EFFECT OF γ-IRRADIATION ON THE SURFACE AND ADSORPTION PROPERTIES OF BENTONITE CLAY

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INTRODUCTION

- ✓ Deep Geological Repository (DGR) is the most widely accepted solution worldwide for the management of high-level radioactive waste. DGR is a multi-barrier system to prevent or delay radionuclide (RN) migration.
- ✓ Radioactive waste emits irradiation, which increases temperature and may result in physico-chemical and geochemical changes in the barrier materials.
- ✓ The radiation emitted by the waste together with the saline pore water in the clay contribute to the corrosion of the canister, which can alter the chemistry of the environment, changing the redox conditions and introducing corrosion products into the bentonite clay.
- ✓ These changes can have consequences for the migration and retention of radionuclides in the barriers.

Gamma Radiation | Temperature | Corrosion | Geochemical Changes

MATERIALS AND METHODS

FEBEX Bentonite Clay

- ✓ Extracted from Cortijo de Archidona in Almería (Spain).
- ✓ Composition: Smectite (93±2%), quartz (2±1%), plagioclase (3±1%), cristobalite (2±1%), potassium feldspar, calcite and tridymite.

γ-Irradiation

- ✓ The bentonite clay was irradiated with two total doses:
  1) 14 kGy of gamma radiation achieved in 9 days with an average dose of 66 Gy/h.
  2) 140 kGy of gamma radiation achieved in 8 days with an average dose of 697 Gy/h.

Both samples was irradiated with ^{60}Co source in a pool-type installation.

- ✓ **Impact on structure**
- Fourier transform infrared spectroscopy (FTIR)
- ✓ **Impact on cation exchange properties**

1) Cationic Exchange Capacity (CEC) → $[Cu(trien)]^{2+}$

Sr^{2+} sorption tests: Sr is selected because it adsorbs on clay mainly by cation exchange

$$K_d = \frac{[C]solid}{[C]eq} \cdot \frac{V}{m}$$

Equation. Distribution coefficient

- ✓ **Impact on surface complexation properties**

2) SeO_3^{2-} sorption tests: selenite is an anionic species which adsorbs on clay mainly by surface complexation

AIM

The **objective** of this research is to determine if the surface and adsorption properties of bentonite clay are affected by two different doses of γ-irradiation.

RESULTS AND DISCUSSION

STRUCTURE AND COMPOSITION

FTIR spectra indicated alumino-dioctahedral montmorillonites (bentonite) with not special differences between the samples

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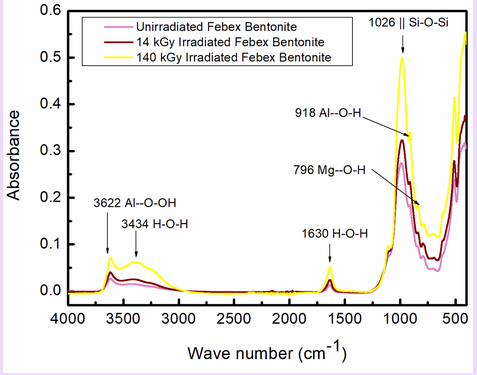
irradiation does not affect the properties of the bentonite clay under the irradiation conditions analysed.



CATIONIC EXCHANGE CAPACITY (CEC)

- CEC is the same within the experimental errors in the unirradiated and irradiated samples.

↓

Table. Comparison of the cation exchange capacity of the three clay samples

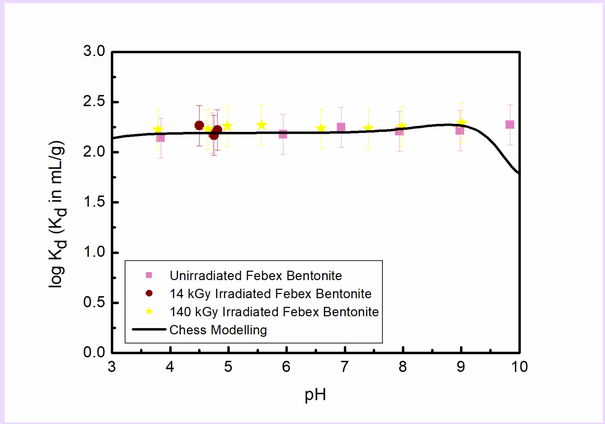
Sample	CEC (meq/100g)
Febex Unirradiated	98 ± 4
Febex 14 kGy Irradiated	99 ± 4
Febex 140 kGy Irradiated	99 ± 4

ADSORPTION EXPERIMENTS

EDGE ^{85}Sr(II): 10^{-6} M ^{85}Sr(II); 2 g/L clay 0.1 M $NaClO_4$; pH 3-10

- Strontium is retained in the clay structure by a mechanism called cation exchange, which mainly depends on ionic strength and not by pH.
- ^{85}Sr sorption edges measured at constant ionic strength in irradiated and unirradiated FEBEX bentonite were equivalent → **the irradiation does not affect strontium sorption under the investigated conditions.**

CONFIRMATION

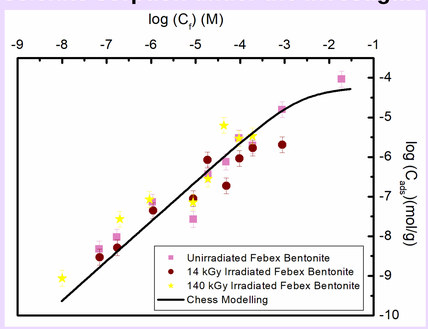


The continuous line in the graph corresponds to the modelling of the data considering cation exchange and cation competition as described in [3].

ADSORPTION EXPERIMENTS

ISOTHERM ^{75}Se(IV): 10^{-8}-10^{-4} M ^{75}Se(IV); 1 g/L clay 0.1 M $NaClO_4$; pH 4

- Selenite adsorption in clays is expected to occur only on the SOH sites, which have much less density than exchange sites (10% of CEC).
- ^{75}Se sorption isotherms show in all the cases a limited retention of selenium, which is expected for sorption of anions in clays. The low adsorption leads to a large experimental errors. Within these errors no large differences are observed between the unirradiated and irradiated samples → **the irradiation does not affect selenite sorption under the investigated conditions.**



Data were simulated with the complexation model described in [2], including the competition of anions measured in solution and introducing the number of sites 1.02 ueq/m^2.

CONCLUSIONS

- ✓ All the experiments carried out in this investigation show that γ-irradiation at the doses investigated have not effect on the main structural properties of the clay.
- ✓ The adsorption of strontium (cation exchange) and selenite (surface complexation) are not affected by irradiation up to 140 kGy.

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References are included in the QR.

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