The effects of polarizable mineral type, amount, mix and grainsize in complex resistivity studies of synthetic mineralized sands

S. R. Jaggar and D. W. Emerson

Petrophysics Laboratory
Department of Geology and Geophysics
The University of Sydney
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Controlled laboratory experiments were run using a computer controlled Solartron (1250A) Frequency Response Analyser coupled to very high impedance amplifiers at low current densities (2×10^{-2} Am^{-2}) to obtain complex resistivity spectra in the 10mHz to 10kHz range from leached quartz sand (37-63 μm diam.) and granulated sulphide (63-1000 μm diam.) mixtures in four electrode cells saturated with brackish (80 Ωm, 20°C) and fresh 100 Ωm) chloride electrolyte. The sulphide particles and the silica background medium grains were angular in shape; the ratio of sulphide to sand size varied from 2:1 (63 μm tests) to 10:1 (710-1000 μm tests). The effects of mineral type, volume percent, grainsize, electrolyte resistivity, grainsize mix, and mineral mix were studied by means of spectral plots over 6 frequency decades, real-imaginary plots, and Cole-Cole parameter ridge regression inversions with up to three dispersions using an additive procedure. Hilbert transform checks on real and imaginary data components were made to monitor measurement linearity. The main crushed minerals studied were galena and chalcopyrite; sphalerite, pyrite, pyrrhotite, and graphite were also used. The test minerals (except for graphite) were not stoichiometric as varying, generally minor, amounts of other minerals (sulphide and silicates) were present in and on the grains; the chalcopyrite contained about 50% pyrite as intergrowths. The sand medium alone gave a flat resistivity and zero-phase spectrum to 2kHz and thereafter presented a rapidly increasing phase attributed to dielectric polarization. *Qualitatively* the results showed: a distinct dependence of the critical frequency on grainsize and salinity with phase peaks shifting to lower frequencies with increasing grainsize and with increasing solution resistivities; phase peaks increasing in value and definition with increasing mineralisation in the 1 to 10% volume range; mixing of sulphide granizes broadening the phase curves, increasing the maximum values and shifting the peak responses; and no discernable dependence of magnitude or position of the phase peak with mineral types and on mineral mixes showedcertain phase effects that require additional experimental investigation before possibly useful or diagnostic responses might be identified. In the complex impendance plane the data plotted as depressed arcs at low to medium frequencies and the initial parts of further arcs were observed sometimes at high frequencies, suggesting kinetics limited charge-transfer and/or double layer controls on the polarizable minerals' interfacial reactions, rather than Warburg diffusion effects, at low to medium frequencies, and dielectric polarization at high frequencies. *Quantitatively* the inverted Cole-Cole m (chargeability), τ(time constant), c(frequency dependence) parameters showed: m correlating with volume % polarizable minerals in the various grainsize ranges; m independent of or showing a slight decrease with increasing grainsize; τ values varying from 5.2 $\times 10^{-6}$ to 9.5 $\times 10^{-3}$ seconds and relating poorly to volume % polarizable mineral but correlating directly to grainsize; and c values varying from 0.5 to 1.0 with most values occurring between 0.6 and 0.9 and higher c values correlating with lower τ values. It is considered that synthetic mineral sand experiments readily provide data that may be interpreted empirically to study various mineral polarization effects, to test theorectical models of polarization behaviour, and to augment the sparse experimental IP data base.