DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

ATLAS OF METAL AND NONMETAL MINERAL PROVINCES, CONTERMINOUS U.S.
OPEN-FILE REPORT 79-576C
HOBBS AND TOOKER—TUNGSTEN


PRECAMBRIAN SHIEI D
LAKE SUPERIOR
CORDILLERAN BELT
CENTRAL PLAINS
COLORADO PLATEAU
COASTAL PLAINS
APPALACHIAN BELT
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
Mill City
Pine Creek
Emerson
Searles L.
Atolia
Climax
Boulder Co
Hamme
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EXPLANATION
Inferred boundary of tungsten province, where possible to define--Number index in table 1
Approximate boundary of major physiographic region
Inferred boundary separating accreted Phanerozoic oceanic crust and old continental crust underlain by Precambrian basement rocks
Deposits whose production, minable minerals, and potentially minable materials generally exceed 10,000 short tons of tungsten metal (valued at >$96 million)
Type A--Active mines having production of tungsten in 1975 survey (Mining Magazine, 1976)
Type B--Inactive mine, temporarily inactive past producer considered mined out, or high-potential unmined deposit and active mine, whose current small production was not reported in mining survey
Deposits and occurrences whose production, minable minerals and potentially minable materials range from none (undetermined) to 10,000 short tons tungsten
Type C--Present or possible producers and unevaluated tungsten occurrences

Planimetric base from National Atlas 1:7 500 000, 1970

SCALE 1:5 000 000
100 0 100 200 300 400 500 MILES
100 0 100 200 300 400 500 600 700 KILOMETRES

PRELIMINARY MAP OF TUNGSTEN PROVINCES IN THE CONTERMINOUS UNITED STATES

BY

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Introduction

Tungsten is a commodity whose usefulness and critical importance is related to its unique characteristics, especially to the physical and mechanical properties that it imparts to its compounds and alloys--extreme hardness, the ability to retain hardness and strength at elevated temperatures, high tensile strength, and high resistance to wear. The United States has minable tungsten minerals sufficient to last approximately 15 years at projected rates of use, should all our supply come from known domestic sources. However, imports that came mainly from Canada, Bolivia, Thailand, and Peru (U.S. Bur. Mines, 1976) accounted for more than half of the tungsten used in the United States in 1975. The continuation of such imports together with increased recycling of tungsten alloys, and the use of expensive and inferior substitutes when necessary, will prolong the known domestic supply. The projected increased demand for tungsten (Stevens, 1976) and inevitable eventual depletion of known minable minerals, however, make it imperative that new supplies be found and developed. We believe that the potential for such new discoveries in the conterminous United States is good and that our minable minerals can be greatly extended through geologic research and exploration.

The map of tungsten provinces locates the district, mine, or occurrence areas where tungsten has been found; shows their relative sizes; and outlines those areas where the best potential still lies for the discovery of hypothetical deposits. The map also shows the distribution of some geologic provinces and physiographic regions whose relation to known tungsten deposits may be used as guides to the broader search for this metal.

The map was compiled mainly from the published reports (Lemon and Tweto, 1962; Hobbs, and Elliott, 1974), unpublished records of tungsten resource specialists, and data from the Computerized Resource Information Bank (CRIB) of the U.S. Geological Survey. The assistance of E. K. Keefer and G. T. Mason, Jr., in updating CRIB tungsten files and computer graphics is gratefully acknowledged. Geologic data are from the geologic map of the United States (King and Beikman, 1974). The rationale of province maps and most of the technical geologic terms used are discussed and explained in a companion background report by Tooker (1979).

Characteristics of tungsten provinces

The map shows the location and delineation of tungsten provinces each of which contains a more or less discrete grouping of tungsten districts, mines, prospects, and occurrences. In addition, the boundaries include any subeconomic occurrence of tungsten, large geochemical anomaly, or geologically favorable terrane.

The deposits and occurrences are classified on the basis of size (past production plus expected minable minerals, if any) as defined in part by Lemmon and Tweto (1962) and mining activity (Tooker, 1979). Large deposits of tungsten, those whose combined production and expected minable minerals exceed 10,000 short tons of tungsten metal or 1,261,000 short ton units WO_3 (valued at >$110 million in 1975 prices and equivalent to about 1.5 years demand for primary tungsten are of two types: Type A includes those large mines in production in 1975 that were included in the international mining survey of major world mines (Mining Mag., 1976); type B includes those large mines that are considered mined out, were inactive in 1975, have since been brought into production, are still producing at a much reduced level, or that have yet to be mined but contain large known potential tungsten resources. Deposits and occurrences with combined production and minable minerals between 0 (undetermined) and 10,000 short tons tungsten metal are included in type C. Such mines have had limited or no production and represent present or possible future producers as well as unevaluated tungsten occurrences.

The commercially important tungsten minerals are those of the wolframite group--ferberite, wolframite, and huebnerite--and scheelite. Although tungsten minerals are the only product recovered from many deposits in the United States, they are also recovered as a coproduct or byproduct of such commodities as molybdenum, copper, manganese, antimony, and zinc in some deposits. The two most important operating tungsten mines in the United States produce molybdenum and one of them some copper. Most deposits seem to have a close spatial and genetic association with granitic intrusive rocks and their related porphyries. The deposits occur mostly in quartz veins, contact-metamorphic (tactite) rock, and stockworks formed at high to intermediate temperatures in deep- to intermediate-seated bodies. Less commonly, they occur in hot springs, lake brines, and placers formed at low temperatures on or near the Earth's surface. Hobbs and Elliott (1973) provide more detailed descriptions of these mineralogic and occurrence features; Stevens (1976) discussed the economic availability of the minable minerals of tungsten.

Tungsten provinces

Eighteen provinces, or areas having possibilities of becoming future provinces, are shown on the map and listed in table 1, on the basis of the distribution of data points and presently understood geologic relations. The first six provinces are listed in their relative order of resource importance; the remainder are numbered arbitrarily owing to a lack of sufficient systematically collected data that would permit full delineation of provinces and their potential for minable tungsten minerals. Table 1 also shows the variety of geologic occurrences in each province, where known, and provides an evaluation of future resource potential for the province and an estimate of the status of tungsten resource knowledge in each. Clearly, the Cordilleran belt contains virtually all present possibilities, but the presence of one large deposit as well as scattered other deposits and occurrences in the Appalachian belt suggest that a systematic search for tungsten is warranted in this less well explored geologic terrane.

The great preponderance of tungsten deposits in the United States is located within the western part of the old (Precambrian) block of continental crust and along its junction with the younger accreted (Phanerozoic) block of oceanic-island arc crust. Most of the major domestic deposits and occurrences in provinces 1, 3, 5, 6, 7, 8 (in part), and 11 (possibly) lie in a broad band along this western boundary. They are generally associated with large Mesozoic granitic intrusive bodies, commonly in adjoining tactite (contact metamorphic) zones and veins in the igneous rocks as well as in the enclosing sedimentary and metamorphic rocks. A second group of tungsten provinces (2, 8, 9, and 11), which occurs within the continental crustal block, seems to be associated with younger (Cenozoic) plutons generally clustered around the Colorado Plateau. A third group in the Cordilleran belt, perhaps more closely related to Precambrian rocks is along the northeast border of the belt in provinces 14, 16, and 17. The presently subeconomic tungsten concentrations in Searles Lake, Calif., brines represent a large untapped potential resource.

Some of the provinces elsewhere are poorly defined and understood and should be considered only as potential tungsten provinces until more data for evaluation are obtained. These localities do, however, give some clues about geologic associations of this metal that differ somewhat from those of the main producing mines and that may lead to new discoveries. For example, the sparse disseminated tactite and vein types in the Klamath Mountains (Oregon and California) and the Sierra Nevada foothills, California, seem to be associated with granites of early Mesozoic age, instead of with the predominant, somewhat younger (later Mesozoic) granites of most other Cordilleran Belt deposits. The Hamme deposit in North Carolina, and other central and eastern localities are vein-type deposits that are associated with still older igneous rocks. The Llano occurrence in Texas and other deposits in Colorado and Wyoming are examples of tactite occurrences in a Precambrian terrane. The Colorado Front Range deposits (Tweto, 1960) and the Black Hills replacement deposits in Paleozoic limestone may have been derived from a Precambrian source by remobilization and redeposition. The geologic data for the central and eastern part of the United States are far too speculative, fragmentary, and incomplete with respect to tungsten for us as yet to propose definite provinces. The regions of southeast California and southwest Arizona are also too poorly known to fully assess their potential as provinces.

References cited

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Table 1.--*Locations, type of deposits, estimates of resource potential, and status of resource information of tungsten provinces*

Province			Geologic types of deposits[1]	Preliminary estimates of resource potential			Status of geologic information for resource assessment	
No.	State	Area		High	Medium	Low	Adequate	Insufficient
1	California and Nevada	Sierra Nevada batholith, northwest Basin and Range plutons.	I,II,III,IV,V	X?	--	--	--	X
2	Colorado	Front Range mineral belt.	I,II,III,IV,VI, VII,VIII	X	--	--	X?	--
3	Idaho and Montana	Idaho and Boulder batholiths.	I,II,III,IV,V	X?	--	--	--	X
4	Eastern North Carolina	Hamme district.	I	--	X	--	--	X
5	Southeastern California and southwestern Arizona	Mojave Desert.	I,III,V,VI,VII	--	X?	--	--	X
6	California	Searles Lake.	VIII	X	--	--	X	--
7	Washington and Idaho	Northern borders.	I,II,III.IV	--	--	X	--	X
8	Eastern Nevada and western Utah	Basin and Range province.	I,II,III,VI	--	X	--	--	X
9	Arizona	South edge, Colorado Plateau.	I,II,III,VI	--	--	X	--	X
10	Arizona	Southern.	I,III,VI,VII	--	--	X	--	X
11	Southeastern Arizona and southwestern New Mexico	Rio Grande trough.	I,II,III,IV,VI	--	--	X	--	X
12	Northeastern Oregon		I,II,III,VI	--	--	X	--	X
13	Oregon and California	Klamath Mountains and Sierra Nevada foothills.	I,II,VI	---Unknown---			--	X
14	Montana	West edge, Central Plains.	I,II,III	--	--	X	--	X
15	Montana	Central.	II,III	--	--	X	--	X
16	Wyoming	Atlantic City.	I,II,III	--	--	X	--	X
17	South Dakota	Black Hills (uplift).	I,II,IV	--	--	X	--	X
18	New England States	Diffuse.	I,III,IV	---Unknown---			--	X

[1]Main types of deposits (Lemmon and Tweto, 1962).
I Quartz veins in granite and adjoining sedimentary rocks (commonly associated with gold and base-metal sulfides).
II Breccia, shear, and altered (including replacement) contact zones.
III Tactite, contact-metamorphic skarn zones adjoin granitic plutonic rocks.
IV Pegmatite.
V Placer.
VI Disseminations in sedimentary rocks (including volcanogenic and metamorphosed types).
VII Porphyry dissemination.
VIII Brines and hot-spring deposits.

Background information relating to this map and others in the Atlas of Metal and Nonmetal Provinces in the Conterminous United States is published as U.S. Geological Survey Circular 792 (Tooker, 1979), available free of charge from the U.S. Geological Survey, Reston, VA., 22092