mantle lava do not originate from the same source. His further conclusion was that plume flux does not control the rate of spreading. Blobs (impulse flow) are declining under Iceland at present whereas the spreading rate is increasing, hence Iceland may split into two.

Indirect evidence for mantle plumes was further discussed by M. Langseth of Lamont-Doherty Geological Observatory, New York, on the basis of 62 heat flow measurements in the Norwegian Sea. He showed that Iceland is in the centre of a broad area of high heat flow. He postulated that the thin lithosphere and anomalously high temperature at its base are the result of a spreading rate which is too low for the supply of heat to be dissipated. The conclusion is that something is constraining the plates from moving apart freely. Since Iceland is considered anomalous, this constrained motion does not occur everywhere and the inference could be that different plates show different degrees of rigidity through time. Further evidence on this key problem was provided by Laughton, who showed bending and distortion at the European plate edge along the Azores-Gibraltar fracture zone; and by B. Voigth, Pennsylvania State University, who reviewed borehole measurements of ambient stress in rocks. Voigth showed how the advances in the technique of in situ stress measurements have improved and advocated more deep drilling on land. In addition to providing information on ancient continental collisions and possible identification of seismic layer 3 rocks, stress measurements in deep bore holes might give information regarding rigidity of lithospheric plates.

In order to test the original formulation of the PTH, it was necessary to assume that lithospheric plates were rigid and not deformable during continental drift movements. Many land geologists familiar with faulting and folding within the continental land mass could not accept this assumption and frequently rejected the whole PTH. The assumption was necessary in the initial development of PTH since, without it, purely kinematic determination of plate motions based on matching magnetic patterns and orientation of fracture zones could not be worked out. As the additional evidence acumulates and our understanding of PTH increases, the plate rigidity assumption will be relaxed.

Geophysical evidence for intra-plate deformations will come from regional heat flow measurements, from averaged gravity anomaly interpretations, from higher resolution in interpretations of seismic records, and from measurements of in situ stress in deep bore holes on land as well as at sea.

Direct measurements of displacements between lithospheric plates are now possible and should be undertaken not only at the edges of the plates (as in Iceland or across the Gulf of California) but also between stable shield areas using long baseline interferometry and laser signal bounce from the reflectors on the moon. In addition, equipment should be developed for emplacement on the ocean floor for direct measurements of displacement on the mid-ocean ridges. These experiments are going to be slow and will require persistence over several decades, but the scientific rewards will be great.

Finally, work in experimental petrology and geochemistry is now producing a wealth of new data which is not yet fitting into a simple framework. When these data are sorted out there will undoubtedly be a great leap forward in our understanding of the internal constitution of the Earth. This understanding in turn will lead to a better model of the Earth as a thermodynamic engine.

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17th Conference on Great Lakes Research

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Summary
Limnogeology continues to account for a significant part of the research reported in the annual Conferences on Great Lakes Research. At this year's meeting the emphasis was on stratigraphic studies of post-glacial sediments, surface sediment geochemistry and shore processes. This is a reflection of current practical concerns with sediment loading, "cultural enrichment" of sediments and accelerated shore erosion.

Introduction
The Great Lakes Conference is an annual conference dealing with all aspects of Great Lakes' research including geology and geophysics. The conference is associated with the International Association for Great Lakes Research which provides the direction and continuity but is hosted by individual universities or research centres in the Great Lakes area. This year it was held at McMaster University in Hamilton, Ontario during August 12-14 and was co-sponsored by McMaster and the Canada Centre for Inland Waters (CCIW) in nearby Burlington.

Geologically-oriented papers generally make up 15 to 20 per cent of the technical sessions. This year there were 28 papers presented in three sessions titled Geology-Isotopes in Sediments, Great Lakes Geochemistry, and Shore Erosion/Beaches and chaired respectively by Drs. Tony Kemp and

Richard Thomas of CCIW and Dr. Wyman Harrison of Erindale College. I have asked the session chairmen to pass on their comments on the papers they heard and these form the bulk of the impressions given below.

Technical Sessions

Geology-Isotopes in Sediments (Kemp). The session on geology and isotopes in sediments covered a variety of subjects from phosphorus release in lake sediments and estimates of sedimentation rates to detailed heavy mineralogical and palynological studies. The session was noteworthy for the high quality of the presentations.

Selleck (Rochester) interpreted the easterly increase in per cent hypersthene to monoclinic pyroxene in the sands of southern and eastern Lake Ontario as indicative of eastward transport of sands from the Niagara River bar with increasing dilution of this source material by locally-derived sands. Differences in garnet ratios and high hornblende concentrations in the offshore sands were related to sorting phenomena. In a study of sediments in the northern half of Lake Superior, Dell (CCIW) observed three major units of unconsolidated materials and related them to the late-glacial and post-glacial history of Lake Superior, to the bathymetry of the basin and to modern sedimentary processes acting within the lake. As part of a long term study of Lake Huron, Anderson and Lewis (GSC) reported on a buried plant-detritus bed, indicative of extremely low water levels, in the western region of the lake. The bed was radiocarbon-dated at 9,680 ± 110 years at the base and 8,830 ± 410 years at the top. Pollen, plant macrofossils, insects, ostracodes and mollusks document the periods of emergence and submergence as predicted in a model uplift curve for the site.

Robbins (Michigan) and Edgington (Argonne) presented two stimulating papers on ^{137}Cs and ^{210}Pb dating of Lake Michigan cores. Sedimentation rates determined by this procedure vary from 0.1 to 0.4 cm/year and are approximately the same today as estimated for 7000 years BP. By applying a theoretical model of sedimentation to the ^{137}Cs data, Robbins found that mixing at the sediment-water interface occurs down to a depth of four cm. The ^{137}Cs budget for the lake fitted the predictions of atmospheric fallout over the lake and surprisingly the mean residence time of the Cs was only 0.2 years. On the basis of their results, the authors suggested that the high offshore sedimentation rates and the short residence time of radioactive elements had serious implications for the location of nuclear reactor sites on the shores of the lake.

In an excellent study of the mobility of phosphorus in the sediments of Lake Ontario, Bannerman, Armstrong and Harris (Wisconsin) found that under present conditions in the lake about two per cent of the annual external loading of P is regenerated from the sediments. This P is in the form of loosely-bound inorganic phosphate sorbed onto clay and organic particles. The authors estimated that under more eutrophic conditions the sediments have the potential of regenerating twice the annual external loading of P.

Stable carbon isotope ratios from −20.8 to −27.4 were found in sediment and plankton samples from Lakes Ontario and Erie by Drimmie and Fritz (Waterloo) and Kemp (CCIW). The authors concluded that the decreasing ^{13}C in core samples from both lakes reflected diagenetic processes at the sediment-water interface. Low ^{13}C values observed near the mouth of the Detroit River were probably a reflection of a significant terrestrial input. Elsewhere the sediment organic matter appeared to have been derived solely from plankton from within the lake basin.

Great Lakes Geochemistry (Thomas). This session of ten papers covered a wide field of research ranging from the origin of manganese nodules to problems associated with sediment standards as criteria for dredging. Two papers were read on manganese in Lake Michigan sediments; the first was a good presentation by Robbins and Callender (Michigan) on the upward diffusion of Mn in a core, the second, a discussion by Rossman (Michigan) of the uptake of trace elements by nodules.

Kemp and Dell (CCIW) presented an interesting preliminary report on the influence of the geochemistry and mineralogy of Lakes Ontario and Erie shore materials on the composition of the basin sediments.

The interpretation of the distribution of elements in lake sediments was the subject of several papers. Results were reported for upper Lake Michigan (Cline and Chambers, Lake Survey; Kotsch *et al.*, Michigan State), Lake Erie (Walters *et al.*, Bowling Green) and Thunder Bay, Lake Superior (Mothersill, Lakehead). The Lake Erie report included a discussion of the degree of surface enrichment due to anthropogenic loadings and some attempts to infer industrial sources.

A very interesting paper was presented by Wall *et al.* (Guelph) on the biological transformation of clay-sized sediments in aquatic environments. Under laboratory conditions, the authors observed a progressive decrease in illite, expandables and vermiculite and an increase in quartz and chlorite in association with an increasing microbial population. With verification in natural systems, this process may prove to be highly significant in understanding degradation and transformation of clay minerals during transport and deposition.

Shore Erosions/Beaches (Harrison). The ten papers delivered in this session ranged over four topics: measurement of shore erosion, shoreline management and control of erosion, beach process-response and dune sedimentation.

Shore erosion measurements were reported for the Ohio shoreline of Lake Erie by Carter and Benson (Ohio G.S.) and for the east coast of Lake Michigan by Pritchett (CERC). The three papers were essentially descriptive and were incomplete in that no error analyses were presented for the measurements taken.

Three papers were presented on shore erosion control and shoreline management. Quigley (UWO) discussed his successful and inexpensive ($70-90/m^3) use of

gabion groynes on the east coast of Lake Huron. Clinton presented a number of new ideas for low-cost shore protection currently being tested by the State of Michigan. Of these the "Longard System' of sand-filled nylon and polyethylene tubes seemed the most promising. Garrett outlined the shoreline management programme of the Metro Toronto Conservation Authority and its three-fold policy of regulation, acquisition and shore protection.

Beach process-response studies were reported in three papers which ranged in quality from an informative progress report on beach and inshore geometry of the western end of Lake Ontario (Coakley, CCIW) through an attempt to relate wave energy to erosion for the west shore of Lake Ontario (Hegler, Waterloo) to a confusing paper by Tanner (Florida State) in which Lake Michigan beach processes took second place to those of the Florida coast. None of the foregoing provided any fresh insights into the workings of the coastal sediment regime.

The best paper of the session was a presentation by Peat (Queens) on a study of dune sedimentation on the Wellington bay-mouth bar of Prince Edward County, Ontario. This was a well-organized and comprehensive study of the evolution and current status of an area of dunes in which there is a potential conflict between recreational use and sand-mining operations.

The remainder of the conference was composed mainly of biological and physical papers, many of which were concerned with the results of the International Field Year programmes on Lake Ontario. Readers interested in this aspect of the conference or in further details of the geological presentations should consult the Conference Proceedings Volume which will be available in mid-1975. Next year's conference will be held at Albany, New York from May 27 to 30 and will be co-hosted by the State University of New York and Sea Grant.

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