The Metallic Ores of Chili.

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THE ores which I have the honour to submit for your inspection were collected by me in Chili. They consist of numerous compounds of copper, silver, gold, &c., and represent the very varied minerals obtained in that country.

Besides the primary metal there is usually at least one secondary body of value present.

The proportion in which this secondary metal—I mean secondary as regards quantity—is present in metallic ores does not seem to be a mere chance affair, but seems to follow some law. My attention was directed to this matter by the silver ores from the district of "Lomas Bayas" near Copiapó. These ores contain gold in a certain proportion, not in relation to the gross weight of the ore but to the contents in silver. As you will see by Table I. the proportion is nearly 1 of gold to 100 of silver, and so near

TABLE I.

Assays of Ores of Silver and Gold.

Silver.	Gold.
.00385	·0000385
·003930	·0000400
·014715	·0001550
·015536	·0001640
·004516	·0000440
·005150	·0000500
·003566	·0000335
·002880	·0000308
·004320	·0000400
·004760	·0000500
·005040	·00C0550
·003040	·0000250
·007900	·0000700
·008060	·0000700

does this proportion hold good that if the results of assay vary much from it the assay is distrusted, and often has to be repeated.

Table II. shows assays of copper and silver ores. In some of these

Cu is to Ag : : 1000 : 1
Some „ „ „ : : 100 : 1
Some „ „ „ : : 200 : 1

and other various proportions.

TABLE II.

ASSAYS OF ORES OF COPPER AND SILVER.

Copper.	Silver.
·422	·00042
·262	·00026
·285	·00033
·338	·00040
·198	·00180
·145	·00134
·109	·00115
·168	·00195
·591	·00030
·358	·00196

Table III. shows the proportions of silver to lead yielded by galenas

TABLE III.

GALENAS.

	Lead.		Silver.
Finisterre	1	:	0·000923
Lozere	1	:	0·003929
Savoy	1	:	0·002745

from different parts; the decimals representing the proportions of silver to 1 of lead, being almost multiples of the lowest, as 1 : 3 : 4, and the decimal on Table IV. gives another multiple 15, so that we have silver to lead as 1 : 3 : 4 : 15 in these examples.

These relationships between the figures clearly point, I think, to some law regulating the proportions of different metals found in company in nature.

If we now turn to the composition of minerals, we shall find indications that this law has some reference to the combining weights of the metals.

Line 2 of Table IV., taken from Dana's Mineralogy, shows the average composition of Bournonite in ten samples from different parts of the globe.

TABLE IV.

Ratios of Equivalents.

	S.	Pb.	Sb.	Cu.	Fe.	Zn.	Ag.	Sn.	As.
Galenite	12·8	10	1	1		3	·14		
Bournonite ...	6	2	2	2					
Polybasite	10		1	1·5	0·08		12·8		·98
Enargite	9		1	7					2·00
Stannite.........	8			4	1	1		2	
Cubanite	12			3	7				
Chalcopyrite ...	11·2			1	1				
Barnhardtite ..	2·67			2	1				

The composition is nearly the same in all, and if we sum up the figures in each column and take the averages we find the average composition to be as shown. If we now reduce these averages to equivalents we get the figures

	S	Sb	Pb	Cu
	6·09	2·13	1·96	2·06
or say	6	2	2	2
which give	19·65	24·98	42·38	12·99=100

with which results we find the figures in the table to agree almost exactly, and the probable formula will be 2 PbS, Cu_2S, Sb_2S_3.

Table V. shows the composition of pyrargyrite in four samples, the averages of which are

	S	Sb	Ag
	17·455	23·10	58·90
and $\frac{\text{Average}}{\text{Equiv.}}$ =	5·453	1·894	5·454
or say	6	2	6
which give	17·71	22·51	59·78 =100.

Formula 3 $Ag_2S + Sb_2S_3$

TABLE V.

Pyrargyrite.

	S.	Sb.	Ag.
Average of Four Analyses...	17·155	23·1	58·9
Equivalents	S_6	Sb_2	Ag_6
In 100 parts	17·7	22·5	59·8

In both these minerals the sulphur is equally divided between the antimony and the other metals, one half being taken up by the antimony and the other half by the other metals present. In the pyrargyrite the second half of the sulphur is taken up by the only other metal present, viz. silver, but in the Bournonite the other metals present, viz. lead and copper, lay equal claim to the second half of the sulphur and divide it exactly between them.

This would appear to indicate a tendency of some metals to claim a half or other large share of the non-metallic element in the mineral, and of other metals to share the other half or remainder as equally as possible among them.

We have examples of this in galenite, where lead is present in the largest proportion, and by taking up its proper share of sulphur to form PbS, will leave only a very small share of sulphur to divide up among the other metals, which have been able to get into the mineral by dividing this remainder among them; the zinc, however, claiming a preference, and putting in 3 equivalents, thus appropriating one half of the remaining sulphur, while the antimony, iron and copper are each represented by 1 equivalent.

In stannite, where copper supplies $4=\frac{1}{2}$ of the 8 metallic equivalents present, tin supplies $2=\frac{1}{2}$ of the remainder, and iron and zinc 1 equivalent each to complete the number. In this example the number of equivalent of the non-metal is the same as that of the metals. Another example is Barnhardtite, in which copper and iron are combined with sulphur in the ratios of 2 equivalents of copper to 1 equivalent of iron.

In chalcopyrite the same metals are combined with sulphur in the ratio of 1 of copper to 1 of iron. And in Cubanite the same metals are combined with sulphur in the ratio of 3 of copper to 7 of iron. In these few examples we see that the metals, in their joint combinations with non-metals, manifest preferences, but the preferences are not always on the same side, but, like good friends and good fellows, the metals mutually prefer one another even to the extent at times of taking equal shares; and they evidently do so by rule, whatever that rule may be.

Among the specimens on the table are a few rarities. One of these is a specimen of nitrate of soda, not the commercial substance, nor taken from the "salitreras," but taken from a much more elevated source, viz. from the Cordilleras at a height of about 14,000 feet above the sea. I have always understood that the source of Chili or Peruvian saltpetre is in the beds beneath the surface soil found in Peru and Chili. This is certainly the commercial source of nitrate of soda. But where do these beds get their supply from? The "salitreras" are found in flat, low-lying tracts of country, and are residues left by the evaporation of water whose journey towards the sea has been stopped at those places by the nature or formation of the ground; but where does the water get the nitrate from? Some rocks contain soda which is gradually dissolved out as the rocks are decomposed by the weather, and carried away by rain and snow waters; and I have heard that it is converted into nitrate by the action of the nitrogen of the atmosphere. But this process is slow, and somewhat evenly spread over the face of the earth, and, I think, can scarcely account for the immense accumulations of nitrate in certain parts. Some may be formed in this way, but I think the water which supplies those "salitreras" must encounter the nitrate in some more handy form, and the sample before you shows what that form is. The genuineness of this sample I can vouch for, for I was present and saw it taken from its vein and have kept it carefully ever since.

At the height stated, about lat. 24° S, at the edge of a valley where the rocks are broken off abruptly, a "cateador" saw veins of some sort and a white crystalline substance in some of them, and, as it is these men's business and habit to pick up and examine everything they come across to find out whether it is of value or not, he picked off some, and, among other tests, he put a sprinkling on his lighted cigarette, when the increased combustion of the paper and tobacco at once told him what he had found. Well, in the rocks at this place there are a great many veins of this nitrate, between hard rock on either side; the length of the crystals in the bottle—about 1½ inches—shows the thickness of some of the veins from which they were taken, the crystals run transversely and have somewhat the appearance of lump sal-ammoniac. These veins were found cropping out here and there over a large area, and the thin soil in many places contained a large amount of nitrate. This specimen of nitrate is very pure, giving no indications of either sulphates or chlorides, and yielding to analysis 99·1 per cent. nitrate of soda.

Here, I think, we have the primary source—so far as it is possible for us to trace—of the great deposits of "salitre," in the "salitreras" of Chili and Peru. I don't think this source will ever become a commercial one, from the inaccessibility of its position. The cost of transit of supplies and of the nitrate, and the cost and difficulty of labour at that elevation, would be too great. It might pay if it had simply to be dug up as at the lower levels, but it would have to be mined and the veins followed in hard rock, so that for commercial purposes the source of supply will still be the "salitreras" of the plains. But to mineralogy the primary source must be the nitrate pure and crystalline existing in veins in the rocks at the higher and the highest elevations of the Andes.

Beds of salt are also found in the same locality referred to, and salt lakes at that great height supply huge blocks of salt for domestic and amalgamating purposes.

Another specimen is of vitreous native sulphur, broken off the outcrop of a vein of that substance 6 feet thick, which is seen to run for miles along the hillside at the same elevation.

There are also a few flat pieces of stone with which the mountain sides are covered as a thin layer over a great part of the same region. They will let you see the kind of rock existing there.

Another specimen is of sulphate of lime in needles, from a surface deposit in the desert of Atacama.

One specimen of silver ore contains ruby silver—pyrargyrite. Some contain native silver, and others are of different composition.