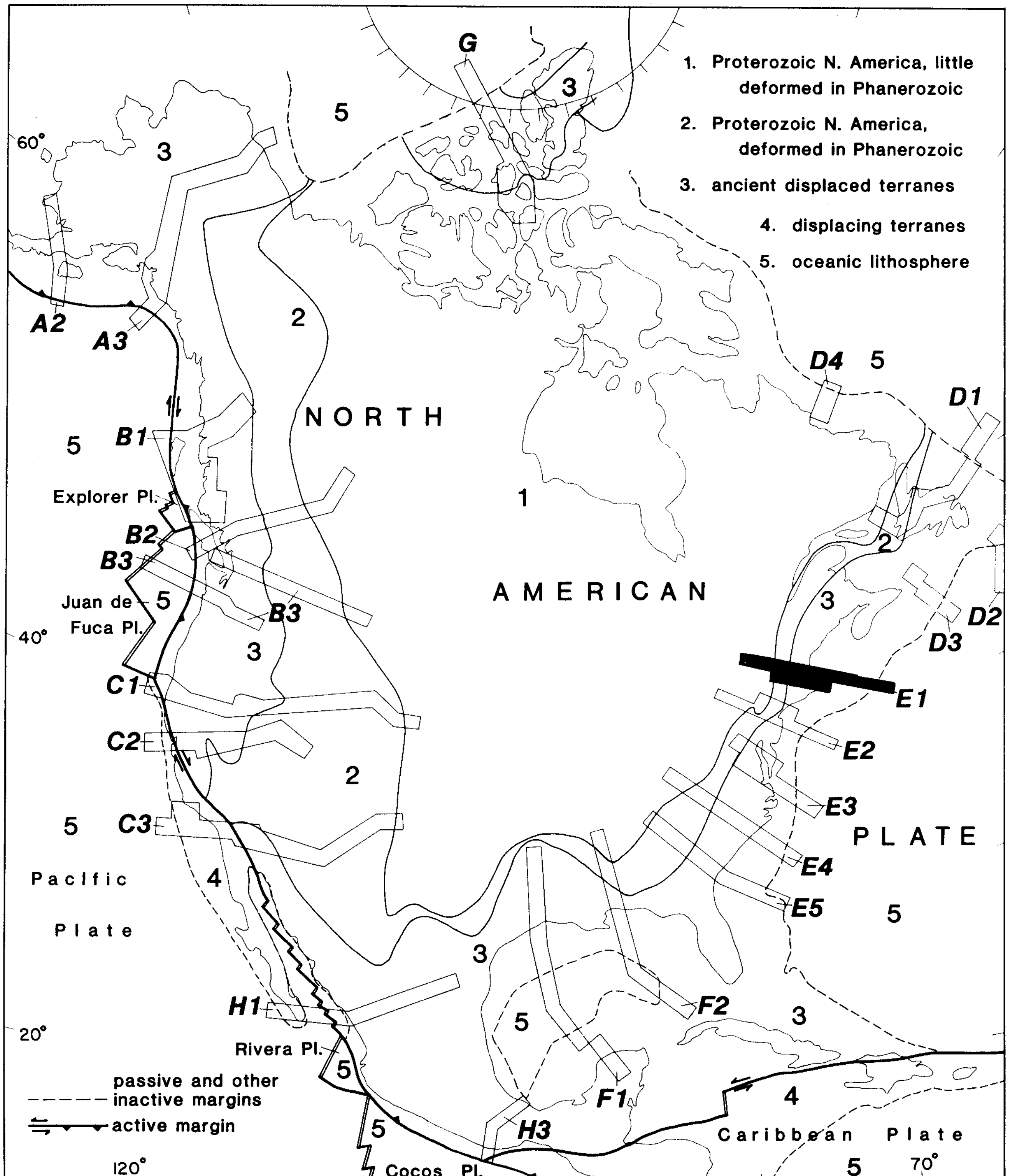
Centennial Continent/Ocean Transect #17
E-1 Adirondacks to Georges Bank

Centennial Continent/Ocean Transect #17

E-1 Adirondacks to Georges Bank

J. B. Thompson, Jr., W. A. Bothner, P. Robinson, and K. D. Klitgord
with contributions by
C. P. Fallon, A. M. Hussey II, D. R. Hutchinson, Y. W. Isachsen, P. Karabinos,
W.S.F. Kidd, P. W. Ollila, J. L. Rosenfeld, and J. S. Schlee,
and excerpts from the bedrock maps of New Hampshire, Massachusetts,
Connecticut, and Rhode Island.
R. C. Speed, Coordinator



The Geological Society of America

TRA-E-1

Centennial Continent/Ocean Transect #17
E-1 Adirondacks to Georges Bank

On the map sheet explanation:

Continent - Ocean Transect E-1

ADIRONDACKS TO GEORGES BANK

PREPARED BY

James B. Thompson, Jr., Wallace A. Bothner, Peter Robinson, Yngvar W. Isachsen, and Kim D. Klitgord

REGIONAL CONTRIBUTIONS:

ADIRONDACKS: Y. W. Isachsen, Paul W. Ollila, C. Page Fallon
TACONICS and HUDSON-CHAMPLAIN VALLEY: W. S. F. Kidd,
VERMONT: J. B. Thompson, Jr., Paul Karabinos, J. L. Rosenfeld
NEW HAMPSHIRE: New Hampshire Bedrock Map; J. B. Lyons, W. A. Bothner, R. H. Moench, J. B. Thompson, Jr., Compilers
MASSACHUSETTS: Massachusetts Bedrock Map; E-An Zen, Editor; R. Goldsmith, N. M. Ratcliffe, Peter Robinson, R. S. Stanley, Compilers
CONNECTICUT: Connecticut Bedrock Map: John Rodgers, Compiler
RHODE ISLAND: Rhode Island Bedrock Map; A. H. Quinn, Compiler, O. D. Hermes, L. P. Gromet
MAINE: A. M. Hussey, II
OFFSHORE: K. D. Klitgord, J. S. Schlee, D. R. Hutchinson, W. A. Bothner

A GUIDE TO CONTINENT OCEAN TRANSECT E-1

Adirondacks To Georges Bank

by

James B. Thompson, Jr.[1], Wallace A. Bothner[2], Peter Robinson[3], Yngvar W. Isachsen[4], and Kim D. Klitgord[5]

1. Department of Earth and Planetary Sciences, Harvard University, Cambridge, MA 02138
2. Department of Earth Sciences, University of New Hampshire, Durham, NH 03824
3. Department of Geology and Geography, University of Massachusetts, Amherst, MA 01003
4. Geological Survey and New York State Museum, Albany, NY 12230
5. U.S. Geological Survey, Woods Hole, MA 02543

CONTENTS

I. Introduction

The geologic strip-map for Transect E-1 cuts a swath from the Thousand Islands region on the New York-Ontario border to the Atlantic Ocean floor off Georges Bank (see Fig. 1). It includes portions of New York, Ontario and of all of the New England states. The western part, mainly in New York, belongs to the North American craton. The remainder of the onland portion, east of Logan's Line, belongs to the Appalachian Orogen.

Southeastward from Logan's Line the transect crosses a series of distinctive terranes. Several of these terranes are believed to be exotic, and to have been accreted to the North American craton during the Paleozoic. Superposed on these are several grabens and half-grabens containing early Mesozoic sediments and mafic volcanics. There are also Mesozoic eruptive complexes of an alkalic nature cutting across the Appalachian Orogen from southern Quebec, across New England, and continuing as a chain of seamounts offshore. Cenozoic rocks are limited to a small, but significant occurrence near Brandon, Vermont (BL on Fig. 2) and a few occurrences in the Cape Cod region and on the adjacent islands in southeastern Massachusetts.

Offshore the corridor passes over the Gulf of Maine and Long Island Platforms, thence across Georges Bank and into the North Atlantic Basin. The Gulf of Maine and Long Island Platforms (Fig. 2) are underlain by Paleozoic metamorphic and plutonic rocks and early Mesozoic grabens, as in the adjacent onland regions, but are partially covered offshore by a 1-3 km section of late Mesozoic and Cenozoic sediments, and by a veneer of Pleistocene moraine and other glacial deposits. A broad, late Mesozoic sedimentary basin lies beneath Georges Bank and overlies a complexly rifted basement. A Mesozoic carbonate shelf-edge facies bounds the seaward side of Georges Bank, and is succeeded to the southeast by a deep water sedimentary wedge overlying the ocean floor in the adjacent part of the North Atlantic Basin.

The onland bedrock geology, as recorded on the strip map, represents the labors of scores of workers over many decades. Much of the mapping has been done by faculty members and graduate students at a number of universities, mainly in the northeast. There have also been extensive contributions from the New York State Museum (Isachsen and Fisher, 1970), the geological surveys of Vermont (Doll and others, 1961), New Hampshire (Billings, 1956; Lyons and others, 1986), and Maine (Osberg and others, 1985; Hussey, 1985), and by the U.S. Geological Survey (Thompson and others, 1990), partly in collaborative cooperation with state agencies in Massachusetts (Zen and others, 1983), Rhode Island (Hermes and others, 1990), and Connecticut (Rodgers,1985).

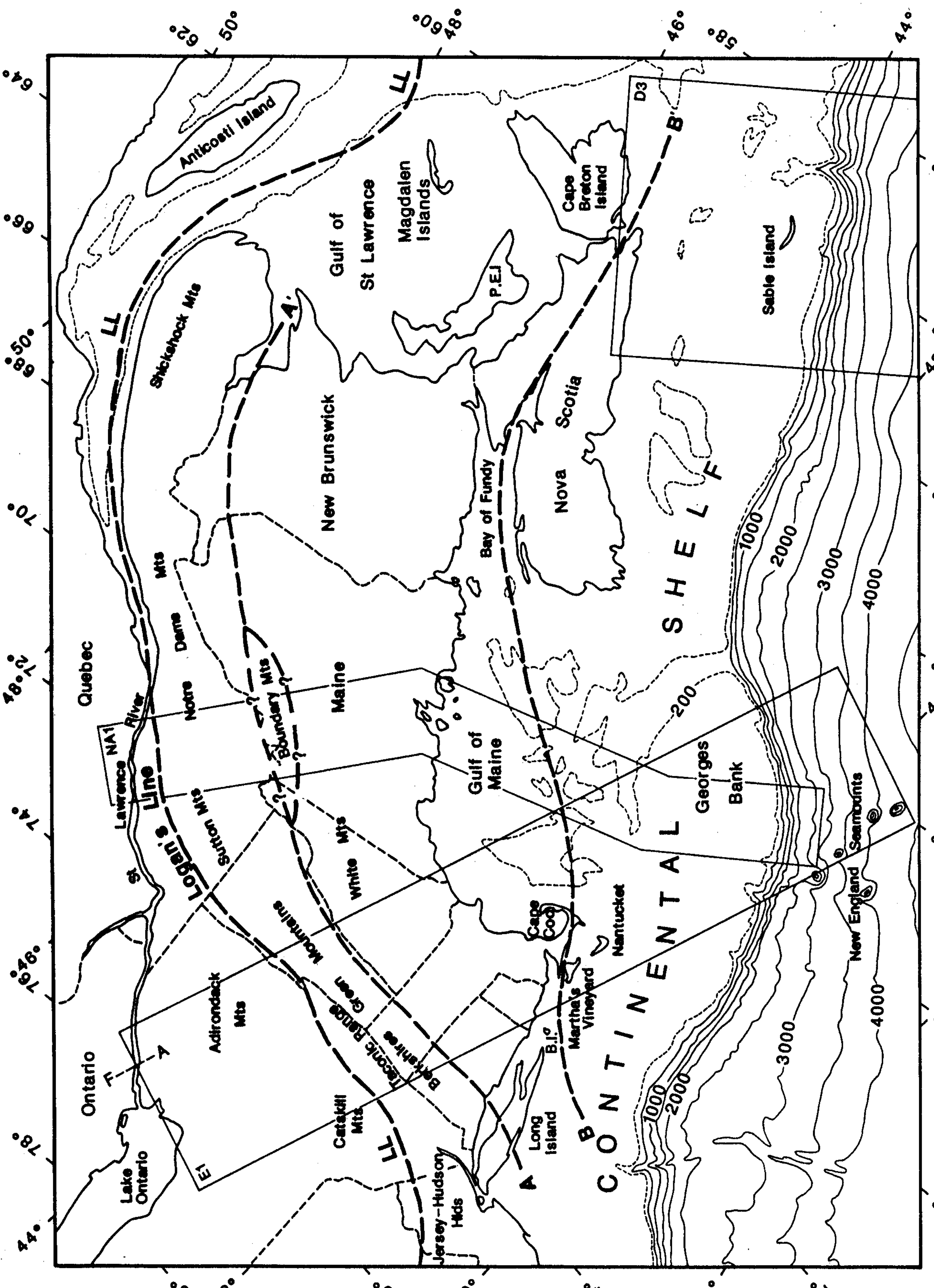

Anticosti Island
LL
Gulf of St Lawrence
Magdalen Islands
Cape Breton Island
D3
B'
Sable Island
P.E.I
A'
Shickshock Mts
New Brunswick
Nova Scotia
Bay of Fundy
Quebec
Notre Dame Mts
Maine
Boundary Mts
NA1
St Lawrence River
Logan's Line
Sutton Mts
White Mts
Gulf of Maine
Georges Bank
Seamounts
New England
Cape Cod
Nantucket
Martha's Vineyard
B.I.
Green Mountains
Taconic Range
Berkshires
Adirondack Mts
Ontario
F
A
Catskill Mts
Long Island
Jersey-Hudson Hlds
Lake Ontario
E1
B
A
CONTINENTAL SHELF
200
1000
2000
3000
4000
50°
48°
46°
44°
42°
40°
38°
78°
76°
74°
72°
70°
68°
66°
64°
62°
60°
58°

Figure 1. Topography, related studies and some major geologic lineaments: E-1 is the area of this transect; D-3 is that of Keen and Howarth (1985); NA-1 is that of Stewart and others (1989). Frontenac Arch (FA) and Logan's Line (LL). Line A-A' separates occurrences of 100 Ma Grenvillian basement (to NW) from 600 Ma Avalonian basement (to SE). Line B-B' separates the Avalonian Terrane (to NNW) from the Meguma Terrane (to SE). Offshore contours are at 500 m intervals except for the 200 m contour (dashed).

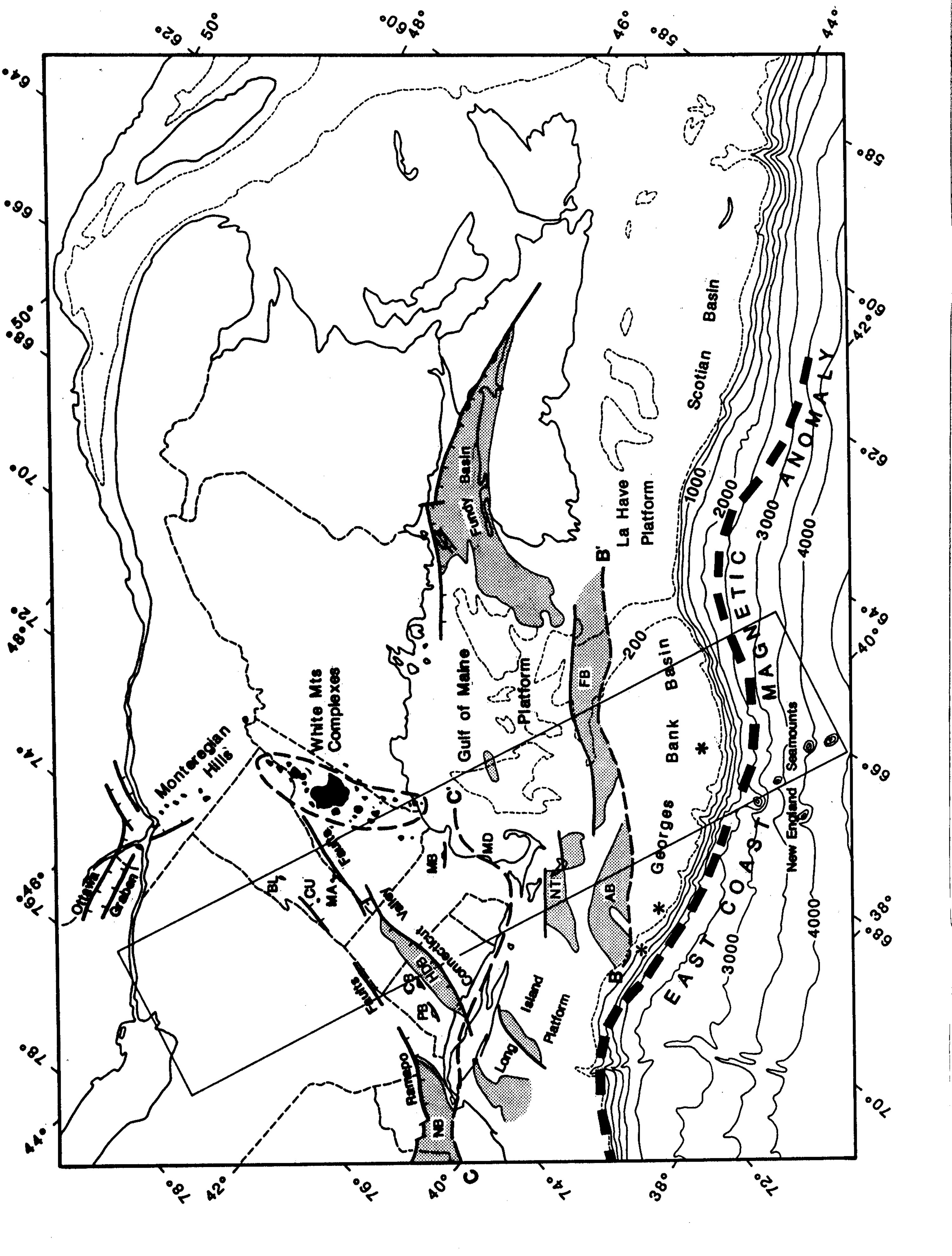

Ottawa Graben
Monteregian Hills
White Mts Complexes
Gulf of Maine
Platform
Fundy Basin
La Have Platform
Scotian Basin
Georges Bank Basin
Long Island Platform
Connecticut Valley
Ramapo
Faults
NB
HDB
CB
PB
BL
CU
MA
MB
MD
NT
AB
FB
B
B'
C
C'
EAST COAST MAGNETIC ANOMALY
New England Seamounts
200
1000
2000
3000
4000

Figure 2. Post-Alleghanian features (Cenozoic and Mesozoic): Postrift features include the Georges Bank and Scotia Basins, each with a carbonate bank on its seaward side. Line B-B', offshore, is the basement hinge zone. Line C-C' is the northwest limit of postrift coastal plain sediments. The Monteregian and White Mountain plutonic-volcanic complexes are shown in black. The Monteregian complexes and the younger (Cretaceous) White Mountain Complexes are post-rift as are the New England seamounts. The earlier White Mountain complexes (Jurassic-Triassic) are synrift or earliest post-rift, and are entirely enclosed (with some of the younger ones) in the dashed oval extending from southern Maine into northern New Hampshire. Also shown are the synrift Newark (NB), Hartford-Deerfield (HDB), Fundy, Nantucket (NT), Atlantis (AB), and Franklin (FB) Basins (all stippled) and some of their associated fault systems, as well as the smaller Pomperaug (PB), Canton City (CB) and Middleton Basins (MB). Additional synrift basins occur beneath thick glacial drift on Nantucket and adjacent islands and elsewhere on the the continental shelf (see display panels). Brandon Lignite (BL); buried seamounts are shown by asterisks; Mount Ascutney (MA); Cuttingsville Stock (CV); Marshfield-Duxbury area (MD).

Offshore data come from two main sources, a grid of geophysical profiles (magnetics, gravity, and multichannel seismic reflection profiles) and well logs from two COST (Continental Offshore Stratigraphic Test) wells, plus several shallow holes, and bedrock samples obtained from the submarine canyons that indent the south side of Georges Bank. Gravity, magnetic, and seismic reflection profiles have helped define the configuration of the basement and the boundary between oceanic and continental crust. Correlation of the seismic reflection profiles with well logs has been used to study the nature of the basin fill, and has made it possible to correlate major sedimentary units with those in other basins along the Atlantic margin. The offshore data have been acquired during a series of studies by the U. S. Geological Survey, Woods Hole, MA, the Woods Hole Oceanographic Institution, and other cooperating agencies. The results of these studies have been summarized by Schlee and Klitgord (1988), Klitgord and others (1988) and by Hutchinson and others (1988).

The gravity map of the area (Panels 7 and 8) encompassed by the E-1 transect was computer-generated from an updated data set covering the northeastern United States and adjacent Canada compiled by Bothner and others (1980, and references therein). Some 16,000 gravity stations on and offshore are included. Station spacing is variable: onshore, generally 2-3 km; offshore, 5 -10 km except along ship track lines where gravity data were collected at about 1 km spacing (5 minute intervals, see Simpson and others, 1981 for details). Complete Bouguer gravity, with computer terrain corrections applied from 167 to 0.895 km of the station, is mapped at 2 Mgal intervals onshore, and free air gravity, at 5 Mgal intervals, offshore.

Aeromagnetic data are from U. S. Geological Survey (Klitgord and Behrendt, 1979; Behrendt and Klitgord, 1980; Zietz and others, 1980). Deep seismic profiling across New York and New England by COCORP (Ando and others, 1983, 1984), across the Gulf of Maine (Hutchinson and others, 1988), and the travel-time residuals of Taylor and Toksoz (1982) and of Taylor and others (1980) have been used to constrain the cross-sections A-A' and B-B'. Heat-flow data of Birch and others (1968) and of Jaupart and others (1982) are plotted on the gravity map. Abbreviated geographic or geologic names, shown in parentheses in the text, are plotted on appropriate plates and figures for location purposes.

Acknowledgments: We wish to thank the members of the advisory committee: C. J. Ando, L. D. Brown, A. M. Dziewonski, P. C. England, G. W. Fisher, P. Karabinos, W. S. F. Kidd, J. B. Lyons, R. S. Naylor, N. M. Ratcliffe, J. L. Rosenfeld, J. S. Schlee, R. S. Stanley, and N. M. Toksoz for their advice and encouragement. An initial grant from the Joint Oceanographic Institutions is gratefully acknowledged. We also wish to give special thanks to D. W. Rankin, J. L. Rosenfeld, Jane Selverstone, R. C. Speed, D. B. Stewart, and M. R. Van Baalen for their many helpful comments on the manuscript at various stages during its preparation. Startup funds were provided by Subcontract P.O. 28508, sponsored by the Woods Hole Oceanographic Institution, under a grant from Joint Oceanographic Institutions, Inc., for "Regional Data Syntheses of Area III, North of New England Seamounts".

II. Synopsis in Space and Time

The cratonal basement rocks exposed in the area of the Transect belong to the Grenville Province (1,000 Ma) of the Canadian Shield. The principal area is in the Adirondack Mountains, a broad dome or foreland massif that was formed in Phanerozoic time, and that is connected to the main Canadian Shield, through the Thousand Islands region, via the Frontenac Arch (Fig. 1). South and east of the Adirondacks to Logan's Line the basement is overlain by nearly flat-lying Paleozoic sediments ranging in age from Late Cambrian to Late Devonian.

Logan's Line, extending south through northwestern Vermont and east-central New York marks the northwestern boundary of the deformed belt of the Paleozoic Appalachian Orogen. The rocks southeast of Logan's Line record a history of the rifting of an ancient supercontinent, commencing late in the Proterozoic, and followed by the formation of a passive continental margin on the western shore of a Proto-Atlantic or Iapetus Ocean, that persisted until the early Middle Ordovician This margin became an active one as Iapetus began to close during the latter part of the Ordovician. The first major deformational event was the Taconian Orogeny, but activity continued throughout much of the remainder of the Paleozoic. Tectonic events during this active era included the accretion of island arc material and of several fragments of exotic basement terrane. The accretionary events culminated during the mid-Devonian in a collisional event, the Acadian Orogeny. By the end of the Devonian the extensive Avalon Composite Terrane (600-700 Ma basement) of coastal New England and the Maritime Provinces of Canada, and the Fennoscandian or Baltic craton, were both firmly welded to the North American craton forming Laurasia. The post-Acadian pattern of terranes, however, was further modified by major strike-slip movements during the Carboniferous, and by a late Permian compressional event, probably caused by the final suturing to Laurasia of the African Meguma Terrane (now visible on land only in Nova Scotia) during the Alleghanian Orogeny. New England, however, appears to have been affected by strong, post-Acadian Paleozoic activity only in the southeast and near-coastal regions, in marked contrast to the Central and Southern Appalachians, where Alleghanian deformation extended over 200 km inland.

At the beginning of the Mesozoic, North America was briefly part of a second supercontinent, Pangaea. Rifting began again during the Triassic, however, and by the Middle Jurassic a new passive margin was created that has continued to the present with the formation, through continued spreading, of the modern North Atlantic Ocean. The early stages of this rifting in the New England region were marked by extensional faulting and mafic volcanism in the Connecticut Valley region (Fig. 2), and also in the Bay of Fundy and its southwestward extension beneath the Gulf of Maine. During the later stages of rifting, and during the early stages of seafloor spreading, a series of plutonic-volcanic centers developed extending from the Ottawa Valley across the Eastern Townships of Quebec to the New England coast (Fig. 2). The New England seamounts and also some intrusive centers buried beneath Georges Bank probably represent the offshore extension of this Late Cretaceous igneous activity. We therefore have a record of geologic events, including several periods of tectonic activity, that extends back into the Proterozoic. Although some remnants of the earliest records are easily read, much has been lost by erosion, burial or tectonic and metamorphic reworking. Late features are superposed on earlier ones, so to confuse and confound the interpretation of the latter. Geologic history is thus most easily deciphered and read from the end, rather than from the beginning. We shall therefore abandon the usual sequence followed by textbooks and work our way back, stepwise, through geologic time. By removing the veil of a later event we may appreciate more clearly what remains of an earlier one. The natural breaks for this stepwise examination are at the major tectonic events: the opening of the Atlantic, and the earlier Alleghanian, Acadian, Taconian, Avalonian, and Grenvillian orogenies that are known to have affected this region.

The New York-New England Appalachians, thanks in part to the many centers of learning scattered among them, have been the subject of several plate tectonic interpretations, most of these concerned primarily with Acadian and earlier events. Notable among them are those of Bird and Dewey (1970), Osberg (1978, 1983), Robinson and Hall (1979), Rankin (1975, 1976), Rankin and others (1988), Zen (1983, 1989) and Skehan (1988). Rast (1988) has recently provided an interpretation of Alleghanian-Variscan events, and overall syntheses have been provided by Gromet (1989) and Keppie (1985, 1989). Adjacent transects (Fig. 1) related to this one are D-3 by Keen and Haworth (1985) to the north, E-2 by Drake and others (1986a, 1986b, and in preparation) just to the south, and a new transect by Stewart and others (1989) just to the north. Although these syntheses and reconstructions have much in common, there are also significant differences. Geologic interpretation, even in well-studied areas, can never be certain in all respects. We offer below our own version.