09-Engineering and Computer Simulation of Inorganic Crystal Structures

09.01 – Computer Simulation of Inorganic Crystal Structures

MS-09.01.01 COMPUTER MODELLING OF INORGANIC CRYSTALS by C.R.A. Case and J.M. Newsam, BISOM Technologies Inc., 9685 Scranton Road, San Diego CA 92121, USA

Computer simulation techniques are now playing a major role in modeling and increasingly predicting the structures and properties of inorganic materials. This introductory lecture will review the main techniques used in the field, including both quantum mechanical methodologies based on force fields. Recent applications will be described in the fields of microporous crystal structures and high temperature superconductors.

MS-09.01.02 COMPUTER SIMULATION AND CRYSTAL STRUCTURE PREDICTION by C.M. Freeman and J.M. Newsam, BISOM Technologies Inc., 9685 Scranton Road, San Diego CA 92121, USA

We describe techniques for predicting and solving crystal structures based on simple interatomic interaction potentials and powder diffraction data. Computational methods have traditionally commanded a central role in the solution and refinement of crystal structures. Similarly computer simulation procedures, which commonly draw on crystallographic findings, have established an important position in the rationalization of the physical properties of the condensed phases of matter. The parallel evolution of computational crystallography and computer simulation has led to a distinct overlap between the two fields. Recently procedures have been described which exploit the standard techniques of computer simulation in combination with hybrid potential energy functions to yield structures which are sterically and experimentally plausible. These real space techniques have been especially useful in the investigation of microporous framework structures, for which powder diffraction may be the sole experimental possibility. In contrast to traditional refinement procedures, which have tended to use rapidly convergent but locally biased least squares methods, the analogy with physical simulations, has prompted the use of simulated annealing as an optimization method in the majority of studies. Metropolis Monte Carlo or Molecular Dynamics based annealing procedures provide significant search capabilities framework structures, solids, condensed metal oxides and molecular crystal structures will be described. Acknowledgement: The Biozym Catalysis and Sorption Project is supported by a consortium of industrial, academic and government institutions.

MS-09.01.04 CALCULATION OF THE CRYSTAL STRUCTURE AND THERMODYNAMIC PROPERTIES OF OXIDES AND MINERALS USING FREE-ENERGY MINIMISATION TECHNIQUES by Stephen C. Parker and Alison Wall, School of Chemistry, University of Bath, Claverton Down, Bath, UK

The aim of this work is to develop reliable simulation techniques which can predict the structural and physical properties of oxides and minerals at varying conditions, in which the structural parameters are varied until the configuration with lowest energy is achieved. An important development is that lattice dynamics are employed to calculate the vibrational behaviour and hence the thermodynamic properties including heat capacities and free-energy. The approach has been shown to model the elasticity, heat capacity and thermal expansion of the Mg$_2$SiO$_4$ polymorphs under ambient conditions with a high degree of reliability. We have extended the range of applications in two ways. Firstly, to simulate the relative stability and stability of a range of minerals at varying pressures to infer the equations of state and phase diagram. We shall illustrate this work by describing the predicted phase stability of magnesium silicate pyroxenes for which there is still considerable experimental uncertainty. Secondly, to predict whether the minor elements including iron, calcium and aluminium in a magnesium silicate assemblage form a solid solution with the major mineral phases, to define distinct new mineral structures. The success achieved to date shows that with reliable interatomic potentials these techniques provide a valuable link between the atomistic and thermodynamic behaviour of minerals.


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