Hydrosaline melt inclusion provinces in Romania

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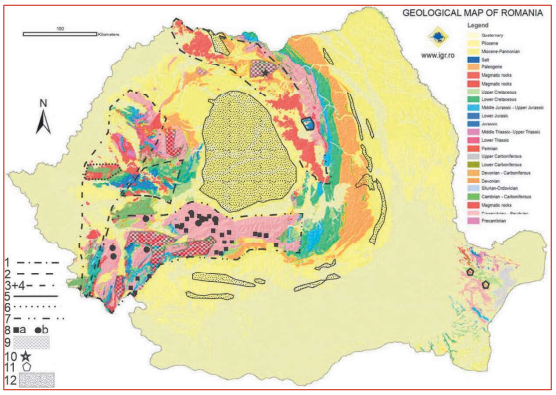
Introduction

This study deals with hydrosaline melt inclusion occurrence and distribution in different geological environments on the Romania's Territory.

Definition: high salinity fluids (26-90 wt% NaCl eq.); Complex brines with $FeCl_2$, $CaCl_2$, NaCl, KCl; hydrosaline chloride liquids; aqueous fluids, simple brines etc (e.g. Kouzmanov & Pokrovski, 2012); **Troom conditions show one or more salt microcrystals inside the aqueous solution or hidrosaline melt phase (daughter phases *vs.* trapped microsolids); Supercritical aqueous salt solutions may equally well be regarded as concentrated brines or hydrous salt melt (**Aranovich & Newton, 1996**); Fused salts are simple ionic salts that are essentially fully ionized (e.g. the halides of alkali and alkaline earth materials** (e.g. Grjothem, 1981)**; Occurrence: magmatic-hydrothermal systems, sedimentary brines, metamorphic fluids or pure solid Inclusions (e.g. halite, sylvite);**



Geological sketch map of the hydrosaline melt inclusions provinces*-, districts and occurrences*** from Romania**

1. Eastern Carpathians: Oaş Gutâi, Ţibleş,Toroioaga, Bârgău, Harghita*; 2. Neogene porphyry copper in Metaliferi Mountains*; 3. Upper Cretaceous porphyry copper and skarns*; 4. Upper Cretaceous Granites and pegmatites from Banat, South and North Apuseni Mountains*; 5. Ditrău alkaline massif; 6. Permian Highiş rhyolites and granites**; 7. Pre-, and Variscan granitoids in South Carpathians***; 8. a. Eclogites and b. granulites in South Carpathians***; 9. Metamorphic pegmatite districts**; 10. Upper Precambrian MVT- carbonate formation in the Rodna-Guşet district**; 11. Proterozoic and Cadomian sulfide deposits***; 12. Submarine halite deposition zones*;**

Examples and characteristics

1. Miocene porphyry Cu-Au-Mo from Metaliferi Mountains

…"this peculiar melt and fluid inclusions association is characteristic for the potassic zone in PTD's from Metaliferi Mountains and must be considered , until now, as unique i.e. "locus tipicus" from porphyry copper alpine metallogeny's perspective." Pintea, 2001

Hydrosilicate melt - hydrosaline melt inclusion microthermometry - Miocene Deva porphyry Cu-Au-Mo deposit (Pintea, 1993; 1996; 2014; 2015; Pintea et al., 2019)

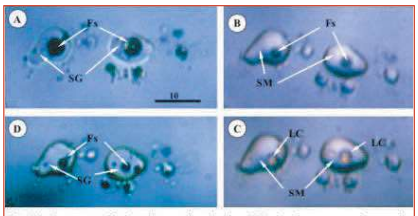


Fig. 74. Sequence of microphotographs showing HT-microthermometry in complex silicate-hydrous salt melts inclusions in quartz from Deva porphyry Cu-Au (Mo) deposit. At room temperature conditions (**A**) the microcavities contains a rich silicate glass and a fluid formed by vapor- rich phase, a halite cube and some opaque. On heating the halite melted around 550°C and at 1085°C (**B**) the fluid bubble is more reduced in volume and contain silicate melt and a dark vapor bubble from which was released around 1267°C a yellow chloride melt (**LC**) surrounded by a vapor film (dark meniscus), (**C**). Back again to the room temperature (**D**) the fluid is redistributed in several small dark bubbles and the microcavities have changed their shape. The final homogenization temperature is impossible to be determined accurately because of the pemanent immiscibility between the two trapped phases, the silicate melt and the hydrosilicate melt, +/- vapor rich. Scale bar in microns (modified from Pintea, 2014a). It should be emphasized that the silicate melt rim appearance in hydrous salt melt inclusions depicted in **Fig 73i**, and the first appearance o the salt melt rim in silicate melt inclusions from this sequence in **B** could be the maximum "normal" trapping temperature of hydrous salt melt inclusions in the porphyry copper systems as already was proved experimentally by Burnham (1979) and reloaded by Becker, 2008 ; Bodnar, 2010. More recently, magmatic control on porphyry copper genesis was published by Audetat and Simon, 2012. Scale bar in µm.

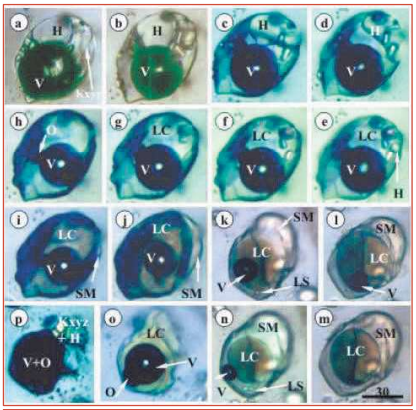
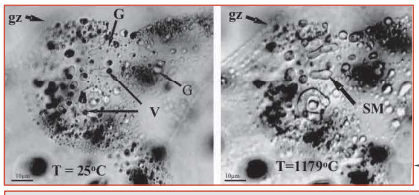


Fig. 73. Sequence of microphotographs showing the complete microthermometric cycle in a hydrous salt melt inclusion trapped in a primary quartz growth zone from Deva porphyry Cu-Au(Mo) deposit (Pintea, 1995b, 2014 modified) **a**. 25°C, **b**. 243°C, **c**. 450°C, **d**. 504°C, **e**. 594°C, **f**. 599°C, **g**. 648°C, **h**. 840°C, **i**. 1086°C, **j**. 1219°C, **k**. 1284°C, **l**. 1317°C, **m**. 1394°C, **n**. 1284°C, **o**. 1062°C, **p**. 25°C. TmNaCl=598°C, Th (melt- V (melt) =1347°C. Other melting temperature recorded for x (Tm_1=113°C), y (Tm_2=122°C, 288°C-sylvite), z (Tm= 602°-840°C), Tmo= 1170°C and remicleated at 1130°C. x, y- chloride hydrates-sylvite solid phase, z- silicate phase(s), and anhydrite-?, O- Fe,Cu sulphide-?, V-Vapor, L_1- chloride liquid, L_2- silicate liquid, g- sulphate globules-?, K- mixture of salt microcrystals remicleated at room temperature.. Experiment duration = 5h. Note: Above ca. 1100°C the microcavity have been seriously damaged and their volume increased probably because the chloride liquid phase have dissolved quartz from the walls, and silicate melt liquid increased also in volume, but chloride part seem to be unchanged during the overheating steps. In this case it was estimated that immiscibility occurred at 1086°C, which could be considered as the real "heterogeneous" trapping temperature of the (L+V) chloride mixture and the silicate melt counterpart (see also Steele-MacInnis and Bodnar, 2013). Scale bar µm.



Cluster of silicate-hydrosaline melt inclusions in quartz zone from Deva porphyry Cu-Au-Mo deposit, at indicated temperatures, G-glass, V- fluid.

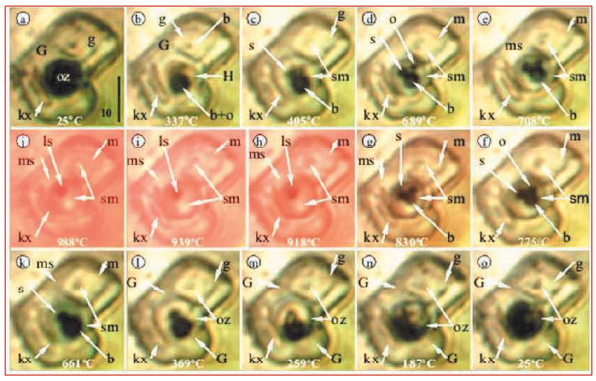
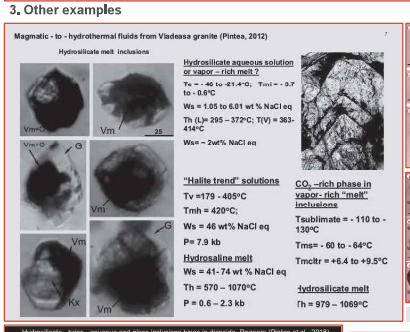


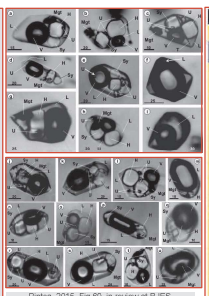
Fig. 6. Silicate melt - salt melt microthermometry showing immiscibility in a glassy inclusion from coarse grain quartz from Oraviţa porphyry Cu-Mo-(Au) prospect (Nicolae adit). Notations: G- glass, g- another glass, kx- anhydrite, H- halite, b- bubble, o- opaque, sm- salt melt, m- another melt, ms- silicate melt, s- sulfide (chalcopyrite), ls- liquid sulfide, oz- ore fluid (bubble+halite+opaque+other phases). Scale bar: 10µm.

P-T-X data from Neogene porphyry Cu-(Au)-(Mo) deposits in Metaliferi Mountains ranged between 320o-1426oC, 0.08-12.8kb, 39-89 wt% NaCl equiv., XNaCl= 0.17-0.64, considering heterogeneous trapping and post entrapment modifications. The Upper Cretaceous porphyry Cu-(Mo)-(Au) deposits in Banat, shown lower data with 150o-300oC, 20-30 wt% NaCl eq., and 1-3 kb pressure (Pintea et al., 2019).

3. Other examples

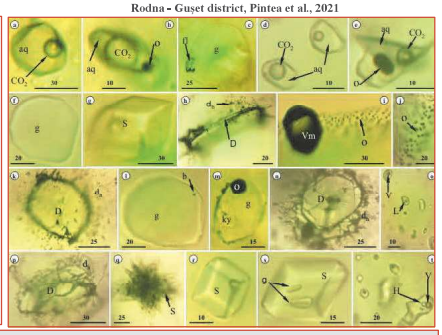


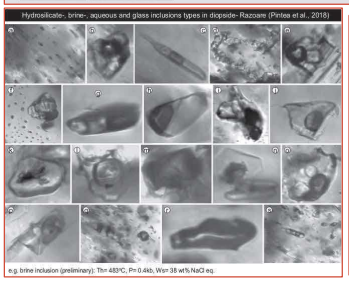
Pintea, 2012

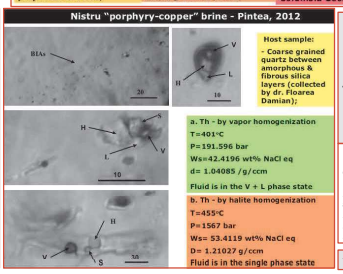


Pintea, 2015, Fig 60, in review at RJES

Rodna - Guşet district, Pintea et al., 2021







Conclusion: The presence and distribution of hydrosaline melt inclusions from Romania allowed us to separate several distinctive provinces, districts and occurrences. Their PVTX characteristics would be a solid database on further transport and depositional processes evolution study from the upper mantle and shallow earth crust in barren and productive geodynamic systems.

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