NEW ENGLAND INTERCOLLEGIATE GEOLOGICAL CONFERENCE

GUIDEBOOK

for field trips in

Central New Hampshire and

Contiguous Areas

John B. Lyons
Glenn W. Stewart

Editors

63rd Annual Meeting
October 2 and 3, 1971
Concord, New Hampshire

Conference Organization

Herbert Tischler
Glenn W. Stewart
John B. Lyons
Dabney M. Caldwell, Secretary, New England Intercollegiate Geological Conference

Field Trip Leaders

Franz E. Anderson, University of New Hampshire, Durham, N.H.
Wallace A. Bothner, University of New Hampshire, Durham, N.H.
Russell G. Clark, Dartmouth College, Hanover, N.H.
Evan Englund, Dartmouth College, Hanover, N. H.
Henri E. Gaudette, University of New Hampshire, Durham, N.H.
Richard P. Goldthwait, Ohio State University, Columbus, Ohio
Robert C. Greene, U.S. Geological Survey, Menlo Park, Calif.
Carl Koteff, U.S. Geological Survey, Boston, Mass.
John B. Lyons, Dartmouth College, Hanover, N. H.
Richard S. Naylor, Massachusetts Institute of Technology, Cambridge, Mass.
Lincoln R. Page, U.S. Geological Survey, Boston, Mass.
Douglas Rumble III, University of California, Los Angeles, Calif.
Andrew F. Shride, U.S. Geological Survey, Denver, Colorado
Byron D. Stone, U.S. Geological Survey, Boston, Mass.
Daniel A. Sundeen, Chevron Oil Company, Midland, Texas
Herbert Tischler, University of New Hampshire, Durham, N.H.
J. Robert Wilson, Phillips Academy, Andover, Mass.
William W. Vernon, Dickinson College, Carlisle, Penn.

Requests for Guidebooks $3.00 (U.S.)

Dabney M. Caldwell, Boston University, Boston, Mass.
John B. Lyons, Dartmouth College, Hanover, N.H.
Herbert Tischler, University of New Hampshire, Durham, N.H.

TABLE OF CONTENTS

FOWARD

The purpose of the New England Intercollegiate Geological Conferences is to provide a field demonstration of work recently completed or currently in progress, primarily for the purpose of encouraging an exchange of ideas. We hope that the 63rd Annual Meeting will be stimulating in this respect.

Commencing with Billings' classic paper on the Littleton-Moosilauke area in 1937, the modern era has witnessed a vast effusion of literature on all aspects of the geology of New Hampshire culminating during 1951-1956 in a 3-volume summary, The Geology of New Hampshire; Part I Surficial Geology by J. W., L., and R. P. Goldthwait; Part II, Bedrock Geology by M. P. Billings; Part III Minerals and Mines by T. R. Meyers and G. W. Stewart. An up-dating and re-interpretation of the geology of New Hampshire is one of the major themes of the 1968 Studies of Appalachian Geology, Northern and Maritime, edited by E-an Zen, W. S. White, J. B. Hadley, and J. B. Thompson, Jr. It would seem that with all the attention, time and talent lavished upon New Hampshire its geological problems should largely be solved. If this Conference does nothing else, it should dispel that illusion.

The 1951 summary of the surficial geology of New Hampshire by the Goldthwaits was based upon reconnaissance studies covering the entire state, with detailed mapping along major valleys. Groundwater problems served as the impetus for surficial mapping in parts of southeastern New Hampshire by Edward Bradley (1964, U.S. Geological Survey Water-Supply Paper 1695), and till fabric studies have been carried out in the central part of the state by L. D. Drake (1968, Ph.D. Dissertation, Ohio State University). However, careful quadrangle-by-quadrangle investigations of glacial and surficial geology are just commencing in New Hampshire. Two of the 1971 NEIGC excursions (Trips A-1 by Goldthwait and B-4 by Koteff and Stone) will explore the progress made to date in refining our understanding of Quaternary history. Important by-products of these studies are an assessment of the State's major mineral resource, sand and gravel, and a better understanding of its rapidly mounting groundwater problems.

SKETCH MAP OF

MAJOR STRUCTURES IN

NEW HAMPSHIRE

Modified from Billings, 1956

KEY

White Mtn Plutonic – Volcanic Series

New Hampshire Plutonic Series

Ollverian Plutonic Serles

0 10 20 30

Scale in Miles

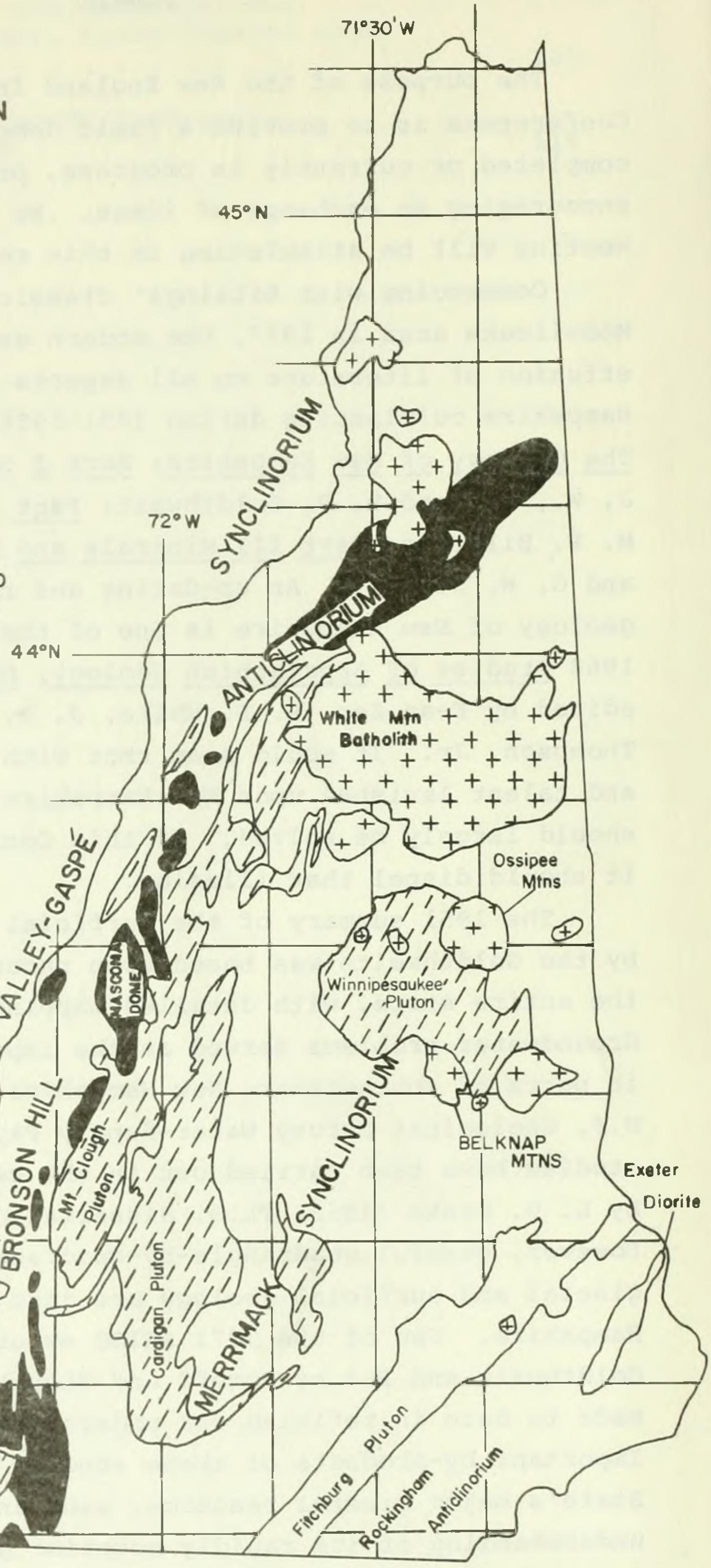


Figure 1.

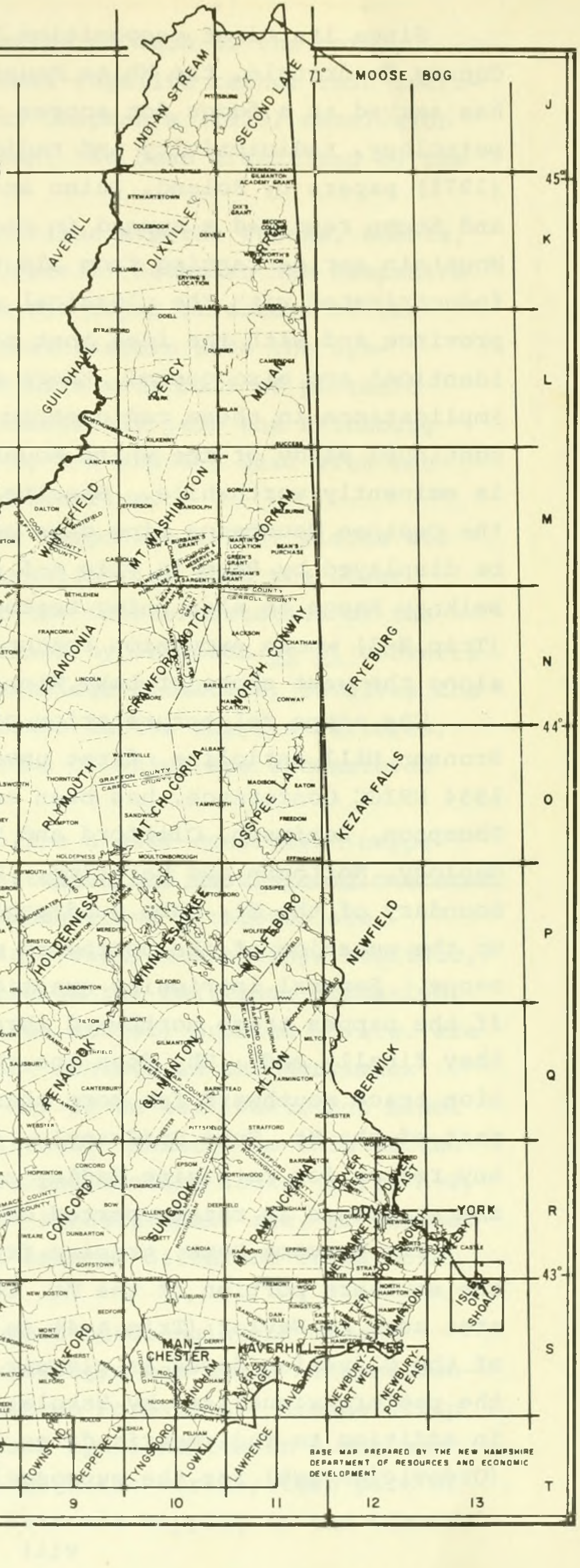
Figure 2.

LOCATION OF U.S. GEOLOGICAL SURVEY MAPS IN NEW HAMPSHIRE

Letters along the side and numerals across the top are for reference to quadrangle map locations.

U.S.G.S. Quadrangles may be purchased from the Geological Survey, Washington, 25, D.C. or from local stationery and book stores. When ordering maps from Washington use name reference as shown on map.

Maps of the same area on 2 scales. Wherever the same name applies to 2 or more maps covering the same area, an order should also include the series designation (7 1/2' Haverhill, 15' Haverhill).



Since its first recognition by Billings in 1928 in the North Conway Quadrangle, the White Mountain Plutonic-Volcanic Series has served as a focus for scores of studies of its structure, petrology, radioactivity and radiometric age. Only recently (1971) papers by Foland, Quinn and Giletti, and by Armstrong and Stump reported a spread in radiometric ages for the White Mountain series ranging from 218 to 100 m.y. To geologists indoctrinated with the classical concept of a petrographic province and with the idea that rocks which are petrographically identical are also coeval, there are some rather staggering implications in these radiometric dates, suggesting that the continued study of the White Mountain Plutonic-Volcanic Series is eminently worthwhile. Results of recent field studies in the Ossipee Mountains ring dike complex and adjacent areas will be displayed by Page in Trip A-5 and by Wilson on Trip A-8. The Belknap Range is also being restudied by Bothner and Gaudette (Trip B-3) whose excursion features some elegant new exposures along the west shore of Lake Winnipesaukee.

The nappe reinterpretation of the structure along the Bronson Hill anticline, first unveiled by J. B. Thompson at the 1954 NEIGC Conference, has been expanded and elaborated upon by Thompson, Robinson, Clifford and Trask in Studies of Appalachian Geology, Northern and Maritime. Their map stops at the southern boundary of the Mt. Cube Quadrangle where Rumble (Trip A-6) takes up the question of the northward extension of the Skitchewaug nappe. Several intriguing questions arise in the Mount Cube area. If the nappes trace northward through this quadrangle, where do they finally end? Why does the thick (5000 feet ?) Albee Formation trace southward for more than 100 miles into the northern part of the Mt. Cube Quadrangle, and terminate there? Is there any reason for retaining Hadley's (1942) Orfordville Formation if the structure is reinterperted on the nappe basis?

The Mascoma Dome, tracing from the Mascoma Quadrangle into the southern portion of the Mt. Cube Quadrangle is the type area used by Naylor (Trip A-4) to expound his interpretation of the Oliverian domes as classic mantled gneiss domes, fitting the pattern visualized by Eskola. Central to Naylor's argument, in addition to radiometric dates which show a Highlanderoft (Ordovician age) for the supposedly Lower Devonian Oliverian

Magma Series, is the reinterpretation of much of the core material of the Mascoma Dome as meta-rhyolite rather than intrusive granite, and the rejection of Chapman's (1939) conclusion that the Clough Quartzite (Silurian) has been granitized by the Mascoma Dome.

East of the Bronson Hill anticline are the stocks, sheets, and batholiths of the Middle to Upper(?) Devonian New Hampshire Plutonic Series which cut through the major structure of the Merrimack Synclinorium. On its southeastern side the synclinorium abuts against a 5 to 10 mile wide belt of plutonic and metamorphic rocks grouped collectively into the Fitchburg Pluton. Four excursions, A-2, A-3, B-2 and B-6 deal with the somewhat murky geology of the synclinorium.

Billings' Geologic Map of New Hampshire (1955) places all of the metamorphic rocks of the synclinorium into the Lower Devonian Littleton Formation, but the reinterpretation of the geology of the Bronson Hill anticline by Thompson et al converts some of the Littleton into the Partridge Formation, involves the Mt. Clough pluton of Bethlehem Gneiss in the nappe structures, and raises additional problems, some of which are encountered on these excursions.

Along the Bronson Hill anticline a self-consistent nappe interpretation is possible if quartzites and quartz conglomerates formerly mapped as Orfordville, Clough, and Littleton are considered to be Clough, and if dark rusty-weathering, sulfidic, graphitic, black schists are mapped as the Partridge Formation. This raises the c.b.s. (cruddy black schist) problem -- i.e. are all rusty sulfidic, graphitic black schists in the Merrimack synclinorium Partridge? If not, how do we tell Partridge black schists from those of other formations? Related to this is the question of whether calcareous metasedimentary rocks (Trips A-2, A-3, B-6) have a single assignable stratigraphic age, or whether they represent facies variants of several different formations and ages.

Vernon (Trip B-6) in the Concord Quadrangle and Greene (Trip A-2) in the Peterborough Quadrangle map their metasedimentary units as members of the Littleton Formation. Greene (Trip A-2) fixes the axis of the Merrimack synclinorium in a northeasterly trending line passing through the northwestern part of the Peterborough Quadrangle, and Vernon's mapping in the Concord

Quadrangle is consistent with the projection of this axis through the northwestern part of the Concord Quadrangle. From here it would extend northeasterly, passing through the Ossipee Lake Quadrangle (Wilson, Trip A-8), and meeting the Maine state line at a latitude of approximately 44° 00' N.

In contrast to the interpretation just cited, the Generalized Geologic Map of the Northern Appalachian Region by Zen, White, Hadley and Thompson projects an antiform of inverted(?) Ordovician rocks (Partridge?) from southwestern New Hampshire toward Concord, with its axis lying a few miles east of Green's projected trace of the Merrimack synclinorium. To say, then, that there is some current uncertainty concerning the structure of the synclinorium is to understate the problem. The structural complexity within the synclinorium itself is demonstrated by Englund in the Holderness Quadrangle (Trip B-2), where at least 2 and probably 3 cycles of deformation may be deciphered within the Littleton (?) formation. Here, as elsewhere, the black schist problem is both the hope and despair of a final resolution of structure and stratigraphy.

The largest body of the Kinsman Quartz Monzonite in New Hampshire is the Cardigan pluton, which is 60 miles long and up to 12 miles wide. Its origin has been controversial and this question, its possible relation to nappe structures, and its 3-dimensional shape (a surprisingly thin sheet) are the subject of Trip A-3 by Lyons and Clark.

The Fitchburg Pluton, a complex of metamorphic and igneous rocks up to 10 miles wide, extends from near the Maine border through the city of Manchester and into Massachusetts. Although two excursions were originally planned to examine the pluton in the Manchester and Suncook Quadrangles, neither trip materialized. Those on Trip A-2, however, are alerted to look closely at the Massabesic Gneiss, an extraordinarily coarse-grained sillimanite-potash feldspar gneiss on which R. P. Naylor (oral communication) has determined a tentative Rb-Sr Precambrian age. If the date is confirmed, it adds another complication to a belt of rocks generally considered to be in normal stratigraphic succession on the eastern limb of the Merrimack synclinorium, or on the western limb of the Rockingham anticlinorium. A confirmed Precambrian date on the Massabesic Gneiss would, of course,

suggest the possibility that it represents some of the root zone for nappes which may extend from here to western New Hampshire.

The Rockingham anticlinorium, in the Haverhill Quadrangle, is cut by a variety of intrusives related to the Hillsboro Plutonic Series which progress from granite (the oldest) to norite (the youngest). On Trip A-7 Sundeen will demonstrate the field criteria used to determine the igneous sequence, and will set forth his ideas on deep crustal melting as a mechanism for explaining the abnormal intrusive sequence.

At the boundary between southeastern New Hampshire and northeastern Massachusetts is the Newburyport pluton whose age has been variously assigned from the Precambrian to the Devonian, and whose relation to other plutonic groups in northeastern Massachusetts such as the Salem Gabbro-Diorite and the Dedham Granodiorite has long been controversial. In Trip B-5, Shride details the evidence which allows him (1) to delineate three variants within the Newburyport pluton, (2) to demonstrate that a major regional fault, the Scotland Road Fault, separates the Newburyport pluton from another group of diorites and quartz monzonites to the south, and (3) to show that these latter rocks are unrelated to either the Newburyport pluton or the Salem Gabbro-Diorite.

Finally, no series of geological field excursions should end without a bow to the oceans from whence, we are now told, all good geological things come. Anderson and Tischler (Trip B-1) will show to those lucky enough to clamber aboard ship (a nautical first for the NEIGC) the research they have been doing during the past two years in the tidal estuary of Great Bay.