American Mineralogist, Volume 101, pages 2155–2167, 2016

CHEMISTRY AND MINERALOGY OF EARTH'S MANTLE

Graphite-diamond relations in mantle rocks: Evidence from an eclogitic xenolith from the Udachnaya kimberlite (Siberian Craton)

Denis S. Mikhailenko[1,*], Andrey V. Korsakov[1], Pavel S. Zelenovskiy[2], and Alexander V. Golovin[1]

[1]V.S. Sobolev Institute of Geology and Mineralogy of the Siberian Branch of the RAS, 3, Ac. Koptyuga avenue, Novosibirsk 630090, Russian Federation
[2]Institute of Natural Sciences, Ural Federal University, Ekaterinburg, Lenin Avenue 51, 620000, Russia

Abstract

Relations of graphite and diamond have been studied in a garnet-kyanite-clinopyroxene+sulfide+coesite/quartz+diamond+graphite eclogite xenolith from the Udachnaya-East kimberlite pipe in the Yakutian diamond province. Euhedral crystals of diamond and graphite occur in the intra- and intergranular space. The equilibrium conditions of diamond formation reconstructed by geothermobarometry for the Grt-Cpx-Ky-Coe mineral assemblage are 1020 ± 40 °C and 4.7 GPa. Raman imaging of graphite enclosed in diamond shows high ordering and a 9 cm^{-1} shift of the ~1580 cm^{-1} band. This Raman shift of graphite, as well as a 5 cm^{-1} shift of the 1332 cm^{-1} band of diamond, indicate large residual stress in graphite and in diamond around the inclusion, respectively. According to FTIR spectroscopy, nitrogen in diamond is highly aggregated and exists mainly as the A centers, while no other phases occur near graphite inclusions. Therefore, diamond in the analyzed eclogite sample must be quite old: it likely had crystallized long (~1 Byr) before it became entrained with kimberlite melt.

New data show that graphite can stay in the upper mantle for billions of years without converting to diamond. Crystallization of various carbon polymorphs, both in laboratory and natural systems, remains poorly constrained. Graphite present in mantle and UHP rocks may be a metastable phase crystallized in the diamond stability field. This fact should be taken into consideration when deducing petrological constrains and distinguishing diamond and graphite subfacies in upper mantle.

Keywords: Diamond, graphite, metastable graphite, pseudomorphs, UHPM