

bismuth found in Saxony. Calcium vanadate, called vanadiolith, has been found, and also free vanadic acid has been discovered on the shores of Lake Superior in small quantities. Good specimens of nearly all these minerals, and of many varieties of some of them may be seen in the National Museum at Washington, D.C., and some of them, especially the vanadinites, are very beautiful.

Roscoelite is a vanadium mica which has been mined for many years in the western part of the United States and contains about 25 per cent. V_2O_3 . As one might suppose from its being a mica, it presents great difficulties in treatment, and vanadium products prepared from roscoelite find it hard to compete with those from more readily worked ores.

Carnotite is now a well-known mineral. It occurs on sandstone and other substances as a yellow incrustation or impregnation. It is a potassium-uranyl vanadate and possess the formula: $K_2O \cdot 2UO_3 \cdot V_2O_5 \cdot 3H_2O$. It has been largely mined in Colorado and Utah as a source of radium, and most of the world's radium to-day is made by a Pittsburgh corporation from the uranium content of this ore. It has not yet been found practical to use it as an ore of vanadium, even with the radium as a valuable by-product, but research work is being done continually on this proposition by the corporation alluded to, which controls immense holdings of carnotite

establishment in the world, as it is very near the summit of the Andes. The increase in vanadium-content made by this simple operation is readily seen by an inspection of the two following analyses made by Kent-Smith.

Before Roasting—	Per. Cent.
VS ₃	39.84
MoS ₂	1.57
FeS.....	4.07
NiS.....	1.49
S.....	30.57
SiO ₂	13.60
Al ₂ O ₃	2.46
Alkalies, rare earths, lime....	1.40
Moisture.....	5.00
After Roasting—	Per Cent.
V ₂ O ₅	58.08
MoO ₃	2.62
Fe ₂ O ₃	4.98
NiO.....	2.24
S.....	0.23
SiO ₂	25.00
Al ₂ O ₃	4.52
Alkalies, rare earths, lime	2.56

By this operation the vanadium content is raised from less than 14 per cent. to rather more than 30 per cent. In the same deposits with the patronite appear other



VANADIUM ORE TRAIN, PERU

deposits. The United States Bureau of Mines is also making radium from carnotite and selling the vanadium residues to a steel concern which works them up into vanadium alloys.

Immense amounts of impregnated sandstones, with small, but uniform, content of vanadium go under the name of vanadiferous sandstone, and await a metallurgical process sufficiently efficient to extract their small vanadium content.

The most important and the most curious ore of vanadium is patronite, an impure sulphide of vanadium containing much free sulphur, which occurs in asphaltite deposits in the Peruvian Andes. These deposits were discovered in 1905 by Patron, after whom the ore is named. These mines have been developed and are owned by the American Vanadium Company, of Pittsburgh, who ship the ore from Callao to their plant at Bridgeville near Pittsburgh, where it is made into ferro-vanadium. Over 75 per cent. of the world's production is made by this company, from this source. The patronite is not shipped as mined, but is roasted at a plant at the mines, probably the most lofty industrial

minerals which seem to be oxidation products of patronite, but are not mined. The genesis of these deposits is a complete mystery, but it seems to be in some way connected with the highly vanadiferous lignites of Mendoza and other places and the vanadiferous asphaltites of Yauli.

Physical and chemical properties of vanadium.—Pure metallic vanadium was prepared for the first time in 1904 on a very small scale, and consequently the many published statements regarding the physical properties of the element prior to this date are of small value. Roscoe tried to obtain it by reducing VCl_3 with hydrogen, and obtained a silvery metallic powder, which, however, contained some hydrogen. Moissan's vanadium obtained in the electric furnace contained considerable carbon. It was whitish and exhibited a metallic fracture. Weiss and Aichel reduced oxides of vanadium with Mischmetall and obtained a white regulus which showed facets of hexagonal-rhombohedral crystals, which agreed well with the element's position in Mendeleeff's Table along with arsenic, antimony and bismuth, which also take this habit.