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Progress Report on the Mineral Fragment Colloid Study at SNL WIPP Geochemistry

Revision 0

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I. INTRODUCTION

I.1. Revision History

This is Revision 0 of this report. Revision n ($n \geq 1$) will retain the outline of Revision n-1 and present detailed summaries of new tasks completed by the time of release of Revision n.

This report, identified GEOC-22-07 in the work structure of SNL WIPP, is one of the three deliverables laid out at the beginning of FY22 for the colloid study at SNL WIPP Geochemistry. The other two, i.e., GEOC-22-05 and GEOC-22-06, are combined into this report (GEOC-22-07).

I.2. Current Status

In the WIPP conceptual model, inorganic colloids (intrinsic and mineral fragments) may form by nucleation when the aqueous phase becomes supersaturated with respect to the constituents of the colloids or when mixed metal ions undergo hydrolysis reactions (Kim, 1992, Johnson and Toth, 1978; Nitsche et al., 1992; Nitsche et al., 1994; Reed et al., 2013a). In addition to nucleation, mineral fragment particles may be released from the host rock due to changes in chemistry or physical disruption, corrosion of the waste, solid materials within the waste, by the degradation of cement, and by the use of drilling mud (Mariner & Sassani, 2014).

Actinide transport associated with mineral fragment colloids (MFCs) is implemented in the WIPP performance assessment model by the CONCMIN parameter which defines the bounding (or conservative maximum) concentration of actinide associated with MFCs. While sedimentation experiments were conducted for a range of mineral and material types: bentonite, kaolinite, montmorillonite, vermiculite, illite, anhydrite, calcium carbonate, magnesite, hematite (mechanically disaggregated), hematite (chemical precipitate), limonite, goethite, magnetite, quartz, siderite, brucite, strontianite, diatomaceous earth, pyrite, and cellulosic materials (Papenguth et al., 1996). Particle number concentrations used to define the range of values for mobile actinide associated with mineral fragment colloids were derived from experiments on three minerals: hematite, goethite, and bentonite (Papenguth et al., 1996).

Magnesium oxide (MgO) is used in the WIPP as a chemically engineered barrier material to decrease actinide mobility. Consequently, the repository will contain a large mass of MgO post-closure. The total possible number of particles in an aqueous suspension could be influenced by the number of original available particles. Due to the large mass of MgO projected to be present in the repository it

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is pertinent to experimentally confirm the CCA assumption that magnesium mineral fragment colloids would aggregate and fall out of suspension in WIPP ionic strength and pH conditions.

II. GOALS AND HYPOTHESES

SNL WIPP Geochemistry will characterize change of the stability of MFC suspensions in brines. This investigation will be conducted using the methods described in Test Plan TP 22-02 Investigation of the Stability of Mineral Fragment Colloids Forming from Magnesium Oxide Revision 0 (Foli et al. 2022b). Subsequent revisions to TP 22-02 will account for investigations in increasingly complex chemical systems or any change in base material.

Engineered barrier material derived magnesium colloids will be initially assessed in simple systems beginning with only deionized (DI) water and with as-received engineered barrier material. Subsequent experimentation will investigate incrementally increased conditions of chemical system complexity, ionic strength (I), and acidity (pH) until final experiments are performed in WIPP simulated brines (GWB and ERDA-6) with the goal of determining particle stability, the particle size fraction of stable particles, and mineralogical identity of the colloidal particles.

This report supplies data collected during method development for TP 22-02. The work was conducted in the simplest possible system ($MgO(s) – H_2O$) and operated under the two following competing hypotheses:

H-1: Engineered barrier material derived magnesium mineral phases will form stable colloidal particle suspensions in DI water.

H-2: Engineered barrier material derived magnesium mineral phases will aggregate quickly and preclude formation of stable colloidal particle suspensions in DI water.

III. MAGNESIUM (Mg) MINERAL FRAGEMENT COLLOIDS

III.1. $MgO(s) - H_2O$

Work to date on the $MgO(s) – H_2O$ system reflects method development for MFC characterization. This work is summarized in Foli et al., 2022a. This work formed the basis for the experimental method outlined in TP 22-02. On-going experimentation in the $MgO(s) – H_2O$ system continues under TP 22-02.

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IV. CONCLUSIONS

IV.1. MgO(s) – H_2O

Initial experimentation confirmed the ability of dynamic light scattering to measure potential mineral fragment colloidal suspensions (Foli et al., 2022a). Neither hypothFesis presented in Section II can be confirmed or rejected by the analysis conducted to date.

V. FUTURE WORK

V.1. Magnesium Colloids

The initial material of interest which will undergo rigorous experimentation is Martin Marietta engineered barrier magnesium oxide (MM MgO). Method development R&D work associated with the development of TP 22-02 utilizing MM MgO(s) – H_2O is summarized in Foli et al., 2022a. To accomplish a comprehensive analysis of MM MgO MFCs in WIPP relevant brines, it is necessary to incrementally increase the complexity of the chemical system. Table 1 summarizes the different MM MgO MFC stability experiments which will be undertaken in their respective time schedule.

Table 1. Systems to be investigated for MgO(s)-based MFC stability and anticipated time of completion.

System	Scheduled
MgO(s) – H_2O	To be completed by September 2023
MgO(s) – NaCl - H_2O	To be completed by September 2023
MgO(s) – $MgCl_2$ - H_2O	To be completed by September 2024
MgO – $MgCl_2$ – NaCl - H_2O	To be completed by September 2024
MgO – GWB	To be completed by September 2025
MgO – ERDA-6	To be completed by September 2025

V.2. Other Mineral Fragment Colloids

After comprehensive analysis of MFC stemming from MM MgO is achieved, future investigations will study the colloidal potential of additional MFCs. These materials could include, but are not limited to: iron, lead, neodymium, and aluminum.

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