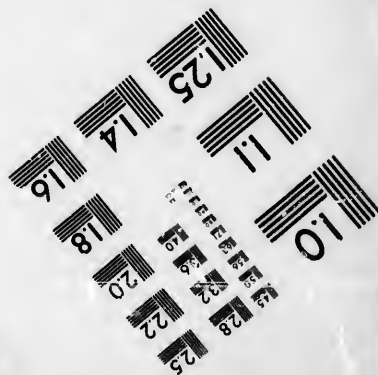
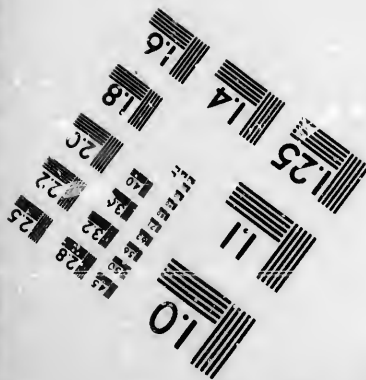
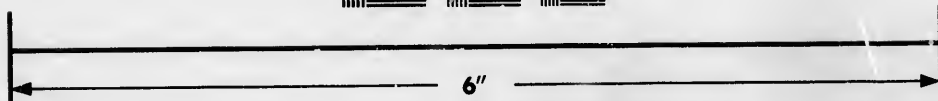
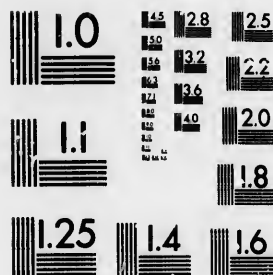


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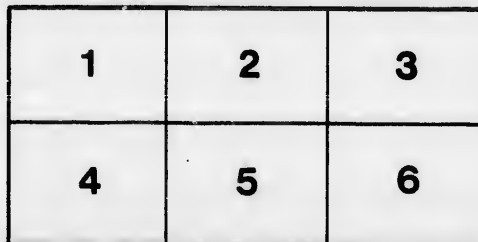
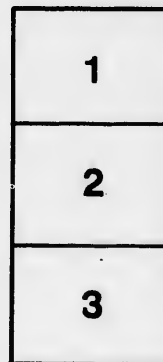
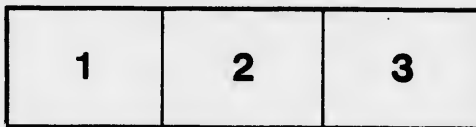
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*Errata.*—1. In analysis vi., p. 11, the oxygen of 27.72 of alumina should be 12.95, instead of 13.95. This correction being made, the oxygen ratios for the protoxyds, sesquioxys and silica become 7.62:13.73:23.25=1:1.80:3.05, instead of 1:1.93:3.05. In this case therefore, as well as in analysis vii., there is present a certain excess of protoxyds and silica corresponding nearly to a ter-silicate.

2. On page 13, line 20, for 32.22, read 38.22.

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CONTRIBUTIONS  
TO THE HISTORY OF  
EUPHOTIDE AND SAUSSURITE.

BY

T. STERRY HUNT,  
Of the Geological Survey of Canada.

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[FROM THE AMERICAN JOURNAL OF SCIENCE, VOL. XXVII, MAY, 1859.]

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## ON EUPHOTIDE AND SAUSSURITE.

1. THE name of euphotide was originally given by Haüy to a rock composed of diallage and a white compact mineral which he designated as *feldspath tenace*, (the compact feldspar of Werner, the lemanite of Delamétherie, and the jade of de Saussure senior). The well-marked contrast of colors which suggested the name of euphotide is seen in the beautiful *verde di Corsica* or *verde antico di Orezza*, and in some varieties of the rock from Mt. Rose. In these the diallage is represented by a grass-green smaragdite, and this mineral and hypersthene being regarded by Haüy as varieties of diallage, he included under the head of euphotide, the *verde di Corsica*, (for which alone d'Halloy retains the name of euphotide,) the hypersthene or hyperite of other authors, and the granitone of the Italians. This last by an error of Von Buch, in which he has been followed by Gustav Rose, is very frequently called gabbro. The true gabbro of the Italians is however a diallagic ophiolite. (Brougniart, *Classif. des Roches*, 1827, p. 75.)

Brougniart defines euphotide to be a mixture of diallage with jade, petrosilex, or compact feldspar, and including d'Halloy's two species, euphotide and granitone, but excluding hyperite, he distinguishes as varieties, jadian and feldspathic euphotides, besides ophitic (serpentinous) and micaceous euphotides, the latter being sometimes talcose.

Coquand (*Traité des Roches*, 1857,) has followed Haüy with regard to the euphotides, while Senft (*Die Felsarten*, 1857,) places in one group, under the head of hyperite, three genera, eclogite, gabbro, and hypersthene, in the second of which he includes rocks made up of labradorite or saussurite with diallage or smaragdite. The eclogite of Haüy is composed of diallage or smaragdite, and red garnet; it often holds disthene (cyanite) through the predominance of which it passes into disthene (disthenfels), while hypersthene or hyperite (hypersthenefels, G. Rose) is a mixture of saussurite or labradorite with hypersthene (d'Halloy, Senft.).

Distinctions like some of the above based upon the contained varieties of pyroxene are evidently of secondary importance, and it becomes necessary to define with more strictness the nature of the other element of the rocks in question. The jade of the Swiss Alps to which de Saussure junior, afterwards gave the name of saussurite, was described by de Saussure senior, as compact, tenacious, greenish-white in color, hard enough to scratch quartz, and having a specific gravity of 3.318—3.389.

Mohs gives 3·256 for the density of a granular saussurite from Piedmont, and 3·34 for a compact variety from the Canton of Vaud, while Naumann assigns to the mineral a density of 3·40. These authors thus agree in ascribing to saussurite a specific gravity much above that of the feldspars.

Klaproth and de Saussure junior, both analyzed specimens of the saussurite from the shores of the Lake of Geneva (Iemanite, I and II) while Boulanger subsequently examined the saussurite from the euphotide of Mt. Genève (III), and from two localities in Corsica, the valley of Orezza (IV) and the banks of the Fiumalto (V).

	I.	II.	III.	IV.	V.
Silica,	49·00	44·00	44·6	43·6	34·0
Alumina,	24·00	30·00	30·4	32·0	24·4
Peroxyd of iron,	6·50	12·50	....	....	....
Lime,	10·50	4·00	15·5	21·0	31·8
Magnesia,	3·75	....	2·5	2·4	6·4
Soda,	5·50	6·00	7·5	....	....
Potash,	....	·25	....	1·6	....
	<u>99·25</u>	<u>96·75*</u>	<u>100·5</u>	<u>100·6</u>	<u>96·6</u>

The physical and chemical characters of the above specimens offered considerable differences. The saussurite II. is described by de Saussure as leek-green, subtranslucent, with an oily lustre, and a finely granular, scaly fracture; it scratched quartz and had a density of 3·261. At a high temperature it fused without loss of weight, into a glass much softer than the original mineral, and having a density of only 2·8. This saussurite, which was free from any admixture of smaragdite, was scarcely attacked by boiling sulphuric acid.—(*Journal des Mines*, vol. xix, p. 205, A. D. 1805.)

The saussurite from Mt. Genève (III) according to Boulanger is associated with a greenish-brown smaragdite, and is itself greenish-white and compact, not scratched by the knife, and having a density of 2·65. He describes another euphotide from the same locality as having a lamellar base, with cleavages like feldspar, sometimes chatoyant, hard, not attacked by acids, and with a density of 2·58. The analysis of this undoubted feldspar gave him, silica 66·6, alumina 18·5, lime 1·8, soda 6·0, potash 4·3 = 97·2.

The euphotide of Orezza is described by Boulanger as composed of green diallage, a blackish matter also apparently a variety of diallage, and saussurite, the whole arranged in parallel bands, giving to the mass, which is very tough, a schistose fracture. The saussurite (IV) was very compact, less hard than III, and had a density of 3·18. It was easily fusible and not attacked by concentrated sulphuric acid.

\* Besides 0·05 oxyd of manganese.

SECOND SERIES, VOL. XXVII, No. 81.—MAY, 1859.



The euphotide of the Fiumalto consisted of green diallage with curved lamellæ in a white paste, which was tender, easily cut with a knife, and had a density of 3.30 (v). It was readily fusible and easily attacked by sulphuric acid, with which the analysis was made; the separated silica being dissolved by a solution of potash which left a residuc, supposed to be diallage, and equal to 3.8 parts, which added to the above analysis makes the sum 100.4; alkalies were absent.—(*Ann. des Mines*, [3], viii, p. 159.)

Notwithstanding the peculiarities presented by saussurite, modern mineralogists have generally referred it to labradorite or some other feldspar, (see Beudant, Bischoff, Dana, Delesse, etc.). Jameson, separates it from the feldspars on account of its greater specific gravity, but recent authors seem to have entirely lost sight of this characteristic. Coquand describes saussurite as having a density of 2.87, while according to Delesse it is seldom inferior to 2.80. These authors agree in declaring the mineral to be decomposable by acids like labradorite, while Bischoff and Senft, without alluding to its density, assert that saussurite is not attacked by acids.

An analysis of saussurite by Stromeyer gives the composition of labradorite, while Lory on the other hand has described as euphotide a rock from Levaldens in the Dauphinese Alps, which is made up of an olive hornblende and a white mineral having the cleavage of a feldspar and the composition of andesine.—(*Bull. Soc. Geol. de France*, [2], vii, 540.)

Delesse examined the white base of a euphotide from Odern in the Vosges, and another from Mt. Genève. Both of these were highly crystalline and exhibited the polysynthetic macles of the feldspars of the triclinic system. When pulverized and treated with muriatic and sulphuric acids they swelled up and were decomposed. Delesse has however described them as saussurite. That from Odern gave him, silica 55.23, alumina 24.24, lime 6.86, magnesia 1.48, protoxyd of iron 1.11, soda 4.83, potash 3.03, water and volatile matters 3.05 = 99.83. The euphotide of Mt. Genève contained diallage, a serpentine-like substance, and a ferriferous carbonate of lime, besides the feldspar, whose crystalline laminæ were more than one-third of an inch in length, and gave by analysis, silica 49.73, alumina 29.65, lime 11.18, magnesia 0.56, protoxyd of iron 0.85, soda 4.04, potash 0.24, water and volatile matters 3.75 = 100.00. Of the volatile portion according to Delesse, at least 2.50 p. c. is water, the remainder being carbonic acid. (*Ann. des Mines*, [4], xvi, pp. 238 and 267.) This feldspar resembles that of the orbicular diorite of Corsica which gave to Delesse, silica 48.62, lime 12.02, alkalies 3.61, and 0.49 of water.

Under the name of saussurite von Rath has described a mineral which with hornblende (uralite) forms the greenstone of Neurode in Silesia. It had the hardness, cleavage, and crystalline structure of labradorite, but with a specific gravity of 2.99, and gave by analysis, silica 50.84, alumina 26.00, peroxyd of iron 2.73, lime 14.95, magnesia 0.22, potash 0.61, soda 4.68, volatile 1.21 = 101.24.—(*Pogg. Ann.*, xcv, 555.)

2. Accepting the view maintained by Rose, Bischoff and Delesse, that saussurite is nothing more than a feldspar, I referred to this species the compact feldspars of the Laurentian rocks of Canada, described in my report of 1854. Associated with the limestones and ophiolites of this most ancient geological series, is a great body of crystalline stratified rocks, composed essentially of anorthic feldspars, sometimes almost without admixture, but frequently associated with green granular or cleavable pyroxene, which passes through a kind of bronzite into hypersthene. Small quantities of epidote, garnet, and more rarely mica and quartz, are also met with, and magnetite and ilmenite are common. Different varieties of these rocks would be referred by lithologists to the species labradophyre, dolerite, and euphotide. The feldspars are sometimes very coarsely crystalline but often compact; they have a hardness of 6.0, and vary in density from 2.67 to 2.73, and in composition from andesine to vogsite. The denser varieties are those in which lime and alumina predominate; all of them contain besides soda small quantities of potash. The analyses of numerous varieties of these feldspars will be found in the Report cited above, and in the *L. E. and D. Philos. Magazine*, [4], ix, 262.

The euphotides examined by Delesse and Lory are apparently nothing more than varieties of dolerite, by which term we understand a rock composed essentially of a triclinic feldspar, with some variety of pyroxene, which may be augite, hypersthene, or diallage. According to G. Rose, smaragdite, which is the variety of pyroxene regarded as characteristic of euphotide, has often the external form of pyroxene with the cleavage of hornblende, constituting the variety uralite, while in the euphotides of Baste and Veltlin hornblende occurs with the diallage, and sometimes replaces it entirely, giving rise to a rock composed of saussurite and hornblende. Sandberger has observed crystals of pyroxene forming macles with others of hornblende, and the latter often surround the crystals of pyroxene, or as I have remarked in specimens from Madawaska, small crystals of deep green hornblende are implanted upon large prisms of greenish-white pyroxene. Smaragdite according to Hisinger and Delafosse consists of laminae of pyroxene and hornblende united in a more or less regular manner. Since diorite is distinguished from dolerite by the substitution of hornblende for pyroxene, it

is evident that feldspathic aggregates like those of Baste present a transition from the one to the other species of rock.

Diorite is distinguished from diabase according to Senft by containing a feldspar insoluble in acids (albite or oligoclase,) and by the frequent presence of quartz, while in diabase the feldspathic element is less silicious and decomposable by acids; (labradorite or a variety approaching anorthite).<sup>\*</sup> When however we consider the manner in which these feldspars pass into one another, this distinction between diorite and diabase seems of but secondary importance. We have seen that the orbicular diorite (or diabase) of Corsica contains a feldspar near anorthite in composition, while others in the Vosges, according to Delesse, contain labradorite and andesine, the latter with quartz. Lory has described a diorite from the crystalline schists of the mountains of Chalanches (Isère) which is made up of a chromiferous hornblende, with crystalline andesine and a pale greenish-yellow epidote often intimately mixed with the feldspar, and so abundant as to characterize the rock. This epidote gave by analysis, silica 40·6, alumina 30·2, lime 17·7, protoxyd of iron 11·2 = 99·7.

3. Diorites, as already mentioned, sometimes contain albite. Associated with the Silurian ophiolites of Canada we often find beds of rock which are mixtures of albite with hornblende or pyroxene, sometimes with small portions of carbonates. These diorites are tough, granular, sub-translucent, greenish or bluish-gray in color, weathering superficially to an opaque white and having a somewhat waxy lustre. Hardness 6·0; density 2·71—2·76. The hornblendic element is sometimes nearly amorphous, but at other times forms cleavable grains; by ignition these portions become darker, while the feldspar is rendered whiter and more opaque, and often exhibits striæ upon the cleavage surfaces.

A fine grained variety of this diorite from Orford was examined; it had a somewhat yellowish-green color and a subconchoidal fracture. After ignition the striated crystalline grains of feldspar were distinctly seen. The powdered rock does not effervesce with nitric acid, which appears to be without action upon it. The analysis gave as follows:

			Oxygen.
Silica, .....	63·60	63·40	33·81
Alumina, .....		12·70	5·93
Soda, .....		7·95	} 2·07
Potash, .....		·13	
Lime, .....	7·28	7·50	2·14
Magnesia, .....		3·37	1·35
Protoxyd of iron, .....	4·23		·94
Loss by ignition, .....		·40	
		<u>99·68</u>	

<sup>\*</sup> See R. H. Scott, *L. E. and D. Phil. Mag.*, [4], xv, 518.

The oxygen ratios of the alkalies and alumina in the above analysis are very nearly as 1:3, and if to these we add the silica corresponding to twelve equivalents, or in round numbers to 24.00 of oxygen (equal to 45.00 of silica) we shall have 65.78 parts of albite, in which the oxygen ratios are 1:3:12. The oxygen of the remaining silica and protoxyds equal 9.81:4.43, showing a slight excess of silica over the proportion required to form a pyroxene.\*

The feldspathic base of dioritic and doleritic rocks is sometimes even more silicious than albite, and passes into petrosilex, which may be regarded as a mixture of feldspar with quartz, or perhaps a distinct feldspar like krablite. Brongniart mentions petrosilex as sometimes forming the base of euphotide, and Thompson has described under the name of saussurite a mineral which occurs with diallage at the Lizard in Cornwall, having a density of 2.80, and yielding by analysis 82.0 p. c. of silica, besides alumina, lime, magnesia and oxyd of iron. In this connection I may cite from my report above referred to, the analyses of two varieties of petrosilex. The first (A) forms great beds among the ophiolite rocks of Orford; it is apparently homogeneous, somewhat translucent, very tough and with a sealy conchoidal fracture; it is distinguished from the diorites just described by the absence of the white opaque coating upon the weathered surfaces. Color greenish or grayish-white; lustre waxy, dull. Hardness 6.0; density 2.635—2.639. The second (B) from St. Henri, is a finely granular greenish rock, which occurs interstratified with shales and limestones in unaltered Silurian strata which are regarded as the equivalents of the ophiolitic series. It is somewhat less compact and tenacious than the last, which however, it closely resembles.

	A.	B.
Silica,.....	78.40	71.40
Alumina,.....	11.81	13.60
Soda,.....	4.42	3.31
Potash,.....	1.93	2.37
Lime,.....	.84	.84
Magnesia,.....	.77	2.40
Protoxyd of iron,.....	.72	3.24
Loss by ignition,.....	.90	2.50
	99.79	99.66

4. While engaged in the examination of the various feldspathic rocks which are associated with the ophiolites of Canada, I was constantly looking for some mineral whose hardness and specific gravity should correspond to those of the jade or saussurite of

\* See for further analyses the Report of Geol. Survey of Canada for 1856, p. 453, in which the above analysis is calculated for the old equivalent weights of silica. In the present paper the equivalent of SiO<sub>2</sub>, has been reckoned at 14+16=30.

de Saussure and Mohs. At length I met with a very heavy rock which occurs with the ophiolites of Orford, and closely resembles an ophitic euphotide. It is made up of a white garnet having the aspect of saussurite, intermingled with a small amount of a soft green serpentine, which fills the interstices between irregular rounded masses of the garnet; portions of the latter mineral half an inch in diameter, are easily obtained in a state of purity. It is distinguished by a hardness of 7.0, and by its density, which for selected fragments, was found to be 3.522—3.536. It is amorphous, finely granular, and extremely tenacious, with a conchoidal fracture; lustre feeble, waxy; color yellowish or greenish-white; sub-translucent. After intense ignition, which did not however effect its fusion, the pulverized mineral gelatinized with hydrochloric acid. Its analysis was made after fusion with carbonate of soda, and gave:—

Silica, .....	38.60	.....	38.80
Alumina, .....	22.71		
Lime, .....	34.83		
Magnesia, .....	.49		
Oxyds of iron and manganese, .....	1.60		
Soda and a trace of potash, .....	.47		
Loss by ignition, .....	1.10		
	<u>99.80</u>		

This mineral agrees closely in composition and properties with lime-alumina garnet, whose theoretical composition is represented by silica 40.1, alumina 22.7, lime 37.2 = 100.0. Croft obtained for a white garnet from the Ural mountains, having a density of 3.504: silica 36.86, alumina 24.90, lime 37.15 = 98.10.

At the falls of the river Guillaume in St. François, (Beauce,) there is also found a heavy rock which is composed in great part of garnet. It forms a bed in contact with an ophiolite, and has a somewhat variable aspect; in some portions it has a sub-conchoidal fracture with traces of crystallization; lustre shining, somewhat silky, color yellowish-white, sub-translucent. This variety, which is apparently homogeneous and exceedingly tough, has a hardness of 7.0, and scratches deeply the surface of agate; its specific gravity was found to be 3.333—3.364. It also occurs as a greenish-white or grayish-white somewhat granular rock, cavities in which are lined with small indistinct crystals; the density of this variety was 3.397—3.436.

Other specimens from the same locality exhibit the garnet intermingled with large cleavable masses of dark-green hornblende, which passes into a pearl-grey or lavender-grey variety. Small fragments of the garnet from this mixture had a density of 3.496; they were white, opaque, with a conchoidal fracture, and somewhat vitreous lustre. Intermingled with the garnet and hornblende, was another white or yellowish-white amorphous mineral, with a waxy lustre and a hardness of 6.0; the density

of a nearly pure specimen of it was 2.729, of another fragment 2.823. This, combined with its hardness, renders it probable that it is a feldspar; but it is very difficult to separate it from the garnet, or even to distinguish between the two species by the eye alone. Another specimen of a white granular rock from the same locality, which had been taken for garnet, had a density of only 2.800, and was supposed to be chiefly feldspathic in its nature. The specific gravity of the greyish hornblende was 3.046.

A specimen of the first described variety, having a density of 3.333 was selected for analysis; its powder did not effervesce with heated nitric acid, which however dissolved from it considerable alumina and lime. By the ignition of the rock, its yellowish color was only changed by the appearance of rare points of blackish-green. The analysis gave as follows:—

		Oxygen.
Silica, . . . . .	44.85	23.69
Alumina, . . . . .	10.76	5.03
Peroxyd of iron, . . . . .	3.20	.96
Lime, . . . . .	34.38	9.77
Magnesia, . . . . .	5.24	2.09
Loss by ignition, . . . . .	1.10	
	99.53	

If we suppose the alumina the peroxyd of iron and a portion of lime to form a garnet in which the oxygen ratios of the protoxyds, sesquioxys and silica are 1 : 1 : 2, the residual lime and silica with the magnesia will be in the proportions requisite to form a pyroxene. We have lime 21.07, alumina 10.76, peroxyd of iron, 3.20, silica 22.69=57.72, with the oxygen content 5.99 : 5.99 : 11.98. There remains then for the pyroxene, lime 13.31, magnesia 5.24, silica 22.16=40.71, containing oxygen 5.87 and 11.71=1 : 2. The observed density of the rock corresponds very closely with that calculated for a mixture of lime-alumina garnet and pyroxene in the above proportions.—(*Geol. Survey of Canada, Report, 1856, p. 449*).

5. The great density of the above described garnet rocks and their association with hornblende, serpentine and feldspar, led me to suppose that similar rocks might have furnished to different chemists some of the discordant facts which are met with in the history of euphotide and saussurite. I have recently, however, through the kindness of Prof. Arnold Guyot, now of Princeton, New Jersey, had an opportunity of examining a collection of the euphotides of Switzerland, made by him in the course of his researches on the distribution of the erratic rocks of the basin of the Rhone. Prof. Guyot then traced the euphotides, which are found in scattered blocks and pebbles for a distance of nearly one hundred and fifty miles, to the valley of Sass, or rather to the corresponding chain of the Sassgrat, which forms a part of

Mt. Rose.\* The euphotides of the Alps according to other observers are associated with protogine, ophiolites and crystalline schists.

I had now before me the original euphotides which had been studied by Häuy and de Saussure, and through the liberality of Prof. Guyot was furnished with numerous specimens of the characteristic varieties. Their examination has afforded me the following mineral species: saussurite, smaragdite, actinolite, talc, feldspar, and rarely pyrites.

The saussurite, which is generally predominant, is very uniform in its characters; it is always finely granular or compact, very tough, and with a sub-conchoidal or splintery fracture. Its color is white, passing into greenish bluish and yellowish-white, rarely with flesh-red stains; sub-translucent; lustre feeble, waxy. Hardness 7.0; scratches quartz. Specific gravity 3.33—3.38. A euphotide containing cleavable masses of smaragdite an inch in diameter, afforded me portions of bluish-white saussurite, apparently homogeneous, and having a density of 3.336—3.365. Another specimen of euphotide, containing a good deal of talc, and only small grains of smaragdite, had a density in the mass of 3.315, but selected fragments of the saussurite gave the number 3.385. Another large fragment of greenish-white saussurite had a specific gravity of 3.338, while a fourth specimen of euphotide holding only small lamellæ of smaragdite, and mingled with greenish-gray talc, had a distinctly granular texture, and a density of only 3.16—3.20.

The smaragdite of all these varieties of euphotide has a grass green color passing into emerald and olive-green. Lustre somewhat pearly; hardness 5.5; specific gravity of fragments from the first-mentioned euphotide, 3.10—3.12. The smaragdite generally exhibits only the cleavages of pyroxene, but in some cases it is irregularly penetrated by slender prisms of hornblende.

Talc is rarely absent from these euphotides, and is often abundant in small foliated or radiated masses, enclosed in the saussurite. The talc is generally silver-white, but occasionally appears greenish from the presence of minute crystals of dark green actinolite, which may be seen penetrating the talc, in close proximity to the yellowish-green smaragdite. The latter I have always found enclosed in the saussurite.

A bluish-gray or lilac feldspar is often met with in these euphotides, and is at once distinguished from the saussurite by its color, cleavage, translucency, vitreous lustre, and inferior hardness. I have not observed cleavage faces of this feldspar more than a fourth of an inch in length, although in some specimens it is rather abundant. Grains of it are sometimes imbedded in the talc, but it more generally occurs in the saussurite.

\* See also Jas. Forbes, *Travels through the Alps*, p. 362.

This feldspar is completely decomposed by heated sulphuric acid, and contains a large proportion of lime, characters which show it to be labradorite or an allied variety.

Two specimens of saussurite were selected for analysis, the bluish-white variety from the first mentioned euphotide having a specific gravity of 3.365, (VI) and selected fragments of a greenish-white variety from the second, with a density of 3.385, (VII). This was penetrated by talc, from which it was impossible, completely to separate it. The eleutriated mineral was decomposed by prolonged fusion with carbonate of soda, the separated silica and alumina being in each case carefully analyzed. The alkalis were determined by J. Lawrence Smith's method of igniting with carbonate of lime and sal-ammoniac, and consisted of soda with but traces of potash. The results were as follows:

	VI.	Oxygen.	VII.	Oxygen.
Silica,	43.59	23.25	48.10	25.65
Alumina,	27.72	13.95	25.34	11.94
Peroxyd of iron,	2.61	.78	3.30	.99
Lime,	19.71	5.63	12.60	3.60
Magnesia,	2.98	1.19	6.76	2.70
Soda,	3.08	.80	3.55	.91
Loss by ignition,	.35	....	.86	....
	100.04		100.31	

Boiling concentrated sulphuric acid removed only traces of alumina and lime from the pulverized saussurite, which was however partially decomposed by this acid after having been strongly ignited.

The hardness and specific gravity of saussurite assign it a place with epidote. Rammelsberg has recently published the analyses of six varieties of lime-alumina epidote or zoisite, varying in density from 3.25 to 3.36, and finds the oxygen ratios of the protoxyds, peroxyds and silica to be nearly as 1 : 2 : 3, often however with an excess of silica. The ratios of his analyses vary between the limits 1 : 1.94—2.16 : 2.95—3.36.—(*Berlin Acad. Ber.* 1856, 605).

If we follow Rammelsberg, who has regarded the small amount of iron in the zoisites, as peroxyd replacing alumina, we have for the analysis VI the ratios 7.62 : 14.73 : 23.25 = 1 : 1.93 : 3.05, while for VII we have 7.21 : 12.93 : 25.65, showing an excess both of silica and protoxyd, due to the intermingled talc. If we regard this surplus of protoxyd as magnesia it would equal 5.70 per cent of talc, and deducting the elements of this from the analysis, we have for the oxygen ratios of the saussurite the numbers 1 : 2 : 3.29. Saussurite has then the hardness, specific gravity and chemical composition of a lime-alumina epidote or zoisite, containing small portions of magnesia and soda, which are frequently present in this species. The analyses of



various epidotes give from two to six per cent of magnesia, and from one to more than two per cent of soda.\*—(See Dana's *Mineralogy*, 4th Ed., ii, 407).

6. The composition of zoisite as already noticed by Rammelsberg is identical with that of meionite, a species which is shown by its hardness of 6.0 and its density of 2.6—2.7, to belong to the dimetric division of the feldspar group, where it is to the scapolites what anorthite (with the ratios 1 : 3 : 4,) is to the triclinic feldspars. The mineral described by Boulanger as saussurite from Mt. Genève, with a density of 2.65, gives according to his analysis (III) the oxygen ratios 7.37 : 14.18 : 23.75 = 1 : 1.91 : 2.22, and appears to have been meionite. In de Saussure's analysis, (II) if we regard the iron as protoxyd, we obtain the ratios 5.22 : 14.02 : 23.50, but there is then a deficiency of 4.50 p. c. in the analysis of an anhydrous mineral. Klaproth's results (I) seem to indicate a mixture of a silicate like pyroxene or talc as in VII, while the anomalous softness of v and the facility with which it is decomposed by acids, render it difficult to form any conclusion about the saussurite of the Fiumalto examined by Boulanger. His analysis of the saussurite of Orezza (IV) gives the oxygen ratios 7.23 : 14.95 : 23.25 = 1 : 2.06 : 3.21, so that it has the composition of meionite and zoisite, while its specific gravity is between the two. Although inferior in hardness, it resembles zoisite in resisting according to Boulanger the action of concentrated sulphuric acid.

The saussurite of Orezza evidently demands farther study; it remains to be seen whether the *verde di Corsica* or *verde antico di Orezza*, as it is also named, (the corsilite of Pinkerton, *Petrology*, ii, 78), which is regarded by d'Halloy as the typical euphotide, is not distinct from that of Mt. Rose. Delesse found the specific gravity of the Corsican euphotide to be only 3.10. The name

\* Laurent in an essay on the silicates published in 1849, insisted that distinctions based on the relations between the proportions of protoxyds and sesquioxys are of but secondary importance, since these oxyds may replace each other to an indefinite extent in many silicates, without altering the mineral type. This principle Laurent then illustrated by the epidotes among other species, showing from Hermann's analyses of thirteen specimens (of which the analyst had made three sub-species,) that although the oxygen ratios of the protoxyds and sesquioxys offered considerable variations, it was possible by admitting the substitution of the one for the other, to reduce all these epidotes to the same formula with garnet,  $\text{SiO}_2\text{R}_2$ , *i. e.*,  $\text{SiO} + \text{RO}$ , in which RO, represents both protoxyds like CaO, and sesquioxys like  $\text{AlO} (= \text{Al}_2\text{O}_3 \div 2)$ .—(*Comptes Rendus des Travaux de Chemie*, 1849, p. 277).

This idea of Laurent although at the time rejected, is now universally admitted. Dana has adopted it in the 4th Ed. of his *Mineralogy*; Hermann has recently reviewed his own analyses and accepts Laurent's view, while Rammelsberg who illustrated it in his laborious researches on the tourmalines, has recently applied it to the augites and hornblendes containing peroxyd of iron. But while there is no doubt of the general and wide application of this principle of the homœomorphism of protoxyds with sesquioxys, it is nevertheless true as Dana has remarked, that in the epidotes the variations in the oxygen ratios of the protoxyds, sesquioxys and silica are about 1 : 2 : 3, which may be looked upon as the normal ratio for epidote, as 1 : 1 : 2 is for garnet, and 3 : 2 : 5, for idocrase.—(This Jour., [2,] xxv, 406).

of *verde di Corsica*, which in the arts is applied to the rock as a whole, is by Beudant restricted to the contained smaragdite.

I have lately examined a pale yellowish-green compact and apparently homogeneous rock, which forms great beds among the crystalline schists of the Shickshock mountains in Gaspé, and has somewhat the aspect of saussurite. Its hardness is 7.0 and its density 3.04—3.09. It is exceedingly tough and sonorous, has a conchoidal fracture with a feeble waxy lustre, and is translucent on the edges. The analysis gave as follows:

		Oxygen.
Silica.....	62.60	33.38
Alumina.....	12.30	5.78
Protoxyd of iron.....	9.40	2.82
Lime.....	14.10	4.03
Magnesia.....	.72	.29
Soda with a trace of potash.....	.43	.11
Loss on ignition.....	.16	

99.71

The oxygen of the protoxyds and peroxyds in the above analysis equals 4.43 and 8.60. If to these we add the silica corresponding to 13.00 of oxygen, we shall have 61.33 parts of epidote, leaving 32.22 parts of silica uncombined. The density of the mass is that of a mixture of epidote and quartz in the above proportions, and in some specimens where the rock becomes granular, the two species are easily distinguishable. (*Geol. Survey of Canada, Report*, 1858). This epidote rock then is completely distinct from the saussurite of Orezza.

The two silicates zoisite and meionite offer a remarkable instance of that isomerism in mineral species upon whose importance I have long insisted. The relation of the specific gravity to the empirical equivalent weights of minerals, must enter as an essential element into a classification which shall unite the chemical and natural-historical systems. Similar isomeric relations exist between kyanite and sillimanite, rutile and anatase, and as I have elsewhere endeavored to show, among the carbon-spars. It becomes necessary in the study of mineral species to determine their relative equivalent weights, to which specific gravity must be the chief guide.—(*Proc. Am. Assoc. Adv. Science*, 1854, pp. 240-247).\*

\* The action of heat upon organic bodies of high equivalent tends to resolve them into simpler and less dense forms, (we except of course the simultaneous productions of small portions of more complex hydrocarbons). Similar results are obtained when the denser silicates are fused. Thus according to Magnus the specific gravity of garnet is lessened one-fifth by fusion, while that of idocrase is reduced from 3.34 to 2.94. Epidote by ignition has its density changed from 3.40 to 3.20 according to Rammelsberg, and saussurite is converted by fusion into a soft glass of specific gravity 2.8. The silicates thus modified are decomposable by acids like the basic feldspars; idocrase and garnet crystallize after fusion, the latter according to von Kobell in octahedrons. Deville found the density of hornblende and pyroxene to be reduced by fusion from 3.2 to 2.8, orthoclase from 2.56 to 2.35, and labradorite from 2.889 to 2.525.

7. *Smaragdite*.—The smaragdite or diallage of the euphotides appears to have been first examined by Vauquelin, who found in a specimen from Corsica with specific gravity 3·0; silica 50·0, alumina 21·0, lime 13·0, magnesia 6·0, oxyd of iron 5·5, oxyd of chromium 7·5, oxyd of copper 1·5=104·5. (Beudant, *Mineralogie*, ii, p. 134). Boulanger subsequently analyzed the diallage from the euphotide of the Fiumalto already described. It had a density of 3·10, and gave silica 40·8, alumina 12·6, lime 23·0, magnesia 11·2, protoxyd of iron 3·2, protoxyd of manganese 1·4, oxyd of chromium 2·0, water 5·2=99·4.—(*Ann. des Mines*, [3], viii, 159).

I have analyzed the grass-green smaragdite already described as occurring in masses an inch in diameter imbedded in the saussurite vi. It was to some extent penetrated by the latter mineral, and contained irregularly disseminated slender prisms of hornblende, apparently associated with talc. The analysis gave as follows:

Silica, .....	54·30
Alumina, .....	4·54
Lime, .....	13·72
Magnesia, .....	19·01
Protoxyd of iron, .....	3·87
Oxyd of chromium, .....	·61
Oxyd of nickel, .....	traces
Soda, .....	2·80
Loss by ignition, .....	·30
	99·15

A partial analysis of another specimen gave alumina 3·80, lime 14·22, magnesia 18·07, protoxyd of iron 2·34. The pale green color of the powdered smaragdite becomes brownish on ignition. The small portion of nickel, whose presence I have already shown in a great number of chromiferous serpentines and diallages,\* gave evidence of a trace of cobalt before the blowpipe. The oxygen ratios of the silica, alumina and protoxyds in the above analysis are as 28·96 : 2·12 : 13·29. Its composition is evidently that of a pyroxene, with some admixture of saussurite and probably of talc. A portion of the latter mineral from one of the euphotides of Mt. Rose, was submitted to analysis, and allowing for a small admixture of saussurite, was found to have the composition of ordinary talc, being a hydrated silicate of magnesia with a little iron and a trace of nickel.

*Conclusions*.—1. The true euphotide is distinct from the diallagic dolerites, with which most modern lithologists have confounded it, and which are composed of pyroxene and a feldspar having the constitution of andesine, labradorite, or a still more basic variety approaching to anorthite. By the substitution of hornblende for pyroxene these dolerites pass into diorite or diabase.

\* This Journal, [2.] xxvi, 237.

2. The euphotides of Mt. Rose according to my observations are composed of smaragdite (a pyroxene containing chrome and nickel,) in a base of saussurite, which is a compact zoisite, or lime-alumina epidote, containing portions of magnesia and soda, and having a hardness of 7.0 and a specific gravity of 3.33—3.38; characters which at once distinguish it from the feldspars. These euphotides also contain as accidental minerals, talc, actinolite and occasionally a vitreous cleavable feldspar resembling labradorite.

3. While the minerals analyzed as saussurite by Stromeyer and Delesse are feldspars, that from Mt. Genève examined by Boulanger has the composition and specific gravity of meionite, a species which is isomeric with zoisite; the saussurite from Orezza according to the same observer has a like composition but a density intermediate between these species. The saussurite examined by Thompson is apparently a petrosilex.

4. By its great density and its composition, the euphotide of Mt. Rose is related to certain rocks in which a white garnet, resembling saussurite, is mixed with serpentine, with hornblende, and with a feldspathic mineral. These aggregates associated with ophiolites, albitic diorites, and a rock made up of epidote and quartz, occur in the form of beds in the crystalline schists of the altered Silurian series in Canada.\*

\* See my *Contributions to the History of Ophiolites*, this Journal, [2], vol. xxv, 217, and xxvi, 284.

