J. W. Trefethen

State Geologist's Report

ON THE

GEOLOGY OF MAINE

1930 - 1932

SECOND SERIES

By
JOSEPH CONRAD TWINEM
State Geologist
and
EDWARD H. PERKINS
Assistant Geologist

Augusta
1932

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Bibliography on the Geology of Maine

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Introduction

The bibliography of the Geology of Maine includes publications on economic and historical geology, mineralogy, paleontology, petrology, physical and physiographical geology and underground waters. In addition many general publications, newspapers and magazine articles are listed if they are of geological importance.

This bibliography has been compiled from various sources, including bulletins of the U. S. G. S. entitled "Geologic Literature of North America from 1785-1918," Bulletin No. 746, and "The Bibliography of North American Geology from 1919-1928," Bulletin No. 823. Much valuable material was also obtained from Cyrus C. Babb's report on the "Bibliography of Maine Geology," Reprint from the third annual report of the Maine State Water Storage Commission; "The Bibliography of American Natural History" by Max Meisel and the "Sixth Biennial Report of the State Survey Commission, 1909-1910."

The author wishes to thank Dr. Edward H. Perkins, Professor of Geology at Colby College for his valuable assistance and contributions to this bibliography.

It is hoped, from the large number of requests that are received by the State Geologist, that this Bibliography will, in some measure, be of service and assistance to those interested in the various publications on the Geology of Maine.

List of Abbreviations

abst.	abstract
Acad.	academy
adv.	advancement
Agric.	agriculture, etc.
Am.	America
An.	annals, annual, etc.
anal.	analytical
arch.	archives
Assoc.	association
Bul.	bulletin, etc.
Bur.	Bureau
Can.	Canada; Canadian
chem.	chemical, chemistry
circ.	circular
Co.	County
Col.	collection
Coll.	college
Comm.	commission
comp.	comparative
Contr.	contractor, contributions, etc.
Dept.	department
diss.	dissertation
Econ.	economic
Ed.	edition, editor, etc.
Eng.	engineer, engineering
fig.	figure, figures
fol.	folio
Geod.	geodetic, etc.
G. S.	geological survey
g. s.	geological series
Geol.	geology, etc.
Hist.	history
ill.	illustrated with figures
Inst.	institute, institution
Jour.	journal, etc.
lab.	laboratory
Mass.	Massachusetts
Me.	Maine
Mem.	memoirs
Mex.	Mexico, Mexican
Min.	mineral, mining, etc.
Miner.	mineralogist
Minn.	Minnesota
Mon.	monograph
mus.	museum
N. B.	New Brunswick
N. E.	New England
n. d.	no given date of publication
N. H.	New Hampshire
n. p.	no given place of publication
N. S.	Nova Scotia
n. s.	new series
N. Y.	New York
Nat.	natural; naturalist
No.	number
P.	papers
P. P.	Professional Papers
Ph.	Philosophical
Phila.	Philadelphia
Phys.	Physics
pls.	plates
pp.	pages
priv. pr.	privately printed
priv. pub.	private publication
Proc.	Proceedings
Prog. Rpt.	Progress Report
pt.	part
Pub.	publication
Rec.	record
Rev.	review
Rpt.	report
Sc.	science, scientific, etc.
sec.	section
ser.	series
seism.	seismology, seismological
Soc.	Society
St.	State
Sum. Rpt.	summary report
Surv.	Survey
Tech.	Technology, etc.
Tr.	transactions
U. S.	United States
Univ.	University
vol.	volumes
Wash.	Washington
W. S. P.	Water Supply Paper
Zeit.	Zeitschrift
Zool.	zoology, etc.

Geological Publications

ACAD. NAT. SC. PHILA.: Academy of Natural Sciences of Philadelphia, Journal; Proceedings; Mineralogical and Geological Section, Proceedings. Philadelphia, Pa.

AGRIC. of N. Y.: Agriculture of New York.

AM. ACAD. ARTS. SC.: American Academy of Arts and Sciences, Memoirs, Proceedings; Boston, Mass.

AM. ASSOC. ADV. SC.: American Association for the advancement of Science, Memoirs, Proceedings: Salem, Mass.

AM. ASSOC. GEOL. NAT.: American Association of Geologists and Naturalists, Boston, Mass.

AM. CHEM. SOC. JOUR.: American Chemical Society Journal, Easton, Pa.

AM. GEOL.: American Geologist, Minneapolis, Minn.

AM. INST. MIN. ENG.: American Institute of Mining Engineers, Bulletin, Technical Publications, Transactions, New York.

AM. JOUR. SC.: American Journal of Science, New Haven, Conn.

AM. MIN. CONG.: American Mining Congress. See also International Mining Congress. Report of Proceedings, Denver, Colo.

AM. MINER: American Miner.

AM. MINER.: American Mineralogist, Philadelphia and Lancaster, Pa., now Menasha, Wis.

AM. NAT.: American Naturalist, Philadelphia, Pa., N. Y., (and elsewhere).

AM. PH. SOC.: American Philosophical Society, Proceedings, Transactions, Philadelphia, Pa.

AM. QUART. JOUR. AGRIC. SC.: American Quarterly Journal of Agriculture and Science, (later the American Journal of Agriculture and Science), Albany, N. Y.

AN. PHYSIK: Annalen der Physik und Chemie (J. C. Poggendorff) Leipzig.

APPALACHIA: Published by the Appalachian Mountain Club, Boston, Mass.

ASSOC. AM. GEOL.: Association of American Geologists and Naturalists, Reports.

ATLANTIC MONTHLY, Boston, Mass.

BOSTON ADVERTISER, Boston, Mass.

BOSTON DAILY MAIL, Boston, Mass; now non-existent.

BOSTON HERALD, Boston, Mass.

BOSTON JOUR. NAT. HIST.: Boston Journal of Natural History, Memoirs, Proceedings, Boston.

BOSTON SOC. ARTS.: Boston Society of Arts, Proceedings.

BOS. SOC. NAT. HIST.: Boston Society of Natural History, Memoirs, Anniversary Memoirs, Proceedings; Occasional papers.

BOWDOIN SC. REV.: Bowdoin Scientific Review, Brunswick, Maine.

BRITISH ASSOC. RPT.: British Association for the Advancement of Science, Reports, London.

CAN. GEOL. SURV.: Canada Geological Survey, Annual Report; Summary Report; Memoirs; Museum Bulletin; Victoria Memorial Museum, Bulletin, Ottawa, Ontario.

CAN. INST. and CAN. JOUR.: Canadian Institute and Canadian Journal, Toronto.

CAN. NAT.: Canadian Naturalist and Geologist and Proceedings of the Natural History Society of Montreal.

CAN. REC. SC.: Canadian Record of Science, Montreal.

CAN. ROYAL SOC.: Canada, Royal Society; Transactions, Montreal.

CHEM. GEOL. ESSAYS: Chemical and Geological Essays, Boston, Mass.

CHEM. NEWS: Chemical News, London.

CINCINNATI SOC. NAT. HIST. JOUR.: Cincinnati Society of Natural History, Journal.
COLBY COLL. BUL.: Colby College Bulletin, Waterville, Maine.
EASTPORT SENTINEL, Eastport, Maine.
ECON. GEOL.: Economic Geology, Lancaster, Pa.
ENG. MIN. JOUR.: Engineering and Mining Journal, New York, N. Y.
ESSEX INST.: Essex Institute, Bulletins, Proceedings, Salem, Mass.
GEOGRAPHICAL REVIEW, Published by the American Geographical Society of New York, 1901-1932.
GEOL.: The London Geologist, 2 vols., 1842, 1843, edited by Charles Maxon, London
GEOL. MAG.: Geological Magazine, London.
GEOL. NAT. HIST. CAN.: Geology and Natural History of Canada, Annual Reports.
GEOL. SKETCHES: Geological Sketches, Boston, Mass.
GEOL. SOC. AM.: Geological Society of America, Bulletin, Rochester, N. Y., and elsewhere.
GEOL. SURV. MINN.: Geological Survey of Minnesota, Minneapolis, Minn.
GEOL. SOC. PHILA.: Geological Society of Philadephia, Bulletin, Philadelphia, Pa.
GRANITE, A. M. Hunt and Co., Boston, Mass.
GROTH'S ZEIT. f. KRYST U. MIN.: Groth's Zeitschrift für Krystallographie and Mineralogie, Leipzig, Germany.
HARPER'S MAG.: Harper's New Monthly Magazine, New York.
HARVARD COLL. MUS. COMP. ZOOL.: Harvard College, Museum of Comparative Zoology, Bulletin; Annual Report; Memoirs, Cambridge, Mass.
HOME and FARM, Louisville, Ky.
INDUSTRIAL JOURNAL, Bangor, Maine.
JAHRBUCH MINER.: Jahrbuch fur Mineralogie, Geognosie, Geologie und Petrefaktenkunde (Leonhard und Bronn) Heidelberg.
JEWELER'S CIRCULAR, New York.
JOHN HOPKINS UNIV. CIRC.: John Hopkins University Circular, Baltimore, Md.
JOUR. ANAL. APP. CHEM.: Journal of Analytical and Applied Chemistry.
JOUR. FRANKLIN INST.: Journal Franklin Institute, Philadelphia.
JOUR. GEOL.: Journal of Geology, Chicago, Ill.
JOUR. N. E. WATER WORKS ASSOC.: Journal New England Water Works Association, New London, Conn.
JOUR. PHYS.: Journal de physique, de chimie, d'histoire naturelle et des arts, Paris.
JOUR. U. S. ASSOC. CHARCOAL IRON WORKERS: Journal U. S. Association of Charcoal Iron Workers.
MacFARLANE'S AMERICAN GEOLOGY RAILWAY GUIDE.
ME. BOARD AGRIC.: Maine Board of Agriculture, annual report, Augusta, Maine.
ME. HIST. SOC.: Maine Historical Society, Collections, Portland, Maine.
ME. NAT.: The Maine Naturalist, published by the Maine Naturalist Company, Portland, Me.
ME. ST. COLL. LAB.: Maine State College Laboratory, Bulletins, now University of Maine State Highway Laboratory, Orono, Maine.
ME. ST. SURV. COMM.: Maine State Survey Commission, Augusta, Maine.
ME. ST. WATER STORAGE COMM.: Maine State Water Storage Commission, annual report, Augusta.
MINN. GEOL. NAT. HIST. SURV.: Minnesota Geological and Natural History Survey, Minneapolis, Minnesota.
MIN. WORLD.: Mining World, Chicago, Illinois.

MOUNTAIN MAGAZINE: Published by the Associated Outdoor Clubs of America, 1922-1932.

NAT. ACAD. SC.: Natural Academy of Sciences, Proceedings, Memoirs, Washington, D. C.

NAT. HIST. GEOL. ME.: Natural History and Geology of Maine. Reports of Commissioner of Agriculture, Augusta, Maine.

NAT. HIST. SOC. N. B.: Natural History Society of New Brunswick, Bulletin, St. John.

NAUTILUS, Philadelphia, Pennsylvania.

NEUES JAHRBUCH für MINERALOGIE, GEOLOGIC, und PALÄONTOLOGIE; Beilage Band. Stuttgart.

NORTHERN, The Northern, published by the Great Northern Paper Co., 1922—

N. Y. ACAD. SC.: New York Academy of Sciences, Annals; Memoirs; New York.

N. Y. SOC. NAT. HIST.: New York Society of Natural History, Proceedings.

N. Y. ST. MUS.: New York State Museum of Natural History, Annual Report, Bulletins, Memoirs, Albany, N. Y.

PAN.-AM. GEOL.: Pan-American Geologist, Des Moines, Iowa.

PETERMANNS MITT: Petermanns Mitteilungen; Ergänzungsheft, Gotha.

PHIL. ACAD. NAT. SC.: Philadelphia Academy of Natural Sciences, Proceedings, Philadelphia.

POP. SC. MONTHLY: Popular Science Monthly, New York, N. Y.

PORTLAND ADVERTISER, non-existent, Portland, Maine.

PORTLAND DAILY PRESS, PORTLAND, Maine, now Press Herald, Portland, Maine.

PORTLAND SOC. NAT. HIST.: Portland, (Maine) Society of Natural History, Proceedings.

PORTLAND SUNDAY TIMES, non-existent, Portland, Maine.

PORTLAND TRANSCRIPT, non-existent, Portland, Me.

RHODORA, Boston, Mass.

ROCHESTER ACAD. SC.: Rochester Academy of Science, Proceedings, Rochester, N. Y.

ROCK PRODUCTS, now American Stone Trade, Chicago, Ill.

ROCKS and MINERALS, published by Rocks and Minerals Association, Peekskill, N. Y., 1925-1932.

SC. AM.: Scientific American, New York, N. Y.

SCIENCE, new series, Cambridge, Mass., and elsewhere, now New York.

SCIENCE GOSSIP.

SEISMO. SOC. AM.: Seismographical Society of America, Bulletin, Stanford University, Cal.

SMITHSONIAN INST. REPT.: Smithsonian Contributions and Report, Washington, D. C.

SOC. GEOL. FRANCE: Societe geologique de France, Bulletin; Memoires, Paris.

SOC. MEX. GEOG. ESTADISTICA.: Sociedad mexicana de geografia y estadistica Boletin Mexico, D. F.

TECH. QUAR.: Technology Quarterly and Proceedings of the Society of Arts. Earlier Technology Quarterly. Mass. Inst. of Tech., Boston.

TORREYA, Lancaster, Pa.

U. S. BUR. MINES: United States Bureau of Mines, Bulletin; Technical Paper, Washington, D. C.

U. S. BUR. SOILS: United States, Bureau of Soils, Bulletin.

U. S. COAST and GEOD. SURV.: U. S. Coast and Geodetic Survey, Reports, Washington, D. C.

U. S. DEPT. AGRIC.: United States, Department of Agriculture, Bulletins.

U. S. GEOL. SURV.: United States Geological Survey, Annual Report; Bulletin; Monograph; Mineral Resources; Professional Paper; Water-Supply Paper; Geologic Atlas, ——— folio (No. ———); Topographic Atlas.

U. S. NAT. MUS.: United States National Museum, Annual Report; Bulletin, Proceedings.

UNIV. of PENNA. LAB.: University of Pennsylvania. Contributions to Laboratory, Phila.

WASH. ACAD. SC. JOUR.: Washington, D. C. Academy of Sciences, Journal; Proceedings.

WHEELERS HISTORY OF BRUNSWICK and TOPSHAM, Boston, Mass.

YALE BICEN. PUB.: Yale University Bicentennial Publications. Contributions to mineralogy and petrography—edited by S. L. Penfield and L. V. Pirsson.

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3. Late Quaternary changes of level in Maine: Am. Jour. Sc., 5th ser., 15: 319-336, 2 figs., April, 1928; Abst. Geol. Soc. Am. Bull., 38, No. 1: 144, March 30, 1927; Pan-Am. Geol., 47 No. 2: 151-152, March, 1927.
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2. On Some Dikes in the Vicinity of Johns Bay, Me. Am. Geol. 23: 275-280, pls., 8-11, map, 1899.
3. The Physiography of Mount Desert (Island): Geog. Soc. Philadelphia, Bull., 17, No. 4: 117-130, 4 pls., map, October, 1919.

Bastin, Edson Sunderland

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2. Clays of the Penobscot Bay Region, Me. U. S. Geol. Surv. Bull. 285: 428-431, 1906.
3. The Lime Industry of Knox County, Me. U. S. Geol. Surv. Bull. 285: 393-400, 3 figs., 1906.
4. Feldspar and Quartz Deposits of Maine, U. S. Geol. Surv. Bull. 315: 383-393, 1907.
5. (with Brown, C. L. and Smith, G. O.) Description of the Penobscot Bay Quadrangle (Me.) U. S. Geol. Survey, Geol. Atlas, fol. 149: 14 pp., 2 maps, and structure-section sheet, 1907.
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8. (with Leighton, H.) Road materials of Southern and Eastern Maine. U. S. Dept. Agric. Off. Pub. Rds. Bull. 33: 56 pp., 4 pls., 1908.

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11. Origin of the Pegmatites of Maine. Jour. Geol. 18: No. 4. 297-320, 3 figs., 1910. Abst. Science, n. s. 31: 321, fel. 25, 1910.
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3. A Fulgurite from Waterville, Me. Am. Jour. Sc. 3d ser. 43: 327-328, 1892.
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Maine Geological Survey -- History*

"By act of the state legislature dated March 28, 1836, a geologic survey of the State of Maine was authorized. Charles T. Jackson was appointed state geologist. The investigation was continued during the following three years. The published results, considering the difficulties of transportation at that time and the non-existence of accurate maps are interesting. They include three annual reports entitled 'Geology of the State of Maine' and dated 1837, 1838 and 1839; a Report entitled 'Report of an exploration and survey of the territory of the Aroostook River'; and a Report entitled: 'Second Annual Report of the geology of the public lands belonging to the two states of Maine and Massachsuetts. The state appropriated $5,000 for the survey.'

"By act of March 16, 1861, a detailed survey of Maine was authorized, and a report of the natural history and geology of the state was made by C. H. Hitchcock, geologist, and Ezekiel Holmes, naturalist . . . " Extracts from Hayes, p. 63. (See Annot. Bib).

* From "A Bibliography of American Natural History," by Max Meisel, B.S., B.L.S.

Jackson's assistants were James T. Hodge for Massachusetts, and Dr. T. Purrington for Maine.

The assistants for the 1861 survey were G. L. Goodale, botanist and chemist; John C. Houghton, mineralogist; A. S. Packard, Jr., entomologist, and C. B. Fuller, marine zoologist. G. L. Vose, N. T. True, John DeLaski, Oliver White, L. W. Bailey assisted in minor capacities. See also Merrill, (1), p. 290, 346-47, 511-12, (see Annot. Bib.) for critical discussion. For documents in state collection, see Hasse, (2), 1907, p. 73. See also Merrill. First 100 years. Amer. Geol. 1924. p. 189-91, 404-5.

Reports were also made by S. L. Stephenson to Jackson in 1839; and by P. A. Chadbourne, N. S. Manross, J. G. Rich, B. F. Fogg, A. E. Verrill, J. W. Dawson, and Forrest Shepherd, to Messrs. Holmes and Hitchcock, 1862-63.

According to Merrill (see Bibliography: 1920, below), the cost of the Maine surveys totalled $18,000.

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8. Maine

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p. 13- 86 Topographical geology.
p. 87-116 Economical geology.
p. 117- 19 Specimens in the state cabinet.
p. 121- 27 Explanation of geological terms.

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River and Lake Survey Maps

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Paleontology

Petrology

Selected Bibliography of Minerals and Their Identification

By

OLIVER BOWLES

Selected Bibliography of Minerals and Their Identification [1]

By OLIVER BOWLES [2]

INTRODUCTION

Many inquiries are received by the United States Bureau of Mines for the names of elementary books on geology, mineralogy, methods of identifying minerals, prospecting, and similar subjects. In response to this demand the following brief bibliography has been prepared. As many of the inquiries are received from those who have limited technical knowledge of the subjects involved, the bibliography includes the simpler texts which present the subjects in non-technical language. Other texts contain glossaries which define the technical terms used. A short note following the title indicates the character of each book, the number of pages, and the price. Thus, elementary mineralogists, or geologists, prospectors, mineral collectors, nature students, or travellers may select the texts that best suit their requirements and their capabilities.

To supply the needs of more advanced students, quite a number of the standard texts used in schools and colleges are included in a second group. A short list of books on economic geology and mineralogy has also been added.

ELEMENTARY BOOKS

The following books are elementary in character and are best adapted for those who have a limited technical knowledge of geology and mineralogy:

Anderson, J. W. *Prospector's handbook.* 12th rev. ed., D. Van Nostrand Co., Inc., New York, 210 pp. $2. A guide for the prospector and traveler in search of metal-bearing or other valuable minerals. Contains a glossary of terms used.

Burdick, A. J. *Valuable minerals,* how to find and know them. 2nd ed., The Beaumont Gazette, Beaumont, Cal., 1928. 32 pp., 50 cents. A non-technical pamphlet consisting of notes on prospecting and mineral testing.

Butler, G. M. *A pocket handbook of minerals.* 2nd ed., John Wiley & Sons, Inc., New York, 311 pp. $3. A book designed for use in the field or classroom; contains little reference to chemical tests. Gives physical characters needed to identify most of the minerals which students or collectors are apt to encounter.

Cox, H. S. *Prospecting for minerals.* 8th ed., J. B. Lippincott Co., Philadelphia, 1921, 260 pp. $2.50. Contains brief notes on geology, description of minerals, determinative tables; and a discussion of non-metallic minerals, ores, and fuels. Written in non-technical language, easily understood by beginners.

Dana, E. S. *Minerals and how to study them.* 2nd ed., John Wiley & Sons, Inc., New York, 1897, 380 pp. $2.

Dana, E. S. and Ford, W. E. *Dana's Manual of Mineralogy.* 13th ed., John Wiley & Sons., Inc., New York, 1912, 460 pp. $3. A book for the student of elementary mineralogy, the mining engineer, the geologist, the prospector, and the collector. Revised and rewritten by W. E. Ford.

1 "Printed by permission of the Director, U. S. Bureau of Mines. (Not subject to copyright.) from I. C. E 140, by Oliver Bowles.

2 Supervising engineer, building materials section, U. S. Bureau of Mines.

Foye, J. C. *Handbook of mineralogy.* 5th rev. ed., No. 86, Van Nostrand Science Series. D. Van Nostrand Co., Inc., New York. 75 cents. Covers determination, description, and classification of common minerals.

Gratacap, L. P. *A popular guide to mineral collections.* D. Van Nostrand Co., Inc., New York, 335 pp. $4. Prepared for the use of visitors to public cabinets of minerals, and for elementary teaching in mineralogy. (Illustrated.)

Loomis, F. B. *Field book of common rocks and minerals.* G. P. Putnam's Sons, New York, 1923. $3.50. Designed for the identification of rocks and minerals. Contains 47 colored plates and numerous illustrations from photographs.

McLeod, Alexander. *Practical instructions in the search for, and determination of the useful minerals, including the rare ores.* 2nd ed., John Wiley & Sons., Inc., New York, 254 pp. $2.50. Furnishes simple means for determination of minerals.

Merritt, W. H. *Field testing for gold and silver.* D. Van Nostrand Co., Inc., New York, 155 pp. $2.50. A practical manual for prospectors and miners.

Miller, W. G. and Parsons, A. L. *Minerals and how they occur.* Rev. ed., The Copp Clark Co., Ltd., Toronto, 1928, 255 pp. $1.25. An outdoor book to meet the needs of the general reader and prospector as well as those of students in the secondary schools. Describes rocks, fossils, crystals, and minerals in a very simple way.

Osborn, H. S. *Prospector's field-book and guide.* Revised by M. W. von Bernewitz. 10th ed., Henry Carey Baird & Co., Inc., New York, 364 pp. $3. Describes minerals and their occurrence with methods of testing. Contains useful tables and a glossary of terms.

Platt, William. *A popular geology.* The MacMillan Co., New York, 1924, 118 pp. $1. A very simple popular discussion of soils, rocks, fossils, and mountains.

Scott, W. B. *An introduction to geology.* 2nd ed., The MacMillan Co., New York, 1907, 816 pp. $4. A book intended to serve as an introduction to the science of geology, both for the future specialist, and for those who wish to gain a general knowledge of the science.

von Bernewitz, M. W. *Handbook for prospectors.* McGraw-Hill Book Co., Inc., New York, 319 pp. $3. A guidebook for prospectors, giving practical information on equipment, methods of procedure and mining laws. Contains brief reference to geology, mineralogy, and the occurrence, description, detection, and use of various minerals.

Standard Textbooks

The following are standard textbooks on geology and mineralogy:

Brush, G. J. *Manual of determinative mineralogy, with an introduction on blow-pipe analysis.* Revised and enlarged by S. L. Penfield. 16th ed., John Wiley & Sons, Inc., New York, 1909, 312 pp. $3.50. A standard textbook on mineralogy and blowpipe analysis.

Cahen, Edward, and Wootton, W. O. *Mineralogy of the rarer metals.* 2nd ed., J. P. Lippincott Co., Philadelphia, 1920, 246 pp., $6. Presents a discussion of all the rare metals, under such headings as detection, properties, metallurgy, industrial application, production, and value.

Dana, E. S. *A textbook of mineralogy, with an extended treatise on crystallography and physical mineralogy.* Revised and enlarged by W. E. Ford, 3rd ed., John Wiley & Sons, Inc., New York, 1922, 720 pp. $5. A comprehensive treatment of crystallography and mineralogy.

Eakle, A. S. *Mineral tables for the determination of minerals by their physical properties.* John Wiley & Sons, Inc., New York, 1922, 73 pp. $1.50.

Kemp, J. F. *Handbook of rocks for use without the microscope.* 5th rev. ed., D. Van Nostrand Co., New York, 283 pp. $3. A standard textbook and guide in the field classification of rocks; for students, mining men, and geologists. Contains a glossary of the names of rocks and other lithological terms.

Kraus, E. H., and Hunt, W. F. *Tables for the determination of minerals by means of their physical properties, occurrences and associates.* McGraw-Hill Book Co., Inc., New York, 1911, 254 pp. $2.50.

———————————. *Mineralogy.* 2nd ed., McGraw-Hill Book Co., New York, 1928, 604 pp. $5. A general mineralogy designed particularly for classes of beginning students. It has numerous illustrations, including photographs of minerals and crystals; also gives data on gems and precious stones and on uses of economic minerals.

Lewis J. Volney. *A manual of determinative mineralogy.* 3rd ed., John Wiley & Sons, Inc., New York, 1921, 298 pp. $3. A standard textbook containing tables for the determination of minerals by means of their physical properties, also by blowpipe and chemical tests.

Moses, A. J., and Parsons, C. L. *Elements of mineralogy, crytsallography and, blowpipe analysis from a practical standpoint.* 5th ed., D. Van Nostrand Co., New York, 1916, 631 pp. $4.50. A standard reference book including descriptions of minerals, their formation and occurrence, tests for their identification, and their economic importance and uses in the arts.

Phillips, A. H. *Mineralogy, an introduction to the theoretical and practical study of minerals.* The Macmillan Co., New York, 1912, 699 pp. $4.50. A standard textbook of mineralogy, in three parts: 1. Crystallography; 2. Descriptive Mineralogy; 3. Determinative Mineralogy.

Pirsson, L. V. and Knopf, Adolph. *Rocks and rock minerals.* 2nd ed., John Wiley & Sons, Inc., New York, 1926, 426 pp. $3.50. A standard textbook, with a particularly instructive table for determination of common rocks.

Rogers, A. F. *Introduction to the study of minerals and rocks.* McGraw-Hill Book Co., New York, 1921, 527 pp. $4. Covers the whole field of mineralogy, including crystallography, blowpipe analysis, and descriptive and determinative mineralogy; for use in the field or in the classroom.

Rutley, Frank. *Elements of mineralogy.* 19th ed., revised and enlarged. D. Van Nostrand Co., Inc., New York, $2.50. A general text covering all common minerals.

Warren, C. H. *A manual of determinative mineralogy.* McGraw-Hill Book Co., New York, 1922, 163 pp. $2. A book for use in general courses in mineralogy. Contains simple blowpipe tests and determinative tables. (Flexible, pocket size.)

Standard Economic Texts

The following books are standard texts on economic geology and mineralogy:

Emmons, W. H. *The principles of economic geology.* McGraw-Hill Book Co., Inc., New York, 1918, 612 pp. $5. The material relating to metallic ores and minerals is particularly valuable.

Ladoo, R. B. *Non-metallic Minerals.* McGraw-Hill Book Co., New York, 1925, 686 pp. $6. Covers the whole field of non-metallic minerals except fuels and hydrocarbons, emphasizing particularly the methods of mining and preparation, uses, markets, specifications, and tests.

Lindgren, Waldemar. *Mineral deposits.* 3rd ed., McGraw-Hill Book Co., Inc., New York, 1928, 1049 pp. $7. A leading treatise on economic geology.

Ries, Heinrich. *Economic geology.* 5th ed., John Wiley & Sons, Inc., New York, 843 pp. $5. Contains material relating to clays and other non-metallic minerals which is particularly valuable.

ECONOMIC GEOLOGY

Progress Report of Highway Materials Survey of Maine

By H. WALTER LEAVITT

and

DR. EDWARD H. PERKINS

Progress Report of Highway Materials Survey of Maine

By H. WALTER LEAVITT

Since the establishment of the Highway Materials Testing Laboraties at the University of Maine in 1914, there has been collected much information concerning the rocks, sands, and gravels of the State, in connection with the examination of samples submitted for analysis. However, because of the lack of uniformity in the methods of sampling and the general inadequacy of the data accompanying the samples as to the exact location, area, and volume of the deposit, and the omission of any information as to the glacial and geological character of the deposits, the information gained from this service of the Highway Materials Testing Laboratories is not a satisfactory basis for informing those interested concerning the resources of the State in these important highway materials. There is an urgent demand for such information today because of the extensive road and bridge building program of this state, with the resultant increased need for greater quantities of better quality material.

Accordingly, such a State Materials Survey was started on June 17, 1930 and is still in progress. The cooperating agencies behind this project are the Maine State Highway Commission; the University of Maine (Coe Research Fund); and the Maine Technology Experiment Station, Paul Cloke, Director. Valuable assistance and help has also been furnished by Mr. Joseph Conrad Twinem, State Geologist; Dr. Edward H. Perkins, Assistant State Geologist; Mr. M. R. Stackpole, District Engineer Water Resources Branch of the Maine Public Utilities Commission; and Professor James W. Goldthwait of the Department of Geology at Dartmouth and geologist for the New Hampshire State Highway Department.

This project is unique in that it is planned to be the most complete survey of its kind ever attempted by any state. New Hampshire has worked along similar lines and the New Hampshire Highway Reports for the years 1919-20, 1921-22, and 1925-26 give excerpts from progress reports of their work. Some of the mid-western states have also made gravel surveys, but so far as the authors have been able to learn the scope of the work has, in most cases, been limited to economic interests only. The Maine Survey will include both economic and geological data. The final report will be divided into two parts and published separately. Part I will deal with the economic aspects of the survey which are of immediate interest to engineers and contractors using the materials for building purposes; and Part II will describe the glacial geology of the State. Part I will supplement

Maine Technology Experiment Station Bulletin No. 6*, and will be edited by the writer of this report. Part II will supplement the report of Mr. Geo. H. Stone, "The Glacial Gravels of Maine and their Associated Deposits," U. S. Geological Survey, Vol. XXIV, (1899) and will be reported by Dr. Edward H. Perkins, Professor of Geology at Colby College, and consulting geologist of this survey. The method which Dr. Perkins plans to use follows later in this report and is entitled "Glacial Geology of the Buckfield Quadrangle."

The field work of this survey started June 17, 1930. During the first season's work the party consisted of Horace A. Pratt, Assistant Field Engineer; Joseph M. Trefethen, Assistant Field Geologist; Dr. Edward H. Perkins, Geologist; and H. Walter Leavitt, Director of the Survey. The second season's work employed the same crew with the addition of two new members, Mrs. Pratt and Mrs. Trefethen. The equipment consisted of one and one-half ton G. M. C. State Highway truck with canvas covered body, (See Fig. 1) tenting and camping outfit, sampling kits, etc.

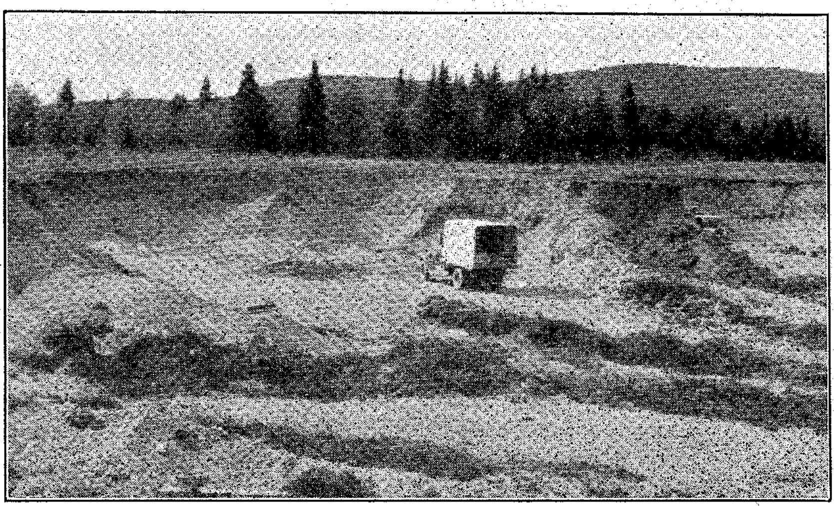


Fig. 1
The Covered Truck in a Gravel Pit

The method of attack consisted in first locating all deposits that had been opened. Information as to locality of existing deposits was obtained from local road men, maintenance patrol men, town road commissioners, and local inhabitants. Whenever and wherever these worked deposits were extensive enough to define the local conditions, no exploring was done. When few deposits were found, an

* *Results of Physical Tests on Maine Gravels, Rocks, and Sands.* Me. Tech. Expt. Sta. Bull. No. 6, pp. 45 and Map, by H. Walter Leavitt, June 1924.

endeavor was made to locate new deposits. The geologists were very helpful in this connection, in many cases their study of the topographic sheets leading to some important discoveries. After the location of a deposit, the whole crew began immediately to gather the required information. Fig. 2 and Fig. 3 below show the forms of data sheets used.

Maine State Materials Survey
Gravel

No. G. *936* Date *9-8,* 193 *1*
See S. *745* Party *Pratt & Pratt*
Town *Bluehill* Route No. *106*
Owner *Allen Fisk*
Type of Deposit *Delta*
Surface *Bushes*

% G— *20*	Overburden *1* ft.
Tot. Vol. *200,000* c. y.	Ave. Face *20* ft.
Grav. Vol. *40,000* c. y.	

Lithologic	Count	Shape %	
Aplite	*1*	Round	*2*
Diabase		Subangular	*41*
Diorite		Angular	*55*
Felsite	*4*	Flat	*2*
Gabbro		Wear Test	
Gneiss	*9*	Ap. Sp. Gr.	
Granite	*43*	Grading:	
Limestone		*Fine*	
Pegmatite			
Phyllite		Use:	
V. Quartz		*Tar by State*	
Quartzite	*7*		
" (Micac).	*21*	Remarks:	
Rotten	*4*	*Fisk lives in Ellsworth*	
Sandstone	*6*		
Schist		*Can go deeper*	
Shale			
Slate			
Trap	*5*		
Total			

Fig. 2

Maine State Materials Survey
Sand

No. S. *745* Date *9-8,* 193 *1*
See G. *936* Party *Pratt & Pratt*

Town *Bluehill* Route No. *106*
Owner *Allen Fisk*

Type of Deposit *Delta*
Surface *Bushes*
Overburden *1* ft.
Ave. Face *20* ft.
% S— *80*
Total Vol.— *200,000* c. y.
Sand Vol.— *160,000* c. y.
Grading: *Coarse*

Use: *Tar*

Remarks: *See G-936*

Fig. 3

A nestable set of sieves was used to screen the proper sizes for the test samples. The location data was recorded, together with such charactertistics as character of top of pit, amount of overburden, average face, etc. The geologists classified the deposits as to glacial origin, etc. A lithological count was made upon 100 gravel pebbles, selected at random and recorded on the gravel data sheet. A rough estimate was also made of the volume of the deposits and the respective percentages of sand and gravel. The location of the deposit was marked on topographic sheets by the method shown in Fig. 4.

Whenever possible, as in the case of Figure 4, the U. S. Topographic sheets are used for basic maps in the survey, all the survey data being indicated in red. The Maine State Highway Commission's system of numbered routes are also indicated in red. The numbers of the samples are located in the margin of the map as "S-271" for sand sample No. 271 and "G-218" for gravel sample No. 218. The position of the deposit is marked by a red dot. Some deposits were located but not sampled. These are indicated by small red dots such as the one located in the lower left hand portion of the top half of the quadrangle near sample G-302. Portions of two eskers are shown by long discontinuous red lines running diagonally across the maps. Such deposits locally known as "horsebacks" or "whalebacks" are good sources of sand and gravel. It will be noted that several samples were taken from these two esker systems.

This particular section of the State is quite well supplied with both sand and gravel deposits. Many portions of the State, however, are not so well blessed and in those portions the data of this survey will be very valuable. Of course, most all the deposits shown are of good and acceptable quality. One interested in the physical characteristic of any deposit must refer to the record of tests performed upon the sample taken for that deposit. In this way, not only the good and bad materials may be located, but in sections where there are many deposits, one may choose that deposit which gives the best test results for the particular use to which the material may be put.

The area of the State to be surveyed is shown in Fig. 5. This cut also shows the areas covered in the first two season's work. In 1930, 3,694 square miles were surveyed and a total of 670 samples were taken for test. In 1931, an area of 6,739 square miles were surveyed, and 1,264 samples were taken. Improved technique and the two additional members of the survey party made possible this marked increase over the first season's work. There is left for the season of 1932, 7,639 square miles to complete the survey. It is expected that it will be necessary to gather 1100 or 1200 samples to complete the project.

No small portion of the work involved in this survey is the testing of the samples collected by the field party. These samples are trucked to the Highway Materials Testing laboratories in Wingate Hall at the University of Maine. Here they are being tested by the regular laboratory force consisting of Mr. Leo Day, Mr. Clayton Sawyer and Mr. R. L. Annis. Mr. Pratt has also devoted much time to the testing work, as well as to the final mapping and drafting work.

The gravel samples are given a severe wear test during which eleven barrels of the material of four sizes are rotated in a steel drum for 10,000 revolutions. The time required for each wear test is five hours. Four samples are run at the same time, and the machines are equipped with an electric stop-clock so that an extra run can be made at night. Other testing upon gravel is performed as indicated in the outline of gravel tests which follows:

Sample No.
Town
Owner
Date Tested
Specific Gravity

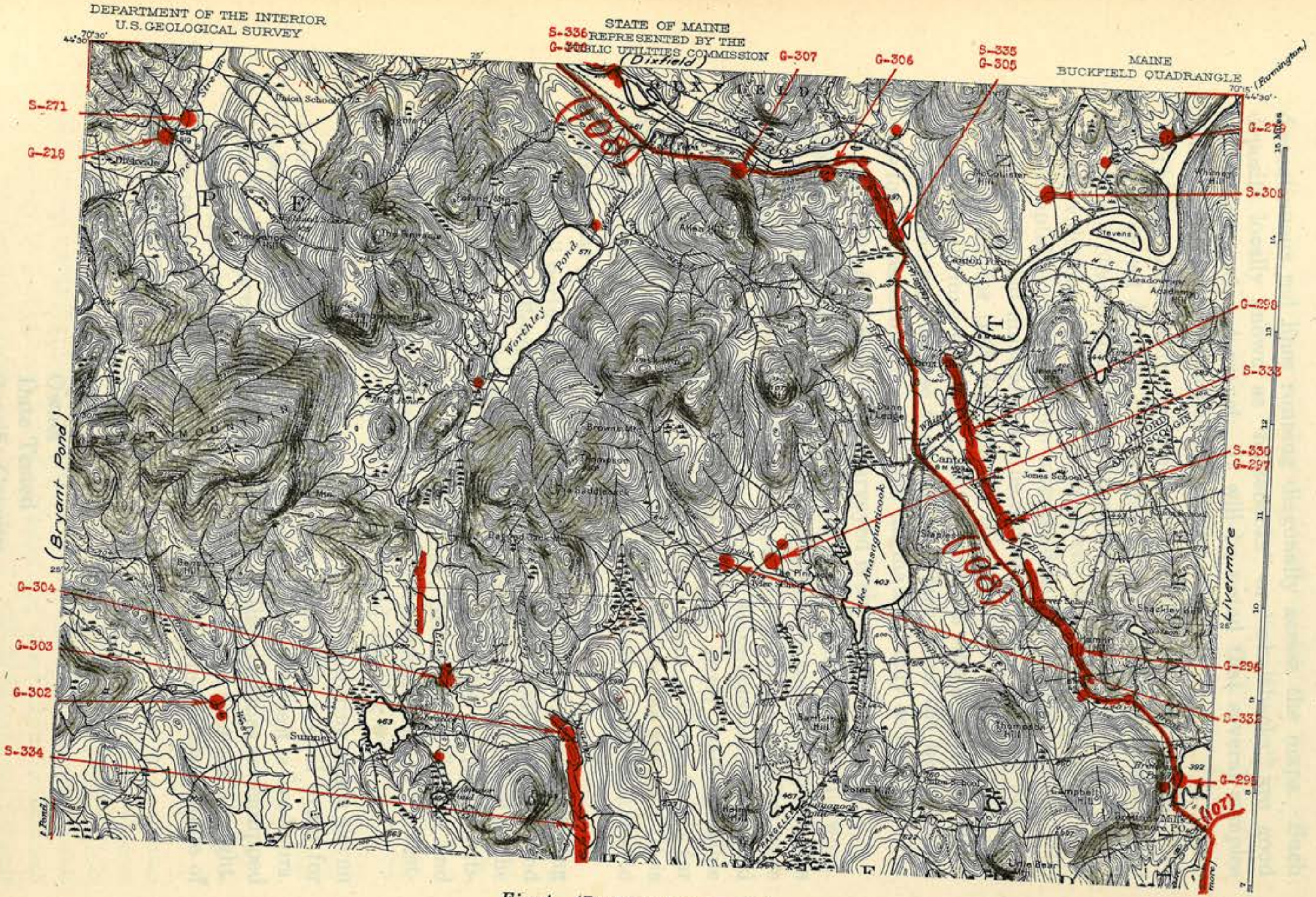


Fig. 4 (*Buckfield Quadrangle*)

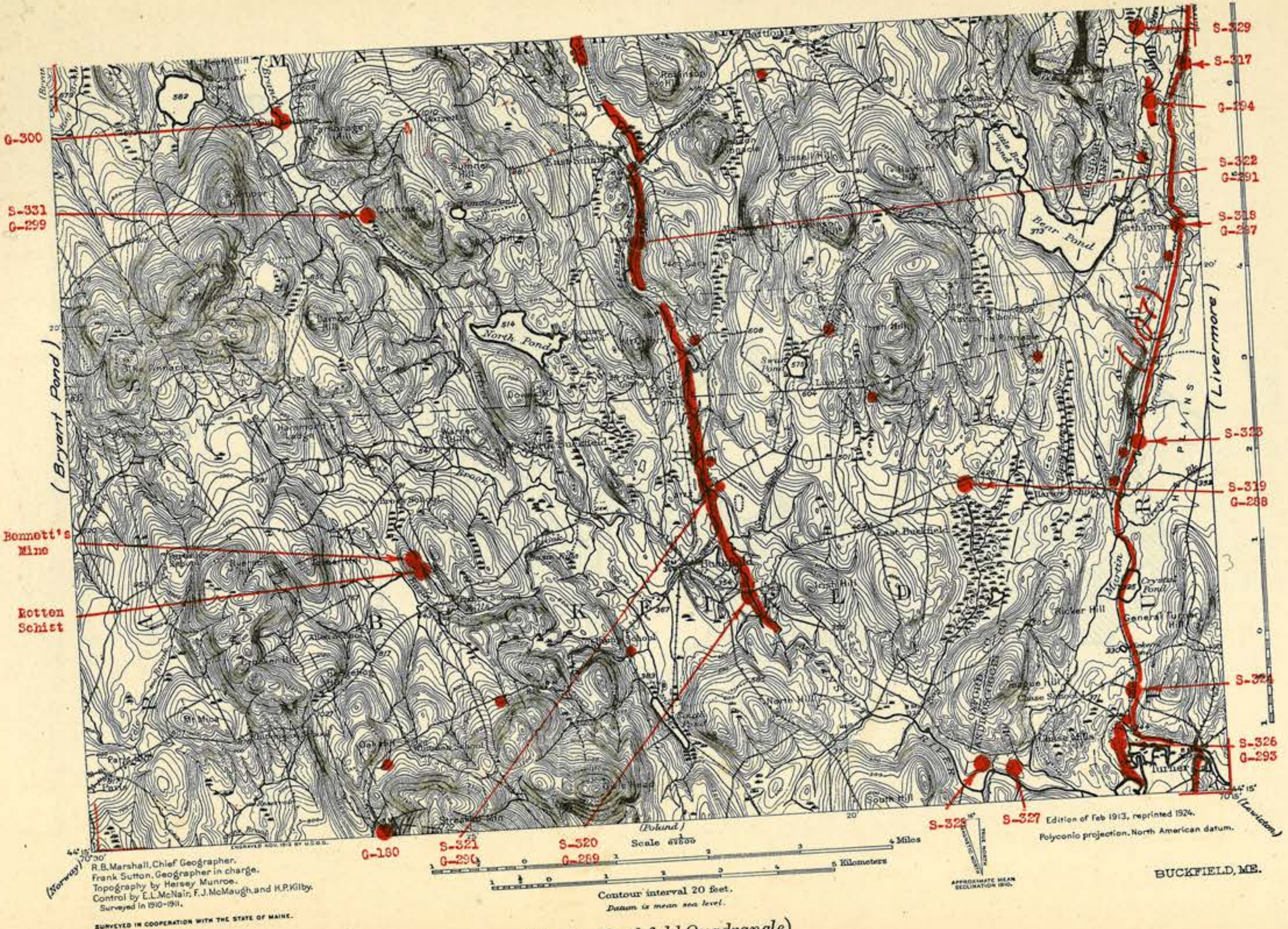
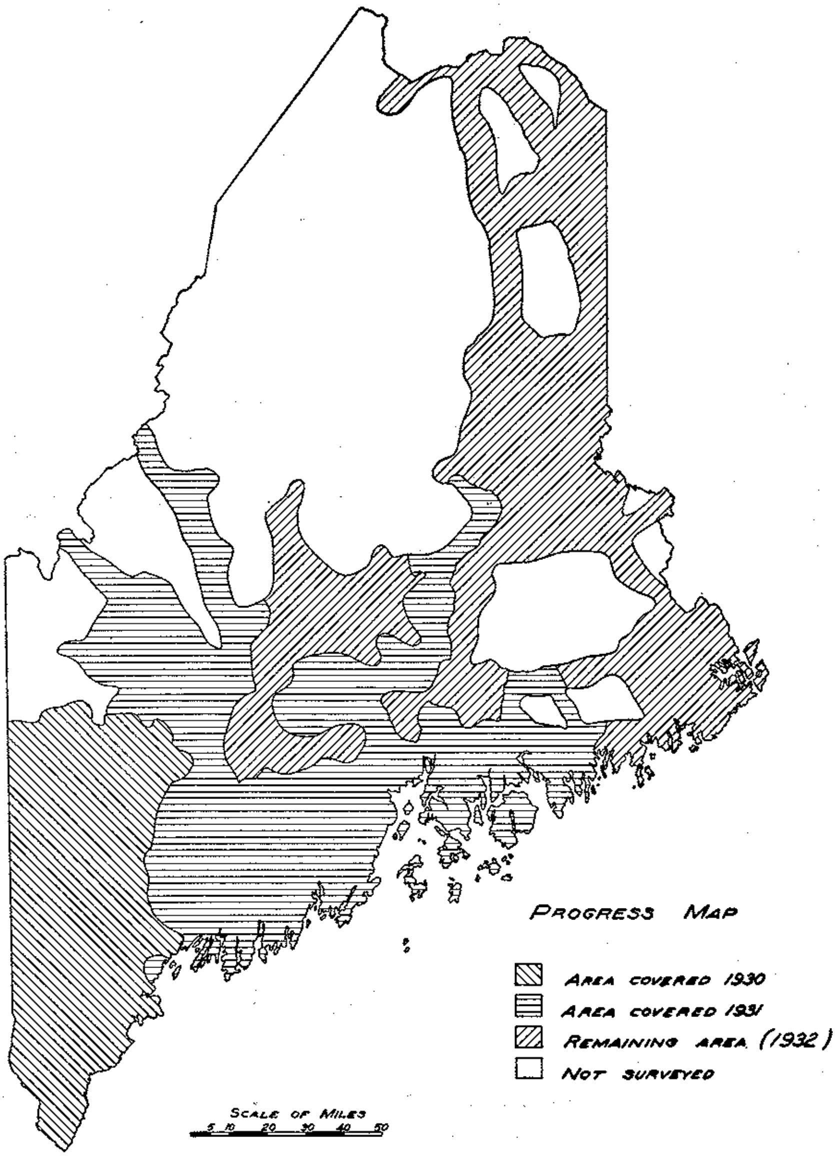


Fig. 4 (Buckfield Quadrangle)



PROGRESS MAP
AREA COVERED 1930
AREA COVERED 1931
REMAINING AREA (1932)
NOT SURVEYED
SCALE OF MILES
5 10 20 30 40 50

Fig. 5

Wear Test, % Loss
Shape
Lithological Count
Type of Deposit
Volume in Cubic Yards
% Gravel in Pit
Surface
Overburden (in ft.)
Average face (in ft.)
Grading
Used for
Remarks

The sand samples are tested also in the Highway laboratories. Briefly, the sand is mixed with a standard portland cement and tested in tension and compression at the ages of seven and twenty-eight days. Twelve test specimens are made from each sample of sand. The grading of the sand is also determined, as well as the colorimetric test for organic impurities and other tests as outlined in specimen of sand data sheet as follows:

Sand No. S.
Town
Owner
Date Mixed
Color
% Water
Flow
% Granitic
Mechanical Analysis
Tensile Strength (7 and 28 day)
Compressive Strength (7 and 28 day)
Volume in Cu. Yds.
Specific Gravity
Surface Area
Surface
Overburden (in ft.)
Average Face (in ft.)
Type of Deposit
Used for
Remarks

The rock samples are also given a wear test somewhat similar to that of the gravel samples. A specimen of the rock data follows:

Sample No.
Town

Owner
Date Tested
Specific Gravity
Wear Test, % Loss
French Coef. of Wear
Type of Rock
Remarks

The report will be published in two volumes as previously indicated. Volume I will give the data of immediate concern to the engineering and commercial interests. There will be over two hundred pages of maps similar to Fig. 4. In addition there will be data test reports on at least 3,000 samples.

The issuing of this report at this time is for the purpose of acquainting the people of the state with the scope of the project with the hope that some constructive criticisms may result. It is the desire of all of the members of the survey to make this work as useful as possible. With this end in view, they sincerely hope that those who read these pages will send in their criticisms and suggestions of both the economic and geologic phases of this work so that the final report may be more valuable to all concerned. All suggestions should be addressed to the author at the University of Maine, Orono, Maine.

Glacial Geology of the Buckfield Quadrangle*

By

DR. EDWARD H. PERKINS

Physiography

The topography of the Buckfield Quadrangle* consists of rolling hills separated by valleys tending in a general northwest-southeast direction. The chief valley is that of the Androscoggin River crossing the northern part of the quadrangle. The highest elevation is in the northwestern part of the quadrangle, where one of the peaks of Black Mountain reaches the height of 2,200 feet. The lowest point is Turner village, which is at an elevation of a little less than 300 feet.

This topography is the result of a long period of erosion punctuated by intermittent uplift and ending in the events of the glacial period.

Early in Tertiary time a great plain extended over this part of Maine, dotted here and there by isolated hills of resistant material. Rivers flowed over this plain to the sea to the southeast. This plain was elevated and the rivers revived, cutting valleys in the weaker beds of rock. These valleys were widened until broad valley floors were formed. Uplift occurred once more, and again the rivers cut down making valley floors and plains inside the older ones. This process was repeated several times until just before the ice age, the country reached very nearly the present topography. The plains which had been formed at the various levels are recorded by accordant hill tops and rock-carved terraces along the valley sides.

The drainage just before the glacial period followed the present valleys, but the major streams were different than now. The Androscoggin River in the upper part of its course probably flowed westward into the Connecticut River.[1]. Its present valley was occupied by a stream flowing eastward to the neighborhood of Canton where it was joined by a stream from the north. Below the junction the stream flowed southeastward to join a major stream which flowed southward from northwestern Maine to Casco Bay.

The coming of the continental glacier buried the region in ice covering even the highest peaks. As the ice advanced it scoured over the hills, rounded off the sharp crests and leaving the subdued topography of today. At weak places in the ridges the ice eroded deep U-shaped valleys parallel to the direction of ice movement. Examples of these valleys are the notch between Tumbledown Dick Mountain and Black

* Note: This paper illustrates the method of geological discussion of Vol. II of Highway Materials Survey of Maine.

* See Fig. 4 of accompanying *Progress Report of Highway Materials Survey of Maine*, by H. Walter Leavitt.

1 Former Courses of the Androscoggin River. Irvine B. Crosby. Jour. of Geol., 30, 232-247, 1922.

Mountain, and the valley of the West Branch of the Nezinscot River between North Buckfield and North Sumner.

The melting of the ice left the valleys filled with gravel and sand deposits of various types and the rivers from the melting ice were forced to find their courses over these deposits. The result was that the surface of the glacial deposits, rather than the bed rock topography determined the courses of the streams. The present drainage is therefore out of adjustment with the old topography. In places, where the valleys were dammed or ice blocks melted, lakes and swamps were formed; and where streams were forced over ledges, waterfalls developed. In fact, most of the beauty of the Maine scenery and the economic value of the streams is the direct result of the great ice ago.

Bed Rock

The bed rock of the Buckfield Quadrangle consists of two types: metamorphosed sediments, and igneous rocks.

The metamorphosed sediments represent muds, sands, and limestone laid down in a sea which covered the eastern part of North America. These sediments were a product of weathering and erosion on the old land of Nova Scotia to the east of the present coast line. Streams carried this material westward to the sea and spread it in beds over the sea floor. The beds gradually became cemented and compacted into rock; the sands becoming sandstones, the muds becoming shales, and the limey material limestones. Later intrusions of igneous materials and folding of the earth's crust recrystallized the rocks. Mica and other foliated minerals developed and the rocks became the highly crumpled and foliated gneisses and schists of today.

The igneous rocks were intruded into the sediments as magma or very hot rock solutions. Some of this material may have reached the surface as lava flows from volcanoes. In the Buckfield quadrangle all such surface material has been removed by erosion, but to the west in the White Mountains such volcanic rocks are found. The magma below the surface cooled slowly forming masses of crystalline granite. The granite masses were probably intruded at different times as some of the masses have been altered into foliated gneisses showing that they were intruded before the mountain folding movements. Other masses show no signs of compression and cut the older foliated granites and therefore represent a period of intrusion later than the youngest orogenic movement.

Closely associated with the granites are the pegmatite intrusions. These were formed by the intrusion of very active rock fluids which replaced the intruded sediments forming the great bodies of feldspar, quartz, and mica which are of such economic value to the state. In many cases the first pegmatite intrusions were followed by later fluids which deposited the rare minerals as tourmaline, beryl, pollucite, apatite, etc., which have made the Maine pegmatites famous among mineral collectors. Such intrusions which are especially well known are the pegmatite bodies at Mt. Mica in Paris, Bennett's (Mine) Quarry in Buckfield, and Ragged Jack Mountain in Hartford.

The age of the bed rock of the Buckfield quadrangle has never been determined. No fossils have been found and on account of the intense metamorphism of the rocks it is doubtful if any will be. Judging from the evidence in other parts of New England and Canada the sediments are Precambrian or Paleozoic while the granite and pegmatite intrusions were intruded in Precambrian times or during the Devonian and Permian periods of the Paleozoic era. Probably there are representatives of all these ages.

Glacial Geology

The deposits of the glacial period are of great value especially for road work and hence were carefully mapped by the Road Materials Survey.

As the ice melted away the first exposed surface consisted of the hill tops which rose through the ice as nunataks. As the melting continued the exposed surface became greater until ice tongues were left along the valley. These tongues receded northward and westward until the land was clear of ice. The retreat of the ice was followed by the advance of the sea which filled the valleys of Turner and Buckfield in the southern part of the quadrangle and extended up the Androscoggin valley across Canton and Dixfield.

The glacial deposits are of two types; till, material deposited by ice alone, and wash, material deposited by the combined action of ice and water.

Till consists of coarse and fine material mixed with none of the stratification or sorting characteristic of water work. Over the hill tops and higher lands it is very thin and sometimes entirely absent. Locally in the valleys where it accumulated about the sides or end of the ice tongue it may be very thick.[2] These deposits are common in most of the valleys of the Buckfield quadrangle. As a source of road material they are useful only as fill.

Wash deposits are composed of eroded material from the glacier worked over and deposited by water. These deposits have been washed and sorted and are deposited as beds or strata. On account of their method of formation they are far more valuable for highway material than till. The chief faults are the variability of composition due in part to the material furnished by the ice and in part to the great fluctuations in the melt-water streams.

2 In western Maine these till deposits are known as "marl." Geologically, this use of the word is incorrect as true marl is a fine grained earthy limestone usually formed in fresh water.

As the ice receded from the quadrangle during the later stages of melt the front receded northward. The first valley floor to be uncovered was the lowland about Turner Village. At this point the ice broke into two tongues, one extending up the Turner Plains toward Brettun's Mills and the other up the valley of the Nezinscot toward Buckfield. As the front of this western valley glacier receded gravels were deposited between the valley walls and the ice. These appear today as Kame terraces on the valley sides between Turner and Buckfield and were composed of well stratified material which should be excellent although limited sources of gravel. From the receding ice front sand and fine gravel was washed into the sea which followed the ice up the valley and was deposited as a sand plain. As this plain was built to water level an upper layer of coarse material was laid over the sand forming the present surface of the plain. Thus a plain of this time is likely to yield gravel only in a thin wide spread surface layer.

At Buckfield the Nezinscot ice tongue in turn split into two, one receding up each branch of the stream. The West Branch glacier as it melted back deposited terraces along its sides, while along the center of the valley, a sub-glacial stream deposited gravels, forming an esker which may be traced from North Buckfield to West Sumner. An isolated mass of ice was protected from the sun on the north side of Down's Hill and lingered until the main ice had receded up the valley. The water from this isolated block formed a group of gravel Kames between Down's Hill and Mount Oxford which should be a source of good gravel. North Pond is a kettle hole where the last residue of this ice mass melted. The ice continued receding up the West Branch of the Nezinscot forming terraces along its sides but the esker formed along the valley floor has been buried. The last stand of this ice was in the valley heads of Black Mountain from which the last of the melt water washed the sand plains of Sumner.

The ice tongue filling the valley of the East Branch of the Nezinscot was larger as the extensive and well developed gravel deposits testify. Kame terraces at several levels are found along the valley walls especially east of Mt. Oxford, at East Sumner, and along the eastern side and to the south of Fields Hill. Along the valley floor a discontinuous esker was formed which may be traced all the way from Buckfield to Worthley Pond in Peru. Both the kame terraces and the esker should furnish good supplies of gravel.

The valley of the West Branch of the Nezinscot opens out into the valley of the Androscoggin River at East Peru. Only a gravel dam forms the divide between Worthley Pond and the West Branch and only glacial material forms the divide between the East Branch and West Branch in Sumner. Before the glacial period a stream of some size probably flowed southward through Dixfield and down the valley of the East and West Branch of the Nezinscot to Turner. Why did not the postglacial Androscoggin follow this valley instead of taking its roundabout course through Jay? The answer probably is that the ice lingered in the mountain-surrounded valley of Worthley Pond until the Androscoggin's course had been determined. The basin of Worthley Pond is a kettle hole formed by the melting of the last of this ice.

The large ice tongue which filled the valley of Martin Stream and covered the Turner sand plains repeated the history of the other two tongues. It receded northward up Martin Stream building terraces against its sides and an esker on the valley floor. Its wash into the sea which followed it formed the Turner Sand plains beneath which all but the highest parts of the esker is buried.

At Brettun's Mills the ice was broken into a series of isolated blocks about which gravels were deposited. On the melting of the ice a reticulated kame system was left with Brettun's Pond filling the largest depression.

Between Brettun's Mills and the Androscoggin at Gilbertville is one of the largest eskers of the region. It was deposited by a large stream flowing in the ice from the present valley of the Androscoggin southeastward through Canton.

The question arises once more as it did in Peru, why did not the Androscoggin River flow southeastward through Canton instead of swinging northward to Jay? The reason is probably that the valley now occupied by Leavitt Brook was checked by the esker gravels. The water backed up until it formed a lower path to the north.

As the glacier receded up the Androscoggin valley it spread a wash plain over the valley floor between the kame terraces. Most of this material was sand but here and there are coarser bands of gravel representing the old stream channels.

During the post-glacial uplifts the Androscoggin carved the flood plain into a series of terraces at lower levels than the original kame terraces. In places these terraces have been worked for gravel but usually they are too sandy to yield suitable materials.

GENERAL GEOLOGY

Elevation and Geological Formation of Maine Mountains

By

EDWARD H. PERKINS

Elevation and Geological Formation of Maine Mountains

By EDWARD H. PERKINS

The elevations are mostly from the maps of the United States Geological Survey. Where not otherwise indicated the compiler is responsible for the geological formation. Letters indicate authorities as follows: AK, Arthur Keith, U. S. Geological Survey; FK, the late F. J. Katz, U. S. Geological Survey; P, the late L. V. Pirsson, of Yale University; and ES, Edward S. C. Smith, of Union College.

Mountain	*Township*	*Elevation*	*Geological Formation*
Abraham	Mount Abraham	3765	Granite gneiss
Agamenticus	York	692	Alkalie granite
Apatite	Auburn	480	Pegmatite-Schist
Attean	Attean	2441	Granite (AK)
Bald	Dedham	1261	Porphyritic granite
Bald, Boundary	Sandy Bay	——	Slate (AK)
Bald, Moxie	Bald Mountain	2630	Porphyritic granite
Bannock	Industry	1230	Quartzite
Battie	Camden	800	Quartzite Conglomerate
Bauneg Beg	North Berwick	840	Schist (FK)
Bear	Riley	3120	Gneissic granite
Bigelow	Dead River	4150	Injection gneiss
Black	Rumford	2355	Granite, Pegmatite
Blue	Avon	3187	Quartzite
Blue Hill	Blue Hill	940	Quartz schist
Blue Ridge	Taunton and Raymond	1877	Rhyolite
Boarstone	Elliottsville	——	Quartzite
Burnt Jacket	Attean	2084	Granite (AK)
Cadillac (Green)	Acadia Nat. Park	1532	Hornblende granite
Carr Pond	West of Portage	——	Micaceous Quartzite
Champlain (Newport)	Acadia Nat. Park	1060	Hornblende granite
Chase	Mount Chase	——	Greenstone schist (AK)
Coburn	Upper Enchanted	3718	Rhyolite
Crocker Town	Crocker Town	4168	Gneissic granite
Daisey Mount.	T 3 R 7	——	Diabase
Depot	T 14 R 6	——	Quartzite
De Boullie	T 15 R 9	——	Biotite granite
Double-top	3 R 10	——	Granite (ES)
Flying Squadron (Dry)	Acadia Nat. Park.	1260	Hornblende granite

Frye	Montville	1130	Muscovite schist
Green (Somerset)	T 4 R 18	——	Sandstone
Griffin	New Vineyard	2109	Quartzite
Hardwood	T 9 R 18	——	Micaceous Quartzite
Harris	Dixmont	1233	Micaceous Quartzite
Haskell	Jefferson	493	Mica Schist
Hedgehog	15 R 6	1594	Rhyolite
Hogback	Montville	1115	Muscovite schist
Katahdin	3 R 9	5267	Granite
Kennebago, W.	4 R 4	——	Rhyolite (ES, AK)
Kineo	Kineo	1806	Rhyolite
Lawler	T 2 R 6	——	Quartzite
Levenseller	Searsmont	1020	Micaceous Quartzite
Little Kineo	Day's Academy	1931	Rhyolite
Lobster	Middlesex Canal	——	Volcanic Agglomerate (ES)
Megunticook	Camden	1280	Quartzite
Mars Hill	Mars Hill	——	Conglomerate
Mosquito	The Forks	2230	Granite
Moxie	Spaulding	2925	Diorite (ES)
Norway Bluff	T 9 R 9	——	Trachyte
Old Bluff	Concord	1180	Pyritiferous slate
Old Spec	Grafton	4250	Granite, Pegmatite, Gneiss
Ore Mountain	Katahdin Iron Works	——	Conglomerate
Parlin	Parlin Pond	2430	Diorite (P)
Passadumkeag	Grand Falls	1200	Diorite
Peaked	Clifton	1140	Porphyritic granite
Pemetic	Acadia Nat. Park	1262	Hornblende granite
Philip	Rome	730	Granite
Pickard	Dixmont	1221	Micaceous Quartzite
Pleasant Pond	Spaulding	2480	Andalusite schist
Plumbago	Newry	2420	Schist, Pegmatite
Priestly	West of Fish River lakes	——	Micaceous Quartzite
Pogy	4 R 9	——	Rhyolite (ES)
Ragged	Indian, No. 4	——	Quartzite
Ragged Jack	Peru	1520	Granite, Pegmatite
Round	T 11 R 8	——	Rhyolite
Russell	T 5 R 16	——	Quartzite
Sabattus	Wales	802	Quartz schist
Saddleback	Sandy River	4098	Porphyritic Granite
Sally	Attain	2221	Granite (AK)
Sargent	Acadia Nat. Park	1344	Hornblende granite

Schoodic	Winter Harbor	437	Diorite
Shaw	Day's Academy	1664	Rhyolite
Sonbunge		——	Rhyolite (ES)
Spencer, Big	X	——	Rhyolite (AK, ES)
Spencer, Little	Middlesex Canal	——	Granite (AK)
Spruce	Woodstock	2120	Gneiss, Pegmatite
Squaw	Big Squaw Mountain	——	Injection gneiss, schist, syenite, granite
Squa Pan	T 11 R 4	——	Trachyte
Sugarloaf	Crocker Town	4237	Gneissic granite
Traveler	5 R 9	——	Rhyolite (ES)
Three Brooks	T 15 R 6	——	Tuff
Tumbledown	No. 6	3035	Injection gneiss
Vienna	Vienna	1200	Biotite granite
Waldo	Frankfort	1062	Granite
Kennebago, W.	4 R 4	——	Rhyolite (ES, AK)
Whitecap	Rumford	2197	Granite, Pegmatite

The following are the largest mountains in order of their elevations:

Katahdin	5267 feet
Old Spec	4250 feet
Sugarloaf	4237 feet
Crockertown	4168 feet
Bigelow	4150 feet
Saddleback	4098 feet

PALEONTOLOGY

Oldhamia in Maine

By

EDWARD S. C. SMITH

Oldhamia in Maine

By

EDWARD S. C. SMITH

The genus Oldhamia (Murchisonites) was set up by Edward Forbes in 1848 to peculiar, radially arranged fronds which to him were suggestive of some sort of bryozoan. These forms appeared in greenish arenaceous and purplish argillaceous slates of lower Cambrian age at Bray Head, County Wicklow, Ireland. In 1859, J. R. Kinahan gave added descriptions and figures of specimens from this locality. Later J. W. Slater and others gave these problematic forms some attention, and referred them to the algae.

In 1895 C. D. Walcott wrote a short paper mentioning the discovery of Oldhamia in the Cambrian rocks of Farnham Province of Quebec, and Rensselaer County, New York. By this time the European paleontologists had established two species, Oldhamia antiquia and O. radiata, but Walcott described the New York specimens as Oldhamia (Murchisonites) occidens sp. nv. Those from Quebec were not named as, according to Walcott, they were too poorly preserved for exact identification. In 1900 G. F. Matthew described Oldhamia from Caton's Island, in the "Long Reach" of the St. John River a few miles above St. John, New Brunswick, and B. F. Howell has reported Oldhamia from the purple of lower Cambrian slates of Weymouth, Mass.

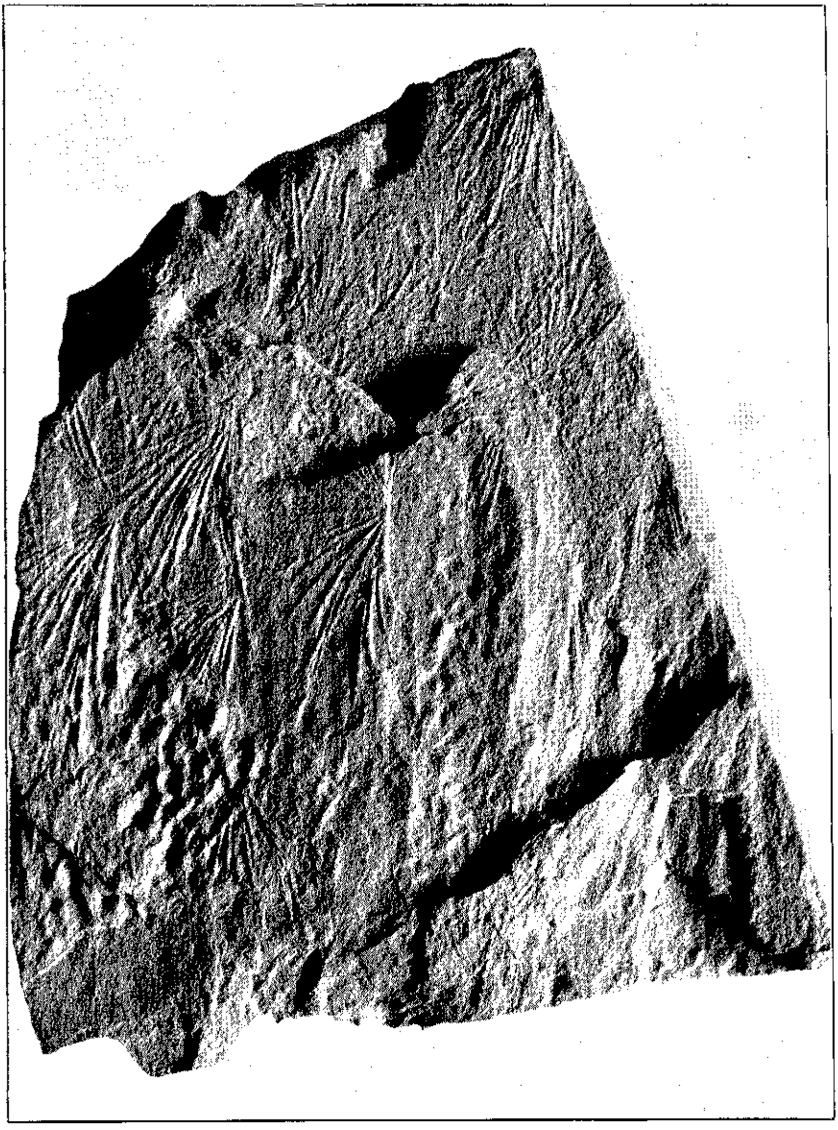
In the summer of 1927, during the course of an investigation of the rhyolite of the Traveller Mountains, a thick series of green sandstones and slates just east of the mountains became the object of examination by the writer. This series is well exposed along the course of the East Branch of the Penobscot River in Township 5, Range 8, Penobscot County and at several localities between the "Grand Pitch" and the "Hulling Machine" falls occur the beds bearing *Oldhamia* (*Murchisonites*) *occidens*. The specimens in the best state of preservation are from the purplish red slates although good ones are found in the greyish green sandy beds and fair ones in the reddish sandy beds. These localities were visited the following field season by the writer in company with Dr. Howell who considers them the most notable occurrences of this fossil at present known, both as to quantity of productive beds and splendid state of preservation, being equaled perhaps as to quality only by the Nassau, N. Y. locality mentioned below.

The Maine organisms are found as branching clusters of a dozen or so stems or tubes at the bases of which may often be seen a bulbous enlargement. The stems or tubes average from one to two centimeters in length and are about 0.25 millimeters in thickness, many of which appear to be segmented. They are usually to be found as casts on the one surface with corresponding depressions on the other. Recently, (1929) Dr. Rudolf Ruedemann, State Paleontologist of the New York State Museum, has described a new locality for *Oldhamia occidens* at Nassau, N. Y., discovered by him while mapping the geology of the Capital District, N. Y. In addition to bulbous bases on the stems he cites several other hitherto undescribed structures all suggestive of a calcareous alga.

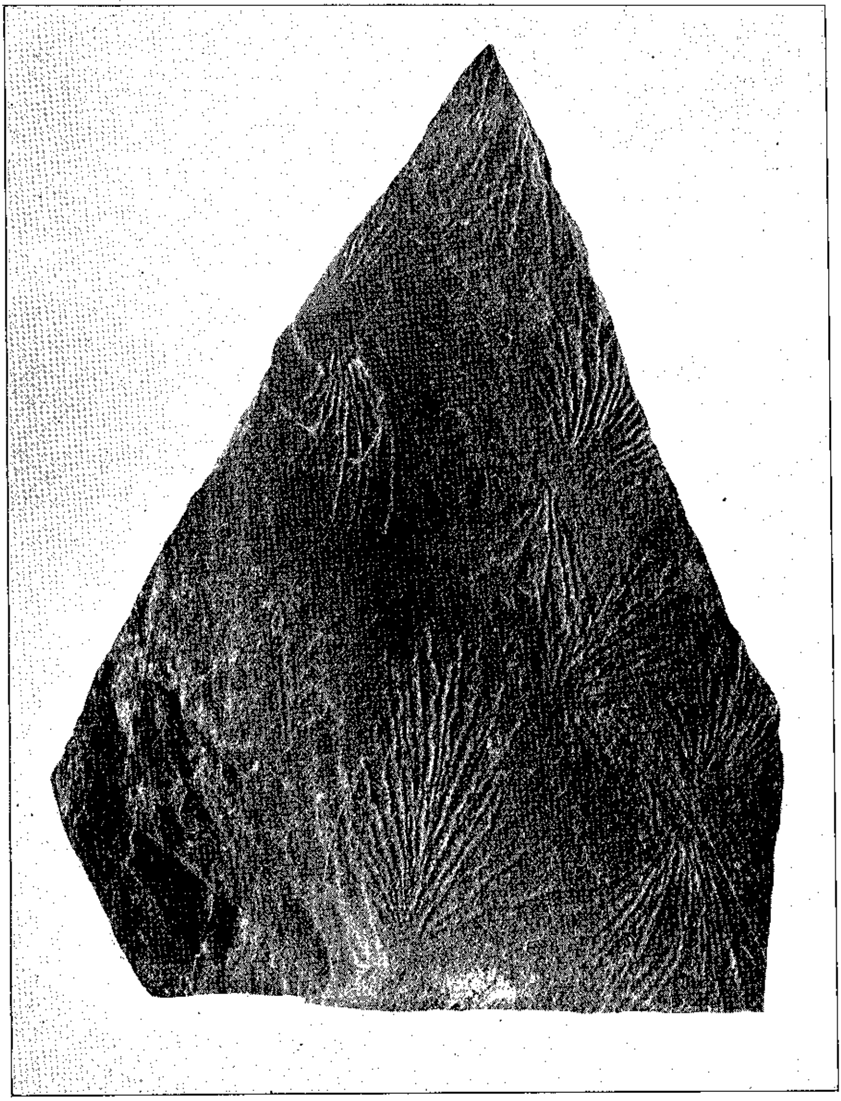
So far as the writer is aware the Maine *Oldhamia* are the first Cambrian fossils which have been found within the boundaries of this state although on stratigraphic grounds certain formations in the Penobscot Bay and Rockland areas have been assigned to the Cambrian by members of the U. S. Geological Survey. While working in Aroostook County many years ago the late H. S. Williams suspected certain slates to be of Cambrian age but stated that "Positive evidence of the age is wanting." More recently C. W. Brown has urged the correlation of "the fine-grained, even-bedded, Purplish, quartzose flagstones" of North Haven, Mount Desert and elsewhere on the Maine coast with the Cambrian of Nahant and Braintree, Mass.

To the writer the significance of the discovery of *Oldhamia occidens* in Maine lies in the fact that it furnishes definite evidence of the existence of a Lower Cambrian seaway in central Maine. The similarity amounting almost to identity of the Irish sediments with those of Maine and New York suggests that this Lower Cambrian seaway was continuous through the regions mentioned.

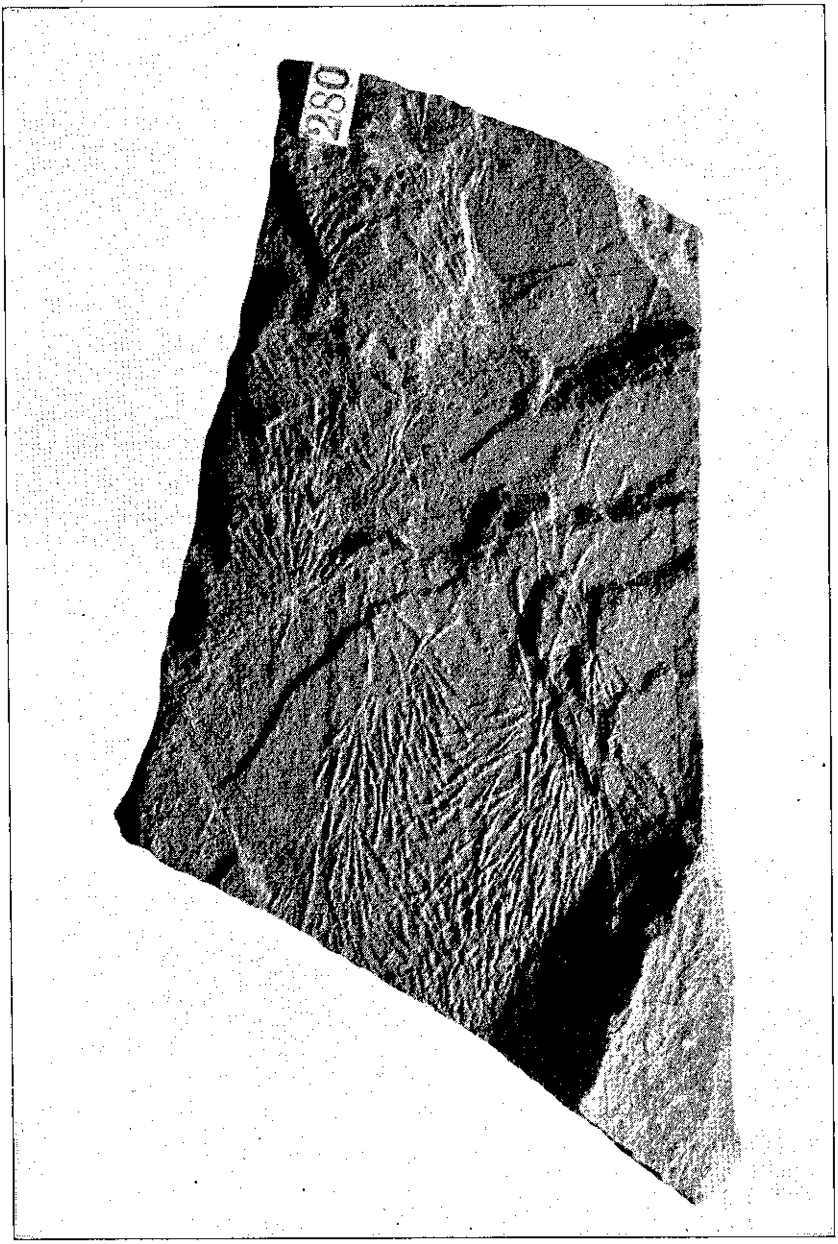
Although not nearer than several miles the known Devonian (Moose River) sandstones exposed farther up the East Branch appear on structural grounds to be separated from the Lower Cambrian either by a fault or a profound unconformity. If the Lower Cambrian has been fauled down into its present position, it is possible that it is the only occurrence, but perhaps there may be other fortunately located areas which will be discovered in the future.



Oldhamia occidens. from grey arenaceous slate
T. 5, R. 8, Penobscot County, Maine



Red slate with specimens of Oldhamia occidens,
T. 5, R. 8, Penobscot County, Maine



Oldhamia antiqua, from the green arenaceous slates of Bray Head, County Wicklow, Ireland

New Fossil Localities in Maine

By

EDWARD H. PERKINS

New Fossil Localities in Maine

By

EDWARD H. PERKINS

I. Grindstone

A new locality for the "worm trails" known as *Nereites* has been found just below Grindstone on the East Branch of the Penobscot River. A Forestry Camp Site is located at this point on Route 211 about half way between Stacyville and Medway. The Penobscot River flows over ledges, which outcrop at the camp site. The rocks are dark blue limy slates interbedded with coarser more sandy beds sprinkled with minute pyrite crubs. The beds strike N2OE and dip 80-85° NW.

When the place was visited by the author in company with Doctor L. H. Merrill, then State Geologist, the resemblance of the beds to those in Waterville where *Nereites* is found was noted. After half an hour hunt two specimens of the trails were found. These were typical and closely resembled those found at Waterville.

The Waterville trails have been found associated with Silurian graptolites (1) and so the new find places the Grindstone beds in that period.

II. Houlton

In the construction of a new hotel in Houlton, a ledge was uncovered in the center of the town. This was examined by Roy A. Bither, of Ricker Junior College, who found a slab containing two graptoliths. These were submitted to Doctor Rudolf Ruedemann who identified the fossils and submitted the following notes which he has permitted us to use.

"A slab of black slate sent by Prof. Edward H. Perkins and collected by one of his students at Houlton, Maine contains fragmentary graptolites, *viz.*

Climacograptus cf. hughesi Nicholson and

Rastrites cf. peregrinus Barrande

The rock is strongly compressed and the graptolites therefore distorted and unfit for positive identification. Nevertheless there is little doubt that they represent two species, in both the form of the thecae and the dimensions. *Climacograptus hughesi* ranges in Great

1 A New Graptolite Locality in Central Maine, Edward H. Perkins, with Notes on the Graptolites, by Rudolf Ruedemann. Am. Jour. Sci., 5th ser., 8, 223-227. 1924.

Britain through zones 16-21, or nearly all of the Birkhill (Llandovery), *Rastrites peregriuns* only through upper 19 and 20 and occurs doubtfully in zone 21. It is therefore a fair conclusion that the slate containing these two graptolites belong: either to upper zone 19 or 20. As *R. peregrinus* is most common in zone 20, it is probable that zone 20 is represented in the slab from Maine. That is the zone of *Monograptus convolutus* (upper most Middle Birkhill and lower Upper Birkhill.")

STRUCTURAL GEOLOGY

The Hallowell Intrusives

By

HORACE TRUE TREFETHEN

Table of Contents

The Hallowell Intrusives

Introduction

The district in which the Hallowell Granite occurs is roughly about two hundred square miles in area. It embraces in whole or in part, the townships of Augusta, Hallowell, Chelsea, Windsor, and Vassalboro, in Kennebec County, Maine. The area is included in the Augusta and Vassalboro quadrangles of the United States Geological Survey topographic maps.

This paper embodies the result of investigations concerning the distribution and the structure of the so-called Hallowell granite.

Augusta, the largest city near the district, is on the Maine Central Railroad, and the granite area itself is traversed by several state highways and numerous country roads.

Previous Work

The report of Dr. Charles T. Jackson, state geologist in 1838, contains the first recorded geological study of the Hallowell Granite. (Jackson, 1838, pp. 92-95)* His report, like all that have followed, dealt only with conditions at the quarries located on Lithgow Hill, and made no attempt to describe the extent of the outcrop, or explain its structure.

Hitchcock mentions the Hallowell Granite briefly in his report on the geology of Maine, (Hitchcock, 1861, p. 196), but on the whole, does nothing more than repeat the observations of Jackson in 1837.

The most complete report available is the one by Dale in U. S. Geological Survey bulletin on the New England granites. (Dale, 1923). The section of this publication devoted to Maine is an enlargement and revision of a previous bulletin on the granites of the state. (Dale, 1907.)

The above reports have been made, without exception, from the economic standpoint. The extent of the granite area has never been determined, and no study of its structure has ever been published. These reports have been concerned only with the smaller granite area on the west bank of the Kennebec, localized about Lithgow Hill. No recognition has been made of the fact that the same granite extends eastward, on the other side of the Kennebec River, over a much larger area.

Physiography

The region in which the Hallowell granite occurs is one of moderate relief. The even skyline indicates that it is a portion of one of the

* For publications cited, see list of references at end of thesis.

several piedmont terraces developed in central Maine during the Tertiary Period. (Perkins and Smith, 1925, p. 216) and rejuvenated by glaciation and uplift during the Pleistocene and post-Pleistocene times.

The drainage, tributary to the Kennebec, has been disorganized by glaciation. A great number of ponds and lakes exist in the debris-dammed remnants of pre-glacial river valleys.

The topography is dominated by two features.

(1) the north-east south-west ridges, which are due to the more resistant folded sediments with an average strike of N 35° E, and which are common over large areas of Maine, and,

(2) local oval hills of granite the long axes of which have a general north-west south-east trend. Lithgow Hill, west of Augusta, and Bolton Hill, west of Togus Pond, are good examples. (See map.) Glaciation is responsible for the peculiar trend of these hills. The ice moving from the northwest tended to elongate their more or less circular outline into elliptical form through lateral erosion. The lower and less resistant ridges of the country rock were also cut through in many places, though not sufficiently to destroy their trend, except in a very few cases where because of unusually resistant strata small areas stand well above the general level. Such an area may be seen in the case of the small hill on the Augusta-Vassalboro town-line, just north of Seven Mile Brook.

Throughout this area bed rock outcrops are common above the three hundred foot level, particularly on the southeast slopes where only thin deposit of till was made; below this level, except in some of the stream beds, the country is mantled with marine clays which were laid down during the period of depression, subsequent to glaciation. The shape of the outcrops is roughly circular to irregular and they often occur as knobs in the higher hill tops.

By reference to the map it will be seen that the granite occurs in two districts on opposite sides of the Kennebec River. The western area centers about Lithgow Hill, while Togus Pond and Porcupine Hill are about the middle of the eastern area.

Structure

Biotite Schist

The country rock of the district, into which the granite is intruded, is biotite schist. This schist varies in composition and structure, from laminated slates to more or less massive quartzites. Biotite in varying amounts is present everywhere. This biotite schist occurs over large areas of central Maine, extending to the Rockland limestone on the east, passing beyond the Waterville slates in the north, and having undetermined boundaries on the west and south. That the schist is of sedimentary origin may be seen in those areas where it has the slaty structure mentioned above. Here the outline of the original beds can be clearly traced. The formation has been folded until the dip of the beds is vertical or steeply inclined to the southeast. The strike is variable, varying from 20 to 60 degrees east of north with an average strike of N 35°E. Because of the amount of metamorphism, however, no detailed structure can be worked out.

The metamorphism shown by the schist is very evidently due to regional force or forces, and in no degree to the intrusion of the Hallowell Granite. This is shown by the fact that outcrops a number of miles from the contact zone show as much alteration as those in which the schists and granites are closely associated. The strike of the schistosity is apprpximately that of the strata, N 35°E, and has no relation to the granite masses which in numerous places cut the structure at high angles. The schistosity, then, is not connected with the granite intrusion, but is associated with antecedent folding.

The almost negligible amount of metamorphism which can be traced to the intrusion would seem to indicate that at the time it took place the country rock over a large area was heated. This supposition is further supported by the lack of any marginal chilling about the borders of the granite.

This schist can apparently be correlated with the Branch Pond Formation of Perkins and Smith. (Perkins and Smith, 1925, pp. 224, 225.)

Hallowell Granite

The Hallowell granite is a muscovite biotite rock of light gray color and fine texture. The texture and biotite content vary within small limits, over the area examined. Associated with the main masses of granite are differentiated dikes which will be considered later.

As stated above, the granite occurs in two masses, one on each side of the Kennebec River. By reference to the map their boundaries, size, and areal distribution may be seen. It will be noted that the area west of the river is roughly circular in shape, about three and a half miles in diameter, and reaches its maximum elevation, five hundred feet, at the centre, in Lithgow Hill. The eastern area is roughly oval in outline, and lacks the symmetry of plan possessed by the western district. Along the central portion of its major axis, however, it is distinctly higher than the surrounding country. The hills north and west of Togus Pond form the nucleus of this area and reach an elevation of four hundred sixty feet. Profiles of the areas (Figures 1 and 2) show their relative heights and surface features.

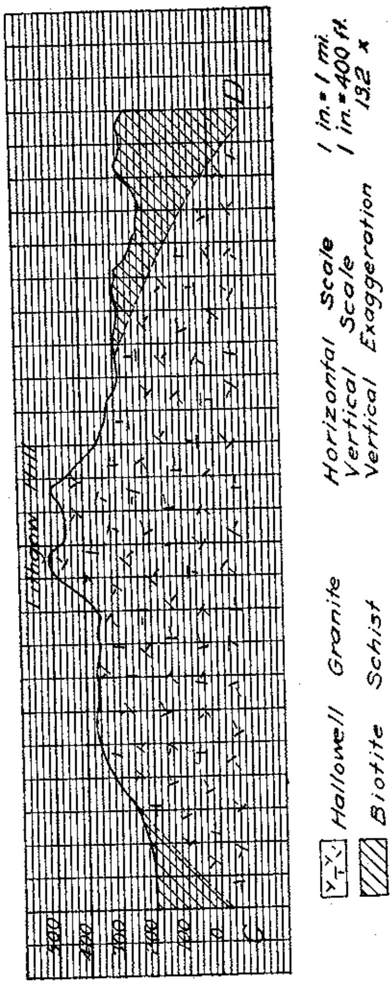


Figure 1. Section along line C-D (see map in back of book) through Lithgow Hill showing dome-like form of intrusive.

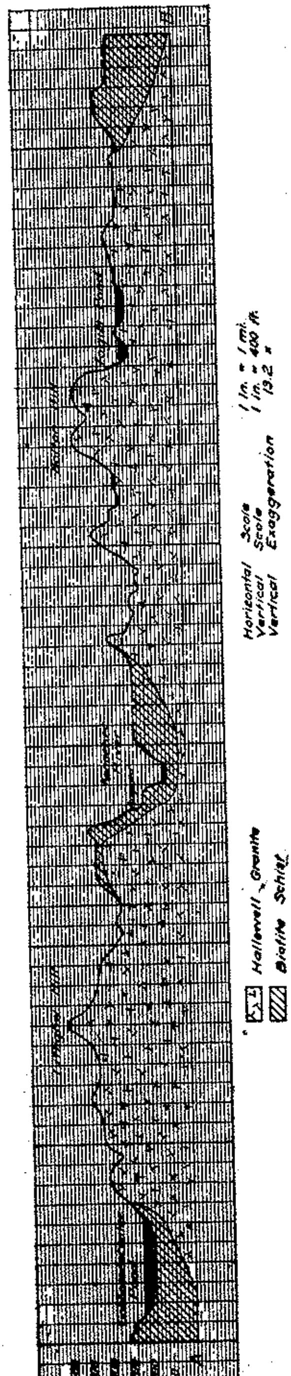


Figure 2. Section along line A-B (see map in back of book) through the eastern and western cupolas of the batholith.

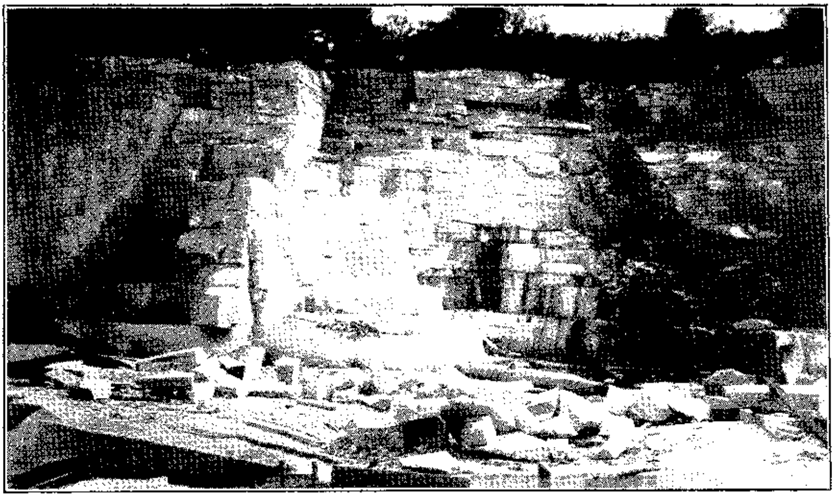


Figure 3-A. Sheet Structure in East Wall of Lithgow Hill Quarry

Figure 3-B. Sheet Structure in North Wall of Lithgow Hill Quarry

Notice parallelism of sheet structure with the surface and increase in thickness of the sheets downward.

The contact between the edges of the granite masses and older schists is very indefinite. More properly the two could be said to merge into each other over a contact zone varying from a few feet to several miles in width. In most cases, as one passes over this zone, from the schists toward the granites, quartz veins first become abundant and small pegmatite dikes appear, often forming the backbones of the little ridges which occur in this zone. Closer to the granite mass outlying dikes and knobs of granite occur, and the outcrops of schist decrease in size and frequency. Occasionally small areas of schist can be found completely included by the granite, and fragmental inclusions up to several feet in size are common.

In these contact zones there also occur dikes, and more rarely, rather massive outcrops of tourmaline granite. In this rock crystals of black tourmaline take the place of the usual biotite content of the Hallowell granite. This tourmlaine granite seems to be a peculiar differentiate of the Hallowell Magma, and so far as known is unique in Maine. A more detailed description of this rock will be found under the section on petrography.

The Hallowell granite is cut by two important sets of joints and numerous smaller joints, both types varying with the location. In some outcrops a faintly gneissoid foliation can also be observed. The following table gives data, taken from various widely scattered localities, on the important joints and the foliation.

Table I

Locality	*Main Joints*	*Minor Joints*	*Foliation*
A	N 42° E	N 87° E	N 4° E
B	N 60° E	N 13° E	N - S
C	N 75° E	N - S	None
D	N 82° E	N 12° E	None
E	N 102° E	N 3° W	None
F	N 112° E	N 22° E	None

List of Localities

A. Abandoned quarry west of Hallowell.
B. Lithgow Hill Quarry.
C. Abandoned quarry on China Road east of Augusta.
D. Hill northwest of Hallowell.
E. Hill west of Three Mile Pond.
F. Hill west of Three Mile Pond.

Sheet structure is very well developed in both areas of the granite and is especially well exposed in the quarry walls. (See Figure 3.)

Near the surface the sheets are only a few inches thick but their depth gradually increases downward until they have a thickness of six or eight feet at the bottom of the quarry. Dale attributes the cause of this sheet structure, at all lower levels, to compressive strain, while the surface sheets he considers due to expansion caused by solar heat. (Dale, 1923, pp. 26-37).

It will be noted that in the photograph the sheet structure is horizontal. It varies in different places, however, being roughly parallel to the surface trend of the granite.

Associated with the Hallowell granite are found differentiates of three kinds, tourmaline granite, pegmatite dikes and quartz veins. The tourmaline granite appears only about the margin of the Hallowell granite, but the pegmatites and quartz veins are found cutting the granites, and in the schists at considerable distances from the intrusion. The relative ages and structural relations of these differentiates may be seen in an excellent exposure along Bond Brook, northwest of Augusta. Here a cliff face gives a section in which can be observed the Hallowell granite intruded in the schist, the younger pegmatite cutting the granite, and the still younger quartz vein cutting the pegmatite. (Figure 4.)

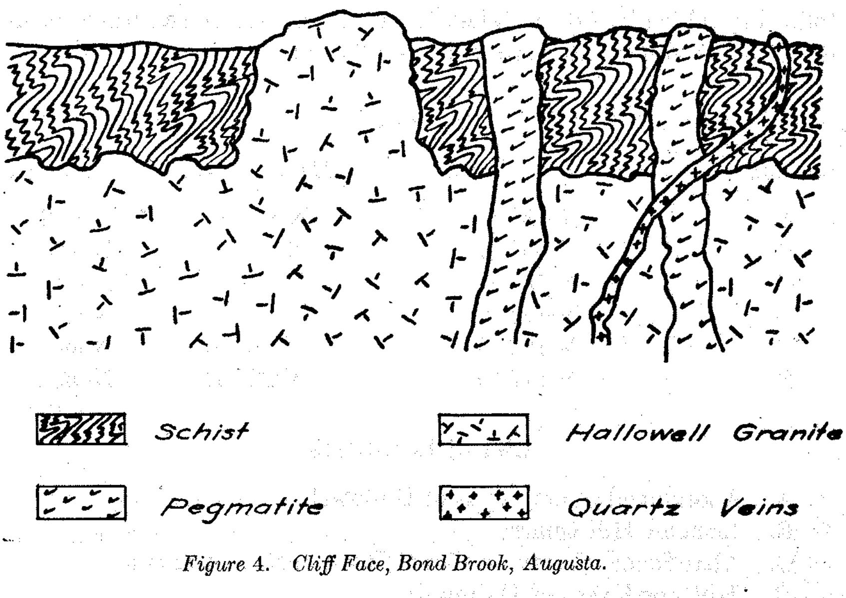


Figure 4. Cliff Face, Bond Brook, Augusta.

No tourmaline granite appears here, but where present is always cut by the pegmatite and quartz. The age relations stand thus; oldest, Hallowell granite, and in order, tourmaline granite, pegmatite dikes, quartz veins.

Mode of Occurrence

There is very strong evidence pointing to the intrusion of the Hallowell granite as batholithic in nature. Much of this evidence has been presented under previous sections, but will be summed up here.

The occurrence of the granite in two dome-like masses of similar composition and structure indicates that they are cupolas of a batholith which thus far has been laid bare by erosion at these points only. The great width and irregularity of the contact zone indicates that the lower portion of the batholithic roof is still covered by the schist. Figures 1 and 2 illustrate this, the uncovered cupolas showing at Lithgow and Bolton Hills, while a covering of schist still remains over the Kennebec River area. The present valley of the Kennebec here, is undoubtedly due to the form of batholith. The profile (Figure 2) shows that the river follows the path of least resistance through the weaker metamorphic trough between the resistant granite domes on either hand.

The abundance of inclusions is still another evidence for the batholithic mode of occurrence, these as before noted vary in size. Most of them possess the same strike as the country rock and are apparently truncated roof pendants. The abundance of these pendants indicate that the top of the granite intrusion was not far above the present level. The form of the granite itself is characteristic of intrusions at considerable depth, probably in or near the zone of flowage. As this means a cover of considerable thickness it is obvious that a vast deal of erosion has gone on since the time of intrusions.

Petrography

Biotite Schist

The country rock into which the granite is intruded is a bluish-gray biotite schist. On weathering this rock usually stains a dark rust brown from the oxidation of small amounts of iron present. Megoscopic examination shows mainly quartz grains and biotite mica. Occasionally small quantities of muscovite are present. The bedding is visible and supplies clear proof for the sedimentary origin of the schist. The percentages of quartz and mica vary greatly with the strata. The foliation is parallel to the bedding.

Under the microscope the schist shows practically the same features as noted above. (Slide P-6)[1]

1 The slides referred to are on file in the Geological Dept. of Colby College. They were prepared from specimens selected to show average conditions prevailing in localities from which they came. An index to the slides will be found at the end of the paper.

Major minerals:

Biotite—shows parallel arrangement of crystals as the result of metamorphism.

Quartz—somewhat shattered; extinction undulatory, also result of strain.

Minor minerals:

Muscovite—much shredded.

Apatite—scattered crystals in quartz.

Normal Granites

The Hallowell granite is a light gray, fine textured rock. The megascopic minerals are feldspar, quartz, muscovite, biotite and occasional small garnets. The feldspar is more or less prophyritic, with the average diameter of the phenocrysts slightly over five millimeters. The other particles average about .75 millimeters in diameter. In some instances the biotite is smeared or slickensided, showing faulting after the magma has cooled.

The phenocrysts have a tendency to line up parallel to the faint gneissic structure of the rock.

Microscopic examination of the normal granites (Slides P:1, P-2).

Major minerals:

Quartz—abundant, undulatory extinctions.

Microcline Plagioclaise—about equal amounts of albite and anorthite (Andesine).

Minor minerals:

Biotite—this shows parallel arrangement of the crystals as the result of strain. This gneissic tendency of the normal granite is mentioned above.

Muscovite—slightly less in amount than the biotite.

Apatite—rare.

Kaolin—small amounts resulting from weathering of feldspar.

Coarse Normal Granite

Megascopically this granite is of somewhat different aspect since the mineral particles are larger. This gives it a coarser appearance. It is also somewhat lighter in color.

Under the microscope this granite (Slide P-5) shows the same composition as the normal type. The crystals are larger. There is somewhat less biotite and it fails to show any alignment like that noted in Slides P-1 and P-2. This is a coarser phase of the normal type, and was undoubtedly intruded at a somewhat later date.

Tourmaline Granites

The tourmaline granite occurs about the margin of the Hallowell, in various places. This rock is coarser in texture than the normal granite and contains less quartz. The feldspar is porphyritic, some of the phenocrysts being a centimeter in diameter. Scattered throughout the ground mass are black tourmaline crystals of varying sizes. (Two or three centimeters down to a millimeter or less). There is no megascopic mica.

Microscopic examination of the tourmaline granites. (Slides P-3, P-4).

Major minerals:

- Microcline—abundant.
- Quartz—undulatory extinctions.
- Plagioclaise—between oligoclaise and andesine; much less abundant than in the normal granites.

Minor minerals:

- Tourmaline—quite abundant; the crystals cut the other minerals and seem to be due to replacement of them by tourmaline at a later stage of the intrusive period.
- Biotite—present in small amounts though not shown by megascopic examination. Like the biotite in the coarse normal type it does not show any parallel arrangement of crystals.
- Apatite—rare.

The tourmaline granite seems to be an intermediate stage between the true granites and the pegmatites.

Pegmatites

Pegmatite dikes are found over the entire area studied, cutting both schists and granites of the various types. These dikes vary in width from an inch or two, to more than a foot. They are composed of quartz and feldspar crystals of varying sizes, and minor amounts of muscovite mica, black tourmaline and occasionally small garnets. Because of their coarse texture no slides were prepared.

The extinctions of the quartz, which are undulatory in every case, the gneissic tendency of the granites, and more locally the slicken sides, all show that the rock masses have been under rather severe strain. This was probably incident to the intrusion and cooling of the magma.

Age Relations

Because of the thoroughness of metamorphism it is impossible to date the sediments by means of fossils. Had any existed they must f necessity have been destroyed in the complex folding to which the area has been subjected. The nearest formation which has been definitely dated is the Waterville slate. This is known to be of Clinton, or mid-Silurian age, (Perkins, 1924, pp. 223-227). Since the schist is highly metamorphic even away from the granite intrusion, and does not pass gradually into the unmetamorphic Silurian, it must of necessity be pre-Silurian.

In the absence of any fossil record the date of deformation becomes of primary importance in determining as closely as possible the age of the schist. Previous to the Silurian there were two periods of orogenic movements in eastern North America which could have caused such metamorphism. The first was the Killarney Revolution, which came during the Late Proterozoic. The second was the Taconic Disturbance in the Late Ordovician. Recent work seems to indicate that only over a small area of western New England was this latter disturbance of an orogenic nature. (Pirsson and Schuchert, 1924, pp. 243-244) (Clark, 1921). Eliminating the Taconic Disturbance, we have left the Killarney Revolution as the cause of our regional metamorphism. This occurred in the Killanean and would obviously place the rocks themselves in a still earlier period. This schist closely resembles known Precambrian rocks of southern New England.

The granites are intruded in the schists, hence they are younger. Dale classes the Perry Basin granites, to the eastward, as late Silurian or early Devonian, and is of the opinion that most of the Maine granites, with the exception of those in the southwest, are of the same age. (Dale, 1923, p. 209). A dike of granodiorite cuts the Waterville slate and is therefore late or post-Silurian. Since general igneous acitivty was taking place in Maine at this time, it seems reasonable to suppose that the Hallowell granite was also intruded during the late Silurian or Early Devonian. At best this is only a supposition, as the granite might also have been intruded in the Ordovician or in the Carboniferous period, since igneous activity was taking place in both these times.

Economic Aspect of the Hallowell Granite

The quarry on Lithgow Hill, now operated by the Hallowell Granite Works, Inc., was first opened in 1826. Since that time it has been in continuous operation, and several new openings on various parts of the same hill, have been made by the company.

At the present time six derricks are in operation in the quarries, their capacities vary from ten to forty tons each. In the cutting plant five derricks are used, with two outside cranes for loading. The plant is equipped with saws, pneumatic tools, and surfacing machines. Much of the product is of such nature as to require finishing wholly by hand, and about three hundred cutters are employed. Because of the skilled artisans at this plant, granite from other quarries is often brought here for finishing. The product is transported from the cutting sheds to Hallowell by auto truck or trolley freight. There the stone may be loaded directly on the sea-going barges in the Kennebec River, or shipped by freight on the Maine Central Railroad.

Because of its fine texture and light color, the Hallowell granite is particularly adapted for carving, and is used extensively for monumental work and architectural embellishment. Some of the better known monuments and buildings constructed from it are: the Manhattan Bridge Plazza, and the Hall of Records, in New York City; the Marshall Field Building in Chicago; Academic and Library Buildings of the Naval Academy at Annapolis; the Soldiers and Sailors Monument in Boston.

Summary

The area covered by this report is located near the city of Augusta, Maine. Previous material available in the district has been concerned only with the economic aspect of the granites.

Physiographically the region is one of moderate relief dominated by two factors; north east south west ridges, the result of folding and erosion, and oval hills of granite, the result of intrusion and glacial erosion. The drainage is tributary to the Kennebec.

The country rock of the region is biotite schist. It is of sedimentary origin and shows regional metamorphism. It is a bluish gray in color and stains rust brown on exposure.

The granite is intruded in this schist in a mass which has two areal exposures, one on each side of the Kennebec River. Tourmaline granite, pegmatites, and quartz veins, are present as differentiates from the original magma. The quartz content of all rocks of this district show undulatory extinctions and give evidence of molecular strain.

The age relations are uncertain. Without much question the schist is Precambrian. The granites are probably late Silurian or early Devonian but any positive evidence of their age is lacking.

The Hallowell Granite Works, Inc., operates a quarry on Lithgow Hill, from which they take a high grade building and monumental stone.

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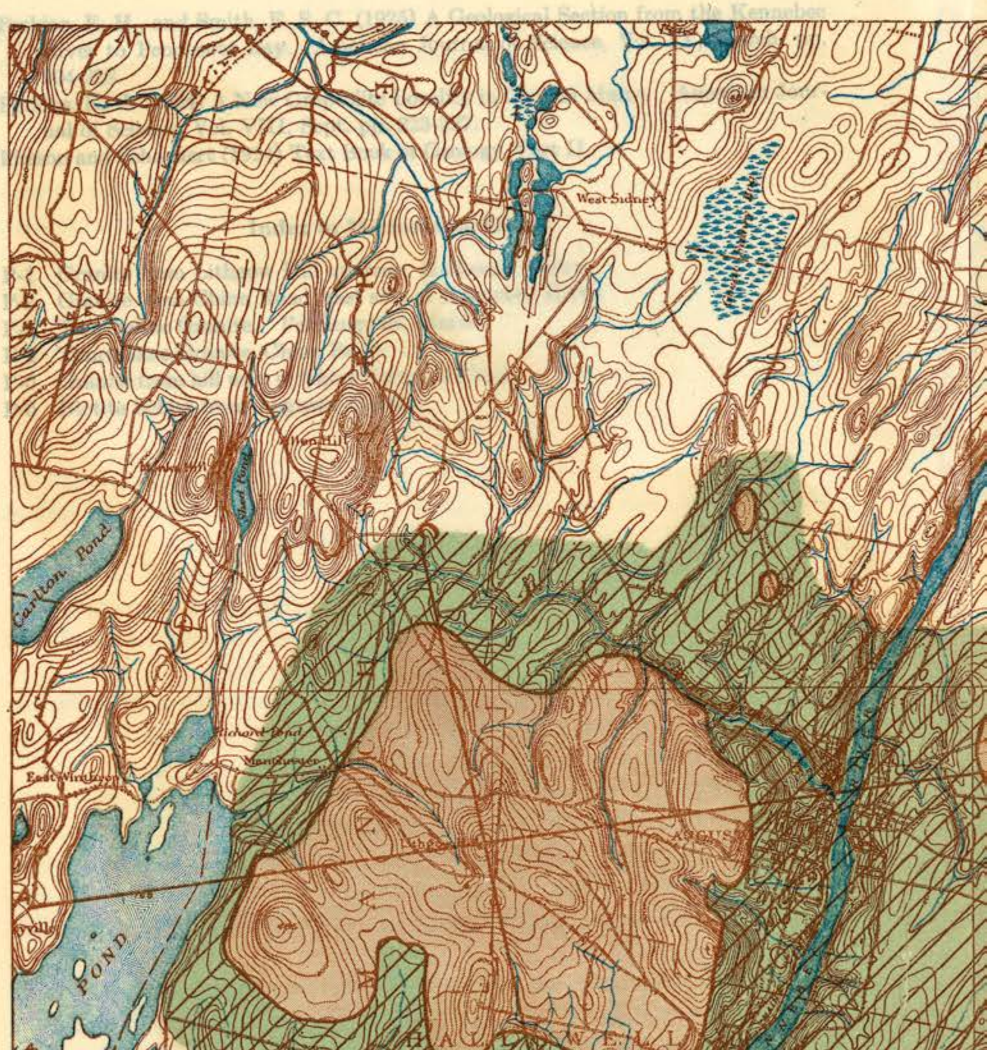
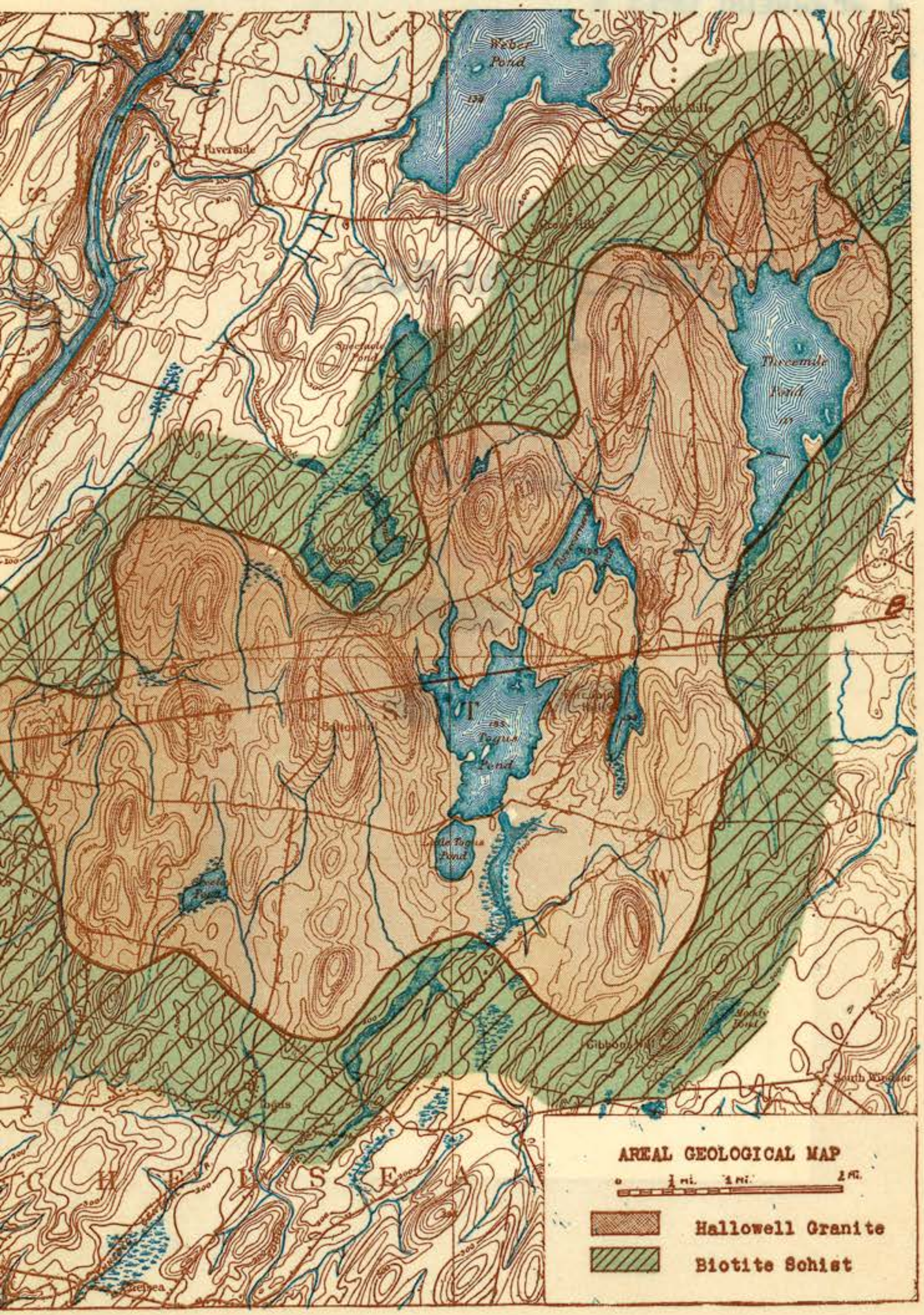
Index to Microscopic Slides

P-1 Granite from Lithgow Hill quarries, Hallowell, Maine.
P-2 Granite from China Road, east side of Kennebec River.
P-3 Tourmaline Granite. Farmingdale, Maine.
P-4 Tourmaline Granite, China Road.
P-5 Granite from hill west of Three Cornered Pond.
P-6 Biotite Schist from Augusta District.


West Sidney
Carlton Pond
East Winthrop
POND
Sanborn Pond



Weber Pond
Threemile Pond
Togus Pond
Little Togus Pond
Riverside
South Windsor
Chelsea
AREAL GEOLOGICAL MAP
Hallowell Granite
Biotite Schist

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