

INTERNAL MORPHOLOGY OF YAKUTIAN DIAMONDS - A CATHODOLUMINESCENCE AND INFRARED MAPPING STUDY.

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Introduction.

It has long been known that the internal morphology of diamonds can be extremely complex. It can be revealed in whole stones to a limited extent by birefringence (BR) or UV photoluminescence (PL), and, more completely, by X-ray topography (XT), or directly from an examination of external morphology (EM), especially via the existence of ridges on resorbed dodecahedra which often indicate octahedral zonation. On fractured, cleaved, sawn or polished surfaces, fine detail can be revealed by chemical etching (CE) - sometimes already present on natural fractures or cleavages - or by cathodoluminescence (CL), but this information does not convey any quantitative information concerning the nature of the individual zones. If, however, it can be combined with microspectroscopy, especially in the mid-infrared region (IR), then the presence of organic species (i.e. those involving C, O, N, H and S) can be detected and, to some extent, quantified, and can be related to C and N isotope data and inclusion chemistry. Furthermore, since laboratory experiments have provided activation energies for the nitrogen aggregation processes, mantle residence times and temperatures for the various zones can be inferred from the one-phonon spectra.

Practical considerations.

To obtain satisfactory maps, diamond plates approx. 0.5mm in thickness are preferred, because this gives adequate absorbance in the two-phonon region at 1992cm^{-1} used to place the other absorption features on an absolute scale, while at the same time ensuring that most other absorption features will not be too strong to measure.

Because of the extremely fine scale (~ 10 microns) of some individual zones, it is unrealistic to make complete maps of specimens measuring even 5×5 sq.mm at a resolution certain to record all the existing detail. Even intervals of 100 microns would produce 2500 spectra in such a case, and this is unrealistic. There is, however, a more important problem connected with mapping, and that is the fact that zones often lie obliquely across the polished plate, so that an IR measurement made normal to the plate may intercept sections of two or more zones, in which case successive measurements will suggest a gradual transition from one regime to another, rather than the abrupt change which actually occurs. In our experience, CL photographs of both sides of the plate provide the best way of investigating the situation. Ideally, these two photographs should be mirror images of one another, but this is seldom the case, and means that quantitative data concerning individual zones can only be obtained from certain regions of the map. In this connection it has also been found that some plates contain a small highly aggregated nucleus from which a reliable IR spectrum can only be obtained at a precise x,y location derived from the pair of CL photographs.

The basic problem involved in using contour maps to record the spatial distribution of spectral information is that a contour map can only display one feature at a time, whereas in the case of diamond it is the *relative changes among a number of features* which contain the required information. In order to overcome this difficulty, the Mendelssohn miniplot (Milledge & Mendelssohn, 1988) was devised to show the 1-, 2- and 3-phonon regions of an individual spectrum superposed in a plot $2.5\text{cm} \times 2.5\text{cm}$, with 8 plots per line. Arrays of these plots, taken at intervals of 250 μm , correspond to a map at a magnification of $\times 100$, and the system has

proved so useful that all spectra are now measured with an associated miniplot for record purposes. Consideration of thousands of such plots has led to improved assessments of IR data (Mendelssohn & Milledge 1995). Although major features of the spectrum can be assessed by inspection from miniplots, hydrogen or platelet or carbonate peaks, which are often very weak, cannot, and it is here that the contour maps have been found to be especially valuable for showing not only the spatial distribution of weak peaks, but also their relations to one another (Fig.2a,b), to the main features of the spectrum, and in particular, to zoning seen in CL photographs.

This specimen belongs to the suite considered by Bulanova et al. (1995), and is one of twelve for which such maps have been obtained.

In order to obtain time/temperature information of geological interest from IR spectra, contour maps of the major peaks are not immediately useful, because intensity data for the observed absorption features have first to be ratioed in various ways. This is now conveniently done via PC spreadsheets, and for this the PC-based OPUS/3D software used to obtain the maps in Fig.2 has a particularly useful option, which produces "traces" such as those shown in Fig 1a; these are the consecutive values of a particular feature for each spectrum in a map, in a form which can be transferred directly to a spreadsheet, thus saving an enormous amount of time and effort in the final interpretation of the data.

Bulanova, G.P., Milledge, H.J. and Pavlova, L.A. 1995. 6th IKC Abstracts (this volume)

Mendelssohn, M.J. and Milledge, H.J. 1995. 6th IKC Abstracts (this volume)

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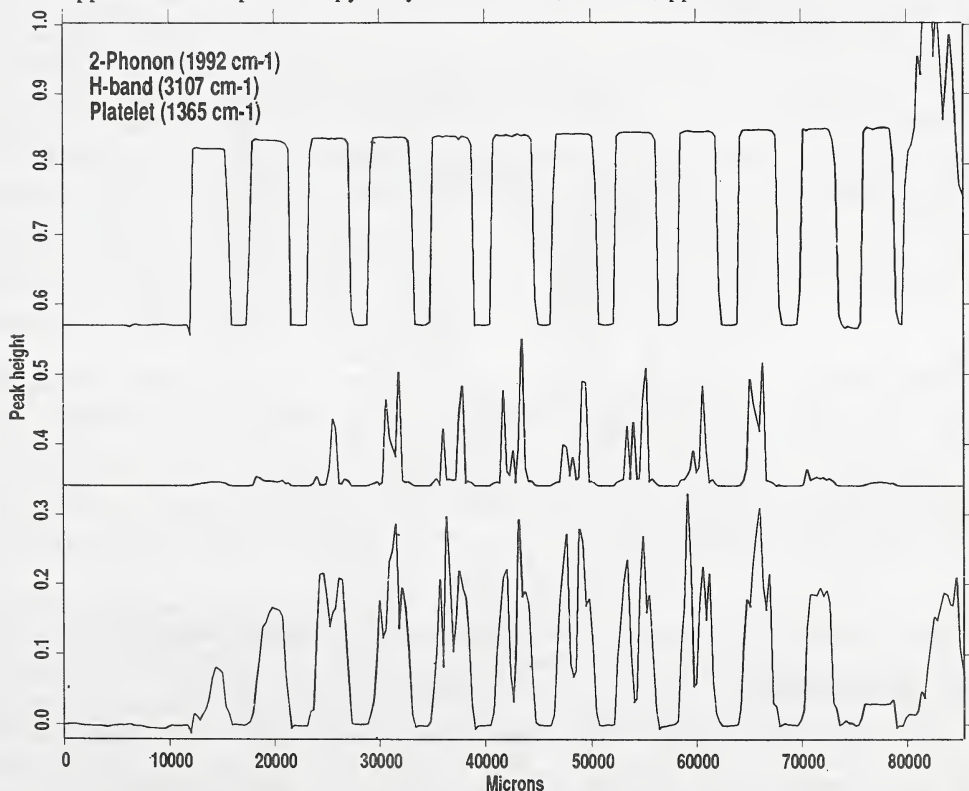


Fig.1. Traces (complete data for successive traverses) for the absorptions mapped in Fig.2

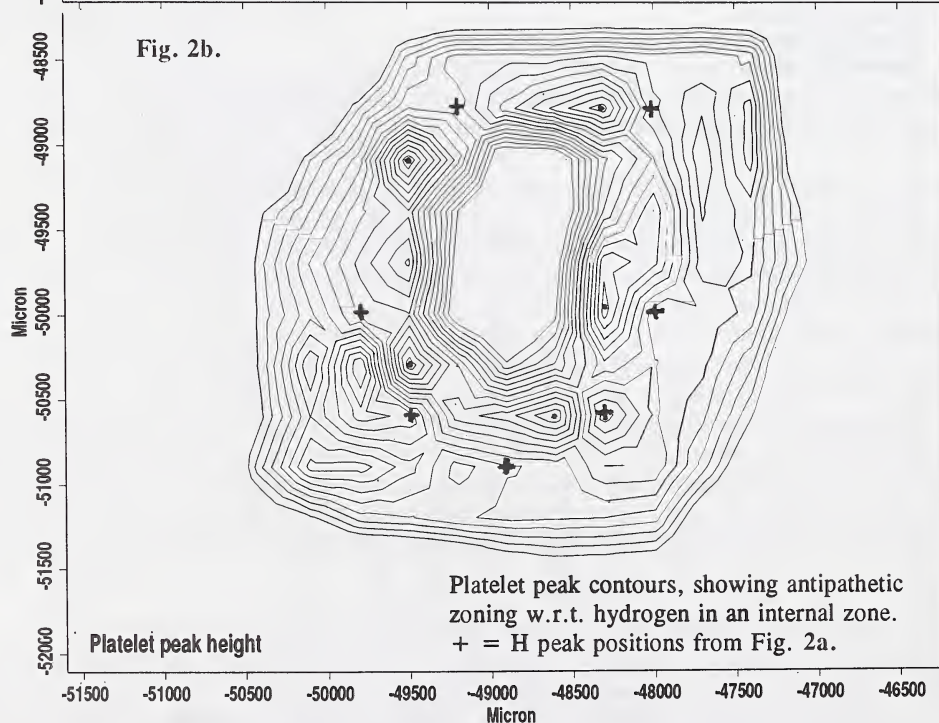
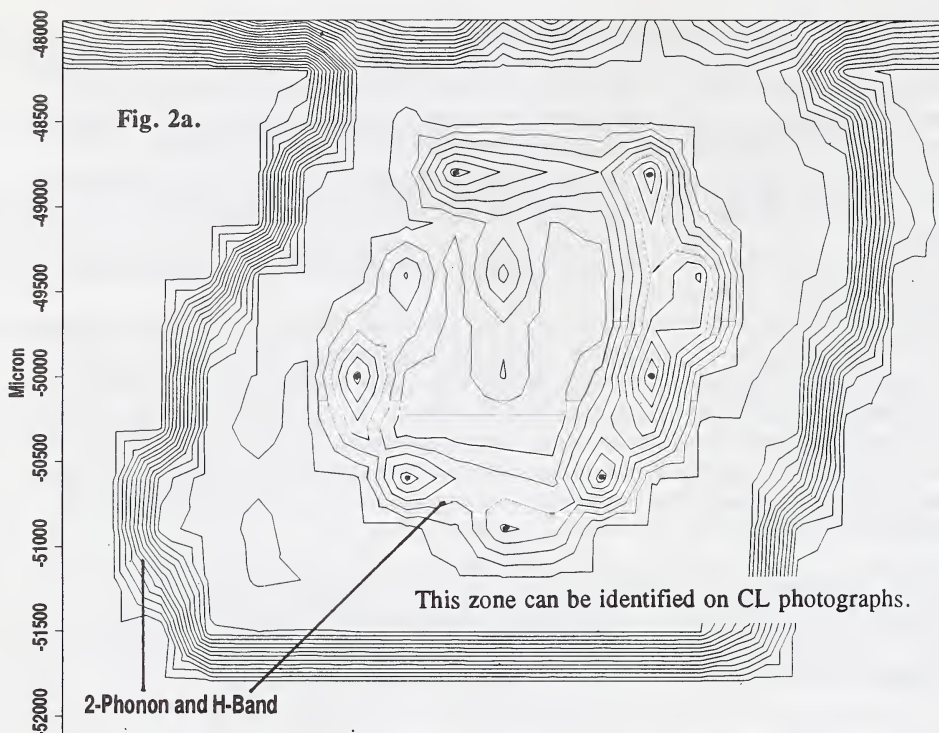


Fig. 2 (a). Contour map for hydrogen (3107 cm^{-1}) superposed on 2-phonon (1992 cm^{-1}) absorption, which also outlines the plate. (b). Platelet peak contours.