

female having placed all her eggs on the sides of the cage, it was decided to terminate the experiment.

As a result I had fifty-two males, all attracted to a single female, in a locality in which the species is not more than ordinarily common. All arrived in the latter half of the night, indicating either that the sense of smell in the males is extraordinarily acute, and that they travel long distances to find the female, or else that it is their habit to be abroad only after midnight. I have no very reliable data upon which to base a conclusion on these points. The scent glands of the female are to be looked for on the under side of the abdomen, where such organs have already been discovered in certain smaller members of the same family of moths. The male organs of smell are doubtless the conspicuously branched antennæ.

### IS GRANITE EVER METAMORPHIC?

BY C. CALLAWAY, D.SC., F.G.S., WELLINGTON, SALOP,  
ENGLAND.

It is not so many years since it was commonly believed that granite was frequently of metamorphic origin. Numerous cases were quoted of a gradual passage between sedimentary strata and granite; and, as it was held to be incredible that a sediment could be produced from granite, it was inferred that the granite was an altered form of the sediment. The present writer shared in the popular belief, and in several papers written on the more ancient of the Archæan rocks of Great Britain, he assumed that the granitic masses called "Dimetian" and "Malvernian" were metamorphosed stratified rocks. But scepticism soon began to creep in. Case after case broke down on examination, until, within the area of the British Islands, he was unable to find a genuine case of a passage between a sediment and a granite. A few examples will here be given.

In North Wales, several cases were alleged. At Twt Hill, in the town of Caernarvon, granite was said to pass into a quartzose conglomerate. The gradations did indeed appear to be perfect in the field, but the microscope proved that the naked eye was not a reliable guide. It was shown that the granite passed into the conglomeration through the intermediate form of arkose, and even the authors of the metamorphic theory voluntarily surrendered it. A second locality was in central Anglesey. Here a band of granite strikes across the island, trending in the same direction as the adjacent sedimentary and schistose rocks. On one side of it lies hállefintá, passing into schist. The granite has been described as "Dimetian," and the hállefintá as a younger formation called "Arvonian." The writer has given prolonged attention to these rocks, and has discovered localities where the granite is seen to send veins into the hállefintá. The granite must, therefore, be of less antiquity than the hállefintá, and of eruptive origin. In other parts of Anglesey, certain sediments of Ordovician age have been supposed to be here and there converted into granite; but the most recent investigation of these rocks does not confirm this hypothesis.

In England the facts are similar. The schistose and gneissic rocks of the Malvern Hills have been described as metamorphic Cambrian strata. At a later period they were referred to the Laurentian system, being still regarded as altered sediments. The present writer has been studying these rocks for several years, and has described them as exclusively of igneous origin. The oldest varieties are diorites, and into these there have been intruded granites, felsites, dolerites, and other diorites. Subsequently to consolidation, these masses

have been subjected to enormous pressures, which have produced shear-zones, in which the eruptive rocks have been converted into various gneisses and schists. A very good summary of the writer's papers on these rocks has recently (February 9, 1894) been given in *Science* by Prof. J. W. Redway. Some of the conclusions are still under discussion; but the eruptive origin of the diorites and granites has been admitted by all those who have reviewed the work in the field.

The Hebridean gneisses of Scotland have recently been examined by the Geological Survey of Great Britain. The conclusion of the Director-General (Sir A. Geikie) is that "after a most careful search in these rocks, not a vestige have we yet found of any unquestionable sedimentary material." The writer has given some attention to alleged examples of metamorphic granite in Ireland. In County Donegal a great mass of granite rises amidst quartzites, limestones, and schists, and it has been affirmed that there is a gradual passage between the schists and the granite. The writer examined the junction of the two kinds of rock on both sides of the granite mass, and found the clearest proof of igneous intrusion. At some points the granite veins are seen to run into schists, and to branch in the ordinary manner. Elsewhere the granite is in contact with limestone, and has altered it, producing in it an abundance of garnets as well as some lime-augites.

In western Galway there is another alleged case of the passage of sedimentary rocks into granite. These, also, the present writer has examined. He has found clear evidence of breaks between the sediments and the schists into which they were supposed to pass. He has also ascertained that the "metamorphosed conglomerates" adduced in proof of the sedimentary character of the Galway schists are mixtures of schist, granite and diorite, or of two of them. A foliated structure sometimes appearing in the granite was seen to be due to regional pressure, and not to sedimentation.

A third case, occurring south of Wexford, was also investigated. The writer came to the conclusion that the granite of the Carnsore district nowhere passed into crystalline schists, and that the schists were sharply separated from the sedimentaries by faults. It is possible that some of the schists have been formed from igneous rocks, but, if so, they belong to a different period from the Carnsore granite, which shows no signs of foliation.

In adducing these examples the writer infers no conclusion wider than the facts. He does not deny that there may be such a thing as metamorphic granite; he merely points out that certain alleged proofs have broken down on examination. Nevertheless, the results of the most recent work by other geologists have tended to confirm his investigations, and to suggest extreme caution in accepting other supposed cases of a passage between granite and stratified rocks.

One cause of error in the past has been the assumption that a banded structure was always the result of sedimentation. This view is now exploded, and need not be dwelt upon here. It has recently been shown that even rocks with all the appearance of a banded grit may be of igneous origin. The writer has described a very interesting case of this kind in the Malvern Hills. A granitoid diorite is crushed and decomposed. The hornblende passes into chlorite and iron oxide, which are inter-laminated with finely comminuted feldspar. Both in the field and under the microscope the rock has the appearance of a true sediment. Yet it may be traced without a break into the diorite on one side and into a mica-gneiss on the other. In the old days this grit would probably have been regarded as a conclusive proof that the whole series was of sedimentary origin.