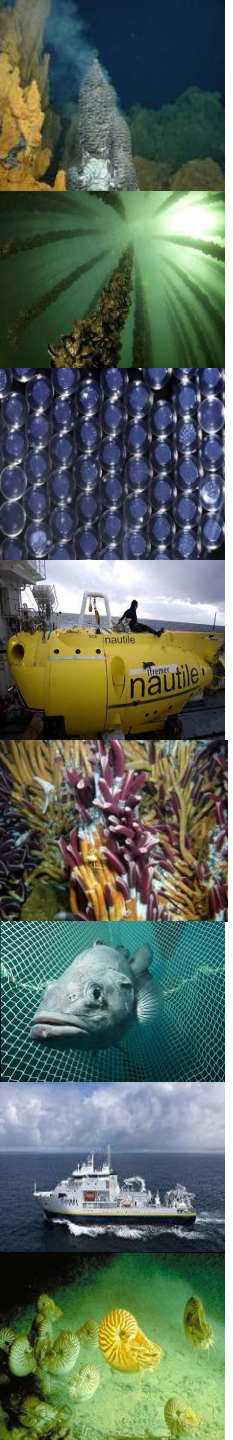
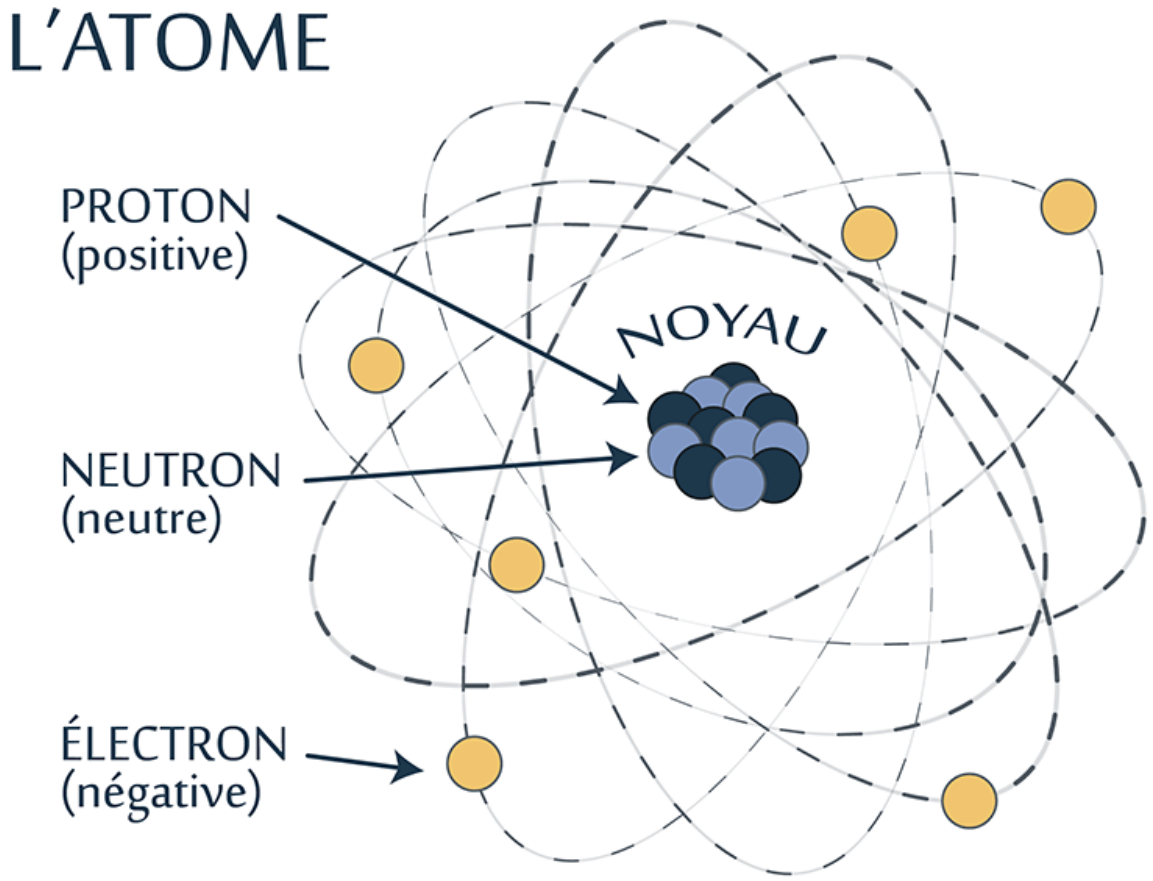


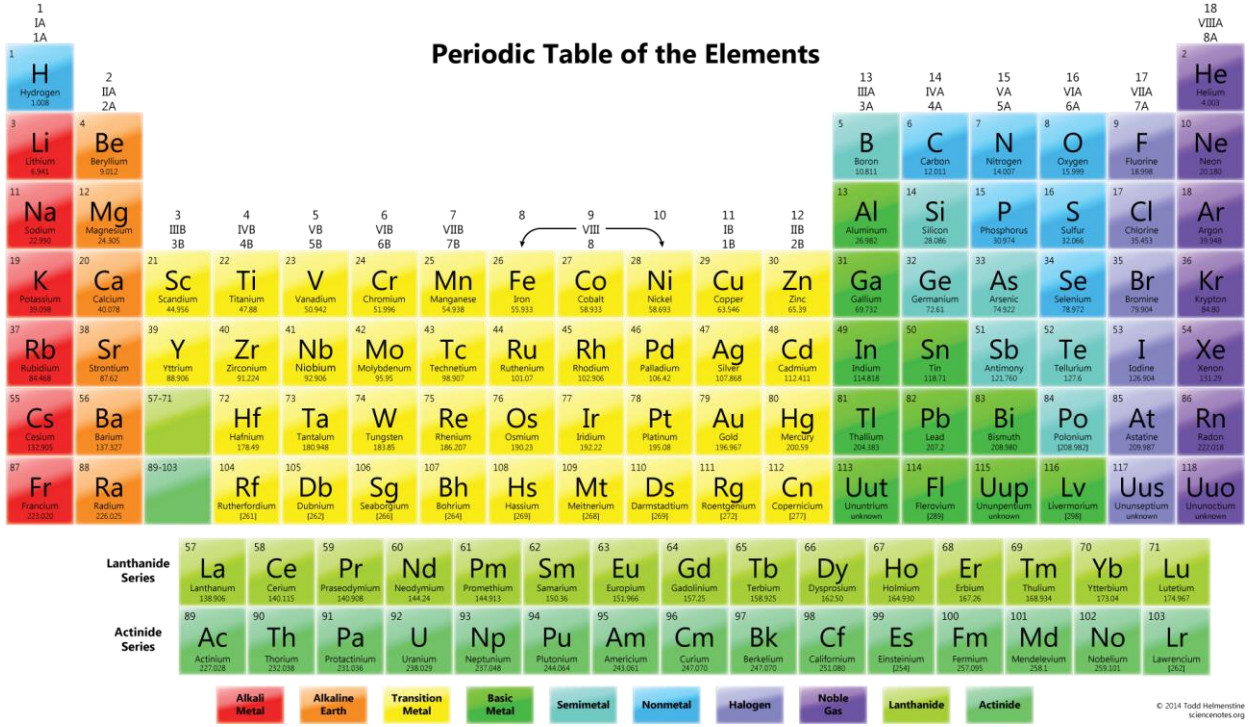
Applications isotopiques des métaux dans le ROCCH : principes, applications et perspectives

Daniel F. Araújo

Principes

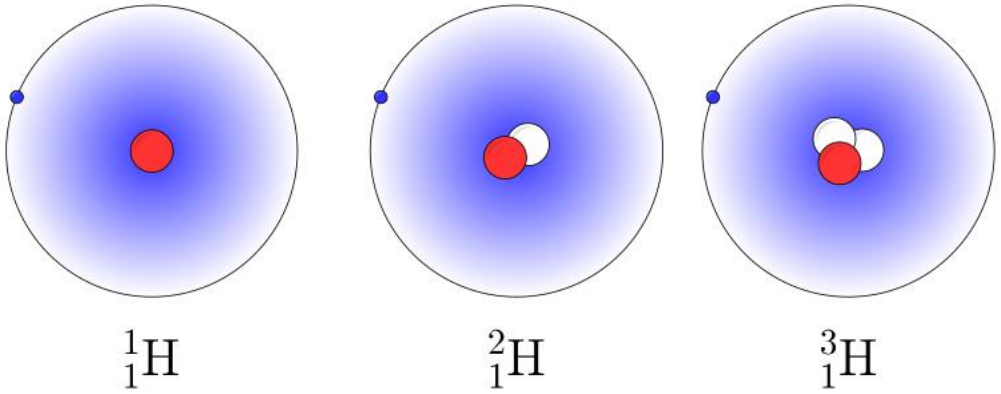

L'ATOME
PROTON
(positive)
NEUTRON
(neutre)
ÉLECTRON
(négative)
NOYAU


Nombre de nucléons
(= protons + neutrons)
A
Numéro atomique
(= nombre de protons)
Z
X
Symbole de l'élément
(par ex : H / C / Fe / etc.)



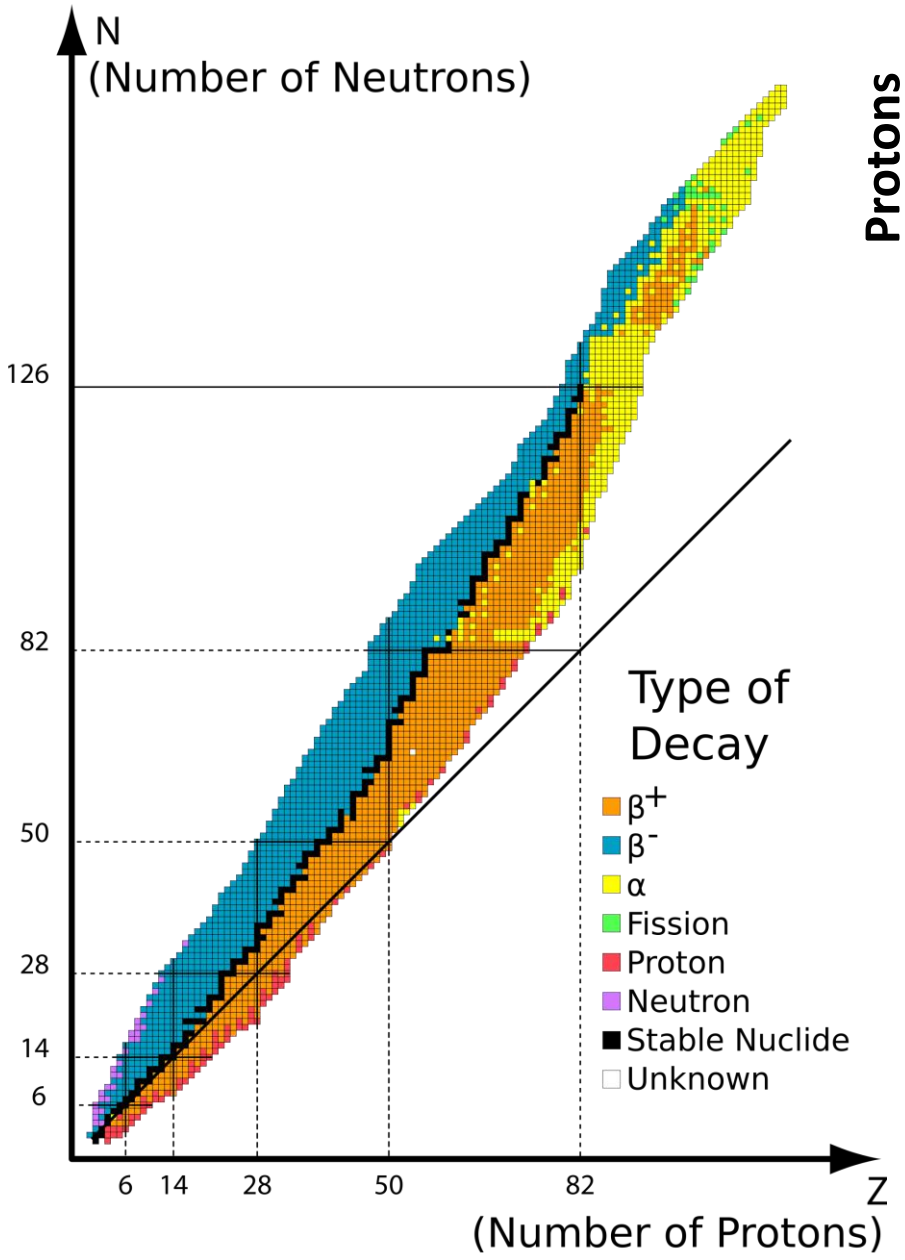
élément chimique = atomes qui présentent le même nombre de protons dans leur noyau.

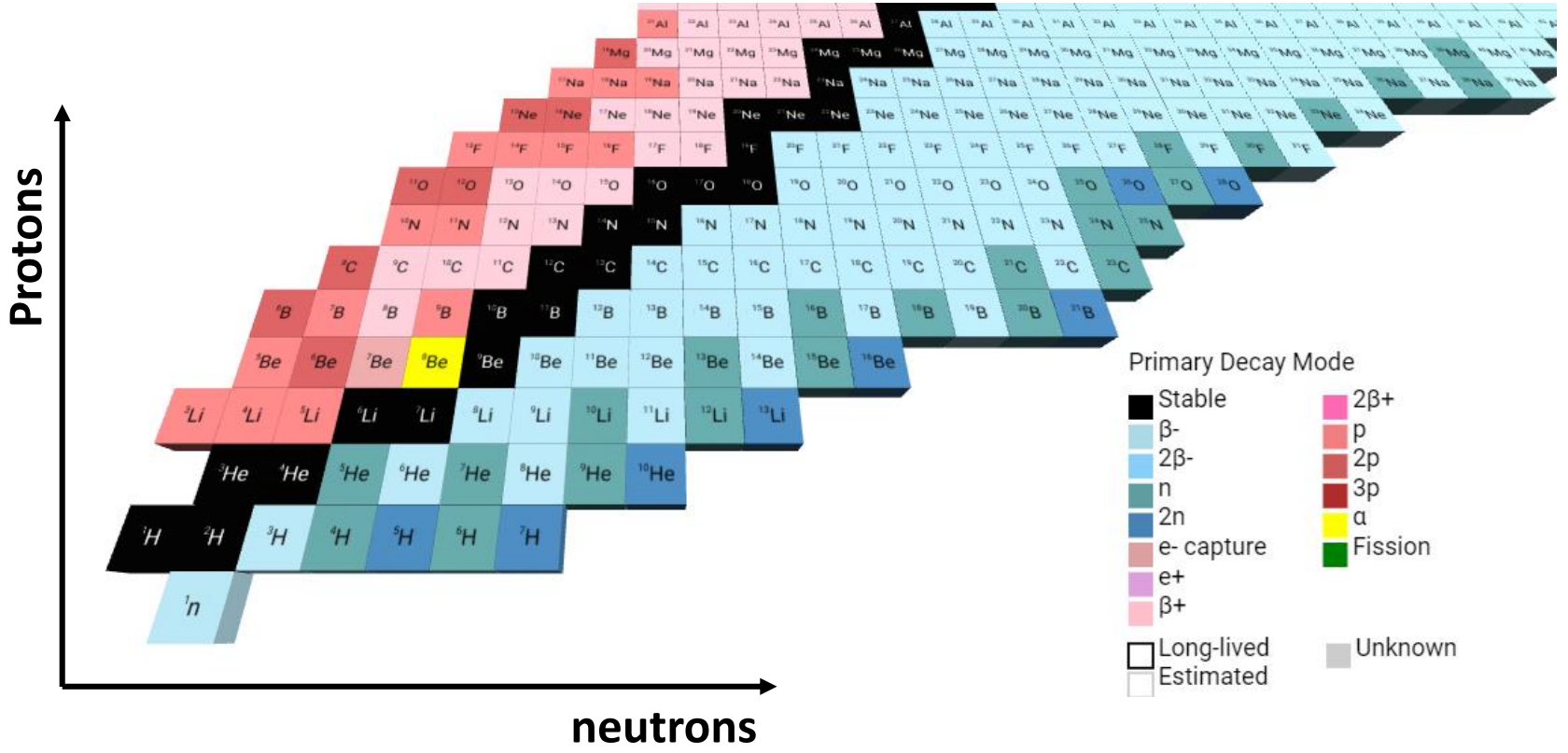
Qu'est-ce que ce sont les isotopes?



« Iso » + « topes » = « même place »

Isotopes = atomes du même élément chimique qui différent dans le massa atomique (numéro de neutrons).

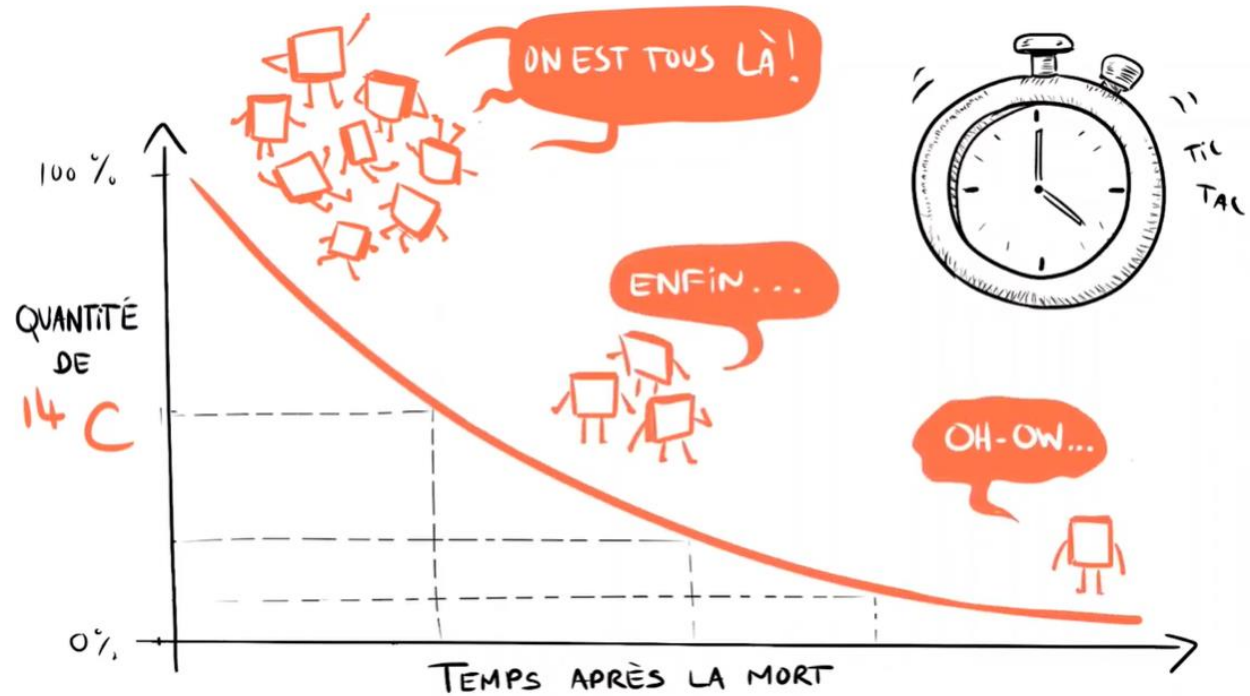




Isotopes stables = non-radioactives.

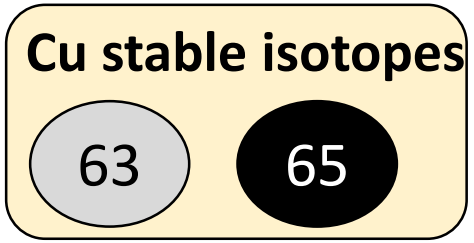
Isotopes radioactives = noyau atomique se désintègre au cours du temps.


JE SUIS PLUTÔT COMMUN
TRÈS STABLE
ET LÉGER !
12C
14C
JE SUIS RARE...
INSTABLE
ET PLUS LOURD!


ON EST TOUS LÀ !
ENFIN...
OH-OW...
TIC TAC
100 %
0 %
QUANTITÉ DE 14C
TEMPS APRÈS LA MORT

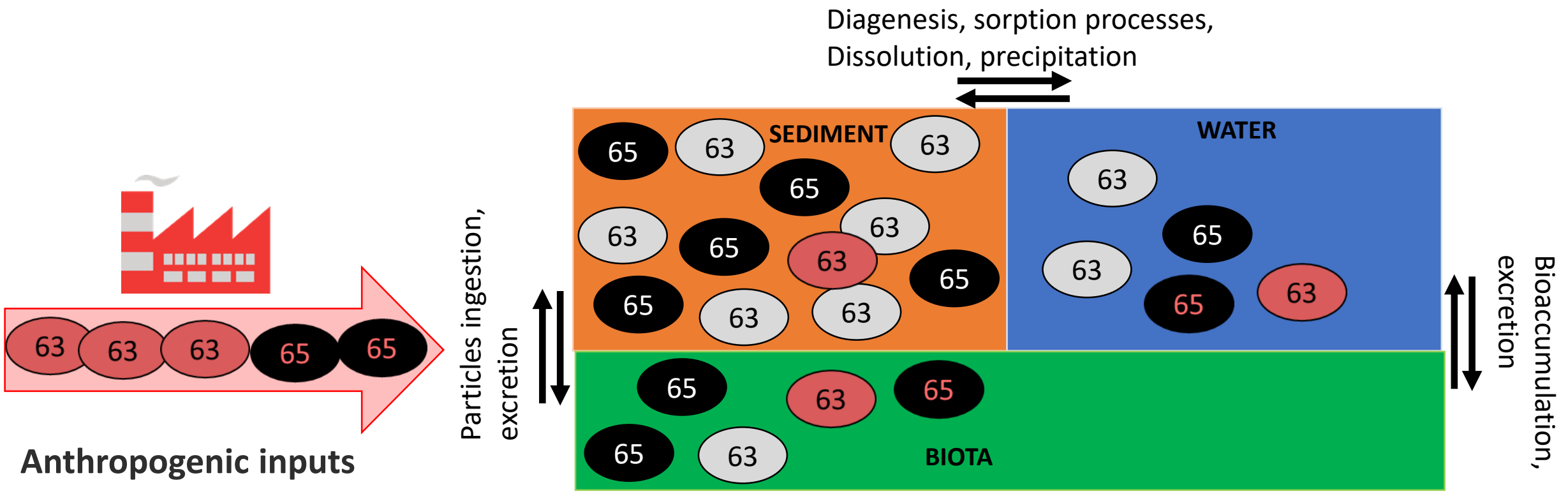
Isotopes stables

Les abondances relatives des isotopes stables peuvent varier dans la nature…

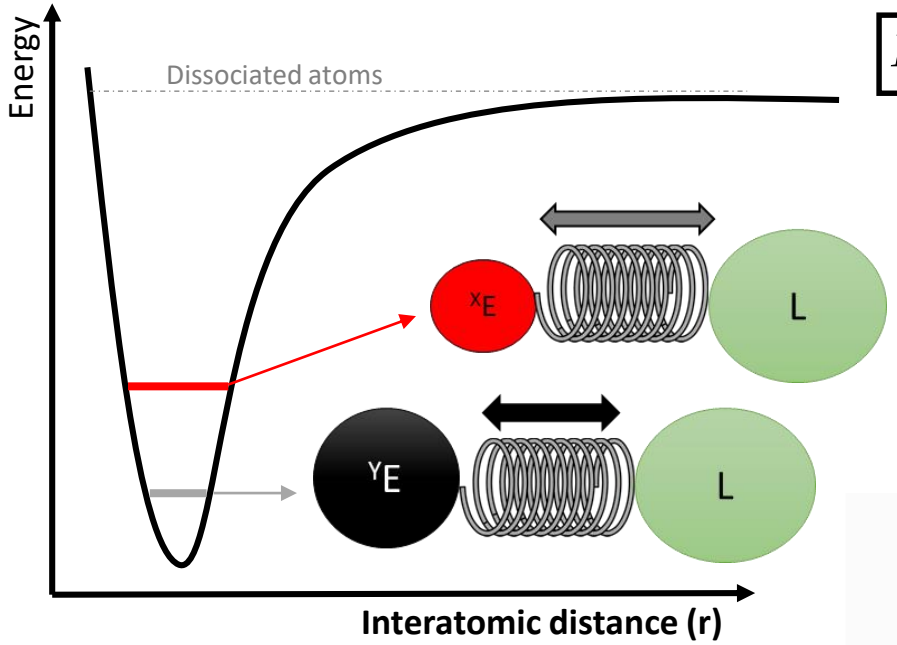


Traceurs des processus biogéochimiques

Traceurs des sources anthropogéniques

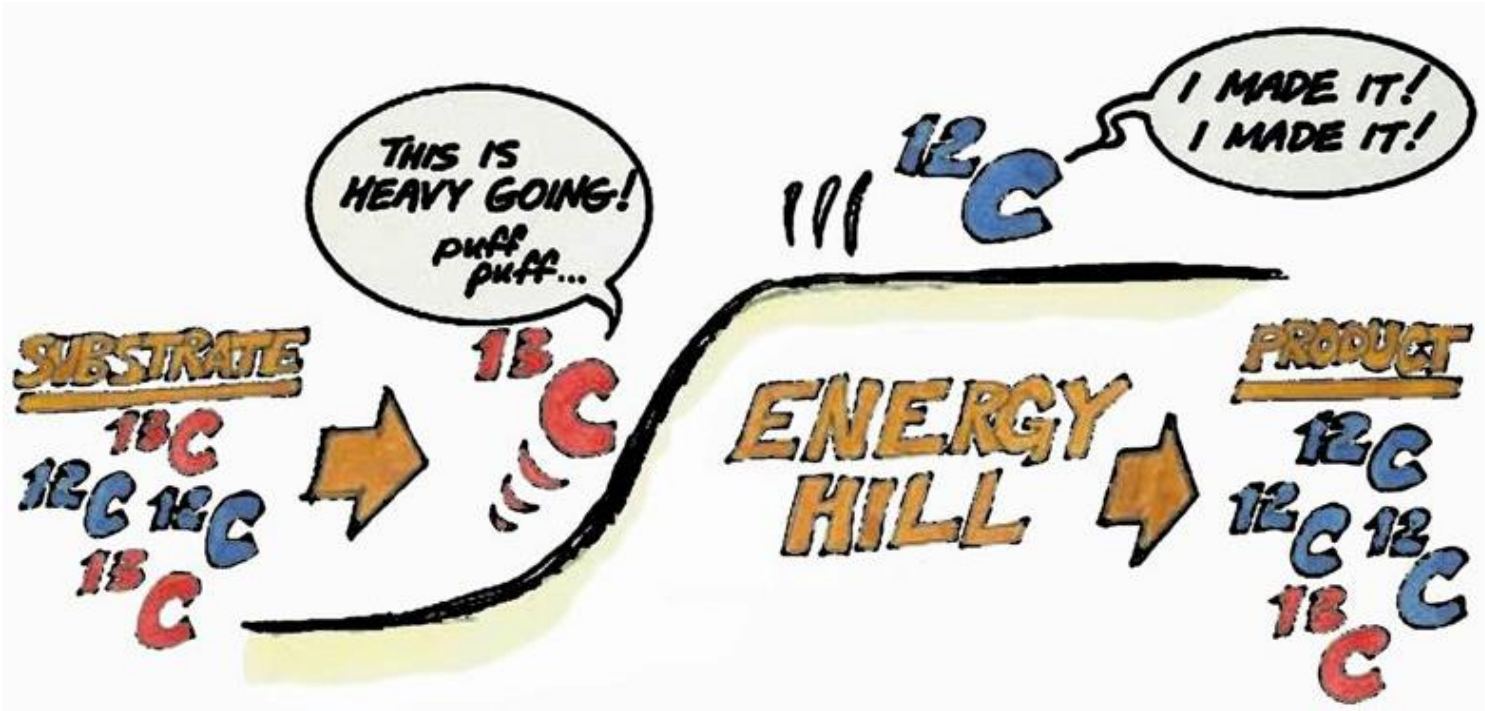


The origin of the isotope fractionation
(at a qualitative level explanation)

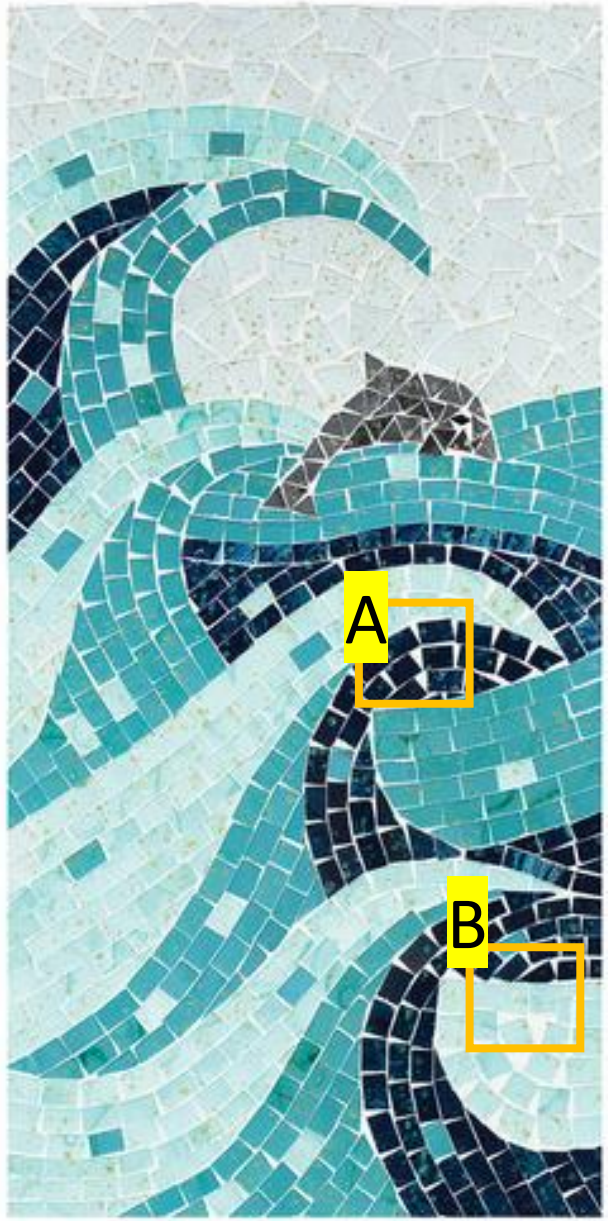


$$E_{vibracional} = \tfrac{1}{2} h\nu$$

$$\nu = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

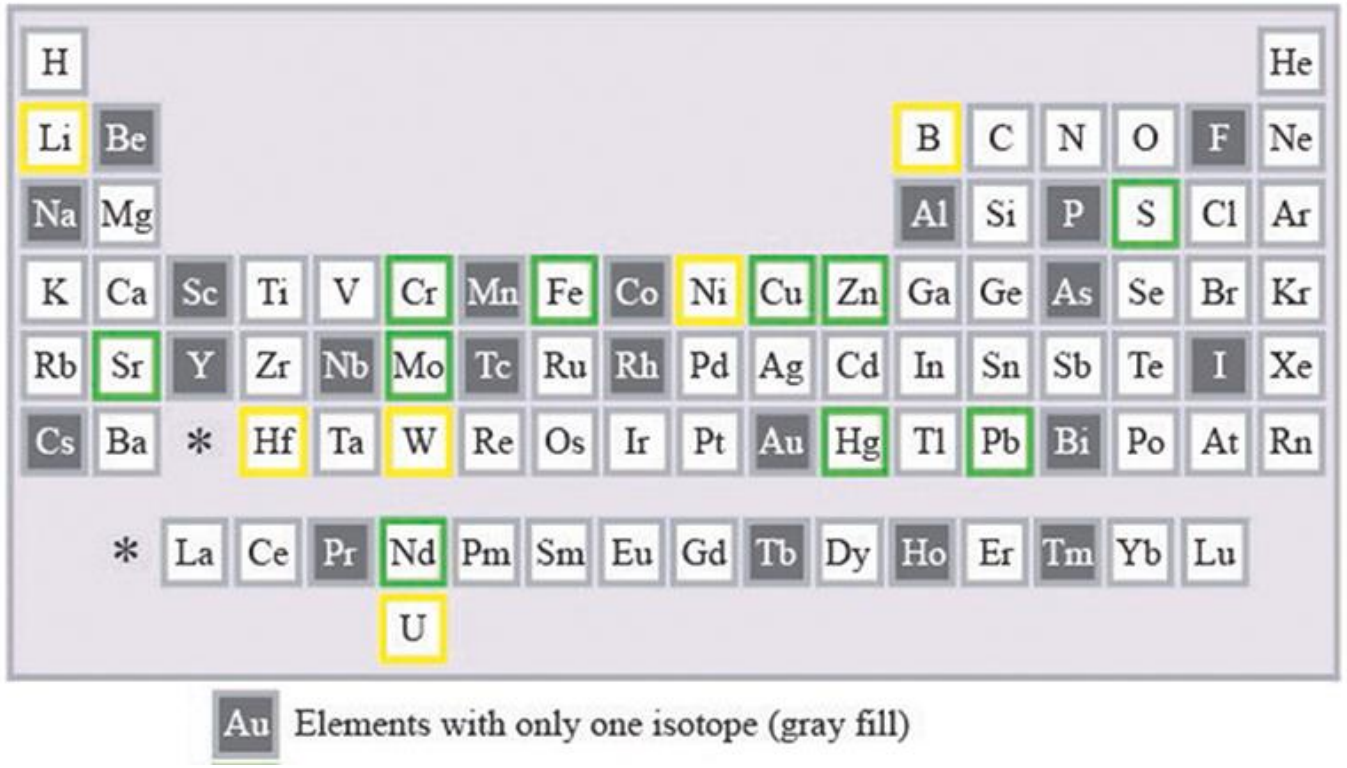


L'isotopie et l'art…

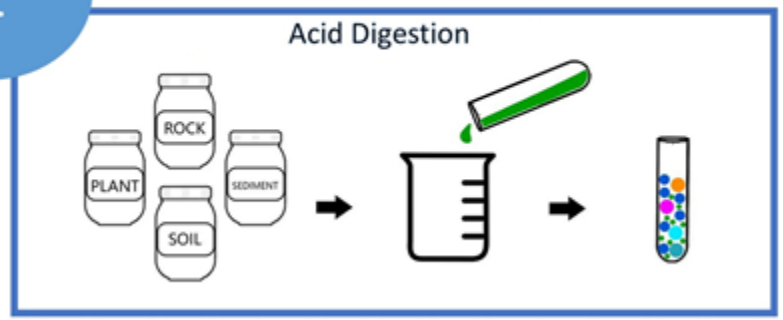


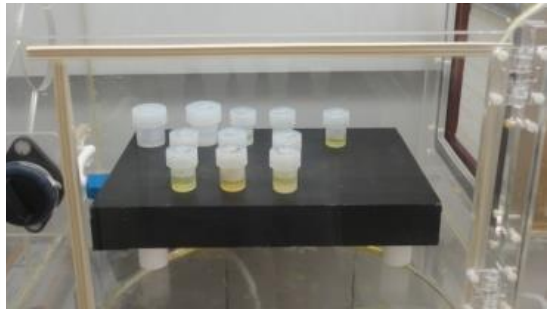
Nombre de fragments de tonalité foncé

Nombre de fragments de tonalité claire

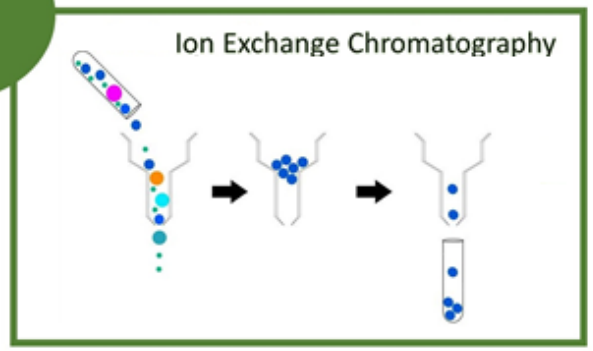


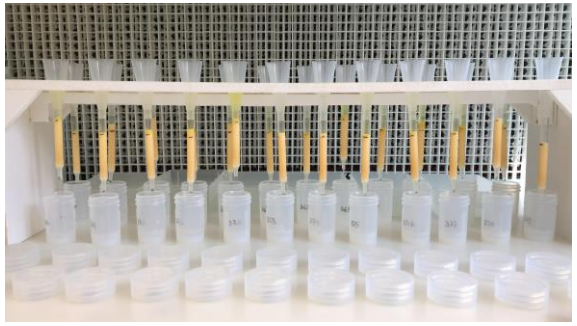
1





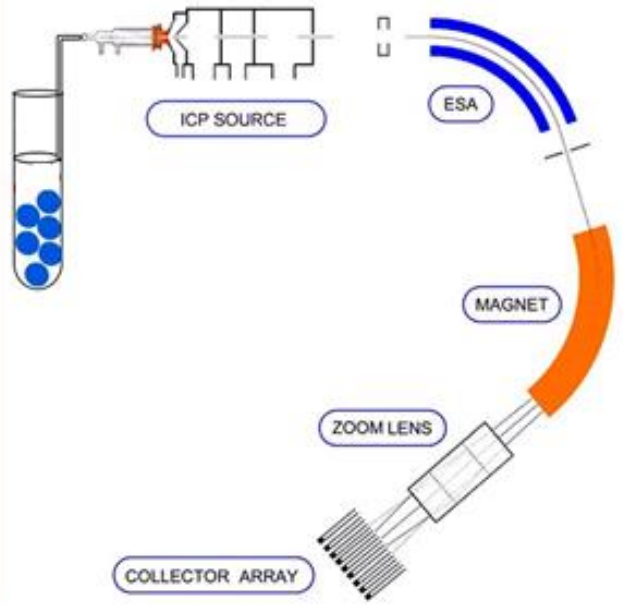
2



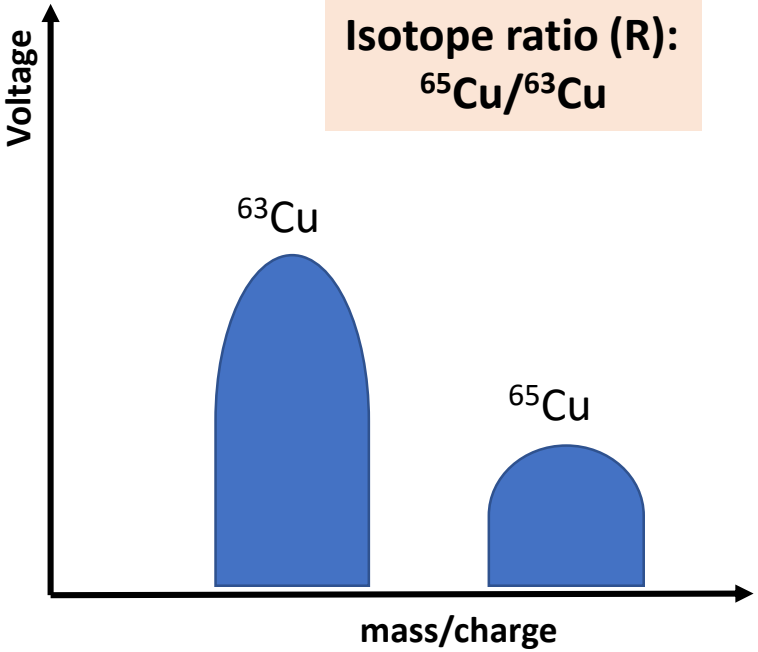


3

isotope Ratio Measurements by MC-ICP-MS



Isotope ratio (R): $^{65}Cu/^{63}Cu$



Araújo et al.2017

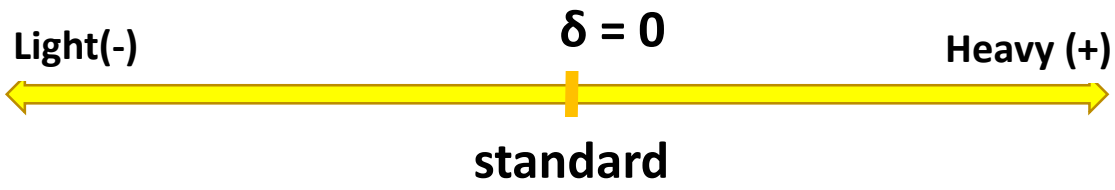
R ($^{65}Cu/^{63}Cu$)
Sample 1: 0,45390
Sample 2: 0,45395

Variations below 0.1 per mil!

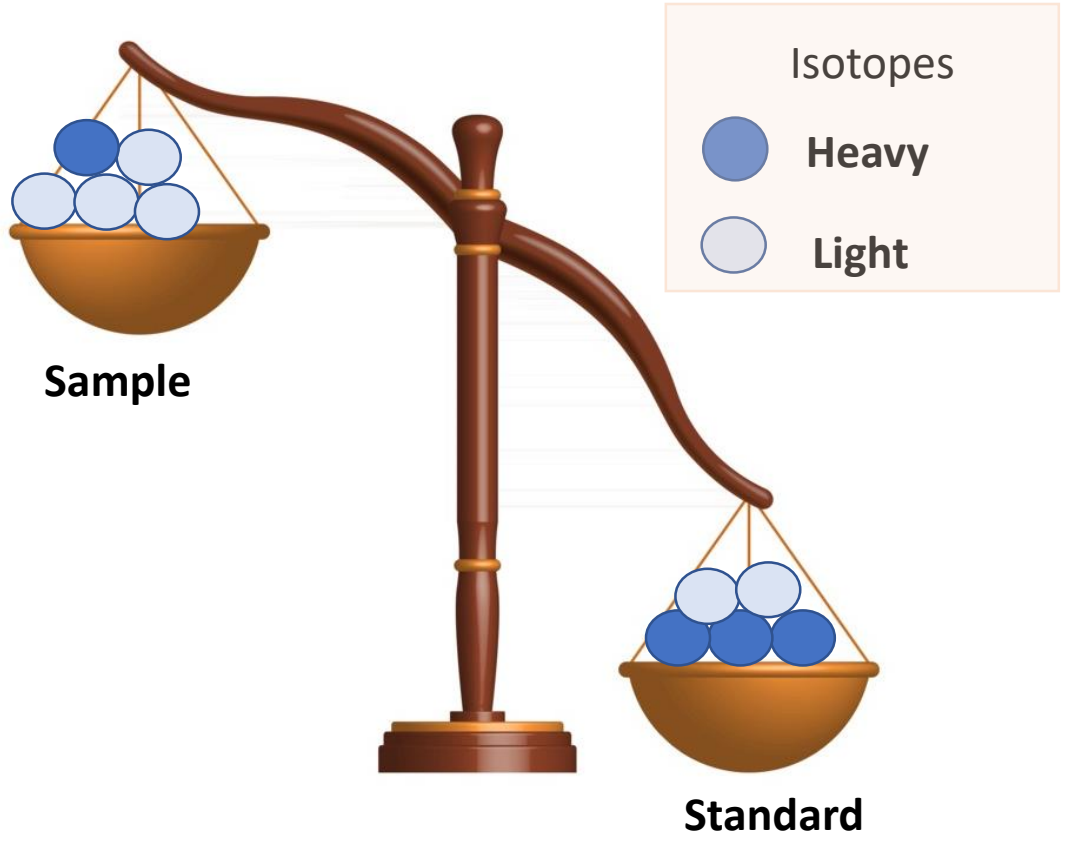
Absolute ratios are not practical!

« δ notation »

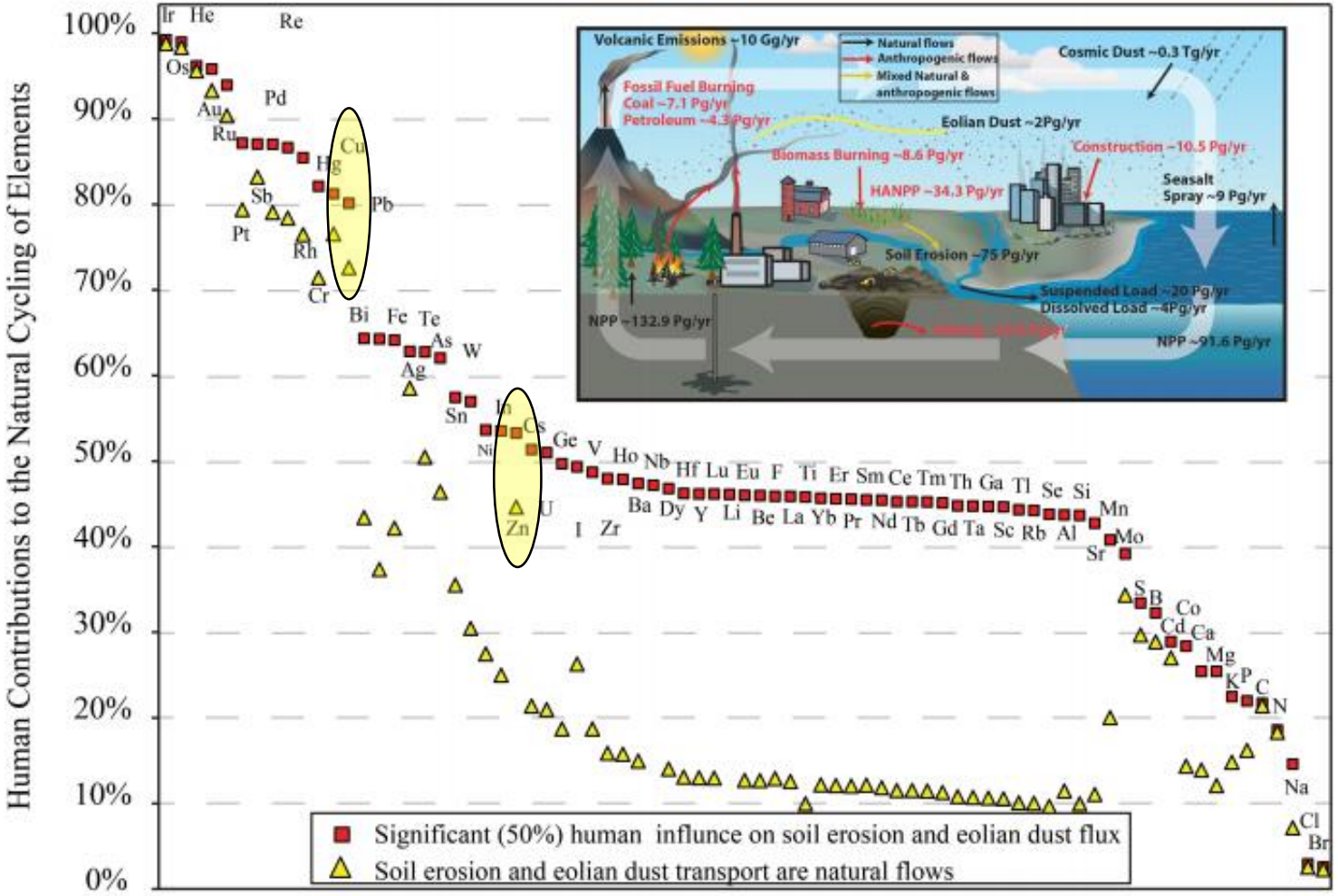
$$\delta \quad (‰) = \left(\frac{R_{sample}}{R_{standard}} - 1\right) \text{x } 1000$$



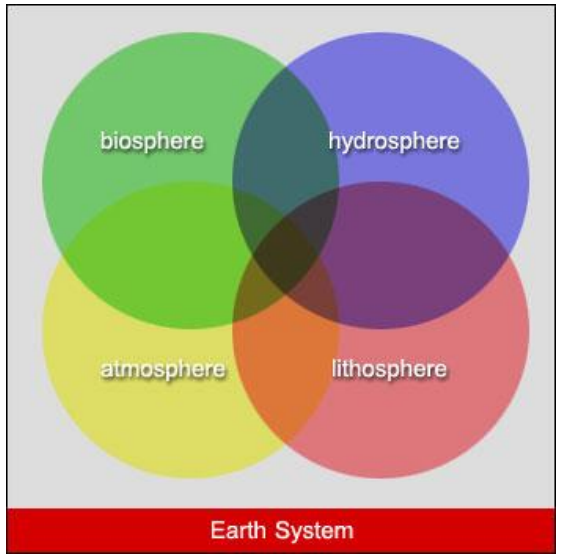
$$\delta^{65}\text{Cu}(‰) = \left(\frac{^{65}\text{Cu} / {}^{63}Cu_{sample}}{^{65}\text{Cu} / {}^{63}Cu_{standard}} - 1\right) \text{x } 1000$$

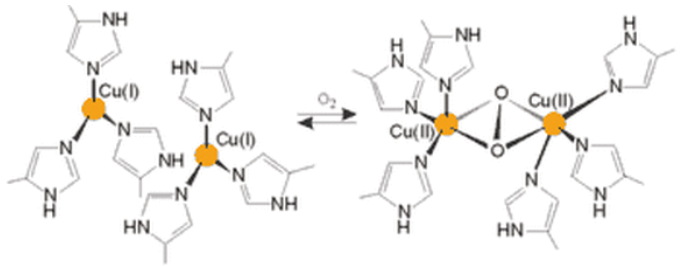


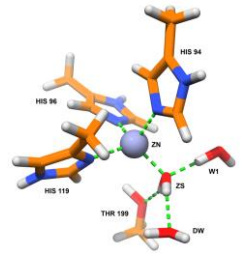
Pour quoi les isotopes de Cu et Zn ?

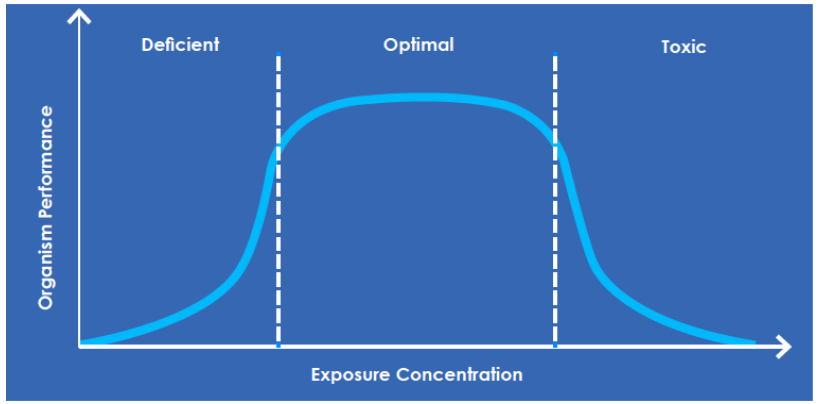


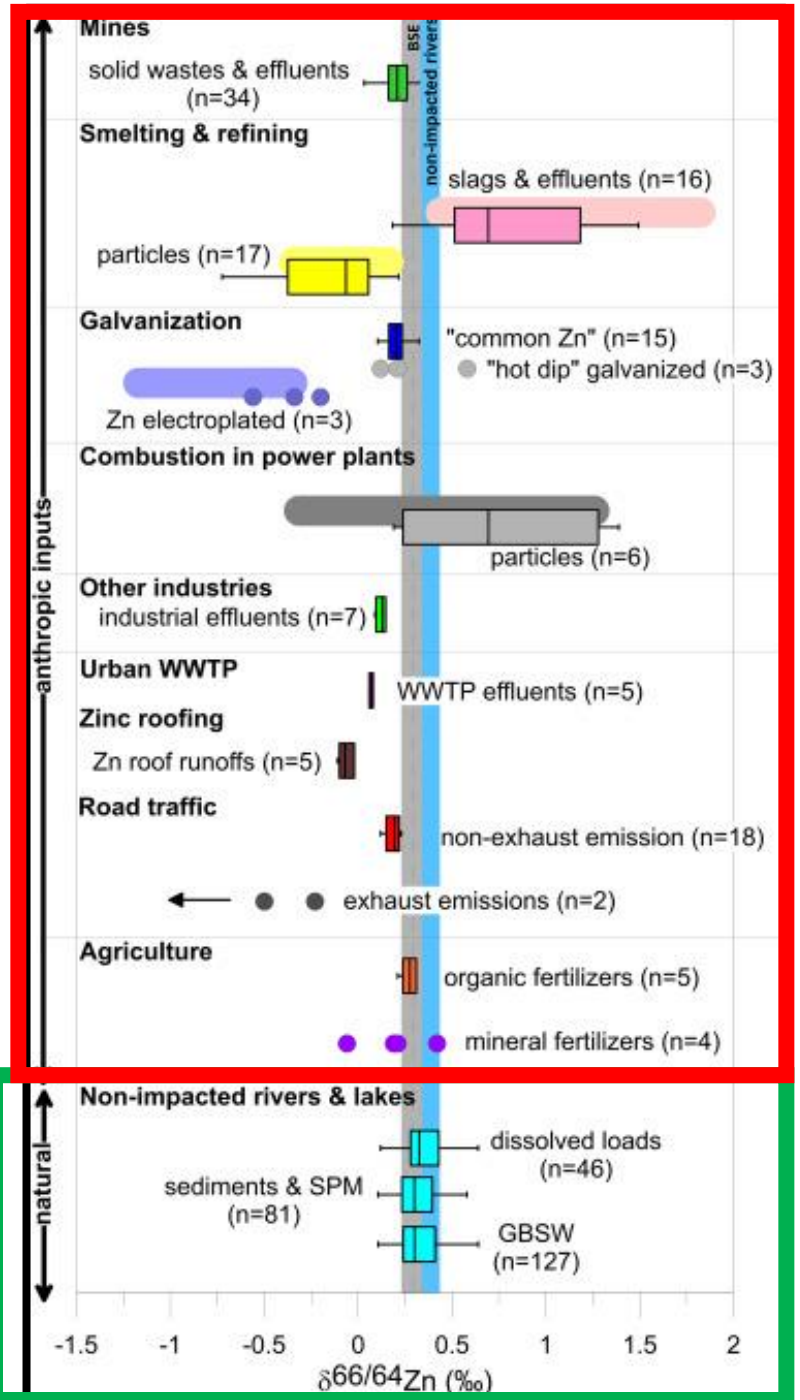
Sen and Bernhard Peucker-Ehrenbrink, 2012



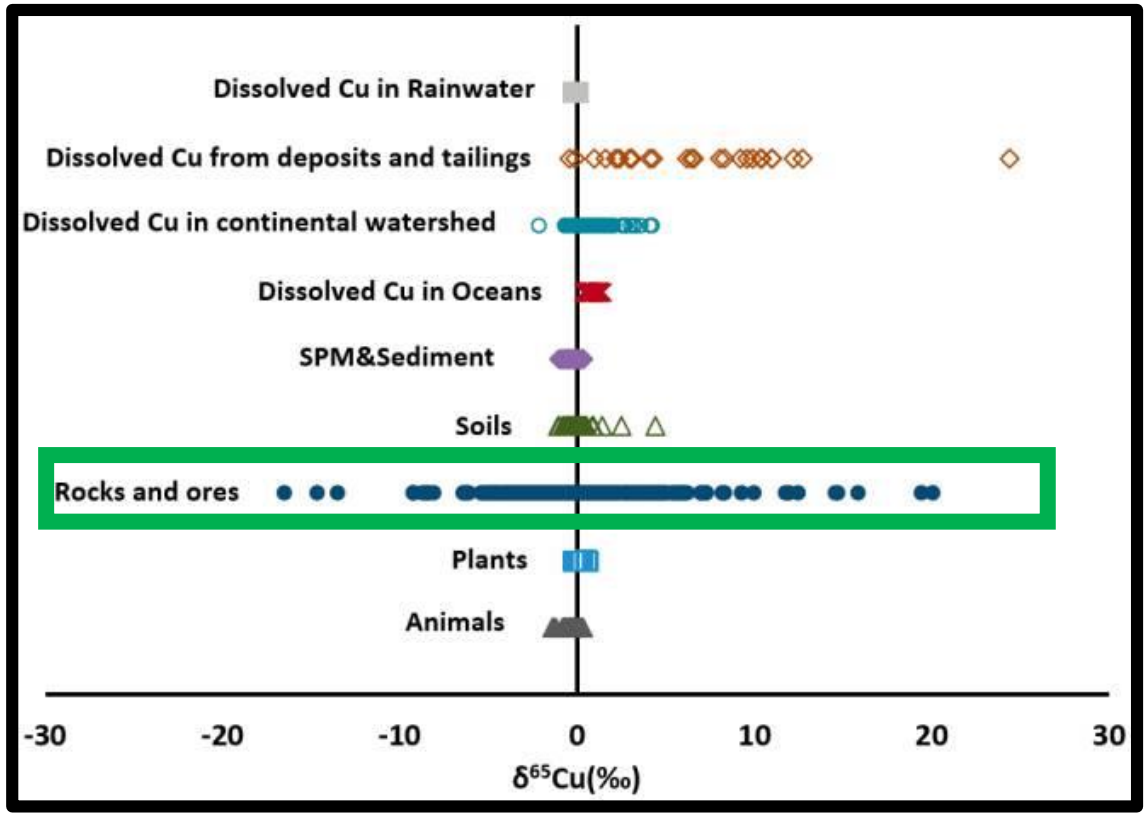






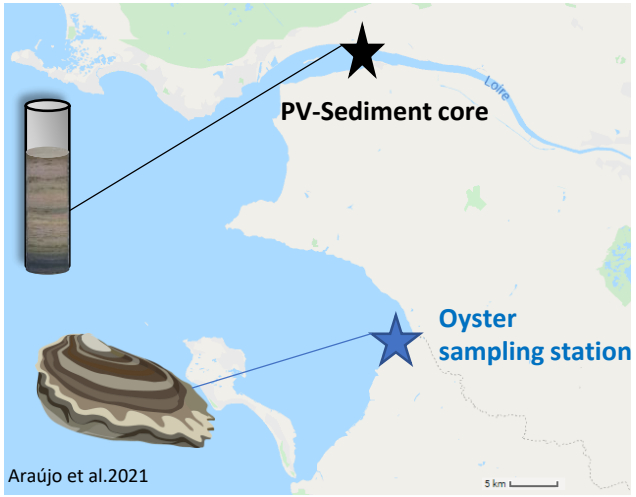


Desaulty and Pelet-Giraud, 2020

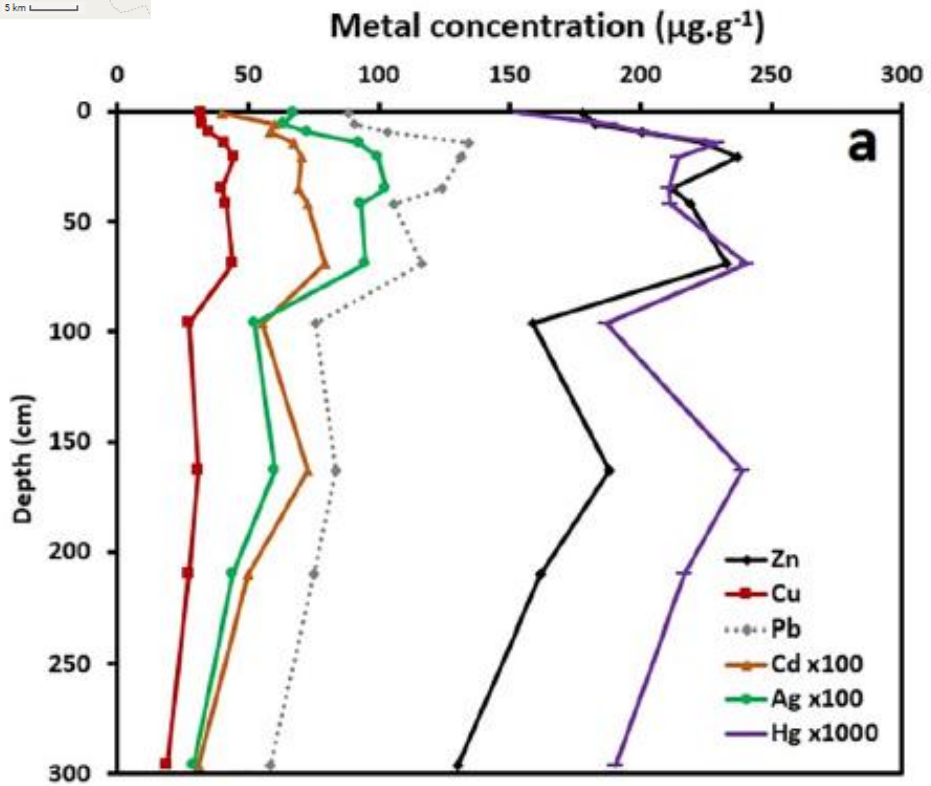


Wang et al., 2017

Estuaire de la Loire



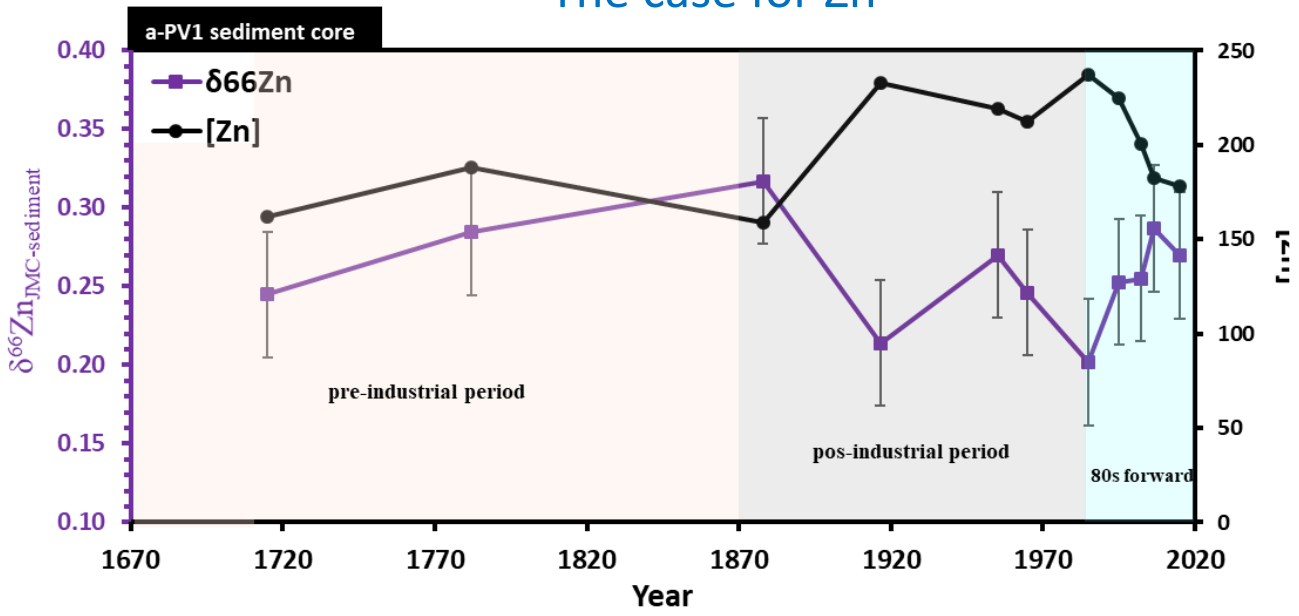
- **Un réceptacle de contaminants métalliques.**
- Sources urbaines, minières, viticoles, et industriels.
- Échantillons de sédiments et bivalves disponibles.

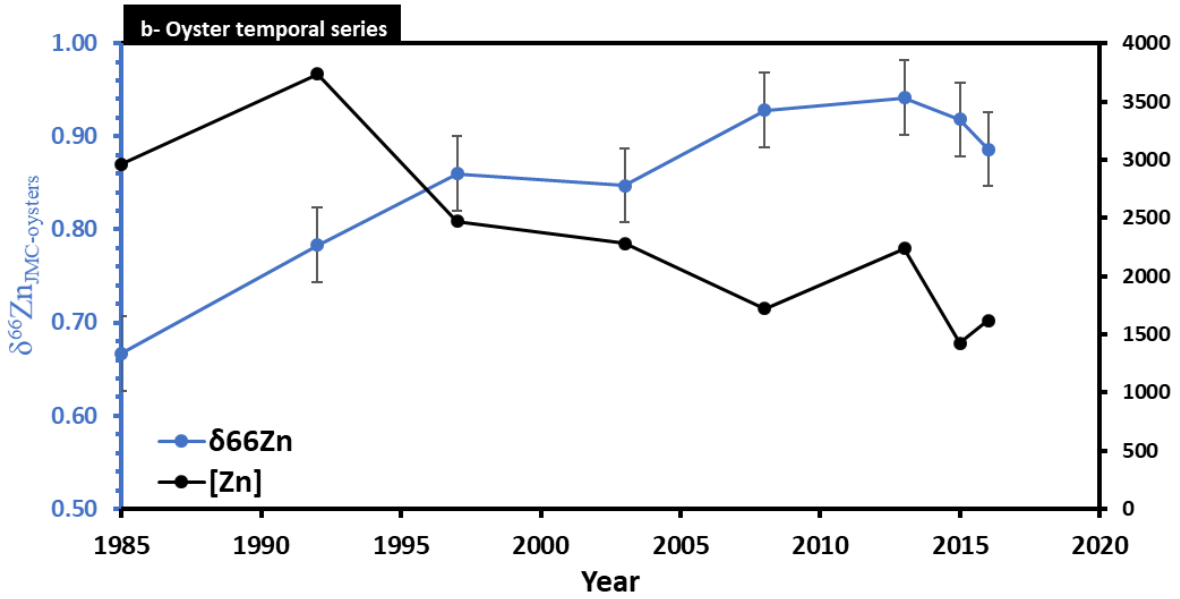


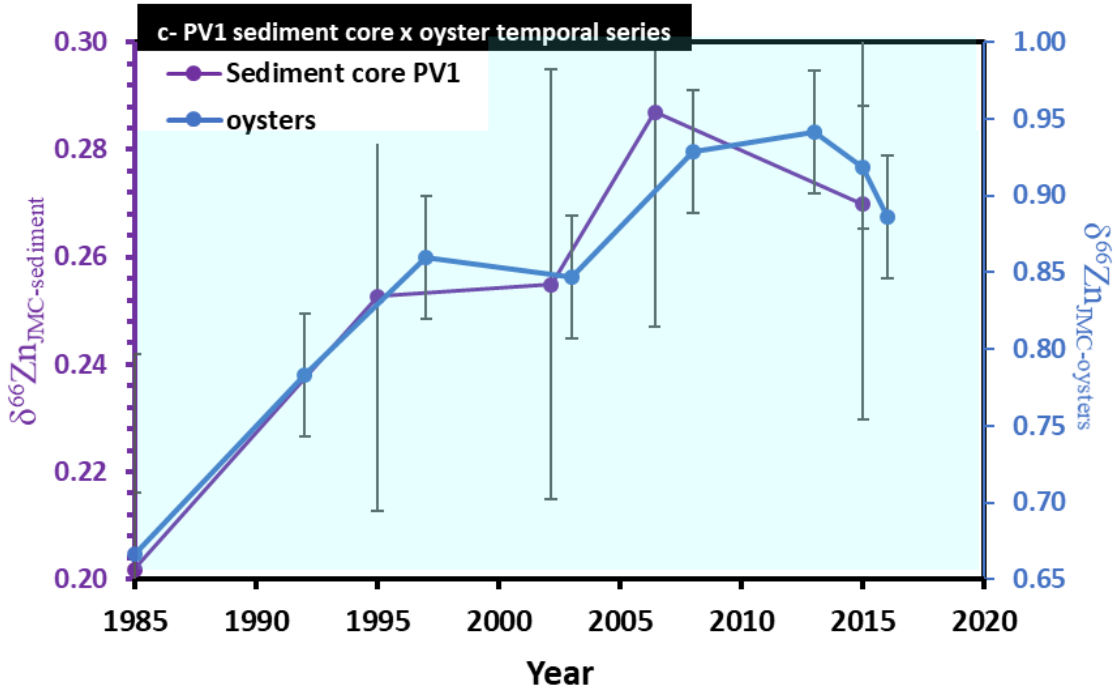
L'identification et quantification des sources sont inconnues pour la plupart des contaminants métalliques.

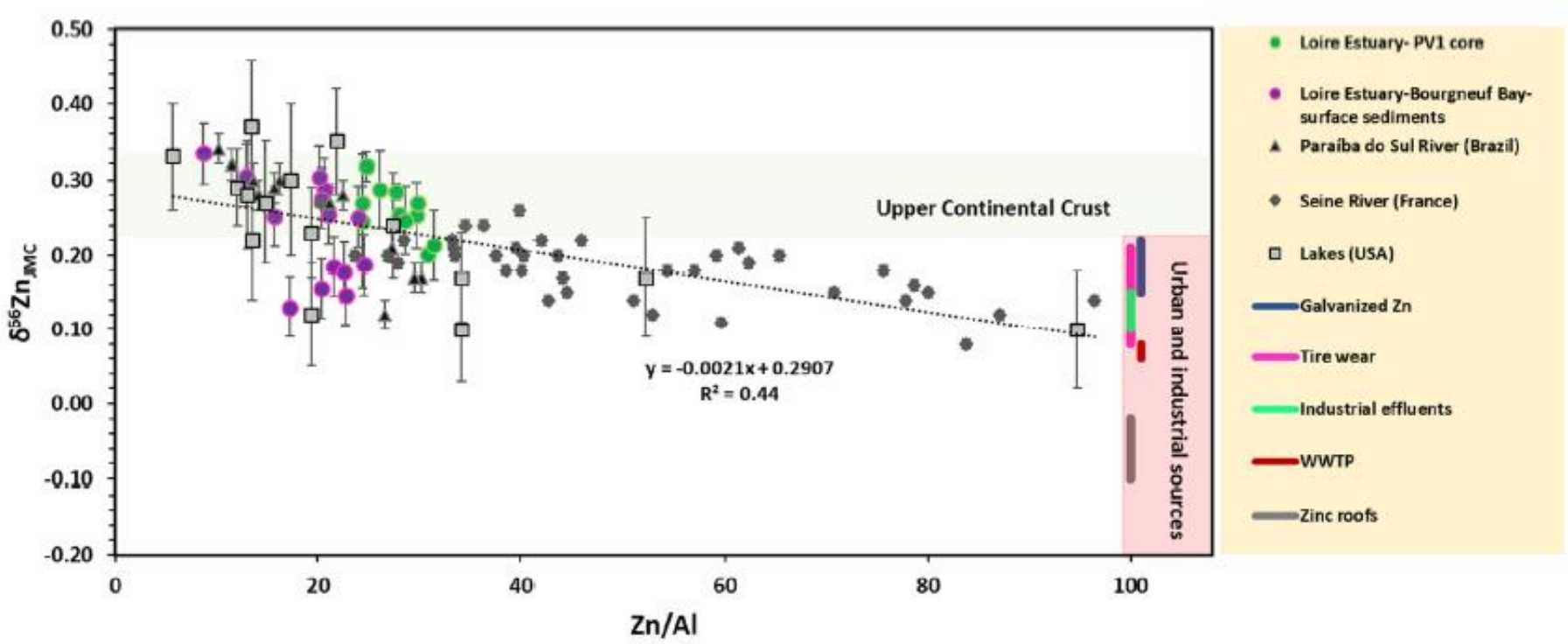
Applications des isotopes pour discriminer les sources anthropogéniques anciennes et actuelles.

The case for Zn



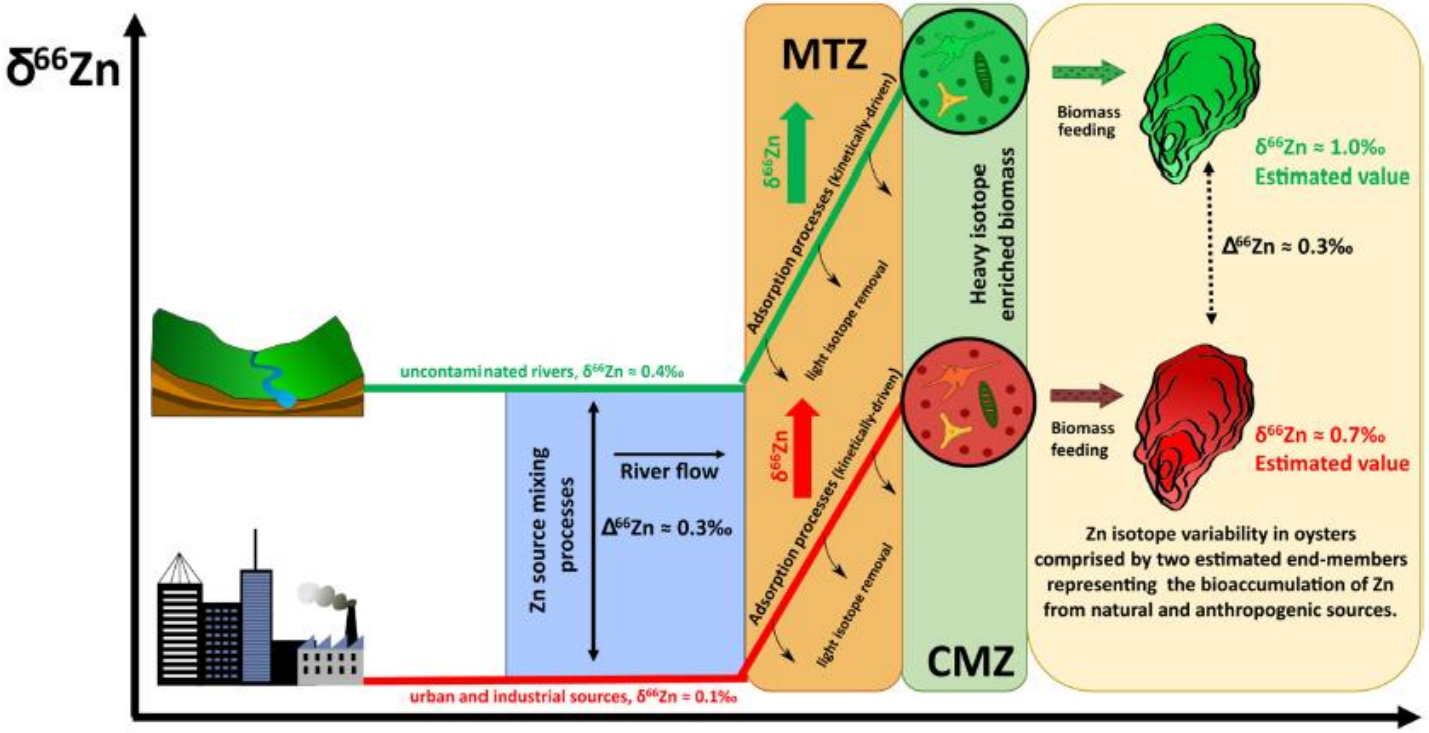


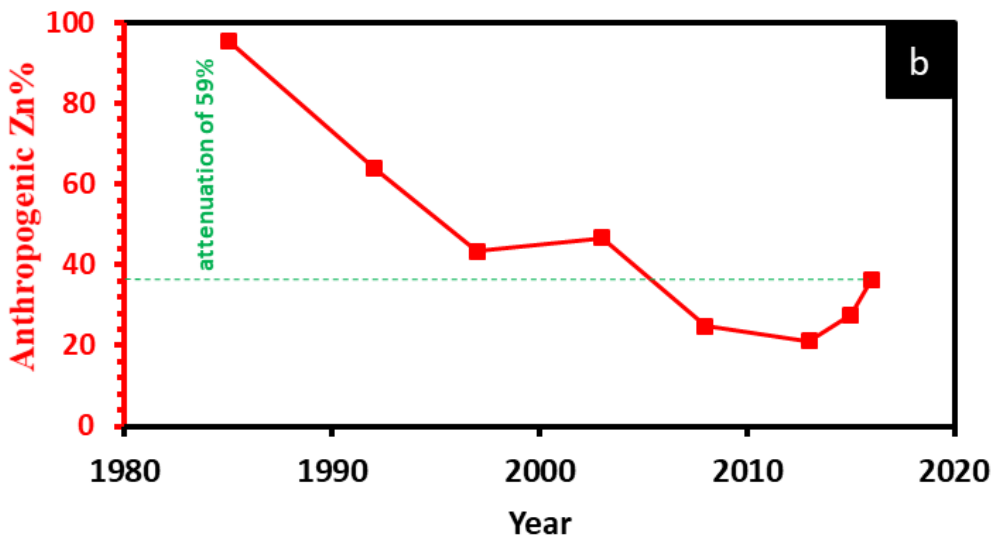




- La plupart des sources industriels et urbaines ont des moyennes isotopiques centrées autour de **0.1‰**, qui font de leur discrimination un défi analytique.

- Malgré cet inconvénient, les signatures $\delta^{66}Zn$ constituent un outil de suivi des empreintes anthropiques urbaines et industrielles dans les systèmes aquatiques.





ACS ES&T Water
pubs.acs.org/estwater
Article

Application of Zn Isotope Compositions in Oysters to Monitor and Quantify Anthropogenic Zn Bioaccumulation in Marine Environments over Four Decades: A "Mussel Watch Program" Upgrade

Daniel F. Araújo,* Emmanuel Ponzevera, Dominik Jakob Weiss, Joël Knoery, Nicolas Briant, Santiago Yepez, Sandrine Bruzac, Teddy Sireau, and Christophe Brach-Papa

Cite This: https://dx.doi.org/10.1021/acsestwater.1c00010
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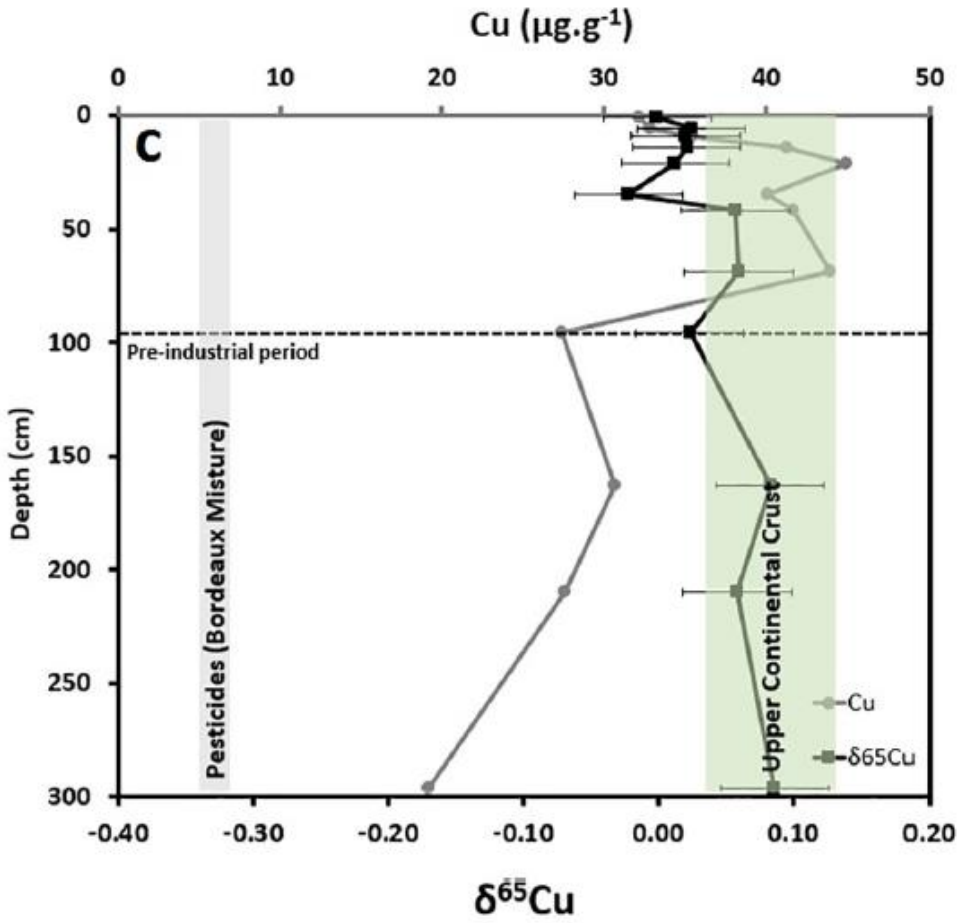
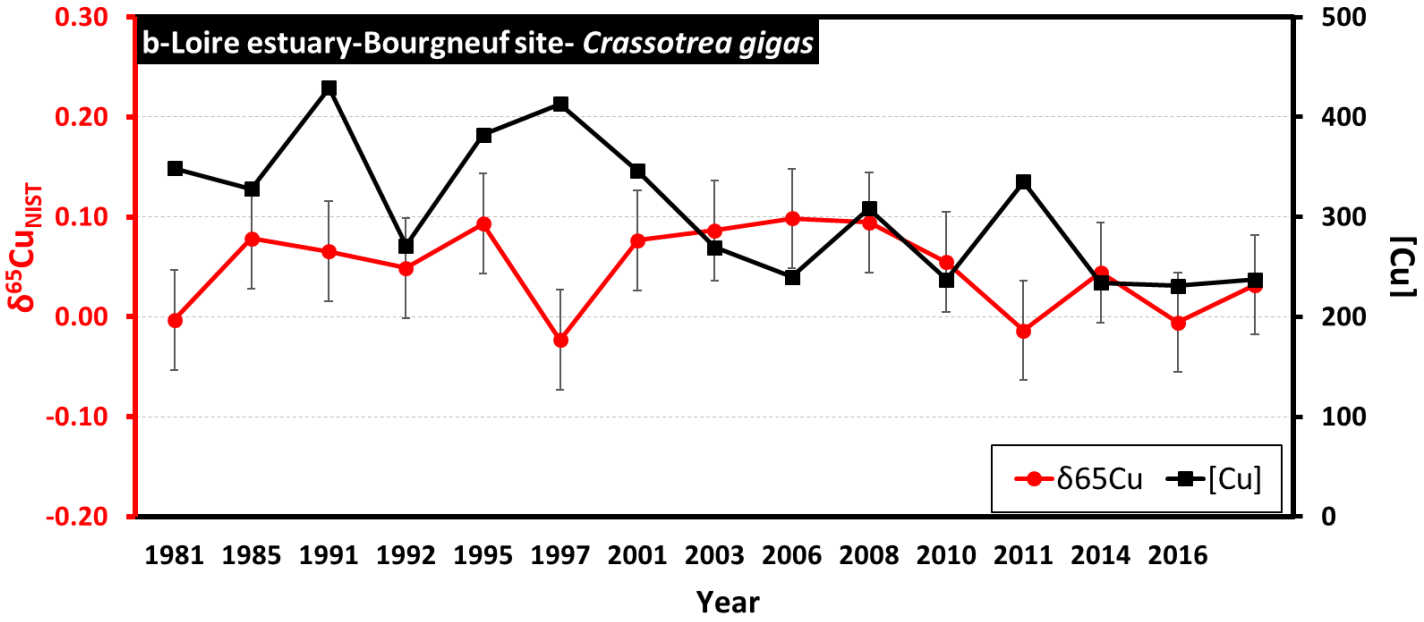
ABSTRACT: The application of zinc (Zn) isotope compositions in bivalve organisms to quantify anthropogenic Zn bioaccumulation in marine biota is of great interest to environmental marine management programs such as the "Mussel Watch Program". Field studies, however, are urgently needed to test its practical value. To this end, we investigated Zn isotope variations in the oyster *Crassostrea gigas* collected over four decades near the Loire estuary (France), where previous geochemical studies provided evidence for a regionally uniform but temporally variable metal contamination. We show that the Zn temporal isotope profile of oysters matches that of the sedimentary records with an isotope offset of approximately +0.5–0.7‰

The case for Cu



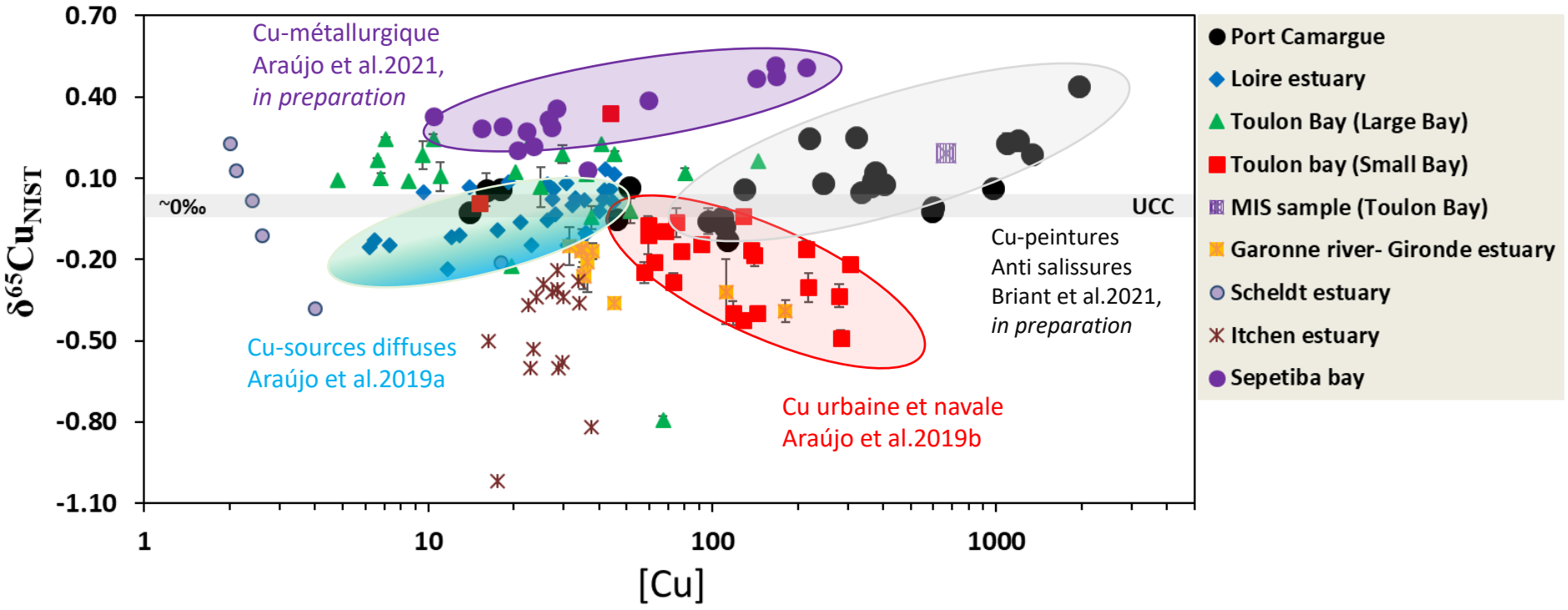


Les informations isotopiques sont plus déclaratives que les concentrations, quand celles-ci sont à niveaux proches du fond biogéochimique naturel.

Marine Pollution Bulletin 143 (2019) 12–23

Daniel F. Araújo[a,*], Emmanuel Ponzevera[a], Nicolas Briant[a], Joël Knoery[a], Teddy Sireau[a], Meryem Mojtahid[b], Edouard Metzger[b], Christophe Brach-Papa[a,c]

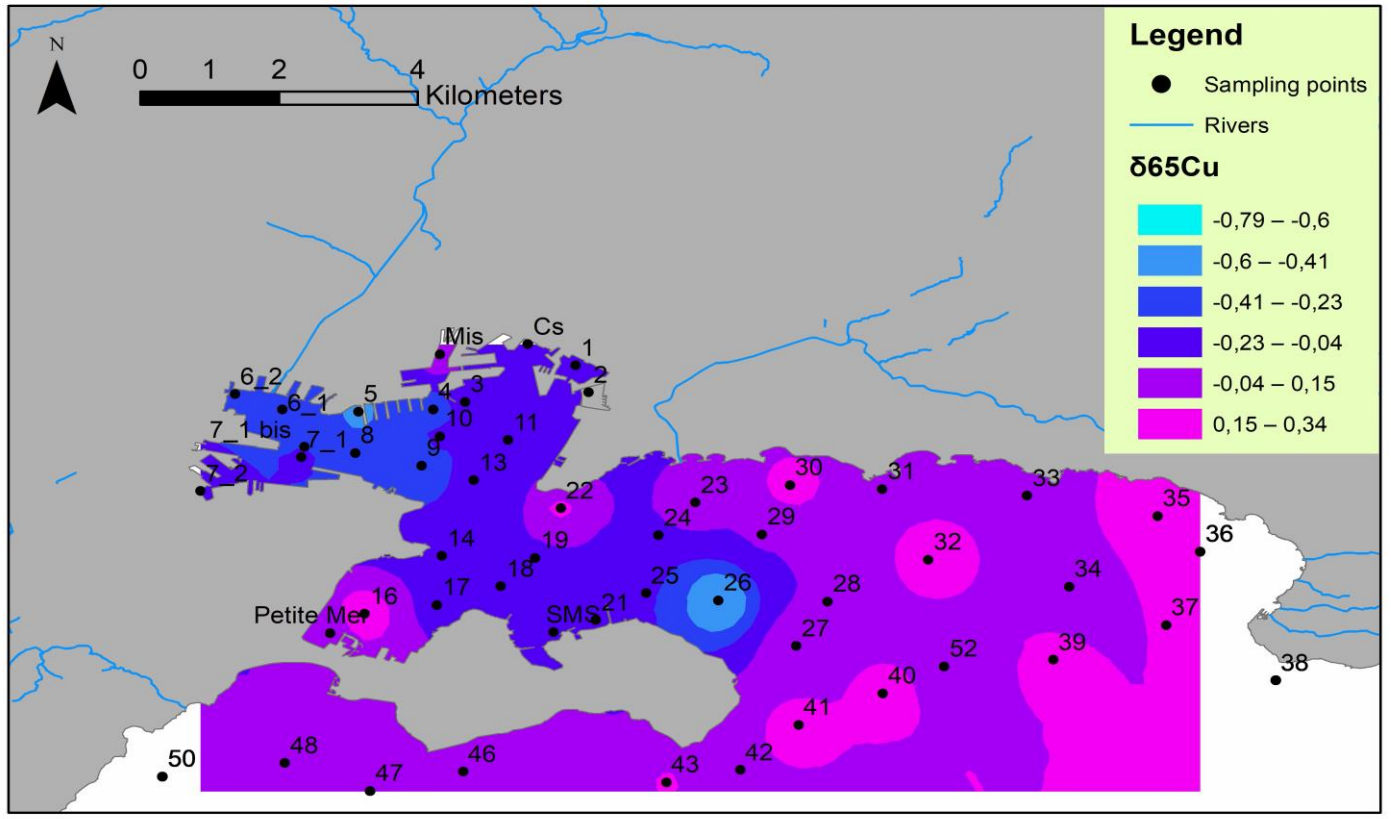
L’application des isotopes stables **Cu et Zn** dans des sédiments en systèmes marins et côtières sous différents contextes de pollution:



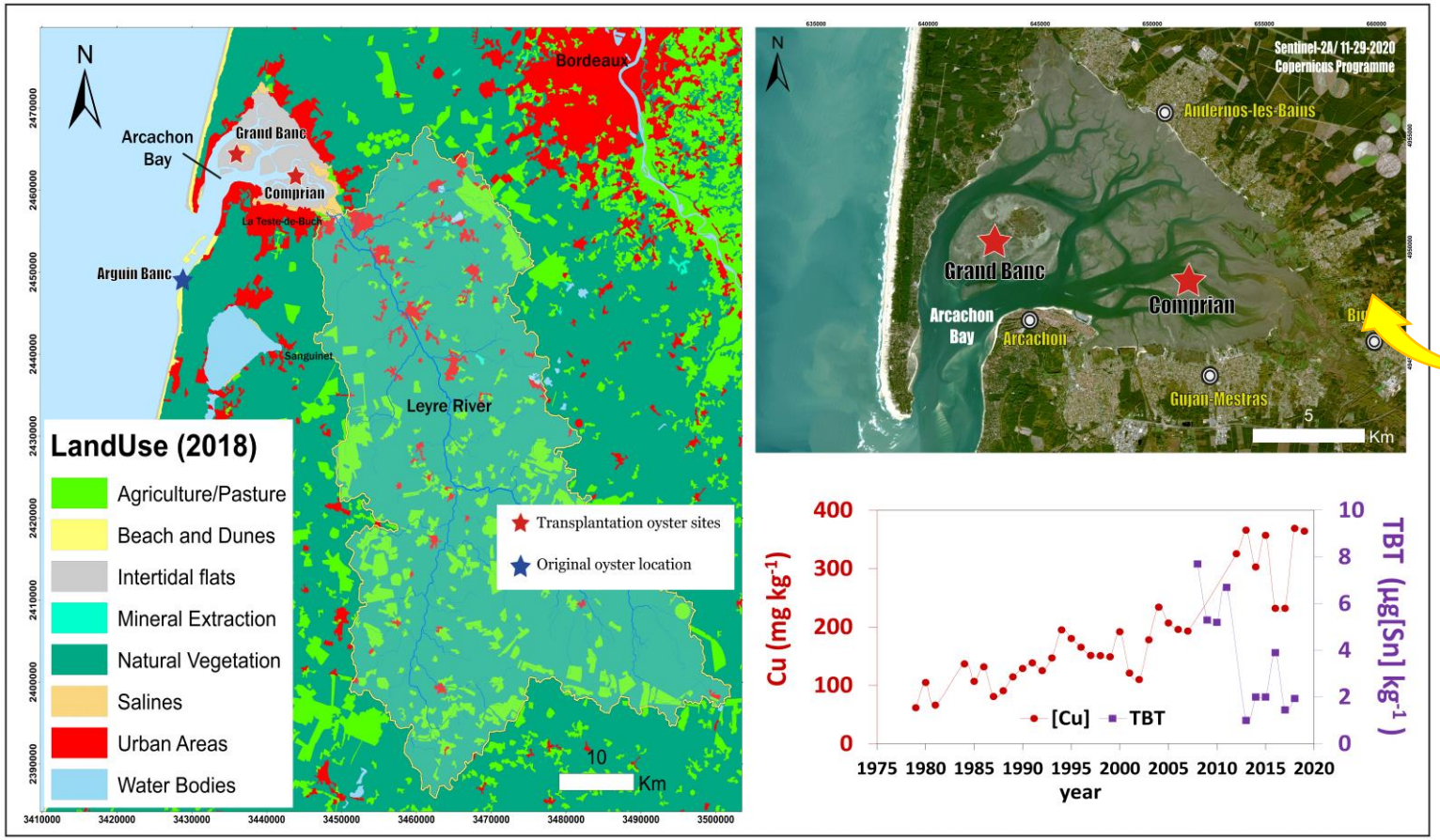
La Rade de Toulon

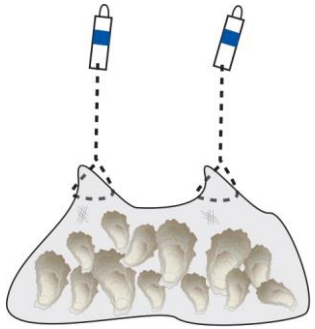
Applied Geochemistry 111 (2019) 104440

Daniel F. Araújo [a,*], Emmanuel Ponzevera [a], Nicolas Briant [a], Joël Knoery [a], Sandrine Bruzac [a], Teddy Sireau [a], Christophe Brach-Papa [b]



La baie d'Arcachon



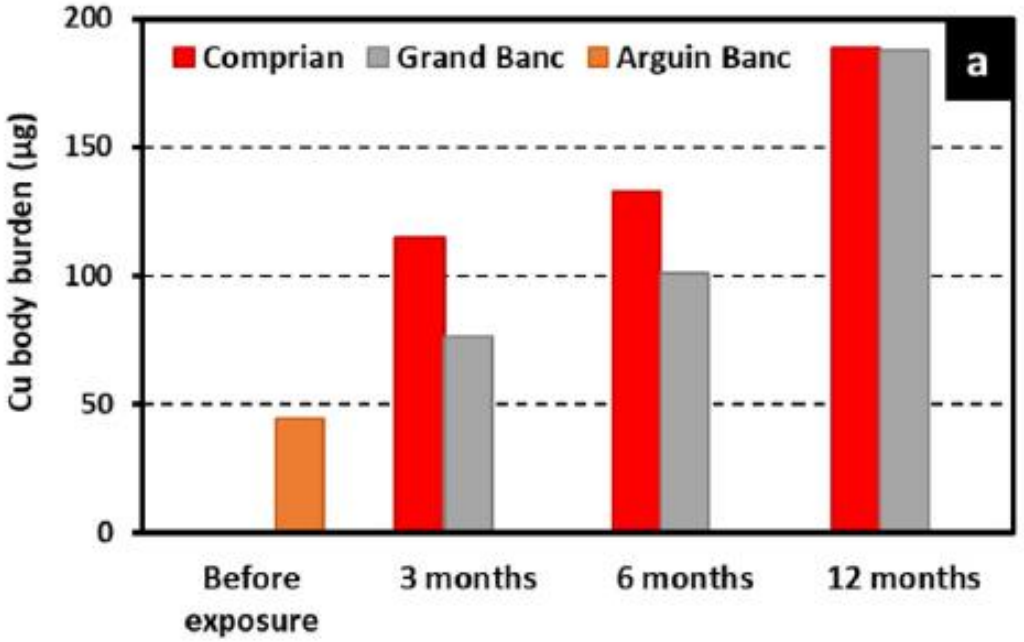


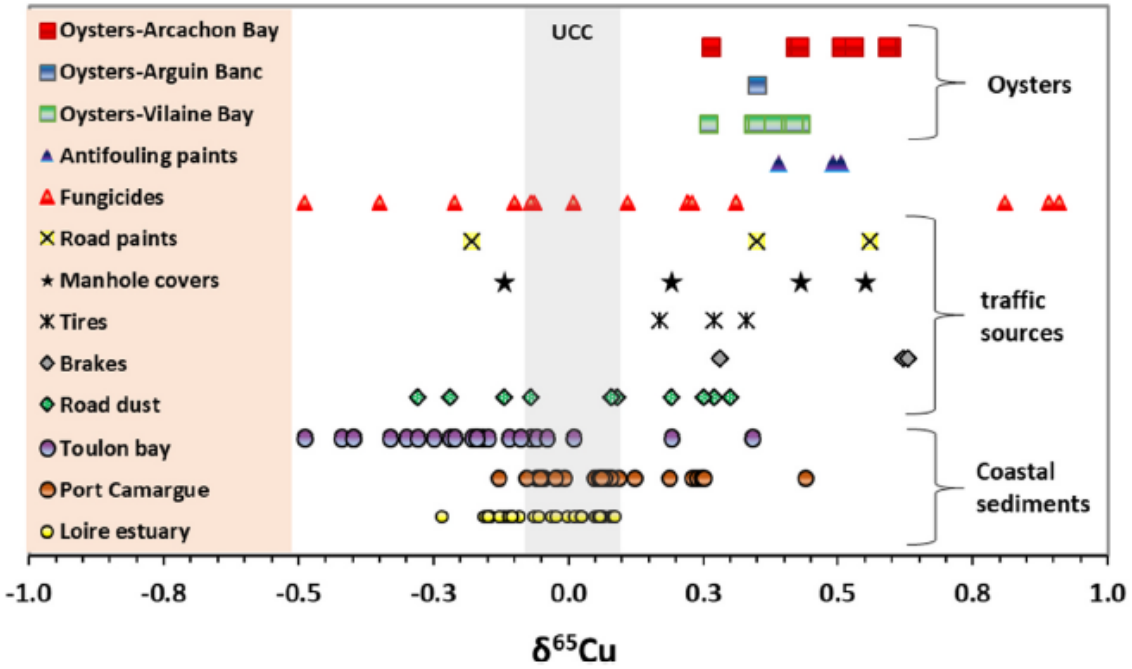
Transplantation des huîtres

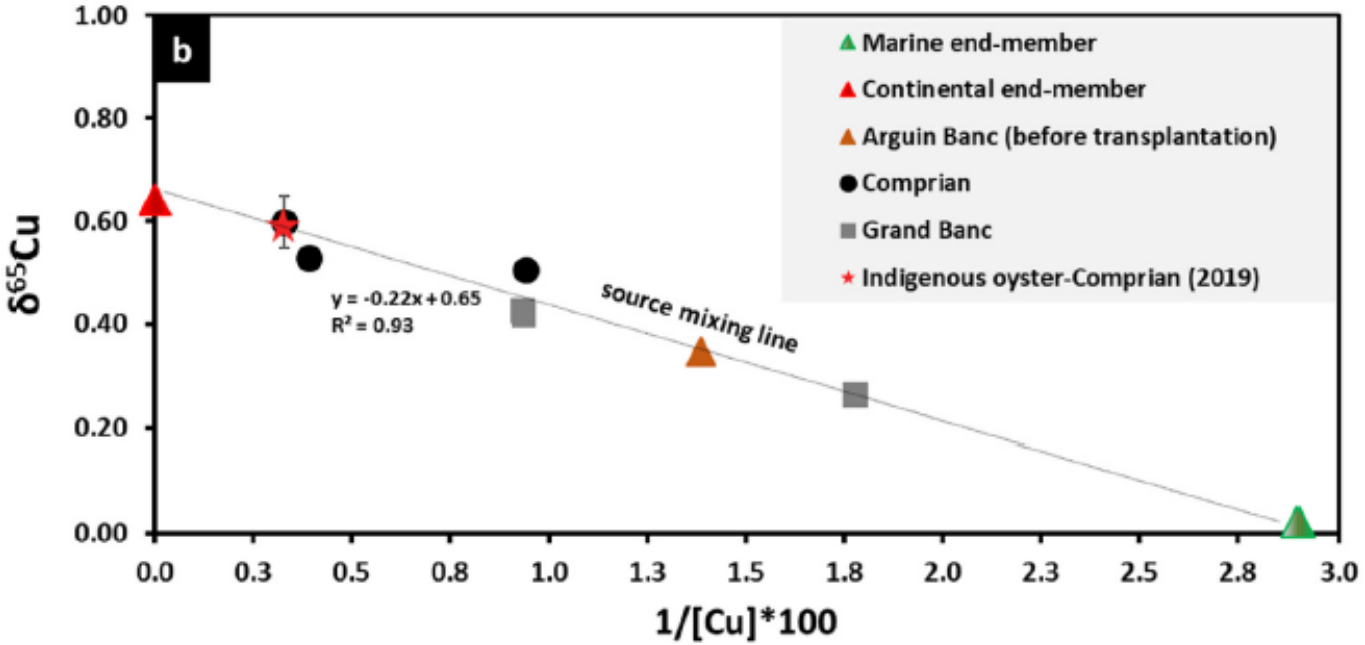
l'hypothèse: (1) les signatures isotopiques des huîtres transplantées après l'exposition sur site reflètent les sources Cu locales.

(2) Les décalages isotopiques temporelles permettent de quantifier et identifier des sources anthropogéniques.

Une alternative aux sites marins sans banque d'échantillons disponible.







δ65Cu (‰)	Anthropogenic Cu (%)
0.35	52
0.50	77
0.53	81
0.60	92
0.26	39
0.42	63
0.43	65
0.59	90

Perspectives

- **Utiliser différentes espèces dans la surveillance isotopique:** Il faut vérifier le fractionnement isotopique potentiel lors de l'absorption biologique et de la distribution interne.

ENVIRONMENTAL Science & Technology

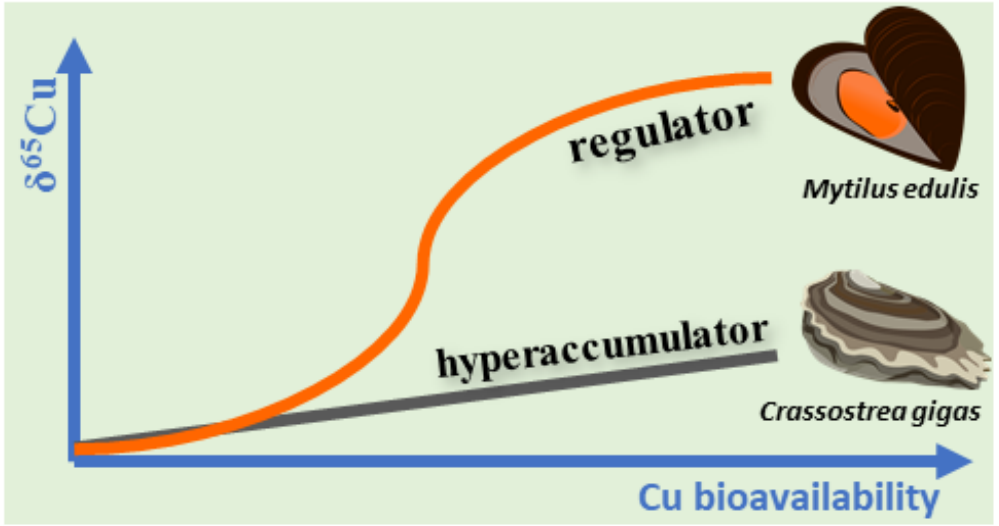
Environ. Sci. Technol. 2021, 55, 324–330

pubs.acs.org/est

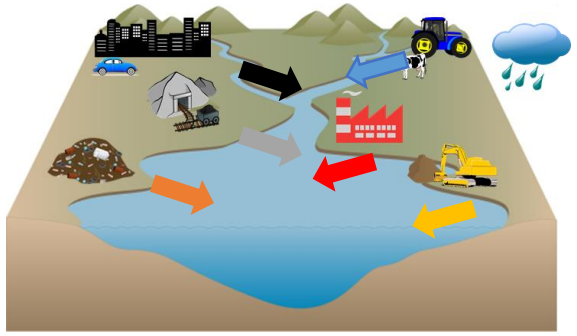
Article

Differences in Copper Isotope Fractionation Between Mussels (Regulators) and Oysters (Hyperaccumulators): Insights from a Ten-Year Biomonitoring Study

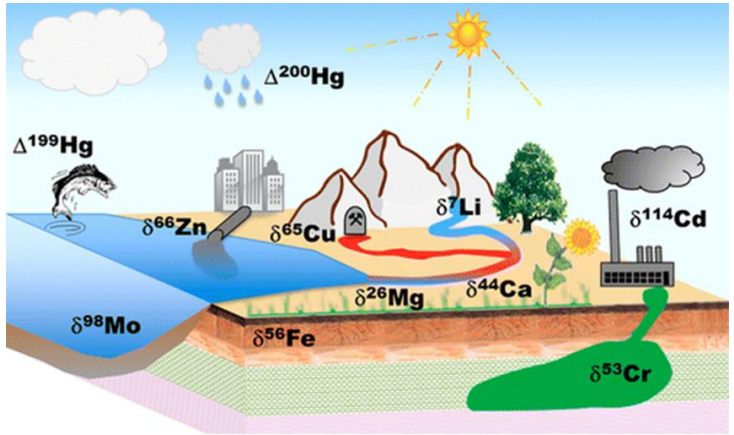
Daniel F. Araújo,* Emmanuel Ponzevera, Nicolas Briant, Joël Knoery, Sandrine Bruzac, Teddy Sireau, Anne Pellouin-Grouhel, and Christophe Brach-Papa



1. Comment identifier les multiples sources et leurs évolutions spatio-temporelles ?



✓ **Approche multi-isotopiques (Cd, Ag, Sb, TCE éléments)**



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ORIGINAL RESEARCH
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Industrially Purified Nd Materials Identified by Distinct Mass-Dependent Isotopic Composition

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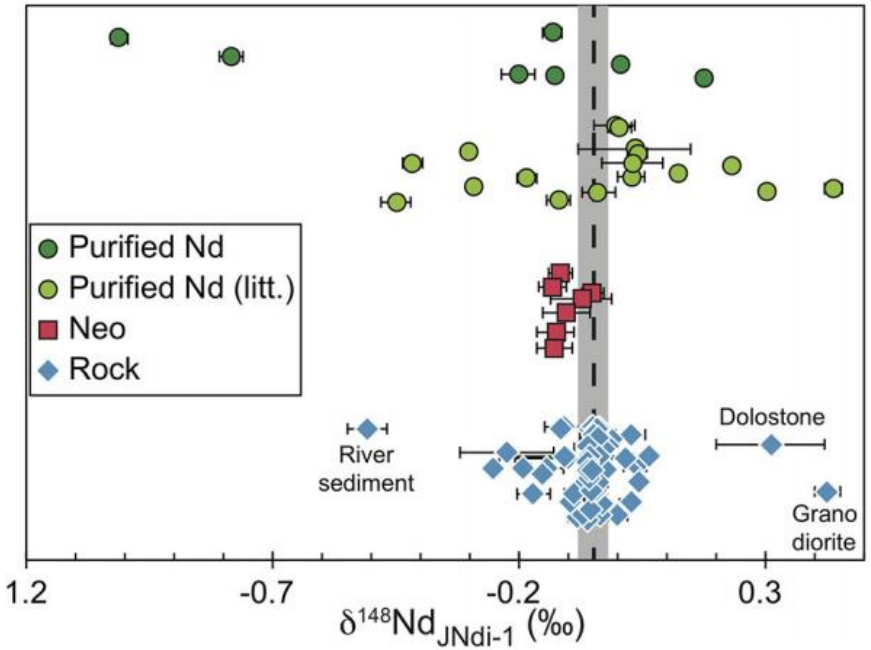
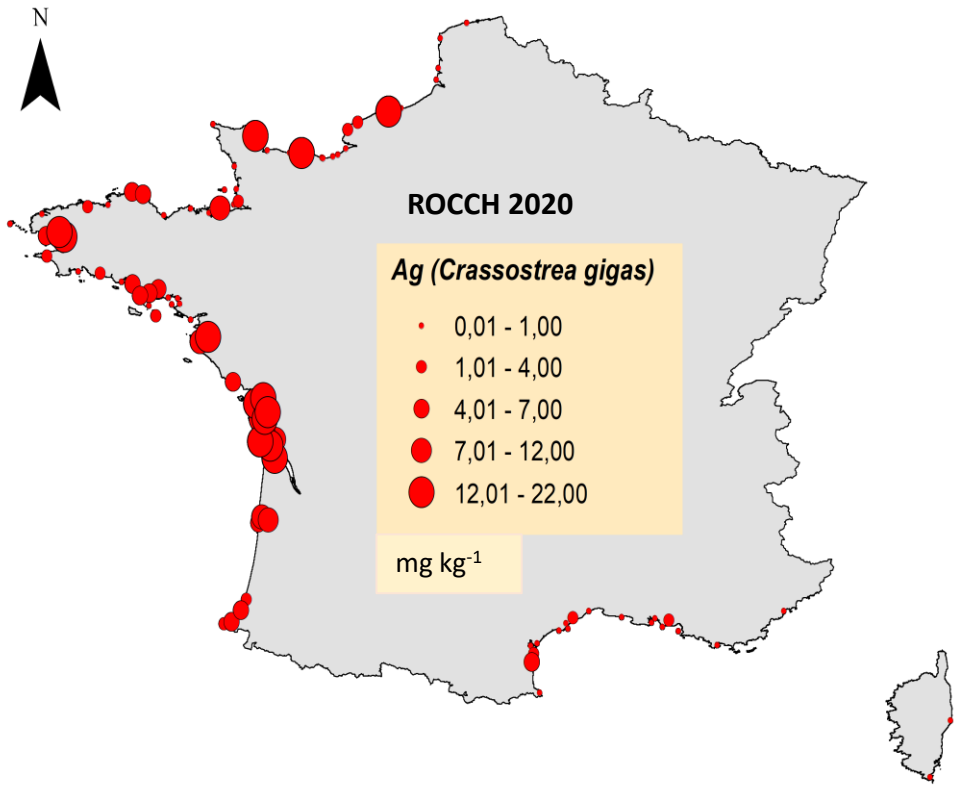


Continuum Terre-Mer



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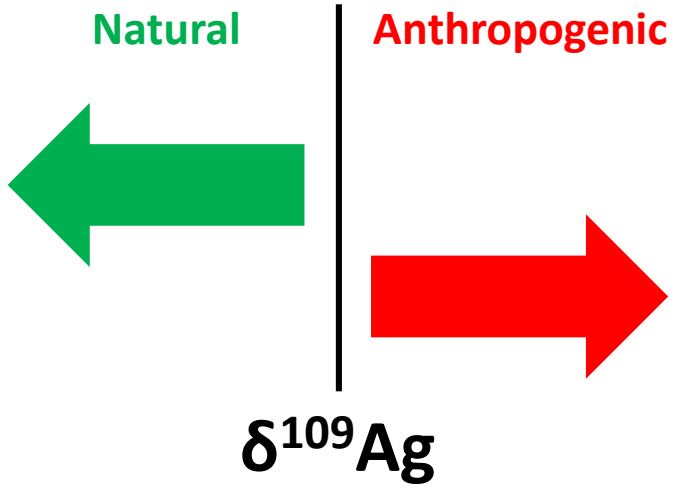
nature nanotechnology

Stable silver isotope fractionation in the natural transformation process of silver nanoparticles

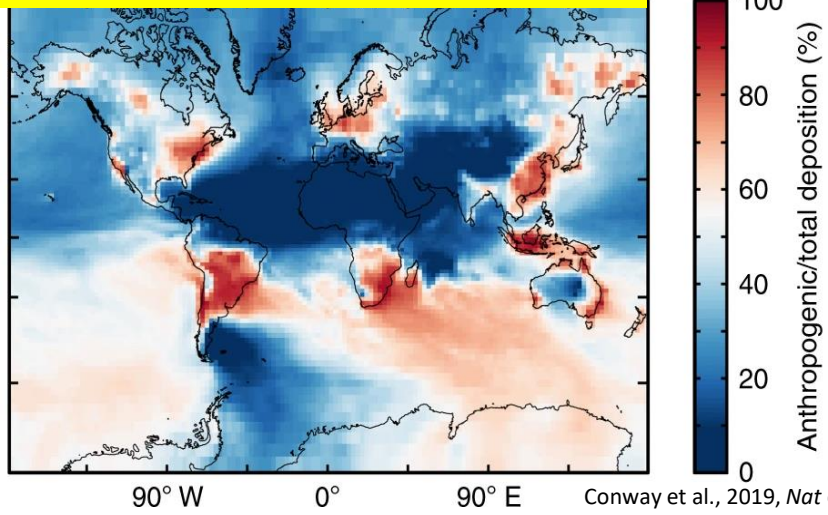
Dawei Lu, Qian Liu*, Tuoya Zhang, Yong Cai, Yongguang Yin and Guibin Jiang*



Continuum Terre-Mer

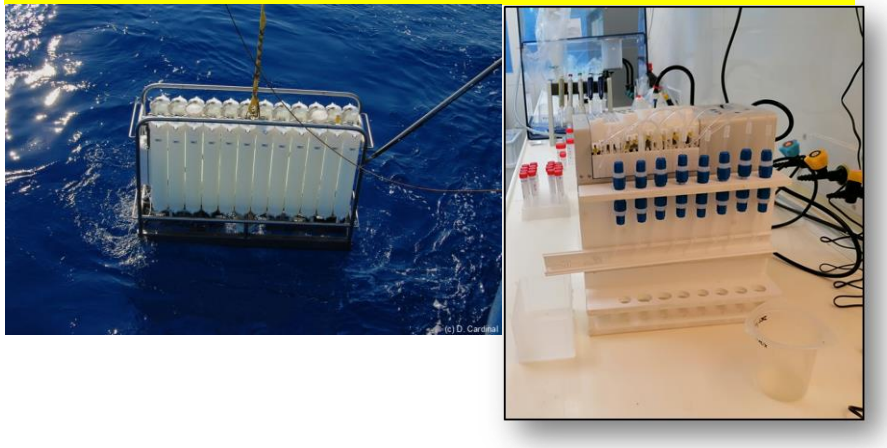
✓ Mise en place des différentes stratégies d'échantillonnage en considérant différentes échelles spatio-temporelles

Aérossol atmosphérique

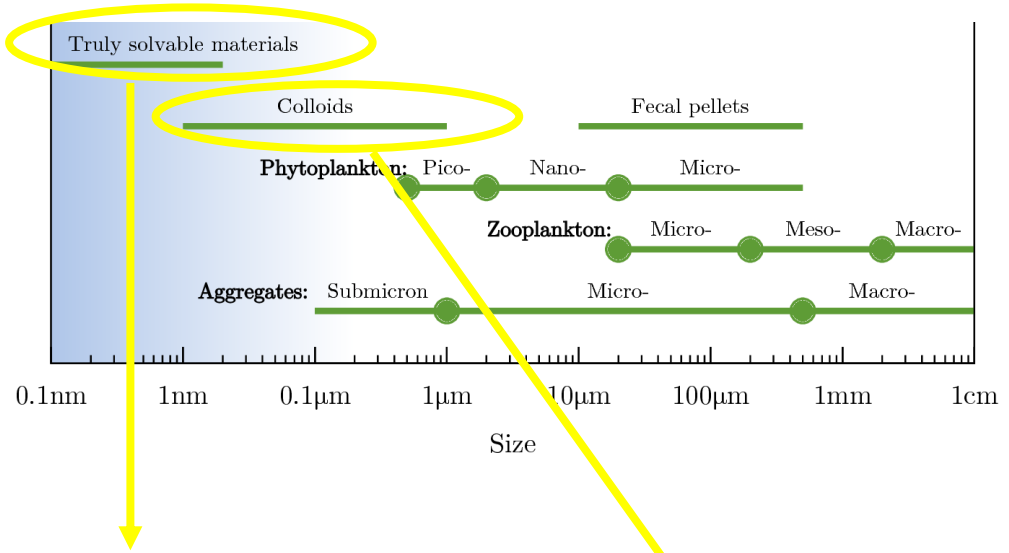


Conway et al., 2019, *Nat Commun* 10, 2628

Eau marin

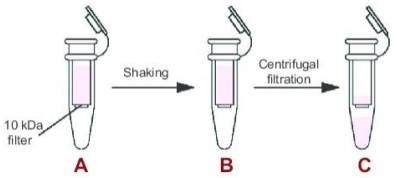


✓ Echantillonnage spécifique pour différentes phases ou classe de taille des particules

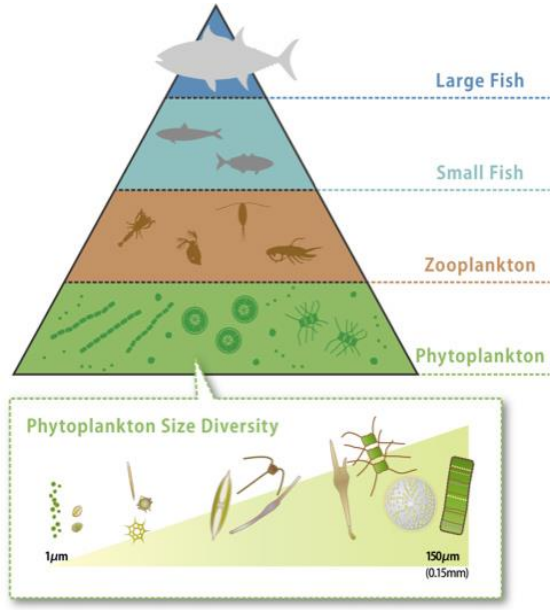


DGT –échantillonner passive- phase dissoute

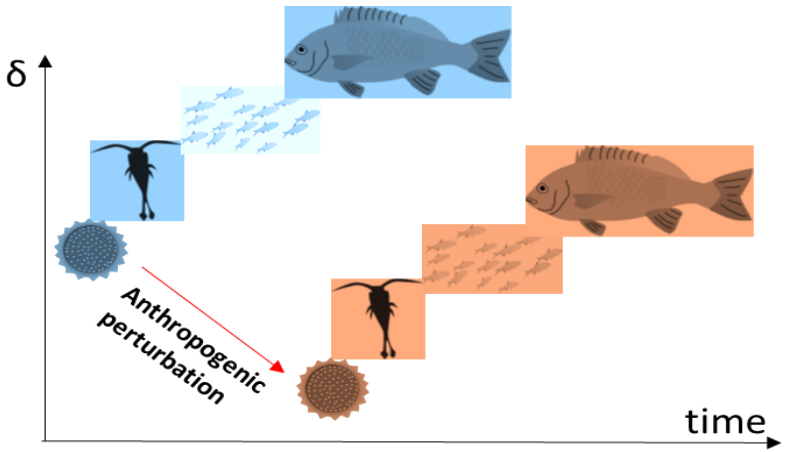
Ultrafiltration – phase colloïdale



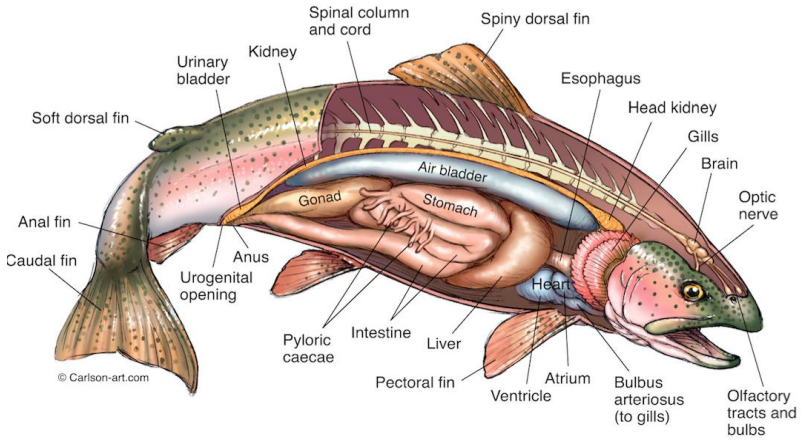
3. Quel est le devenir des contaminants au sein des réseaux trophiques ?



ttps://www.jamstec.go.jp



Les taux d'incorporation et fractionnement isotopique diffèrent-ils selon les taxons, les types de tissus ou les éléments ?



Merci !