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DIAMONDS FROM CAPIIBARY, PARAGUAY

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INTRODUCTION

Diamonds have been recovered from Paraguay since the early 1960s, but no scientific study of them has been previously reported. Here we present the first study of alluvial diamonds from the Capiibary occurrence, Paraguay, describing their external morphology, internal structure, mineral inclusions and nitrogen content and aggregation.

GEOLOGICAL SETTING

The Capiibary diamond occurrence Fig. 1) is located in the south-western portion of the Department of San Pedro, approximately 150 km east-northeast of Asuncion. The diamonds have been recovered from stream sediments by artisan workers ("garimperos") and Company exploration activity.

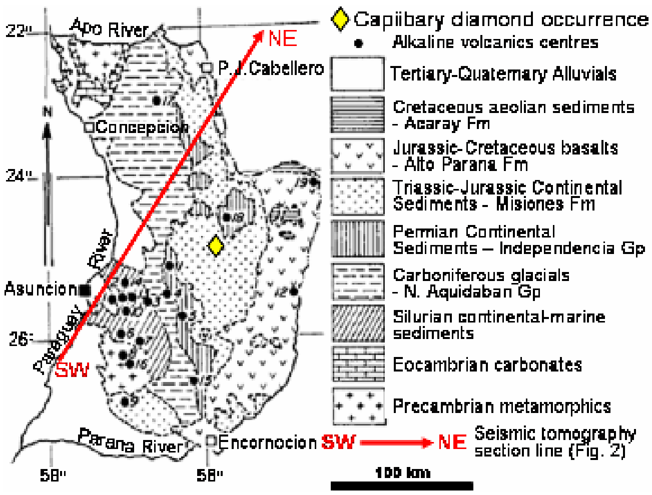

Fig. 1. Geology of south eastern Paraguay and location of Capiibary diamond occurrence (after Gomes et al., 1996). Note that seismic section line (Fig. 2) continues further NE across Brazil.

The South American platform of Eastern-Paraguay here forms part of the Parana Basin succession of Palaeozoic to Mesozoic sediments capped by the early Cretaceous Parana basalt flows. The Capiibary diamond occurrence itself is within the outcrop area of the Misiones Formation, a sequence of Jurassic-Cretaceous aeolian sediments cut by Mesozoic tholeiitic dykes. It lies some 230 km south of the Chiriguelo carbonatite complex and around 115 Km north of the early Cretaceous Ybytyruzú alkaline volcanics for some of which a lamproite affinity has been suggested and which are reported to have yielded diamonds from weathered outcrops and adjacent soils.

Seismic tomography (Fig. 2) suggests that the sedimentary sequence at Capiibary is underlain by a thick cratonic lithosphere, linked to either a southerly extension of the Precambrian Rio Apá block outcropping further north or a northerly extension of the Precambrian Rio de la Plata cratón which outcrops in southern Paraguay.

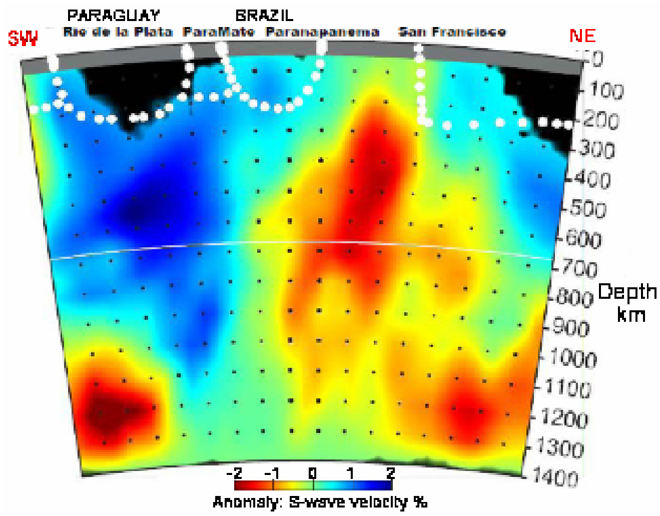

Fig. 2. S-wave seismic tomography X-section SW-NE from south eastern Paraguay to Sao Francisco Craton area in eastern Brazil (after Rocha et al., 2011).

DIAMOND MORPHOLOGY

The fourteen Capiibary diamonds we have studied are typically ~1 mm size, pale brown or colourless (Fig. 3), with 1 yellow, 1 grey and 1 olive-green stone recorded. Most stones are octahedra or partially resorbed octahedral-dodecahedral transition forms. Two dodecahedra and one pseudohemimorphic form (the latter usually associated with recent derivation from mantle xenoliths), were also noted.

A small proportion of the stones show rhombic cracks (Fig. 4), usually a result of wear during fluvial or marine transportation. However, there is an absence of other wear features such as abraded edges or broken points. Green radiation damage spots are common, as often seen on weathering zone or alluvial stones. Brown radiation spots (Fig. 4) were observed on one stone, indicative of heating resulting from low grade metamorphism.

Fig. 3 Diamonds from Capiibary

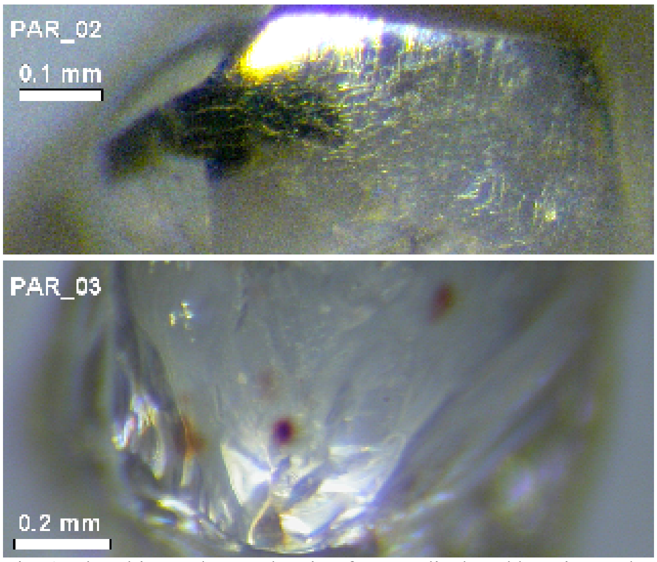

Fig. 4. Rhombic cracks, an abrasion feature, displayed by Diamond PAR-02, whilst PAR_03 shows brown radiation spots.

This combination of rhombic cracks and radiation spots, especially the brown metamorphosed ones, may suggest some of the stones have been recycled from formerly buried sediments, for example the Misiones Formation which forms the local underlying country rock at Capiibary. But the absence of evidence of strong abrasion may suggest that the Capiibary stones have not suffered long distance transport.

ULTRAVIOLET AND CATHODOLUMINESCENCE

Under ultraviolet light the diamonds luminescence blue or occasionally yellow reflecting the probable presence of N3 centres. Cathode luminescence imagery of polished plates made from the diamonds by polishing along dodecahedral crystallographic planes show regular internal octahedral growth zonation.

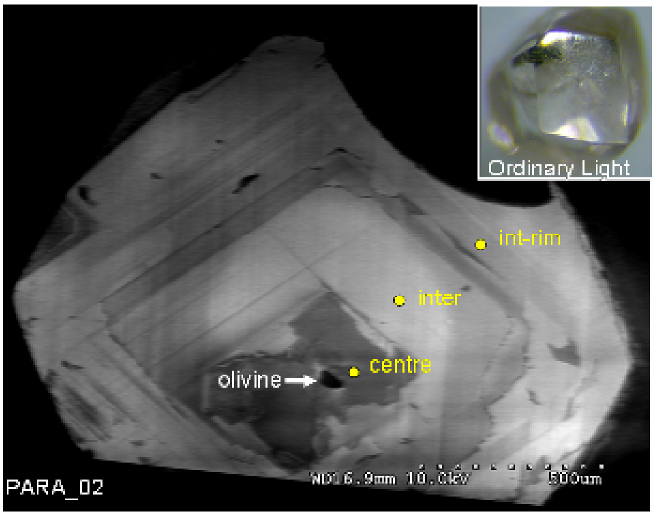

Fig. 5. Cathodoluminescence image of central section through dodecahedral diamond PARA_02. The core shows initial sectorial cubo-octahedral growth surrounded by regular octahedral zonation followed by final resorption. At the centre is an inclusion of olivine acting as a nucleation seed. The yellow points mark the sites of fourier transform infrared measurements.

MINERAL INCLUSIONS

Mineral inclusions recovered to date from Capiibary diamonds are entirely of highly forsteritic olivines (Fo 92-94). Electron microprobe analyses of the olivines are given in Table 1. Such a high forsterite content is indicative of an Archean harzburgitic or depleted lherzolite lithospheric mantle origin (Boyd, 1989; Pearson and Nowell, 2002; Pearson and Wittig, 2008).

The olivine inclusions show morphology imposed by the diamond host, which, together with absence of any surrounding cracks, implies a syngenetic origin for them.

Table 1. Electron microprobe analyses of olivines from Capiibary diamonds.

Diam #	Par-02	Par-03-incl.1	Par-03-incl.2	Par-04	Par-06
SiO_2	42.02	41.42	41.67	41.11	42.10
Al_2O_3	0.03	0.01	0.01	0.04	0.03
Cr_2O_3	0.07	0.02	0.00	0.05	0.09
FeO	6.25	7.04	6.94	7.53	5.99
MnO	0.09	0.09	0.09	0.09	0.07
MgO	51.05	50.85	51.07	50.40	51.38
CaO	0.01	0.00	0.01	0.05	0.03
Na_2O	0.00	0.02	0.01	0.03	0.00
K_2O	0.00	0.00	0.00	0.01	0.00
NiO	0.37	0.42	0.36	0.38	0.32
Total	99.90	99.88	100.15	99.70	100.01
Mg#	0.936	0.928	0.928	0.923	0.939
Paragen-esis	Harz	Lherz /harz	Lherz /harz	Lherz/ harz	Harz

FOURIER TRANSFORM INFRARED SPECTROSCOPY

Fourier transform infra red spectra ("FTIR") show strong hydrogen peaks for many of the stones (Fig. 6, Table 2). Spectral deconvolution yielded N contents typically around 200-300 ppm, with IaA-IaB aggregation in which the IaB component generally predominates (Table 2.). Platelets are often well developed, e.g. Fig. 6.

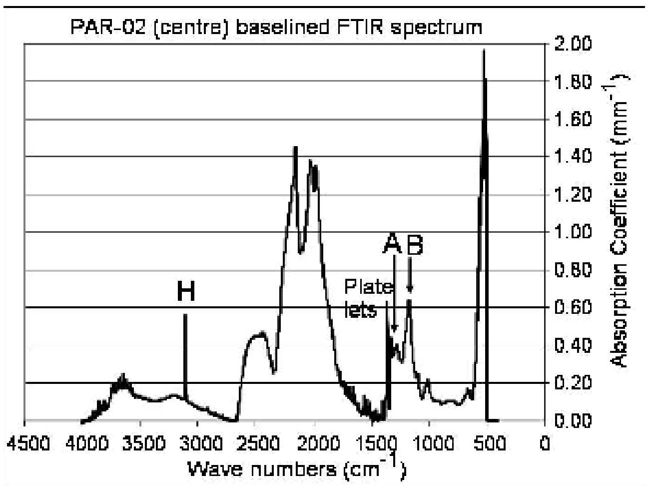

Fig. 6. Infrared spectrum of PAR_02 (Fig. 5), typical of Capiibary diamonds.

Table 2. Capiibary diamonds - N content, aggregation and H presence from FTIR spectroscopy.

Diam	N ppm	%IaB	H peak
Par-01 centre	48	56	V. high
Par-02 centre	325	89	V. high
Par-02 intermediate	391	90	V. high
Par-02 int-rim	197	84	V. high
Par-04 centre	Type II	0	Trace
Par-04 rim	Type II	0	Trace
Par-05 centre	63	83	High
Par-05 rim	244	42	High
Par-06 centre	194	57	High
Par-06 rim	206	57	nd
Par-07 centre	825	52	nd
Par-07 rim	810	52	nd
Par-08 centre	226	49	Low
Par-08 rim	306	56	Low
Par-09 centre	659	70	Trace
Par-09 rim	328	56	Low
Par-10 centre	187	49	Low
Par-10 rim 4	209	60	Low
Par-10 rim 5	213	52	High

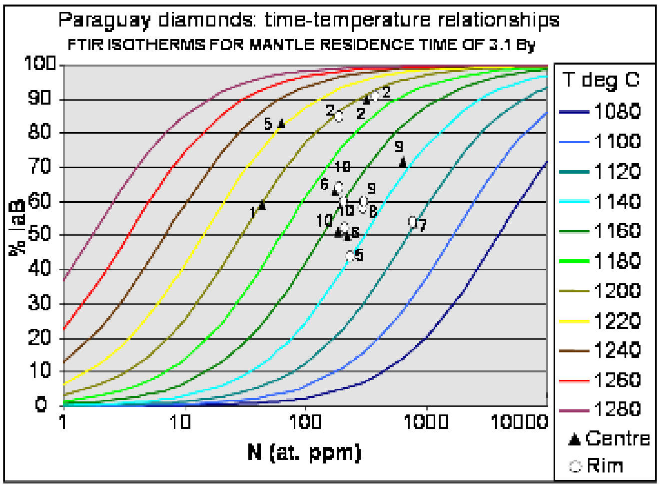

Fig. 7. Time–temperature relationships for Capiibary diamonds at an assumed mantle residence time of 3.1 By.
Nos. 1-10 are Capiibary diamond sample numbers.

In common with the Archean ages frequently recorded for diamonds from depleted peridotitic lithosphere, an assumed age of 3.2 Ga can be used in trials of time/temperature/nitrogen aggregation relationships. Given the dominant Cretaceous age of alkaline intrusives in Paraguay and kimberlites in adjacent Brazil, a mantle residence time of 3.1 Ga has been fitted to these relationships (Fig. 7), yielding diamond formation temperatures of around 1140-1170^{o}C which would be reasonable for diamonds of lithospheric peridotitic mantle derivation.

CONCLUSIONS

It is concluded that the Capiibary alluvial diamonds have, at least in part, been recycled from a former sedimentary host such as the local Misiones Formation, although the lack of strong abrasion features suggest their distance of transport was not very long. The high Fo-values of the olivine inclusions suggest a depleted lithospheric mantle origin, which would be in keeping with the seismic tomography evidence of a depleted cratonic lithospheric keel beneath south eastern Paraguay. The time-temperature relationships determined from the nitrogen aggregation characteristics would fit within the normal range for lithospheric mantle diamond formation temperatures if an Archean age is assumed for the lithospheric keel. It is therefore possible that any ultramafic lamprophyres, kimberlite or lamproites that might be associated with the widespread alkaline volcanics in Southeastern Paraguay (Presser, 1998) could serve as possible primary volcanic hosts for the Capiibary diamonds.

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