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Stishovite paradox in genesis of the superdeep diamond

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Stishovite was experimentally discovered [1] as high-density polymorph of SiO_2 stable at 9 – 50 GPa. A paradoxical paragenesis of stishovite and magnesiowustite (Mg,Fe)O was disclosed among primary inclusions in lower-mantle superdeep diamonds [2]. This contradicts to a common knowledge that SiO_2 and MgO paragenesis is forbidden for low-pressure SiO_2 polymorphs – quartz and coesite. The “stishovite paradox” does not manifest itself in the lower mantle ultrabasic compositions as is seen from experimental pyrolite assembly magnesiowustite+Mg-perovskite+Ca-perovskite at 50 GPa. In basic basalt composition stishovite is formed together with Ca-perovskite, Mg-perovskite and Al-bearing phases under the lower mantle PT-parameters [3]. In this case stishovite is taken as product of oceanic basalt subducted into lower mantle, but not in situ lower-mantle primary mineral. Paragenesis of stishovite and superdeep diamond has opened up fresh opportunity for detailed study. Magnesiowustite (Mg,Fe)O inclusions in superdeep diamonds are characterized by a wide variation of FeO content between 10 and 64 mol. % [2]. It is interesting that ringwoodite (Mg,Fe)2SiO4 solid solutions are decomposed into Mg-perovskite $(Mg,Fe)SiO_3$ + magnesiowustite (Mg,Fe)O + SiO_2 (within 30 – 42 mol. % Fe2SiO4) and magnesiowustite + stishovite (within 42 – 100 mol. % Fe2SiO4). Based on experimental data, melting phase diagram of MgO – SiO_2 – FeO system at 30 GPa is constructed [4]. Subsolidus assembly includes solid solutions of (Mg,Fe)-perovskite and (Mg,Fe)O. With increase in FeO content in the system, liquidus relations are determined by two univariant cotectics L + (Mg,Fe)O + $(Mg,Fe)SiO_3$ and L + SiO_2 + $(Mg,Fe)SiO_3$ having come to invariant peritectic L + (Mg,Fe)O + SiO_2 + $(Mg,Fe)SiO_3$. Mg-perovskite is eliminated by peritectic reaction L + $(Mg,Fe)SiO_3$ = (Mg,Fe)O + SiO_2 that gives rise to third univariant cotectic L + (Mg,Fe)O + SiO_2. The physicochemical peritectic mechanism is also operating in the MgO – SiO_2 – FeO – $CaSiO_3$ system where Ca-perovskite is stable. Thus, the ”stishovite paradox” has physicochemical substantiation. Fractional crystallization of magnesiowustite in ultrabasic lower-mantle magma could lead to a rise of FeO content in the residual melts and activate the peritectic mechanism of the “stishovite paradox’ formation. This is resulted in a transfer to basic residual melts and in situ formation of stishovite-magnesiowustite-Ca-perovskite rocks where stishovite is a primary lower-mantle mineral. This mechanism can be extended to the origin of stishovite and “stishovite paradox” in the superdeep diamond inclusions. By mantle-carbonatite model [5], the parental media of upper-mantle diamonds and inclusions are presented by carbonate-silicate-carbon melts. Carbonate-based parental media are applicable to origin of lower-mantle superdeep diamonds and inclusions. In this case the reasons arise from the presence of primary Na-, Mg-, Fe-, Ca-carbonate inclusions in superdeep diamonds and experimental evidence for congruent melting of carbonates under PT-conditions of the lower mantle [6, 7]. Support: RFBR grant 11-05-00401.

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