NOTES ON THE ECONOMIC GEOLOGY OF THE SYRACUSE AREA

by

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Mineral production in Onondaga County dates back to the latter part of the 18th century and has been an important factor in the economy of the county every since. Industrial minerals and rocks have accounted for most of the production and natural gas the remainder. In 1962 Onondaga County ranked second in total value of minerals produced in the state and also was second in limestone production (Minerals Yearbook).

Salt

Salt springs near Onondaga Lake were visited by French missionaries from Canada as early as the middle of the 17th century. Production of salt started around the southern part of the lake in 1788, at first from the salt springs and then from wells drilled into the glacial gravels that contained brine (Newland, 1921, p. 222). Salt continued to be produced in substantial quantities for over 100 years until about 1908. The maximum yearly production, according to Luther (1895, p. 252) was attained in 1862 when the output was 9,053,874 bushels. The total production of salt in the yards around Onondaga lake from 1797 to 1904 amounted to 430,000,000 bushels or over 12,000,000 tons (Hopkins, 1914, p. 34). Decrease in the salt content of the brines and competition from other sources caused production to begin to decline about 1890 and to terminate about 1908.

In 1888 the Solvay Process Company began producing salt brine from wells in the Tully valley about 17 miles south of Syracuse. The brine is piped to the Company's plant at Solvay where it is used for the manufacture of sodium chemicals, particularly soda ash. The brine is obtained from salt beds in the Syracuse formation at depths of 1100 to 1200 feet.

Limestone

One of the largest limestone quarries in the state is operated by the Solvay Process Division of the Allied Chemical Corporation at Jamesville. The Clark Reservation, Jamesville, and Pools Brook limestone members of the Manlius formation and part of the Edgecliff member of the Onondaga limestone are quarried primarily for use in the manufacture of soda ash. Agricultural limestone also is produced, and limestone is furnished to the Alpha Portland Cement Company for manufacture of portland cement at its Jamesville plant. The part of the Onondaga limestone above the Edgecliff member is quarried separately for crushed stone.

The General Crushed Stone Company quarries the Olney limestone and part of the Thacher limestone for crushed stone at its quarry on the north side of Rock Cut Channel in the southwest corner of the Syracuse East quadrangle (stop 4, trip C).

Considerable building stone has been quarried in the past from the Manlius and Onondaga formations. In recent years dimension stone for flagging, walls, and house construction has been produced at small quarries at Brickyard Falls south of Manlius and west of Townsend Road about 1 3/4 miles east of Fayetteville. Elmwood dolomite and the top of the Olney are quarried at the former and Olney and Thacher limestone at the latter.

Sand and Gravel

Sand and gravel totalling 1,452,000 tons were produced from nineteen pits in Onondaga County in 1962 (Minerals Yearbook). Most of the production was from pits in the vicinity of Nedrow, Fayetteville, and East Syracuse where glacial deposits are worked. The gravel deposit worked on the east side of Burdick Road, a short distance northwest of Fayetteville, is of particular interest because it is a multiple delta deposited in rising glacial lake waters. A readvance of the ice covered the gravel with from a few feet to 17 feet of glacial till. Several gravel pits are operated in the large glacial lake delta deposits in Onondaga Creek Valley south of Syracuse.

Shale

The upper part of the Chittenango member and the lower part of the Cardiff member of the Marcellus shale formation are quarried by the Alpha Portland Cement Company on the east side of Gates Road east of Jamesville (stop 2, trip E). The shale is used for the manufacture of portland cement at the company's Jamesville plant. Because of a higher content of sulfur in the Chittenango due to the presence of some pyrite, barite, and gypsum, the quarry is benched and the Chittenango and Cardiff are quarried selectively. The large calcareous concretions present in two zones in the Chittenango shale are discarded in the quarry.

Light Weight Aggregate

The Onondaga Brick Company produces lightweight aggregate from Vernon shale at its plant near Warners northwest of Syracuse. The shale is quarried on the northwest side of Brickyard Road about half a mile northwest of the plant. This quarry has the best exposures of the Vernon shale in the vicinity of Syracuse.

Pottery

The Syracuse Pottery Company manufactures flower pots from red clay dug near its plant at Warners. The Onondaga Pottery Company (Syracuse China) imports its raw materials for china manufacture from outside the State.

Industrial Minerals & Rocks Formerly Produced

Gypsum, natural cement, and bricks formerly were produced in Onondaga County in important amounts. Gypsum was first discovered in New York at Camillus in 1792 and production was started in that area about 1810. For many years gypsum production was next in importance to salt in the county (Luther, 1895, p. 266).

All of the merchantable gypsum mined in Onondaga County was obtained, according to Newland (1929, p. 81) from the top of the Camillus, now called the Forge Hollow or Scajaquada member of the Bertie formation. This gypsum unit is reported to range from 25 to 65 feet in thickness. The most important quarries were between Fayetteville and Jamesville. The largest production came from a group of quarries in the wooded hills north of Woodchuck Hill Road southwest of Fayetteville (stop 6, trip C) where the gypsum is thickest. All of these quarries had stopped operating by 1909 except the Heard quarry, the largest of the group, which continued until 1914. (Newland, 1929, p. 83). The gypsum was used mainly in agriculture for "land plaster". When this use declined and purer gypsum was required for the manufacture of gypsum plaster and wallboard, the deposits in Onondaga County could not compete with the higher grade deposits in Genesee County.

Natural Cement

Rock suitable for the manufacture of natural cement was first discovered in the town of Sullivan in Madison County not far east of Syracuse. Production of cement was begun in 1818 for use in construction of the Erie Canal and soon became an important industry in Onondaga County (Luther, 1895, p. 269). It remained so until early in the present century when competition from portland cement caused a rapid decline in production.

Elmwood A and C argillaceous dolomite (waterlime) beds, with thicknesses from 3 to 6 feet, were the source of the raw stone. Quarries in these units were worked all along the outcrop and provide good exposures for study of the Elmwood beds and the overlying Clark Reservation and Jamesville limestones.

Bricks

The Syracuse Brick Company manufactured brick at its plant on Court Street in Syracuse until 1962. Vernon red shale quarried near Cicero was crushed and ground to make the clay raw material.

Quicklime

Quicklime formerly was manufactured in considerable quantity from selected beds in the Manlius and Onondaga limestone formations. Except for the lime produced by the Solvay Process Division for manufacture of alkalies, no quicklime has been produced in Onondaga country for many years. Most of the production had ceased by 1914 (Hopkins, 1914, p. 28).

Economic Geology Bibliography

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Some Aspects of Economic Geology of Aggregate Materials in Western New York

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"Perfection of means and confusion of goals seem - in my opinion - to characterize our age". Einstein, A. (1950), Out of My Later Years

Introductory Statement

The intent of this section of the guidebook is: (1) to introduce some concepts of the application of geology to our culture, (2) to show how such geologic concepts have been applied at the General Crushed Stone quarry at DeWitt, (3) to show how this orientation has led to geologic research in western New York which has helped to understand geologic interrelationships which have both social and theoretical values.

Aggregate Geology Research in a Philosophical Framework

For several years research has been done at Rensselaer Polytechnic Institute largely under the sponsorship of the New York State Department of Public Works on some fundamental characteristics of many of the rocks which are used as aggregate in New York State. The orientation of this research is not a common one in geology, and therefore the author feels that it is advisable to place the research in a "philosophical" context.

The study of aggregate materials is a part of the broad field of what might be called "extroverted" geology, or geology applied outside of itself to the human-social environment. On the other hand, "introverted" geology might be used as a description of geology applied internally or geology "as an end in itself"* and having little or nothing to do with people. "Introverted" geology in recent years has had a great upsurge, particularly in universities. Paradoxically, this upsurge coincides with a real threat of depletion of many of the rock materials on which our economy is based, and with a decrease in job opportunities for geologists.

Properties of Rocks: Characteristically geologists describe a few fundamental parameters of rocks such as color, texture, structure, and approximate mineralogy. Such parameters are meaningful in geology as a method of determining a rock's name and origin. To describe a rock properly in such a manner and to recognize the significance of the described properties requires such extensive training and experience that many geologists never acquire the needed competence. Because of the inherent difficulty in such description and the training needed, the determination of the common geologic parameters are here called "sophisticated" techniques.

*Leggett, R. F. (1963), Geology in the Service of Man in The Fabric of Geology, Addison - Wesley Pub. Co., Inc.

A problem in "sophisticated" geologic description is that it says very little about the properties of a rock which are significant to physicists, chemists, engineers, or for that matter, anyone other than geologists. And, by largely ignoring other properties geologists not only fail to communicate outside of their field but may miss important relationships which point to the origin and nature of many rocks.

What are some of the other parameters which can be measured? A partial list of those which might be considered by the geologist to be "unsophisticated" follows*:

1. chemical composition
2. insoluble residue, percent
3. reactivity in alkali solution
4. normative mineralogy
5. X-ray analysis
6. water absorption
7. specific gravity (true, bulk dry, bulk saturated, apparent)
8. rate of water absorption
9. rate of water loss in vacuum or at elevated temperatures
10. longitudinal compressional wave velocity
11. shear wave velocity
12. Poisson's ratio
13. thermal expansion
14. abrasion resistance
15. freeze-thaw soundness tests
16. magnesium sulfate soundness test
17. sodium sulfate soundness test
18. wet-dry resistance
19. pore-size distribution
20. porosity
21. permeability
22. thermodynamic character of water and ice in rock (enthalpy, free energy, entropy, etc.)
23. freeze-points for internal water
24. internal pressures during water absorption
25. internal surface area
26. dielectric constants
27. compressive strength
28. tensile strength
29. isotopic ratios

Note that so-called unsophisticated parameters are mostly quantitative and the description largely numerical. Although they also are likely to require complex instrumentation, the <u>act</u> of making the measurements is relatively routine and can generally be relegated to technicians.

*For details of most of the techniques see: Dunn, J. R. (1963), Characteristics of Various Aggregate Producing Bedrock Formations in New York State, N.Y.S.D.P.W. Eng. Res. Ser. RR 63-3, 258 pp.

Although the measurements are expressed in the language of neighboring sciences, geologists are essential as interpreters of data, as catalysts in the translating of such facts to more effective use of rock materials by men, and as advisors on sampling procedures.

Of the above parameters, the first 25 either have been or are being measured at Rensselaer as a part of the research on aggregate materials. In addition, of course, the usual geologic parameters are also being determined. It is noteworthy that a few of the measurements were taken with the view that good description is its own justification, but later were found to have valuable interrelationships with other measurements.

Sampling: Proper sampling is, in any research on rock, a particularly complicated problem and any technique used is a compromise which depends on many variables. In the case of the Rensselaer research the sampling technique used was an outgrowth of the two purposes of the research: (1) to obtain useful data about rocks in western New York, and (2) to try to correlate the data internally.

The sampling technique finally used was to log the quarry faces geologically first and then select blocks of rock which were hopefully typical of the most common lithologies which were described. All research was on these blocks. The most obvious short-coming is that it never is known how typical a block is. However, studying single blocks made it possible to make direct correlations between parameters with some assurance that all data from a block were obtained from very similar material.

(The opposite situation commonly occurs when non-geologists try to correlate measurements on geologic materials without a proper knowledge of the nature of the distribution of characteristics of rocks. Better communication between geologists and their neighbors would reduce such problems.)

The General Crushed Stone Quarry, DeWitt, New York

An example of the application of "extroverted" geology - as defined here - is in the research done at the DeWitt Quarry of General Crushed Stone Co. under the sponsorship of the New York State Department of Public Works. Plate 1 shows the characteristics measured for typical lithologies. On the column, which is a stratigraphic section of the quarry face, are located positions of samples which were taken for study. The parameters which were measured are concerned with the basic physical and chemical characteristics of the individual blocks. The intent was to make all determinations which could conceivably be of value in understanding the potential uses of the rocks.

Because measurements of this type were made for every active quarry from Utica to Buffalo which is using the Manlius or Lockport formations for crushed stone, broader understanding of the nature of aggregate materials has been obtained.

Some Relationships between Measured Parameters

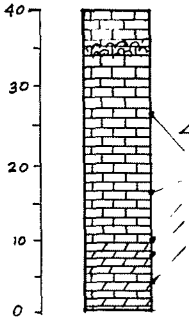
Eighty-three blocks of carbonate rock from western and central New York were studied. Because the lithologies included a wide range of carbonates, it has been possible to see some relationships of potential scientific and social value. A few typical relationships are noted below.

PLATE 1

DATA PERTAINING TO SAMPLES FROM GENERAL CRUSHED STONE CO. QUARRY DE WITT, NEW YORK

Extracted from Dunn (1963)

Stratigraphic Section of Quarry Face



Sample Designation	CHEMICAL ANALYSES: Moisture	Loss on Ignition	Insoluble Matter	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	NORMATIVE ANALYSES: Carbonates: Calcite	Dolomite	Total	Clays: Illite	Sericite	Ferri-Sericite	Chlorite	Montmo-rillonite	Total	Quartz	Minor Constit.	Insoluble Residue
OZ	0.00	36.72	0.92	13.18	0.67	1.02	0.05	42.95	3.52	0.03	0.41	70.02	11.99	82.01	0.00	0.00	4.86	3.10	0.00	7.96	12.34	0.65	15.84
R2	0.07	42.49	1.06	3.24	0.31	0.37	0.03	47.34	5.52	0.07	0.24	72.64	21.67	94.30	0.00	0.74	1.38	2.71	0.00	4.83	1.91	0.93	5.01
OD	0.02	38.38	3.16	11.10	2.63	1.19	0.12	25.70	17.15	0.02	0.47	4.26	76.05	80.31	7.09	0.00	0.00	0.76	3.22	11.07	5.24	0.85	18.20
RA	0.00	37.28	3.54	11.32	2.63	1.19	0.10	25.42	16.59	0.05	1.55	5.76	72.36	78.12	19.26	2.98	0.00	0.00	0.00	22.24	0.52	1.08	18.78
RB	0.00	43.04	0.98	4.28	0.50	0.65	0.05	37.78	11.65	0.04	1.02	37.22	55.82	93.04	0.00	8.62	0.00	0.00	0.00	8.62	0.15	0.72	6.46

CONTINUATION OF DATA MEASURED FOR SAMPLES SHOWN ABOVE

Sample Designation	X-RAY CLAY-MICA ANALYSES: Å Gp. Rep.: 7 Å	10 Å	14 Å	Using 14Å as Unity Relative: 7/14	10/14	SPECIFIC GRAVITY: Bulk Dry	Bulk Saturated	Apparent	True	% POROSITY	COMP. WAVE VELOCITY x 10^4 ft/sec: Normal to bedding	Parallel to N.-S.	Parallel to E.-W.	SHEAR WAVE V_t x 10^4: Perp. to bedding	Perp. to ea. other and in plane of bedding		POISSON'S RATIO: Perp. to bedding	Perp. to ea. other and in plane of bedding		Coefficient of THERMAL EXP. x 10^{-6} (-100° F to +160° F): Normal to bedding	Parallel to N.S.	Parallel to E.W.	N.Y.S.D.P.W. SOUNDNESS % Loss: $MgSO_4$	Na_2SO_4	Deval Abrasion	% WATER ABSORPTION
OZ	---	T	T	---	---	2.70	2.71	2.76	2.75	2.5	1.92	2.02	2.01										3.9	1.3	-	0.3
R2	---	X	X	---	1.3	2.73	2.73	2.74	2.74	1.2	1.93	2.08	2.09							5.00	4.64	4.64	1.4	0.0	3.2	0.0
OD	X	X	X	1.2	1.0	2.54	2.62	2.77	2.81	1.6	1.52	1.54	1.59	8.48	8.38	8.48	0.27	0.29	0.30				35.8	3.7	-	3.3
RA	X	X	X	1.3	1.5	2.60	2.68	2.80	2.81	0.3	1.38	-	1.31										36.0	5.5	-	2.7
RB	---	T	T	---	---	2.73	2.76	2.81	2.76	-	1.89	1.90	2.02										0.9	0.8	-	1.0

1. Thermal Expansion and Calcite-Dolomite Ratio:

The thermal expansion of limestones and dolomites is about what one would anticipate if the weighted thermal expansion of calcite and dolomite in the carbonate rock were corrected for quartz content. Variations from a straight line are probably caused by structural considerations and clay minerals. The range found was from 3.26×10^{-6} in/in/°F for two perpendicularly oriented samples in the plane of bedding (93.95% carbonate, of which 91.51% is calcite) to 9.07×10^{-6} in/in/°F (83.97% carbonate, of which 76.83% is dolomite). Samples cut perpendicular to the bedding had a tendence to have slightly higher expansions than those parallel to the beds indicating a slight tendency for the c-axes to be vertical. Contrary to previous fabric analyses no tendency was observed for limestones to have more preferred crystal orientation than dolomites.

2. Water Absorption and Soundness:

A roughly proportionate relationship exists between the weight percentage of water absorbed by aggregate in 24 hours and the magnitude of freeze-thaw test losses (tests as specified by the N.Y.S. D.P.W.). The number of exceptions to the general rule indicate, however, that freeze-thaw sensitivity is not a function of absorbed water alone.

3. Dolomite and Clay Content, and Freeze-Thaw Sensitivity:

Freeze-thaw sensitivity of aggregate, as measured by the N.Y.S. D.P.W. freeze-thaw test, has a roughly directly proportionate relationship to the dolomite content and the clay content. It was observed microscopically that dolomite crystals tend to be clear and calcite crystals cloudy. The implication was that when dolomite replaces calcite during the process of dolomitization clay is rejected to the boundaries of dolomite crystals. Reasoning that this might make the dolomite-associated clay component more available to water, i.e. more easily wetted, the following correction was made on clay content.

$$\text{(1) Wettable clay} = \frac{\text{\% calculated clay} \times \text{\% dolomite}}{\text{\% (dolomite + calcite)}}$$

In effect, the only clay considered wettable is that associated with dolomite.

If this assumption were correct, the percent of corrected clay should be proportionate to the percent of water absorbed. Plate 2 shows that this is nearly the case for 16 of the 17 most freeze-thaw sensitive rocks of the 83 which were tested. The fact that a line which follows the trend of the points does not seem to go through the origin indicates that some water is taken up in pores not associated with clay-associated dolomite.

It is particularly noteworthy that the type of clay does not seem to be critical and that the clays detected (illite, kaolinite and chlorite) are not particularly expansive or water absorbent.

4. Wetting and Drying and Freeze-Thaw Sensitivity:

Of seventeen rocks subjected to wetting and drying cycling seven deteriorated by cracking during the test. These rocks also expanded and contracted during

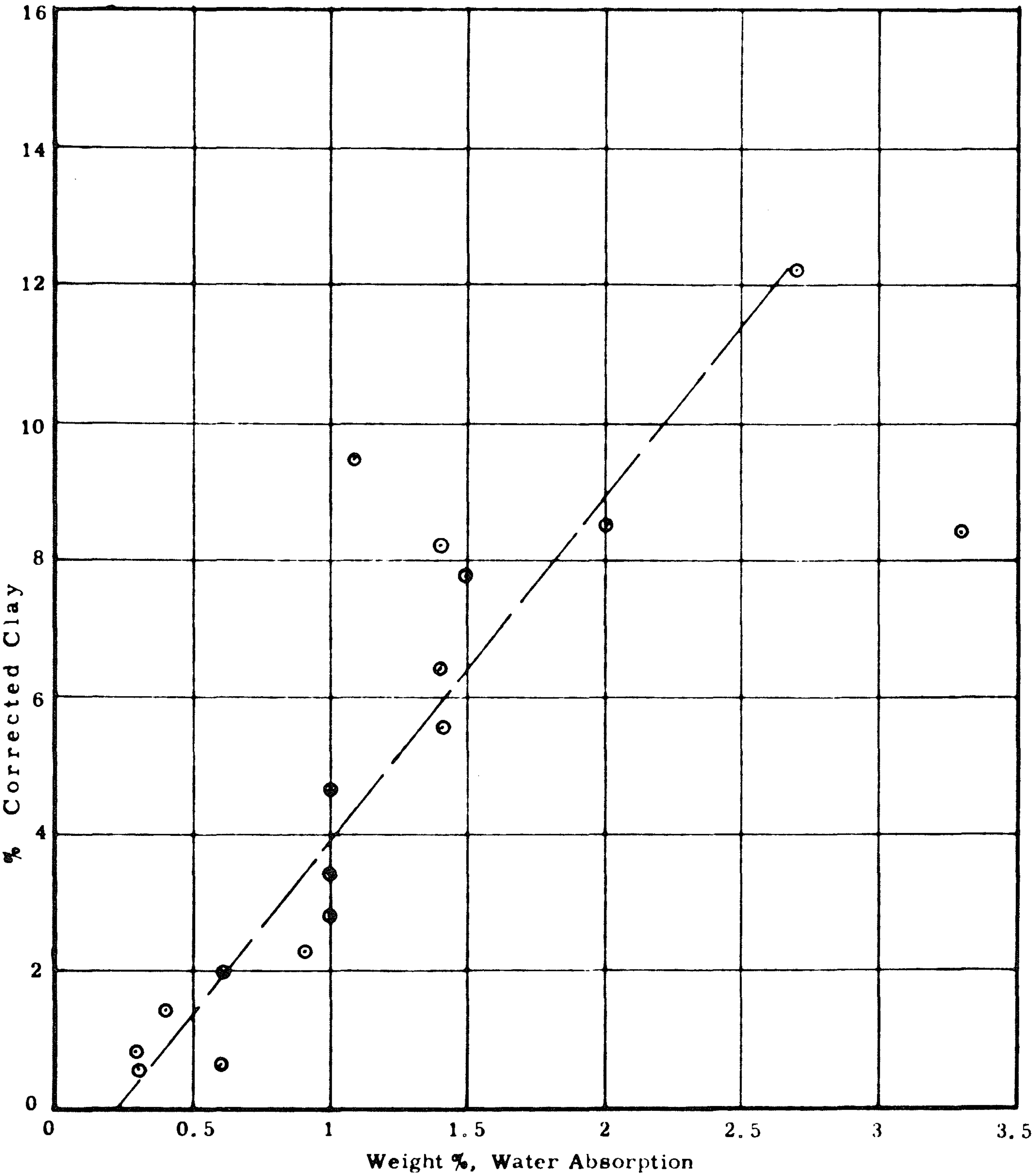


PLATE 2

PER CENT CORRECTED CLAY VERSUS PER CENT ABSORPTION FOR 17 FREEZE-THAW SENSITIVE CARBONATE ROCKS

wetting and drying and all were highly freeze-thaw sensitive. The cause of such deterioration seems to be most reasonably associated with clays even though no expansive clays were detected.

Many of the relationships which have been determined are being used in continuing research which will lead, it is hoped, to broader knowledge of the reasons for the behavior of rocks -- to the ability to anticipate reactions to external and internal forces. Ultimately the research should lead to more definitive testing procedures for rocks and to more effective use of the common rocks around us.

5. Some Observations of Freeze-Thaw Sensitive Rocks:

Rocks which fail on the freeze-thaw test have low outcrop tendencies. In addition they tend to absorb over 90% of their water in 24 hours and tend to retain some water even in prolonged vacuum. The high retention probably indicates low partial pressures for the retained water, low free energy and low entropy. The best guess at this time is that such water is clay-associated and is ordered, i.e. has crystalline form.

6. Some Correlations with Distressed Concrete:

Rocks which have caused distress in concrete could have more than one cause of weakness, i.e. any two of the following: (1) freeze-thaw sensitivity, (2) wet-dry deterioration, (3) chemical reactivity with portland cement. The common denominator for these problems seems to be clay.

Concluding Statement

The communication with people working fields outside of the field of geology, such as physics, chemistry, engineering or business, is largely the province of what has been called "extroverted" geology. Geologists working in the "extroverted" fields are likely to be concerned not only with normal geologic description but with quantitative (or less sophisticated) parameters of a fundamental physico-chemical nature. Geologists are essential for the interpretation of such data and the selection of sampling procedures. Basic physico-chemical characteristics were determined at Rensselaer for blocks of rock from all quarries operating in the Lockport and Manlius formations between Utica and Buffalo. The General Crushed Stone Company quarry at DeWitt is used as an example of the technique. On the basis of the research several potentially valuable relationships of a theoretical and practical nature have been observed.