BYNE DECAY :

The Case of Alcide d'Orbigny's foraminiferal collection

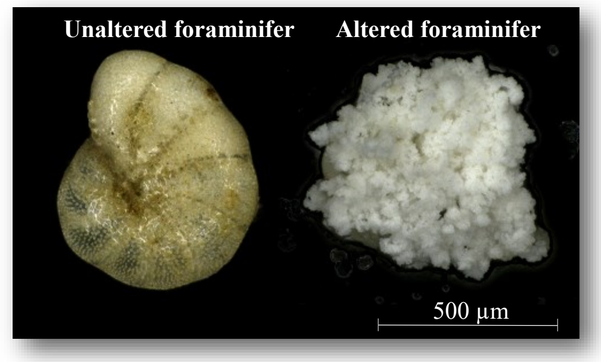
Clara Hairie[1,3], Véronique Rouchon[1], Oulfa Belhadj[1], Annachiara Bartolini[2], Marie-Béatrice Forel[2], Eddy Dumas[3], Nathalie Steunou[3]

[1] *French Natural History Museum, Center for research on preservation, 36 rue Geoffroy Saint-Hilaire CP21, 75005 Paris, France*
[2] *French Natural History Museum, Center for research on palaeontology - Paris, 8 rue Buffon, CP 38, 75005 Paris, France*
[3] *University Versailles St Quentin en Yvelines, University of Paris-Saclay, Lavoisier Institute of Versailles, 45 avenue des Etats-Unis, 78000 Versailles, France*

Context

Occurrence of crystalline efflorescence on calcareous objects stored in polluted environments is commonly known as "**Byne decay**". It results from the emission of acidic **volatile organic compounds** (VOCs) by storage materials, that react with calcium carbonate in the porous substrates. This leads to the formation of various calcium organic salts, among which acetates and formates, and causes irreversible deteriorations to the objects. [1]

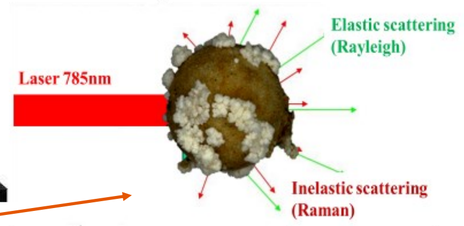
Lately, preliminary studies on the state of conservation of the **foraminifer collection of Alcide d'Orbigny** (1802-1857), housed at the French Natural History Museum, highlighted the presence of similar degradations. The variety of salts was studied through different analytical methods and investigations of historical archives were made to apprehend the impact of the decay.



Methodology

Altered foraminifers were observed with a **scanning electron microscope** (SEM) and degradation products were analyzed by **non-invasive µ-Raman spectrometry.**

Acquisition of the raman emission:



Calcium salts—formates and acetates—were synthesized in laboratory and characterized by **powder X-ray diffraction**, **infrared** and **Raman spectroscopies** to obtain references. Photographs of the specimens of the d'Orbigny collection were taken using a **stereo microscope** coupled with a digital imaging system* and compared with those from the foraminifer data-sheets created by Maurice Lys in the 1940's. [2]

*RECOLNAT Project ANR-11-INBS-0004

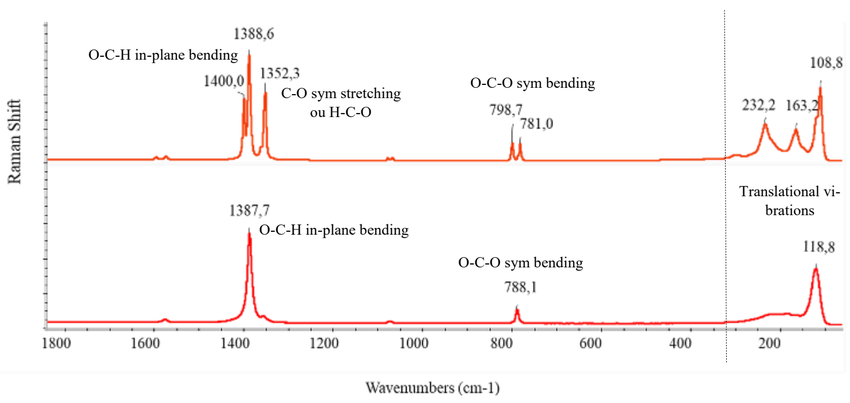
Total number of foraminifers versus altered specimens from different origins - D'Orbigny collection-

	Australia	Austria	Cuba	Spain	France	Hungary	Italy	Peru	UK
Total number	104	791	286	31	1180	164	642	43	189
Altered specimens	40	164	115	11	170	49	92	16	45

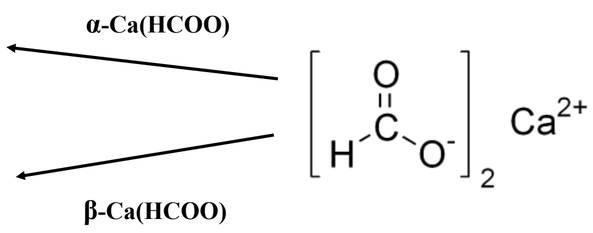
1/4
of the collection suffers the Byne decay

Salts analysis

Calcium formates (or methanoates) are the principle chemical species present on the specimens. Two different phases, the **tetragonal β-calcium formate** and the **orthorhombic α-calcium formate** were identified. However, there was no trace of calcium acetate on the surface of the foraminifers.

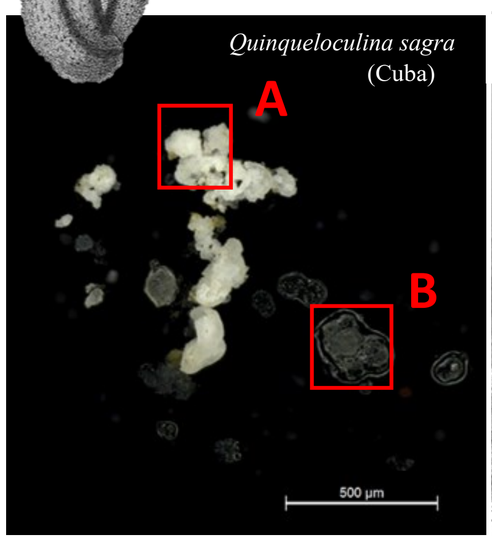


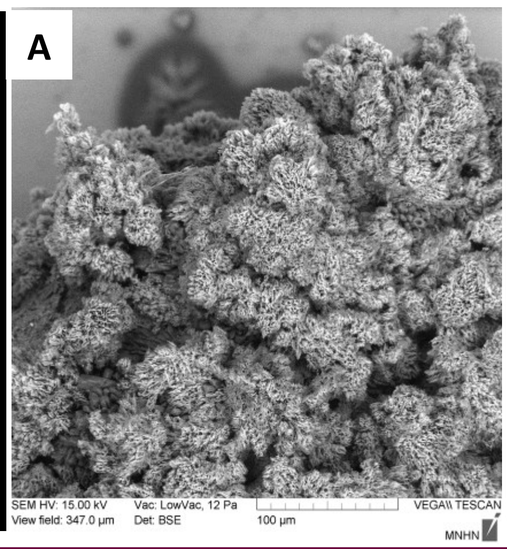
Raman signals of the two calcium formates.

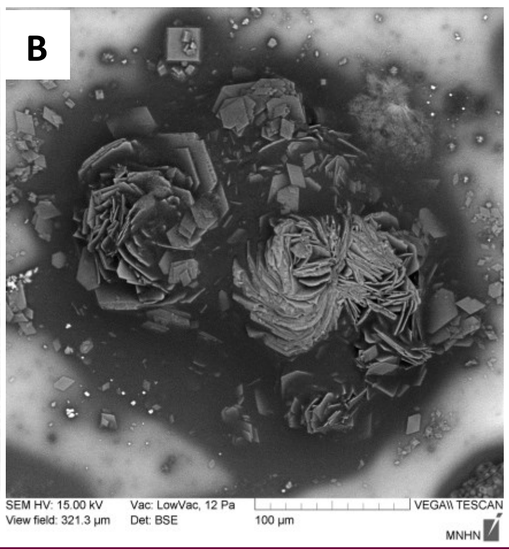


This observation differs with the species identified in the literature that are mostly acetate-based salts. [1] The single presence of calcium formates in the context of Byne decay has never been observed before.

SEM images of altered specimens highlighted characteristic morphologies for the two different phases. The tetragonal phase (figure A) shows **dendritic** crystallizations while the orthorhombic phase (figure B) crystallizes in **rosette-like** morphologies.

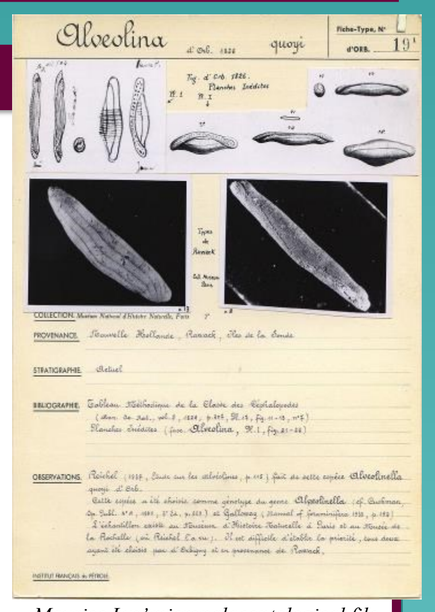






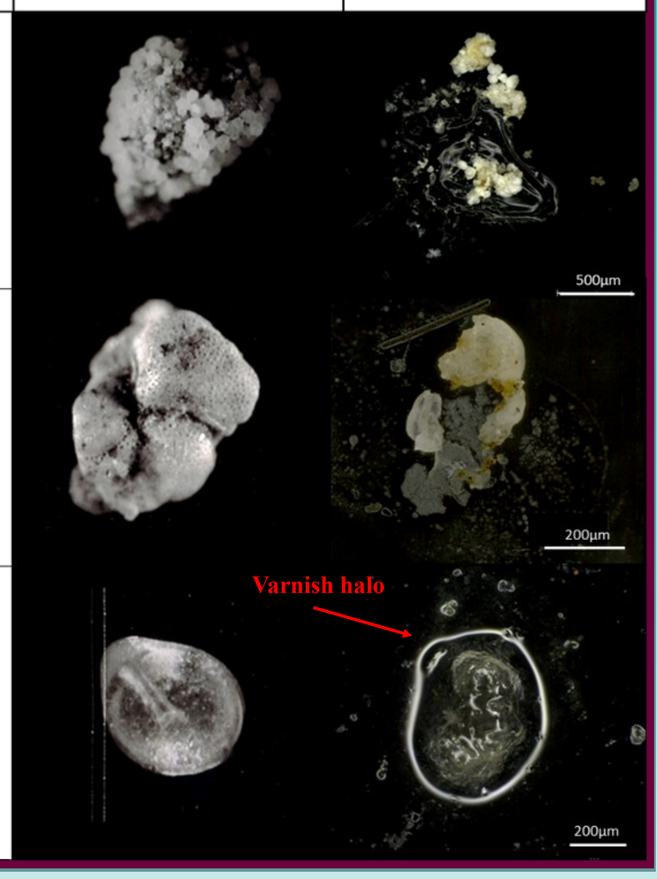
Specimens evolution

Comparison of the same specimens around **1949 versus 2016** clearly shows the activity of the degradation in the last decades. However, if some foraminifers were **already impacted** in the late 40's (1&2), others deteriorated more recently. This category seems to be linked with the application of **varnish** (3) as it was custom on palaeontological objects in the 70's.



Maurice Lys' micropalaeontological file, 1949 (MNHN)

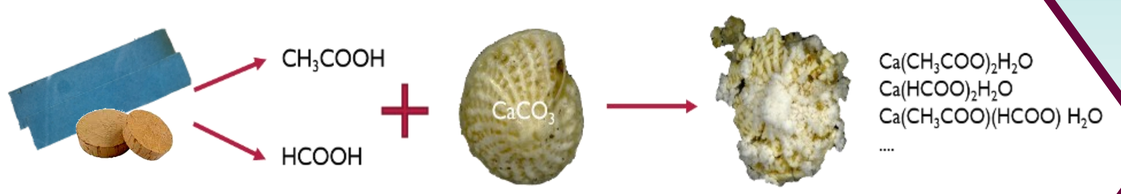
D'Orbigny's drawings (19th century)	Lys' photographs (1949)	MNHN photographs (2016)
1 *Textularia candeiana* (Cuba)		
2 *Rotalina canariensis* (Canary Islands)		
3 *Oolina compressa* (Falkland Islands)		



Conclusion and future investigations

⇒ Most of the deteriorations happened **prior to the 50's**, with continuous evolution until today that conducted to the **entire destruction** of certain specimens.

⇒ The unique **presence of formates** over acetates calcium salts differs from usual Byne's deterioration products.



⇒ Deeper investigations must be performed to determine the influencing factors in the nature and variability of the salts, including the **substrate** (composition, porosity…) and **storage materials** that are suspected to be the principle source of VOCs.

[1] N.H. TENNENT & T. BAIRD, The deterioration of mollusca collections : identification of shell efflorescence, Studies in Conservation, Vol 30, **1985**, page 73-85
[2] M. LYS et J. SIGAL, Présentation d'un fichier micropaléontologique—Alcide d'Orbigny, Extrait de la Revue de l'Institut Français du Pétrole et Annales des combustibles liquides, Vol.II, N°4, avril **1947**, page 179.

Soutenu par
MINISTÈRE DE LA CULTURE
Liberté Égalité Fraternité
UVSQ université PARIS-SACLAY
ÉCOLE DOCTORALE INTERFACES
Approches Interdisciplinaires : Fondements, Applications et Innovation
MUSÉUM NAL HIST NATURELLE
cnrs
CR2P
ANR EUR-17-EURE-0021
FONDATION DES SCIENCES DU PATRIMOINE