In each of these a vertical section of the coal exhibits numerous very thin horizontal yellow lines, not unlike what we see in our English spore-bearing coals; but I have no proof that these lines were due to spores."

Mr. E. T. Newton, F.G.S., some years ago examined microscopically a piece of compact coal from Andreas's (or Andries's) Nek, a spur of the Stormberg, sent by the late Dr. G. Grey, see Quart. Journ. Geol. Soc. vol. xxvii. 1871, p. 51; and he says that "the coal is bright and bituminous, with partings of dull material, apparently 'mother-coal,' but there are no traces of spores. The section shows the bituminous part as dark-brown laminae, similar to the bright parts of Wallsend coal; but there are no spores to be distinguished. The 'mother-coal' remains black and opaque in section."¹

CORRIGENDA.—At page 410 (September Number of GEOL. MAG.) for the woodcut and the description substitute the following:—

A portion of one of the blocks from the Kat River, Eastern Province, South Africa, showing four of the small shells (*Cyrena? neglecta*) and parts and sections of others. Natural size.

At p. 410, line 7 from bottom, for "*Cyrenæ*" (?) read "*Cyrenæ?*"

V.—THE EFFECTS PRODUCED BY EARTH-MOVEMENTS ON PRE-CAMBRIAN AND LOWER PALÆOZOIC ROCKS IN SOME SECTIONS IN WALES AND SHROPSHIRE.

By HENRY HICKS, M.D., F.R.S., Sec.G.S.

(Read at British Association, 1890.)

IN this paper I purpose giving a few examples to show the powerful influences which have been exerted by Earth-movements in producing changes in the rocks, and in obliterating the evidences of succession in some of the disturbed areas in Wales and Shropshire. For a long time past it has been well known that certain changes such as cleavage, etc., have been induced in the rocks in Wales and elsewhere by pressure, but only of late years has the magnitude of the results due to Earth-movements been

¹ See also the "Mining Journal," Decemb. 4, 1886, for a paper on the Coals of South Africa.

fully understood. The difficulties experienced by geologists who visit these areas for the first time are mainly due to their being unable or unwilling to recognize the extraordinary effects produced by these Earth-movements, and especially to the complications resulting from faults and thrusts. In these areas it commonly happens that portions of the pre-Cambrian rocks are forced in among the Lower Palæozoic rocks so as to appear either to be parts of the series or to be intruded into it. In other places it occasionally happens that not only are lower beds of the same series made to appear to overlie much newer beds, but the pre-Cambrian rocks are, in some cases, thrust over those of Palæozoic age.

The rocks in the neighbourhood of St. David's, Pembrokeshire, have suffered in a remarkable degree from the effects of Earth-movements, and some geologists who have visited that area have been led to make not only serious errors, but some very extraordinary statements, from being unable to recognize this fact.

A section across the St. David's promontory shows that after the Cambrian and Ordovician rocks had been gradually deposited over an irregular surface of pre-Cambrian rocks, great Earth-movements took place which caused the Cambrian and Ordovician rocks to be bent into great folds. These folds were broken during these movements by numerous faults, some of great magnitude. Subsequent denudation has revealed the presence, within these folds, of the pre-Cambrian rocks on which the newer rocks were deposited, and has enabled us to recognize the enormous dislocations of the strata which have taken place, and the changes induced in the rocks during the movements. Although there are evidences of several folds of Lower Palæozoic rocks, containing cores of pre-Cambrian rocks, in North Pembrokeshire, it will be sufficient to refer to the one which occurs in the promontory of St. David's, taking a line across it from St. David's Head on the N.W. to St. Bride's Bay to the S.E. of the city of St. David's. At, and near, St. David's Head, great masses of intrusive basic rocks traverse the Arenig rocks, in a direction nearly parallel with the lines of bedding, being probably portions of sheets in the form of Laccolites. These, along with the slates, have suffered from the pressure, proving that the folding took place after they were intruded into the slates. The Arenig rocks are separated from the Tremadoc rocks along this line by a thrust-fault which has diminished the thickness of the strata by about 1500 feet. Other faults in the arch-limb of this fold have repeatedly caused newer rocks to be thrust forward to hide the underlying series, and near the axis, beds at least 5000 feet apart in the succession are by that means brought into contact. On the S.E. side of the axis the Cambrian beds have been inverted and faulted so as to cause the older beds to overlie the newer, evidently by movements from N.W. to S.E.

In the pre-Cambrian core itself the Pebidian rocks are not only sheared to an enormous extent, but are also made, on the S. side, by reversed faults to appear to lie under parts of the granitoid rocks (Dimetian). This result causes the Dimetian to look in places as

if intruded into the Peibidian beds, whilst in reality it is everywhere bounded by faults, some of them of pre-Cambrian, others of post-Cambrian age. Similar effects to those witnessed at St. David's and in other areas in N. Pembrokeshire, may be seen in sections in Carnarvonshire, especially in the area between the Menai Straits and the Snowdon district. In the part of this area lying between Carnarvon and Llyn Padarn, not only are the Cambrian rocks, by reversed faults, made to appear to underlie pre-Cambrian rocks, but even Arenig beds are faulted so as to dip under both. The movements in this area have taken place mainly from S.E. to N.W. and the rocks of the Snowdonian range have been driven westward by repeated thrusts.

In a section in Shropshire, extending from the Longmynd across Caer Caradoc, Lower Palaeozoic rocks are faulted on the W. side so as to appear to underlie the pre-Cambrian rocks of Caer Caradoc, whilst on the E. as the result of thrust-movements, the older beds have been hidden by much newer ones. Here the post-Ordovician movements were mainly, as in Carnarvonshire, from S.E. to N.W.

The changes which have been produced in the rocks themselves are also very marked. The granitoid rocks give evidence of having been greatly crushed by the Earth-movements in pre-Cambrian times, and in the lines of fracture secondary minerals have been freely deposited. That these secondary minerals date back to pre-Cambrian times is shown by the fact that the pebbles of these granitoid rocks in the Cambrian conglomerates contain all the evidences of the early crush with secondary minerals in the crush-lines, in addition to those of subsequent fractures and deformation by pressure after they had been entombed in the conglomerates. In some places the granitoid rocks and diorites have suffered so much from pressure that they have put on a distinctly gneissic aspect. Some of the felstones in pre-Cambrian times were crushed so that they were formed into felsitic schists, and fragments of these schists occur frequently in the Cambrian conglomerates. Various dykes in the pre-Cambrian rocks exhibit indications of having suffered greatly from mechanical pressure in pre-Cambrian times, the diabase dykes in the Dimetian being frequently cleaved so as to look almost like slates. Fragments of these and of many other cleaved and altered rocks are often found in the Cambrian conglomerates.

In the Cambrian and Ordovician rocks the evidences of pressure during subsequent Earth-movements are also abundant, and secondary minerals have been freely developed along planes of cleavage and in lines of fracture. The effects on some of these rocks near thrust-planes are well exemplified by the remarkably distorted condition of some of the fossils. In one case near St. David's an *Orthis*, which in its normal condition was about seven lines in width, was so distorted that it measured over 27 lines, and others were still further drawn out so as to be almost unrecognizable.