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SHORT NOTE

Blueschist relics in the Mesozoic cover series of the Menderes Massif and correlations with Samos Island, Cyclades

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Abstract

In the western part of the Menderes Massif, Selçuk-Dilek Peninsula, relics of Tertiary HP metamorphism under epidote-blueschist facies conditions were recognized in the Mesozoic cover series. This subduction-related high-pressure metamorphism, with temperature of less than 470 °C and minimum pressure of about 10 kbar, was subsequently followed by a Barrovian-type overprint under greenschist facies conditions during Late Eocene / Early Oligocene. Based on the lithostratigraphy and the two-fold Tertiary metamorphism, the Mesozoic cover series in this area can be correlated with the Vourliutes unit on Samos Island, belonging to the Cycladic Crystalline Complex.

Keywords: blueschist, eclogite, Menderes Massif, Samos Island, Cycladic Crystalline Complex.

Introduction

The Menderes Massif (MM), composed of a large crystalline nucleus within the Alpidic orogenic belt, is exposed in western Anatolia. This crystalline complex is bordered to the north and west by the Izmir-Ankara Zone and to the south by the Lycian nappes of the Taurides. The MM is considered to be linked to the Cycladic Crystalline Complex to the west in the Central Aegean Sea, as a part of Median Crystalline Belt (DÜRR et al., 1978). The latter is one of the world's typical blueschist belts.

Some relic eclogites related to high-pressure metamorphism in the MM were recorded in the Precambrian "core series" (CANDAN et al., 1994; OBERHÄNSLI et al., 1995). In recent years, some evidence for high-pressure metamorphism, most probably not related to the HP event in the "core series", has been detected in the "cover series". The aim of this short note is to document the presence of blueschists as well as eclogites in the Mesozoic cover series of the MM, and to correlate the Selçuk region, in the western part of the MM, with the Island of Samos in the Cycladic island arc.

Geology and phase relationships in the high-pressure rocks

The relics of Tertiary high-pressure metamorphism in the Mesozoic cover series were recognized in the areas of Selçuk, Kusadase and Dilek Peninsula (Fig. 1). The relevant rocks include

i) blueschist metabasites and metapelites, and
ii) high-pressure blocks in a metamorphosed olistostrome.

Blueschist relics were only detected in the Dilek Peninsula, where marble-schist successions with minor metabasite intercalations display predominantly greenschist facies assemblages. In three localities, well-preserved blue amphiboles were found in metabasites within thin epidote-crossite-rich layers and lense-shaped bodies, which are suggesting a protolith of mafic volcanic tuffs (Fig. 1). Furthermore, carbonate-rich metapelites, most probably mixed with volcanic material, contain blue amphibole porphyroblasts up to 2 cm in length. Some of the crossites rimmed by barroisitic green amphiboles are altered into actinolite and chlorite. Phyllitic metapelites, inter-

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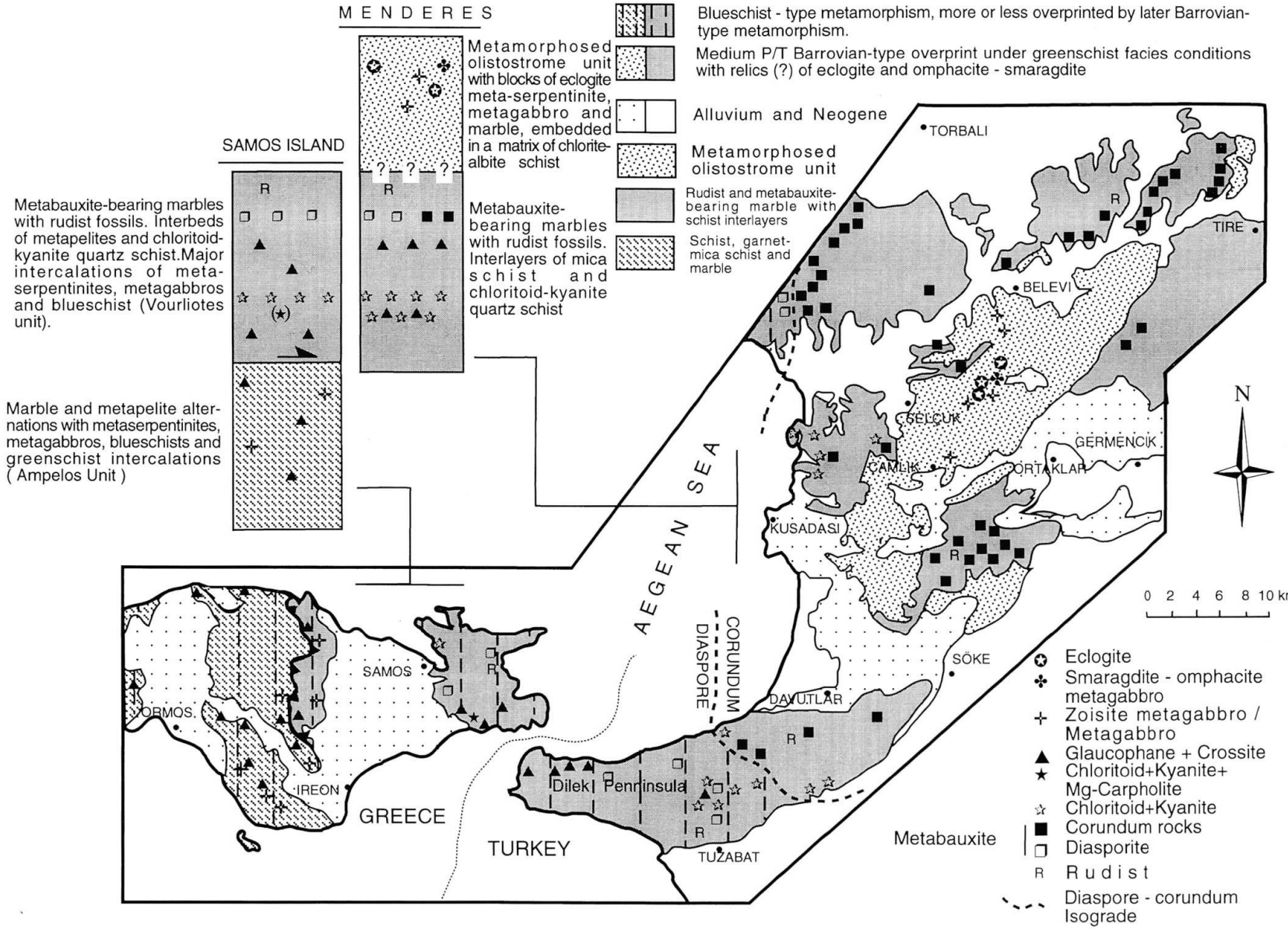

Fig. 1 Correlation of the main Mesozoic units between Samos Island, Cyclades, and the western part of Menderes Massif. Relic outcrops of Tertiary blueschist metamorphism are shown. The geological map of Samos is modified after PAPANIKOLAOU (1979) and OKRUSCH et al. (1985). The localities of metabauxites and rudists are after ÖNAY (1949) and ÖZER (1993).

Tab. 1 Representative microprobe analyses of Na and Na–Ca amphiboles from blueschist facies metabasites. H_2O recalculated from stochiometry.

	Na amphibole			Na–Ca amphibole		
	3–35	**3–38**	**3–41**	**3–43**	**3–19**	**3–30**
SiO_2	56.24	56.65	56.36	56.21	50.89	50.35
TiO_2	0.03	0.00	0.04	0.04	0.10	0.12
Al_2O_3	7.33	6.14	7.87	7.35	4.83	5.09
Cr_2O_3	0.03	0.02	0.02	0.00	0.05	0.00
Fe_2O_3	8.57	9.14	6.84	7.37	8.65	7.42
FeO	8.83	9.14	9.38	9.97	18.28	10.47
MnO	0.14	0.18	0.11	0.07	0.31	0.35
MgO	9.18	9.00	9.05	8.84	11.69	11.71
CaO	0.65	0.38	0.75	0.62	7.81	8.13
Na_2O	6.91	6.85	6.73	6.99	3.38	3.13
K_2O	0.00	0.00	0.03	0.00	0.17	0.19
H_2O*	2.13	2.12	2.13	2.12	2.06	2.04
Total	100.04	99.61	99.30	99.57	100.20	98.98
Numbers of ions on the basis of 23 O and 2 OH						
Si	7.898	8.006	7.943	7.942	7.394	7.395
Ti	0.003	0.000	0.004	0.004	0.011	0.013
Al	1.213	1.023	1.306	1.224	0.827	0.880
Cr	0.003	0.002	0.002	0.000	0.005	0.000
Fe^{3+}	0.906	0.972	0.726	0.783	0.946	0.820
Fe^{2+}	1.037	1.080	1.106	1.178	1.249	1.286
Mn	0.016	0.021	0.013	0.008	0.038	0.043
Mg	1.923	1.896	1.902	1.861	2.532	2.563
Ca	0.097	0.057	0.114	0.093	1.215	1.279
Na	1.881	1.876	1.840	1.914	0.952	0.891
K	0.001	0.000	0.005	0.000	0.031	0.035
OH	2.000	2.000	2.000	2.000	2.000	2.000

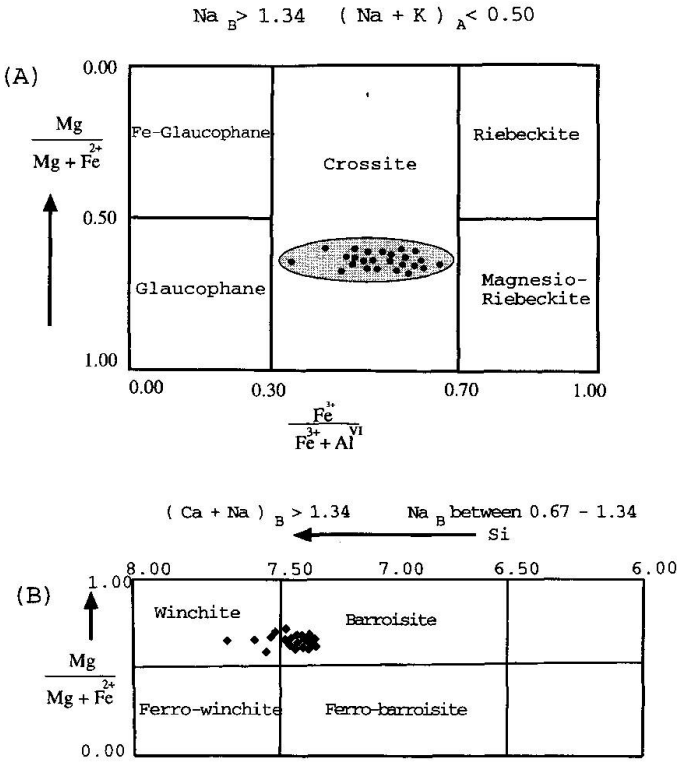

Fig. 2 Compositional diagrams of (A) alkaliampbiboles and (B) Na–Ca amphiboles from blueschist facies metabasites (after LEAKE, 1978).

bedded with marbles, exhibit a greenschist assemblage of chlorite + albite + chloritoide + white mica + quartz. Irrespective of the retrograde minerals, the mineral assemblages of blueschists can be summarized as:

Metabasites
crossite + epidote + albite + phengite
crossite + epidote + albite

Metapelites
crossite + calcite + epidote + albite
crossite + calcite + epidote + phengite

All assemblages also contain additional quartz.

Blocks with high-pressure mineral assemblages occuring in the metamorphosed olistostrome unit (Fig. 1) are mainly composed of eclogite, smaragdite-omphacite metagabbro and flaser metagabbro. The high-pressure relics, mostly associated with strongly foliated metaserpentinites, are well defined around the Selçuk area. Transitional metamorphic stages from gabbro to eclogite are recognized in some blocks. Most of the eclogites display retrograde alteration to garnet amphibolites. Fresh eclogites with zoisite/clinozoisite-omphacite-rich layers, forming lenses and schlieren up to 10 meters, are characterized by the following assemblages:

Eclogite
omphacite + garnet + zoisite + epidote
omphacite + garnet + zoisite + rutile

Zoisite-omphacite-rich rocks
omphacite + epidote + zoisite
omphacite + zoisite

Mineral geochemistry and P-T estimations

Representative sodic and sodic-calcic amphibole analyses of the blueschist metabasites are given in table 1. Textural evidence reveal that sodic amphiboles which were generated by the high-pressure metamorphism are partly or completely altered into green amphibole and chlorite. Al_2O_3 and Na_2O contents in blue amphiboles range

between 6.1–7.9 and 6.3–7.0 wt% respectively and CaO is lower than 1.2 wt%. Sodic amphiboles plotted on the LEAKE (1978) diagram concentrate in the crossite field (Fig. 2a). Green amphiboles, which are partly scattered into the winchite field, generally display a barroisitic composition in the Na–Ca amphibole diagram (Fig. 2b).

Distribution of the blueschist relics coincides roughly with the diaspore-corundum isograde in the Dilek Peninsula, as well as on the Island of Samos. In the eastern part of Samos, metamorphic temperature and pressure for the HP metamorphic phase was estimated at 440 °C and 12 kbar (OKRUSCH et al., 1985). If such a temperature value is accepted for the Dilek Peninsula, the crossitic sodic amphiboles, which have a compositional scatter between groups 5 and 3 in the epidote-blueschist facies sytem after EVANS (1990), lead to assume minimum pressures between 7.5 and 9.5 kbar, respectively. At 9.5 kb pressure, a maximum temperature of 470 °C is given experimentally by HAAS (1972) for the diaspore-corundum isograde. Therefore, as a consequence of the absence of corundum in the metabauxites coexisting with blueschist assemblages on the Dilek Peninsula, the maximum temperature must have been less than 470 °C during high-pressure metamorphism.

Discussion

The Attica-Cycladic crystalline complex in the central Agean Sea is characterized by spectacular outcrops of eclogites and blueschists. This complex underwent high-pressure metamorphism at a grade corresponding to the transition between eclogite and epidote-blueschist facies metamorphism in Late Eocene / Early Oligocene time, and was subsequently overprinted by a medium-pressure Barrovian-type metamorphism under greenschist to amphibolite facies conditions at the Oligocene/Miocene boundary (ALTHERR et al., 1979).

The Island of Samos is a part of the Cycladic Blueschist Belt, and is situated two kilometers NW of the Dilek Peninsula. According to THEODOROPOULOS (1979) the crystalline series of Samos form a normal stratigraphic succession, whereas PAPANIKOLAOU (1979) and OKRUSCH et al. (1985) regard it as a nappe pile. The Ampelos nappe, which contains widespread blueschist relics, glaucophane metagabbro, glaucophanite and omphacitic rocks (MYPOSKOS and PERDIKATSIS, 1984; OKRUSCH et al., 1985; CHEN, 1992), is made up of three tectonic units: Vourliutes, Ampelos and Aghios. The Vourliutes unit which is exposed in the eastern part of Samos, consists of interbedded marbles and metapelites with minor ultramafic and mafic intercalations (OKRUSCH et al., 1985). This isoclinally folded succession (CHEN, 1992) with widespread blueschist relics is typified by metaclastic quartzitic phyllites with the striking assemblage of kyanite + chloritoide. One sample containing kyanite + chloritoide ± Mg-charpholite is reported (OKRUSCH et al., 1985). Metabauxite deposits in the marbles with coexisting diaspore + chloritoide, but without corundum, were documented by PAPANIKOLAOU (1979). The same authors also recognized traces of rudist fossils, suggesting an Upper Cretaceous age (Özer, 1993) for the metabauxite-bearing marbles (Fig. 1).

The age of the HP metamorphism, which affected the core series (CANDAN et al., 1994; OBERHÄNSLI et al., 1995) and most probably was accompanied by a HT-granulite facies event, is unknown. The blueschist and eclogite relics in the Mesozoic cover series are restricted to the Selçuk-Dilek Peninsula, in the western part of the MM (DORA et al., 1995). The rock succession of this region can be divided into two main units, from bottom to top, (i) interbedded marbles and schists, and (ii) a metamorphosed olistostrome unit. Although a gradational contact between these two units is suggested by ERDOGAN and GÜNGÖR (1992), the true character of this contact is controversial. An isoclinally folded marble-schist succession is dominated in its lowest part by metaclastites, metaconglomerates with quartzite pebbles, quartzites and quartz phyllites, which are characterized by assemblages of chloritoide + kyanite. The metaclastic units include blueschist bearing metabasites, and change gradually upward to thick metacarbonate series interbedded with minor carbonate-rich blueschists and chloritoide-chlorite phyllites. The marbles with well-preserved rudist fossils indicating an Upper Cretaceous age (ÖZER, 1993), are characterized by the widespread occurrence of metabauxites, diasporites and corundum-bearing rocks. In terms of lithostratigraphic succession and the presence of blueschist relics the marble-schist succession in particular can be correlated with the Vourliutes unit of Samos.

Although the metamorphosed olistostrome unit comprise spectacular high-pressure blocks, no high-pressure relics have been recognized in the matrix which is dominated by chlorite-albite schists. It is still open to discussion whether these high-pressure blocks are exotic or whether they suffered high-pressure metamorphism together with the matrix under transitional conditions from epidote-blueschist to eclogite facies as on

Syros and Syfnos islands (MATTHEWS and SCHLIESTED, 1984; RIDLEY and DIXON, 1984). As an alternative interpretation, we suggest that the matrix has been completely overprinted by the later greenschist assemblages, while the mafic blocks mostly preserved their HP assemblages. This olistostromal unit, which does not crop out on the Island of Samos, could be correlated with the metamorphosed olistostrome unit in Syros (RIDLEY and DIXON, 1984; OKRUSCH and BRÖCKER, 1990).

The blueschist relics from the Selçuk area reveal that a subduction-related high-pressure/low-temperature metamorphism affected the western end of the MM under epidote-blueschist to eclogite (?) facies conditions during Tertiary time. The HP/LT assemblages were subsequently overprinted by a Barrovian-type medium-pressure metamorphism under greenschist to amphibolite facies conditions during Late Eocene / Early Oligocene boundary (SATIR and FRIEDRICHSEN, 1986; DORA et al., 1995; HETZEL and REISCHMANN, 1996). The newly presented evidence of a HP event during the Tertiary metamorphic evolution provides strong support for the correlation of the Menderes Massif and the Cyclades crystalline complexes, as previously proposed by DÜRR et al. (1978) and OKRUSCH et al. (1985).

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