FLUID INCLUSION GEOTHERMOMETRY USED TO RECOGNISE AN ANCIENT "SILICA SINTER"

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ABSTRACT-The Da Yuwan "silica sinter" in the Shui Koushan Mining District was described by Haynes (1989) who attempted to prove that a hot spring system existed here in the early Cretaceous. The deposit has been reassessed using fluid inclusion geothermometry. The "sinter", in fact, is a silicified breccia without any flow textures or plant fossils. Study shows that it contain two generations of fluid inclusions. The earlier fluid was trapped in primary or pseudo secondary inclusions along growth zones in quartz at about 130-200 °C and with apparent salinities of 2.4-7.0 % eqv NaCl. Most secondary inclusions are single phase or necked. The results suggests that the Da Yuwan silicified breccia body is unlikely to be a subaerial deposit but formed below ~100 m depth in an epithermal system interpreted to be of meteoric origin but are probably mixed with connate water.

INTRODUCTION

Fluid inclusion geothermometry is a useful tool that is widely used to assess hydrothermal systems, At the Shui Koushan Mining District, Hu Nan, China, fluid inclusion geothermometry was used to examine an ancient " silica sinter ".

Shui Koushan is an old Pb - Zn mining district with an exploration history of about 100 years. During the past two decades. Some precious metal deposits here have been studied. Haynes (1989) was the first person to suggest that a hot spring system was probably associated with precious metal deposits in this area. This conclusion was based on his interpretation of magmatic-hydrothermal activity and the Occurrence of a" silica sinter " deposit exposed on the north bank of the Xiang Jiang River. The "silica sinter" was belived to be restricted on the Cretaceous palm-surface.

Silica sinter, as a surface manifestation of a hot spring system, has been recorded in many active geothermal fields. It is characteristiced by arcuate shaped terraces, white, banded amorphous silica (which ages to cristobalite and then to quartz) deposits with "ripple forms" and sometimes contains plant materials (Browne, 1991). In places, such as at Yang Bajin, Tibelt, depositing fluid silicifies and cements surface deposits.

By recognising these features, ancient silica sinter has been identified at many ancient hot spring systems, such as Mclaughlin, California (Lehrman,1986); Guckhorn, Nevad (Plahuta,1986) and some Japanese fields (Sillitoe, 1985). Since it forms only at the surface, sinter serves an important role in determining the paleohydrology of an extinct geothermal system.

It is easy to recognise silica sinter in a modem geothermal system, but it is difficult to do so in ancient systems, due to erosion, weathering, deformation and recrystallisation . However, fluid inclusion geothermometry may help in some cases.

GEOLOGY

The main geological features of the Shui Koushan mining district are shown in Fig.1. The pre-Cretaceous sediments are Devonian limestones, carbonaceous dolomite and limestone, siliceous rocks and carbonaceous shales of Early to Middle Permian age. Jurassic sandstones unconformably overlies these sediments in places. All of these were deformed into a series of anticlines and synclines which trend almost north-south. The Lao Yazao granodiorite was intruded about 143-160 m.y.ago and a metasomatic skarn was formed at its contacts.

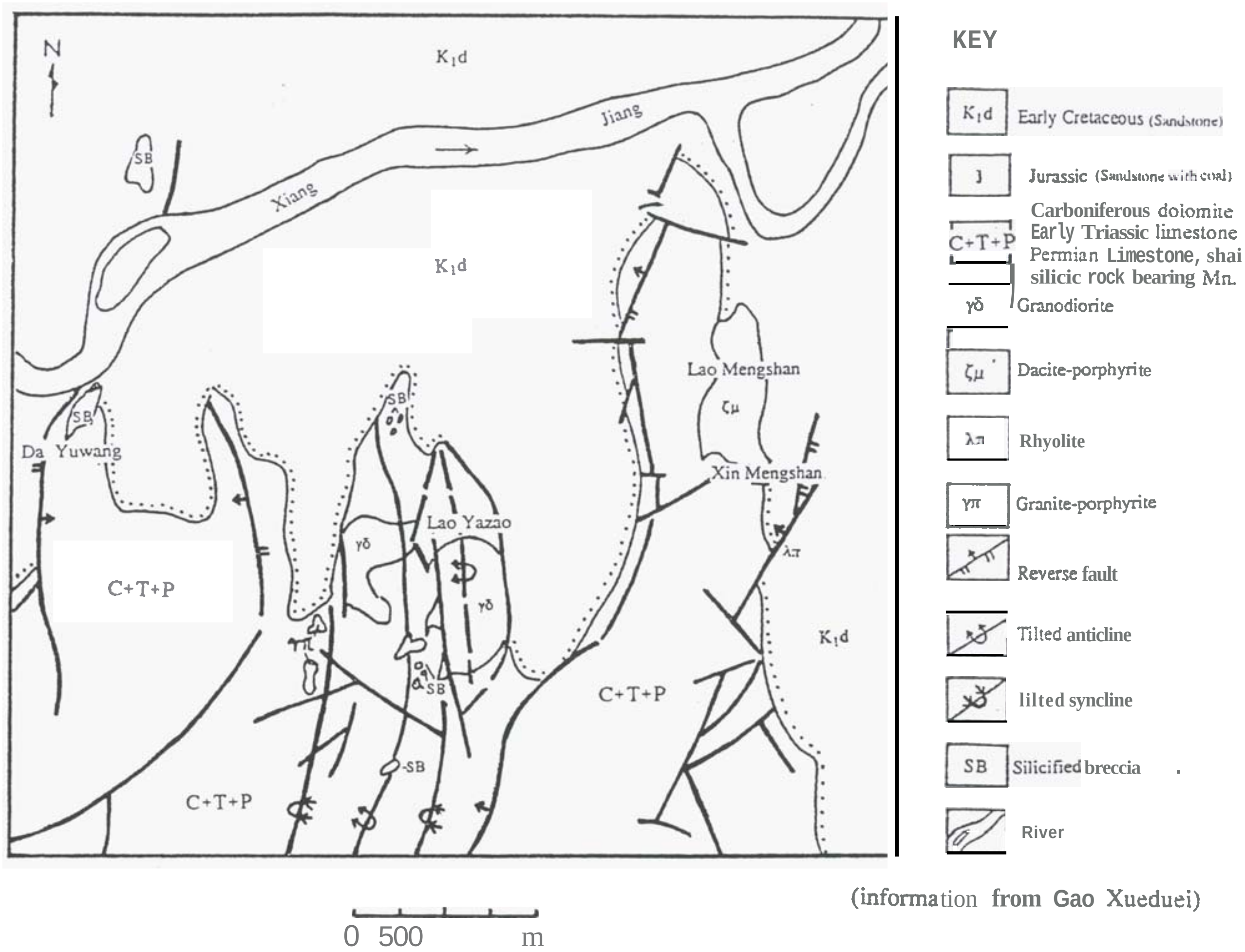


Fig.1. Geological Mape Of Da Yuwan, Shui Koushan Mining District.

In Late Jurassic and Early Cretaceous times, the whole area rose above sea level accompanied by a series of NE reverse faults. A paleo-surface with a basal conglomerate was formed in the Early Cretaceous. East of the Lao Yazao intrusion, the Lao Menshan andesite, erupted at about 120 m.y.(K/Ar), and to the south at Xin Menshan, a rhyolite diatrime was emplaced 80 m.y.(?) ago.

Numerous silicified breccia bodies with a variety of sizes and forms were developed within these locations controlled by anticlines, faults, an intrusion and the unconformity. The Da Yuwan breccia body is one of these. It is situated on the north bank of the Xian Jiang River and is probably located on a north trending fault.

OCCURRENCE ANI) PETROGRAPHIC FEATURES OF THE DA YUWAN "SILICA SINTER".

Photo 1 shows the breccia body. It is about 3*35 metres across and has a maximum thickness of 1.5 metres. The breccia body is roughly oblong and often covered by fluctuating river water level. The body itself has been partly fragmented by fluvial action. Quaternary alluvial and slope wash material occur directly behind the body and are underlain by an altered breccia body. An oucrop of Cretaceous basal conglomerate is exposed locally below the altered breccia body and is also silicified.

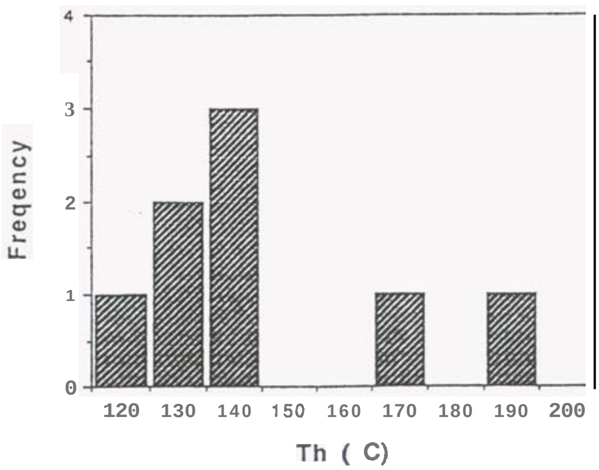
The river bank breccia body is composed of angular fragments, rounded gravels and two lensoid shaped siliceous layers. The fragments of the fragments seem to be "sorted" and their size commonly rang from 2*1.3 to 1.5*1.5 cm. but some are from 0.4*0.4 cm or 12*11, 7*3 cm. The fragments include chert, silicified limestone, sandstone and shale derived from the Permian sequences. Cement is rare. Most fragments are filled with well crystallized quartz. The maximum length of the quartz crystals is 1.0 cm. The two siliceous layers, 2-3 cm thick, consist of microcrystalline to cryptocrystalline quartz. Some quartz may be detrital, but this is not very obvious because of the strong silicification. Their most likely source rock was lensed siltstone rather than a hydrothermal silica deposit.
Beside the main body there are several local, small and yellow-white altered breccia blocks which are

cemented by poorly crystallized quartz and filled by some opal veins. In places, the underlying Quaternary loose sediments are altered.

Photo.1. Da Yuwan silicified breccia is situated on the bank of Xiang Jiang River.

FLUID INCLUSION STUDY

Several well crystallized quartz crystal were selected for the fluid inclusion study using a **U.S.G.S.** designed heating and freezing stage. Two generations **of** fluid inclusions occur. One is of primary or pseudo-secondary inclusions which occur in crystal growth zones. The other is secondary inclusions that are present along cracks thoughout the crystals. Generaly the inclusions are irreqularly shaped with a variety of sizes. **Most** of the secondary inclusions are single phase, but some two phase inclusions are present which have been necked significantly. Even within the growth zones the inclusions are not very well developed and necking is also common. *So* necked inclusions have been avoided in this study except to measure freezing temperature.



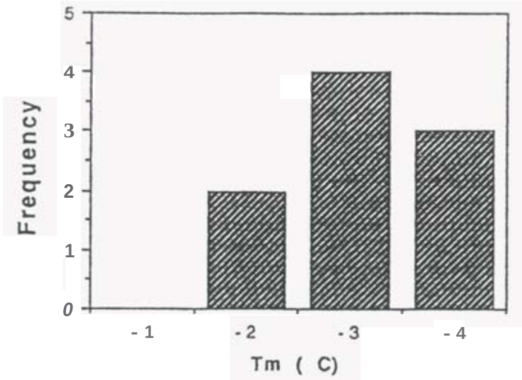


Fig.2. Histogram plots of homogenization temperature (Th) and melting temperature (Tm) measured in quartz crystal from the Da Yuwan silicified breccia.

Only 7 inclusions were suitable for the homogenization measurements. They are primary ,**i.e.,** from the growth zones, and are all regularly shaped without any single phase inclusions nearby. Rare negative-crystal inclusion exsit. Some **of** above inclusions and several necked inclusions have been chosen for the melting temperature measurement. The results of the homogenization and melting temperature, together with the apparent salinities are shown in Fig.2.

DISCUSSION

There are no published accounts of fluid inclusion **data** measured on modem **silica** sinter. Normally it is difficult to find inclusions which can be measured due to the very poor crystallization of quartz. However, any inclusions formed in **a** surface environment under air pressure, that temperature is less than 100°C. Although we do not know about the conditions of millions years ago, there is no evidence that the **air** pressure was over 1.0.. For most geothermal--epithermal systems, the fluid circulating is meteoric water or at least dominated by it; this gives very low salinities. By contrast, fluid circulating in a **from** a hydrothermal-magmatic system usually have very high salinities but a range of temperature (Table 1).

Compared with the **data** from modem geothermal-epithermal and the ancient hydrothermal-magmatic systems, the homogenization temperatures **of** inclusions **from** the quartz **of** Da Yuwan breccia body are over 100 °C (~130-198°C) with apparent salinities of **2.4** -7.0% eqv NaCl. This **means** that it is unlikely to be a subaerial deposit. However, the fluid is contains a high proportion meteoric water mixed with some connate water **and** the *so* called " sinter" is interpreted to have interpreted to have formed within a epithermal environment, probably deeper than 100 metres below ground surface. However,the bossible true sinter is some small silicified breccia blocks with opal veins underlaying **loose,** altered Quarternary sediments nearby the main breccia body, which we metioned before. The true sinter was formed unmistakable in the Quaternary time but not in the Cretaceous.

Table 1. Comparison of fluid inclusion results between the Da Yuwan and known epithermal deposits, magmatic systems.

Location	Th (oC)	Tm (oC)	Apparent Salinity % eav NaCl	Note	Reference
Wairakei, N.Z.	-245	0.0 - 0.6	0.0 -1.5	active geothermal field	Zhang lan 1989
Tolukuma, PNG.	-245	0.0- -1.0 rare <-.1.0	0.0 - 1.7	epithermal hot spring gold deposit	(Clarke,D.S) The fluid inclusion work has been done by Zhang lan, 1991
Golden Cross, N.Z.	1). 200 2). 270 3). >350	-0.5 - -1.6 -29.4 - -29.7 -25.4 - -20 -7.0 - -10.2	0.7 - 26 26.25 - 29.0 1.2 - 13.5	epithermal gold deposit; the higher salinity inclusions occur in the deeper part of the system	Ronde, et al, 1988
Tayoltita, Mexico	1). 2).250 -290 3).250 -310	N.A.	4.1 - 9.7 3.3 -8.4 1.9 -9.7	epithermal gold-silver deposit. meteoric+ connate water	Smith, et.al, 1982
San Luis Potosi, Mexico.	1).300 -320 2).150 - 220 3).350 - 520	N.A.	10 -22 27 - 50	Granit	Chryssoulis, 1983
Da Yuwan, Shui Koushan, China	122.5 - 196.4	-2.5 - -4.5	2.4 -7.0	Cretaceous ? Silicified breccia is cemented by hydrothermal quartz.	Zhang lan, 1992

Note: The apparent salinity calculations are based on the equation of Potter 11, et al, 1977

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