

exist in a comet's head could give us the hydrogen spectrum which was discovered with such richness in the *Nova*, and which is represented in the spectra of most nebulae.

The *Nova* now exists as a nebula so far as its spectrum goes, and the fact not only goes far to support the view I have suggested as against that of Zöllner, but it affords collateral evidence of the truth of Thomson and Tait's hypothesis of the true nature of nebulae.

The nebular hypothesis in its grandeur and simplicity remains untouched by these observations; the facts so far from being in direct opposition to it help us, I think, all the better to know exactly what a nebula is.

There is another point of extreme interest to the spectroscopist if we accept the bright line observed in the star by Dr. Copeland and others to be veritably the chief nebula line.

It is clear from Dr. Vogel's diagram (given in last week's *NATURE*) that this line brightened relatively with each decrease in the brilliancy of the hydrogen lines. On December 8, 1876, it was much fainter than F, while by March 2, 1877, F was a mere ghost by the side of it. On any probable supposition the temperature must have been higher at the former date.

Now it is well known that within certain limits the lines in the spectrum of a compound body get brighter with *decrease* of temperature, because at the higher one the compound almost entirely ceases to exist as such, and we get the lines of its constituents. It is a fair theory then to suggest that the famous nebula line may belong to a compound. Nay the fact as it stands alone further points to the possibility that the compound in question contains hydrogen as one of its constituents.

J. NORMAN LOCKYER

Craig Dhu, Kingussie, September 10

#### THE GLACIAL GEOLOGY OF ORKNEY AND SHETLAND

NO one can claim to speak with more authority on matters Orcadian than Mr. Laing, and few men are better fitted to judge of evidence and probabilities. His interesting letter (see p. 418 of this number of *NATURE*) calls attention to certain points which he regards as affording a crucial test of the value of some contending hypotheses in geology.

He asserts (1) That there is no evidence that the Orkney and Shetland Islands have ever participated in the general glaciation of Britain. (2) That these islands contain no raised beaches or marine terraces to prove any alteration of the relative levels of sea and land.

I. It would indeed be extraordinary on any hypothesis that no traces of glaciation should exist in Orkney. Could it reasonably be supposed that at a time when "the adjacent islands of Great Britain and Ireland" lay under a deep mantle of snow and land-ice which protruded even from the opposite shores of Caithness, these northern islets enjoyed a happy immunity from the cold which sealed up the more frigid south? I am afraid that on the contrary we must believe Orkney to have been in as evil case as its neighbours, no matter even if it should have succeeded in subsequently divesting itself of all traces of its wintry garb. It will not be necessary to

discuss the bearing of Mr. Laing's facts upon any rival geological doctrines if it can be shown that the facts themselves do not exist. He courteously invites examination and disproof, and I think with all deference to him that I can point to evidence which when he next revisits his county will satisfy him that Orkney is no exception to the general glaciated condition of Scotland.

I have twice visited Orkney, and each time was too intent upon the curious history of the Old Red Sandstone of that region to have time to note all the features bearing upon the glaciation of the islands. But these features were too striking to escape notice, and I find in my notebooks and on my map records of the observations jotted down at the time. So far from there being, as Mr. Laing asserts, no trace of ice-work among these islands, I found them to be well glaciated and to contain in particular, excellent illustrations of (1) *roches moutonnées*, (2) boulder-clay, and (3) valley-moraines.

1. Mr. Laing mentions the granitic axis which runs north from Stromness. When he has occasion to cross it again, gun in hand, let him stop here and there on the exposed hummocks and he will find them admirably ice-worn and striated. Well-preserved surfaces of this kind overlook the wild cliffs of Yesnaby, and others, of equal clearness, occur on the slopes behind Stromness. But further examination will show him that these markings are not confined to the hard granite and gneiss. Thus on the roadside at the south-east end of the Lake of Stennis, beautifully striated flagstones may be seen, the striae in all these cases running north-west and south-east, as if produced by a movement from the latter quarter. Nay, even among the soft yellow sandstones of Hoy, well smoothed and striated surfaces may be noticed on the summit of the cliffs near the Old Man, at a height of 600 or 700 feet above the waves of the Atlantic.

2. Unmistakable boulder-clay occurs in Orkney. It is not generally or thickly spread over the surface, as in the lowlands of Scotland, but rather, as in Caithness, lies here and there in hollows, the rest of the surface of the islands being covered with a thin argillaceous soil, derived, as Mr. Laing points out, from the decay of the underlying flagstones. A thick mass of this boulder-clay lies on the north-west side of Shapinsha, another in the sheltered hollow of Kirkwall Bay, and a third forms a notable feature on the north coast of Flota. Mr. Laing cannot but be familiar with these and other localities, and he probably refers the deposits there to disintegration of the rock underneath. Of course the boulder-clay consists here, as elsewhere, mainly of the *débris* of the rocks below, and as these rocks are flagstones, breaking up into sharp-edged fragments, the stones in the clay are very commonly more or less angular. If, however, he finds, as he will assuredly do, that many of the stones are well polished and striated along their major axis, he may be satisfied that the deposit is a glacial one.

3. So far, the evidence which I have adduced shows that the Orkney Islands participated in the general wide-spread glaciation of the adjacent mainland. But we may believe that in so northern a locality, if the form and height of the ground in any manner permitted, the lingering snows would still form glaciers on the hills, though they had retreated from the lower grounds. Now there is only one mass of high ground in Orkney—the island

of Hoy, and there, if anywhere, traces of the last glaciers should be found. Two years ago, when engaged with my friend and colleague, Mr. B. N. Peach, in making a careful examination of the north end of that interesting island, I found what we had been in search of—a beautiful and complete proof of the unconformability between the Upper Old Red Sandstone and the Caithness flags. So engrossed were we with the magnificence of the natural sections where this structure is displayed, that we had climbed into the mouth of the green corrie below the Coulox Hill before we were aware that we stood upon a glacier-moraine. But from the top of the ridge, and, still better, from the steep grassy slope on the west side, three or four successive horse-shoe-shaped mounds could be seen extending across the valley, and becoming progressively lower and shorter when traced upwards, till the last of them died out at the base of the acclivity behind. Not only were they in external form and arrangement as perfect examples of moraines as could be desired; their internal composition bore ample testimony to the same origin. My companion and I found further proof that the other valleys of Hoy had also once nourished their separate glaciers, the most striking evidence being supplied by a moraine-mound nearly half a mile long and fifty or sixty feet high, which runs across the mouth of the glen to the east of Hoy Hill on the north-east side of the island. The angular rubbish of this moraine rests upon a stiff, red, sandy boulder-clay full of striated fragments of red sandstone. The hills from which these glaciers descended rise from 1,400 to 1,550 feet above the sea. That so small and so low an island as Hoy should have had its glaciers, creeping probably even down to the sea-level, need not surprise us, when we remember that small ocean-girt groups of mountains, like those of Skye and Mull, had their glaciers, and that even in Arran, more than three degrees of latitude further south, and from hills little more than 100 feet higher than those of Hoy, glaciers existed on such a scale as to leave behind them the huge moraines of Glen Cloy.

Mr. Laing refers also to Shetland, and though he states that his acquaintance with that region is not so intimate as his knowledge of Orkney, he believes that as little evidence of glaciation can be found there as among his native islands. In this case, too, I am afraid his statements are too absolute. It is now many years since Mr. C. W. Peach chronicled the occurrence of abundant striated rock-surfaces and boulder-clays with striated stones in the Shetland Islands (see "Report" of British Association for 1864, Sections, p. 60). From my own observation also I can speak confidently as to the correctness of these determinations. Even on the low and remote westerly islet of Papa Stour Mr. B. N. Peach and myself found boulder clay and many transported blocks of gneiss, schist, and other rocks foreign to the immediate locality, while the prevailing pink porphyry showed glacial striae running N. 5° W. On the Mainland also, between the head of Bixetter Voe and Walls, we observed some curious mounds which if not true moraines are at least parts of the glacial series. Since our visit my colleague, Mr. John Horne, has spent some time in Shetland and has obtained ample evidence of the presence of a sheet of ice over that region (see NATURE, vol. xv. p. 139). There can indeed be no doubt that both Shetland and

Orkney have been severely ice-ground and that the movement of the ice has been on the whole along a north-west and south-east line. So far therefore from these islands offering any exception or difficulty in regard to this geological question they bear their independent and concurrent testimony to the now generally received doctrine.

II. There is, however, one very remarkable feature of Orkney and Shetland to which Mr. Laing has referred, and with regard to which my own observations, so far as they go, thoroughly bear out his statement. I allude to the absence of raised beaches. During the surveys which I have made in conjunction with Mr. B. N. Peach we have continually asked each other what has become of the familiar raised beaches which skirt the Scottish coast-line even as far as the shores of Sutherland. Mr. Horne was equally struck by their absence. It is indeed inconceivable that if our raised beaches be due to a rise of the ocean level from the accumulation of a polar ice-cap (a doctrine which I for one have never accepted) there could fail to be found some remnants of them among the innumerable sheltered creeks and bays of these northern islands, in positions where on the near mainland they would assuredly be found. Well-marked raised beaches skirt the north coast of Sutherland within sight of the hills of Orkney. And yet I never observed any trace of a terrace which by possibility could be made to do duty for a raised beach, either in Orkney or in Shetland, and Mr. Laing's much wider acquaintance with these islands confirms my belief that such terraces probably do not exist in Shetland, if not also in Orkney. But the difficulty of accounting for their absence is not inconsiderable, even if we hold that our raised beaches point to successive elevations of the land. Why should they cease with the northern bays of the mainland of Scotland? Can we suppose that the upheaval so marked in Sutherland did not affect Orkney?

During a recent visit to Sutherland and Caithness I tried to find some satisfactory solution to these questions. It is important to observe that on the mainland the raised beaches disappear when we pass from the crystalline rocks into the Old Red Sandstone. Travelling, for example, along the coast-line from Inverness, by the Beaully, Cromarty, and Dornoch Firths, we find ourselves, almost without intermission, upon one or other of the level sandy terraces which form so conspicuous a feature of these shores. Even upon the strip of Jurassic rocks the same platform runs on to Helmsdale. But northwards the coast rises in one long line of precipice, from which slice after slice is cut as the lines of joint split open under the influence of air and sea. I have seen no satisfactory raised beach in Caithness. The only places where, from the shape of the coast-line, the existence of such deposits was possible are in Thurso Bay, on the coast between Dunnet and Duncansbay Heads, and in the bays between Freswick and Wick. But even on these more sheltered and less precipitous shores the rock usually stands up in low cliffs and runs out in reefs, or steep banks of boulder-clay rise from the edge of the beach, or ridges of blown sand stretch for some distance inland. Now the rocks of Orkney are identical with those of Caithness; they split up into the same long lines of sea-cliff, they are swept by the same stormy seas, and

washed by the same heavy tempestuous rains. Along by far the larger part of the immensely-extended coast-line of these islands no raised beach could have been formed, or, if formed, could have remained until now. So rapid is the retreat even of the solid cliffs, that both there and in Caithness a Pict's house may now and then be found, from which the outer walls on the seaward side have disappeared, together with the solid ground on which they stood, while the surge is ever breaking at the base of the cliff below. Even into the sheltered inlets the same vertical sea-cliffs often run, so that the possible localities for the formation and preservation of raised beaches are comparatively few in number. A more diligent search among these few resting-places may yet reveal the existence of some fragments of marine terraces in Orkney. In the meantime the want of raised beaches in Caithness, where, to judge from the proximity of those in Sutherland, they probably at one time existed, should put us on our guard against a too hasty and sweeping inference from their absence in Orkney.

With regard to Shetland, however, the case is far stronger. Rocks of many varied kinds form the islands of that group running out into ridges and chains of islets, and inclosing innumerable *vøes* and land-locked inlets. Nowhere could there be a more admirable surface for the formation and conservation of raised-beaches. The absence of these deposits cannot therefore be accounted for except, as I am constrained to believe, on the supposition that they never existed there at all. That interrupted elevation of the land, to the pauses in which the raised-beaches point, seems to have lessened towards the north. It is still traceable by means of these terraces on the northern shores of the mainland. Evidence of it has not been detected in Orkney, though as I have said, this may not show that it did not affect these neighbouring islands. But when we recede to the far Shetlands, all trace of the former lower level of the land ceases—at least it is not preserved in lines of raised beach.

ARCH. GEIKIE

#### PENNINGTON'S "BARROWS OF DERBYSHIRE"

*Notes on the Barrows and Bone-Caves of Derbyshire. With an Account of a Descent into Eläen Hole.* By Rooke Pennington, B.A., LL.B., F.G.S. (London: Macmillan and Co., 1877.)

MR. PENNINGTON has done good service to science by publishing his "Notes." The objects he describes belong to the palæolithic, the neolithic, and the bronze ages of Britain and Western Europe generally; but, following Prof. Boyd Dawkins, the author includes the entire period between the close of the palæolithic age and the earlier part of the iron age under the comprehensive name of the prehistoric ages. Moreover, to bring the eras of the archæologist into correlation with those of the biologist, he reminds the reader that during the prehistoric ages, "the animals living in Europe were generally speaking the same as those which live there now," whilst palæolithic man was accompanied by the mammoth, and many other extinct forms.

The author's prehistoric researches were conducted partly in caverns, but mainly in barrows. The latter,

usually heaps of stone and turf, were either of an oblong form, or, much more frequently, "round heaps, like a basin or saucer turned upside down."

The circular barrows appear to have been in some cases nearly fifty feet in diameter, and fully five feet high at the centre. That on Abney Moor was surrounded with a rampart of earth fifty feet in exterior diameter, and having on it ten upright equidistant stones about three feet high, whilst the inclosed mound measured but twenty feet across. Almost all the barrows appear to have yielded human bones, and in some instances more or less complete skeletons, some of which occupied stone cists, whilst others did not. The body of a young man, about seventeen years of age, had the skull protected with four stones, one being a cap stone, whilst large pieces of limestone were piled irregularly round the rest of the skeleton. All the bodies found entire were in a contracted position, and there seems to have been a tendency to place them on the left side, facing north or north-westerly. Two or more skeletons were found in some cases in the same barrow, and two were met with in the same cist in a barrow on Gaurtriss Hill. In Siggett barrow the skeleton of a child was found very near the feet of that of an adult. Some of the barrows contained evidence of cremation; thus, in the centre of that on Abney Moor was a large flat piece of sandstone, on which human bones, accompanied by flint flakes, a chert flake, beads of jet and of amber, and a good arrow head, had been carefully deposited. There was satisfactory evidence that the funeral fire had been lighted on the spot.

Relics of water-rat, horse, red deer, roe deer, *Bos longifrons*, goat, hog, and dog were also found in the barrows, and, with the exception of the first only, commingled with the human remains. In a cist in Oxlow barrow part of a boar's tusk had been placed with the human skeleton. The horse, roe deer, goat, and dog appear to have been the least prevalent forms. On the other hand, when speaking of water-rats, the author says, "I never explored either a burial mound or a cave without finding plenty of them;" and in one instance he says "Rats came out by spadefuls."

Of articles made or selected by man the barrows yielded a cut antler, quartzite and other "foreign" pebbles, chipped flints, pottery, chert flakes, beads of jet and of amber, holed stone hammers, bone pins, arrow heads, and bronze rings and celts.

The prehistoric caves and "rock shelters" situate in Cave Dale, Hartle Dale, and Creswell Crags, contained, with the exception of roe-deer only, remains of all the barrow animals, and of wolf, fox, shrew, badger, cat, hare, rabbit, duck, and fowl, in addition. They also yielded flint flakes, a holed sandstone hammer, charcoal, pottery, some of which was Roman, a cut stag's horn, a bone comb, pieces of jet, a celt and some ornaments in bronze, a few iron articles, and a coin of Hadrian.

When speculating on his discoveries the author remarks of the skeleton of the youth supposed to be about seventeen, that the people who buried him must have been "actuated by some other feelings of respect than those springing simply from personal valour or wisdom. This boy must have been of some rank; possibly the eldest son of the chief. The rudiments of government and of