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# Iron-rich melts, magmatic magnetite, and superheated hydrothermal systems: The El Laco deposit, Chile

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## Appendix DR1. Calculation of volume of fluid needed for a hydrothermal origin for the El Laco magnetite-apatite deposit.

The calculation of the amount of fluid needed to form a deposit of magnetite as massive El Laco with 1.5 Gt of magnetite ore has been calculated following the lever rule assuming the complete separation of an aqueous phase at 950°C from a crystallizing andesite originally having 3% wt $H_2O$ (Stern et al., 1975; Burnham, 1979) and does not include significant amounts of water in hydrous magmatic minerals such as mica or amphibole that may also be present. The initial magmatic fluid is assumed to have a salinity of 7 wt% NaCl eq. (Heinrich et al., 2004) and it exsolves at low pressure in two immiscible high and low density aqueous fluids, respectively. The brine has between 40 and 60 wt% $FeCl_2$ as measured from Koděra et al. (2014) in brines separating from a diorite melt. Density of the andesite is assumed to be 2.8 g/cm$^3$ and that of magnetite 5 g/cm$^3$.

**References cited**

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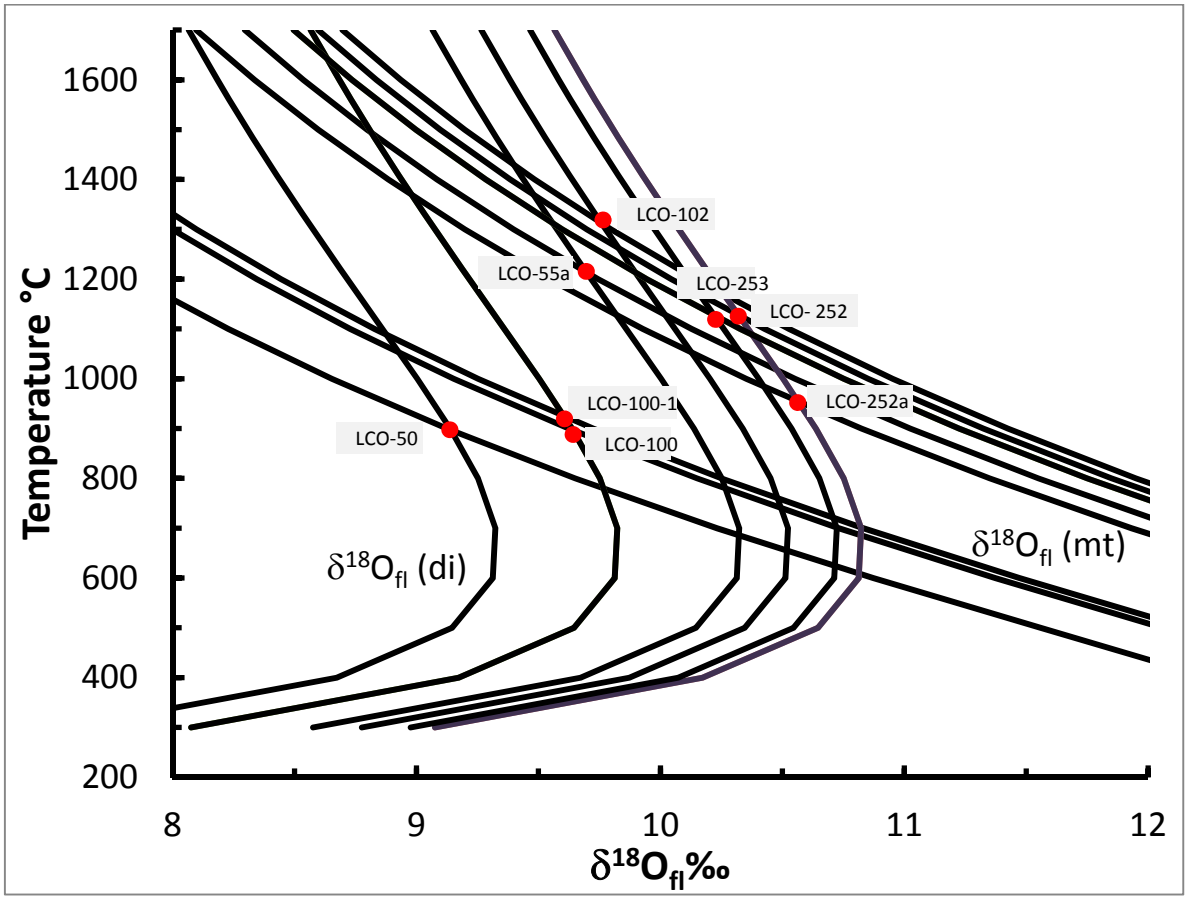


Figure DR1: Temperature vs calculated $\delta^{18}O_{fluid}$ for diopside-magnetite pairs estimated from the isotope values and the fractionation factors in Table DR1. The pairs give internally consistent temperatures despite the steep slope of the $\Delta_{mt\text{-}H2O}$ and $\Delta_{di\text{-}H2O}$ curves at high temperatures. Most estimated temperatures cluster around 900 and 1150 $^{o}$C.

Table DR1. Stable isotope data for El Laco ores and related rocks.

| Sample | Description | $\delta^{18}O_{SMOW}$ (‰) | | | T°C ($\Delta_{mt-di}$) |
|---|---|---|---|---|---|
| | | Whole rock | Magnetite | Diopside | |
| LC-13 | El Laco - pre-ore andesite | 7.4 | | | |
| LC-33 | El Laco - post-ore andesite (plug) | 8.4 | | | |
| LC-34 | El Laco - post-ore andesite (plug) | 9.6 | | | |
| LC-35 | El Laco - post-ore andesite (plug) | 7.5 | | | |
| LC-36 | El Laco - post-ore andesite | 7.7 | | | |
| LC-37 | El Laco - post-ore andesite | 8.7 | | | |
| LC-38 | El Laco - post-ore andesite | 8.1 | | | |
| LC-6 | El Laco - massive magnetite stratabound ore | | 4.7 | | |
| LC-7 | El Laco - massive magnetite stratabound ore | | 4.9 | | |
| LC-8 | El Laco - massive magnetite stratabound ore | | 4.4 | | |
| LC-8a | El Laco - massive magnetite stratabound ore | | 4.4 | | |
| LC-8b | El Laco - massive magnetite stratabound ore | | 4.8 | | |
| LC-9 | El Laco - massive magnetite stratabound ore | | 4.6 | | |
| LC-9a | El Laco - massive magnetite stratabound ore | | 4.8 | | |
| LC-9b | El Laco - massive magnetite stratabound ore | | 4.8 | | |
| LC-10 | El Laco - massive magnetite stratabound ore | | 5.0 | | |
| LC-11 | El Laco - massive magnetite stratabound ore | | 4.6 | | |
| LC-11a | El Laco - massive magnetite stratabound ore | | 4.6 | | |
| LC-24 | El Laco - massive magnetite intergrown with apatite dykes | | 4.5 | | |
| LC-25 | El Laco - massive magnetite intergrown with apatite dykes | | 4.5 | | |
| LC-26 | El Laco - massive magnetite intergrown with apatite dykes | | 4.5 | | |
| LC-26b | El Laco - massive magnetite intergrown with apatite dykes | | 4.3 | | |
| LCO-50 | Veins diopside-magnetite-anhydrite | | 4.4 | 7.2 | 897 |
| LCO-55a | Veins diopside-magnetite-anhydrite | | 6.3 | 8.2 | 1213 |
| LCO-56 | Veins diopside-magnetite-anhydrite | | | 8.1 | |
| LCO-100 | Veins diopside-magnetite-anhydrite | | 4.9 | 7.7 | 897 |
| LCO-100-1 | Veins diopside-magnetite-anhydrite | | 5.0 | 7.7 | 924 |
| LCO-102 | Veins diopside-magnetite-anhydrite | | 6.7 | 8.4 | 1312 |
| LCO-105 | Veins diopside-magnetite-anhydrite | | | 7.8 | |
| LCO-252 | Veins diopside-magnetite-anhydrite | | 6.6 | 8.7 | 1126 |
| LCO-252a | Veins diopside-magnetite-anhydrite | | 6.1 | 8.7 | 953 |
| LCO-253 | Veins diopside-magnetite-anhydrite - magnetite | | 6.5 | 8.6 | 1126 |

Notes: Analyses of stable isotopes were obtained at the Servicio General de Isótopos Estables, Universidad de Salamanca, Spain. Error is better than ±0.1‰ and the estimated temperature is ±50°C. Fractionation factors from Zheng and Simon (1991) for magnetite (mt)-$H_2O$, Zheng (1993) for diopside (di)-$H_2O$ and Zhao and Zheng (2003) for andesite-$H_2O$. Equilibrium temperature obtained from the comparison between the $\Delta_{mt-H2O}$ and $\Delta_{di-H2O}$.

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