A CHEMICAL AND MINERALOGICAL EXAMINATION OF A COPPER ORE FROM MYSORE

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Introduction—A copper ore containing a high percentage of copper was received some time back from Biligere, Nanjangud Taluk, by Dr K R Krishnaswami of this Department who suggested to me to investigate its exact mineralogical nature and to work out the conditions for extraction of copper therefrom

Smeeth and Sampat Iyengar[1] made the following remark regarding the nature of occurrence and distribution of this ore "In the Nanjangud Taluk, 1¼ miles S S E of Biligere, pieces of green copper ore were found in the soil and some pits have been sunk to a depth of 40 feet under a prospecting license The rock is a steeply dipping decomposed gneiss with an interbanded dolerite dyke of a few yards in width The latter is considerably decomposed and shows strings and patches strongly impregnated with carbonate of copper" They pointed out that some pockets of this ore in the dolerite dyke is rich in copper ranging from 9 to nearly 24 per cent. The quantity of ore available has not been estimated

Megascopic and microscopic properties—The ore is dirty brown in colour and is of two different types, one of which is hard and compact and the other is a bleached earthy powder The compact ore forms sharp angular masses with an irregular to subconchoidal fracture Sometimes the surface is coated with a thin film of a green mineral which is probably malachite When a thin section is examined under a microscope in transmitted light it shows a more or less dark ground mass with fine interlocked veins of a rich green transparent material In addition to these veins the green material is also present in a dispersed condition throughout the mass of the ore The veins are present abundantly only near the surface of fragments and there are very few veins in the interior The interior of individual fragments is very dense as compared to the outer shells where alteration has proceeded to some extent In addition to the green mineral the groundmass also contains fine-grained quartz distributed uniformly throughout the field. The main mass of the ore, however, is made up of the reddish brown oxide of iron.

Chemical analysis.—A carefully prepared sample of the ore was analysed as follows:—A weighed quantity of the finely powdered mineral was ignited and the loss of weight was determined. In a separate portion of the sample both water and CO_2 were determined by combustion analysis and it was found that combined weight of these two constituents agreed closely with the total loss on ignition.

A complete analysis of the ore is carried out as follows. A weighed quantity of the ore is dissolved in a hot 1:1 mixture of concentrated hydrochloric and nitric acids and boiled for a few minutes after which the mass is evaporated to dryness. After adding hydrochloric acid twice or thrice it is repeatedly evaporated to dryness to expell completely all the nitric acid present. Afterwards the dried residue is taken in dilute hot HCl and the silica is filtered off and estimated as usual. The filtrate obtained after the removal of silica is used for estimating copper. A current of hydrogen sulphide is passed into the hot solution and the passage of gas is maintained till the solution cools to room temperature. The precipitate of copper sulphide is filtered off and washed with water containing H_2S. It is then ignited in an open porcelain crucible and weighed as CuO. To check this result, the cupric oxide in the crucible is dissolved in HNO_3 and the copper in the solution obtained is determined both by the volumetric and electrolytic methods.

The filtrate after removal of copper sulphide is boiled well to free it from all H_2S and then oxidised with a little HNO_3. The third group metals present in the solution are precipitated as hydroxide by the addition of ammonia and ammonium chloride. The precipitate is filtered, washed with a ten per cent solution of ammonium nitrate and then ignited and weighed as oxides. These oxides are then dissolved in 30 to 40 cc. of 1:1 H_2SO_4 and the solution obtained is diluted to 200 cc. Aliquots of this solution (25 cc.) are reduced with zinc and sulphuric acid in a Jones reductor and titrated against standard $KMnO_4$ solution. From the consumption of standard $KMnO_4$ noticed, it was easy to estimate the quantity of iron present.

Tests for aluminium, magnesium and alkalies were made and they were found to be absent. Calcium is present only in traces. Ferrous iron was determined in a separate portion by the well known hydrofluoric-sulphuric acid method described elsewhere in this thesis (part II-B, p. 100).

The composition of the ore is as follows —

TABLE I

Percentage chemical composition		Copper present as *per cent*	CuO present as carbonates %	Mol Prop	Mineral composition %
SiO_2 (Insoluble matter)	14.70			0.245	14.70
Fe_2O_3	49.14			0.307	Hydrous iron oxide = 55.52
FeO	0.60			0.008	Siderite = 0.93
CaO	trace				
CuO	20.60	Cuprite 0.69 Carbonates 15.77	19.74	0.248	Cuprite = 0.78 Malachite = 20.12 Azurite = 7.58
CO_2	6.28			0.143	
H_2O	8.41			0.467	
Total	99.73				99.63

The results of analysis of the specimen are given in table I above, which also includes the computations of mineral compositions.

It can be gathered from the above table that after allowing for the CO_2 present in siderite, the balance of CO_2 was much more than the quantity which would be present if all the copper were in combination as malachite. It, therefore, appears that a copper ore with a higher CO_2 content is also present and this indicates the presence of azurite in the specimen examined The exact proportions of malachite and azurite present could not be found excepting by indirect calculation as shown in table I, for the reason that it was very difficult to effect any separation of the two minerals Methods of air elutriation were employed for this purpose but these failed to separate them Table I shows that only about two per cent of water will be required to satisfy the quantity of basic carbonates present and the rest, viz , about six per cent is perhaps combined with the iron oxide which would therefore exist as hydrous oxide of iron.

Chemical methods were also employed to find out exactly the mineralogical nature of the ore

The presence of cuprite and copper silicate was established as explained below A weighed quantity of the finely crushed ore was leached with 100 cc 1 20 HCl for two hours The residue from the above treatment was well washed and digested with a solution of 100 cc. 1 10 HCl on the water-bath for about 8 hours After this it was filtered and the solution was tested for copper The insoluble residue was then washed thoroughly and ignited The ignited powder was boiled with 200 cc of concentrated nitric acid for about 2 hours after which the excess of Nitric acid was removed by evaporation The dry residue thus obtained was then taken up with 50 cc of hot 1 2 H_2SO_4 the solution boiled vigorously for about an hour The insoluble portion of the above was separated by filtration and the residue after thorough washing was reserved for further treatment as given below —The filtrate was diluted to 100 cc and its copper content was determined as usual The amount of copper thus obtained was taken to represent the copper present as cuprite in the ore

The insoluble matter from the H_2SO_4 treatment was examined under the microscope after careful drying It was found to be composed mainly of fine grains of quartz and also of a pale-green transparent mineral, probably a silicate of copper This material was, therefore, fused with sodium carbonate and the cooled melt was taken in dilute HCl and evaporated to dryness The dry residue was taken in dilute H_2SO_4 and the silica was filtered off, ignited and weighed as

SiO_2 Copper was determined in the filtrate as usual From the results of the above investigations, calculations yielded the following mineral composition of the specimen —

Cu present as carbonate = 15 77 per cent
(malachite and Azurite)
Cu present as cuprite = 0 69 per cent
Cu present as copper silicate = 0 25 to 0 35 per cent

Table I shows that the compact ore is rich in copper, holding about 27 5 per cent of copper carbonates roughly ¾ of which is malachite and the rest is azurite Almost all the iron is present as a brownish-red hydrous oxide having a composition midway between goethite and limonite Perhaps it is a mixture of limonite and hematite The ferrous iron is probably present as the carbonate, viz, siderite

As a result of several experiments it was found that 19 10 per cent of CuO in this ore is soluble in 1 20 HCl and that 1.22 per cent insoluble

Earthy and Powdery Ore—In addition to the compact ore described above an earthy powdery ore was also examined in detail This ore is also from the same locality and occurs more abundantly than the compact variety

The chemical composition of the ore is as follows —

TABLE II

	per cent
SiO_2	14 78
CuO	16 88 — 15 30
Fe_2O_3	53 70
Loss	14 51
Total	99 87

Concentration of a 100 mesh powder of this ore by means of a single vessel elutriator was resorted to and four fractions were obtained as shown below —

TABLE III

Concentration by Elutriator

Fractions	Rate of flow of water	Period	Material collected	per cent
1	240 cc in 4 minutes	15 minutes	*A*	10
2	320 cc ,,	1 hour	*B*	36
3	600 cc ,,	2 hours	*C*	22
4	Material left behind		*D*	32

The copper, silica and iron contents of the four fractions given in table III were determined and these are given in table IV

TABLE IV

Composition of the various concentrates

Concentrates	SiO_2	CuO	Fe_2O_3	Total
A	12 50	34 11	29 30	75 91 per cent
B	14 02	18 19	54 51	86 72 ,, ,,
C	16 75	9 23	65 57	91 55 ,, ,,
D	20 31	5 05	71 10	96 46 ,, ,,

Extraction of the copper from the earthy copper ore by dilute mineral acids —The material was finely powdered and treated with dilute mineral acids for varying periods and then filtered The copper content in the filtrate was determined by electrolysis[2], using a rotating electrode The iron was determined by precipitation as hydroxide and igniting and weighing it as ferric oxide

TABLE V

DIGESTION OF THE ORE WITH DILUTE HCl, H_2SO_4 AND HNO_3 AND THE COPPER AND IRON CONTENT OF THE RESULTING SOLUTION

(*The digestion was always carried out at room temperature 25°—27°*)

Expt No	Dilution of acid	Duration of treatment	HCl		H_2SO_4		HNO	
			Cu dissolved	Fe_2O_3 dissolved	Cu dissolved	Fe_2O dissolved	Cu dissolved	Fe_2O dissolved
			%	%	%	%	%	%
1	1 20	½ hour	11 23	0 91	11 26	1 72	11 02	1 90
2	,,	1 hour	11 31	1 37	11 31	1 76	11 09	2 24
3	,,	2 hours	11 45	1 33	11 13	1 85	11 14	2 25
4	,,	5 ,,	11 42	1 58	11 26	2 23	10 98	2 41
5	,,	9 ,,	11 41	1 65	11 27	2 84	11 00	3 63
6	1 10	2 ,,	11 20	2 18	11 22	2 14	10 31	2 65
7	,,	5 ,,	11 24	2 44	11 18	2 61	11 00	3 11
8	,,	9 ,,	11 29	2 53	11 27	3 34	11 15	4 36
9	1 30	2½ ,,	10 95	1 38	11 06	1 56	10 81	1 68
10	1 . 40	,,	10 87	1 28	11 01	1 42	10 66	1 64
11	1 50	,,	10 84	0 95				

Table V shows that the iron content of the solution derived from the leaching of the ore by acids increases proportionately with the strength of the acid used and also with the duration of treatment. Further, these factors do not seem to affect much the amount of copper extracted from the ore which remains more or less constant and shows only very slight variations. Very dilute acids such as 1 : 50 HCl dissolve in an interval of 2½ hours 10.84 per cent of Cu. Stronger acids such as 1 : 10 HCl dissolve in an interval of 9 hours only 11.29 per cent Cu, the difference being only 0.45 per cent. The best results are obtained when the ore is digested with 1 : 20 HCl for periods ranging from ½ hour to 2 hours. Of the three mineral acids hydrochloric acid is the best suited for this purpose, because at a dilution of 1 : 20 it extracts the maximum amount of copper without at the same time bringing much iron into solution.

Summary.—A specimen of copper ore from the Nanjangud Taluk, Mysore District, was examined both chemically and microscopically and the results obtained are as follows:—

The specimen was found to contain copper in the following combinations:—malachite, azurite, cuprite and an unidentified silicate of copper.

The existence of hydrous iron oxide was suggested.

The mineral was impure and contained silica and iron in considerable proportion.

A method was worked out for extraction of the copper present in the mineral by careful digestion with acids of regulated strength. Hydrochloric acid (1 : 20) was found most efficient because it extracted most of the copper without at the same time extracting any significant quantity of iron.

The author wishes to record his thanks to Dr. K. R. Krishnaswami for his kind help during the course of this work.

REFERENCES

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