

The Characteristics of Petrography and Fluid inclusions of Vein in Geothermal System of Ilan Plain, Taiwan

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ABSTRACT

This study firstly applied fluid inclusions of veins in the core of geothermal area to provide the evolution of thermal fluid in Taiwan. The first one is to analyze the mineral assemblages in veins by microscope. The second aspect to observe the fluid inclusions and minerals relationship. The third is to measure the values of melting temperature and homogenized temperature of fluid inclusions by micro-heating stage, and then calculate the salinity of fluid inclusion. The results show that the veins are consist of quartz and calcite and formed along cleavage. Quartz and calcite are commonly mosaic deposited that is first stage geothermal fluid, and the deposit of second stage is calcite that cut the quartz grain of first stage. In the first stage, the homogenized temperature and salinity of geothermal fluid are 240°C -260°C and 2~6 wt.% NaCl eq., respectively. However, the secondary stage, the homogenized temperature and salinity of geothermal fluid are 280°C -290°C and 2~6 wt.% NaCl eq., respectively. Finally, this study infers to the veins are produced by meteoric water with anomaly heating, and the temperature value of geothermal fluid is about to 280°C -290°C in the HongTsaiLing of Ilan Plain.

1. INTRODUCTION

Taiwan National Energy Program-Phase II has been carrying out in the Ilan Plain for the development of a new geothermal power plant from 2012-2016. Three higher geothermal gradient areas, Sanxing, Dongshan and Yuanshan, that results shows about 4-8 °C/100m based on long-term shallow bore-holes in situ temperature data (Liu et al., 2016). In this project, it had one drilling well about 1,500m depth and collected core sample from 700m-900m. We collected vein samples that are parallel slaty cleavage.

This study combined the petrography and fluid inclusion of vein to provide the evolution of geothermal fluid in Ilan Plain. In petrography, we observed the mineral assemblages and their relationship. In fluid inclusion of different minerals, we described the fluid inclusion of different type, and measured the homogenized temperature and calculated the salinity of fluid inclusion.

2. SAMPLING SITE AND CLASSIFICATION OF SAMPLES

Ilan Plain is located in the northeastern Taiwan. The upper most part of the plain is covered by Holocene alluvium sediments ranging from 100 to 1200 meters including gravel, sand and mud, according to reports of seismic reflection and drill wells description (Figure 1) (Zhang, 2010).

This study had classified the veins according the mineral assemblages and their relationship (Capps, 1914; Johnston, 1940; Richard, 1954) that samples are 749.49m-749.59m, 795.0m-795.2m, 795.45m-795.72m, 797.72m-797.9m, 801.12m-801.4m, 805.4m-805.54m, 859.3m-859.5m. These samples are filling in the slaty cleavage and they parallel slaty cleavage. We classified three types: Type I consists quartz and located at 749.49m-749.59m depth; Type II is calcite-quartz and located at 795.45m-795.72m, 797.72m-797.9m, 801.12m-801.4m, 805.4m-805.54m; Type III includes calcite-quartz and located at 795.0m-795.2m and 859.3m-859.5m.

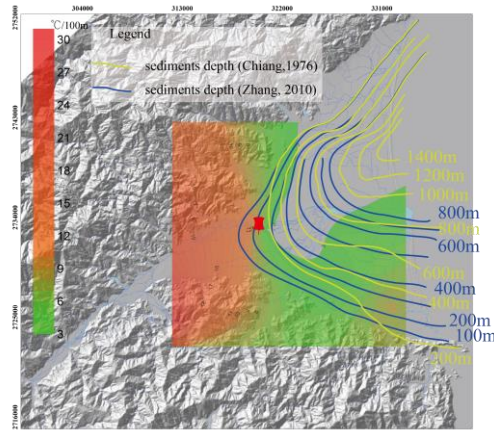


Figure 1: The sampling site. The red symbol is drill well site that is located in higher geothermal potential area in Sanxing of Ilan Plain.

3. RESULTS AND DISCUSSION

3.1 The petrography and fluid inclusion of Type I

The Type I is pure quartz filled in vein not any the other minerals fill in it and only at 749.49m depth. In petrography, quartz presents different textures for example fibrous, subhedral and anhedral (Figure 2a and 2b). The fluid inclusion type has three types including primary, secondary and pseudosecondary (Figure 2c). The homogenized temperature and salinity of primary fluid inclusion are 242 °C-270 °C and 2 wt.%-6 wt.%. The homogenized temperature and salinity of secondary fluid inclusion are 228 °C-243 °C and 4 wt.%- 6 wt.%. The homogenized temperature and salinity of pseudosecondary fluid inclusion are 242 °C-269 °C and 2 wt.%- 4 wt.% (Figure 2d).

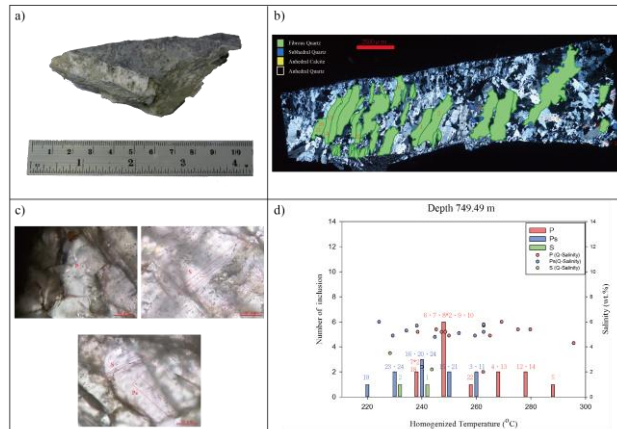


Figure 2: The petrography and fluid inclusion of Type I. (a) Hand specimen. (b) Petrography of quartz vein. (c) Primary, secondary and pseudosecondary fluid inclusions in quartz vein. (d) Homogenized temperature and salinity of fluid inclusion in quartz vein.

3.2 The petrography and fluid inclusion of Type II

The Type II is quartz and calcite filled in vein. In petrography, quartz presents different textures for example fibrous, subhedral and anhedral, and calcite displays anhedral texture (Figure 3a and 3b). Here, we found that calcite cuts the quartz grain that infer to Type II has two stages geothermal fluids. The first stage consists quartz and calcite, and the secondary stage is only calcite. The fluid inclusion type has two types including primary and pseudosecondary (Figure 3c). In quartz, the homogenized temperature and salinity of primary fluid inclusion are 220 °C-264 °C and 3.8 wt.%- 5.5 wt.%. In calcite, the homogenized temperature and salinity of primary fluid inclusion are 245 °C-296 °C and 3.7 wt.%- 7.5 wt.% (Figure 3d).

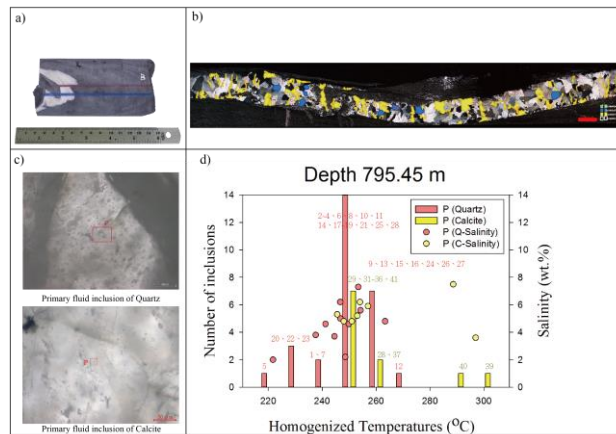


Figure 3: The petrography and fluid inclusion of Type II. The Type II for example in 795.45m depth. (a) Hand specimen. (b) Petrography of quartz-calcite vein. (c) Primary fluid inclusions in quartz-calcite vein. (d) Homogenized temperature and salinity of fluid inclusion in quartz-calcite vein.

3.3 The petrography and fluid inclusion of Type III

The Type III is quartz and calcite filled in vein. In petrography, quartz presents different textures for example fibrous, subhedral and anhedral, and calcite displays anhedral texture (Figure 4a and 4b). The fluid inclusion type has two types including primary and pseudosecondary (Figure 4c). In quartz, the homogenized temperature and salinity of primary fluid inclusion are 233 °C-264 °C and 2.0 wt.%- 4.5 wt.%. The homogenized temperature and salinity of pseudosecondary fluid inclusion are 238 °C-253 °C and 3.0 wt.%- 4.0 wt.% (Figure 4d).

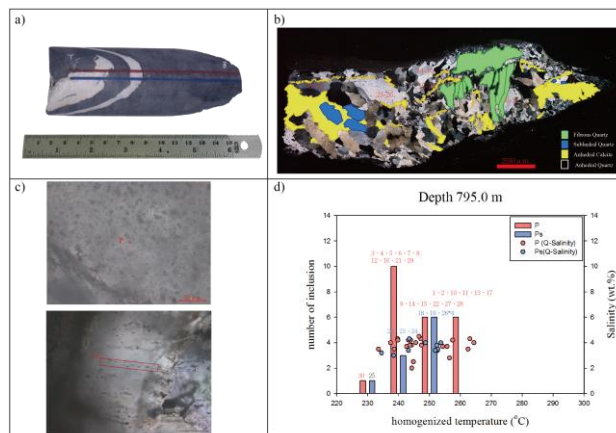


Figure 4: The petrography and fluid inclusion of Type III. The Type III for example in 795.0m depth. (a) Hand specimen. (b) Petrography of quartz-calcite vein. (c) Primary and pseudosecondary fluid inclusions in quartz-calcite vein. (d) Homogenized temperature and salinity of fluid inclusion in quartz-calcite vein.

3.4 The evolution of geothermal fluid in Ilan Plain

Based on the contact relationship of minerals in petrography, geothermal fluids of two stages were displayed in Ilan Plain (Figure 5). Here found anhedral calcite cut the anhedral quartz grain that means quartz is precipitated in vein at first stage. And, some calcite and quartz of first stage are relationship like mosaic texture that infers to some calcite and quartz are simultaneously formed. In second stage, it only found calcite filled in vein that suggested the geothermal fluid of this stage is calcite precipitation (Figure 5a). The temperature of geothermal fluid of second stage is higher than first stage according to the homogenized temperature values of two stages (Figure 5b). Finally, this study combined the fluid inclusion report of host rock in northern Ilan Plain and suggested that the meteoric water was heating by anomaly heat (Wang, 1999)

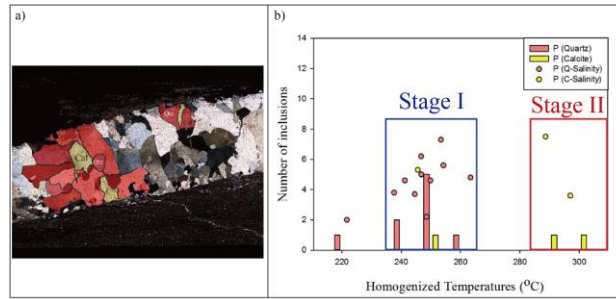


Figure 5: The evolution of geothermal fluid in Ilan Plain. (a) The contact relationship of calcite and quartz. (b) Homogenized temperature in two stages.

4. CONCLUSION

- (1) According to the mineral assemblages and their relationship of vein, this study classified three types: Type I consists quartz and located at 749.49m-749.59m depth; Type II is calcite-quartz vein and located at 795.45m-795.72m, 797.72m-797.9m, 801.12m-801.4m, 805.4m-805.54m; Type III includes calcite-quartz vein and located at 795.0m-795.2m and 859.3m-859.5m.
- (2) Only Type II recorded geothermal fluids of two stages. In first stage, the homogenized temperature and salinity of vein are 240 °C-260 °C and 2-6 wt.% NaCl eq.. In secondary stage, the homogenized temperature and salinity of vein are 280 °C-290 °C and 2-6 wt.% NaCl eq.. In Ilan Plain, the evolution of geothermal fluid is inferred to the geothermal fluid temperature of secondary stage is higher than first stage, and its temperature is about 280 °C-290 °C.
- (3) This study firstly combined the mineral assemblages, their relationship and fluid inclusion of vein, and it had well interpretation for evolution of geothermal fluid in Ilan Plain.

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