

## GERMANIUM ISOTOPIC DISTRIBUTION IN ORDINARY CHONDRITES: INFERENCE ON OXIDATION STATE OF PARENT BODIES.

G. Florin<sup>1</sup>, B. Luais<sup>2</sup>, T. Rushmer<sup>3</sup>, O. Alard<sup>4</sup>, <sup>1,2</sup>CRPG Nancy, France (gflorin@crpg.cnrs-nancy.fr, luais@crpg.cnrs-nancy.fr), <sup>3,4</sup>Macquarie University Sydney, Australia (Tracy.Rushmer@mq.edu.au, olivier.alard@mq.edu.au)

**Introduction:** Ordinary chondrites (OCs) are undifferentiated meteorites composed of an assemblage of primitive components that underwent thermal metamorphism on their parent body. The three H, L, LL groups of OCs are distinguished by an increase in oxidizing conditions from the H group to the most oxidized L and LL groups. That has been highlighted by  $\Delta^{17}\text{O}$ -%Fa correlation and decrease in metal content from H (~8%) to LL (~2%) [1]. They are also characterized by an increase in germanium content [2, 3], a moderately siderophile and volatile element, which is also sensitive to redox conditions [4]. All these features have led authors to argue that the three OCs groups would at least come from three different parent bodies [1, 5]. On each OC parent body, decay of  $^{26}\text{Al}$  and  $^{60}\text{Fe}$  triggers thermal metamorphism and results in texture, mineralogy and chemistry modifications. They define petrographic types that range from the unequilibrated type 3 to the highly equilibrated type 6. This has been modeled in an "onion shell" structure [6], or through impact and reassembly mechanisms [7]. In order to precise thermodynamic conditions of formation, as well as nebular versus parent bodies processes, we have investigated germanium elemental and isotopic variations of metal, silicate and sulfide phases in H, L and LL ordinary chondrites.

**Samples and methods:** Fifteen ordinary chondrites, 8 H, 6 L and 1 LL, have been chosen to represent all petrologic types (from 3 to 6 grade) and various shock stages. About 500mg of each meteorite samples have been processed for Ge elemental and isotopic measurements of bulk and metal, sulfide and silicate separated fractions. Metal and silicate, sulfide, bulk fractions have been dissolved in concentrated  $\text{HNO}_3$ ,  $\text{HF}+\text{HNO}_3$  medium, respectively. Then germanium purification from Fe-Ni and silicate matrices has been completed using cationic (AG 50W-X8 hydrogen form) and anionic (AG 1W-X8 chloride form) resin following Luais protocol [8, 9]. Germanium isotopic measurements have been performed at the CRPG, Nancy, France [8, 9] using the NeptunePlus MC-ICP-MS coupled to a hydride generator system. Ge isotopic composition is reported as  $\delta^{74/70}\text{Ge}$  ratios with respect to NIST 3120a Ge standard solution. We report a long-term reproducibility of  $2\text{SD}\approx 0.1\text{‰}$  on  $\delta^{74/70}\text{Ge}$  of Ge standards and geostandards.

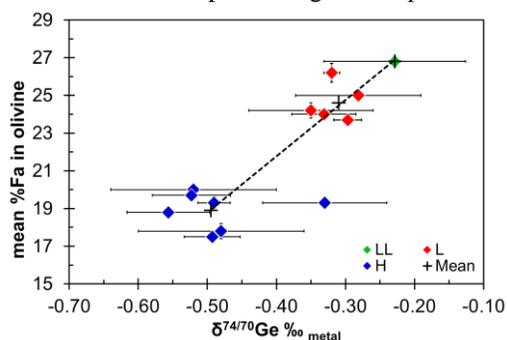


Figure 1:  $\delta^{74/70}\text{Ge}_{\text{metal}}$  vs %Fa olivine in OCs

H3 to H6 groups.  $\delta^{74/70}\text{Ge}$  of bulk, metal and silicate in H6 cannot be distinguished, reflecting metal-silicate isotopic exchange triggered by an increase in oxidation and temperature.

The  $\Delta^{17}\text{O}$ -%Fa correlation defined for three OCs groups has been explained by an increase of accreted oxidizing agent from H to LL [1]. Figure 1 displays a similar correlation between  $\delta^{74/70}\text{Ge}$  in metal and %Fa in olivine; the same correlation also exists between  $\delta^{74/70}\text{Ge}$  and  $\Delta^{17}\text{O}$  (not shown there). During post-accretion heating, metal underwent a gradual oxidation that is a function of the proportion of oxidizing agent accreted, which allows metal-silicate exchange and gradual re-equilibration from H to LL. This process triggers an increase of  $\delta^{74/70}\text{Ge}_{\text{metal}}$  from H to LL parent body. A high  $\delta^{74/70}\text{Ge}$  of the oxidizing component can be proposed. As variation of oxygen isotopic composition in the accretionary disk is a function of heliocentric distance [10], we similarly suggest that  $\delta^{74/70}\text{Ge}$  increases with distance from the sun. Thus, H parent body has been formed closest from the sun in the driest zone, L parent body in an intermediate zone and finally LL parent body in the furthest and  $\text{H}_2\text{O}$ -rich zone. In the light of these new data, Ge isotopes can be recognized as novel tracers of redox conditions in the accretion disk.

**References:** [1] Rubin A.E. (2005) *GCA* 69: 4907-4918. [2] Chou C. & Cohen A.J. (1973) *GCA* 37: 315-327. [3] Chou C. et al. (1973) *GCA* 37: 2159-2171. [4] Schmitt W. et al. (1989) *GCA* 53: 173-186. [5] Clayton R.N. et al. (1991) *GCA* 55: 2317-2337. [6] Weiss B.P. & Elkins-Tanton L.T. (2013) *Annu Rev Earth Pl Sc* 41: 529-560. [7] Monnerieu M. et al. (2013) *GCA* 119: 302-321. [8] Luais B. (2007) *EPSL* 262: 21-36. [9] Luais B. (2012) *Chem Geol* 334: 295-311. [10] Yang L. (2011) *LPS XLII*, Abstract #1602.

**Results and Discussion:** We present the first Ge isotopic measurements of bulk and separate phases (metal, sulfides and silicates) of selected H, L and LL OCs. Bulk, silicate and sulfide isotopic measurements have been carried on the H group while L and LL have been analyzed for metal only. Bulk of H chondrites display  $\delta^{74/70}\text{Ge}_{\text{mean}}$  of  $-0.51 \pm 0.16\text{‰}$ , silicates have mean values of  $-0.67 \pm 0.33\text{‰}$  whereas sulfides are characterized by the lightest  $\delta^{74/70}\text{Ge}_{\text{mean}}$  value of  $-1.60 \pm 0.2\text{‰}$ .  $\delta^{74/70}\text{Ge}$  values for metal increase from  $-0.49 \pm 0.15\text{‰}$ ,  $-0.31 \pm 0.06\text{‰}$  to  $-0.23 \pm 0.1\text{‰}$ , from H, L to LL group respectively (Figure 1). We record no significant variation in  $\delta^{74/70}\text{Ge}$  values of the metal phase with metamorphism in H and L chondrites.

However,  $\Delta^{74/70}\text{Ge}$  values between metal and silicate decrease from