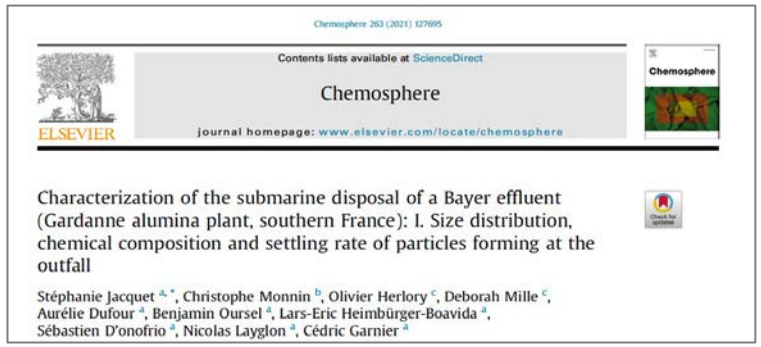
Metal contaminants in the Cassidaigne Canyon: impact of the Bayer effluent of the Gardanne alumina plant

S. Jacquet (MIO), C. Monnin (GET)

- ❑ Gardanne alumina plant (1893)
- ❑ Bauxite extraction (Bayer process)
- ❑ Residu/ slurry « red mud »

  - 1893-1966: tailing ponds (red mud)
  - 1967-2015: Canyon (red mud)
  - 2016: Bayer effluent (at sea) + solid part (tailing pond)
    High pH (12.5) - High metals content liquid effluent
  - 2018: effluent treatment in the plant
    pH and metals concentration decreases


Chemosphere 263 (2021) 127695

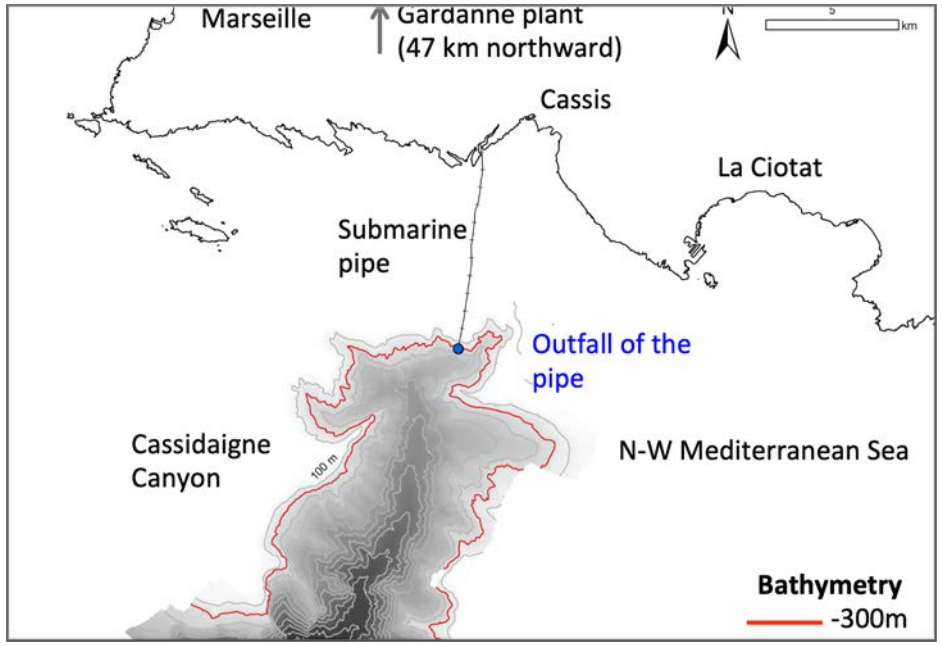
Contents lists available at ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

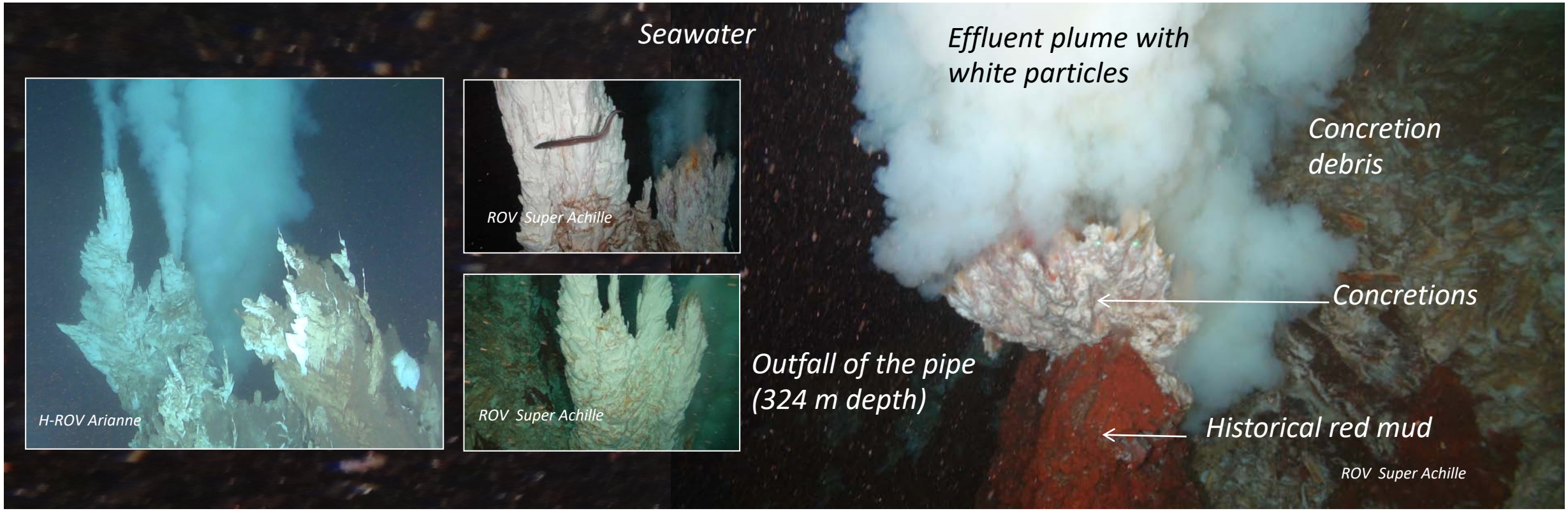
Characterization of the submarine disposal of a Bayer effluent (Gardanne alumina plant, southern France): I. Size distribution, chemical composition and settling rate of particles forming at the outfall

Stéphanie Jacquet [a, *], Christophe Monnin [b], Olivier Herlory [c], Deborah Mille [c], Aurélie Dufour [a], Benjamin Oursel [a], Lars-Eric Heimbürger-Boavida [a], Sébastien D'onofrio [a], Nicolas Layglon [a], Cédric Garnier [a]



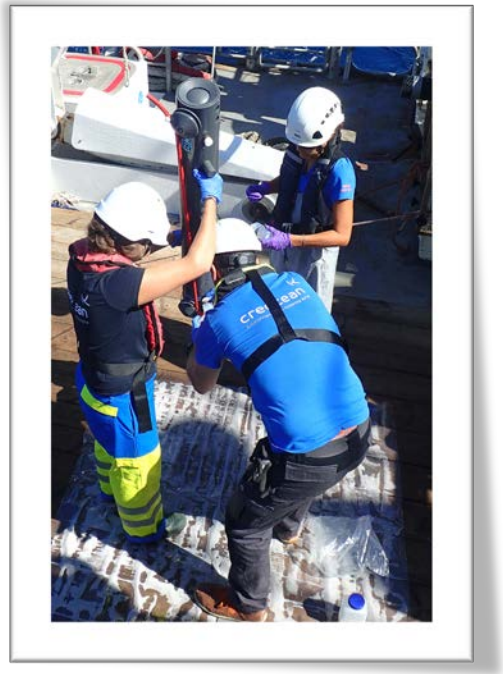
2016

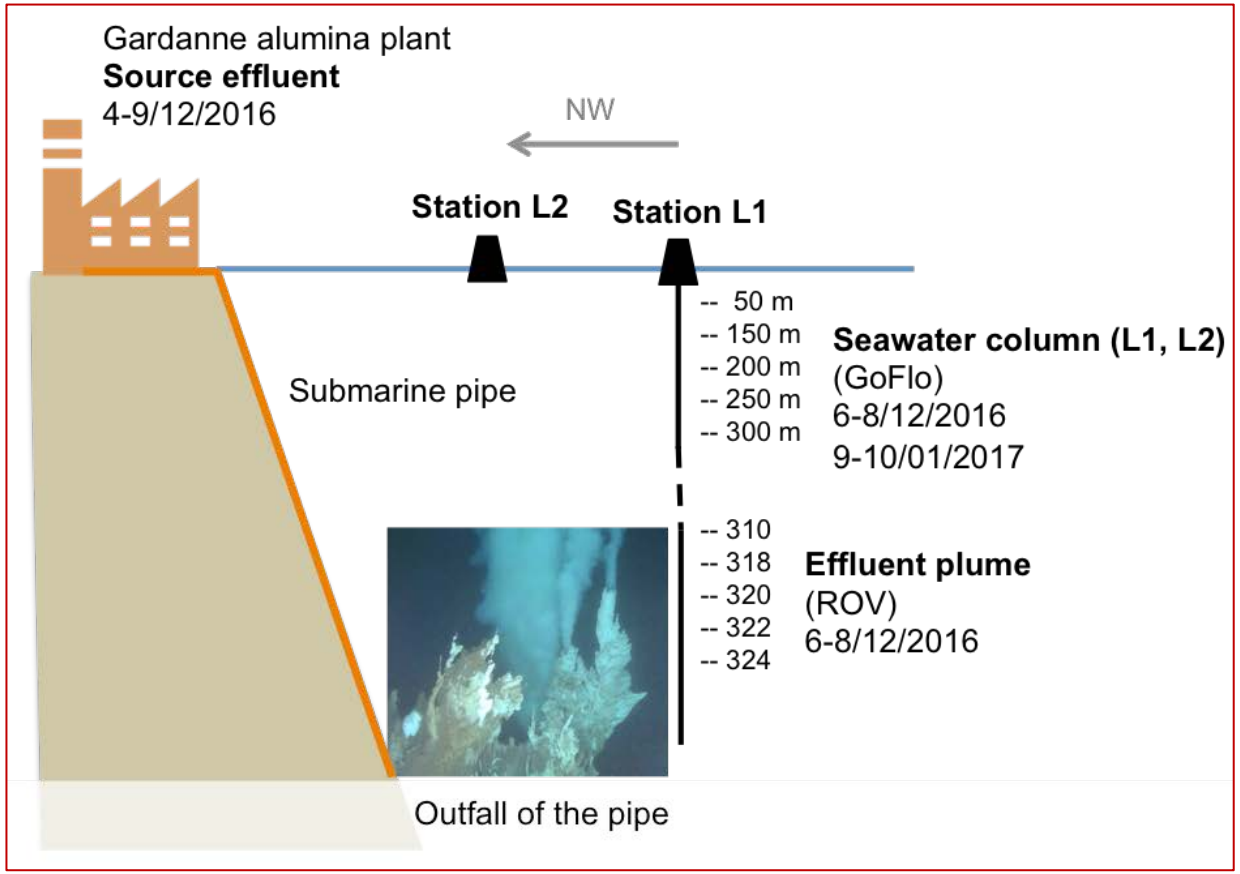
"Hydrothermalisme industriel"



Sampling

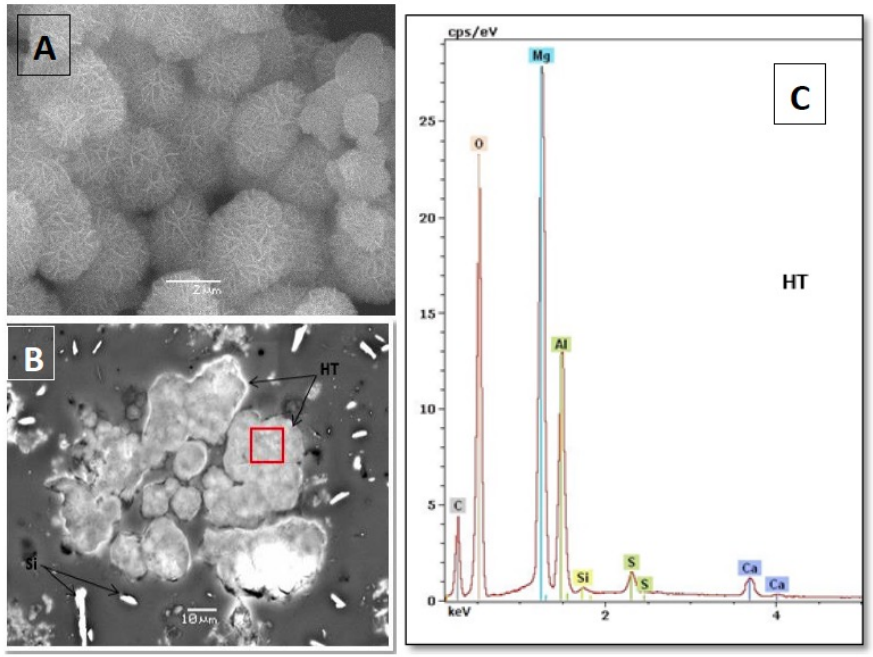
- ❑ Source effluent (Gardanne plant)
- ❑ Effluent plume (outfall - ROV)
- ❑ Seawater column (L1 outfall, L2 non-impacted– GoFlo)
- ❑ Concretions & particles
- ❑ Sediments





Mineralogical & Chemical composition

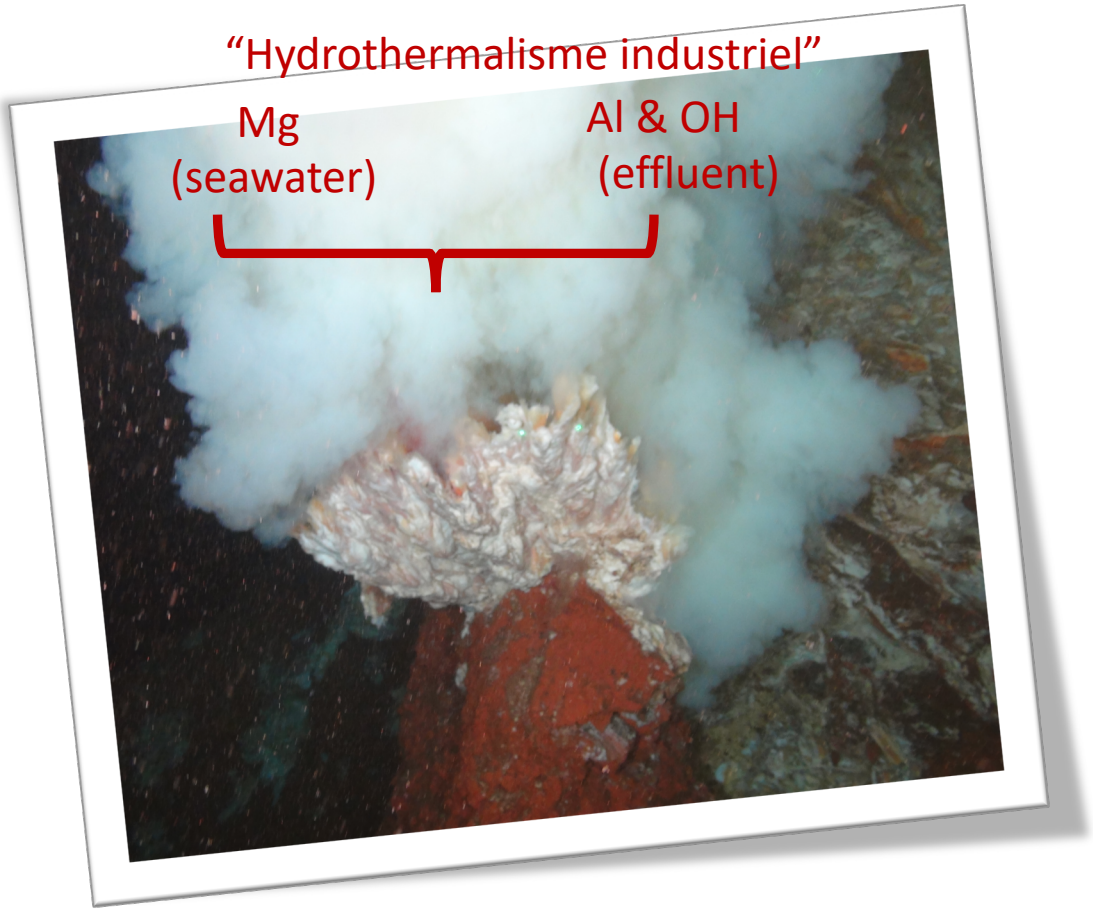
- Mineralogical composition: hydrotalcite (HTC), Mg-Al Double Layered Hydroxide
- Group 1: HTC (core of concretions), Groups 2-3: HTC + brucite + calcium carbonate (layer)
- Chemical composition (SF-ICP-MS): Mg, Al, Ca, S.
- Main metals of interest: As & V

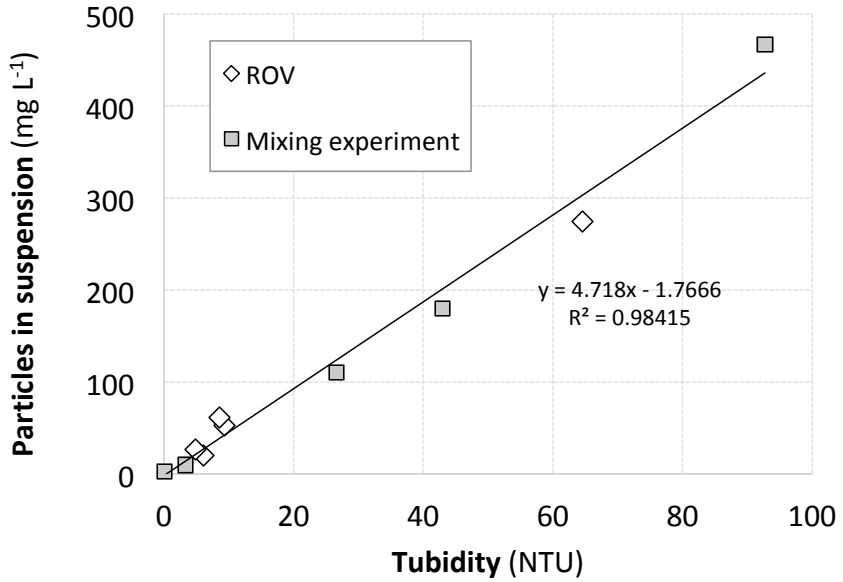


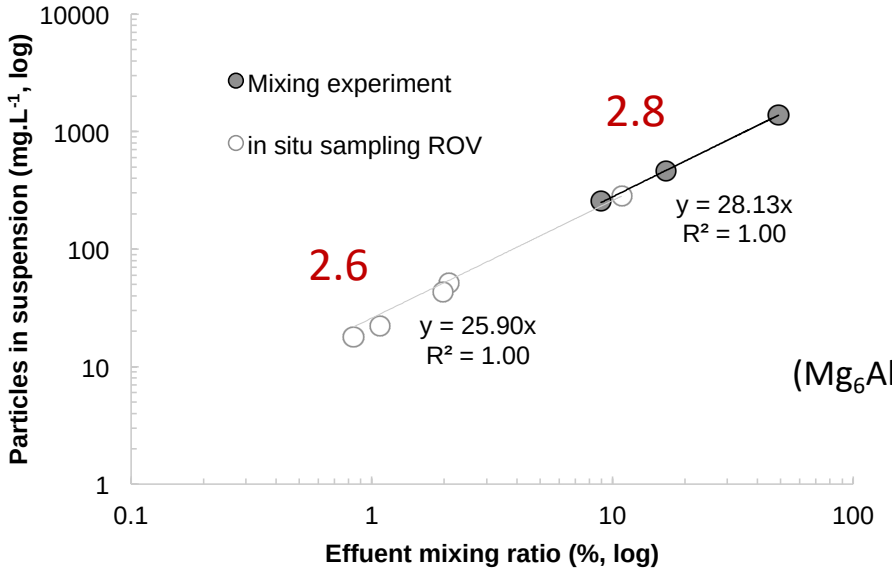
Unit	Element	Group 1 mean
mg g^{-1}	Mg	**443**
	Al	**285**
	Ca	**10**
	S	**7**
µg g^{-1}	Si	**1681**
	V	**1178**
	K	**277**
	Sr	**234**
	P	**76**
	As	**73**
	B	**47**
	Mo	**13**
	Fe	**11**
	Ti	**3**
	Cu	**1.81**
	Zn	**1.71**
	Sn	**1.04**
ng g^{-1}	Rb	**791**
	U	**688**
	Ba	**558**
	Cr	**287**
	Ni	**263**
	Co	**151**
	Sb	**116**
	Mn	**96**
	Ag	**51**
	Cd	**50**
	Pb	**19**
	Hg	**12**
	Th	**10**

Formation yield

- 1 NTU - 4.7 mg L^{-1} of suspended particles
- 1L of effluent – 2.5 g of (dry) particles (25 g wet)



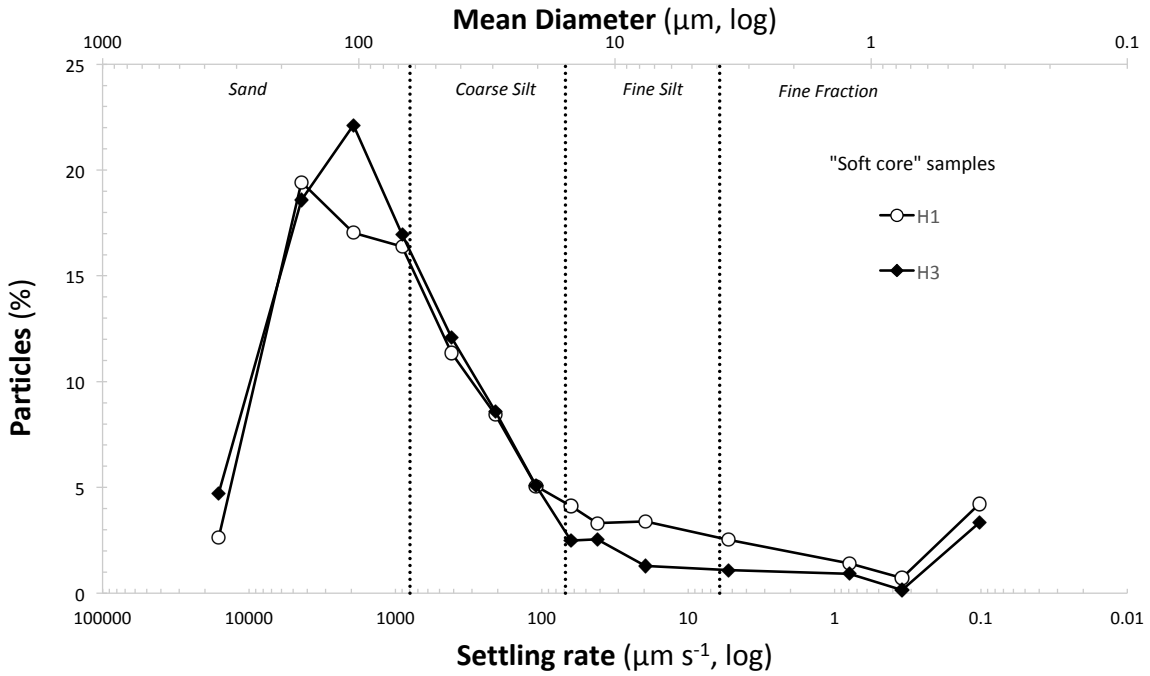




2 HTC
mineral formula
$(Mg_6Al_2(OH)_{16}[CO_3]\cdot 4H_2O)$
molecular weight

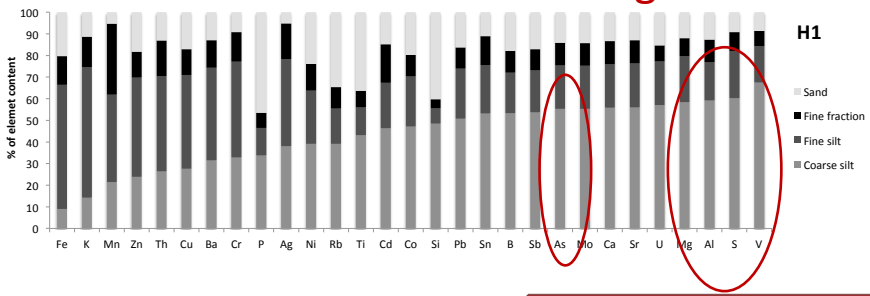
Size distribution- Settling rate

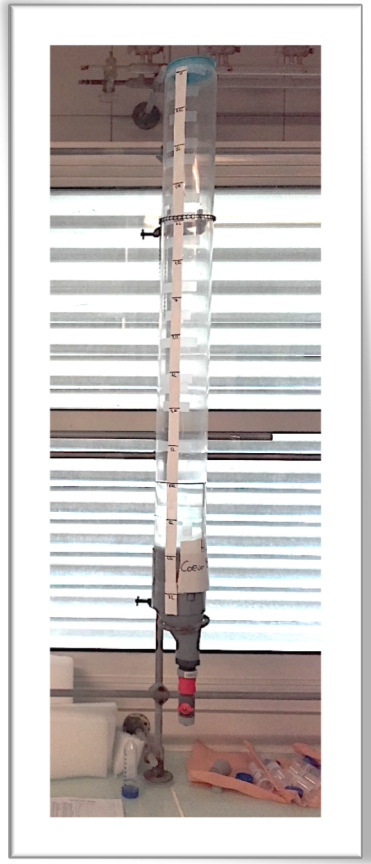
- Particles: mean diameter between 15.6 and 63 um and settling rate around **96 m d^{-1}** (53-60 % of the total concretion mass).
- Main elements (Mg, Al, Ca, S) and metals (As & V)



Sample	Fraction	Settling rate µm s^{-1}	% SPM
H1 soft core	Sand (>63 µm)	5779	22%
	Coarse silt (15.6-63 µm)	1018	53%
	Fine silt (3.9-15.6 µm)	64.1	16%
	Fine fraction (<3.9 µm)	1.72	9%

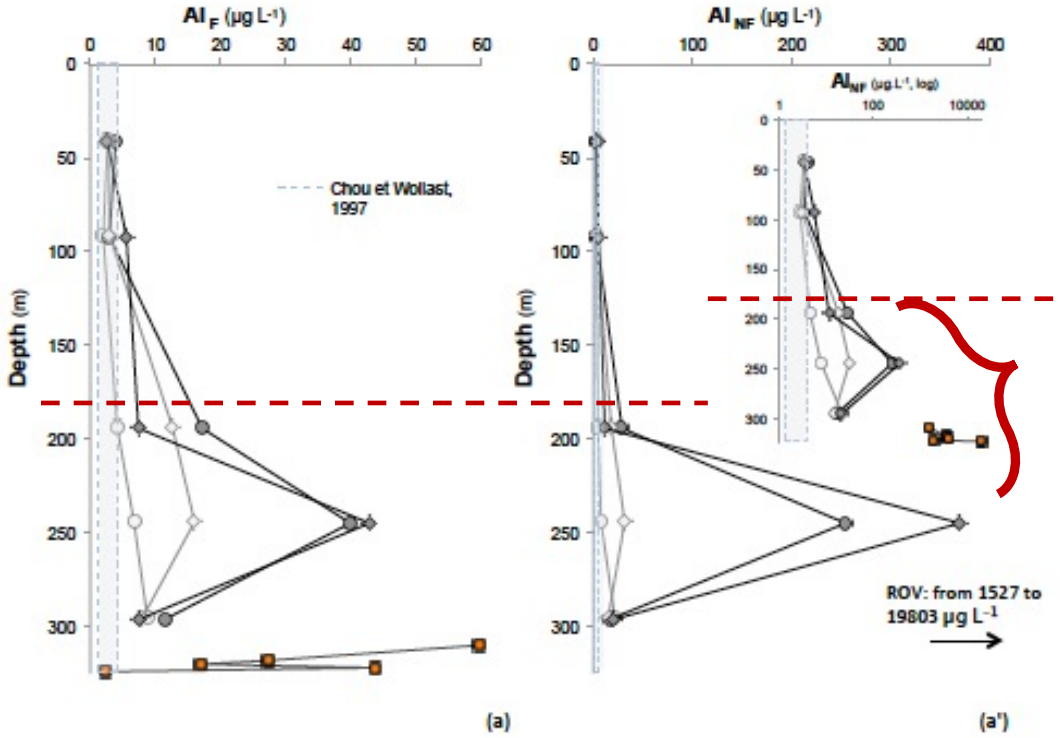
Mg- Al –As- V

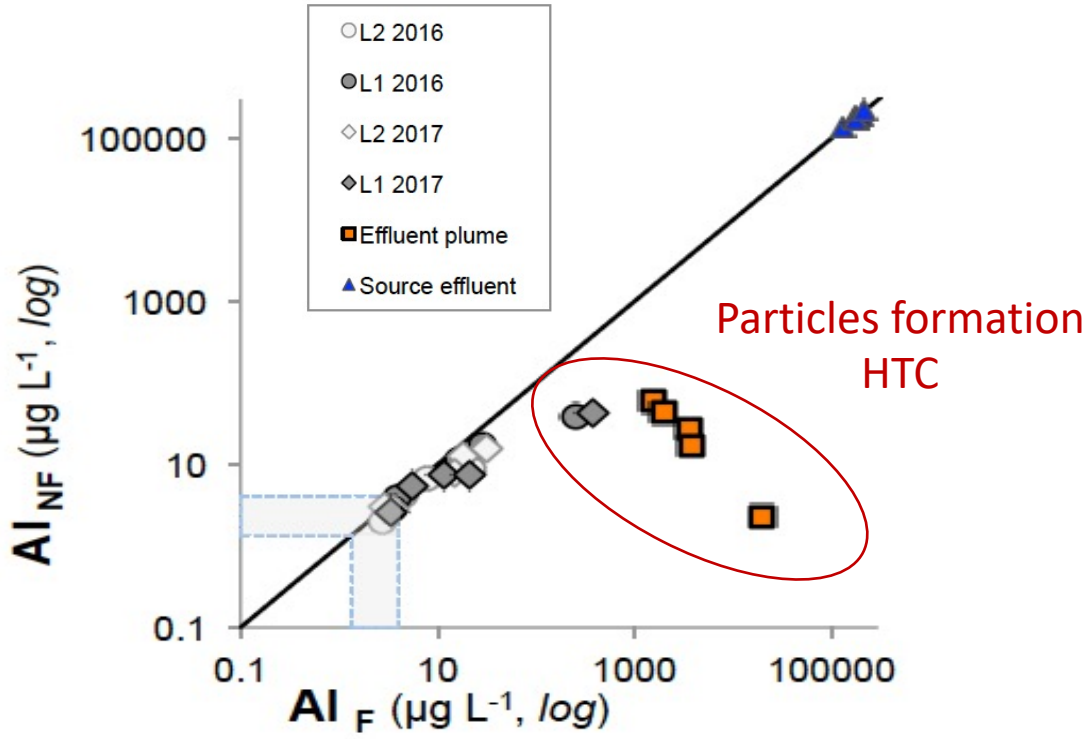




Metals in the Effluent plume & Water Column

- The effluent contribution is mainly notable in the upper 10 meters above the outfall but it can be reported starting 200 m depth
- There is a depletion in dissolved Al (and in a lesser extent As) when the effluent mixes with seawater, reflecting the in situ formation of particles and concretions.

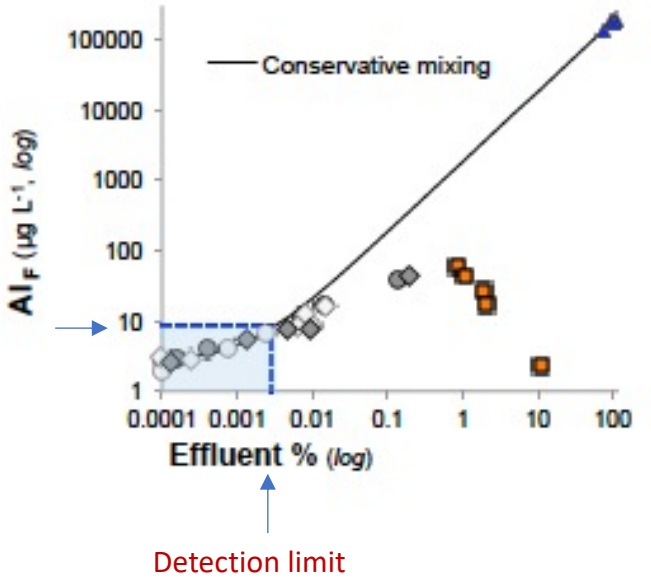




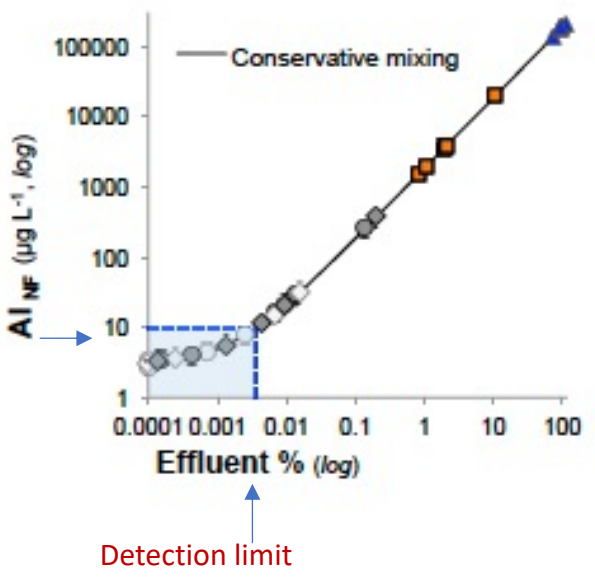
Metals in the Effluent plume & Water Column

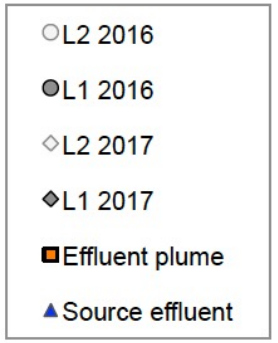
- Calculations show that the effluent contribution can be detected up to 0.003 % for Al (2.4 % for V and 10 % for As)
- Under a dilution factor of the effluent of around 10^4, Al (NF concentrations) can be used to detect the effluent presence.

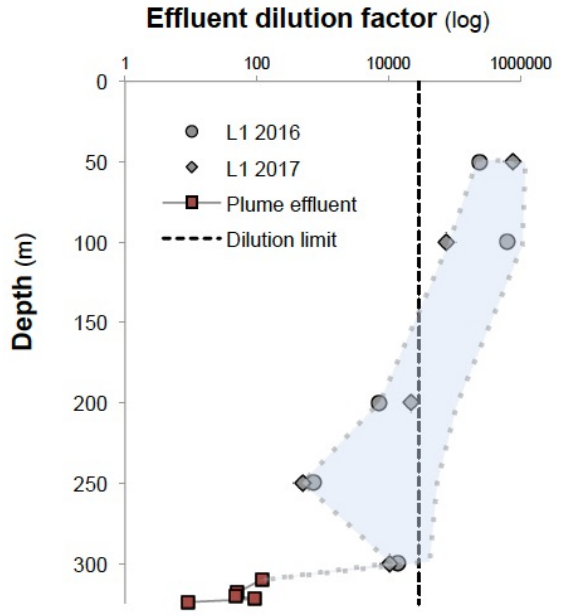
Filtered



Total

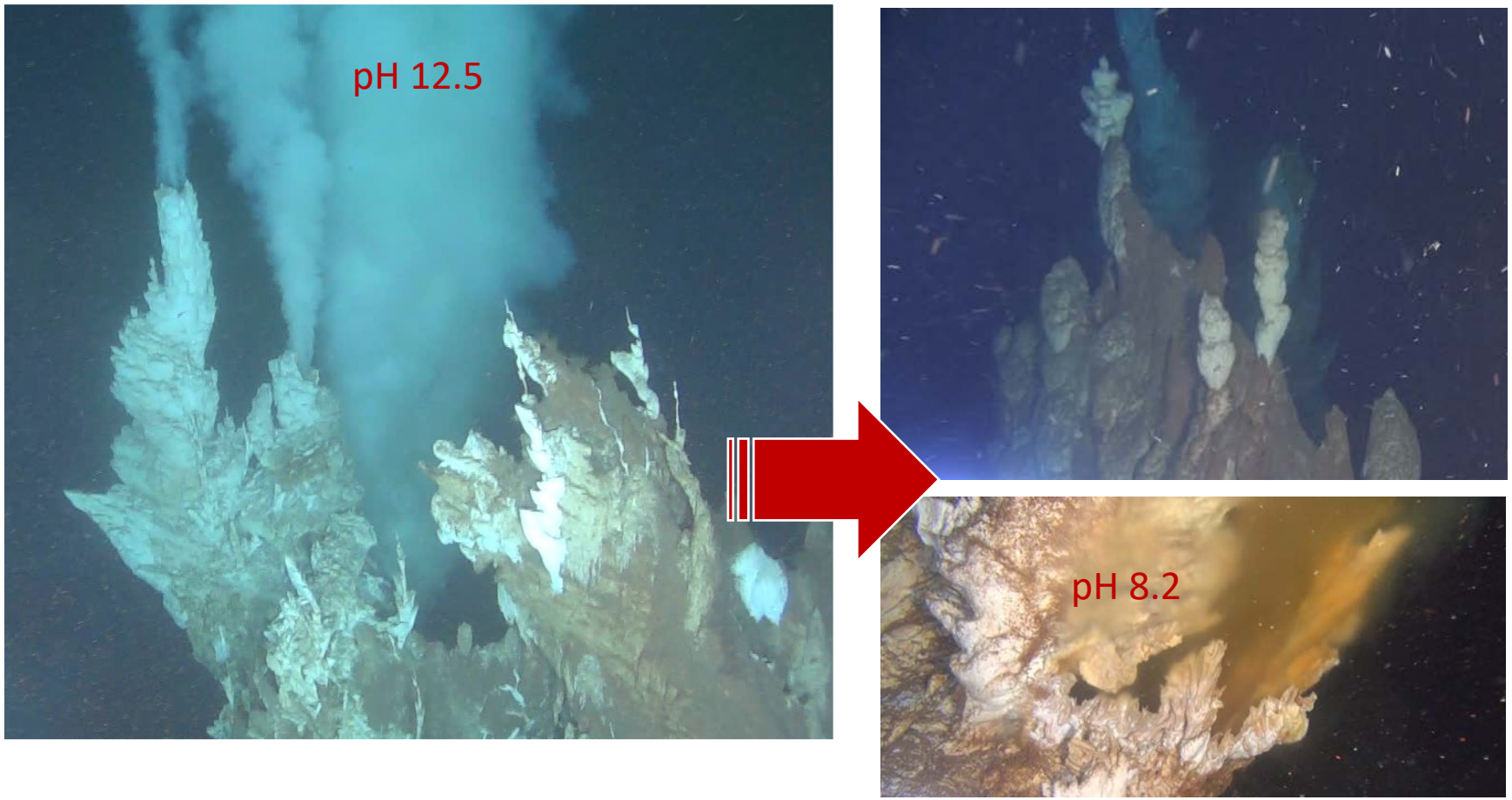






2016 2019

- Changes of the source effluent -starting 2018 : pH and metals concentration decrease – **No HTC formation**
- Would destabilisation of the concretions affect metals dispersion in the surrounding seawater ?



Concentrations evolution (2016 - 2019 - 2020 cruises)

- Source effluent variability (+ particles presence)
- No HTC formation
- Metals concentration increase in the water column (origin?)