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SHORT NOTE

Coesite from the Dabie Shan eclogites, central China

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Abstract: A coesite inclusion in garnet from an amphibolitized eclogite is described from the Dabie Shan region in central China. The eclogite with coesite occurs as a nodule (boudin?) in a several metres thick marble band in a regional eclogite facies terrain dominated by leucocratic garnet-bearing gneisses and eclogite bands. Probable quartz pseudomorphs after coesite have also been discovered as inclusions in garnet and omphacite from other localities in the Dabie Shan region, suggesting that a crustal slice of over 1000 km^2 in area has been subducted to depths of over 90 km.

Key-words: coesite, eclogite, Dabie Shan, China.

Introduction

Coesite, a high-pressure polymorph of SiO_2 stable above 25 kbar at metamorphic temperatures, is known from the eclogite-facies rocks from the Western Alps (Chopin, 1984) and Scandinavian Caledonides (Smith, 1984). A third occurrence of coesite from crustal high-pressure metamorphic rocks is reported here from the eclogites of the Dabie Shan, central China (Fig. 1).

Dabie Shan is a large high-grade metamorphic complex situated between the Sino-Korean Block in the north and the Yangtze Block in the south (Fig. 1). It forms the eastern part of the Triassic Qinling orogen produced during the intra-continental collision between these two blocks (Huang, 1978; Klimetz, 1983; Mattauer *et al.*, 1985; Sengör, 1985; Hsü *et al.*, 1987, Wang *et al.*, 1989). In the east the high-grade metamorphic rocks of the Dabie Shan are abruptly terminated by the sinistral Tanlu fault which displaces the suture 550 km northward to the Shandong region (Fig. 1). The steeply dipping Mozitan-Xiaotian fault, which may mark the site of a Triassic suture, forms the northern boundary of the Dabie Shan metamorphic complex (Fig. 1). In the south a poorly exposed major fault zone juxtaposes the Dabie Shan metamorphic rocks against the Sinian to Triassic sedimentary rocks of the Yangtze Block. Terrigenous, post-Triassic rocks are transgressive over the older units.

Dabie Shan metamorphic complex

Two zones can be recognized in the Dabie Shan metamorphic complex. The northern zone is characterized by abundant migmatitic gneisses, syn- to late-metamorphic granitoids and rare eclogite, ultramafic lenses and marbles. The southern zone represents largely a regional eclogite-facies terrain. Fine-grained, leucrocratic, banded gneisses with the common mineral assemblage quartz + plagioclase + microcline + epidote + garnet + white mica ± biotite ± kyanite ± opaque make up the bulk of the southern zone. Eclogite bands and lenses, impure marble bands and, very rarely, ultramafic lenses occur intercalated within the leucrocratic gneisses. There are thousands of eclogite bands and lenses in various stages of preservation and ranging in size from a few centimetres to several metres. The common mineral assemblage in the eclogites is omphacite + garnet + kyanite + zoisite + phengite + rutile ± colourless hornblende ± quartz, without paragonite.

Impure marble bands in the southern zone range in thickness from 0.5 to several metres and generally comprise phlogopite, garnet, clinopyroxene, olivine, white mica and epidote in addition to carbonate minerals. They commonly contain eclogite nodules from a few centimetres to one metre in size, which may represent boudinaged diabase dykes.

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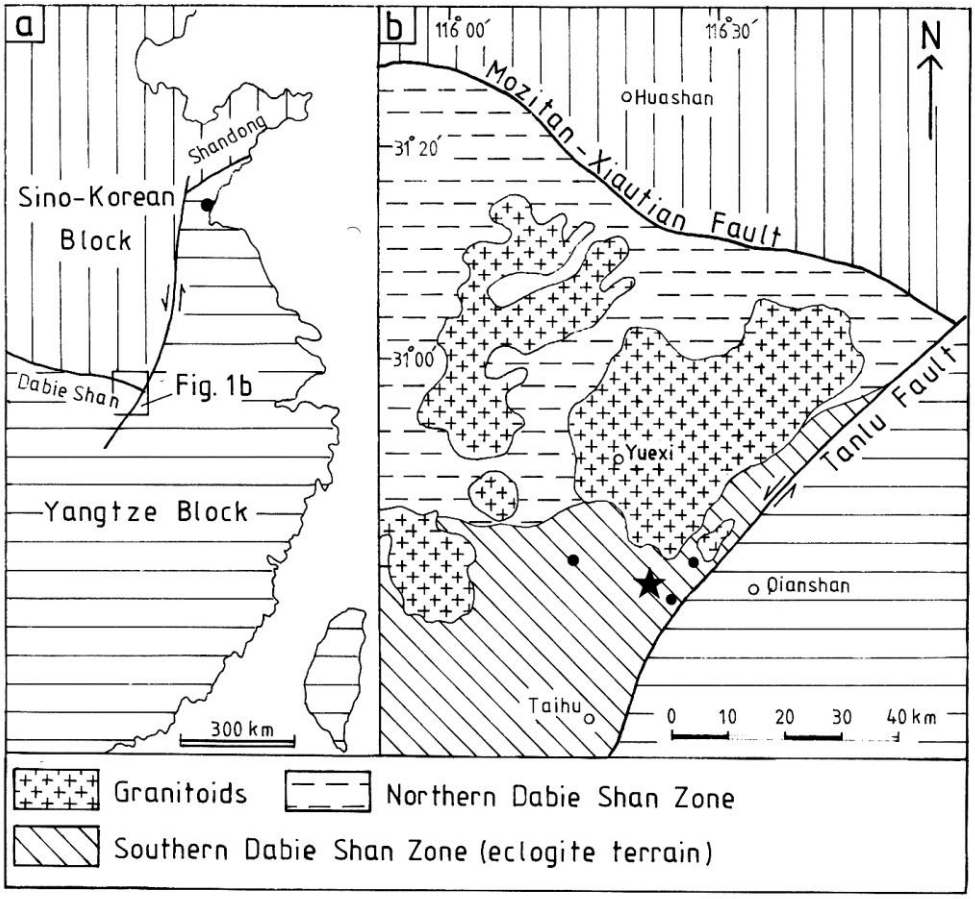

Fig. 1. a) Tectonic map of the eastern China showing the location of the Dabie Shan region. The filled circle in Shandong province shows the location of probable quartz pseudomorphs after coesite (Yang & Smith, 1989). b) Simplified tectonic map of the Dabie Shan region. The filled star and the filled circles show the locations of the coesite and probable quartz pseudomorphs after coesite, respectively. The westernmost circle is the occurrence reported by Zhiqin (1987).

Coesite occurrence

Relict coesite has been discovered from one small amphibolitized eclogite nodule in an impure marble band exposed on a stream section 22 km south of the town of Yuexi and 5.5 km southeast of the village of Wumiao in the southern zone of the Dabie Shan (Fig. 1). The several metres thick marble band contains a large number (>15) of small (3—40 cm across) mafic lenses. Four samples from different lenses were collected; all are strongly amphibolitized eclogites with very little or no omphacite preserved; only one mafic lens (C233C) contains relict coesite as inclusion in a garnet porphyroblast.

The sample with coesite (C233C) consists of garnet porphyroblasts up to 9 mm across surrounded by very fine-grained hornblende-plagioclase symplectite after omphacite. Omphacite is only preserved as rare inclusions in garnet. Garnet compositions ($Sp_{3.6}Pyr_{10.2}Gr_{43.8}Al_{42.4}$) are similar to those from other eclogite nodules in marble in the Dabie Shan and are considerably richer in grossular component than the garnets from the eclogites intercalated with the gneisses (Okay *et al.*, in prep.). Garnet grains have distinctive kelyphitic coronas and are being replaced by dark green hornblende + epidote + plagioclase. Minor constituents include interstitial calcite, rutile rimmed by sphene, ilmenite, apatite, quartz and coesite. A modal analysis of the sample based

on over 1500 point counts yields: garnet 26.9., hornblende + plagioclase symplectite 41.7, hornblende 17.9, epidote 4.4, calcite 3.2, ilmenite 2.4, sphene 1.5, plagioclase 1.4, rutile 0.3, apatite 0.1, and, as inclusions in garnet, omphacite 0.1, quartz 0.1, coesite <0.1.

Coesite was identified in an inclusion in the core of a 8 mm large garnet by its distinctive optical properties (Fig. 2) and by microprobe work. It is monocrystalline, measures 0.2 mm across and has a 0.05 mm thick replacement rim of polycrystalline quartz showing radial growth (*cf.* Chopin, 1984). Radial fractures in garnet around the coesite inclusion, a typical feature of coesite inclusions, are well developed (Fig. 2).

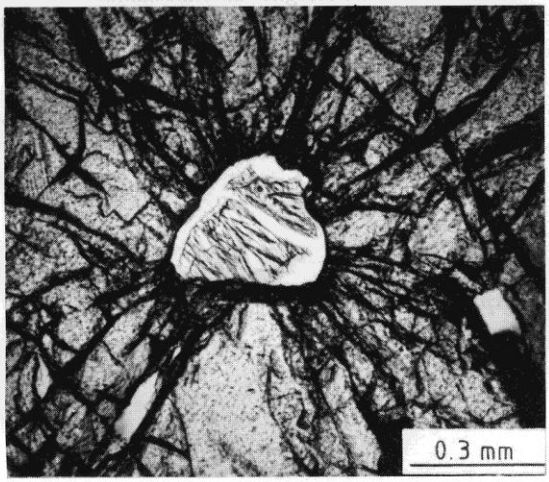

Fig. 2. Photomicrograph from sample C233C showing the relic coesite partly inverted to quartz (lower relief) as inclusion in garnet. Note the radial fractures in garnet around the inclusion and the replacement of coesite by quartz around the rim and along the fractures.

Although we discovered relict coesite in only one sample, we found multicrystalline quartz inclusions with radial cracks around them in garnet and omphacite, respectively, in two eclogite samples from the southern zone of the Dabie Shan complex (Fig. 1); both of these eclogites occur as nodules in impure marble bands. These inclusions are interpreted as probable quartz pseudomorphs after coesite. Quartz pseudomorphs after coesite inclusions in garnet were also reported from the Dabie Shan region by Zhiqin (1987, locality shown on our Fig. 1); the preservation in one inclusion of the radial, feathery quartz texture rimming a central zone of almost cryptocrystalline quartz (*cf.* Smyth, 1977; Chopin, 1984) leaves in this case no doubt as to the former presence of coesite. Furthermore, relict coesite has also been independently found by another group in the Dabie Shan (Maruyama, pers. comm. 1989).

Conclusions

The presence of thousands of eclogite bands and lenses, the structurally conformable contacts between the eclogites and the country rocks, the high-pressure parageneses observed in some gneisses (*e.g.* jadeite + quartz + garnet + sodic amphibole, Okay *et al.*, in prep.) all indicate that the eclogite-facies metamorphism was regional in the southern zone of the Dabie Shan.

The presence of coesite and probable quartz pseudomorphs after coesite in various localities in the southern zone of the Dabie Shan suggests that a crustal slice measuring over 1000 km^2 in area has been subducted to depths of over 90 km. The temperatures of the eclogite-facies metamorphism in Dabie Shan, as determined by the garnet/clinopyroxene geothermometry, were around 750 °C (Okay *et al.*, in prep.). The regional extent of the coesite-bearing eclogites in the Qinling orogenic belt is also suggested by the quartz pseudomorphs after coesite in the southern Shandong province (Yang & Smith, 1989) generally regarded as the eastern part of the Qinling orogen offset by the Tanlu fault (Fig. 1a). There, the occurrence of highly magnesian staurolite (Enami & Zang, 1988) is additional evidence for unusually high pressures.

Our observations provide further support to the growing recognition that subduction of continental crust to dephts significantly more than the thickness of the thickest known crust (~ 70 km in Tibet and Altiplano) is much more widespread in continental collision zones than hitherto considered. An active example of this phenomenon may be now going on under the Pamirs, where a possible continental slab is detected to depths of over 120 km (Roecker, 1982).

The occurrence of coesite in a strongly amphibolitized eclogite shows that there is no direct connection between the extent of retrogressive amphibolitization and the preservation of coesite. The preservation of coesite as an inclusion depends on the size and mechanical state of the enclosing host mineral. An initially unfractured and large garnet or omphacite can preserve coesite by forming an impermeable barrier to the incoming fluids even if the rest of the rock is strongly amphibolitized.

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References

Chopin, C. (1984): Coesite and pure pyrope in high-grade blueschists of the Western Alps: a first record and some consequences. *Contrib. Mineral. Petrol.*, **86,** 107–118.

Enami, M. & Zang, Q. (1988): Magnesian staurolite in garnet-corundum rocks and eclogite from the Donghai district, Jiangsu province, east China. *Amer. Mineral.*, **73,** 48–56.

Hsü, K. J., Qingchen, W., Jiliang, L., Da, Z., Shu, S. (1987): Tectonic evolution of Quinling Mountains, China. *Eclogae Geol. Helv.*, **80,** 735–752.

Huang, J. Q. (1978): An outline of the tectonic characteristics of China. *Eclogae Geol. Helv.*, **71,** 611–635.

Klimetz, M. P. (1983): Speculations on the Mesozoic plate tectonic evolution of eastern China. *Tectonics,* **2,** 139–166.

Mattauer, M., Matte, P., Malavieille, J., Tapponnier, P., Maluski, H., Qin, X. Z., Lun, L. Y., Qin, T. Y. (1985): Tectonics of the Quinling Belt: build-up and evolution of eastern Asia. *Nature,* **317,** 496–500.

Roecker, S. W. (1982): Velocity structure of the Pamir-Hindu Kush region: possible evidence of subducted crust. *J. Geophys. Res.*, **87,** 945–959.

Sengor, A. M. C. (1985): East Asian tectonic collage. *Nature,* **318,** 16–17.

Smith, D. C. (1984): Coesite in clinopyroxene in the Caledonides and its implications for geodynamics. *Nature,* **310,** 641–644.

Smyth, J. R. (1977): Quartz pseudomorphs after coesite. *Amer. Mineral.* **62,** 828–830.

Wang, X., Jin, Y., Liou, J. G., Liang, W., Pan, G., Xia, M., Maruyama, S. (1989): Eclogites in the Dabie Mountains, central China. Third int. Eclogite Conf., Würzburg, *Terra Abstracts* **1.**

Yang, J. & Smith, D. C. (1989): Evidence for a former sanidine-coesite-eclogite at Lanshantou, eastern China, and the recognition of the Chinese "Su-Lu coesite-eclogite province". Third int. Eclogite Conf., Würzburg, *Terra Abstracts* **1.**

Zhiqin, Xu (1987): Etude tectonique et microtectonique de la chaîne paléozoïque et triasique des Quilings (Chine). Thèse de doctorat, Univ. Sci. Tech. Languedoc, Montpellier.

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