Where, on the contrary, the materials are coarse, we may suppose the rise to have been more rapid and the velocity of the current greater. When, again, large blocks have been transported, a more energetic movement is made manifest." What rate of tide-run is sufficient to move about "large blocks"? "Some indication of the duration of the uplift is afforded by the mass of material moved, and the distance traversed." Comparison with observed effects of tides seems to show that to move large blocks the duration must be very short if the uplift be moderate, or the uplift extremely great if the duration be moderate. The Tides also teach that high speeds are generated only in confined channels. The water pours through the Swinge, the Race of Alderney, the Gouliot Pass, or the Sound of Lihou; but in the open bay of St. Aubin's a thirty feet fall does not create any remarkably strong current off the shore.

There are two classes of catastrophe whose effects have probably magnified our ideas as to the potency of rapid rises or falls. When reservoirs or other dams burst, as in the St. Gervais calamity lately filling the newspapers; when earthquake waves roll in on to the land, as after the Krakatau eruption, direful disaster has been wrought. But neither catastrophe is properly comparable with the cases we have been considering. A reservoir is usually hundreds of feet above the sea-level. If its dam gives way the water flows off down this distance: the results, therefore, are analogous to what would happen if the land were elevated these hundreds of feet *instantaneously*. The earthquake wave, too, sweeps up the shore at a rate far exceeding what we can call 'rapid'; it rises its thirty or forty feet in a few seconds. Also its analogies belong to the case of a sinking, not of an uplifted, land.

We accordingly conclude that the effects of 'Rapid' emergence of land from below the sea will not differ from what we see happening daily between high water-mark and low, unless the rapidity is vastly greater than twenty or thirty feet in six hours; whilst even this moderate rapidity far transcends the powers of any agents with which we are at present acquainted.

IV.—THE SO-CALLED SERPENTINES OF THE LLEYN.

By CATHERINE A. RAISIN, B.Sc.

IN the south-west of the Llyn peninsula, the country inland is generally covered by drift, but the Survey map marks some isolated patches of rock as "Serpentine." When I first visited the district, with the kind encouragement of Professor Bonney, under whom I was continuing my work at University College, I made a collection of these so-called "Serpentines" from ten different localities. The one at Porth din llyn had been shown by Professor Bonney to be mainly diabase,¹ and others of the examples have been since described in a previous number of this Magazine

¹ On the Serpentine and associated Rocks of Anglesey; with a Note on the so-called Serpentine of Porth din llyn. By Prof. T. G. Bonney, Q.J.G.S., 1881, vol. xxxvii. p. 48.

and elsewhere,¹ but we have yet no complete account. I have, therefore, attempted to give a short summary, as preliminary to some discussion of the district.

In four of the exposures the rocks, which are much alike, are recognised as diabase by Mr. Harker. Although abstaining from any definite opinion of their geological position, he notices certain characters in describing rocks, which, in eastern Carnarvonshire, are shown to be of Bala age. Masses from near Pwllheli and from other parts of the county certainly present much resemblance; and the four examples which I am considering might very well be intrusions along a N.E. to S.W. line, roughly in the direction of the strike or a strike fault. Lithologically they consist mainly of an ophitic dolerite undergoing a process of uralitisation, but the bosses also include more compact varieties, and many parts of the rock exhibit secondary changes due to crushing or development of minerals (often epidote).

1. *Trefgraig*.²—At least three varieties are shown in the quarry.

(a) An ophitic dolerite, the felspar being somewhat decomposed, colourless augite, clear and well-preserved, occurring in one slide, in another a pale greenish hornblende. The latter mineral includes fibrous alteration, products and added growth, which sometimes surround a central core with a different crystalline orientation. Ilmenite is developed in the usual form of bars like sagenite.

(b.) A finer-grained microporphyritic diabase. Veins which occur in the slide in some cases cross a felspar crystal, cementing it with felspar. A structure of this kind is attributed by Mr. Harker to infiltration along a line of "maximum shearing strain."³ In the Trefgraig slide, however, the felspar of the vein, containing only very minute enclosures, contrasts sharply with the more decomposed substance of the original mineral. Each boundary is marked by bending of the crystal planes, and we should expect that any infiltration would have spread beyond this line. Again, although other parts of the vein are filled with serpentinous mineral, it seems at some places where it heals up broken augite to consist of felspar.

(c.) A fine-grained devitrified basalt or andesite, which contains a few slightly larger microliths of felspar and augite. It is associated with the dolerite first described, into which it seems to intrude, the larger crystals of the coarser rock being apparently snapped and sometimes crushed along the boundary line.

Some evidence of mechanical disturbance can be traced in the Trefgraig mass, and one specimen from near the edge is much crushed.

2. *Hendrefor*.⁴—The rock appears to be a uralitic diabase, retaining

¹ Notes on the Igneous Rocks of Lleyrn. By J. V. Elsdon, 1888, *Geol. Mag.* Decade III. Vol. V. p. 303. The Bala Volcanic Series of Carnarvonshire and Associated Rocks. By A. Harker, 1889, Cambridge, pp. 83, 86-88, etc.

² The Monian system of Rocks. Rev. J. F. Blake, *Q.J.G.S.*, 1888, vol. xlv. p. 531. The Bala Volcanic Series. A. Harker, pp. 83, 87.

³ The Bala Volcanic Series of Carnarvonshire. A. Harker, p. 26. See also *Q.J.G.S.*, 1889, vol. xlv. p. 253, fig. 4.

⁴ Mr. J. V. Elsdon, *loc. cit.* p. 304. Mr. A. Harker, *loc. cit.* p. 87.

traces of ophitic structure, some of the hornblende being bluish-green and very dichroic. In one brecciated example, granular epidote is scattered abundantly over the slide, replacing crystals and forming veins.

3. *Tyhen*.¹—A specimen better preserved apparently than those examined by Mr. Elsdén consists of fairly clear felspar and augite with an intimate ophitic structure, and contains some viridite patches marking probably another pyroxenic or allied mineral. Ilmenite and pyrite are present. A much more compact rock appears to be enclosed within this fine dolerite, probably intruding into it, as at Trefgraig and Methlan.

4. *Methlan*.²—A diabase or ophitic dolerite with some alteration products. A compact dyke ($1\frac{1}{2}$ " wide) is exposed by the side of the road.

Of the next four masses, two are described by Mr. Harker as including decomposed basalts.³ The Careg Fawr crag is comparatively small and uniform, but at Porth din lleyn, as has been shewn, and also at Careg, a more complex mass occurs. Some examples from the latter place, like a specimen from near Hendre uchaf, show more pronounced microlithic development, but at all the localities we find a compact rock now altered, doubtless once glassy and of basic or fairly basic composition.

5. *Porth din lleyn*.—We are indebted to Professor Bonney for the description of these agglomerates and diabases, and for an examination which proved the absence of serpentine in this part of the Lleyn.⁴ He described the rocks on the eastern coast of the promontory, and noted on the western side a similar diabase cut by amygdaloidal doleritic dykes, doubtless, as suggested, of later date.⁵ Certain varieties are porphyritic, containing brighter green felspars within a dull green matrix. The ground mass in two rocks,⁶ although they are not entirely identical, shows under the microscope many of the characters which occurred in certain specimens described by Mr. Elsdén.⁷ In one slide, epidote not only replaces crystals, but small rounded amygdules consist partly of that mineral, partly of viridite and of calcite. The porphyritic felspars are decomposed and saussuritic, often averaging $\frac{1}{4}$ " in length. They form one point of likeness between these rocks and a specimen which I obtained further southward in the Lleyn. The well known Lambay porphyry also bears some resemblance in the character of

¹ Mr. J. V. Elsdén, *loc. cit.* p. 304. Rev. J. F. Blake, *loc. cit.* p. 531. Mr. A. Harker, *loc. cit.* p. 87.

² Mr. J. V. Elsdén, *loc. cit.* p. 304. Mr. A. Harker, *loc. cit.* p. 87.

³ Mr. A. Harker, *loc. cit.* pp. 87, 88.

⁴ Q.J.G.S., 1881, vol. xxxvii. pp. 48-50. Prof. T. G. Bonney.

⁵ Q.J.G.S., 1881, vol. xxxvii. p. 50. Prof. T. G. Bonney. Compare also Q.J.G.S. 1888, vol. xlv. p. 461. Mr. A. Harker. The Bala Volcanic Series of Carnarvonshire. Mr. A. Harker, p. 111; *Geol. Mag.* 1880, Vol. VII. p. 457. Mr. A. S. Reid.

⁶ One of the rocks was obtained from a boss on the grassy slope and has a bright green polished surface with streaks coloured by red halmatite. Sheep are continually rubbing themselves against the projecting stone, and the polishing is evidently due to their action.

⁷ Mr. J. V. Elsdén, *loc. cit.* p. 308.

its ground mass and of certain of its porphyritic feldspars, although others differ somewhat in their narrower longer shape.¹ One of the Porth din llyn examples occurs in the cliff of a small cove beyond the boat-house, as if it were a broad dyke; and a tangle of rocks on the beach suggests that the porphyritic greenstone has enclosed within it a compact diabase. Even in this case the intruding mass need not be of much later date, but might belong to the same volcanic period. This remark also applies to another rock at Porth din llyn, which is a fairly typical basalt, dark purplish or black and microcrystalline; it appears to be similar to a mass on the beach at Porth wen, probably a dyke. On microscopic examination the latter exhibits lath-shaped feldspars, much magnetite and some viridite. Further examples of this type occur to the south.

A junction with schists is mentioned by Mr. Elsdon, but I could find no true metamorphic rocks. Schistose masses occur, the exact nature of which, in many cases, is extremely doubtful, but I have identified among them rocks of igneous origin. One slide proves that a diabase was veined by calcite, and that vein stuff and igneous rock were crushed together, so that the original character is masked; but amygdaloids and microliths of the ground-mass can still be recognized.

One rock of interest is exposed at low tide on the face of the promontory beyond the boat-house. It is a whiteish, sub-crystalline limestone, partly a breccia, the fragments of which project on the weathered fawn-coloured surface. The microscope slide seems to have the structure of limestone rock, apparently dolomitised, rather than of mineral vein, traversed, however, by clearly marked secondary veins of calcite and of quartz. Some rather dusty or silicified enclosures, which occur, seem to me to be not organic but of igneous origin. So the precipitation of the calcareous material may have been contemporaneous with volcanic eruptions.

6. *Careg Fawr* (South of Aberdaron).—Of this I need say little, as Mr. Harker has fully described all its important characteristics.² My slides do not happen to show any indications of a perlitic structure, but exhibit some of the larger cracks, which can be seen in the field sometimes limiting spheroids. The crag stands squarely up from the more level ground, as Mr. Harker states, like an intrusive mass; but it need not therefore belong to a later geologic period.

7. *Careg* (North of Aberdaron).—At this place, thick veins or masses of jasper are found, and limestone also occurs, but it is close to a small outcrop of the schistose rocks of the district. The dull purplish or greenish bosses and crags, which are doubtless those called "serpentine,"³ are certainly igneous, apparently rather basic, and some originally glassy in character. At places spheroids can be

¹ I am much indebted to Mr. Thos. Davies, F.G.S., for kindly allowing me to see slides of the Lambay porphyry, and other Irish specimens, in the collection of the Mineralogical Department at the British Museum of Natural History.

² Mr. A. Harker, *loc. cit.* pp. 87, 88.

³ The Geology of North Wales. Mem. of Geol. Survey, p. 230 (2nd ed.)

recognized, which are often shiny and palagonitic at their exterior. In small quarries and knolls on the western face of the hill, the rock is a green and purplish breccia. Although it presents some resemblance to an agglomerate, I am doubtful whether this is the true explanation. Many of the purple fragments are parts of spheroids, or are spheroids which are fissured, with the fine greenish matrix filling the interspaces. The microscope slides and the hand specimens prove a fluidal structure, certainly within, and probably outside, the small fragments, which even include some ordinary brown tachylite. I believe that a second movement of lava took place breaking a mass partially consolidated. This might have occurred within the pipe or neck of a small vent, but it is probable that the mass represents, at least in part, lava which flowed at the surface. At the top of the hill the rock is less disturbed, and consists, as shown by the microscope, of lath-shaped feldspars within a matrix containing very minute augite, magnetite, and other incipient crystals. Thus we find at Careg gradations from tachylite to a micro-crystalline condition.

At one place on the eastern slope above the house is a green diabase with green porphyritic feldspars. Ilmenite crystals glisten on the surface, and the slide exhibits the characters of a fine-grained dolerite, with decomposed feldspars, very fresh white augite, and a constituent now green and serpentinised. The rock is doubtless intrusive and may be of later age.

8. *West of Hendre-uchaf*.—The patch of rock shown on the word Cil y bwth was probably exposed in a quarry, now completely grassed and marked only by a curve in the sloping ground; and the outcrop near Bachwen I also failed to see.

West of Hendre-uchaf I obtained specimens of an old basalt or diabase, compact in structure, with patches of purple and greenish colour. Microscopic examination shows the darker part to consist of lath-shaped feldspars amid a black deposit of magnetite. The feldspars exhibit a somewhat spherulitic grouping at places especially within the ferruginous aggregates. Small porphyritic crystals, often fractured or incomplete, slightly dichroic, yellow in colour, now serpentinised, are probably a hydrous ferro-magnesian silicate. A similar mineral forms small acicular or shuttle-shaped microliths.¹

The rocks in the two remaining examples are clearly elastic.

9. *North of Braich anchwog*.—(Annelog). This small patch is a purple and green agglomerate. The rocks included, as seen on examination with the microscope, are basalt or andesite, consisting chiefly of feldspar microliths, with more or less viridite or magnetite. Pyrite and secondary limonite occur. The pieces are rounded or sub-rounded, separated by palagonite; and calcite is deposited both within and between them. In the small quarry, the fragments are of no very great size, the larger being about six or seven inches

¹ See figures in Brit. Petrol. J. J. H. Teall, p. 14 (after Zirkel); U. S. Explorations of 40th parallel. Microo. Petrol. F. Zirkel, pl. i. fig. 20; Typical Forms of Crystallites. F. Rutley. Min. Mag. Dec. 1891, p. 268, fig. 17. Crenulites.

across. There is apparently no stratification, and the mode of occurrence seems to mark this as a small volcanic vent.

10. *North of Mynydd anelwog*.—(Annelog). The low crag near the spring consists of an ash, finer than, but of very similar materials to, the agglomerate just described. Fragments of andesite or basalt are almost identical with the constituents of the preceding specimen, and those of green viridite might be derived from the same source, while occasionally a piece of scoria occurs. The fragments as seen by microscopic examination are small, with slightly irregular outline, and separated by strings of fine dust.

Thus all the patches of "serpentine," except the two mentioned, have now been examined, with the result that not only is there no serpentine present but there is no uniformity in their character, and I shall be able to show that similar rocks occur at many other places in the neighbourhood. Sometimes these "serpentine" are dolerites or compact diabases (andesites or basalts); sometimes they are true volcanic agglomerates. Although, in many cases, they are not interbedded, some probably represent lava flows, or an ash of transported fragments. This result, therefore, further illustrates the characters, which were first described by Professor Bonney from Porth din lleyn. His paper thus gave the key-note to the understanding, not only of that locality, but of others. The question of the geological age of these masses can only be discussed in connection with the surrounding district, since it affords additional examples of similar and allied rocks.

NOTICES OF MEMOIRS.

I.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. Sixty-second Meeting, Edinburgh, August 3rd, 1892. President, Sir ARCHIBALD GEIKIE, LL.D., D.Sc., For. Sec. R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom.

TITLES OF PAPERS READ IN SECTION (C), GEOLOGY, AUGUST 4-10.

Professor C. LAPWORTH, LL.D., F.R.S., F.G.S., President of Section.

The President's Address.

O. W. Jeffs.—Report of the Committee on Geological Photographs.

J. Lomas.—On the Glacial Distribution of the Riebeckite-Eurite of Ailsa Craig.

Dr. H. W. Crosskey.—Report of the Committee on Erratic Blocks.

J. W. Gray and *P. F. Kendall*.—The Cause of the Ice Age.

W. A. E. Ussher.—The Granites of Devon and Cornwall.

Dr. A. Irving.—The Malvern Crystallines.

J. G. Goodchild.—The St. Bees Sandstone and its Associated Rocks.

H. Woods.—The Igneous Rocks in the Neighbourhood of Builth.

A. G. C. Cameron.—Note on a Green Sand in the Lower Greensand, and on a Green Sandstone in Bedfordshire.

A. G. C. Cameron.—The Fuller's Earth Mining Company at Woburn Sands.