KEYWORDS: diamond coat, biotite inclusions, electron microanalysis, syngenetic inclusions in diamond.

H. H. Wills Physics Laboratory,
University of Bristol, Royal Fort,
Tyndall Avenue, Bristol BS8 1TL, UK

J. C. WALMSLEY*
A. R. LANG

* Present Address: *Nuclear Electric, Berkeley Nuclear Laboratories, Berkeley, Gloucestershire GL13 9PB, UK*

MINERALOGICAL MAGAZINE, MARCH 1992, VOL 56, PP. 111–113

An unusual octahedral diamond

THIS clear and colourless diamond (0.35 cts) from the Alpheus Williams collection (Williams, 1932) on display at the Kimberley Open Mine Museum, South Africa, has been examined in the course of a study (Yacoot, 1990) of the modes of growth and consequent morphologies of some natural diamonds. There are small dodecahedra on the six vertices of the octahedron. Fig. 1*a* is a general view of the specimen and Fig. 1*b* shows one of the dodecahedra at higher magnification. Fig. 1*c* shows some of the unusual facets on the octahedron. From the morphology imaged by these scanning electron micrographs, one infers that the specimen has suffered dissolution: the dodecahedra are rounded and there are {110} bevels between adjacent {111} faces on the octahedron, some of the latter approximating to triangular triakisoctahedral faces $\{hhl\}$, $h > l$.

A Laue picture, taken with polychromatic synchrotron radiation (at the SERC Daresbury Laboratory, Warrington, Cheshire) which illuminated the entire specimen, showed that the dodecahedra were not mis-orientated from the octahedron and that the specimen was a single crystal. That having been established, the diamond was examined by X-ray topography (Lang, 1957, 1958; Moore, 1988) using Mo-$K\alpha_1$ radiation and the $4\bar{4}0$ reflexion ($\lambda = 0.71$ Å, $\theta_B = 34°15'$). Such a diffraction geometry produced images of crystal sections almost parallel (offset by 1°) to the $(\bar{1}11)$ plane. Fig. 1*d–f* shows the first three section topographs in a series of six that imaged the crystal at 0.5 mm intervals.

The topographic image through the centre of the crystal (Fig. 1*f*) shows incomplete growth banding in the octahedron, together with several areas of localised strain. The twelve-sided outline of the topograph is similar to a section of a rounded (diakis) rhombic dodecahedral diamond described by Moore (1973). A very dark circular region can be seen in the centre of the topograph, which is the imperfect nucleus from which crystal growth started. Other topographs in the series show more growth banding in the octahedron. Fig. 1*d* and *e* show growth bands within the dodecahedra, which appear to make re-entrant angles with another. These dodecahedra are the remnants of dissolved octahedra (Moore and Lang, 1974) on the vertices of the (major) octahedron.

The topographs show that crystal growth started from an imperfect and highly strained nucleus and the growth banding confirms that growth was on {111} planes. That some of the growth banding in the major octahedron is incomplete, being partially intersected by the six minor octahedra, suggests that dissolution occurred prior to the formation of these minor octahedra. This dissolution would have started at the major octahedron's six vertices, turning them into nucleation centres for further growth. Faceted growth then occurred in the ⟨111⟩ directions at these vertices, resulting in the formation of the six minor octahedra. Although the growth bands appear to diverge from the surfaces of the minor octahedra, independent growth did not occur towards the centre of the specimen. (If this had happened from separate centres, there would certainly have been some mis-orientation between the major and minor octahedra. The chance of six minor octahedra adhering in perfect orientation to the vertices of an octahedron is extremely unlikely.) Finally, the specimen suffered some more dissolution which

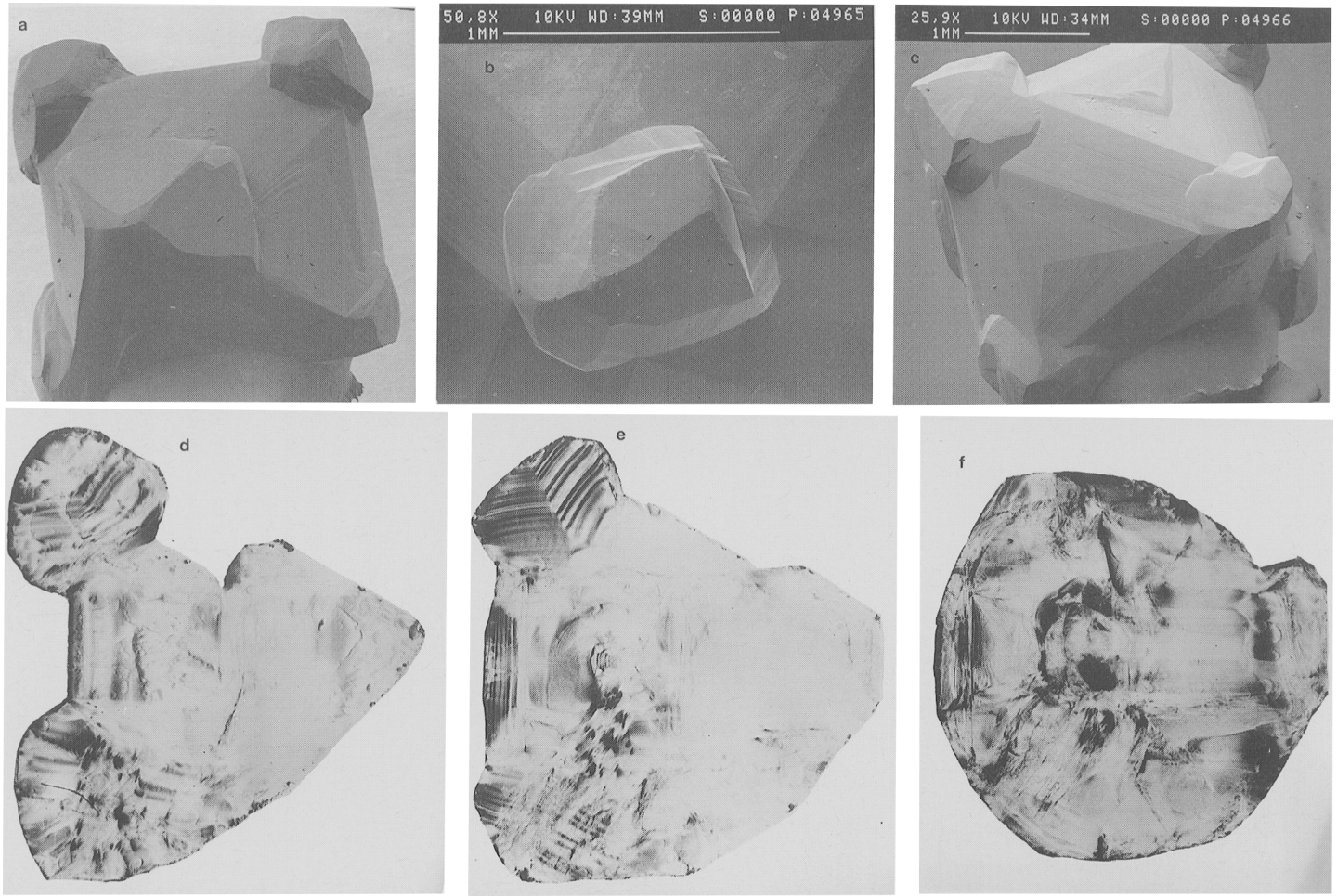

FIG. 1. (*a*) Scanning electron micrograph: general view of specimen. Image width = 3.5 mm. (*b*) A minor octahedron that has become a rounded rhombic dodecahedron by dissolution. Scale make 1 mm. (*c*) SEM showing high-index facets and bevels on the body of the specimen. Scale mark 1 mm. (*d*) X-ray section topograph, 1 mm from the centre. Image width 3 mm (projection of diffraction vector pointing horizontally to the left). (*e*) X-ray section topograph, 0.5 mm from the centre. Image width 3 mm. (*f*) X-ray topograph, mid-section. Image width 3 mm.

caused the six minor octahedra to become dodecahedral. Furthermore, the minor octahedra (now dodecahedra) protected the major octahedron from being stripped at its vertices (the usual way that octahedral crystals of the diamond structure are dissolved; Moore and Lang, 1974). Consequently only {110} bevels (and not large rounded faces) were formed, together with the unusual high-index faces. In summary, this diamond grew as an octahedron, suffered some dissolution, grew again with minor octahedra on its corners, then suffered further dissolution.

Acknowledgements. We are very grateful to Dr Robert Burns (Diamond Research Laboratory) and Mr Dudley Holmes (Kimberley Open Mine Museum) for loan of this extraordinary specimen.

References

Lang, A. R. (1957) *Acta Metallurgica,* **5** 358–64.
—— (1958) *J. Applied Physics*, **29**, 597–8.
Moore, M. (1973) *Dissolution, Defects and Disorder in Diamond and Diamond-like Substances,* Ph.D. Thesis, University of Bristol.
—— (1988) *Industrial Diamond Review*, **48**, 59–64.
—— and Lang, A. R. (1974) *J. Cryst. Growth*, **26**, 133–9.
Williams, A. F. (1932) *The Genesis of the Diamond*, Vol. I and II, E. Benn.
Yacoot, A. (1990) *X-Ray Studies of Diamond: Morphology and Radiation Counting Behaviour,* Ph.D. Thesis, University of London.

[*Manuscript received 28 December 1990; revised 23 May 1991*]

KEYWORDS: crystal growth, diamond, morphology, X-ray topography.

A. YACOOT*

Dept. of Physics, King's College, University of London, Strand, London WC2R 2LS

M. MOORE

Dept. of Physics, Royal Holloway and Bedford New College, University of London, Egham, Surrey TW20 0EX

* *Now at National Physical Laboratory, Teddington, Middlesex TW11 0LW.*

MINERALOGICAL MAGAZINE, MARCH 1992, VOL 56, PP. 113–115

Manganoan–cadmian tetrahedrite from the Tunaberg Cu–Co deposit, Bergslagen, central Sweden

THE cobalt-bearing copper ores of Tunaberg, southeastern Bergslagen, central Sweden, occur in skarn-altered marbles in a metamorphosed volcano-sedimentary sequence. The ores generally consist of chalcopyrite with minor cobaltite, galena, bornite, cubanite, pyrrhotite and sphalerite. In this paper the occurrence of manganoan–cadmian tetrahedrite associated with alabandite, stannoidite and bismuth in a massive galena aggregate from the Tunaberg ore deposit is described. Cadmium-bearing tetrahedrites (Pattrick, 1978; Voropayev *et al.*, 1988; Dianwu Jia *et al.*, 1988) and manganese-bearing tetrahedrites (Basu *et al.*, 1984; Burkhart–Baumann, 1984) have been reported previously from a few localities, but manganoan–cadmian tetrahedrite has not been described before.

Electron-probe microanalyses (EPMA) were performed with a Cambridge Instruments Geoscan operated at an acceleration potential of 15 kV, a probe current of 40 nA, and equipped with a Link energy-dispersive system (EDS), and with a Microscan 9 instrument. Standards used were pure metals for Ag; synthetic CdS (for Cd); stibnite (for Sb, S), bismuthinite (for Bi), chalcopyrite (for Cu), troilite (for Fe), sphalerite (for Zn), and rhodonite (for Mn). To avoid errors in the analysis of Cd and Ag in tetrahedrite due to overlapping peaks of the Ag-$L\beta_1$ and Cd-$L\alpha$ peaks, the positions of these peaks were carefully