The tungsten deposits of Xihuashan, China: Charles S. Hutchison, Dept. of Geology, University of Malaya, Kuala Lumpur

The Nanling Range of S.E. China is the richest tungsten province in the world and Xihuashan is the most important mining district, situated in its central part, in southern Jiangxi province, about 9 km NW of the county town of Dayu, which lies about 100 km SW of Ganzhou city.

The Xihuashan tungsten vein deposits occurs in Early Yanshanian (Jurassic) medium grained biotite granite. The deposits were discovered in 1908. About 3000 tons of ore are now treated daily. Most of the ore veins taper and die out when the Cambrian country rocks are approached. The 615 commercial ore veins are of sizes variable in length from 300 to 600 m generally. Width is generally 0.4 m to 3.6 m. The commercial mineralization extends down to 200 m generally, but never below 300 m. Three sets of fissure veins strike 65° - 75°, 80° - 90°, and 275° - 285°, all steeply dipping.

The gangue minerals are quartz and alkali feldspar. The major ore mineral is wolframite, and it is associated with economically extractable cassiterite, molybdenite, bismuthinite, beryl, scheelite, and rare earth minerals.

The veins show excellent reversed zoning. The high temperature minerals cassiterite, beryl and topaz are common in the upper parts of the veins, while wolframite, molybdenite and bismuthinite are concentrated in the middle levels. They diminish downwards as the low temperature sulphides increase downwards, and the lowest parts of the veins are usually of barren quartz.

Wall-rock alteration is important and pronounced. Greisenization (and silicification) is intense in the upper part but rather weak at depth.

The average grade for the whole deposit is 1.086% WO_3. The tungsten mineralization is mainly concentrated within 200 m below the roof of the granite, with the richest mineralization at the top of the cupola roof and at the contact between different granite phases. Local enrichment occurs where two or more veinlets intersect.

Mineralization was in the order (early silicates, oxides, sulphides, carbonates late), and was related to a range of sub-solidus magmatic-

hydrothermal phenomena, beginning with alkali metasomatism, through albitization, to greisenization.

The Dangping tungsten-beryllium deposit lies 4 km north of Xihuashan, with which it shares the same geology. Over 210 veins are commercial. This deposit was located and surveyed in 1958. The quartz veins all occur in E-W fissures (75 - 85%) dipping generally at 85°. Average length of a vein is 251 m, average thickness 0.3 m. The veins extend down to 200 m. Branching and swelling is common. The veins die out into the Cambrian country rock (hornfels) and mineralization is confined to the Early Yanshanian granite.

The main ore minerals are wolframite and beryl, with bismuthinite, scheelite and chalcopyrite being of secondary importance. Quartz is the main gangue, occurring with muscovite, fluorite, and calcite. The commercial wolframite mineralization extends to a depth of 60 to 80 m below the contact with hornfels, but beryl and molybdenite extend as deep as 80 to 100 m. High tungsten correlates with low beryllium, and vice versa. The mineralization stages are (1) W - Mo, (2) W - Be - Mo (3) W- sulphide. Wall rock alteration is mainly greisenization.

The Piaotang tungsten-tin vein deposit is about 18 km NE of Xihuashan. It is a cassiterite-wolframite polymetallic quartz vein deposit, controlled by NE and E-W fissure vein systems. Two igneous rocks types intrude the Middle to Upper Cambrian flysch rocks. They are quartz diorite (exposed) and biotite granite (occurring at depth). The diorite is Hercynian (274 Ma) and the granite is Early Yanshanian (Jurassic). It is the granite that was responsible for the mineralization, which occurs within the sediments, strongly hornfelsed to andalusite-biotite-chlorite assemblages. 11 veinlet zones and 5 large veins are commercially mineralized, mostly within the hornfels. The largest main vein (No. 3) is over 1200 m long and extends 600 m down, with a width varying from 10 m to over 40 or more. It is composite, made of several veinlets, E-W trending, containing cassiterite-wolframite. There are 4 metallogenic periods and 7 hydrothermal episodes:

1. *garnet-diopside-actinolite skarn stage*
2. *molydenite-beryl-quartz veins (minor wolframite)*
3. *cassiterite-wolframite-quartz veins (minor beryl)*
4. *sulphide-cassiterite-wolframite quartz veins (main episode)*
5. *sulphide quartz veins (with minor wolframite)*
6. *sulphide-chlorite quartz veins*
7. *fluorite-carbonate veins (with minor pyrite)*

There is a complex overlap of the stages near the granite, in the inner zone.

The frequency of veins and the richness of mineralization increases downwards to the granite contact. When any vein system extends into the granite, its complexity is lost and is replaced by a single quartz vein.

Isotope studies indicate that the mineralization results from metal transportation by hydrothermal waters of magmatic origin.

The Dalongshan Tungsten-Molybdenum vein deposit lies about 13 km NE of Xihuashan. This is a large quartz vein deposit in Cambrian country rocks. The 30 commercial veins are generally 500 m long. The longest is 800 m. They extend to a depth of 300 to 500 m, with thicknesses of 1.0 to 0.25 m. Tungsten and molybdenum are the main elements, but tin, bismuth and beryllium are important by-products. The mine *began in 1955. The responsible granite is of Early Yanshanian (Jurassic) age, found at depth in the mine.*

There are 3 vein trends: WNW, NW and ENE. The mineralogy is extremely varied and includes: wolframite, molybdenite, cassiterite, native bismuth, bismuthine, scheelite, chalcopyrite, pyrite, pyrrhotite, beryl, bismuthinite, tungstic ochre, covellite, quartz, muscovite, lepidolite, fluorite, calcite, chlorite.

The following stages are recognized: 1) W-Mo, (2) W-Be-sulphides (main), (3) Be-pyrite, (4) calcite-fluorite. Cassiterite in the outer zone is different both in colour and crystallinity from the inner zone.

Wolframite is richest where veins branch, thicken, or change dip. Where there is wall rock alteration, the mineralization is richest. This includes silicification and greisenization, tourmalinization, topaz enrichment, sericitization and chloritization.

General Comments

The polycyclic igneous events of S.E. China range from Donganian (Middle Proterozoic), through Xuefengian (Upper Proterozoic), Caledonian (Devonian), Hercynian-Indosinian (Triassic), Early Yanshanian (Jurassic) to Late Yanshanian (Cretaceous). From the earliest to the latest, the granites become progressively depleted in siderophile elements such as vanadium, chromium, cobalt and nickel, and also in zinc, copper and lead. By contrast, those elements which have a strong affinity for the continental crust, such as tin, tungsten, molybdenum and beryllium, become progressively richer in the younger granites.

The Chinese view is that these elements became concentrated in granitic magmas that were ultimately derived from the Lower Palaeozoic or Proterozoic sedimentary strata (the source beds). Polyphase granitic activity caused tin and tungsten to become progressively enriched in the younger granites, derived originally from the source beds, but mobilized several times through anatectic granitic magmatism of S-type.

Also, at sub-solidus temperatures, the W and Sn is enriched in the hydrothermal quartz veins and greisen zones as a result of alkali feldspar metasomatism within the deeper parts of granite cupolas. This alkali feldspar formation caused the release of W and Sn, which is then deposited at the greisenization stage at the contact zone with the country rocks.

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