II.—On some Minerals containing Arsenic and Sulphur from Chili.

BY FREDERICK FIELD.

Arsenic and Silver.—A remarkable instance of the oxidation of arsenic, when in combination with copper, appears in the mineral Condurrite, examined by Professors Faraday and Blyth. In the northern part of Chile, where little or no rain falls, and the mines have only been recently worked, many minerals in a highly oxidized state are found, which have been preserved untouched from the absence of any solvent. Arsenic is obtained sometimes as arsenious acid, and sulphur as sulphuric acid, in combination with the oxides of iron and copper. In Peru, even crystals of native sulphate of silver have been observed. From a mine in the immediate neighbourhood of Copiapo, I received some specimens of a mineral consisting apparently of native arsenic, having a specific gravity of 5·75, breaking easily under the hammer with a fine granular fracture, and presenting an iron grey colour when broken. It could be reduced to the finest powder by trituration.

Analysis gave the following results in 100 parts:—

Arsenic	.	.	.	.	.	.	79·21
Silver	.	.	.	.	.	.	12·56
Cobalt	.	.	.	.	.	.	3·24
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							95·01

No sulphur could be detected, and other metallic elements were sought for without success. Many analyses gave, more or less, the same results, always leaving a loss of nearly 5 per cent. It occurred to me that a considerable portion of the arsenic might exist in an oxidized state; and this seemed the more probable on account of the low specific gravity of the mineral (the same as that of metallic arsenic), while it contained so large a percentage of silver.

On digesting some of the pulverized compound in warm water

for a few hours, the liquid after filtration was decidedly acid to test paper; and on the introduction of a few drops of hydrochloric acid and the passage of a current of sulphuretted hydrogen, a very bulky precipitate of sulphide of arsenic was produced: that *arsenious* and not *arsenic* acid was present was evident from the immediate precipitation of the sulphide.

30·00 grs. of the mineral digested for twenty-four hours in ten ounces of water, kept at a temperature of about 150° Fahr., lost 5·15 grs. in weight, and the filtered solution yielded 6·42 of sulphide of arsenic. Before the passage of the sulphuretted hydrogen, the filtrate was acidulated with hydrochloric acid, and the precipitate was of a pure canary yellow. After standing many hours, the sulphide was separated by filtration; a few drops of sulphide of ammonium caused a brownish-black colour when added to the filtrate, which deposited slight flakes, after some time, of what proved to be sulphide of cobalt. Although arsenite of cobalt is insoluble in water, it becomes slightly soluble when digested in solution of arsenious acid, sufficiently so, at least, to give a reaction with alkaline sulphides. This accounts for the trace of cobalt found in the liquid.

The composition of the mineral appears to be as follows:—

Arsenic	66·17
Arsenious acid	17·22
Silver	12·56
Cobalt	3·24
Oxide of cobalt	traces
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	99·19

M. Domeyko, to whom I sent a specimen of this mineral, having examined it through a very strong lens, imagines that the silver is mechanically mixed in a very minute state of division, through the mass of arsenic, arsenious acid, and arsenide of cobalt.

Sulphide of Copper and Arsenic.—I am not aware that any simple natural combinations of arsenic, sulphur, and copper, have hitherto been discovered. The mineral tennantite, although its analysis differs somewhat in the hands of various chemists, always contains iron, and the many varieties of fahlore, generally have, in addition to this element, more or less antimony, zinc, and silver.

The following are some analyses of tennantite :—

	(1.) Phillips.	(2.) Kudernatsch.	(3.) Fearnley
Copper .	47·70	48·94	42·60
Arsenic .	12·46	19·10	19·01
Sulphur .	30·25	27·76	29·18
Iron .	9·75	3·57	9·21
	<hr/> 100·16	<hr/> 99·37	<hr/> 100·00

I have obtained lately from quite a newly discovered mine in the Cordilleras of the Andes, splendid specimens of a mineral, consisting essentially of arsenic, copper, and sulphur, with mere traces of iron and silver. The mineral occurs in highly crystalline black masses, covered with layers of cyanose (sulphate of copper), and having a specific gravity of 4·39, hardness about 3·8. The mean of several analyses gave the following composition :—

Copper	48·56
Sulphur	31·80
Arsenic	19·10
Iron	·42
Silver	traces.
	<hr/> 99·88

probably having the formula $3\text{Cu}_2\text{S} \cdot \text{AsS}_5$, which requires—

Copper	48·60
Sulphur	32·42
Arsenic	18·98
	<hr/> 100·00

and may be considered as a tribasic sulpharsenate of copper, corresponding to the tribasic sulpharsenate of potassium, if we admit that Cu_2 replaces the K as it does Ag in many minerals.

I have proposed the name *guayacanite* for this mineral, as it was first brought from the mine to the large copper-smelting works of Guayacan, in Chili.

Guayacanite may be considered as tennantite in which the iron is replaced by arsenic :—

CONTAINING ARSENIC AND SULPHUR.

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	Guayacanite.	Tennantite.
Copper	48·56	47·70
Sulphur	31·80	30·25
Arsenic	19·10	12·46
Iron	42	9·75
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	99·88	100·16

Pursuing researches upon the arsenical minerals which occur from time to time, owing to the rapid development of mineral wealth in this quarter of the globe, I examined a small iron-grey coloured metallic vein, traversing a larger one of blue carbonate of copper. This mineral was obtained from a mine about twenty-five leagues south-east of Coquimbo. It was very difficult to free the mineral from adherent particles of carbonate of copper, &c., but a great portion was removed by digestion in acetic acid, and when thus purified gave—

Copper	35·82
Sulphur	17·91
Arsenic	14·20
Residue and Oxide of Iron	28·24
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	96·17

There were also traces of antimony, zinc, and silver, and probably some carbonate of lime which was not estimated, as the object was principally to learn the relative proportions of copper, arsenic, and sulphur, which were found to stand to one another in 100 pts. as under :—

Copper	52·73
Sulphur	26·36
Arsenic	20·91
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	100·00

Or, $3\text{Cu}_2\text{S} \cdot \text{AsS}_3$, which formula requires—

Copper	52·89
Sulphur	26·44
Arsenic	20·67
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	100·00

This may be considered as a tribasic *sulpharsenite* of copper, as the former mineral was a tribasic *sulpharseniate*.

Both of these minerals, when digested in solutions of the alkaline sulphides, lose weight, and the greater part of the sulphide of arsenic is dissolved.

In like manner, the dark and light varieties of Rosicler may be considered as tribasic sulphantimonite and tribasic sulpharsenite of silver.

Specimens of great purity of the dark variety gave—

Silver	.	.	.	.	.	.	59·01
Antimony	.	.	.	.	.	.	23·16
Sulphur	.	.	.	.	.	.	17·45
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							99·62

Or, $3\text{AgS} \cdot \text{SbS}_3$, and the light variety :—

Silver	.	.	.	.	.	.	64·88
Arsenic	.	.	.	.	.	.	15·12
Sulphur	.	.	.	.	.	.	19·81
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							99·81

corresponding to $3\text{AgS} \cdot \text{AsS}_3$.

Specimens have been forwarded for the acceptance of the Society, to the care of Mr. Abel.

I am at present engaged in the investigation of a mineral containing sulphur, antimony, copper, and iron, with small quantities of silver. The blackish-looking ore is thickly sprinkled with bisulphide of iron, and as yet I have obtained no specimen pure enough for analysis. From the relative proportions of antimony and copper, little doubt exists that it will prove to be a tribasic sulphantimonite of copper.