Isotopic study of Gallium in meteoritic and terrestrial samples

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Introduction

Although it is considered to be a moderately siderophile element, **gallium is abnormally enriched in the mantle (4ppm)** compared to other moderately siderophile elements. Therefore it is usually assumed that there is **little or no Ga in the core** (e.g. McDonough 2003). The over-abundance of Ga in the mantle puts **constraints on the condition of formation of the Earth and on the core-mantle differentiation**. Ga also has a relatively **low condensation temperature**, hence may be useful for **constraining the volatilization history**. Since these processes may lead to fractionation of gallium isotopes, documenting the isotopic composition of Ga in terrestrial and extraterrestrial samples may help us identify the Earth and understand history of the volatile elements.

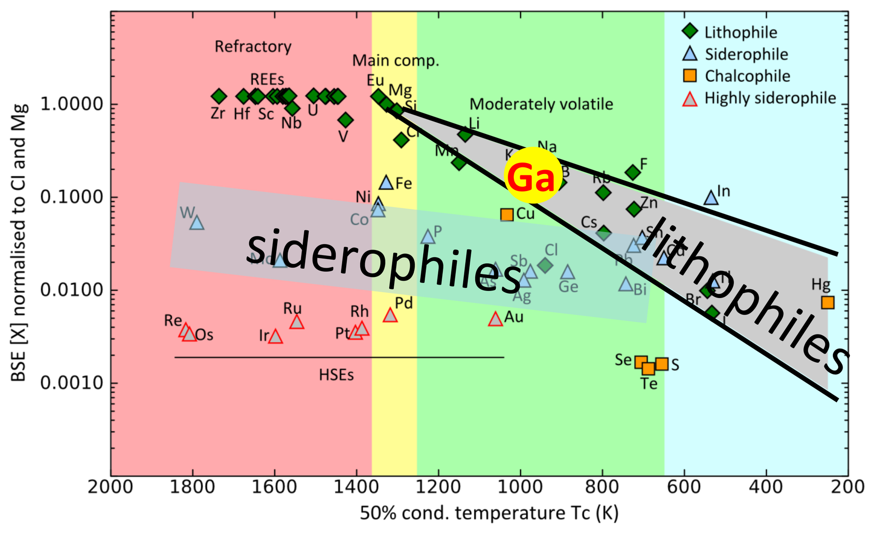


Figure from Paul Savage, pers. Comm. Adapted from data in McDonough (2001)

Method

<u>Ga isotopes:</u> ^{69}Ga (60.1%), ^{71}Ga (39.9%)

<u>Ga purification:</u> For isotopic analysis, **Ga needs to be purified**. The most important elements to remove are **Fe (matrix effect) and Ba (interference)**. This requires a 3 step column chromatography: 1st step: remove all elements but Fe; 2nd step: remove Fe (repeated 3 times depending on sample); 3rd step: remove Ba

Chromatography results: 100% recovery of Ga, >99% Fe removed, >90% Ba removed. Ba removal is not always sufficient and data correction for $^{138}Ba^{++}$ interference is applied.

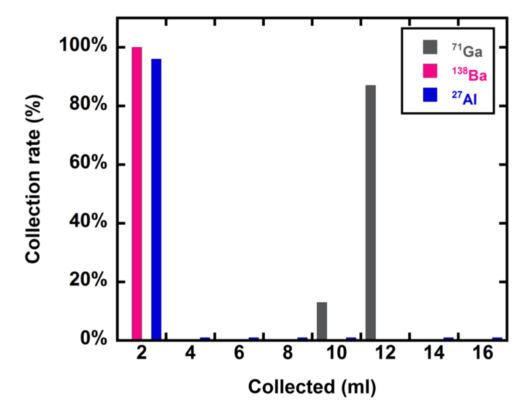
<u>Instrument:</u> Thermo-Fisher Neptune Plus multi collector inductively coupled plasma mass spectrometer (MC-ICP-MS) at Washington University in St Louis/IPGP.

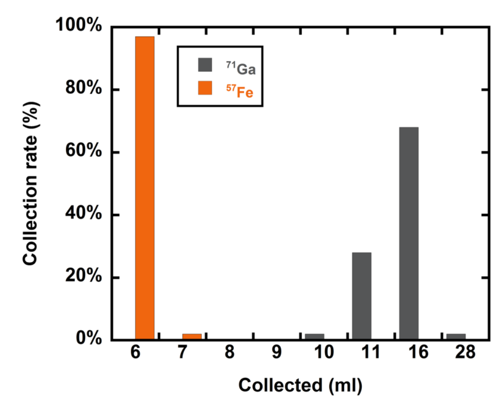
STD: Ga ICP STD.

<u>Analytical precision= 0.05‰ (2SD)</u>

STD: Ga ICP STD.

$$\delta^{71}Ga = \left[\frac{(^{71}Ga/^{69}Ga)_{SAM}}{(^{71}Ga/^{69}Ga)_{STD}} - 1\right] \times 1000$$

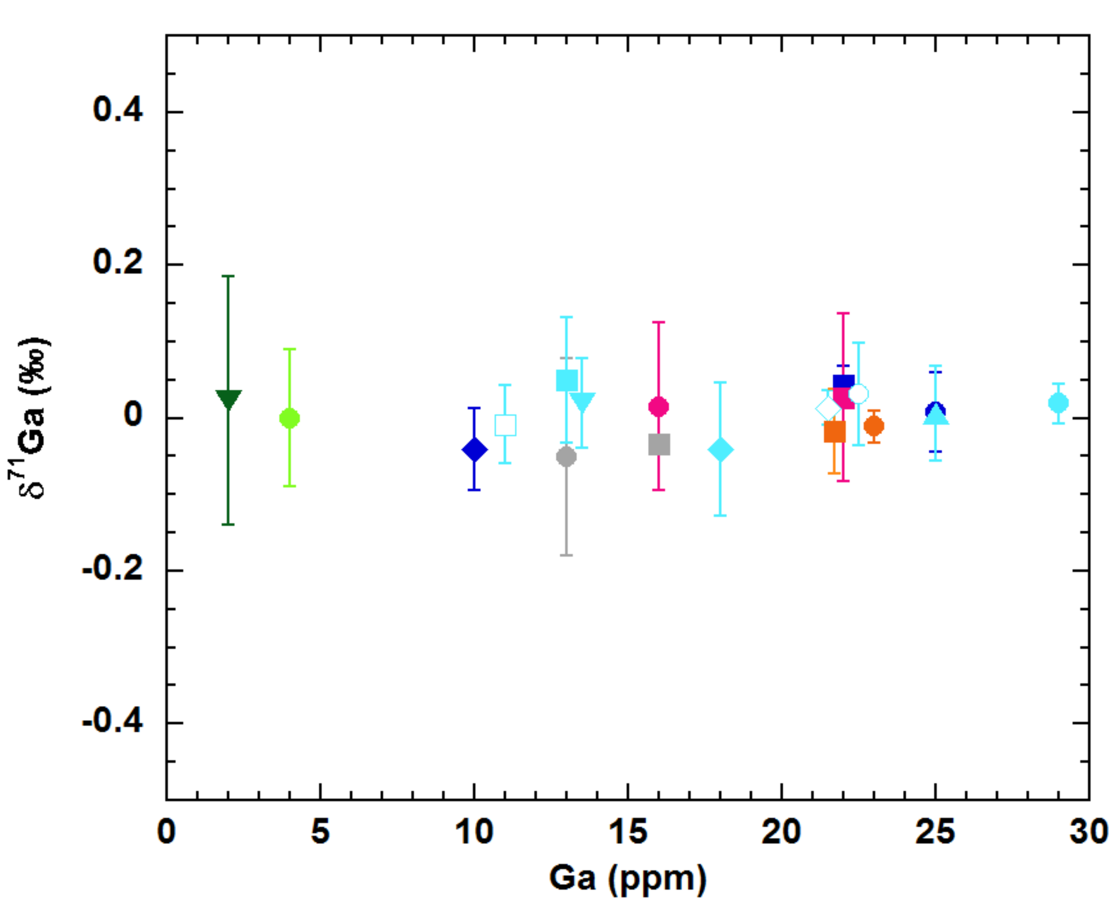


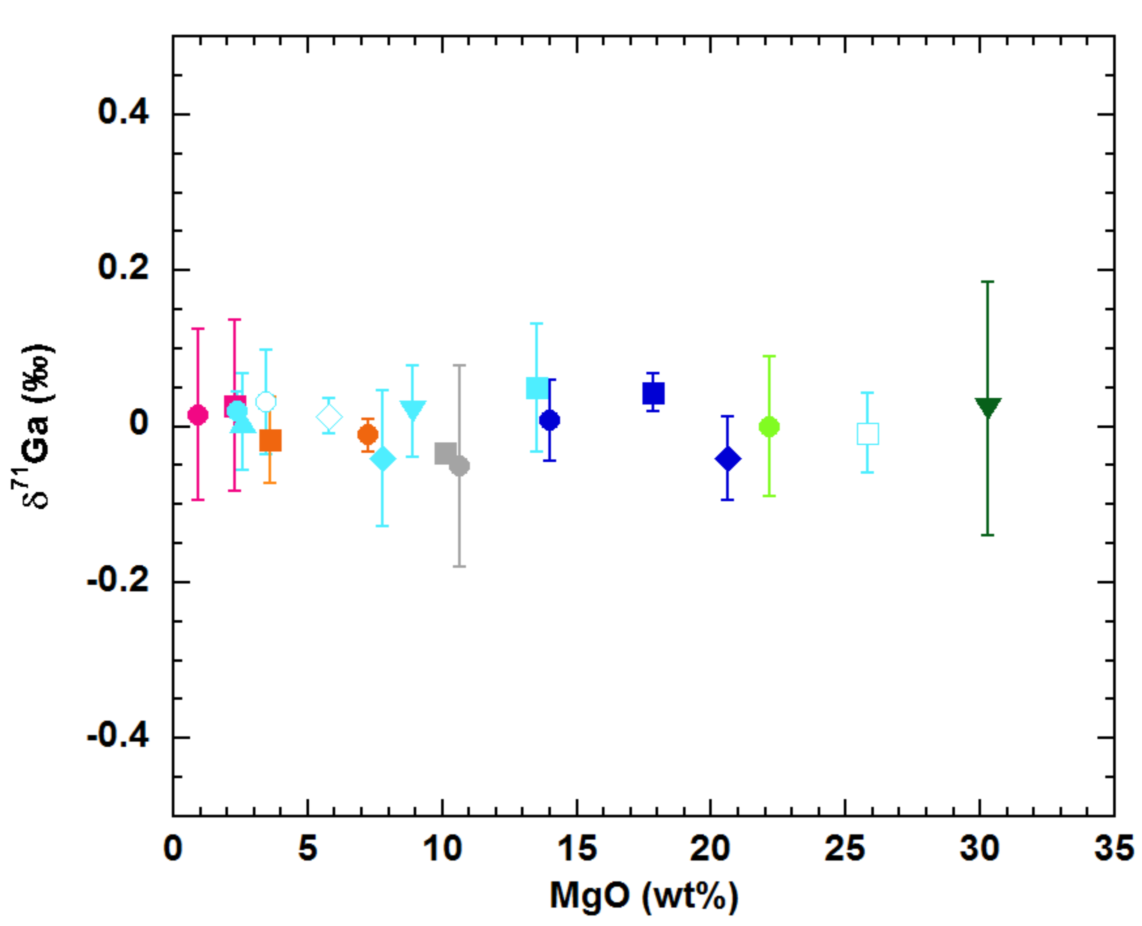


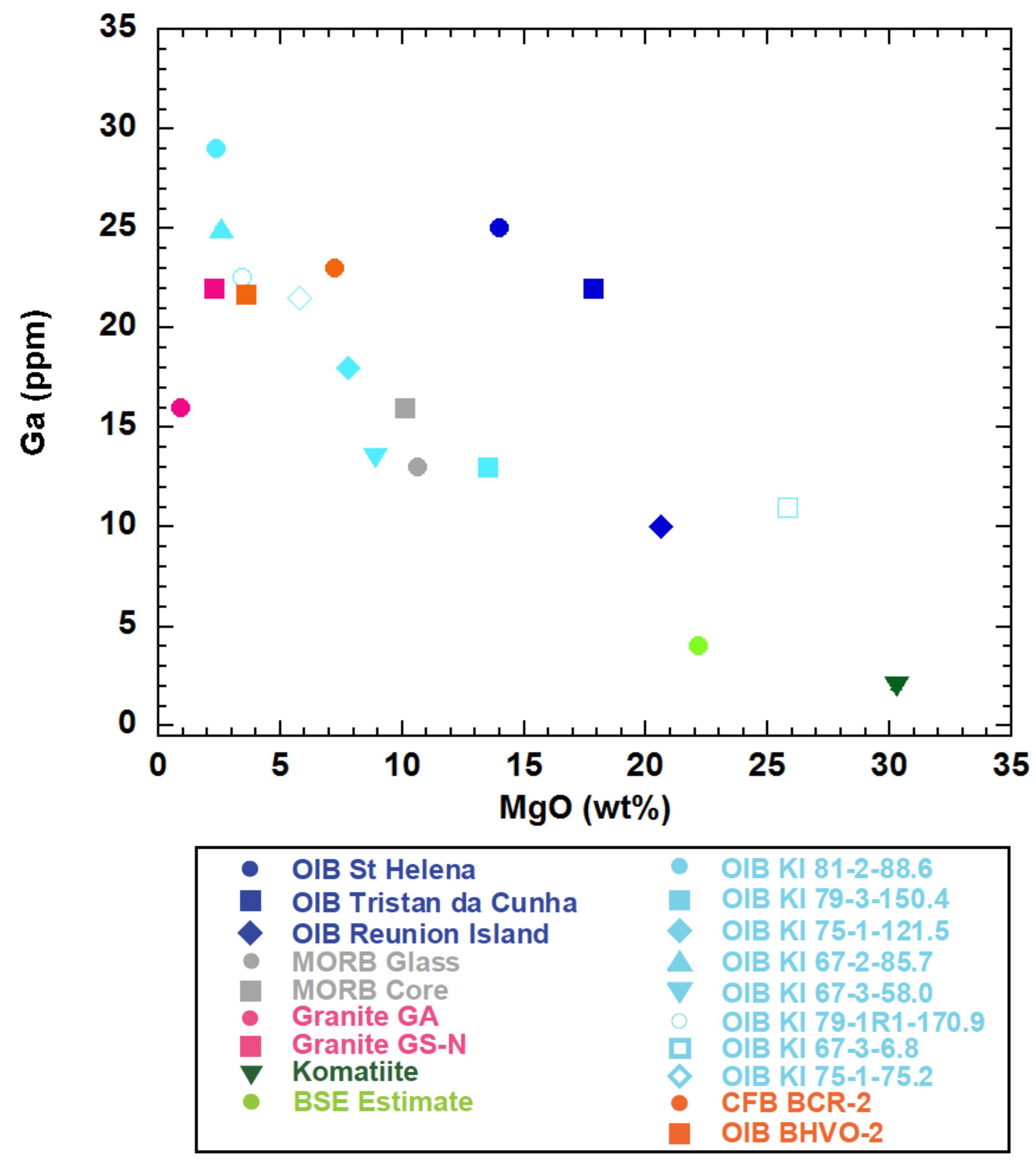
Collection yield of the 2nd and 3rd chemistry and column

Results and Discussions

1) Bulk Silicate Earth for Ga

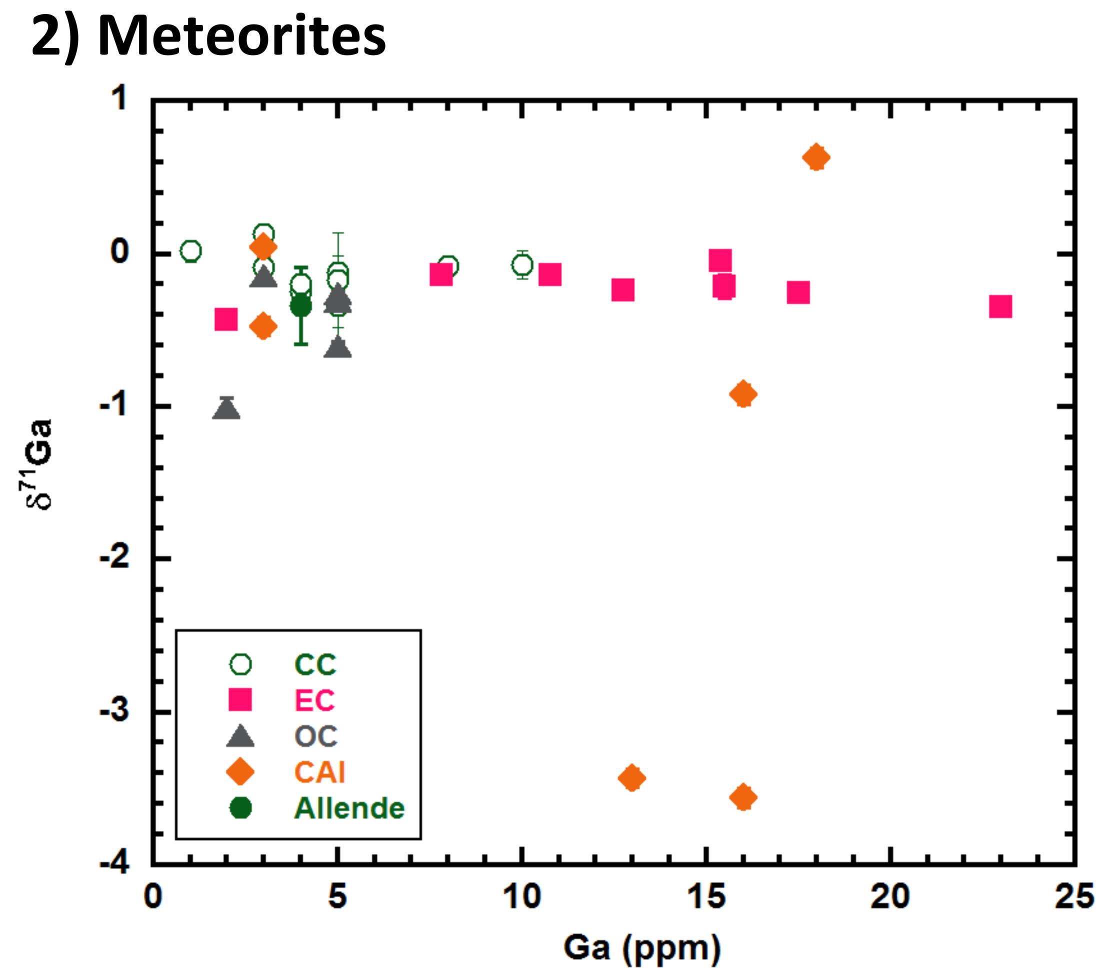


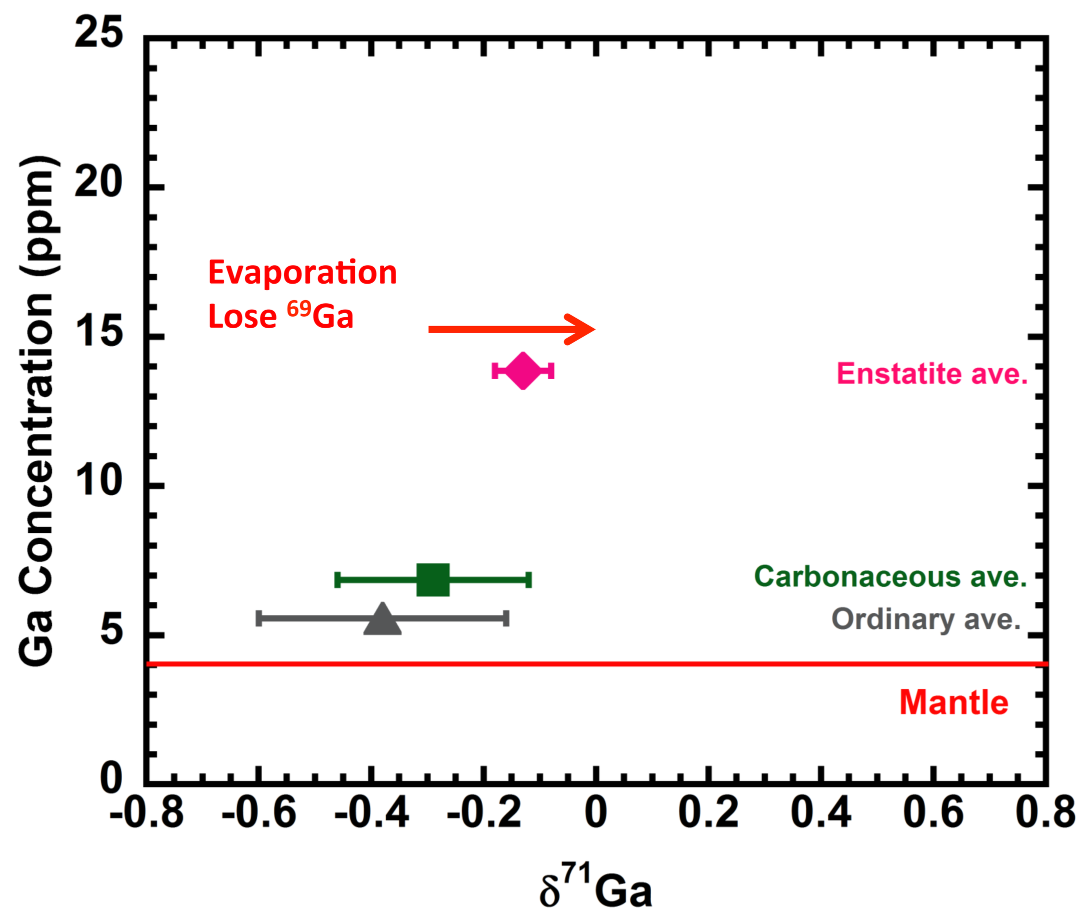




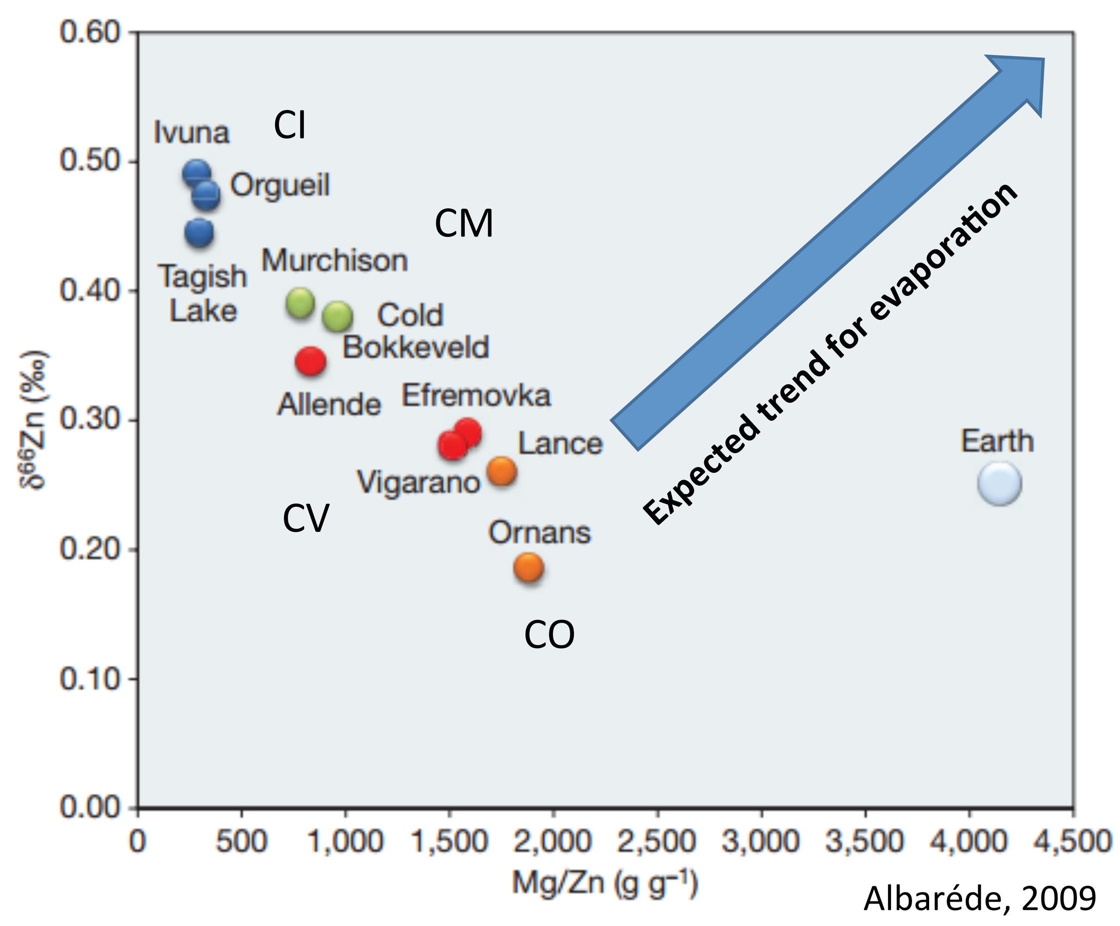
- Samples: OIB, MORBs, Komatiite, Granites
- Bulk silicate Earth value: δ^{71}Ga = 0.00 ± 0.05 ‰
- All samples δ^{71}Ga agrees within error
- **→limited effect of magmatic differentiation on δ^{71}Ga**
- Therefore, **it seems that no Ga fractionation occurs between crust- mantle differentiation**.

2) Meteorites

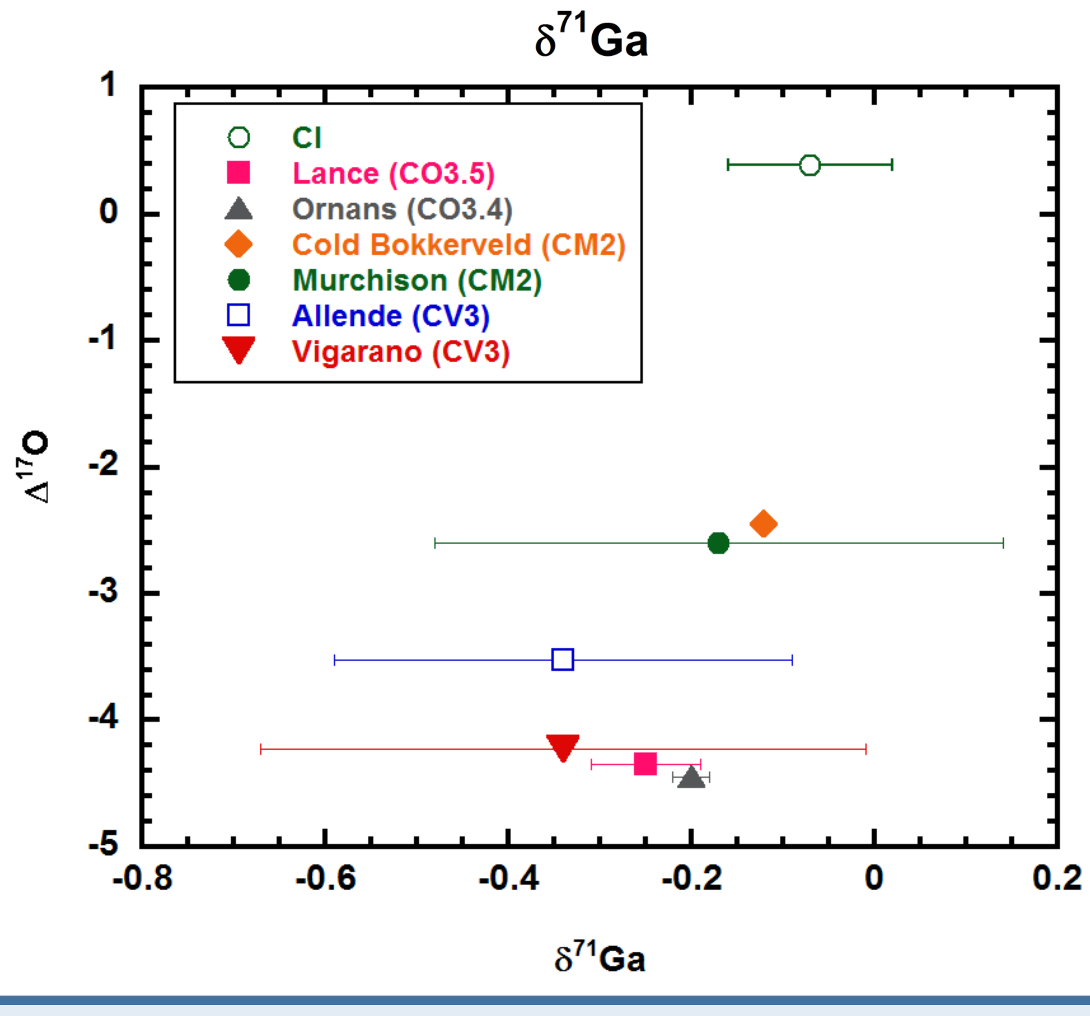




- Samples: Carbonaceous (11), Ordinary (6, Antarctic Meteorites = Find), Enstatite (8)
- All of the meteorite samples are isotopically lighter compared to the Bulk Silicate Earth
- Is this due to evaporation?
- Volatility trend: Rich CI > CM > CO > CV poor
- Carbonaceous chondrite types do not follow a volatility trend
- Same can be observed with Zn isotopes
- Zn T_{50} = 726 K Ga T_{50} = 968 K
- Mixing of two end members?



Albarède, 2009



Conclusions

- Bulk silicate Earth value: δ^{71}Ga = 0.00 ± 0.05 ‰
- **→limited effect of magmatic differentiation on δ^{71}Ga**
- **Carbonaceous, ordinary, and enstatite chondrites are isotopically lighter** compared to the **Bulk Silicate Earth**
- Carbonaceous chondrites **do not follow a evaporation trend**
- **The cause for this trend is unknown**

Refs. Corogne et al., 2008, *GCA*, 72, 574-589; McDonough, 2003, *Treatise on Geochemistry*, 547-568; McDonough, 2001, *The Composition of the Earth*; Albaréde, 2009, *Nature*, 461, 1227-1233