European Mineralogical Conference
Vol. 1, EMC2012-153, 2012
European Mineralogical Conference 2012

Clusters of "hidden phase" as primary nanoparticles for formation of structural units of opal-like natural nanomaterials

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Half a century before a sensational discovery was made. It turned out that noble opal consists of regularly located spherical particles of silica, which sizes in diameter form 150-450 nm. Further on it was found out that they, in turn, are built of smaller, but also spherical particles. By advanced analytical techniques similar globular internal structure is often found in many other natural materials. However the mechanism of formation the nanoparticles composing opal-like materials, hitherto remains unclear. This report gives general principle of building amorphous particles of the type of opal-like structural units, developed on base of the quataron concept of nanoparticles genesis.
The main idea of the quataron concept is that in supersaturated media specific nano-clusters – clusters of "hidden" phase or quatarons are formed, which according to classical theory of nucleation should not be. However, quatarons are not actual new phase nuclei. They cannot be described in terms of known states of substance. Actually quatarons represent a separate intermediate phase at nanolevel. In terms of classical theory they are pre-nucleation clusters. Quatarons are the basis for all kinds of equilibrium nanoparticles from ordinary tetra- and octahedral groupings to widely known fullerenes or dense dodecahedral, icosahedral clusters, colloidal particles.
The circumstance that only quatarons, which radius exceeds 4delta, where delta is diameter of cluster-forming atoms (molecules), can be potential centers of crystallization, has fundamental importance for forming amorphous nano-micro particles. Quatarons of smaller sizes represent amorphous "quasi-liquid" or "quasi-solid" objects. Exactly they are the base (primary) particles for forming structural units of opal-like materials. The main mechanism for forming self-assembled “solid” or “liquid” materials is an aggregation of quatarons sized from delta to 2delta. Quatarons in interval from 2delta to 4delta are capable to form larger secondary clusters by way of their merging.
Different variants of aggregation and interaction of quatarons are considered. It is established that forming structural units of opal-like materials is related with fractal aggregation of primary particles (quatarons). Typical sizes of structural units are reached at the third level of fractal aggregation of quatarons, more rare at the second one. The suggested model is confirmed by AFM data of study the internal structure of the units of natural and synthetic opals, other amorphous materials, as well as by the data on the structure of crystal-forming media obtained by spectroscopic methods.
This study was supported by RFBR 11-05-004432a, Scientific School 1310.2012.5, PBI of RAS 12-T-1022.