

Underwater dosimetry of EP1 Epagnette shipwreck (Somme, France)



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Study area

The EPA1-Epagnette wreck and its cargo of clay roofing tiles were discovered in 2002 during a underwater survey in the Somme river near the village of Epagnette (Epagne-Epagnette, Somme, France).



EP1-Epagnette excavations 2011-2017 :

- part of an interdisciplinary research program on *medieval and modern sea-river shipping*, under the supervision of Eric Rieth (LAMOP-CNRS, National Navy Museum),

- excavations were undertaken since 2011. After a site evaluation campaign in 2011, a first multi-annual excavation program took place between 2012 and 2014, followed by a second one between 2015 and 2017



The scientific responsibilities within the research team of the EP1-Epagnette wreck are shared since 2011 in the following way:

General direction of the excavation: Eric Rieth, CNRS LAMOP - National Maritime Museum

Architectural study: Eric Rieth, with the collaboration of Jean-Louis Gaucher

Topography and treatment 3 D of topographic surveys: Pierre Texier, Inrap until 2014; Sylvain Rassat (SRA Picardie and since 2016, CNRS / Paris-Sorbonne University) and Benoit Pandolfi (Amiens Métropole, 2015).

Study of the cargo: Fabrice Casagrande, Inrap

Study of the river landscape: Virginie Serna, Mission of the General Inventory of Cultural Heritage, Ministry of Culture.

Study of tiles: Sandrine Mouny, Laboratory of Archeology and History EA TRAME 4284, Jules Verne University, Amiens

Documentary study: Christophe Cloquier, Central Library of the Armed Forces Health Service, Val-de-Grâce, Paris, with the collaboration of Eric Balandra

Dendrochronology: Catherine Lavier, Laboratory of Molecular and Structural Archeology, CNRS / Pierre et Marie Curie University, Paris

Luminescence dating: Antoine Zink, Elisa Porto, C2RMF, Ministry of Culture, Paris

On-land drawings of architectural samples and computer graphics: Michel Philippe, departmental museum of prehistory of Le-Grand-Pressigny.



Cassini Map (18th.c.)



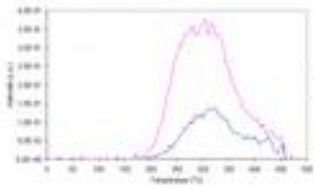
Headquarters map (19th c.)



IGN Map 1:25 000

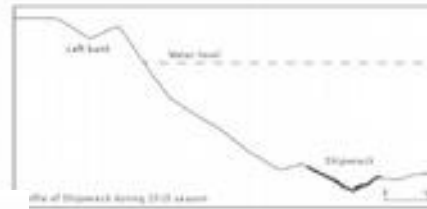
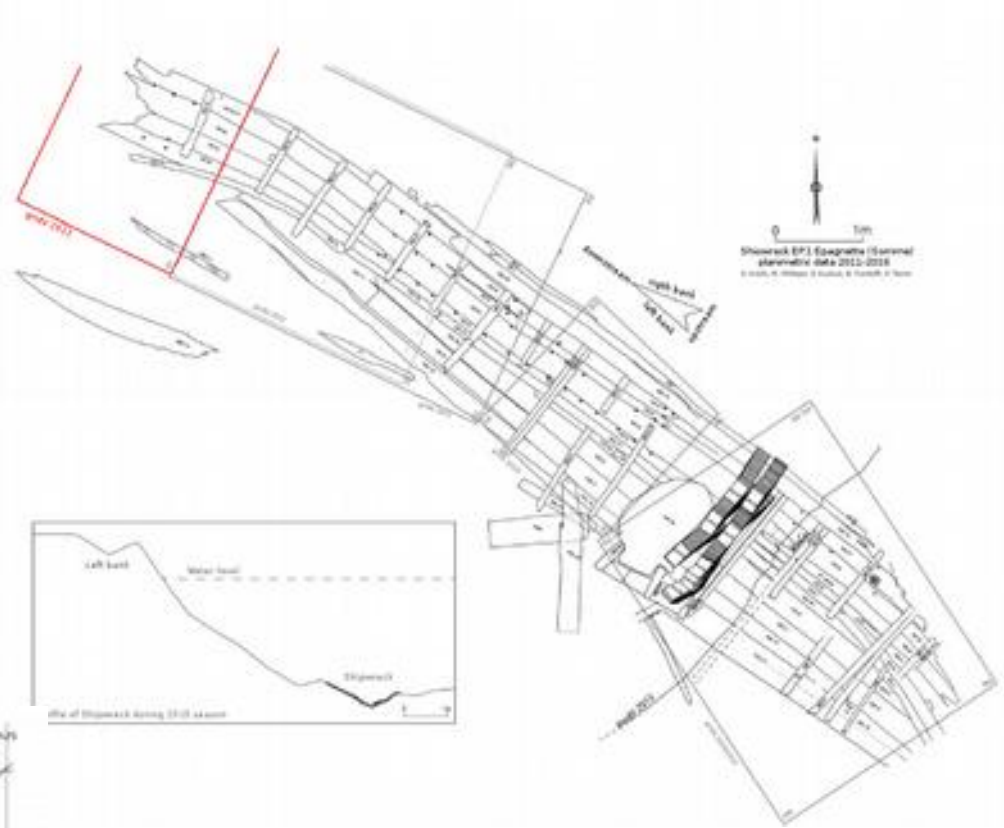
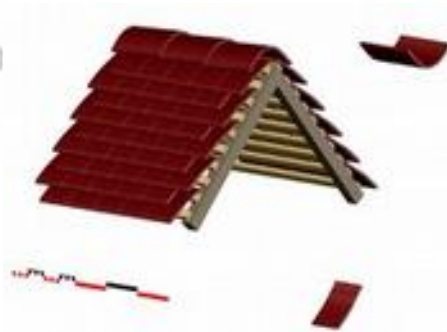


cadastral chart

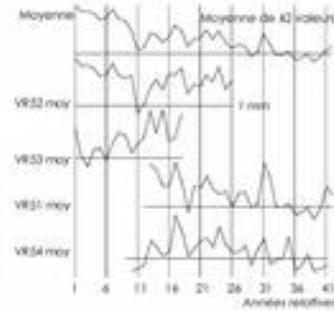
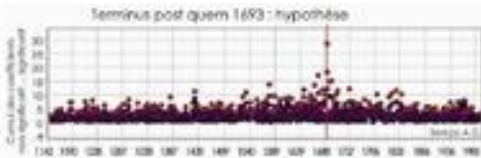


TL dating test

EPA1 flat tile	250y 370y 350 y
EPA2 flat tile	360y 290y 240y
EPA3 flat tile	70y 40y

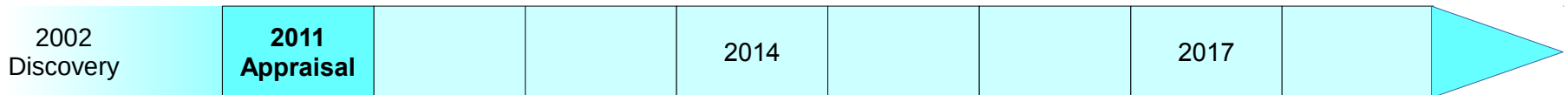


dendrochronological dates



1st program 2012-2014

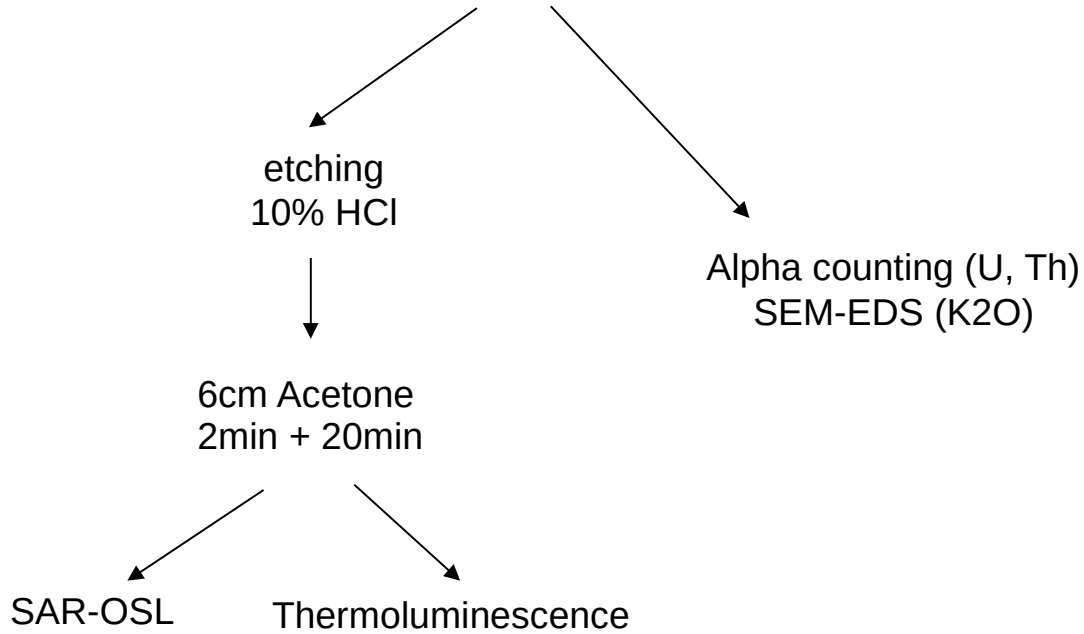
2nd program 2015-2017

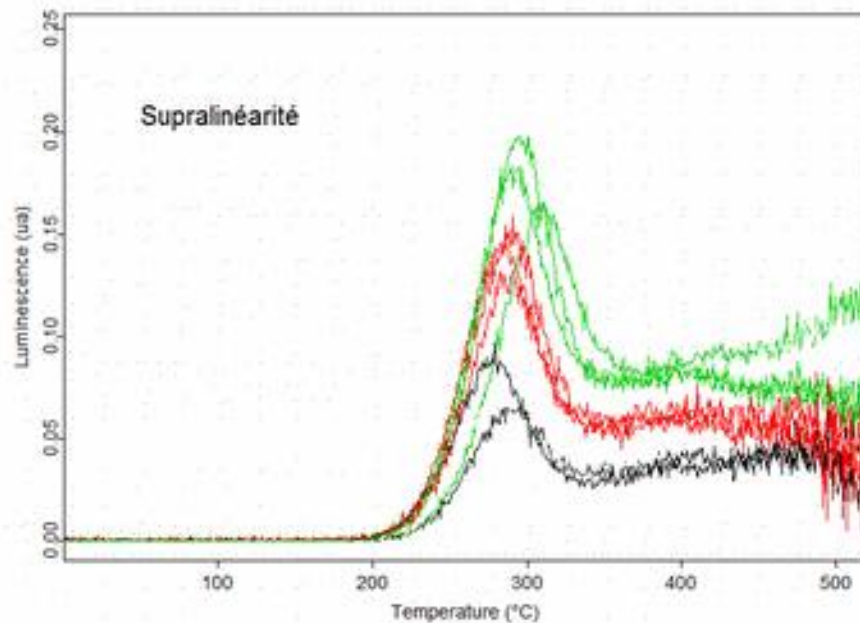
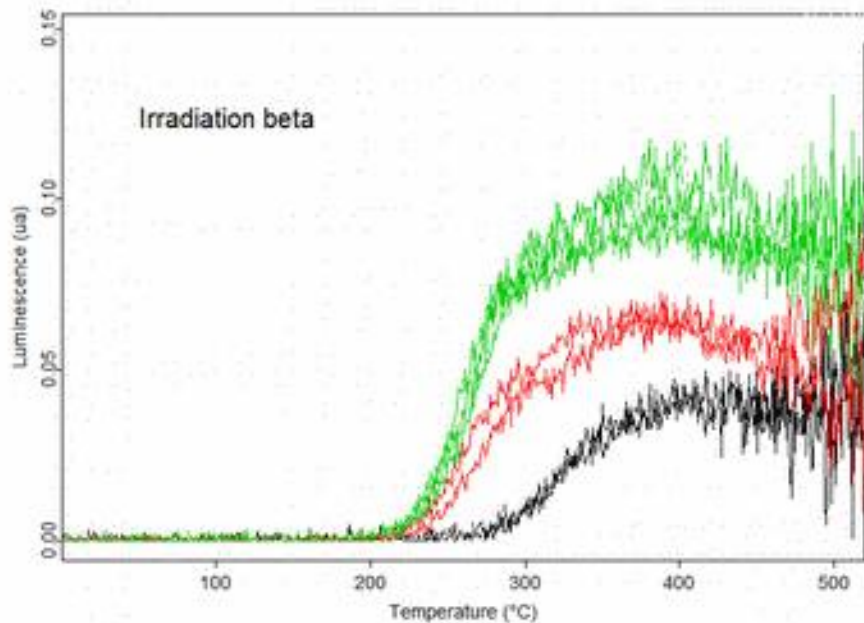


Sampling



External dosimetry





n° inv. EPA12_H

Thermoluminescence

1ère chauffe : fichier 0504173.binx

beta : Nat

Nat+1.5Gy

Nat+3Gy

2nde chauffe : fichier 2804171.binx

supra : 1.5Gy

3Gy

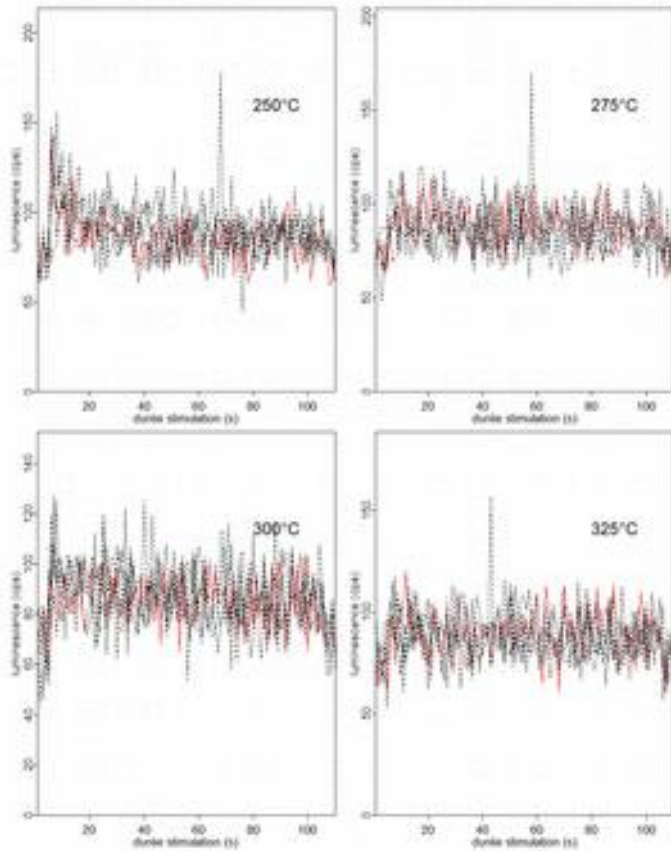
4.5Gy

IR-OSL

Courbes de IR-OSL EPA12_H

en rouge, la courbe correspondant au signal archéologique

la mesure dure 110s, la simulation optique débute au bout de 5s et dure 100s

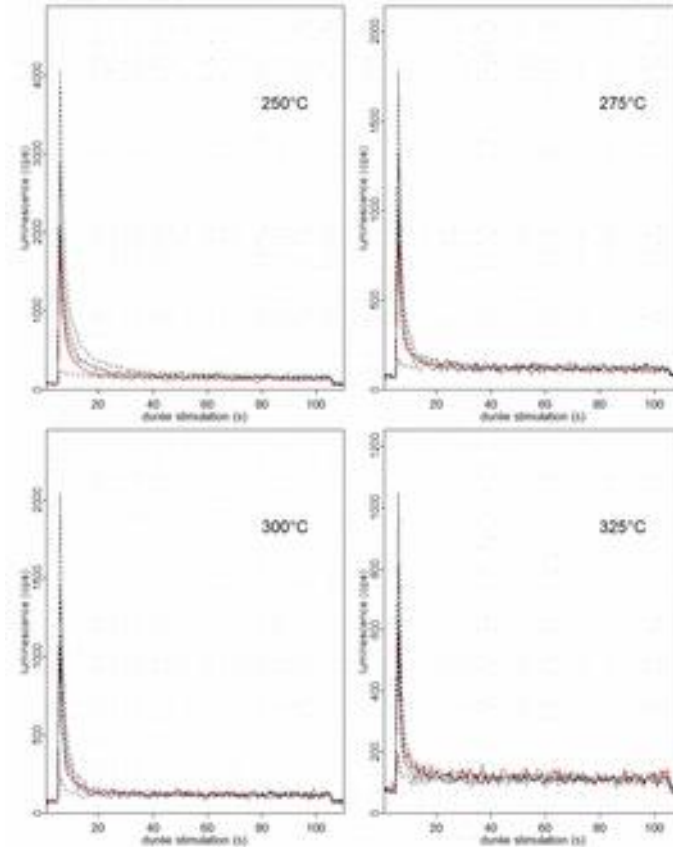


BL-OSL

Courbes de BL-OSL EPA12_H

en rouge, la courbe correspondant au signal archéologique

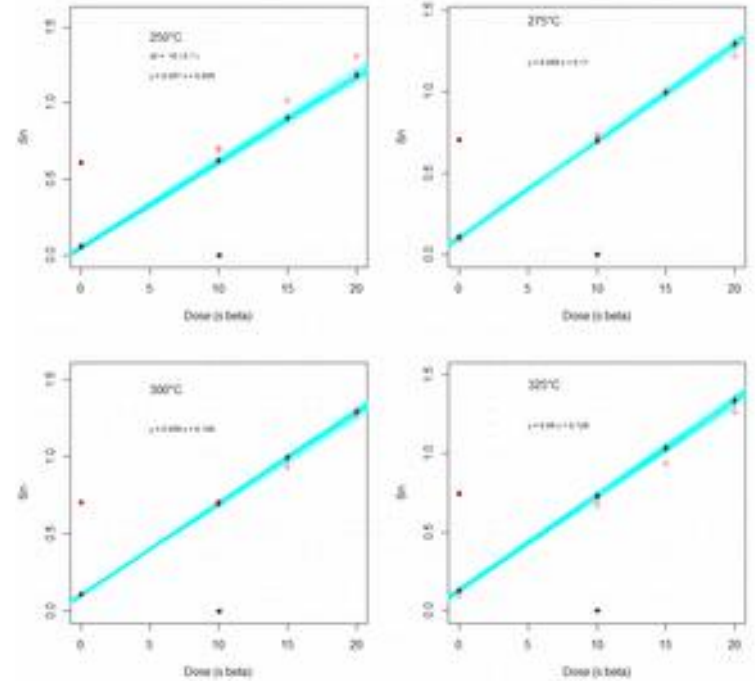
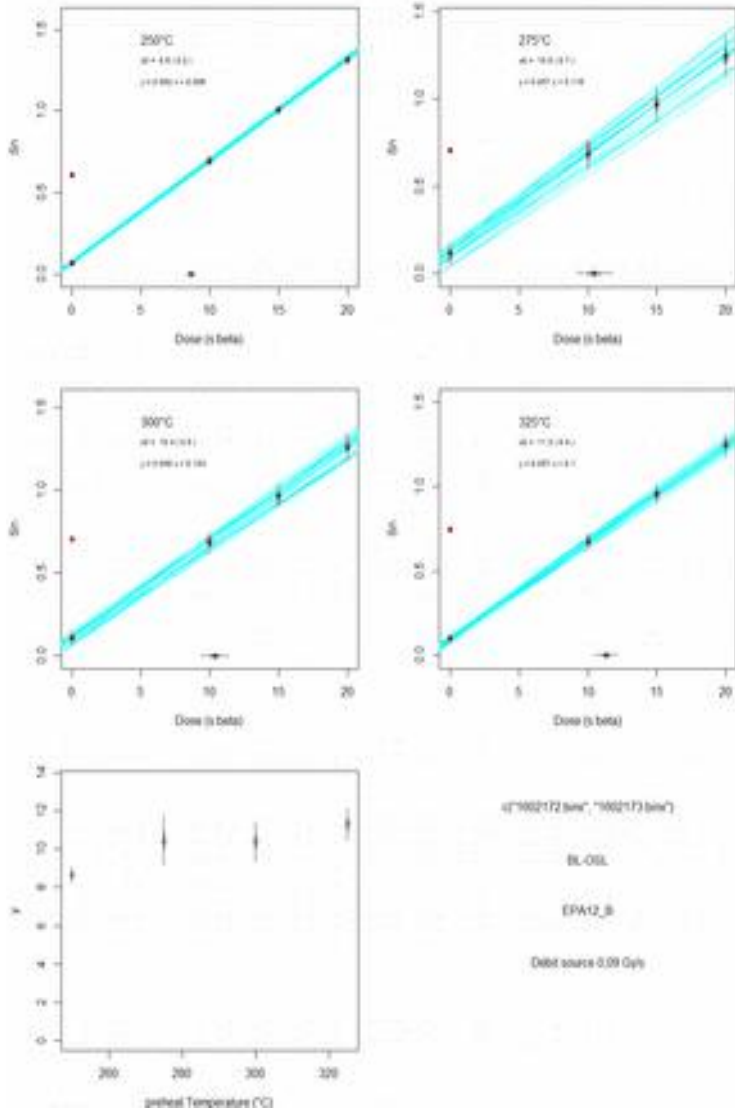
la mesure dure 110s, la simulation optique débute au bout de 5s et dure 100s



Polymineal fraction
No IR-OSL
Fast decay of BL-OSL

=> main phosphor : Quartz

BL-OSL



same data as on the left side, but assuming the archaeological dose independent of the preheat temperatures

How to estimate the palaeodose ?

Working with tiles from the inner of the cargo (to reduce the part of external dose)

in situ (underwater) dosimetry using OSL dosimeter

numerical simulation with DosiVox

underwater dosimetry



June 2016, four dosimeters were prepared to be immersed...



nail

Colored wire as a marker

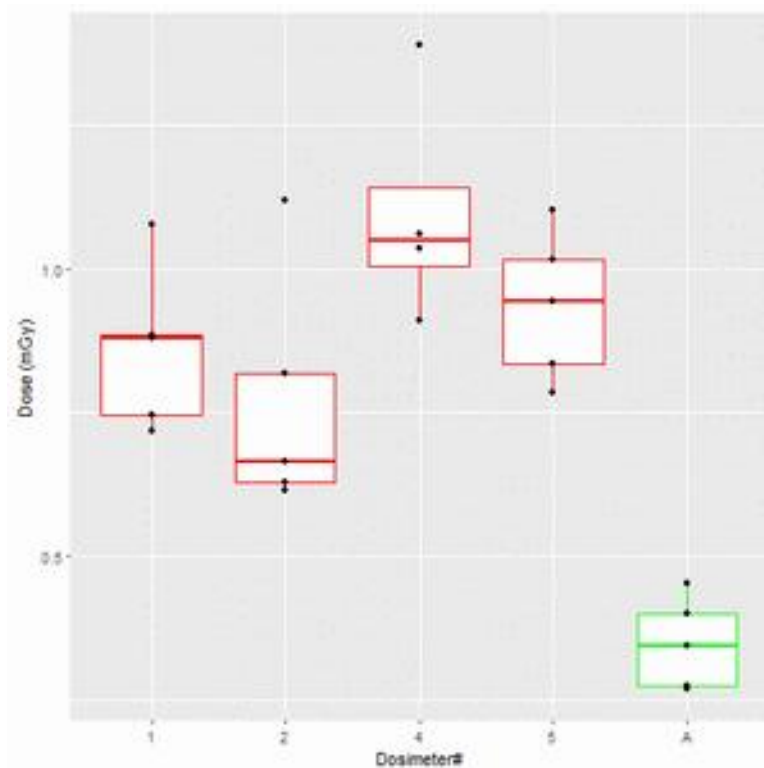


OSLD
5x Al₂O₃-C pellets
inside plastic container
filled by quartz (Merck)

... one year later. All dosimeters are back!



Results of dosimetry



The doserate at the level of the tiles (dosimeter #1 to 5) is higher than the doserate measured in our office (dosimeter #A).

Contribution of the tiles ?
Tiles (infinite matrix) 0.93 mGy/y

Model and numerical simulation

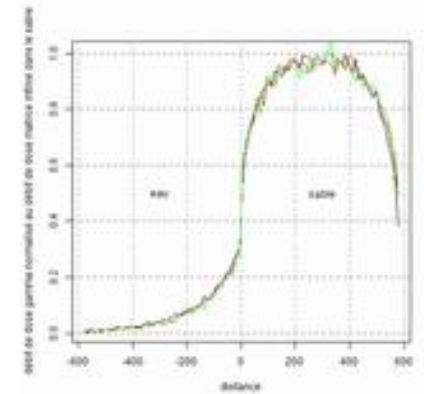
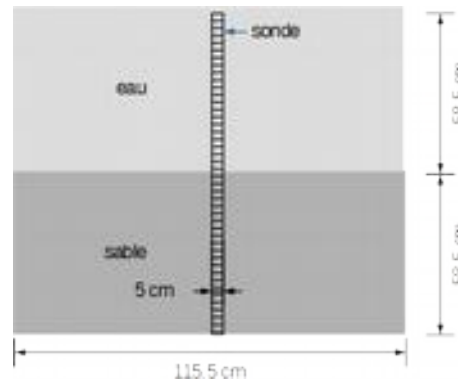
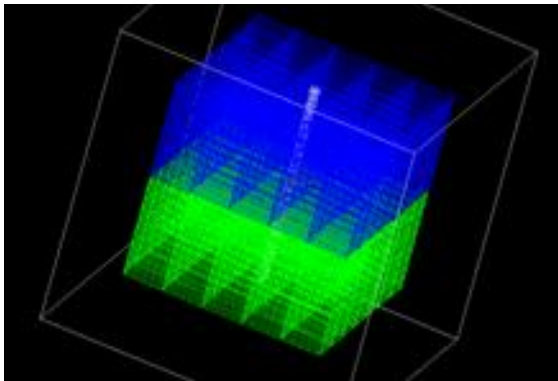
Name	components	dry density (g/cm ³)	water content (%)	K ₂ O (%)	U (ppm)	Th (ppm)
water	H ₂ O	1	0	0	0	0
sand	SiO ₂ 50%, CaCo ₃ 25%, limestone 25%	1.3	55	0.7	1.5	5.0
Tile	SiO ₂ 71.9%, AL ₂ O ₃ 16.4%, Fe ₂ O ₃ 6.4%, MgO 0.7%, CaO 1.5%, na ₂ O 0.3%, K ₂ 1.4%, TiO ₂ 0.9%, MnO 0.1 %, SO ₂ 0.1 %, P ₂ O ₅ 0.3%	1.7	18	1.6	3.0	9.4

1 Voxel = 1 tile (165 x 235 x 13 mm)

Grid #1: X = 7; Y=5; Z=90 (Tiles on face)
(physical value 1155 x 1175 x 1170 mm)

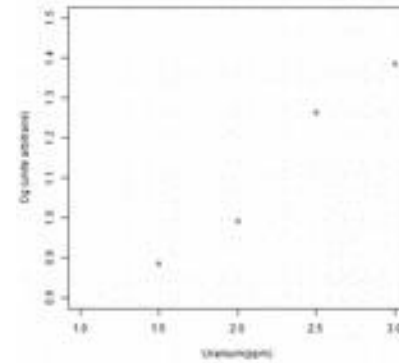
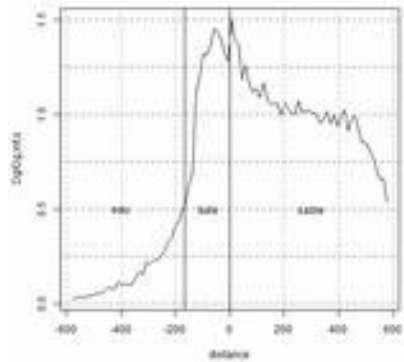
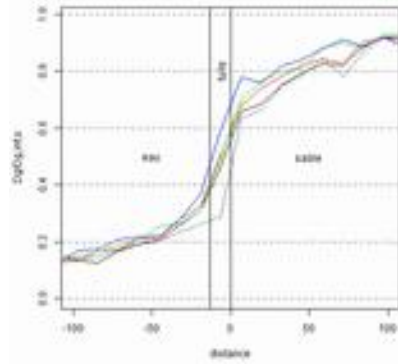
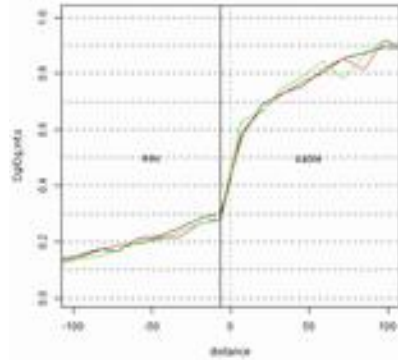
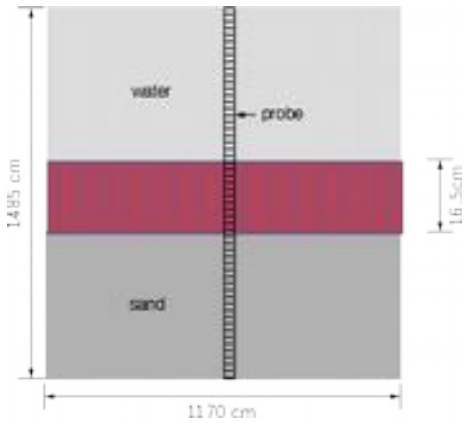
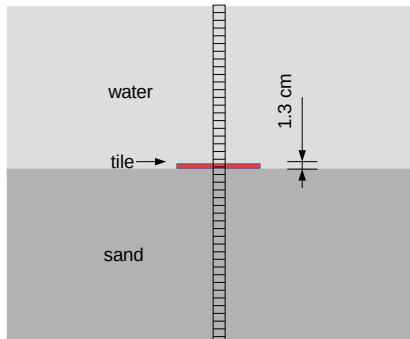
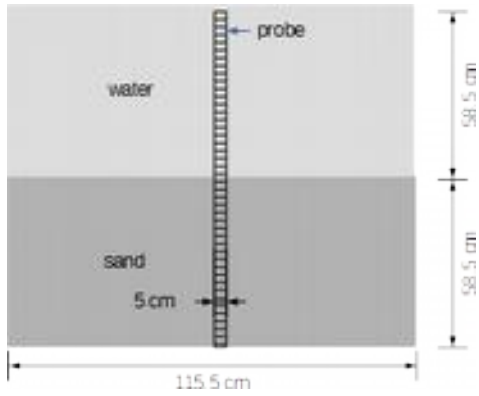
Vertical probe: z-step 13 mm

Grid #2: X = 90; Y=5; Z=9 (Tiles on large edge)
(physical value 1170 x 1175 x 1485 mm)



Dose rate normalised for a infinite matrix of sand

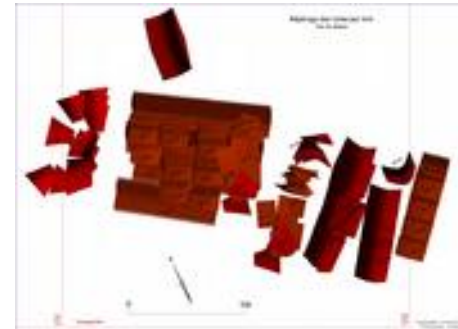
Model and numerical simulation



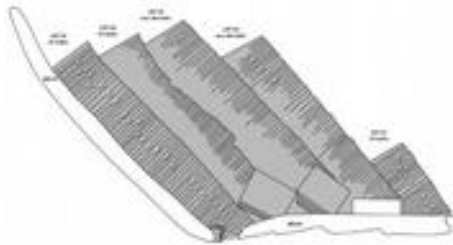
dry tile

silt

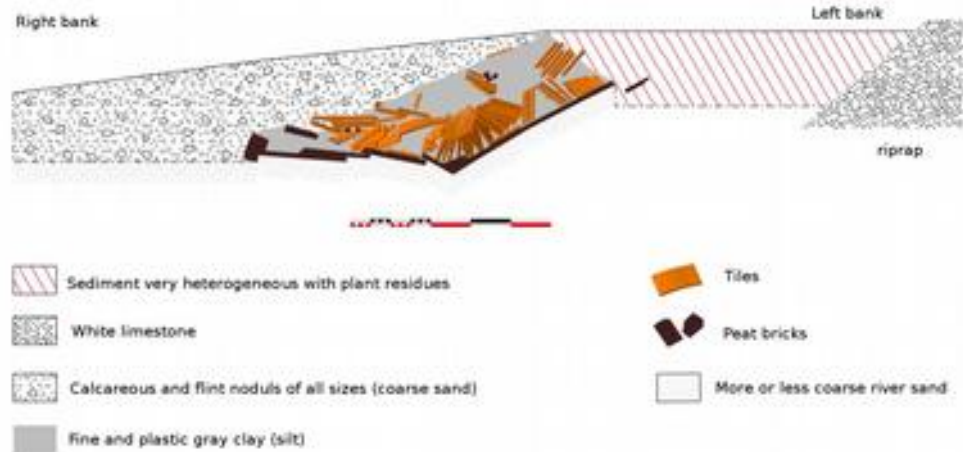
wet tile



Planimetric view the tiles excavated in 2012
(topography and CAD: F. Casagrande)



Distribution of the tiles in the wreck
(CAD: F. Casagrande, P. Texier, Inrap)

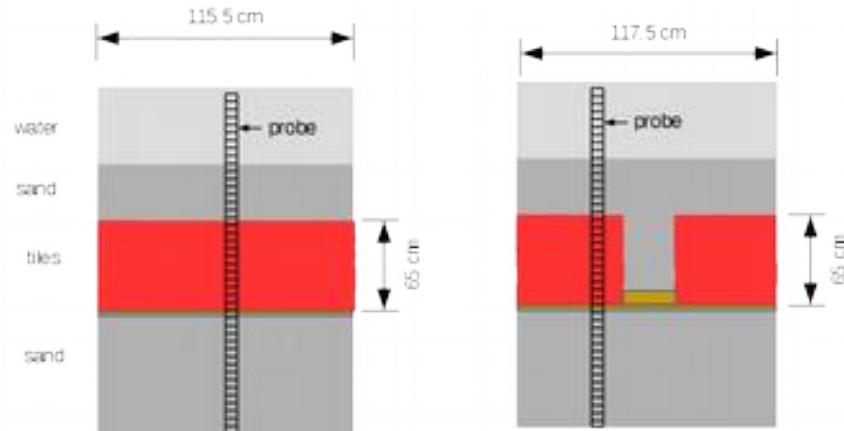


Stratigraphic cross-section of the wreck between the MB 62 and MB 63 frames
(F. Casagrande, Inrap)

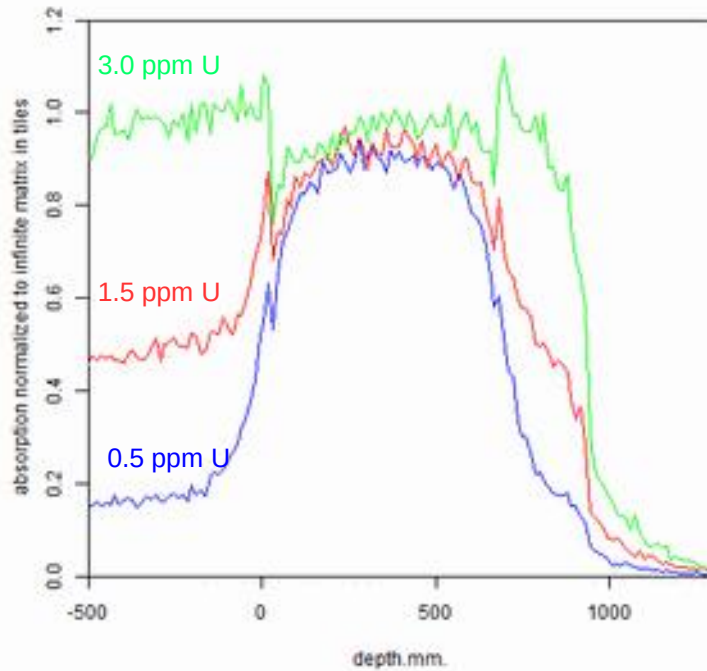
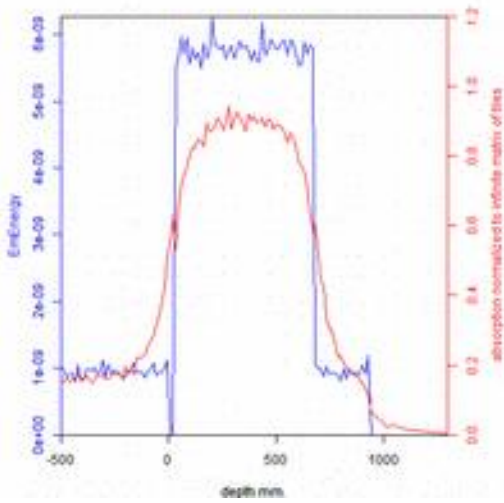
Grid #3: X =7; Y=5; Z=150 (Tiles on face*)
 (physical value 1155 x 1175 x 1950 mm)

water X=7; Y=5; Z=30
 sand X=7; Y=5; Z= 20
 tile X=7; Y=4; Z=50
 wood X=7; Y=5; Z=2
 sand X=7; Y=5; Z=48

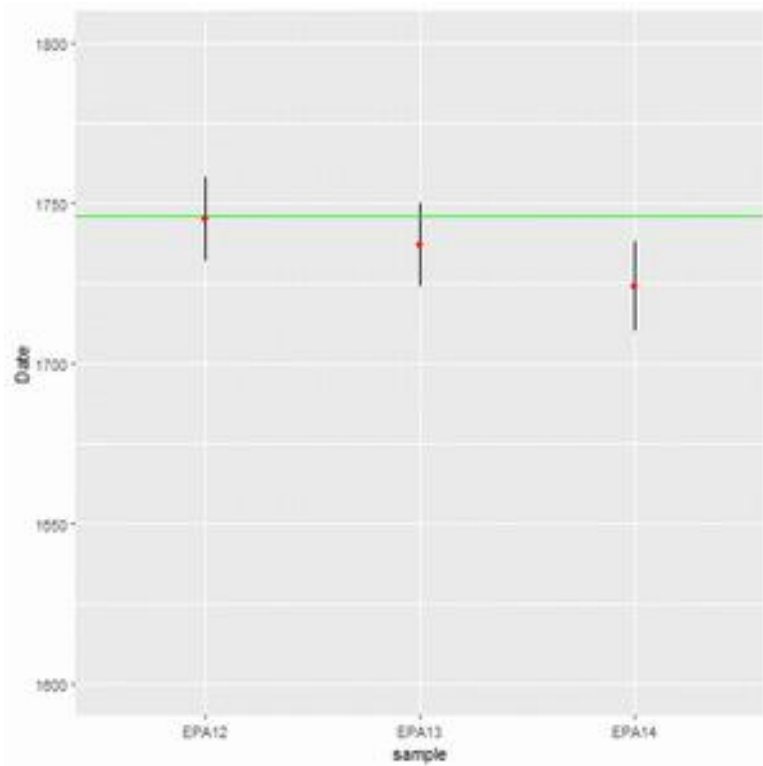
new material:
 wood (*Quercus sp.*)
 H 6%; C 50%; O 22%; N 22%
 dry density 0.6 g/cm³
 wetness 80%
 no radioelements



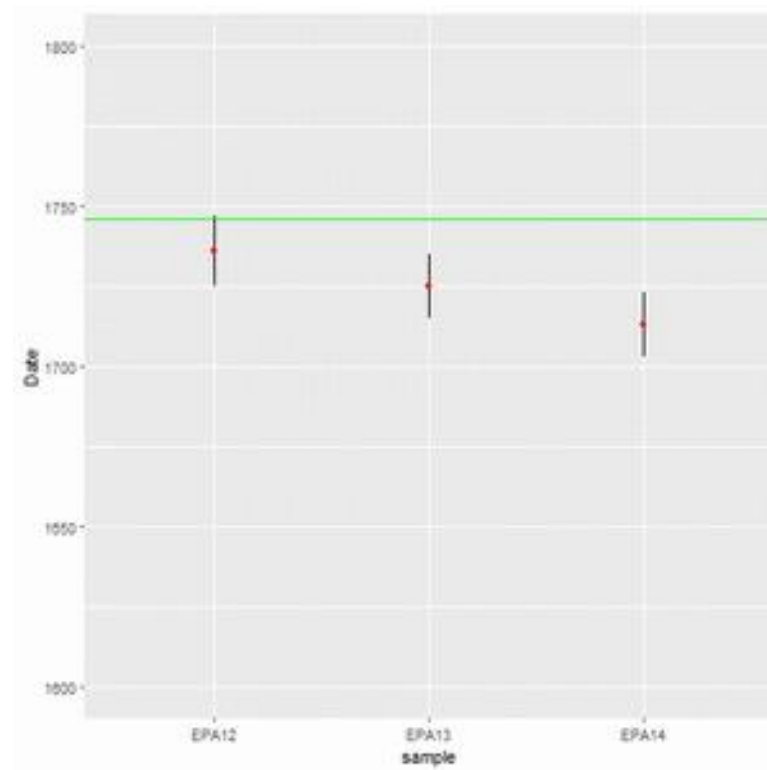
Sand 1.5 ppm U



95 (4%)	0.88(0.04) mGy/y
89 (6%)	0.83(0.06) mGy/y
85 (7%)	0.79(0.07) mGy/y



Date using dosimetry measurements
0.91(0.20) mGy/y



Date using numerical simulation with 0.5ppm U
0.79(0.07) mGy/y

Conclusions

Dosimetry investigation

- it is possible to estimate the annual dose in water by means of dosimeters.
- Numerical simulation provides a good idea of the dose distribution within the cargo.
- We advise against the measurement of isolated tiles whose estimation of the dose is much more complex.

Luminescence dating agree with tree-rings dating to suggest a sinking in mid 18th c.

Acknowledgement

Special thank to Eric Rieth (Direction générale du programme) and the archaeological team:

Michelle Affonso (logistic), Eleonora Antuña, Hélène Botcazou, Fabrice Casagrande, Etienne Champelovier (technical manager COH, until 2012), Peter Clark, Christophe Cloquier, Ine Demerre , Romain Fougero, Jean-Louis Gaucher, Christian Peschang (technical manager COH, since 2013), Michel Philippe, Peter van der Plaetsen, Bernard Plutniak, , Cécile Sauvage, Virginie Serna

our 'excursion-mates'

Catherine Lavier, Nicolas Lira, Kevin Romeuf, Rémi Brageu



Thank you !

