other substances may well be an expression of the colloidal thinness of the flakes, yielding relatively enormous surface area with respect to quantity of material. The reason why bentonite is better adapted than many typical colloids to technical adsorption operations such as water-softening appears to be that the relatively large breadth of the particles gives their aggregates an open texture, combined with a certain rigidity, which permits the solutions being treated to come into unusually complete contact with the adsorbing surfaces.

CLERICI SOLUTION FOR MINERAL SEPARATION BY GRAVITY

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Clerici solution, a mixture of thallium malonate, $CH_2(COOTl)_2$ and thallium formate, HCOOTl is a heavy liquid little known, but it has been prepared and used with much satisfaction in the mineralogical laboratory of Harvard University. At ordinary room temperature the concentrated solution has a density of 4.25. Clerici, in his original article[1] says that by increasing the temperature, the density of a concentrated solution at 35° is 4.4, at 50° about 4.65, and at 90°–100° pyrite floats. It is possible to dilute with water in any quantity and to reconcentrate. It is more mobile than Thoulét solution, odorless and slightly amber colored. As with most heavy solutions care must be taken that minerals such as sulfides are not altered with long standing in hot solutions but at ordinary temperatures the solution appears to be stable and chemically inert.

The solution may be prepared by neutralizing two equal parts of thallium carbonate with equivalent amounts of formic acid and malonic acid, mixing the two solutions of thallium formate and thallium malonate, filtering and evaporating until almandite floats. One hundred eleven grams of malonic acid dissolved in a little water will neutralize 500 grams of thallium carbonate, and

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[1] E. Clerici. Preparazione di liquidi per la separazione dei minerali. *Atti. R. A. Lincei, Rome,* **16,** 187-195 (1907).

Descriptions of the preparation and use of Clerici solution are to be found in P. Eskola: On the Eclogites of Norway, *Videnskap. Skrift., 1MN.Kl., Kristiania,* No. **8,** p. 6 (1921), and in F. Hörner, Beiträge Zur Kenntnis des Staurolits. Inaug. Diss. Heidelberg, **1915,** quoted in Rosenbusch-Wülfing, Mik. Physiographie **I,** p. 692 (1924).

115 grams of 85.5 per cent formic acid will neutralize the same amount of thallium carbonate. One kilogram of thallium carbonate will make approximately 300 cc. of Clerici solution. If the solution is made from the dry salts thallium formate and thallium malonate, 7 grams of each will dissolve completely in 1 cc. of water but 10 grams of each will leave a part undissolved.

Through the kindness of Mr. Sidney J. Jennings, three pounds of metallic thallium were given to the mineralogical laboratory. This metal was worked up into thallium carbonate before it was learned that the salt could be purchased.[2] The thallium carbonate was prepared from the metal by two different methods. The first, which we do not recommend, was to decompose the metal in dilute HNO_3, expel the excess acid by evaporation, dissolve the crystallized thallium nitrate in water and precipitate the lead, which was present as the only appreciable impurity, with H_2S. The solution was again evaporated and the nitric acid expelled with sulphuric acid. The thallium sulfate was dissolved, the SO_3 removed by precipitating with $Ba(OH)_2$ and standing over night. The excess barium was eliminated by passing CO_2 into the solution and again letting the mixture stand over night. The clear solution was then syphoned off and evaporated to dryness on the steam bath. The thallium carbonate was purified by dissolving, filtering and recrystallizing. The process is tedious, and very wasteful for the precipitates carry down a large amount of thallium. The inorganic salts, unlike the organic ones, have such a small solubility that the large quantities of solutions involved were very difficult to manage.

The second method takes time but is simple and wastes none of the thallium. The metal was filed into very small particles, moistened, and let stand with a large surface exposed to warm, damp air. After a day or so the white oxide was dissolved by boiling in water, and poured into another vessel, leaving the moist residue to stand again for some time. A few weeks of this treatment oxidized almost all the thallium. After passing CO_2 through the solution, it was evaporated to crystallization and the thallium carbonate purified by dissolving, filtering and recrystallizing.

The index of refraction in relation to the different specific grav-

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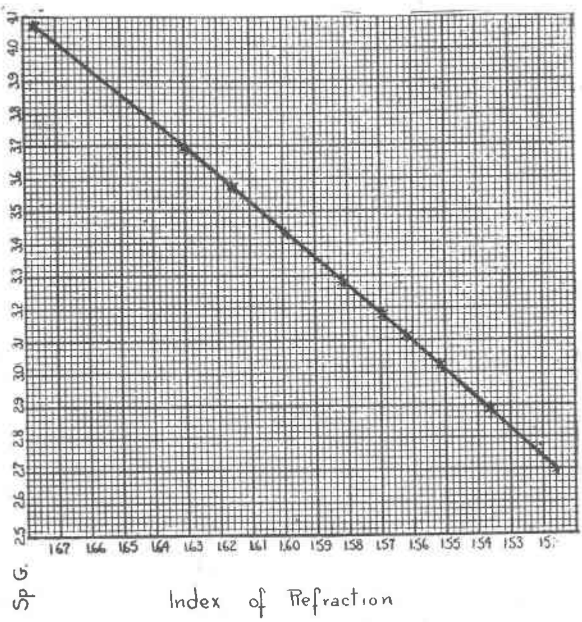
[2] Kahlbaum quoted thallium carbonate in 1924 at $12 per kilo. Metallic thallium is apparently rarely to be had. It comes in small bars of 4 or 5 ounces weight. The price quoted in 1924 was about $8 per kilo.

ities is shown in the following chart which is only an approximation because of the sensitiveness of the solution to temperature change and evaporation. The specific gravities were determined by the Westphal balance.



The measurements upon which the chart is based, are contained in the following table.

Table of Measurements at 19.5°C

Indices of Refraction	Specific Gravity
1.6761	4.076
1.6296	3.695
1.6154	3.580
1.5990	3.434
1.5815	3.280
1.5693	3.184
1.5620	3.114
1.5515	3.024
1.5363	2.884
1.5156	2.692

I am very much indebted to Prof. Esper S. Larsen for the determination of the indices and to Prof. Charles Palache through whose interest and help the research was undertaken.