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Supplemental Material

ANALYTICAL TECHNIQUES

X-ray micro computed tomography (CT) scans were carried out at the Stellenbosch CT Scan Facility. These samples were scanned twice each, with low and high voltage settings. The low voltage scans have improved material discrimination and are hence easier to segment and visualize. The presence of dense inclusions in some samples, which can cause beam hardening artefacts, degrading the image quality, prompted the scanning at high voltage. Scanning at higher voltage reduces material contrast but reduces artefacts from dense inclusions. The combination of the two data sets therefore provides a more holistic analysis and more visualization and analysis capabilities. The low voltage scan settings were as follows: 100 kV, 200 µA, 500 ms per image with no averaging of images and 2000 images in steps in one full rotation of the sample. The high voltage scans were done at 160 kV, 120 µA, 1000 ms per image with averaging of 2 images per step position with 1600 images in one full rotation of the sample. In the high voltage case 0.5 mm of copper filters were used for beam filtration. The scan resolution was set to 20 µm in all scans, and post-scan data reconstruction made use of a beam hardening correction algorithm with a relatively high value of 7 (values from 0 to 10 are possible in the Datos software provided with this instrument). This beam hardening correction corrects for the sometimes-visible cupping effect, when the edge seems brighter than the middle of a sample, also inherently due to beam hardening.

Major mineral phases (garnet, clinopyroxene and diamond) within the diamondiferous eclogite displayed sufficiently different X-ray absorption for them to be distinguished using X-ray CT scanning (Figure S6). In general, diamonds display a low absorption, with clinopyroxene and secondary phases displaying overlapping intermediate absorption and garnet displaying relatively high absorption (Figure S6).

SAMPLE LOCATIONS

The Newlands and Excelsior olivine lamproites, formerly Group II kimberlites and orangeites, are located in the Barkly West district, to the NW of Kimberley. Newlands consists of a series of en-echelon dykes and blows. Rb-Sr dates suggest an age of 114.1 +/- 1.6 Ma (Smith et al. 1985). Re-Os systematics for the diamond-bearing eclogites suggest formation in the Archean (Menzies et al., 2003). The Excelsior (later called Ardo) mine is no longer in operation. It is on a southern offset of an extension of the Sover-Doornfontein-Mitchemanskraal dyke systems (close to the Frank Smith kimberlite). Two major phases of olivine lamproite occur, which are known as the Black and Red phases. Sampled diamond indicator minerals from the Black, more diamondiferous, phase are 90% peridotitic garnets; the Red phase contains 54% peridotitic and 45% eclogitic garnets.

The Orapa kimberlite is located on the western margin of the Zimbabwe craton and consists of two pipes that coalesce near the surface (Field et al., 1997). The Orapa kimberlite erupted in the Cretaceous and has a U-Pb age of 93.1 Ma (Allsopp et al., 1989). Orapa is well-known to contain abundant eclogite xenoliths relative to peridotitic with both graphite- and diamond-bearing eclogites been recovered.

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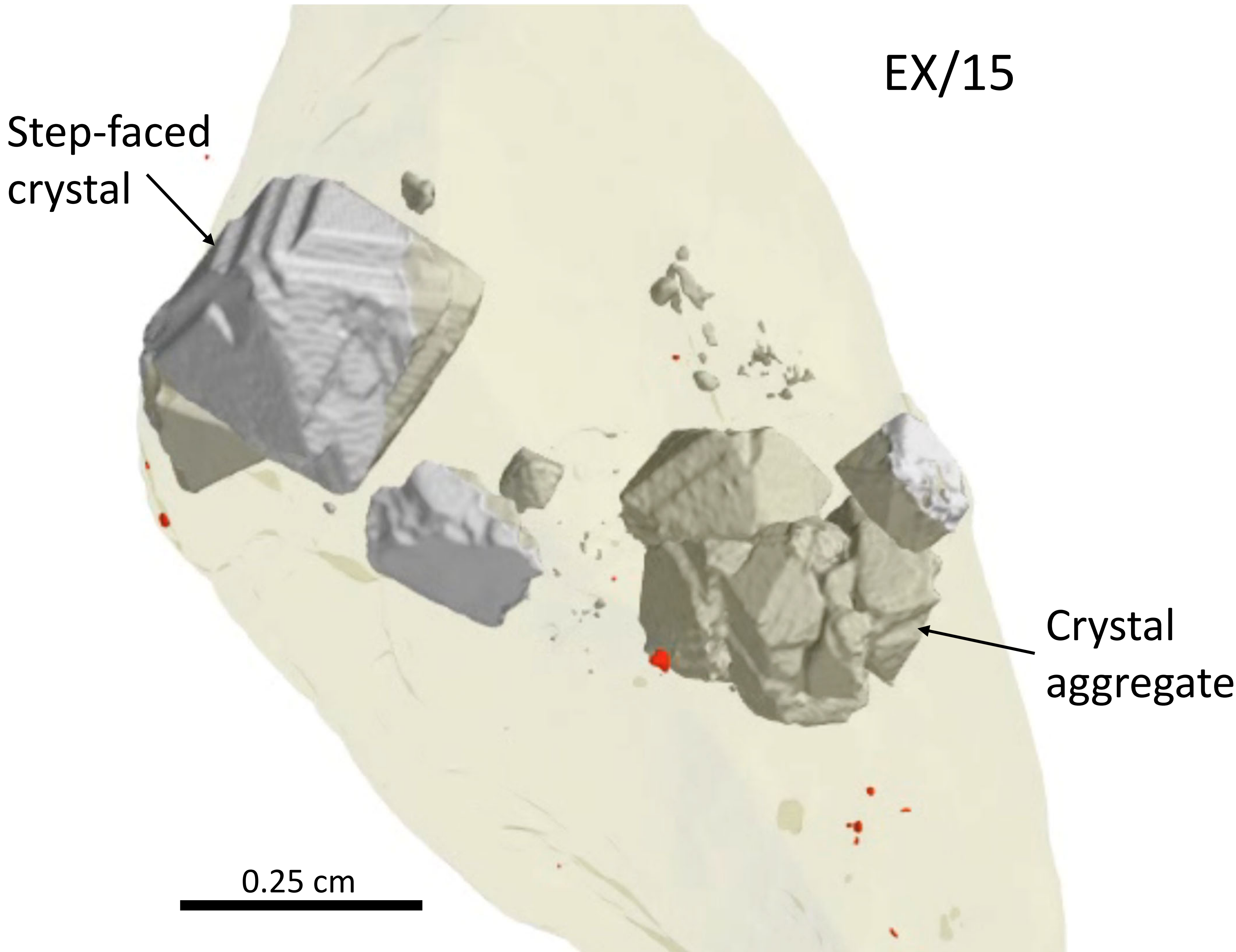
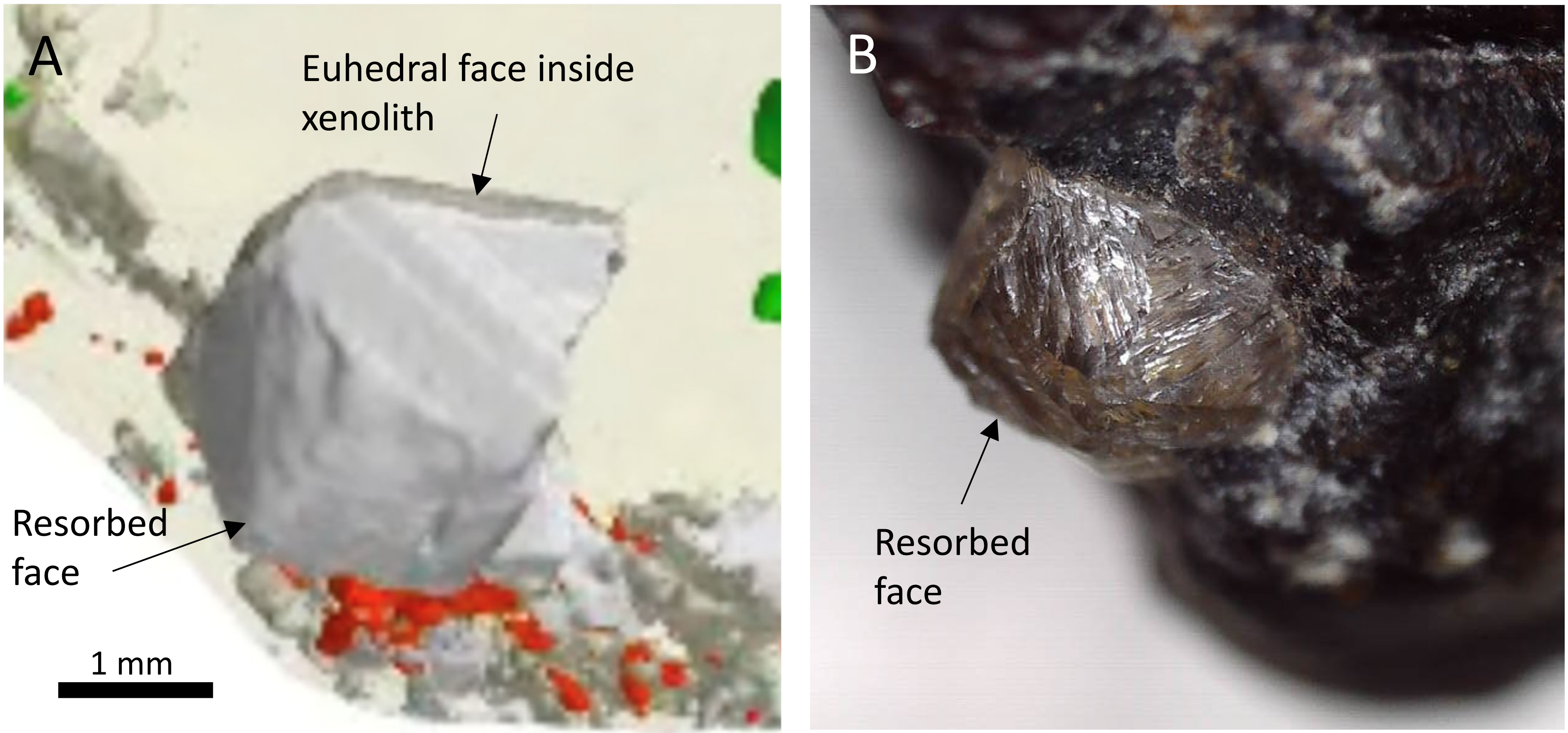
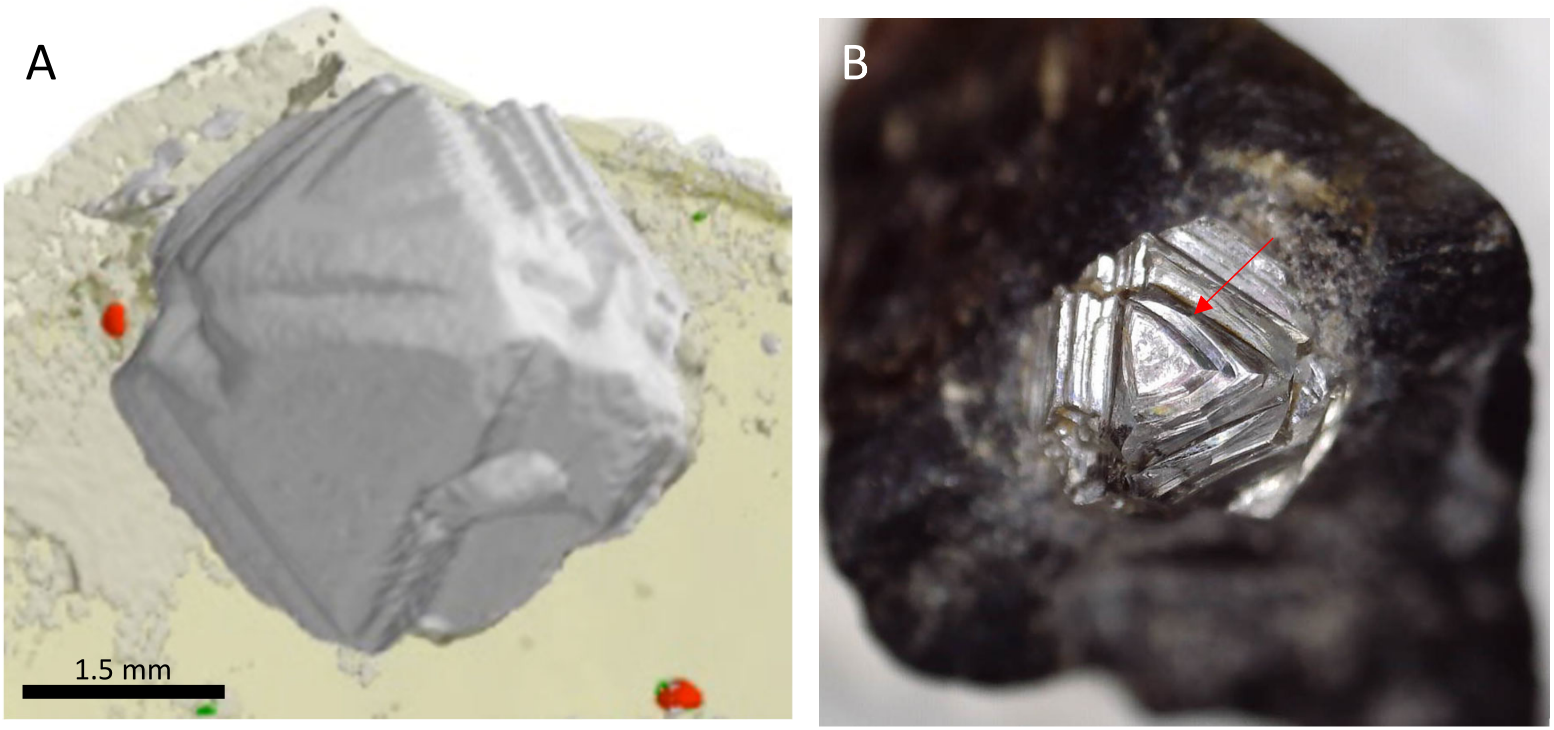
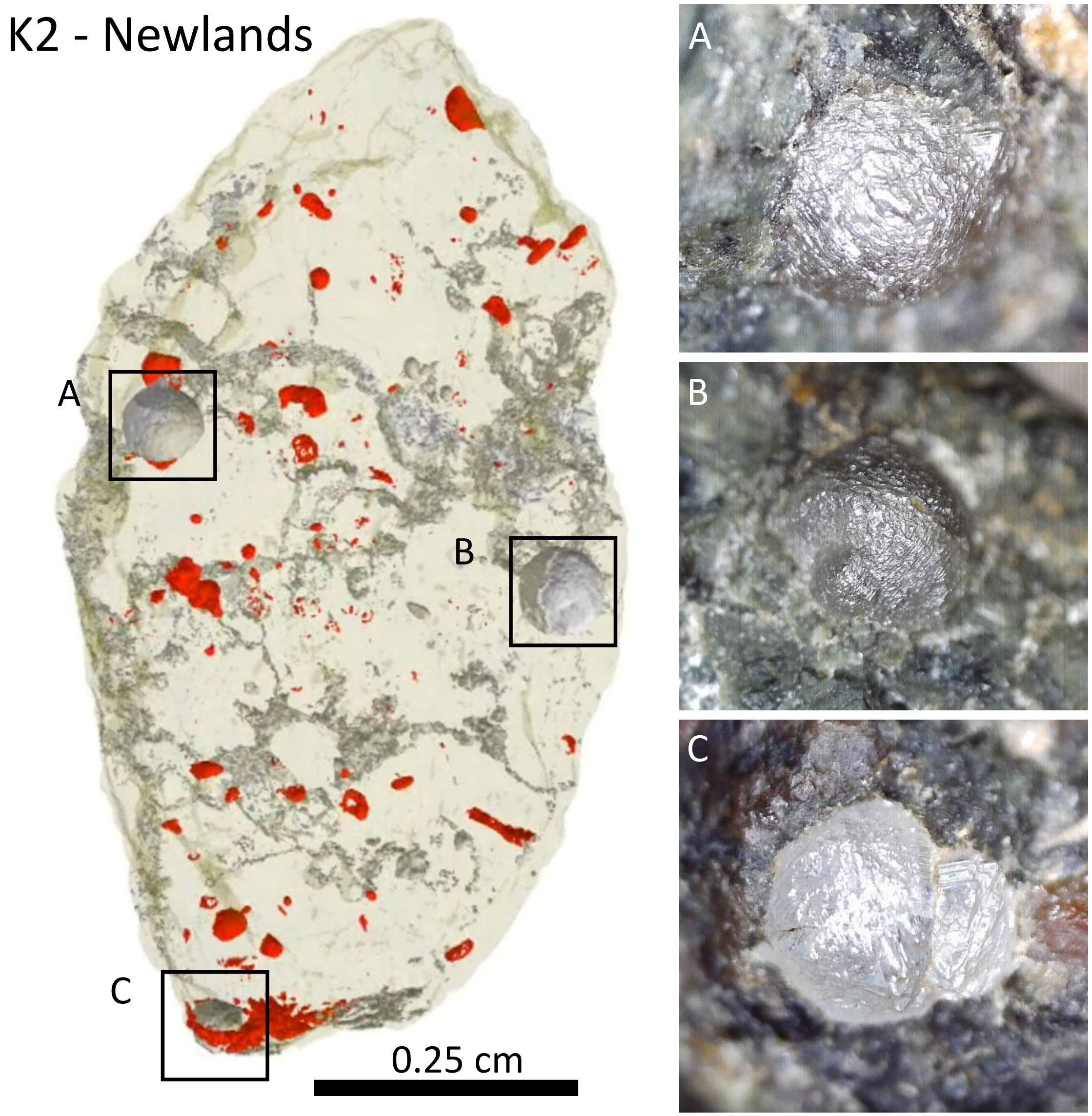
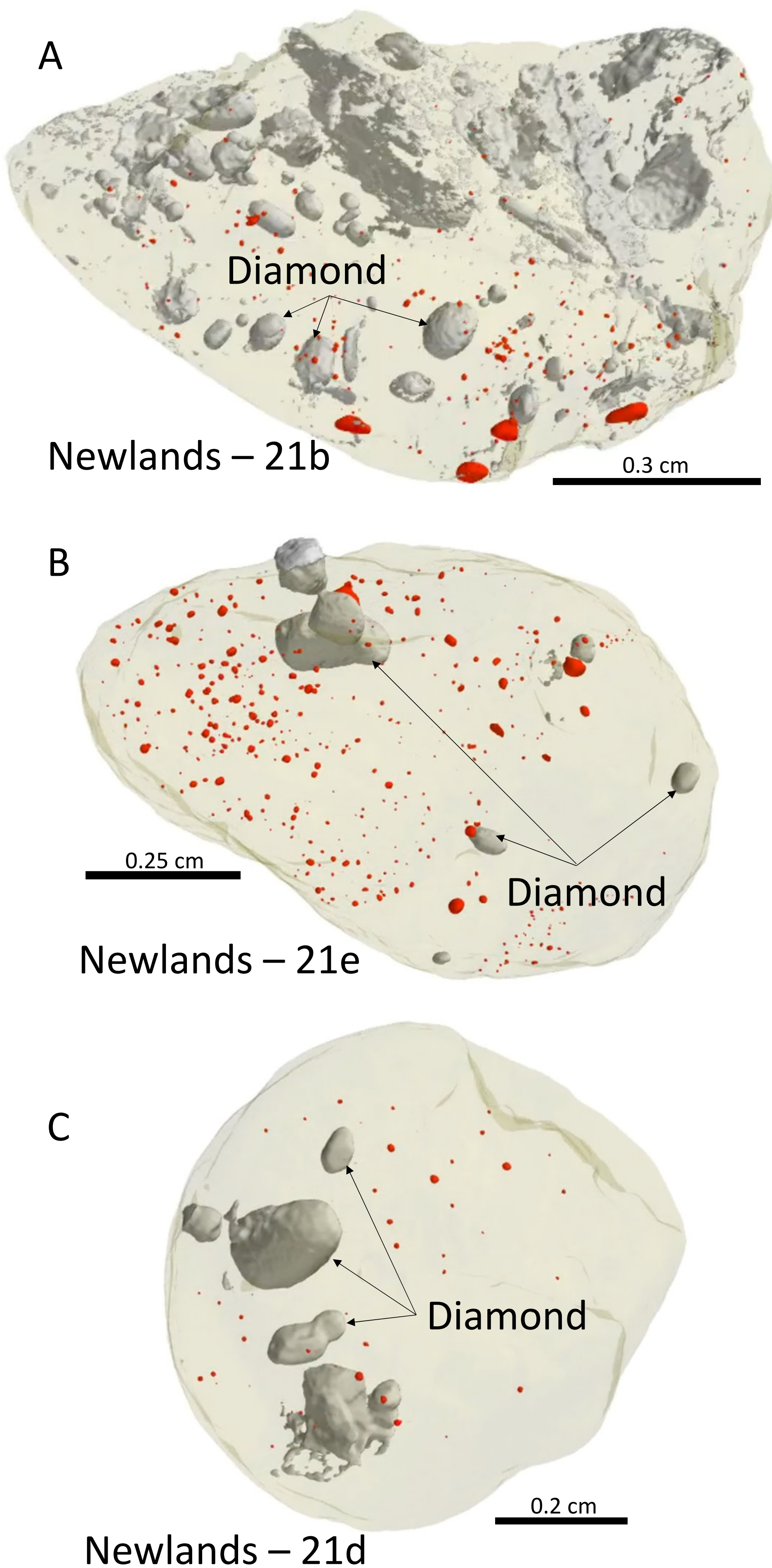


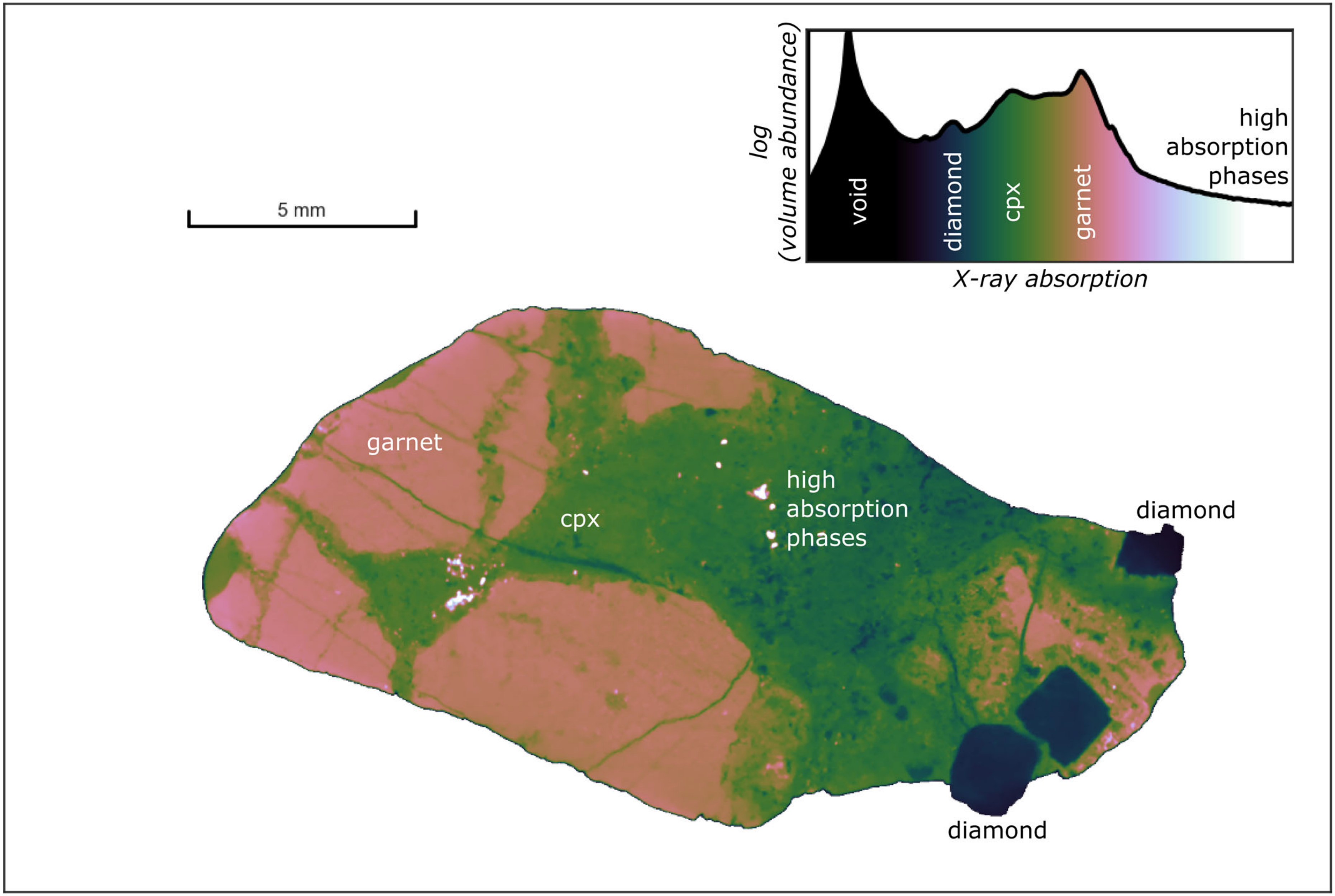
EX/15
Step-faced crystal
Crystal aggregate
0.25 cm


A
Euhedral face inside xenolith
Resorbed face
1 mm
B
Resorbed face


A
1.5 mm
B


K2 - Newlands
A
B
C
0.25 cm
A
B
C


A
Diamond
Newlands – 21b
0.3 cm
B
Diamond
0.25 cm
Newlands – 21e
C
Diamond
0.2 cm
Newlands – 21d



5 mm
log
(volume abundance)
void
diamond
cpx
garnet
high
absorption
phases
X-ray absorption
garnet
cpx
high
absorption
phases
diamond
diamond

Sample name	Location	Diamond size (mm)	Diamond %	Diamond morphology	Comments
EX/10	Excelsior	~3mm	4.2	Two large euhedral step-faced diamonds. One is a single crystal and the other is an aggregate of multiple crystals	- See SOM Figure 3.
EX/15	Excelsior	Most are ~2mm with one larger aggregate ~4mm	8.1	<10 diamonds total all with euhedral step-faced crystals.	- Appear to be associated with metasomatic pathways. - See main manuscript Figure 2 and SOM Figure 1.
EX/25	Excelsior	~3.5mm	1.7	One large euhedral step-faced diamond.	- Possibly several very small diamonds.
EX/22	Excelsior	~5mm	2.3	One large diamond broken at the surface of the xenolith. The interior of the diamond reveals one crystal face with clear step-faces and a second that is resorbed and cracked.	- Possibly several smaller diamonds.
EX/19	Excelsior	One larger ~2mm crystal and several <0.5mm crystals	1.9	Euhedral step-faced crystals with some irregular faces	
EX/20	Excelsior	~Seven larger 1-2mm diamonds and numerous smaller <0.5mm crystals	1.8	Larger crystals are step-faced either as single stones or aggregates. Smaller diamonds are rounded sometimes with blade-like morphology.	- Two distinct populations: 1) larger euhedral diamonds and 2) smaller rounded diamonds. - Main text Figure 4.
EX/21	Excelsior	Multiple diamonds generally <1.5mm	2.6	Euhedral diamonds with step-faces	- Diamond exposed at the surface contains indications of initial stages of lamproite resorption in the development of pseudo-ditrigonal faces. See SOM Figure 3.
EX/18	Excelsior	~50 diamonds in two populations. - Population 1: 1 - 2 mm - Population 2: <0.5mm	6.4	- Population 1: Uniform size, euhedral stepped-faced crystals and aggregates. - Population 2: Highly rounded, resorbed crystals.	- Diamonds of population 1 with step-faced crystals are arranged in two distinct planes - Diamonds of population 2 are resorbed and lie off the two planes observed for population 1. - See main manuscript Figure 1 and 4
EX/16	Excelsior	Tens of diamonds ranging in size from sub-mm to 2mm	2.7	Euhedral step-faced crystals	- Diamonds appear in two distinct planes.
EX/24	Excelsior	Uniform in size ~1.5mm with few small <0.5mm diamonds	9.0	High abundance of diamonds predominantly of euhedral step-faced crystals.	- See main manuscript Figure 1.
EX/17	Excelsior	Large variation in size. Six diamonds ~1mm in size. One much larger and several much smaller.	1.2	Euhedral step-faced crystals.	
AK1/10	Orapa	Single diamond of ~3mm	1.6	Euhedral step-faced crystal. Appears to be flattened/resorbed on the inside of the xenolith compared to euhedral on the part sticking out.	- Pseudohemimorphic crystal but in the opposite orientation to that expected with resorbed face on the interior of the xenolith.
AK1/19	Orapa	Range in size from ~0.5 to 3mm	4.9	All diamonds are rounded with near spherical morphology. No euhedral faces observed even on diamonds that are completely contained within the xenolith.	- See main manuscript Figure 3.
JJG144	Newlands	Single large ~4mm diamond	2.2	Single diamond with multiple crystals of step-faced diamonds.	
21a	Newlands	High abundance >12 diamonds with a range in size.	na	Abundant rounded and unusual diamond morphologies	
21b	Newlands	High abundance >30 diamonds with range in size up to 1.5mm.	na	All diamonds are rounded with near spherical morphology. No euhedral faces observed even on diamonds that are completely contained within the xenolith.	- One highly unusual hook-shaped phase with diamond attenuation but not clear if it is a diamond. - See SOM Figure 5
21c	Newlands	Two diamonds of different sizes. <2mm.	na	Two diamonds that are both rounded.	
21d	Newlands	Large size range with one large ~2mm diamond and multiple smaller <1mm diamonds.	na	All diamonds are rounded with near spherical morphology. No euhedral faces observed even on diamonds that are completely contained within the xenolith.	- See SOM Figure 5
21e	Newlands	Large size range with one large ~2mm diamond and multiple smaller <1mm diamonds.	na	All diamonds are rounded with near spherical morphology. No euhedral faces observed even on diamonds that are completely contained within the xenolith.	- See SOM Figure 5
K2	Newlands	Multiple diamonds of uniform size ~2mm.	0.93	All diamonds are rounded with near spherical morphology. No euhedral faces observed even on diamonds that are completely contained within the xenolith.	- Multiple diamonds have been removed from the surface of the xenolith and so the abundance is underestimated. All cavities left are rounded indicating that diamonds extracted were likely rounded as well. See main manuscript Figure 3 and SOM Figure 4.
JJG4001	Newlands	Two large diamonds ~3mm and several smaller stones <0.5mm.	4.5	Large and small stones have euhedral step-faced crystal morphology.	
AHM/K16	Newlands	Two diamonds of differing properties. One large 3mm in size the other much smaller <0.5mm.	1.6	Larger diamond is euhedral with step-faces. Smaller diamond is rounded to near sphere in morphology.	- See main manuscript Figure 2 and 4c
JJGX01	Newlands	Single diamond ~2.5mm.	1.5	Distinct pseudohemimorphic morphology where diamond is euhedral with step-faces inside the xenolith but where exposed at the surface is rounded and resorbed.	- Only xenolith with distinct pseudohemimorphic diamond. - See SOM Figure 2.
JJGX002	Newlands	Unusual elongate diamonds 2-3mm in length.	2.5	Unusual blade-like diamonds elongate in shape.	- Unusual morphology. Unique in this suite of xenoliths.