Application of sedimentology to development of sand and gravel resources in McHenry and Kane Counties, northeastern Illinois.

James C. Cobb

Gordon S. Fraser

ILLINOIS MINERAL NOTES 82
December 1981

Illinois Department of Energy and Natural Resources
STATE GEOLOGICAL SURVEY DIVISION

Drafting by Fred Graszer

Cobb, James C.

Application of sedimentology to development of sand and gravel resources in McHenry and Kane Counties, northeastern Illinois / by James C. Cobb and Gordon S. Fraser. – Champaign, Ill. : Illinois State Geological Survey, December 1981.

17 p. ; 28 cm. – (Illinois Mineral Notes ; 82)

1. Sediments (Geology). 2. Mineral resources. 3. Geology–Illinois–McHenry County. 4. Geology–Illinois–Kane County. I. Fraser, Gordon S. II. Title. III. Series.

Printed by authority of State of Illinois/1981/1200

Application of sedimentology to development of sand and gravel resources in McHenry and Kane Counties, northeastern Illinois.

James C. Cobb

Gordon S. Fraser

The authors extend our sincere gratitude to John M. Masters for his major contribution to this work.

CONTENTS

ILLINOIS STATE GEOLOGICAL SURVEY
Robert E. Bergstrom, Acting Chief
Natural Resources Building
615 East Peabody Drive
Champaign, IL 61820

Application of sedimentology to development of sand and gravel resources in McHenry and Kane Counties, northeastern Illinois.

ABSTRACT

The application of the sedimentological model of an outwash plain to appropriate sand and gravel deposits in McHenry and Kane Counties permits reasonably accurate predictions concerning the textures of the various materials in the deposit. These predictions can be of use to pit operators who wish to locate the most desirable type of material for extraction, to landowners in outwash plain areas who want general information about their property, and to land-use planners who must allocate land for specific uses.

The sand and gravel deposit, an important source of aggregate, consists of a heterogeneous mixture of materials. Different areas of the deposit are characterized by certain combinations of sediments. These combinations (assemblages) include: (1) a coarse-grained, highly heterogeneous *marginal assemblage* found on the eastern margin of the outwash deposit; (2) a coarse-grained, but somewhat less heterogeneous, *proximal assemblage* occurring in a band paralleling the marginal assemblage; (3) a relatively finer grained and better sorted *medial assemblage* occurring in a band paralleling the western edge of the proximal assemblage; and (4) a fine-grained *distal assemblage* found beneath the proximal and medial assemblages.

These sediments were deposited in a series of coalescing outwash fans extending westward from the glacial ice margin. The change in characteristics of the sediments within the outwash deposit can be attributed to a progressive change in sedimentary processes, particularly a decrease in stream flow away from the glacial ice margin.

INTRODUCTION

A large outwash deposit trends northwest-southeast in southeastern McHenry County and extends into northeastern Kane County (fig. 1). This report focuses on the part of the deposit from the vicinity of Crystal Lake to just south of Algonquin in northeastern Kane County.

The outwash is a chief source of sand and gravel aggregate for construction materials in the Chicago metropolitan area and has been mined extensively for many years (Willman, 1971). Pressure from urban and rural land utilization has limited the extension of some current workings and curtailed the availability of new mining sites in the deposit. Additional difficulties in locating and developing reserves of this resource at a reasonable price will be experienced in the future unless ways are found to resolve these land-use conflicts. A better understanding of the sedimentary history of these types of deposits can aid future decision making.

The purpose of this investigation is to identify the kinds of sediments that compose the outwash deposit, to characterize them in terms of source and sedimentary history, and to reconstruct the sedimentary history of the outwash deposit. Finally, we will show trends in grain size, sorting, and sediment distribution—information which may be of use to aggregate producers, landowners, and land-use planners.

The methods used in this investigation include surface and subsurface mapping of the outwash deposit, descriptions of exposures and measured sections, sand/silt/clay analysis, particle-size determinations, and trough axis and cross-strata orientations (Cobb, 1974).

PREVIOUS STUDIES

Previous investigations of glacial geology in the subject area are cited by Anderson and Block (1962) and Hackett and McComas (1969). They emphasize the importance of this area as a source of sand and gravel. Masters (1978) confirms the continuing economic importance of these deposits. Similar deposits that extend into northwestern Du Page County and that often extend eastward under relatively thin, sandy till deposits (Kempton et al., 1977) correspond closely to those deposits in the study area. The formal deposit and landform names used in this paper follow terminology established by Willman and Frye (1970).

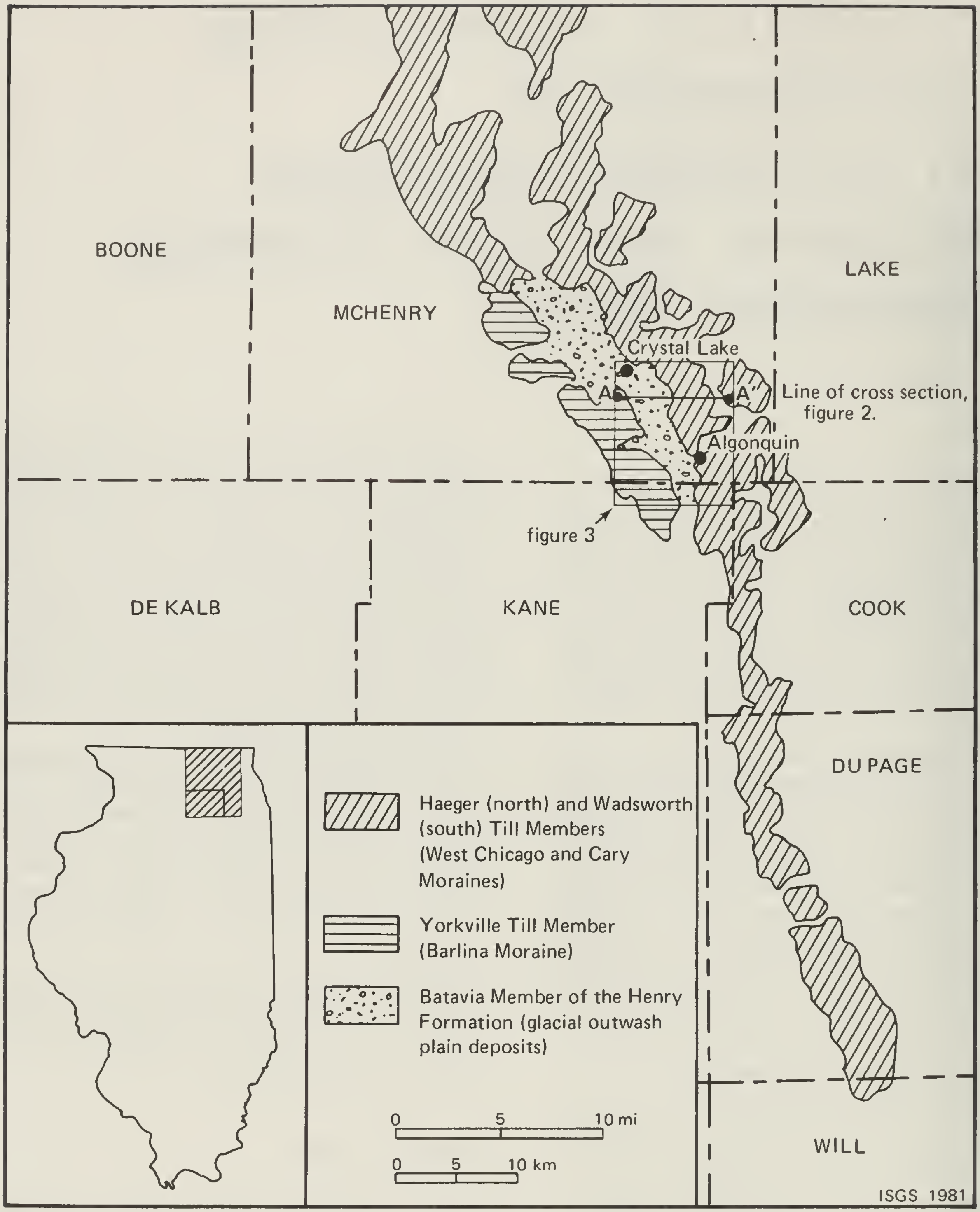


Figure 1. Location map of the study area. The deposit boundaries were reproduced from Willman and Frye, 1970, plate 1.

GEOLOGIC SETTING

The present report provides geological details about the outwash deposit in the Crystal Lake-Algonquin area, defined by Masters (1978) as type I bouldery outwash plains. Similar deposits are present elsewhere in McHenry, Kane, and Du Page Counties (Masters, 1978, pl. 1). The outwash deposit is Woodfordian (late Wisconsinan) in age and is assigned to the Batavia Member (Henry Formation). The outwash occupies a trough between till deposits (fig. 1). The deposit is nearly 30 m (98.4 ft) thick at the eastern margin and thins to the west. It overlies till with a generally level, slightly undulating surface (Tiskilwa Till Member of the Wedron Formation). The upper surface of the outwash deposit slopes to the southwest. The Yorkville Till Member (Wedron Formation) is the western boundary and forms a well-defined ridge (Barlina Moraine). The Haeger and Wadsworth Till Members (Wedron Formation) form the eastern and northeastern boundaries of the outwash and consist of a hummocky ridge on the east and a lobate ridge to the northeast (West Chicago and Cary Moraines).

GEOLOGIC HISTORY

The present distribution of materials in the area of the outwash deposit is the result of several periods of erosion and deposition caused by the advance and melting of at least three lobes of continental glaciers from the Lake Michigan Basin and their associated meltwaters (fig. 2). The Tiskilwa and Yorkville Till Members were deposited respectively by two ice advances in such a way that the land surface was higher in the west than to the east. When the next glacial lobe began to encroach on the study area from the east and north, the lower land became flooded with meltwater, and clays, silts, and sands were deposited (fig. 2, L, DL). As the glacier advanced closer to the study area, outwash sands and gravels accumulated on the lowland deposits (fig. 2, MD). As the glacier advanced into the study area, meltwaters pouring out of the ice front reworked the earlier deposits and replaced them, in part, with coarser and less-sorted sand and gravel. The glacier overrode the eastern part of its own outwash deposit, while its meltwaters washed coarser material farther west and south (fig. 2, PX, MR). As the ice lobe melted, it left deposits of the Haeger Till Member on top of the outwash and on the east side of the outwash deposit. Fine-grained alluvium accumulated along the west side of the outwash deposit, adjacent to the remains of the Yorkville Till Member.

SEDIMENTOLOGY

Although the outwash deposit consists of a heterogeneous mixture of sediments ranging in size from clay to boulders, four combinations, or assemblages, of sediments are characteristic of certain portions of the deposit. In general, these assemblages, with the exception of the distal assemblage, are arranged in bands that parallel the margin of the Haeger Till Member (fig. 3). The distal assemblage occurs below other assemblages where it was, at least partially, preserved by burial; it was largely eroded from along the eastern edge of the Yorkville Till Member. These assemblages (figs. 2 and 3) are:

1. Marginal assemblage (MR). Found in a band along the eastern margin of the outwash deposit.
2. Proximal assemblage (PX). Occurring in a band paralleling the western margin of the marginal assemblage and extending west up to 2 km (1.2 mi) from the Haeger Till Member.
3. Medial assemblage (MD). Occurring in a band

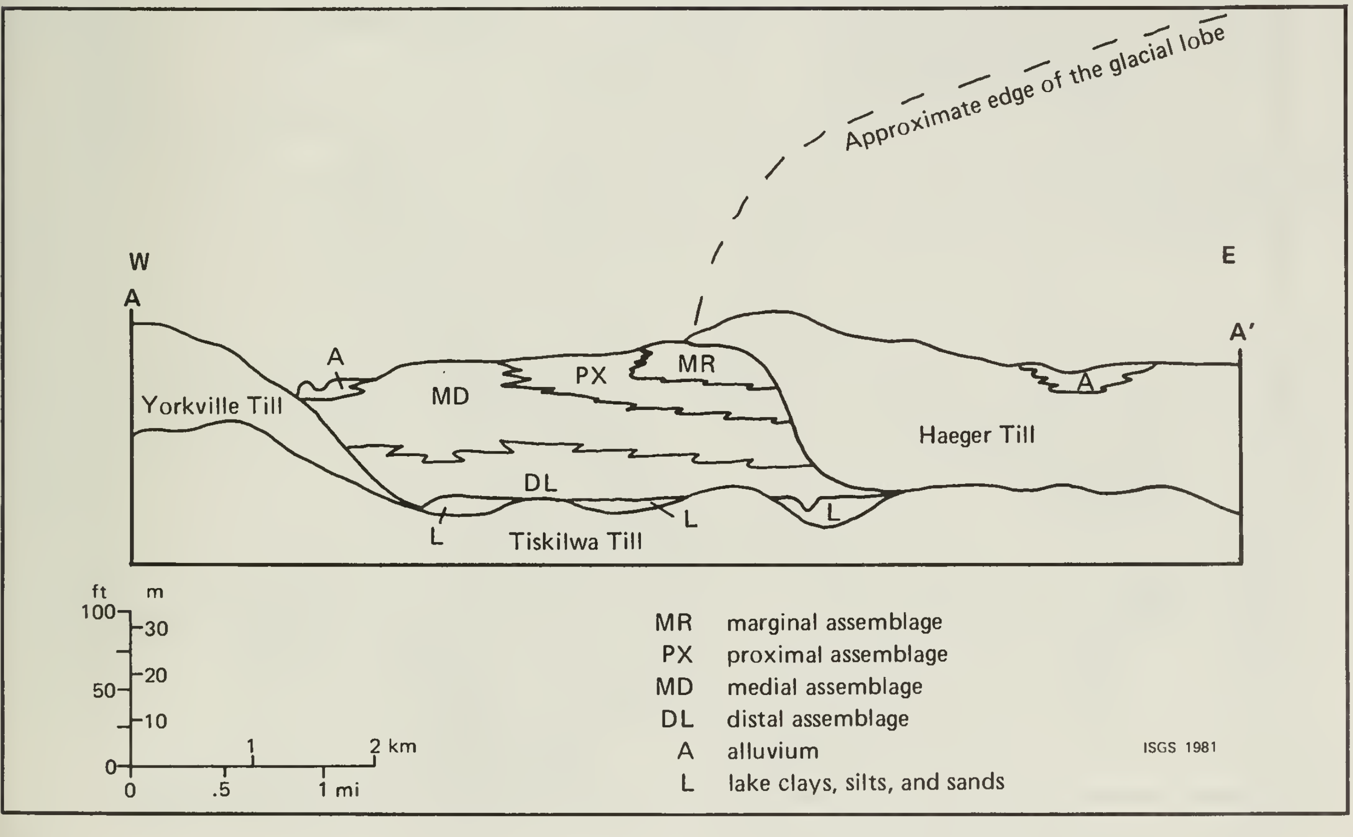


Figure 2. Generalized east-west cross section of the outwash deposit near Crystal Lake. Location is shown on figure 1.

paralleling and west of the proximal assemblage.

4. Distal assemblage (DL). Found underlying medial and proximal assemblages. Occurrences of this assemblage along the western margin of the outwash deposit have probably been eroded.

Marginal assemblage

The marginal assemblage is composed of the widest variety of sediments and grain sizes of the four assemblages discussed. Marginal assemblage sediments are characterized in figure 4, which shows nature of bedding and sediment, grain-size distribution, and interpretation of the sediments. The extremes in the sediments of the marginal assemblage are attributed to the close proximity of their deposition to the glacial source and to the wide variety of sedimentary processes that occur near the terminus of a glacier that is issuing forth huge volumes of debris-laden meltwater while it is slowly advancing over its own outwash sediments. These marginal sediments are divided into four distinct

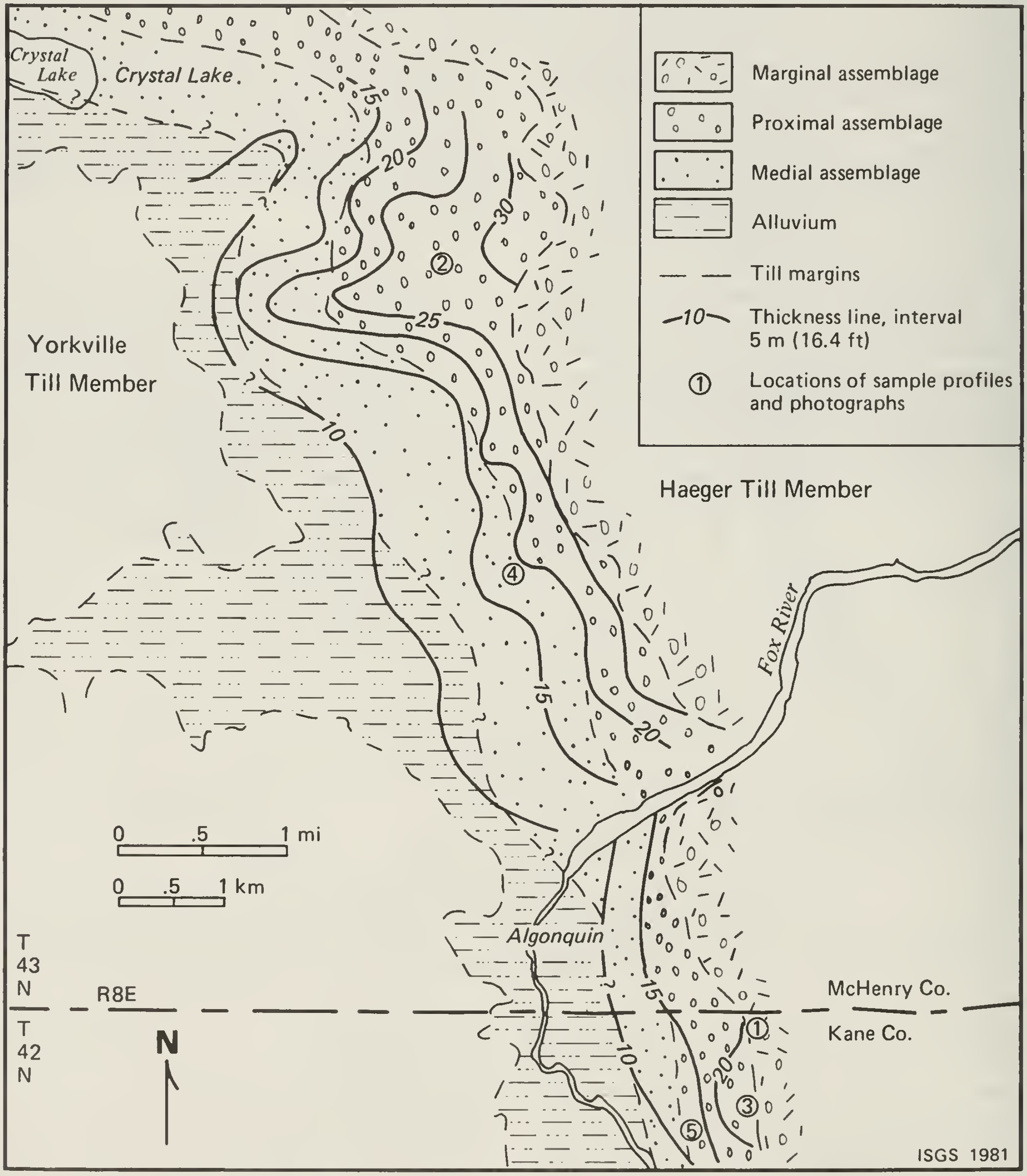


Figure 3. Distribution of outwash assemblages and locations of sample profiles and photographs.

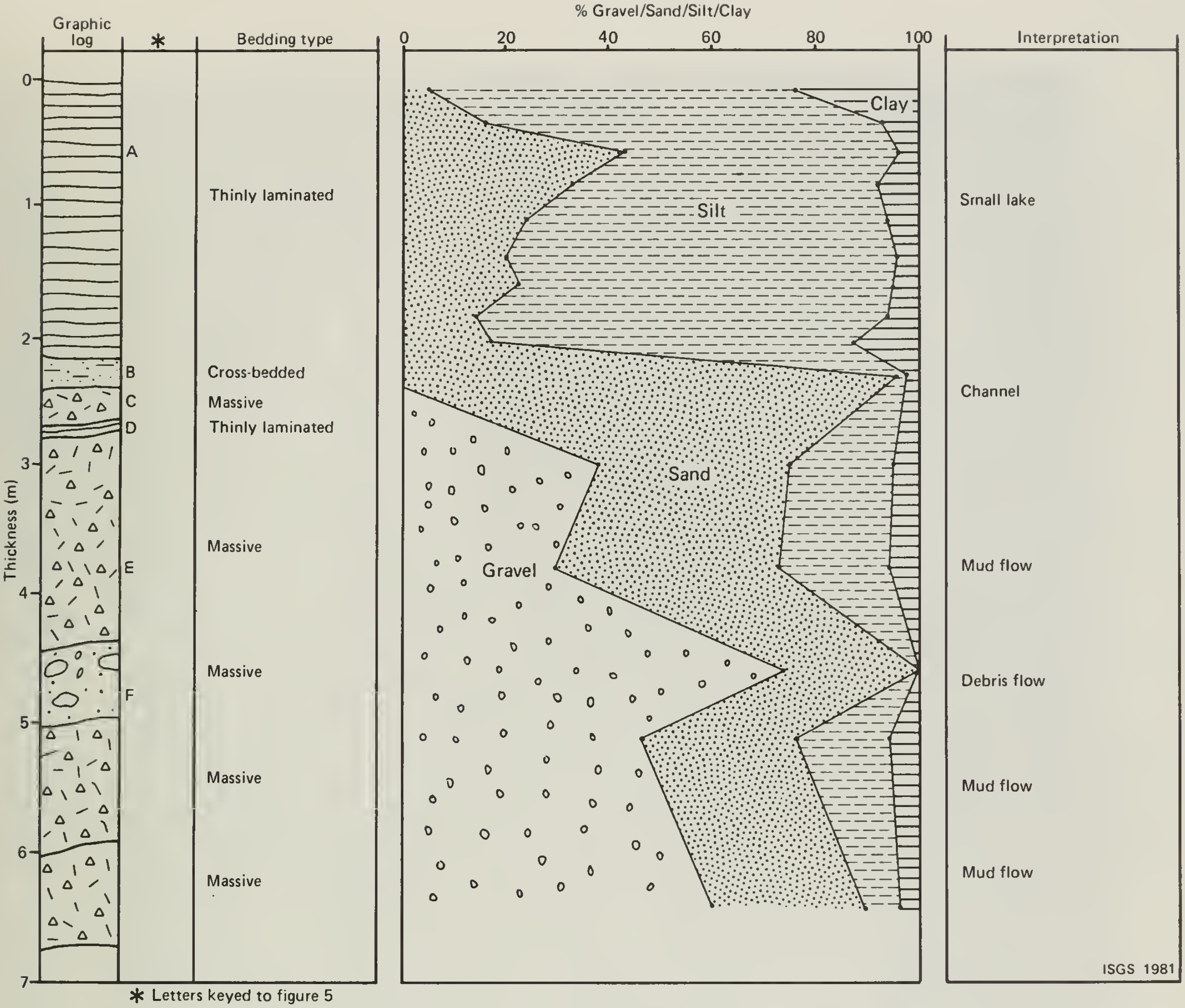


Figure 4. Marginal assemblage showing bedding types, grain size, and depositional interpretations. Letters A through F correspond to the units on figure 5. Location 1 on figure 3.

types: (1) heterogeneous muddy cobble gravel (C, E); (2) sandy cobble gravel (F); (3) laminated silt and clay (A, D); and (4) cross-bedded sand and usually gravel (B). The heterogeneous character of the marginal sediments creates some difficulties to mining because of the large amount of fine-grained material (silt and clay).

The most common sediment in this assemblage is a heterogeneous, massive, muddy cobble gravel (C and E, figs. 4 and 5), which is composed of up to 85-percent sand, pebbles, and cobbles. Boulders are also common. The mud, which consists mainly of silt-sized material, constitutes up to 25 percent of the sediment. The muddy cobble gravels occur in successive, massive layers as much as 2.5 m (8.2 ft) thick. These layers are differentiated by subtle color differences, amount of mud in the matrix, and thin, irregular scour and fill surfaces between the massive layers.

In some cases, particularly where the mud content is low, the muddy cobble gravels are an excellent source of aggregate. The muddy cobble gravels extend westward from the moraine as thinning, lenticular bodies and interfinger with aggregate materials that contain much less matrix mud. In these cases, the extraction and washing of muddy cobble gravel is especially worthwhile for access to the underlying gravels that contain much less mud.

The second most common sediment in this assemblage is the sandy cobble gravel (F, figs. 4 and 5). This gravel occurs in beds that extend for many meters in pit exposures and in lenses of limited lateral extent that are up to 2 m (6.5 ft) thick. In some cases, the beds are vertically size-graded with coarser clasts and low matrix content at the base and finer clasts and higher matrix content in the upper parts. Pods of boulder gravel that contain a sandy matrix also occur within the muddy cobble gravels.

Figure 5. Photograph of a pit face of marginal assemblage material containing: (A) contorted, thinly laminated lacustrine muds; (B) cross-bedded sand; (C) muddy cobble gravel; (D) erosion surface overlain by thinly laminated mud; (E) muddy cobble gravel; and (F) lenticular sandy cobble gravel. Location 1 on figure 3.

The cobble gravels that are rich either in mud or sand suggest deposition of mud and debris flows in an outwash fan. Sediment characteristics that indicate these processes are: size-graded beds, contorted contacts between successive flows, erosional surfaces between successive flows, lenticular shape of some individual flows, and pods of boulder gravel that show evidence of sinking into other muddy cobble gravels.

The mining of sandy cobble gravels yields a wide range of aggregate products, particularly in the large gravel sizes, and only small amounts of mud. Because the sandy cobble gravels predominantly occur with the muddy cobble gravels, their resource contributions are similar and the undesirable mud content affects them both.

The third most common sediment that occurs in the marginal assemblage is a laminated silt and clay (mud) (A, figs 4 and 5). It is found in basinlike depressions in the muddy cobble gravels. Sand composes up to 50 percent of the laminated deposit. Well-sorted sands in inclined beds are found on the margins of the laminated mudfilled basins. The most extensive deposits of this sediment are in basins, up to 3 m (9.8 ft) deep and 100 m (328 ft) across, that invariably occur in the upper part of outcrops where the marginal assemblage is exposed (fig. 5). Smaller, lenticular bodies of the laminated mud deposits occur throughout the section of marginal assemblage sediments. Whenever deposits of the laminated muds are found in the top of marginal assemblage exposures, they are stripped off prior to mining.

The fourth and least common sediment type composing the marginal assemblage is sand and gravel that occurs in inclined beds and fills large erosional channels cut into the muddy cobble gravels. (This channel type of sediment is better illustrated later in figure 8 than in figure 5.) The inclined sets are up to 4 m (13.1 ft) thick and persist laterally for several hundred meters. Lenticular deposits composed of cross-stratified, fine-grained pebbly sands also fill erosional cuts in the muddy cobble gravels but have a limited lateral extent. Other such erosional cuts up to 2 m (6.6 ft) are filled with well-sorted, medium- to fine-grained, and medium- to coarse-grained sand. These sands have layers of granules and pebbles. The inclined beds of these pebble sands are in sets up to .5 m (1.6 ft) thick.

Some of the channel fills are very coarse-grained. The large lateral extent of the channels, and the thickness of the deposits indicate that these materials were deposited by large, powerful streams emerging from the glacier. The orientation of the trough axes and the direction of maximum dip of inclined beds indicate that these streams were flowing east to west. The mining and processing of these sands and gravels provide a wide range of sand, granule, and fine gravel products.

Proximal assemblage

The proximal assemblage occurs adjacent to the western edge of the marginal assemblage. Sediments in the marginal assemblage contain a higher frequency of large clasts, but because of the abundance of silt and clay, the marginal assemblage averages finer grained than the proximal, the coarsest grain assemblage of the four types. Clasts in the proximal assemblage range from fine sand to boulders; mud (silt and clay) occurs in small lenses and as a very minor component of the matrix material. The proximal sediments are in size-sorted layers of cobbles, pebbles, or sand, or in heterogeneous layers containing a wide range of materials.

Figure 6 shows the bedding types, mean grain size, percentage of sand and gravel, and representative grain-size histograms for the proximal deposits. Coarse-grained beds may have an open framework texture with no matrix, between the pebbles. Bedding in this assemblage mainly reflects high flow erosional processes. It is horizontal, poorly defined, and discontinuous (figs. 6 and 7), giving an overall alternating array of beds that are everywhere, either truncated or lenticular.

Although high flow erosional features are dominant characteristics of the proximal assemblage, rare exposures show the record of original lower flow depositional processes in the assemblage. In the outcrop shown in figure 8, a channel filled with sand and interlayered sand and pebbles, often in steeply inclined cross-beds (fig. 8, B, C, D), is enclosed by coarse sediments more diagnostic of the proximal assemblage (fig. 8, A, E).

The sediments of the proximal assemblage, their structures, textures, alternating arrays, erosional surfaces, and proximity to the source moraine suggest that they were deposited by streams choked by sediments and flowing in rapidly shifting channels. The bulk of these sediments were transported in accreting gravel bars that formed and were subsequently partially eroded.

The mining of the proximal assemblage produces a highly desirable variety of gravel and sand aggregate products. In the proximal sediments there is an abundance of gravel up to cobble size with scattered boulders. Approximately 80 percent of the proximal material is gravel, 18 to 19 percent is sand, and only 1 to 2 percent is mud. Most mines in the Crystal Lake-Algonquin area are producing aggregate from proximal sediments.

Medial assemblage

Sediments of the medial assemblage are better sorted and finer grained than those of the proximal assemblage. Figure 9 shows the characteristic bedding types, mean grain size,

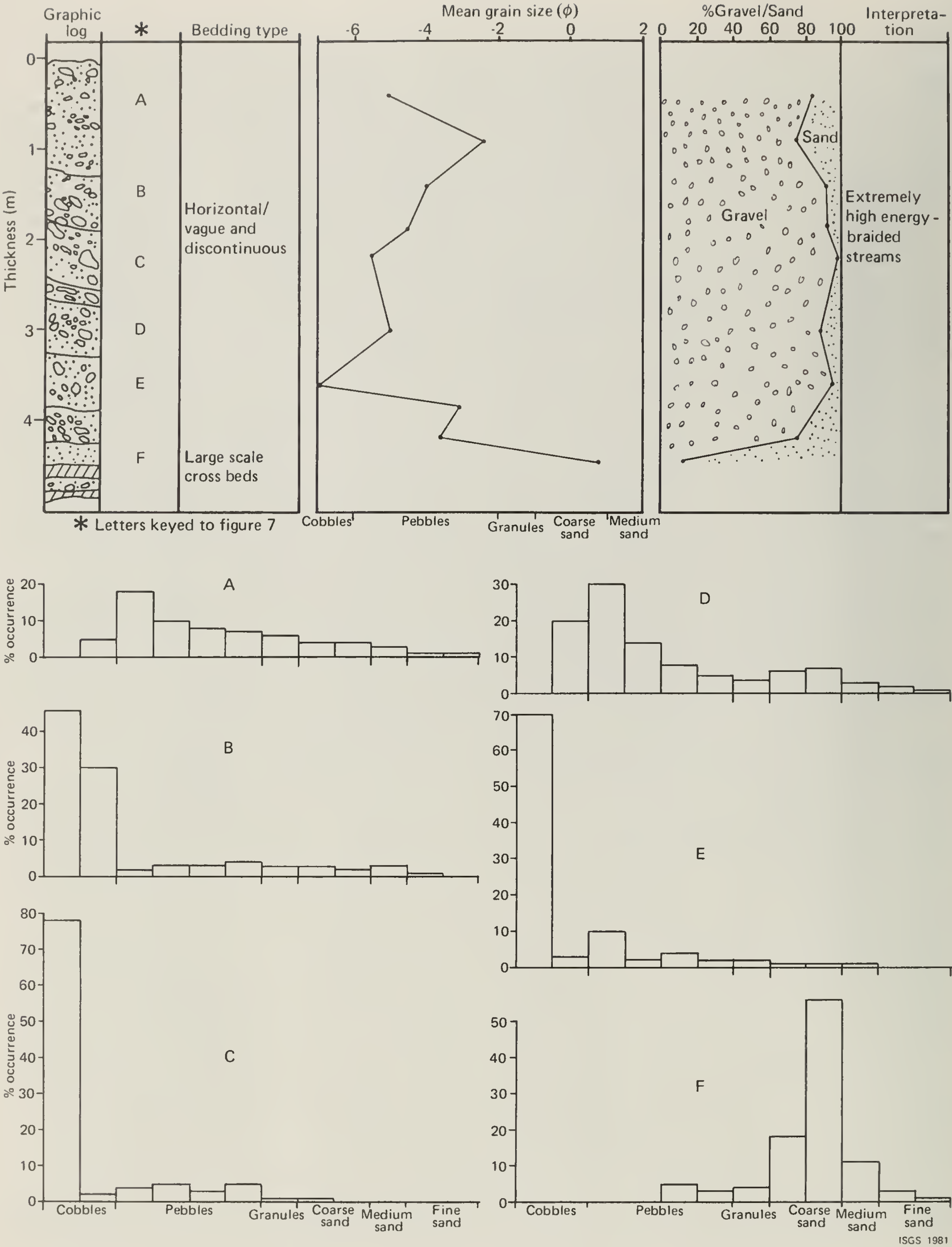


Figure 6. Sample profile of a pit face of proximal assemblage material showing bedding types, grain size, selected histograms, and depositional interpretations. Letters A through F correspond to the units on figure 7 and the selected histograms. Location 2 on figure 3.

Figure 7. Photograph of a pit face of proximal assemblage material containing several coarse cobble gravels arranged in poorly defined, horizontal beds. Cross-bedded sands occur near the base. Location 2 on figure 3.

Figure 8. Photomosaic of a pit face containing a channel-fill sequence in proximal assemblage material: (A) horizontally bedded cobble gravel; (B) cross-bedded pebbly sands and sandy gravels; (C) cross-bedded sand; (D) inclined bedded sandy gravel; and (E) horizontally bedded cobble gravel. The cross-bedded sands and fine gravels in the channel deposits (B, C, and D) were probably deposited during relatively

sand-to-gravel ratios, and grain-size histograms for the principal medial sediments. The medial assemblage is characterized by greater continuity of bedding. The beds are thinner than those of the proximal assemblage and are laterally more persistent.

Because of its textures, stratifications types, and position down-slope from the source area (the snout of the glacial lobe), the medial assemblage was probably deposited by braided streams that flowed less rapidly than when close to the glacier. Figure 10 illustrates the interbedded nature of the layers of cross-bedded sand and horizontally bedded cobble gravels of the medial assemblage.

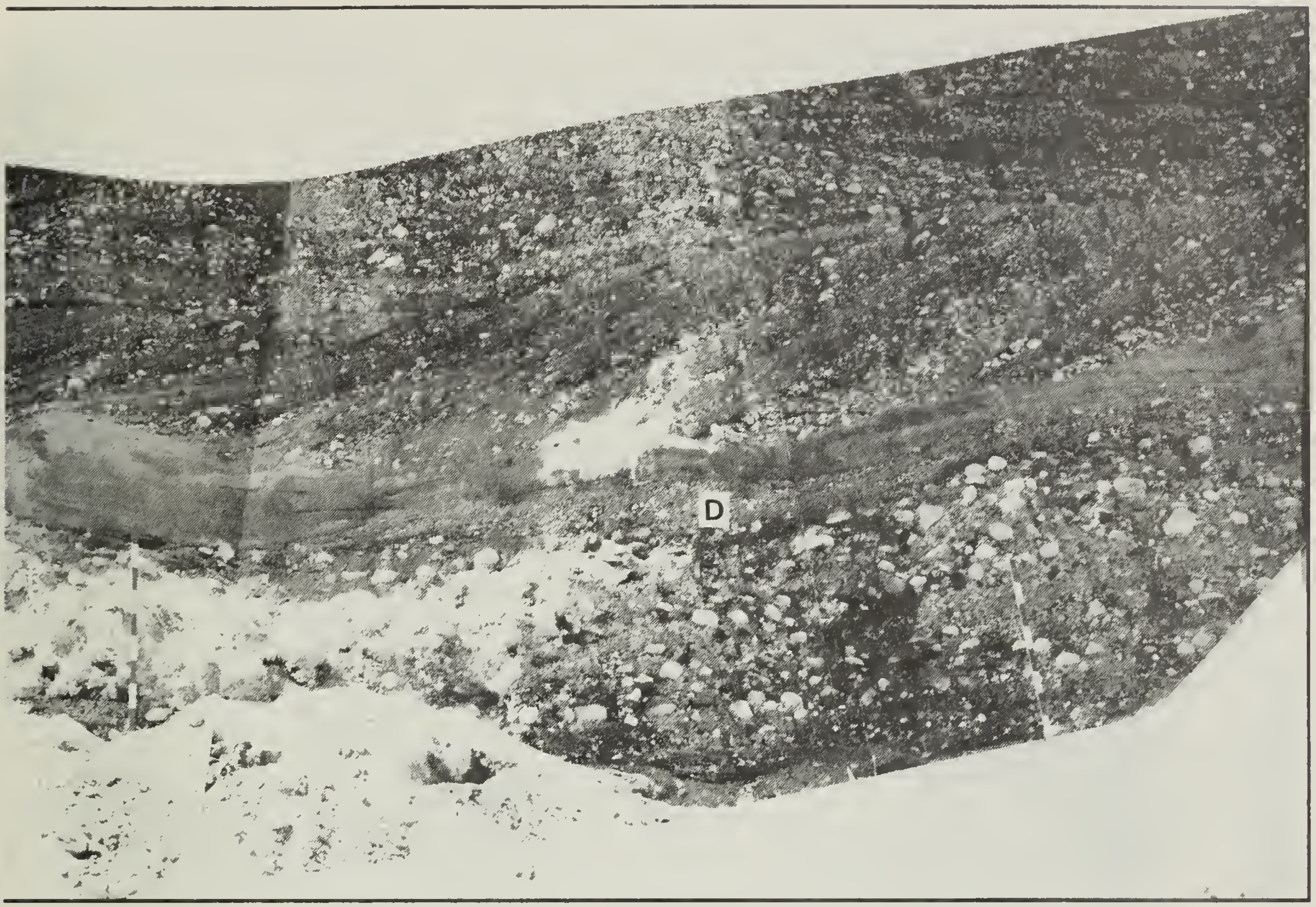
Extraction of sand and gravel from the medial assemblage in the study area has already been extensive. The medial assemblage produces an abundance of sand, granules, and pebbles. Mud is scarce in the medial sediments. About equal amounts of sand and gravel are present in this assemblage.

Distal assemblage

The distal assemblage is the least exposed of the four outwash assemblages. The only surface exposures are where mining of the other assemblages has cut deep enough to expose the distal sediments. These deeper parts of the gravel pits are frequently underwater. The principal bedding types, mean grain size, sand-silt-clay composition, histograms of particle-size data, and interpretations of the deposits are shown in figure 11.

The distal assemblage sediments are very fine grained. The two distinct sediments of the distal assemblage are laminated muds and fine-grained, cross-bedded sands.

The laminated muds overlie an irregular surface that developed on the Tiskilwa Till (fig. 12). In places, a lag gravel is at the base of the laminated deposit and consists of sand and gravel and occasional preserved fragments of wood. Deposits of the laminated mud are up to 2 m (6.6 ft) thick and are thickest in depressions in the till surface. The



low flow stages. They are bounded at the top and bottom by horizontally bedded cobble gravels that were deposited during high flow (flood) stage. Location 3 on figure 3.

laminated muds are size-graded into alternating silty and clayey layers up to 10 cm (3.9 in.) thick.

Overlying the laminated muds are cross-bedded, fine- to medium-grained sands (fig. 12). The thicker deposits of these sands occur in channels cut into the laminated muds.

The laminated muds were deposited in one or more proglacial lakes that occupied portions of the lowland between the Yorkville Till and the Haeger glacier prior to the deposition of the other outwash sediments. Subsequently, the lakes were drained and streams established themselves on the emergent lake plain. These streams cut into the laminated mud deposits and deposited the cross-bedded sands.

Aggregate products from the distal assemblage are principally various size grades of sand. Currently it is being dredged in two pits where the sand is also being mixed with coarser material from overlying assemblages. The sand is mined only in pits where the mining of coarser-grained assemblages has exposed the distal assemblage.

COMPARISON WITH PRESENT-DAY GLACIO-FLUVIAL DEPOSITS

Modern glacio-fluvial sediments often accumulate in outwash plains and fans. Deposition is characterized by a variety of processes that include mud and debris flow and lacustrine and stream deposition. Downstream variations in grain size and stratification have also been observed (Boothroyd, 1972) in modern glacial settings. The results of these processes have been recognized in the sediments of the outwash deposit in the study area.

The comparison of the outwash plain in the present study to modern glacio-fluvial deposits shows that it probably formed a series of coalescing outwash fans emerging from the Haeger glacial ice. These outwash fan sediments, as recognized in the marginal, proximal, medial, and distal assemblages, extend westward into the intermorainic lowland and southward where they were funneled parallel to the trend of the intermorainic area.

Several sediment distribution characteristics that the

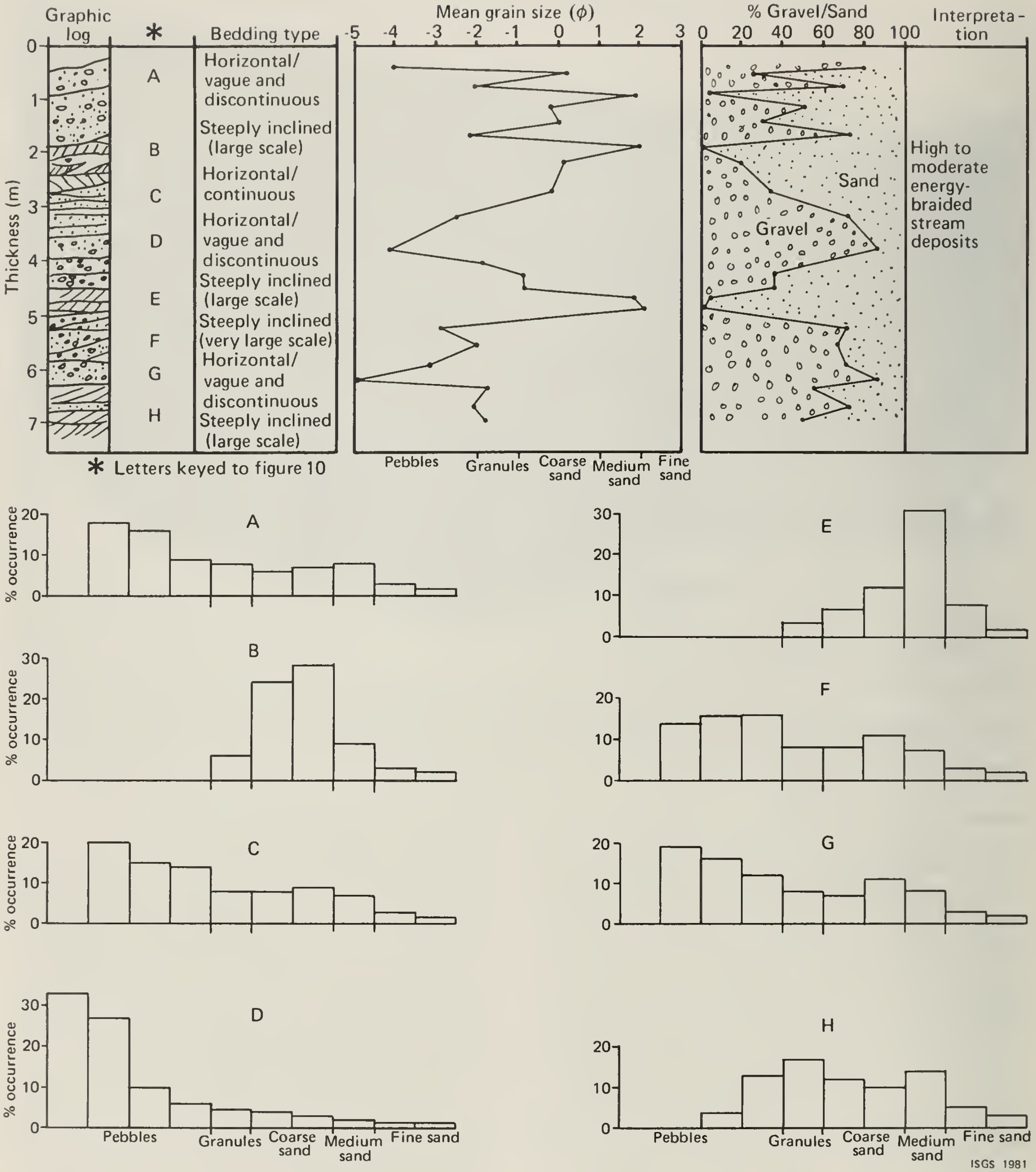


Figure 9. Sample profile of a pit face of medial assemblage material showing bedding types, grain size, selected histograms (samples A through H), and depositional interpretations. Letters A through H correspond to the units in figure 10 and the selected histograms. Location 4 on figure 3.

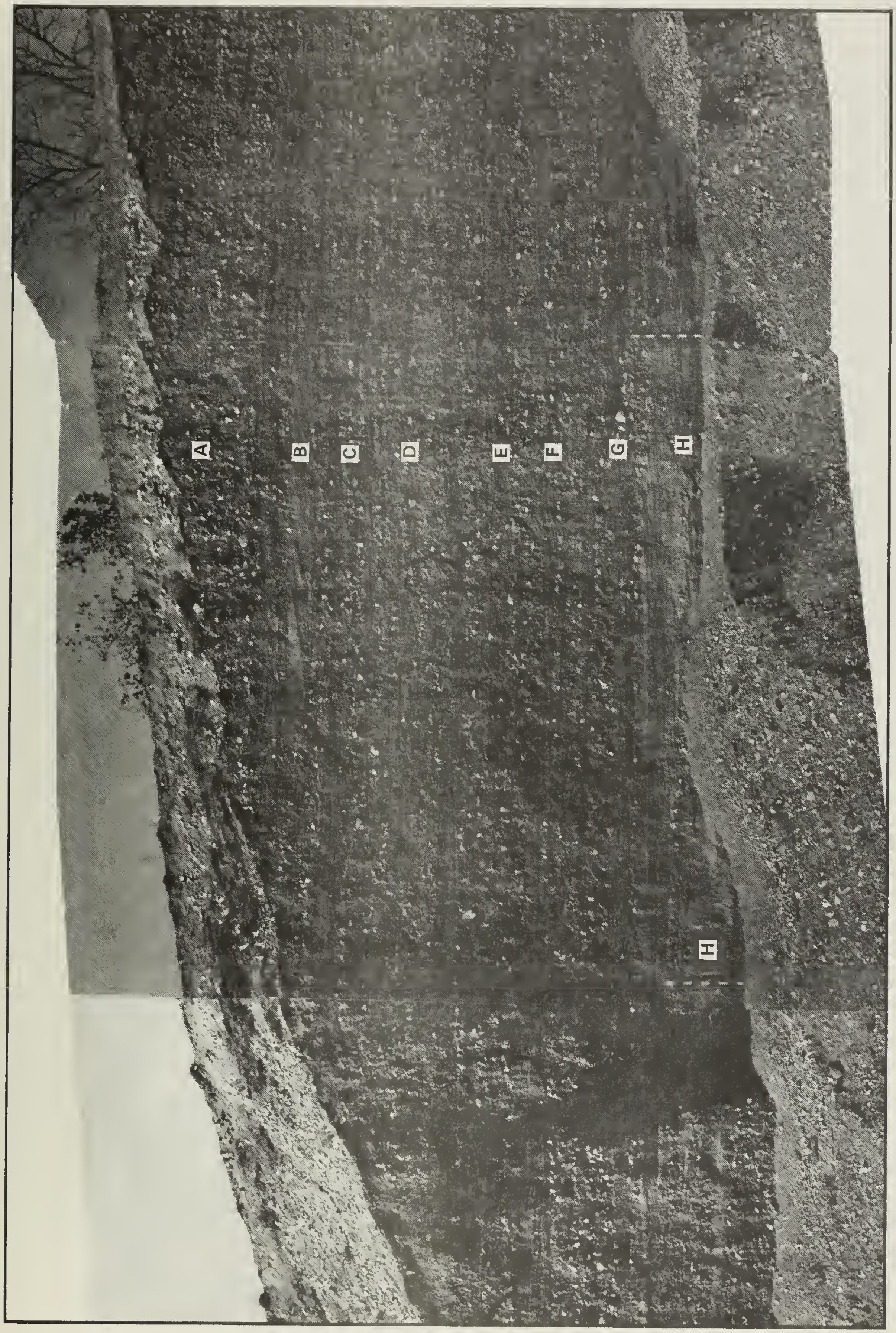


Figure 10. Photomosaic of a pit face containing medial assemblage material that illustrates the interbedded nature of their cross-bedded sand layers and horizontally bedded cobble gravels. Location 4 on figure 3.

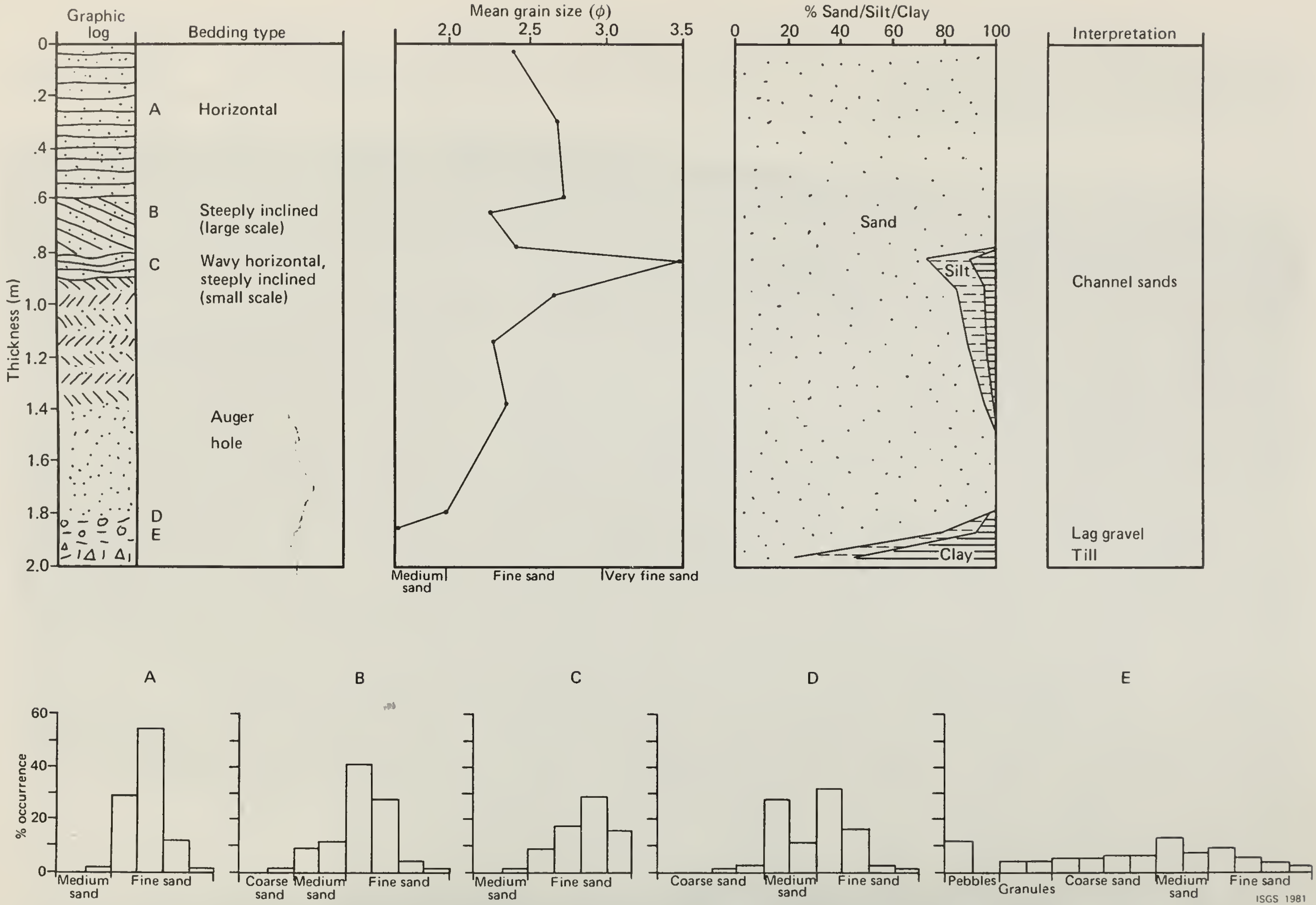


Figure 11. Distal assemblage showing bedding types, grain size, selected histograms (samples A, B, C, D, and E), and depositional interpretations. Location 5 on figure 3.

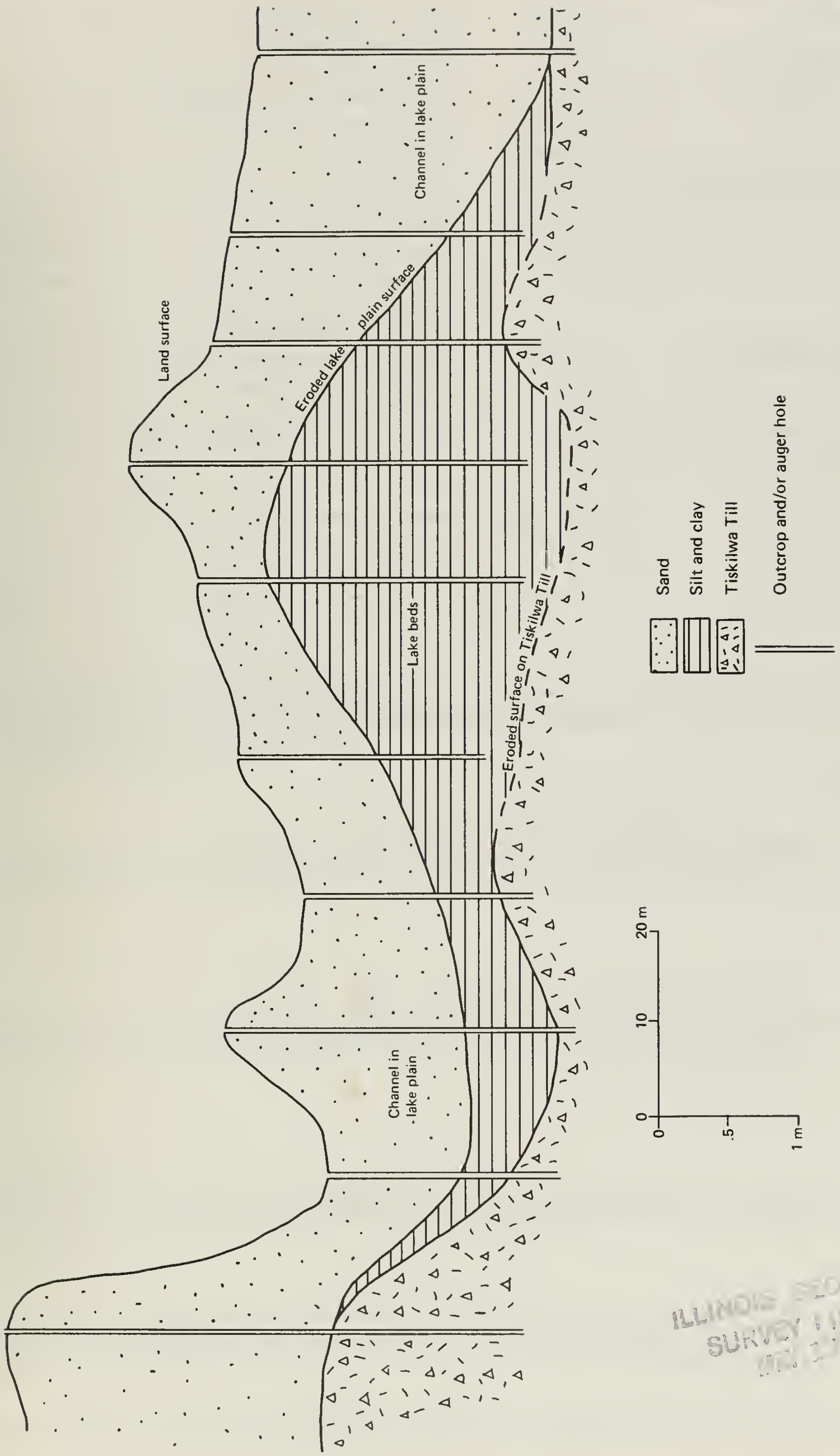


Figure 12. Cross section of outcrops and auger holes in distal assemblage material consisting of fine-grained, cross-bedded sands and laminated silts and clays. Location 5 on figure 3.

outwash in the present study has in common with some modern outwash deposits are:

1. Decrease in mean grain size and maximum grain size away from the source.
2. Increase in sorting and in the sand to gravel ratio away from the source.
3. Decrease in abundance and thickness of horizontally bedded units away from the source.
4. Increase in various types of cross-bedded units away from the source.

DEVELOPMENT OF SAND AND GRAVEL RESOURCES

Characteristics of the outwash assemblages that can be interpreted as quality parameters for aggregate are schematically represented for the outwash deposit in figure 13. The distribution of these parameters shows the proximal and medial assemblages to have the most desirable combination of sediment characteristics. The proximal and medial assemblages are particularly desirable because of their large mean grain size, large maximum grain size, and low mud content.

The optimum deposit for use as an aggregate resource contains a large range of particle sizes and a low mud content. The large particle-size range may include components from fine sand up to coarse gravel. This wide range is desirable because a variety of aggregate products can be made from a single, well-graded deposit.

The outwash deposit in this study contains an especially desirable range of particle sizes but has significant proportions of mud and oversize boulders in some parts. A low mud content is desirable because the extra costs of handling, separating, and disposing of this waste material may detract

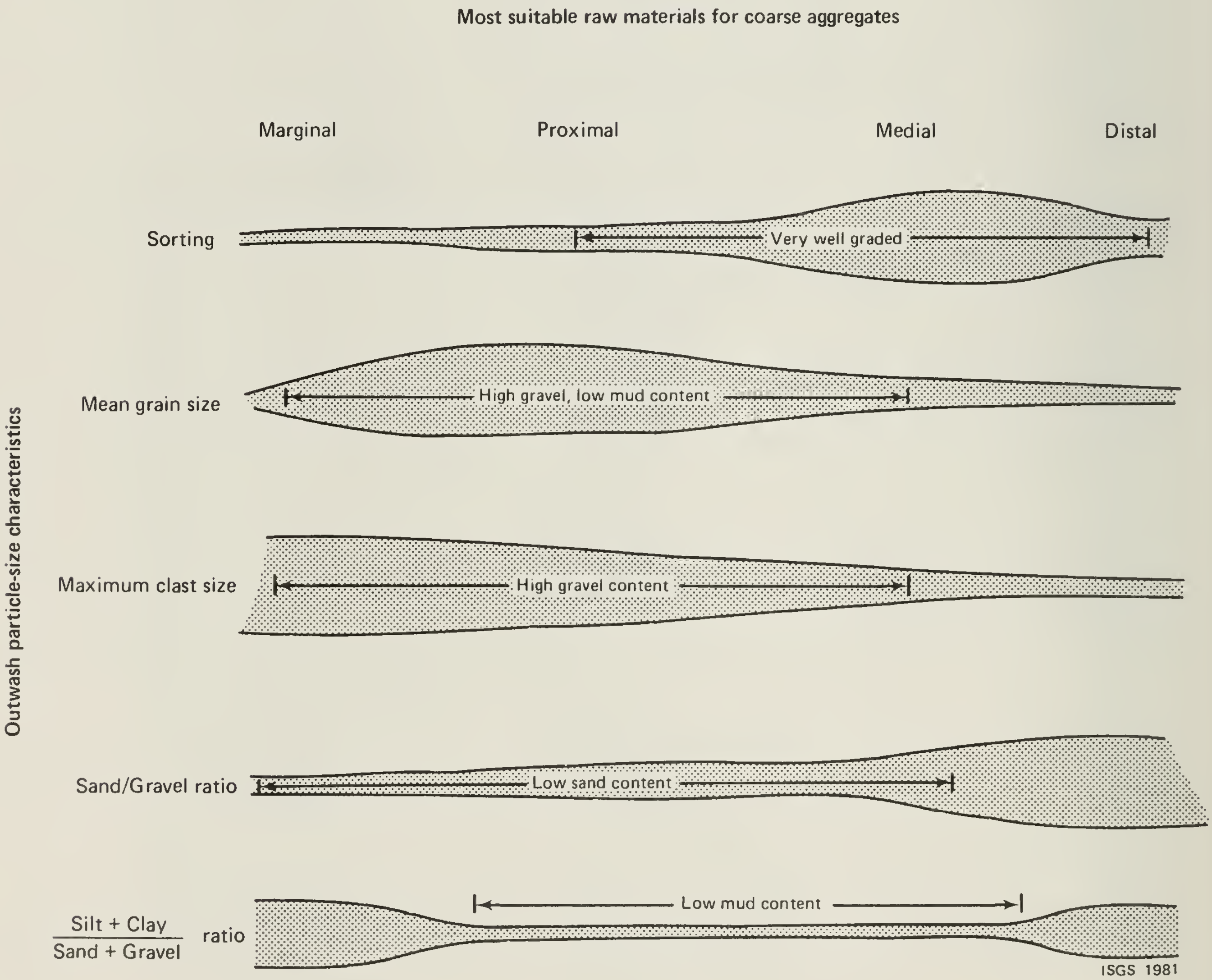


Figure 13. Diagram showing relation between outwash assemblages and particle-size characteristics to the suitability of the material as construction aggregate.

somewhat from the overall economics of deposits. Similarly, boulders that are too large to be economically transported or crushed are not desirable unless they can be stock piled and sold for riprap or landscaping. The sediment history and recognition of the four assemblages in this deposit make possible the prediction of excessive concentrations of the less desirable materials. In the case of the outwash deposit in this study, the marginal assemblage and the distal assemblage may have excessive concentrations of oversize boulders and/or mud in some places.

The optimum materials, therefore, are the sand-rich gravels in the proximal and medial assemblages (fig. 13). These gravels have only small amounts of mud and few oversize boulders. The proximal assemblage is particularly desirable because crushed gravel can be produced from the abundance of gravel in the assemblage as well as a wide variety of other screened products.

The application of these sediment descriptions may also be used for exploration for additional sand and gravel deposits in northeastern Illinois and other glaciated areas. The map of Woodfordian moraines (Willman and Frye, 1970, pl. 1) and particularly the map of sand and gravel resources in northeastern Illinois (Masters, 1978, pl. 1) show many outwash deposits between moraines that may have collected significant amounts of material suitable for development as a source of construction aggregate. These are the areas most likely to have a sequence of sediments similar to that of the outwash in the Crystal Lake-Algonquin area.

REFERENCES

Anderson, R. C., and D. A. Block, 1962, Sand and gravel resources of McHenry County, Illinois: Illinois State Geological Survey, Circular 336, 1 pl., 15 p.

Boothroyd, Jon C., 1972, Coarse-grained sedimentation on a braided outwash fan, northeast Gulf of Alaska: University of South Carolina, UNR Technical Report No. 6-CRO, 127 p.

Cobb, J. C., 1974, Sedimentology of an outwash fan deposit in the Woodfordian (late Wisconsinan) of northeastern Illinois: Eastern Kentucky University, Richmond, Kentucky, unpublished M.S. thesis, 77 p.

Hacket, J. E., and M. R. McComas, 1969, Geology for planning in McHenry County: Illinois State Geological Survey, Circular 438, 31 p.

Kempton, J. P., J. E. Bogner, and Keros Cartwright, 1977, Geology for planning in northeastern Illinois: Illinois State Geological Survey, open file, eight sections prepared for Northeastern Illinois Planning Commission, 96 pl., 77 p.

Masters, John M., 1978, Sand and gravel and peat resources in northeastern Illinois: Illinois State Geological Survey, Circular 503, 1 pl., 11 p.

Willman, H. B., 1971, Summary of the geology of the Chicago area: Illinois State Geological Survey, Circular 460, 77 p.

Willman, H. B., and J. C. Frye, 1970, Pleistocene stratigraphy of Illinois: Illinois State Geological Survey, Bulletin 94, 204 p.