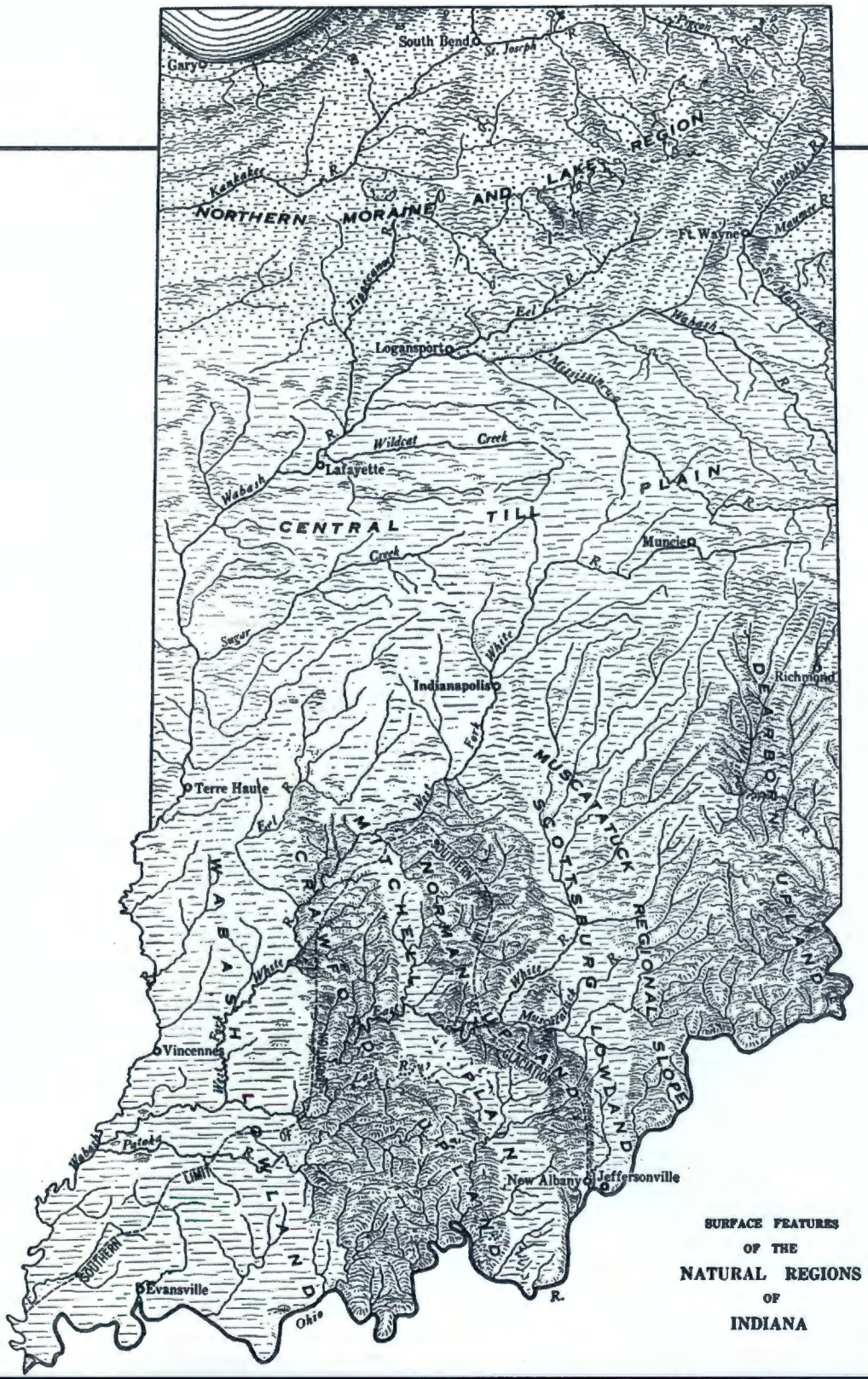
PHYSIOGRAPHIC DIVISIONS OF INDIANA

Special Report 61



INDIANA UNIVERSITY
INDIANA GEOLOGICAL SURVEY

STAFF OF THE INDIANA GEOLOGICAL SURVEY

Administration (812 855-5067)
John C. Steinmetz, Director/State Geologist
John R. Hill, Associate Director
Susan McGlocklin, Administrative Secretary
Charlotte A. Smith, Business Manager
Helen Stephenson, Financial Records Assistant
Amanda Wilson, Certification Coordinator

Basin Research Coordinator (812 855-4213)
Brian Keith, Petroleum Geologist

Education Extension (812 855-7636)
Jeff Kirby, Education Specialist

Energy Resources Section (812 855-5412)
John A. Rupp, Geologist and Head
Jerry R. Burton, Geologic Technician
James T. Cazee, Cartographic Specialist and Geologic Draftsman
Sherry Cazee, Sample and Core Library Supervisor
Erik Kvale, Sedimentologist
Maria Mastalerz, Coal Geologist
Todd Thompson, Sedimentologist
Charles W. Zuppann, Petroleum Geologist

Environmental Section (812 855-7428)
Edwin J. Hartke, Geologist and Head
N. K. Bleuer, Glacial Geologist
Steve Brown, Glacial Geologist
John Haddan, Field Laboratory Technician
Denver Harper, Environmental Geologist
Nancy Hasenmueller, Environmental Geologist
Jennifer Olejnik, Geologist
Carl B. Rexroad, Paleontologist
Julie Salter, Database Coordinator

Geochemistry (812 855-2687)
John B. Comer, Head
Tracy Branam, Geochemist
Marilyn DeWees, Secretary
Margaret V. Ennis, Geochemist
Ronald Smith, Geochemist

Geophysical Research (812 855-7428)
Ray René, Geophysicist

Mineral Resources Section (812 855-2687)
Henry L. Barwood, Head
Marilyn DeWees, Secretary
Walter A. Hasenmueller, Geologist
Kathryn R. Shaffer, Mineral Statistician
Nelson R. Shaffer, Geologist

Photography Section (812 855-1370)
Barbara T. Hill, Head
John Day, Photographic Specialist

Physical Facilities and Services Section (812 855-3596)
Sam Frushour, Head
Jay Arnold, Drilling Foreman
Sam Riddle, Driller

Technology Transfer Section (812 855-3951)
Richard T. Hill, Head
Deborah DeChurch, Editor
Janis Fox, Senior Office Manager
Kathleen Griffin, Network Support Specialist
David Held, Cartographic Specialist
Paul Irwin, GIS/Database Analyst
Karen Like, Cartographic Specialist
Wei Qin, Database Developer/Administrator
Kimberly Sowder, Cartographic Coordinator
Donna Webb, Secretary

Contract Personnel
Carol Conolly, Coal Resources Specialist
Chris Dintaman, Geologist/GIS Specialist
Nathan Eaton, Geotechnical Systems Analyst
John Johnston, Geologist, Research Associate
Mike O'Neal, Geologist
Robin Rupp, Database Manager
Neal Schroeder, Systems Analyst/Programmer
Kevin Spindler, Computer Modeler
Licia Weber, Geologist
Alex Zlotin, GIS Analyst/Programmer

Research Affiliates
Lewis M. Brown
John B. Droste
Henry H. Gray
Norman C. Hester
Noel Krothe
Greg Olyphant
Richard Powell

For sale by Publication Sales, Indiana Geological Survey,
611 N. Walnut Grove, Bloomington, Indiana 47405
Phone: 812 855-7636
Fax: 812 855-2862
Web site: http://www.indiana.edu/~igs
For information, e-mail: IGSinfo@indiana.edu

Physiographic Divisions of Indiana

By Henry H. Gray

INDIANA UNIVERSITY
INDIANA GEOLOGICAL SURVEY SPECIAL REPORT 61

BLOOMINGTON, INDIANA: 2000

AUTHOR

Henry H. Gray retired as Head Stratigrapher of the Indiana Geological Survey after many years of service; at present, he is a research affiliate of the Survey.

Front cover: One of the earliest physiographic maps specifically of Indiana, from J. E. Switzer, The Geography of Indiana, Ginn and Co., (1937; fig. 4). Physiographic divisions are those of Malott (1922).
Back cover: Hill-shaded relief map of Indiana, derived from U.S. Geological Survey digital elevation models by Alex Zlotin of the Indiana Geological Survey.

CONTENTS

Introduction 1
1. Northern Moraine and Lake Region 1
1a. Lake Michigan Border 2
1b. Valparaiso Morainal Complex 3
1c. Kankakee Drainageways 3
1d. St. Joseph Drainageways 3
1e. Plymouth Morainal Complex 3
1f. Warsaw Moraines and Drainageways 3
1g. Auburn Morainal Complex 4
2. Maumee Lake Plain Region 4
2. Maumee Lake Plain 4
3. Central Till Plain Region 5
3a. Bluffton Till Plain 5
3b. Iroquois Till Plain 5
3c. Tipton Till Plain 6
3d. New Castle Till Plains and Drainageways 6
3e. Central Wabash Valley 6
4. Southern Hills and Lowlands Region 7
4a. Wabash Lowland 7
4b. Boonville Hills 7
4c. Martinsville Hills 8
4d. Crawford Upland 8
4e. Mitchell Plateau 8
4f. Norman Upland 9
4g. Scottsburg Lowland 10
4h. Charlestown Hills 10
4i. Muscatatuck Plateau 10
4j. Dearborn Upland 11
Topography of the Buried Bedrock Surface 11
Acknowledgments 14
References 14
Appendix 1. Approximate areas of the physiographic divisions of Indiana 15

ILLUSTRATIONS

Figure
1 Sketch maps showing generalized flow direction of the several ice streams that made up the Wisconsin glacier in Indiana 2
2 Map of Indiana showing bedrock topography and topographic divisions of the buried bedrock surface north of the Wisconsin glacial boundary 13

PLATES

Plate
1 Map of Indiana showing physiographic divisions ..... back pocket

THIS PAGE INTENTIONALLY LEFT BLANK

PHYSIOGRAPHIC DIVISIONS OF INDIANA

By Henry H. Gray

INTRODUCTION

It has now been more than 70 years since C. A. Malott (1922) definitively outlined the physiographic regions of Indiana. Earlier observations, for example, by Newsom (1898), Dryer (1912), Leverett and Taylor (1915), and Fenneman (1917), along with earlier work by Malott himself, were incorporated into his treatise. Relatively minor revisions have since been suggested by Wayne (1956) and Schneider (1966).

Since Malott's time, complete topographic coverage of Indiana at 1:24,000 scale has become available and advances have been made in knowledge and understanding of Indiana geology, particularly of the glacial geology of the northern two-thirds of the state. Aerial photographs at several scales are available for the entire state, and the soils in every county have been mapped in detail. It is not possible to cite all these resources, but they make it appropriate to revise and refine Malott's concepts of the physiographic regions of Indiana. I do not, however, offer as exhaustive a discussion as did Malott.

The physiographic sections defined and described below are grouped into four regions (Plate 1). The northernmost region is essentially the Northern Moraine and Lake Region of Malott (1922), somewhat differently subdivided. The topography of this region is almost entirely the result of glacial action, and because the drift is thick, no exposures of bedrock are known in the entire region. A small part of the Maumee Lake Plain Region, which is extensive in northwestern Ohio, reaches into northeastern Indiana. The Central Till Plain Region, essentially the Tipton Till Plain of Malott, is for the first time subdivided into several sections. Here also glacial influence is dominant, but the drift is thinner and in many places, especially along streams, bedrock appears at or very near the surface. In the definition and classification of these three regions I have been guided in many details by the work of Fleming and others (1994).

The Southern Hills and Lowlands Region, that part of the state that has not been profoundly affected by the latest (Wisconsin) glaciation and in which bedrock is at or near the surface in much of the region, is subdivided into sections that for the most part are refinements of Malott's regions. All names for the sections, including those newly defined here, were chosen from prominent geographic features—towns, counties, lakes, or rivers.

Homoya and others (1985) have defined Natural Regions of Indiana that are in some places more or less congruent with the physiographic sections herein described. The Natural Regions are defined by biological assemblages and are influenced, therefore, by other underlying factors as well as topography—climate, soils, and drainage, for example—and so the coincidence is not complete. Comparison of Homoya's map (1985, pl. 1) with the map presented here (Plate 1) provides the best way to evaluate the correspondences, but in the text that follows, reference is made in those places where the physiographic and natural regions are most similar.

1. NORTHERN MORAINE AND LAKE REGION

This region is nearly coincident with Malott's (1922) Northern Moraine and Lake Region, and although it includes tracts of lake plain and large areas of outwash, it is dominantly morainic and contains within its borders almost all of Indiana's natural lakes. It is appropriate, therefore, to retain Malott's name. The topography of this region has been created almost entirely by depositional and erosional action of the latest, or Wisconsin, glaciation. The physiographic sections described below differ from the sections described by Malott, mainly through better understanding of the three glacial lobes that built the present topography.

Even at its maximum extent—which was not all accomplished at exactly the same time—ice of the Wisconsin glacier exhibited distinct flow-patterns (fig. 1). One result of this is the different composition of tills associated with the separate ice streams; another is the character and lineation of the physiographic features left behind. These show that deposits of the Huron–Erie Lobe, which entered the state from the east along the axis of the upper Wabash Valley, are by far the most extensive, spreading to the Wisconsin glacial boundary in central and southeastern Indiana and to the Illinois state line near Kentland, where they overlap deposits of the Lake Michigan Lobe. Deposits of the Lake Michigan Lobe extend to the Wisconsin glacial boundary in west-central Indiana and are at the surface only in areas of lesser size, but they also are widely present beneath the overriding blanket of Huron–Erie Lobe deposits.

By about 15,000 years ago, the ice margin had retreated to northern Indiana and each of the ice streams developed a lobate margin and a distinctive behavior pattern. The Erie

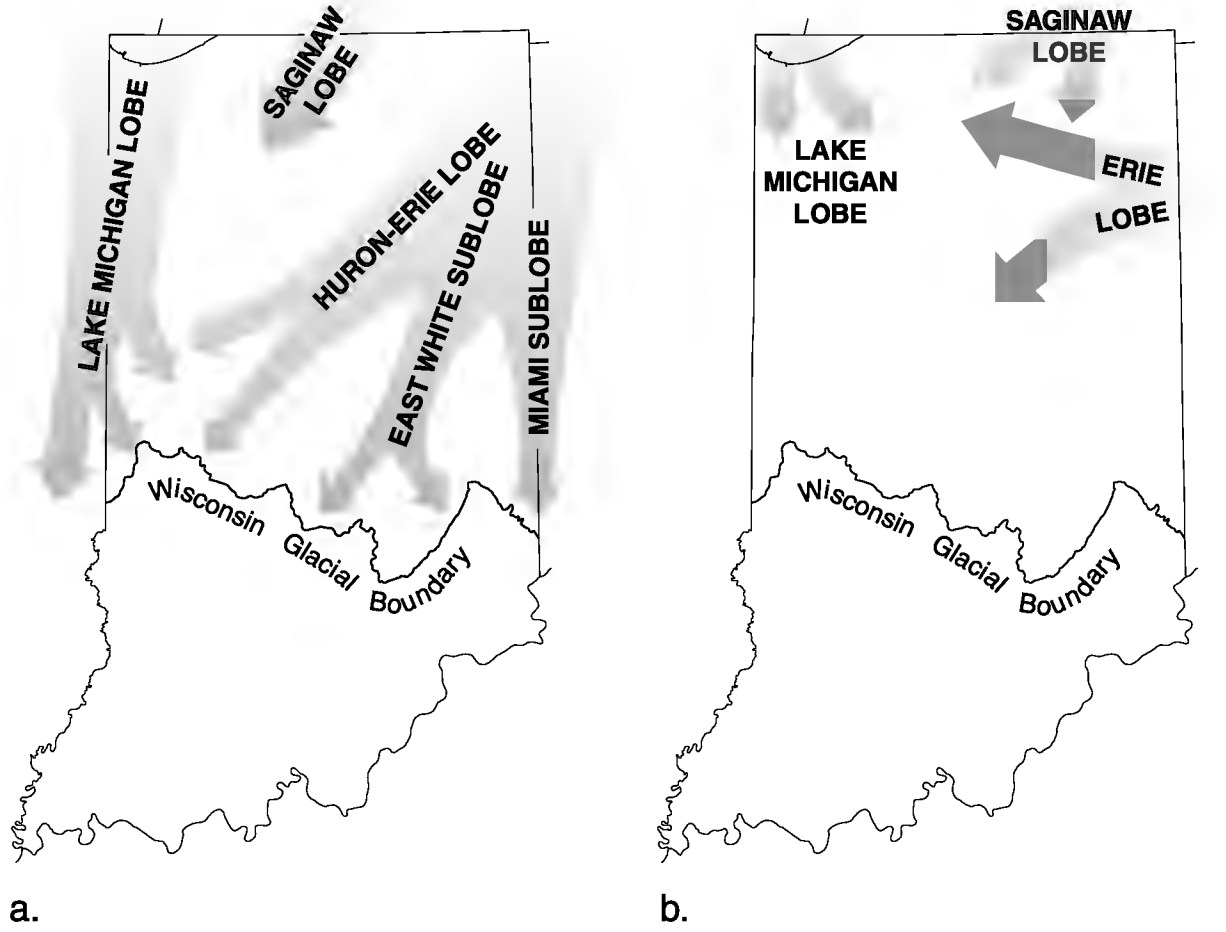


Figure 1. Sketch maps showing generalized flow direction of the several ice streams that made up the Wisconsin glacier in Indiana: a) about 20,000 years ago; b) about 15,000 years ago. Because of the vacillating activity of the several lobes and in some places extensive overriding of one lobe over another, it is not possible to show lobe margins in any meaningful way.

Lobe readvanced out of the basin of Lake Erie, bringing with it much clay from the floor of a temporary proglacial lake; the less active Saginaw Lobe advanced southwestward down the axis of Saginaw Bay only as far as northeasternmost Indiana, bringing a sandier load. And whereas earlier these and the Lake Michigan Lobe sparred for position across the central area of the Northern Moraine and Lake Region, leading to considerable stratigraphic and topographic complexity, the area of interaction was, during this latest phase of glaciation, much reduced.

1a. The Lake Michigan Border (Plate 1), which is essentially Malott's (1922) Calumet Lacustrine Section, is a belt 4 to 11 miles (6 to 18 kilometers) wide along the southern shore of Lake Michigan. The Valparaiso Morainal Complex (1b) adjoins the Lake Michigan Border on the south.

This section is a complex of moraines, beach ridges, lake-floor deposits and related washed surfaces, and dunes. These are among the most recently constructed major landforms in Indiana. As ice of the Lake Michigan Lobe receded from the Valparaiso Morainal Complex, beginning some 15,000 years ago, the massive moraines blocked southward drainage and a crescent-shaped lake was formed between the glacier margin and the moraine. This lake found an outlet westward, eventually down the Des Plaines and Illinois Rivers. Beach ridges mark the series of lake shores, and indistinct and discontinuous moraines record minor readvances of the ice. Continued recession of the ice allowed lake levels to fall until eventually the entire lake basin was free of ice so that drainage could exit, as it does now, by way of the Straits of Mackinac.

The most recent and relatively stable stage of Lake Michigan has built beaches and massive dunes, for example, those in Dunes State Park and at Indiana Dunes National Lakeshore. Also in parts of this section are large areas of made and modified land, especially in industrial districts and along the shore of Lake Michigan.

1b. The Valparaiso Morainal Complex is a belt some 13 to 20 miles (21 to 32 kilometers) wide that is roughly concentric with the shoreline of Lake Michigan. It is bounded by the Lake Michigan Border (1a) on the north and by the Kankakee Drainageways (1c) on the south.

The section includes two major landforms: 1) the Valparaiso and Tinley Moraines, which were designated the Valparaiso Moraine Section by Malott (1922); and 2) a set of merged alluvial fans that grades from the moraine southeastward to the Kankakee Drainageways. The moraine consists mainly of areas of ridged till and is transected by numerous tunnel-valley tracts in which bodies of till and stratified drift are complexly interspersed. Each of these tunnel valleys, in one of which is sited the city of Valparaiso, represents a major outlet through which meltwater was channelled beneath the glacier or within an ice-walled open conduit to the margin of the ice. Lakes occupy depressions in the till areas and in the tunnel-valleys. The moraine is topographically diverse and its moderate relief stands in contrast to sections to the north and south.

The area of merged alluvial fans is most prominent along the southeastern margin of the section, mainly in La Porte County, and occupies almost half the area of the section. The fan surface is relatively smooth but slopes gently southeastward and is strongly marked by abandoned southeast-trending channels and swarms of small subcircular ice-block depressions. Because of the sandy nature of the underlying alluvial deposits and the low water table, few of these depressions contain lakes.

1c. The Kankakee Drainageways is an extensive flat and poorly drained section bordered on the north by the Valparaiso Morainal Complex (1b), on the south by the Iroquois Till Plain (3b), and on the east by the Plymouth Morainal Complex (1e) and the Warsaw Moraines and Drainageways (1f). It includes a major part of the area called the Kankakee Lacustrine Section by Malott (1922).

Although the Kankakee River is now the unifying feature of this section, at the time moraines were being built on its northern and eastern margins, drainage was also importantly to the south, to the Wabash River, and meltwater streams spread sandy outwash deposits across the entire area. As the glaciers disappeared, the Kankakee and Tippecanoe Rivers inherited the drainage of this section. Extensive shallow lakes occupied broad depressions; westerly winds spread a veneer of blanket sand and built skirmishes of crescentic dunes across the drier areas. About 100 years ago the area was extensively ditched and drained for farming, a process that has continued to the present time, but much of the land remains somewhat poorly drained.

1d. The St. Joseph Drainageways is an extensive alluvial plain that lies along the northern border of the state and that is bounded on the south by the Plymouth Morainal Complex (1e). On the west it is transitional into the Kankakee Drainageways (1c). The St. Joseph Drainageways was included in the Kankakee Lacustrine Section by Malott (1922).

Topographically most of this section is relatively low-lying. A cluster of low dunes east of the St. Joseph River near the point where it enters the state constitutes the major topographic relief. The Pigeon, Elkhart, and St. Joseph Rivers, which drain the section axially, collected meltwater from the Lake Michigan, Saginaw, and Huron–Erie Lobes of the Late Wisconsin glacier and for a time directed that drainage down the Kankakee Drainageways. When the ice began to clear the Lake Michigan basin, drainage was diverted into the present lower course of the St. Joseph River, hence the bend at South Bend.

1e. The Plymouth Morainal Complex is bounded on the north by the St. Joseph Drainageways (1d), on the west by the Kankakee Drainageways (1c), and on the southeast by the Warsaw Moraines and Drainageways (1f). The Plymouth Morainal Complex was included in Malott's (1922) Steuben Morainal Lake Section.

This complex is dominantly morainal and was built by ice of three lobes—the Lake Michigan Lobe on the northwest, the Saginaw Lobe on the northeast, and the Huron–Erie Lobe on the southeast. These did not create a so-called interlobate moraine, but rather competed for space intermittently, so that ice of whichever lobe was most active overrode deposits and ice of other less active lobes. Deposits of the three lobes now are complexly stacked on each other and the principal aspect of the topography is, therefore, a jumble of discontinuous ridges and unorganized hummocky topography of moderate relief. Interspersed stratified drift is especially prominent in the northwest part of the section, whereas till-dominated forms are common to the south.

The southwest part of the section is drained by the Yellow River, which flows into the Kankakee; in the northeast, a prominent trough carries the Elkhart River, which collects drainage from a part of the Warsaw Moraines and Drainageways, across the Plymouth Morainal Complex and into the St. Joseph River. The many lakes in the section occupy ice-block depressions or other topographically low spots; Lake Maxinkuckee and Lake of the Woods are among the better known. Sites of many former lakes now are filled by muck and peat.

1f. The Warsaw Moraines and Drainageways is a northeast-southwest trending area bounded on the northwest mainly by the Plymouth Morainal Complex (1e), on

the west by the Kankakee Drainageways (1c), and on the southeast by sections of the Central Till Plain (3a, c) and the Auburn Morainal Complex (1g). The section was included in Malott's (1922) Steuben Morainal Lake Section.

This section is distinguished from the Plymouth Morainal Complex by extensive integrated systems of outwash and by more organized till tracts. About half of the section, a belt primarily along its southeastern border, is dominantly morainal and was built mainly by the action of the Huron–Erie Lobe of the Wisconsin glacier; in this part of the section, ridged till is common and topographic relief is moderate. The northwestern part of the section is occupied by a row of broad, northwest-sloping outwash fans that lie in front of the morainal upland. Surfaces of these fans range from smooth to pitted to hummocky, and large areas lack any indication of integrated drainage. The heads of most of the fans emanate from tunnel-valleys—broad, flat-bottomed troughs as much as a mile wide and 20 miles long that cut sharply across the morainal uplands. Most of the sediment that built the fans apparently was conveyed by meltwater flowing subglacially through the tunnel valleys when the ice margin stood at the adjacent moraines.

At the toe of the fan complex in the western part of the section the meltwater was directed to the southwest so that it formed an extensive area of outwash parallel to the northwest boundary of the section. The Tippecanoe River now flows down this tract. In the northeast part of the section, in the area drained by the Elkhart and Pigeon Rivers, influence of the Saginaw Lobe also is strong and the topography is more complex and somewhat more rugged. These two rivers carried meltwater to the St. Joseph River.

Most of the lakes in the section occupy ice-block depressions in morainal areas and along outwash tracts; Lake Wawasee and Tippecanoe Lake are among the largest of these. Numerous scattered small areas of peat and muck mark the sites of former lakes.

1g. The Auburn Morainal Complex is in the northeast corner of the state and is bounded on the northwest by the Warsaw Moraines and Drainageways (1f), on the south by the Bluffton Till Plain (3a), and on the southeast by the Maumee Lake Plain (2). The complex was included in Malott's (1922) Steuben Morainal Lake Section.

Much of this section is characterized by till ridges of moderate relief, northern limbs of major moraines associated with the Erie Lobe of the Late Wisconsin glacier. Most prominent of these are the Fort Wayne and Wabash Moraines, which are separated by the valley of the St. Joseph River (of the east). Northern limbs of the Salamonie and Mississinewa Moraines merge and become indistinguishable in the Columbia City area and northeastward. During the building of all these moraines, meltwater drainage was directed mainly to the southwest, down the Eel River, Cedar Creek, and the St. Joseph River, all of which at that time flowed into the Wabash River. Diversion of the St. Joseph into the Maumee River came at a somewhat later date (see region 2, below).

Toward the northeast corner of the section, deposits of the Saginaw Lobe are intermingled with Erie Lobe deposits, the topography is jumbled, and relief is somewhat more rugged. The drainage history is complex but much of the meltwater in this area was directed down the Elkhart and Pigeon Rivers to the St. Joseph River (of the north), in a pattern inherited by present streams.

Sylvan Lake and Lake James are among the largest of the many lakes in this section; most were formed in ice-block depressions or in broad, over-deepened troughs cut by subglacial meltwater streams. Many of the lakes in this section are fed by ground water and have neither perceptible inlet nor outlet. Deposits of muck and peat mark the sites of many former, mostly small or shallow lakes that now are filled with these organic-rich deposits.

2. MAUMEE LAKE PLAIN REGION

2. The Maumee Lake Plain (Plate 1), called by Malott (1922) the Maumee Lacustrine Section of the Northern Moraine and Lake Region, extends from the Ohio line to the Auburn Morainal Complex (1g) on the northwest and to the Bluffton Till Plain (3a) on the southwest. The Maumee Lake Plain is coincident with the Black Swamp Natural Region of Homoya and others (1985) and is the westward extension of Brockmann's (1997) Maumee Lake Plain of northwestern Ohio.

This small region is not subdivided. Its boundaries are determined by the inner margin of the Fort Wayne Moraine, a prominent relief feature that stands in sharp contrast to the lake plain, whose flatness is broken mainly by a few very low beach ridges of silt and sand. After the Fort Wayne Moraine was built as one of the final constructional activities of the Erie Lobe of the Late Wisconsin ice sheet, the ice retreated and a crescent-shaped lake was formed between the margin of the ice and the base of the moraine. About 14,000 years ago water from this lake spilled over the moraine at what is now Fort Wayne and created a cataclysm, the Maumee Torrent[1], the effects of which are noted down the entire length of the Wabash Valley. This phase of the lake's

1. The term "Maumee Torrent" appears to have been inserted so casually into geologic literature that its first usage is difficult to determine. The earliest mention I have found to date is that of Thornbury (1958) where use of the term is such as to imply that it had already been in common use.

history was brief, however, as lowering water levels left only a thin veneer of post-glacial lake deposits across a substrate of till and older lake sediments.

In its later history, this lake, named Glacial Lake Maumee by early students of Indiana physiography (for example, Dryer, 1889; Leverett and Taylor, 1915) but now considered simply an ancestral stage of Lake Erie, drained eastward. The complex history of its sequence of outlets is not of concern here, but lowering of the lake level allowed the St. Joseph and St. Marys Rivers to flow eastward rather than westward from their junction at Fort Wayne, thus forming the Maumee River.

3. CENTRAL TILL PLAIN REGION

This region is nearly coincident with Malott's (1922) Tipton Till Plain, the principal exception being along the southeastern margin, where he excluded from the till plain an area transitional into parts of the Southern Hills and Lowlands Region. The transitional area is, however, physiographically a till plain similar in origin to areas to the north; extending the Central Till Plain southward to the Wisconsin glacial boundary provides a more readily and sharply determined southeastern border of the region.

The surface material throughout most of the region is till of eastern, or Huron–Erie Lobe, source. Till of northern, or Lake Michigan Lobe, source forms the surface material principally in the far southwest corner of the region and in a few other scattered small inliers in the western part.

The name Central Till Plain is here adopted following studies by Fleming and others (1994) as being appropriate for a region of limited topographic diversity that extends across Ohio and Illinois as well as Indiana. It differs somewhat from the Central Till Plain Natural Region of Homoya and others (1985). The Central Till Plain Region is here for the first time subdivided physiographically into sections. These divisions are in part based on the more complex "terrains" observed by Fleming and others (1994).

3a. The Bluffton Till Plain is a major part of Malott's (1922) Tipton Till Plain. It is bounded on the northeast by the Maumee Lake Plain (2), on the north by the Auburn Morainal Complex (1g) and the Warsaw Moraines and Drainageways (1f), on the west by the Tipton Till Plain (as here redefined, 3c), and on the south by the New Castle Till Plains and Drainageways (3d). This section is nearly coincident with the Bluffton Till Plain Section of Homoya and others (1985).

The section is dominantly till plain of low relief but also includes the best-defined concentric sequence of moraines in the state. Once considered classical recessional moraines of the Erie Lobe and thought to mark still-stands of the retreating ice margin, they now are understood each to record a minor re-advance following a stage of ice recession and deposition of extensive and thick lake deposits. Each re-advance, which fell short of the immediately previous marginal position, incorporated clayey materials from the lake deposits; hence the soils across much of this section are clayey. The outermost moraine, the Union City Moraine, is discontinuous and inconspicuous, but associated clayey soils mark the boundary of the Bluffton Till Plain where the moraine is unrecognizeable. Later moraines—the Mississinewa, Salamonie, Wabash, and Fort Wayne Moraines—are more prominent.

Most of the drainage pattern in this section was inherited virtually without modification from the several episodes of glaciation. The Eel River, which flows along the northwestern border of the section, collected drainage from the northern limbs of several of the moraines. The Mississinewa, Salamonie, and Wabash Rivers each mark the outer margins of moraines of the same names, and each in its time collected the ice-marginal drainage associated with its respective ice margin. The upper reaches of the White River were defined by the Union City Moraine in the area where it is best developed. And the St. Marys River, which drains the outer margin of the Fort Wayne Moraine, initially took ice-marginal drainage from that re-advance and directed it down the Wabash, but as lake levels were lowered in the Lake Erie basin, after the Maumee Torrent (see region 2, p. 4), the St. Marys joined the St. Joseph to form the Maumee River, which flows eastward across the Maumee Lake Plain to Lake Erie.

3b. The Iroquois Till Plain includes the northwesternmost part of Malott's (1922) Tipton Till Plain. It is bounded on the north and east by the Kankakee Drainageways (1c), on the southeast by the Tipton Till Plain (3c), and on the southwest by the Central Wabash Valley (3e). The Iroquois Till Plain is nearly coincident with the Grand Prairie Section of Homoya and others (1985).

The northern boundary of the section is the north margin of the Iroquois Moraine and is sharp and well defined; the southeastern boundary is somewhat arbitrarily but distinctly defined as the northwest valley wall of the Wabash River; but the eastern boundary is transitional into the southern extension of the Kankakee Drainageways and can best be defined by including areas of blanket sand and lacustrine deposits in that section and retaining in the Iroquois Till Plain areas that are underlain primarily by till.

The topography of this section is dominantly flat and the few low rises that interrupt the plain are mostly moraines that initially were built by the Lake Michigan Lobe of the Late Wisconsin ice sheet and, therefore, have generally an

east–west orientation, but that were later buried by relatively thin eastern-source deposits of the Huron–Erie Lobe. In a few areas, till of eastern source is absent so that windows of northern source till are at the ground surface. Drainage patterns are not well defined—some westward, some eastward, some southward—and much of the section remains poorly drained, even though it has been extensively ditched to make it suitable for farming.

3c. The Tipton Till Plain (here redefined) is one of the largest of the physiographic sections into which Indiana is here divided. This section is bounded on the northeast by the Bluffton Till Plain (3a), on the southeast by the New Castle Till Plains and Drainageways (3d), on the southwest by the Martinsville Hills (4c), on the west by the Central Wabash Valley (3e), and on the northwest by the Iroquois Till Plain (3b).

Boundaries of this section generally are clear, if arbitrary. The northwest valley wall of the Wabash River delineates the northwest margin, the Union City Moraine and a change to more clayey soils marks the northeast boundary, the northwest valley wall of the White River defines the southeast boundary, and the limit of till deposits of the Huron–Erie Lobe of the Wisconsin ice sheet marks the southwest; all these boundaries are sharp. The boundary on the west is transitional, where the till plain becomes much dissected near the Wabash River.

Throughout the vast area of the Tipton Till Plain its topography is relatively uniform and of very low relief. Only a few irregularities—outwash fans, kames, and moraines—are found, mainly along the southwestern and western margins of the section. The till plain owes its uniformity to the way in which it was constructed: by relatively narrow tongues of ice that surged across a flat, wet, and slippery substrate, then stagnated and melted in place. One by one these near-contemporary events of from somewhat more than 20,000 to 17,000 years ago shaped the entire till plain, each leaving behind extensive areas of ground variously patterned by ice-disintegration features.

The Tipton Till Plain is drained by a group of moderate-size streams of subparallel to subradial pattern, nearly all of which flow westerly to southwesterly, ultimately to enter the Wabash River, either directly or via the White River. Most of the plain is sufficiently well drained to be prime farmland, among the best in Indiana.

3d. The New Castle Till Plains and Drainageways, the largest of the physiographic sections here described, is bounded on the north by the Bluffton Till Plain (3a), on the northwest by the Tipton Till Plain (3c), and on the south by sections of the Southern Hills and Lowlands Region (4). All the boundaries are sharp: on the north, soils are distinctively more clayey; the northwest valley wall of the White River marks the northwest boundary; and on the south, the boundary is defined by the maximum southern extent of till deposits of the Huron–Erie Lobe of the Wisconsin ice sheet. The distinguishing feature of the New Castle Till Plains and Drainageways is the number of tunnel valleys that cross it in a southerly to southwesterly radial pattern that reflects the lobate shape of what has sometimes been called the East White Sublobe of the Huron–Erie Lobe of the Wisconsin ice sheet. These tunnel valleys fed the White River, the East Fork of White River and several of its tributaries, and the several forks of the Whitewater River. In some places drainageways now abandoned cut across the till plains from one of these drainage lines to another. This crisscross pattern of meltwater features dissects a relatively featureless plain of low relief that would otherwise be indistinguishable from the Tipton Till Plain.

As recognized by Malott (1922), southeastern parts of this section are transitional into sections of the Southern Hills and Lowlands Region. Specifically, an area around Rushville, Shelbyville, and Greensburg has much the same character as the Muscatatuck Plateau (4i), and an area from Richmond to Connersville, Liberty, and Brookville is much like the Dearborn Upland (4j). Thickness of glacial deposits in most of this area is less than 50 feet and bedrock outcrops are common, so that the underlying configuration of the bedrock surface can be readily perceived, but the physiography of the land surface is nevertheless that of a till plain laced with major glacial drainageways.

3e. The Central Wabash Valley is bounded on the north by the Iroquois Till Plain (3b), on the east by the Tipton Till Plain (3c), and on the southeast by the Wabash Lowland (4a). Northern and eastern boundaries of the section are transitional and are arbitrarily set on the basis of increasing dissection of the till plain toward the Wabash River; the southeastern boundary is clearly defined by the margin of the Wisconsin till sheet.

The distinguishing feature of the section is the deep dissection of this part of the Central Till Plain Region by the Wabash River and its tributaries, notably Coal Creek, Sugar Creek, and the Vermillion and Little Vermillion Rivers. This aspect of the section was recognized by Homoya and others (1985), who included a somewhat larger area in their Entrenched Valley Section. All these streams have been superposed from the surface of the till sheet and probably were inherited from Late Wisconsin glacial drainageways. In cutting downward following entrenchment of the Wabash River, which continued to carry large volumes of glacial discharge for some time after this area was deglaciated, these tributaries have become entrenched across areas of topographically high bedrock and so have created a number of scenic rock-walled gorges. This is the only section of the Central Till Plain in which the surface till is attributed almost entirely to the Lake Michigan Lobe of the Wisconsin glaciation.

Despite entrenchment of the major streams to depths as great as 200 feet (60 meters), overall the physiographic aspect of this section is that of a till plain, so that between the deep valleys the upland surface has generally low relief.

4. SOUTHERN HILLS AND LOWLANDS REGION

The irregular line on the map (Plate 1) that marks the Wisconsin glacial boundary once was thought to represent the maximum southern extent of a simple, single ice sheet, or at most of a few advances within a sharply limited span of time. We now know that this line is a composite representing the termini of many advances that took place over a span of a few thousand years (see Tipton Till Plain, 3c, page 6), so that the till deposits that mark the boundary are of somewhat different ages along different parts of the boundary. Despite this complexity, the Wisconsin glacial boundary is clearly defined and makes a useful line of division between the Central Till Plain Region and the Southern Hills and Lowlands Region, which embraces Malott's (1922) seven physiographic divisions of southern Indiana. The common element in this region is that for the most part differences in bedrock character define the several sections.

This is not to say that the region escaped or was unmodified by glaciation. Nearly three-fifths of the region was covered by one or more of the pre-Wisconsin ice sheets; these left extensive deposits that since have been much modified by erosion. Furthermore, major rivers of the region—the Wabash, the White and its East Fork, and the Ohio—carried vast volumes of meltwater and their valleys were substantially modified during Wisconsin time. Overall, however, these effects were essentially postscripts in the physiographic history of this region.

4a. The Wabash Lowland of Malott (1922), as here redefined, is bounded on the north by the Central Wabash Valley (3e), on the east by the Martinsville Hills (4c) and the Crawford Upland (4d), and on the southeast by the Boonville Hills (4b). The Boonville Hills was considered a part of the Wabash Lowland by Malott, but is here described as a separate section, in part because it is nonglaciated and has somewhat more rugged relief. Virtually all the Wabash Lowland as here redefined was glaciated during one or more of the pre-Wisconsin glacial events, and the preglacial topographic features of the section have therefore been somewhat modified.

The dominant streams of the Wabash Lowland are the Wabash River, the Eel, the White, and the East Fork of the White. These have extensive floodplains flanked by broad terraces underlain by outwash sand. Thick lake deposits consisting of laminated silt occupy some of the tributary valleys. The greater part of the section, however, consists of rolling hills of low relief. Near the edge of the major river valleys the hills are capped by dune sand that was blown from the valley flats, principally during Wisconsin time. On the upland, areas of pre-Wisconsin till plain are particularly extensive northward, and the entire upland is capped by a layer of loess that in most places is about 6 feet (2 meters) thick.

Beneath these deposits, and exposed in many places, is bedrock, principally shale of Pennsylvanian age. These rocks are relatively soft and are not resistant to erosion, so that overall the section is characterized by relatively low relief and low altitude, in contrast to neighboring sections. Strip mines are extensive in some parts of the section, and although many mined areas have been reclaimed, they classify nevertheless as made and modified land.

Prominent features of the Wabash Lowland south and east of the White River are broad areas of low, poorly drained flatland that lies between the low rolling hills but that is not strictly part of the alluvial areas. Some of these areas have the form of low terraces. Underlying deposits are of enigmatic origin: neither classically lacustrine nor demonstrably alluvial, they appear loess-like but differ from loess by not being clearly of aeolian origin.

4b. The Boonville Hills. The southeastern and nonglaciated part of Malott's (1922) Wabash Lowland is here distinguished as the Boonville Hills. The section is bounded on the north and west by the Wabash Lowland (4a) and on the east by the Crawford Upland (4d). It is almost coextensive with the Driftless Section of the Southwestern Lowlands Natural Region of Homoya and others (1985), which is distinguished by vegetational characteristics that are related to the underlying geology.

Possibly because the Boonville Hills has not been glaciated, it is somewhat hillier than the Wabash Lowland, but it is not as rugged as the Crawford Upland. Bedrock, principally shale of Pennsylvanian age, is present everywhere at shallow depth and outcrops are common. A blanket of loess, as much as 10 feet (3 meters) thick in the west but thinning eastward to about 3 feet (1 meter), covers the upland in most places. Strip mining has been extensive, so that there are large areas of made and modified land in the eastern part of the section.

A minor part of the section consists of bottomlands along the Ohio River that are underlain principally by sandy outwash deposits. Flooding by overflow of the Ohio River is common on the lower bottomlands, but the soils themselves are relatively well drained. Bottomlands along lesser streams, such as Pigeon Creek and the Patoka River, are underlain by thick deposits of lacustrine silt; soils in these areas commonly are soggy and poorly drained internally.

Homoya and others (1985) define these narrow bottomlands, notably along the Ohio and Patoka Rivers, as part of their Southern Bottomlands Natural Region.

4c. The Martinsville Hills includes northernmost parts of three of Malott's (1922) regions, which otherwise are here retained as sections. This section is bounded on the north by the Tipton Till Plain (3c), on the west by the Wabash Lowland (4a), and on the south by the Crawford Upland (4d), Mitchell Plateau (4e), and Norman Upland (4f).

The section is distinguished by strong glacial modification of the underlying bedrock topography, such that resemblances to the bedrock-defined sections to the south are subdued and boundaries between them cannot be sharply drawn within the section. The topography is nevertheless sufficiently rugged to contrast with the Wisconsin till plains to the north and the pre-Wisconsin till plains to the west. Though the southern boundary is gradational, it is fairly well defined, in part by the southern extent of moderately thick and nearly continuous pre-Wisconsin drift. The glacial boundary itself, however, is in most places 6 to 12 miles (10 to 20 kilometers) south of the section boundary.

Eastern and western parts of the section are more rugged than the central part, which contains lacustrine areas and small areas of till plain. In this three-part division the section topographically resembles those sections to the south where the topography is more obviously bedrock-controlled. Reasons for the similarity are two: 1) in most of the section, drift is not thick enough to conceal altogether the underlying bedrock topography, and 2) erosional processes adjacent to the White and Eel Rivers and Walnut Creek, all of which carried much meltwater during Wisconsin time, appear to have been effective in removing a large part of the pre-Wisconsin drift.

4d. The Crawford Upland is substantially identical to Malott's (1922) region of the same name except for the removal on the north of a strongly glaciated part to the Martinsville Hills (4c), as explained above. The section is bounded on the west by the Wabash Lowland (4a) and the Boonville Hills (4b) and on the east by the Mitchell Plateau (4e).

The northern boundary of the section is somewhat indistinct and reflects the northward increase in the influence of the pre-Wisconsin glaciers. The western boundary is transitional and is defined by the more rugged topography of the Crawford Upland in contrast to the subdued topography of its western neighbors. This boundary can be statistically determined on the basis of the greater abundance of steeper slopes in the Crawford Upland, but as drawn here, and differing to some extent from Malott (1922), it was determined by inspection of topographic and soil maps. From Bloomfield south almost to Jasper the eastern margin of the pre-Wisconsin ice sheet in southwestern Indiana is essentially at the western boundary of the Crawford Upland.

The escarpment that sharply marks the eastern margin of the Crawford Upland is a major topographic feature of southern Indiana and extends from the Ohio River in Harrison County to the vicinity of Spencer, where it disappears beneath a cover of glacial deposits. For many years this escarpment has been known as the Chester Escarpment because it is in part upheld by rocks of Chesterian (late Mississippian) age. Traced southward into Kentucky, this escarpment merges with an escarpment of somewhat different character, the Dripping Springs Escarpment; the name Chester Escarpment is not used outside Indiana. As this is primarily an Indiana feature, I believe that it should have a nonstratigraphic Indiana name, and I therefore designate it the Springville Escarpment for the settlement of that name at the foot of the escarpment in northwestern Lawrence County. As mapped, the eastern boundary of the Crawford Upland differs only in detail from Malott's boundary, owing entirely to the better maps now available.

Through-flowing streams, the White, East Fork, and Ohio Rivers, cut deep, narrow valleys across the upland; between these valleys, topography of the section is also uniformly rugged. Local relief commonly is 200 to 300 feet (60 to 90 meters). Bedrock includes shale, sandstone, and limestone of Mississippian age in the eastern part of the upland and shale and sandstone of Pennsylvanian age in the western part. In northernmost parts of the section, the topography has been somewhat modified by the activity of pre-Wisconsin glaciations.

Sinkholes, karst valleys, and caves are common along the eastern margin of the section where beds of limestone are important elements in the bedrock. In many places throughout the upland, resistant rock layers etch out prominent ledges on the hillsides or uphold broad upland flats, and in the southernmost part of the area a subtle and discontinuous east-facing escarpment marks the eastern edge of basal Pennsylvanian sandstones. In Kentucky a continuation of this feature is more impressive and is called the Pottsville Escarpment.

4e. The Mitchell Plateau differs little in concept or extent from Malott's (1922) Mitchell Plain. The descriptive name is changed here because the section is indeed a limestone plateau dissected by major stream systems, many of which are deeply entrenched, and by extensive and in places deep karst development. The Mitchell Plateau is nearly coincident with Homoya and others' (1985) Mitchell Karst Plain Section.

The section is bounded on the west by the Crawford Upland (4d); the boundary is sharply defined at the base of the Springville Escarpment, as discussed above. On the north the plateau is bounded by the Martinsville Hills (4c). This boundary is gradational as the influence of pre-Wisconsin glaciation becomes more prominent northward; indeed, the northernmost part of the Mitchell Plateau includes lacustrine areas and patches of till such that it could have been assigned to the Martinsville Hills. Malott (1922) included a part of that section in his Mitchell Plain, but it is separated here for reasons described above.

On the east the Mitchell Plateau is bounded by the Norman Upland (4f). This boundary is diffuse; Malott (1922) defined it largely in terms of karst, but karst features are minimal along the eastern margin of the plateau and the boundary is here defined as the eastern extent of limestone bedrock and related soils, small outliers being ignored. Thus the Mitchell Plateau is a plateau underlain by the thick limestone formations that make up the middle part of the Mississippian rocks in Indiana.

There are three physiographic aspects of the Mitchell Plateau. Much of the northern half, that part north of the East Fork of White River, is deeply dissected by several large streams. Steep slopes and limestone ledges are common in these areas and much of the upland is in the form of irregular branching ridges. South of the East Fork of White River, principally in Washington and Harrison Counties, the eastern part of the plateau includes broad areas of rolling hills underlain by thick red clay, or terra rossa. Commonly thought to be a residuum resulting from extensive solution of limestone, the terra rossa is actually more complex and includes material of varied origin.

Associated with both areas, most prominently and extensively in western parts of the plateau, are large patches of classic karst characterized by a profusion of sinkholes that in places are counted in the thousands per square mile. Caves are numerous throughout the section, and in and near extensive karst areas all drainage is by way of underground routes that emerge as large springs along the valleys of deeply entrenched streams. Adjacent to the Blue and Ohio Rivers karst features so dominate the topography that these streams have few surface-flowing tributaries and the plateau surface is left "hanging" as much as 200 feet (60 meters) above stream level.

4f. The Norman Upland is essentially the same as Malott's (1922) region of the same name except for the placement here of a northern, glacially modified part of the region into the transitional Martinsville Hills (4c), which bounds the Norman Upland on the north. This boundary is relatively sharp and in places is coincident with the southern margin of the pre-Wisconsin glaciations. On the west the upland is bounded by the Mitchell Plateau (4e). The transitional nature of that boundary is explained above.

The eastern boundary against the Scottsburg Lowland (4g) and the Charlestown Hills (4h) is sharply defined as the base of the Knobstone Escarpment[2], the most striking physiographic feature in Indiana. This escarpment rises about 600 feet (180 meters) above the Ohio River south of New Albany and is prominent northward for almost 100 miles (160 kilometers) to a point northwest of Columbus, north of which it is increasingly obscured by a cover of Wisconsin glacial deposits. Beneath these deposits the escarpment can be traced another 100 miles northwestward to a point southwest of Lafayette, but there it has no surface expression. Although the escarpment was a formidable barrier to the pre-Wisconsin glaciers, one (or more) of them surmounted it and left a ragged fringe of till along the eastern margin of the upland, but the topography was little modified.

Although the Norman Upland is characterized throughout by rugged topography and high relief, three physiographic aspects can be distinguished. In the northern part, dissection adjacent to the deeply entrenched valleys of Beanblossom and Salt Creeks and their tributaries has in most places left only vestigial upland flats among a maze of dendritic ridges; extensive dissection here probably is related to the fact that these streams carried much pre-Wisconsin meltwater and have therefore become deeply entrenched. South of this area, and mainly in Jackson County, dissection has not been so thorough and large areas of upland remain. These two areas together form Homoya and others' (1985) Brown County Hills Section. South of the East Fork of White River the Norman Upland is relatively narrow and in many places consists mainly of the dissected front of the Knobstone Escarpment. This part of the section is recognized by Homoya and others (1985) as the Escarpment Section of the Shawnee Hills Natural Region. Except along its northern and eastern margins, the section has escaped glaciation.

The Norman Upland owes its rugged topography to the bedrock that underlies it—siltstone of the Borden Group of Mississippian age. Though the character of these rocks ranges from sandstone-like to shale-like in their response to

2. The Knobstone Escarpment was named long ago for rocks of the Borden Group, which then were called the "Knobstone" in southern Indiana and adjacent Kentucky. If we were naming this feature today we should use a geographic name, but as the name Knobstone is no longer used in stratigraphic application, it seems appropriate to retain it in a relic sense for this grand topographic feature. The continuation of the Knobstone Escarpment in Kentucky is called Muldraugh Hill.

erosion, the difference is in most places not sufficient to make prominent ledges along the hillsides, which tend therefore to have relatively smooth though steep slopes. These slopes along with the poor soils associated with the Borden rocks are among the reasons that the Norman Upland was cleared and settled relatively late in Indiana's history. Many farms proved to be unprofitable, however, and now, with reforestation, large areas are returning to woodland.

4g. The Scottsburg Lowland is here modified from Malott's (1922) region of the same name by removal of: 1) a small area north of the Wisconsin glacial boundary to the New Castle Till Plains and Drainageways (3d); and 2) a somewhat larger area in the south of the region, mainly in Clark County, that is here defined as the Charlestown Hills (4h). Other sections that surround the Scottsburg Lowland are the Muscatatuck Plateau (4i) on the east and the Norman Upland (4f) on the west.

The northeastern and northern boundaries of this section are sharply defined by the limit of the Wisconsin till sheet; the western boundary, at the base of the Knobstone Escarpment (described above), also is sharp. The southern boundary is placed at the drainage divide between the Muscatatuck River and Silver Creek. The eastern boundary, which is difficult to place with precision, divides the relatively low and nearly level lands of the Scottsburg Lowland from the equally flat but slightly sloping limestone-based upland surfaces of the Muscatatuck Plateau.

The East Fork of White River drains the major part of the Scottsburg Lowland axially. Adjacent to this stream is a broad floodplain replete with active meanders, and flanking this are low terraces underlain by Wisconsin outwash sand and gravel. Dunes fringe these areas, most extensively on the east. The Muscatatuck River crosses the southern part of the lowland. This stream carried no meltwater during Wisconsin time, and therefore no sand, and so the broad valley flats and terraces in this part of the lowland are underlain mainly by deposits of silt and clay, which in part are of lacustrine origin. Extensive lowland flats similar to those described in the Boonville Hills (4b) lie between and adjacent to the major stream tracts, and low hills underlain by pre-Wisconsin till lie against the edges of the section.

Beneath this complex of glacial deposits is shale of Devonian and Mississippian age that is not resistant to erosion. Outcrops of these rocks are few. An anomalous part of the section, the only part that is not low and that has extensive outcrops of bedrock, is the Brownstown Hills, just southeast of the town of that name. This small but rugged area is underlain by an outlier of siltstone of the Borden Group, which is more resistant to erosion than the shale that underlies the lowland, and which thus gives rise to topography much like that of the Norman Upland.

4h. The Charlestown Hills is the southern, more hilly part of Malott's (1922) Scottsburg Lowland. It is here defined as a separate section because of its unique topographic and geologic character.

The Knobstone Escarpment, the base of which sharply defines the western boundary of the Charlestown Hills against the Norman Upland (4f), has a nearly north–south trend from New Albany northward to the north edge of Clark County. At this point the escarpment turns northwestward, and in so doing forms a sharp promontory. To the north of this point are the extensive flats of the Scottsburg Lowland (4g), which drain to the Muscatatuck River. Southward, drainage is to the Ohio River via Silver Creek and its tributaries, and the dominant landforms are low hills. This entire section has been glaciated, but glacial influence is relatively minor. Till deposits are thin and scattered, and although the stratigraphy has not yet been worked out, possibly only two tills may be recognized in this section, whereas to the north it appears that more, and more varied, tills may be present. It is reasonable, therefore, to speculate that this drainage divide, which is here taken to mark the northern boundary of the Charlestown Hills, also marks the southern limit of some of the major pre-Wisconsin glacial advances that profoundly affected the Scottsburg Lowland.

On the northeast, the Charlestown Hills section is bounded by the Muscatatuck Plateau (4i), the limestone uplands of which rise subtly above the low shale hills. Like the Scottsburg Lowland, the Charlestown Hills section is underlain by relatively soft shale of Devonian and Mississippian age, but because the glacial cover is less pervasive, outcrops are rather common.

Large though it is, the Ohio River, which bounds the Charlestown Hills on the south, is almost incidental to the physiography of the section. The river's activity has mainly been limited to the construction of outwash terraces near Jeffersonville, which in turn, by blocking the mouth of Silver Creek, contributed to the deposition of lacustrine silt and clay in the lower reaches of that creek; but because the Ohio is a relative newcomer to the area it has not extensively modified the major aspects of the landscape, which were created before the river was formed.

4i. The Muscatatuck Plateau is bounded on the east by the Dearborn Upland (4j), on the northwest by the New Castle Till Plains and Drainageways (3d), and on the west by the Scottsburg Lowland (4g) and the Charlestown Hills (4h). This section differs from Malott's (1922) Muscatatuck Regional Slope in two details. First, a large area of classic Wisconsin till plain at the north is removed to the New Castle Till Plains and Drainageways. Malott considered this a transitional area, and indeed it shares some characteristics with

the section as redefined here, but this change makes it possible to draw the boundary sharply at the Wisconsin glacial margin. Second, the eastern boundary is in many places drawn farther to the east so as to include in the section an area of limestone plateau that contrasts with the steep slopes and narrow ridgetops of the Dearborn Upland. The western boundary is indistinct, as previously described.

Except that it has been glacially modified, in many respects the physiography of this section is similar to that of the Mitchell Plateau and it is correspondingly named here. The upland surface slopes westward at a rate somewhat less than the dip of the underlying limestone and dolomite strata of Silurian and Devonian age, so that it transects older and older rocks eastward. In most areas the upland is covered by relatively thin pre-Wisconsin till, and the till is capped by silt that resembles, but is not demonstrably, loess. Mimicking the orientation of streams on adjacent parts of the Central Till Plain, many of the streams flow at a slight angle to the direction of slope of the plateau, and it seems likely that they owe their orientation to one of the pre-Wisconsin glacial events.

Karst development of the Silurian and Devonian carbonate rocks that underlie the Muscatatuck Plateau is less pervasive than that of the Mitchell Plateau and is largely restricted to narrow areas close to the deeply entrenched streams. Although it may be that karst is extensive beneath the thin drift cover and has simply been reexposed near the entrenched streams, such has not yet been proved.

4j. The Dearborn Upland differs from Malott's (1922) region of the same name by two exclusions, both of which are explained above: 1) an area of plateau in northeastern Ripley County and adjacent parts of Franklin and Dearborn Counties is removed to the Muscatatuck Plateau (4i), and 2) a large transitional area to the north, including much of Fayette, Union, and Wayne Counties, is removed to the New Castle Till Plains and Drainageways (3d). Both changes recognize the dominant morphology of those areas and also make boundaries more readily and sharply defined.

This section, like its counterparts, the Norman Upland (4f) and the Crawford Upland (4d), is characterized by steep slopes, sprawling dendritic ridgetops, and dissection by a maturely developed stream network. Local relief is as great as 400 feet (120 meters). These properties are determined mainly by the character of the bedrock, which is mostly shale with numerous beds of limestone, few of which are substantial enough to form ledges on the hillsides. Remnant deposits representing several pre-Wisconsin glaciations are found at many places in the Dearborn Upland, which in this way differs from the other uplands of southern Indiana.

A look at the map suggests that the Dearborn Upland could be considered merely a dissected fringe that edges the Muscatatuck Plateau, and it might appear that it owes its morphologic development to the adjacent Ohio River, but its origin is more complex than that. To explain, some discussion of the Ohio River and its origin and history are necessary. In most of southern Indiana, the major elements of the drainage system have remained more or less in place for the past few million years, at least, but in the Dearborn Upland, until a little before 700,000 years ago, drainage was to the north and the Ohio River did not exist as such. A major stream, considered the ancestral Kentucky River, flowed northward in a valley similar to that of today's Ohio but only about half as deep. Far to the north, a major pre-Wisconsin glacial event blocked the northbound route and forced drainage from a large area as far east as Virginia into what is now the Ohio valley. This valley was repeatedly deepened and then partially refilled by glacial outwash. A substantial increase in relief and steepening of the slopes are the principal effects of these events in the Dearborn Upland.

TOPOGRAPHY OF THE BURIED BEDROCK SURFACE

All the above physiographic divisions are based on surface topography that can be directly observed, but there exist many buried topographic surfaces, the most obvious of which is the bedrock surface (fig. 2) that directly underlies the pervasive cover of glacial and other unconsolidated deposits in the northern two-thirds of Indiana. Compilations of subsurface data have allowed this surface to be mapped (for example, Gray, 1982), and so, even though we have never seen it, and even though it is not strictly topographic, we may describe the topography of this surface.

This buried surface is complex and is not everywhere of the same age. Many bits and pieces of a lengthy geologic history are recorded on it. Much of it is old, but streams even now are notching valleys into the bedrock in some places—Sugar Creek in Parke County and the Wabash River at Logansport are conspicuous examples. In contrast, a major buried topographic feature, the deeply entrenched Teays or Teays–Mahomet Valley, which crosses northern parts of the state from Berne to Boswell, at least in part is more than 700,000 years old and has a long and complex history that is only partly known. The bedrock surface is not well delineated in far northeastern Indiana, where the glacial deposits are as much as 500 feet (160 meters) thick, and there are other areas in which details of the bedrock surface remain unclear.

In an early overview, Wayne (1956) subdivided this buried surface into named lowlands, uplands, plains, and plateaus. Wayne's work was based on a map in which the topography of the bedrock is shown as the inverse—that is, lacking surface altitude data, which were not widely available at the time, he had to rely on thickness of the drift cover to delineate bedrock topographic features. His physiographic subdivisions are less clear on more recent maps that directly show the altitude of the bedrock surface (for example, Gray, 1982a, b; Bruns, Logan, and Steen, 1985a, b, c). The principal difference among Wayne's divisions is that the lowlands on the bedrock surface appear to be extensively dissected by complex networks of buried valleys that may be composites of superimposed valley networks of several ages.

Using dissection as the principal criterion for subdivision of the bedrock surface, I have adopted as many of Wayne's names as seems practical in a somewhat simplified concept. Thus there is a central set of contiguous lowland tracts that sets off three major upland areas and one minor area. The divisions in the south directly reflect the nature of the bedrock, but the northern divisions, except one, are virtually independent of bedrock character. Again, the names have been chosen from geographic features—counties or towns.

In west-central Indiana the Clinton Lowland (fig. 2) is a shallow reflection of the Central Wabash Valley (3e) described earlier. In most of this area the drift cover is sufficiently thin that the buried topography and the surface topography are similar and bedrock outcrops are common. Only down the axis of the Wabash River valley itself is the drift cover thick. Next east, the Montgomery Upland represents the merger of northward extensions of the Crawford Upland and the Norman Upland. Here the sub-Pennsylvanian disconformity has truncated not only the Chesterian rocks, which to the south form the basis of the Springville Escarpment, but also the mid-Mississippian limestone sequence that in southern Indiana defines the Mitchell Plateau and thus serves clearly to separate the two uplands. The Mitchell Plateau cannot well be differentiated north of the Wisconsin glacial boundary. In contrast, the northern continuation of the Knobstone Escarpment, which marks the eastern margin of the Montgomery Upland, as discussed earlier is one of the most prominent buried topographic features in the state.

Skipping for the moment the lowland complex, in east-central Indiana the Bluffton Plateau is an extensive upland surface developed principally on limestones and dolomites of Silurian and Devonian age. It includes areas that, as explained above, have earlier been considered buried northward extensions of the Muscatatuck Plateau and the Dearborn Upland. Deep valleys are etched into the upland surface; notable among these is the well-known but incompletely understood Teays Valley. This valley drained westward to join the ancestral Mississippi River in central Illinois and its closure and filling somewhat before 700,000 years ago diverted much drainage from the east into what is now the Ohio River. There is limited karst development in the carbonate rocks of the plateau, mainly adjacent to the major buried valleys; if karst ever was more extensive, evidence of it has perhaps been obliterated by repeated glaciation.

A complementary plateau, the Rensselaer Plateau, occupies much of northwestern Indiana. This plateau is much more extensive than the Silurian and Devonian carbonate rocks that underlie its western part; a southern part is underlain by rocks of the Borden Group, the same group of rocks that underlie the Norman Upland in southern Indiana, and the eastern part of the plateau is underlain by black and gray shale of late Devonian and early Mississippian age. Because the drift is thick and data are sparse across much of this area, it may be that the shale area is more dissected than it now appears to be and should perhaps be assigned to the lowland complex. A small upland area in northeastern Indiana, the Lake George Upland, is underlain by Mississippian sandstone that becomes more prominent in Michigan, in the area of the Irish Hills and around Jackson.

The lowland complex, which extends essentially unbroken from southern Shelby and Johnson Counties to the northernmost reaches of the state, seems best divided by the apparent direction of flow of the networks of valleys impressed on it. Throughout much of the lowland complex, shale is the bedrock and drift cover is moderate (in the south) to very thick (in the north). With the explicit understanding that our concepts of many of these valleys have changed with each successive interpretation, and that they will further change in the future, I suggest, on Figure 2, boundaries and names appropriate to the divisions as now perceived. Thus, drainage from the De Kalb Lowland appears to have exited the state to the northeast and from the La Porte Lowland, to the north. These features may principally have been of preglacial or early interglacial age and are deeply buried by drift. Drainage from the Lafayette Lowland, better known through its association with the Teays–Mahomet system, exited to the west and appears to be dated from somewhat before to somewhat after the magnetic reversal of 700,000 ybp. Drainage from the Greenwood Lowland somewhat less certainly appears to have exited to the southwest and may in part be younger than that to the north. Drift here is rather thin so that surface drainage networks may have been incised into the bedrock.

Again, it is worth restating that these surfaces are complex and that although the drainage networks seem convincing, it is well to expect significant changes as more detailed studies are made.

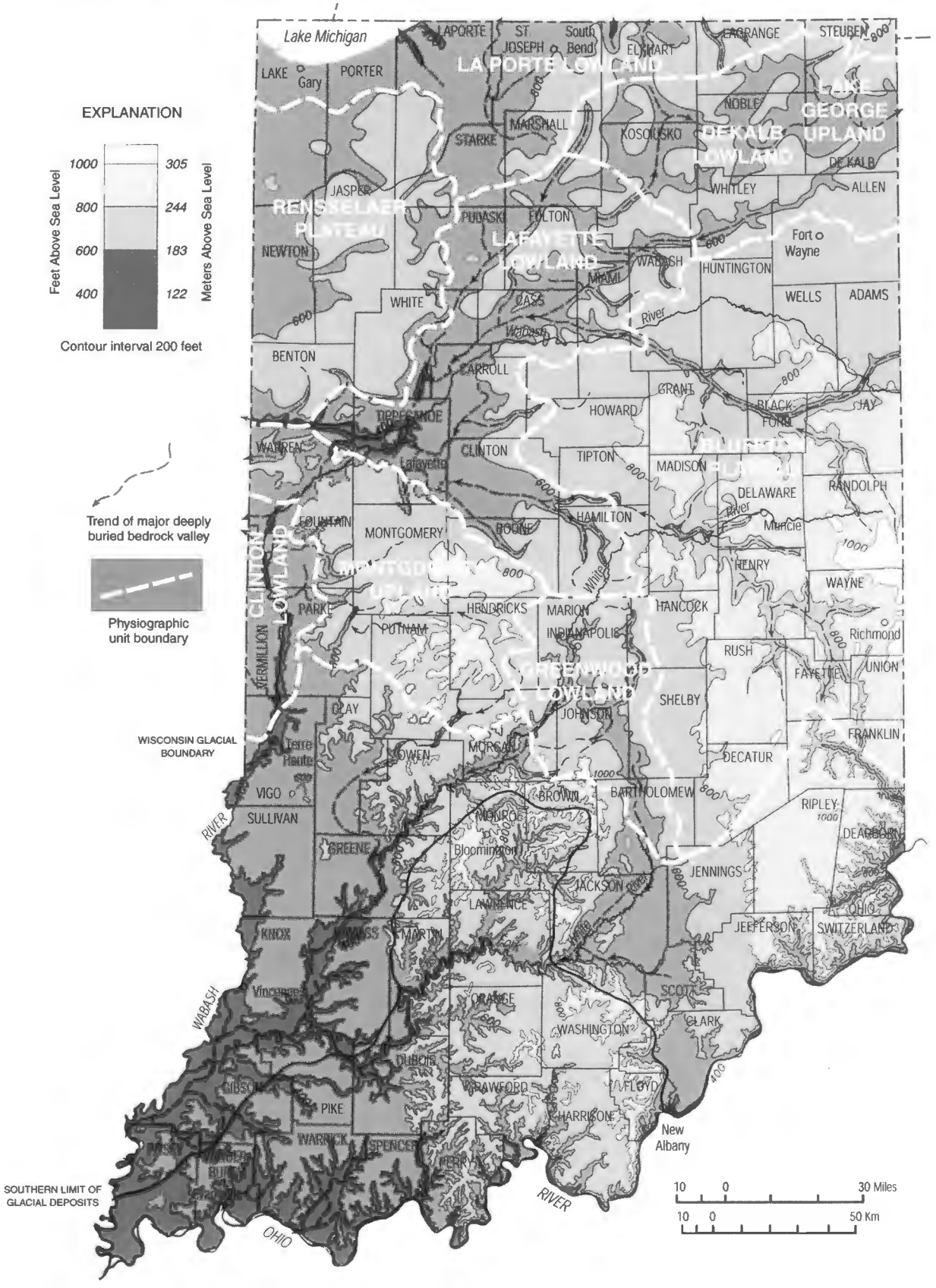


Figure 2. Map of Indiana showing bedrock topography (from Indiana Geological Survey, 1983) and topographic divisions of the buried bedrock surface north of the Wisconsin glacial boundary.

ACKNOWLEDGEMENTS

Many colleagues have assisted me with criticism and discussion as I have developed these concepts over the years. With the usual proviso that I hold all responsibility, not they, I do wish especially to credit (in alphabetical order) N. K. Bleuer, Steve Brown, Anthony Fleming, Gordon S. Fraser, and Richard L. Powell. And I appreciate the patience and craftsmanship of Rea Kersey and Kimberly Sowder in the preparation of the illustrations.

REFERENCES

Brockman, C.S., 1997, Physiographic regions of Ohio: Ohio Division of Geological Survey, map with explanation.

Bruns, T. M., Logan, S. M., and Steen, W. J., 1985a, Maps showing bedrock topography of the Teays Valley, western part, north-central Indiana: Indiana Geological Survey Miscellaneous Map 42, scale 1:100,000.

Bruns, T. M., Logan, S. M., and Steen, W. J., 1985b, Maps showing bedrock topography of the Teays Valley, central part, north-central Indiana: Indiana Geological Survey Miscellaneous Map 43, scale 1:100,000.

Bruns, T. M., Logan, S. M., and Steen, W. J., 1985c, Maps showing bedrock topography of the Teays Valley, eastern part, north-central Indiana: Indiana Geological Survey Miscellaneous Map 44, scale 1:100,000.

Dryer, C. R, 1889, Geology of Allen County, *in* Sixteenth Annual Report of the Indiana Geological Survey, p. 107–114.

Dryer, C. R., 1912, Geography of Indiana, supplement to High School Geography: American Book Co., New York, Cincinatti. (A 1919 revision also is available, in which many of the physiographic names were changed.)

Fenneman, N. M., 1917, Physiographic divisions of the United States: Annals, Association of American Geography, v. 6, p. 19–98.

Fleming, A.H., ed., and others, 1994, Atlas of hydrogeologic terrains and settings in Indiana, northern part: Indiana Geological Survey Open-file Report 94-17.

Gray, H.H., 1982a, Map of Indiana showing topography of the bedrock surface: Indiana Geological Survey Miscellaneous Map 35.

Gray, H.H., 1982b, Map of Indiana showing topography of the bedrock surface: Indiana Geological Survey Miscellaneous Map 36.

Homoya, M.A., Abrell, D.B., Aldrich, J.R., and Post, T.W., 1985, The natural regions of Indiana: Proceedings of the Indiana Academy of Science, v. 94, p. 245–268.

Indiana Geological Survey, 1983, Map of Indiana showing topography of the bedrock surface: Indiana Geological Survey Miscellaneous Map 39.

Leverett, Frank, and Taylor, F. B., 1915, The Pleistocene of Indiana and Michigan and the history of the Great Lakes: U. S. Geological Survey Monograph 53.

Malott, C.A., 1922, Handbook of Indiana geology, part II: Physiography of Indiana: Indiana Department of Conservation Publication 21, p. 61–256.

Newsom, J. F., 1898, A geological section across southern Indiana, from Hanover to Vincennes: Journal of Geology, v. 6, p. 250–256.

Schneider, A.F., 1966, Physiography, *in* Natural features of Indiana, 1816–1966: Indiana Sesquicentennial Volume, Indiana Academy of Science, Indianapolis, p. 40–56.

Thornbury, W. D., 1958, The geomorphic history of the upper Wabash Valley: American Journal of Science, v. 256, p. 449–469.

Wayne, W. J., 1956, Thickness of drift and bedrock physiography of Indiana north of the Wisconsin glacial boundary: Indiana Geological Survey Report of Progress 7.

Appendix 1. Approximate areas of the physiographic divisions of Indiana

	Square Miles	Square Kilometers
1. Northern Moraine and Lake Region		
1a. The Lake Michigan Border	350	900
1b. The Valparaiso Morainal Complex	1,000	2,600
1c. The Kankakee Drainageways	1,800	4,700
1d. The St. Joseph Drainageways	300	750
1e. The Plymouth Morainal Complex	1,100	2,850
1f. The Warsaw Moraines and Drainageways	1,750	4,500
1g. The Auburn Morainal Complex	1,300	3,400
	7,600	19,700
2. Maumee Lake Plain Region	250	650
3. Central Till Plain Region		
3a. The Bluffton Till Plain	3,600	9,300
3b. The Iroquois Till Plain	1,700	4,400
3c. The Tipton Till Plain	4,300	11,100
3d. The New Castle Till Plains and Drainageways	4,400	11,400
3e. The Central Wabash Valley	700	1,800
	14,700	38,000
4. Southern Hills and Lowlands Region		
4a. The Wabash Lowland	3,800	9,800
4b. The Boonville Hills	1,250	3,200
4c. The Martinsville Hills	600	1,550
4d. The Crawford Upland	2,500	6,500
4e. The Mitchell Plateau	1,200	3,100
4f. The Norman Upland	1,100	2,850
4g. The Scottsburg Lowland	800	2,100
4h. The Charlestown Hills	250	650
4i. The Muscatatuck Plateau	1,300	3,400
4j. The Dearborn Upland	1,000	2,600
	13,800	35,750

THIS PAGE INTENTIONALLY LEFT BLANK

OVERSIZED DOCUMENT

The following pages are oversized and need to be printed in correct format.

EXPLANATION

NORTHERN MORAINE AND LAKE REGION

- 1a — LAKE MICHIGAN BORDER. Beach ridges, dunes, lake plains, and minor morainal areas
- 1b — VALPARAISO MORAINAL COMPLEX. Ridged till of northern source crossed by tunnel-valleys and bounded by an alluvial-fan apron
- 1c — KANKAKEE DRAINAGEWAYS. Broad tracts of sandy outwash, lake plains, and scattered clusters of dunes
- 1d — ST. JOSEPH DRAINAGEWAYS. Broad tracts of sandy outwash
- 1e — PLYMOUTH MORAINAL COMPLEX. Disorganized ridged till and stratified drift of northern, northeastern, and eastern source
- 1f — WARSAW MORAINES AND DRAINAGEWAYS. Ridged till of eastern source crossed by tunnel-valleys and bounded by an alluvial-fan apron
- 1g — AUBURN MORAINAL COMPLEX. Ridged till of eastern source and minor areas of outwash

MAUMEE LAKE PLAIN REGION

- 2 — Lake plain with a few low beach ridges

CENTRAL TILL PLAIN REGION

- 3a — BLUFFTON TILL PLAIN. Large areas of till plain with a concentric series of end moraines
- 3b — IROQUOIS TILL PLAIN. Till plain of very low relief with minor areas of end moraine
- 3c — TIPTON TILL PLAIN. Till plain of low relief with extensive areas of ice-disintegration features
- 3d — NEW CASTLE TILL PLAINS AND DRAINAGEWAYS. Till plains of low relief crossed by many major tunnel-valleys
- 3e — CENTRAL WABASH VALLEY. Till plain deeply dissected by the Wabash River and major tributaries

SOUTHERN HILLS AND LOWLANDS REGION

- 4a — WABASH LOWLAND. Broad terraced valleys and low till-covered hills
- 4b — BOONVILLE HILLS. Bedrock hills of moderate relief
- 4c — MARTINSVILLE HILLS. Bedrock hills of high relief strongly modified by pre-Wisconsin glacial activity
- 4d — CRAWFORD UPLAND. Bedrock hills of high relief
- 4e — MITCHELL PLATEAU. Rolling clay-covered upland of low relief and large areas of karst, entrenched by major valleys
- 4f — NORMAN UPLAND. Bedrock hills of high relief
- 4g — SCOTTSBURG LOWLAND. Broad terraced valleys and low till-covered hills
- 4h — CHARLESTOWN HILLS. Bedrock hills of low relief somewhat modified by pre-Wisconsin glacial activity
- 4i — MUSCATATUCK PLATEAU. Broad till-covered uplands entrenched by major valleys
- 4j — DEARBORN UPLAND. Bedrock hills of high relief

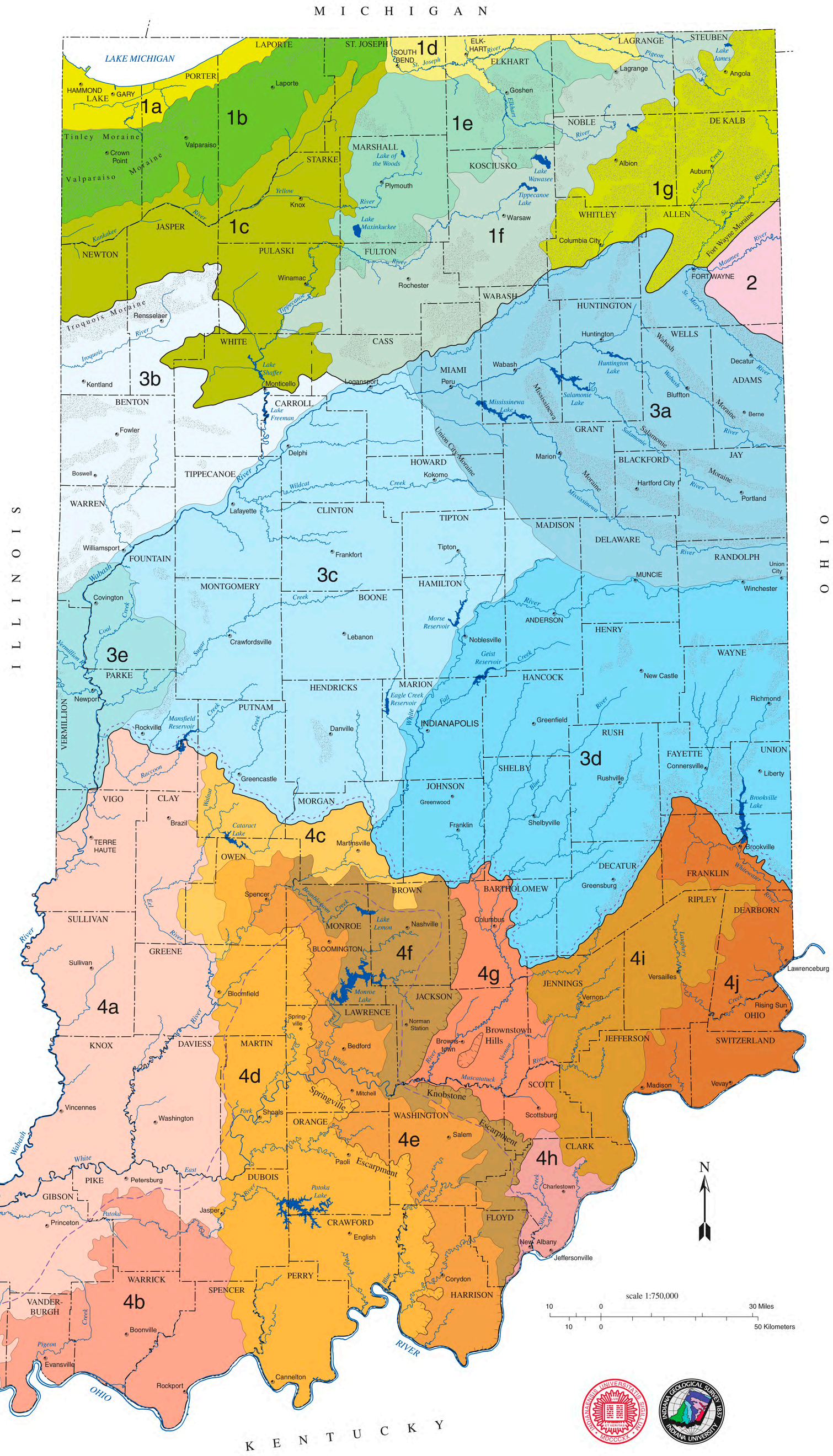
Moraine

Southern limit of Wisconsin glacial deposits

Southern limit of older glacial deposits

This map was compiled by Indiana University, Indiana Geological Survey using data believed to be accurate; however, a degree of error is inherent in all maps. This product is distributed "AS-IS" without warranties of any kind, either expressed or implied, including but not limited to a particular purpose or use. No attempt has been made in either the design or production of this map to define the limits or jurisdiction of any federal, state, or local government. This map is intended for use only at the published scale of 1:750,000. A detailed on-the-ground survey and historical analysis of a single site may differ from this map.

COPYRIGHT 2000 INDIANA UNIVERSITY
INDIANA GEOLOGICAL SURVEY
ALL RIGHTS RESERVED



Base map digitized from USGS Map of Indiana, scale 1:500,000

MAP OF INDIANA SHOWING PHYSIOGRAPHIC DIVISIONS

by

Henry H. Gray

2000

Digital compilation by Kimberly H. Sowder and Rea Williams Kersey