Interfacial interaction of arsenic(V) with Mg-containing calcite and calcite

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ABSTRACT: Carbonate system has a significant effect on the migration and transformation of trace elements in groundwater. But impure calcite (such as Mg-containing calcite) is the main occurrence pattern of carbonate in nature groundwater system. In this study, batch adsorption experiments were carried out to investigate the interfacial interaction of arsenic(V) on Mg-calcite and calcite. Characterization methods were employed to compare the changes after reaction. The adsorption reactions showed that the adsorption capacity of Mg-containing calcite was higher than pure calcite.

1 INTRODUCTION

Carbonate system has a significant effect on migration and transformation of trace elements in groundwater (Yokoyama *et al.*, 2012; Stollenwerk, 2003). There are several relevant researches on surface adsorption and co-precipitation of the pure calcite (Monteshermendez *et al.*, 2009). However, it is not well understood about interaction between non-pure calcite and arsenic (As). In natural groundwater system, there is no pure calcite, impure calcite (such as Mg-containing calcite) is the main occurrence pattern of carbonate. In this study, on behalf of impure calcite, interfacial interaction of As(V) with Mg-containing calcite was simulated.

2 METHODS/EXPERIMENTAL

Mg-calcite was prepared with calcium to magnesium ratios, which is 9:1 (Long *et al.*, 2011, 2012; Xu *et al.*, 2013). Then batch adsorption (isothermal, kinetic adsorption) experiments were carried out to investigate the interfacial interaction of As(V) on Mg-calcite and calcite. Characterization methods, such as Laser Particle Size Analyzer, XRD, FTIR and SEM, were employed to determine the Mg-calcite, calcite, and after their interaction with As(V) in surface morphology, polymorphs and chemical elements.

3 RESULTS AND DISCUSSION

On this basis, the characteristics and mechanism of As(V) adsorption on Mg-Calcite were investigated.

3.1 Characteristic of calcite

Mg-calcite prepared by the precipitation method was nearly spherical and had a particle size of about

Figure 1. FE-SEM Images of (a) Ca_9Mg_1 , (b) Calcite (Ca_nMg_m refers to the Mg-calcite, prepared with the initial Ca:Mg molar ratio of n:m.).

25–40 μm . With the increase of the magnesium content in the initial solution, the grain size increased slightly and the crystallinity decreased (Fig. 1).

3.2 Adsorption experiments

Isothermal batch adsorption experiments (24 h) of Mg-calcite and calcite with different As(V) concentrations (0~300 μM), followed Freundlich adsorption isotherm model. Kinetic adsorption of Mg-calcite and calcite with 30 μM As(V) with different reaction times (10 min~120 h), which was a comparatively fast reaction within the first 10 h, followed by a slower and at a relatively constant reaction rate until equilibrium was achieved, and the adsorption behavior was in accordance with the second-order kinetic adsorption equation.

3.3 Adsorption capacity

Adsorption reactions showed that the adsorption capacity of Mg-calcite is of the order, calcite < Ca_9Mg_1 ; the maximum arsenic adsorption potential of Ca_9Mg_1 was 0.00344 mol kg^{-1} calcite, which was higher than that of calcite (Fig. 2). This phenomenon is mainly due to the impact of integrated Mg in crystal lattice of calcite, which could result in a

Figure 2. Adsorption isotherms at initial arsenic concentration of 300 μ M.

mineral surface with higher positive charge and greater propensity for the adsorption of negatively charged species of arsenic.

4 CONCLUSIONS

The results of this research showed that the interaction of As(V) with Mg-calcite can be directly impacted by Mg content. The presence of Mg in the solution had led to the morphology and phase transformation from calcite to other calcium carbonate forms (such as aragonite and vaterite) in the process of precipitation.

The adsorption capacity of Mg-containing calcite was higher than pure calcite. So, in the arsenic polluted groundwater, such as that in the Northern China, the adsorption capacity of the aquifer medium for As(V) is enhanced when the content of Mg-calcite increases in the aquifer sediments.

REFERENCES

- Long, X., Ma, Y. & Qi, L. 2011. In vitro synthesis of high Mg calcite under ambient conditions and its implication for biomineralization process. *Cryst. Growth Des.* 11(11): 2866–2873.
- Long, X., Nasse, M.J. & Ma, Y. 2012. From synthetic to biogenic Mg-containing calcites: a comparative study using FTIR microspectroscopy. *Phys. Chem. Chem. Phys.* 14(7): 2255.
- Monteshernandez, G., Conchalozano, N. & Renard, F. 2009. Removal of oxyanions from synthetic wastewater via carbonation process of calcium hydroxide: applied and fundamental aspects. *J. Hazard Mater.* 166(2–3): 788.
- Stollenwerk, K.G. 2003. Geochemical processes controlling transport of arsenic in groundwater: A review of adsorption. *Arsenic in Ground Water. Springer US.* 67–100.
- Xu, J., Yan, C. & Zhang, F. 2013. Testing the cation-hydration effect on the crystallization of Ca-Mg-CO₃ systems. *Proc. Natl. Acad. Sci. USA.* 110(44): 17750–177505.
- Yokoyama, Y., Tanaka, K. & Takahashi, Y. 2012. Differences in the immobilization of arsenite and arsenate by calcite. *Geochim. Cosmochim. Acta* 91(91):202–219.