



Investigation of dental amalgam electrode behaviour for the long term monitoring of nuclear waste disposal.

Jordan Daoudi^{1,3}, Stéphanie Betelu¹, Johan Bertrand², Théo Tzedakis³, Ioannis Ignatiadis¹

¹ BRGM (French Geological Survey), Orléans, France. j.daoudi@brgm.fr; s.betelu@brgm.fr; i.ignatiadis@brgm.fr

² ANDRA (French national radioactive waste management agency), Châtenay-Malabry, France. Johan.Bertrand@andra.fr

³ LGC (Chemical Engineering Laboratory), UPS, Toulouse, France. tzedakis@chimie.ups-tlse.fr

Context High level radioactive nuclear waste : long-term storage and reversibility

- **Robust barrier** : Callovian-Oxfordian geological formation (from 400 to 600m deep)

Clayey formation : ions adsorption phenomena and very low permeability

➤ **slow down radionuclide mobility**

Continuous storage environment monitoring over several decades :

rocks mechanical parameters, temperature, **pH, redox potential (Eh), conductivity**

Analytical challenge

Major analytical constraints

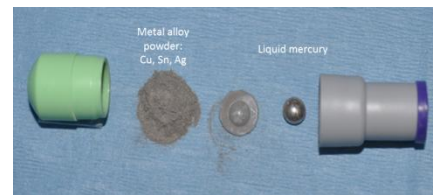
- $4 < \text{pH} < 12$; $25 < \text{T}^\circ < 100$; $-500 < \text{Eh} < 500$ mV/SHE

- **Water content variations** : partial desaturation, saturated periods

- **Presence of redox perturbations** : radionuclides, corrosion products (Fe species, H_2), sulphide (due to sulphate reducing bacteria (SRB) activity)

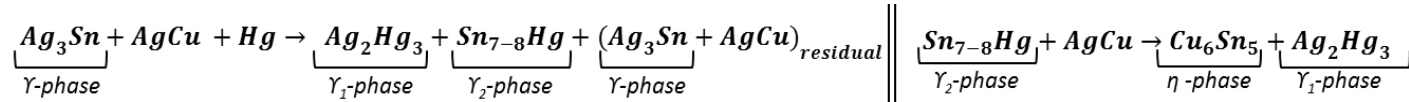
- Presence of gases : H_2 , CO_2 , H_2S , CH_4 ...

Synthesis of dental amalgam

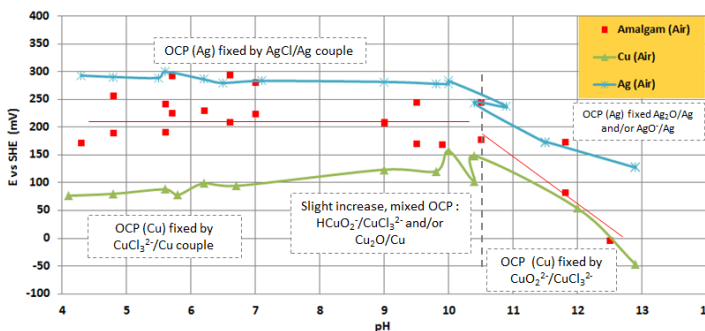


Metals constituting the dental amalgam	Mass percentage ($\pm 3\%$)	Relative Standard Deviation (%)
Hg	43,4	2,8
Ag	34,2	2,1
Sn	14,6	1,7
Cu	7,8	2
Ir	Traces	-
Ge	Traces	-

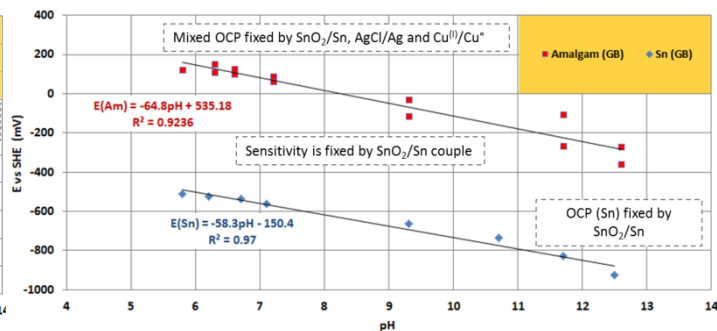
ICP-MS analyses (LGC, Toulouse)



Bibliography: γ_1 -phase is the most noble¹, γ -phase is weakly altered due to its electrochemical stability in the buccal environment², γ_2 -phase is described as the most reactive¹, probably due to the formation of a $\text{Sn}^{(\text{IV})}$ oxide



In air, the amalgam OCP is mainly influenced by Ag, but also Cu. Sn seems to have no influence.



In glove box, the amalgam OCP is a mixed potential (AgCl/Ag, $\text{Cu}^{(\text{I})}/\text{Cu}$ and SnO_2/Sn). The sensitivity is due to the presence of the SnO_2/Sn couple

Conclusions and perspectives

- More experiments/analyses are needed to clarify amalgam electrochemical behavior such as surface analyses coupled with electrochemical measurements
- In absence of oxygen, amalgam electrode could be used as pH electrode as it presents a near-Nernstian Slope

Reference: ¹Acciari H.A., Antonio C., Guastaldi A.C., Brett C.M.A. (2001) - Corrosion of dental amalgams: electrochemical study of Ag-Hg, Ag-Sn and Sn-Hg phases. *Electrochimica Acta* ; 46: 3887-3893.

²Toumelin-Chemla T., Toumelin J.P., Degrange M. (1998) - L'amalgame dentaire et ses alternatives - Evaluation et gestion des risques, Edition Lavoisier tec & doc, chapitre 3 : 23-25.