record is obtained (instead of one traced by an electronic recorder on graph paper) it is most convenient to first transfer it to some convenient graph or ruled paper.

The method of obtaining the derived curve consists of observing successive values of change of temperature $(T-T')$ for equal increments of T. A convenient increment is 10° C. This is expressed as $\Delta(T-T')/\Delta T$ where ΔT is taken as 10° C. The derived differential is the graph obtained by plotting the temperature differences against T: $d(T-T')$ vs. T.

The inset in Fig. 1 represents an enlargement of a portion of curve B. The differences in temperature (represented by any convenient unit) between the kaolinite sample and the standard, on heating from 500 to 570° C., are 0.8, 1.5, 1.8, 2.8, etc., units for each 10° increase in temperature. These values are plotted against 500, 510, 520, 530° C., etc., respectively.

The slight "bump" on the large endothermic peak (curve B) plots as a straight horizontal line (between 550 and 560° C.) in the derived curve. The base line under the two peaks of the derived curve can be objectively drawn with precision. Apparently the important part of the reaction starts at 500° C. The area to be measured under this peak can be delimited by extending the straight-line portion of the derived curve (from 500–550° C.) back to the base line.

Two independent operators can select a base line and duplicate the measured areas under the curve within 3 per cent. Usually the differential curve obtained from two portions of the same sample check rather closely, consequently, when suitable samples are chosen to construct an area vs. quantity-of-mineral-present curve, the derived differential technique greatly improves the accuracy of the method.

References

Foote, P. S., Fairchild, C. O., and Harrison, T. R. (1921), Pyrometric Practice: *U. S. Bureau of Standards, Technologic Paper No. 170.*

Rowland, R. A., and Lewis, D. R. (1951), Furnace atmosphere control in differential thermal analysis: *Am. Mineral.*, **36**, 80–91.

THE ST. PETER SANDSTONE-GLENWOOD SHALE CONTACT

W. G. Ernst, *Carleton College, Northfield, Minnesota.*

Introduction

Between Northfield and Cannon Falls, Minnesota, some 40 miles south of St. Paul, on State Highway 19, mesas rise to heights of 60 feet or more above the preglacial Cannon River Valley flood plain (1). These prominences, when traced by aerial photographs, are seen to pass southward into undissected tableland. Figure 1 reveals that simple headward stream erosion has been responsible for the topography. The hills are capped by the Spechts Ferry and McGregor limestone members of the

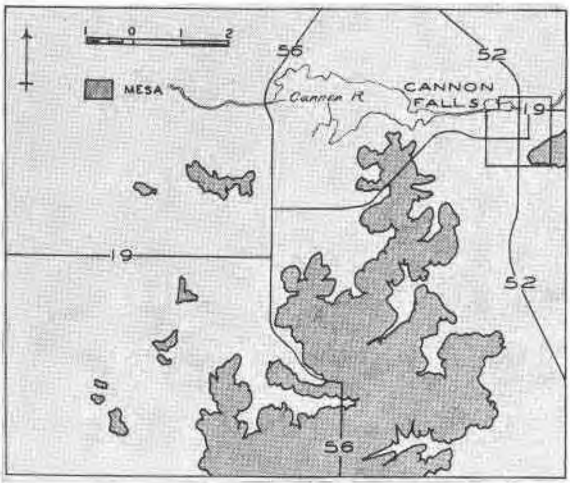

FIG. 1. Location of mesas in the Cannon River Valley.

Middle Ordovician Platteville formation (2). Below these resistant layers are the readily weathered Glenwood shale member of the Platteville, and the friable Middle Ordovician St. Peter sandstone (3). Figure 2 exhibits the stratigraphic relationship, while also showing a secondary mesa-forming horizon between the Glenwood above, and the St. Peter below. This horizon owes its superior resistance locally to abundant limonite cement. Solution etching indicates the presence of carbonates. This intermediate bed will be called the "transition zone," and will be found to be a reworked phase of the underlying sandstone.

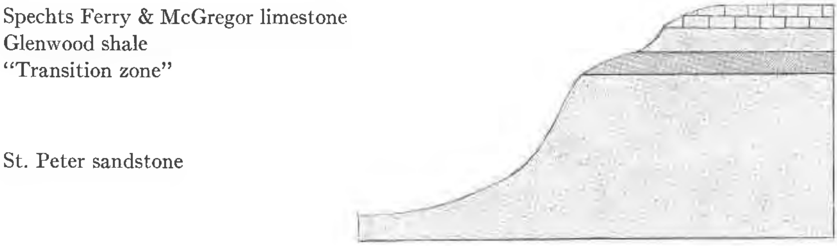

FIG. 2. Stratigraphic Section.

The Problem

Thiel states that the upper five to ten feet of the St. Peter sandstone contain heavy mineral grains, especially garnet, foreign to the formation as a whole, but quite similar to the assemblage in the overlying Glenwood beds; considering this he deduces that this zone represents reworked sandstone of Mohawkian age, and should be classified as an early stage of Glenwood sedimentation (4, 5). Following Thiel's suggestion, the writer analyzed the heavy mineral content of a vertical section of 35 feet, from the base of the McGregor limestone member down into typical St. Peter sandstone. The channel samples were taken at road cuts one-tenth of a mile east of U. S. Highway 52 at the south city limits of Cannon Falls. Characteristic St. Peter material was then compared with Upper St. Croixian series Jordan sandstone just below its contact with the overlying Oneota dolomite.

Method of Analysis

Samples approximately two pounds in weight were taken at every lithologic and textural change in character of the beds. The shales were then dried and pulverized by abrasion between a steatite table surface and a block of soft wood. The sandstone samples were friable enough to be broken down into individual grains between the fingers. The samples were then screened by hand, using U. S. standard sieves. Grains retained were divided into three diameter sizes: (1) between .420–.250 millimeters; (2) between .250–.125 millimeters; and (3) less than .125 millimeters. Heavy mineral separation tests were then run using acetylene tetrabromide (sp. gr. 2.95 at 20 degrees Centigrade). Samples were placed in a funnel containing the heavy medium, and after a sufficient time, the high density grains were drained off by means of a petcock. The acetylene tetrabromide was then neutralized by the addition of benzene. Finally, the minerals were mounted in canada balsam. In all, fifty-seven slides were analyzed. Very few grains were present in the .420–.250 millimeter size, so percentage figures there may be distorted. No attempt was made to record the percentages of the original samples which were retained as heavy grains.

Description of the Samples

All samples, *A1–A6*, are from Cannon Falls. Horizons *A1* through *A3* are Glenwood shale and horizons *A4* through *A6* are St. Peter sandstone.

Horizon A1. The first sample is a greenish brown shale taken two feet below the contact with McGregor limestone. It is a fairly blocky layer, exhibiting little pyrite, the coloring being due to a great deal of limonite, which tends to coat the quartz grains to such an extent that they sink with the heavy minerals. Much of this quartz shows secondary bipyramidal enlargements. Epidote and minor amounts of chlorite may also be partially responsible for the color. Garnet and zircon are noted. Most of the sand grains are between .250–.125 millimeters diameter with very few grains in the smallest size.

Horizon A2. Five to six feet below the base of the McGregor is found a somewhat arenaceous shale, of alternating blue, brown, and green layers. Here again there is much limonite. Epidote is absent and garnet and zircon are relatively abundant. Staurolite is present in great quantities in both *A1* and *A2* horizons and is apparently a local flood mineral, since its presence has not been reported elsewhere. Again the .250–.125 millimeter size is most productive of minerals in number and variety.

Horizon A3. One foot below horizon *A2* is an argillaceous, gray-green sandstone, of which 60 per cent of the grains have greater diameter than .420 millimeters. Quartz shows little secondary growth and there is less hydrated iron "ore." There is a general paucity of heavy minerals, kaolin, etc., apparently making up most of the fines. Garnet suggests Middle Ordovician sedimentation.

Horizon A4. Seven to ten feet down from the contact between limestone and shale, alternating layers of brown and white sandstone are observed. In some areas, this sandstone forms "shoulders" on the otherwise uniformly descending flanks of mesas. The re-

TABLE 1. GRAINS COUNTED

Horizon	Size of grains in mm.	Almandite	Zircon	Schorlite	Staurolite	Magnetite	Ilmenite	Leucoxene	Rutile	Pistacite	Chlorite	Pyrite	Indicolite	Hornblende	Ceylonite
	.420–.250	4	1		4	10	2	1	3	2				1	
A1	.250–.125	15	14	1	37	25	7	10	7	37	7	3	3	4	
	.125–.000	3	2		3	2				1				1	
	.420–.250	2	1		1	2	1	1							
A2	.250–.125	12	9	1	7	4		5		1	2	3	1		
	.125–.000	6	4		1	1				1			1		
A3	.420–.250	1				2							1		
	.250–.125	1	3	1		2		3	1				1		
A4	.420–.250	1	1												
	.250–.125	10	17	7	2	8	1	1	1						
	.420–.250		1	1		2						2	1		
A5	.250–.125		49	13	10	11	3	6	2			9	1	1	
	.125–.000		99	1	4	2				1		7			
	.420–.250		4			1									
A6	.250–.125		4	9		6			1						
	.125–.000			2		1						1			
B1	.250–.000	80	7	3	9	8			1			12		3	
B2	.250–.000	32	4	1	71	4	1	1	1			1			1

Table 2. Individual Grain Percentages

Horizon	Size of grains in mm.	Almandite	Zircon	Schorlite	Staurolite	Magnetite	Ilmenite	Leucoxene	Rutile	Pistacite	Chlorite	Pyrite	Indicolite	Hornblende	Ceylonite
	.420–.250	14	4		14	36	7	4	10	7				4	
A1	.250–.125	9	8	1	22	15	4	6	4	22	4	2	2	2	
	.125–.000	25	17		25	17				8				8	
	.420–.250	25	13		13	25	13	13							
A2	.250–.125	27	20	2	15	9		11		2	4	7	2		
	.125–.000	43	28		7	7				7			7		
A3	.420–.250	25				50							25		
	.250–.125	8	25	8		17		25	8				8		
A4	.420–.250	50	50												
	.250–.125	21	36	15	4	17	2	2	2						
	.420–.250		14	14		29						29	14		
A5	.250–.125		48	12	9	10	3	6	2			8	1	1	
	.125–.000		87	1	4	2				1		6			
	.420–.250		80			20									
A6	.250–.125		20	45		30			5						
	.125–.000			50		25						25			
B1	.250–.000	65	6	2	7	6			1			10		2	
B2	.250–.000	27	3	1	61	3	1	1	1			1			1

sistance and color is due to abundant limonite. Garnet is still present, but otherwise it is similar to the St. Peter sandstone below. Like horizon *A3*, it probably represents a reworked deposit of Mohawkian seas.

Horizon A5. At a distance of twelve feet below the base of the McGregor member, pure, white, fairly well cemented sandstone is observed. Zircon is the predominant heavy mineral, garnet is absent. There is an anomaly in the presence of staurolite. This horizon, according to Thiel, represents the final stage of Chazyan time. No garnet is noted in the underlying Ordovician sandstone.

Horizon A6. Pure sandstone is definitely noted here, 35 feet below the contact between shale and limestone. It is massive and poorly cemented. There is a scarcity of heavy grains. Zircon, tourmaline, and magnetite predominate; no garnet was observed.

Compared to the heavy mineral assemblage of typical St. Peter sandstone, two analyses of Jordan sandstone are presented.

Horizon B1. At an elevation of approximately 685 feet above sea level, drill cuttings from the Carleton well, Northfield, Minnesota, show a typical Jordan sandstone; this is 15 feet below its contact with the Oneota dolomite. The heavy mineral content is principally garnet, with minor amounts of zircon, magnetite, and staurolite.

Horizon B2. Eighteen feet below the first sample, another was examined. It shows a good deal of garnet, but in addition, there is an amazing increase in amount of staurolite. The general percentages agree with the work of James F. Anderson, Carleton College, who in 1941 prepared, but did not publish, a petrographic log of the Owatonna, Minnesota, New City Water Well. However, it must be admitted that the staurolite count in the above work is much lower in both St. Peter and Jordan sandstones than this writer noted at Cannon Falls and Northfield. (Tables 1 and 2.)

Conclusions

(1) The channel samples seemed to substantiate the aforementioned work of Thiel. Garnet, so typical of the Mohawkian deposition, is present only in the "transition zone," or upper few feet of the St. Peter; this zone is mineralogically more closely related to the overlying shale than to the underlying sandstone (Fig. 3).

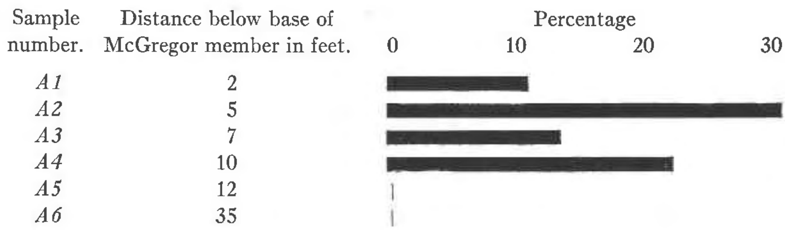

Fig. 3. Percentage distribution of garnet in channel, .420–.000 mm.

(2) The positive occurrence of large amounts of staurolite in the channeled material may be explained as local flooding. The source of the staurolite may have been in metamorphic rocks which were above sea level for some time, inasmuch as the Upper Cambrian Jordan sandstone exhibits it as well as the St. Peter and Glenwood beds, of Lower and Middle Ordovician respectively; more likely, the staurolite of Mohawkian age was derived from older strata which had been locally uplifted at this time.

(3) Ignoring local flood granules, widespread heavy minerals lend themselves to correlation of well-sorted clastic horizons.

Acknowledgments

The writer is indebted to Dr. Duncan Stewart of Carleton College, whose assistance made this paper possible, as well as to Dr. G. A. Thiel of the University of Minnesota, who suggested the topic.

References

1. Leverett, Frank, and Sardeson, F. W. (1919), Surface formations and agricultural conditions of the south half of Minnesota: *Minn. Geol. Surv., Bull.* **14,** 109.
2. Stauffer, C. R., and Thiel, G. A. (1941), Paleozoic, and related rocks of southeastern Minnesota: *Minn. Geol. Surv., Bull.* **29,** 70.

3. *Ibid.*, p. 66.
4. Thiel, G. A. (1935), Sedimentary and petrographic analysis of the St. Peter sandstone: *Geol. Soc. Am., Bull.* **46,** 612–613.
5. Thiel, G. A. (1937), Petrographic analysis of the Glenwood beds of southeastern Minnesota: *Geol. Soc. Am., Bull.* **48,** 120.

Bibliography on Uranium in Colorado and Utah

The Geological Society of America published the following article in the June, 1954, issue of its Bulletin: "Bibliography and Index of Literature on Uranium and Thorium and Radioactive Occurrences in the United States. Part 3: Colorado and Utah," by Margaret Cooper of the Division of Raw Materials, U. S. Atomic Energy Commission. Since this 124-page bibliography may prove helpful to both geologists and laymen interested in uranium prospecting, the Society has prepared reprints for public sale at 50 cents per copy. Remittance must accompany orders, which should be sent to:

The Geological Society of America
419 West 117 Street
New York 27, New York

Dr. A. N. Winchell is preparing a third edition of his "Microscopic Characters of Inorganic Substances" and will welcome data on compounds not included in previous editions as well as more up-to-date data on compounds already listed. This book will cover data on inorganic solids other than natural minerals. Information on compounds of commercial nature will be included if possible, provided satisfactory evidence of exact composition is given. Any other suggestions should be forwarded to Dr. Winchell, 88 Vineyard Road, Hamden, Connecticut.

The Arizona Bureau of Mines has published Bulletin No. 163 of Mineral Technology Series No. 47, entitled "Minerals and Metals of Increasing Interest-Rare and Radioactive Minerals," by Richard T. Moore. Price 30 cents (free to residents of Arizona). Address University of Arizona, Tucson, Arizona.

A conference on silicosis and occupational chest diseases jointly sponsored by the McIntyre Research Foundation of Toronto, Canada, and the Saranac Laboratory of Saranac Lake, New York, has been arranged for Monday, Tuesday, and Wednesday, February 7, 8, and 9, 1955, in the Town Hall at Saranac Lake. The papers to be presented in the five full sessions will all report on original work conducted or sponsored by either the McIntyre Research Foundation or the Saranac Laboratory. In addition there will be papers presented by guest lecturers.

The business arrangements including reservations will be handled by Norman R. Sturgis, Jr., and the treasurer will be Clarence L. Wagner, both of the Trudeau-Saranac Institute staff. All communications concerning the conference should be addressed to Mr. Sturgis, Saranac Laboratory, Saranac Lake, New York.

Bulletin No. 164 of the Arizona Bureau of Mines—Mineral Technology Series No. 48, entitled "Exploration and Development of Small Mines," by H. E. Krumlauf, is now available. Price 25 cents (free to residents of Arizona). Address University of Arizona, Tucson, Arizona.