NOTICES OF MEMOIRS.

ABSTRACTS OF PAPERS READ BEFORE SECTION C (GEOLOGY), BRITISH ASSOCIATION, TORONTO, 1897.

I.—PRELIMINARY NOTICE OF SOME EXPERIMENTS ON THE FLOW OF ROCKS.—By FRANK D. ADAMS and JOHN T. NICHOLSON, McGill University, Montreal.

THESE experiments aim at ascertaining whether it is possible, by subjecting rocks artificially to pressure under the conditions which obtain in the deeper parts of the earth's crust, to produce in them the deformation and cataclastic structures exhibited by the folded rocks of the interior of mountain ranges or of the older formations of the earth.

Three factors contribute toward bringing about the conditions to which rocks are subjected in the deeper parts of the earth's crust: (1) great pressure from every direction; (2) high temperatures; (3) action of percolating waters. In the present experiments the attempt has been made to reproduce only the first of these conditions; in subsequent experiments the endeavour will be made to reproduce all three of them.

The experiments have been made chiefly with pure Carrara marble. Columns of the marble, 2 centimetres and 2½ centimetres in diameter and about 4 centimetres in length, were very accurately turned and polished. Heavy wrought-iron tubes were then made, imitating the plan adopted in the construction of ordnance, by rolling long strips of Swedish iron around a bar of soft wrought iron, and welding the strips to the bar as they were rolled around it. The core of soft iron composing the bar was then drilled out, leaving a tube of welded Swedish iron 6 millimetres thick, so constructed that the fibres of the iron run around the tube, instead of being parallel to its length. This tube was then very accurately fitted on to the column of marble. This was accomplished by giving a very slight taper to both the column and the interior of the tube, and so arranging it that the marble would pass only about half-way into the tube when cold. The tube was then expanded by heating, so as to allow the marble to pass completely into it, and leave about 3 centimetres of the tube free at either end. On allowing the tube to cool, a perfect contact between the iron and marble was obtained, and it was no longer possible to withdraw the latter. Any very slight failure to fit at any point, if such a failure existed in any case, was rendered harmless by the fact that under a comparatively low pressure the limestone is found to be sufficiently elastic, not only to fill up any such minute space, but even to stretch the tube, and, on the pressure being relieved, to contract again to its original form, so that it will drop out of the tube which has been thus enlarged. Into either end of the tube containing the small column an accurately fitting sliding steel plug was inserted, and by means of these the marble was submitted to a pressure far above that which would be sufficient to crush it if not so inclosed. The machine employed in obtaining the pressure was so arranged that the pressure might be maintained for weeks, or even months, if required. Under these circumstances, the conditions of pressure to which the marble is subjected are those in the "zone of flow" of the earth's crust—those, namely, of a pressure above that of its elastic limit, while yet unable to break in the ordinary manner, owing to the tube which confines it having a still higher elastic limit. Under the pressure, which was applied gradually and in some cases continued for several weeks, the tube was found to slowly bulge until a very marked enlargement of the portion surrounding the marble had taken place. The tube was then cut through longitudinally by means of a milling machine along two lines opposite one another.

The marble within, however, was still firm, and held the respective sides of the iron tube, now completely separated, so tightly together that it was impossible without mechanical aids to tear these apart. By means of a wedge, however, they could be separated, splitting the marble through longitudinally. The column in one experiment was reduced from 40 millimetres to 21 millimetres in height. The deformed marble differs from the original rock in having a dead white colour, the glistening cleavage faces of calcite being no longer visible, and although not so hard as the original rock, it is still firm and compact, and especially so when its deformation has been carried out very slowly. No accurate measurements as to its strength have yet been made, but it will withstand a sharp blow, and fragments of it, weighing 10 grams, have been allowed to fall through a height of over 2½ metres (8 feet) on to a wooden platform, from which it rebounded without breaking. Thin sections of the deformed marble, when examined under the microscope, show that the calcite individuals composing the rock have in many cases been twisted and flattened, and in the majority of cases a very fine polysynthetic pressure-twinning has been induced in them, with movement along gliding planes, as well as several other structures seen in nature in highly deformed rocks.

The experiments therefore show that limestone, even when dry and at ordinary temperatures, does possess a certain degree of plasticity, and can be made to "flow," the movements set up developing many structures which are characteristic of rocks which have been squeezed or folded in the deeper portions of our earth's crust.

II.—The Glaciation of North-Central Canada. By J. B. Tyrrell.

In the region immediately west of Hudson Bay the earliest glaciation of which any traces were recognized, flowed outwards from a gathering-ground which lay north or north-west of Doobaunt Lake. Subsequently this gathering-ground moved south-eastward, until it centred over the country between Doobaunt and Yath-kyed Lakes. From one or other of these centres the ice seems, to the writer, to have flowed westward and south-westward to within a short distance of the base of the Rocky Mountains; southward, for more than 1,600 miles to the States of Iowa and Illinois; eastward into the basin of Hudson Bay; and northward into the Arctic Ocean.

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No evidence was discovered of any great elevation of this central area in Glacial or immediately Pre-Glacial times, and, in the absence of such evidence, it would seem not improbable that the land then stood at about the same height above the sea as it stands at present. In this case, the moisture giving rise to the immense precipitation of snow would have been derived from the adjacent waters of Hudson Bay and the Arctic Ocean.

The name Keewatin glacier has been applied to this central continental ice-sheet. In general character it appears to have been somewhat similar to the great glacier of North-Western Europe, with a centre lying near the sea-coast, a steep and short slope seaward, and a very much longer and more gentle slope towards the interior of the continent. But there was this difference between the two, that the centre of the latter was over a high rocky country, from which the ice naturally flowed outwards towards the surrounding lower country; while the centre of the former was over what is now, and was probably also then, a low-lying plain, on which the snow accumulated to such depths as to cause it to flow over country very considerably higher.

After the Keewatin glacier had reached its full extent, it began gradually to decrease in size. As it disappeared from the Northern States and the North-West Territories of Canada, it left a series of moraines, many of which can be readily traced across the unwooded country as ridges of rounded stony hills. While retiring down gradually descending slopes, many temporary extra-glacial lakes were formed in front of it, and were drained one after another as it retired to still lower country. Before it had withdrawn from the Winnipeg basin, it was joined by an advancing glacier from the east, and, in front of the two, Lake Agassiz, one of the largest of the extra-glacial lakes, was formed.

In its final stages the general gathering-ground of the Keewatin glacier seems to have moved still farther eastward, or nearer to the coast of Hudson Bay, and to have broken into several separate centres, one of which lay over the country south-east of Yath-kyed Lake, while another was probably located north of the head of Chesterfield Inlet.

After the retirement of the Keewatin glacier the land in the vicinity of Hudson Bay stood from 500 to 600 feet below its present level, and gradually rose to its present height.

III.—Glacial and Interglacial Deposits at Toronto. By Professor A. P. Coleman, Ph.D., Toronto University.

THE ravines of the river Don at Toronto and the lake cliffs of Scarborough Heights, a few miles to the east, provide exceedingly interesting sections of the drift, from 100 to 350 feet in thickness, displaying three or more sheets of till and a varying number of interglacial beds.

The most important section, at Taylor's brickyard in the Don Valley, shows a lowest till overlying Cambro-Silurian shale of Hudson River age. Upon this rest 18 feet of sand and clay, containing many unios and other shells, as well as leaves and pieces

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of wood. Some of the unios do not now live in Canadian waters, but are found in the Mississippi; and several species of trees now belonging to the States to the south occur with them, indicating a climate decidedly warmer than the present. Above this come stratified clay and sand, with a caribou horn and remains of insects and plants belonging to a colder climate than the present. This set of clays and sands is best shown at Scarborough, where the series rises 148 feet above Lake Ontario, and contains many species of extinct beetles, as well as shells of mollusca, mosses, and wood of hardy trees.

A complicated middle till overlies these beds, which were deeply eroded before the advance of the ice. Another less important fossil-bearing interglacial bed occurs above the middle till at elevations up to 240 feet above the lake, and is followed by a third till. Great changes in the level of the water occurred in connection with these climatic changes, the lake being much lower than at present before the first glacial advance and after the first interglacial time. During the deposition of the middle till, and also while the last sheet of till was being deposited, the water stood from 250 to 300 feet above the present level of the lake, which stands 247 feet above the sea. The retreat of the last ice-sheet was followed by the Iroquois episode, leaving a well-marked elevated beach. The length of time required for the first interglacial period is probably to be estimated at thousands of years; and during this time, at the beginning of which the climate was very warm, the ice-sheet of the Laurentide glacier must have completely disappeared. The correlation of the series of events described with those of the drift of the United States and of Europe is difficult, but probably the chief interglacial period corresponds to Jas. Geikie's Neudeckian, or the interval between the Iowan and Wisconsin glacial advances.

IV.—On the Structure and Origin of certain Rocks of the Laurentian System. By Frank D. Adams, Ph.D., F.R.S.C., McGill University, Montreal.

THE paper presents the results of recent and somewhat extended studies of several areas of the Laurentian of Canada, and deals more particularly with the origin of certain members of this system as indicated by their structure or composition. While it is impossible in the present state of our knowledge to arrive at any definite conclusions concerning the origin of many, or perhaps even of the majority, of the rocks composing the Laurentian, the origin of certain members of the system can be determined. Some of these, although now possessing a more or less distinct and even highly pronounced foliation or stratiform appearance, can be proved to be igneous or intrusive rocks, while it can be shown that others are of aqueous origin.

To the former class belong the anorthosites and many of the orthoclase gneisses. These rocks, although frequently distinctly foliated, can in many places be traced into perfectly massive varieties, and form great intrusions, interrupting and cutting off the older members of the system. The foliation and stratiform appearance, which led the older geologists to class them as altered sediments, is due to movements induced by pressure, and they show protoclastic or cataclastic structure in great perfection.

To the aqueous rocks, on the other hand, belong the crystalline limestones and certain gneisses usually associated with them. These rocks not only differ in structure from those above referred to, but have a chemical composition not possessed by any igneous rock. The cataclastic structures are very subordinate, and the rocks are characterized by a very extensive recrystallization, accompanied by the development of new minerals.

It may therefore be said, without going beyond that which the facts warrant, that there are in the Laurentian at least two distinct sets of foliated rocks. One of these, comprising the limestones, some quartzites, and *certain garnetiferous or sillimanite gneisses, represents*, in all probability, highly altered and extremely ancient sediments. The other set, intimately associated with these, is of igneous origin, and comprises numerous and very extensive intrusions, both acid and basic in character, which were probably injected at widely separated times. Those masses which were first intruded, and have been subjected to all the subsequent squeezing and metamorphism, are now represented by well-defined and apparently interstratified augen-gneisses and granulites; others, intruded at later periods, though showing the effects of pressure, retain more or less of their massive character; while still others, which have been injected since all movements ceased, are recognized by all as undoubted igneous intrusions.

REVIEWS.

I.—International Geological Congress. — Congrès Géologique International. Compte-Rendu de la Sixième Session, en Suisse. 8vo; pp. xii, 710, with Supplement (Table of Strata). Lausanne, April, 1897.

THE Sixth Session of the International Geological Congress was held at Zurich in 1894, and just before the Seventh Session was held at St. Petersburg, nearly three years after date, the volume of 1894 proceedings was issued. Like the previous volumes published by the Congress, the present work contains a miscellaneous series of discussions, reports, and original papers on various geological subjects, together with records of excursions. Most of the articles are in French, but some are in German, and others in English; and among the subjects dealt with are Ontogeny and Phyllogeny, the structure of gneisses and gabbro, New Zealand glaciers, the geology of Arabia and Palestine, Alpine geology. Contact metamorphism, and Quaternary and Tertiary classification.

Perhaps the most important article is that by Professor Renevier entitled "Chronographe Géologique," being an explanatory statement to accompany a second edition of his "Tableau des Terrains Sedimentaires," which originally appeared in 1873–4 in the *Bulletin de la Société vaudoise des sciences naturelles*, vol. xii, and

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