bable that they are due to the withdrawal of rock-salt which has been going on there of late years only. In this case the depth at which the cavities are being formed and rock-collapses are, as I believe, taking place, is much greater than in the Sunderland case, the borings for salt being from 1000 to 1200 feet deep.

I will conclude with a quotation from my paper on the Breccia-gashes,[1] p. 174:—"The forms of these gashes, which are gullet-shaped and tapering downwards, unlike the sea-caves; the breccia with which they are filled; the matter with which the fragments are cemented; the half-broken beds which so often bridge over the upper portions of the fissures; and the unbroken beds immediately above and below them, which would be inconceivable had the fissures and their infillings been due to real earthquakes. All these things are necessary accompaniments of the rock-collapses which, it has been shown, must in time past have happened frequently, are happening still, and must happen more and more frequently in the future."

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. Fifty-fifth Meeting, Aberdeen, 1885.

List of titles of papers bearing upon Geology and Palæontology read in other Sections of the Association than in Section C (Geology).

Section A.—Mathematical and Physical Science.

Report of the Committee on Underground Temperature.

Report of the Committee on Meteoric Dust.

C. Meldrum.—A Tabular Statement of the Dates at which and the Localities where Pumice or Volcanic Dust was seen in the Indian Ocean.

Prof. Ewing.—On Measurements of Movements of the Ground.

H. R. Mills.—Physical Condition of Water in Estuaries.

Section B.—Chemical Science.

Prof. W. Irwin Macadam.—Description of a Mineral from Loch Bhruïthaie, Inverness-shire.

F. Maxwell Lyte.—On the use of Sodium or other Soluble Aluminates for Softening and Purifying hard and impure Water.

Section D.—Biology.

Prof. O. C. Marsh.—On the Size of the Brain in Extinct Animals.

Prof. E. Hull.—On the Cause of the Extreme Dissimilarity between the Faunas of the Red Sea and Mediterranean, notwithstanding their recent connection.

Prof. E. Hull.—On the Origin of the Fishes of the Sea of Galilee.

Dr. Macfarlane.—On a Microscopic Fungus in Fossil Wood, from Bowling.

[1] See Trans. N. E. Inst. Min. Eng. vol. xxxii. (1884), where full references to most of the writers who have noticed the breccias are given.

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SECTION E.—GEOGRAPHY.

J. Y. Buchanan.—Oceanic Islands and Shoals.

Gen. Sir R. Lefroy.—On the Depth of the Permanently Frozen Stratum of Soil in British North America.

SECTION G.—MECHANICAL SCIENCE.

W. Smith.—The Movement of Sand in Aberdeen Bay.

SECTION H.

Thomas Wilson.—A New Man of Mentone.

W. Pengelly—Happaway Cavern, Torquay.

Dr. J. G. Garson.—The Human Remains found in Happaway Cavern, Torquay.

Dr. R. Munro.—The Archæological Importance of Ancient British Lake-Dwellings and their Relation to analogous Remains in Europe.

PAPERS READ BEFORE SECTION C (GEOLOGY).

II.—ON THE AVERAGE DENSITY OF METEORITES COMPARED WITH THAT OF THE EARTH.

By the Rev. E. HILL, M.A., St. John's College, Cambridge.

THE mean density of the earth, though not yet exactly determined, is certainly about twice the average density of the rocks which compose its superficial crust. One conjecture which very naturally follows from this fact is that the constituents of its interior may essentially differ from the constituents of that crust. Professor Judd in his treatise on Volcanoes has alluded to this, and brings forward in addition the argument that materials are occasionally brought from below to the surface which resemble the materials of meteorites; bodies which generally have a high specific gravity and sometimes consist entirely of iron.[1] The thought has occurred to me that it would be interesting to ascertain the average specific gravity of meteorites, in order to estimate what would be the density of a body formed by the aggregation of a multitude of such objects.

To conduct such an investigation properly would involve enormous labour of research, and I have contented myself by using the materials furnished by Dr. Walter Flight's most valuable "Chapters on Meteorites," published in the GEOLOGICAL MAGAZINE, during the years 1875, 1882, and 1883. From those chapters I have obtained the specific gravities of sixty-five different meteoric masses there described. The mean of these values, found by addition and division by 65, gives as result 4·84.

This method of obtaining the mean will be correct, if the various sizes were equally distributed through each of the different specific gravities. This would be rather a rash assumption, and it may seem fairer to bring into account the different masses of the specimens. From Dr. Flight's papers, with some other materials, I have found fifty-seven cases in which both weight and specific gravity are recorded. Taking the sum of the weights, the sum of the corresponding volumes, and dividing, we obtain as final result a specific gravity of 5·71.

[1] "Volcanoes," p. 320.

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But in this enumeration is included the great Cranbourne meteorite, which weighs $3\frac{1}{2}$ tons, and exceeds all the rest put together. A mass so great swamps the rest, and makes the calculation unsatisfactory, affording at best a maximum limit. Several others are very large. Suppose we exclude all over 250 lbs. There remain fifty-two cases, and the above process applied to these yields as result a specific gravity of 4·58.

I have tried yet another method. I have seen somewhere a statement that in the British Museum are specimens of 260 meteorites, of which 55 are metallic. Now it becomes obvious on tabulating the specific gravities that the vast majority are either metallic with specific gravities lying between 7 and 8, or stony with specific gravities between 3 and 4. Separating the 57 cases previously alluded to into these two groups, and finding the respective average specific gravity by the second method, the results are 7·61 and 3·73. From 55 specific gravities of 7·61 and 205 of 3·73, we get an average of 4·55. This method is open to the objections made against the first, but in a slightly less degree from the larger numbers dealt with.

It is probable that metallic masses more readily attract attention than stony meteorites, but on the other hand some appear to decay very rapidly. Thus it does not seem possible to say that either class has a better chance of obtaining admission to our calculations; or a preponderating influence on the results. We may say, therefore, as a general result, that an assemblage of such meteoric masses as fall upon the earth, if collected from space indiscriminately and aggregated into a single mass, would form a body whose specific gravity would probably lie between 4·5 and 5·7, so long as its dimensions were moderate.

Such a body, however, if it grew to be of planetary size, might become denser from the pressure due to its own attraction. How much denser we cannot say. But since water has been compressed by $\frac{1}{11}$th of its bulk under a pressure of 2000 atmospheres (Ency. Brit., art. Elasticity), and a like pressure would be experienced at a depth of about four miles of the earth's crust, at least as much may be expected in such an aggregated mass. Such a compression would raise even the lowest of the above results, viz. 4·5, to 4·9. And twice the compression would raise it to 5·4. Now 5·6 is the value usually adopted as the best estimate of the specific gravity of the earth. The density of the earth is, therefore, perfectly consistent with its being an aggregation of meteoric materials. Whether we regard meteorites as fragments of a planet, as condensations of cometary matter, or as self-existent bodies, they are certainly specimens of matter scattered widely over the solar system, and may very possibly be fair samples of its materials. And small as is the catalogue even of all we know, they contain all the most important constituents of the earth's crust, and even of its soil.

If the earth be an aggregate of meteoric materials, so must be the other planets. Now the densest of these is Mercury with a specific gravity about 6·3; Venus is about the same as the Earth; and Mars somewhat less. All these specific gravities are perfectly consistent with such an origin. The others are very much lighter, ranging down to Saturn with a specific gravity of about 0·7. But high temperature and gaseous envelopes may have much to do with these apparent low densities: a cloudy envelope which should extend to one-fourth of the radius would halve the estimate of density. The fact that seems most seriously discordant with the hypothesis is the low specific gravity of the Moon, which is estimated at only 3·5. But this at any rate is about the specific gravity of the "stony" group of meteorites. And we may compare the fact that the superficial crust of the earth, and also some meteoric constituents, have lower specific gravities still. We naturally expect the lightest constituents on the surface of a planet, and a satellite may have affinity with the crust.

The conclusion then is that on the hypothesis that the Earth has assumed its present condition either by aggregation or solidification, out of matters previously existing within the solar system, it is probable that its nucleus will be largely composed of metallic materials. But since all the meteorites known would together scarcely load a barge, this conclusion must be admitted to rest on a very slender basis.

III.—Some Results of a Detailed Survey of the Old Coast-lines near Trondhjem, Norway.

By Hugh Miller, F.G.S., H.M. Geological Survey.

During a short visit to Norway in October, 1884, it appeared to the author that the best way to help to a solution the vexed questions connected with the coast-terracing of Norway was to execute a careful survey of a few square miles of some suitable coast region upon a sufficiently large scale. The neighbourhood of Trondhjem is remarkably well suited to this purpose. The map employed was partly a municipal chart on the scale of $\frac{1}{10000}$, and partly an enlargement of the Ordnance Map. The limit of all the terraces and marine deposits is the famous "strand line" west of the town, a double range of old coast-cliff cut in the rock of the mountain-side. Its upper line is 580 feet above the sea, and answers to the "marine limit" over Norway generally. Numbers of level terrace-lines have been incised—chiefly in greenish clays, like brick-clays—all along the arable slopes east of the town between this rock-terrace and the sea. Above the Bay of Leangen, two miles east of town and river, and far beyond all erosive influence of the latter, thirty of these lines were mapped one above another in the first 300 feet of ascent, a distance of one mile and a half. Many of these are small but extremely distinct, the earthy clays being well suited to retain sharp impressions of successive sea-margins, which these unequivocally are. The present coast-line, neatly etched out by the waves in Trondhjem and Leangen bays, is the key to these tiers of older ones. It also resembles them in having made little or no impression where the coast becomes rocky, the lines of incision in both cases stopping short at once when they reach the harder material. The old coast-lines are most numerous in well-sheltered positions. Thus a single pair of large terraces in an exposed situation east from Christiansten, where they face the open water of the fjord and the prevalent north-westerly storms, is represented in the recess above Leangen Bay by ten or twelve. The same fact is brought out on rising from this recess to the higher and more exposed ground. Thus, while thirty-three or thirty-four terraces are mapped below 350 feet (approximate) elevation, only nine or ten appear between that level and the rock-terraces of the upper marine limit, the numerical average height of the terraces thus rising by more than a half. In recesses of the coast further east, but beyond the map, these upper terraces seem to be preserved in considerably greater numbers. The number actually mapped was forty-three, or with the rock-terraces, forty-five. The largest number of terraces hitherto described at any one place in Norway seems to have been eighteen.

Some of the general conclusions of the author are as follows:—1. These terraces are all post-glacial, *i.e.* formed since the rock-glaciation of the district. This is confirmed by the condition of the high coast-cliff, which has been cut in ice-rounded rock, but is not itself glaciated. It appears, however, from the fauna of the raised shell-banks of the country (as worked out by Sars and Kjerulf), in which recent shells do not rise above 380 feet, that the seas of the upper levels were still glacial; and, though the Trondhjem fjord was free from land-ice, other deeper fjords and higher coasts may still have had glaciers coming into conflict with the sea, and producing the glaciated rock-terraces described by Sexe. All the evidence obtained discountenances Sexe's view that these rock-terraces were cut out by glaciers, as well as Carl Petersen's that they were rasped out by floating-ice coasting the shores. On the clay terraces coast-ice has left no more sign of its presence than the winter freezing of our British rivers leaves upon our river terraces. 2. If the country was upraised by a succession of elevatory jerks as supposed by most geologists from Keilhau downwards, most of these would seem to have been small—much smaller, at least, than is supposed by Kjerulf. It is improbable that even Leangen Bay was secluded enough to contain a record of all the original coast-lines. The longer pauses and greater storms may have effaced an unknown number, by a process of excision exemplified in all its stages by the map. It is hard to say, in fact, where the subdivision would end if all were preserved. The smaller terraces remind the eye of the incised lines and little planes engraved on the sandbanks bordering rivers after a flood, in which case there is no periodicity in the subsidence of the waters. 3. The preservation or excision of the terraces thus seems to depend as much upon local circumstances—exposure to storms, resistance of coast-line, etc.—as upon anything else. It is impossible at present to predicate which of them shall in any given place remain. Whether elevation by jerks, therefore, be postulated or not, all hope of correlating these terraces throughout the country must be deferred until their heights have been accurately determined by level. The measurements hitherto made, not even excepting those of Professors Kjerulf and Mohn, are probably inadequate for the purpose. This observation seems to apply also to the terraces graven in rock. In their aneroid measurements of the upper strand-line at Trondhjem these observers differ by fifty-five feet. 4. On entering the mouth of the Trondhjem Valley, the terraces come under an influence other than that of the sea-waves. The valley was worked out, in deposits partly levelled out by the sea, according to the laws of river terracing under the accelerating influences of a falling sea-level. The processes of automatic river terracing are beautifully exemplified within the district mapped, in the deep lobe-shaped curve of the river just before it enters the sea. The terraces have been added one after another to the point of the lobe of land thus surrounded, which is known as Öen.

IV.—Some Results of the Crystallographic Study of Danburite.

By Dr. Max Schuster.

IN studying the characters of the faces and the structure of the Danburite crystals found in Switzerland, the author has met with vicinal faces of a peculiar kind, for which he proposes the term 'transitional faces' (Tschermak, Min. Mittheil. vi. 1884, p. 511). Attention is called to the fact that these faces are easily affected by those causes which produce an unequal development of faces otherwise symmetrically disposed, and an illustration is given of the way in which their indices are numerically related to those of the principal faces of the crystal.

Paper read in Section D (Biology).

V.—On the Origin of the Fishes of the Sea of Galilee.

By Professor Edward Hull, LL.D., F.R.S.,
Director of the Geological Survey of Ireland.

WHEN preparing a memoir for the Palestine Exploration Society on the physical history of Arabia Petræa and Palestine, I was confronted with two biological problems: one on the origin of the fauna of the Sea of Galilee (or Lake of Tiberias); the other on the cause of the extreme dissimilarity between the faunas of the Red Sea and Mediterranean, notwithstanding the ascertained fact that the seas themselves have been physically connected within very recent times. With the former problem I propose here to deal as far as the fishes are concerned; with the latter I shall deal presently.

The abundance of the fishes which inhabit the waters of the Sea of Galilee is known both from sacred and secular history, and has been testified to by several recent observers. The characters and habits of these fishes have also been ably discussed and illustrated, especially by Canon Tristram[1] and Professor L. Lartet,[2] from which it has been determined that nearly one-half of the species are

[1] Fauna and Flora of Palestine, preface, p. xii. Mem. Palestine Survey, 1884.

[2] Poissons et Reptiles du Lac de Tibériade, Archives du Musée d'Histoire Naturelle de Lyon, tome iii. 1883.

peculiar to the lake and its tributaries; while of the rest only one—namely, *Blennius lupulus*—belongs to the ordinary Mediterranean fauna; two others—namely, *Chromis Niloticus* and *Clarias macracanthus*—are found in the Nile; seven other species occur in the rivers of South-western Asia; and ten more are found in other parts of Syria. Tristram considers that this assemblage points to a close affinity of the fauna of the Jordanic basin with that of the rivers of Tropical Africa (Æthiopian); but what most strikes the observer is perhaps the speciality of the species to Jordanic waters, sixteen out of a total of thirty-six species being peculiar. This view seems to be borne out also by an analysis of the molluscous forms, which are for the most part also peculiar, for no less than sixteen species of *Unio* are special to Jordanic waters.[1] Assuming that the forms which are common to Jordanic and other waters have been distributed in a manner similar to that by which we have to account for the distribution of lacustrine forms in other parts of the world, we have yet to account for the presence of the forms which are special and peculiar.

This leads to a consideration of the manner in which the Jordanic basin was first formed and afterwards modified; and without entering here into this wide question, which I have endeavoured to deal with in the memoir above referred to, I may be allowed to summarize my conclusions somewhat as follows:—

In the first place, it must be recollected that as the whole region on both sides of the Jordanic valley was originally overspread by strata of the Eocene period (known as the *Nummulitic Limestone*), this region formed the floor of the ocean down to the close of the Eocene period; the only possible lands in the district may have been those of the Crystalline rocks of the Sinaitic group of mountains.

The geological period, which succeeded, that of the Miocene, was that in which land first appeared in the Palestine area. The bed of the sea was locally elevated into dry land, but at the same time most of the leading physical features by which that land is now diversified were traced out and finally determined. Chief amongst these was the line of the great Jordan-Arabah depression—marked out by a line of fault or displacement of the strata, ranging from the slopes of the Lebanon on the north to the Gulf of Akabah on the south. It seems to me probable that as the land on either side of this depression was being elevated, the displacement of the strata on either side of the great fault was also proceeding, and the floor of the sea was subsiding along the line of the Jordan valley. An inland lake of considerable extent was thus formed, the waters of which were first derived from those of the ocean itself, in which were enclosed the fishes, molluscs and other forms which inhabited these waters themselves. There are good grounds for believing that once the lake was enclosed and shut off from the outer sea by a barrier of land, it was never again physically connected with the outer sea. The saddle of the Arabah valley, rising some 600 feet above the highest limit to which the waters of the old Jordanic lake ever

[1] Tristram, *ibid.* p. 178. The molluscs have been also recently described by M. A. Locard, Malacologie du Lac de Tibériade, 1883.

ascended, would have proved an effectual barrier towards the south.[1] Towards the west the barrier would have been much more elevated. Hence the living forms in the waters of the inland salt lake were isolated from those of the ocean, and had either to adapt themselves to their new conditions or to die out.

We may suppose that the first to disappear would be the corals, crinoids, and starfishes. On the other hand, fishes, molluscs, and crustaceans, having greater powers of adaptation, would in many cases survive. Meanwhile, the law of "descent with modification" would now come into operation, and we may suppose that throughout the Miocene and Pliocene periods the process of modification in form, colour, and habit gradually proceeded. The fittest forms survived, and differentiation between those of the outer and inner seas, resulting, as we have seen, in almost an entire specific change, was effected.

The above view seems in accordance with recent observations regarding the adaptability of many marine forms to new lacustrine conditions, provided the process of change is sufficiently gradual. Professor Sollas, whose memoir on "The Origin of Fresh-water Faunas"[2] is very suggestive, arrives at the conclusion that, as the conversion of comparatively shallow continental seas into fresh-water lakes has taken place on a large scale several times in the history of the earth, this has been accompanied by the transformation of some of the marine into fresh-water forms. The Jordan valley lake, originally salt, has shrunk back into two or three lakes connected by a river. The Dead Sea alone remains salt and lifeless. The waters of the Sea of Galilee are fresh, and teem with life. In reply to my enquiry whether the above views would harmonize with his own, Professor Sollas writes: "I have always regarded the curious fishes of the Sea of Galilee as evidence of a previous marine communication, but it never occurred to me to speculate as to the age of that connection. If this sea (that of Galilee) were stocked from the Eocene ocean, it would fit in very well with the history, as I believe it, of other fresh-water faunas." It is gratifying to me to have the concurrence on this point of so able an authority. I conclude, therefore, that the special forms of fishes now inhabiting the Sea of Galilee are the descendants of those which lived in the Eocene ocean.

REVIEWS.

THE GEOLOGY OF THE COUNTRY AROUND IPSWICH, HADLEIGH, AND FELIXSTOW. By WILLIAM WHITAKER, B.A., F.G.S., etc. (With Notes by W. H. DALTON, F.G.S., and F. J. BENNETT, F.G.S.) Memoirs of the Geological Survey. 8vo. pp. vii. 156. London, 1885. Price Two Shillings.

THIS Memoir contains a detailed account of the formations that are met with in the country around Ipswich, or in the tract embraced by Quarter-sheets 48 N.W. and N.E. of the Geological Survey Map.

[1] See Mount Seir, Sinai and Western Palestine, pp. 95 and 99, etc.
[2] Scientific Trans. Royal Dublin Society, vol. iii. ser. 2.

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