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COMPARATIVE FLUID INCLUSION STUDIES OF THE SAN MARTÍN SKARN (MEXICO) AND THE EPITHERMAL COMSTOCK LODE (USA) AND PACHUCA-REAL DEL MONTE (MEXICO) DEPOSITS

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ABSTRACT

The San Martin (Mexico), Pachuca-Real del Monte (Mexico) and Comstock Lode (USA) are base-metal and silver deposits within Cretaceous to Tertiary volcano-sedimentary host rocks. The first is a skarn type deposit whilst the second and third are epithermal vein-type deposits. A fluid inclusion study of quartz, sphalerite and fluorite was undertaken to characterize mineralizing solutions which have different compositions and temperatures. Microthermometric measurements were made based on the recognition of changes of two-phase liquid-rich, two-phase vapor-rich and multiphase (NaCl) inclusions during heating and freezing experiments. Homogenization temperatures and salinities of fluid inclusions in quartz and fluorite from San Martin range from 300 to 320 °C and 5.0 to 40 eq. wt. % NaCl based on Tm_{ice} and T_{NaCl}. Halite as a daughter mineral is often present in quartz and fluorite. However in the other districts, the Th and salinity values in sphalerite (Pachuca-Real) and quartz (Comstock) are lower: 265 °C and 3.4 % eq. wt. NaCl and 251 °C and 0.3 eq. wt. % NaCl respectively. Data from a single zoned quartz crystal provides evidence of fluid evolution at the Comstock Lode. Temperatures and salinities observed were 249 °C and 0.6 eq wt % NaCl at the core and 245 °C and 0.1 eq wt % NaCl at the rim. The salinity and temperature of the hydrothermal brines seems to be an important factor in explaining the precipitation of the ore minerals. These deposits are characterized by temperatures <350 °C and salinities from 0.2 to 4.93 wt % eq. NaCl. Estimated pressures and depths range from 41 to 103 bars and 472 to 1394 meters.

Keywords: Fluid inclusions, Microthermometry, Epithermal, Silver-Base Metal Deposits.

RESUMEN

San Martín (Mexico), Pachuca-Real del Monte (México) y Comstock Lode (USA) son depósitos de metales base y plata emplazados en rocas volcanosedimentarias del cretáceo y Terciario. El primero es un depósito del tipo skarn mientras que el segundo y tercero son del tipo epitermal. Un estudio de inclusiones fluidas en cuarzo, esfalerita y fluorita fue desarrollado para caracterizar las soluciones mineralizantes las cuales presentan diferentes composiciones y temperaturas. Las temperaturas de homogenización y salinidad de los fluidos presentes en las muestras de cuarzo y fluorita de San Martín varían entre 300 y 320 °C y 5.0 y 40 % eq. peso NaCl con base en la Tm_{ice} and T_{NaCl}. La Halita como mineral hijo es frecuente en las muestras de cuarzo y fluorita. Sinembargo, en los otros distritos los valores en esfalerita (Pachuca-Real) y cuarzo (Comstock) son relativamente mas bajos: 265 °C y 3.4 % eq. peso NaCl y 251 °C y 0.3 % eq. peso NaCl respectivamente. Mediciones de un cristal de cuarzo zonado evidencian una evolución de los fluidos durante las fases de mineralización en Comstock Lode. En este fueron observadas temperaturas y salinidades de 249 °C y 0.6 % eq peso NaCl en el núcleo y 245 °C y 0.1 % eq wt. NaCl hacia el borde. La salinidad y temperatura de los fluidos hidrotermales parece ser factores importantes que influyen en la precipitación mineral. En general estos depositos se caracterizan por temperaturas <350 °C y salinidades entre 0.0 to 40 % en. peso de NaCl. Las presiones y profundidades estimadas varían entre 41 y 103 bars y los 472 y 1400 metros.

Palabras claves: Inclusiones fluidas, Microtermometría, Epitermal, Depósitos Plata-Metales Base.

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1. INTRODUCTION

The Comstock Lode (USA), Pachuca-Real del Monte (Mexico) and San Martin (Mexico) are well known base-metal and silver deposits. The current research in fluid inclusions focused on selected samples from these deposits. The data presented herein are of preliminary character. This paper presents data obtained directly from fluid inclusions through which salinities and minimum trapping temperature of the fluids are interpreted. Vikre (1989), Dreier (1976), and Rubin and Kyle (1988) have previously measured temperature and salinities in these deposits. These authors also discuss the geological basis for the present study. The aim of this report is to determine the temperatures and compositions of fluid inclusions in quartz, fluorite and sphalerite, and assess the role of the hydrothermal brines in ore genesis.

2. FLUID INCLUSION SAMPLING AND ANALYTICAL METHOD

The current study was developed according to Shepherd *et al.,* (1985), Roedder (1984), and Goldstein and Reynolds (1994). The samples obtained by Dr. Stuart F. Simmons were taken from several localities at Pachuca-Real del Monte (Mexico), San Martin (Mexico) and Comstock Lode (USA). Eight doubly polished plates were prepared and optically examined to catalog the types of fluid inclusions present and to assess the suitability of inclusions for the heating-freezing measurements. The homogenization temperature and ice final melting temperatures were determined using a Fluid Inc. USGS-adapted heating-freezing stage located at the University of Auckland. The accuracy of the measurements was ± 2.0 °C for the Th and ± 0.2 °C for the Tm. The results were plotted on histograms and their distribution analyzed and compared with previously published data sets.

3 GEOLOGICAL SETTING

3.1. Pachuca–Real del Monte District: The Pachuca-Real del Monte District is situated in the south-east of the state of Hidalgo (Mexico), about 90 km north east of Mexico D.F. (FIGURE 1). According to Nolan (1933) this District is a silver-gold district: the ores typically occur in veins localized in faults and are low in base-metal. The overall Ag/Au ratio for Pachuca is up to 200 (Dreier, 1976). In this region, sedimentary and volcanic rocks range in age from Cretaceous to Quaternary (Geyne et. al. 1963). The sedimentary sequence is dominated by Cretaceous siliciclastic rocks of The Mexcala and Mendez Formations and is unconformably overlain by Tertiary volcanic rocks of the Pachuca Group; Zumate Formation, Taranga Formation, Atotonilco el Grande Formation, basalts, and the Navajas Rhyolite. The youngest Quaternary deposit lies at the top of the stratigraphic sequence. The district occurs within the middle and upper part of the volcanic sequence and is cross cut by mainly east-west trending normal faults dipping to the south. Additional information on the stratigraphy and structure of the District are described by Dreier J. E. (1976).

3.2. San Martin District: This deposit is located in the central-west of the State of Zacatecas, Mexico (FIGURE 1). It is a skarn deposit which produces copper, zinc and silver from veins and replacement veins from metasomatized Cretaceous carbonate strata adjacent to an Eocene quartz monzonite intrusion (Rubin and Kyle, 1988). The district lies in the Mesa Central, between two major tectonostratigraphic provinces, where Cretaceous carbonate sequences underlie Tertiary volcanic rocks. In the district, the Cuesta del Cura Formation (Cretaceous) hosts most of the ore bodies. The Cerro de la Gloria Stock (Tertiary) intrudes these sedimentary rocks and ranges in composition from quartz monzonite to granite, granodiorite and porphyry rhyolite. The enclosing contact aureole comprises metamorphic and metasomatic rocks and these have been classified in four distinct zones (Gomez, 1978). Further information on the stratigraphy and structure of the San Martin Deposit are described in Rubin and Kyle (1988).

3.3. Comstock Lode Deposit: This deposit is situated in the Comstock District, Nevada (USA), 24 km south of Reno (FIGURE 1). In this area, metasedimentary, metavolcanic, intrusive and volcanic rocks range in age from Mesozoic to Miocene (Thompson, 1956; Thompson and White, 1964). The Cretaceous quartz monzonite is covered by a Tertiary volcanic sequence made up of the Santiago Canyon Rhyolite tuffs and overlying andesitic to rhyodacitic ash flows and flow breccias of the Alta Formation. The Davidson Granodiorite intrudes this sequence. The

Kate Peak intrusive rocks (porphyritic intrusions) of 12 to 16 Ma in age (Bonham and Papke, 1969; Silberman and McKee, 1972; Whitebread, 1976; Vikre *et al.*, 1988) cross-cut all the older rocks. Nevertheless, the similar age and slightly different chemical compositions suggests a possible comagmatic source with the Davidson granodiorite. (Thompson and White, 1964; Vikre *et al.* 1988).

The Kate Peak extrusive rocks overlie the Alta Formation. They are composed of volcanoclastic rocks of dacitic, rhyolitic and andesitic composition. The Comstock Lode is 13.7 Ma in age and hosted by the Kate Peak and Alta Formations (Vikre *et al.*, 1989). The main structural feature in the area is the Comstock Fault. The main mineralized veins strike in a north east direction almost parallel to the Comstock Fault, but some veins strike in a near east-west direction. The geology and structure of this district is described by Vikre (1989).

FIGURE 1: Location map of the Studied Deposits.

4. FLUID INCLUSION PETROGRAPHY

Primary, pseudosecondary and secondary inclusions were identified. Primary fluid inclusions are those which are present along well-defined growth zones or occur as isolated features. Pseudosecondary inclusions occur as planar arrays along healed fractures, but terminate within the limits of former growth zones; they commonly show equant and flat shapes. Secondary inclusions occur as planar groups along healed fractures that extend to the edge of the host crystals; they have flat shapes and show evidence of necking.

4.1. Pachuca –Real del Monte District: One sample of sphalerite (Sample N8PR) was analyzed. The sample was taken from the Dios te Guia Vein in the 650 level (the deepest). This is 0.1 to 0.7 m wide and is composed of coarse to fine grained quartz (with breccia and crustiform textures), rare calcite, coarse sulfides, sphalerite, galena and pyrite. The Ag content is about 500 g/ton, Au about 1-2 g/ton and Pb and Zn about 1-2 %. Fluid inclusions in sphalerite coexist with numerous solid inclusions of chalcopyrite known as chalcopyrite disease (Barton and Bethke, 1987).

Two types of fluid inclusions were identified: primary and secondary. The microthermometric data were obtained from the primary inclusions. These inclusions are mainly faceted with either hexagonal negative crystal and rectangular shapes. They are randomly distributed, but the hexagonal ones are oriented parallel to the C-axis of the crystal (FIGURE 2a). At room temperature these inclusions range in size from 01 to 0.03 mm and may be classified as two-phase liquid-rich inclusions with a liquid:vapor ratio about 75:25. The secondary inclusions form a planar array along healed fractures and range in size from 0.01 to 0.2 mm. These show evidence of necking and display variable liquid-vapor ratios.

4.2 San Martin District: Fluid inclusions were studied in fluorite, quartz and bladed quartz. In the fluorite (Sample N4SM) and quartz (Sample N5SM) samples, three types of fluid inclusions were identified. At room temperature these comprise: two-phase liquid-rich inclusions; multiphase inclusions (salt saturated inclusions containing up to two daughter minerals plus vapor) and two-phase vapor-rich inclusions (sample N4SM) with a thin film of liquid that lines the inclusion cavity and is difficult to see (FIGURE 2b). The liquid-rich inclusions display a liquid:vapor ratio of about 80:20 while the liquid-vapor ratio in the multiphase inclusions is lower due to the presence of daughter minerals (halite). The coexistence of two-phase liquid-rich inclusions and vapor-rich inclusions indicate that they were probably deposited from boiling solutions (Roedder, 1984). The quartz sample N6SM at room temperature contains only two-phase liquid-rich inclusions and shows a liquid: vapor ratio of approximately 80:20. In the bladed quartz (Sample N7SM), only two-phase liquid-rich inclusions were observed. They show similar liquid-vapor ratios.

Primary fluid inclusions occur in all samples. They occur in growth zones (bladed quartz) or are distributed randomly in the host crystal (fluorite and quartz). In fluorite, these range in size from <0.01 mm to 0.04 mm, and most display rectangular, rounded or irregular shape. However, these inclusions sometimes occupy a planar array and appear secondary in origin. Halite is the main daughter mineral, and it varies from irregular to cubic shape. The inclusions in quartz show irregular, equant, oblate and less frequently negative crystal shapes. These range in size from 0.01 mm to 0.05 mm. In places they occupy a planar array along healed fractures indicating secondary origin. The daughter mineral present is commonly halite (FIGURE 2c). The inclusions in the bladed quartz are primary in origin; this is demonstrated by their zonal distribution across the crystal (FIGURE 2d). They are irregular in shape and range in size from 0.1 to 0.03 mm. Some tabular inclusions are oriented parallel to the growth zones.

4.3. Comstock Lode Deposit: Fluid inclusions were found in quartz crystals from the Kendal Pit. All of the inclusions are primary in origin. Sample N1C shows the zonal distribution of these inclusions (FIGURE 2e). At room temperature, they form two phase liquid rich inclusions displaying a liquid-vapor ratio of about 75:25. They show random orientation and distribution across the crystals and across the individual growth zones. Most of them have irregular shape and range from 0.01 to 0.03 mm in maximum size.

5. FLUID INCLUSION MICROTHERMOMETRY

Microthermometric measurements were made based on the recognition of changes in the solid, liquid and vapor phases in the inclusions during the heating-freezing processes. The homogenization temperature (Th) was determined by observing the gradual decrease in the vapor phase (bubble) on heating until it homogenized to a liquid phase. To determine the ice final melting temperature (Tm_{ice}), the inclusions where cooled to about –120 °C. At this temperature, liquid froze to ice, and the vapor bubble shrinks because of the increasing volume of the ice. The sample was then slowly warmed and the temperature at which the last ice melted (Tmi_{ce}), was recorded. When daughter minerals are present, their final melting temperature (Tm_{NaCl}) were also recorded. Details on this technique are described in Roedder (1984), Shepherd et al. (1985) and Goldstein and Reynolds (1994). The Th was used to estimate the minimum temperature of the fluids at the time the inclusions where trapped. In two-phase liquid-rich inclusions, the salinity (wt% NaCl equivalent) was determined from the Tm_{ice} using the state equation of Bodnar, (1992). In halite saturated inclusions, the salinity was determined from NaCl dissolution temperature using the state equation of Sterner et. al, (1988). Both Th and Tm were measured for the same fluid inclusions.

5.1. Pachuca – Real del Monte District: Two-phase liquid-rich inclusions homogenized between 230 to 280 °C. These are in the range of values measured by Dreier (1976). Tm ranges between –1.0 to –3.3 °C indicating that inclusion solutions are dilute and contain 2.9 to 5.1 eq. wt.% NaC (Bodnar, 1992). The overall trend of increasing salinity with decreasing temperature (FIGURE 3a) suggests that vapor loss concentrated dissolved salts in the residual liquid as occur in active geothermal systems.

5.2 San Martin District: Multiphase fluid inclusions in fluorite (Sample N4SM) homogenized in the range of 149 to 364 °C. This range of homogenization temperature is wider than that of 227 to 319 °C in Rubin and Kyle (1988). The inclusions in quartz (Sample N5SM) homogenized to liquid between 309 to 340° C. The halite final melting temperature (Tm_{NaCl}) from the fluorite sample was impossible to measure because fluid inclusions decrepitated at about 375 °C. In the quartz crystal, the Tm_{NaCl} ranged from 343 to 358 °C. The corresponding salinity for halite saturated inclusions in quartz and fluorite is about 39 and 41% eq wt NaCl, respectively. Although, occasionally a second unidentified daughter mineral (sylvite?) is present. At room temperature, it has rounded edges, but it did not reappear after heating. The final melting temperature of just one crystal at 93 °C was recorded.

Two-phase liquid-rich inclusions homogenized to liquid in the range: 231-311 °C (N4SM), 300-330 °C

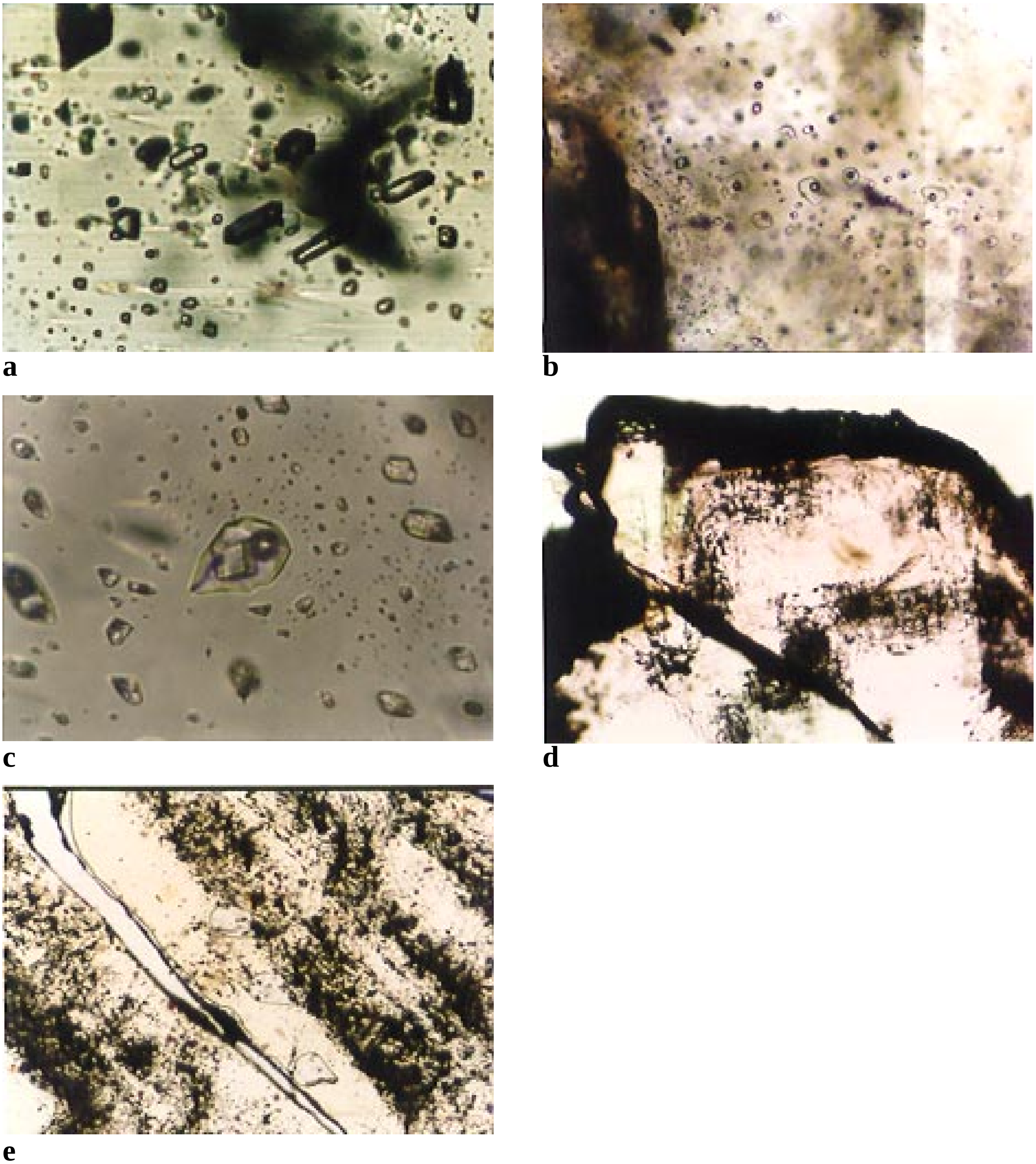

FIGURE 2. (a) Photomicrograph showing the negative crystal shapes, random distribution and parallel orientation of two phase fluid inclusions along the C axis in a sphalerite crystal, sample N8P (Pachuca-Real de Monte). Photo 0.16 mm across. (b) Three types of inclusions in fluorite: Two-phase liquid-rich inclusions, multiphase liquid + vapor + salt and two-phase vapor-rich inclusions, sample N4SM (San Martin). Field of view 0.63 mm across. (c) Photomicrograph of a multiphase inclusion containing perfect cube of halite plus vapor, sample N5SM (San Martin). Inclusion 0.02 mm in width and 0.03 mm in length. (d) Zoned bladed quartz crystal showing the distribution of the primary two-phase liquid rich inclusions. Two main zones can be distinguished, sample N7SM (San Martin). Field of view 0.63 mm across. (e) Zoned quartz crystal showing the distribution of the primary two phase fluid inclusions. Two of the four main zones are visible in this photo. The core is at the lower left part and the rim at the upper right part of the photo, sample N1C (Comstock Lode). Field of view 1.1 mm across.

(N5SM), 300-339 °C (N6SM) and 186-328 °C (N7SM). The Th range in fluorite is close to the range of 163 to 305 °C in Rubin and Kyle (1988). The data scatter in Figure 3b show no systematic trends easily related to boiling or mixing processes. Instead, the wide range of data indicates solutions ranged in Tm_{ice} –0.6 to –7.4 °C and salinities from 0.0 to 10.5 eq wt % NaCl. The Tm_{ice} range for the fluorite is similar to the range of 0 to –5.5 °C in Rubin and Kyle (1988). However, the mean salinity is lower than the value of 8.5 eq. wt. % NaCl reported by the same authors.

5.3. Comstock Lode District: Two-phase liquid-rich inclusions homogenized to liquid in the range of 209 to 280 ºC. The Th median of 251 °C, is lower than the value of 288 ° at Cedar Hill, but higher than the value of 233 °C at American Flat (Vikre, 1989). The Tm_{ice} range between 0.0 and 0.8 °C indicate that inclusion solutions are slightly brackish and contain 0.0 to 1.4 eq. wt.% NaCl (Goldstein and Reynolds, 1994). The homogenization Th and Tm_{ice} data of primary inclusions from four distinct growth zones in quartz (Figures 2e-3c) are plotted in figure 3d. While there is no significant change in temperature (~ 250 °C), the salinity becomes slightly more dilute with time. This evidence suggests that there were successive discrete episodes of quartz precipitation.

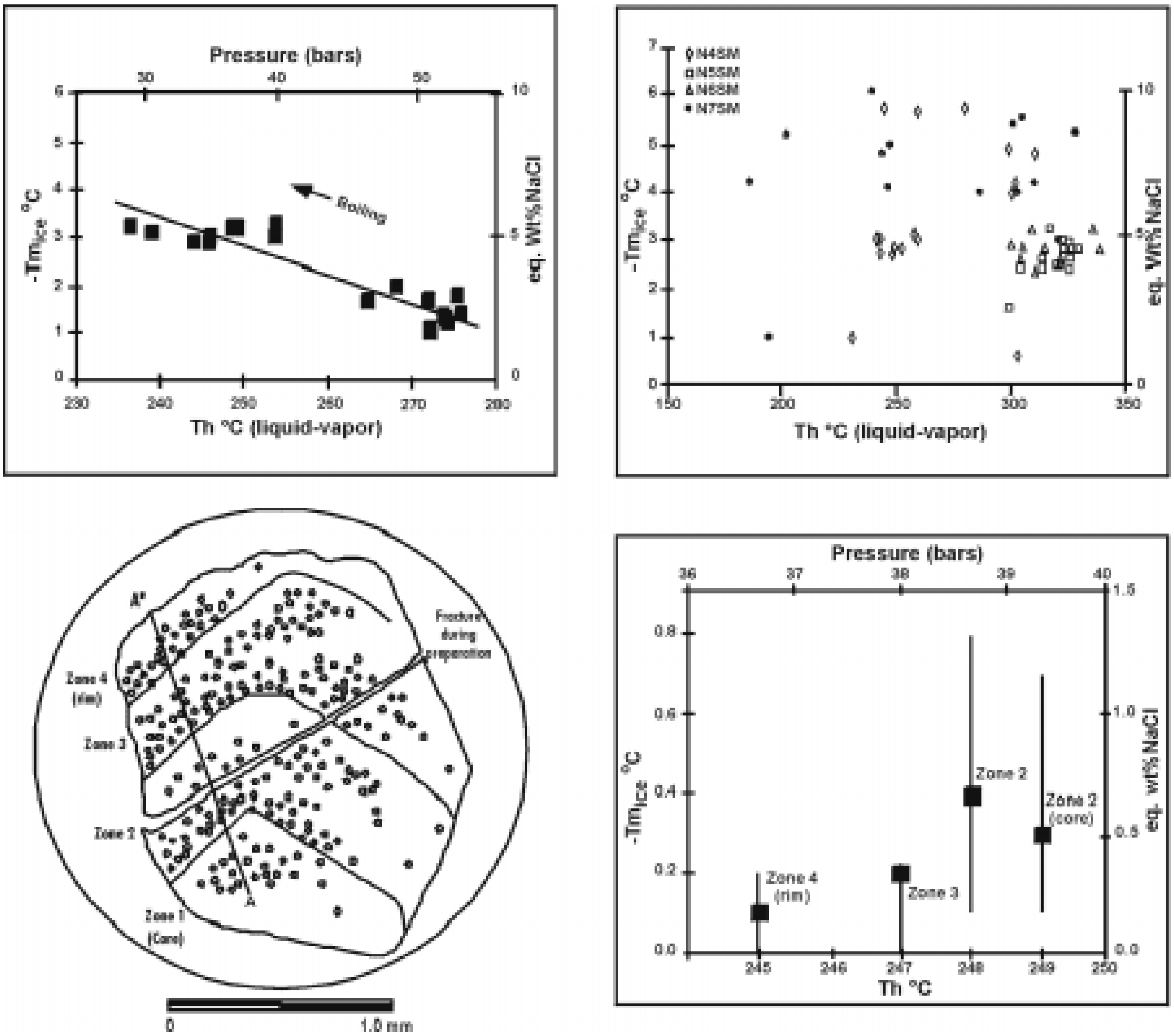

FIGURE 3. (a) Th, Tm_{ice} wt % NaCl of fluid inclusions from Pachuca-Real del Monte. (b) Scatter plot of Th Vs Tm_{ice} and salinity for two phase fluid inclusions in fluorite and quartz, San Martin Deposit. (c)Sketch showing the four growth zones a quartz crystal, sample N1C (Comstock Lode). Measurements along cross section A–A'. (d) Final ice melting temperature, homogenization temperature and salinities in the different zones of the quartz crystal.

6. PRESSURE AND DEPTHS

Part of the aim of this study is to assess the minimum pressures and depths at the time the hydrothermal fluids were trapped as fluid inclusions. Estimated pressures, depths and equivalent densities (TABLE 1) were calculated using the median values of Th and salinity for each sample. Here we assumed that the salt present in the fluids is represented by NaCl and that the pressure in the systems corresponds to a hydrostatic pressure. The hydrostatic pressure and depths were estimated using the boiling curves of Haas (1971).

TABLE 1. Estimated pressure, depth and density for fluid inclusions from Comstock Lode (USA), San Martin (Mexico) and Pachuca-Real del Monte (Mexico).

Deposit	Sample	Temperature (°C)	Depth (meters)	Pressure (bars)	Density (g/cm^3)
Comstock Lode	N1C	251	472	41	0.798
	N3C	255	509	43	0.792
San Martín	N4SM	258	495	44	0.833
	N5SM	322	1394	112	0.722
	N6SM	315	1256	103	0.738
	N7SM	267	533	49	0.867
Pachuca -Real	N8P	265	512	46	0.830

As can be seen from the table above, the data of the two samples from Comstock Lode are only slightly different. Even the zoned quartz crystal (Sample N1C) does not show significant changes in temperature and salinity during the growth of the crystal, the slight variation in pressure (FIGURE 3d) is possibly related to changes in the elevation of the water table due to tectonic, climatic or topographic effects (Simmons, 1991). Estimated pressures and depths of the samples from San Martin may be divided into two groups. Those of high pressure and great depth (N5SM and N6SM), and those of low pressure and shallow depth (N4SM and N7SM). The first group is probably associated with the intrusion of the Cerro de la Gloria stock, whilst the second may correspond to late stages of the fluid migration (away from the intrusive contact) with possibly cooling and mixing in open fractures.

The pressure and depth at Pachuca-Real del Monte are about 46 bars and 533 m respectively. However, the inclusions with relatively high Th and low salinity (2.9 eq wt % NaCl) have pressures about 56 bars while the inclusions with relatively low Th and high salinity (5.1 eq wt % NaCl) have pressures about 36 bars.

7. DISCUSSION OF THE RESULTS

From the above observations, the fluid inclusions from different deposits reflect the multistage evolution of hydrothermal activity during their formation. Careful fluid inclusion petrography and microthermometry of these samples has allowed a partial reconstruction of their fluid history. In general these deposits are characterized by temperatures <350 °C and low salinities from 0.0 to 41 eq. wt. % NaCl. Similar to active geothermal systems, fluid circulation was probably driven by the intrusive heat sources near these deposits. These intrusions may also have contributed some of the water or metals in the fluids (Wetlaufer, 1979; Henley and Ellis, 1983). The Th-Tm data from the three deposits are compared in FIGURE 4. Most of the data fall into three recognizable groups. San Martin shows hotter fluids that are generally more saline than the fluids at Pachuca-Real del Monte and Comstock Lode.

The San Martin District zonation is a reflection of a large-scale temperature gradient associated with the fluid composition (salinity) and probably with the different stages of mineralization. Insights of the earlier stages of fluid composition and temperature are given by inclusion assemblages in fluorite crystals from the Cerro de la Gloria Stock (N4SM).

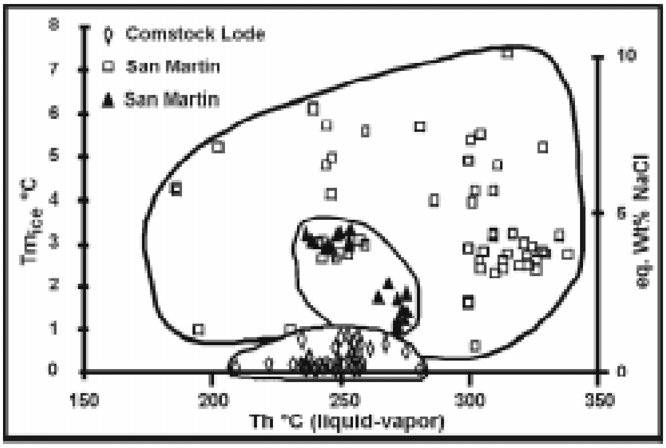

FIGURE 4. Plot of Th Vs Tm for all of the available fluid inclusion data from Pachuca-Real de Monte, San Martin and Comstock Lode Deposits

Furthermore the samples from the San Marcial vein (N7SM) and elsewhere in the district, may be considered to be related to later stages with different rates of mixing and probably associated with mineral deposition.

A simple fluid history in the selected samples of Comstock Lode can be demonstrated by the fluid inclusions study of the single quartz crystal that contains several recognizable growth zones recording at least four stages of fluid inclusions entrapment. These stages in some instances can be clearly correlated with stages of ore mineral deposition. On the other hand, plotting the data of the inclusions in sphalerite from Pachuca-Real del Monte (FIGURE 3a) suggests a boiling trend involving steam loss.

Using the minimum pressure and depth determinations above, two considerations may be deduced. At local scale, variations in pressure suggest that hydrothermal fluids flowed in pulses with mixing and contributing to some of the variation in salinity. These processes may involve different stages of ore mineral deposition associated with variable physical-chemical conditions (these changes favored the ore mineral precipitation). At regional scale these deposits show differences in pressure and depth (TABLE 1). The minimum pressure and depths in the samples from Pachuca-Real del Monte and Comstock Lode are in the range of the typical epithermal deposits (< 1 km). In contrast, the samples from San Martin may be divided in two groups of pressure and depth. Those with pressure >100 bars and depth > 1200 m; and those with pressure <50 bars and depths about 500 m.

8. CONCLUSIONS

The results from San Martin deposit suggest that circulation of aqueous solutions of decreasing temperature and salinity occurred. The highest temperatures and salinities may be synchronous with the emplacement of the Cerro de la Gloria Stock. The lower values reflect probably late stages of mineral precipitation after the intrusive event.

The formation of the zoned quartz crystal at Comstock Lode commenced about 250 °C, at that time the hydrothermal brines were about 0.3 eq. wt. % NaCl. By the final stage of deposition, the temperature dropped to about 245 °C and the salinity about 0.1eq. wt. % NaCl. This clearly reflects a continuous evolution of the fluids during the ore deposition, with decreasing in temperature and salinity. The mean temperatures at Comstock Lode is 251 °C.

Data from Pachuca-Real del Monte show two different conditions during the entrapment of the fluid inclusions. The first at temperatures about 270-280 °C, the second about 240-250 °C. In contrast with the San Martin Deposit, the hydrothermal fluids were less saline suggesting that different factors (i.e. lithology or time), could exert a strong control in the precipitation of ore minerals. However both fluids are in almost the same range, thus this different could be of small significance.

In general, most of the fluid inclusions from the three deposits are characterized by temperatures < 350 °C and low salinities from 0.35 to 4.93 wt% eq. At regional scale, the San Martin Deposit shows the highest temperatures and salinities (304 °C and 3 % eq. wt. NaCl); Pachuca-Real del Monte shows the intermediate values (265 °C and 2 % eq. wt. NaCl) and Comstock Lode the lowest values (251 °C and 0.2 % eq. wt. NaCl).

The results obtained suggest that fluids forming these deposits decreased in temperature and salinity with time as the inclusions were trapped. Changes in pressure also occurred between the different deposits and in the different zones at each deposit. At regional scale, the Comstock Lode deposit is characterized by pressures from 41 to 43 bars and depths from 472 to 509 m according to Haas (1971). The Pachuca-Real del Monte district shows pressures and depths about 49 bars and 533 m, respectively. In contrast, the San Martin district presents two different groups of pressure and depth; one from 103-112 bars corresponding to 1256-1394 m; and the second group from 44 to 49 bars and from 495 to 533 m. Variation in pressure at Pachuca-Real del Monte and Comstock Lode are possibly related with changes in the elevation of the water table due to tectonic, climatic or topographic effects.

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