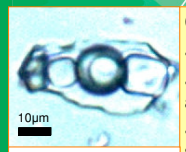
Source and evolution of the Osborne ore fluids

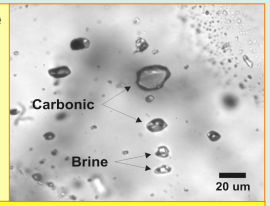
pmd*CRC



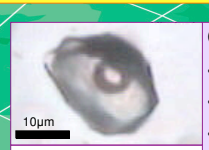
Stage 1

CO_2-bearing Brine

- Rare (<2% of flinc)
- Found in ore stage and pegmatitic quartz
- High salinity (~50% salts)
- CO_2 ± <10% CH_4/N_2



This may represent the earliest fluid in the ore forming system, prior to fluid unmixing or may be a product of fluid mixing. Fluid inclusion trails containing both brine and CO_2 inclusions support unmixing processes which may be trigger ore deposition.



Stage 2b

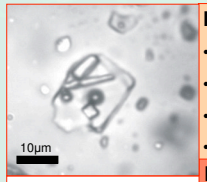
Carbonic Fluid

- CO_2 rich
- Minor CH_4/N_2
- Rare CH_4 rich flinc
- Density 0.68-0.99 g/cm^3

Raman Compositions

	CO_2	CH_4	N_2
Peg.	≥92%	≤0.4%	≤8%
Ore	≥94%	≤6%	-

Often found in inclusion trails associated with multisolid brines, they give trapping pressure estimates of 2-2.5 kbar (6-8km). Different gas ratios measured in carbonic inclusions in ore stage quartz and pegmatites.



Stage 2a

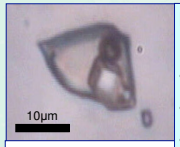
Primary Brine

- Multisolid brines
- <64 wt% NaCl equiv.
- Trapped at 500-650°C
- In silica flooding quartz

Brine composition from LA-ICP-MS (ppm)

	Ore	Peg.
Na	109694	107064
Mg	200	140
K	42976	28388
Ca	23792	20979
Mn	6174	4593
Fe	84803	62593
Cu	43	13
Zn	2343	2333

High salinity primary brine inclusions hosted in early silica flooding quartz. May be associated with hydrothermal iron-oxide precipitation. Often have spatial relationship with CO_2 inclusions.



Stage 3

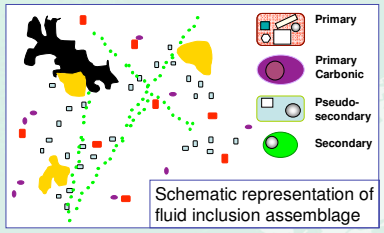
Pseudo-secondary Brine

- 17-34 wt% NaCl equiv.
- Trapped at >400°C
- Radiate from sulphide grains

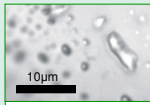
Brine composition from LA-ICP-MS (ppm)

Na	38268	Mn	92
Mg	134	Fe	2502
K	24795	Cu	9
Ca	18473	Zn	30000

Moderate salinity pseudo-secondary brine inclusions hosted in 2nd generation quartz and radiating in trails from sulphide grains. Dominant inclusion type in late stage cross-cutting veins.



Schematic representation of fluid inclusion assemblage



Stage 4

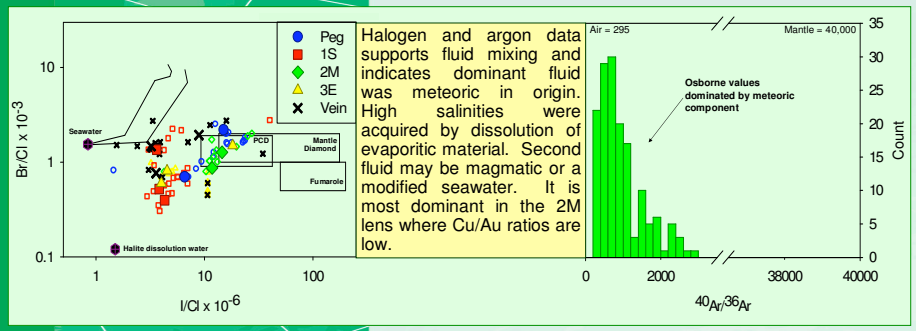
Secondary Brine

- Liquid-vapour flinc
- <12 wt% NaCl equiv.
- Trapped at >200°C
- Typically small

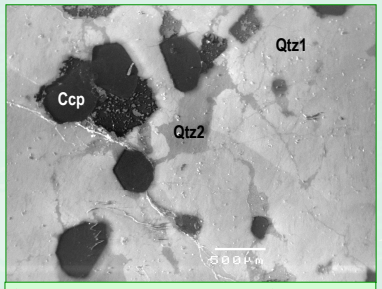
Secondary fluids, trails cross-cut all other features. Probably unrelated to mineral deposition.

Albitisation **Iron-oxide precipitation** **Peak Metamorphism** **2nd generation quartz** **Late-stage veining** **Late fluid flow** **Time**

Silica flooding **Pegmatite anatexis** **Sulphides deposited**



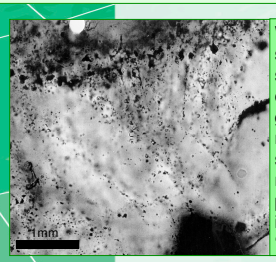
Halogen and argon data supports fluid mixing and indicates dominant fluid was meteoric in origin. High salinities were acquired by dissolution of evaporitic material. Second fluid may be magmatic or a modified seawater. It is most dominant in the 2M lens where Cu/Au ratios are low.



Cathode-luminesence image of Osborne ore. Sulphides are hosted by secondary quartz (dark grey) that cuts through and replaces silica-flooding quartz (light quartz).

Summary

1. The fluid inclusion assemblage at Osborne comprises 5 types of inclusions.
2. The assemblage may document successive fluid flow events or the progressive evolution of a single fluid or mixing product.
3. Halogen and argon data suggests that at least two fluids are implicated in the formation of the Osborne deposit
4. Fluid one is a high salinity evaporite dissolution fluid of upper crustal/surficial origin.
5. Fluid two has a slightly lower salinity and is either of a magmatic or modified seawater origin.
6. If fluid two had a magmatic origin it is required that Osborne lost most of its magmatic $^{40}Ar/^{36}Ar$ signature during an early phase of devolatilization.
7. Variable mixing may account for the variation in redox state and Cu:Au ratios that are observed across the Osborne deposit.
8. The distinction between ore stage halogen signatures and those measured in the moderate salinity fluids (in pseudosecondary fluid inclusions) in late stage quartz veins suggest the presence of a third fluid or the evolution of the mixing product.



Within the Osborne Ore samples trails of pseudo-secondary inclusions are observed along sulphide grain boundaries and radiating from the sulphide grains. Thus the moderate salinity fluids preserved in these inclusions may represent 'spent' ore fluids.

CRC AUSTRALIA

predictive mineral discovery

Cooperative Research Centre

Louise Fisher
James Cook University
Mark Kendrick
University of Melbourne

Phone: +61 7 4781 5572
Fax: +61 7 4725 1501
Email: louise.fisher@jcu.edu.au
www.pmdcrc.com.au