by the conductivity, using the word "conductivity" (as above explained) in such a sense as to include convection. The rate of increase downwards must, therefore, be the same at all depths at which this conductivity is the same.

This reasoning applies to superposed strata at the same place, and assumes them to be sufficiently regular in their arrangement to ensure that the flow of heat shall be in parallel lines, not in converging or diverging lines.

5. If we have reason to believe that the flow of heat upwards is nearly the same at all places, then the above reasoning can also be applied approximately to the comparison of one place with another—that is to say, the rates of increase downwards, in two masses of rock at two different places, must be approximately in the inverse ratio of their conductivities. In the cooling of a heated sphere of heterogeneous composition, the rates of flow would at first be very unequal through different parts of the surface, being most rapid through those portions of the substance which conducted best; but these portions would thus be more rapidly drained of their heat than the other portions, and thus their rates of flow would fall off more rapidly than the rates of flow in the other portions. If the only differences in the material were differences of conductivity, we might on this account expect the outflow to be after a long time nearly the same at all parts of the surface. But when we come to consider differences of "thermal capacity per unit volume," it is clear that with equal values of "diffusivity," that is of "conductivity divided by thermal capacity of unit volume" in two places, say in two adjacent sectors of the globe, there would be the same distribution of temperatures in both, but not the same flow of heat, this latter being greatest in the sector in which the capacity and conductivity were greatest.

Where we find, as in Mr. Deacon's observations at Bootle, near Liverpool, and to a less marked degree in the observations of Sir William Fairbairn and Mr. Garside, near Manchester, an exceptionally slow rate of increase, without exceptionally good conductivity, it is open to us to fall back on the explanation of exceptionally small thermal capacity per unit volume in the underlying region of the earth, perhaps at depths of from a few miles to a few hundred miles.

6. A question which was brought into consideration by Prof. Hull, in connection with the great difference between the rate of increase at Dukinfield and that at Rosebridge, is the effect of the dip of the strata upon the vertical conduction of heat. Laminated rocks conduct heat much better along the planes of lamination than at right angles to them. If k_1 denote the conductivity along, and k_2 the conductivity normal to the planes of lamination, and if these planes are inclined at an angle θ to the horizon, the number of feet per degree of increase downwards correrponding to a given rate of outflow through the surface, will be the same as if the flow were vertical with a vertical conductivity:—

$$k_1 \sin^2 \theta + k_2 \cos^2 \theta.$$

Prof. Herschel finds about 1·3 as the ratio of the two principal conductivities in Loch Rannoch flagstone, and 1·875 as the ratio in Festiniog slate.

The dip of the strata at Dukinfield is stated by Mr. Garside to be 15°, and we have $\sin^2 15° = ·07$, $\cos^2 15° = ·93$.

If we assume $k_1 = 1·3\ k_2$, as in the case of flagstone, we find for the effective vertical conductivity $k_2\ (·09 + ·93) = 1·02\ k_2$, so that the number of feet per degree would only be increased by 2 per cent.

It is not likely that the two conductivities in the strata at Dukinfield are so unequal as even in the case of flagstone, so that 2 per cent. is a high estimate of the effect of their dip on the vertical rate of increase so far as pure conduction is concerned. The effect of dip in promoting the percolation of water is a distinct consideration, but the workings of the Dukinfield mines are so dry that this action does not seem to be important.[1]

(*To be continued.*)

METAMORPHIC ROCKS OF BERGEN[2]

THE metamorphic rocks of the Bergen Peninsula in Norway continue to attract the attention of Norwegian geologists, and we have before us, as an addition to the well-known works of Naumann, Leopold von Buch, Esmark, Keilhau, Kjerulf, and Hjörtdal, a new elaborate and interesting work by M. Hans H. Reusch, which deals with the same subject. These rocks consist, as is known, of a variety of quartziferous talc-mica schists, diorite, clay-slates, conglomerates, and strongly-developed gneisses and granites. Various and very different opinions have been expressed as to the origin of these rocks. The researches of M. Reusch give a key to this question, as he has discovered in the clay-slates, which seem to constitute the upper part of these vertical strata, numerous fossils belonging to the lower part of the Upper Silurian formations, namely *Halysites catenularia* and *Cyathophyllum*, changed into white calcareous spar, a few tubular bodies (presumably *Syringophyllum organum*), some gasteropods (*Murchisonia* or *Subulites?*) some trilobites, as *Calymene*, also *Phacops* or *Dalmannites*, and some brachiopods. The presence ot these fossils is the more interesting as the whole series of schists was often considered as of igneous origin. As to the gneisses and gneisso-granites of the peninsula, M. Reusch has given great attention to their structure and to the remarkable results of pressure which the rocks have undergone. He shows how granitic veins were folded and crumpled, how a kind of transversal stratification has arisen in beds of stratified gneiss under the influence of pressure, and he concludes, from an accurate study of the subject, that altogether the rocks show a far greater degree of plasticity than might have been supposed. "It seems that there are masses, as, for instance, the gneiss of Svenningdal, that have on one side a true stratified structure (not merely parallel or schistose structure) which could hardly be found in a rock of igneous origin, and on the other side send veins, or have included fragments which have undergone metamorphic changes."

One of the most attractive features of M. Reusch's work is the attention he has given to metamorphic phenomena and to changes caused by the pressure undergone by strata during their folding. The metamorphic phenomena were especially studied in the Osören district. The limestone which contains Silurian fossils has become marble, and the cause of metamorphism was not contact with some eruptive rock, but rather (as was observed in the Bernese Oberland by Swiss geologists) pressure and the molecular movements which pressure has occasioned in rocks. The clay, in which trilobites and other animals were entombed at Vagtdalen, has become a rock like muscovite-schist with porphyritically inclosed clusters of mica. As to the gneiss which appears among undoubtedly Silurian rocks, the author is inclined to consider it as sedimentary and as having been originally formed of loose materials. The granulite is clearly stratified and of sedimentary origin. The changes produced by the folding of strata and by the pressure they have undergone, are described with much accuracy and illustrated by many drawings. The fossils are nearly all compressed and elongated; the formerly conical coralla have received the shape of flat elongated biscuits, in accordance with the direction of pressure and stretching. The same is true with regard to all other fossils. In the green conglomerates at Osören, all the stones are flattened and elongated, acquiring thus a shape which they could not have possessed originally; very many of them have such a shape as to give in a cross-section the form of a lance-shaped leaf. The same structure, remarks the author, may be observed with the aid of a microscope in the "hones" from Eidsmarken in the South of Norway. Altogether the work of M. Reusch, although not rich in conclusions and generalisations, will be a welcome addition to the accurate knowledge of the still little understood metamorphic rocks. The Norwegian text of this work is accompanied with a rather too short *résumé* in English. P. K.

[1] Though the workings are dry there is a large quantity of water in the superincumbent strata.

[2] Hans H. Reusch, "Silurfossiler og Pressede Konglomerater i Bergenskifrene."—Universitetsprogramm for förste Halvaar (1883). Kristiania, 1882.

CHEMICAL NOTES

CARNELLEY [*Chem. Soc. Jul.* Trans., 1881, p. 317] has repeated his experiments on the effect of pressure on the melting-point of mercuric chloride, and has obtained results which show that this salt cannot be obtained in the solid state at temperatures appreciably above its melting-point.

JAHN [*Berliner Berichte*, xv. p. 1238] has made a series of careful determinations of the density of bromine vapour, which, when compared with similar observations on chlorine made by Ludwig, show that bromine vapour does not attain the normal density (Br = 79·95) until it is heated to 160° above its boiling-point; and also that although chlorine exhibits smaller divergences from the normal density than bromine, it nevertheless