processed by the method of Clayton and Mayeda (1963) to produce CO<sub>2</sub> gas. Hydrogen isotope analyses were conducted for both the primary and secondary stage fluids. To this purpose, a detailed petrographic study was carried out to

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select the appropriate samples that would minimize the percentage of other stage inclusions. However, any samples adequate for secondary stage fluids in vein II were not found. Oxygen isotope analysis was conducted using the Finnigan MAT 252 with dual-inlet mass spectrometer at Indiana University with analytical precision of better than  $\pm 0.1\%$ . Carbon and hydrogen isotope compositions were measured on a VG Isotech PRISM II spectrometer at the Korea Basic Science Institute. The analytical precision of both  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  measurements is within  $\pm 0.1\%$  and better than  $\pm 1.0\%$  for D/H analysis.

### 3. Discussion

Vein I is generally found in the marble and is represented by talc mineralization in the deposits. Repeated boiling of carbonaceous fluids produced abundant  $\text{XCO}_2$  fluids (type IIB1) and low amounts of  $\text{XCO}_2$  or aqueous fluids (type IIA, III). Halite±sylvite-bearing type IV inclusions of the primary and secondary stage are common and occasionally mixing took place between highly saline aqueous fluids and carbonaceous fluids.

The fluid mixing model can be applied to the coexistence of abundant  $\text{CH}_4\pm\text{H}_2\text{O}$  (type I),  $\text{H}_2\text{O}-\text{CO}_2-\text{CH}_4$  fluids with variable  $\text{CH}_4/\text{CO}_2$  ratios (type IIB2,  $\text{XCH}_4 > 0.1$ ), and minor type IIB1 inclusions in vein II (Fig. 1), which occurs typically at points of amphibolite-metapelite contact and is less important than vein I as far as talc mineralization is concerned. The  $\text{CH}_4$ -rich inclusions seem to be derived from the reheating of C-bearing metapelite rocks during contact metamorphism.

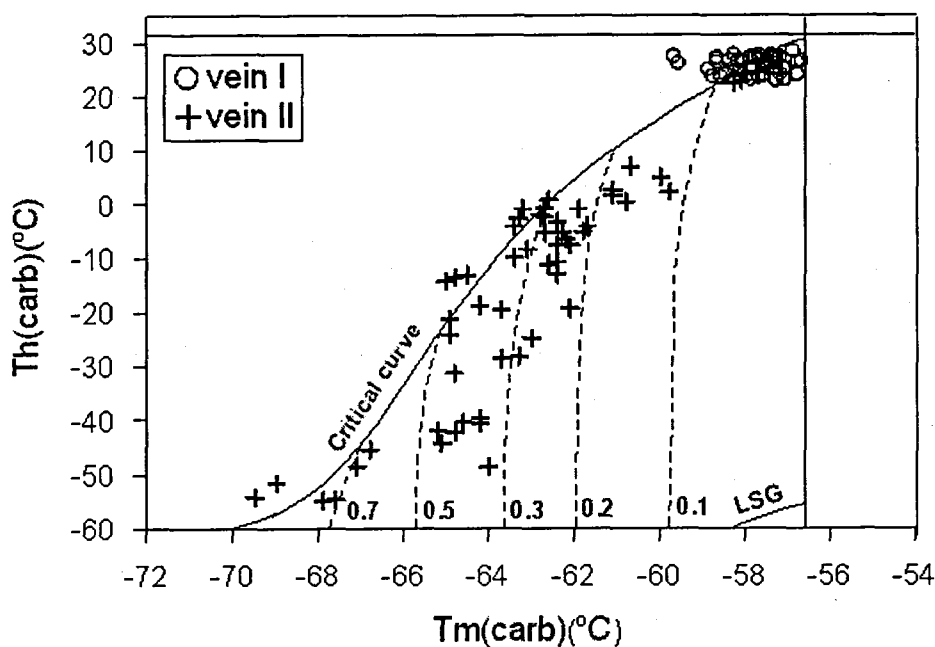


Fig. 1.  $T_m(\text{carb})$  vs.  $T_h(\text{carb})$  diagram for  $\text{H}_2\text{O}-\text{CO}_2-\text{CH}_4$  fluid inclusions in vein quartz.

In most type IV inclusions, total homogenization is established by halite dissolution rather than by vapor disappearance, which is interpreted to mean that the fluids could hardly be a product of fluid immiscibility but were derived directly from a water-saturated crystallizing melt. Occurrences of type IV inclusions along trails in both vein I and II are chronologically behind other primary inclusions and are closely related to the talc mineralization. This was caused by strong infiltration of aqueous fluids during the retrograde stage.

It is interpreted that progressive pressure decrease occurred from the primary hypersaline stage, 500-1400 bars, through the carbonaceous stage, 320-480 bars, and finally, to the secondary hypersaline stage, 150-700 bars at temperature of 260 to 315°C (Fig. 2). The estimated pressures of primary type IV inclusions correspond to depths of about 1.9 to 5.3 km, assuming a lithostatic system that would have been subjected to fracturing induced by overpressuring of the system. Inasmuch as evidences for immiscibility were observed in type II inclusions, it is likely, though not required, that they were under hydrostatic pressure. The estimated trapping depths of these inclusions would be about 3.1 to 4.8 km, which is similar to the depth range for primary type IV inclusions, even though the depths for type II inclusions could be greater if active immiscibility decreased the bulk density of the solution with abundant vapor bubbles (Haas, 1971). According to the calculated pressure conditions, the trapping depths of secondary type IVB inclusions became shallower up to 1.5 km in a hydrostatic system.

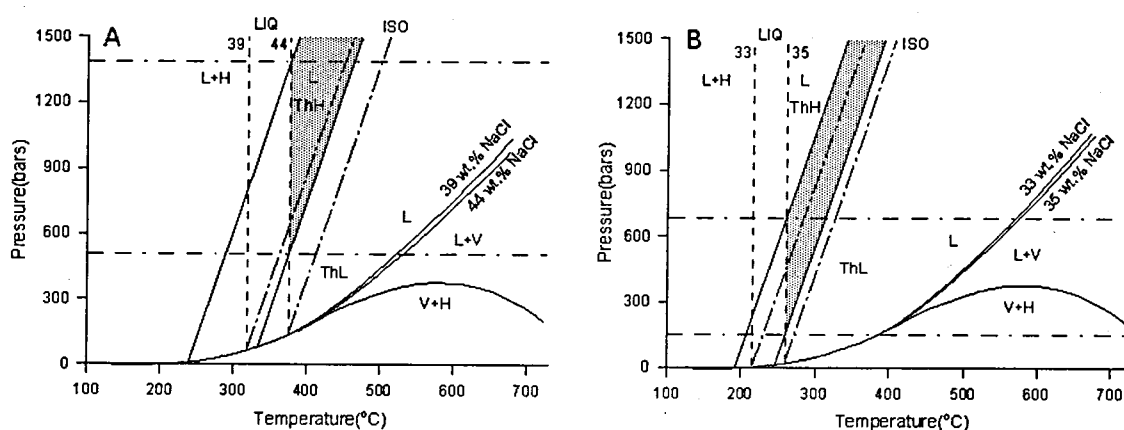


Fig. 2. P-T diagram illustrating trapping conditions of type IVB fluid inclusions. Diagram A for primary type IVB inclusions with liquid-vapor homogenization between 240 and 335°C, halite melting between 320 and 375°C, and salinities from 39 to 44 wt.% NaCl. Diagram B for secondary type IVB inclusions with liquid-vapor homogenization between 195 to 245°C, halite melting between 215 and 260°C, and salinities from 33 to 35 wt.% NaCl. Shaded areas represent the typical trapping conditions of each stage of type IVB inclusions.

The  $\delta^{13}\text{C}_{\text{CO}_2}$  values of inclusion fluids of vein I, 0.1 to 2.4‰, seem to have resulted from the isotopic exchange of magmatic carbon with  $^{13}\text{C}$ -enriched  $\text{CO}_2$  liberated from the decarbonation of the calc-silicate formation. Distinctly lower  $\delta^{13}\text{C}_{\text{CO}_2}$  values of vein II, -3.5 to -1.7‰, originated from the strong effect of metasediment-derived fluids, which provided  $^{13}\text{C}$ -depleted  $\text{CO}_2$  along with the minor effects of decarbonated  $\text{CO}_2$ . Higher  $\delta^{18}\text{O}_{\text{H}_2\text{O}}$  values are seen in vein I than in vein II for water in equilibrium with the vein quartz. Both belong to the magmatic water range, and can be also attributed to the effect of  $^{18}\text{O}$ -enriched fluids resulting from the decarbonation reaction. Nearly constant hydrogen isotope compositions of inclusion fluids from the primary to the secondary stage in vein I indicate the consistent effect of magmatic fluids on calc-silicate formation and talc mineralization. The lower  $\delta\text{D}$  values of vein II may reflect fractionation effects between magmatic water and other gases, mostly  $\text{CH}_4$  from metasediment-derived fluids.

#### 4. Reference

- Clayton, R. N. and Mayeda, T. K. (1963) The use of bromine pentafluoride in the extraction of oxygen from oxides and silicates for isotopic analysis. *Geochim. Cosmochim. Acta* 27, 43-52.
- Haas, J. L. (1971) The effect of salinity on the maximum thermal gradient of a hydrothermal system at hydrostatic pressure. *Econ. Geol.* 66, 940-946.