NOTICES OF MEMOIRS.

I.—Recent Researches in Bench Cavern, Brixham, Devon.

By William Pengelly, F.R.S., F.G.S., etc.

As long ago as 1839 the workmen in a limestone quarry on the southern shore of Torbay, and adjacent to the town of Brixham, laid bare at the back of the quarry the greater part of a vertical dyke composed of red earth and angular pieces of limestone. The quarrying operations, then discontinued, were resumed in 1861, when the entire dyke was disclosed, and among the materials of an incoherent part of it which fell down, were found some hundreds of osseous remains, including skulls, jaws, teeth, vertebræ, portions of horns, bones, and pieces of bones, identified by Mr. W. A. Sanford, F.G.S., as relics of the Cave-Hyæna, Wolf, Fox (2 species), Bear, Wild Bull, Reindeer, Hare, and Arvicola (2 species). The Hyæna was by very much the most prevalent form; but there was nothing indicating that he found a habitual home there. Not a coprolite was met with, nor was there a single bone scored with his teeth-marks, or broken after any of his well-known modes. The entire absence of anything betokening the existence of man was equally marked. It must be remembered, however, that the finds then met with were all from a mass of heterogeneous material which had filled a fissure nowhere more than two feet wide, and in places not more than a very few inches—not from a cavern in the proper sense of that term.

Adjacent to the left bottom corner of the dyke was the mouth of a low narrow tunnel, having a floor of stalagmite and extending into the hill to an unknown distance, but certainly upward of 30 feet. The proprietor of the quarry declined to allow any scientific investigations to be made, stating that he meant to make such researches himself; but this was never done.

In September, 1885, Mr. W. Else, Curator of the Museum of the Torquay Natural History Society, obtained permission from the gentlemen into whose hands the property had passed, to make such explorations as he might find desirable both in the dyke and in the tunnel; and from that date he has spent on the work all the odds and ends of time he has been able to command. His more recent researches have been mainly carried on in the tunnel, where he found the stalagmite floor, from 6 to 12 inches thick, formed on a reddish cave-earth, having a maximum thickness of 14 inches, and lying on a continuous limestone basis. Beyond a few remains of Hyæna nothing of interest occurred in the stalagmite, but the contents of the cave-earth were more numerous and interesting. In July, 1887, 24 specimens of bone selected from Mr. Else's finds—21 being from the cave-earth in the tunnel and 3 from the dyke—were forwarded for identification to Mr. E. T. Newton, of the Geological Survey of England, who at the end of a very few days returned them with a list containing not only the names of the species to which they belong, but also those of the bones themselves.

Of the 21 from the tunnel one is a relic of a Fox, while all the

others are those of the Cave-Hyæna. The three from the dyke represent the Cave-Bear, *Rhinoceros tichorhinus*, and a species of Deer. Among the tunnel finds there were also three coprolites and a solitary part of a left lower jaw of Hyæna divested of its lower border—two facts indicating that the Hyæna occasionally visited the tunnel. Here also was found one, and but one, flint-flake tool. It has the white colour so prevalent in the tools found in the cave-earth of Kent's Hole, and was met with under circumstances admitting of no doubt of its having been made and used by a human contemporary of the Cave-Hyæna in Devonshire.

II.—On Some Important Extra-Morainic Lakes in Central England, North America, and elsewhere, during the Period of Maximum Glaciation, and on the Origin of Extra-Morainic Boulder-clay. By Professor H. Carvill Lewis, M.A., F.G.S.[1]

THE lakes so characteristic of all glaciated districts are due to several causes. Some few are due to an actual glacial scooping out of the rock floor, many to an irregular deposition of the drift, by which former watercourses are obstructed, and still others to the terminal moraine or to the glacier itself. These latter, known as *morainic lakes*, may be divided into *inter-morainic lakes*, *moraine meres*, and *extra-morainic lakes*, according to their position—back of, in, or outside—the moraine. Extra-morainic lakes, if dammed up by the ice front, are temporary in character, disappearing with the retreat of the glacier; but, as they may be of enormous extent if the glacier is large, they may produce deposits of much geological importance. Instances of such lakes occur in Switzerland, and ancient examples occur as well in Northern Germany, Asia, North America, and Central England. They are to be expected wherever a glacier advances against or across the drainage of a country. Mr. Belt supposed that Northern Asia was covered by a lake of this character, caused by the Polar glacier obstructing the rivers flowing north.

In North America, where the terminal moraine has been accurately mapped for thousands of miles, deposits of boulder-clay and erratics occur outside of the moraine, and have been supposed to be due to an older glacier in the first glacial epoch. But the general absence of striæ or of glacial erosion or moraines in this district prove that a glacier was not the agent of deposition. Nor are there any traces of marine life in the deposits. This extra-morainic boulder-clay is narrow in Pennsylvania, where the author has called it "the Fringe," but west of the Missouri is 70 miles wide; and in British America, between the great moraine called the "Missouri Coteau" and the Rocky Mountains, is 450 miles wide and over 1000 miles long. It only occurs where rivers had flowed *toward* the glacier, and is explained as the deposit of great temporary freshwater lakes dammed up by the ice front, the erratics having been dropped by icebergs.

Similar deposits occur in England outside of the terminal moraine,

[1] Abstract of a paper read at the Manchester Meeting of the British Association, September, 1887.

and have been the subject of much discussion; being held by some to be proof of marine submergence, by others to be the ground-moraine of a glacier. The "great chalky boulder-clay" is the best known of these deposits. There are serious objections to the two theories heretofore advanced to explain this, whilst the hypothesis of extra-morainic freshwater lakes, dammed up by the glaciers, is sustained by all observed facts. The most important of these lakes was one caused by the obstruction of the mouth of the Humber by the North Sea glacier, whose terminal moraine crosses that river at its mouth. This large lake reached up to the 400 feet contour line, and extended southward nearly to London, and westward in finger-like projections into the many valleys of the Pennine Chain. It deposited the "great chalky boulder-clay," and erratics were floated in all directions by icebergs. It was bounded in the Vale of York by the Stainmoor glacier, and Charnwood Forest was an island in it. At its flood period it overflowed south-westward by torrential streams into the Severn Valley and elsewhere, carrying the "Northern Drift" into the south of England. Other glaciers in England were bordered by similar but smaller lakes wherever they advanced against the drainage. Three such lakes were made by the Aire glacier, the largest of them extending to Bradford. The Irish Sea glacier caused many similar lakes high up on the west side of the Pennine Chain, and at its southern end north of Wolverhampton. The overflow streams from the most southern of these lakes joined those issuing from Lake Humber in the Birmingham district, characterized by a "commingling of the drift," otherwise inexplicable. An examination of the supposed evidences for glaciation, and for a great marine submergence in Central and Southern England, shows that neither theory is sustained by the facts. Thus, the supposed striæ on Rowley Rag prove to be rootmarks or ploughmarks; those reported at Charnwood Forest to be due to running water or perhaps icebergs; the supposed drift on the chalk wolds to be a local wash of chalk flints; the high level gravels on the Cotteswold Hills to be pre-glacial; the shells at Macclesfield, Moel Tryfaen, and Three Rock Mountain to be glacier-borne, and not a proof of submergence; the drift on the Pennine plateau of North Derbyshire to be partly made by icebergs floating in Lake Humber, and partly a decomposed Millstone Grit or Bunter Sandstone; and the Welsh erratics on Frankley Hill at a height of 800 feet to be due to a more ancient glaciation.

The conclusion that the glacial phenomena of England are due neither to a universal ice-cap nor to a marine submergence, but to a number of glaciers bordered by temporary fresh-water lakes, is in accordance with all the observations of the author in England and elsewhere.

Postscript.—Since the paper was read, of which the above is an abstract, I have found traces of the existence of a very much older series of glaciers than those here described. Since the period of these ancient glaciers, which in many places were more extensive than the modern ones, earth movements have occurred and erosion has removed almost all their deposits and generally obliterated the

striæ, so that the region subject only to the older glaciation now resembles a non-glaciated area. The glaciers and their bordering lakes described above should therefore be considered as belonging to the second or last glacial epoch.

III.—The History and Cause of the Subsidences at Northwich and its Neighbourhood, in the Salt District of Cheshire.

By Thos. Ward, Esq.

THE frequent occurrence of subsidences in the neighbourhood of Northwich makes it desirable to learn their history and cause.

Northwich overlies extensive beds of salt. These occupy about three square miles. The first or 'top' rock-salt lies at a depth of about fifty yards from the surface, and is covered by Keuper marls, and these by the drift sands and marls. Between the two beds of salt there are 30 feet of indurated Keuper marl. The second, or 'bottom' rock-salt, is over 30 yards in thickness. These beds of salt occupy the lowest portion of an old Triassic salt lake.

The first bed of rock-salt was discovered in 1670, the second in 1781. From about 1730, at which date the river Weaver and the Witton brook were rendered navigable, until after 1781, all the rock-salt mines were in the 'top' bed, and the whole of these with one exception have been destroyed, and in almost every case by water, leaving funnel-shaped nearly circular holes. These are now filled with water and are known as 'rock-pit' holes. The rock-salt mines are now in the lower bed and very rarely fall in. When worked to the boundary, water and brine, either or both, break in or are let in, and the mines are utilized as huge reservoirs.

The falling in of a rock-salt mine is a very rare occurrence, and subsidences of this kind do not give rise to the reports which are met with in the newspapers. The first reported destruction of a mine was in 1750, and from that date to the end of the eighteenth century every two or three years a mine collapsed. In the present century, at considerable intervals of time, collapses of mines have occurred, but these with scarcely an exception were old abandoned 'top' mines.

The subsidences which are so destructive in the town of Northwich and the neighbourhood are entirely caused by the pumping of brine for the manufacture of white salt. It was only about 1770 or shortly afterwards that the first sinking was noticed; since that date subsidence has gone on very rapidly, and much destruction of property has resulted. Large lakes or 'flashes,' one of more than 100 acres in area, and of all depths up to 45 feet, have been and are being formed. Prior to 1770 not more than 30,000 tons of salt were sent down the Weaver navigation; by the end of the century it reached 100,000 tons, and in 1880 had increased to 1,087,000 tons. The whole of this salt was taken off the surface of the first bed of rock-salt by the solvent action of water. In fact, water is the instrument used to mine and carry off the salt to the pumping centre. The brine pumps set up a circulation of the salt water or brine lying on the rock-salt, which flows to the pumping centres. The brine thus removed is replaced by fresh water, which on its

passage to the pump saturates itself taking up sufficient salt to make a solution containing about 26 per cent. of salt. This continual removal of salt from the surface of the rock-salt lowers it, and the overlying earths either follow the diminishing surface continuously, or else after remaining suspended for a time suddenly fall into the cavity from which the water has extracted the salt. The brine currents on their way to the pumping centres form deep valleys or troughs, and the surface of the ground overlying forms a facsimile of these hollows. The property on the sloping sides of the valleys is pulled to pieces and destroyed; the windows and doors all get out of form owing to the unequal sinking of the various portions of the house. When, owing to the different nature of the marls and the abundance of sand overlying them, a sudden sinking takes place, the hole extends to the surface and swallows up anything upon the surface—as a horse in a stable, barrels of beer in a cellar, or water butts and other utensils in a yard. The damage done to property is enormous, but thus far no human life has been lost. The most serious part of the matter is that the brine-pumper takes not only his own salt in solution, but that of all his neighbours over whose salt beds the water flows, and neither asks their consent nor pays them for the salt thus obtained. Worse even than this, the owner of the property overlying the brine 'run' suffers most serious damage to buildings, etc., but can obtain no compensation, because amongst the number of brine-pumpers he cannot prove who is doing the particular mischief complained of. This peculiar phenomenon of subsidence in the salt districts is worthy of more consideration than it has hitherto received from scientific men.

IV.—On the Occurrence of Porphyritic Structure in some Rocks of the Lizard District.[1] By Howard Fox and Alex. Somervail.

Prof. Bonney has described a porphyritic diabase which is seen on the shore at Polpeor; it cuts, in an intricate manner, through micaceous and hornblendic schists. The authors have traced this rock further, and have recognized a porphyritic structure in many dykes and intrusions along the coast which cut through the serpentine, and also in the darker bands of Professor Bonney's 'granulitic group.'

Descriptions of these various localities were given and illustrative specimens exhibited. The crystals of felspar are found to be most numerous in those rocks which lie in the closest proximity to the gabbros and serpentine. They have their long axes at various angles, and are mostly small except at Parn Voose, Cavouga, and Green Saddle. The felspathic and hornblendic lines often circle round the crystals.

Without discussing any theory as to the true nature and origin of the whole of the schists, the authors think that the porphyritic structure so prevalent in the dark bands of the 'granulitic group,' in many of the micaceous and other rocks, as also in the later intrusions cutting the serpentine, indicate an igneous origin for many rocks hitherto regarded as schists.

[1] See Mr. Teall's paper, *ante*, pp. 484–493.