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Blueschists from Topsin, Swat District, NW Pakistan

BLUESCHIST rocks, the first to be found in Pakistan, were reported by Shams (1972) from near Topsin (34° 53.5′ N.; 72° 34.5′ E.) and also by Desio (1977) from Shangla, a nearby locality also in Swat District, northern Pakistan. Recently, further occurrences were reported from the area by Tahirkheli (1979). The rocks form part of the so-called Lower Swat-Buner Schistose Group of Palaeozoic age (Martin *et al.*, 1962). To the north the blueschists are bounded by an amphibolite zone which is succeeded by a basic complex, considered to have suffered regional metamorphism up to the granulite facies (Jan and Kempe, 1973; Jan, 1979*a*, *b*). On the north-east is an alpine-type serpentinite mass thought to be a tectonically emplaced block (Jan, 1979*c*). Phyllite and quartzose mica schists outcrop to the east and west, also belonging to the Lower Swat-Buner Schistose Group. To the south-west, the blueschist rock body thins out and disappears under alluvial cover. A major regional thrust immediately to the north of the Schistose Group, the so-called Patan Line, has been accepted as marking the edge of the subduction zone related to the suturing of the colliding Indian and Eurasian lithospheric plates (Desio, 1977). This thrust has since been renamed the Main Mantle Thrust by Tahirkheli *et al.* (1979), who regard it as the zone of obduction of the basic complex (the Kohistan Sequence) on to the Indian plate. This has increased the importance of the discovery of the blueschists and warrants an account of their petrology.

One type of rock (14348; Table I) is schistose, greenish grey in colour, and strongly foliated with shiny, slickensided surfaces. The blue amphibole is associated with micaceous folia, along with quartz, albite, muscovite, garnet, chlorite, epidote and traces of tourmaline, rutile, sphene and apatite. A younger phase of albite (0.03% CaO) forms porphyroblasts which contain trails of matrix minerals as well as of the blue amphibole. The other type of rock (14363) is a heterogeneous, dark bluish black metadolerite, variously composed of a granular aggregate of epidote, chlorite, garnet, quartz, and minor sphene and rutile, with blue amphibole forming clusters of large crystals.

The chemical compositions of the two rock types are given in Table I, along with their amphibole compositions and structural formulae. Plotting of the amphibole compositions in the $Mg/(Mg+Fe^2)$ *versus* $Fe^3/(Fe^3+Al^{vi})$ diagram (fig. 1) for the glaucophane-riebeckite group shows them to be crossites comparing closely with four compositions from Deer *et al.* (1963).

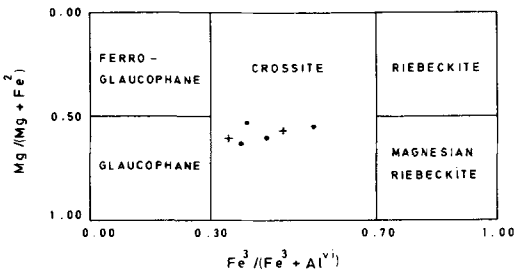

FIG. 1. Crossites from Topsin rocks plotted in the $Mg/(Mg+Fe^2)$ *versus* $Fe^3/(Fe^3+Al^{vi})$ diagram (Leake, 1978). Crosses, Topsin crossites; solid circles, crossites from Deer *et al.* (1963), fig. 82.

Thus, the blueschist rocks from Topsin illustrate typical assemblages such as are taken to mark plate subduction or obduction zones in fold mountain belts (Ernst, 1975), as in the Himalayas (cf. Farah and DeJong, 1979). Their discovery shows that the anomalous status attributed to the Himalayas as collision-type mountains lacking blueschist metamorphism (Powell and Conaghan, 1973) is no longer applicable.

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TABLE I. *Rock and amphibole analyses*

	1	2	3	4
SiO_2	74.31	47.71	52.3	55.4
TiO_2	0.18	0.24	0.09	0.05
Al_2O_3	11.67	18.20	7.8	8.0
Fe_2O_3	0.80	8.89	8.0	—
FeO	2.16	4.97	11.0*	15.7†
MnO	0.32	0.26	0.16	0.10
MgO	1.77	5.62	8.2	8.8
CaO	1.60	9.52	1.91	0.97
Na_2O	3.25	2.96	6.8	7.0
K_2O	3.12	0.30	0.02	0.02
H_2O^+	0.34	0.46	—	—
H_2O^-	0.32	0.08	—	—
Total	99.84	99.21	96.28	96.04

Minerals	Modal Composition‡ (vol.%)		Ions on the Basis of 23(O)				
Crossite	12.2	42.1	Si	7.63	8.00	7.89	8.00
Albite	25.8	—	Al	0.37		0.11	
Muscovite	10.3	—	Al	0.97	5.00	1.24	5.00
Quartz	42.7	—	Ti	0.01		0.01	
Epidote	1.2	44.1	Fe^3	0.88		0.64§	
Rutile	0.3	0.5	Fe^2	1.34		1.23§	
Chlorite	3.0	—	Mn	0.02		0.01	
Garnet	4.0	13.3	Mg	1.78		1.87	
Tourmaline	0.5	—					
			Ca	0.30	2.22	0.15	2.08
			Na	1.92		1.93	

1. Glaucophane-bearing rock no. 14348. Analyst Shafeeq Ahmad.
2. Glaucophane-bearing rock no. 14363. Analyst Shafeeq Ahmad.
3. Electron probe analysis of crossite in 14348. Average of 2 analyses. Analyst G. C. Jones.
4. Electron probe analysis of crossite in 14363. Average of 3 analyses. Analyst G. C. Jones.

* FeO determined by semi-micro colorimetric analysis of 2 mg of separated material.
† Total iron as FeO
‡ Mode in column 2 applies to different rock of the same type.
§ Fe^3:Fe^2 ratio calculated to give 13 cations exclusive of Ca and Na.

Electron probe analyses made using a Cambridge Instruments Geoscan, accelerating voltage 15 kV, current 0.22×10^{-7} amps. Analysed silicates, oxides, and pure metals were used as standards and results computer corrected for matrix effects. Each analysis obtained from at least six point counts on each grain to check for homogeneity.

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