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Microdiamonds, their classification and tectonic implications for the host eclogites from the Dabie and Su-Lu regions in central eastern China

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ABSTRACT

We have found >10 *in situ* microdiamonds in thin sections of eclogites from the Dabie and Su-Lu regions of central eastern China since the first occurrence of microdiamond in eclogites from the Dabie Mountains (DMT) reported in 1992. The microdiamonds are found not only in the central part but also in the northern part of the DMT. Several free crystals have been recovered from the crushed eclogites from the central DMT. Most *in situ* microdiamonds are inclusions in garnets but a few larger ones are intergranular. Most of the diamondiferous eclogites in the central part of the DMT are associated with coesite. Most importantly, the observation of microdiamonds in northern Dabie lead us to question the supposition that this is a low-*P* metamorphic terrane. All the diamondiferous eclogites from both the north and central DMT are of continental affinity as demonstrated by their negative ε_{Nd} values. Therefore, both the north and central eclogite belts in the DMT are considered to be from the deep subducted terrane. Five *in situ* microdiamonds and two free crystals are first reported in this paper. The dimensions of the *in situ* microdiamonds are 30−180 μm and the free crystals are up to 400−700 μm across. All the microdiamonds are confirmed as such by Raman spectroscopy. The results of an infrared spectroscopic investigation on two larger free crystals and two *in situ* microdiamonds show that all the microdiamonds from both the Dabie and Su-Lu regions are mixed types IaA and IaB diamonds and there is no indication of any synthetic microdiamonds in our samples because such synthetic microdiamonds are always rich in type Ib.

Keywords: microdiamond, Raman, infrared spectroscopy, Dabie Mountains, Su-Lu region, China.

Introduction

The central DMT has long been considered an ultrahigh-*P* metamorphic belt where microdiamonds (Xu *et al.*, 1992) and coesite (Xu, 1987; Okay *et al.*, 1989; Wang *et al.*, 1989; Wang *et al.*, 1993; Zhang *et al.*, 1993; Su *et al.*, 1996) were found in eclogites and their country rocks (Wang and Liou, 1991) at many localities. The diamondiferous and coesite-bearing eclogites are believed to be of continental origin because of their negative ε_{Nd} values (Xu *et al.*, 1992; Li *et al.*, 1996), so the central Dabie (ECL_2 in Fig. 1) is regarded as an ultrahigh-*P* metamorphic belt (UHP). The northern Dabie was treated as a low-*P* terrane because no eclogites or any high−ultrahigh-*P* minerals had been found before 2000. Thus, it was previously thought of as a low-*P* terrane (Maruyama *et al.*, 1994; Wang *et al.*, 1994; Wang and Cong, 1996; Zhai *et al.*, 1995; Zhang *et al.*, 1996). However, eclogites were discovered in 2000 and subsequently microdiamonds were found in those eclogites (Xu *et al.*, 2003). At first, in order to confirm the

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discovery of microdiamonds from the central DMT (Xu *et al.*, 1992), we searched in great detail for microdiamonds in >300 selected thin sections and 30 kg of crushed eclogites over the period 2001–2004. Microdiamonds were found not only in eclogites from the central Dabie, but also in eclogites from north Dabie and the Su-Lu region. Diamondiferous eclogites in north Dabie also show continental origin through their negative ε_{Nd} values. Therefore, north Dabie is an UHP belt also. This provides important evidence, which should be taken into account in any geometric construction of the DMT (Xu *et al.*, 1992, 1994, 2001, 2002*b*; Eide, 1995).

Microdiamonds have been reported from several UHP terranes, e.g. Kokchetav (Sobolev and Shatsky, 1990), Dabie Mountains (DMT), Su-Lu region (Xu *et al.*, 1992, 2003), Qinling, China (Yang *et al.*, 2002), western gneiss region in Norway (Dobrzhinskaya *et al.*, 1995; van Roermund *et al.*, 2002) and Saxonian Erzgibirge in Germany (Massone, 1999). Microdiamonds reported here are the second findings from the north DMT, but the third findings from the central DMT.

The occurrence of coesite in the eclogites (Okay *et al.*, 1989; Wang *et al.*, 1989) and their country rocks (Wang and Liou, 1991) from central DMT, and the continental affinity of these coesite- and microdiamond-bearing eclogites from both central and north DMT (Xu *et al.*, 1992; Li *et al.*, 1996; Xu *et al.*, 2000, 2001; Cong *et al.*, 1995, 1996; Liu *et al.*, 2000), indicate that both (Fig. 1) are from a deep subducted continent crust (Xu *et al.*, 2005).

In order to check the origin of the microdiamonds by optical microscopy under polarized light, two free crystals and two larger *in situ* microdiamonds were first identified by infrared (IR) spectroscopy. The results show that all the tested crystals are of mixed types IaA and IaB diamond. This may well be the first IR spectroscopy investigation of *in situ* microdiamonds in thin sections. Although the result of one of the IR spectra of the *in situ* microdiamonds is not of high quality, the information on diamond types is valuable. The problems with the quality are due to the small size of the microdiamonds and to interference by the epoxy and glass in the thin sections. To minimize this problem, the investigation was carried out under reflected light instead of the usual transmitted light, meaning that the signal would be weaker and would deviate slightly from standard tests. Our work, including IR spectroscopy, on both the free crystal and *in situ* microdiamonds from the Dabie and Su-Lu regions, confirms that they are all naturally formed and composed mainly of the types IaA and IaB diamond (Xu *et al.*, 1992, 2003).

Geological outline of the Dabie Mountains and Su-Lu region

The DMT is located in central eastern China, geologically between the Sino-Korean and Yangtze Continents. Eight petro-tectonic units are recognized (Xu *et al.*, 2002*a*,*b*, 2005) shown in Fig. 1*a*. They are, from north to south: hinterland basin (HB), meta-flysch (MF), banded gneiss and ultramafic rock belt (UM), eclogite belt 2 (ECL_2), eclogite 1 (ECL_1), Dabie Complex (DB), Susong and Zhangbaling Group (SZ) and foreland basin (FB). Among these units, the ECL_2 and UM have been proven to be in the UHP terrane, while ECL_1 is uncertain (Xu *et al.*, 2005). The unmetamorphosed bed older than early Triassic in the foreland belt was subjected to intense southward thrusting and folding, indicating that the continental subduction was stopped at that time (Condie, 1989). This is in agreement with isotopic dating of peak metamorphism (230 Ma; Li *et al.*, 1996) of eclogites from the ECL_2 unit. The Maobei eclogite in the Su-Lu region is located in the ultrahigh-*P* metamorphic belt shown in Fig. 1*b*, which can be roughly correlated with the ECL_2 unit in the DMT displayed in Fig. 1*a*.

Research methods and results

Geologists are more confident in the *in situ* mocrodiamonds than in the free crystals retrieved from crushed eclogites as evidence of the UHP nature of the host rocks. Because most diamondiferous eclogites are usually rich in garnets, we paid more attention to the more garnet-rich thin sections of eclogites. In order to find the scarce microdiamonds, 10–20 thin sections, each 50–100 mm thick, were made for each selected specimen. From a total of 300 thin sections, 10 *in situ* microdiamonds were found. Free crystals are recovered by the following means: (1) ~25 kg of eclogite were crushed and sieved to a $\leqslant 1$ mm size fraction, (2) ~200 g of the resulting material were selected; (3) mechanical gravity concentration; (4) mechanical cobbing; (5) flotation; (6) dissolution in heated NaOH and HCl; and (7) separation in heavy solution.

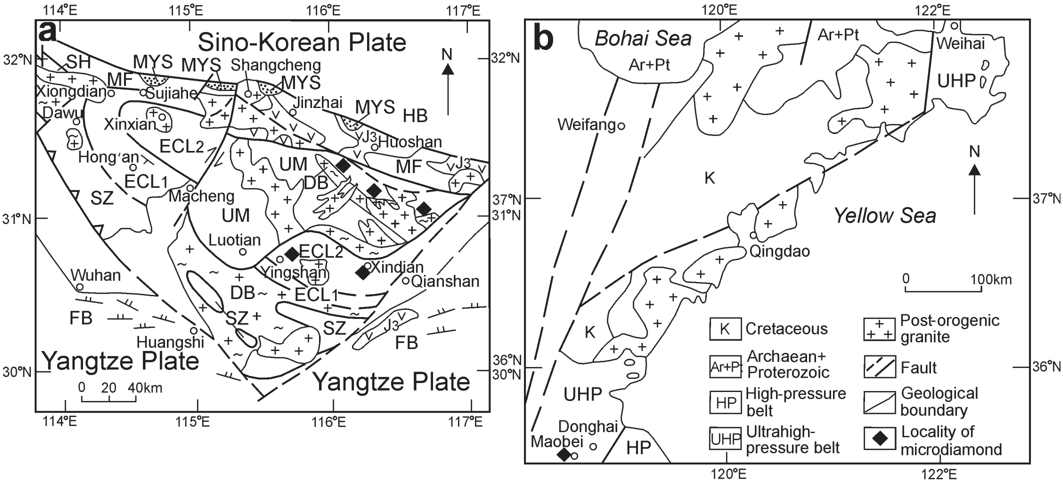

FIG. 1. Sketch map of geology of the Dabie Mountains (*a*) and Su-Lu region (*b*). The Dabie Complex (DB) in the eastern part of the UM is a tectonic enclave or a tectonic sheet. HB – Hinterland basin, MYS – Meishan-Yangshan coal series; SH – Sujiahe metatectonic melange; MF – Metaflysch; UM – Ultramafic rock belt; DB – Dabie complex; ECL1 – Taihu-Hong'an-Xuanhuadian eclogite belt; ECL2 – Qianshan-Yingshan-Xinxian eclogite belt; SZ – Susong-Zhangbaling GRS; FB – Foreland belt; ◆ – locality of diamonds; VV – Mesozoic volcanics; ++ – granitoid; K+R – Cretaceous + Tertiary; – fold and thrust belt in FB.

Thin sections polished with carborundum were examined, first with a polarizing microscope (Olympus BX60). More than 30 diamond-like crystals were found in >300 thin sections but only 10 of them were confirmed as microdiamonds, some of which are mingled with other minerals including retrograde graphite. Two free crystals and two large *in situ* microdiamonds were tested by IR spectroscopy after Raman analysis.

Raman spectroscopy analyses were carried out in the Central Laboratory of Analyses, China University of Geosciences, and confirmed at the National State Laboratory of Earth Sciences, Nanjing University. The conditions under which the Raman spectroscopy was carried out in the two laboratories were the same: an RM 1000 device was used with Ar^+ laser at 514.5 nm and power of 2 nW, a slit of 25 μm, and an objective lens ×50. The thin sections used for Raman analyses were 30–80 mm thick. Photomicrographs were taken by digital camera (Olympus DP-11) connected to the microscope.

The IR spectroscopy was carried out in the Center of Materials Analysis, Nanjing University. The system includes a Neuxus 807 FT-IR (Fourier transform) with an IR microscope coupled to a spectrometer, using 200 scans (300 scans for Fig. 7*c*) at a resolution of 80 cm^{-1} over the range 4000–650 cm^{-1}.

Microscopic and Raman examination

All the microdiamonds reported here are isotropic, with higher relief than that of the host garnets; they show no birefringence or interference figures.

Microdiamonds from the Su-lu region

Three *in situ* microdiamonds were found in thin sections of the Maobei eclogite shown in Fig. 2*a,b*. All were confirmed by Raman spectra (Fig. 2*c,d*). Two smaller microdiamonds were measured at 60 and 30 μm wide, respectively. Both are translucent, green and octahedral, enveloped in a bubble created during development of the thin section (Fig. 2*a*). A larger crystal was measured at 120 μm in diameter and is probably a composite of a hexahedron and an octahedron in crystal form (Fig. 2*b*). It looks opaque under natural light, but is translucent and pale green when the conoscope is added; it is intergranular between garnet grains. The Su-Lu microdiamonds were identified by Xu *et al.* (2003), but the results of the first IR spectroscopic analysis of them is reported here. The presence of *in situ* microdiamonds in the thin sections reported here confirm the discovery of the free crystal microdiamonds from the crushed eclogite (Yang *et al.*, 1999) in the same locality (Fig. 1*b*).

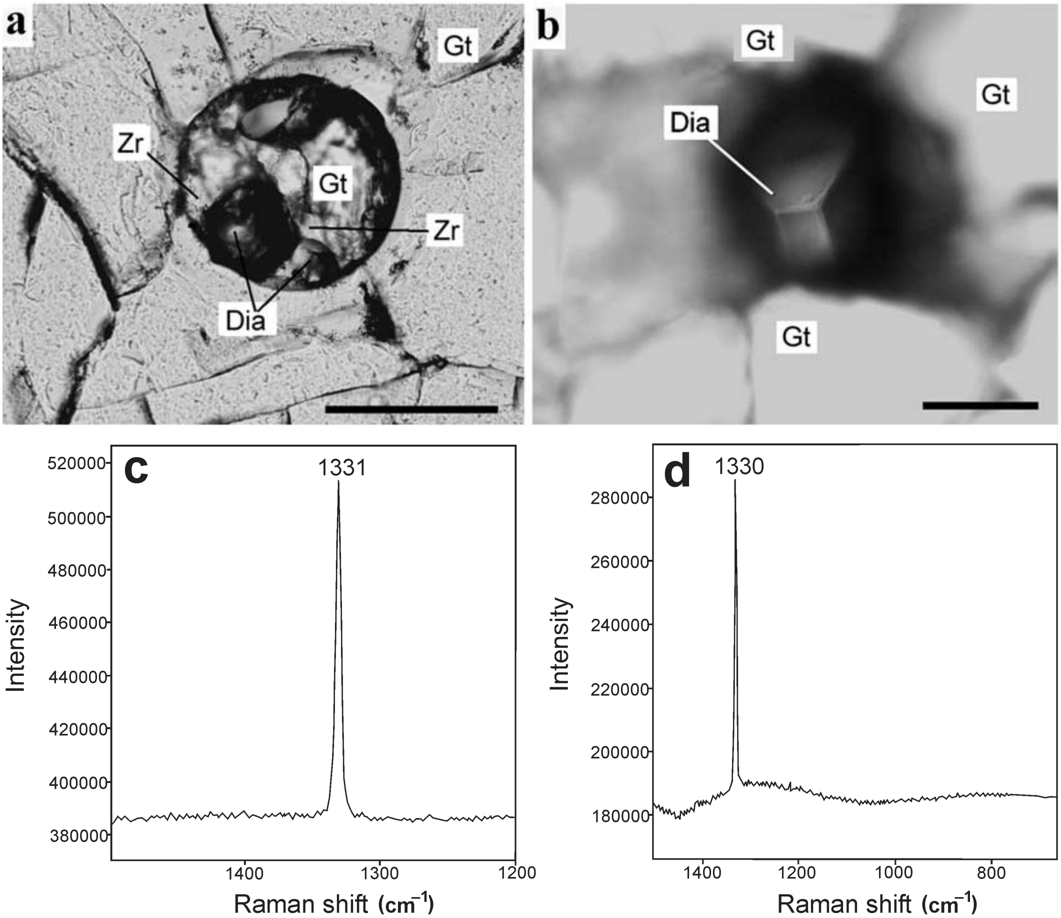

FIG. 2. Photomicrographs of microdiamond from the Maobei eclogite, (after Xu *et al.*, 2003). The scale bar is 100 μm. (*a*) Microdiamond inclusion in garnet (sample 8002-1). (*b*) Intergranular microdiamond (sample 800202). (*c,d*) The Raman spectra of microdiamond in parts *a* and *b*, respectively. Gt – garnet; Zr – zircon; Dia – diamond.

Microdiamonds from the middle Dabie Mountains (ECL2).

All the eclogites in this unit (Fig. 1) are of continental origin as demonstrated by their negative ε_{Nd} values (Li *et al.*, 1996). Two free microdiamonds were recovered from crushed eclogites in the ECL2 unit. The larger crystal, 720×600 μm in size (Fig. 3*a*) is translucent and pale green, tetragonal in form with a visible triangle decoration or cleavage trace on the crystal surface. The smaller crystal is 400×350 μm in size and darker in colour due to impurity (Fig. 3*b*). Both of these free microdiamonds are proven by Raman spectra (Fig. 4*a,b*). The *in situ* microdiamonds are found from the Xindian and Mifengjian eclogites. The diamondiferous eclogites are always rich in garnets with more grossular and almandine end-members (Xu *et al.*, 1992, 1994). The biggest microdiamond with zonal structure is 180×180 μm in size (sample 10233). The central part is an octahedron (120×120 μm) with two smaller microdiamond inclusions (30×30 μm) (Fig. 3*c*). A hexagonal zone, which looks like the section of a composite of octahedral and cubic crystals, envelops the central octahedral crystal. There are two graphite inclusions (20×25 μm and 25×30 μm) in the outer zone, which is obscured in the picture as it is out of focus (Fig. 3*c*). The host and inclusion microdiamonds (Fig. 3*c*, 1332 cm^{-1} in Fig. 4*c*–*a*), and the inclusion graphite (Fig. 3*c*, 1608–1364 cm^{-1} in Fig. 4*c*-*b*) are proven by Raman spectroscopy. This microdiamond was briefly described previously (Xu *et al.*, 2003), but

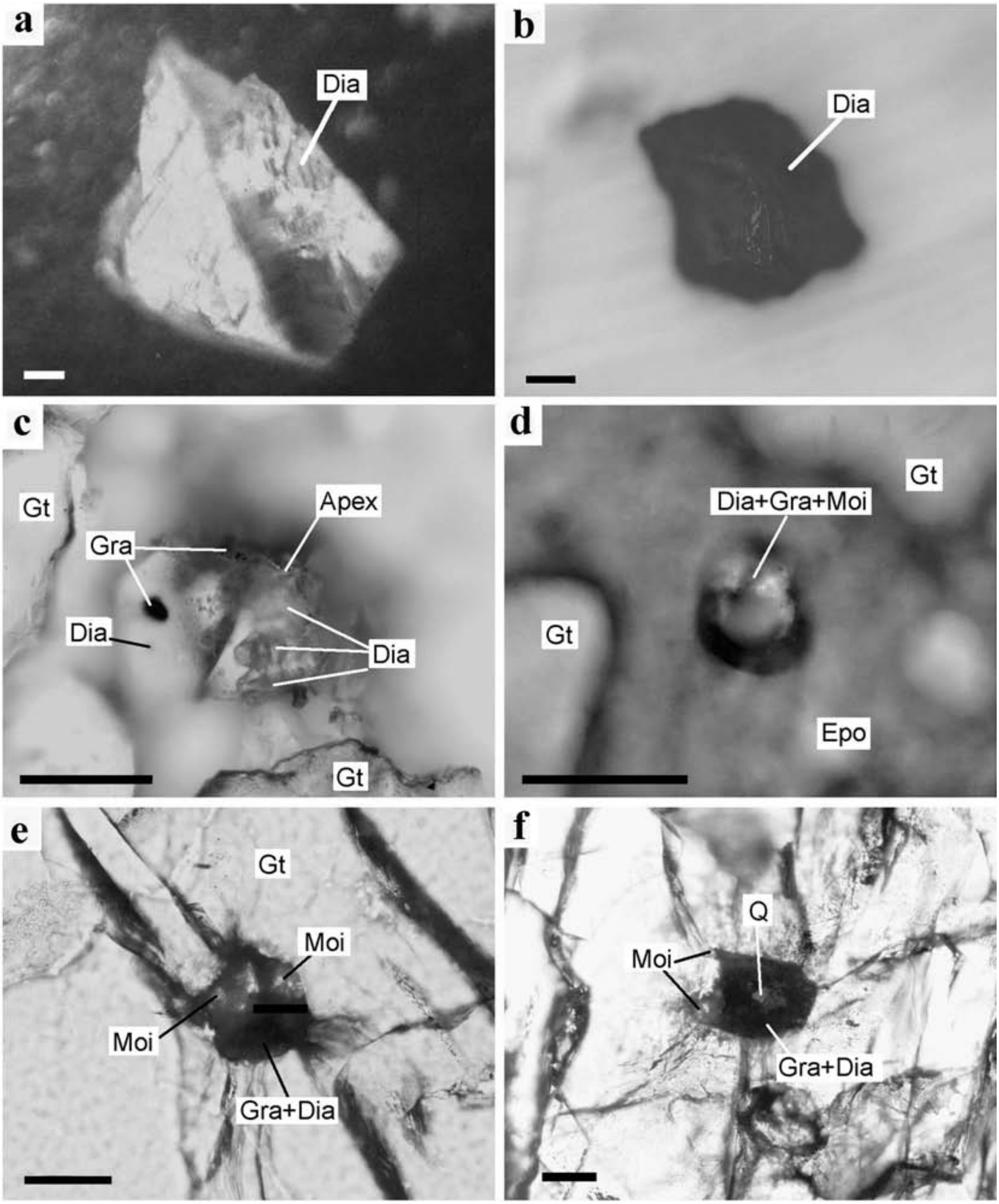

FIG. 3. Photomicrographs of microdiamonds and related minerals in eclogites from the central part of DMT. The scale bar is 100 μm. All the photos are taken under uncrossed nicols except for part *d* under reflected light. (*a,b*) Free crystals F1 and F2 recovered from the crushed Xindian eclogite. (*c,d*) *In situ* microdiamonds, graphite, moissanite and microdiamond inclusions in garnet in thin sections 10233 (after Xu *et al*., 2003) and 5513 from Xindian eclogites. (*e,f*) Microdiamonds, moissanite, graphite and quartz as inclusions in garnet from Mifengjian eclogite near Yingshan, Hubei Province. Dia – microdiamond; Gra – graphite; Moi – moissanite; Q – quartz; Gt – garnet; Apex – apex of the octahedral crystal; Epo – epoxy.

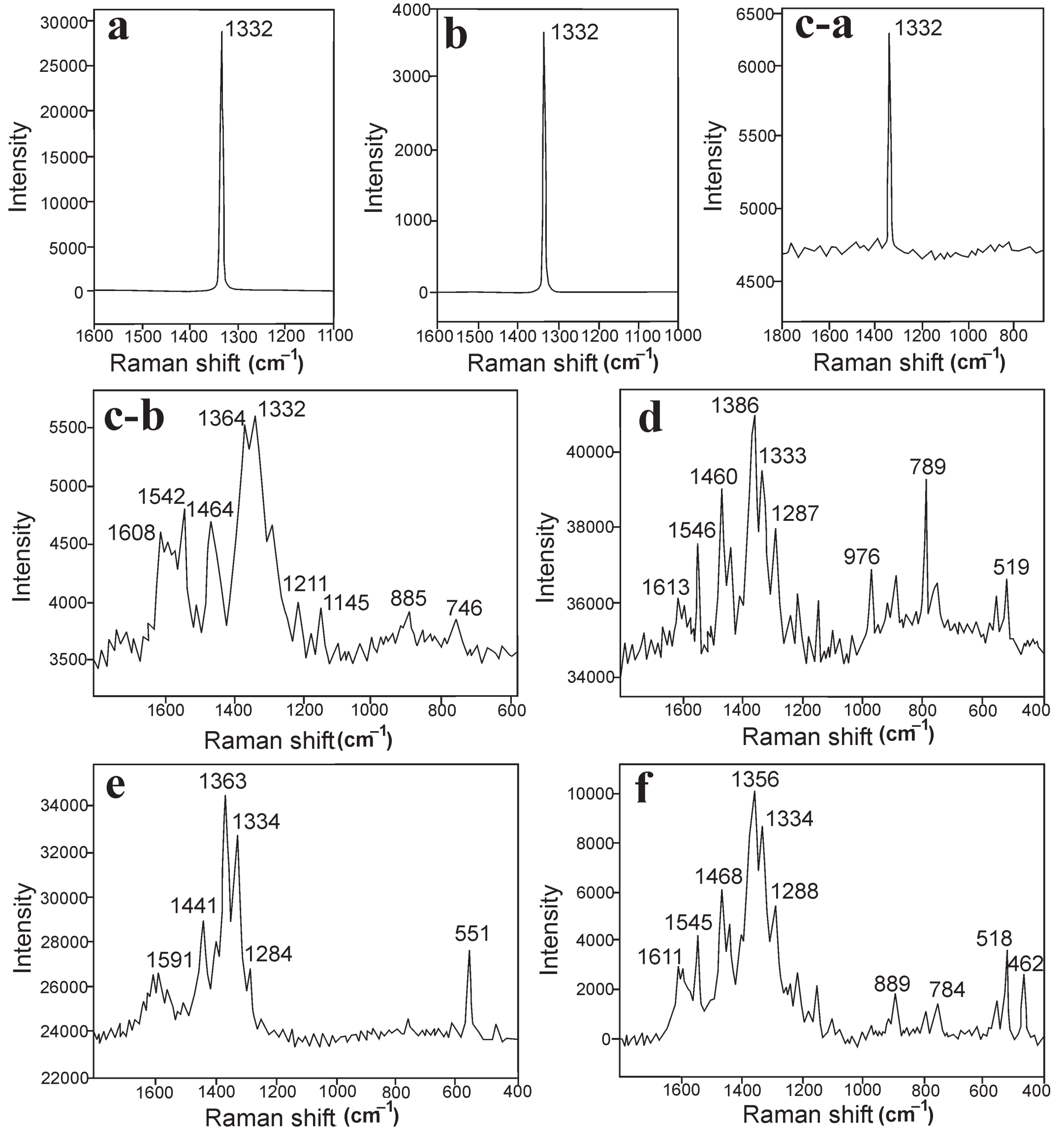

FIG. 4. Raman spectra of microdiamonds and related minerals in eclogites from Dabie Mountains. (*a,b*) Raman spectrum of the free crystal microdiamond from Xindian (see Fig. *3a,b*); the Raman shift for the microdiamond is 1332 cm^{-1}. (*c-a*) Raman shift for both the larger and inclusion microdiamonds (Fig. 3*c*) in eclogite from the Xindian eclogite enveloped by marble. (*c-b*) Raman spectrum for the graphite inclusion in the outer zone of the larger microdiamond (see Fig. 3*c*) in the same eclogite as in part *c-a*. (*d*) Raman spectrum of the retrograde microdiamond (see Fig. 3*d*) in eclogite close to Xindian. (*e,f*) Raman spectrum of the microdiamonds in Fig. 3*e,f* and related minerals in Mifengjian eclogite near Yingshan, Hubei Province.

is made the subject of an IR spectroscopy investigation here. All the other microdiamonds including the free crystals are new discoveries. Microdiamond (Fig. 3*d*, 1333 cm^{-1} in Fig. 4*d*) in eclogite found near the Xindian village (sample 5513) is mixed with graphite and moissanite; it is dark under natural light, has a semi-metallic lustre under reflected light (Fig. 3*d*), and is associated with graphite (1613–1386 cm^{-1} in Fig. 4*d*) and moissanite (mainly 976 and 789 cm^{-1} in Fig. 4*d*).

Microdiamonds and retrograde graphite are also found in Mifengjian eclogite (sample 304-1) close to Yingshan (Fig. 1*a*). Microdiamonds (Fig. 3*e*, 1334 cm^{-1} in Fig. 4*e*), graphite (1591–1363 cm^{-1}, Fig. 4*e*) and possible moissanite (551 cm^{-1} in Fig. 4*e*) mingled together as an integral inclusion in a size of 100×100 μm which were proven by Raman spectra. The radial fractures in the host garnet in Fig. 3*e* may be produced by volume change when the diamond was transformed to graphite.

In another sample (304-2) of Fig. 3*f*, microdiamond (Raman shift 1334 cm^{-1} in Fig. 4*f*) is associated with graphite (1611–1356 cm^{-1} in Fig. 4*f*) and a possible moissanite (784 cm^{-1} in Fig. 4*f*). It is suggested that the moissanite (Fig. 3*d,e,f*) is an exotic, i.e. the abrasive (carborundum) used to polish the thin sections. Raman shift 462 cm^{-1} was produced by a quartz inclusion (Figs 3*e*, 4*f*).

Microdiamonds were found not only at the same locality of the first occurrence but also at some other localities (Fig. 1). It confirms our first findings (Xu *et al.*, 1992), and indicates that the ECL_2 overall is an UHP terrane. If the diamond has to be formed under a pressure $\geqslant 4$ GPa and temperature >900ºC, the host crust rocks must have subducted to a depth of ~120 km (Carmichael *et al.*, 1960; Sobolev and Shatsky, 1990; Xu *et al.*, 1992).

Microdiamonds from north Dabie Mountains(UM unit)

The north Dabie Mountain is the UM unit in Fig. 1. Microdiamonds and retrograde graphite (Fig. 5*a,c*, 1332 cm^{-1} in Fig. 6*a,c*) were found during 2004 in the Naobozhai (Fig. 5*a*, sample 02112-15) and Baizhangya (Fig. 5*c*, sample 02111-2) eclogites. The graphite (Fig. 5*a*, 1609–1367 cm^{-1} in Fig. 6*a*), associated apatite (Fig. 5*a*, 966 cm^{-1} in Fig. 6*a*) and moissanite (may be exotic) (Fig. 5*a*, 552 and 789 cm^{-1} in Fig. 6*a*) are gathered together with microdiamonds as an integral inclusion 50×50 μm in size in the host garnet. In another part of the same thin section, an aggregate of graphite (Fig. 5*b*, 1584 and 1364 cm^{-1} in Fig. 6*b-a*), osumilite (Fig. 5*b*, 473, 538 and 670 cm^{-1} in Fig. 6*b-b*) and sulphates (Fig. 5*b*, 287, 334 and 371 cm^{-1} in 6*b-c*) are found. The osumilite is one of the typical minerals of granulite-facies metamorphism at temperatures >900ºC (Bucher and Frey, 1994), indicating the high-*T* overprinting after eclogite-facies metamorphism. In a microdiamond and graphite from the Baizhangya eclogite joined in a single tetrahedral crystal (Fig. 5*c*), the microdiamond is transparent and the graphite is dark or opaque under natural light. Microdiamonds from both the Naobazhai and Baizhangya eclogites are revealed and but can only be discerned by the Raman shift at 1332 cm^{-1} (Fig. 6*a,c*).

The negative ε_{Nd} values indicate the continental origin of all the dimondiferous eclogites (Liu *et al.*, 2000; Xu *et al.*, 2001). This means that these eclogites were once subuducted to a depth of >120 km. However, if another ultrahigh-*P* signal is taken into account, the subduction depth should be >200 km (see below).

In addition to microdiamonds, other ultrahigh-*P* signatures were also found from eclogites in the north DMT. The most important one is the rod-like exsolution of rutile, apatite and clinopyroxene along <111> in host garnet (Fig. 5*d*) from most eclogites. Similar phenomena from kimblite pipes (Haggerty and Sautter, 1990) and eclogite from the Su-Lu region (Ye *et al.*, 2000) have been reported. Experiments have shown that garnet can host high Ti, Na and P contents at very high-*P* conditions and decompression resulted in exsolution of pyroxene, rutile and apatite. Considering the chemical composition, the Su-Lu eclogite with exsolution of rutile, apatite and clinopyroxene was postulated to be formed at *P* >7 GPa, and $T \cong 1000$ºC (Ye *et al.*, 2000); we suggest that these are also the conditions for the eclogites from north Dabie. This exsolution in garnets indicates that the northern Dabie unit also has to have the ultrahigh-*P* metamorphism history (Xu *et al.*, 2003) and it is likely that the UM is the highest-*P* metamorphic unit among those shown in Fig. 1.

IR investigation

The classification of microdiamond based on the impurity of nitrogen is closely related to its origin. In order to classify the microdiamonds, two free crystals F1, F2 and two *in situ* grains 10233 and 8002-2 were examined by IR spectroscopy. In the IR spectrum (Fig. 7*a*) of the F1 microdiamond (Fig. 3*a*), the absorption peak at 3107 cm^{-1} indicates the existence of hydrogen; two smaller peaks at 2924 and 2854 cm^{-1} may be produced by the CH2- and CH3-. Peaks at 2500 cm^{-1} and 1975 cm^{-1} including the valley between 2500 and 2159 cm^{-1} are the diagnostic vibration of

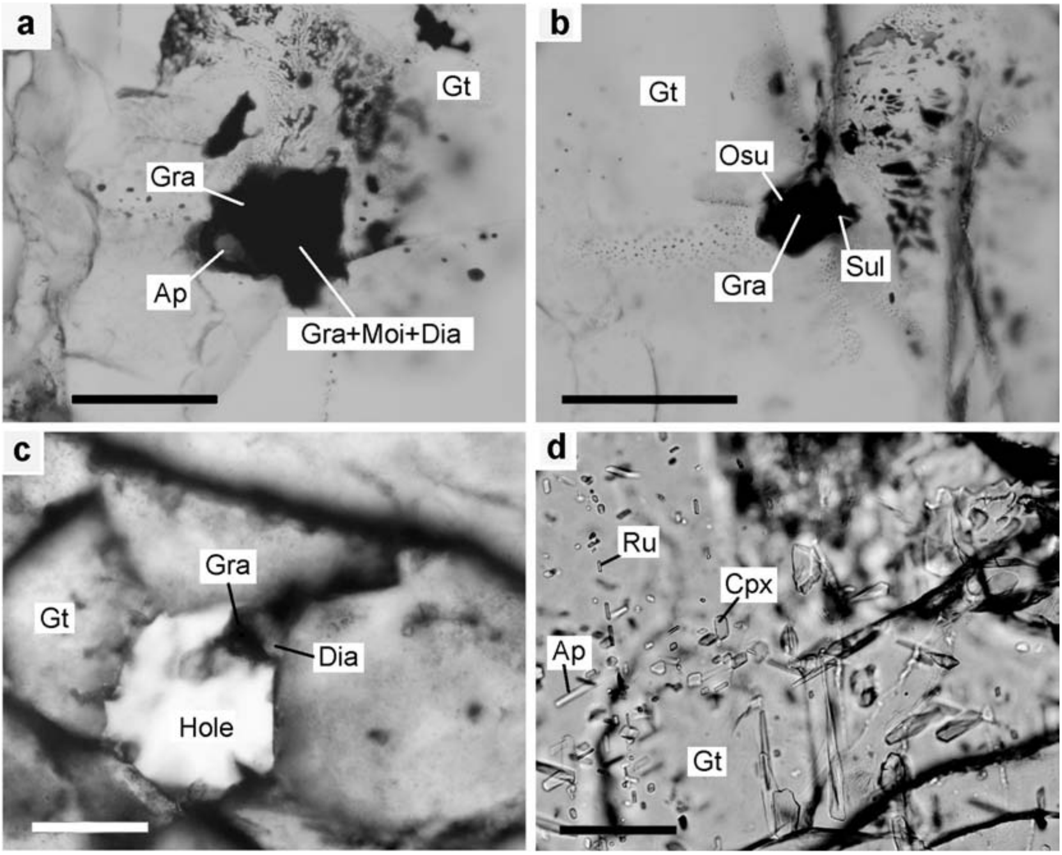

FIG. 5. Photomicrographs of microdiamonds and exsolution in garnet from eclogite in the UM unit in Fig. 1. The scale bar is 100 μm. (*a,b*) Microdiamonds with alteration products in eclogites from Naobozhai (sample 02112-15) in northern Dabie Mountains. (*c*) Microdiamonds and graphite in eclogite from Baizhangya (sample 02111-2) in the northern Dabie Mountains. (*d*) Rod-like exsolution along the <111> direction in host garnet in eclogite from the northern Dabie Mountains. Dia – microdiamond; Moi – moissanite; Gra – graphite; Ap – apatite; Ru – rutile; Cpx – clinopyroxene; Osu – osumilite; Sup-sulphate; and Gt – garnet.

diamond itself. The peak at 1282 cm^{-1} is due to the aggregate of double nitrogen atoms, and the 1177 cm^{-1} peak results from the aggregate of four nitrogen atoms. The absence of a peak around 1130 cm^{-1} means that there is no type Ib diamond involved. Thus, the corresponding microdiamond is likely to be mixed types IaA and IaB diamond. The IR spectrum (Fig. 7*b*) for the F2 microdiamond (Fig. 3*b*) is similar to that in Fig. 7*a*. It shows absorption peaks from 2500 cm^{-1} to 1972 cm^{-1} of diamond itself, the peak at 2921 cm^{-1} is similar to one at 2924 cm^{-1} in Fig. 7*a*, but it has no peak at 3107 cm^{-1} for hydrogen; peaks from 1366 cm^{-1} to 1014 cm^{-1} represent the nitrogen impurity. The co-existence of peaks of aggregate of four nitrogen atoms (1173 cm^{-1}), flake-shaped (1366 cm^{-1}) and aggregate of double nitrogen atoms (1275 cm^{-1}) indicate that the microdiamond in Fig. 3*b* is also the mixed types IaA and IaB diamonds (Orlov, 1973; Xie *et al.*, 1999). A similar test was performed for the free microdiamonds from Kazakhstan which are determined to be mixed types Ib-IaA diamonds (De Corte *et al.*, 1998).

The IR spectra (Fig. 7*c,d*) of *in situ* microdiamonds in Fig. 3*c,d* are strongly disturbed by both the slide-glass and epoxy used for making the thin sections, and the signal is weaker. Although the spectrum in Fig. 7*c* is not of high quality, some useful information is still obtained. The absorption peaks at 2926 cm^{-1} and 2855 cm^{-1} are similar to those in Fig. 7*a*,

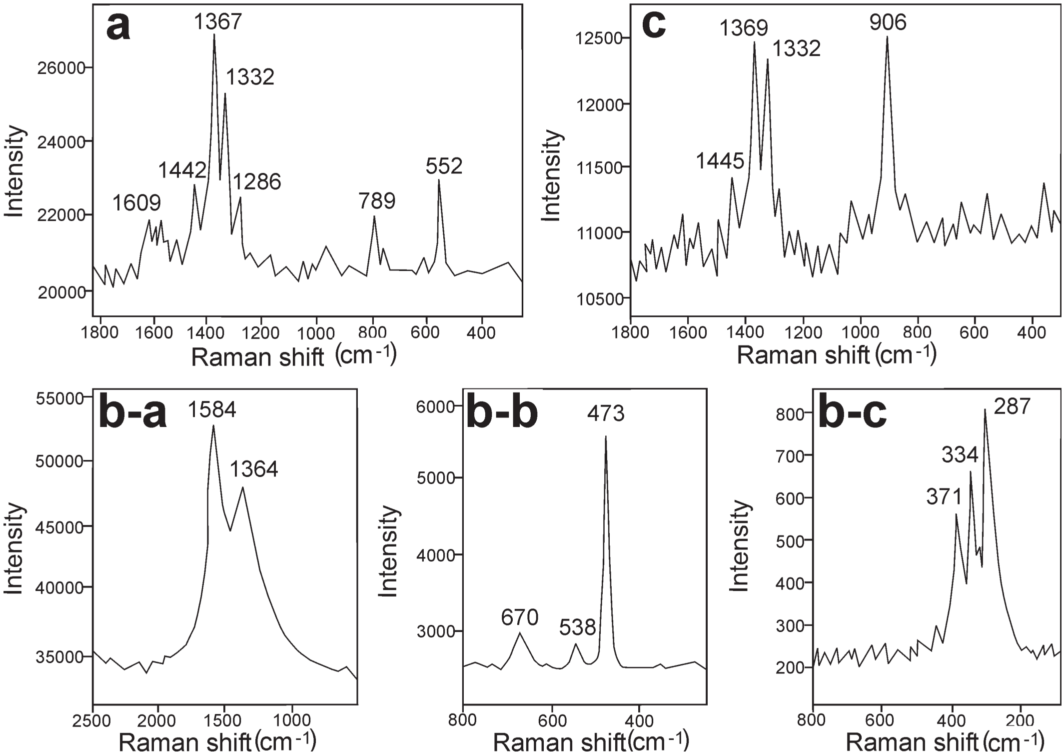

FIG. 6. Spectra of microdiamonds and related minerals in eclogites from the northern Dabie Mountains. (*a,b*) Raman spectra of microdiamonds and related minerals (see Fig. 5*a,b*) in the Naobazhai eclogites. (*c*) Raman spectrum of microdiamond and graphite in the Baizhangya eclogite (Fig. 5*c*). Explanations are given in the text.

indicating the existence of CH_2- and CH_3-; the vibration spectrum of microdiamond itself is at 2162 cm^{-1}, the broad peak at 2500 cm^{-1} and a valley between them, although very weak, is due to interference from the epoxy and/or glass slide. A peak at 1374 cm^{-1} may correlate with the major absorption at 1370 cm^{-1} of the flake-shaped nitrogen while a peak at 1172 cm^{-1} may correspond to the major absorption peak at 1175 cm^{-1} due to the aggregate of four nitrogen atoms (Xie *et al.*, 1999; Orlov, 1977). This *in situ* microdiamond is thus also probably the mixture of types IaA and IaB diamonds. The sharp absorption peak at 1681 cm^{-1} in the IR spectrum is probably related to H_2O or to double-bonded hydrogen and oxygen atoms.

The IR spectrum (Fig. 7*d*) of the *in situ* microdiamond from the Su-Lu region (Fig. 2*b*) is better than that shown in Fig. 7*c*, the broad peak around 2500 cm^{-1} and the peak band at 2158−1991 cm^{-1} including a valley between 2500 and 2158 cm^{-1} can be understood to represent the diamond itself; peaks at 1735 and 1649 cm^{-1} reveal the presence of C=O. If the peak at 1392 cm^{-1} is comparable to 1370 cm^{-1} (deviation 1.6%), there should be a IaB type component in the diamond; the peak at 1285 cm^{-1} could be the indicator of diamond of type IaA (Orlov, 1973; Xie *et al.*, 1999). It is likely that peaks at 1469 and 2929 cm^{-1} are produced by a bending vibration of CH_2- and CH_3-, which might come from the epoxy in thin sections. Such an IR spectrum is similar to those in Fig. 7*a,b*, although the signals are weaker. Thus the microdiamond does seem to be a mixture of types IaA and IaB diamond also.

In all the spectra of our microdiamonds, there is no peak typical of type Ib diamond (at ~1130 cm^{-1}), which is always the main component of synthetic diamond, although it can be a component of the naturally formed diamond as well (de Corte *et al.*, 1998).

In all the IR spectra, especially those from *in situ* microdiamonds, the absorption peaks deviate

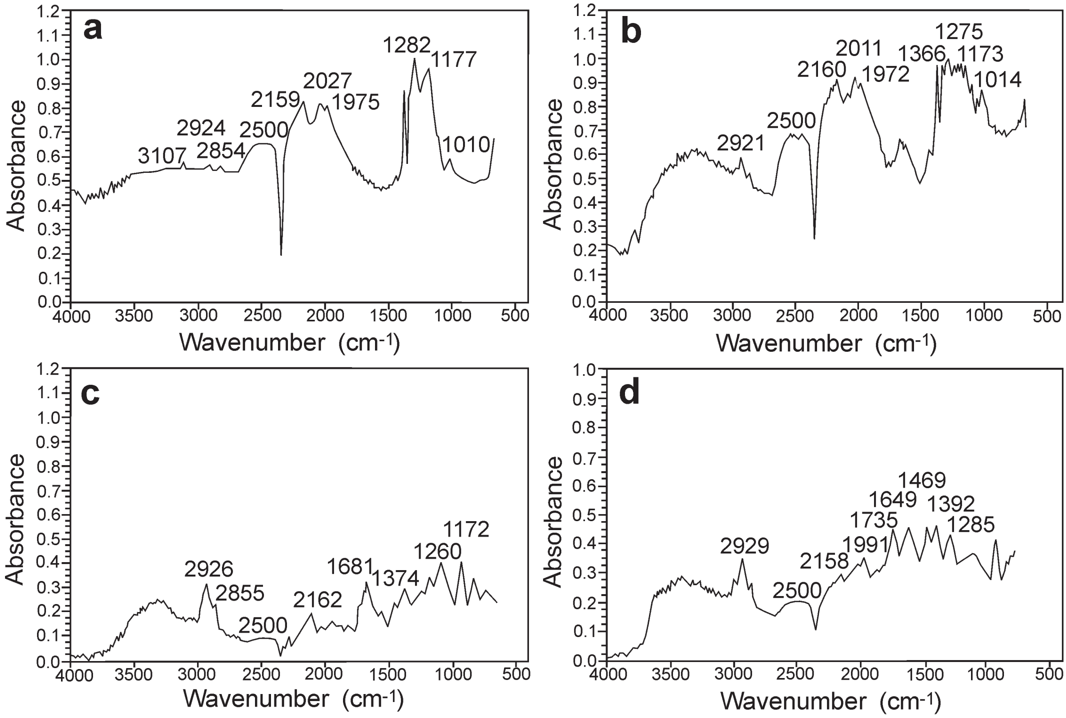

FIG. 7. IR spectra of microdiamonds from the Dabie Mountains and the Su-Lu region. (*a*) IR spectrum for the free microdiamond in Fig. 3*a*. (*b*) IR spectrum for the microdiamond in Fig. 3*b*. (*c*) IR spectrum for the *in situ* microdiamond in Fig. 3*c*. (*d*) IR spectrum of the *in situ* microdiamond in Fig. 2*b*.

from the standard absorption peaks (Xie *et al.*, 1999; Orlov, 1973) by 1 to 2%. This is probably caused by the interference by the epoxy and the slide glass. A diagnostic feature of our microdiamonds is a lack of a single nitrogen atom peak (1130 cm^{-1}) in the IR spectra of both the free crystal and *in situ* microdiamonds. This means that these microdiamonds were formed in a geological process unlike synthetic diamonds developed over a short duration. This is consistent with the suggestion by Chrenko *et al.* (1977) and was recognized by de Corte *et al.* (1998). Such a conclusion is in reasonable agreement with the microscopic observation mentioned earlier. The Raman spectra of *in situ* microdiamonds must show some differences from, but are essentially similar to, those obtained from the free crystal diamonds using the traditional method, otherwise it would be meaningless to test the microdiamonds in thin sections. We suggest that what we have reported are probably the distinctive features of Raman spectra of *in situ* microdiamonds in thin sections.

Conclusions

(1) Infrared investigation shows that all the microdiamonds we studied are of mixed types IaA and IaB diamond. The lack of a type Ib component means that the microdiamonds were formed in a geological process and a synthetic origin can be excluded. This is in accord with our microscopic examinations of the *in situ* microdiamonds in thin section.

(2) Infrared spectra of *in situ* microdiamonds in thin sections show some differences from, but are very similar to, those obtained from the free crystal diamonds under traditional method.

(3) All the diamondiferous eclogites in both the Dabie Mountains and Su-Lu region have been subjected to ultrahigh-*P* metamorphism. The petro-tectonic unit UM in the northern Dabie Mountains may have subducted to a depth >200 km as proven by the exsolution of rod-like clinopyroxene, rutile and apatite in the direction <111> in the host garnets. It may have even been subjected to the highest-*P* metamorphism among the units shown in Fig. 1.

(4) The unit ECL2 in Fig. 1 has been subducted to a depth of ~120 km as indicated by the occurrence of microdiamonds.

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