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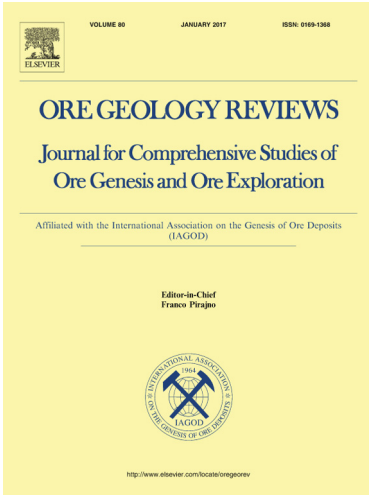

On the origin of large type IIa gem diamonds

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On the origin of large type IIa gem diamonds

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Abstract

The processes of formation of some diamond types still raise contentious issues, mainly on the origin of the largest diamond crystals recovered from kimberlites. These diamonds constitute less than 2% of worldwide resources and correspond to rare type IIa. They possess some peculiar features: (i) silicate and oxide inclusions are extremely rare, (ii) their $\delta^{13}C$ ranges from -17 to -21 ‰. The detailed estimation of the Premier pressure-temperature-oxygen fugacity parameters and the physic-chemical modeling of diamond growth-dissolution processes suggest that extra-large diamonds have multiple origins. Their formation may occur from lower mantle to crustal depths. Their main building-up takes place from fluids in the pegmatitic veins solidified along the contacts of kimberlite magma at a crustal depth. The model explains the main features of the largest kimberlitic diamonds, i.e. their great sizes, light $\delta^{13}C$ signatures, low nitrogen contents, high degree of resorption, absence of mantle-derived mineral inclusions and their occurrence in the form of rare isolated crystals in the host kimberlite.

Keywords: diamonds, kimberlites, fluids, mantle, crust

Introduction

Diamond is recognized as an extraordinary recorder of astrophysical and geodynamic events, which extend from far reaches of space to the Earth's deep interior. Processes of diamond formation still raise contentious issues, principally on the origin of the largest diamond crystals (bigger than 100 carats) recovered from kimberlites. Most of these diamonds correspond to the rare type IIa. They constitute less than 2% of worldwide resources, and include the largest gemstone ever found, the Cullinan (3106 ct), extracted from the Premier kimberlite, as well as the famous alluvial stones from India such as the Koh-I-Noor. These large diamonds mainly occur in well-known South African kimberlite mines (e.g. Cullinan and Jagersfontein), in several Lesotho kimberlites, in particular at Letseng la Terai, Mothae and Kolo, in Botswana (AK6, now Karowe), Jwaneng (Orapa), in Canada, West Africa and India (Gurney and Helmstaedt 2012; Moore 2009, 2014).

Type II diamonds have extremely low nitrogen contents (N< 30 ppm) and consist from two groups: IIa and IIb. As revealed by (IR) spectroscopy (Custers 1952; Collins 1982) type IIa are B-free and type IIb contain B. They represent a number of discrete parageneses, grown under variable mantle conditions. Eclogitic, peridotitic, websteritic and ultra-deep inclusions are reported in them (Moore 2009). Large type IIa gem diamonds have some distinctive features: (i)