Refinement of kaolin and silica sand by microbial removal of iron impurities

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Kaolin clay and silica sands are minerals used in a wide range of industrial applications, particularly in paper, ceramics and glass manufacturing. These minerals are formed by the mechanical and chemical breakdown of rocks and, depending on the geological conditions of deposition they are often associated with iron (hydr)oxides that are either adsorbed to the mineral surfaces or admixed as a separate iron bearing phase. Unfortunately, iron (hydr)oxide impurities in raw kaolin and silica sands dramatically affect their quality and value. Several physical and chemical refining methods are currently being used to remove as much iron impurities as possible from these raw minerals, including magnetic separation, alkali and acid treatments. However, because of technological and environmental disadvantages associated with these processes, microbial leaching is now being considered as an alternative method.

In this study, we have examined the Fe(III) removal efficiency from kaolin and silica sand by a series of iron-reducing bacteria from the *Shewanella* species (*S. alga* BrY, *S. oneidensis* MR-1, *S. putrefaciens* CN32 and *S. putrefaciens* ATCC 8071). The microbial reduction of Fe(III) was achieved using batch cultures under non-growth conditions. The rate and the extent of Fe(III) reduction was monitored daily for 5 days as a function of the initial Fe(III) content, *Shewanella* species and temperature. The bacterially-treated minerals were analysed by transmission electron microscopy (TEM), X-ray diffraction (XRD) and transmission Mössbauer spectroscopy (TMS) to observe any mineralogical transformation. The whiteness and ISO brightness of the kaolin was measured by spectrophotometry.

All *Shewanella* species were able to couple the oxidation of lactate to the reduction of Fe(III) associated with the kaolins and silica sands. However, there are differences among species with respect to the rate of reduction and extent of Fe(II) production. *S. putrefaciens* ATCC 8071 is the most effective, with an increase in kaolin whiteness from 57.7% to 67.8%, and a decrease in yellowness decreased from 10.1% to 6.3% at 20°C. ISO brightness increased from 76% to 80%.

Determination of Sr concentrations in lunar plagioclase by electron microprobe analysis

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We have measured Sr concentrations in plagioclase in a variety of lunar samples to investigate how variations might correlate with rock type, petrogenetic history, or reservoir. Sr concentrations in lunar plagioclase are relatively low (a few 100s of ppm), thus it is not typically measured because its analysis requires fairly severe analytical conditions.

Analyses were done on the JEOL 8200 electron microprobe at Washington University. Sr was simultaneously counted on four wavelength-dispersive spectrometers (one high intensity). Nominal conditions were 15 keV, 100-200 nA, 20-50 µm beam diameter (to prevent Na volatilization), and 150-300 second count times (per spectrometer). Analytical uncertainties (99% CI) were ± 11-18 ppm.

Sr concentrations vary considerably, from 200 to 650 ppm, correlating positively with Na_2O (Fig. 1). We see increasing Sr concentrations from the core to the rim of normally zoned plagioclase grains, reflecting crystallization trends. Different lunar samples or sample suites also define different trends in Fig. 1, representing differences in initial composition, i.e., reflecting different reservoirs. For example, the three KREEP samples in this study (SaU 169 IMB, Ap12 IMBs, KREEP basalts) all have different trends; does this then indicate three different reservoirs of KREEP? Different suites of lunar samples tend to populate different regions of Figure 1 (or define distinct trends, e.g., MIL 05035), suggesting that with more study, Sr concentrations could be used to identify the provenance of plagioclase mineral grains in polymict samples.

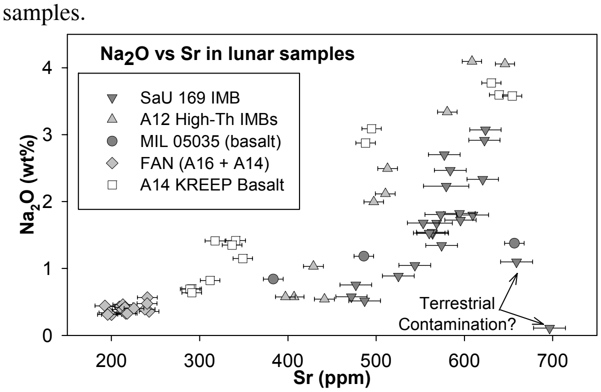

Figure 1: Na_2O vs. Sr in selected lunar samples.