Origin of the Shangla Blueschists, Swat Himalaya, Pakistan

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Abstract: Chemical analyses of two metasedimentary and one meta-igneous-type blueschist rocks from Swat suggest that the former type is hypersodic as compared with many of the world occurrences. The blue amphibole is crossite of appropriate chemical composition. The rocks are believed to be of metasomatic origin, having suffered soda activity of pore fluids. An yet younger phase of soda activity originated from serpentinisation of the Alpurai ultramafic mass and was responsible for growth of the albite porphyroblasts that contain helicytic trails of the blue amphibole.

The blueschist zone is taken to mark a typical fossil trenchplate subduction suture in terms of theories of global tectonics. Radiometric age of muscovite from a metasedimentary blueschist type is 84 ± 1.7 m.y. or upper Coniacian which compares suitably with other ages obtained from the region. The presence of this early Alpine subduction zone of the Swat Himalaya is taken to represent the continuation of the Indus Suture Line.

INTRODUCTION

A major controversy in the application of concepts of global tectonics to the Himalaya has been the alleged absence of blueschist metamorphism (Powell and Conaghan, 1973) which was considered rather anomalous if the Himalaya was to be recognized as a continent-continent collisional type mountain (Dewey and Bird, 1970). Such a claim was made, however, due to ignorance of the discovery of blueschist rocks from near Topsin (Shams, 1972) and from Shangla (Desio, 1974), a locality at a short distance towards east in the Swat Himalaya. Recently further discoveries have been made (Tahirkheli, 1979) that have established a rather regional status of this unique petrotectonic phenomenon. In this way, it has been possible to trace the tectonic suture zone between the Indian and the Eurasiatic lithospheric plates. This has also made it possible to apply plate tectonics concepts to problems of mineralization in the regions of northern Pakistan (Sillitoe, 1979).

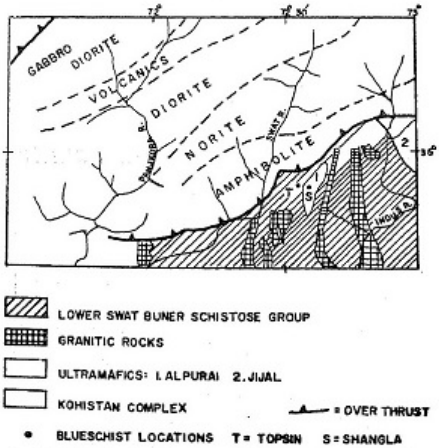

Fig. 1. Geological sketch map of Upper Swat and adjoining areas (after Desio, 1977).

While considerable attention is being given to application and extension of results derived from evidence provided by the blueschist metamorphism in terms of theories of plate tectonics, little progress has been made regarding the intricate problems concerning origin of the rocks in the Himalaya. The present article is particularly concerned with formation of the Shangla blueschists, employing this title to include the Topsin occurrences as well due to their close location and popularity of the former location name.

THE SHANGLA BLUESCHISTS

The geological set-up of the Shangla area (Fig. 1) has been described already (Shams, 1972; Desio, 1977) alongwith salient structural and tectonic features of the area. In the first report of the author (Shams, 1972), modal and chemical analyses were given of two blueschist rocks of metasedimentary origin, distinguished by presence or absence of garnet. Since then, another blueschist type was discovered to be of meta-igneous origin (Shams *et al.*, in press). Fig. 2 shows plotted positions of the three rock types in Na_2O — MgO — FeO and (FeO + Fe_2O_3) — (Na_2O+K_2O) — MgO diagrams, alongwith enclosed areas of plotted positions of large number of world data (Earnst, 1963; Coleman and Lee 1963). It is notable that, in contrast to the meta-igneous type, the two metasedimentary blueschists lie outside the areas enclosing the world data with

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Table 1. Chemical composition and structural formulae of two blue amphiboles (crossites) from Swat, Pakistan.

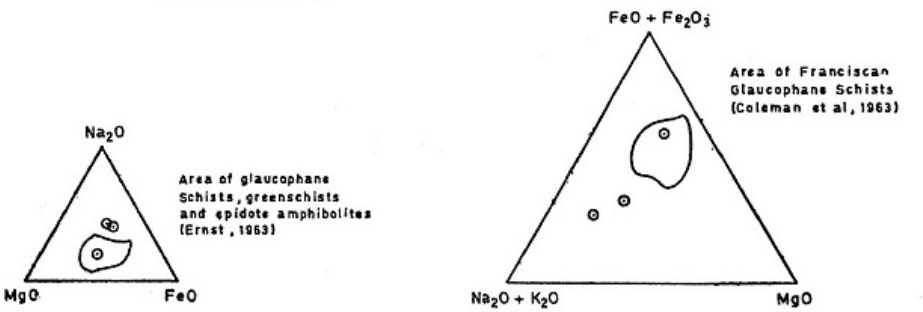
	Amphibole Analyses			Ions on the basis of 23(O)			
	(1)	(2)		(1)		(2)	
SiO_2	52.3	54.4	Si	7.63	8.00	7.89	8.00
TiO_2	0.09	0.05	Al	0.37		0.11	
Al_2O_3	7.8	8.0	Al	0.97		1.24	
Fe_2O_3	8.0	—	Ti	0.01		0.01	
FeO	11.0	15.7 *	Fe^3	0.88		+0.64	
MnO	0.16	0.10	Fe^2	1.34	5.00	+1.23	5.00
MgO	8.2	8.8	Mn	0.02		0.01	
CaO	1.91	0.97	Mg	1.78		1.87	
Na_2O	6.8	7.0	Ca	0.30	2.22	0.15	2.08
K_2O	0.02	0.02	Na	1.92		1.93	

Electron probe analyses carried out by G.C. Jones, London.

* Total iron as FeO.

+ $Fe^3 : Fe^2$ ratio calculated to give 13 cations exclusive of K and Na.

FIGURE 2



SHOWING PLOTS OF COMPOSITION OF GLAUCOPHANE ROCKS FROM SWAT, IN RELATION TO WORLD OCCURRENCES (total areas outlined).

particularly higher soda content. The blue amphibole itself was earlier identified as crossite of the riebeckite-glaucophane series on the basis of optical determinations (Shams, 1972), this has been confirmed now on the basis of chemical composition and structural formula (Table 1) as compared with known minerals (Fig. 3).

ORIGIN OF SHANGLA BLUESCHISTS

In connection with the origin of the Shangla blueschists, the following points are important:

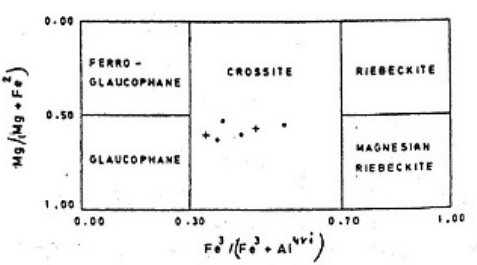


Fig. 3. Plots of chemical compositions of amphiboles in terms of $Mg/(Mg+Fe^2)$ vs $Fe^3/(Fe^3+Al^4)$
(+) Amphiboles from Swat, Pakistan.
(•) Crossites from Deer, Howie and Zussman (1963).

1. The blueschists are part of the Green Schists member of the Lower Swat-Buner Schistose Group of Palaeozoic age. Besides blueschist lithologies, the Green Schists are composed of chlorite schists, epidote-albite schists, epidote-quartz-feldspar schists, epidote-actinolite schists, actinolite-talc schists and magnetite-chlorite-actinolite schists (Martin *et al.*, 1962).

2. A North-South elongated body of Alpine-type ultramafic-serpentinite rocks occurs within the Green Schists formation, with its southern portion attenuated and broken into large pods and boudins. The blueschists appear to be closely associated with the ultramafic mass with tectonic relations.

3. The blueschist rocks occur both outside the ultramafic mass (Shams, 1972) as well as inside (Desio, 1977).

4. In the North, the blueschists are in contact with the so-called Upper Swat Hornblendic Group Complex of Martin *et al.* (1962), now renamed as Swat Kohistan Complex by Jan and Mian (1971) and claimed to be regionally metamorphosed basic igneous rocks. The southern margin of the Complex, in contact with the schists, is composed of amphibolites which are partly derived from basic lava flows and tuffs (Jan, 1977).

5. Chemically, the metasedimentary-type blueschists are hypersodic to the extent of being higher in soda content than are most of the world examples (Shams, 1972). Significantly, such rocks contain albite porphyroblasts among the younger phases and carry helicytic trails of matrix minerals, including the blue amphibole.

6. The blueschist of meta-igneous-type appears to be of normal chemical composition that is comparable to similar world occurrences (Fig. 2).

In view of the above set of evidence, it is believed that the metasedimentary-type blueschists from Shangla area had developed as a result of soda metasomatism on original lithologies of the Green Schists formation. In this connection, it is considered that soda activity took place in two stages; firstly, when the blue amphibole was formed and secondly, when the albite porphyroblasts were grown. In the first stage, the necessary soda became available from within the sediments as part of the pore fluid of marine origin. The soda activity had increased due to expulsion of water on campaction during subduction of the sediments into the trench at the leading edge of the Indian plate. This had assisted to increase concentration and consequently chemical potential of the pore fluid, further helped by rise in temperature which is considered necessary for the growth of blue amphibole (Korzhinski, 1958). It is not considered essential that soda activity of the pore fluid had increased due to serpentinisation of the Alpuri ultramafic mass by way of withdrawing necessary water from the sediments in the sense of Gresens (1975).

For the second stage of soda metasomatism, responsible for the growth of albite porphyroblasts, the Alpuri mass is considered the source of metasomatising fluids which carried minor soda that is always carried by ultramafic bodies and is expelled during serpentinisation (Taliafero, 1943; Brothers, 1954; Chesterman, 1960). The presence of helicytic trails inside albite porphyroblasts shows, however, that the latter grew during active tectonic movements after the blue amphibole had developed. Besides setting age relations, this period of soda metasomatism is considered coeval with the period of tectonic upthrusting of the Alpurai ultramafic mass. That some of the blueschists are reported to occur within the ultramafic mass (Desio, 1977) is yet another evidence that the former had formed already prior to their tectonic involvement. This tectonic episode can be related to the upthrusting of the Swat Kohistan Complex along the Main Mantle Thrust of Tahirkheli (1979) and hints towards at least one possible field guide to locate blueschists in the Himalaya.

In the above connection, it is essential to note that the Shangla-type blueschists would mark and should be available only along fossil trench areas related to plate subduction zone. The ultramafic bodies in the intra-plate regions, such as in the Harichand area, Dargai, will not carry blueschists as the typical trench-subduction zone was not present.

As far as blueschist of the meta-igneous-type is concerned, the transformation is believed to be predominantly allochemical.

AGE OF BLUESCHIST METAMORPHISM

A K/Ar date for the muscovite from a metasedimentary-type blueschist from near Topsin gave an age of 84 ± 1.7 m.y. or upper Coniacian equivalent to lower Senonian or Upper Cretaceous. This age is early Alpine and compares satisfactorily with other ages obtained from the region. For instance, a pegmatitic hornblende from noritic gabbro of the Upper Swat Hornblendic Complex or the Swat Kohistan Complex gave an age of 67 m.y., which is top Maastrichtian equivalent to top Senonian at the end of the early Alpine period. On the other hand, alkali rocks of the post-orogenic period to the South of the suture zone gave ages that range from 41 to 50 m.y. (Kempe, 1973). Thus, presence of an early Alpine subduction zone running through lower Swat Himalaya can be accepted and can be taken to be continuation of the Indus Suture Line (Gansser, 1964) in the region west and southwest of the Nanga Parbat-Haramosh tectonic protrusion (Shams and Desio, in press).

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