A STUDY ON THE CONCENTRATION TESTS AND BENEFICIATION OF THE ULUDAĞ TUNGSTEN ORE

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INTRODUCTION :

Wolfram is, in the real sense of the word, the strategic metal of our age. Up to the turn of the century this metal had practically no commercial value, and it was after the manufacturing of high - speed steel cutters exhibited at the Paris exposition in 1900 that the wolfram metal gained importance. Wolfram has the highest fusion degree (3410° C) among metals, and hence, this led to its use in the filaments of electric bulbs, which consume only 1 % of the wolfram products.

An important consumption line of the wolfram metal is the manufacture of such tools as drill bits, cutters, shapers, etc., as wolfram carbide is the hardest of the artificial materials. Armor piercing shells treated with wolfram carbide were responsible for many unexpected results in tank battles during World War II.

Today wolfram plays an important strategic part in the application of high-temperature resisting steel used in jet planes, gas turbines etc., because no other metal can substitute it in this respect.

HISTORY

The author of this report saw wolfram minerals in the province of Bursa first in 1950, scheelite minerals in the outcrops of (molybdenite, pyrrhotite and magnetite) granitic-limestone contact ore occurence of the Kuzbudaklar-Delice Köy region, 10-12 kms. south of Uludağ, while prospecting radioactive and rare minerals (1,2). M.T.A. decided to stake the wolfram occurrence in Bursa in 1951; the author and N. Danışman went to this district and observed that mineralization has spread on a large area along the contact. In examining also the Uludağ massif (mountain) (3) they have found scheelitic ($CaWO_4$) tactite outcrops, occurring in the granite - marble contact near the summit (photo 1). The rich and large and the most promising outcrop, southwest of the Çayırlı Dere Lake, has been later on the basis of No. 1 exploration pit (photo 2).

Here the pits went through an ore, 65 m. in length and averaging 1.54 % WO_3.

GEOGRAPHIC POSITION

The mineralization area is situated at an elevation of 2100-2300 m. northeast of the western summit of Uludağ-(elevation 2486 m.) which is one of the highest mountains of the north-western Anadolu. The area is 15-16 kms. distant from the city of Bursa at bird's flight and has an access to the city by a 44 kms. road, part of which is asphalt paved. There is a good road 32 kms. in length from Bursa to Mudanya, the port of export of the former.

GEOLOGY

The Uludağ massif consists of a big anticline, 40 kms. long and 20 kms. wide, WNW-ESE and sloping gently towards the south (4).

The main structure of the mountain comprises of crystalline schists and granitic plutons. The paleozoic marbles forming the summits in the region prove to be a secondary syncline.

Intrusions (5) of granitic plutons making up the nucleus of the massif, contact the limestone along an area of 4 kms. south of Kuşaklıkaya from the Çayırlı Dere Lake, in the northern part of this syncline, thereby giving rise in several parts consisting of contact minerals (Photo 1). The largest of the tactite masses and the richest, so far as the scheelite content is concerned, are the occurrences from Çayırlı Dere Lake (photo 2). This region is the east end of the granite-limestone contact at the surface, which contact plunges under the gneiss, amphibolite-limestone contact zone towards the east. From the genesis point of view, the occurrence appears to be a contact-pneumatolithic and a high hydro - thermal formation.

Structure of the Scheelite Occur rence :

We have, by drilling and by opening pits, established in the scheelitic scarn occurrence areas of the Çayırlı Dere, at a depth of over 100 meters, a granitic-limestone contact gently sloping towards the south and to the east.

The upper part of the granite has undergone metasomatosis and abounds in scheelite. Following that there is the so - called floor zone which does not contain tactite. Calcite, quartz, feldspar, tremolite, muscovite, pyrite, magnetite, scheelite, wolframite, blende, fluorspar and apatite have been at the above sequence order observed under microscopic examinations. Parallel to the granitic contact the tactite lenses, which form bands in the limestones and which are generally separated from the floor zone by limestones, are poor in average scheelite content as compared to the said zone, but are in large number so far as the reserve is oncerned. The tactite lenses contain the following minerals (sequence order according to the quantity hereof): garnet, diopside, quartz, calcite, tremolite, epidote, pyrite, magnetite, limonite, scheelite, actinolite, fluorspar, hematite, blende, chalcopyrite, chlorite, malachite, apatite, and sulpho- bismuthite of lead (please refer to special supplemental tests).

Proven Reserves :

The investigations (8) have established that there are 10 000 000 tons of proven reserves averaging 0.434 % of WO_3; of which reserves 3 000 000 tons are in the lower zone (ore - bearing limestone granite) with an average of 0.618 % WO_3 and 7 000 000 tons at the upper zone (tactite) averaging 0.356 % WO_8.

Probable Reserves;

The estimation of the proven reserves referred to above, is limited to the areas where drilling has been carried out. The masses continue towards the east along the contact zone. During exploitations it will be necessary to explore by drilling this area which probably constitutes the larger part of the reserves.

It will be proper to point out here that new reserves can be explored by detail prospections based on what is seen in the granite-limestone contacts of the neighbourhood.

Comparison of these Reserves with the World Reserves :

The following tabulation is illustrative of the countries where there are important wolfram reserves and of the tonnage of the reserves in terms of 60 % WO_3 concentrates :

China	1 865 798	metric	tons
USA	80 000	short	»
Burma	80 000	»	»
Brazil	45 000	»	»
Bolivia	40 000	»	»
Korea	25 000	»	»
Portugal	20 000	»	»

Despite the fact that the above figures are based on the information furnished in 1938 - 1945, it gives us a fair idea thereon. By producing 60 % WO_3 concentrate with an approximate recovery of 70 %, 50 000 metric tons of wolfram concentrate can be produced from the 10 000 000 proven ore reserves at Uludağ. According to the table Turkey ranks fourth in the wolfram reserves of the world, after China, U.S.A. and Burma.

Reserves proven in 1950 by drillings, of the King Island Wolfram mine, which is actually mined and is known to be the largest scheelite occurrence, has a reserve of 2 625 000 tons (0.64 % WO_3) (10). Whereas in the lower zone of Uludağ alone, 3 000 000 tons of ore nearly of the same grade have been proven to exist. Consequently the wolfram mine in Uludağ is one of the largest scheelite mines of the world.

Concentration of Scheelite :

The fact that the minimum prescribed for the sales of scheelite concentrates is 55 % — 65 % WO_3, and that the grade of the workable ore is about 0.4 %, suffices to show that it would not be easy to obtain economically higher yield from the concentration process. With a view to making use as much as possible of the domestic reserves, the USA has fixed the prices when these were the highest guaranteed, to pay them by 1958. Therefore the price of the domestic wolfram ore in the USA is about twice as high as that of the wolfram ores imported from abroad. Consequently the wolfram ore handling plants in the USA may use, to get higher yields, as much as possible cost raising methods (such as flotation - chemical solution), whereas the other countries often make sacrifices from yields so that the cost price might be low.

We have conducted the tests always by methods permitting industrial production.

Samples, Basis of the Tests:

In discussing the geological structure of the occurrence, it was pointed out that the upper zone contained ore-bearing tactite and that the lower zone contained ore - bearing limestones and granites. The lower zone has been studied only by drillings. Of the upper area, 3 kinds of samples (garnetic, pyritic and limonitic) of ores bearing tactite have been picked - up, as based on their mineralogical structures. Although it seems impossible to handle these three ores separately, yet it has been deemed proper to study them separately with a view to obtaining comparative work results in the concentration tests.

As the garnet scarn type constitutes 60 %-70 % of the ore of the upper zone, this type has been taken as a basis. The pyritic tactites form 20 % - 30 % and the limonitic tactites, hardly 10 % of the ores. The average density is 3.35 (8).

No test has been made on the lower zone ores; however according to the mineralogical determinations, inasmuch as 80-90 % of the ore is quartz, calcite and feldspar and since the presence of such minerals (non-magnetic heavy oxide minerals) hampering concentration, has not been detected, a plant to handle the upper zone ores can easily handle the lower zone ores.

The lower zone contains also wolframite (Fe, Mn WO_4). Therefore the ratio of this mineral to scheelite has to be determined in the first place, and should the presence of wolframite prove to be significant, then it would be better to handle the lower zone ore in the plant, but separately, as if handled with the ore-bearing tactite, the wolframite will be separeted on the magnetic separator together with garnet.

Study of the Samples Containing Garnet:

729 kg. of ore collected from the 18 th meter of pit No. 2, were, without breaking or grinding for average samples, picked under ultra - violet lamp at the onset of the concentration for the separation of the sterile ores. To serve this purpose, pieces larger than 7 cm. were well washed with water and picked with the ultra-violet ray. As 90 % of the scheelite crystals are smaller than 2 m/m this operation was rather difficult; the results obtained thereform are as follows:

	Qty.	WO_3 Content
Pieces larger than 7 cms	% 5	0.80 %
Sterile pieces	% 1	0.20 %
Scheelitic »	% 4	0.96 % .

The above figures show that the sterile pieces are not sterile in the very sense of the word, and that they contain higher WO_3 than the plant resudie, but in consideration of the fact that the quantity is only 1 % of the ore handled at the plant it should be disregarded for the Uludağ ore.

Preparation of the Average Sample:

For chemical analysis the ore in its entirety has been reduced by the cone and quarter method and crushed in the jaw - crusher to 28 6 mm., 6.68 mm., and in the crushing rolls to 2 mm. and the portion to be analysed ground in the disc - pulverizer.

The chemical analysis of the average sample is as follows:

WO_3	0.69 %
Fe_2O_3	15.84 %
MnO	2.54 %
CaO	21.57 %
MgO	2.59 %
Al_2O_3	8.50 %
SiO_2	42.36 %
S	0.15 %
Ignition loss	6.04

Mineralogical Structure of the Ore:

80 % of the minerals consist of garnet, diopside and tremolite (photos 3 and 4). The additional minerals are found in the following sequence order: quartz, calcite, pyrite, blende, epidote, magnetite, scheelite, limonite, hematite, actinolite, chlorite, hedenbergite and chalcopyrite. Malachite, fluorspar and apatite are rarely observed.

Separation of Scheelite :

From a comparison of the densities of these minerals it is clear that these minerals can be separated gravimetrically from seheelite :

	d	hardness
Scheelite	5.90-6.20	4.5-5.0
Magnetite	4.96-5.18	5.5-6.5
Pyrite	4.95-5.17	6.0-6.5
Hematite	4.90-5.30	5.5-6.5
Garnet	3.50-4.30	6.5-7.5
Malachite	4.00	3.5-4.0
Separation limit		
Diopside	3.01-3.6	5.5-6.0
Epidote	3.02-3.5	6.0-7.0
Calcite	2.7	3.0
Quartz	2.65	7.0

The methods applied in the industry are based on this principle. Consequently, the scheelite concentrate obtained by this method contains in ample quantities minerals whose densities are over 4. Therefore for the preparations of these minerals a second process is required. The easiest way to separate pyrite and the other sulphides is no doubt flotation. Another way which is most frequently practiced in industry is the roasting method, whereby these sulphides become magnetic. With the exception of malachite all other heavy minerals can be removed by a magnetic separator.

On the other hand, as it will be seen from the degrees of hardness of these minerals, the soft scheelite crystals which will be subject to grinding among abrasive minerals such as quartz, garnet and epidote are suitable to yield slime in ample quantity.

As for the concentration of very small particles this can be made only by means of flotation. In the U. S. A. establishment of the wolfram prices at higher levels enabled the application of flotation and chemical methods which are costlier but which keep the yield high. Whereas in other countries flotation is only applied to recover fine and high grade residues.

Grain Liberation :

With a view to determining the liberation and the breaking up of the scheelite during grinding, which plays an important part in the selection and application of ore dressing methods, an average sample has been ground so as to pass through 10-mesh (1.651 mm) sieve, The sieve analysis and the WO_3 percentages are as follows :

	Qty	WO_3
Mixed scheelite grains :		
over 20 - mesh sieve	25.6 %	0.75 %
» 28 » »	15.2 %	0.82 %
Free scheelite grains :		
over 35 - mesh sieve	11.2 %	0.96 %
» 48 » »	6.4 %	0.96 %
» 65 » »	9.2 %	0.91 %
» 100 » »	7.6 %	0.83 %
» 150 » »	5.6 %	0.70 %
» 200 » »	5.2 %	0.80 %
» 325 » »	4.0 %	0.77 %
under 325	10.0 %	0.70 %

Examination of the WO_3 content shows to us that scheelite breaks up uniformly along with the other minerals during the grinding process. Dispersal of quantities in between the sieve shows that the ore is subject to a normal breaking up; however, the parts which went through the 325 - mesh sieve can be considered to be schlamm in the gravimetric table concentration, which part corresponds to 1/10 of the ore.

The binocular microscopic examination of the grains has shown that these grains must be ground so as to pass through the 28 - mesh sieve in order that over 90 % of the scheelite crystals may be set free (photos 5 and 6).

Tabling, Flotation and Magnetic Separation Tests :

10 kg. of ore were crushed in the jaw - crusher to a size of 6 mm. which

ill turn was ground, in the crushing rolls, to go through 28-mesh (0.589 mm.) sieve.

Sieve - analysis	+ 35 mesh		13.2 %
	+ 48	»	16.0 %
	+ 65	»	16.8 %
	+100	»	15.2 %
	+150	»	9.2 %
	+200	»	8.4 %
	+325	»	7.8 %
	—925	»	13.4 %

The ore was divided into 3 parts, namely, + 65 mesh sieve product + 200-mesh sieve product and under 200 mesh sieve product, to be tested on the table.

The middlings obtained by tabling were washed a second time, thus yielding 3 types of products: scheelite con centrate abounding in garnet (WO_3 15 % - 20 %), middling and residue.

As the middlings actually contain free scheelite crystals, in industrial practice they will be rebrought on the table, without being ground (for tests Denver Equipment Co's Wilfley No. 12 Vibrating Table has been made use of). The following reagents were used in removing pyrite and such sulphides as blende, chalcopyrites etc. from the concentrates and the latter was handled in 0.5 kg Fagergren laboratory cell.

The reagents used for flotation were:

$CuSO_4$	200 gr/t
Conditioning	5 minutes
Na-Ethyl xanthate	100 g/t
Aerofloat 25	100 gr/t
Flotation	3 minutes
K-Amyl Xanthate	100 gr/t
Flotation	2 minutes
L : S	4 : 1
PH	7

Following this process, they were passed twice through the Wetherhill type magnetic band separator

1) Magnetite concentrate
2) Garnet »

has been obtained, then,

In the magnetic spiral separator (Rillenscheider, Godderidge - Lorenz, Elektromnschinen Bau Ges., Graz)

3) Rillen middling

which contained the other slightly magnetic minerals, fine garnet and some fine scheelite and which would be re-washed in the industrial practice and the non-magnetic part

4) Scheelite concentrates have been produced.

The results obtained are tabulated as follows :

+ 65 mesh (0.208 mm.), Quantity : 46.70 %

	Scheelite conc.	Rillen middling	Magnetite	Garnet	Pyrite	Table middling	Table tailing	Feed
Qty %	1.35	0.07	0.10	5.86	0.01	4.98	88.245	100
WO_3	75.74 %	28.74 %	0.10 %	0.10 %	0.36 %	1.28 %	0.17%	0.79 %
Recovery %	70.20	2.10	0.01	0.74	0.004	8.04	18 92	100

+ 200 mesh (0.074 mm), Quantity : 33.70 %

	Scheelite conc.	Rillen middling	Magnetite	Garnet	Pyrite	Table middling	Table tailing	Feed
Qty %	0.74	0.41	0.23	3.72	0.01	7.08	87.81	100
WO_3	75.45 %	5.70 %	0.64 %	0.10 %	0.86 %	0.36 %	0.12 %	0,70 %
Recovery %	77.80	3.25	0.19	0.51	0.005	3.52	14.73	100

— 200 mesh (0.074 mm), Quantity : 19.60 %

	Scheelite conc.	Rillen middling	Magnetite	Garnet	Pyrite	Table middling	Table tailing	Feed
Qty %	0.25	0.85	0.25	1.14	0.001	2.17	95.84	100
WO_3	74.07 %	30.64 %	2.40 %	0.11 %	0. 36 %	0.66 %	0.42 %	0.70 %
Recovery %	26.40	13.14	0.84	0.17	0.0005	2.04	57.40	100

Study of the foregoing tables shows that the concentration of the + 200 mesh sieve grains would yield a minimum of 70 % recovery excluding the mixed ore. The concentrates contain 75 % of WO_3. In trying to obtain 60 % WO_3 concentrate which percentage is the percentage called forfor sales, the recovery will be higher.

Although the concentration recovery of the - 200 mesh sieve is low, yet it affects little the general recovery as this ore corresponds to $^1/_5$ of the raw ore. When the wolfram prices are favourable it will be possible to dress this fine residue by means of flotation (please see last tests).

If we combine these test results we get

	Scheelite	Rillen middling	Magnetite	Garnet	Pyrite	Table middling	Tailing	Feed
Qty. %	0.64	0.24	0.17	4.21	0.008	5.13	89.60	100
WO_3	75.30 %	19.02 %	0.53 %	0.10 %	0. 86%	0.85 %	0.20 %	0.71
Recovery%	63.06	6.16	0.12	0.56	0.004	5.90	24.20	100

The recovery is 75.12 %, middlings included. The Scheelite concentrate is very clean and free from foreign matters causing penalties, and contains fine garnet and other silicate crystals and a few pyrite grains.

The magnetite concentrate contains more than 60 % of iron and will be stoked as an iron ore. The pyrite concentrate will also be separated for ore-dressing in the future.

Andradite - Grossular isomorphic mixture grains of garnet make up more than 95 % of the garnet concentrate which be used as abrasives in the industry, and contains in lesser quantities magnetite, hematite, limonite, limonitised pyrite, tremolite, epidote, scheelite and wolframite.

Chemical Analysis of the garnet conc.

SiO_2	34.56 %
Al_2O_3	14.98 %
Fe_2O_3	14.84 %
CaO	29.81 %
MgO	2.59 %
WO_3	0.14 %
MnO	1.74
Ignition loss	0.44
	99. 10

Tests on Pyrite Bearing Tactite Ores :

Structure of this ore picked from the 69.60 metres of the pit No. 3, is the same as that of the garnet bearing ore, the only difference is the fact that this ore contains slightly more pyrite. The samples weighing 857 kgs. and received in 23 bags, have been broken and reduced to a size in the same manner as described above, the average samples obtained therefrom.

The chemical analysis of this ore is as follows :

WO_3	1.10 %
S	0.53 %
Fe_2O_3	14.18 %
MnO	1.57 %
SiO_2	42.80 %
Al_2O_3	10.99 %
CaO	21.35 %
MgO	3.76 %
Ignition loss	6.24 %

The screen test of the ore ground in the crushing rolls to pass through a 10 - mesh (1.65 mm) sieve, for the grain liberation and WO_3 content is as follows:

+ 1.168 mm. mixed	+ 14 mesh - sieve	17.00	0.76 %
— 1.168 mm. 90 % free	+ 28 » »	25.65	0.93 %
	+ 35 » »	10.00	1.30 %
	+ 48 » »	8.35	1.50 %
	+ 65 » »	7.85	1.55 %
	+ 100 » »	7.45	1.55 %
	+ 200 » »	9.95	1 45 %
	— 200 » »	13.75	1.35 %

From the grain liberation view point, this ore yields better results. In tests to be made on 20 or 28 mesh-sieves more than 90 % of the scheelite crystals will be free whereas study on the WO_3 content will show that scheelite in this ore is ground easily.

Test made on the ore prepared so as to pass through the 20 mesh sieve:

1 — 10 kgs. of ore were crushed in the cylinder crusher and ground in the disc pulverizer so as to pass completely through a 20 - mesh sieve and removed from the light minerals by washing in the Wilfley vibrating table. Pyrite was separated from the table concentrate via flotation. The flotation residue was passed through the Wetherhill magnetic separator and magnetite and garnet concentrates were obtained. Following that Rillen middling (containing some scheelite along with fine garnet and the silicates) was separated in the magnetic spiral separator.

The sales conditions of the concentrates require among others, that the percentage of the sulphur content should not exceed 0.5 %. Therefore, the concentrate has been roasted in a sealed container for 15 minutes at a temperature of 650° 0 (in the rotary kilns; 5 minutes suffice for this operation). At this temperature the pyrite crystals covered with magnetite oxyde layer were separated easily from scheelite in the magnetic separator.

The results of this process are tabulated below (A)

The recovery, together with the middlings, is 78.47 %.

When the roasting mixture was added to the concentrate, no significant decrease was observed in the content but the recovery increased a lot.

WO_3	64.00 %
Recovery	68.19 %

2 — Disregarding flotation of the pyrite, a second test has been made on another sample taken from the same zone, and to reduce the quantity of the table middlings, the ore was ground to have a - 28 mesh sieve product.

The results obtained from this test are shown below (B)

A	Scheelite conc.	Roasting middling	Rillen middling	Magnetite	Garnet	Pyrite	Table middling	Tailing	Feed
Qty. %	0.86	0.04	0.20	0.15	2.10	0.25	4.60	92.00	100
WO_3 Cont.	66.90 %	58.68	2.75 %	0.55 %	0.28 %	0.03%	1.93%	0.19%	0.86%
Recovery %	65.70	2.49	0.64	0.10	0.56	0.01	10.28	20.22	100

B	Scheelite conc.	Roasting middling	Rillen middling	Manetite	Garne	Table middlig	Tailing	Feed
Qty. %	0.82	0.71	0·10	0.26	2.92	4.17	91.02	100
WO_3 Cont.	76.44 %	82.30 %	84.81 %	1.07 %	0.38 %	0.81 %	0.22 %	1.14 %
Recovery %	55.20	20.10	3.09	0.24	0.84	2.98	17.55	100

Together with the middlings, the recovery is 81 37 %.

The foregoing test results show that as the roasting middlings are high grade, scheelite in ample quantities would be back in the process cycle.

Limonitic Samples :

The limonitic samples picked up from the 48.50 meter of pit No. 1 represent hardly 1/10 of the tactite ores of the upper part of the Uludağ ore beds. These samples differ from the former ones in that they contain more schlamm, because the pyrite and the chalcopyrites in these samples have, due to oxidation, turned respectively into limonites and malachites. The limonitic samples are richer than the former samples in so far as the scheelite content is concerned. Despite the fact that their copper and zinc (carbonates) content is high, yet, this is not important, as these will be processed by blending them with ores coming from the other zone. The chemical analysis of these samples is as follows :

WO_3	1.32 %
CuO	2.06 »
S	0.37 »
ZnO	12.08 »
Fe_2O_3	18.93 »
MnO	3.69 »
SiO_2	34.86 »
Al_2O_3	6.94 »
CaO	7.61 »
MgO	2.09 »
Ignition loss	10.06 »
Ag	106 gr/t

Sieve analysis and WO_3 percentages of the sample passing through 10-mesh sieve.

	Qty %	WO_3%
14 mesh sieve	12.4	2.10
20 » »	17.6	1.90
28 » »	11.6	2.20
48 » »	18.8	2.01
100 » »	15.2	1.12
200 » »	9.6	0.82
200 » »	14.8	0.76

The finer portions of this sample are low in WO_3 content, which shows that scheelite is less affected by oxidation and that the scheelite keeps its compaction.

Grain liberation has been determined to be 20 mesh (0.833 mm).

Concentration tests:

The ore found to pass through 20-mesh sieve, has been washed at the shaking table, than dried and then passed through the magnetic separator and finally roasted in the closed container 15 minutes at a temperature of 650° C, left to cool and then passed once more through the magnetic separator.

The results obtained are shown below.

Recovery, middlings included, is 78.53 %.

Since there was not enough pyrite in the table concentrate, flotation has not been carried out. (Following the roasting procedure the limonites and the pyrites were removed by the magnetic separator.) The garnet on the

	Scheelite conc.	Roasting middling	Rillen middling	Coarse grained middling	Garnet bonc.	Magnetite	Table middling	Tailing	Feed
Qty %	1.80	0.19	0.35	0.26	1.58	0.04	2.47	93.31	100
WO_3	51.67 %	11.79 %	1.12 %	11.81 %	0.69 %	0.55 %	2.55 %	0.29 %	1.81%
Recovery%	71.40	1.72	0.30	0, 28	0.88	0.02	4.83	20.62	100

35 - mesh sieve, contained scheelite mixed crystals; these were separated and analyzed.

There remained some malachite in the concentrate. Cu has been fixed to be 0.42 %, which percentage should not be over 0.05 sales. However as this ore corresponded to a minor portion of the reserves, we did not try to remove the copper and to increase the grade of WO_3.

Mixed Blend Sample Tests :

By weighing and blending samples of each zone in the ratio at which they represent the general ore mass a proper blend specimen corresponding mineralogically to the upper zone of the Uludağ ore mines was prepared. Therefore

7 kgs of Garnetic sample
2 » » Pyritic »
1 » » Limonitic »

were blended, ground, to pass under a 28-mesh sieve and tested. The test gave the following results :

Sieve analysis and WO_3 distri bution :

	Qty %	WO_3	WO_3 distribution
+ 35 mesh sieve	21.00	0.97 %	21.60
+ 48 » »	14.50	1.02 »	15.60
+ 65 » »	14.25	0.97 »	14.60
+ 100 » »	13.45	0.97 »	13.75
+ 150 » »	8.80	0.90 »	8.35
+ 200 » »	7.00	0.83 »	6.10
— 200 » »	21.00	0.90 »	20.00
	100.00	0.946 »	100.00

these results prove to us that the ore undergoes a normal grinding and that 20 % of WO_3 goes under the 200-mesh sieve.

Concentration test :

Results of tests conducted on 10 kgs. of ore passed through 28-mesh sieve are shown below.

Recovery, middlings included, is 76.08 (Roasting middlings was removed on the magnetic spiral separator).

Impurities in the scheelite concentrate :

Mo 0.47 % (isomorphic dissemination in scheelite crystals)
Cu 0.03 % (Malachite crystals)
S 0.71 % (due to unburnt pyrite)

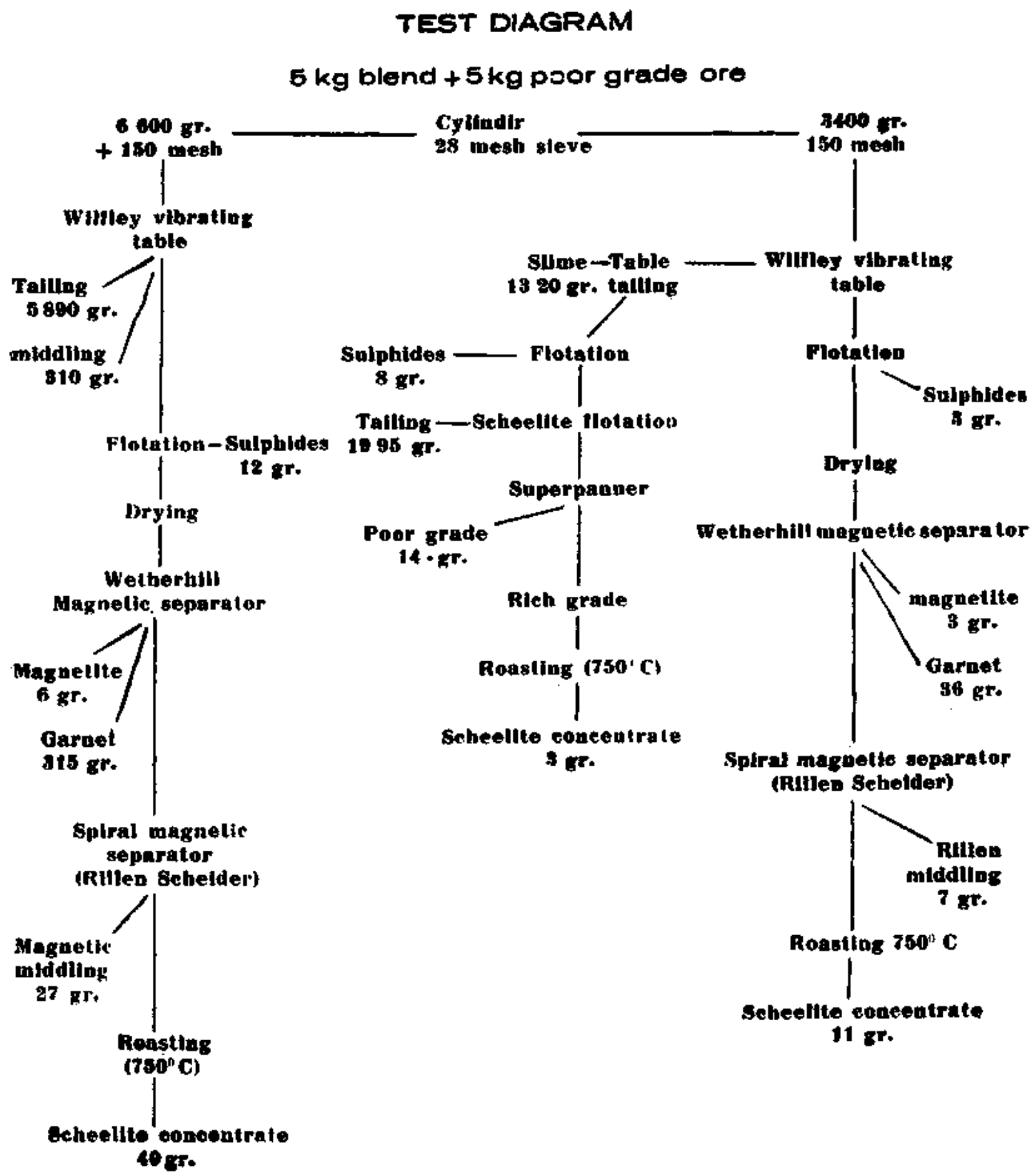
The molybdenum and copper contents of the concentrate meet the sales requirements thereof. As for the sulphur percentage, this can be reduced under 0.50 % by increasing the roasting temperature, or by roasting the concentrate after removing pyrite by means of flotation.

More than 75 % of wolfram in the table tailing, which is thrown away, forms part of the fine portion (0.100 mm) which passed under 150 mesh-sieve. So far as the $W0_3$ grade is concerned, the ore exceeds 0.434 % WO_3 which percentage is a general average.

Final test made on ore corres ponding to the general average :

The mixed blend sample has been mixed with poor grade WO_3 (0.1 % WO_3) and a test sample representing the general average in grade was prepared and underwent the following treatement:

	Scheelite conc.	Roasting middling	Magnetite	Garnet	Table middling	Table + 150 mesh	Tailings — 150 mesh	Feed
Qty	0.82	0.81	0.17	5.89	5.05	67.50	30.26	100
WO_3	68.20 %	19.60 %	0.81 %	0.14 %	0.59 %	0.13 %	0.50 %	0.855%
Recovery%	65.50	7.10	0.06	0.97	3.48	5.23	17.66	100



TEST DIAGRAM
5 kg blend + 5 kg poor grade ore
6 600 gr.
+ 150 mesh
Cylindir
28 mesh sieve
3400 gr.
150 mesh
Wilfley vibrating
table
Tailing
5 890 gr.
middling
310 gr.
Flotation – Sulphides
12 gr.
Drying
Wetherhill
Magnetic separator
Magnetite
6 gr.
Garnet
315 gr.
Spiral magnetic
separator
(Rillen Scheider)
Magnetic
middling
27 gr.
Roasting
(750° C)
Scheelite concentrate
40 gr.
Slime – Table
13 20 gr. tailing
Sulphides
8 gr.
Flotation
Tailing
19 95 gr.
Scheelite flotation
Superpanner
Poor grade
14 gr.
Rich grade
Roasting (750° C)
Scheelite concentrate
3 gr.
Wilfley vibrating
table
Flotation
Sulphides
3 gr.
Drying
Wetherhill magnetic separator
magnetite
3 gr.
Garnet
36 gr.
Spiral magnetic separator
(Rillen Scheider)
Rillen
middling
7 gr.
Roasting 750° C
Scheelite concentrate
11 gr.

The sample was crushed in the cylinder crusher to pass through a 28-mesh sieve. The parts which passed and which did not pass through a 150 mesh sieve were treated separately.

The heavy minerals were twice washed in the Wilfley Vibrating Table and from the concentrate so obtained the sulphides were also removed by means of flotation. The concentrate dried after the flotation went through the Wetherhill and magnetic spiral separators and the scheelite concentrate was produced. By roasting the pyrites which remained in the scheelite concentrates in little quantities (3 % - 6 %) for 15 minutes at a temperature of 750°C, concentrate for the market was produced.

As there was much scheelite in the table residue of the -150 - mesh sieve part, the slime in this part was removed by Wailiing and the remainder underwent flotation, whereby first of all the sulphides were removed and then the scheelite floated with oleic acid.

The concentrate yielded by flotation was treated with 1 kg. of $Na_2 SiO_3$ and 1/2 kg. Quebracho per ton of cone, and underwent once again gravimetric concentration in the superpanner, and separated into two parts, namely the rich and poor grades. The former grades will be roasted at 750°C and added to the concentrate, satisfying the market requirements.

As for the poor grade concentrate, since wolfram in this concentrate can be extracted only by means of chemical (dissolution) methods, which are costlier, they will be stockpiled for the time being.

Flotation Reagents Used

Description	Kg/ton	Where added	Time	Ph	L : S
		For the flotation of sulphides			
$CuSO_4$	0.100	Conditioner		7	4/1
Na-Ethyl xanthate	0.100	»	6 min.		
Aerofloat 25 (Phosocresol B)	0.500	Flotation	4 »		4/1
K-Amyl Xanthate	0.500	»	5 •		
		For the flotation of scheelite			
Soda	6	Conditioner	15 min.		4/1
Na-silicate	0.720	»	»	9.8	
Oleic acid	0.150	»	»		
R. 708 (Talloil)	0.150	»	»		
Utinal (Na-dodecyl sulphate)	0.150	Flotation	5 min.		4/1
Oleic acid	0.150				
R. 708	0 100				
Utinal	0.100		5 min.		

The analysis results and recoveries are summarized in the following tables:

	Scheelite conc.	Flotation conc.	Super-panner	Magnetic middling	Table middling	+ 150 mesh table tailing	— 150 flotation tailing
Qty	0.51	0.08	0.14	0.84	8.10	58.90	19.95
WO_3	64.27 %	58.12 %	1.92 %	1.16 %	0.44 %	0.05 %	0.03 %
Recovery %	78.48	8.57	0.60	0.88	3.05	6.59	1.34

	Garnet conc.	Magnetite conc.	Sulphides (pyrite, blende etc.)	Slime	Feed
Qty	3.51	0.09	0.23	13.20	100
WO_3	0.09 %	0.06 %	0.05 %	0.33 %	0.446 %
Recovery %	0.71	0.01	0.03	9.76	100

Recovery, flotation concentrates included: 77.10 %

Recovery middlings included: 81.03%.

a) Sulphur remained at 0.57 % in the concentrate, after the concentrate was roasted at 750°C.

Therefore it is essential to see that the temperature does not go below that figure.

b) Slime loss may be less in industrial practice.

c) The pyrite concentrate can be evaluated in the future (as the presence of Zn : 15.30 %, Au: trace, Ag: 410 g/ton has been detected).

d) Scheelite crystals in the flotation concentrate can go through a 200 mesh sieve.

Test conducted on poor grade ore:

Grade of samples taken from the left of pit No. 3 is 0.10 % WO_3.

The recovery, middlings included, is 71.51 %. A major portion of scheelite running from the table concentrate, is - 200 mesh; however, in consideration of the fact that the grade of the ore is very poor and hence the table recovery would be low, removal was made by a mesh sieve.

The grade of the scheelite concentrate does not meet sales requirements but it is remarkable that with a very poor ore containing 0.10 % WO_3,the recovery obtained, was apporximately 70 %. The results are tabulated below:

	Table scheelite conc.	Flotation scheelite conc.	Superpanner middling	Magnetite middling	Table middling	+ 100 mesh table tailing	— 100 mesh flotation tailing
Qty	0.14	0.01	0.426	0.10	1.88	59.09	27.50
WO_3	46.81 %	54.80 %	0.30 %	0.75 %	0 08 %	0.02 %	0.02 %
Recovery %	62.80	5.27	1.22	0.74	1.48	11.10	5.17

	Garnet conc.	Magnetite conc.	Sulphides	Schlamm	Feed
Qty	0.98	0.04	0.48	9.36	100
WO_3	0.04 %	0.50 %	0.03 %	0.13 %	0.10 %
Recovery %	0.38	0.19	0.15	11.50	100

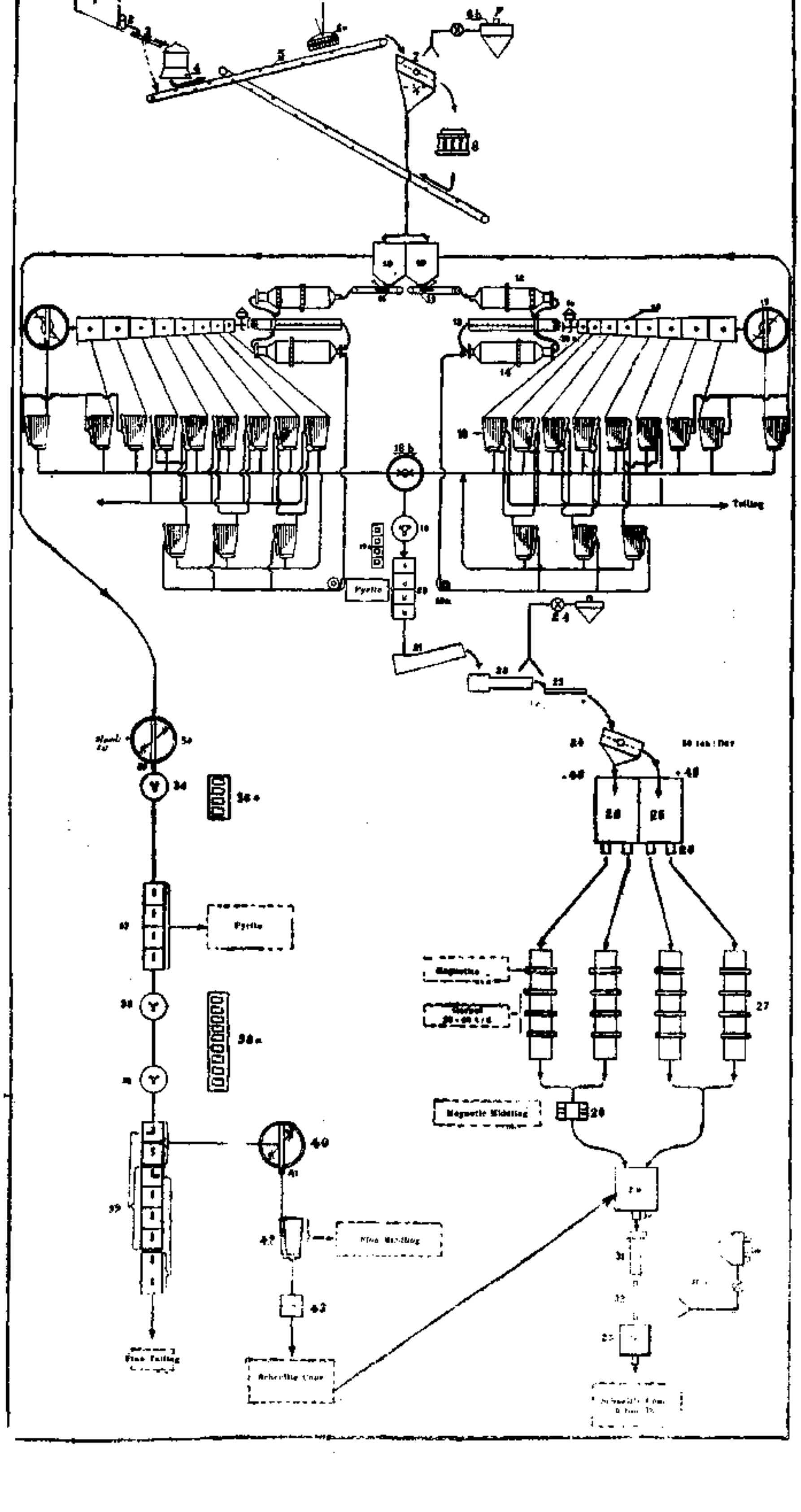
PLANT AND COSTPRICE

Equipment required for the concentrator of a daily capacity of 1000 tons, according to the proposed flowsheet.

Item No.	Name	Size
1	Coarse Ore Bin (1000 ton)	25' x 25' x 30'
2	Chain feeder cap. 200 t/h	
3	Grizzly, aperture : 10 cm.	4' x 8'
4	Gyratory Crusher	20"
5	Belt Conveyor	24" x 100'
6 a	Guard Magnet	24"
6 b	Dust cyclon (36" exhauster)	30" x 8'

PROPOSED FLOWSHEET OF 1000 - TON ULUDAĞ TUNGSTEN ORE CONCENTRATOR

Dr. Reşit TOLUN



Item No.	Name	Size
7	Shaking screen, ap. 1/2"	6' x 14'
8	Short head cone crusher	5 1/2
9	Belt conveyor	24" x 100'
10	2 fine ore bins (500 ton)	24' x 34'
11	2 feedometers	24"
12-14	4 Rod mills (with 40 000 kg.) rods	5' x 8'
13	2 Rake Classifiers	4' x 14' 8"
15	2 samplers	36"
16	2 hydraulic classifiers cap; 500 ton/day Fahrenwald	1.17'
17	2 Hydroclassifiers	12'
18 a	4 SRL sand pumps	2"
18	48 Deister tables	7' x 14'
18 b	Cone dewaterer	10'
19	Conditioner	4 x 4
19 a	4 wet Reagent feeders	24"
20	4 Flotation cells	32" x 32"
21	Akins classifier	36"
22	Dryer (Rotary)	36" x 20'
23	Spiral conveyor	6" x 6'
24	Vibrating screen (with 48 m. clothes)	36" x 60"
25	2 fine ore bins (25 ton)	9' x 10'
26	4 vibrating feeders	18" x 3" x 9"
27	4 Wetherill Magnetic separators (with 8 poles, 30 000-140 000 A. t.)	
28	Dings M_2 type Magnetic separator (Or. Rillenscheider)	
29	Ore bin (10 ton)	7' x 8'
30	Vibrating feeder (Syntron)	18" x 3" x 9"
31	Roaster (Rotary tube)	15" x 15'
31 a	Same as 6-b. Dust cyclone	
32	Spiral conveyor	6" x 6'
33	Ore Bin, cap: 10 ton and automatic sacker	7' x 8'
34	Thickener (with tank)	24' x 10'
35	2 Diaphragm pumps	4"
36	Conditioner	4' x 4'
36 a	4 wet reagent feeders	24"
37	4 Flotation cells	38" x 38"
38	2 conditioners	6' x 6'
38 a	12 Wet Reagent feeders	24"
	1 dry » »	18" x 18'
39	8 Flotation cells	38" x 38"
40	Thickener (with tank)	10' x 6'
41	Diaphragm pump (simplex)	1"
42	Deister slime table	7' x 17'
43	Pan filter (duplex)	3' x 3'
44	Water pump (centrifugal) (8 000 m^3/d)	8"
45	(If a hydro-electric or thermal power plant is not set up, then)	
	Diesel electric generator set.	1350 H. P.

Fob. value of the machinery for the plant: $ 770.700 (N. B. the prices are 1953 prices, the equipment U. S. made and taken from Denver Equipment Co's catalogues ; tenders to be received from Europe will, no doubt, be much more favourable.)

Building Costs :

The location where the plant will be set up has not as yet been determined. However it will be best to erect it somewhere in the neighbourhood of the Bursa-İnegöl highway. The plant will be linked to the highway by a 5 km. road.

Building and erection costs of the plant, whose water requirements will be supplied by the nearby creek, are as follows :

Cost of planning the plant and drawing up of the specifications:

Road (building)	$ 5 000
Earth removal	7 000
Foundations and Concrete	40 000
Buildings (wooden and steel sections)	100 000
Roofing, windows, etc.	15 000
Platforms, etc.	15 000
Total	192 000
Machinery (equipment) Fob.	770 700
Freight	100000
Erection	50 000
Transmission	20 000
Piping	15 000
Electrical installation	15 000
Apparatuses	15 000
Engineering	20 000
Total	1 065 000
General expenses	150 000
Grand total	1407700

The above estimate has been made based on expenses made (12) for several plants set up in the U.S.A. These estimations are standard for the USA. For expenses to be involved in Turkey, it will give us more accurate figures if we take the value of one dollar, as double its official rate of exchange.

Equipment........	$ 770 700	(2 161 000 T.L *
Expenses	$ 637 000	(3 571 000 T.L **
Unforeseen expenses 20 % (for tailing disposal, inclined elevators, heating units etc.)		1 146 000 T.L
Total		6 878 000 T.L.

* 1 $ = 2.803 T.L.
** 1 $ = 5.606 T.L.

Milling cost :

Power required to concentrate 1000 tons of ore per day (3/4 of the total HP)

Crushing	1 500 kW
Others	10 000 »
	11 500 kW.

At the rate of 10 krş/Kws; 1 500 kW 1 150 T.L.

Labor :

Enginee, chemis, accountan and time - keeper	150
4 Shift masters	80
6 Repairmen	60
4 Electricians	40
4 Oilers	32
18 Table and mill, control	144
4 Crusher hand	180
8 Magnetic separator workers	80
16 Repair and maintenance shop ..	160
4 Shippers	40
Labor	1006 T.L.

Reagents (for fine flotation, 200 tons per day)

Copper sulphate	at 1.5 T.L. per kg.	....	40 kg.	60 T.L.
Na Ethyl xanthate	at 3.5 T.L. »	....	20 »	70 »
Aerofloat 25	at 4 » »	....	10 »	40 »
K-amyl xanthate	at 3 » »	....	10 »	35 »
Soda	at 0.20 » »	....	1 200 »	240 »
Na-silicate	at 0.30 » »	....	124 »	37 »
Oleic acid	at 1.50 » »	....	50 »	75 »
R. 708	at 0.75 » »	....	50 »	37 »
Utinal	at 1.00 » »	....	40 »	80 »
				674 »

Mill liners and rods and other reagents	1 000 »
Auxiliary services (Analyses laboratory, stores, workshops ect.) ...	2 000 »
General expenses	1 000 »
Depreciation (in 10 years)	2 000 »
Total of concentration expenses	**8 830 T.L.**

N.B. This total is nearly the same as the daily expenses of the flotation plant, at the Murgul Copper Mines, which plant handles actually 1000 tons of ore per day.

General cost price and profit :

A general cost price prevision has been made by Mr. S. Alpan (8) and this prevision estimates the capital required to start the processing operations. Here, we shall try to calcutate the minimum grade of the ore to yield us profit therefrom in the light of the prices ruling to-day and the minimum cost price to process the average grade known to-day.

Daily expenses of the mining pit operations	11 474 TL.
Concentrator	8 830 »
Compensation for MTA's expenses	180 »

If we figure out the interest on the capital 10 % maximum for the first year, which interest will be less each year until the depreciation of the operation is completed, then an interest 1 000 000 TL, 10 % of 10 000 000 TL capital, for a plant running 333 days a year, is daily. . . . . 3 000 TL.

Total of the daily expenses 23 484 »

or 4.329 TL. per ton of concentrate.

N.B. These expenses are slightly lower than the concentration expenses of the tungsten mines in the USA.

Production :

By means of a 75 % recovery, 6.425 tons of 60 % WO_3 concentrate can be obtained per day from 1000 tons of 0-434 % WO_3 grade of ore.

Apart from this

20-40 tons of garnet concentrate

1-2 » of sulphides (pyrite, blende, etc).

1-2 » of magnetite

will be produced which will be stocked separately in the yard of the plant and valued in the future. It is possible to sell the garnet concentrate as abrasives (polishing and cutting powder), however, fixation of its price has not been possible. This product may bring in a lot of money if consumers are found.

The CIF value of 5 425 tons of 60 % WO_3 concentrate is $ 11 482. ($ 32 per unit, $ 2116 per ton), (price of the Metal Market, April 1955) Which makes: 5425 t. of 60 % WO_3conc.

5 425 tons of.	32 184 T.L.(*)
1 % custom duties	320 »
sea freight 34 TL per ton	184 »
FAS concentrator	31 680 »
Daily sales	31 680 »
» expenses	23 484 »
» profit	8296 »
Annual profit	2 765 000 »
Profit for the total reserve calculated to last 30 years).	82 960 000 »

Therefore to realize a profit on this concentrate, daily sales of 23 988 TL CIF value must be made, in which sales, either the price must be at least $2.385 per unit, or as long as the price remains $ 32.00 per unit, the grade of the ore processed must contain 0.32 % of WO_3.

If we consider this matter from the view point of foreign currency:

Annual WO_3 concentrates sales : $ 3 827 300

Total WO_3 cone, sales (calculated for 30 years). . . . .$ 114820000

These funds would represent an important source of foreign currency which cannot be under estimated.

CONCLUSIONS

Tests conducted on the tactite ore samples of the Uludağ wolfram deposit showed that these ores are favourable for ore-dressing. In view of economic considerations, the tests were aimed to obtain a high recovery. Based on the results yielded from the « Final Test» made on the sample to correspond to the general reserve average, we may say that a minimum of 60% WO_3 wolfram concentrate can be obtained from these ores by a 75 % recovery.

Sales of the garnet concentrate to be produced in ample quantity as by-product, will greatly affect the cost price. Furthermore, magnetite and pyrite concentrates will also be produced, but in little quantities.

Based on the final test, the «Flow Diagram» and a list of equipment for a 1 000 ton per day capacity plant to be set up have been prepared and a simple cost prevision drawn up. Although the present day wolfram prices are low, mining of the Uludağ tungsten ores will be a profitable one and a source for bringing in foreign currency which cannot be underestimated.

- ADDENDUM -

CONCENTRATION TESTS CONDUCTED ON SAMPLES TAKEN FROM CORES

WOLFRAMITE (Fe, Mn) WO4

The floor zone of the Uludağ Wolfram Mine, containing metasomatised granites and ore - bearing limestones could be investigated only by drilling. Therefore in view of the difficulties encountered in taking samples ore dressing tests could not be made on this zone.

As during the microscopic examination of certain cores, Dr. Wijkerslooth has come accross, on (oral information), wolframite among the scheelite minerals. It was in the first place imperative to determine the quantitative ratio of this mineral to scheelite.

Wolframite is in general found together with scheelite, and encircled by it. By immersion and magnifications, it yields dark infra - red reflections (Photos 7 and 8). Magnetite constitutes the principal part of the sample. Furthermore, tremolite, quartz and pyrite minerals have been observed.

Test:

Some 60 gr. samples have been picked from cores taken at a depth of 180 - 182 m. of Drilling No. 37, and ground to pass under 28 - mesh sieve (0.589 mm).

The gangue minerals (quartz and tremolite) were removed on the superpanner vibration table and thereafter pyrite separated by flotation.

The part consisting of magnetite, scheelite and wolframite has been dried and the magnetite removed by means of a hand magnet.

Wolframite, generally in the form of scheelitic mixed grains (Photo 8), has been separated by means of a Wetherhill magnetic separator from the scheelite which is non-magnetic.

Scheelite concentrate product			0.100 gr.
Wolframite	»	»	0.100 gr.

These results prove to us that the quantity of wolframite corresponds almost to that of the scheelite. To get an average result, is contingent upon conducting large scale tests on average samples to be taken from this zone. Should the above test be generalized for the entire bottom zone, it will be necessary to handle the bottom zone ore apart at the ore-dressing plant, for if the wolframite bearing ore is concentrated together with the garnet bearing ore (upper zone), wolframite will be separated at the magnetic separator along with garnet and will be lost.

A new Mineral

Bursalte: Pb_5 Bi_4 S_{11}

This mineral which exists in very little quantity in the mineralogical structure of the Uludağ Wolfram ores and which occurs generally with the zinc blende, has been determined, as described in the previous reports, as molybdenite (or tungstenite) since it had many common properties with molybdenite (6,7).

But since the flotation tests proved that the sulphides occurring in the Uludağ ores dit not contain molybdenite, special emphasis was lain on the determination of this mineral, and to serve this purpose a 50 gr. sample has been picked among the most favourable cores taken at a depth of 124-127 m. (drilling 40).

Examination of polished sections carried out under the ore microscope showed (in the sequence order) blende, tremolite, pyrite, calcite, garnet, quartz, scheelite, chalcopyrite and the new mineral.

The zinc blende constitutes the main part of the ore and contains fragments of chalcopyrites. The new mineral is generally seen in the blende and in the neighbourhood of it (Photo 9); sometimes it is also found in the pyrites and gangue minerals. So far as the structural order is concerned chalcopyrites, pyrite and blende are younger than the mineral in question.

Test :

The 50 gr. sample was ground soas to go under 28 - mesh sieve and underwent selective flotation :

The following reagents have been used :

Na_2CO_3		500 gr/lit.
Na_2SiO_3		250 gr/lit.
Na	CN	50 gr/lit.

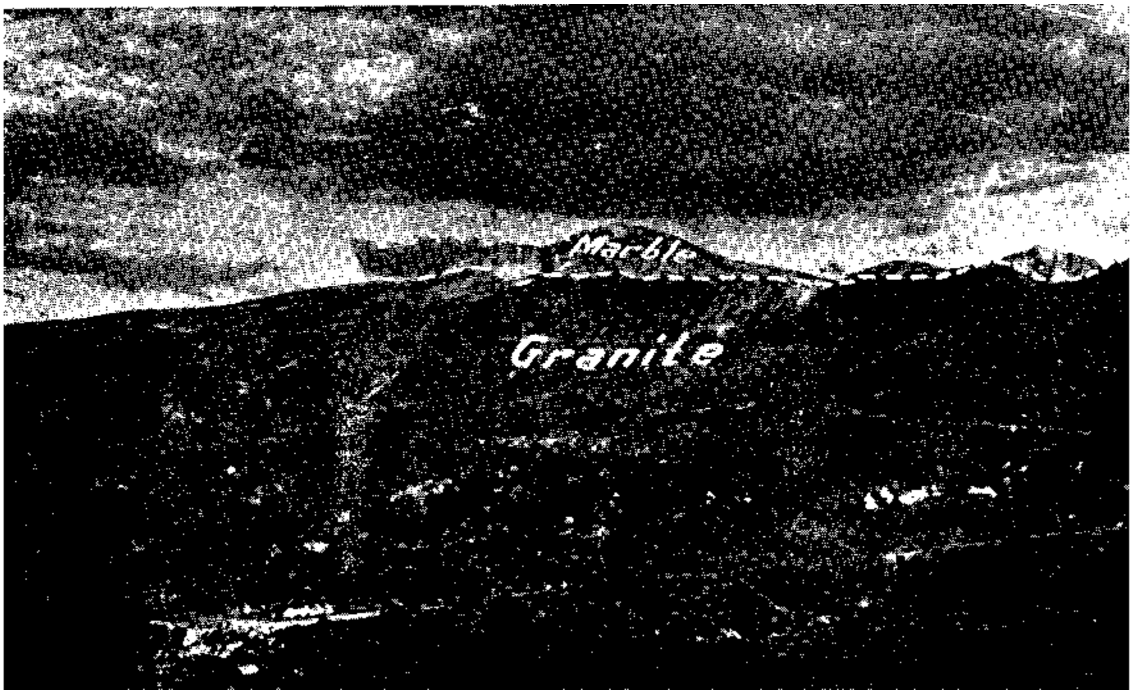


Photo 1 — *Summit of Uludağ (2486 m) as seen from the vicinity of Rasathane. The contact zone of the marbles (white) above, and the granites (grey) below is distinct. The wolfram mine is situated at the left end of this contact.*

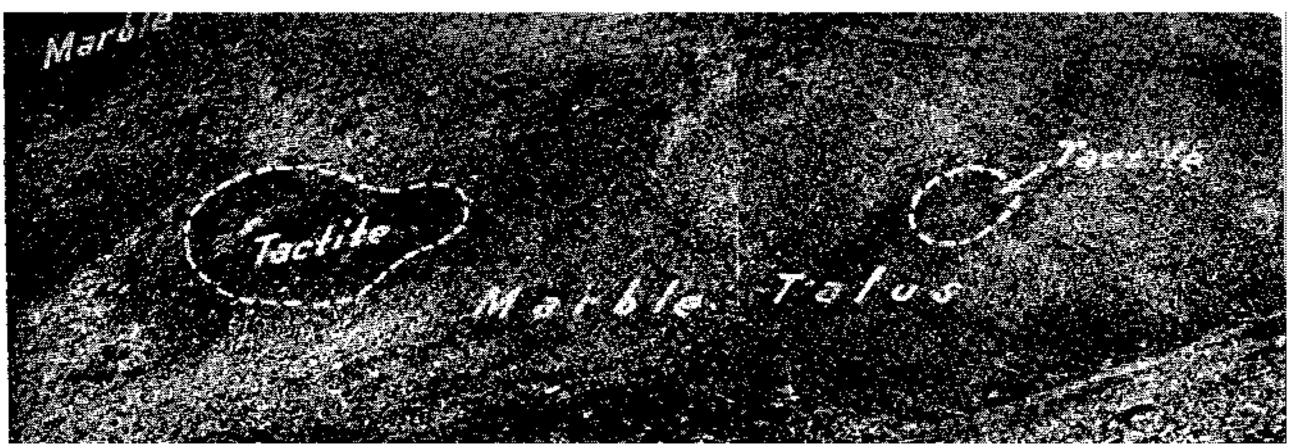


Photo — 2 *Tactite outcrops, containing scheelite in ample quantities. S-W of the Çayırlıdere lake.*

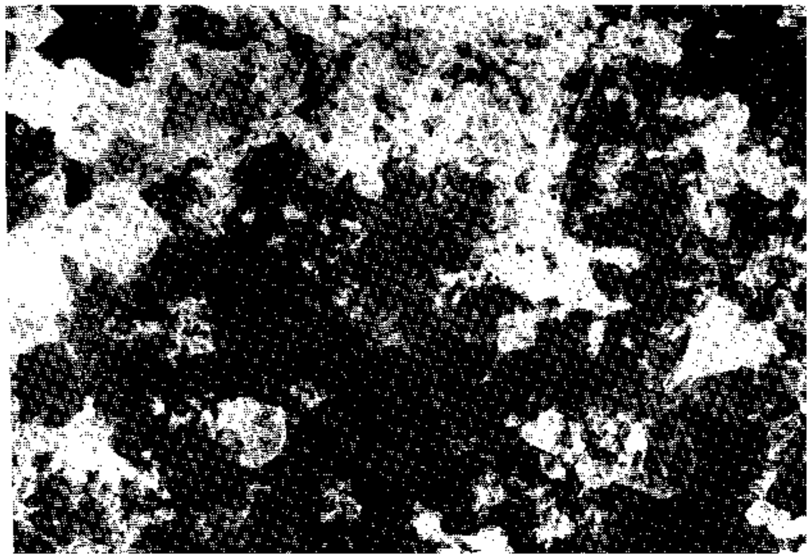


Photo 3 — *(Magnification: 10 X) View under normal light of a tactite polished section on the portion abounding in garnet. Calcite and scheelite (white); garnet (dark grey); magnetite (black).*

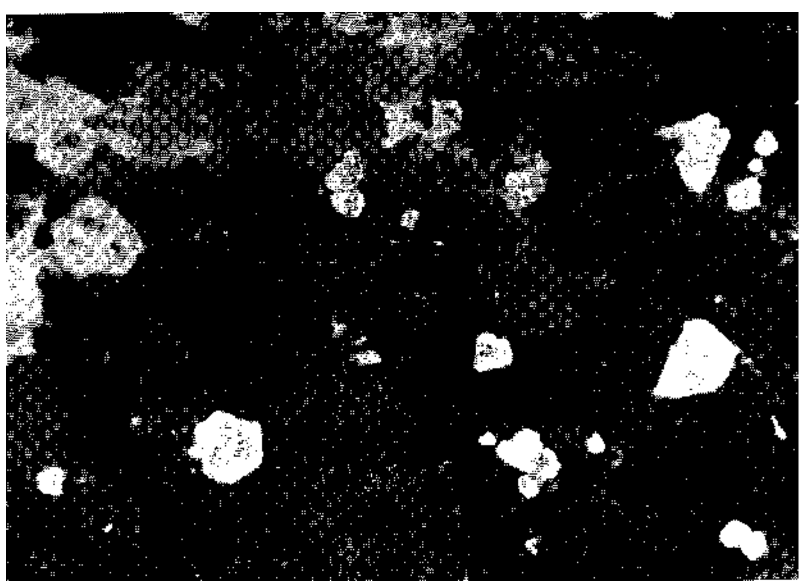


Photo 4 — *Same sample as seen under ultra - violet rays. The scheelite minerals are fluorescent and bright.*

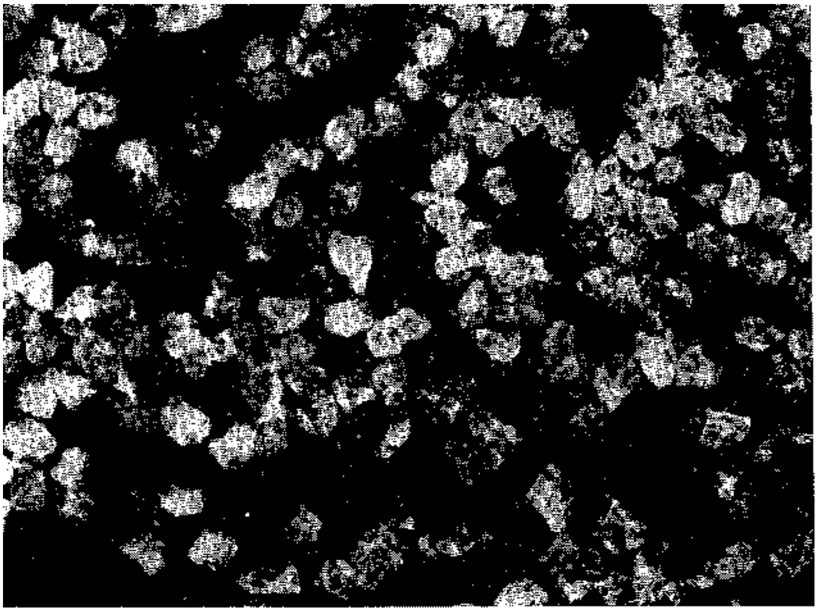


Photo 5 — *(Magnification : 10 X) Table concentrate of grains smaller than 0.589 mm (under 28 - mesh sieve). All the scheelite crystals are free. Pyrites (dark grey); magnetite (black); scheelite (white); garnet (grey).*

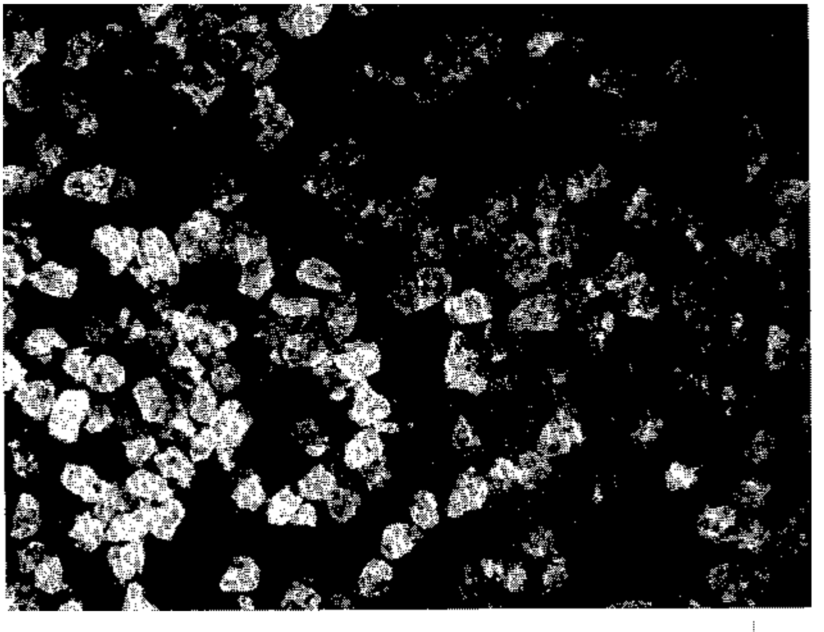


Photo 6 — *Same sample as seen under ultra - violet rays.*

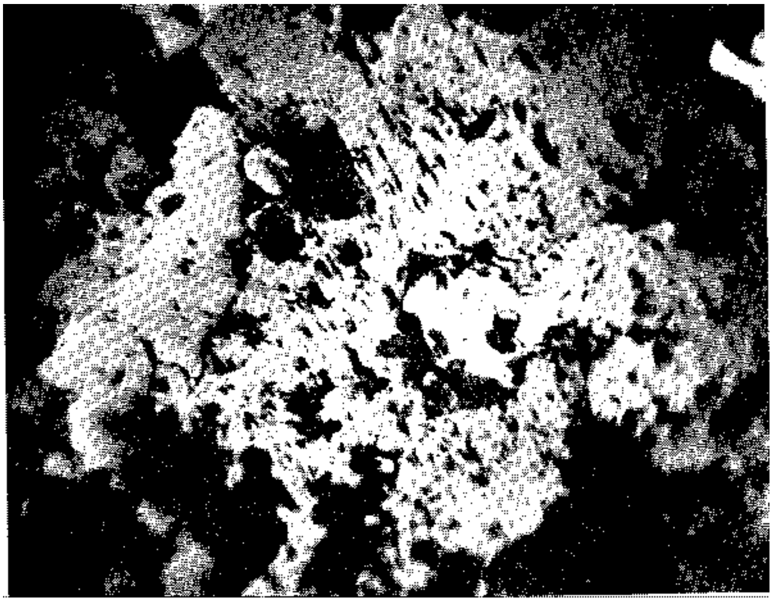
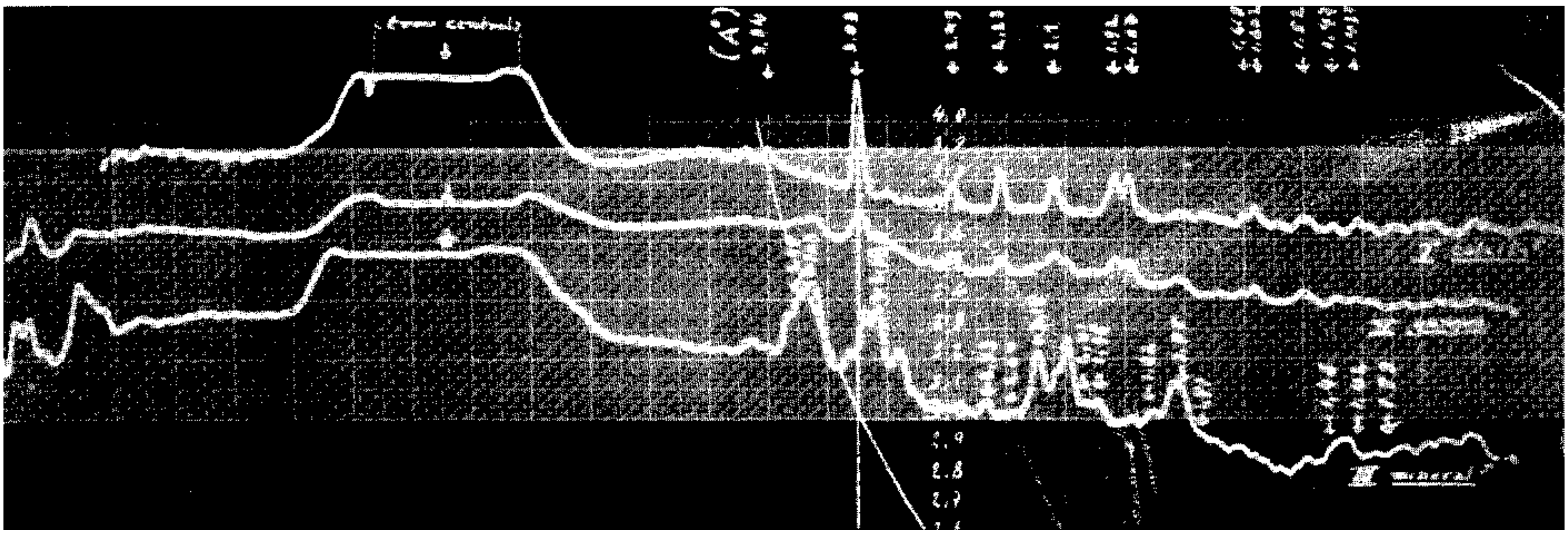


Photo 7 — *(Magnification : 300 X) Examination of a polished section containing wolframite under normal light by means of immersion. Wolframite (light grey); scheelite, (grey); magnetite (white); In the magnetite oligiste is observed in thin lines due to martitization (Drilling No : 25, depth 163.40 m)*

Photo — 8 *(Magnification : 300 X) Polished section containing Wolframite concentrate Occurrence of Wolframite (white) with scheelite (grey) in mixed grains, generally encircled is a proof of metasomatic formation (Drilling No: 37, depth 180 - 182 m).*

Photo 9 — *(Magnification: 80 X) Bursaite (Pb_5 Bi_4 S_{11}) as seen under normal light on the polished section. Bursaite (white); blende (light grey); calcite (dark grey) (Drilling No. 40; depth 124127 m)*

Photo 10 — *(Magnification: 80 X) Polished surface containing a Bursaite concentrate (Blende (grey) which remained scantily is seen as mixed grains)*



Photometric curves of the X - ray spectrograms :
I - Calcite, II - Gangue and III - the new mineral Bursaite.

$ZnSO_4$	100 gr/lit.
PH	8.5
Condition	15 minutes
Kerosene	30 gr/lit.
Pine Oil	25 gr/lit.
K-Amyl Xanthate	50 gr/lit.
Flotation	5 minutes

As the blende contained copper, it was mixed in the concentrate, and the removal had to be repeated (for which the following were used).

Na_2CO_3	500 gr/lit
Na_2SiO_3	250 gr/lit
NaCN	100 gr/lit
Zn SO_4	100 gr/lit
Pine Oil	10 gr/lit
Flotation	2 minutes

Examination of the superpanner (results) showed that the density of this mineral was higher than density of scheelite (6.2). Therefore the flotation concentrate was once more washed on the superpanner and a satisfactorily pure concentrate (2 grs) obtained for the test. In the final concetrate there remained scarcely blende and pyrite.

It has been observed under the microscope that the mineral is prismatic and it has a tabular cleavage. As the hardness degree of the mineral is low, the grains are easily rounded (Photo 10).

Chemical Analysis Results :

Pb	=	39.62 %
Bi	=	37.60 %
8	=	17.32 %
Fe	=	1.98 %
Zn	=	3.18 %
		99.70 %

Based on the foregoing results, the mineralogical composition of the concentrate was calculated to be :

Pyrite (Fe S_2)	4.24 %
Blende (ZnS)	4.78 %
Native Bismuth (Bi)	5.48 .%
$Pb_5Bi_4S_{11}$	85.30 %

thus a new mineral $Pb_5Bi_4S_{11}$ was found.

Native bismuth has been observed in the form of very small inclusions only when polished section were examined microscopically at magnifications 300 x - 500 x.

The chemical composition of the new mineral has been calculated as :

Pb	46.44 %
Bi	37.42 %
S	15.83 %

We could not come across, even in the most recently published books at hand, to a mineral, the composition of which was $Pb_6Bi_4S_{11}$ or 5 Pb S.2 Bi_2S_3. A similar mineral of antimony is Boulangerite ($Pb_5Sb_4S_{11}$) which is quite a common mineral.

Mineralogical properties :

This mineral is metallic grey in colour, prismatic and has a tabular cleavage. Under the ore microscope it shows a high reflective power. It is pleochroitic and anisotropic.

Under the + nicol it shows an oblique extinction; hence its crystalline form is probably monoclinic, the same as its antimony replica Boulangerite.

Talmage hardness: C (chalcopyrites).

X - Ray test results :

The most specific feature of this mineral could be detected over the x-ray and the determination made by D.A. Reelfs, at the Mineralogical Laboratory of the University of Geneva on powder extracted by drills from a clean polished section.

The following table is illustrative of (d) values as A° and (i) relative intensities of lines obtained in the photometric examination of the x-ray spectrogram.

No.	d	I	No.	d	I
1	4.0		15	2.33	
2	3.84		16	2.28	
3	3.80		17	2.24	
4	3.55	8	18	2.15	8
5	3.48		19	2.05	9
6	3.38 / 3.36	9	20	2.01	5
7	3.18		21	1.96	1
8	2.98	7	22	1.92	2
9	2.88 / 2.87	10	23	1.87	1 / 5
10	2.76		24	1.82	5
11	2.66		25	1.77	1
12	2.57		26	1.75	2
13	2.51		27	1.71	
14	2.47		28	1.63	

The most strong lines are :
3,38(9) ; 2.88(10); 2.05(9)

Photocopy of the photometric curves has been appended hereto for comparison pur poses.

As the new mineral is found in the province of Bursa, it was proper to name it Bursaite, after the said province.

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B I B L I O G R A P H Y

1 — Raşit Tolun : Kuzbudaklar (Bursa) Wolfram ih. 4687 **P. 5543,** (1950) M. T. A. Enstitüsü.

2 — Raşit Tolun : Delice köy (Bursa) Wolfram ih. 4688. P. 5544 (1950), M. T. A. Enstitüsü.

8 — Raşit Tolun : Report ou the research of the scheelite occurrences of the Kuzbudaklar Delice koy and Uludağ summit regions (Province of Bursa), report No. 1890 (1951) M. T. A. Enstitüsü Arşivi.

4 — İhsan Ketin : On the Tectonic of the Uludağ Mountain. Bulletin of the Turkish Geological Association.

5 — Ronner, F. : Geology and Tectonic of the Uludağ Wolfram Deposit and its neigbourhood. Report No. 2203 (1954), M. T. A. Enstitüsü Arşivi.

— G. Sağıroğlu : On the Uludağ Wolfram Occurrence. Report No. 2084 (1953). M. T. A. Enstitüsü.

7 — G. van der Kaadeu : Geological Report on the Uludağ Scheelite Deposit Province of Bursa. Report No. 2202 (1954), M. T. A. Enstitüsü.

8 — Sadrettin Alpan : Report 011 the Uludağ Wolfram Mine ill the Province of Bursa. Report No. 2209 (1955), M. T. A. Enstitüsü.

9 - K. C. Li and C. Y. Wang, Tungsten, p. 106, Reinhold publ. Co. (1947)

10 — Tungsten from «Down under Mining» World, January 1953, p. 34

11 — Newest Montana Tungsten Mill, Mining World, 1955, P. 38

19 — Denver Equipment Go. Handbook (1954).