

## A Study of Fluid Inclusions from Core of Ilan Plain Geothermal System, Taiwan

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### ABSTRACT

The Ilan Plain, is located in the Northeastern Taiwan where is heavily influenced by the opening of the Rykyu trough and resulted in thermal anomaly. The origin this anomaly is currently debating. Fluid inclusion samples, taken from 700m to 900m from the total 1500m the core of HongTsaiLing well of Ilan Plain.

The preliminary results showed that most veins are composed of quartz and calcite and formed along cleavage. It is rare to find quartz only veins. Quartz and calcite are commonly mosaic deposited and some recrystallization found for quartz. For the homogenized temperature, the quartz vein display 224°C~295°C in 749.49m-759.59m depth, the calcite vein of 797.72m-797.9m depth is 238°C, and the quartz vein of 797.72m-797.9m depth is 233°C~275°C. In 859.3m-859.5m depth, the quartz vein present 223°C~288°C. The summarized results display that the homogenized temperature of quartz-calcite vein is lower the quartz vein.

### 1. INTRODUCTION

In Taiwan, a new geothermal exploration phase has been carrying out in the Ilan Plain for the development of a new geothermal power plant since 2012. Silica geothermometry and high resolution thermometer are expected to provide much better constraints for the entire operation of this power plant exploration. Three higher geothermal gradient areas, Sanxing, Dongshan and Wujie, are recognized based on long-term shallow bore-holes in situ temperature data. The geothermal gradient is estimated to be about 4-8 °C/100m for these areas (Figure 1)(Chiang, 2010; Liu et al., 2015).

This study is aimed to examine fluid inclusion with mineral assemblage from cores to establish the geochemistry history of the geothermal system in HongTsaiLing well of the Ilan Plain.

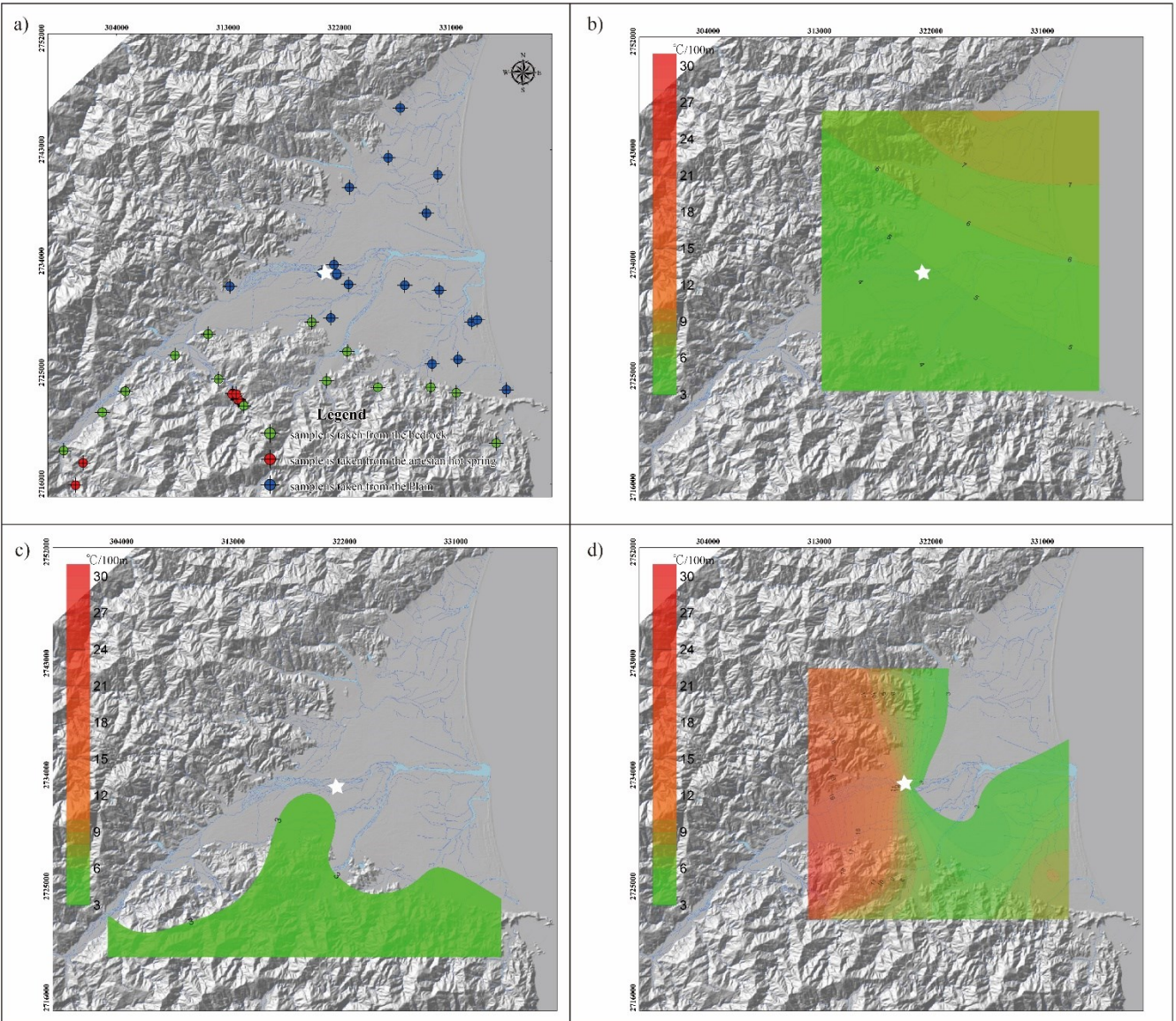


Figure 1: The temperature distribution and sampling location in this study (the white fill star is sampling location). (a) The shallower drill wells site. (b) The temperature distribution in less the 50m depth. (c) The temperature distribution in 50m-100m depth. (d) The temperature distribution in more than 100m depth.

## 2. METHODS

The methods of this study are consist of three aspect. First, we collected vein and described the occurrence of vein. Second, we analyzed petrography of vein. Finally, the fluid inclusion of vein were estimated by micro-heating stage.

### 3. RESULTS AND DISCUSSION

This study analyzed the vein of core in different depth including 749.49m-759.59m, 797.72m-797.9m, and 859.3m. Those samples are filling in the slaty cleavage and they parallel slaty cleavage. The following description:

#### 3.1 The petrography in 749.49m-759.59m depth

In 749.49m-759.59m depth, the vein is consist of fibrous quartz, and the quartz size of near host rock is smaller than center of vein (Figure 2).

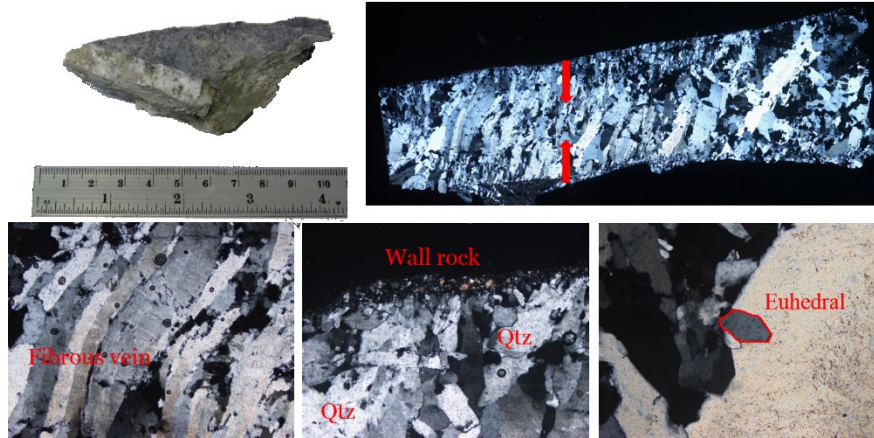


Figure 2: The quartz vein in 749.49m-759.59m depth.

#### 3.2 The petrography in 797.72m-797.9m depth

In 797.72m-797.9m depth, the vein is major composed of blocky quartz and less calcite. The contact relationship of minerals display embayment characteristics in this vein (Figure 3).

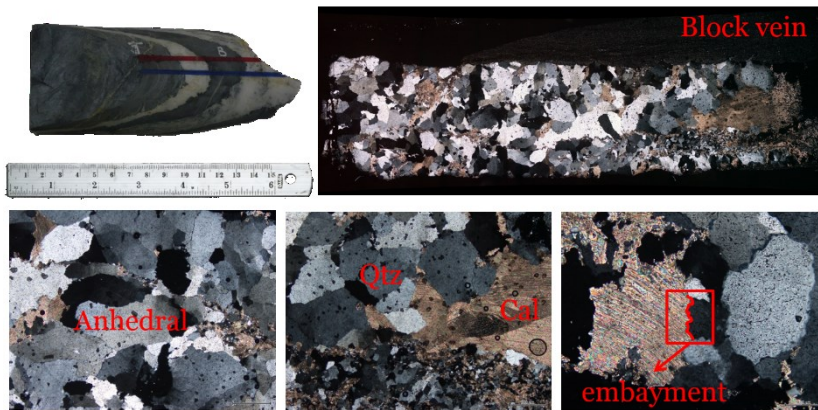


Figure 3: The quartz-calcite vein in 797.72m-797.9m depth.

#### 3.3 The petrography in 859.3m-859.5m depth

In 859.3m-859.5m depth, the vein include blocky quartz, and quartz displays recrystallization characteristics (Figure 4).

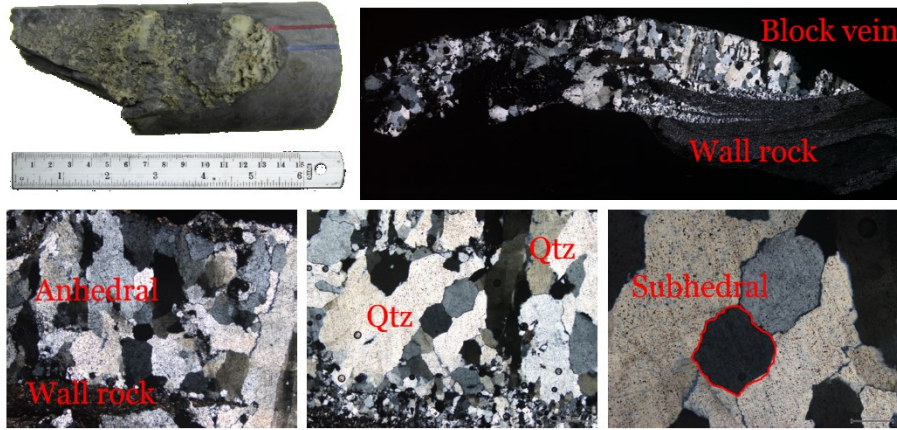


Figure 4: The quartz vein in 859.3m-859.5m depth.

### 3.4 The fluid inclusion in 749.49m-759.59m depth

In 749.49m-759.59m depth, there have three types including primary, secondary and pseudosecondary in quartz vein. The homogenized, melting temperature values and salinity of primary fluid inclusion are 242°C ~295°C, -3.7°C ~-3.3°C, and 4.3wt%~5.4wt%, respectively. The homogenized, melting temperature values and salinity of secondary fluid inclusion are 228°C ~243°C, -1.3°C ~-1.0°C, and 4.6wt%~6.0wt%, respectively. The homogenized, melting temperature values and salinity of pseudosecondary fluid inclusion are 224°C ~262°C, -3.2°C ~-2.9°C, and 2.2wt%~3.5wt%, respectively. The gas-liquid ratio and macro-axis of primary fluid inclusion are 15.8%~35.8%, 4.76μm~23.98μm, respectively (Figure 5a). The gas-liquid ratio and macro-axis of secondary fluid inclusion are 35.0%~38.2%, 3.11μm ~7μm, respectively (Figure 5b). The gas-liquid ratio and macro-axis of pseudosecondary fluid inclusion are 19.4%~36.5%, 2.61μm~9.01μm, respectively (Figure 5c).

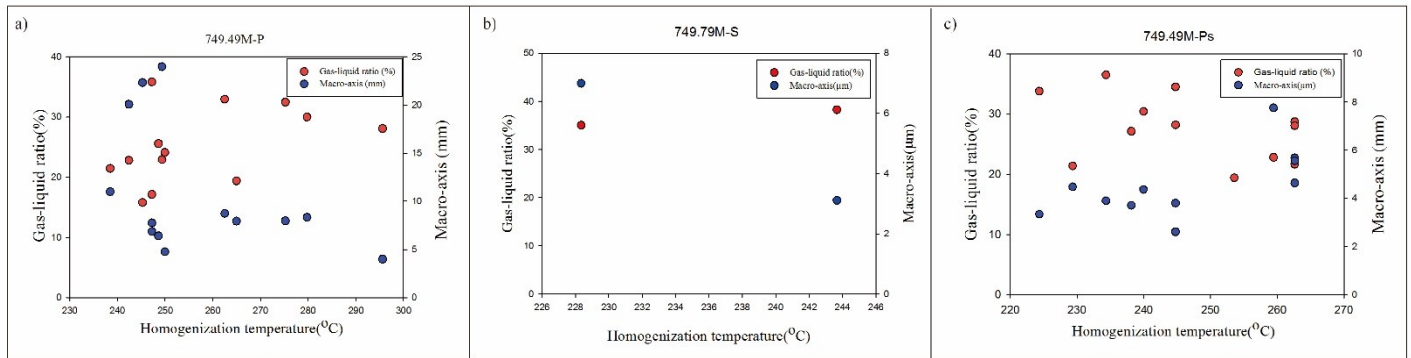


Figure 5: The gas-liquid ratio and macro-axis of different types of fluid inclusion in 749.49m-759.59m depth.

### 3.5 The fluid inclusion in 797.72m-797.9m depth

In 797.72m-797.9m depth, there have two types including primary and pseudosecondary in quartz vein, and only primary fluid inclusion in calcite vein. In the quartz vein, the homogenized, melting temperature values and salinity of primary fluid inclusion are 233°C ~275°C, -2.5°C ~-2.9°C, and 2.4wt%~7.8wt%, respectively. The homogenized, melting temperature values and salinity of pseudosecondary fluid inclusion are 235°C ~247°C, -2.3°C ~-2.6°C, and 3.0wt%~12.3wt%, respectively. The gas-liquid ratio and macro-axis of primary fluid inclusion are 14.8%~43.38%, 9.52μm ~22.71μm, respectively (Figure 6a). The gas-liquid ratio and macro-axis of pseudosecondary fluid inclusion are 18.0% ~24.4%, 8.41μm ~23.58μm, respectively (Figure 6b). In the calcite vein, the homogenized, melting temperature values and salinity of primary fluid inclusion are 238.3°C, -3.4°C, and 5.6wt%, respectively. The gas-liquid ratio and macro-axis of primary fluid inclusion are 28.69%, 4.41μm, respectively (Figure 6b).

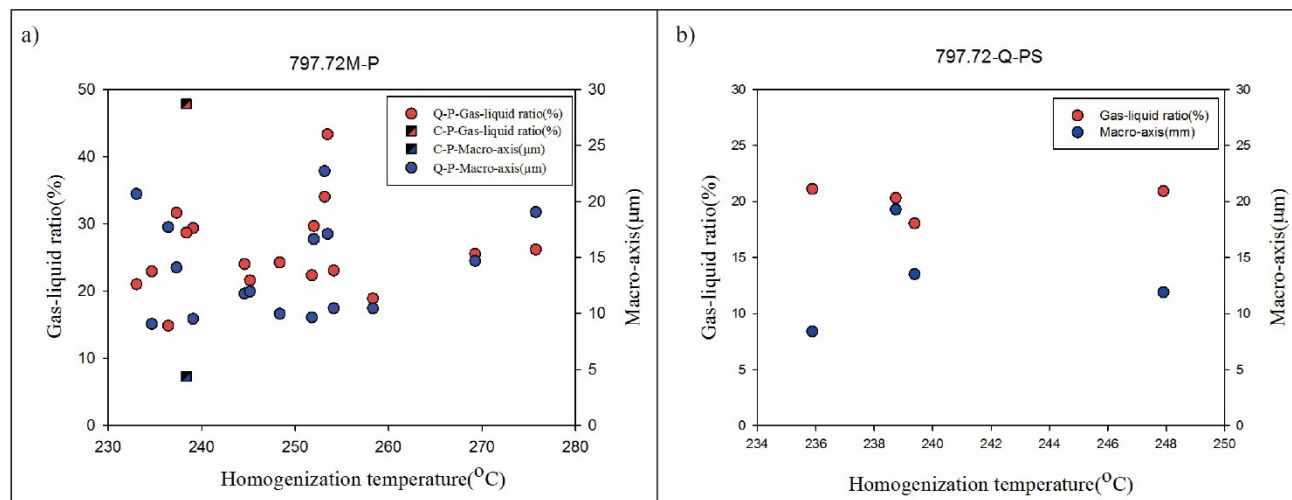


Figure 6: The gas-liquid ratio and macro-axis of different types of fluid inclusion in 797.72m-797.9m depth.

### 3.6 The fluid inclusion in 859.3m-859.5m depth

In 859.3m-859.5m depth, there have three types including primary, secondary and pseudosecondary in quartz vein. The homogenized, melting temperature values and salinity of primary fluid inclusion are 223°C ~249°C, -3.4°C ~-2.3°C, and 2.9wt%~5.4wt%, respectively. The homogenized, melting temperature values and salinity of secondary fluid inclusion are 288°C, -2.8°C, and 4.6wt%, respectively. The homogenized, melting temperature values and salinity of pseudosecondary fluid inclusion are 225°C, -3.5°C, and 5.8wt%, respectively. The gas-liquid ratio and macro-axis of primary fluid inclusion are 17.2%~32.8%, 6.59μm ~17.25μm, respectively (Figure 7a). The gas-liquid ratio and macro-axis of secondary fluid inclusion are 21.7%, 5.08μm, respectively (Figure 7b). The gas-liquid ratio and macro-axis of pseudosecondary fluid inclusion are 30.1%, 4μm, respectively (Figure 7b). However, in the quartz vein of recrystallization, the homogenized, melting temperature values and salinity of primary fluid inclusion are 223°C ~249°C, -3.3°C ~-2.4°C, and 4wt% ~5.4wt%, respectively.

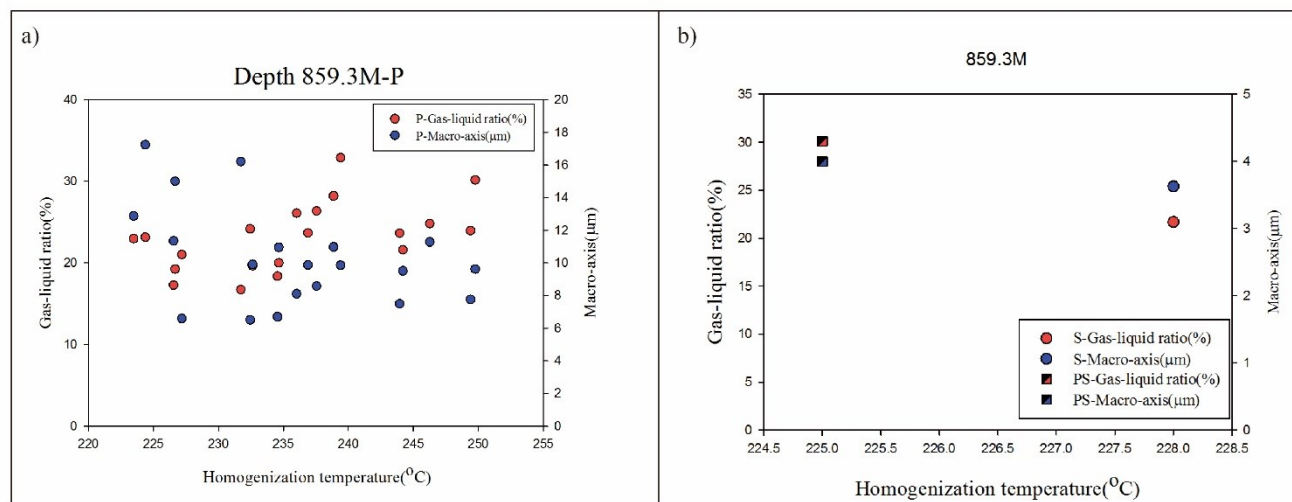


Figure 7: The gas-liquid ratio and macro-axis of different types of fluid inclusion in 859.3m-859.5m depth.

#### 4. CONCLUSION

- (1) For petrography, in 749.49m-759.59m depth, the vein is consist of fibrous quartz, and the quartz size of near host rock is smaller than center of vein. In 797.72m-797.9m depth, the vein is major composed of blocky quartz and less calcite. The contact relationship of minerals display embayment characteristics in this vein. In 859.3m-859.5m depth, the vein include blocky quartz, and quartz displays recrystallization characteristics.
- (2) For the homogenized temperature, the quartz vein display  $224^{\circ}\text{C}\sim 295^{\circ}\text{C}$  in 749.49m-759.59m depth, the calcite vein of 797.72m-797.9m depth is  $238^{\circ}\text{C}$ , and the quartz vein of 797.72m-797.9m depth is  $233^{\circ}\text{C}\sim 275^{\circ}\text{C}$ . In 859.3m-859.5m depth, the quartz vein present  $223^{\circ}\text{C}\sim 288^{\circ}\text{C}$ .
- (3) The summarized results display that the homogenized temperature of quartz-calcite vein is lower the quartz vein.

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