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[Reports - Open file series]

THE KEWEENAWAN GEOLOGY OF ISLE ROYALE, MICHIGAN

By

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Prepared in cooperation with the

National Park Service

[This report is the text of a talk to be given at Duluth, Minnesota, on May 6, 1971, at the Institute on Lake Superior Geology.]

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1. The Keweenawan geology of Isle Royale, Michigan, by N. King Huber. 9 p., plus 6 page-size figs.

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The Keweenawan Geology of Isle Royale

By

N. King Huber

Regional Setting

Keweenawan volcanic rocks crop out at a number of areas around the Lake Superior basin and individual rock sequences have been described from many of these areas. For examples:

Portage Lake Lava Series on the Keweenaw Peninsula

South Range Traps south & west of the Keweenaw Peninsula

North Shore Volcanic Group in Minnesota

Osler Series in Ontario

Isle Royale and the Keweenaw Peninsula are the only 2 of these areas that contain the top of the volcanic sequence and an overlying Keweenawan sedimentary sequence.

The volcanic and clastic sequences on Isle Royale are correlated with those of the Keweenaw Peninsula on the latest published geologic map of the island, that of A. C. Lane in 1898.

The present study has confirmed this correlation and the terms Portage Lake Lava Series and Copper Harbor Conglomerate, as used on the Peninsula, are therefore appropriate for the sequences on Isle Royale.

Isle Royale - general

Isle Royale is on the northwestern side of the Lake Superior syncline and dips toward the southeast.

Dips range from 20 to over 40 degrees on the north side of the island and are generally less than 20 and as low as 5 degrees on the south side.

The Portage Lake Lava Series occupies the bulk of the island, with the Copper Harbor Conglomerate limited to the southwest part of the island, as shown by the yellowish color on the map.

Excellent exposures are found along much of the shoreline of the island but the interior is more or less mantled by surficial deposits.

Portage Lake Lava Series

As on the Keweenaw Peninsula, the Portage Lake Lava Series on Isle Royale consists of a series of lava flows with interbedded sandstones, conglomerates, and tuffaceous rocks, with the fragmental rocks making up less than 10% of the section.

Composition of the flows ranges from basaltic to andesitic, with the mean probably in the basaltic range.

No felsic flows are known from outcrop, although one has been reported from diamond drilling, some 6,200 feet below the top of the lava series.

Textures in the volcanic rocks are varied and only partly reflect compositional differences.

Thus, while the ophitic rocks are probably all basalts, porphyritic varieties may be either basaltic or andesitic and the same is true of the finer-grained traps.

Nevertheless, individual flows usually have a characteristic texture throughout, except for some of the thick internally differentiated flows such as the Greenstone Flow.

These textural distinctions permit one to recognize in the field certain individual flows or groups of flows and to use them for marker horizons within the Portage Lake Lava Series.

Structures can also be useful for correlation as columnar jointing, for example, occurs in only three flows within the exposed section.

Being able to readily recognize some individual flows is especially critical on Isle Royale as the interbedded sedimentary rocks rarely crop out and can only be used locally for stratigraphic control.

Twelve flow units have been distinguished within the sequence on Isle Royale and provide stratigraphic and structural control for geologic mapping; 4 of them are shown on the slide.

Utilizing these marker horizons, a longitudinal section has been constructed for essentially the length of the island.

This section indicates the nature of thickness variations in a SW-NE direction and provides an estimate of a minimum thickness of 11,000 feet for the part of the Portage Lake Lava Series exposed on Isle Royale.

Direction of flow movement, and thus source direction for the lava, has not been determined and the significance of thickness variations is thus uncertain.

In the uppermost part of the Portage Lake Lava Series, there are 7 units of conglomerate and sandstone, shown by red on the map.

These units are relatively thin, with average thickness generally less than 25 feet for most of their length.

They are very persistent, however, and most of them probably extend the length of the island, although this would be very difficult to document.

Two of them can be traced onto the offshore islands at the eastern end of Isle Royale and diamond drilling at the western end reveals at least 5.

Compositionally they are similar to the Copper Harbor Conglomerate higher in the section.

Several similar conglomerate horizons are known from diamond drilling lower in the Portage Lake Lava Series but the only other fragmental units exposed on the island are tuffaceous in nature and include at least one rhyolitic ash bed.

Copper Harbor Conglomerate

The Copper Harbor Conglomerate is indeed a conglomerate over much of its outcrop area on Isle Royale, but it displays some dramatic facies changes into finer-grained sedimentary rocks along strike.

Near the base of the formation at the westernmost part of the island, the rock is a boulder conglomerate with boulders as much as 2 feet in diameter.

Eastward near the base the clasts become progressively finer and the conglomerate appears to thin until at the easternmost outcrops of the formation only sandstone is present and it rests directly upon the Portage Lake Lava Series.

Likewise, higher in the section along the southwestern coast, boulder conglomerates change through a mixture of cobble and pebble conglomerates and sandstones, to sandstone and mudstone in the easternmost outcrops on the offshore island chain.

It will be noted that directional structures in the sedimentarry rocks indicate a direction of transport in the direction of increasing textural maturity.

Also in this same direction the section increases in thickness, below a marker horizon, from roughly 1,500 feet to over 5,000 feet.

The depositional environment producing this sequence is interpreted as being one of a combination of fluvial and lacustrine conditions resulting in piedmont fanglomerates grading outward into playa lake or floodplain deposits.

With the exception of a few quartzite pebbles, essentially all rock fragments in the Copper Harbor Conglomerate are of volcanic origin, with felsic fragments predominating slightly over mafic ones.

The same is true of the clastic units in the upper part of the Portage Lake Lava Series.

All evidence points to a source for these clastic rocks not far to the west of Isle Royale, in the direction of the North Shore Volcanic Group.

It is indeed comforting to see that felsic and mafic volcanic pebble types found in the Copper Harbor Conglomerate, that do not occur in the exposed part of the Portage Lake Lava Series, do occur in the North Shore sequence.

This further suggests the possibility of an unconformity between the North Shore Volcanic Group and the Portage Lake Lava Series, similar to that proposed by Hubbard in western Michigan between the South Range Traps and the Portage Lake Lava Series.

Such an unconformity would permit erosion of the lower volcanic sequences at the margins of the basin while the Portage Lake Lava Series and Copper Harbor Conglomerate were being formed within the basin.

Structure

The physiography of Isle Royale is greatly controlled by the character and structure of the bedrock, with a very pronounced ridge and valley topography developed by differential erosion of the tilted, layered rock sequence.

Superimposed upon the ridge and valley topography are lineaments related to regional joint sets.

One set strikes essentially N-S at the western end of the island and changes progressively eastward to reach an orientation about 30° east of north on the eastern third of the island.

Minor vertical displacement is apparent along some of these lineaments, with the east side always upthrown.

A second set of joints, striking E-W, commonly shows somewhat greater fault displacement, but still no more than a few hundred feet at most.

The movement on these faults is also vertical with the south side always upthrown.

The only major structural distortion on the island is in the Lake Richie area, where the upper part of the Portage Lake Lava Series is warped around a node of apparent uplift and fracturing.

The pattern is suggestive of that which might be caused by a concealed intrusive body.

Although this is a reasonable possibility, no exposures of intrusive rocks of any kind are known on the island.

Summary

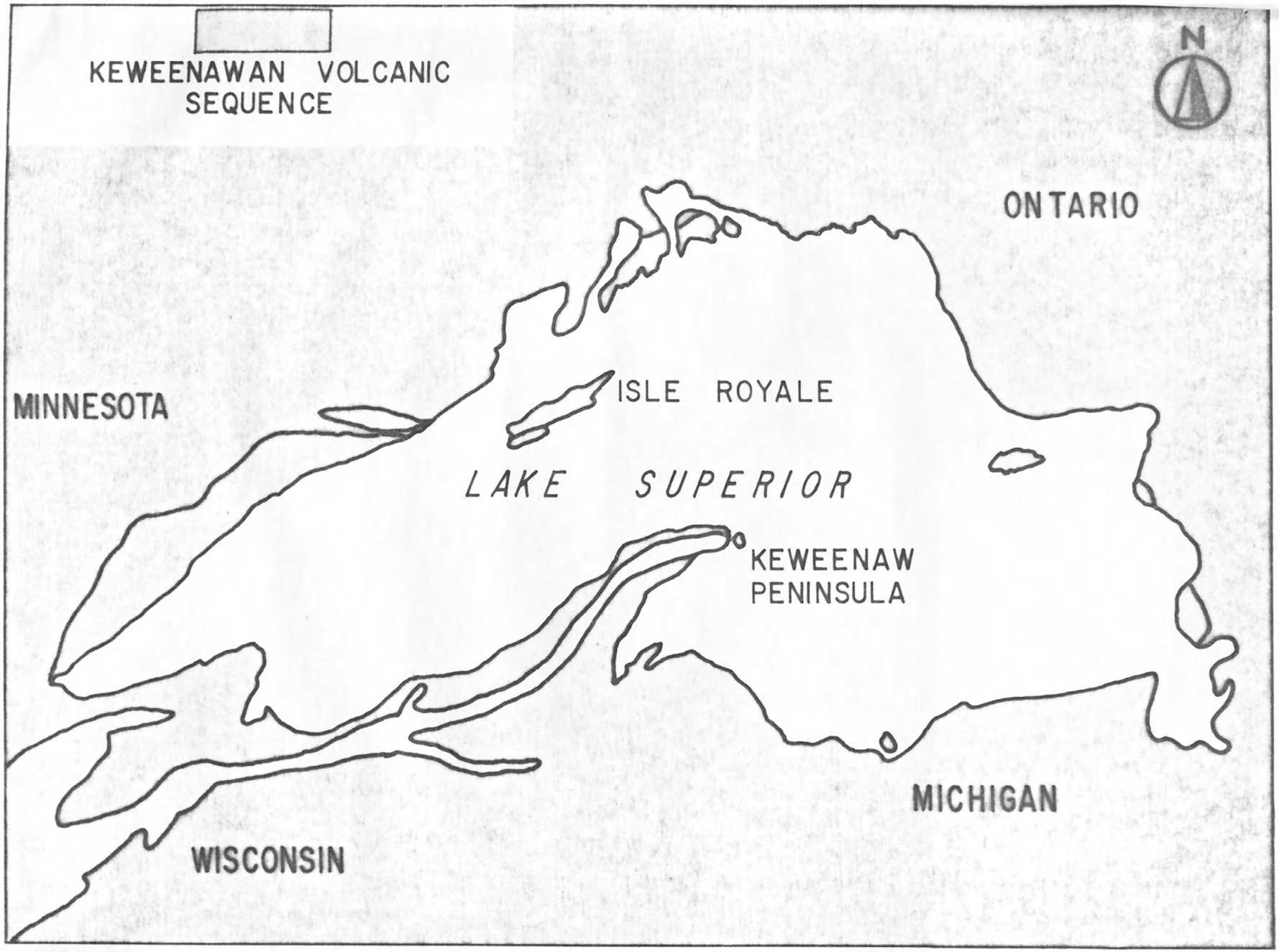
As A. C. Lane long ago pointed out, the stratigraphic section and structure of Isle Royale is essentially a mirror image of that on the Keweenaw Peninsula on the opposite side of the Lake Superior syncline.

At least one individual flow, the Greenstone Flow, and possibly several other flows or groups of flows, can be directly correlated across the syncline.

The sequence on Isle Royale (and the Peninsula) lies stratigraphically above the North Shore Volcanic Group (and presumably the Osler Series and the South Range Traps), and may be separated from it by an unconformity.

Available evidence suggests to me that the major part of the lava for the Portage Lake Volcanic Series, at least, came from a linear source along the axial region of the Lake Superior syncline and that it flowed laterally toward both sides of the syncline.

During periods of volcanic quiescence, clastic debris was shed into the subsiding basin from both sides and with the ultimate cessation of volcanic activity altogether, the thick pile of Copper Harbor Conglomerate and other Keweenawan sediments accumulated.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ISLE ROYALE
LAKE SUPERIOR
KEWEENAW PENINSULA
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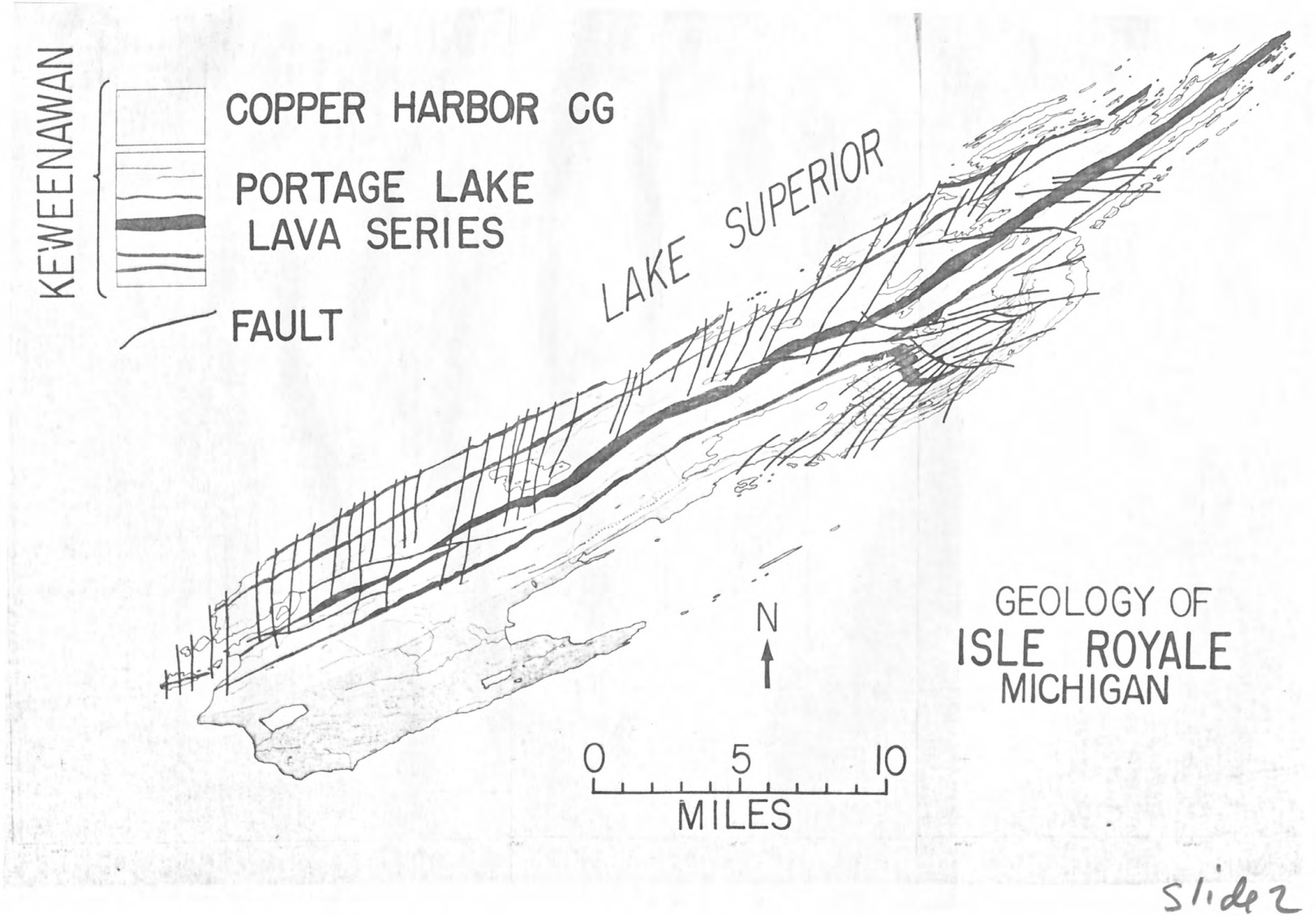
Slide 1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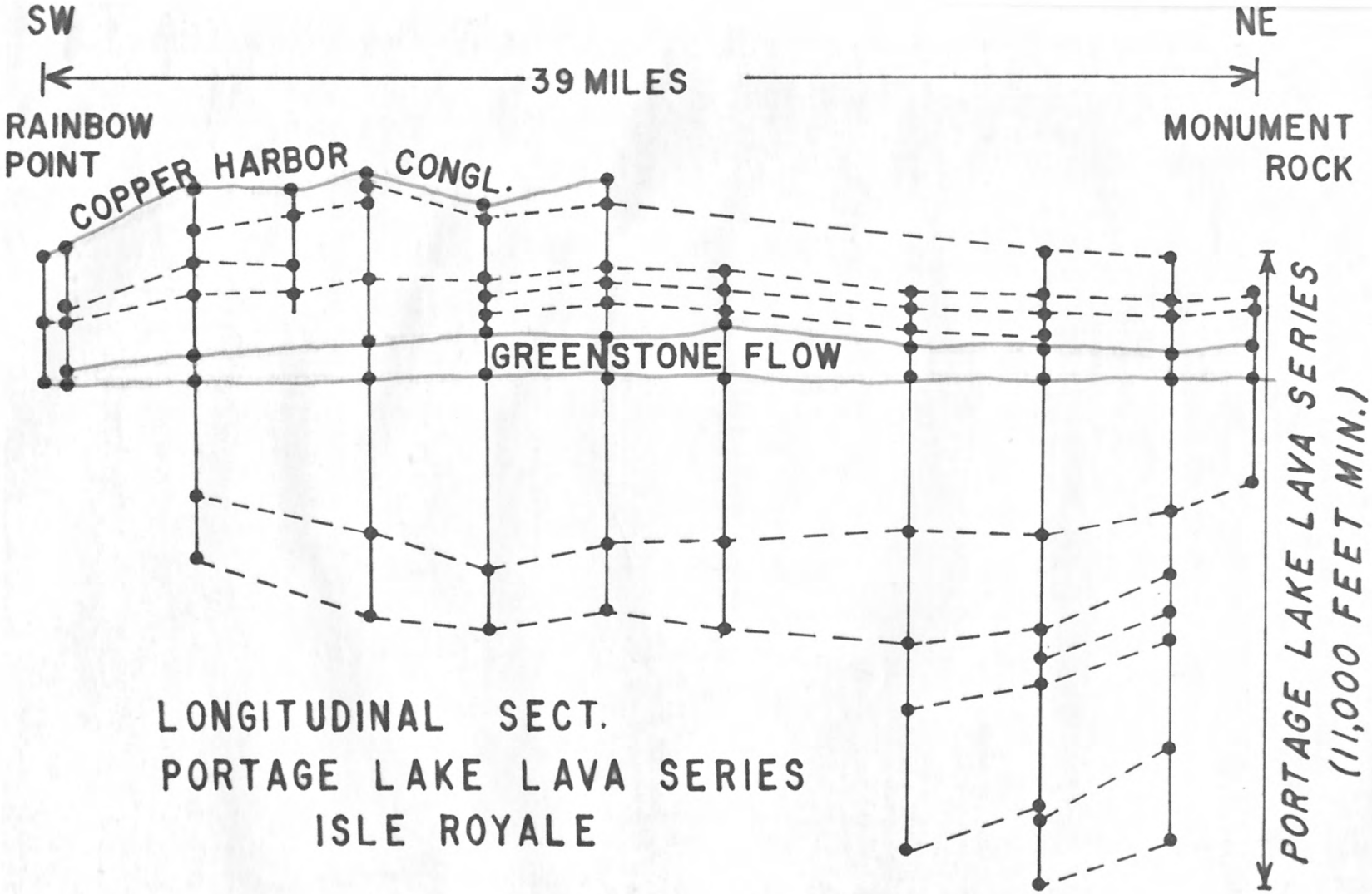
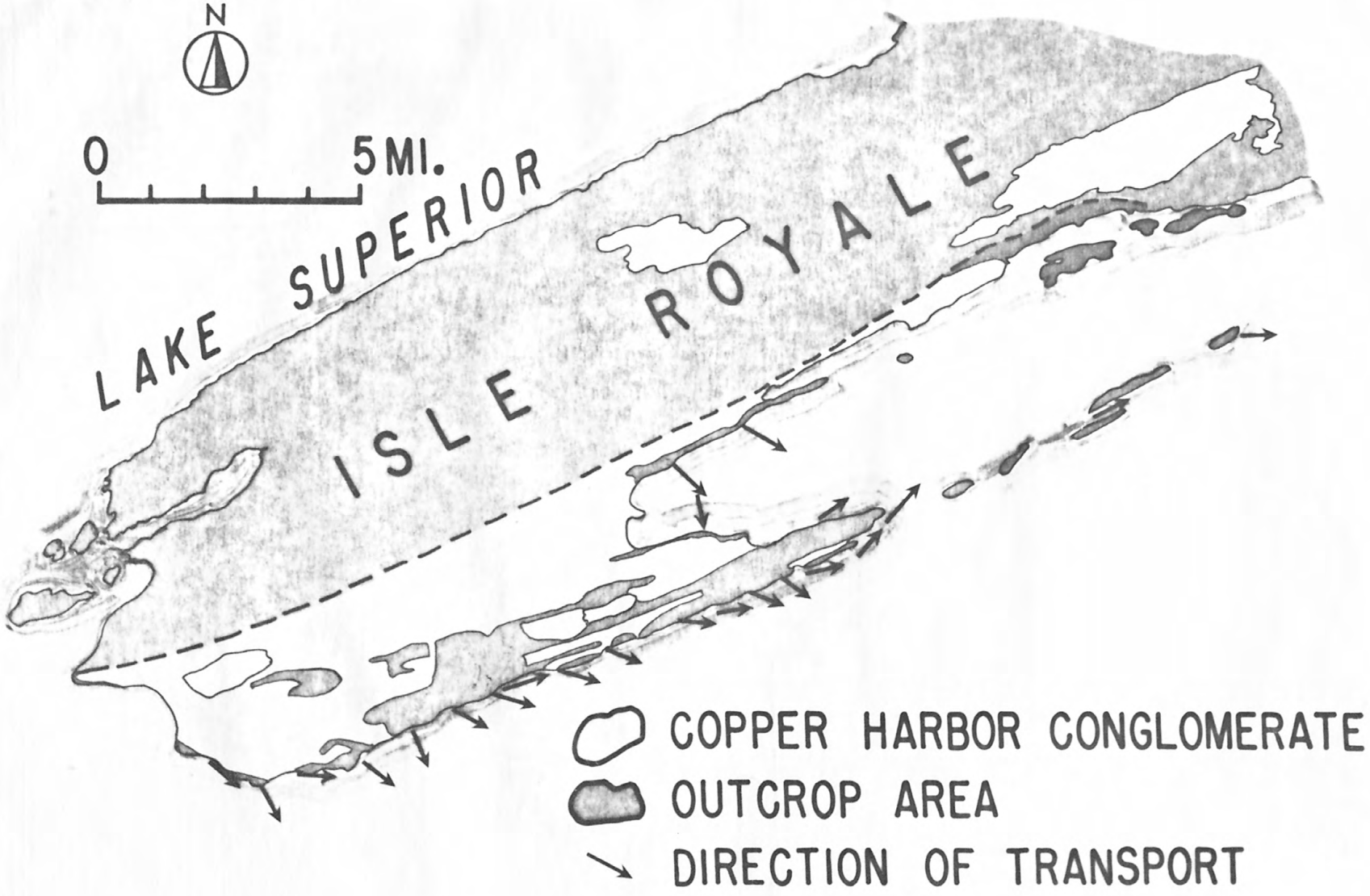
slide 2



LONGITUDINAL SECT.
PORTAGE LAKE LAVA SERIES
ISLE ROYALE

Slide 3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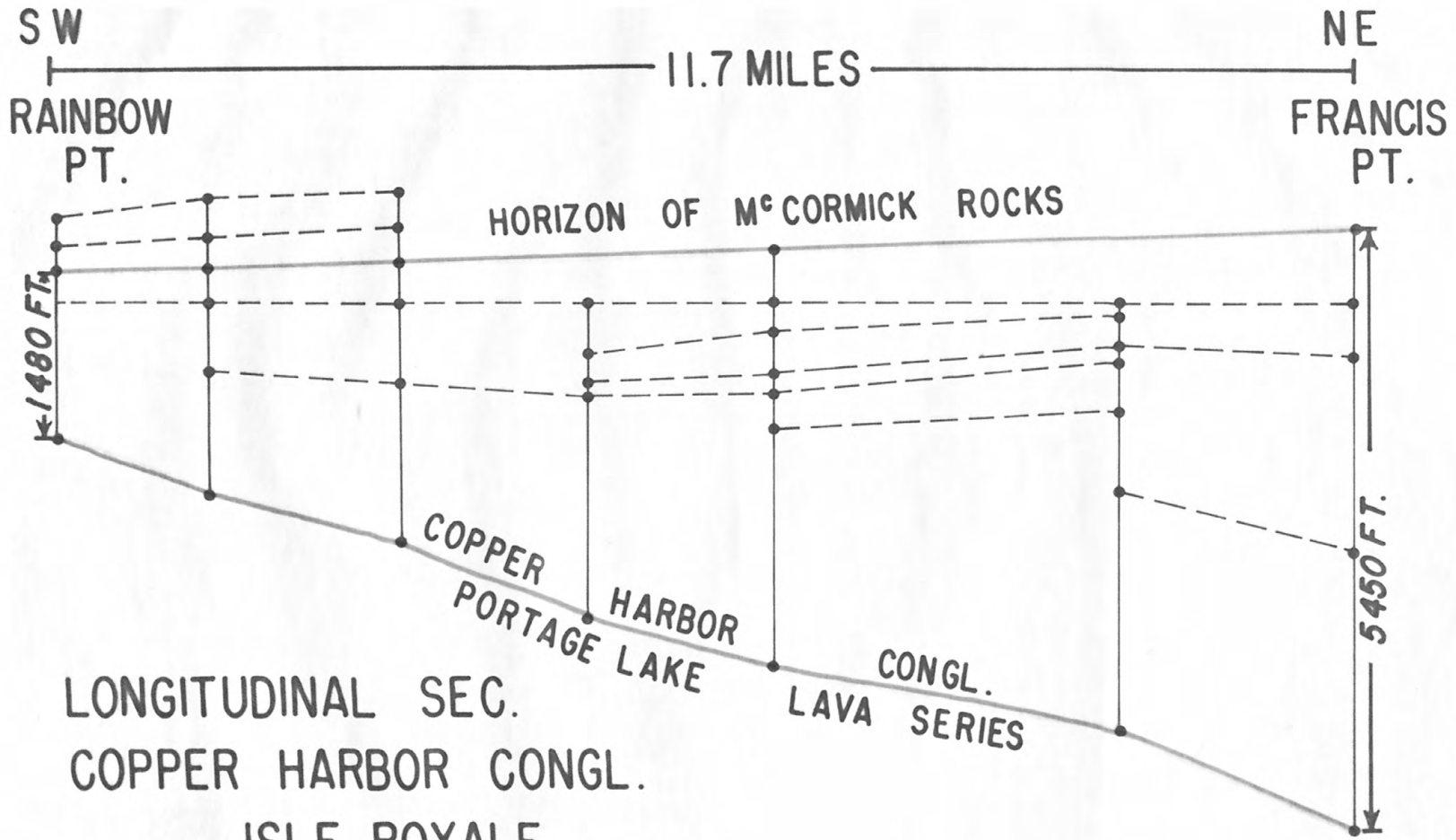
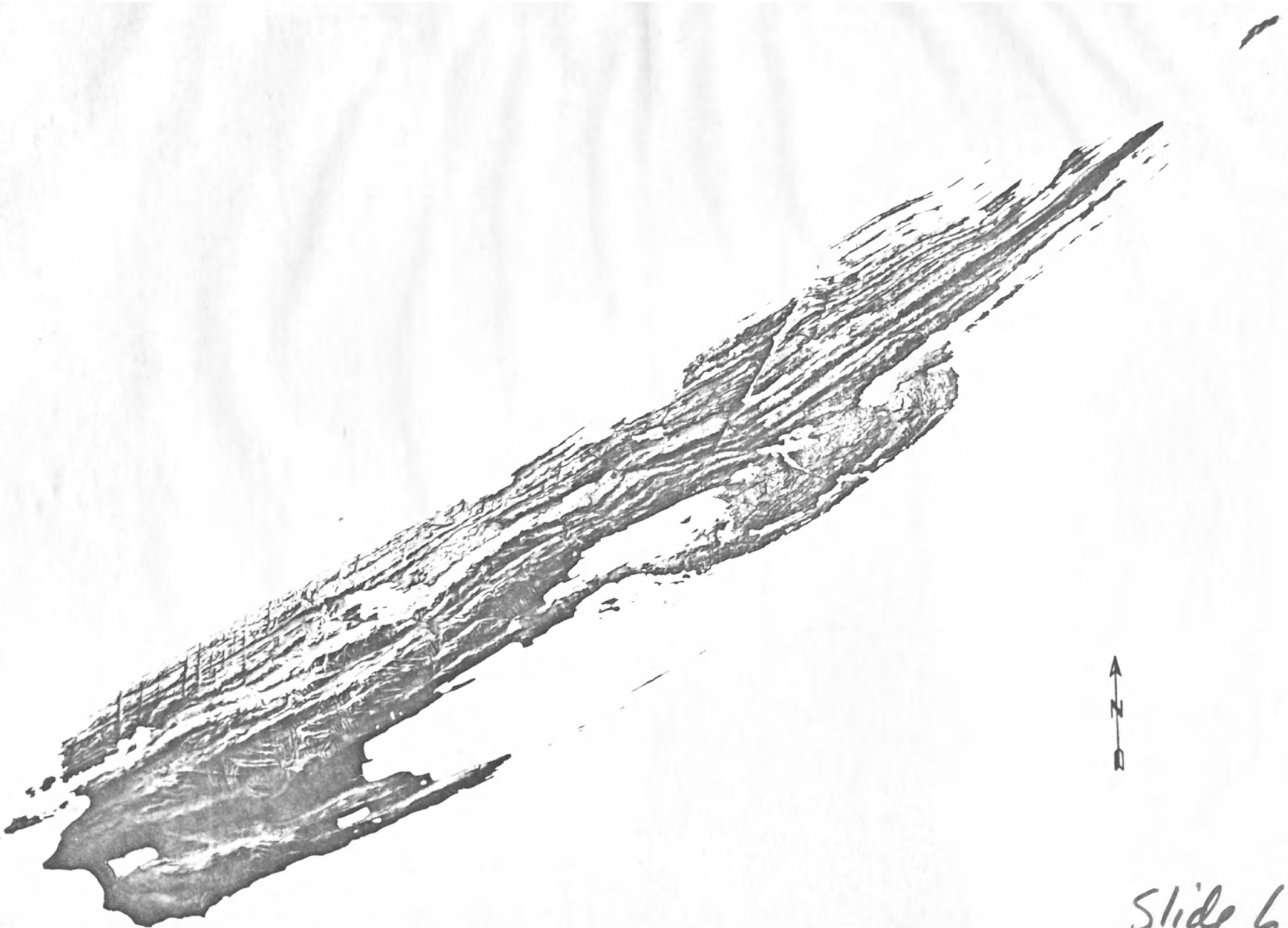
LAKE SUPERIOR
ISLE ROYALE
COPPER HARBOR CONGLOMERATE
OUTCROP AREA
DIRECTION OF TRANSPORT

slide 4



LONGITUDINAL SEC.
COPPER HARBOR CONGL.
ISLE ROYALE

Slide 5



Slide 6