8º Simpósio Brasileiro de Geologia do Diamante
8th Brazilian Symposium on Diamond Geology
8 a 11 de junho de 2025
Cuiabá, MT

Thirty years of Juina as a window to the deep mantle: the gift that keeps giving

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The vicinity of the town of Juina, Mato Grosso State, Brazil, particularly the drainages of the Rio Vinte e Um, Rio Cinta Larga, Rio Juininha and Rio Juina-Mirim, occupies a special place in our knowledge of the Earth's deep mantle. Over thirty years, Juina has consistently contributed the large majority of diamonds evidencing origins within the Earth's deep transition zone and lower mantle (over 410 km below surface). Such diamonds provide the only physical samples from such depths of near-pristine minerals available to scientists for direct study and are, therefore, some of the rarest Earth materials held in laboratories. Depths of origin are known by the assemblages of syngenetic mineral inclusions which Juina diamonds contain (in comparison with known phase relations) and measurements of retained pressure on inclusions by their diamond hosts. While rare, Juina diamonds have contributed an astonishing list of discoveries, including new minerals, which inform on all aspects of the deep transition zone and lower mantle, from petrology, Earth's subduction processes, stable isotopes, rock and mineral physical properties, the carbon cycle and Earth's hydrosphere. The first public, academic work on Juina diamonds was a 1991 abstract by Wilding, within the Harte and Harris research group, presented in Araxá, Brazil (5th IKC). The study established a lower mantle origin for an enstatite / ferropericlase assemblage (with enstatite inferred to be a low pressure reversion from its perovskite structure). The first author of the current work, Hutchison's, association with Juina commenced with a PhD on the topic in the same group – being the first major study of Juina diamonds (published in 1997). Diamonds were supplied by Sopemi S/A. This study, and collaborations, resulted in discoveries of: a new tetragonal form of pyrope garnet (with Hursthouse and Light), evidence of breakdown of majoritic garnet and stability of a separate alumina phase in the lower mantle; deep mantle phase transitions involving sodium and a new Na-pyroxene phase (with Gasparik); determination of the oxidation state of the lower mantle and partial chemical discrimination from the upper mantle (with McCammon); insights into carbon recycling and mantle stable isotopes (with Cartigny); high imposed internal pressures on inclusions in diamonds; and, trace element partitioning among lower mantle phases (with Nixon). Hutchison continued an association with Juina as a director of the Juina Mining Corporation and the management board of Diagem International Resource Corp., conducting mining at Juina. Management of these projects resulted in the discovery of primary sources for Juina alluvial diamonds, including the Accori and Collier kimberlite fields. Hutchison's archive of Juina diamonds, including from commercial work on Type IIa diamonds, yielded the following further discoveries: a Re-Os chondritic model age of 1271 Ma for Juina diamonds (with Pearson); the first discovery of natural ringwoodite and inferences on a huge reservoir of water in the mantle transition zone (work led by Pearson); the development of diamond plastic deformation informing petrophysical properties of the deep mantle, identification of maohokite and huntite in diamond and establishment of the importance of carbonate in deep mantle petrology (works led by Agrosi), diamond growth associated intimately with growth of ferropericlase (work led by Nimis); and, the establishment of considerable complexity in the role of subducted diamond-forming fluids permeating the lower mantle (work led by Mikhail). Independent Juina studies have also revealed evidence for subducted eclogites, pyroxenites and basaltic crust in the lower mantle, and the presence of transition metals such as Cu, Co, Mn and Zn in micro inclusions, informing on mantle redox. The second author to the current work, Kiseeva, has historically contributed to the Juina ouvre by Mössbauer spectrocsopy and single crystal X-ray diffraction evidencing recycling of subducted material into the lower mantle. Current collaboration between the two authors has employed synchrotron Mössbauer spectrocsopy (ESRF) to confirm Fe,Cr,Ni alloy grains as genuine Juina mineral inclusions in diamond, with ferropericlase, and informing on mantle oxidation and bulk chemistry: the Juina gift which keeps giving.

Keywords: diamond; lower mantle; mantle transition zone; São Luis; Brazil