Geophysical Research Abstracts
Vol. 15, EGU2013-9275, 2013
EGU General Assembly 2013

A quantitative analysis of microbially-induced calcite precipitation employing artificial and naturally-occurring sediments

Stephen Lokier (1) and Ginger Krieg Dosier (2)

(1) The Petroleum Institute, Petroleum Geosciences, Abu Dhabi, United Arab Emirates (slokier@pi.ac.ae), (2) bioMason Inc. Research Triangle Park, North Carolina, USA

Microbially-induced calcite precipitation is a strong candidate for the production of sustainable construction materials. The process employs the microbe Sporosarcina pasteurii as an agent to microbially mediate the precipitation of calcium carbonate to bind unconsolidated sediment. As this process can be achieved under ambient temperature conditions and can utilise a wide variety of easily-available sediments, potentially including waste materials, it is envisioned that this procedure could significantly reduce carbon-dioxide emissions in the construction industry.

This study describes and quantifies the precipitation of calcite cement in a range of naturally-occurring sediments compared with a control matrix. The study establishes the optimum treatment time for effective cement precipitation in order to produce a material that meets the standards required for construction whilst keeping economic and environmental outlays at a minimum.

The ‘control sediment’ employed industrial-grade glass beads with a grain size range of 595-1180 microns (16-30 US mesh). Sporosarcina pasteurii were mixed in a solution of urea and calcium chloride and then inoculated into the control sediment. The microbes attach to the surface of the sediment grains and employ urea as a source of energy to produce ammonia and carbon dioxide. By so doing, they increase the pH of the solution allowing calcium carbonate to precipitate at the cell walls to act as nucleation points facilitating the precipitation of cements as a grain-coating and biocementing the unconsolidated sediment.

The solution treatment was repeated at eight hour intervals with samples removed for detailed analysis after each every five consecutive treatments (i.e. 40 hours). The process was repeated to produce 20 samples with treatment times between 40 and 800 hours. Cemented samples were impregnated with blue epoxy and examined petrographically to monitor cement development. Modal analysis was undertaken on each cemented sample to establish the abundance and natures of precipitated cements. Samples were also examined via SEM to monitor cement distribution and quantify the thickness of cements on grain surfaces and at grain-on-grain contacts.

Analysis established that precipitation of calcite continues until 400 hours (50 treatments) after which time there is only an insignificant precipitation of new calcite cement. This is inferred to result from the occlusion of porosity (from 40% to 10%) and observed calcite precipitation at grain-on-grain contacts, both factors reduce the permeability of the samples and, thus, inhibit the flow of solution through the medium. The precipitated calcite cement was found to be dominantly grain-rimming with a consistent thickness averaging 11 microns.

A range of naturally-occurring sediments were collected from surface locations throughout the United Arab Emirates. Samples were submitted to a range of petrographic and geochemical analysis in order to quantify grain-size distribution, grain composition and bulk total carbonate content (7.5-94 wt%). Sub-samples of these sediments were established by sieving and the cementation potential of different size fractions was established. Following treatment, these samples were submitted to the same analysis as those employed for the control sediment. A relationship between both sediment grain-size characteristics and sediment grain composition to cement precipitation was established and is discussed.