

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 ?

Periodic Table of the Elements																		© www.elementsdatabase.com	
1 H																		2 He	
3 Li	4 Be	hydrogen alkali metals alkali earth metals transition metals poor metals nonmetals noble gases rare earth metals										5 B	6 C	7 N	8 O	9 F	10 Ne		
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar		
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr		
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe		
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn		
87 Fr	88 Ra	89 Ac	104 Unq	105 Unp	106 Unh	107 Uns	108 Uno	109 Une	110 Unn										
		58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu				
		90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr				

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- 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)

Periodic Table of the Elements

database.com

hydrogen

alkali metals

alkali earth metals

transition metals

poor metals

nonmetals

noble gases

rare earth metals

58Ni

60Ni

61Ni

62Ni

64Ni

28Ni

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Red box highlights Ni (28) and its isotopes: 58Ni, 60Ni, 61Ni, 62Ni, 64Ni.

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58Ni

60Ni

61Ni

62Ni

64Ni

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

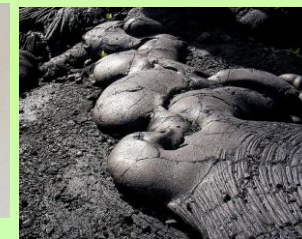


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- And low temperature fractionation ?
- Oceanic and paleoceanographic studies
- nutrient-type profile in seawater (plankton uptake)
- methanogens biosignatures ?
- oceanic metalliferrous deposits



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

Analytical and experimental developments

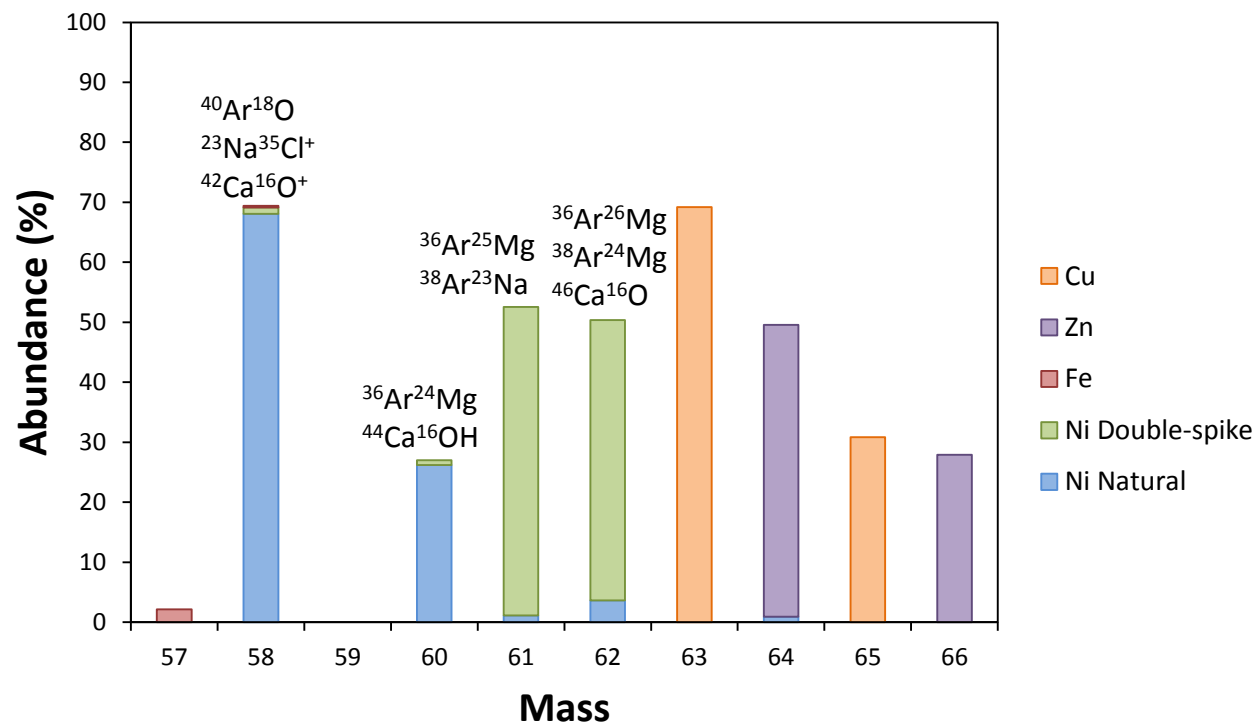
- Ion-exchange chromatography columns

- 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

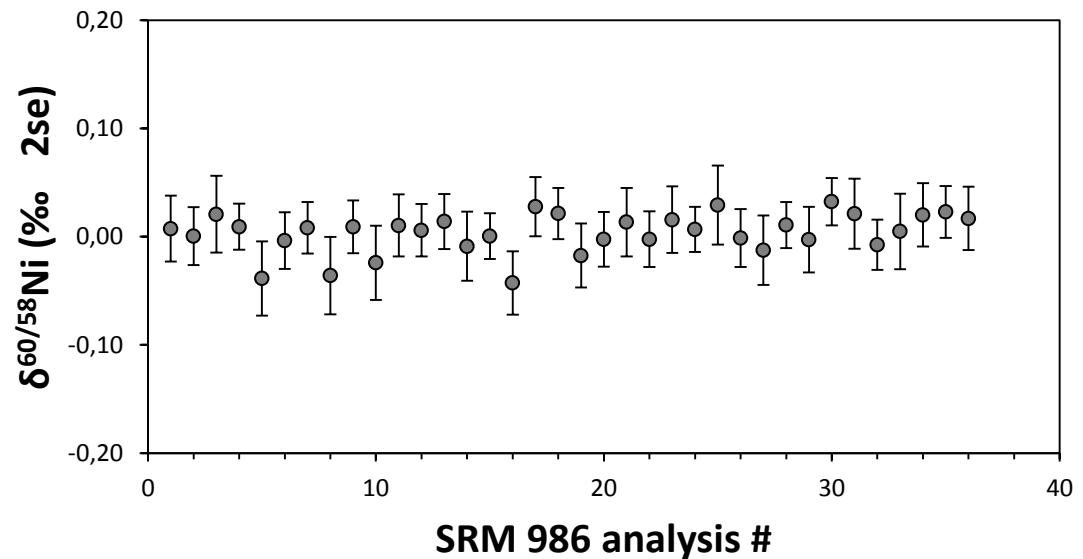
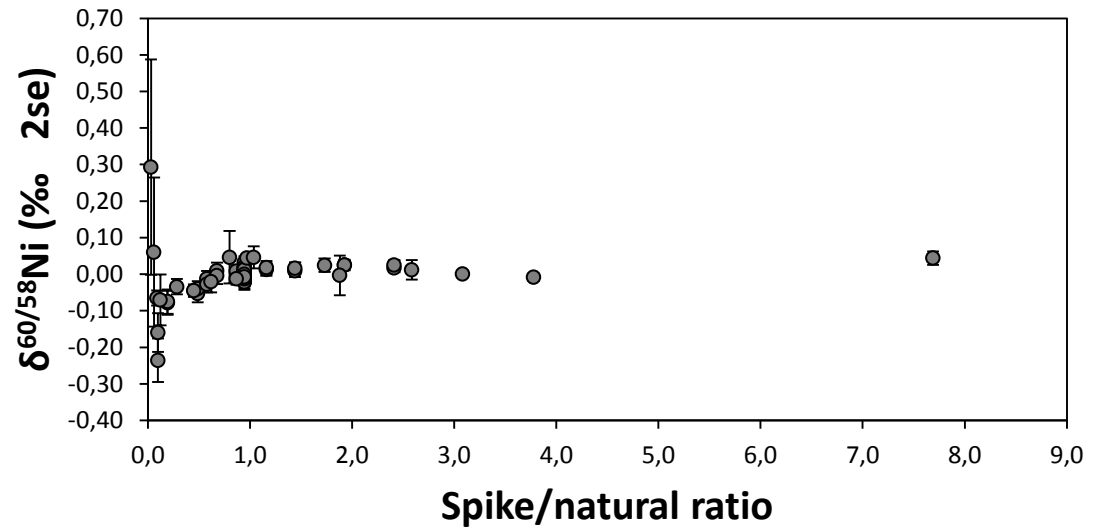
- ^{61}Ni and ^{62}Ni isotopes mixture

Analytical and experimental developments

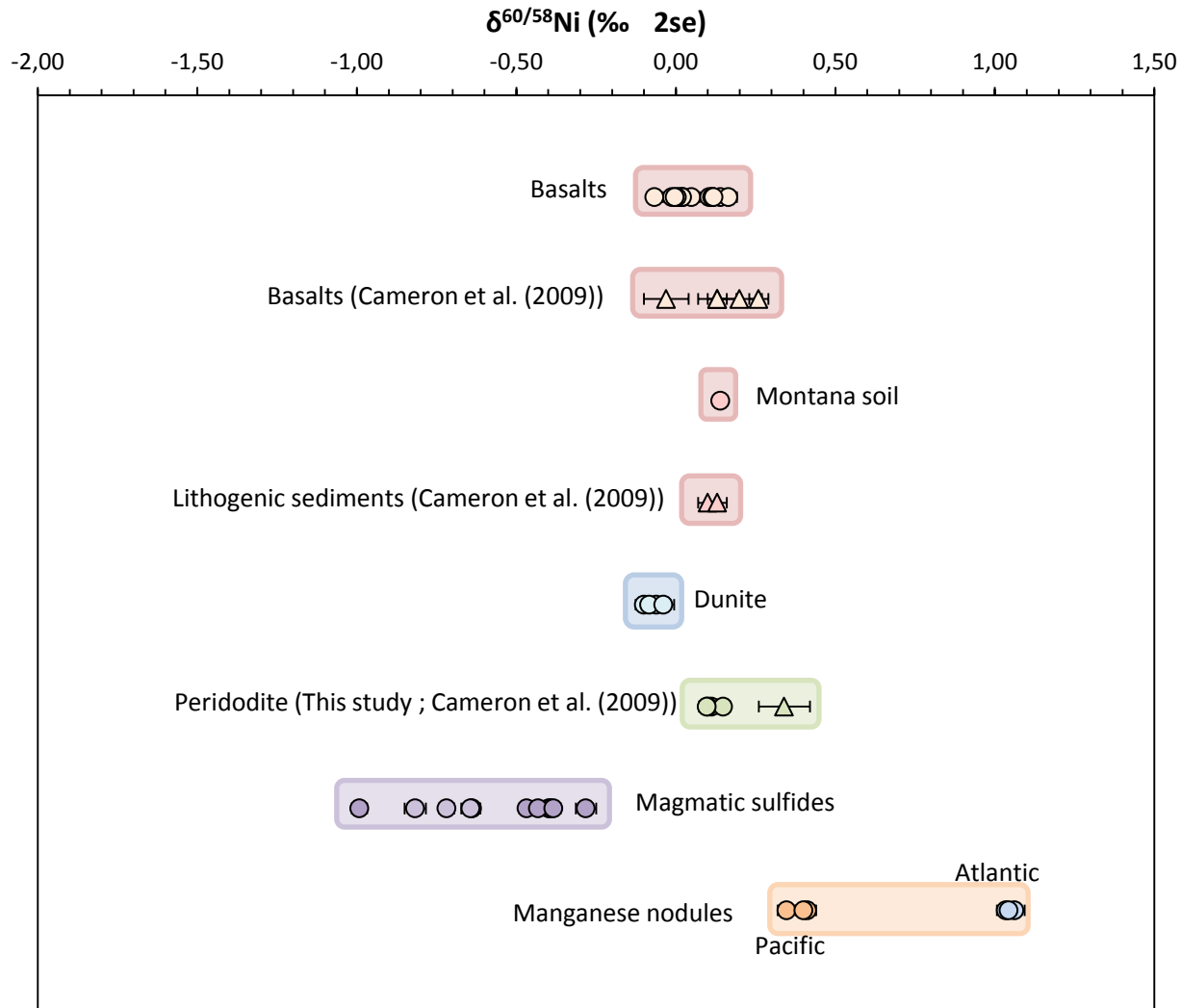
- International isotopic standard NIST SRM 986 for Ni

High precision :

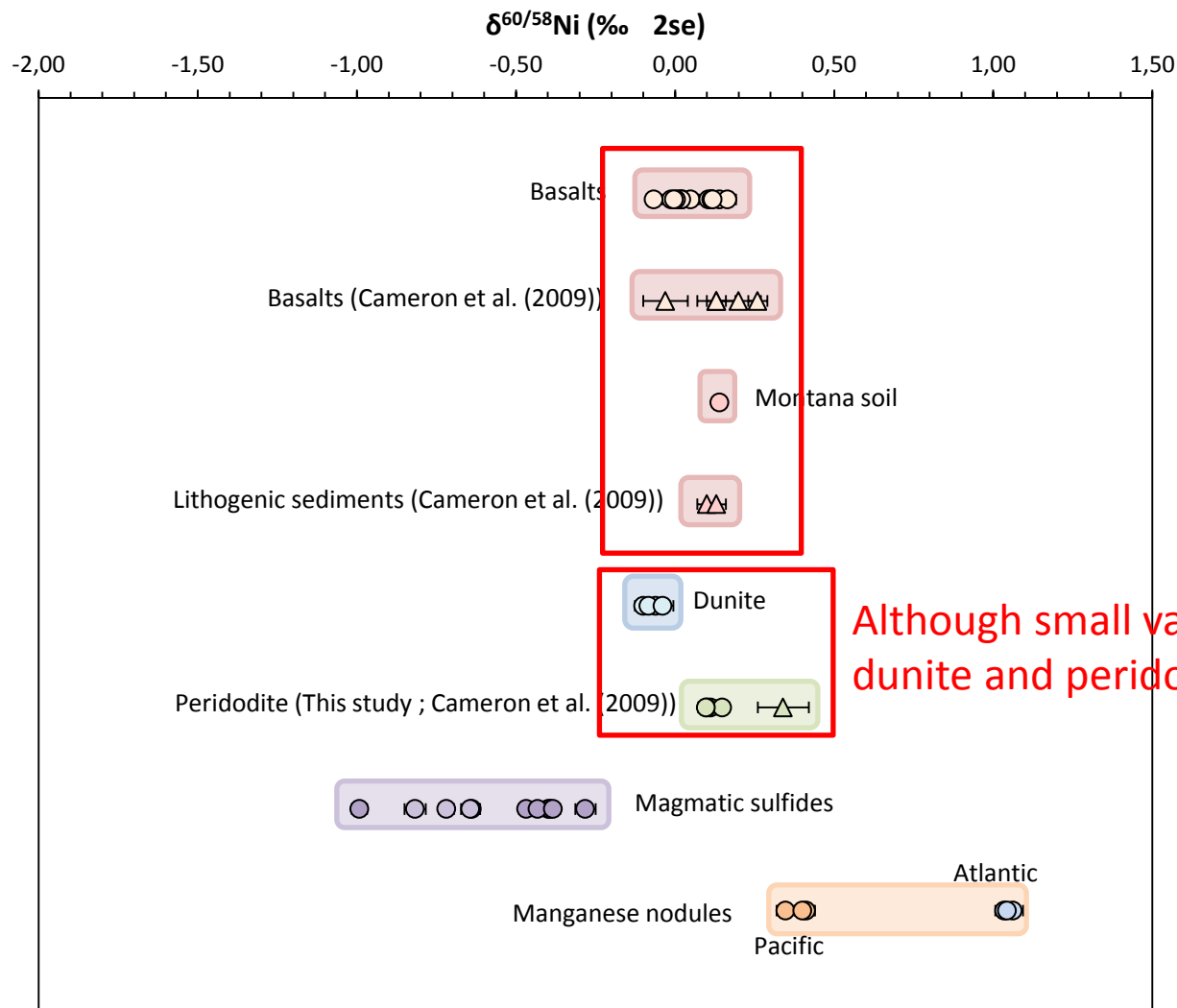
→ 2 sigma error of samples
clusters around 0.03‰



Assessing the Bulk Silicate Earth

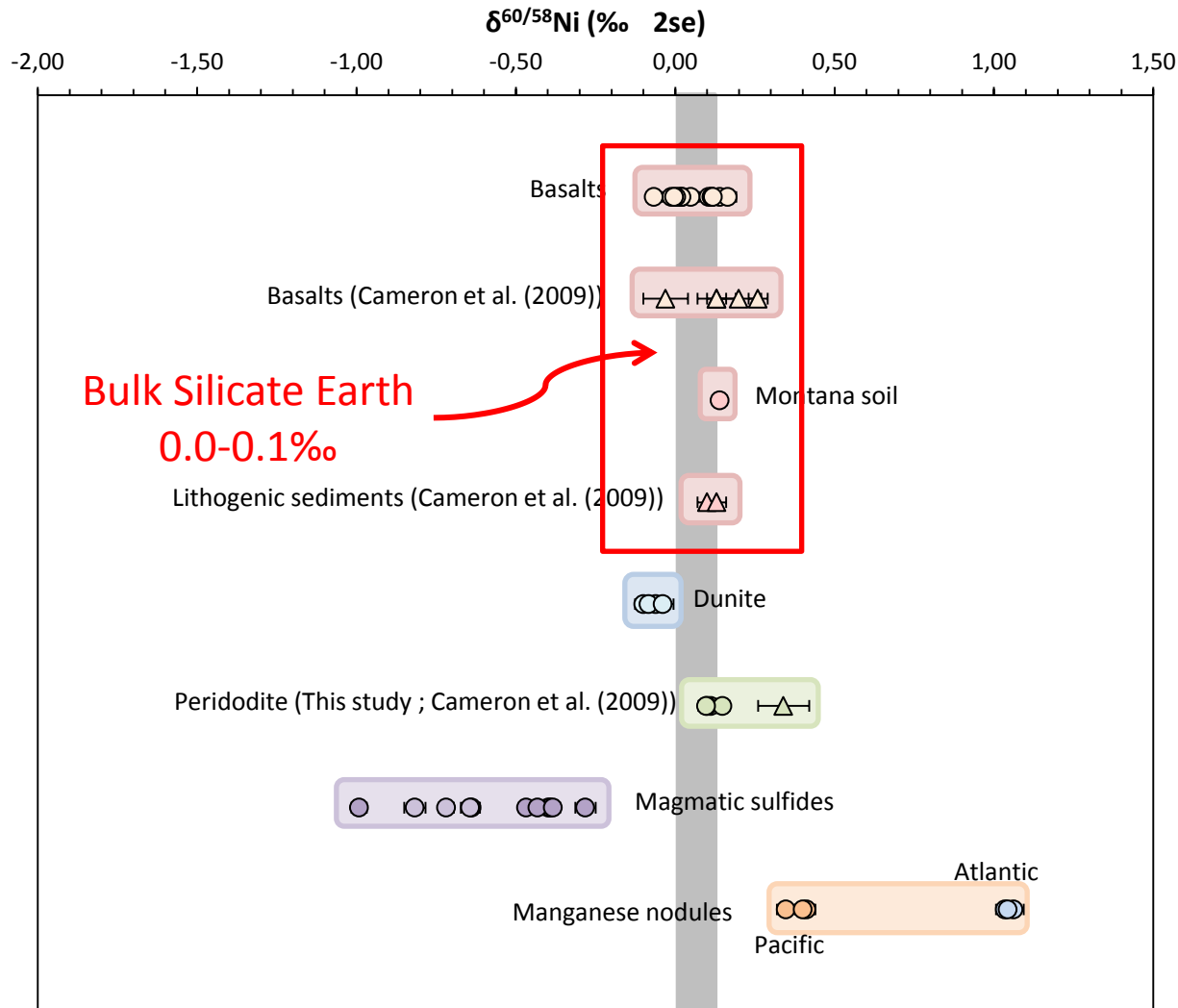


Assessing the Bulk Silicate Earth



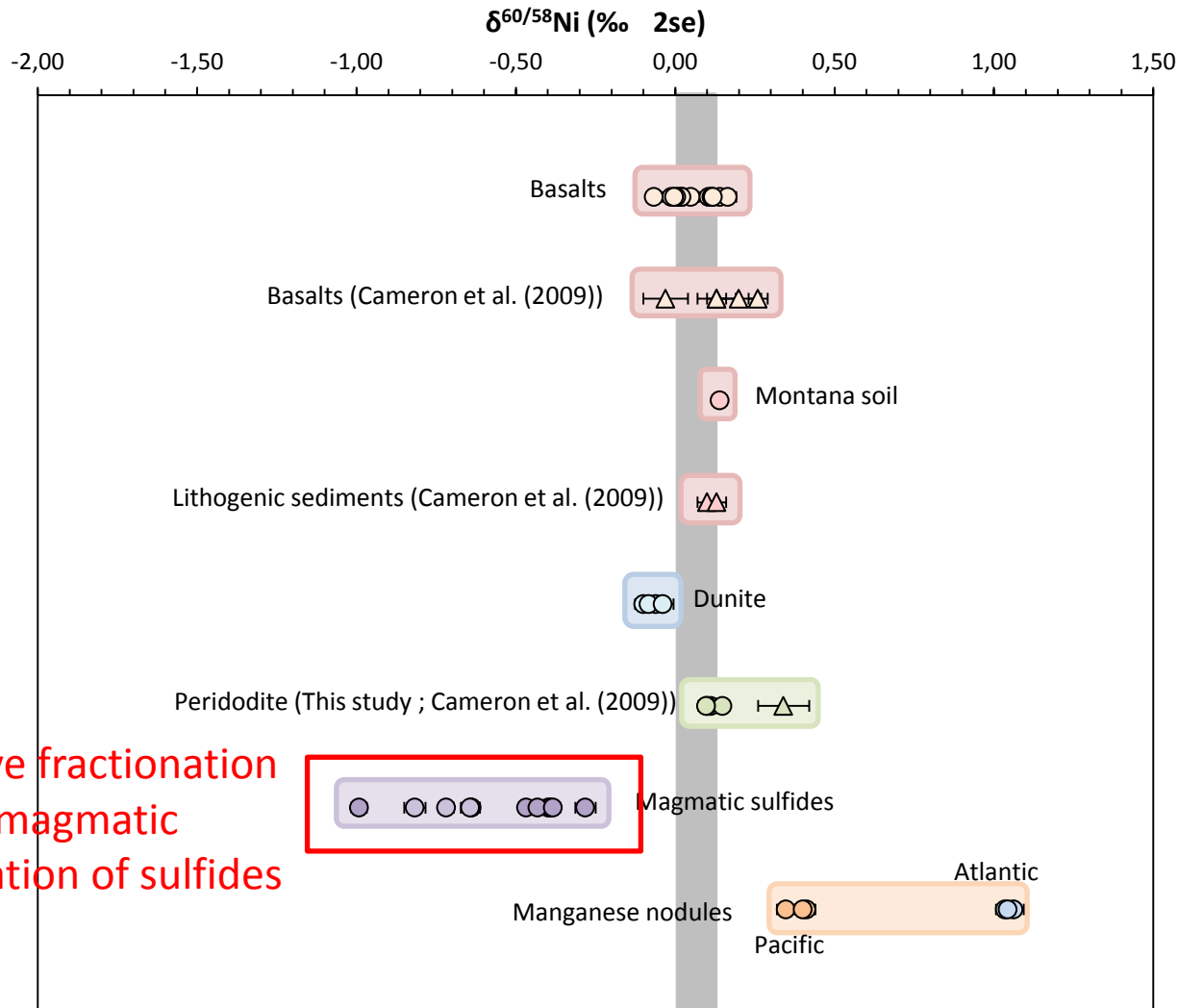
Although small variations in
dunite and peridotite...

Assessing the Bulk Silicate Earth

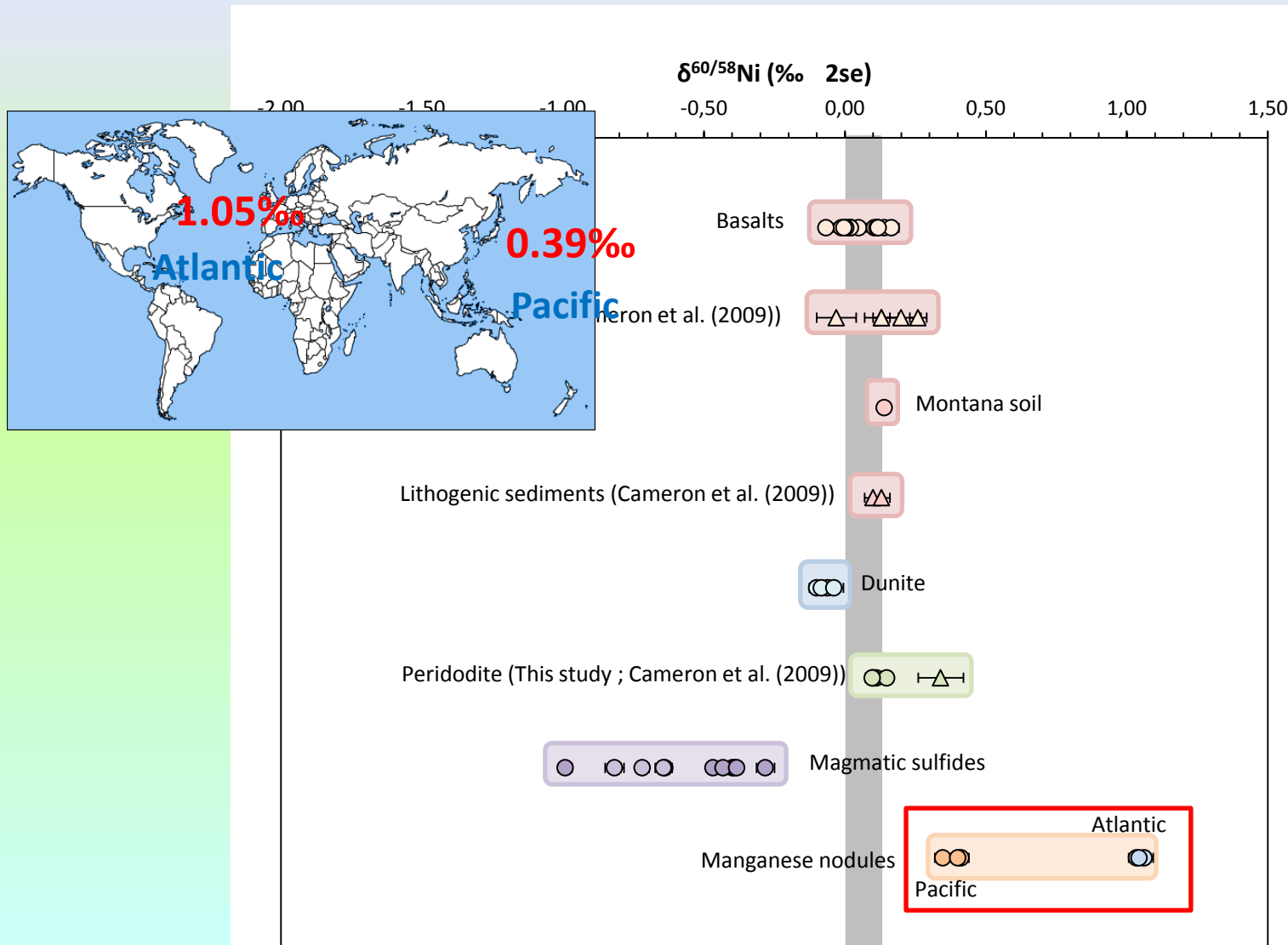


Komatiite-hosted Ni sulfides : high temperature fractionation

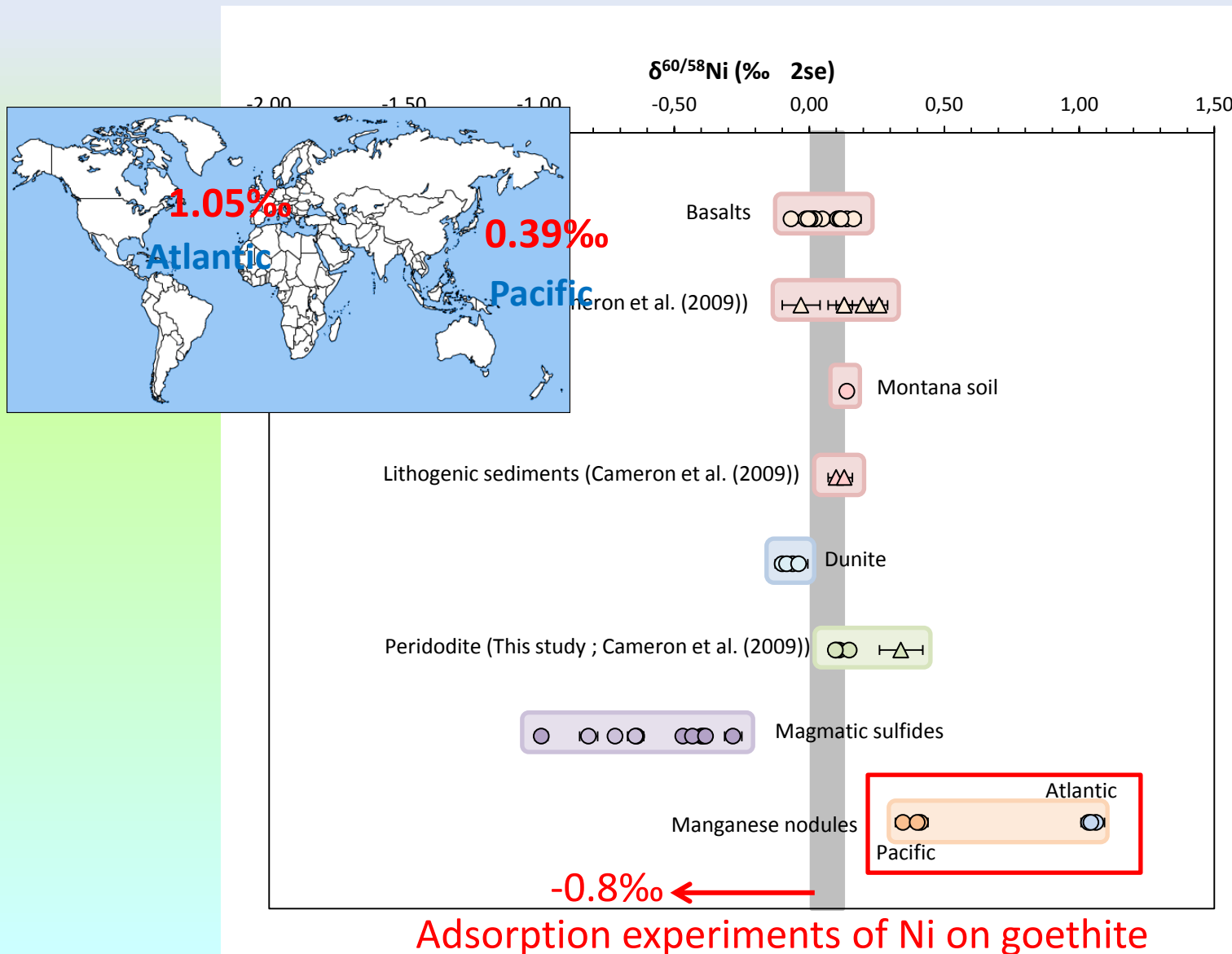
Negative fractionation
during magmatic
segregation of sulfides



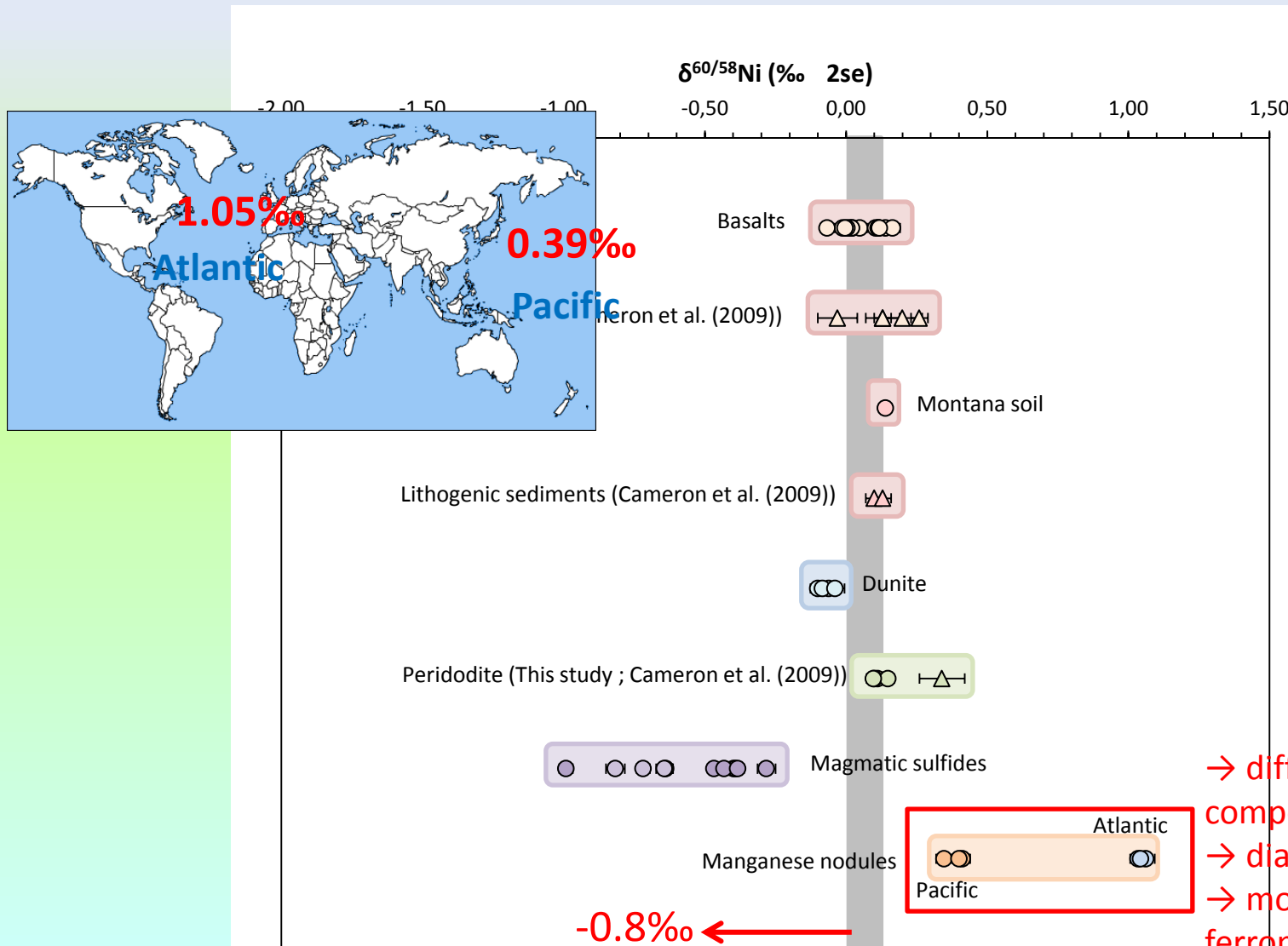
Manganese nodules... a striking difference according to oceans !



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Adsorption experiments of Ni on goethite

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

Conclusions : Ni systematics, a robust geochemical tracer

- Double-spike correction method :
 - high precision (2se of 0.03‰) for $\delta^{60/58}\text{Ni}$
 - 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 !