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Preliminary study of Melt Inclusions and Fluid Inclusions in Sn-W-Cu bearing Tosham Mineralized Igneous body, Bhiwani District, Haryana

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Abstract: Melt Inclusions and four types of the fluid inclusions have been found in the quartz crystals of the quartz porphyry of the Tosham mineralized igneous body. The petrographic study of the melt inclusions and preliminary thermometric data has been generated from the different fluid inclusions. From the preliminary study it is inferred that hydrothermal solution is responsible for the Sn-W-Cu mineralization in the area. The presence of the silicate-melt inclusions in quartz phenocrysts of the quartz porphyry of the Tosham indicats the simultaneous trapping of magmatic fluids and silicate melt which further reveals the separation stage of the liquid phase from the melt. The presence of H_2O-CO_2 inclusions and their homogenization into the liquid and vapor phase at nearly the same temperature indicates the direct result of liquid immiscibility and boiling of aqueous fluids.

Key words: Hydrothermal solution; magmatic fluids; quartz crystals; quartz porphyry.

1. Introduction

Study of melt and fluid inclusions, trapped in mineral quartz of quartz porphyry and mineralized quartz veins of the Tosham mineralized granite body may provides vital information regarding the chemistry of evolved fluid, its PT condition, information regarding the evolution of silicate melts and coexisting fluids may gives an insight to the most critical stage when aqueous fluid gets separated from the parental magma responsible for the Sn-W-Cu mineralization in the Tosham rocks. For this study we have generated some preliminary fluid inclusion data from the mineralized quartz veins and granite and melt inclusions from the quartz phenocrysts of quartz porphyry of the Tosham Igneous body. The aim of the present paper is to focus on different fluid inclusions and melt inclusion found in the mineralized quartz veins (MQV) and different rocks varieties of the plutonic phase of the Tosham igneous body which through light on the fluid characteristics and genetic relationship between the hydrothermal fluid and host rock. The studied inclusions occurred in the center and peripheral part of the quartz phenocrysts.

2. Material and methods

2.1 Study area

The present area (Tosham) forms a part of the Aravalli–Delhi metallogenic province in Northwestern India which host significant Sn-W and Cu mineralization at Balda, Degana and Tosham **(**Bhattacharjee et al., 1993).

The Tosham Igneous Complex (TIC) comprises the overall at least five granite plutons, which are intrusive in the meta-sediments of Delhi Supergroup. These igneous bodies show variable dimensions elliptical and/ or circular outcrop pattern of the plutonic and volcanic igneous phases, exhibiting ring like structures. Except the Tosham all other igneous bodies of the TIC are barren. Rhyolite and tuffs are volcanic rocks present in the area, whereas the plutonic phase comprises the coarse-grained granite, biotite granite, and quartz-felds. Porphyry, k-feldspar porphyry and breccias.

Structural and faulted contacts of different rock units and the major fault zone acted as conducts of different rock units and the major fault zone acted pathways for the mineralizing solutions.

2.2 Methods

2.2.1 Mineralization and Post- magmatic alteration effect

Kochhar (1985) have suggested the porphyry type Cu and Sn mineralization in the area. The mineralized quartz veins occurs in form of quartz-biotite- sulphide vein lets and small networks of quartz-cassiterite vein which are intrusive in the quartz feldspar porphyry and mica granite. The rock varieties of the Tosham igneous body shows intense post magmatic hydrothermal alterations effect, which varies in intensity in different rock varieties. Mica granite shows least effect of post magmatic alteration effect, whereas the acid volcanic (rhyolite), porphyritic varieties of rocks in the area are highly affected by the k-alteration. In the periphery of the mineralized quartz veins the wall rock alteration effect such as

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Table 1: Heating and Freezing data of the different inclusion types of the Tosham granites and quartz veins.

Type of inclusions		MULTIPHASE **(Solid + Liq. + Gas)**			**Aqueous biphase**				**Carbonic inclusions**					**Melt inclusions**
Rock type		**Td. Halite**	**$T_{F.M}$**	**$T_{.M.ice}$**	**T_h ^oC**	**$T_{F.M}$**	**$T_{M.ice}$**	**T_h in ^oC**	**$T_{.m.CO2}$**	**$T_{.h.CO2}$**	**$T_{.m.clath}$**	**$T_{M.ice}$**	**T_h in ^oC**	
Granite	Coarse gr. granite	216.4 - 270.6	-36.9 to -37.4	-8.5 to -20.3	408.3 - 470.3	-37.1 to -38.9	-8.3 to -20.4	295.5 - 442.0	-59.6 to -60.5	-3.0 to +10.5	-	-10.3 to -18.6	300.4 - 460.3	-
	K-fels-porphyry	205.0 - 245.0	-36.7 to -40.1	-10.5 to -21.4	345.2 - 446.1	-36.2 to -37.7	-13.6 to -19.1	280.0 - 467.0	-58.9 to -61.2	-2.0 to +13.0	-	-8.1 to -20.3	306.0 - 406.0	-
	Q-fels-porphyry	201.3 - 248.2	-39.5 to -40.2	-10.8 to -21.5	325.2 - 445.5	-36.8 to -39.2	-9.5 to -21.7	260.5 - 423.0	60.0 to -61.8	-3.1 to +11.5	-	-9.6 to -21.2	265.4 - 402.0	-
Mineralized quartz veins		215.5 - 350.3	-37.2 to -40.6	-9.5 to -22.5	275.4 - 425.2	-38.1 to -40.3	-11.0 to -21.9	236.6 - 360.0	-60 to -62.9	-4.4 to +10.0	+1.1 to +5.1	-9.8 to -22.1	275.3 - 405.0	-

sericitization, tourmalinization and muscovitization effect has been observed.

2.2.2 Fluid inclusion Study

Based on the number of phases identified at room temperature four types of inclusions are identified these are: Multiphase inclusions (Type I), Aqueous biphase (Type II), Aquo-Carbonic inclusions (Type III), Melt inclusions (Type IV) in QVs and rock varieties of the Tosham igneous body.

The microthermometric measurements of the different inclusion types are carried out on Linkam THMSG-600 Heating and Freezing stage at Jammu University. Only the petrographic study of the melt inclusions has been done till now however some preliminary thermometric data of the different fluid inclusions types has been carried out (Table-1).

3. Results

Multiphase inclusions present in the mineralized quartz veins containing halite and sylvite daughter inclusions with little amount of liquid. These are rounded to sub rounded in shape varies 10 to 25µm in size (Fig.1a). Where as, in granite multiphase inclusions are rare and smaller in size containing halite only solid phase Fig.1b.

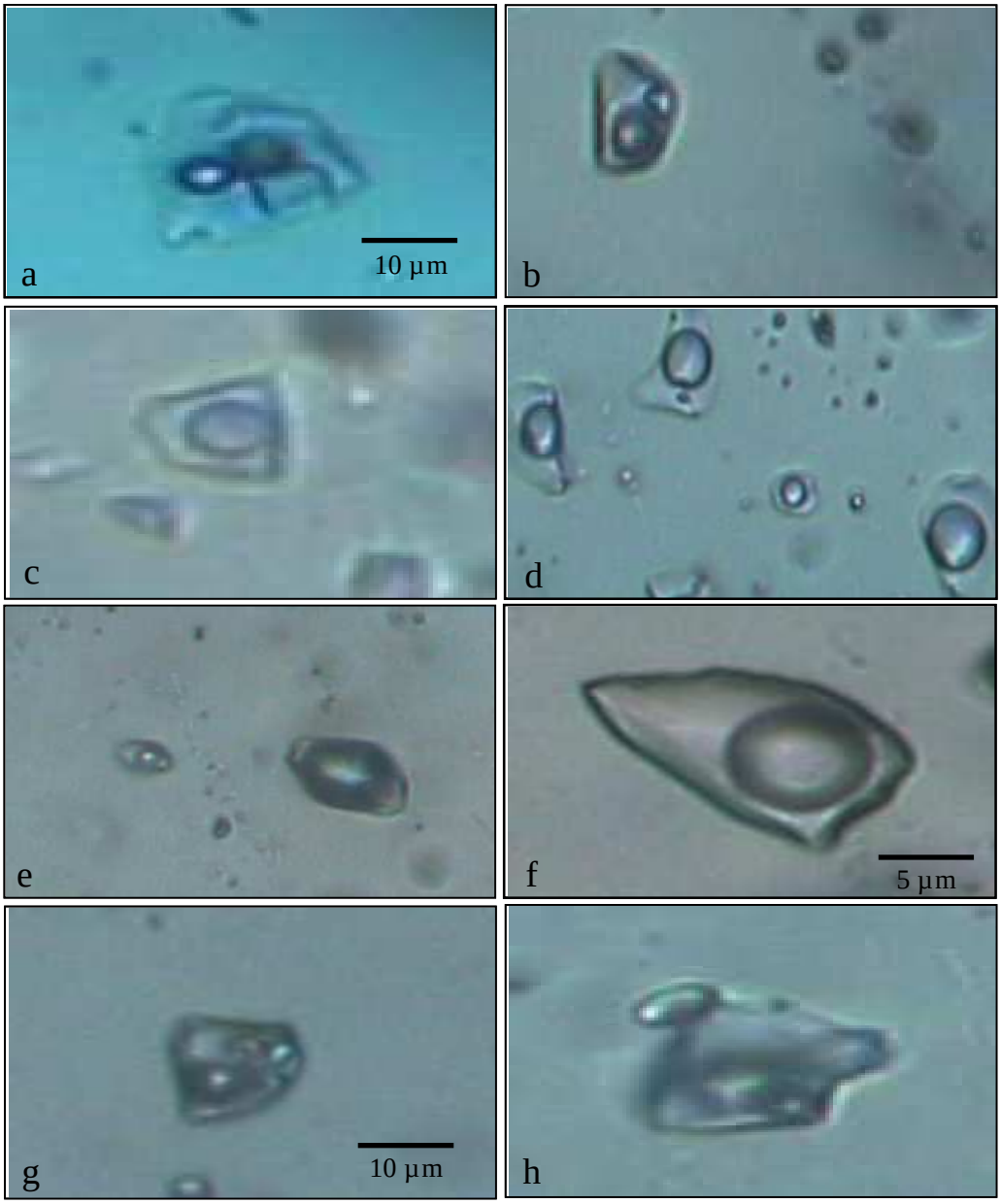

Figure 1 (a-h). **(a)** Multiphase inclusions in the quartz of the granite containing the halite as solid phase and rounded bubble, (**b**) Multiphase inclusion of the quartz veins which are larger in size, **(c)** Aqueous inclusions in the granites, **(d)** Aqueous inclusions in the QVs, **(e)** Aqua-carbonic inclusions (H_2O-CO_2) in the granite, **(f)** Aqua carbonic inclusion sin the QVs, and **(g & h)** Melt inclusions in the granite.

The freezing study of these inclusions is done and salinity has been calculated by using the equation of freezing point depression given by Potter et al, (1977). The first liquid appeared between -36.7 to –40.2° C (T_{FM}) with final ice melting ($T_{M.\ ice}$) -8.5 to -21.5° C in the granites and between -37.2 to –40.6° C (T_{FM}) with final ice melting ($T_{M.\ ice}$) between -9.5 to –22.5° C in the QVs. The salinity is between 12.28 to 23.68 in the granite and between 13.42 to 24.35 in QVs. The dissolution temperature of halite ($T_{d.}$ halite) ranges between 201.3 (quartz porphyry) to 270.6°C (mica granite) and no sylvite has been found so far. In the QVs $T_{d.}$ halite ranges between 215.5 –350.3. The total homogenization temperature of these inclusions in the granite varieties ranges between 275.4 (quartz porphyry) to 470.3 °C. The most of these inclusions homogenized between 350-440° C in the QVs (Fig. 2a).

Aqueous biphase inclusions are characterized by the presence of H_2O in liquid and vapour phases, liquid–gas ratio is variable and liquid is always more than vapour. The shape of the cavity is irregular, inclusions are smaller in size in granites and are subrounded, larger in size in QVs (Fig.1c & 1d in granites and QVs respectively). In the QVs, the degree of fill ranges between 0.70 to 0.90, whereas in granite it ranges between 0.25-0.45.

In the freezing study first liquid appeared between -36.2 to –39.2° C (T_{FM}) in inclusions of the granitic rocks and between -38.1 to –40.3° C in QVs. On further heating final ice melting ($T_{M.\ ice}$) is noted between –8.3 to –20.7° C in granitic rocks with corresponding salinity 12.05 to 23.13, whereas in the QVs ($T_{M.\ ice}$) temperature falls between -11 to –21.9° C, Fig. 2b with salinity ranging between 15.02 to 23.95 equivalent weight percent NaCl. T_h of these inclusions in granitic rocks falls between 260.5 (quartz porphyry) to 467° C in the mica granite, whereas in the QVs this temperature falls between 236.6 to 360° C (Fig. 2c).

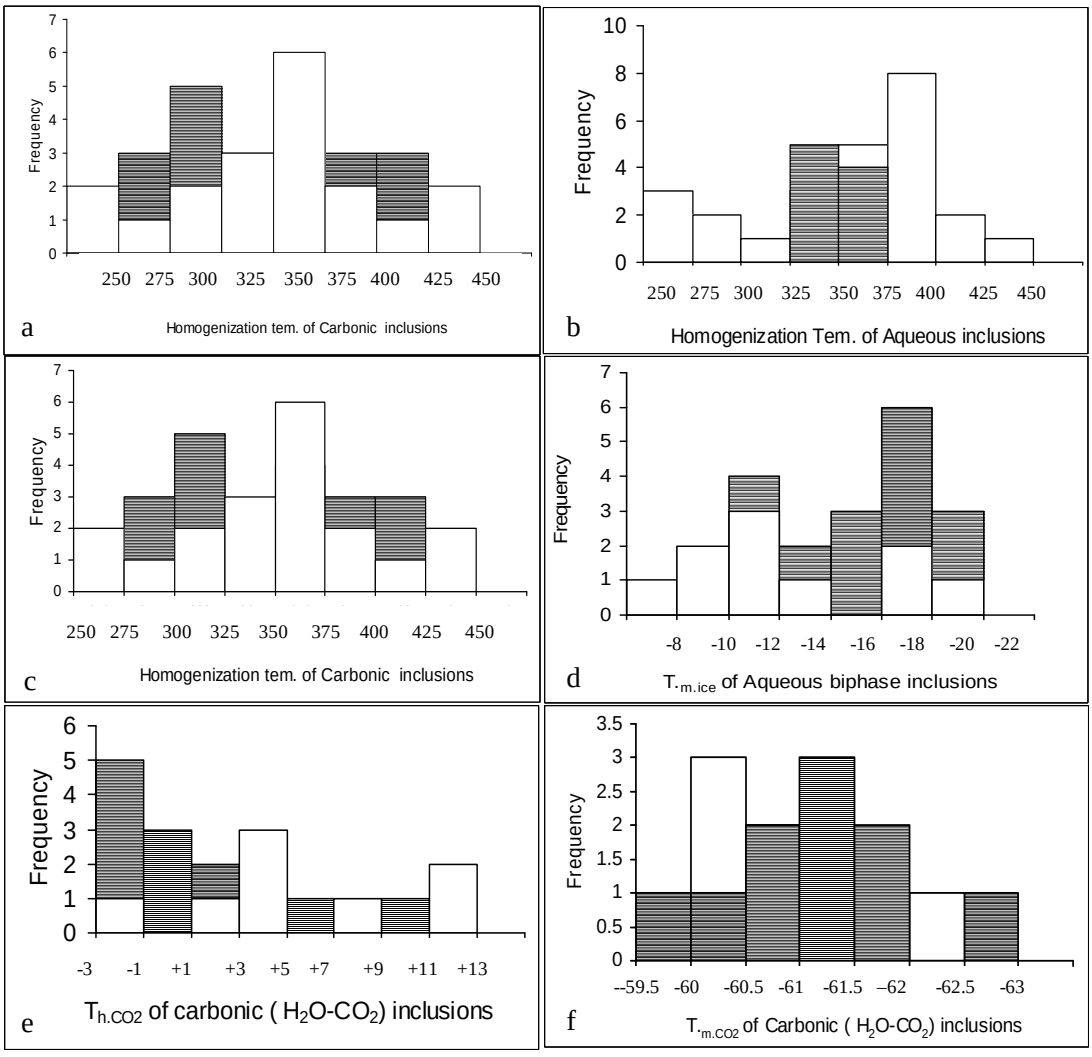

Figure 2. Histogram showing the heating and freezing data plots of the different inclusions types in the granite and quartz veins (MQVs) of the Tosham mineralized body

Aquo-carbonic inclusions Monophase carbonic inclusions are found only in the QVs and have not been identified in the granitic rocks due to their small size. In the quartz veins these inclusions have been identified 2 to 4 µm in size. The aquo-carbonic inclusions consist two immiscible phases (CO_2 and H_2O) at room temperature, which occur as isolated primary inclusions in the granites and mineralized veins with sub- rounded to elliptical in shape. The H_2O: CO_2 ratio fluctuates from inclusion to inclusion. Some inclusions shows high CO_2/ H_2O ratio. The size of such inclusions varies from 10 to 25 microns. (Fig.1e granites & Fig.1f QVs).

The heating and freezing study of the monophase inclusions has not been possible due to their smaller size so only the CO_2-H_2O inclusions have been studied. The T_{FM} is between -36.6 to –40.2° C in granite with final ice melting ($T_{M.\ ice}$) between -8.1 to -21.2° C in the granites and between -38.2 to –40.2° C (T_{FM}) with final ice melting ($T_{M.\ ice}$) between -9.8 to –22.1° C in the QVs. In these inclusions $T_{MCO2,}$ ranges between –58.9 to –61.8° C in the granitic rocks. In QVs the $T_{m.CO2}$ ranges between -60.8 to 62.9° C and mostly -60 to –60.5° C in the granites and –61.5 to 62 in QVs (Fig. 2d). The CO_2 homogenizes ($T_{H.}CO_2$) in the vapour phase between temperature range of –3.1°C to +13°C in the granitic rocks and between –4.4 to +10.1 in the QVs. Clathrate is found in the QVs which dissociates between +1.1 to +5.0° C ($T_{M.}$ clath.). The CO_2 of most of the inclusions homogenizes between +3 to +5 °C in the granitic rocks and -3 to -1°C in QVs. (Fig. 2e). On further heating homogenization of these inclusions took place between 265.4-460.3° C in the granitic rocks and between 275.3 to 405.0° C in QVs Fig. 2f. The salinity of these inclusions ranges from 11.69 to 23.47 in the granitic rocks and between 13.75 to 24.08 in QVs.

Most Melt inclusions contain only one phase at the time of entrapment (silicate liquid), during cooling, that phase may unmix to form a vapor bubble and daughter crystals (Sorby 1858; Roedder 1984). The melt inclusions are observed in the quartz phenocrysts of the coarse-grained granite and quartz feldspar porphyry of the Tosham igneous body. These inclusions contain fluid phase, crystallised silicate-melt inclusions with large gas bubbles in quartz crystals. The shape of the cavity is irregular and ranged in size between 20-30µm (Fig. 1 p & h). The thermometric measurements of these inclusions have not been done yet.

4. Discussion

Presence of different inclusions types in the mineral quartz of the quartz porphyry as well as in the quartz of the mineralized veins, their high homogenization temperature, high salinity, presence of mineralization in veins, physical association of Sn-W-Cu mineralization with the Tosham igneous body, post-magmatic hydrothermal alteration effect established that the hydrothermal solution is responsible for the mineralization in the area. It further supports that the saline brines may represent magmatic fluids exsolved from the granitic magma at the final stages of magma crystallization.

The presence of melts inclusions in the quartz porphyry of the Tosham igneous body indicates an important aspect of magma differentiation in the evolution of the Tosham mineralized igneous body. The presence of the silicate-melt inclusions in quartz phenocrysts of the quartz porphyry of the Tosham indicats the simultaneous trapping of magmatic fluids and silicate melt which further reveals the separation stage of the liquid phase from the melt.

The presence of H_2O-CO_2 inclusions and their homogenization into the liquid and vapor phase at nearly the same temperature indicates the direct result of liquid immiscibility and boiling of aqueous fluids.

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