ART. XXXVII.—*Ludwigite from Peru;* by M. G. EDWARDS.

During an examination of a zone of highly contact-metamorphosed limestones in the province of Yauli, Peru, Mr. D. D. Smythe and the writer encountered a mineral which was identified as the ferric magnesian borate, ludwigite. This mineral was first described by Tschermak[1] from Morawitza in Hungary. Since his time minerals of the ludwigite group have been identified and described from one locality in Sweden, one in Korea, one in Alaska, and from several localities in the United States proper. No occurrence has heretofore been reported, to the writer's knowledge, from South America.

Occurrence and Associated Minerals.—The ludwigite was first observed five miles east of the continental divide of the Andes Mountains near a trail leading from the town of Morococha to Galera, a railway stop on the divide. The altitude of the deposit is 15,500 feet above sea-level. It occurs in an area of metamorphic limestone in contact with a stock of quartz monzonite and is found abundantly over an area of 100 by 200 feet.

Associated with the ludwigite are pyrite, magnetite and serpentine in considerable quantities, with meager traces of chalcopyrite. Its relation to the magnetite and pyrite suggests contemporaneous crystallization. Free quartz is absent.

Since the time of this discovery, ludwigite has been observed in neighboring contact zones. These discoveries, following closely upon the identification of the mineral, led the writer to agree with Shannon[2] in the opinion that the minerals of the ludwigite group exist more commonly in contact deposits than is generally supposed and that some of the minerals assumed to be tourmaline, ilvaite and magnetite may prove upon examination to be members of this group.

Description and Physical Properties.—The color of the Peruvian ludwigite is black. A fresh fracture may show a faintly bluish tinge. Rarely it occurs in fibrous, crystalline aggregates, in which the fibers, either parallel or radiating, measure from one-quarter to one-half inch in length. Characteristically it exhibits a fine velvety texture, and the individual fibers are not detected by the unaided eye. This results in a silky luster which gives

[1] Tschermak, G., Min. Mitth., 59, 1874.

[2] Shannon, Earl V., Ludwigites from Idaho and Korea, Proceedings of the United States National Museum, 59, pp. 667-676, 1921.

a faint sheen to a fresh surface. Its true hardness is difficult to determine on account of this felted texture. The mineral can be picked apart by the fingernail causing a black stain which resembles soot instead of a mass of fibers. The streak is dark green. When ground to a powder it is moderately magnetic with an ordinary horseshoe magnet.

Optical Properties. In thin section the mineral is opaque. In powdered form the smallest fragments under the microscope are transparent at the edges but colored. Pleochroism is strong, the color being brown parallel to the elongation and green perpendicular to it. Index of refraction is above 1.8. Extinction is parallel to the elongation.

Chemical Properties.—The mineral is soluble in hydrochloric, nitric and sulphuric acids. It gives the green flame of boron when treated with sulphuric acid. Hence the blowpipe test, by itself, may be misleading, as tourmaline is the natural assumption. Ordinarily, however, the hardness and streak will suffice for this differentiation.

Composition.—The writer is indebted to Mr. George Plews for the following analysis:

Silica (SiO_2)	3.80
Ferric oxide (Fe_2O_3)	34.55
Alumina (Al_2O_3)	0.92
Ferrous oxide (FeO)	5.27
Magnesia (MgO)	34.80
Lime (CaO)	3.75
Manganese oxide (MnO)	trace
Boric anhydride (B_2O_3)	14.00
Water (H_2O) above 110°	.25
Undetermined	2.66
	100.00

It is assumed that the silica, lime and water are contributed to the analysis from the included gangue. The remaining constituents yield the following ratios:

Constituent	Per cent		Ratios
FeO	5.27	0.0818	0.0889 x 0.92 } 4
MgO	34.80	0.9640	0.0870 x 11.08 }
Fe_2O_3	34.55	0.2417	0.0806 x 3.00 1
B_2O_3	14.00	0.2233 }	0.0780 x 3.00 1
Al_2O_3	0.92	0.0108 }	
	89.54		

The general formula is, therefore, $4(Mg, Fe)O.Fe_2O_3.B_2O_3$ and a mineral of the above composition may be expressed by the formula $3MgO.B_2O_3.(Mg, Fe)O.Fe_2O_3$, placing the Peruvian ludwigite as a member of the magnesioludwigite-ferroludwigite series with approximately nine parts of the former to four parts of the latter. A comparison of the percentages of the essential constituents given by the original analysis (recalculated to 100 percent) and the percentages calculated for a mineral of this composition are as follows:

Constituent	Found	Calculated
FeO	5.88	5.51
MgO	38.87	37.28
Fe_2O_3	38.59	39.77
B_2O_3	16.66	17.44
Al_2O_3		
	100.00	100.00

The Peruvian ludwigite is, therefore, high in the magnesioludwigite molecule; indeed, to date it is exceeded in this respect only by the ludwigite described by Shannon (in the paper previously referred to) from Lemhi County, Idaho, in which the magnesioludwigite and the ferroludwigite molecules appear in the proportions of approximately seven to three. There is a striking similarity in the ludwigites from these two localities in composition, appearance and physical properties.

The Peruvian occurrence adds another link to the chain of evidence corroborating the views of Shannon and others that

1—Ludwigite occurs only as a contact metamorphic mineral;

2—It is probably a fairly contact product of contact metamorphism;

3—Free quartz does not occur in association with ludwigite; (it has been suggested that if the supply of silica is deficient ludwigite forms, whereas if the supply of silica is ample tourmaline forms.)

4—Ferrous iron and magnesia are isomorphous within the group;

5—Ferric iron and boric anhydride are constant in their ratio to each other.

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