

REVIEW

Physical basis of trace element partitioning: A review

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ABSTRACT



Experimental observations on the dissolution of elements in minerals and melts and the partitioning between the two materials show that the concentration (or the partition coefficient) of trace elements depends on the properties of elements as well as those of relevant materials (minerals and melts) and the thermochemical conditions. Previous models of element solubility in minerals contain a vague treatment of the role of the stiffness of the element and have a difficulty in explaining some observations

including the solubility of the noble gases. A modified theory of element solubility in minerals is presented where the role of elasticity of both matrix mineral and the element is included using the continuum theory of point defects by Eshelby (1951, 1954, 1956). This theory provides a framework to explain the majority of observations and shows a better fit to the published results on the effective elastic constants relevant to element partitioning. However, the concept of “elasticity of the trace element” needs major modification when the site occupied by a trace element has large excess charge. The experimental data of the solubility coefficients of noble gases in melts show strong dependence on the atomic size that invalidates the “zero-charge” model for noble gas partitioning. A simple model of element solubility in melts is proposed based on the hard sphere model of complex liquids that provides a plausible explanation for the difference in the dissolution behavior between noble gases and other charged elements. Several applications of these models are discussed including the nature of noble gas behavior in the deep/early Earth and the water distribution in the lithosphere/asthenosphere system.

Keywords: Element partitioning, point defects, the Onuma diagram, strain energy model, hard sphere model, noble gas, Invited Centennial article, Review article