Laboratory measurements of electrical conductivities of hydrous and dry Mt. Vesuvius melts under pressure

Anne Pommier

Université d'Orléans, Institut des Sciences de la Terre d'Orléans, UMR 6113, 45067, Orléans, France

Quantitative interpretation of MT anomalies in volcanic regions requires laboratory measurements of electrical conductivities of natural magma compositions. The electrical conductivities of three lava compositions from Mt. Vesuvius (Italy) have been measured using an impedance spectrometer. Experiments were conducted on both glasses and melts between 400 and 1300°C, and both at ambient pressure in air and at high pressures (up to 400 MPa). Both dry and hydrous (up to 5.6 wt% H_2O) melt compositions were investigated. A change of the conduction mechanism corresponding to the glass transition was systematically observed. The conductivity data were fitted by sample specific Arrhenius laws on either side of Tg. The electrical conductivity increases with temperature and is higher in the order tephrite, phonotephrite to phonolite. For the three compositions investigated, increasing pressure decreases the conductivity, although the effect of pressure is relatively small. The three compositions investigated have similar activation volumes (ΔV=16-24 cm^3/mol). Increasing the water content of the melt increases the conductivity. Comparison of activation energies (Ea) from conductivity and sodium diffusion, and use of the Nernst-Einstein relation allow sodium to be identified as the main charge carrier in our melts and presumably also in the corresponding glasses. Our data and those of previous studies highlight the correlation between the Arrhenius parameters Ea and σ_0. A semi-empirical method allowing the determination of the electrical conductivity of natural magmatic liquids is proposed, in which the activation energy is modelled on the basis of the Anderson-Stuart model, σ_0 being obtained from the compensation law and ΔV fitted from our experimental data. The model enables the electrical conductivity to be calculated for the entire range of melt compositions at Mt. Vesuvius and also predicts satisfactorily the electrical response of other melt compositions. Electrical conductivity data for Mt. Vesuvius melts and magmas are slightly lower than the electrical anomaly revealed by MT studies.