THE MAINE GEOLOGIST

THE NEWSLETTER OF THE GEOLOGICAL SOCIETY OF MAINE

DECEMBER 1980

VOL. 7 NO. 2

SPECIAL GSM MEETING

TIME - 7:00 PM, TUESDAY, FEBRUARY 10, 1981

PLACE - THE AUDITORIUM
THE UNIVERSITY OF MAINE AT AUGUSTA
AUGUSTA, MAINE

SUBJECT - EXPLANATION AND DISCUSSION OF THE NEW MAINE MINERALS POLICY

The State of Maine, through the efforts of a special study committee formed by Richard E. Barringer, Commissioner of the Department of Conservation, is in the process of formulating policy as to the development of mineral resources. This Special Meeting, to be convened at 7:00 PM on Tuesday, February 10th in the Auditorium of The University of Maine at Augusta, will be keynoted by Mr. Barringer, to be followed by individual presentations on specific aspects of the subject. As currently conceived, these talks will be by Walter Anderson or Carolyn Lepage of the Maine Survey on the history of mining in Maine; by Charles Colgan of the State Planning Office on minerals taxation; by Thomas E. Eastler of UM-Farmington on water quality considerations; by Bill C. Scott of Superior Oil Company on government regulations from a mining company viewpoint; and Cheryl Ring of Maine Audubon Society on environmentalists' views of the policy.

Following these talks and a coffee break, the speakers, plus possibly some others of special knowledge or interest, will form a panel for further discussion, with audience participation.

NOTICE OF SPRING MEETING

DATE - FRIDAY, MARCH 13, 1981

PLACE - CHASE HALL LOUNGE
BATES COLLEGE, LEWISTON

SCHEDULE - 1:00 - 5:30: Maine College Student Program (GSA format), to be followed by the customary business meeting.

5:30 - 7:00: Social Hour & Dinner

7:00 Onward: Special Presentations: still being worked out, but possibly on the environmental geology and economic aspects of Maine peat.

FALL MEETING SUMMARY

The regular Fall Meeting of GSM convened at 2:10PM on November 14, 1980 in Memorial Union at the University of Maine - Orono for a business meeting, followed by a 3:25PM adjournment for coffee and lateral displacement to Boardman Hall for talks by UMO Geology Department personnel on current research projects. Starting with about 2 dozen participants, the group grew to something around 60 attendees as the afternoon progressed. A 13-minute sound movie forwarded by John Tewhey from Lawrence Livermore Lab was also run, describing the facilities and operations of the spent reactor fuel storage facility in granite at the Nevada Test Site (once J. Rand and a team of Experts had half-way fathomed some of the idiosyncrasies of the rented sound projector).

The various items of GSM business discussed included: thoughts on the selection of a Director to replace Bob Gerber, who is also GSM President (to be concluded at the Spring Meeting); thoughts on changing the GSM Annual Meeting date from the Mid-Summer to the Fall Meeting (voted no change); thoughts on how the GSA-Bangor NE Section Meeting needs money to defray expenses of facilities & equipment rental, free beer for what used to be called The Smoker (voted to send $100 from GSM to help them out); thoughts on a Special Winter Meeting in February to describe and discuss the newly-conceived State of Maine Minerals Policy (see announcement elsewhere herein); thoughts on the traditional Maine College Student Program at Bates College for the Spring Meeting (heartily endorsed, for mid-March); and thoughts on how to pry articles out of Members' heads and files for publication in this Newsletter (Bob Gerber to crack the whip a little louder).

Following coffee, a series of presentations were made by UMO Geology personnel: Steve Norton on an overview of the National Science Foundation research grant recently approved for the department; Tom Kellogg on benthic forams, diatoms and marine sediments in the Ross Sea area, Antarctica; Tad Pfeffer (working with Terry Hughes) on theoretical and practical problems with ice, and mathematical modeling of ice temperatures in an Antarctic glacial terrain; Joe Chernosky on experimental petrology, physical & chemical properties of earth materials in high temperature and pressure environments; and Steve Johnston on sediment accumulation rates in Maine through the past 200 years. UMO has 66 undergraduates and 15 graduate students (M.S. level) in geology, and based on the Fall Meeting revelations the Department seems headed for a most impressive future. (JRR)

GERRISH ISLAND, REVISITED

THE RYE FORMATION OF GERRISH ISLAND, KITTERY, MAINE: A REINTERPRETATION

By A. M. Hussey II
Department of Geology
Bowdoin College
Brunswick, Maine

On Gerrish Island in Kittery, at the very southern tip of Maine, the Late Precambrian(?) or Early Paleozoic(?) Rye Formation is in contact with the Early Paleozoic(?) Kittery Formation. The Rye Formation was originally described by Katz (1917), who referred to it as the Algonkian Complex. The name "Rye" was proposed by Wandke (1922) for the excellent exposures at Rye Beach, New Hampshire. Billings (1956) divided the Formation into an upper metavolcanic member and a lower metasedimentary member. In my own earlier mapping of these rocks (Hussey, 1962) I followed Billings, and mapped the rocks on Gerrish Island as part of the Rye metavolcanics, later mapping the metasedimentary member in a northeast-plunging antiform at the very southern tip of Gerrish Island (Hussey and Pankiwskyj, 1976).

Two weeks of detailed mapping during the summer of 1980 of shoreline exposures on Gerrish Island has resulted in a very significant revision of the interpretation of the protoliths of the upper part of the Rye Formation, and has clearly shown that the Rye-Kittery contact is a fault zone.

Figure 1 is a geologic map of the coastal portions of Gerrish Island. The major rock unit of the Rye Formation (r on Figure 1) is an association of fine-grained mylonitized dark chocolate-brown metapelite with fibrolitic sillimanite, relict staurolite, and occasionally relict andalusite; thinly pin-striped fine-grained alternating chocolate-brown mylonitized quartz-plagioclase-biotite gneiss and medium greenish-gray mylonitized quartz-plagioclase-hornblende-biotite gneiss; medium-gray, fine- to medium-grained quartz-plagioclase-biotite gneiss. Commonly these lithologies have large (up to 2") partially crushed and rolled porphyroclasts of plagioclase and potash-feldspar abundantly developed.

These rocks, in particular the metapelites, are heavily migmatized and injected by layers of medium- to coarse-grained granite to granodiorite gneiss having a characteristic blastomylonite fabric. The regularity of these feldspathic layers frequently resembles bedding, and is likely, along with the heavy migmatization of the metapelites, the reason why earlier investigators interpreted these rocks to be of metavolcanic origin. Close examination, however, reveals that the even layers commonly cross-cut relict bedding and must, therefore, be injected, not interbedded, material.

Within this lithic association are several thin, but mappable, units: dark gray amphibolite with calc-silicate laminae (a on Figure 1) occurring in two narrow belts up to 75 feet wide on the southern and western shores of the Island; rusty-weathering sulfidic and graphitic schist (g on Figure 1) approximately 50 feet thick; impure marble, 20 feet thick, on the south side of the graphitic schist (included with the schist on Figure 1); and flinty-textured (ATTENTION, ARCHAEOLOGISTS!) finely and evenly pin-striped chalky-weathering dark chocolate-brown ultramylonite, locally with rootless pseudotachylite veins (um on Figure 1).

Ultramylonite forms a 75 to 100 foot wide

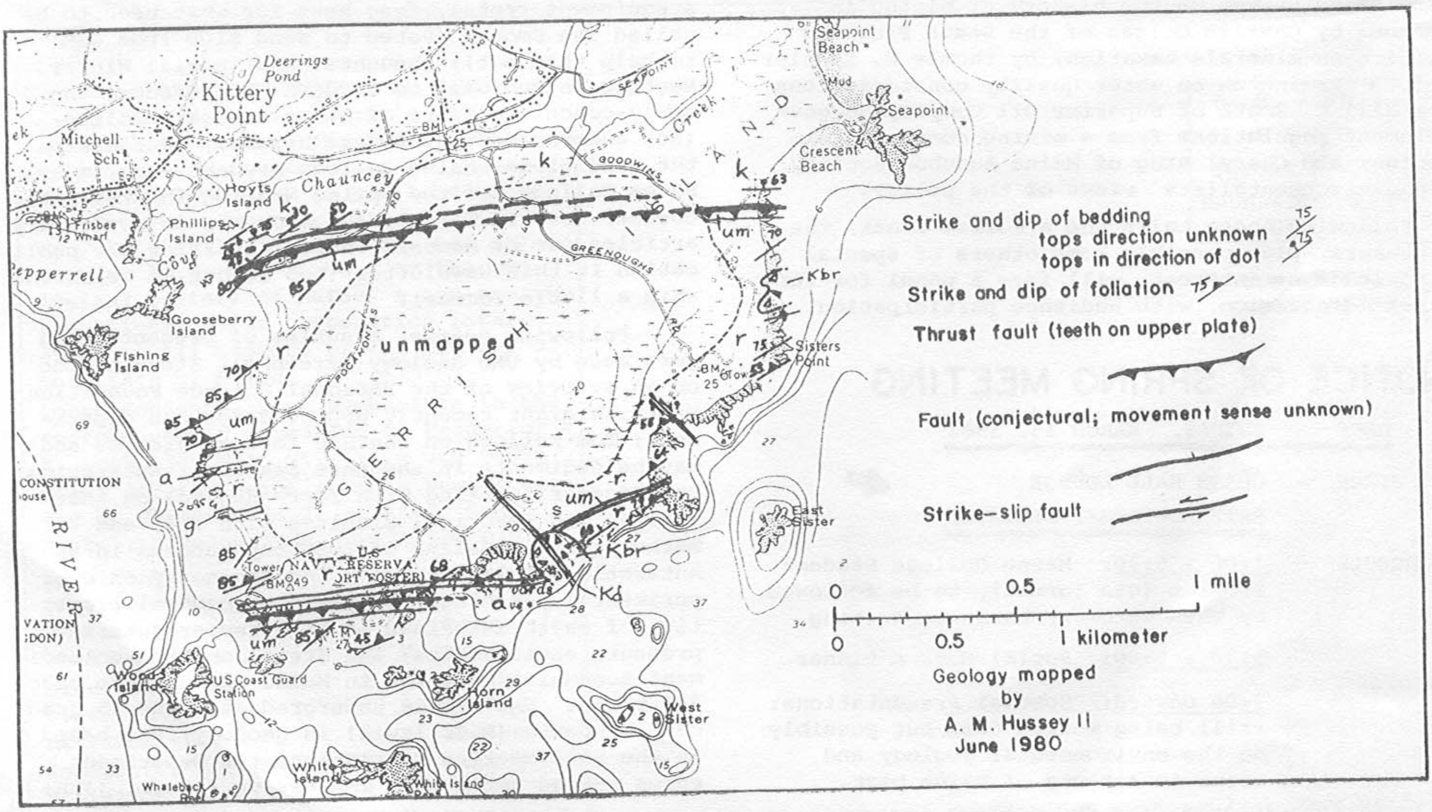


FIGURE 1. GEOLOGIC MAP OF COASTAL PORTIONS OF GERRISH ISLAND, KITTERY, MAINE (Base: USGS Kittery 7½')

zone between the Kittery and Rye Formations, and a 100 to 150 foot wide zone at the southern tip of the Island, plus several thinner zones as shown on Figure 1. These ultramylonite belts are interpreted as ductile fault zones, and the two thicker belts probably represent two significant deep-seated thrust faults: one of which brings the Rye over the Kittery; and the other of which brings slightly lower-grade Rye with relict staurolite and andalusite and little feldspathic injection material (seen at the very southern tip of the Island) into contact with higher-grade more heavily injected Rye that constitutes the greater part of the Formation.

Other rock units include two breccia bodies (Krb on Figure 1) which involve angular blocks of the lithic units of the surrounding Rye Formation and an earlier set of diabase dikes (Hussey, 1962). The northern of the two bodies includes a block of the Kittery Formation up to 10 feet in diameter. These breccias were probably formed at the same time as the Cretaceous-age Cape Neddick and other mafic complexes in southwestern Maine. The breccias are cut by a later set of diabase dikes, the largest of which (100 feet wide) is shown on Figure 1 (as Kd). Diabase and lamprophyre dikes and a few rhyolite dikes of probable Late Triassic to Cretaceous age, cut all the units of the Rye Formation including the ultramylonite bands. The dikes have a general N25-30°E strike, and are so abundant as to cause, through dilation, a 20° to 30° difference between the strike belts of lithic units and the locally-measured strike of foliation or bedding in those units.

CONCLUSIONS

1) No part of the Rye Formation on Gerrish Island appears to be of felsic volcanic origin. Felsic gneiss bands originally thought to be felsic metavolcanics are injected material. The protoliths of rocks of the Rye Formation were pelite, calcareous siltstone, siltstone, sandstone, marble, and carbonaceous shale. The amphibolite with abundant calc-silicate laminae may represent metamorphosed calcareous muds rather than basic volcanics.

2) All units of the Rye Formation except the ultramylonites have been subjected to pervasive cataclasis during migmatization and injection of felsic gneiss layers, causing the characteristic blastomylonitic fabric of the rocks.

3) Blastomylonite fabric and injected materials are absent from the Kittery Formation, suggesting either a hiatus in the ages of the Kittery and the Rye, or a significantly different environment of deformation and metamorphism of the two Formations.

4) Ultramylonite along the Rye-Kittery contact represents deep, ductile-type faulting, probably thrusting, which brought the Rye Formation north over the Kittery Formation.

5) Development of ultramylonite post-dates the development of blastomylonite fabric of the Rye metasediments and injected gneisses.

6) Renewed faulting under conditions of later brittle deformation may be indicated by the topographic lineament that is parallel to and approximately 100-300 feet north of the Rye-Kittery ultramylonite fault zone.

References Cited

Billings, M. P., 1956, Geology of New Hampshire: Part II, Bedrock Geology: New Hampshire Planning & Development Commission, 203p.

Hussey, A. M. II, 1962, The Geology of Southern York County, Maine: Maine Geological Survey Special Studies Series, No. 4, 67p.

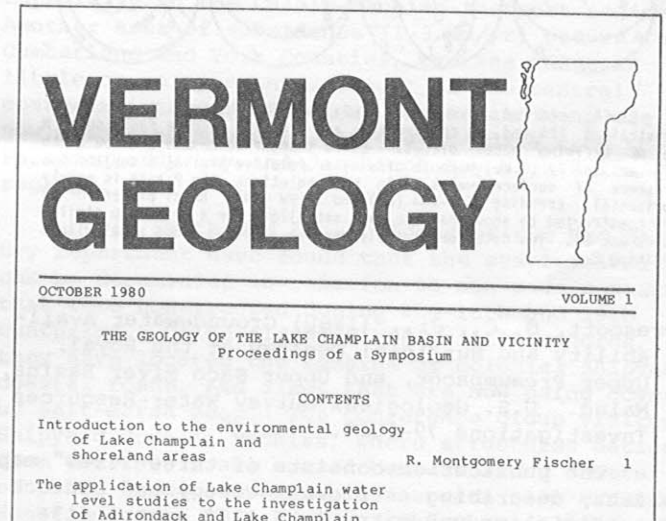
Hussey, A. M. II and Pankiwskyj, K. A., 1976, Preliminary Geologic Map of Southwestern Maine: Maine Geological Survey Open-file Map 1976-1.

Katz, F. J., 1917, Stratigraphy in Southwestern Maine and Southeastern New Hampshire: U.S. Geological Survey Professional Paper 108, p.165-177.

Wandke, Alfred, 1922, Intrusive Rocks of the Portsmouth Basin, Maine and New Hampshire: American Journal of Science, 5th Series, No. 4, p.139-158.

PUBLICATIONS RECEIVED

From time to time people quite kindly send The Editor copies of new or pertinent publications of interest to Maine geologists. Some of these are briefed in the following sections.



VERMONT GEOLOGY

OCTOBER 1980 — VOLUME 1

THE GEOLOGY OF THE LAKE CHAMPLAIN BASIN AND VICINITY
Proceedings of a Symposium

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VERMONT GEOLOGICAL SOCIETY, INC.

VERMONT GEOLOGY, Vol. 1, may be obtained for $4 Postpaid, check payable to Vermont Geological Society, from Stewart Clark, Treasurer, VGS, Box 304, Montpelier, Vermont 05602.

PUBLICATIONS RECEIVED (Continued from Page 3)

Graham, T. and E. F. Chiburis (1980) Fault Plane Solutions and the State of Stress in New England. EARTHQUAKE NOTES, Vol. 51, No. 2, April-June 1980.

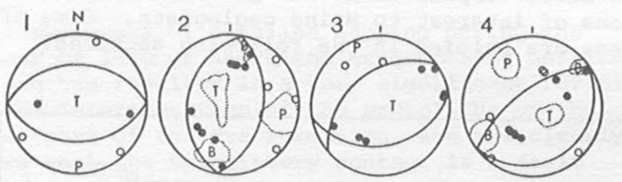
Abstract: An analysis of eighteen New England fault plane solutions indicates that the area can be largely characterized by reverse faulting on north to northeasterly striking fault planes. This implies that New England is predominantly influenced by an east-west to southeast-northwest compressional stress field. This generalization may not apply in certain areas of southern New England.

(Four Maine earthquakes are analyzed in the Graham-Chiburis paper, as summarized by the following excerpts - JRR)

Table 1. Epicentral Data

Event	Lat. N	Long. W	Depth	Geographic Region	Date	Mag.
1	45.04	69.48		Dexter, ME	20DEC78	2.2
2	43.95	69.76	3	Bath, ME	18APR79	4.0
3	43.94	70.40		Crescent Lake, ME	29OCT78	2.5
4	44.04	70.51		Otisfield, ME	04JAN78	3.2

Figure 2. The fault plane solutions



E1-E4 occurred in Maine. E2 and E4 resulted in two well constrained FPS and, as constructed, are dip-slip reverse faulting on N to NE striking nodal planes. E4 is thought to have a shallow depth similar to E2 (3 km) because of similar relative arrival times and the presence of surface waves. In both solutions, the P axis is nearly horizontal, trending ESE-WNW (E2) and SE-NW (E4). Nodal planes for E3 are constructed to show that the data set allows for a mechanism similar to E2 and E4. The data for E1 imply reverse faulting along nodal planes striking E-W.

Prescott, G. C., Jr., (1980) Ground-water Availability and Surficial Geology of the Royal, Upper Presumpscot, and Upper Saco River Basins, Maine. U.S. Geological Survey Water-Resources Investigations 79-1287.

The publication consists of three 34x44" map sheets, describing surficial geology and bedrock & surficial ground water in a 1200 square mile area located primarily in Cumberland and Oxford Counties (roughly within 43°35'-44°25'N, 70-71°W).

Billings, M. P., K. Fowler-Billings, C. A. Chapman, R. W. Chapman and R. P. Goldthwait (1979) The Geology of the Mt. Washington Quadrangle, New Hampshire. New Hampshire Department of Resources & Economic Development, Concord, N.H. 44 pages, 35 figures, 1 colored plate.

"This pamphlet, a revision of one published in 1946, presents the story of the rocks of the Mount Washington quadrangle. The history of the mountains, the formation of the rocks, their folding and uplift, and their shaping by the work of streams and ice is told in simple language for the layman. ...Although the bedrock geology was mapped 40 years ago, more recent investigations show that no basic changes in the distribution of the rock formations is necessary. But some very important new information is available on the age of the rocks, on the physical conditions of metamorphism, and on the rates of erosion. The legend on the accompanying geological map has been extensively rearranged, compared to the 1946 pamphlet, because of the new data on the ages of the rocks." (from the Foreword)

Atlantic Geoscience Society

The AGS has organized a symposium on

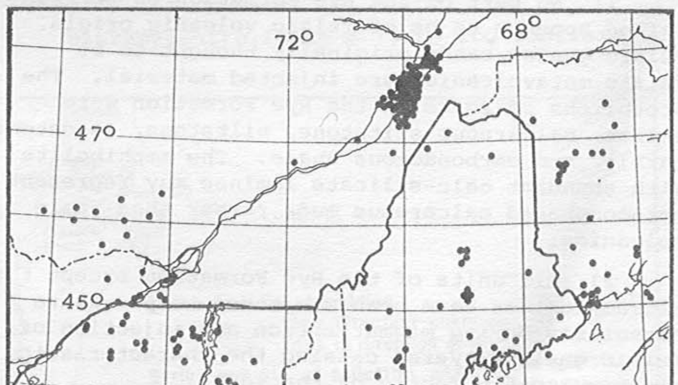
THE ENERGY AND MINERAL RESOURCES OF THE ATLANTIC PROVINCES

to be held at Keddy's Motor Inn, P.O. Box 1510, Forest Hill Road, Fredericton, New Brunswick E3B 5G2 (Phone 506 454-4461) on January 23-24th.

The Friday evening session starts at 6:30 PM with papers on mineral deposits associated with granitoid rocks and with tensional environments, and on the Hibernia Structure. The two Saturday sessions are on mineral and energy resources of the Atlantic Provinces.

Those planning to attend should reserve accommodations directly with Keddy's on or before January 22nd. Registration fee for the symposium is $5 for AGS members, $3 for students. An additional $2 will be charged non-members for AGS membership. For further information, please contact: Rebecca Jamieson, Department of Geology, Dalhousie University, Halifax, Nova Scotia B3H 3J5 (Phone 902 424-3771)

N.E. SEISMICITY



From: Vudler, V. and P. A. Raica (1980) Seismicity of the Northeastern United States. Bulletin No. 18, Northeastern U.S. Seismic Network, Weston Observatory, Weston, Massachusetts 02193 (November 1980; Figure 3)

LAST CALL FOR BERMUDA

During the Spring Semester in 1981, the Colby College Geology Department will offer a semester abroad in Bermuda. This program will consist of a 3 credit-hour Introductory Oceanography course, a 4 credit-hour Junior-level Sedimentation course, and a 5 credit-hour Independent Study course. Room, board, and library & laboratory facilities will be provided by the Bermuda Biological Station. The Biostation is well equipped to handle student groups. Their library receives 150 journals and contains over 10,000 volumes, and their teaching labs have running seawater and other standard facilities. Boats are available for shallow- and deep-water field trips. Students participating in this program will have the chance to study coralgal reefs and carbonate environments in the field. Environmental problems of sewage disposal and oil pollution will be observed at first hand, and the many organism-sediment relationships important in sediment production and modification will be examined by the group. This program will run for 9 weeks and will be conducted by Associate Professor Harold Pestana, Department of Geology, Colby College, Waterville, Maine 04901. For details, please contact Prof. Pestana before mid-January 1981.

? Alleghanian ? Alleghenian ?

The culminating Late Paleozoic orogenic episode in the eastern U.S. used to be called the Appalachian Revolution, easy enough to spell once you got the right number of p's and l's in mind. Then along came Herbert P. Woodward (1957, AAPG Bull., 41, p.2312) and renamed the cataclysm "Alleghany" (sic), a concept that seems to have settled into our hearts and minds with considerably less anguish than its spelling. These days, we are continually bumping into the indiscriminate spelling variations of Alleghany, Allegheny, Alleghanian, Alleghenian, Alleghanyan, etc. The AGI Glossary (1972, p.16) spells it Allegheny (but without citing Woodward), and clues us not as to an Alleghenian or Alleghenyan preference.

On query, A. M. Hussey II, who sprang from roots deep in Pennsylvania soils, will advise one that there are no Alleghanys in that state so it can't possibly be Alleghany. However, Woodward's early work was in Virginia, where both a town and a county in the Valley & Ridge Province are named Alleghany; and his first use of the word (in an orogenic sense) was published in Virginia (1932, Va.Geol.Surv.Bull. 34, p.98-101) as Alleghany.

Who knows what spelling we should use? Has the USGS issued an Ultimate Decree? The IGCP? UNESCO? GSA? AAPG? Should the GSM?? (JRR)

Subsidence ~ 9 mm/yr

CRUSTAL SUBSIDENCE IN WASHINGTON COUNTY, MAINE

By Woodrow Thompson
Maine Geological Survey
Augusta, Maine 04333

On November 7-8, the Maine Geological Survey hosted a field trip and conference in Machias to examine some of the evidence for subsidence of the earth's crust in Washington County. Participants included Neil Steuer (Director of Site Safety Research for the U.S. Nuclear Regulatory Commission), Pat Barosh (Coordinator of the NRC's New England Seismotectonic Study), and scientists from various disciplines who are working on the NRC Crustal Warping Study which is administered by the Maine Geological Survey. The purpose of the Seismotectonic Study is to document the occurrence of earthquakes and deformation of the earth's crust inasmuch as they relate to the siting of nuclear power plants. Much of the Maine program is concentrated on the coast because there are zones of greater earthquake activity in this area, and it is convenient to use changes in sea level as an indicator of crustal warping.

It is known that sea level along the Maine coast is rising at a rate that exceeds the worldwide rise in eustatic sea level. Thus it is evident that the crust is sinking. The cause of this subsidence is poorly understood, but the multidisciplinary approach of the NRC study is telling us much about the rate and geographic distribution of the downwarping. Starting with evidence from the most recent period, David Tyler and Willy Weng of the UMO Department of Civil Engineering have investigated changes in bench mark elevations. Their data show that the most rapid subsidence (up to 9 mm/yr) is occurring in Washington County, especially in the Calais-Machias-Eastport region. Another area of subsidence (1-3 mm/yr) occurs in Cumberland and York Counties, whereas there is little or no apparent movement in the central coast or interior of Maine. Tyler and Weng are now gathering magnetic and gravity data from the Passamaquoddy Bay and Penobscot Bay high-seismicity regions.

David Smith and Anne Bridges of the UMO History Department have found that the sea-level rise can be documented in relation to man-made features that were constructed during the 18th and 19th centuries. Using old maps and written records, they have located the remains of colonial shipyards, coastal roads, and dikes that are now being covered by salt-marsh peat. The conference group visited Shipyard Cove in Machias, where structures dating from the 1800's are buried beneath about a meter of peat. Some salt-marsh dikes were also examined. Scott Anderson, Harold Borns and Charles Race (UMO Department of Quaternary Studies) explained how they are trenching some of these dikes to see how much sea level has risen against them. Borns, Anderson and Race are also coring salt marshes in several coastal towns to determine the rate of marine transgression. This work will extend the record back a few thousand years. Beginning next spring, archaeological sites will also be investigated by UMO personnel.

Woodrow Thompson, Harold Borns and Kristine Crossen are attempting to determine whether postglacial crustal movements are reflected in the elevations of glacial-marine deltas and raised beaches in southern Maine. The elevations of the deltas' topset/foreset contacts are first measured by altimeter, and key deltas are then surveyed more precisely. Contouring of the elevation data will yield an isobase map, on which any prolonged subsidence (at today's rate) should be apparent. The conference participants visited the Columbia

(Please continue on Page 6)

CRUSTAL SUBSIDENCE (Continued)

Falls area to see how this methodology is being applied.

Olcott Gates (SUNY-Fredonia) and David Westerman (Colby College) reported on faults and other bedrock structures in Washington County. Gates pointed out that the northwest-trending Oak Bay Fault underlies Passamaquoddy Bay. It is likely that this structural feature is related to the rapid downwarping and geophysical anomalies that occur in the Bay area. The group visited an outcrop where glacial till overlies a fault of the Oak Bay system, but no evidence of Holocene deformation was evident at this or other outcrops studied by Gates and Westerman. The next step will be to carry out subbottom profiling of the sediments beneath Passamaquoddy Bay, since this is the most probable location for continuing fault movement. Recent seismic activity in the Passamaquoddy Bay area was summarized by Barosh. Additional recording stations have been installed around the Bay, and they reveal that the region is now experiencing an upswing in the frequency of earthquakes.

At the Machias meeting it was decided to publish the findings to date of the Crustal Warping Study. In addition to their importance to the NRC and the scientific community, they bear upon the problem of accelerated coastal erosion and the possible build-up of stresses in the earth's crust that could result in a destructive earthquake. The participants in the Machias conference will also conduct a symposium on the neotectonics of coastal Maine at the April GSA meeting in Bangor.

SALT WATER WELLS

HYDROGEOLOGIC SETTING AND GEOCHEMISTRY OF RESIDUAL PERIGLACIAL PLEISTOCENE SEAWATER IN WELLS IN MAINE

By Dorothy H. Tepper
Department of Geological Sciences
University of Maine, Orono, Maine

The following is a summary of my recently completed Master's thesis research. This work was done at UMO in the Department of Geological Sciences, with the cooperation of the Quaternary Institute, the Civil Engineering Department, and the Maine Geological Survey.

INTRODUCTION

By 1978, Glenn Prescott (USGS) and Brad Caswell (MGS) had identified 33 domestic wells in Maine (Figure 1) which yielded ground water with chloride (Cl^-) concentrations ranging from 250 to 8250 ppm (background values are less than 10 ppm). These wells, referred to as "inland salt water wells" were not affected by pollution or modern seawater intrusion.

Both Prescott (1962) and Caswell (1978) suggested that the high Cl^- may result from entrapment of seawater from the Late Wisconsinan marine submergence in regions of nearly stagnant ground water flow. Scandinavian workers have also described numerous salt water wells located below the Holocene marine limit. The high Cl^- in these wells has been attributed to seawater which has been trapped in the glacial overburden or bedrock fractures since deglaciation.

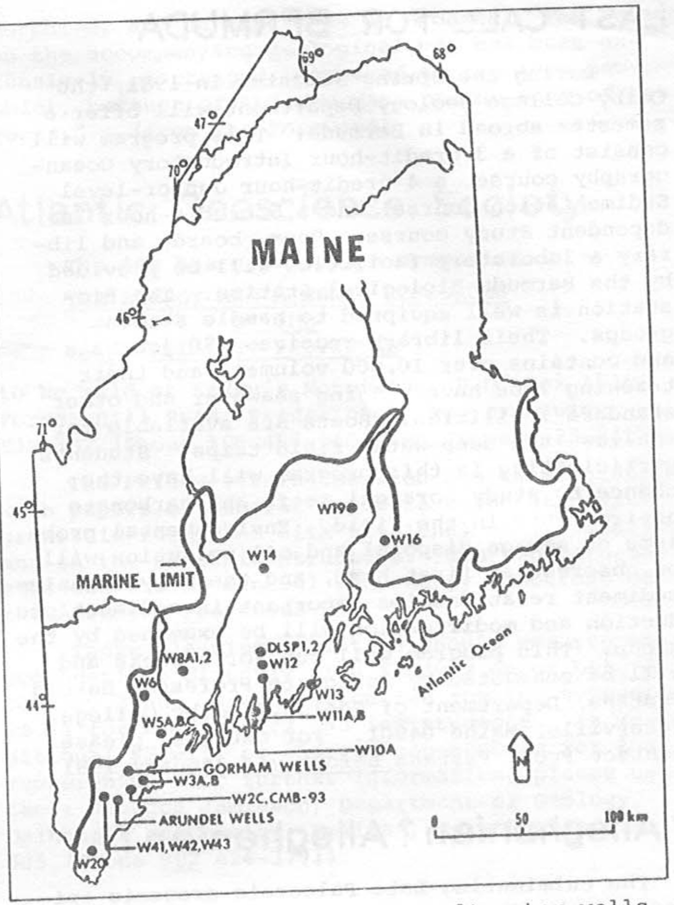


Figure 1. Location of inland salt water wells. All are below the Late Wisconsinan marine limit. Based on Caswell (1978) and Goldthwait (1949).

PURPOSE

Although saline ground water is not a widespread problem in Maine, it is very costly and inconvenient for the homeowners involved. The salt water is not only unfit for drinking, it also corrodes pipes and household appliances. The purpose of my research was to determine the origin of the high Cl^- and to define the hydrogeologic controls on its occurrence. As a result of this work, it is now possible to assess the risk of encountering high Cl^- in ground water for any given area, providing that the necessary hydrogeologic data are available. This can save prospective well owners the expense of drilling a well that cannot be used because of high Cl^-.

RESEARCH DESIGN

The problem of determining whether seawater from the period of marine submergence during deglaciation was the source of high Cl^- reported in inland salt water wells in Maine was investigated through studies of regional geochemistry and hydrogeology. The chemistry of ground water samples from wells with high (>250 ppm) and with low (40-250 ppm) Cl^- and from adjacent wells was analyzed in order to:

1. characterize and then compare the chemistry of the saline ground water to that of dilute seawater;

2. compare the trends of Na, K, Mg and Ca concentrations to those reported in residual seawater from deglaciation in Scandinavia;

(Please continue on Page 7)

3. delineate the distribution and boundaries of the high Cl^-;

4. look for evidence of pollution.

Because most of the inland salt water wells are located in Gorham and Arundel, these areas were studied in detail. The following factors were investigated in order to characterize the hydrogeologic setting of the inland salt water wells:

1. bedrock surface topography, lithology and fracture patterns;
2. overburden stratigraphy, type and thickness of deposit;
3. well depth, yield and other physical parameters;
4. potentiometric surface gradient;
5. ground water chemistry.

Additional hydrogeologic and geochemical information was provided by Cl^- monitoring in 15 wells on a weekly basis for intervals of 3 to 6 months. The purpose of the monitoring was to determine whether Cl^- would remain relatively constant with time, as a test of how hydrologically stagnant the salt water-bearing zones were. Continuous water-level recorders were installed on three salt water wells which did not contain pumps, in order to characterize water level changes in the local aquifer.

CONCLUSIONS

1. Inland salt water wells in Maine are located below the Late Wisconsinan marine limit and occur in both igneous and metamorphic rocks. They are located in the deepest depressions in the local bedrock surface, which were covered by deeper water and submerged longer than higher areas during the marine transgression. As a result of the density contrast between seawater and fresh water, and the greater volume of seawater available in the deeper areas, more complete replacement of fresh water in fractures by seawater occurred in the bedrock depressions.

2. Proximity to faults, pluton margins, and river valleys, which tend to follow less-resistant, possibly fractured or faulted areas in bedrock, are characteristic structural settings for the salt water wells. Seawater entered the bedrock, which has very low primary permeability, in faulted or fractured areas.

3. Because they are in fractured areas, the salt water wells have higher-than-average yields.

4. Salt water wells are in relatively stagnant hydrogeologic zones where the thick, relatively impermeable marine clay overburden impedes recharge of fresh water and discharge of salt water. The potentiometric surface in the vicinity of the salt water wells is either flat or gently sloping. The salt water wells may be in fracture zones that are relatively isolated from the regional flow system.

5. High Cl^- in sand and gravel deposits between the marine clay and bedrock may be due to upward flow of saline water from the bedrock, or to entrapment of seawater within these often confined and isolated coarse-textured deposits; there may also be some downward flow of interstitial saline water from the marine clay into the sand and gravel and/or bedrock.

6. The source of high Cl^- in bedr
found on lakeshores may be seawater tha
ped in these lake basins after the marin
sion. There is some evidence of hydraulic
nections between lake basins and the surroun
fractured bedrock.

7. The variability of Cl^- over a small area both vertically and laterally is best explained in terms of the local fracture pattern and the number and yields of fresh water fractures that a particular well intersects. Further, the rate of water extraction results in variable salinity levels.

8. There is no correlation between depth and Cl^-. However, saline aquifers may be stratified, with fresher veins found closer to the bedrock surface.

9. Salt water wells occur in areas where the fractured bedrock is behaving as a relatively elastic, confined aquifer.

10. The chemistry of the inland salt water wells is characterized by strong correlations between Cl^- and concentrations of K, Na, Mg and Ca, the dominant cations in seawater.

11. The chemistry of the inland salt water wells is not geographically controlled.

12. In comparison to levels predicted by dilution of seawater with fresh water, there are significant changes in element ratios in the ground water of the inland salt water wells. The degree of depletion or enrichment of each element during dilution is always most extreme at higher Cl^-. In general, Na and Ca have been enriched and Mg and K have been depleted. Although there is a proportional relationship, the enrichment in Na and Ca is not balanced by the depletion in Mg and K. These changes in element ratios are probably due to ion exchange and ion filtration reactions with the marine clay and bedrock.

13. The chemistry of ground water with >350 ppm Cl^- is dominated by the influence of relict seawater. The effects of ion exchange and ion filtration are more obvious in ground water which has been diluted to below 350 ppm Cl^-.

14. Based on the hydrogeologic and geochemical evidence, the most likely source of the high Cl^- in inland salt water wells in Maine is seawater which has been trapped in regions of relatively stagnant ground water circulation in the overburden and bedrock since the period of marine submergence during deglaciation.

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