ILLINOIS STATE GEOLOGICAL SURVEY

M. M. Leighton, Chief
Urbana

GUIDEBOOK

FIELD CONFERENCE ON NIAGARAN REEFS IN THE CHICAGO REGION

Prepared by

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Held in connection with the
35th Annual Convention of the
American Association of Petroleum Geologists
at Chicago

April 28, 1950

INTRODUCTION

This field conference is being carried out by the Illinois State Geological Survey at the request of the Executive Committee of the American Association of Petroleum Geologists.

The committee in charge of arrangements is as follows: M. M. Leighton, Chairman, H. A. Lowenstam, G. O. Raasch, H. B. Willman, and L. E. Workman.

SOURCE OF DATA

Information on the Niagaran strata is largely from unpublished manuscripts by H. A. Lowenstam, H. B. Willman, and L. E. Workman in the files of the Illinois State Geological Survey.

Descriptions of Pleistocene features are based largely on the Chicago Areal Geologic Maps by J Harlen Bretz.

PUBLICATIONS

As a convenience to those who may wish additional information on the Chicago region and Niagaran reefs in Illinois, copies of the following publications may be purchased at the registration desk:

"Geology of the Chicago Region, Part I - General," by J Harlen Bretz, Illinois Geological Survey Bulletin 65, 50 cents.

"Niagaran Reefs in Illinois and Their Relation to Oil Accumulation," by H. A. Lowenstam, Illinois Geological Survey Report of Investigations 145, 25 cents.

Chicago Areal Geologic Maps (22 sheets), Illinois Geological Survey, $2.20 per set. A set of the Berwyn, Calumet City, and Hinsdale geologic maps, which cover areas where stops will be made, may be purchased for 45 cents.

Figure 1. - Route map, showing major exposures of Niagaran reefs (klintar) in the Chicago region.

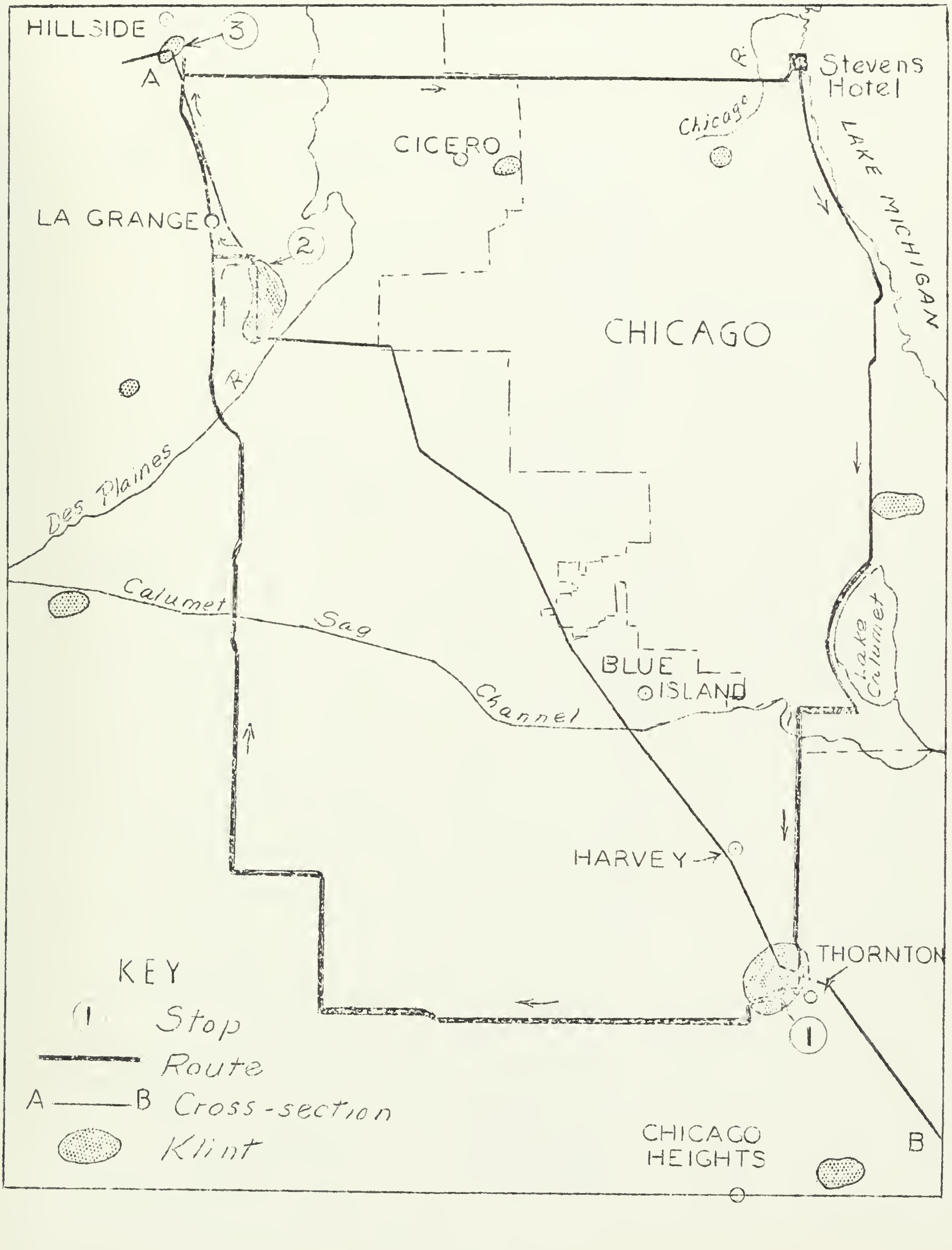
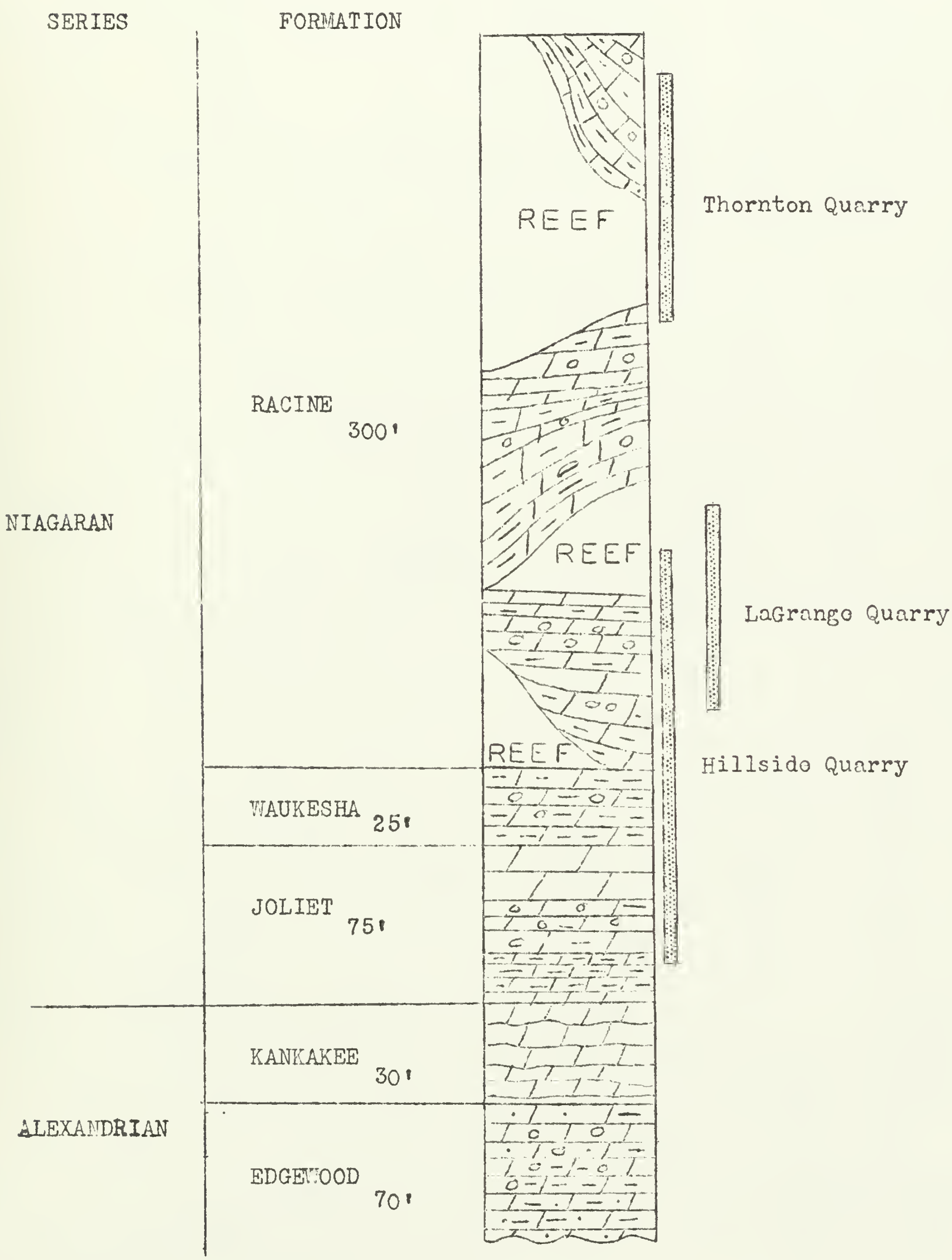


Figure 2. - Generalized stratigraphic section of Silurian strata in northeastern Illinois, showing the approximate stratigraphic position of the quarries to be visited.



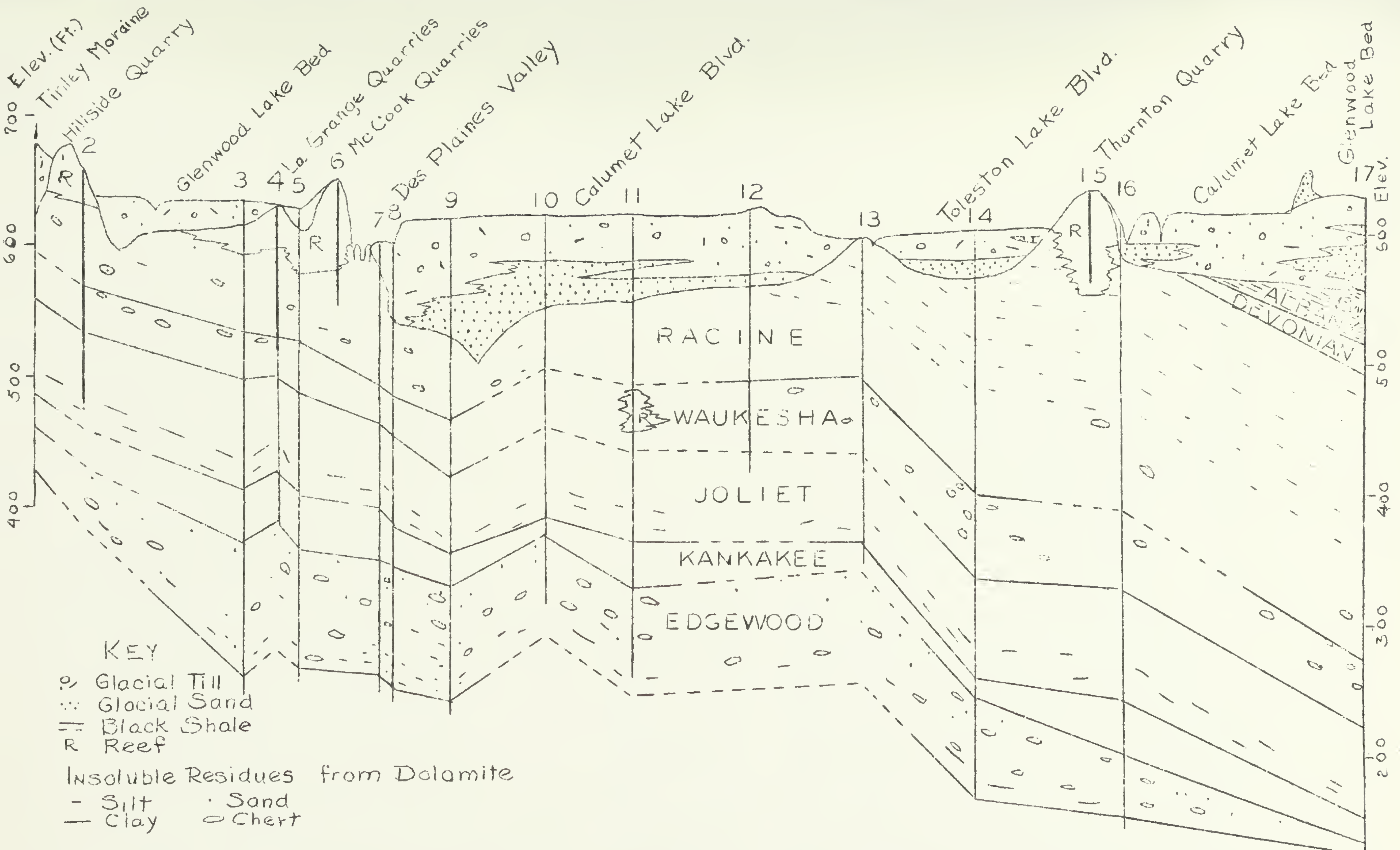


Figure 3. - Cross-section Silurian system, Hillside, Illinois, to Dyer, Indiana.

Illinois State Geological Survey

L. E. Workman, April 17, 1950

FRIDAY - APRIL 28, 1950

LEADERS

H. A. Lowenstam
G. O. Raasch
D. H. Swann
J. S. Templeton
H. B. Willman
L. E. Workman

GENERAL DIRECTIONS

The trip will start promptly at 8 A.M. Buses will load on Michigan Avenue between 8th and 9th Streets, just south of the Stevens Hotel. You will be assigned to a bus and will make the entire trip in that bus. As transportation is contracted, refunds cannot be given to those who miss the bus.

REMEMBER YOUR BUS NUMBER AS THE BUS WILL BE MOVED AFTER UNLOADING. Buses will not travel in a caravan but will be dispatched as soon as loaded. The bus driver has an itinerary and map but assistance in following the route by those riding near the driver will be appreciated.

LOG

Leaving the starting point (fig. 1), the Outer Drive near the shore of Lake Michigan is followed south for about 6 miles, passing the Chicago Natural History Museum and Soldiers Field. The road is on made land but on the right (west) across the Illinois Central Railroad the city proper is built on the bottomland of Glacial Lake Chicago, here 15 to 20 feet above the level of the present lake. Many low bars, spits, and beach ridges of sand and gravel built during the lowest (Toleston) stage of Lake Chicago occur on the lake plain, but because of excavations and construction they are inconspicuous features in the built-up part of the city.

Turn right (west) on U. S. Highway Alternate 30 on the north side of the Museum of Science and Industry. Follow Alternate 30 around the west side of the Museum and then through Jackson Park to Stony Island Avenue. Jackson Park is the site of the 1893 World's Fair.

Continuing south on Alternate 30 (Stony Island Avenue), the Stony Island klint is reached at 92nd Street, about 3 miles south of Jackson Park. From 87th Street to 92nd Street, the klint may be seen on the left (east) extending as an east-west ridge a little more than a mile long, about 1 1/4 miles wide, and rising about 25 feet above the lake plain (fig. 1). The Stony Island klint is typical of several in the Chicago Region. Because of the superior weather resistance of the reef-type dolomite, many of the reefs were prominent oval or nearly circular hills on the preglacial erosional surface. Before it was covered by glacial drift the Stony Island klint was a hill rising about 50 feet above the general level of the deeply dissected bedrock surface. After burial by the glacial drift it was partially exhumed by erosion in the glacial lakes and was an island during the late stages of Lake Chicago. Throughout the hill, bedrock lies immediately beneath a thin cover of soil. Several road-cuts and quarries, now mostly filled, formerly showed the characteristic reef lithology, and the radial dip of the beds on the flanks of the hill.

From Stony Island the route continues south on Alternate 30 for about 5 miles along the west side of Calumet Lake, a large shallow lake at nearly the same level as Lake Michigan, to which it is connected by the navigable channel of the Calumet River. On the left (east), across the lake, are the plants of the International Harvester and other large concerns at South Deering; on the right (west) are the plants of the Pullman Car Manufacturing Company at Pullman, as well as many other large industrial plants.

South of Lake Calumet turn right (west) on 130th Street (road to Blue Island).

At 1.5 miles turn left (south) on Indiana Avenue (County Road M). Little Calumet River is crossed in .6 mile and about a block south the road crosses the Tolleston beach and rises about 10 feet to the flat covered by the Calumet stage of Lake Chicago. Continue ahead on Indiana Avenue.

Two miles farther south Little Calumet River is crossed again.

Slightly over 2 miles farther south the road ascends the north slope of the Thornton klint (fig. 4) joining Vincennes Avenue on the slope. The klint has a relief of 25 to 30 feet. Calumet beach of Lake Chicago is on the slope of the klint.

Continue south on Vincennes road on top of the Thornton klint. The North quarry of the Material Service Corporation, which we shall visit, may be seen on the right (west) of the road (fig. 4). The North quarry is separated from the South quarry by a narrow ridge of rock on which is Ridge Road. The North quarry is entirely in a reef near the top of the Niagaran of this region (fig. 2). At the north end of the North quarry, reef-flank beds dip steeply to the north. At the south end similar strata dip steeply to the south. Between the dipping beds is the core of the reef, about one-third mile across from north to south. All the rocks in the North quarry are pure reef-type dolomite. Relatively impure interreef-type dolomite occurs only in the South quarry.

Turn right (west) on Ridge Road at the 4-way stop in the middle of Thornton.

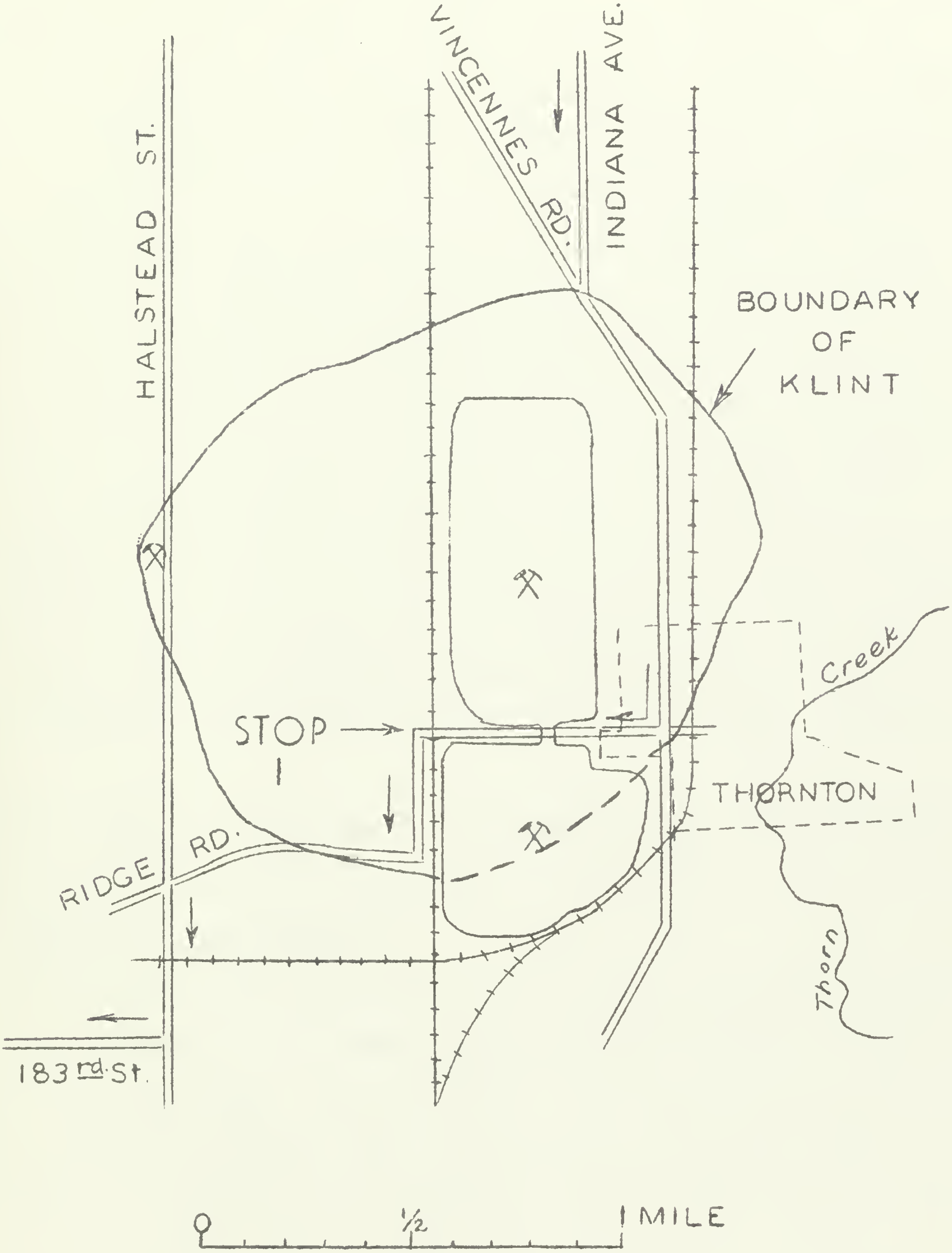
Buses will unload at the entrance to the Brown Derby Grove across the Baltimore and Ohio Railroad on the west side of the quarry.

STOP 1. - QUARRY OF THE MATERIAL SERVICE CORPORATION AT THORNTON, ILL.

Assemble at the southwest corner of the North quarry for a general view of the quarry and a preliminary talk on the geology of Niagaran reefs and the general setting of the Thornton reef.

Procedure. - Because of the difficulty of transporting adequate sound equipment about the quarry and of assembling a large party at various places in the

Figure 4. - Surface extent of the Thornton klint and locations of the quarries.



quarry, the route to be followed and the localities to be examined are shown on the accompanying map (fig. 5). Descriptions of the features to be observed at each locality are given on the following pages and there will be no talks at the localities. Leaders (distinguished by red bandanas) will be stationed at most of the localities to point out features and answer questions. A further opportunity for questions and discussions will be given at the lunch stop. Members of the party may spend as much time as they desire in studying parts of the reef structure in which they are particularly interested. However, those who wish to examine all the localities described should bear in mind that, allowing an average of 5 minutes for walking between localities, only about 15 minutes can be spent at each locality.

At 12 noon you are due at the Brown Derby Grove for lunch (fig. 5).

Samples. - If you wish to collect samples but do not have transportation for them, the committee will arrange to have them shipped to you by express collect.

To save a walk from the distant incline, the descent to the quarry will be made over blasted rock. The grade is gentle but the rock is loose. Take your time.

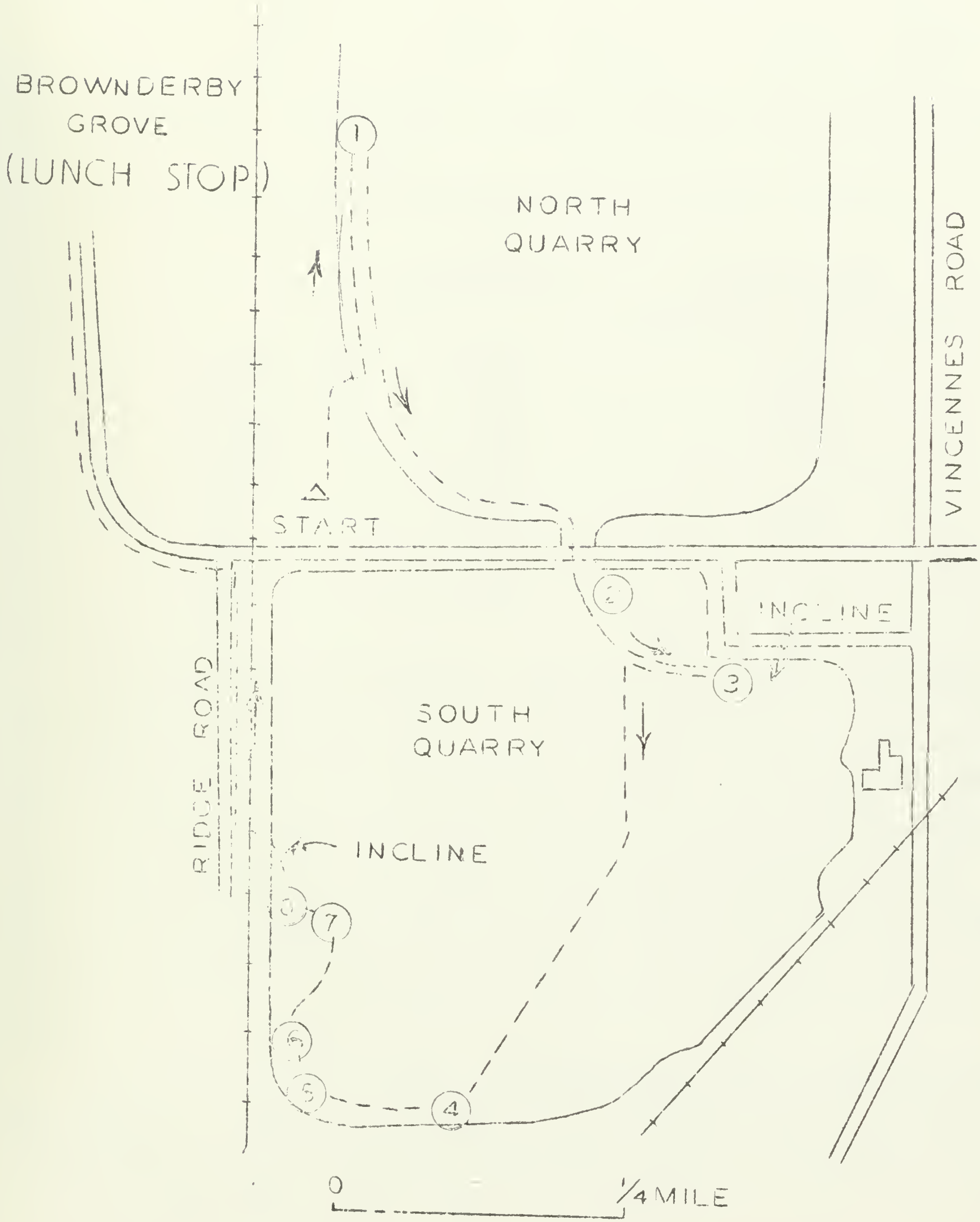
Walk north along the west quarry face until you come to good exposures of reef core, about 600 yards north of Ridge Road.

Locality 1. - The reef-core.

The core of the reef is distinguished by its massive structure and exceptional purity. In this part of the quarry, which is thought to be near the center of the reef (fig. 4), the entire face is reef-core. The top of the reef-core is eroded and the base is not exposed. It is not known how far the reef extends beneath the quarry floor, but the base of the Niagaran strata is about 300 feet below (fig. 3).

The rock in the reef-core is a medium-grained dolomite, commonly medium gray but locally streaked or mottled with light gray. Some areas are very dense

Figure 5. - Material Service Corporation Quarry,
Thornton, Ill.



but vesicular streaks and large vugs are common. The total porosity varies from 6 to 7 percent in the dense areas to about 20 percent in the vesicular parts.

The high purity of the reef dolomite is shown by the chemical analysis in table 1. Insoluble residues are negligible except for occasional well-rounded grains of quartz sand, the local presence of a mere trace of clay, and variable amounts of asphaltum. The sand grains probably were dropped on the reef by animals.

Table 1. - Comparison of Chemical Composition of Reef and Interreef Dolomite

	Reef Rock from North Quarry	Interreef Rock from South Quarry (bed at base of south face)
$CaCO_3$	54.57	36.47
$MgCO_3$	44.30	26.77
SiO_2	0.06	26.39
Al_2O_3	0.25	4.66
Fe_2O_3	0.02	1.12
FeO	0.07	
MgO	21.54	14.70
CaO	30.57	20.43
Na_2O	0.11	
K_2O	0.01	
CO_2	47.12	30.01

The asphaltum which impregnates many porous areas throughout the reef, as well as the bordering interreef rocks, is extremely viscous but on hot days it drips slowly from openings, especially those in fresh exposures. The occurrence of asphaltum in reefs is common in the Chicago region but is not universal. Some exceptionally good reef structures are entirely free from asphaltum and others have very little. It appears to be more common in the higher Niagaran reefs which have strongly developed flank beds than in the reefs lower in the Niagaran, which generally are smaller.

The reef-core and flank beds are characterized by the abundance and diversity of fossils, in contrast to the limited fauna of the interreef beds. Although crystallization and dolomitization have destroyed the fossils in parts of the reefs,

the preservation of fossils as casts and molds is excellent in many places. The framework of the reef appears to have been a mesh of colonial corals and stromatoporoids. The reef assemblages are characterized by large heavy-shelled robust forms in contrast with the small fragile forms in the interreef deposits.

Among the most abundant fossils to be found in the reef are the corals *Favosites*, *Halysites*, *Lyellia*, *Thecia*, *Heliolites*, and *Plasmopora*; the crinoids *Crotalocrinites* and *Eucalyptocrinites*; the brachiopods *Monomerella*, *Conchidium*, *Eospirifer*, and *Wilsonella*; and the trilobites *Bumastus* and *Calymene*.

In some parts of the reef-core the dolomite is almost structureless, but in other parts, as at this locality, poorly defined bedding can be observed. It is usually inclined, the amount and direction varying irregularly in short distances. Much of the inclination of the bedding may be due to slumping. At places the massive structure of the core is interrupted by a few prominent undulating but nearly horizontal breaks or bedding-planes. Although weakly developed here, they can be seen in the fore-reef at locality 5. These appear to mark interruptions in the growth of the reef and are interpreted as growth lines. They show, therefore, that the core is the zone of vertical reef growth. The general lack of well-defined bedding suggests that reef-cores developed in a protected lagoon.

Reefs are distinguished from the interreef strata in electric logs by their consistently higher resistivity and particularly by consistently higher negative self-potentials. This does not apply to the northwestern part of the State where the interreef beds have nearly the same lithology as the reefs and are differentiated by structure and fauna.

Follow the west face southward to observe the transition from the reef-core to the reef-flank deposits. The transition zone is marked by an increase in degree of bedding, with a persistent dip to the south which rapidly increases in steepness until it reaches a maximum angle of 30 to 40 degrees which persists across the zone of reef-flank deposits.

Locality 2. - Reef-flank deposits.

The reef-flank beds are typically developed and may be examined near the tunnel, especially on the south side.

The reef-flank beds are distinguished by high purity, excellent bedding, and a steep dip away from the reef-core. Most of the beds are 2 to 6 inches thick. In parts of the sequence the beds have a remarkably uniform thickness and individual beds maintain a uniform thickness throughout their exposure. In chemical and mineralogical composition the dolomite is similar to that in the reef-core.

The total thickness of the individual beds exposed in the reef-flank zone exceeds 1,000 feet. Before the reef origin was recognized the strong dip was interpreted as a fold in the strata, and the formation was assumed to have very great thickness. However, a well in Thornton, on the outer margin of the dipping beds, penetrated only 465 feet of both Niagaran and Alexandrian strata overlying the Maquoketa shale, a normal figure for this part of the region (fig. 3).

As previously noted, the reef-flank beds at the extreme north end of the North quarry dip north and are identical in character with those observed at this locality. The radial dip of the reef-flank beds is also shown by a quarry on the west side of the reef (fig. 4) where similar beds dip steeply to the west.

The reef-flank beds have the relation and general appearance of fore-set beds in deltas and have been interpreted as representing reef-detritus broken by waves from the core zone and deposited on the steep sides of the reef. Dolomitization has destroyed the original granular character of the matrix material, but the presence of broken and irregularly oriented fossils and the local presence of lenticular beds and breccias supports the detrital origin for at least part of the material.

However, many of the coral growths are oriented parallel to the sloping surface of the beds and appear to have grown in place. In addition, the uniform thickness of individual beds for many feet down the steep slopes offers serious

difficulties to an interpretation of detrital origin. Also the tendency for many of the beds to have about the same thickness suggests a cyclical control of growth. It appears, therefore, that the steeply dipping flank beds may have grown largely in place, representing a lateral growth on the slope of the reef not greatly different from that on the reef-core. The upper margin of these beds may have been high enough to form a rim which gave some protection to the zone of vertical growth which formed the reef-core.

Continue southeastward to the incline for trucks (fig. 5).

Locality 3. - Transition to interreef deposits.

Along the incline the gradual introduction of argillaceous beds into the sequence can be observed. This marks the outer limit of the steeply dipping reef-flank deposits. The rapid flattening of the dip can be seen in the face near the hoisting incline. These beds appear to mark the final stages of growth of the major reef.

Devonian sharks' teeth are found above the incline in the clay-filled joints. Devonian strata were penetrated in a well a short distance to the southeast (fig. 3).

From the base of the incline proceed west to the road fork, then south on the road leading to the hoisting incline. At the point where this road turns east to the base of the hoisting incline, continue south across the tracks. Many routes may be followed in crossing the quarry floor to the next locality, which is on a line towards the 3 cylindrical storage bins beyond the quarry and near the middle of the south face (fig. 5).

Locality 4. - Interreef strata.

The interreef sediments consist largely of still-water deposits which accumulated in the relatively deep water surrounding the reefs. These rocks are characteristically dense, very fine grained, contain argillaceous and siliceous impurities, and are well bedded. The most common fossils are sponges and crinoids,

less commonly bryozoa. Locally a gastropod-trilobite-cephalopod assemblage is found. The most common crinoids are Pisocrinus, Gisocrinus, and Lecanocrinus. The trilobites are mostly Encrinurus and Calymene.

Some rough-water sediments are found in the interreef habitat. These contain only a slight amount of siliceous clastics and are relatively coarse-grained and porous. In physical appearance they are not greatly different from the reef lithology. Crinoidal fragments are generally common with lesser numbers of colonial corals and stromatoporoids.

Lenticular bodies of reef-rock or "baby" reefs are common in the interreef strata.

The sequence of interreef beds exposed near the middle of the south face of the quarry consists of the following major units:

Unit A - Argillaceous dolomite. This dolomite contains 20 to 45 percent insoluble residue. A chemical analysis is given in table 1. It is locally at least 12 feet thick but its base is not exposed. The cross-section (fig. 3) indicates that it continues downward for about 95 feet below the floor of the quarry.

Unit B - Reef-detritus bed. Above the argillaceous dolomite is a distinctive massive breccia 4 to 10 feet thick, consisting of blocks of porous reef-type dolomite in a matrix of argillaceous dolomite, similar to but not so impure as that in Unit A. This is a continuous massive unit, set off from adjacent units by strong bedding-planes. It is easily traced because of the presence at the top of a distinctive 6-inch to 1-foot bed of brown finely porous relatively pure dolomite overlain by 1 to 4 inches of argillaceous dolomite. The unit is described as a reef-detritus bed because the reef blocks appear to have been eroded from the major reef to the north. As will be seen in tracing it in the west face, the reef-detritus bed rises to the north, up the slope of the reef. Some of the reef-type masses in this unit are very large and may have grown in place, but in many blocks the corals are inverted.

Unit C - Nodular cherty dolomite. Overlying the reef-detritus bed is 7 to 10 feet of nodular impure cherty dolomite with thin wavy lenticular argillaceous partings. In several places it grades laterally, within a foot or two, to a mixture of nodules in green shale. Even in the more dolomitic facies this unit contains about 20 percent insoluble residue consisting of micaceous silty clay. In general the nodular character increases toward the reef. At the contact with the fore-reef, to be examined at locality 5, it locally changes to shale containing nodules. The origin of the nodular structure is not clear, but it may have resulted from deposition under the particular type of agitation characteristic of water near the edge of the reef. This nodular character is not well developed in many interreef sections which are presumed to be farther from the reefs, and it therefore may be an indication of reef proximity.

Unit D - Upper variable beds. The uppermost unit (Unit D) is 15 to 30 feet thick and its top is everywhere eroded. At this locality it contains some beds of nodular dolomite similar to that in Unit C but mostly not as impure and with chert less common. Most of the strata are slightly porous and have generally less than 10 percent of insoluble residue. Some beds are pure dolomite of the reef type; a distinctive lens of pure dolomite crowded with silicified horn corals is present near the top of the section. The unit becomes more impure when traced westward toward the margin of the fore-reef and nearer to the main reef. Close to the fore-reef the unit is all nodular and in places is differentiated from Unit C below only by tracing the prominent bedding-plane between them.

Continue westward along the south face of the quarry noting the continuity of the reef-detritus bed to the exposure of the fore-reef in the west face just north of the southwest corner of the quarry.

Locality 5. - The fore-reef.

The fore-reef exposed in the west face near the corner of the quarry is only one of several which were encountered and quarried in expansion of the quarry

southward from the main reef. Although the extent of this fore-reef is not known, it appears to have been a linear feature parallel to the edge of the main reef. Numerous exposures of massive reef-rock in the quarry floor on a line slightly north of east from the exposure in the west face apparently show the continuation of the reef. Exposures of argillaceous dolomite in the floor south of the reef-rock indicate relations similar to those in the west face.

Examination of the fore-reef gives much information on the growth of the reef and its relation to interreef sedimentation. It emphasizes the complexity of conditions around the margin of a large reef and the abruptness of facies variations. Observations on the growth of the fore-reef and other "baby" reefs are not entirely applicable to growth of the main reef. Surrounded as it is by interreef-type sediments, it is apparent that the fore-reef grew in relatively quiet water. There is no evidence that it contributed detrital material to the adjacent sediments. Its growth was essentially vertical and no reef-flank beds were formed.

A preliminary view of the fore-reef from a short distance out in the quarry (fig. 6) will show the major relations - the sharpness of the margins of the reef, the overlapping interreef beds, the absence of reef-flank beds, and the massive structure of the reef-core, broken only by growth lines which are not conspicuous and are not easily traced through the reef.

A close examination of the south side of the reef (fig. 7) shows that the stratigraphic units differentiated in the south face (Locality 4) continue to the reef. The reef-detritus bed (Unit B) ends about 10 feet from the reef and is separated from it by a mass of very argillaceous dolomite like that in Unit A. Unit C laps onto the reef and Unit D overlaps it.

The sequence of events which produced these relations is interpreted tentatively as follows:

1. Deposition of part of the argillaceous dolomite (Unit A).

2. Vertical growth of the fore-reef.

Figure 6. - Sketch showing general relations of fore-reef (Locality 5) near the southwest corner of the quarry; viewed from a short distance out in the quarry.

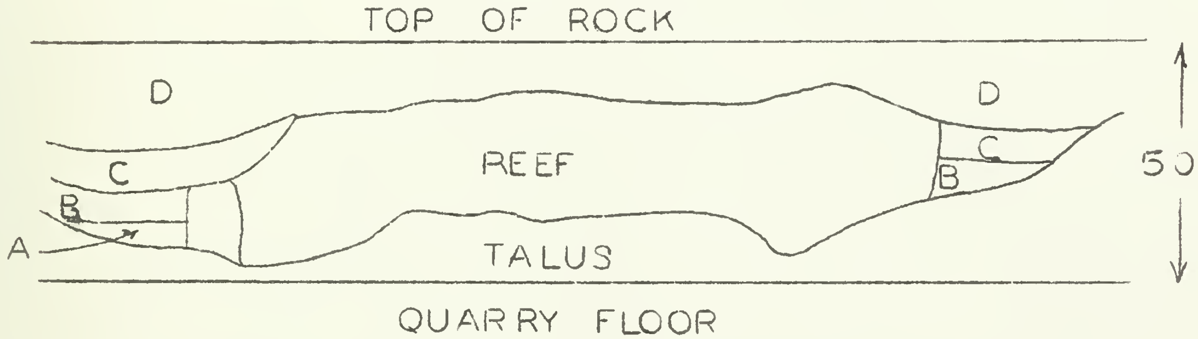


Figure 7. - Sketch showing contact of the fore-reef with interreef strata on the south side of the fore-reef (Locality 5).

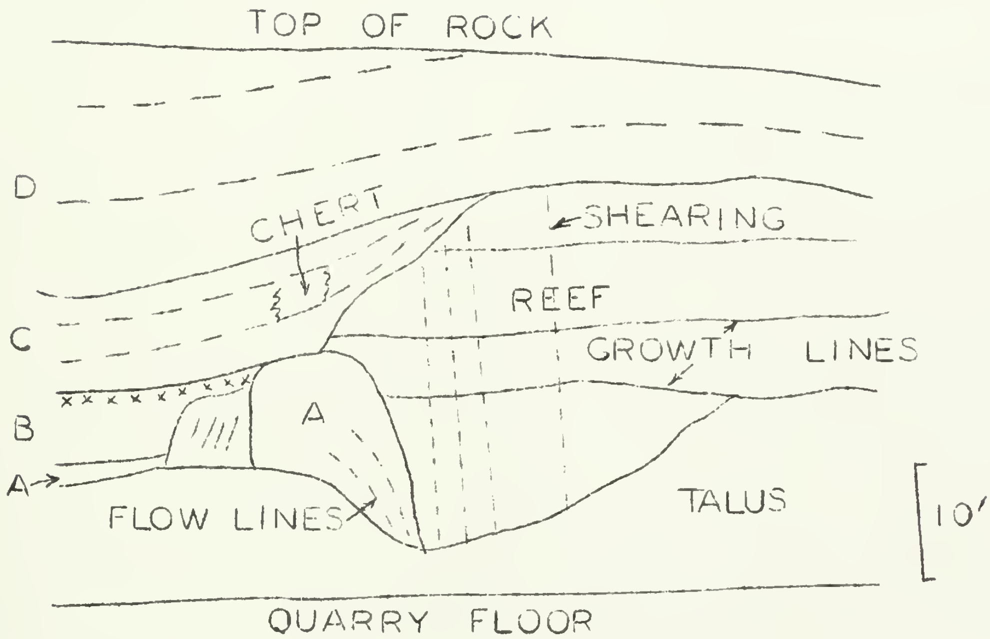
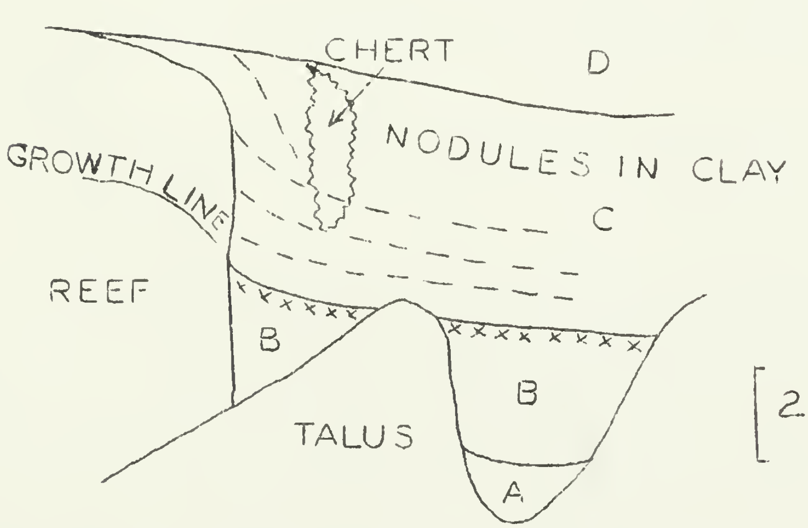


Figure 8. - Sketch showing relations on the north side of the fore-reef (Locality 5).



Letters mark the units described at Locality 4. Unit B is the reef-detritus bed with its distinctive top.

3. Deposition of the reef-detritus (Unit B) in the matrix of argillaceous dolomite. At this stage the fore-reef had an uneven top and stood only slightly above the bottom so that detritus moving down the slope from the main reef on the north overrode or by-passed the fore-reef.

4. The reef then attained such size that the argillaceous mud beneath could not support the weight of the reef. The reef settled and the mud flowed up along the side of the reef breaking through the detritus bed. Flaring flow lines may be observed in the argillaceous dolomite. As will be seen on the north side of the reef the settling appears to have been almost entirely on the south side. The top of the vertical side of the reef is about 10 feet lower on the south side than on the north, which exceeds the regional dip.

5. The fore-reef continued to grow upward. All the reef upward from the tongue at about the middle of the south side grew during this stage. There was almost no deposition of interreef beds during this growth.

6. The argillaceous beds of Unit C were deposited after reef growth ended and they built up the sea floor to the level of the top of the reef. The off-reef dip of the upper surface of the unit may have resulted entirely from compaction of the argillaceous muds by the weight of the overlying sediments. The rigid frame of the reef would prevent its compaction, but concentration of the load on the reef resulted in the development of vertical shears, particularly on the south side where settling had occurred.

7. Unit D was deposited after the reef had ceased to be a topographic feature on the sea floor.

The growth of 10 to 15 feet of the reef without appreciable deposition of interreef beds, as well as the apparent lack of consolidation of the muds beneath the reef, attests the rapid reef growth. Furthermore, the lack of sedimentation marginal to the reef during its growth suggests that waters relatively free from detrital siliceous impurities prevailed during growth of the reef. The increase in

[illegible]

muddiness of the water perhaps accounts for the decline and end of reef activity as shown by the retreating upper slope of the reef.

The presence of dense chert in Unit C near the reef is an interesting problem. The presence of a similar zone in the same unit at the same position on the north side of the reef suggests that the chert is environmentally controlled. Bedding-planes pass through the chert so that the silicification apparently is secondary or at least diagenetic.

Continue northward to the north side of the fore-reef, where the relations are as shown in figure 8.

Note that there is no evidence of settling and flowing of mud on this side of the reef. The reef-detritus bed (Unit B) was deposited against the reef. It may have settled slightly during compaction. The top of the fore-reef at the end of deposition of the reef-detritus bed is shown by the bedding-plane or growth line indicated in the sketch (fig. 8). The bedding-plane dips steeply into the face showing the undulation of the surface at that stage of growth. The surface of the reef may well have been low enough on the west for detritus from the main reef to by-pass the fore-reef.

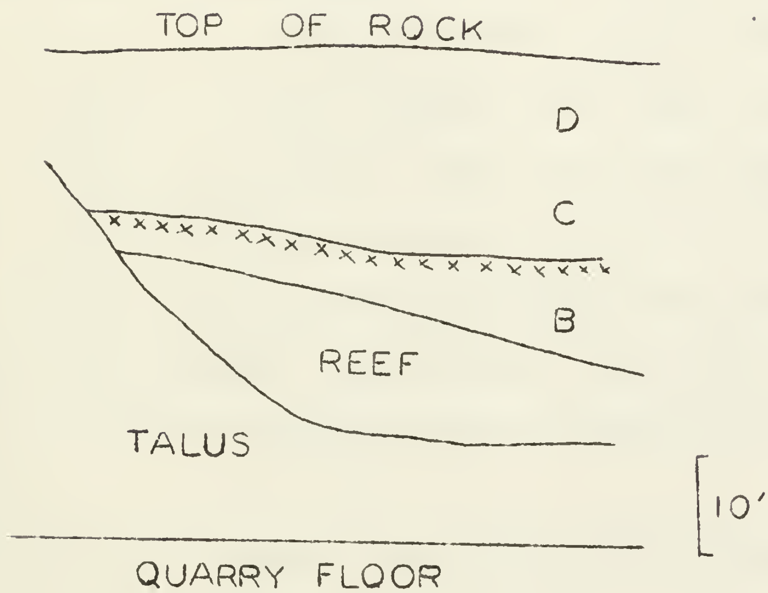
The extreme argillaceousness of Unit C close to the reef is well shown. As Unit C apparently was not deposited until the reef had reached full growth, the steep face of the reef may have provided a protected place favorable for the settling of suspended clay.

Continue northward to the next exposure, which is beyond the first waste pile.

<u>Locality 6. - Reef-detritus on a fore-reef.</u>

In this exposure (fig. 9) the reef-detritus bed (Unit B) rests directly on a reef. Although not continuously exposed, this reef may be continuous with the fore-reef just described. If so, it confirms partial growth of the fore-reef before deposition of the reef-detritus bed.

Figure 9. - Sketch showing relations at Locality 6.



Continue northward passing a long interval of face covered by waste material. Keep to the right and descend to the lowest quarry floor.

Locality 7. - Contact of reef-flank beds of the main reef with a fore-reef.

This exposure is in the edge of the bench close to the water. It is directly east and lower than an exposure in the main west face (Locality 8), and the two sections are combined in figure 10 to show their relation.

Observation of the face north of this locality will show that the steeply dipping reef-flank beds of the main reef continue from this point northward to the north face of the quarry. They were examined at the tunnel (Locality 2). At this locality they end against a fore-reef. Most of the actual contact is covered, but projection of the dip of the reef-flank beds shows that they would cut the reef. It appears, therefore, that the fore-reef was present when lateral growth of the main reef reached this position. Light-colored slightly argillaceous dolomite was deposited later on top of the reef-flank beds and between them and the upper part of the fore-reef.

Climb over this exposure or pass around it on the south in order to reach the main face directly west from Locality 7.

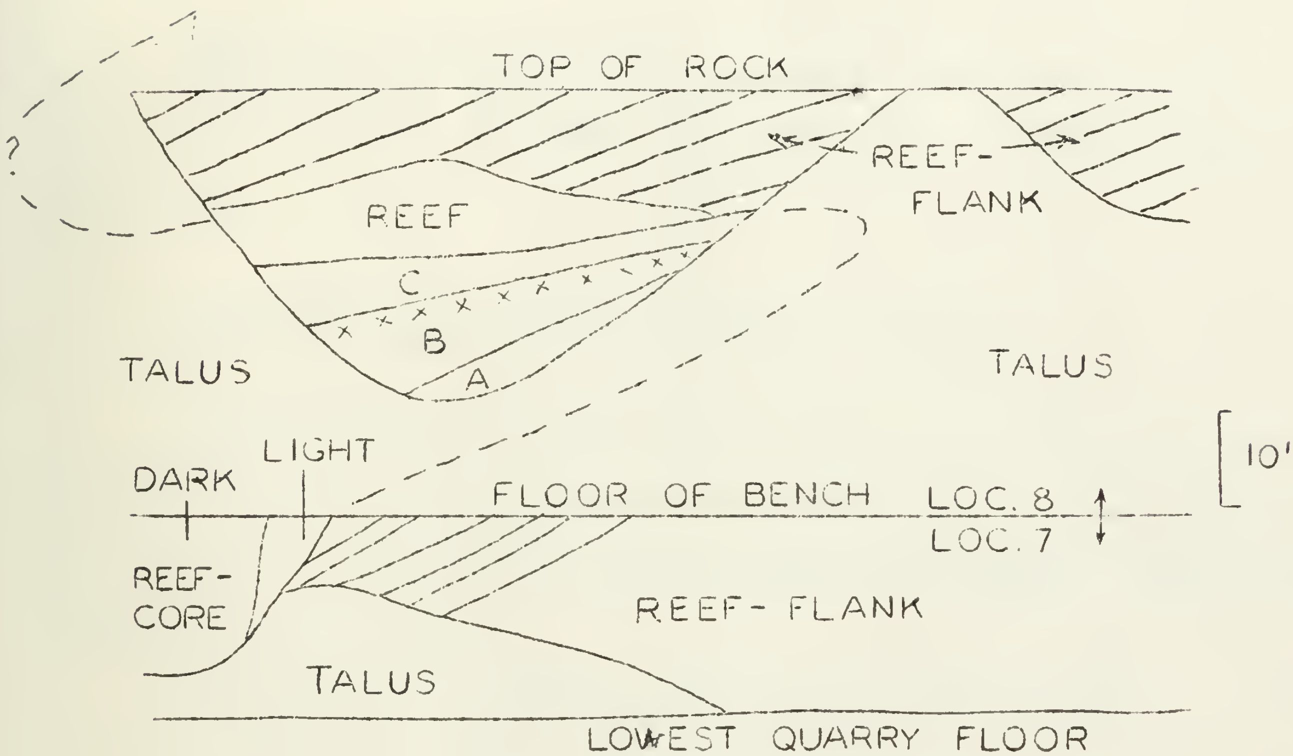
Locality 8. - Contact of reef-flank of the main reef with interreef strata.

This exposure is shown in the upper part of figure 10.

The continuity of the argillaceous dolomite (Unit A) and the reef-detritus bed (Unit B) up the slope of the reef is well shown. As suggested by the projection of the surface of the reef-flank beds from the lower bench (fig. 10), the deposition of the interreef strata (Units A, B, and C) occurred during a recession of the main reef face, and they appear to mark an interval of reduced reef activity. This may be related to the advent of the detrital siliceous muds.

Later, under conditions more favorable for reef growth, the reef expanded laterally over the interreef beds and over a "baby" reef which had started on the surface of Unit C. Erosion of the overlying strata ends the record of succeeding

Figure 10. - Sketch showing relations at Localities 7 and 8. The dashed line shows the projected margin of the reef-flank beds and their interfingering with the interreef beds.



events in the history of the Thornton reef.

Either ascend the quarry face along the exposure or use the incline just to the north to reach the top of the quarry. Continue north along Ridge Road to the Brown Derby Grove where the buses are parked.

LUNCH STOP - We will eat lunch in the park. Rest rooms are available on the west side of the dance pavillion; a drinking fountain is located northwest of the pavillion.

We will leave the lunch stop promptly at 1 o'clock.

Continue south on Ridge Road along the quarry for a quarter mile, then west along the south side of the Thornton klint, here bordered by sand dunes, for another quarter mile (fig. 4). We leave the klint at the cemetery. Halstead Street is reached in a quarter mile.

Turn left (south) on Halstead Street (Chicago Heights Road).

At .4 mile turn right (west) on 183rd Street.

The edge of the Lake Chicago bottom is reached in half a mile and the road ascends to the gently undulatory surface of the Tinley ground-moraine on which the town of Homewood is located. About one mile west of the underpass of the Illinois Central Railroad in Homewood, the more hilly surface of the Tinley moraine is reached and is crossed for 2 1/2 miles.

The front of the Tinley moraine, facing west, is marked by a descent of about 30 feet to a flat which is underlain by the sediments of Lake Tinley, a glacial lake formed when drainage eastward down the back slope of the Valparaiso moraine was dammed by the Tinley ice front. The edge of the lake flat is prominent north of the road. The highway is on the lake bottom for about 2 1/2 miles and then rises slightly to the undulatory topography of the Valparaiso ground-moraine, a half mile before reaching 80th Avenue.

Turn right (north) on 80th Avenue. The route continues on the Valparaiso ground-moraine crossing two branches of the Lake Tinley flat.

At 3 miles turn left (west) on U. S. Highway 6 (159th Street).

At 2 miles turn right (north) on U. S. Highway 45 (96th Avenue). One mile north of the turn the highway ascends the Valparaiso moraine. Characteristic morainal topography may be observed in the 4 miles to Sag Valley. "The Sag" was a former outlet of Lake Chicago. About 4 miles to the west it enters DesPlaines Valley, which also served as an outlet to Lake Chicago. Sag Valley was a swampy area without a stream until the Calumet-Sag Channel, a feeder to the main Chicago Sanitary and Ship Canal in the DesPlaines Valley, was excavated to supply an additional flow of water from Little Calumet River near Blue Island.

On the north side of Sag Valley the highway crosses a terrace underlain by gravel outwash from the Tinley ice-front. The highway then ascends onto the Valparaiso moraine. The Tinley moraine which rises onto the Valparaiso moraine in this area is a half mile to the right (east). About 1 1/2 miles north, just north of the intersection with 95th Street, the highway rises onto the Tinley moraine.

About 2 miles north of 95th Street, DesPlaines Valley is reached, and the highway in succession crosses Illinois Highway 4A, the Chicago and Alton Railroad, the Illinois and Michigan Canal, the Chicago Sanitary and Ship Canal, which connects Lake Michigan with the Illinois Waterway near Joliet, the Diversion Channel of DesPlaines River, the Atchison, Topeka and Santa Fe Railroad, and a major power line.

On the north side of DesPlaines Valley the highway rises onto the Tinley ground-moraine.

Three miles north of Des Plaines Valley turn right (east) on 47th Street (road to Lyons) at the south edge of LaGrange.

At half a mile the road descends to the Lake Chicago flat, crossing the Glenwood (highest stage) beach. The Material Service Corporation quarries are on

the right. Continue ahead (east) beyond the quarry and then turn back to the right (southwest) to the plant.

STOP 2. - MATERIAL SERVICE CORPORATION LAGRANGE QUARRY.

Walk down the incline leading northeast from the east side of the crushing plant. To point out features and discuss problems, leaders will be located at the base of the incline, at the north face, at the north end of the tunnel leading to the South quarry, and in the South quarry. It is anticipated that about 1 hour will be available for this stop.

The strata exposed in this quarry are in the lower part of the Racine formation (fig. 2). There are three quarries at this location and the deepest one, on the east and now filled with water, reached to the Waukesha formation. A diamond-drill core obtained by drilling in the floor of the east quarry reached the top of the Edgewood formation, as shown in the cross-section (fig. 3).

From the incline it will be noted that the section in the quarry consists of a lower light-colored well-bedded sequence of interreef deposits and an upper zone 30 to 40 feet thick which consists of dark-colored irregularly bedded reef-rock. The reefs in this klint, which extends south for about 2 miles, have a complex structure and differ in many respects from the large reef at Thornton. In this area reef growth started from many centers and lenticular bodies of massive reef-core developed. In places they overlap each other in a complicated pattern. Apparently none of the reefs attained sufficient size to have reef-flank beds, or they grew entirely in water too deep to favor lateral growth and development of reef-flank beds.

Most of the massive lenticular reef-cores occur along the base of the upper reef zone. They are overlain by pure reef-type dolomite which is well-bedded. It conforms to the surface of the reef-cores and consequently rises and falls in great waves. It has many of the aspects of reef-flank deposits but lacks the

uniform dip away from a well-defined core. No core or cores have been found to which these deposits may be related. They obviously are younger than the reef cores on which they lie. It appears that they represent a reef-type of growth under conditions favoring the development of bedding like in the reef-flank beds, but lacking the detrital characteristics of those beds. Under this condition they represent essentially a vertical growth rather than the lateral growth of the reef-flank beds.

Near the base of the incline the section in the east quarry face, sketched in figure 11, can be readily examined. Some may prefer to examine other sections first, if the party is large.

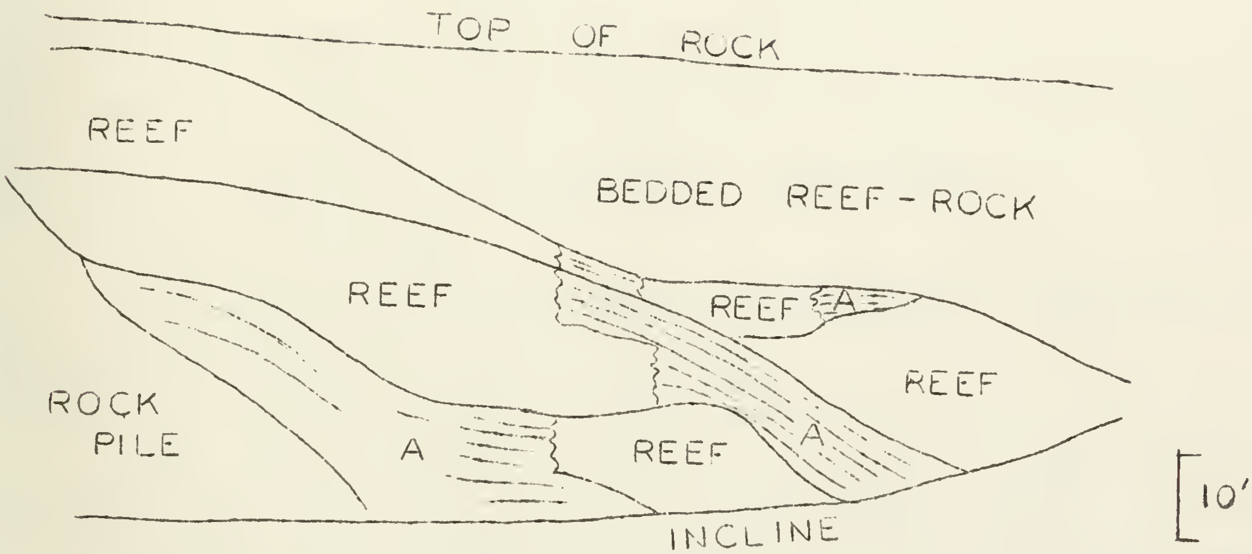
This section shows a complex intergrowth of reef masses, many showing lateral variations to well-bedded interreef-type dolomite. The interreef rocks in this section are only slightly argillaceous and are recognized largely by their bedding, finer grain size, and lower visible porosity. By tracing the break between the reef masses, the surface at various stages during growth of the reefs can be restored. A considerable relief on the sea floor resulted from the thick reef growth on the left (north) side of the exposure.

Continue down the incline and cross on the narrow fill extending to the north face. At this place the cherty argillaceous interreef dolomite is well exposed near water level. An abundant fauna has been described from the chert nodules.

In the interreef rocks a typical "baby" reef may be studied. Some thinning of the beds beneath the reef probably results from squeezing. Laterally the reef is represented only by a thin bed of relatively pure dolomite, which suggests that the reef grew during an interval when the water was comparatively free from siliceous muds.

The contact of the upper zone of reefs on the interreef sediments below can be seen well, although above reach. The occurrence of lenticular masses of reef cores along the base of the reef zone is well shown.

Figure 11. - Sketch of east face of Material Service Corporation LaGrange Quarry near base of incline.



A = Argillaceous interreef type dolomite.

From this point return to the road and continue along it to the tunnel leading to the South quarry. Exposures near the tunnel show the lenticular reef-cores and the steeply inclined bedding of the reef-type strata which mantle the reef-cores.

Continue through the tunnel and examine the quarry face on the left (east). The extremely wavy surface of the reef is shown by the many variations in dip. The contact of the reefs with the underlying interreef beds may be observed on the lower level farther east. Films of green clay which will be noted on fresh bedding surfaces of the interreef beds are characteristic of these strata.

Return to the buses.

Leaving the Material Service Corporation quarries turn left (west) on 47th Street and return to U. S. Highway 45 at LaGrange.

Turn right (north) on U. S. Highway 45 and follow it through LaGrange. About half a mile north of the C. B. & Q. Railroad crossing in LaGrange the highway is on the Glenwood beach and follows it northwest for 1 1/2 miles to Salt Creek at 22nd Street.

About 1 1/2 miles farther north the Hillside klint is reached. The top of this klint is about 50 feet above the Lake Chicago flat.

Turn left (west) on Harrison Street (south edge of Bellwood) to the Consumers Company plant.

STOP 3. - CONSUMERS COMPANY QUARRY AT HILLSIDE.

The section will be studied from the base up. Do not delay the party by stopping to examine the section when going down the stairs. It is anticipated that about 1 hour will be available at this stop.

This is one of the most complete Niagaran sections in the Chicago region (fig. 2), extending from a Racine reef at the top down through Racine interreef beds,

the Waukesha formation, and nearly through the Joliet formation. The basal beds are only about 15 feet above the contact with the Kankakee formation of the Alexandrian series.

Joliet formation. - The lower 60 feet of the section exposed belong to the Joliet formation. Three members are present. The lower 11 feet exposed in the southwest part of the quarry consist of greenish-gray locally pinkish argillaceous dolomite which contains green shale partings and fucoidal bedding-planes. This is a distinctive horizon characterized by an abundant fauna of siliceous foraminifera. The top is marked by a persistent 4- to 5-inch bed set off by relatively strong bedding-planes, a characteristic widely recognized in outcrops in the Joliet region, 40 miles to the southwest. Rock with the same lithology extends down to the top of the Kankakee formation below. Because of the east dip, only the upper 5 feet of this unit are exposed in the deepest part of the quarry, which is near the southeast corner and below the crushing plant.

Above the dolomite with strong shale partings is a member 19 feet thick consisting of fine-grained dense light brownish-gray dolomite with persistent bands of chert nodules and in thicker beds than below. It has a high silt residue which decreases upward. It has been found widely distributed in northeastern Illinois.

This member is overlain by 29 feet of relatively pure porous dolomite which is light gray, locally mottled dark gray or pink, and occurs in 6- to 12-inch beds. This unit has a lithology closely approaching reef dolomite but it contains slightly more impurities, does not have reef structure or a reef fauna. The upper 7 feet is transitional to the Waukesha formation above.

The Joliet formation has been penetrated in only a few of the deeper quarries in the Chicago region, but its distinctive sequence of strata can be traced widely in the subsurface (fig. 3) and in outcrops in the Joliet region.

Waukesha formation. - Overlying the Joliet formation is 23 feet of greenish-gray very silty and argillaceous dolomite comprising the Waukesha formation.

It occurs in massive ledges but is laminated with dark green wavy clay partings. It contains oval silicified nodules showing all gradations from soft incipient chert to dense hard chert. This distinctive unit is traced throughout most of the region but in at least one locality is replaced by a reef.

For many years all the argillaceous cherty beds overlying the Joliet formation and beneath the Racine reefs were included in the Waukesha formation. When subsurface and outcrop studies showed that a considerable part of the strata included in the Waukesha is contemporaneous with reefs which were classified as Racine, the name Waukesha was restricted to the distinctive basal unit. In this quarry, for example, all the strata from the Joliet formation to the reef at the top of the quarry were formerly included in the Waukesha formation.

Racine formation. As used at present the Racine formation includes all the Niagaran strata above the Waukesha formation. It therefore includes all the reefs in this region.

In this quarry the basal 80 feet of the Racine formation consists of inter-reef dolomite which is slightly argillaceous and silty, cherty, dense, fine grained, and contains 15 to 20 percent insoluble residue, largely silt and clay. A few beds of relatively pure reef-type dolomite are interbedded with the impure strata. These may be formed largely of calcareous wash from reefs which are known to occur at this horizon. In some quarries small "baby" reefs are common in these beds.

The interreef strata are overlain by 15 feet of high-purity porous massive dolomite which is the core of the reef which forms the klint. Well-bedded reef-flank beds dipping down the slope of the klint are exposed in a railroad cut one-fourth mile southwest of the quarry.

Return to the buses.

Leaving the Consumers Company Quarry at Hillside, return to U. S. Highway 45 and turn right (south).

At .5 mile turn left (east) on U. S. Highway Alternate 30 (Roosevelt Road) and follow it east for 13 miles to Wabash Avenue, entirely on the Lake Chicago plain.

Turn left (north) on Wabash Avenue. In 4 blocks turn right (east) on Balbo Drive to the Stevens Hotel.