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Report on Advanced Science Seminar on Intertidal Zone Sedimentation, Minas Basin, Bay of Fundy, Nova Scotia, Canada, July 6 to August 11, 1968*

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Introduction

A research seminar "Intertidal zone sedimentation, Minas Basin, Bay of Fundy, Nova Scotia" was held in Parrsboro, Nova Scotia for more than five weeks in 1968 from July 6 to August 11, 1968. The seminar used the classrooms and science laboratory of the Parrsboro Regional High School to conduct its program. This was the first year that the seminar was given.

The seminar was attended by 12 graduate students in geology and oceanography from the United States and Canada. During the seminar, lectures were given by the staff, participants and visitors. Field trips were taken for observation and collection at four intertidal sand bars and a small area of gravel sedimentation. In addition, one-day trips were taken to the Canadian Rock Salt Mine at Pugwash, Nova Scotia, and the Atlantic Oceanographic Laboratory in Dartmouth, Nova Scotia. During the visit to Bedford, arrangements were made to visit the Russian Oceanographic Vessel, R. V. Mikhail Lomonosov, which was in Halifax obtaining supplies and fuel. The participants each completed 4 weeks of independent research on topics of their own choice.

The participants and staff felt the seminar was a great success. An important factor contributing to the success of the seminar was that July, 1968, was the sunniest month in the history of weather records in Nova Scotia.

Participants

Miss Julia C. Badal	U. of Pennsylvania	Geology
Jim L. Barr	U. of Cincinnati	Geology
V.K. Bedi	Rutgers University	Geology
Sherman M. Clebnik	Lehigh University	Geology
Menno G. Dinkelman	Oregon State U.	Oceanography
J. Ross McLean	U. of Saskatchewan	Geology
John V. Mrakovich	Kent State U.	Geology
Barham Parkash	McMaster U.	Geology
Eugene F. Pearson	U. of Wyoming	Geology
Clinton L. Sandusky	U. of Arizona	Geology
Frederick J. Swanson	U. of Oregon	Geology
Mrs. Mary C. Waitt	U. of Texas	Geology

Robert Evans, a graduate student at the University of Kansas, attended the lectures and joined the participants on four of the field trips.

Staff

The teaching duties of the seminar were shared by Dr. George deVries Klein, University of Pennsylvania, and Dr. G. V. Middleton, McMaster University. Paul R. Schluger, a graduate student at the University of Pennsylvania, served as a Teaching Fellow. Klein lectured on general problems of intertidal zone sedimentation, and the sedimentation of the Minas Basin intertidal zone. Middleton lectured on the theoretical basis of sediment transport in fluid media.

In addition, Dr. J. P. Nowlan, Deputy Minister of Mines of the Province of Nova Scotia, lectured on the geology of Nova Scotia, and Dr. B. R. Pelletier, Marine Geology Section, Atlantic Oceanographic Laboratory, lectured on the marine geology and geophysics of the Bay of Fundy.

Visiting lectures were given by Dr. D. G. Kelly, Geological Survey of Canada (Geology of the Cobequid Mountains), Dr. Raymond C. Murray, Chairman of the Geology Department at Rutgers University (Supratidal evaporite sedimentation), Dr. Paul E. Schenk, Dalhousie University (Supratidal dolomite in the Mississippian Windsor Group of Nova Scotia), and Dr. Daniel J. Stanley, Supervisor, Division of Sedimentology, Smithsonian Institution (Marine geology of the Scotian Shelf and slope).

*Manuscript received September 16, 1968

Activities

The last four weeks of the seminar were spent on individual research projects by participants. The participants submitted oral and written reports at the end of the seminar. Abstracts of these reports follow.

Abstracts

A Study of Second Order Ripples by Julian C. Badal, University of Pennsylvania:

An attempt was made to describe second order ripples, and to a lesser degree third order ripples, by study of the internal structure and the relationship of mean particle size and sorting of the sediment to size and angle of dip of crossbedding sets. No relationship was found between either mean size or sorting and size of the set from which the sample was taken. The relationship between mean size or sorting, and angle of dip seems to reflect only the general trend toward finer, better sorted sediment to the southeast across the study area.

The second order ripples were found to be simple forms composed of several crossbedding sets of very uniform angle with coarser layers at the base and within trough structures. The third order ripples, on the other hand, are complex composite forms.

Current Ripple Structures in an Intertidal Zone: Minas Basin, Bay of Fundy by Jim L. Barr, University of Cincinnati:

A gradation, based upon a plot of wavelength and amplitude on logarithmic paper, from asymmetrical current ripples to large scale current ripples exists with intermediate ripples including linguoid ripples, lunate ripples, and small scale ripples.

Orientation of long crested asymmetrical ripples, small current ripples, and large current ripples is determined by the last dominant current flow, usually the ebb-current flow direction, while the bar is submerged under a few tens of centimetres of water. Linguoid ripples, lunate ripples, and shortcrested asymmetrical ripples are oriented by both late stages of current flow and last stage runoff, the latter being governed by the slope of the bar.

Wave current ripples are formed by wave action and occur as a separate group when their size distribution is compared to the other sedimentary current ripple structures.

Cross-Stratification at Pinnacle-Long Island Flats, Five Islands, Minas Basin, Bay of Fundy, Nova Scotia by V. K. Bedi, Rutgers University:

Cross-stratification and grain-size variation study of the Pinnacle-Long Island Flats reveals that the orientation of the bedforms and cross-stratification is in the northwesterly direction in the western half of the flats. In the eastern half, orientation is mainly to the east and southeasterly direction; very few megaripples show a northwesterly orientation. Cross-stratification is well defined in coarse-grained sand in both megaripples and sand waves. It is simple in megaripples, being simple to very complex in sand waves.

Grain size ranges from medium-grained sand to coarse-grained sand from east to west on the flats, similarly the sediment is moderately-well to moderately sorted. Coarse-grained beds are steeply-dipping. There is a correlation between the cross-bed dip angle and the mean grain-size; dip increasing with increasing grain coarseness.

The cross-stratification is mainly due to north-westerly ebb current flow. In the eastern half, it may be due to a southeasterly counter eddy. Stronger northeasterly flood current flow and local topographic features, likewise, may have a role in some of the opposite-oriented bed-forms and cross-stratification.

An Attempted Correlation between the Occurrence of Mya Arenaria and Substrate Texture near Parrsboro, Nova Scotia by Sherman M. Clebnik, Lehigh University:

The pelecypod, *Mya arenaria*, is found in abundance within sediments bordering the mainland and islands about the Bay of Fundy near Parrsboro, Nova Scotia. Two small areas on two islands were selected for an attempted correlation between the distribution and abundance of *M. arenaria* and the texture of the substrate. One site contained predominantly gravelly sediment whereas the other varied from thick mud to gravel-rich sediment.

The clams were differentiated on the basis of size and on being alive or dead. This information was graphically compared to the mean grain size, sand-gravel ratio, and mud quantity, evaluated for samples from selected stations. The plots did not yield any distinct trends, and thus, it is concluded that distribution of *M. arenaria* is not being controlled by substrate texture within the two areas.

Migration of Bedforms by Menno G. Dinkelman, Oregon State University:

A study of the migration of bedforms was carried out on two sand bars on the northern shore of the Minas Basin in the Bay of Fundy. The time available proved to be too shore to be able to establish any relationship between rate of migration of bedform and associated textural parameters. These are probably not the decisive factors in the determination of the rate of migration. Other things to be considered are factors such as shear stress, internal structure of the sand body, current velocities at all stages of the tidal cycle and range of water depth throughout a tidal cycle and a lunar month.

Bedform Migration, Pinnacle-Long Island Flats, Minas Basin, Nova Scotia by J. Ross McLean, University of Saskatchewan:

Sand, which is the dominant textural group on the surface of Pinnacle-Long Island Flats, migrates over a relatively immobile pavement of gravel. This gravel, together with the flanking bedrock islands, control the gross topography and shape of the flats. Migration of major bedforms is controlled by tidal currents. Areas of both ebb tide domination and flood tide domination are present.

Bedforms migrate at average rates of 3.5 to 16.0 centimetres per tidal day, but for most bedforms, the rate is not constant. Some reversals of net migration occur. Rate of migration does not appear to be related to bedform amplitude, wavelength, sand sorting or tidal height and range, but increases with increasing mean grain size. The majority of bedforms migrate upslope.

Depth of scour of bedform crests range from 3 to 24 centimetres and constitute from 15 to 58 percent of the amplitude of the bedform. Greatest depths of scour occur in bedforms exhibiting the greatest amplitude, but the percentage of the bedform scoured increases with decreasing amplitude.

A Study of Cross-Stratification and Grain-Size Analysis on West Bar, Economy Point by John V. Mrakovich, Kent State University:

Cross-bedding and grain-size distribution were studied at West Bar at Economy Point. The area studied consisted of coarse-grained to medium-grained sand which is moderately to well-sorted. The bar shows an increase in grain size and a decrease in sorting in a northwesterly direction across it.

Cross-stratification of the megaripples is usually composite, consisting of a series of cross-bedded sets separated by a lower erosional surface. The cross-strata are planar, dip at the angle of repose, and are conspicuously graded where poorly or moderately sorted. The angle of dip of the cross-strata were found to increase as mean grain-size increased until the sand became very coarse-grained.

Trenches on the top of two sand waves revealed that reversed cross-bedding was preserved under the megaripple cross-bedding at the surface. The reversed cross-bedded sets were found to be very coarse-grained, contain low-angle cross-strata, and to form a maximum of 20 to 25 percent of all cross-bedding. Reversed cross-beds are probably formed on the lower stoss slope, trough and eroded lee slopes.

Grain-size analysis also showed that sorting becomes worse as mean grain-size increases, with the exception of samples from reverse cross-bedded sets; and that no relation exists between set thickness and mean grain-size.

Beach Sediments, Minas Basin, Bay of Fundy, Nova Scotia by Barham Parkash, McMaster University:

Beaches can be divided into two zones - foreshore and backshore. The foreshore is below ordinary high tide, whereas the backshore is above this point. The foreshore has a uniform slope. The slope of the foreshore is strongly controlled by grain size of the beach sediment. Slope of the foreshore increases with increase in the grain size of beach sediment. Grain size increases from sand to pebbles at the top of the foreshore to pebbles to boulders at the base of the foreshore. Sediment sorting is moderate at the top of the foreshore and is poor in the lower parts of the slope. Sediment is bimodal in the lower part of the foreshore.

The backshore is almost horizontal and is marked by one or more swash bars with 3 inches to 9 inches in height and one to two feet in width. The grain size of the swash bars is coarser than the mean size of backshore sediment.

Beach pebbles are mostly bladed to compact bladed irrespective of the composition. Disintegration of Triassic basalts tends to produce a high percentage of "elongated" particles. Wave action may produce a large percentage of broken well rounded particles, when the beach material is derived from the Pleistocene gravels.

Most of pebbles tend to align their long axes parallel to the strike of the beach. In a few cases, a fair number of pebbles may have their long axes in the beach slope direction.

Mud Deposition, Gravel Bar Movement, and Gravel Transport in Parrsboro Harbour, Nova Scotia by Gene Pearson, University of Wyoming:

During a three week period of the summer of 1968, several aspects of recent sedimentary processes were studied in Parrsboro Harbour, Nova Scotia. The research concerned mud deposition, gravel bar movement, and gravel transport aided by seaweed attachment.

Brown and reddish-brown mud forms a thin veneer over much of the area. The mud is derived from erosion of Pleistocene red clay. Laminated Pleistocene silt and clay underlies much of the recent mud, sand, and gravel deposits and crops out along the banks of many of the streams and channelways that drain the harbour during low tide. Outcrops of the red clay can also be found along the lower slopes of the marginal gravel complex and at the base of the cliffs along the northern side of the harbour.

A long rod-shaped gravel bar which stretches across the entrance to the harbour has been built eleven feet to the northwest since the summer of 1967. Gravel transport on the bar during a storm-free period indicated that build-up should be in the opposite direction if normal tidal currents are affecting the bar. It is concluded that increased wave action from the southeast, caused by winter storms, moves the bar in the northwesterly direction.

Sand Distribution from a Point Source by C. L. Sandusky, University of Arizona:

Sand transport based on observations at five stations on Big Bar, Five Islands, Nova Scotia shows the dominance of the ebb-current system. Sand grains of 0.00, 1.25 and 2.25 phi sizes were painted with Day-Glow paint and their transport observed from a point source. Transport in the ebb-current direction, which is to the west, ranged from 22' to 175' per two tidal cycles. The three stations showing ebb-current domination were on the eastern end of the bar, whereas the two stations showing effects of the flood currents were on the western end of the bar. These results show that the western end of Big Bar is being eroded away while a supply of sand is brought from the eastern end to the western end.

Transport of Pebbles by Algae, East Parrsboro Harbour, Nova Scotia by F. J. Swanson, University of Oregon:

In East Parrsboro Harbour, Parrsboro, Nova Scotia, float-bearing marine algae, principally Fucus, have several intriguing and quantitatively significant roles in sedimentation processes. Large plants may transport pebbles and small cobbles by combined float and drag effects. Ebb tidal currents move the weed-pebble complexes downslope, toward the open water of the Minas Basin. Some weed-pebbles become stranded on local upslopes where the plants assume a secondary role of baffles, stabilizing finer sediments, sand and fine gravel, which would otherwise by-pass the site.

In a more general sense, seaweed pebble transport is a mechanism which offers an explanation for some enigmatic, strikingly bimodal sediment size distributions.

The Crane Point Fan - Crescent Bar Complex, Parrsboro Harbour, Nova Scotia by Mary Beth Waitt, University of Texas:

The Crane Point fan is a gravel deposit forming from the reworking of two marginal bars of differing compositions. The crescent bar is finer grained than the fan, being derived from the erosion of crane Point shales, and decreases in grain size with increasing distance from the source.

The crescent bar is formed by longshore drift from west to east but is modified by eddy tidal currents from east to west. The bar as a whole is accreting landward.

Alternating well sorted cobble and pebble layers and poorly sorted granular gravels are being formed on the bar by the burial of storm deposited coarse material by tidal and wave formed ripple structures.

Reports were given on the following topics:

(1) Miss Jilia C. Badal - Diagnetic origin of hematite in Triassic red beds of Connecticut (Class report)
(2) J. L. Barr - Sedimentology of the Berea Sandstone of Ohio (PhD. dissertation)
(3) V. K. Bedi - Geology of the Simla Hills, India (Class report)
(4) S. M. Clebnik - Bryozoan growth forms as a function of environments (Class report)
(5) M. G. Dinkelman - Marine Geology of the eastern Pacific along the Oregon Coast (Cruise report)
(6) J. R. McLean - Stratigraphy and petrology of the Judith River Formation, Saskatchewan and adjacent areas (PhD dissertation)
(7) J. V. Mrakovich - Sedimentology of the Sharon Conglomerate of Ohio (MS thesis)
(8) Barham Parkash - Depositional mechanics of graywackes, Cloridorme Formation (Ordovician), Gaspé, Quebec (PhD dissertation)
(9) E. F. Pearson - Depositional environment of the Permian Forelle Limestone and Satanka Shale of Wyoming (PhD dissertation)
(10) C. L. Sandusky - Tidal flats and tidal lagoons of the Sonoran Coast, Mexico (MS thesis)
(11) P. R. Schluger (Teaching Fellow) - Sedimentology of the Perry Formation of New Brunswick and Maine (PhD dissertation)
(12) F. J. Swanson - Size and shape sorting of pebbles in the Elk River, southwestern Oregon (PhD dissertation)
(13) Mrs. Mary C. Waitt - Sedimentology of inland dunes, Kermit Dune Field, Winkler County, Texas (MS thesis)