GARNETS FROM SIERRA TLAYACAC, MORELOS, MEXICO

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There are several varieties of garnet found in the Sierra Tlayacac. A pink variety (rosolite[1]) from this locality has been described as to chemical composition and specific gravity, but apparently no determination of the refractive index has been recorded, nor is there any description of the several other varieties which occur in the same formation.

The Cornell collection contains abundant material from this locality collected by the late Professor A. C. Gill, during his visit to Mexico in 1893–4. The garnets occur in euhedral forms in a contact rock which is distinctly a "Kalk-silicat-hornfels" produced by a

FIG. 1. Greenish-yellow garnet showing zonal structure and dark core (41×).

reaction between a sandy limestone conglomerate or breccia (probably of Tertiary or late Mesozoic age) and massive Tertiary dikes. The garnets undoubtedly represent hydrothermal alteration products of the impure limestone. The associated minerals are chiefly wollastonite, vesuvianite, and calcite.

Where the garnetiferous material has weathered, the garnets stand out in relief and frequently constitute the only remaining

[1] Also landerite and xalostocite, see L. J. Spencer: *Miner. Mag.*, **14**, 402, 1907.

component of a porous mass which has been called "garnet sponge."

Successive changes in composition of the hydrothermal solutions are quite apparent through zonal growth of the crystals (Fig. 1). This is to be observed in the rosolite as well as in the pale greenish-yellow garnet illustrated.

The predominant form of the garnets is the rhombic dodecahedron though some dark massive garnet occurs. Many of the pale greenish-yellow crystals and some of the pink ones contain a dark core.

Chemical Composition

Two analyses of the pink material are recorded, those of M. A. Damour[2] and C. F. de Landero:[3]

	Damour	de Landero
Density	3.57	3.516*
SiO_2	39.46	40.64
Al_2O_3	21.69	21.48
Fe_2O_3	1.36	1.57
CaO	35.75	35.38
MgO	0.67	0.75
MnO_2	0.96	trace
Unattacked mineral	—	0.17
Volatile matter	0.40	—
	100.29	99.99

* 19.8°C.

The appreciable difference in manganese would tend to suggest the choice of material of deeper color by the first analyst, but the difference in specific gravity seems too great to be explained by the variation in iron and manganese content.

The pale greenish-yellow garnet, quite plentiful in the locality, was chosen by the author for analysis. The qualitative determinations, together with an indication as to the composition of the dark core material, was kindly furnished by Professor J. Papish in the form of a spectrogram (Fig. 2), which indicates the presence of the following elements: silicon, aluminum, iron, calcium, magnesium, and manganese with a probable trace of titanium. Chromium, barium, strontium, alkalies and the heavy metals were absent. The dark material showed a somewhat greater intensity of iron.

[2] *Compt. rend.*, **73**, 1041, 1871.

[3] *Am. Jour. Sci.*, **III**, 41, 321–323, 1891.

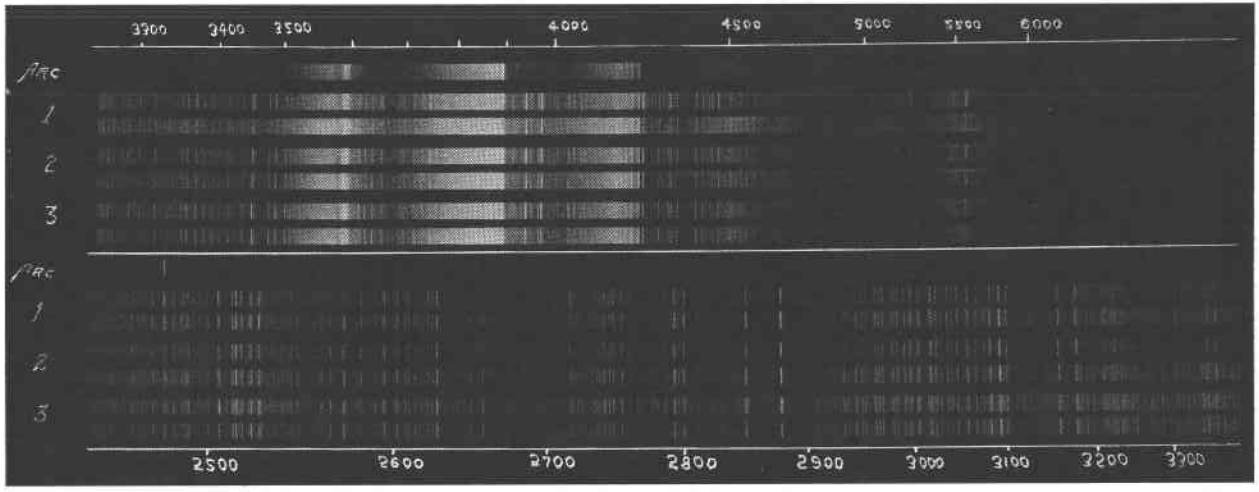

FIG. 2.

1—Pale greenish-yellow garnet, sample I 2—Pale greenish-yellow garnet, sample II 3—Dark brown or black core material.

A sample was prepared for analysis by grinding and separation by means of heavy liquids, after which the material was hand picked with the aid of a lens to exclude contamination by adhering wollastonite or calcite, or material which showed iron stains after washing. Duplicate determinations were made in accordance with the recommendations of W. F. Hillebrand[4] and the results are given in the following tables:

ANALYSIS I (Sample 1.0404 gr.)[5]

		Percent		Ratio of Oxides
SiO_2	.4139	39.78	66.18	3.00
Al_2O_3	.2034	19.56	19.19	1.00
Fe_2O_3	.0468	4.50	2.81	
FeO	.0025	0.24	0.33	
MnO_2	.0017	0.16	0.17	2.96
CaO	.3750	36.06	64.27	
MgO	.0026	0.25	0.62	
TiO_2	probable trace	probable trace		
Volatile matter	.0041	0.41		
	1.0500	100.96		

ANALYSIS II (Sample 1.0029 gr.)

		Percent		Ratio of oxides
SiO_2	.3955	39.43	65.60	3.00
Al_2O_3	.1964	19.58	19.21	1.01
Fe_2O_3	.0457	4.54	2.84	
FeO	.0024	0.24	0.33	
MnO_2	.0015	0.15	0.16	2.95
CaO	.3564	35.53	63.33	
MgO	.0028	0.28	0.69	
TiO_2	probable trace	probable trace		
Volatile matter	.0040	0.40		
	1.0047	100.15		

The relative amounts of the various garnet molecules calculated after the manner of W. E. Ford[6] are:

[4] *U. S. G. S. Bull.* **700,** The Analysis of Silicate and Carbonate Rocks.

[5] The higher percentages of calcium oxide and silica in Anal. I as compared with Anal. II may be due to slightly greater contamination of the sample by wollastonite and calcite.

[6] *Am. Jour. Sci.*, **40,** 33–49, 1915.

	Greenish-yellow garnet Analysis II	Rosolite Anal. by de Landero
Grossularite	84.97%	95.68%
Andradite	13.20	1.50
Pyrope	1.07	2.82
Almandite	0.51	—
Spessartite	0.25	—

Both of these analyses show a high percentage of the grossularite molecule.

Specific Gravity

Determinations made with the pycnometer of the specific gravity of the pale greenish-yellow garnet (Analysis II) were: $d_4^{28.3}$3.5665 and $d_4^{25.7}$3.5670.

A determination of the specific gravity of pink material approximating that of de Landero and from the same locality gave at 20.5°C, 3.512 ($d_4^{20.5}$3.505).

The specific gravity of de Landero's material was 3.516 at 19.8°C.($d_4^{19.8}$3.510).

Computations of densities gave the following comparisons:

	Greenish-yellow garnet Analysis II	Rosolite de Landero's Analysis
Calculated density	3.564	3.533
Measured density	3.567	3.510

Refractive Index

Determination on greenish-yellow material (Analysis II) gave $N_{Na}=1.752$. The pink material ($d_4^{20.5}$3.505) was found to have $N_{Na}=1.741$. A colorless variety, though not plentiful enough for density determinations, showed a refractive index very closely approximating that of rosolite, N_{Na} 1.741. The dark brown or black material usually forming the core of the pale greenish-yellow material has an index above 1.780, the highest liquid available.

Computations of refractive indices and Gladstone's constant gave the following results:

	Greenish-yellow garnet Analysis II	Rosolite ($d_4^{20.5}$3.505)
Calc. Refractive index	1.756	—
Meas. Refractive index	1.752	1.741
Gladstone's constant	2108	2111