MAINE GEOLOGICAL SURVEY

THE GEOLOGICAL SOCIETY OF MAINE 1974

THE MAINE GEOLOGIST

THE NEWSLETTER OF THE GEOLOGICAL SOCIETY OF MAINE

APRIL 1980

VOL. 6 NO. 3

SPRING MEETING '80

With something over 4 dozen in attendance at 1:30PM, John Creasy opened the Spring GSM meeting at Chase Lounge, Bates College, for an informative afternoon of technical presentations by 6 students from various Maine colleges. Abstracts of papers given at the Student Session are published herein on Pages 2 & 3. The Session was broken into 2 segments, Glacial Geology and Postglacial History (R. G. Gerber, presiding), and Bedrock Geology and Petrology (S.G. Pollock, presiding), separated by coffee and donuts. It was an interesting afternoon, and the speakers did a good job all around. The Society is treated very well indeed at these annual Bates programs, and appreciates the work done for all by the Bates Geology Department and the featured speakers.

Following the technical session, the Membership dealt with various business matters, including:

1. Treasurer's Report: Only about one-half the members have paid their 1979-80 dues; those who haven't are so advised here by the color of the address label. It was voted to authorize the Treasurer to open an interest-bearing NOW account.
2. On MAINE GEOLOGY, not enough papers have been received to justify printing Bulletin No. 2 this year. Art Hussey suggested that NORTHEASTERN GEOLOGY should take on the few papers received.
3. On Commissioner Barringer's Advisory Committee for the Maine Geological Survey, Bill Forbes & Donaldson Koons were elected to represent the GSM, with Brad Hall serving as Alternate to assure that at least two GSM members would attend each Survey Advisory Committee meeting.
4. On the 1981 Spring meeting of the Northeastern Section of G.S.A. at Bangor, Art Hussey is Program Chairman, Irwin Novak is Exhibits & Poster Session Chairman, Fred Beck is Treasurer, and Joe Chernosky is Registration Chairman. Dave Westerman was appointed to meet with representatives of the Atlantic Geoscience Society to see how GSM & AGS may arrange co-sponsorship of a session at G.S.A. dealing in some way with recent developments in Maine/Maritimes geology.
5. On the SUMMER MEETING, we'll do DICKEY-LINCOLN, led by Tom Lowell, UMO, and Dave Roy, Boston College, on July 18-20. Watch for the formal announcement to be sent to you in June.

Following a happy hour and supper, David W. Folger, USGS-Woods Hole, discussed, "Georges Bank - Geology, Resources & Environmental Hazards". A very interesting presentation, his talk sparked considerable discussion on the pros and cons of offshore exploration & development.

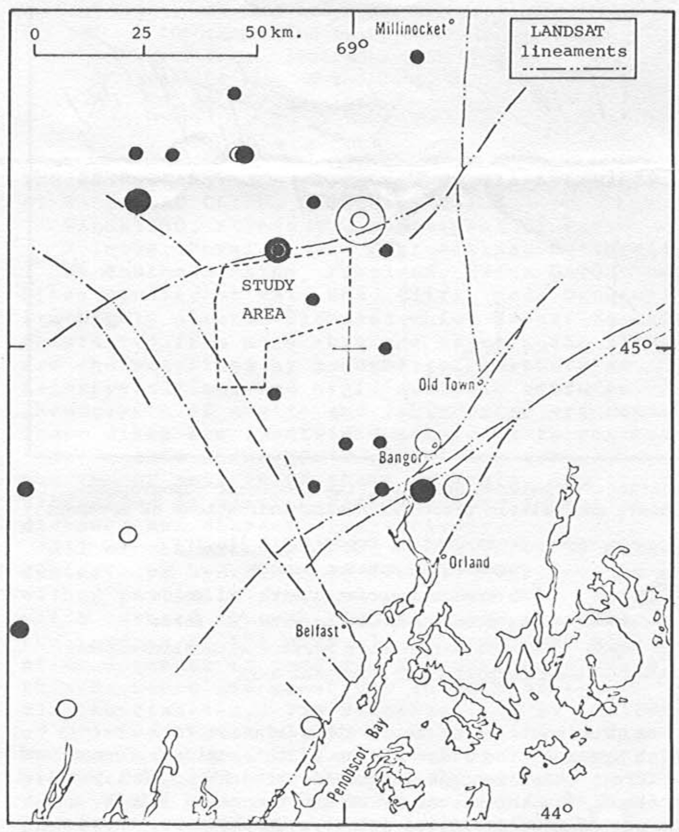
* * * * * *

Those who haven't yet... PLEASE PAY YOUR DUES.

BEDROCK, BRITTLE FRACTURE AND SEISMICITY IN THE DOVER-FOXCROFT / DEXTER AREA, MAINE

By David S. Westerman
Department of Geological Sciences
University of Maine at Orono
Orono, Maine 04469

A wedge-shaped area north of Penobscot Bay extending to Millinocket and Greenville is known to be one of low, but persistent, seismic activity (Barosh, 1978). Formational units in the area exhibit a regional flexure from NNE-NE trends in the southern and western portions to ENE trends in the eastern and northern portions, and the topographic relief paralleling this flexure is readily seen on Landsat imagery.



Wedge-shaped area of low, but persistent, seismic activity. ● = instrumental epicenters; ○ = historically felt events; (after Boston Edison Co., 1976; Figure 16 of Barosh, 1978)

The study area within this "wedge" was located on the southeast limb of the Merrimac Synclinorium, the stratigraphic relationships of which have been recently discussed by Pankiwskyj and others (1976). A synclinal structure within this southeastern limb has rocks of the Vasselboro Formation (Devonian or Silurian) exposed in the core,

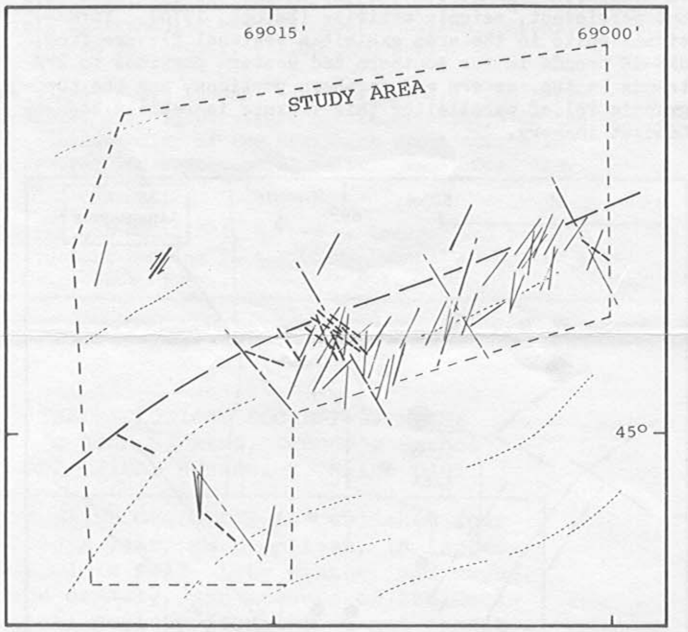
(Please turn to Page 2)

BRITTLE FRACTURE & SEISMICITY (Cont. from Page 1)

flanked on the northwest by the Sangerville Formation and on the southeast by the Waterville Formation, both of Silurian age.

Well-developed cleavage, parallel or sub-parallel to the bedding, is designated the S_{0-1} surface. Subsequent to the isoclinal folding which produced this cleavage, an episode of right-lateral movement produced brittle fractures (S_2) associated with prominent "Z" folds. These fractures trend N13E in the south and west portion of the regional flexure, changing to N32E in the eastern and northern portions.

Superimposed on the S_2 fractures and related folds is another set of close-spaced brittle fractures (S_3) which constitute the axial planes of "S" kink folds. The sense of these folds indicates left-lateral motion, and the two dominant trends are N36W and N68W, both with steep dips. These S_3 fractures are not ubiquitous over the study area, but rather are concentrated in the zone of maximum flexure of the regional trends. Quartz-coated joints, indicative of tension, have three dominant trends (N0E, N90E and N35W), and the parallelism of these trends with the three sides of the seismically active "wedge" can be noted with curiousity.



Relationship between cross-cutting prominent topographic linears and brittle fractures having indications of movement.

- Cross-cutting topographic linears
- Formational contact trends
- S_2 trends associated with "Z" folds
- S_3 trends associated with "S" folds
- Small-scale fault surface with slickensides
- Currier Hill synclinal axis

A prominent set of topographic linears form valleys which transect the ridge system of the regional formational flexure. These secondary linears trend NW to NNW, parallel to the S_3 fractures, one set of quartz-coated joints, and one set of nonmineralized joints. Furthermore, these brittle fractures exhibit a higher density (closer spacing) near the linears than in between.

The N36W trend of the transecting valleys and the corresponding brittle fractures may be related to the development of the regional flexure of the formational units. Both tend to suggest an overall left-lateral sense of deformation which postdates the development of the "Z" folds and their associated S_2 fractures. These S_2 fractures lack topographic expression and can be seen to have been rotated on a regional scale along with the S_{0-1} surfaces.

(Please turn to Page 8)

Maine College Student Program

BATES COLLEGE - MARCH 28, 1980

ABSTRACTS OF PAPERS

BEDROCK GEOLOGY OF A PORTION OF THE POLAND 15' QUADRANGLE, MAINE

CARTER, A.S., EBINGER, E.J., GAMMONS, C.H., PROUST, R.D., and RUDNICK, B., Department of Geology, Bates College, Lewiston, Maine 04240

Metasedimentary and plutonic rocks of the southeast flank of the Merrimack Synclinorium are metamorphosed to sillimanite plus potash feldspar grade in the northwest quadrant of the Poland 15' quadrangle. Stratigraphic units composed of calc-silicate granulite, quartz-biotite-plagioclase schist and pelitic migmatite are correlative with the Sangerville Formation, mid-Silurian in age (Ludman, 1976).

Emplacement of anatectic granitic bodies of the Sebago pluton has augmented regional metamorphism, while syntectonically deforming adjacent strata into a belt of anomalous, northwest trending structures. Large scale (5 km) structures are strongly overturned, with shallow axial planes dipping to the east, and fold axes plunging to the north, away from the locus of granitic intrusion (Guidotti, 1965). Small scale (10 - 20 m) asymmetrical structures with northeast dipping axial planes may represent deformation parasitic to the larger scale folding. These conclusions are consistent with the work of earlier authors (Guidotti, 1965; Moench, 1976).

Structural and petrographic evidence document the newly discovered Ben Barrows fault, a high angle structure with the north side dropped 1 - 2 km relative to the south. The Ben Barrows fault is similar to the Moll Ockett fault (Guidotti, 1965; Warner, 1967), located 20 km to the north, in both structure and geometry. The two faults form a "step" pattern which climbs southward towards the Sebago pluton. Faulting post-dates intrusion, but may be related to regional extension generated during the emplacement of the Devonian plutons.

THE BEDROCK GEOLOGY OF THE SMALL POINT AREA, PHIPPSBURG, MAINE

COVILL, D. R., Department of Geology, Bates College, Lewiston, Maine 04240

Metasedimentary and metavolcanic rock units in the Small Point area are correlated with the Cape Elizabeth, Diamond Island, and Scarboro Formations of the Casco Bay Group (Hussey, 1968). The Spring Point Greenstone is absent. Lithologies include biotite granulite, quartz-mica schist, garnetiferous biotite gneiss, amphibolite, calc-silicate rock, sulfidic schist, and amphibolitic quartzite. The area is at staurolite and sillimanite grades of regional metamorphism.

The area is multiply deformed, with folding ranging from open to isoclinal. Fold amplitude ranges from ten to fifty centimeters. A variation in the attitude of axial surfaces appears to define the axis of the Bath Syncline. Small scale isoclinal folds, less than one centimeter in amplitude, may be related to a separate event.

The area is intruded by a well foliated biotite granite of the New Hampshire Plutonic Series. Partial melting has produced a zone of migmatization above the pluton, to the east of the outcrop of granite, in which silliman-

ite is observed. Granitic pegmatite is associated with the intrusion and forms a shield around the western edge of the granite. It is inferred to be slightly younger than the granite.

SURFICIAL GEOLOGY AND LATE WISCONSINAN HISTORY OF THE WORTHLEY POND 7½ MINUTE QUADRANGLE, MAINE

EUSDEN, John D. Jr., Department of Geology, Bates College, Lewiston, Maine 04240

Four Quaternary units of late Wisconsinan age are recognized in the Worthley Pond quadrangle. The units from oldest to youngest are: (1) till, deposited by NNW-SSE flowing ice; (2) ice-contact stratified drift (eskers, kames and kame terraces) deposited by ice-marginal glacial meltwater; (3) outwash sediments deposited by meltwater during the last stages of ice stagnation; (4) eolian deposits derived from fine grained glacial drift. Active ice, associated with the latest glaciation, is marked by an end moraine in the Worthley Pond/East Branch of the Nezinscot glacial drainage. Evidence of active ice in the Worthley Pond quadrangle may suggest that regionally the last glacial recession was accompanied by remnantal ice activity where topographic and climatologic parameters were favorable. Subsequent to the episode of active ice the following sequence of deglaciation is postulated: stagnation of ice and deposition of ice-contact deposits; deposition of outwash; eolian deposition and modification; swamp and alluvium deposition and post Quaternary erosional modification.

POLLEN ANALYSIS OF POSTGLACIAL SEDIMENTS FROM LAKE LACAWAC AND ITS BOG IN WAYNE COUNTY, PENNSYLVANIA

HUNT, Timothy G., Department of Geology, Colby College, Waterville, Maine 04901

A lake sediment (1030 cm.) and a bog sediment (760 cm.) core were taken from Lake Lacawac and its bog 50 km. north of the late Wisconsin glacial boundary in Eastern Pennsylvania. The two sediment cores were analyzed for arboreal pollen (AP) percentages according to Whitehead (1979). These assemblages are represented at different depths in the two cores due to variations in the sedimentation rates in the bog and lake.

Significant changes in the relative abundances of the major AP types (Pinus, Picea, Abies, Tsuga, Betula, Quercus, and Fagus) are noted throughout both cores. Following deglaciation a tundra community of non-arboreal pollen species and Pinus was gradually replaced by a boreal forest of Picea and Abies. As the climate continued to moderate a mixed coniferous and deciduous forest proliferated with Pinus, Tsuga, and Quercus constituting 20-30% of the total AP count each. The final successional stage with the ameliorating climatic conditions was the northern hardwood forest in which Quercus, Fagus, Betula, and Tsuga constitute 70% of the AP count.

Pollen concentrations in the cores reflect temperature and precipitation variations since the beginning of organic sedimentation following the Wisconsin glacial retreat. Assuming Crowl (1980) is correct that the Wisconsin glacial border is of Woodfordian age (15,000 BP), then I hypothesize that the ice sheet left the Lake Lacawac region shortly thereafter and that organic sedimentation began perhaps 2,000 years later. Following deglaciation arctic tundra conditions developed. Next the vegetational changes showed a drier and warmer boreal forest environment similar to that of southeastern Canada. More recently, temperatures reached a maximum for this post-glacial period and have since cooled slightly and precipitation increased steadily to present levels.

LATE WISCONCIN ICE EXTENT IN THE GULF OF MAINE: EVIDENCE FROM MOUNT DESERT ISLAND, MAINE*

LOWELL, Thomas V., Institute of Quaternary Studies, University of Maine at Orono, Orono, Maine 04469

Late Wisconcin ice extent in the Gulf of Maine is problematical. Moraines occur but their age is speculative. This study uses terrestrial field data as boundary conditions for glaciological models to determine former ice extent. On Mount Desert Island, which features the highest summits along the Maine coast, field mapping shows: 1) basal till on valley floors, 2) plucked bedrock and erosional cirques on ridges, 3) subglacial meltwater channels and P-forms on ridges, 4) striated and polished bedrock surfaces on top of ridges and mountains, 5) regional full-glacial SE ice flow yielding to late-glacial ice flow controlled by local topography, 6) interbedded glacial and marine deposits, 7) lack of tors, and 8) lack of a sequence of weathering zones with elevation.

The glaciation that produced these terrestrial features is assigned a late Wisconcin age by bedrock weathering studies and by a lake-core basal date of 11,355±125 (S1-4043). Basal ice conditions inferred from the field data are: 1) basal ice melting (active till deposition) below 90 m in altitude, 2) basal ice freezing (active bedrock erosion) above 90 m in altitude, and 3) meltwater saturation of the ice-bed interface. Further, minimum late Wisconcin ice thickness is inferred to have been greater than 600 m. Deglaciation occurred largely by calving into marine embayments. These data are compatible with modeling results for a late Wisconcin ice sheet that extended onto the continental shelf as an ice stream in the Gulf of Maine, and that had a surface profile reflecting bedrock topography and basal thermal conditions.

*Reprinted from: Abstracts with Programs, Northeast Section of the Geol. Soc. of Amer., Vol. 12, No. 2, Jan. 1980.

THE PETROGRAPHY AND PETROLOGY OF DIABASE DIKES AT BALD HEAD CLIFF, OGUNQUIT, MAINE

VALENTINO, Albert J., Department of Earth Science, Physics, and Engineering, University of Southern Maine, Portland, Maine 04103

Dikes studied at Bald Head Cliff, near Ogunquit are highly altered diabases which appear to have originated from more than one magma. The dikes are characterized by subophitic, porphoritic, holocrystalline, and hypidiomorphic textures. Phenocrysts of augite and labradorite are common. These dikes are subdivided according to whether they contain phenocrysts of olivine (Fo_{88}), quartz, or neither of these minerals, and are classified as olivine-diabase, quartz-bearing-diabase, and diabase, respectively.

All of the dikes studied are altered by either deuteric or hydrothermal fluids. Olivine, is either partially or totally replaced by fluids which entered through the fractures and around the borders of the crystal. A four step alteration sequence is involved and various steps of this sequence are preserved in each of the olivine-diabases. The sequence is: 1) unaltered olivine, which alters to 2) a poorly defined hydrous magnesium silicate with variable optical properties; this is subsequently altered to 3) talc, which in some cases alters to 4) chlorophaeite. Plagioclase, (Ab_{37-50}), is commonly altered to sericite. The replacement process seems to occur by two mechanisms: 1) a simultaneous replacement of the whole crystal, and 2) a progressive replacement starting at the rims and working inward. Chlorite exists in most of the dikes and presumably originates by hydrothermal alteration of augite.

Based on the correlation of the presence of olivine or quartz, with the relative ages of the dikes, it has been concluded that more than one magma was the source for the Bald Head Cliff dike complex.

DETERMINATION OF AQUIFER TRANSMISSIVITY

By Robert G. Gerber
Consulting Geologist
and Civil Engineer
South Harpswell,
Maine 04079

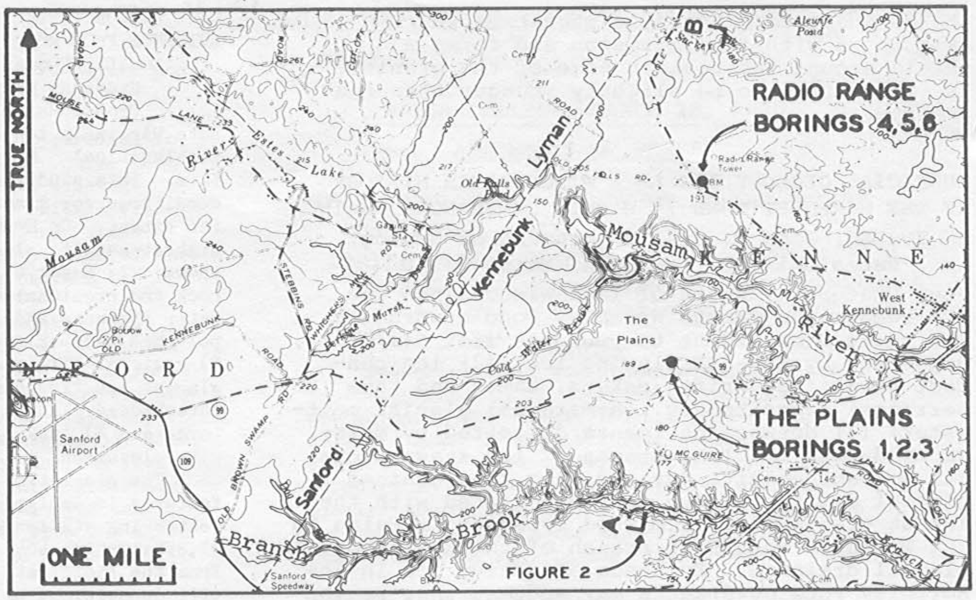


Figure 1. Aquifer study area, showing The Plains and Radio Tower investigation sites, West Kennebunk, Maine.

The Town of Kennebunk, Maine, recently commissioned a study of the aquifers in the sand plains of West Kennebunk. The study (SEA Consultants, 1979) was funded partly by a Maine State Planning Office grant under the Federal Coastal Zone Management program, and partly by Town-appropriated funds.

The purpose of the study was "to present data obtained during the study of aquifer recharge areas in the West Kennebunk area of the Town of Kennebunk, to identify those areas which appear to have the greatest potential for the development of ground water resources, and to recommend guidelines for land use controls for the aquifer recharge areas".

Most of the report deals with the problem of determining the "productivity" of what SEA Consultants defined as two aquifers near "The Plains" and the Radio Range Tower, as shown here on Fig. 1. By determining this "productivity", they could relate the availability of water for residential development to the potential demand from the hypothetical allowable development density under the zoning ordinance. Although the water-quality impact of development was discussed in the report in a general way, SEA Consultants made no attempt to compute the allowable density of development as a function of the capability of the aquifers to attenuate pollutants.

SEA Consultants determined aquifer "productivity" by the following method:

1. At apparently arbitrary locations within each of the two aquifers two clusters of 3 borings were drilled in a triangular pattern, 300' to 400' between borings. Each boring was advanced to what was later defined as the "confining stratum (first significant layer of consolidated material) at the base of the unconfined aquifer." The borings were used to collect continuous soil samples with a standard split spoon sampler or a small-diameter Shelby tube. Consultants logged each boring, ran sieve analyses on the samples collected, and determined porosity from several Shelby tube samples.

2. SEA Consultants surveyed relative elevations of static water level in each boring and interpreted the direction and magnitude of the ground water gradient within each 3-boring cluster by treating the data as a "three-point problem".

3. The horizontal permeability of each aquifer was estimated by the "dye tracer" technique. Rhodamine B dye was injected in the apparent upgradient borehole of each 3-boring cluster. This injection borehole was screened throughout its entire saturated depth. In each of the 2 apparent down-gradient observation boreholes, the Consultants measured the concentration of dye once a day for 12 days. By plotting the dye concentration in each observation hole as a function of time, SEA Consultants calculated a "mean" dye travel time at the centroid of the area under each curve. Permeability was then calculated from the Darcy relationship: $K = V \times \phi \div i$, where K is permeability, V is velocity of dye tracer travel between injection boring and observation boring, ϕ is soil porosity, and i is the ground water gradient between the injection and observation borings.

4. The aquifer "productivity" was calculated by Consultants from the relationship: $Q = K \times i \times A$, where Q is ground water flow rate through a cross-section of the aquifer, K is permeability, i is the gradient, and A is the cross-sectional area of aquifer normal to the ground water gradient. SEA Consultants apparently made the assumptions that all ground water flow was <u>parallel to the streams</u> that bounded each aquifer; that the thickness of the saturated permeable sand deposits as determined by their borings represented aquifer thickness; and that the aquifer "width" was the distance from stream valley to stream valley (tops of bankings; e.g., width for "The Plains Aquifer" was stated as 6900', between Branch Brook

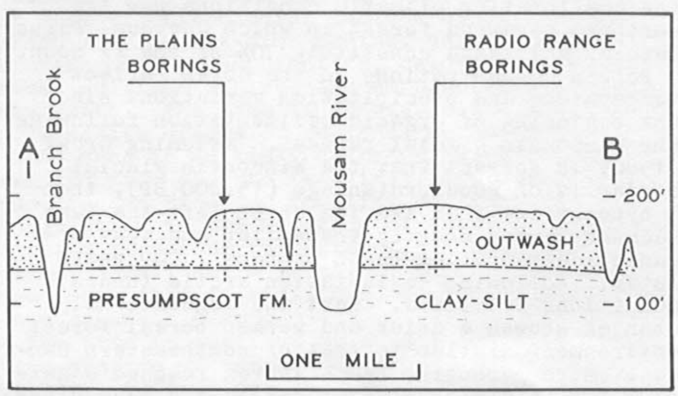


Figure 2. Diagrammatic geologic cross-section.

AQUIFER TRANSMISSIVITY (Cont. from Page 4)

northwest to Mousam River on a line through Borings B-1,-2, and -3). My Figure 2, diagrammatic geologic section A-B, is derived from the borings data and USGS topography. The outwash-Presumpscot contact on Figure 2 is derived from the borings plus Prescott, 1963.

SEA Consultants interpreted their dye tracer results to yield an average permeability over the thickness of the aquifers to be 4,060 and 13,000 feet per day for the Radio Range Tower and Plains aquifers, respectively. By assuming the thickness of the aquifer determined at each boring cluster to be representative for the entire "width" of each aquifer, they calculated that the flow through the Radio Range Tower and The Plains aquifers was 1.41×10^7 and 3.42×10^7 gallons per day, respectively, at the time of the September 1979 measurements.

There are several basic problems with SEA Consultants' methods and interpretations:

1. The dye tracer method is not appropriate for determining an "average" soil permeability in a non-homogeneous soil (i.e., a soil having a permeability that is not constant with depth). The borings logs show the aquifers to be highly stratified, varying from gravelly sand to silt layers, with grain size generally decreasing with depth.

2. Ground water gradient in West Kennebunk is generally toward the local streams rather than parallel to streamflow as assumed by SEA Consultants. Only on the ground water divide between the two streams would the ground water gradient be parallel to the streams. There is very little net ground water flux northeast across th· line of a section drawn northwest-to-southeast between major streams.

Why was the dye tracer test inappropriate as it was applied? The dye concentration-versus-time curves do not yield an "average" seepage velocity over the thickness of the aquifer as assumed by Consultants. In a stratified glaciomarine or outwash deposit, the velocity of dye travel is not constant with depth. The deposit is composed of numerous nearly horizontal layers of coarse sands, medium to fine sands, and even silty clay, as was revealed by project borings logs and detailed descriptions of Shelby tube samples. Each of these strata has a unique porosity, thickness and permeability under identical gradient. In the SEA Consultants dye tracer tests, the concentration-versus-time curves for the first 12 days represent only the travel time for the most coarse stratum.

By way of illustration, assume that there are only two strata in an aquifer; that the two strata have identical porosities and ground water gradients; and that the respective permeabilities are 4000' per day for one stratum having 0.2' thickness, and 0.1'per day for the other stratum having 40' thickness. The "mean" or average horizontal permeability of this 40.2' aquifer section is about 20 feet per day (see Fried, 1975, p.42, for proper way to calculate mean ground water velocities through non-homogeneous media).

The coarse stratum, although only a small percentage of the total aquifer thickness, will carry the majority of the absolute volume of the dye. Once the dye is flushed from this coarse stratum, the high flux of untraced water from this stratum into the observation borehole will dilute the much later arrival of dye from the less permeable strata. Thus, the dye tracer technique as used by SEA Consultants to determine "average" permeability over the total thickness of the aquifer is only appropriate for truly homogeneous soils, and not for the highly stratified soils of the West Kennebunk sand plains.

The error resulting from Consultants' interpretation of dye tracer data is seen in the extraordinarily high values that they calculated for "average" permeability. To calculate ground water flux, one must know the true mean permeability over the thickness of the aquifer, if this is to be multiplied by aquifer thickness as part of the flux calculation. Mean permeability multiplied by aquifer thickness is the aquifer "transmissivity". SEA Consultants' calculated permeabilities of 4,060 to 13,000 feet per day cannot apply over the thickness of the aquifers for the following reasons:

a. The predominant soil in the aquifers is a poorly-graded medium to fine sand (Figure 3 shows typical grain size curves). The average permeability of fine to medium sand should fall in a range of 20 to 100 feet per day (e.g., see Lohman, 1972, p.53).

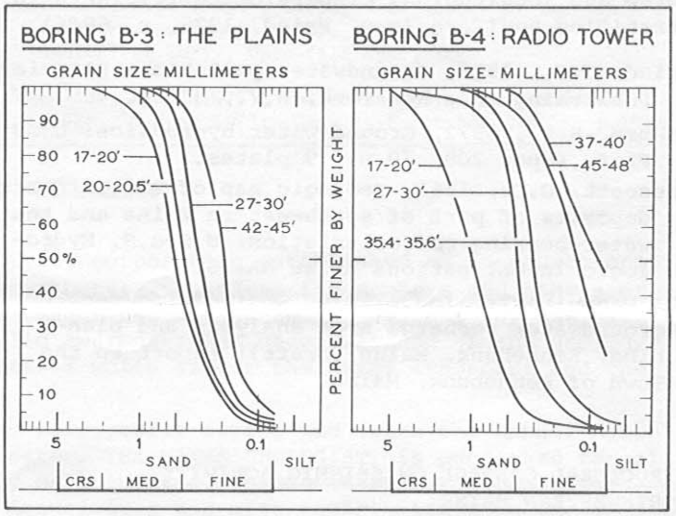


Figure 3. Typical grain size curves, with sample depths indicated for each.

b. The permeability values calculated by SEA Consultants are much higher than those found by pumping tests in high-yield gravel aquifers in Maine. The greatest permeabilities are usually found in eskers having much coarser material than the sand plains of Kennebunk. Permeability calculated from pumping tests in eskers ranges from 1,000' to 4,700' per day.

c. If the Kennebunk sand plains truly had average permeabilities of 4,060 to 13,000 feet per day, water wells placed in these deposits would have phenomenal yields on the order of 10,000 gallons per minute (if the wells were large enough to conduct the flow), whereas actual test wells in this area with which I am familiar produce only on the order of 10 to 20 gallons per minute.

d. The aquifer "productivity" calculated by SEA Consultants is higher than that theoretically possible, based on the recharge capability of the aquifer. Assuming Kennebunk's average annual precipitation is 43", this represents 2.2 gallons per minute per acre as an average. About 60% of precipitation, or 1.3 gallons per minute, will recharge well-drained sand and gravel aquifers.

(Please turn to Page 6)

AQUIFER TRANSMISSIVITY (Cont. from Page 5)

Even if one accepts SEA Consultants' unrealistically high estimates of recharge areas for each of the two aquifers, their estimates of "Productivity" are 3.7 times higher than the average recharge rate for the Radio Range Tower aquifer, and 10.8 times higher than the average recharge rate for The Plains aquifer.

The most accurate method of determining transmissivity of an aquifer is to conduct a pumping test on a well at the point of interest (Lohman, 1972, discusses transmissivity determination from pumping tests). Another approach is to measure the permeability and thickness of each of the strata of an aquifer by in-place constant or falling-head permeability tests (or by laboratory tests on undisturbed samples), and to calculate transmissivity as the sum of the products of each bed's permeability multiplied by its thickness. Although the dye tracer technique is not appropriate for determining average permeability in nonhomogeneous aquifers, with proper controls the technique is useful in determining local transverse and longitudinal dispersion coefficients in stratified aquifers (e.g, Fried, 1975, p. 68ff).

Fried, J.J., 1975, Groundwater pollution: Elsevier Publishing Co., New York, N.Y., 330 p.

Lohman, S.W., 1972, Ground-water hydraulics: USGS Prof. Paper 708, 70 p., 9 plates.

Prescott, G.C., 1963, Geologic map of the surficial deposits of part of southwestern Maine and their water-bearing characteristics: U.S.G.S. Hydrologic Investigations Atlas HA-76.

SEA Consultants, Inc., 1979, Engineering report, groundwater recharge area analysis and planning, Kennebunk, Maine (draft): report to the Town of Kennebunk, Maine.

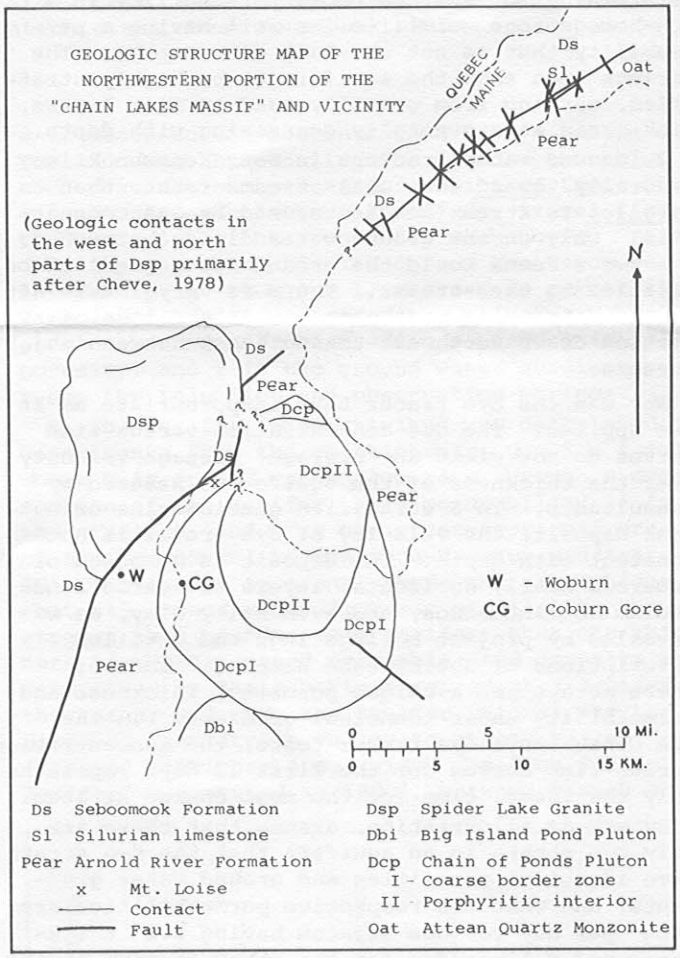
STRUCTURAL CONTROL ON SEISMIC ACTIVITY, NORTHWESTERN MAINE

By David S. Westerman
Department of Geological Sciences
University of Maine at Orono
Orono, Maine 04469

On June 15, 1973, an earthquake occurred along the Maine-Quebec border which was felt as far as 400 km. away. The maximum intensity (VI) was experienced by residents in and north of Woburn, Quebec, and the quake was reported to have a magnitude of 4.8 (Wetmiller, 1975). Mapping in the area was conducted during the summer of 1979 for the purpose of analyzing the structural setting which may have been conducive to this seismic activity, and a full report on that work is on open-file at the Maine Geological Survey (Westerman, 1980).

The study area is located at the western end of the "Chain Lakes massif" of Boone and others (1970) which marks the core of the Boundary Mountain Anticlinorium. Metavolcanics, gneisses and massive granulites of the Arnold River Formation are exposed along the northwestern margin of this Precambrian massif, being characterized by the ubiquitous presence of quartz "eyes" and lithic fragments. This unit is bounded to the north and west by Devonian metasediments of the Seboomook Formation, and the contact between these formations consists of northeasterly-trending segments offset by apparent left-lateral displacement along lineaments trending N 10-15° E.

The Arnold River Formation has been intruded by the Chain of Ponds Pluton, which is roughly circular (cylindrical?) and has sharp outer contacts. This pluton is concentrically zoned with an external coarse quartz monzonite border zone containing abundant large xenoliths. The vast majority of these xenoliths are gneisses of the Arnold River Formation, but serpentinized ultramafic xenoliths and, very importantly, relatively undeformed metasedimentary xenoliths (Dev.?) occur within this outer border zone. The inner zone of the Chain of Ponds Pluton consists of medium-grained, porphyritic granodiorite with hornblende and Na-rich feldspar pheoncrysts and accessory euhedral sphene. This central zone is younger than the coarse outer zone as evidenced by the presence of porphyritic granodiorite dikes in the coarse quartz monzonite, and cross-cutting intrusive relationships exposed in the northern portion of the pluton.



The following sequence of events is proposed to have led to the existing structural setting of the region:

1. The Arnold River Formation was deposited during the Precambrian in a region dominated by extensive, explosive volcanism, followed by deep burial, high grade metamorphism, uplift with retrograde metamorphism, and erosion.

2. Subsidence of the region during the Silurian and into the Devonian resulted in the deposition of sedimentary units on the Arnold River Formation.

3. The Arnold River Formation in the "Chain Lakes massif" rose as a solid block developing a normal fault along its northwest margin. This boundary was offset by "hinge" faults resulting from differential rates of uplift within the "massif".

4. During the rise of the "massif", the associated pressure reduction (augmented by the extensional faulting) caused melting at depth. The highest-level melts had quartz monzonite compositions and they rose in the vicinity of the "hinge" fault, through the gneiss by cylindrical fracturing and stoping.

5. Granodiorite melt from the lower levels migrated up the conduit prepared by the coarse quartz monzonite, forming the core of the Chain of Ponds Pluton. This same magma migrated up the north side of the boundary fault, following the conduit of an earlier granitic melt, to form the core of the Spider Lake Granite. The somewhat elongated and irregular shape of this latter pluton was due to the nature of the strongly foliated rocks which it intruded, primarily by forceful injection. (Alternately, the Spider Lake Granite may represent the downfaulted roof of the Chain of Ponds Pluton.)

6. Continued extensional activity of the "hinge" fault permitted the emplacement of younger dikes in its vicinity.

The geometric structure resulting from the proposed events can be described as two major tectonic blocks, each with radically different physical and mechanical characteristics, which are in near-vertical contact with "hinges" causing offsets in their boundary. Near-vertical, cylindrical plutonic masses, namely the Chain of Ponds Pluton and the Spider Lake Granite, are located on opposite sides of one such offset. These plutons are massive and relatively homogeneous in structure compared to the rocks in which they are enclosed. If regional stress is currently accumulating, it seems likely that it would be released in areas of such relatively simple geometry where structural discontinuities are concentrated. Despite this interpretation of the region having a higher-than-average probability for seismic activity, no evidence of post-glacial deformation of the bedrock was observed.

Boone, G.M., Boudette, E.L. and Moench, R.H. (1970), Bedrock geology of the Rangely Lakes - Dead River basin region, western Maine: in Boone, G.M. (ed), Guidebook for field trips in the Rangely Lakes - Dead River basin region, western Maine: 62nd NEIGC, p. 1-24.

Cheve, S.R. (1978), Geologie du sud-est des cantons de l'est: Min. Rich. Nat. Quebec, Rapport interimaire, 80p.

Westerman, D.S. (1980), Geologic structure of the Chain of Ponds Pluton and vicinity, northwestern Maine: Maine Geological Surv., Open-file Rpt., 36p.

Wetmiller, R.J. (1975), The Quebec-Maine border earthquake, 15 June 1973: Can. J. Earth Sci., v.12, p.1917.

MEMBERSHIP DUES STATEMENT

THE GEOLOGICAL SOCIETY OF MAINE, INC. is a non-profit Maine corporation established as an educational Society to advance the professional improvement of its members; to inform its members and others of current and planned geologic programs in Maine; to encourage continuing social contact and dialogue among geologists working in Maine; and to further public awareness and understanding of the geology of the State of Maine, and of the modern geologic processes which affect the Maine landscape and the human environment.

The Society holds three meetings each year, in the late fall, early spring and (with the Annual Meeting and sometimes field trips) in mid-summer. A newsletter, THE MAINE GEOLOGIST, is published for all members four times a year (more or less), approximately on a quarterly basis starting in September. The Society year runs from August 1st through July 31st. Annual dues and gift contributions to the Society are tax deductible. There are three classes of annual memberships:

$5 REGULAR MEMBER - Graduate geologists, or equivalent, with 1 year of practice in geology, or with an advanced academic degree in geology

$4 ASSOCIATE MEMBER - Any person or organization desirous of association with the Society

$2 STUDENT MEMBER - Persons currently enrolled as students in college who are interested in geology

$2 APPLICATION FEE - A one-time fee to all new members, payable when applying for membership

ANNUAL RENEWAL or APPLICATION FOR MEMBERSHIP - THE GEOLOGICAL SOCIETY OF MAINE

NAME ______________________________
(Please print or type)

ADDRESS ______________________________
(Permanent Mailing Address)

____

____
Zip Code

Regular Member $5 per year $________

Associate Member $4 per year $________

Student Member $2 per year $________

Application Fee $2 One-time $________

TOTAL ENCLOSED : $________

MAIL TO: FREDERICK M. BECK, TREASURER
The Geological Society of Maine
140 Main Street
Yarmouth, Maine 04096

Please make checks payable to:

THE GEOLOGICAL SOCIETY OF MAINE, INC.

BRITTLE FRACTURE & SEISMICITY (Cont. from Page 2)

Barosh (1978) suggested the possibility of a relationship between the existence of low, but persistent, seismic activity in the Dover-Foxcroft / Dexter area and the regional flexure of the underlying bedrock. The results of this study suggest a structural correlation between that flexure and the NW trending set of brittle fractures, which can be seen as the youngest deformational features in the area. Many of these fractures show evidence of left-lateral motion ("S" kinks) and extensional motion (quartz filling and down-dip movement perpendicular to the hinges of the kinks). The ages of these fractures is presumably great, and no evidence has been observed to indicate post-Pleistocene movement in the bedrock of the region. If the seismic activity is related to the reactivation of an ancient fracture system with a surface expression preserved, the youngest system (NW trend, left lateral) appears to be the most likely candidate.

A full report on this study is available on open-file at the Maine Geological Survey (Westerman, 1980).

Barosh, P.J. (1978), The Penobscot lineament zone, Maine: U.S. Nuclear Reg. Comm. Rpt., 51p.

Boston Edison Company (1976), Epicentral locations of historical earthquakes of intensity IV or greater and all instrumental events: Boston Edison Company, Pilgram Unit No. 2, 1:1,000,000 scale.

Pankiwskyj, K.A., Ludman, A., Griffin, J.R. and Berry, W.B.N. (1976), Stratigraphic relationships on the southeast limb of the Merrimack synclinorium in central and west-central Maine: Geol. Soc. Amer. Mem. 146, p. 263-275.

Westerman, D.S. (1980), Report on bedrock and brittle fracture mapping in the Dover-Foxcroft / Dexter area: Maine Geol. Surv., Open-file Rpt., 16p.

COMING EVENTS

May 2, '80 - GROUNDWATER CONFERENCE, at the Augusta Civic Center (Irwin D. Novak, Dept Earth Sci, Physics and Engin, USM, Portland, Maine 04103)

May 19-21, '80 - GEOLOGICAL ASSOCIATION OF CANADA / MINERALOGICAL ASSOCIATION OF CANADA, ann mtg and field trips, Halifax, N.S. (David J.W. Piper, Dept of Geology, Dalhousie University, Halifax B3H 4H6)

July 18-20, '80 - GEOLOGICAL SOCIETY OF MAINE, ann mtg in Presque Isle with Dickey-Lincoln area field trips (William H. Forbes, Div of Math and Sci, U of Me, Presque Isle, Maine 04769)

Aug. 18-20, '80 - AMERICAN QUATERNARY ASSOCIATION, biennial mtg at UMO with field trips before and after (Harold W. Borns, Dept Geol Sci, UMO, Orono 04469)

Oct. 11-13, '80 - NEW ENGLAND INTERCOLLEGIATE GEOLOGICAL CONFERENCE, Presque Isle, Maine (David C. Roy, Dept of Geology and Geophysics, Boston College, Chestnut Hill, Massachusetts 02167)

Spring '81 - NORTHEAST SECTION GEOLOGICAL SOCIETY OF AMERICA, Bangor (Walter A. Anderson, Maine Geological Survey, Augusta, Maine 04333 and Philip H. Osberg, Dept Geol Sci, UMO, Orono 04469)

DUES !! (APPLICATION-PAGE 7)

In keeping with past custom, DUES obligations are color-coded on your address label: White = paid-up; Yellow = Dues owed for 1979-80; PINK = DUES OWED for both 1979-80 and 1978-79. Write a check today.

THE GEOLOGICAL SOCIETY OF MAINE
c/o John R. Rand, Cundy's Harbor
RD2 - 210A, Brunswick, Maine 04011

THE MAINE GEOLOGIST is published four times a year, more-or-less, in September, late Fall, late Winter, and maybe June or July, for members of the Geological Society of Maine, a non-profit educational Maine corporation interested in all aspects of the geology of the State of Maine.

Correspondence about membership in the Society should be mailed to Frederick M. Beck, 140 Main St., Yarmouth 04096.

Items for inclusion in this Newsletter may be directed to J. R. Rand, Cundy's Harbor, RD2-Box 210A, Brunswick 04011.

U. S. POSTAGE
PAID
Permit No. 20
BRUNSWICK, MAINE
04011

NON-PROFIT ORGANIZATION

Address Correction Requested

DONALD KALE
Bureau of Geology
Dept. of Conservation
Augusta, Maine 04330

ANNUAL MEETING - PRESQUE ISLE / JULY
FIELD TRIPS - DICKEY-LINCOLN / 18-20