MICRO-STRUCTURAL VARIATIONS IN MANTLE DERIVED GARNETS.

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As the most deeply sourced rock, kimberlite cares a large numbers of mantle derived crystals, as well as diamonds with their mineral inclusions, upto the Earth's surface. It makes the possibility to obtain the information on the mantle environment from the compositional and structural characters of these crystals.

There were many comprehensive studies on the compositional characters of these mantle derived crystals [1,2] . But to date, very few studies on their structural features were reported. In this work, the capability of undestructive, "in situ", micro–zone analysis of Raman "structural microprobe" technique has been used to distinguish some micro–structural variations in the mantle derived garnets, as well as in the pyrope inclusions of diamonds.

The Raman spectra of over sixty pyrope grains had been obtained: 24 from the kimberlites of China; 8 from lamproites of China and Austrilia; 3 are the pyrope inclusions taken out by cracking their host diamonds; the others were selected from picrite–porphyrite, serpentine, alkaline basalt, lumburgite, ultrabasic beccia etc.. Figure 1 shows the typical Raman spectra of these pyropes. The spectrum of mantle derived pyrope demonstrates the degeneration of long–range ordering in its structure, which means that its translational symmetry in three dimentions was interrupted or distorted by some micro–structural defects and variations [3].

The first type of micro–structural variation is the polyhedral distortions due to the substitutions of cations at S_6 and D_2 sites [4]. These distortions are exhibited by the frequency shifts of three main Raman bands, and by the increase of site–group splitting $[\tilde{V}_B-(\tilde{V}_C+\tilde{V}_D)/2]$ as well as the decrease of factor–group splitting $[\tilde{V}_C-\tilde{V}_D]$ in the Infrared spectra of the mantle derived pyropes (Fig.2) . This structural character has begun to be used to discriminate the diamondiferous rocks in Chinese exploration works.

The second type of micro–structural variation is the formation of amorphous structural elements through the irregular polymirization of (SiO_4) tetrahedra [5]. The Raman spectroscopic evidences for the appearance of these elements are the enlargement of bandwidths, the rise of spectral background, and the appearence of some distinguishable distortions in bandwings. In addition, the polymirization of (SiO_4) tetrahedra was demonstrated by the obvious changes in relative intensities of three main Raman bands, especially by the strong decrease of $\sim$ 920cm^{-1} band which representing the symmetric stretching vibration of "isolated" SiO_4tetrahedra (Fig.1) . The appearance of amorphous structural elements in mantle derived crystals suggests a possible mechanism of phase–transition under the special environment in the Earth's mantle, i.e. from a crystal phase to an amorphous phase [6] . It could be considered that at a very high pressure but relative low temperature conditions, such as in certain deep region of the upper mantle beneath an old craton, where some crystals can not get enough energy to overcome a potential threshold of transforming to another crystal phase, so had to take the amorphous status, which is more compressable, to adapt their high–pressure environment.

The third type of anomalous structural element found in some mantle derived pyropes is the structural hydrous component. It was distinguished by three Raman bands and two overlapped Infrared bands in 3500–3800cm^{-1} region (Fig.3) . These spectra also verify that the hydrous component enter pyrope structure by substituting (SiO_4) tetrahedron at S_4 site in forms of $(O_4H_4)^{4-}$[7] . According to the model of Solomon [8] , at "low asthenosphere

(160km—300 / 400km)″, some mantle water began to enter the structures of magnesium–silicates in forms of substituting the oxygen anion as $(OH)^-$ group when free–fluid phase of water with very high density still exist. At the depth > 300 / 400km, the free–fluid phase will disappear, almost all mantle water will be dissolved in the crystal structures of mantle minerals. Therefore the existence, and the quantity of the structural hydrous component found in a mantle derived crystal might offer the information of its forming depth.

The second and third anomalous elements were found coexisting in the structure of a pyrope inclusion (100x250 μm) which was taken out from a diamond grain (3x2.1mm). This experimental result approve the possible genetic corelation of these two micro–structural variances in the special environment of the upper mantle where diamond forms:

$$Mg_3Al_2(SiO_4)_3 + nH_2O = Mg_3Al_2(SiO_4)_{3-x}(O_4H_4)_x + nSiO_2$$

The fourth type of anomalous structural element found in some mantle derived pyropes is the elements of Majorite phase [9] . It was distinguished by an extra band near ~ 930cm^{-1} in the Raman spectra, and an extra set of diffraction points in the electron diffraction patterns of these pyropes (Fig.4) . As we know, the solid–solusion of Majorite and pyrope is one of the major phases in the bottom of the upper mantle and in the transition zone. So the existence, and the quantity of Majorite phase element in a pyrope grain will mark the T–V conditions and the depth where the pyrope was formed.

In conclution, some micro–structural variations in the mantle derived garnets have been distinguished mainly by micro–Raman spectroscopic investigation. To study further the inducing conditions of these variations, will be helpful to advance our understanding of the mantle environment and the related geological processes.

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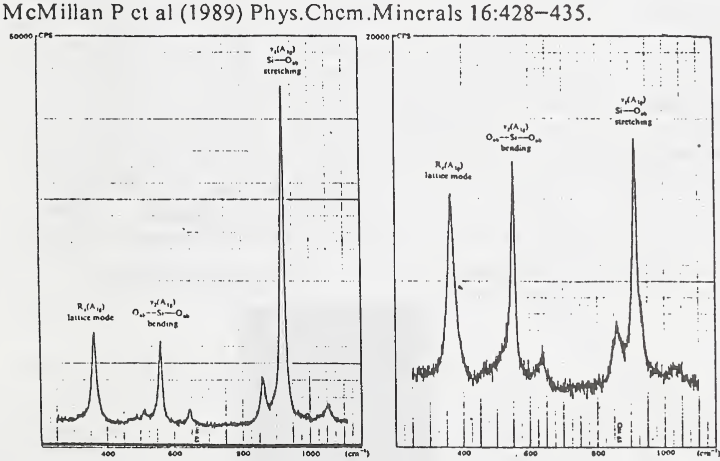
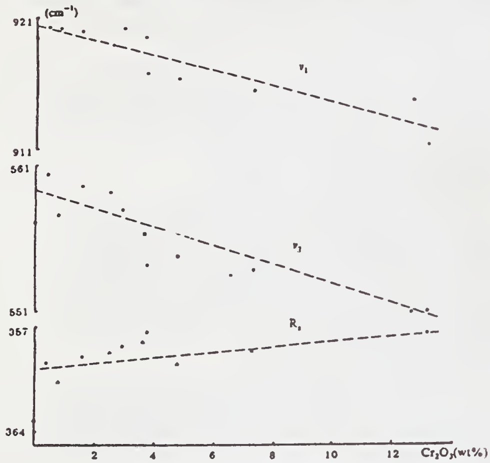


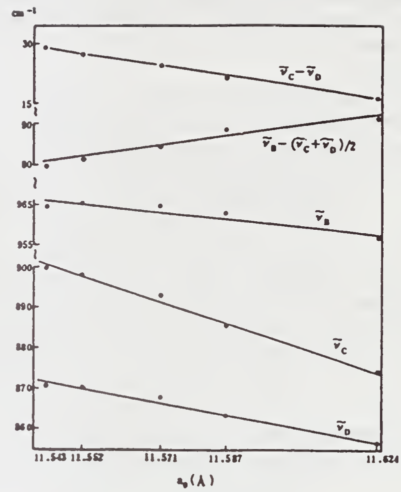
(a) pyrope of shallow source; (b) mantle derived pyrope.

Figure 1 Typical Raman spectra of megacryst pyropes:

Figure 2 The characters of frequency shifts:

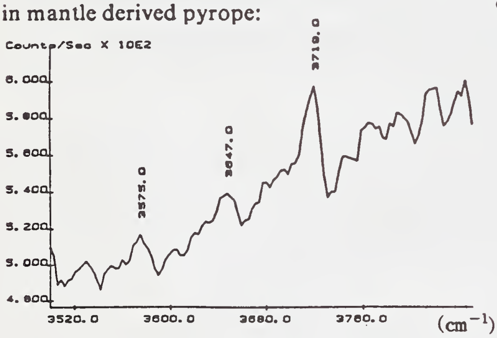


(a) in Raman spectra;

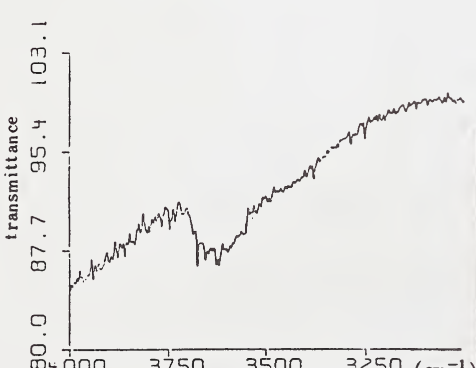


(b) in Infrared spectra.

Figure 3 Stretching vibration bands of $(O_4H_4)^{4-}$ in mantle derived pyrope:

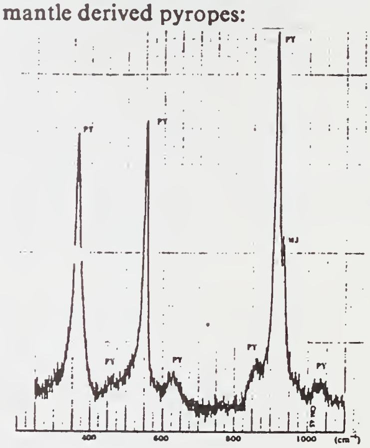


(a) In Raman spectrum;

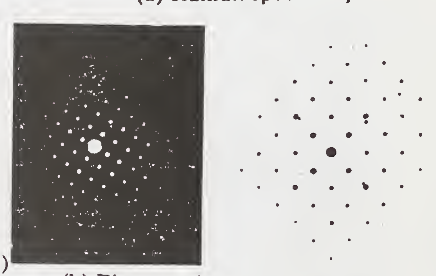


(b) In Infrared spectrum.

Figure 4 Experimental evidences for the existing of Majorite structural elements in mantle derived pyropes:



(a) Raman spectrum;



(b) Electron diffraction pattern.