Nickel isotopes variations in natural systems and implications for their use as a geochemical tracer

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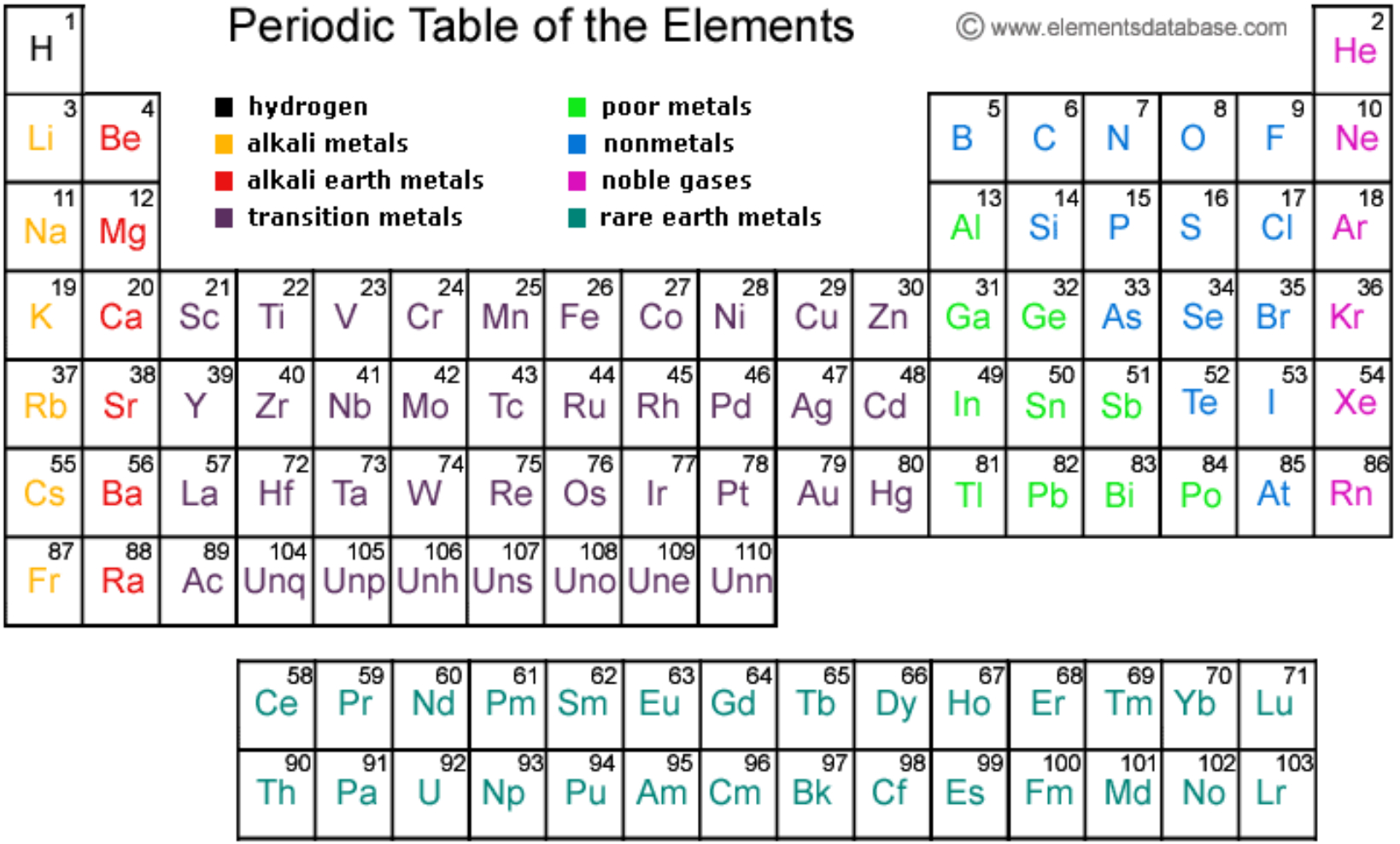
Introduction : what do we know about Ni isotope systematics ?



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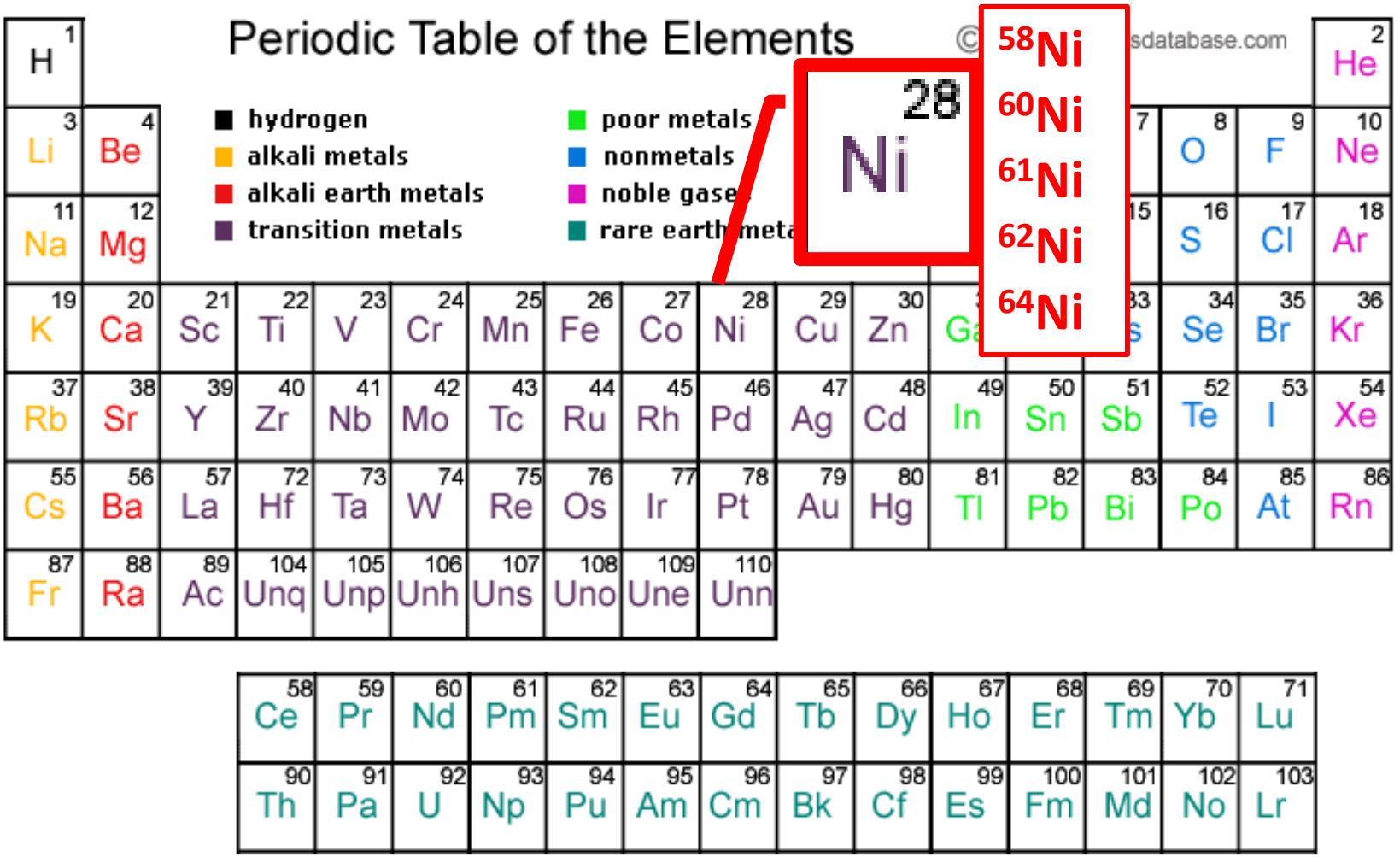
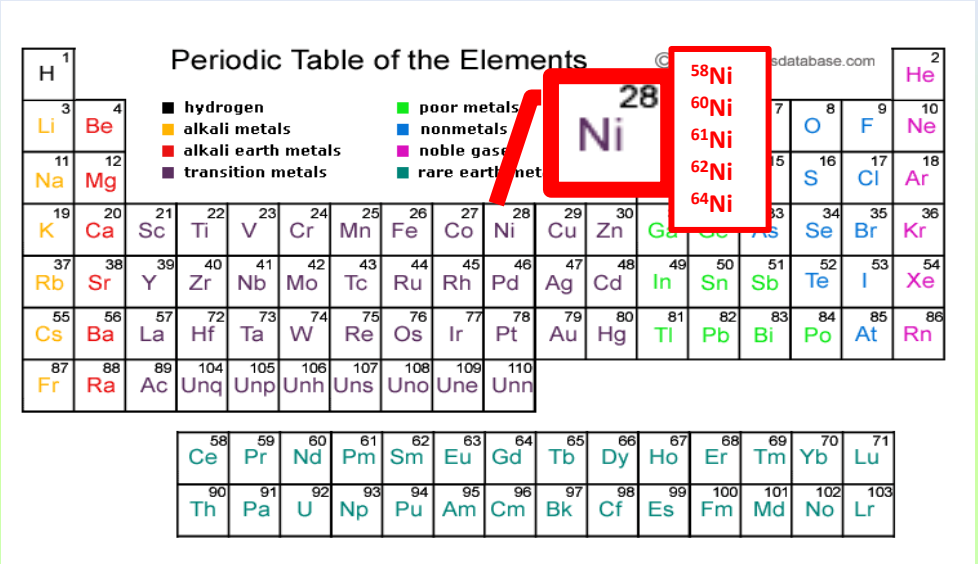


Introduction : what do we know about Ni isotope systematics ?

- Ni isotope studies in extraterrestrial rocks :
→ nucleosynthetic processes (Quitté et al. (2006), Tanimizu et Hirata (2006), Cook et al. (2007), Moynier et al. (2007),…)

- Negative fractionation between metal and silicate (Huh et al., 2009)

- Enzyme co-factor : Ni fractionation in methanogens (Cameron et al., 2009)



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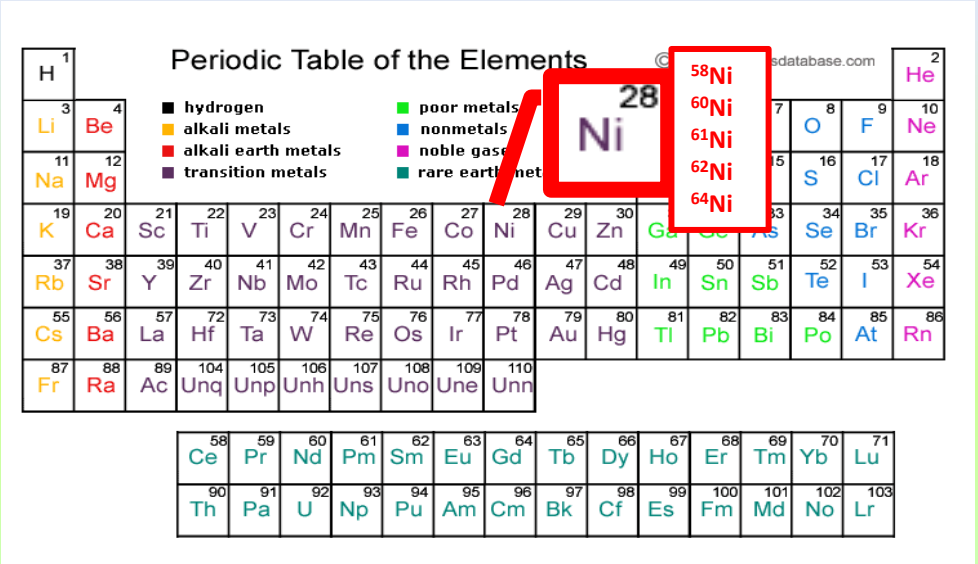

Very little is known about Ni isotope composition in terrestrial rocks formed at both high and low temperatures

Introduction : how Ni isotopes fractionate in terrestrial rocks ?

• High temperature fractionation in terrestrial rocks ?

→ ubiquitous distribution in Earth's rocks
→ ore deposits
→ compatible element during magmatic processes






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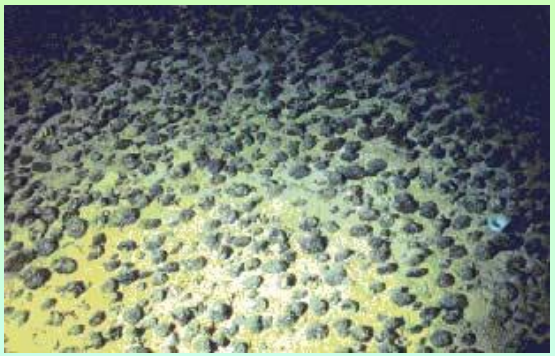
• And low temperature fractionation ?

• Oceanic and paleoceanographic studies

→ nutrient-type profile in seawater (plankton uptake)
→ methanogens biosignatures ?
→ oceanic metalliferrous deposits



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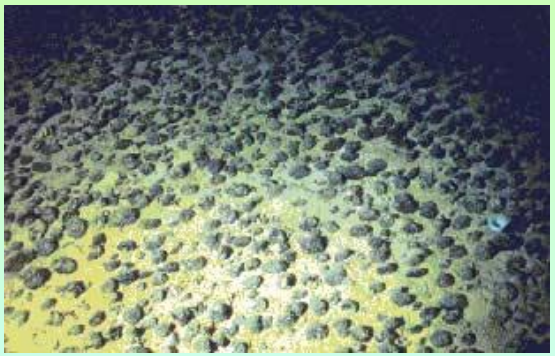

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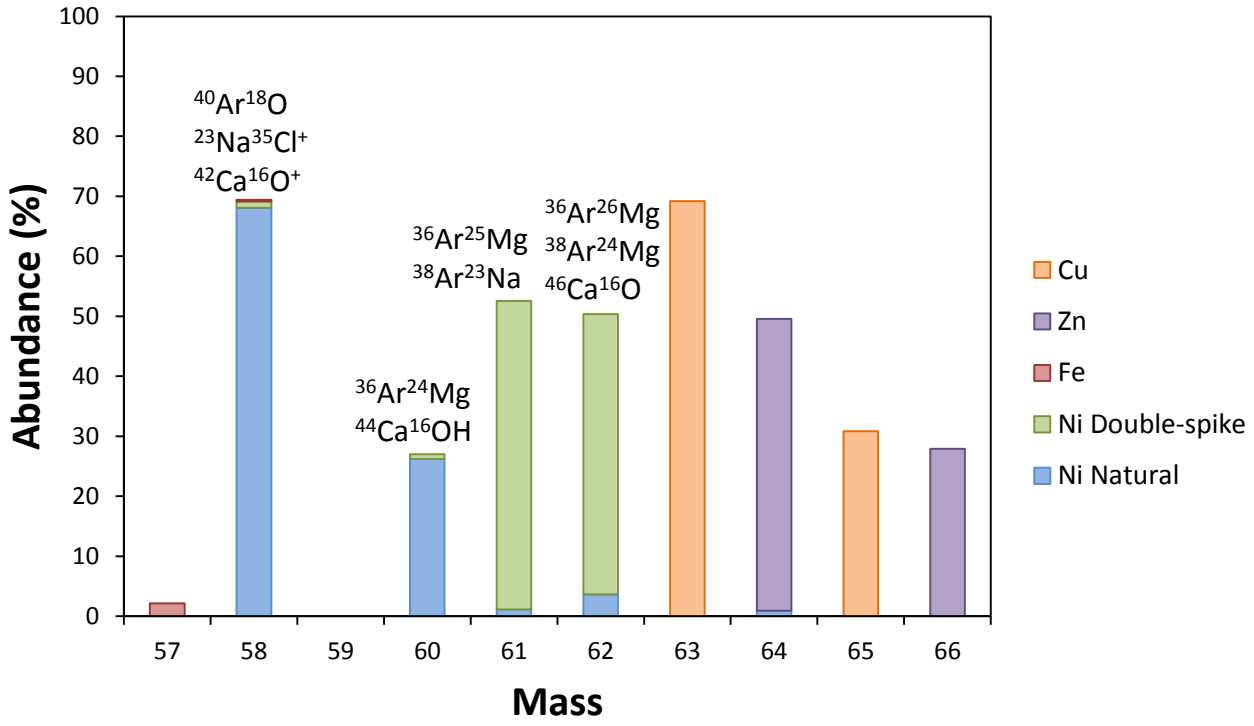
Require an appropriate experimental and analytical protocol for all type of rock matrices and Ni concentrations

Analytical and experimental developments

- Ion-exchange chromatography columns

- Two-steps separation procedure :

→ Anionic resin AG1-X8
→ Ni specific resin
→ yield > 85%

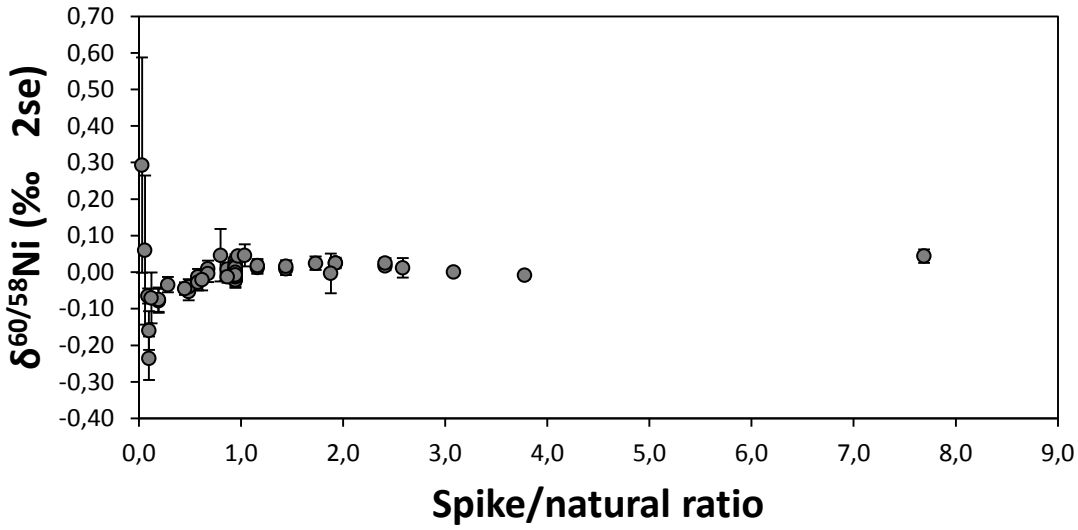


- Measurements of ^{58}Ni, ^{60}Ni, ^{61}Ni,^{62}Ni, ^{57}Fe (for correction on ^{58}Ni) by multi-collector ICP-MS in medium resolution

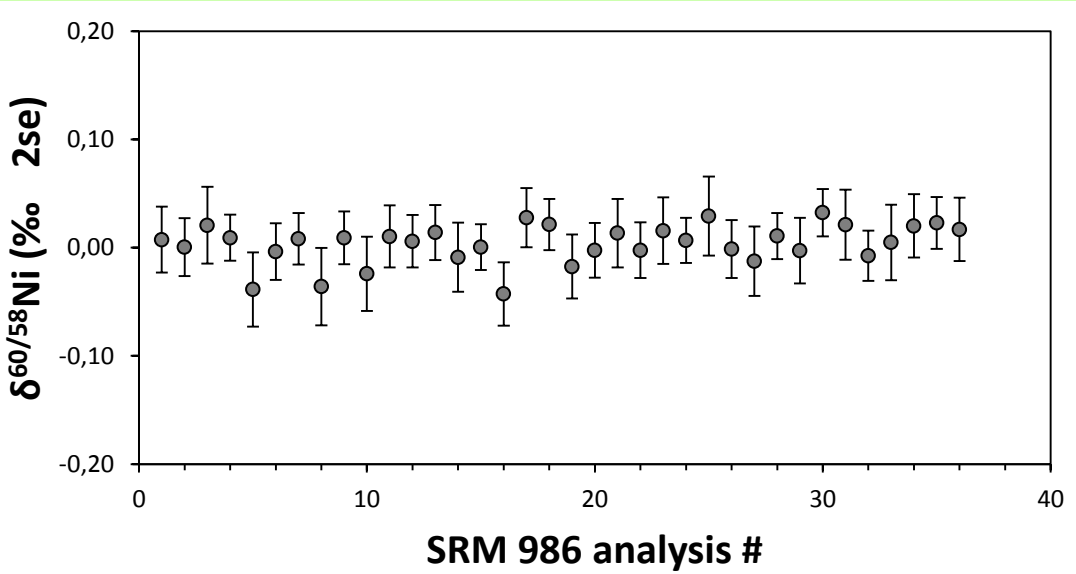
- Correction of instrumental mass bias by the double-spike method
→ ^{61}Ni and ^{62}Ni isotopes mixture

Analytical and experimental developments

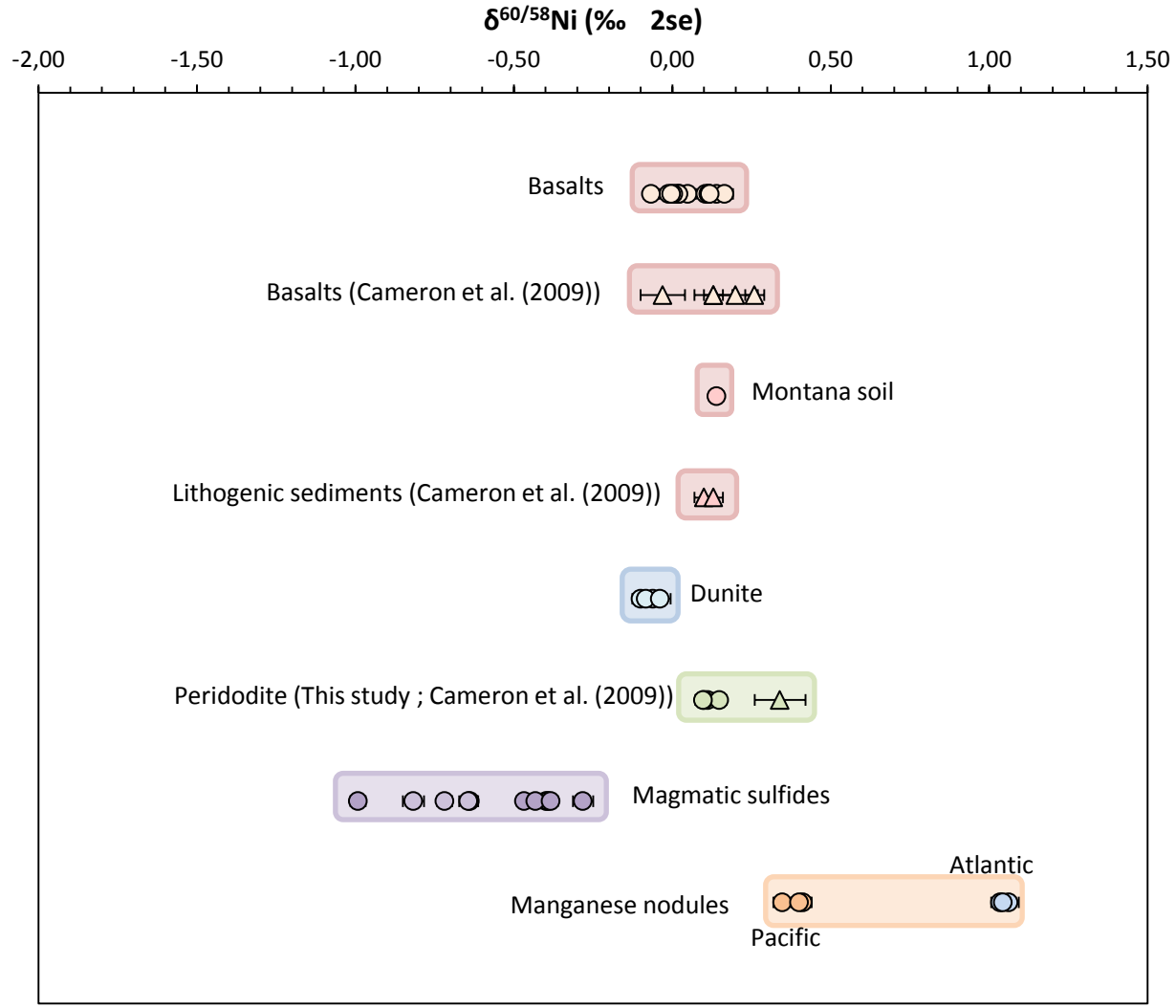
- International isotopic standard NIST SRM 986 for Ni



High precision :
2 sigma error of samples clusters around 0.03‰



Assessing the Bulk Silicate Earth



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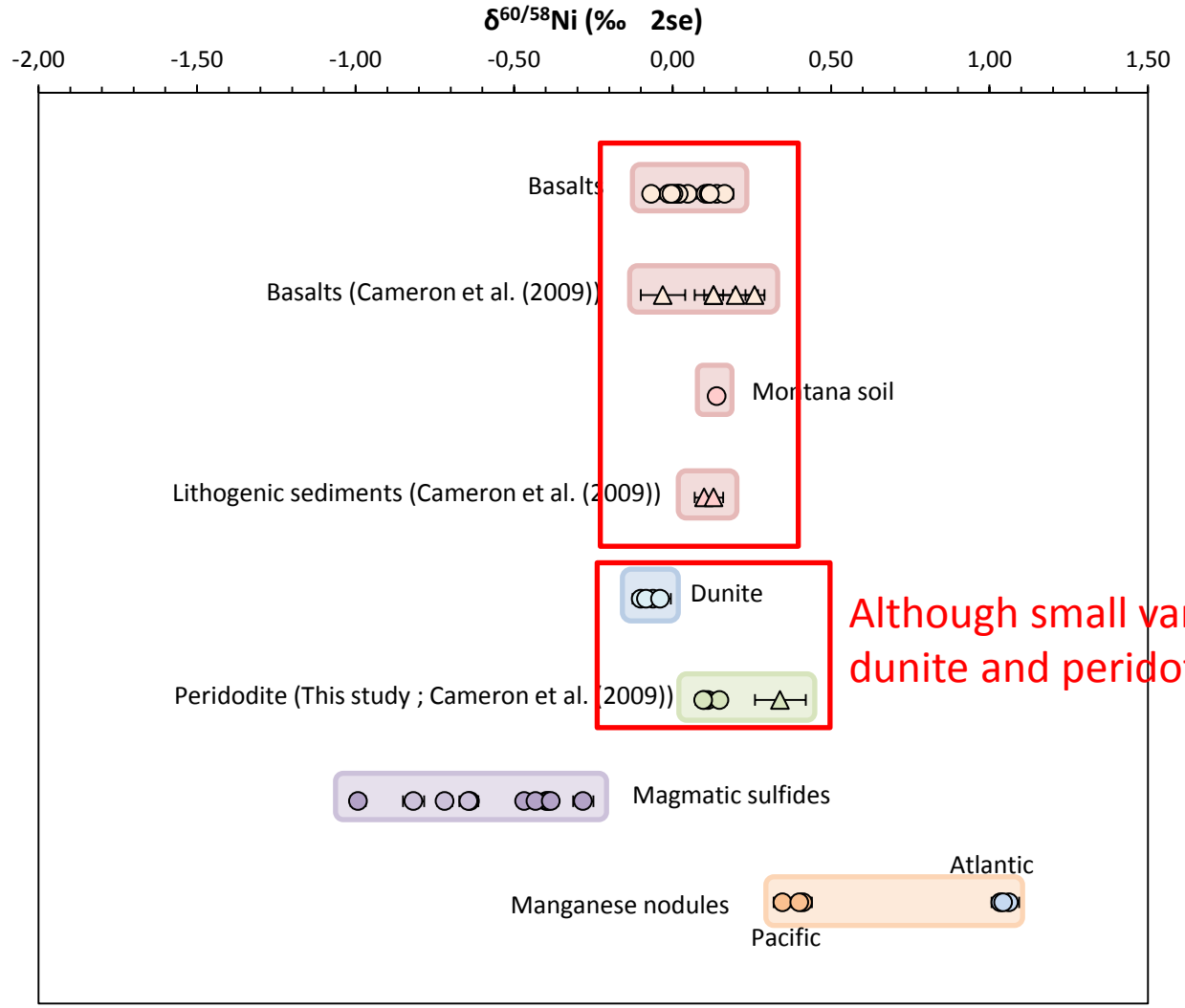
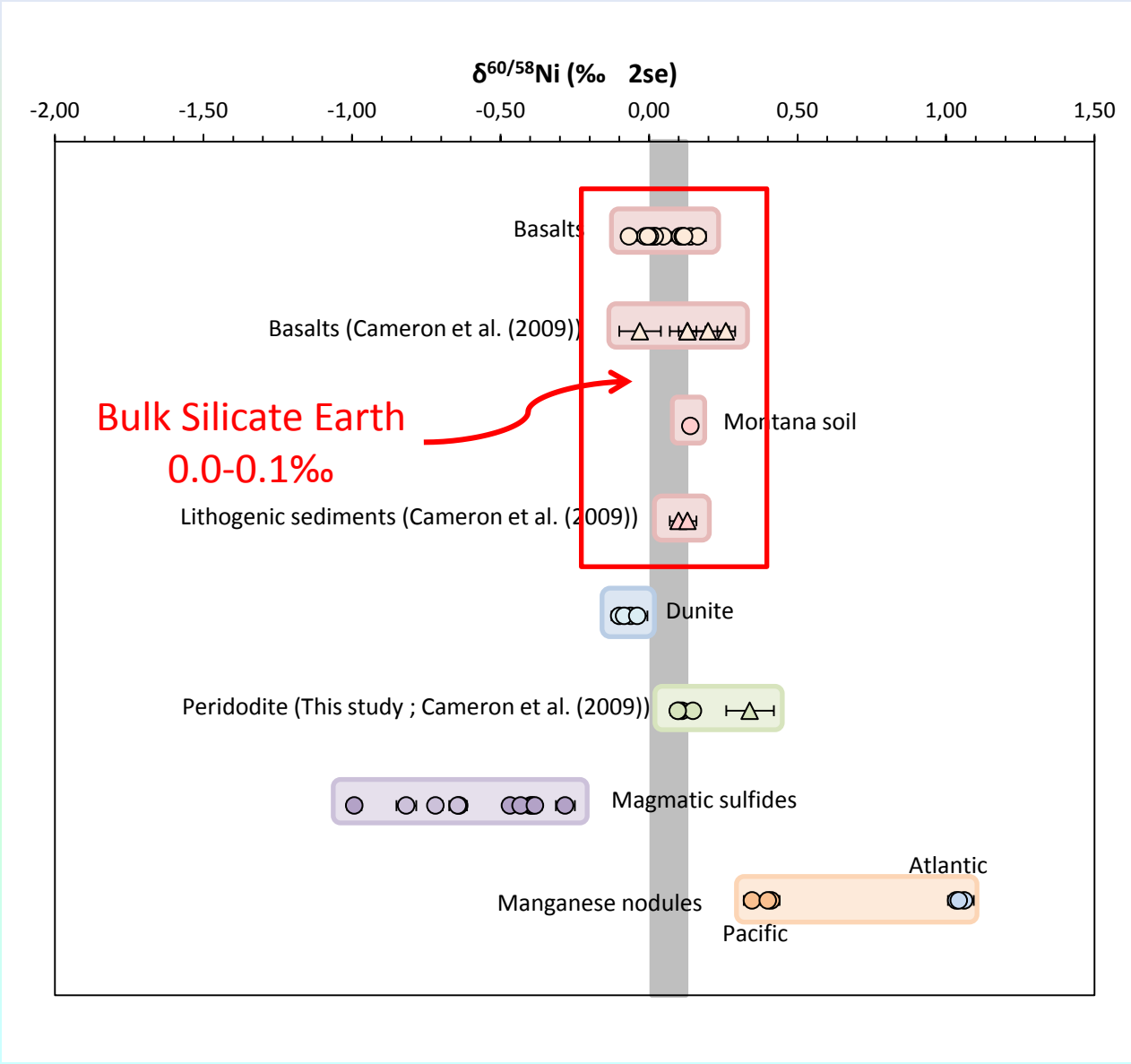
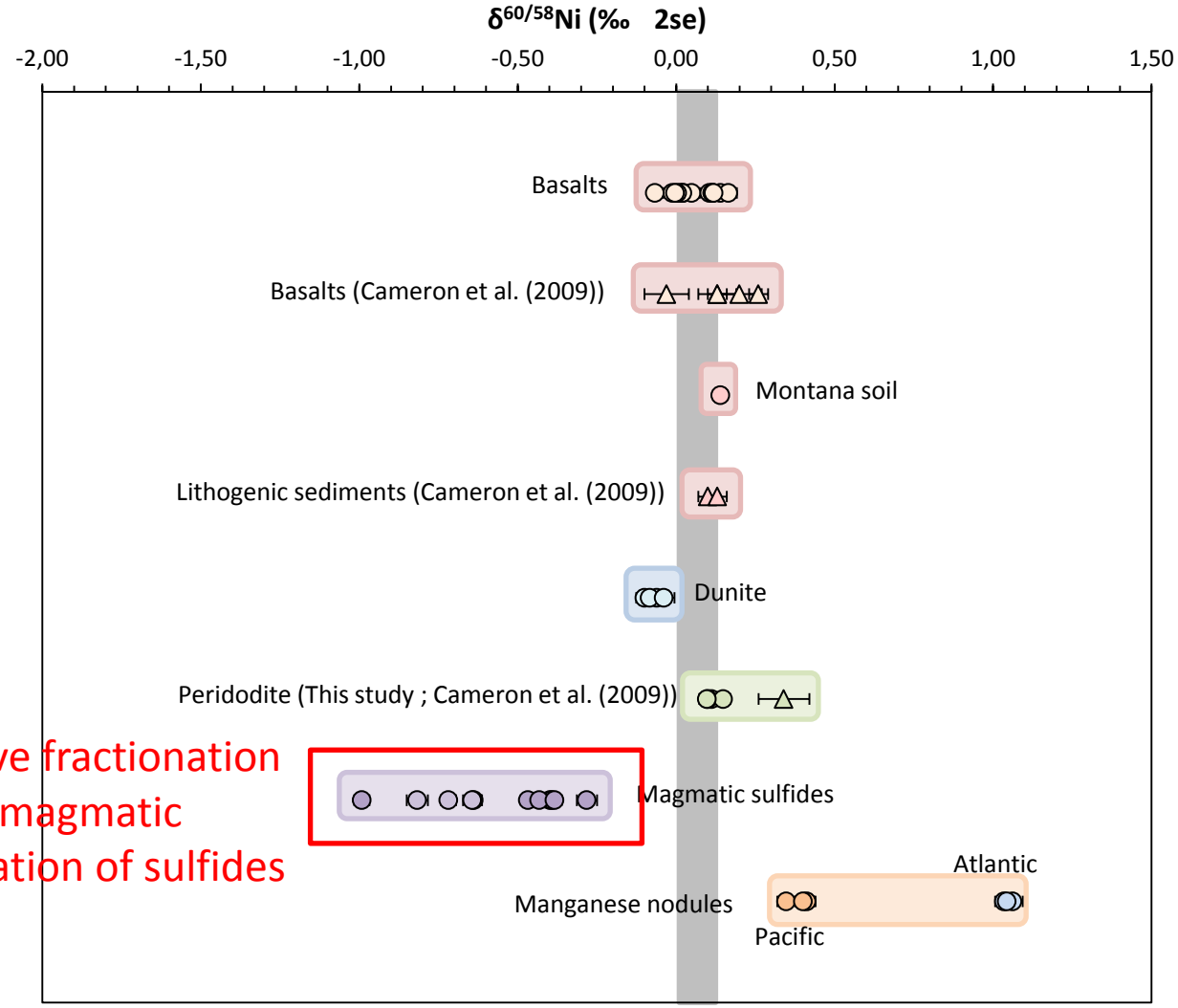


Although small variations in dunite and peridotite…

Assessing the Bulk Silicate Earth

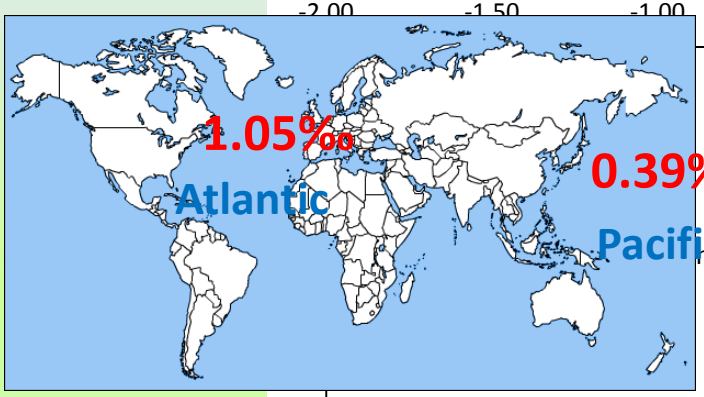


Komatiite-hosted Ni sulfides : high temperature fractionation



Negative fractionation during magmatic segregation of sulfides

Manganese nodules… a striking difference according to oceans !



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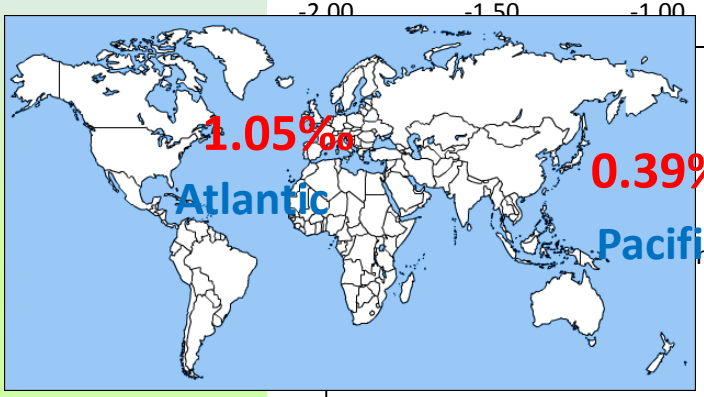

Adsorption experiments of Ni on goethite

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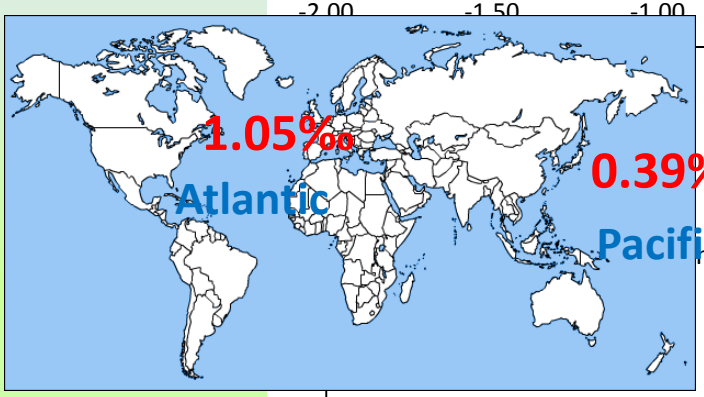

→ difference in isotopic composition of seawater
→ diagenetic processes…
→ more to learn from ferromanganese crusts

Adsorption experiments of Ni on goethite

Conclusions : Ni systematics, a robust geochemical tracer

• Double-spike correction method :
→ high precision (2se of 0.03‰) for $\delta^{60/58}$Ni
→ broad range of rock matrices and Ni concentrations that can be analyzed

• Estimation of Bulk Silicate Earth isotopic composition : 0.0-0.1‰

• Significant natural variations of Ni isotope fractionations
→ high temperature : light isotope enrichment in magmatic sulfides
→ low temperature : heavy isotope enrichment in hydrogenous deposits

• Geochemical cycling of Ni in modern and ancient oceans :
→ ferromanganese crusts
→ Banded Iron Formations

Thank you for your attention !