SCHEELITE MINERALISATION IN BHURKHOLA AREA,
SARBHANG DISTRICT OF BHUTAN : AN EXAMPLE
OF SYNGENETIC TUNGSTEN DEPOSIT

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ABSTRACT

Petrographic study of the tungsten-bearing rocks of Bhurkhola area in the Sarbharg district of Bhutan shows that they contain grossularite, hornblende, epidote, quartz, calcite, biotite, diopside, scheelite and sulphides. This mineralogical assemblage was earlier interpreted as skarn, produced from contact metamorphism of the calc-silicate. Lack of hornfelsic texture and typical contact metamorphic minerals in the metasediments, and above all the absence of granite nearby, indicate that contact metamorphism and metasomatism are absent in the area. The scheelite-bearing rock may better be described as skarnoid.

Scheelite occurs in layers parallel to the bedding. It also defines a lineation parallel to the F1 fold axis. Crystallisation of scheelite may accordingly be considered to be synkinematic with F1 folding.

Absence of granitic activity in the area does not support the metasomatic-pneumatolytic origin of tungsten mineralisation. Synkinematic crystallisation of scheelite with F1 folding suggests that tungsten was deposited along with other sediments in the basin. Hence the tungsten mineralisation could be of syngenetnic origin.

INTRODUCTION

Tungsten mineralisation usually occurs in granite, pegmatite, quartz veins and in skarns and greisens developed in the metasediments due to the metasomatic and pneumatolytic action of igneous rocks (Enaudi et al., 1981). Such types of tungsten deposits are seen in Canada (e.g., Cantung, Mahtung), China, Australia (e.g., Kings Island), Korea (Sangdong), India (e.g., Degana, Balda, Pali), etc. However, tungsten mineralisation in the Bhurkhola area of Bhutan seems to be of syngenetnic type. It has no relationship with granitic intrusion, and the metasedimentary rock carrying such mineralisation is a medium-grained calc-gneiss/skarnoid composed of grossular garnet, hornblende, clinzoisite-epidote, biotite, calcite, quartz, diopside, scheelite and sulphides. The evidences presented here indicate that the tungsten mineralisation in the study area may be of syngenetnic type. Syngenetnic type of tungsten mineralisation is also reported from Brazil, Australia (Kwak et al., 1982) and Rajasthan, India (Biswal, 1989; Chande and Biswal, 1989).

REGIONAL GEOLOGY

The Bhutan Himalaya can be divided into three broad E-W trending tectono-stratigraphic belts (Fig. 1; Anon, 1979). These are (1) the Southern Frontal Belt, (2) the Central Crystalline Belt and (3) the Tethyan Belt. All the belts are mutually separated by thrusts. The rocks of the Central Crystalline Belt, ranging in age from Precambrian to Tertiary, and divided into Thimphu Formation (2a) and Paro Formation (2b). The Thimphu Formation consists of a number of rock types, such as medium- to high-grade metasediments, migmatites and granites. A thick sequence of metasediments (average 5 km) occurs all along its southern contact. The metasediments comprise calc-gneiss, biotite
marble, mica schist and graphite schist and carry an impression of amphibolite facies of metamorphism. Scheelite, the tungsten mineral, occurs within the above-mentioned calc-gneiss at many places. The most promising one occurs at Bhurkholæ (26° 58' 40'' : 90° 23' 30''), in the Sarbang district (Fig.1).

**GEOLOGY OF THE BHURKHOLA DEPOSIT**

The Bhurkholæ area is represented by metasedimentary rocks comprising mica schist, graphite schist, quartzite and calc-gneiss belonging to the Thimphu Formation (Fig. 2). Mica schist is the predominant rock type in the area. It is made up of muscovite, biotite, quartz, feldspar and sillimanite in order of abundance. The graphite schist occurs as thin bands consisting of graphite, quartz and calcite. The quartzite is composed of quartz, muscovite and feldspar. The calc-gneiss contains layers of grossularite, hornblende, epidote and biotite alternating with layers of carbonate minerals. The thickness and proportion of different minerals in these layers vary from place to place. Layers composed of grossular garnet, hornblende and clinzoisite-epidote are present in mappable dimension. These calc-silicate layers carrying scheelite and sulphide mineralisation were earlier identified as skarn and the minerals in them were considered to be the product of contact metamorphism (Kishore and Shashidharan, 1990). Since neither there is any granite body nearby nor the contact metamorphic textures and mineralogical assemblages exist in the metasediments, the above-mentioned bands in calc-gneiss can better be described as skarnoids. Coarse-grained skarnoids are less foliated than the fine-grained ones.
The metasediments show imprint of a pervasive cleavage (S₁) parallel to the bedding plane (S₀). S₁ is defined by parallel alignment of flaky minerals such as biotite, muscovite and nematoblastic hornblende (Fig.3). The quartz feldspar and calcite grains show flattening parallel to this plane.

Fig 2: Geological map of Bhurkholu tungsten prospect, Sarbang District, Bhutan.
This schistosity is developed parallel to the axial plane of a system of reclined, isoclinal and rootless \( F_1 \) folds developed on \( S_0 \) surface (Fig. 4). This axial-plane schistosity strikes ENE-WSW with 60° dip towards NNW and imparts an ENE-WSW trend to the lithounits. A set of open folds (\( F_2 \)) with N-S striking axial plane is developed on \( S_1 \) surface. These small-scale structures are also reflected in the large-scale structures of the area. The calc-gneiss band shows \( F_1 \) closure (Fig. 2); the hinge zone occurs in the SW corner of the map and is marked by right-angle intersection between \( S_0 \) and \( S_1 \). The mica schist occurs in the core. The calc-gneiss band does not close near the hinge, but is extended far towards west because of flattening. Extremely attenuated parasitic \( F_1 \) folds are developed in the thin calc-gneiss and graphite schist bands on the northern limb but are absent in the thick calc-gneiss band of the southern limb. Superposition of the open \( F_2 \) fold along N-S axial plane over the \( F_1 \) fold has given rise to hook-shaped outcrop pattern.

**NATURE OF MINERALISATION**

Skarnoids contain tungsten mineralisation in the area. Skarnoid bandings are present in all parts of the calc-gneiss. The skarnoid present in the calc-gneiss of the southern limb of major \( F_1 \) fold has a strike extension of 1.5 km with average width of 15 m and carries economic grade of scheelite mineralisation. 3.6 million tonnes of ore reserve with an average grade of 0.22% of WO₃ has been estimated for 120 m vertical depth of the ore body. The mica schists in close proximity of the skarnoid band also carry scheelite. The scheelite grains are well crystalline and prismatic. The grain size varies between 1 mm and 5 mm. The size of the scheelite grains proportionately varies with the size of the grains of calc-silicates in the skarnoids. Ore microscopic study shows that calcite, quartz and biotite crystallised earlier than scheelite whereas the garnet and hornblende grains are later than scheelite. The scheelite grains occur in layers parallel to the bedding. The scheelite layers show \( F_1 \) folding. Since the \( F_1 \) folds are isoclinal in the area, scheelite layers also show parallelism with axial-plane schistosity in most parts except at the hinge of folds. On the schistosity surface \( S_1 \), distinct scheelite mineral lineations are present parallel to the intersection lineation between \( S_0 \) and \( S_1 \).
ORIENTATION OF MINERAL FABRIC

An attempt is made to correlate the time of crystallisation of the minerals with folding through the study of the mineral fabric. Thin sections parallel to the axial plane of the fold (ab section) and perpendicular to fold axis (ac section) are studied.

‘ab’ section or S1 plane (Fig.5) : In this section the minerals are mostly prismatic with their longest axes parallel to the fold axis (b' direction). Hornblende, biotite and scheelite grains show a distinct linear arrangement with their longest axes oriented parallel to each other. Garnets, although occurring as equidimensional grains, show linear arrangement. Because of this preferred orientation, a perfect mineral lineation is developed on S1 surface.

‘ac’ section (Fig.6) : The section is prepared from the hinge zone of F1 fold. The hornblende, scheelite and garnet grains occur in distinct layers which describe the F1 fold. Hornblende and biotite being triclinic minerals, show the alignment of their longest axes parallel to the axial trace of the fold. Since scheelite is tetragonal, equidimensional basal sections are seen.

The above study indicates that the compositional bands defined by scheelite, hornblende, calcite and biotite trace the F1 fold. These bands, therefore, define the bedding plane in the calc-gneiss. The individual minerals crystallised in such a way that their prismatic sections are oriented parallel to the axial plane of the fold. Since the F1 fold is isoclinal, the prismatic section is parallel to the S0 plane in the limb and cut it at high angle in the hinge of the fold. The longest axis remains parallel to the fold axis.

All these evidences lead to the conclusion that hornblende, garnet, biotite and scheelite are formed during F1 folding and the regional metamorphism is synkinematic to F1 folding.

DISCUSSION

Lack of quartzofeldspathic stringers in the foliation planes, hornfelsic texture in the country rock and high-temperature minerals such as wollastonite and andalusite in the metasediments indicate
that the tungsten deposit is not related to the metasomatic-pneumatolytic activity of granitic intrusion. Moreover, no granite body is present within 2 to 3 km radius and up to 200 m vertical depth in the area studied. Schistose and gneissose textures are intact in the metasediments.

The garnet-hornblende-epidote bands in calc-gneiss of the area were identified by earlier workers (Kishore and Shashidharan, 1990) as skarns, produced due to contact metamorphism; such bands may also be developed by bimetasomatism of calcareous sediments with surrounding argillaceous sediments during regional metamorphism (Newberry, 1988). This bimetasomatism is easily accomplished here because of thinner nature of the calcareous rocks present inside thick formation of mica schist. This has helped in easy exchange of Al, Fe, OH, etc. resulting in the development of alumino-silicates in calc-gneiss. As it is developed during syntectonic regional metamorphism, a planar fabric is developed over it. The resulting assemblage is termed as skarnoid.

Synkinematic crystallisation of scheelite with F₁ folding and lack of granitic activity in the area suggest the presence of tungsten prior to the onset of F₁ folding. Therefore, it is suggested that the tungsten was deposited along with other calcareous sediments in the basin. Scheelite crystallised during F₁ folding and regional metamorphism. Because of tight isoclinal nature of F₁ folds, scheelite and other calc-silicates were concentrated in definite bands which are named as skarnoids. Presence of tungsten brine may be related to volcanic activity in the basin. The association of sulphide minerals with scheelite suggests that tholeiitic-type exhalation might have contributed tungsten into the sea. This type of explanation is given for the syngeneitic tungsten deposit at Broken Hill of Australia (Kwak et al., 1982). Tholeiitic type of rocks are also reported from southern Bhutan (Gansser, 1983).

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REFERENCES


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