



JOURNAL
OF THE
WASHINGTON ACADEMY
OF SCIENCES

VOLUME VII, 1917

BOARD OF EDITORS

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BUREAU OF STANDARDS

ADOLPH KNOPF
GEOLOGICAL SURVEY

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BUREAU OF PLANT INDUSTRY

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE
WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
THE WAVERLY PRESS
BALTIMORE, MD.

MINERALOGY.—*Tungstenite, a new mineral.*¹ BY R. C. WELLS and B. S. BUTLER, Geological Survey.

Although two sulphides of tungsten are described in textbooks of chemistry, none has hitherto been found as a mineral. It is therefore a pleasure to announce the discovery of tungsten sulphide as a prominent mineral in certain specimens of ore from the Little Cottonwood district, Utah. The analysis of the complex mixture in which tungsten sulphide occurs has proved unexpectedly difficult, so that it is not yet possible to state definitely the formula of the sulphide, although it is believed to be WS_2 . As it will require considerable time to complete the necessary analytical determinations it seems advisable, in view of the unusual character of the material, to publish our preliminary results at this time. On account of the apparent resemblance to molybdenite in formula and some of its properties the new mineral has been named *tungstenite*.

The material in which tungstenite was found was given to Mr. V. C. Heikes, of the Salt Lake City office of the United States Geological Survey, by Mr. J. J. Beeson, geologist for the Emma Consolidated Copper Company, of Little Cottonwood district, Salt Lake County, Utah, with the suggestion that it be tested for selenium. Mr. Heikes forwarded the material to one of the writers (B. S. B.), who has been engaged in geological work in the district and who later, with F. C. Calkins, examined the deposit from which it came, though this was before the character of the mineral had been determined. The chemical examination and recognition of the tungsten sulphide was by the other writer (R. C. W.). No selenium could be determined, but on treating some of the material with aqua regia a yellow insoluble powder was noted and identified as tungstic oxide. Further study indicated that the tungsten is present as sulphide very intimately associated with a number of other minerals.

The Emma mine, from which the material was obtained, is located in the Little Cottonwood district, Salt Lake County, Utah, about 25 miles southeast of Salt Lake City. The mine was

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an important producer of lead-silver ores in the seventies. The ore shoot was followed until it was cut off by a fault. Attempts at the time to locate the continuation beyond the fault were unsuccessful and the mine was idle for many years. In 1916 Mr. Beeson by a detailed geologic study procured data that in 1917 led to the finding of the extension of the ore shoot. It was from this extension below the oxidized zone that the material here described was obtained.

TABLE 1
CHEMICAL ANALYSIS OF TUNGSTENITE (By R. C. W.)

	PER CENT	FOR TEN- NANTITE AND TETRA- HEDRITE	FOR PYRITE	FOR GALENA	FOR TUNG- STENITE	ATOMIC RATIO
W.....	44.7				44.7	1.00
S.....	29.1	2.5	9.2	0.6	16.8	2.18
Fe.....	8.8	0.8	8.1			
Zn.....	0.4	0.4				
Mn.....	0.6	0.6				
Ni.....	0.3	0.3				
Pb.....	4.1			4.1		
As.....	1.0	1.0				
Sb.....	0.8	0.8				
Cu.....	1.3	1.3				
Ag.....	0.4	0.4				
SiO ₂	0.3					
H ₂ O.....	0.7					
Undetermined.....	7.5					
	100.0	8.1	17.3	4.7	61.5	

Two specimens of the material were examined chemically. The first specimen contained a much slickensided substance resembling graphite intimately associated with quartz, calcite, pyrite, galena, and various accessory minerals. Tungstenite was identified in the slickensided material but it was not the only mineral present. The second specimen appeared to be much purer than the first and an average sample of it was analyzed with the results shown in table 1. This specimen was of a uniform gray color where it had been broken from a larger piece, but two sides were somewhat slickensided. On close examination

abundant small somewhat rounded grains of pyrite could be detected in it. A polished section revealed a little galena also. The analysis indicates tennantite and tetrahedrite, which were not distinguished in the single polished section of the material examined. A portion of the polished section which had a slightly bluish tinge was identified by microscopic reaction as tungstenite. The tungstenite is so soft that it wears away much faster than pyrite during polishing. The hardness appears to be about 2.5. Particles which are very easily cut from the massive piece with a knifeblade appear under the microscope to consist of feathery leaves or flakes resembling graphite. The mineral is opaque. It marks paper, soils the fingers slightly, and rubs up between a mortar and pestle like graphite. The cleavage and fracture could not be determined. The luster varies from dull to brilliant metallic; the color is dark lead gray; and the streak is dark gray. The actual specific gravity of the second specimen mentioned was 6.43. Allowing as well as possible for the impurities and undetermined material, the specific gravity of the tungstenite is calculated to be about 7.4. This may be compared with the following specific gravities, MoS_2 4.7, FeS_2 4.9, MoO_3 4.5, WO_3 6.3.

Tungstenite appears to be unattacked by hydrochloric acid or nitric acid. It is decomposed by aqua regia or by fusion with sodium nitrate. Its behavior in a bulb tube and on charcoal can not be stated definitely because of the impurities, though it appears to be a rather stable compound, not even being oxidized, by roasting in air. It burns with incandescence in oxygen.

Tungsten was determined by decomposing the ore with aqua regia. The solution was evaporated to dryness and the insoluble material taken up in dilute hydrochloric acid and filtered off. After extracting it with ammonium acetate to remove any lead sulphate present it was heated with ammonium hydroxide. A few per cent of residue remained insoluble in ammonia and contained some tungstic oxide, a little silica, some iron, and other material not yet determined. The filtered ammoniacal solution was evaporated to dryness and the residue was ignited and weighed as tungstic oxide. The other constituents were determined as in the analysis of tetrahedrite, after decomposing a portion of

the ore with chlorine in a hot tube. As the analysis stands the sample analyzed consists of 8.1 per cent of tennantite and tetrahedrite, 17.3 per cent of pyrite, 4.7 per cent of galena, and 61.5 per cent of tungstenite.

The geology of the district in which tungstenite has been found may be briefly summarized as follows: A series of Paleozoic limestones, shales, and quartzites, and pre-Paleozoic quartzites and shales, has been much broken by thrust faulting and subsequently intruded by quartz monzonite and quartz diorite which occur as stocks. Following the intrusion and accompanying mineralization there was much normal faulting and some reverse faulting.

The Emma ore body occurs as a replacement of a brecciated zone in Paleozoic limestone where it is crossed by a mineralizing fissure. The ore shoot follows the intersection of the breccia zone and fissure, pitching rather steeply to the northeast. About 450 feet below the outcrop the ore shoot is cut off by a strong fault, the continuation on the opposite side of the fault being about 250 feet lower. There is very little oxidized material in the portion of the shoot below the fault from which the tungstenite was taken.

The important vein minerals are quartz, galena, pyrite, tetrahedrite, argentite, and possibly some other silver minerals not yet determined. The detailed study of the ores will probably reveal other minerals. For a part of the shoot at least, the central portion consists mainly of rather fine-grained quartz that has almost completely replaced the limestone and that contains but relatively small amounts of metallic minerals. Surrounding this is a zone in which the limestone is less completely replaced and metallic minerals are more abundant.

Pyrite was the earliest metallic mineral to form in the deposit and this was followed by the galena, tetrahedrite, silver minerals, and tungstenite. The tungstenite is apparently in part contemporaneous with the galena and in part later than the galena. The fact that the specimens containing the most of this mineral have been found near a minor faulted zone suggests that there may have been an enrichment in tungsten along that zone, though that is not certain.