Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 817

An Experimental Study of the Surface Areas of the Fontainebleau Sandstone: Are Geometric, Reactive, and Adsorptive Surface Areas Equivalent?

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Both the rates of precipitation/dissolution reactions and the quantity of elements adsorbed onto solids during water-rock interaction are proportional to the surface area of minerals exposed to the reactive fluid. For simplicity, in the present study the surface area consistent with minerals dissolution/precipitation rates are termed 'reactive' surface areas, and those consistent with aqueous metal adsorption are termed 'adsorptive' surface areas. Although there have been an exhaustive number of studies characterizing the rate constants for dissolution/precipitation reactions and equilibrium constants of metal adsorption reactions, almost no studies have been performed to determine the reactive and adsorptive surface areas of rocks. The purpose of this study is to measure directly both the 'reactive' and the 'adsorptive' surface area surface area of a simple rock to determine 1) if these two types of surface areas are in agreement, and 2) the extent to which these surface areas are equal to those determined using simple geometric models. 'Reactive' and 'adsorptive' surface areas have been determined on the Fontainebleau sandstone. This rock is ideally suited for this initial study of mineral surface areas owing to its uniform grain size, mono-mineralic composition (~100 per cent quartz), and that samples are available over wide porosity/permeability ranges. All surface areas were measured on rock cores using a pressurized flow reactor (described in detail by Keiffer et al., 1999). 'Reactive' surface areas were determined by comparing the quantity of Si released from a whole core dissolution experiment to the dissolution rate of a sample of Fontainebleau powder of known surface area, as measured using B.E.T. techniques. 'Adsorptive' surface area was determined from the quantity of Na adsorbed and desorbed while passing alternatively a pH 2 and a pH 9 solution containing 10^{-4} m/kg Na. Experimental results show that 'reactive' and 'adsorptive' surface areas are equivalent within analytic uncertainty. Moreover these values agree closely with geometric surface areas computed using simple mathematical models, including that of Canals and Meunier (1995). For example, for a sandstone core with a 9.8 per cent porosity, the measured 'reactive' surface area was 170 cm^{-1}, the 'adsorptive' surface area obtained from Na adsorption experiments was 141 cm^{-1}, the 'adsorptive surface area obtained from desorption experiments was 110 $cmcm^{-1}$, and the geometric surface area obtained using equations reported by Canals and Munier (1995) was 101.4 cm^{-1}. This observation suggests that one can use with confidence simple geometric models to compute the quantity of surface area involved in both mineral dissolution/precipitation reactions and the quantity of metal adsorption reactions during water/rock processes.

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