the 'crossed nicols' condition the analyser is held in place against *H* by the small stop *M*. The *o'* and *e'* rays from the crystal on entering the analyser are resolved into two components, and of these only one is transmitted. The light leaving the analyser is therefore made up of the resolved portions of *o'* and *e'*, and is indicated by the arrows *Ko* and *Ke*, both lying in the same plane, but one behind the other.

The way for the more rigid explanation of the birefringence colours is often made easy by some such phrase as the following: "The two resolved portions of the polarized ray enter the crystal plate perfectly 'in step', but as one is retarded more than the other while passing through the crystal, it falls behind, and when brought by the analyser into the same plane the two rays are found to be no longer 'in step', and consequently interfere with each other." The interference can be illustrated by soldering to each arrow a portion of a sine curve wire (as at *N*). By varying the distance between the arrows the quartz wedge and kindred phenomena can be well shown.

If a large cork be used for *L*, and the amplitudes of *Ko* and *Ke* be varied as with *o'* and *e'*, one can illustrate the impossibility of obtaining complete extinction with uncrossed nicols.

Pleochroism is exemplified by removing the analyser and clipping differently coloured glass plates (e.g. brown and green) over the *o* and *e* slots in the crystal plate *F*. The *o'* and *e'* arrows may be coloured accordingly, and the variation of the tint as the crystal is rotated is brought out well by varying the lengths of the *o'* and *e'* arrows as before, to give the two colour intensities in all positions. A little mechanical contrivance may be added to do this automatically, but would require nice workmanship.

The model may be used to illustrate several other points, but its application to these ends will occur to every teacher, and need not be mentioned here.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science, Eighty-third Annual Meeting, held at Birmingham, September 10-17, 1913. List of Titles of Papers read in Section C (Geology) and in other Sections bearing upon Geology.

Presidential Address by *Professor E. J. Garwood, M.A., V.P.G.S.* (see ante, p. 440).

Professor Charles Lapworth, F.R.S.—On the Geology of the Country round Birmingham.

Professor W. W. Watts, F.R.S.—Notes on the Igneous Rocks of the Birmingham District.

Mr. George Barrow.—The *Spirorbis* Limestones of North Warwickshire (see p. 463).

Mr. Henry Kay.—On the Stream-courses of the Black Country Plateau (see p. 457).

Professor W. J. Sollas, F.R.S.—On the Formation of Rostro-Carinate Flints.

Mr. E. A. Walford.—On the Structure of the Lias Ironstone of South Warwickshire and Oxfordshire (see p. 460).

Mr. T. C. Cantrill.—*Estheria* in the Bunter of South Staffordshire.

Mr. Leonard J. Wills & Mr. W. Campbell-Smith.—Notes on the Flora and Fauna of the Upper Keuper Sandstones of Warwickshire and Worcestershire (see p. 461).

Professor W. G. Fearnsides.—Nodules from the Basal Ordovician Conglomerate at Bryn Glas, Ffestiniog.

Dr. A. Vaughan.—The Division between the Lower and Upper Avonian.

Mr. F. G. Meachem.—On the Progress of the Coal-mining Industry of the South Midlands since the year 1886.

Dr. E. A. Newell Arber.—The Fossil Floras of the South Staffordshire Coal-field (see p. 462).

Mr. R. D. Vernon.—Correlation of Leicestershire Coal-field (p. 456).

Mr. George Barrow.—On Systems of Folding in the Palæozoic and Newer Rocks (see p. 463).

Dr. A. Irving.—The Harlow Boulder-clay and its place in the Glacial Sequence of Eastern England.

Mr. W. W. King & Mr. W. J. Lewis.—On the Discovery of Lower Carboniferous Grits at Lye, in South Staffordshire.

Mr. E. A. Walford.—The Basement Beds of the Great Oolite, the Crinoid Beds, and the place of *Rhynchonella concinna* in the Oolite Series (see p. 459).

Mr. A. R. Horwood.—The Value of a Knowledge of the Rock Soil Distribution of Plants in tracing Geological Boundaries.

Dr. A. H. Cox & Professor O. T. Jones.—The Geology of the District between Abereiddy Bay and Pencaer, Pembrokeshire (see p. 465).

Dr. Gertrude L. Elles.—The Relation of the Bala and Rhiwlas Limestones in the Bala District.

Mr. E. S. Cobbold.—Critical Sections of the Cambrian area called 'The Cwms' in the Caradoc–Comley region of Shropshire.

Dr. A. Irving.—Flint and its Genesis.

Dr. Marie C. Stopes.—Plant Petrifications in Chert and their Bearing on the Origin of Freshwater Cherts.

Dr. Vaughan Cornish.—On the Conditions which govern the Transport and Accumulation of Detritus by Wind and Water (see p. 455).

Dr. Gertrude L. Elles.—On Shelly and Graptolitic Faunas of the British Ordovician.

Miss Clara E. Sylvester.—A first Revision of the British Ordovician Brachiopoda.

Dr. L. Moysey.—Some further Notes on *Palæoxyris* and other allied Fossils, with special reference to some new features found in *Vetacapsula* (see p. 453).

Mr. Frank Raw.—On Sand-worn Rocks at Lilleshall.

Mr. V. C. Illing.—Recent Discoveries in the Stockingford Shales, near Nuneaton (see p. 452).

Mr. V. C. Illing.—Notes on certain Trilobites found in the Stockingford Shales (see p. 452).

Mr. W. D. Matthew.—Discoveries in the American Eocene.

Dr. H. Warth.—Classification of Igneous Rocks.

Mr. C. Carus-Wilson.—Copper in the Sandstones of Exmouth.

Dr. A. H. Cox & Professor O. T. Jones.—On various occurrences of Pillow-lavas in North and South Wales.

Dr. A. H. Cox.—Note on the Igneous Rocks of Ordovician Age.

Professor W. S. Boulton.—On a new form of Rock-cutting Machine.

Mr. C. H. Cunnington.—The Carboniferous Limestone at the Head of the Vale of Neath, South Wales.

Report of the Committee on Erratic Blocks of the British Isles.

Report of the Committee on the Investigation of the Igneous and Associated Rocks of Glensaul and Lough Nafooey Areas, Co. Galway.

Report of the Committee on preparing a List of Characteristic Fossils.

Report of the Committee on the further Exploration of the Upper Old Red Sandstone of Dura Den.

Report of the Committee on the Geology of Ramsey Island, Pembrokeshire.

Report of the Committee on the Old Red Sandstone Rocks of Kiltorcan, Ireland.

Report of the Committee on the Collection, Preservation, and Systematic Registration of Photographs of Geological Interest.

Report of the Committee to investigate the Microscopical and Chemical Composition of Charnwood Rocks.

Section A.—Mathematical and Physical Science.

Rev. A. L. Cortie, S.J.—Solar and Terrestrial Magnetic Disturbances.

Rev. H. V. Gill, S.J.—The Distribution of Earthquakes in Space and Time.

Mr. J. J. Shaw.—Exhibition of a Seismograph.

Section B.—Chemistry.

Professor W. M. Thornton.—The Influence of the Pressure of Gas on the Inflammability of Coal-dust in Air.

Dr. R. V. Wheeler.—The Composition of Coal.

Section D.—Zoology.

Presidential Address by *Dr. H. F. Gadow, F.R.S.*

Professor J. Versluys.—The Carapace of the *Chelonia.*

Professor W. K. Gregory.—Exhibition of a Fossil Skeleton of *Notharctus* sp., an American Eocene Lemur, with remarks on the Phylogeny of the Primates.

Dr. R. Broom—A Mammal-like Milk Dentition in a Cynodont Reptile.

Mr. C. Forster Cooper.—*Thaumastotherium osborni*, a new Genus of *Perissodactyles* presenting some unusual features.

Mr. D. M. S. Watson.—The early Evolution of the *Amphibia.*

Rev. Dr. A. Irving.—The Solutré type of Horse (*Equus robustus*) in Prehistoric Britain.

Professor R. J. Anderson.—On the Skull and Teeth of *Tarsiops.*

Professor R. J. Anderson.—Some Points concerning the Extremities, chiefly in the Mammalia.

Section E.—Geography.

Presidential Address by *Professor H. N. Dickson, D.Sc.*

Dr. C. A. Hill.—The Exploration of Gaping Ghyll, Yorkshire.

Professor W. W. Watts, F.R.S.—Notes on the Geography of Shropshire.

Professor J. W. Gregory, F.R.S.—On Australia.
Miss C. A. Simpson.—The Upper Basin of the Warwick Avon.
Mr. A. G. Ogilvie.—The Physical Geography of the Entrance to Inverness Firth.

SECTION G.—ENGINEERING.

Dr. Vaughan Cornish.—On Land Slides accompanied by Upheaval in the Culebra Cutting of the Panama Canal.
Mr. E. R. Matthews.—Harbour Projections and their Effect upon the Travel of Sand and Shingle.
Dr. J. S. Owens.—The Transport and Settlement of Sand in Water, and a method of exploring Sand Bars.

SECTION H.—ANTHROPOLOGY.

Dr. R. R. Marett.—Recent Archæological Discoveries in the Channel Islands.
Mr. W. Dale.—On present Speculations concerning the Age of certain forms of the so-called Neolithic Celt.
The Evolution of Man from the Ape—
(*a*) *Professor Carveth Reed.*—On the Differentiation of Man from the Anthropoids.
(*b*) *Dr. Harry Campbell.*—The Factors Determining the Evolution of Man from the Ape.
(*c*) *Dr. L. Robinson.*—The Relations of the Lower Jaw to Articulate Speech.
Dr. Capitan.—Recent Discoveries of Paintings in the Palæolithic Caves of the South of France.
Mr. T. C. Cantrill.—Stone Boiling in the British Isles.
Dr. T. J. Jehu & Mr. A. J. B. Wace.—Excavations in the Kinkell Cave, St. Andrews.
Mr. H. J. E. Peake.—The early Bronze Age in the Lower Rhone Valley.
Mr. O. G. S. Crawford.—Trade between England and France in the Neolithic and Bronze Ages.
Rev. F. Smith.—Palæolithic 'Guillotine' Trap-stones.
Rev. Dr. A. Irving.—Prehistoric Horse Remains in the Stort Valley.

SECTION K.—BOTANY.

Professor E. C. Jeffrey & Dr. D. H. Scott, F.R.S.—Devonian Plants showing Structure.
Mr. H. Hamshaw Thomas.—On a new type of Ginkgoalian Leaf.
Dr. E. de Fraine.—A new species of *Medullosa* from the Lower Coal-measures.
Professor F. W. Oliver, F.R.S.—On the Distribution of *Sueda fruticosa* and its role in the stabilizing of active Shingle.
Mr. P. H. Allen.—A Botanical Survey of Maritime Plant Formations of Hunstanton, Norfolk.
Mr. A. R. Horwood.—The influence of River Development on Plant Distribution.
Miss W. H. Wortham.—Some Features of the Sand-dunes in the south-west corner of Anglesey.

SECTION M.—AGRICULTURE.

Mr. J. Parry.—The Afforestation of Watersheds.

II.—*Abstracts of Papers read in Section C (Geology), Meeting of British Association, Birmingham, September 10–17, 1913.*

(1) Notes on certain Trilobites found in the Stockingford Shales. By V. C. Illing, B.A., F.G.S.

AMONG the fossils found at Hartshill Hayes, in the Abbey Shale subdivision of the Stockingford Shales, numerous forms occur, representing young stages in the development of certain Trilobite genera. Among these are the following:—

1. *Liostracus* sp.—The development is similar to that of *Liostracus* as described by G. F. Matthew.

2. *Holocephalina* sp.—The early stages of this genus possess a well-marked glabella, widening anteriorly. This becomes less convex in later stages, its anterior margin disappears, and finally the glabella is only represented by two short posterior grooves.

3. *Paradoxides Hicksii*.—The development is similar to that of *Paradoxides* as described by G. F. Matthew.

4. Certain new forms of *Agnostus*.—The anterior portion of the glabella becomes obliterated in the later stages, while the axis of the tail becomes relatively larger with increased development.

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(2) Recent Discoveries in the Stockingford Shales near Nuneaton. By V. C. Illing, B.A., F.G.S.

DURING recent mapping of the subdivisions of the Stockingford Shales between Nuneaton and Merevale, fossils have been found at various horizons which indicate that the Cambrian succession in this area is almost, if not quite, complete. Among these fossil-bearing horizons are the following:—

1. *Lower Purley Shales*.—Shales from a surface working 200 yards south of Worthington Farm, near Hartshill, contain fragments of *Olenellus*. The fossiliferous beds are 40 feet above the base of Purley Shales.

Mr. Pringle, of the Geological Survey, has found *Olenellus* in nodules at the base of the Purley Shales in Jee's Sett Quarry (Summary of Progress, 1913).

2. *Lower Oldbury Shales*.—(*a*) Excavations in Hartshill Hayes have proved that the basal 90 feet of the Oldbury Shales are of Menevian age. They contain the zones of *Paradoxides Davidis* and *P. Hicksii* in their upper and middle beds, while the lower beds contain *Agnostus atavus*, and correspond with Tullberg's *Ag. atavus* zone, and with part at least of the Lower Menevian of Sweden. The Trilobite fauna includes the genera *Paradoxides*, *Anopolenus*, *Conocoryphe*, *Holocephalina*, *Liostracus*, *Microdiscus*, and *Agnostus*, no less than fifteen species of the last genus having been found. At the top of the series there occurs a calcareous conglomerate, containing fragments of the underlying type of shale and indicating a probable unconformity.

(*b*) In a new cutting near Oldbury Reservoir *Olenus truncatus* and *Ag. pisiformis*, var. *obesus*, occur, proving that these beds are of Upper Maentwrog age.

Between the Maentwrog and Dolgelly horizons a series of curly bedded flagstones have been detected. These are very similar to the Ffestiniog Flags, and their position would seem to indicate that they are of Ffestiniog age. The beds are badly exposed and have yielded no fossils up to the present.

Thus the Oldbury Shales represent a large proportion of the Cambrian succession, and in view of this fact, and also of their extreme thickness (2,000 feet), I propose a further subdivision of this group, the classification of the whole succession being as follows :—

Merevale Shales		Lower Tremadoc.
Oldbury Shales	4. Monks Park Shales	Dolgelly.
	3. Moor Wood Flags and Shales	Ffestiniog.
	2. Outwoods Shales	Maentwrog.
	1. Abbey Shales	Menevian.
Purley Shales	Upper	Menevian (?).
	Mid	
	Lower	
Hartshill Quartzite	Camp Hill Grit	Taconian.
	Tuttle Hill Quartzite	
	Park Hill Quartzite	

(3) Some further Notes on *Palæoxyris* and other allied Fossils, with special reference to some new features found in *Vetacapsula*. By L. Moysey, B.A., M.B., F.G.S.

SINCE the publication of a paper on *Palæoxyris* and other allied organisms in 1910[1] so many fresh specimens have come to hand, and, as was only natural, several previously unrecorded examples have been described, notably some from the Lancashire Coal-measures by Mr. J. Wilfred Jackson,[2] that it seems desirable to record any new features that have been found in the later material, and also any new facts that may lead to the elucidation of the nature of these still very enigmatical organisms.

Taking in the first instance the genus *Palæoxyris*. The species *Palæoxyris helicteroides* (Morris) has been lately found in very large quantities in the Notts and Derbyshire Coal-field. In this area they seem to be restricted to an horizon extending from the roof of the Top Hard Coal downwards to above the Ell Coal; a careful search in the measures below, wherever these are exposed, has not resulted in the discovery of any trace of this fossil. They were, some years ago,[3] discovered in great numbers in the open working of the Barnsley thick coal at Worsborough, near Barnsley, where some 300 odd specimens were collected by Mr. W. Gelder from a space 6 or 7 yards in circumference, together with some specimens of *P. prendeli* (Lesq.) and *P. carbonaria* (Schimper).

A hurried search in other claypits at horizons above and below this coal during the Sheffield meeting of the British Association in 1910 produced enough specimens to make it probable that, if looked for, they may prove to be similarly quite common fossils in the great

[1] L. Moysey, Quart. Journ. Geol. Soc., vol. lxvi, pp. 329–45, pls. xxiv–vii, 1910.

[2] J. Wilfred Jackson, *Lancashire Naturalist*, January, 1911.

[3] R. Kidston, *Naturalist*, 1897.

coal-field of which the Notts and Derbyshire area is merely an extension.

In fact, it seems probable that the habit of collectors to look for fossils only in the Coal-measure shales, to the neglect of the ironstone nodules, may account for the paucity of specimens found in other coal-fields.

The other species, *Palæoxyris carbonaria* (Schimper) and *Palæoxyris prendeli* (Lesq.), seem, on the contrary, to be extremely rare in this area, and, when found, they are usually associated with quantities of *P. helicteroides*.

Vetacapsula cooperi (Machie & Crocker)[1] must still lay claim to being an extremely rare fossil. This genus is not restricted to a definite horizon in Derbyshire and Notts Coal-fields, but has been found to range from between the Waterloo and Ell Coals at Newthorpe Claypit, downwards to the Kilburn Coal at Loscoe Colliery. Three new specimens have been obtained—two from the Silkstone Coal and one from the Kilburn Coal. One of these, a specimen from the Silkstone Coal of the Calow Colliery, Chesterfield, shows a feature of great interest. When first found the fossil presented the appearance of a very much crushed example; but careful development revealed the fact that the fossil was, in reality, a perfectly normal flattened specimen, and the feature that gave rise to the apparent deformity was the presence of a medial, longitudinal flange, or fin-like structure, which extends along the 'median raphæ', emphasized by the original describer of the genus, dismissed in my former paper as possibly due to crumpling, and again brought into prominence by Mr. J. Wilfred Jackson. It seems now that this 'median raphæ', which appears to be a constant feature in every specimen recorded, may be caused in the ordinary specimens by this flange being torn off, and being left embedded in the matrix of the counterpart. It is also instructive to compare this new-found flange with that described by Mr. Bashford Dean on the egg-case of *Chimæra collei*.

From the examination of the four specimens in the author's collection and others elsewhere it is becoming more apparent that there are two distinct species included under the name of *Vetacapsula cooperi*. Owing, however, to the at present uncertainty as to their affinities, and to the rarity of their occurrence, it seems best still to keep them under one trivial name and separate them by applying the designation 'forma *a*' to those specimens in which the pedicle expands suddenly into the body, forming a distinct shoulder in the lower third of the body and giving rise to a 'deformity' or crumpling in that region; and the designation 'forma β' to those in which the pedicle expands more gradually into the body, giving to the specimen an ovate contour, with the 'deformity' or crumpling in the centre.

A curious and interesting feature is seen on the outer edge of all specimens conforming to 'forma β'. Just before the body contracts to form the beak there is found, by examination with the ordinary lens, a minute crenulation or crimping of the edge of the fossil, which may be compared with the markedly rugose lateral webs seen on the egg-cases of *Chimæra collei*, *Rhinochimæra*, and other Chimæroids.

[1] E. J. Machie, *Geol. and Nat. Hist. Repertory*, vol. i, pp. 79–80, 1865–7.

One fresh specimen of *Vetacapsula johnsoni* (Kidston) has come under notice from the Worsborough open works near Barnsley. It is in too crushed and imperfect condition to show any new features.

A new species of *Vetacapsula* has been recently described by Mr. Good [1] from Pembrokeshire. It is very similar to *Vetacapsula johnsoni*, but is extremely small, measuring only 5 mm. across, whereas *Vetacapsula johnsoni* measures 20 mm.

A new specimen of *Fayolia crenulata* (Moysey) has been discovered lately from a small heap of nodules still remaining from the Shipley Claypit. The former example from Shipley consisted of the middle portion of the organism 11 cm. long; another specimen, doubtfully referred to *Fayolia sterzliana* (Weiss), from the same locality, was evidently nearing its proximal or pedicular termination. The new specimen is of interest mainly because it shows the apex or distal termination, which appears to have been dome-shaped. The chief feature is the marked exaggeration of the crenulate 'collerette' which arises from the junction of the two spiral valves, and which forms a sort of spiral 'corona' round the apex of the fossil, strongly reminiscent of the corona at the summit of the egg-case of *Cestracion philippi*.

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(4) On the Conditions which govern the Transport and Accumulation of Detritus by Wind and Water. By Vaughan Cornish, D.Sc., F.R.G.S., F.G.S., F.C.S.

THE author dealt with the conditions of the transport of detritus superficially and in suspension. He pointed out that the rate of subsidence is the constant which best defines the behaviour of a granular material with respect to transportation by currents. He showed how detritus may be classified in three groups according to the value of this constant, these groups being familiar as shingle, sand, and mud, in the case of water-borne material, and gravel, sand, and dust in the case of wind-borne detritus.

It was pointed out that the change of direction of the vertical currents in sea-waves does not occur simultaneously with the change of direction of the horizontal currents, and it was shown that the result of the sequence of the changes is to endow waves with a shoreward action upon shingle and the coarser kinds of sands independently of any motion of translation in the water.

In tides also, rise does not commence simultaneously with flow, nor fall with ebb, and the author showed that the sequence of these changes is such as to make the flood tide more effective than the ebb as an agent of littoral drift, apart from any greater speed of current.

Examples were given of the different positions in which deposits of detritus accumulate according to the rate of subsidence of the particles.

An explanation was given of the effect of a change in the inclination of current to the horizontal in sorting heterogeneous detritus, and examples were given for wind-borne material.

[1] R. H. Good, Quart. Journ. Geol. Soc., vol. lxix, p. 266, pl. xxx, fig. 3, 1913.

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(5) On the Correlation of the Leicestershire Coal-field. By Robert Douglass Vernon, B.A., B.Sc., F.G.S.

THE following is a preliminary account of a study in the correlation of the coal-fields of the eastern portion of the great Midland coal basin. The area in question includes the Derbyshire and Nottinghamshire Coal-field in the north, the Warwickshire Coal-field in the south-west, and the Leicestershire Coal-field, which lies midway between the two. It is with the latter that we are here chiefly concerned. The Carboniferous rocks of Leicestershire include Carboniferous Limestone, Limestone Shales, Grits, and Sandstones that have been referred on lithological evidence to the Millstone Grits, and, lastly, the Coal-measures. Such a sequence at once suggests a correlation with the Derbyshire and Nottinghamshire type, but the presence of unusually thick seams of coal which split towards the north favours a comparison of the Middle Coal-measures of Leicestershire with those of Warwickshire. Finally, in the complete absence of the Transition Series and Upper Coal-measures and the presence of a complex fault system, the Leicestershire Coal-field stands quite apart from either of its neighbours.

For the detailed correlation of the Upper Carboniferous of these tectonic basins we have several independent criteria, both physical and palæontological, but strong theoretical objections may be urged against the use of physical criteria alone, and in practice it was found to be impossible to use either the important sandstones or the seams of coal in the correlation even of the eastern and western portions of the Leicestershire Coal-field itself.

The problem was then attacked from the palæontological side. Fossil plants proved of relatively little value in the subdivision of the Leicestershire sequence, because the lowest and the highest plant-bearing horizons both appear to fall within the Middle Coal-measures. The freshwater lamellibranchiata (*Carbonicola* and its allies) were equally unsatisfactory, so that the work finally resolved itself into a search for Marine Beds and an attempt to lay down their outcrops on the 6 inch maps.

Of the three more or less distinct districts into which the Leicestershire Coal-field may be divided, the Central or Ashby area of so-called unproductive measures yielded no fossils, either plant or animal, and the age of the beds, whether Lower or Middle Coal-measures, remains an open question. The Eastern or Cole Orton area presents serious difficulties to the collector, being for the most part a concealed coal-field worked under a thick Triassic cover, and the results obtained were merely of local interest. Attention was finally concentrated on the western or Moira area, where the sequence is more complete than in the rest of the coal-field, and exposures are much more numerous. Many fossiliferous horizons were discovered, which yielded a rich flora, several rare Crustacea, some fragmentary fish-remains, numerous freshwater lamellibranchiata, and above all an abundant marine fauna from several different horizons and many localities. Unfortunately, no indication of the well-known Ganister Coal Marine Bed (Alton Coal of Nottinghamshire) has yet been found in Leicestershire.

The thickest Marine Bed, which also has the richest fauna, occurs in the higher portion of the Middle Coal-measures about 260 yards above the Moira Main Coal; it crops out at many places in the Moira, Swadlincote, Church-Gresley, and Woodville district, and the outcrop has been laid down on the 6 inch scale.

Such mapping is of value, since for want of an index bed it has hitherto been impossible to map any seam of coal above the Main Coal owing to the variable character of the beds in the higher portion of the Coal-measures, and the structure of this part of the coal-field was, therefore, imperfectly understood. Using this Marine Bed as an index bed, we can now fix the position in the sequence of the Moira Sandstones and Grits and of the valuable series of pot, pipe, and fireclays on which the prosperity of this district so largely depends.

The main interest of this Marine Bed is that in stratigraphical position and in faunal contents it is comparable with the Gin Mine Marine Bed of the North Staffordshire Coal-field, with the Mansfield Marine Bed of the Yorkshire and Nottinghamshire Coal-field, and with the Pennystone Ironstone Marine Bed of Coalbrookdale.

The following is a correlation of the Productive Coal-measures of the East Midland Coal-fields, based upon the chief marine transgressions:—

Yorkshire and Nottinghamshire Coal-field.		West Leicestershire Coal-field.	Warwickshire Coal-field.	
Middle and Lower Coal-measures.	Mansfield Marine Bed.	Pottery Clay Marine Bed.	Doubtful	Middle Coal-measures.
	Strata, 930 feet.	Strata, 750 feet.	Strata, thickness unknown	
	Marine Bed 300 feet below the Top Hard coal.	Marine Bed above the Main Coal.	Marine Bed above the 7 foot Coal	
	Strata, 1,600 feet.	Strata, thickness unknown.		
	Marine Bed above the Alton (Ganister) coal.	Doubtful.	Absent.	

In conclusion, it is shown that in colour, mode of weathering, and other characteristics these Marine Beds are in every way comparable with modern 'Blue Muds'.

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(6) On the Stream-courses of the Black Country Plateau. By Henry Kay, F.G.S.

THE Black Country plateau is roughly outlined by the 400 feet contour-line between Stafford, Worcester, Stratford, and Burton, and is identical with the anticline of the South Staffordshire Coal-field, plus the north-western parts of Cannock Chase and the Warley–Barr area eastward. On its eastern and western sides are synclinal valleys opening to the Trent and Severn.

It is surrounded by a marginal hill barrier, and has large hill masses at Cannock Chase and the Clent region; while it is crossed by hill ranges from Bushbury to Barr Beacon, from Wolverhampton to the Lickeys, and from Quinton to Birmingham. The surface is thus divided into four interior basins, forming separate drainage areas. Save for the exits from these basins, the margin is broken in two places only. The chief physical feature is the possession of the crucial portion of the Midland watershed, which runs across the plateau from Wolverhampton to the Lickeys, and thence eastward along the southern margin.

Arterial drainage is supplied by the Trent and Severn, the former draining five-sixths of the plateau, and the latter receiving only the southward marginal drainage and that of the Stour basin.

The eastern syncline is occupied by the River Blythe–Tame flowing north. The watershed at the southern end of this valley has retreated northwards for 4 miles in post-Glacial time.

The western syncline was formerly drained towards the Dee, and the head-waters of the Severn were originally around Kidderminster, the Clent range being united with the Enville Hills further west. The principal outlet towards the Dee was by the Church Eaton Water, and the outlet into the Trent below Stafford not then in existence. This syncline is now drained northward by the Penk into the Sow and Tame, and southward by the Smestow–Stour into the Severn. Stream piracy is manifest near Wolverhampton.

Marginal streams are characterized by excessive activity, especially southward, notable examples being the Arrow and the Alne. The Arrow, however, represents the captured head-waters of an ancient river flowing through the Moreton Gap into the Evenlode, the pirate stream being the Warwickshire Avon, a strike river originally confined to the country west of Evesham. The watershed then ran southward from the Lickeys to the Cotswolds, being now represented by a long, narrow promontory reaching into Evesham and by Bredon Hill southward. Internal drainage is confined to the four basins. The Cannock basin has now no trunk stream, its waters uniting near the exit below Cannock to form the Saredon Brook. Glacial modification is much in evidence, the south-eastern portion having formed a lakelet with gorge-like overflow through Walsall. The margin of this basin has twice been broached by marginal streams. The Tame basin is triangular in shape and formed by the union of two basins reaching back to pre-Triassic ages, a large buried stream-course existing at Moxley, whilst a very great valley is traceable upwards through Smethwick, Oldbury, and Blackheath. At this point two buried stream-courses are found, each filled with material transported from the Clent Hills. The inference is that this marked the original source of the Trent, as the Upper Trent Valley appears to be of more recent date.

The Stour basin is likewise a combination. Streams descend south-west from Dudley to Stourbridge, and north-eastward from Clent to Halesowen. They are united by a succession of gorges 4 miles in length. This basin is a remarkable instance of extreme post-Glacial denudation to a depth of 300 feet. The Halesowen

streams represent the original head-waters of the river once flowing through Blackheath, Oldbury, and Smethwick.

The Rea basin possesses three eastward-flowing streams successively diverted N.N.E. through Birmingham by a stream working back along the Rea fault. Two of these were captured in pre-Glacial time, the third in consequence of glacial lakelet overflow. The present thrice-notched ridge at King's Heath represents the pre-Glacial land surface. The Middle Cole Valley is wholly post-Glacial. The Lickey anticline has undergone elevation since the initiation of the Rea streams—i.e. in post-Tertiary time. It is crossed by three waterworn gaps excavated *pari passu* with this uprise. The southernmost of these now drains into the River Arrow.

The Warley–Barr area is a region of Tertiary uplift, across which rivers occupying the old pre-Triassic valleys have excavated deep channels. All other streams in this area are very youthful.

Conclusions.—The Trent drainage area has been subjected to excessive piracy and has steadily suffered loss. Its sole gain is that of the Penk at the expense of the Dee. The northern drainage is consequent on the formation of the South Staffordshire anticline, regarding the age of which it bears notable evidence. Speculations as to the former north-west extension of the Thames drainage must therefore be abandoned on reaching the area under consideration.

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(7) On some of the Basement Beds of the Great Oolite and the Crinoid Beds. By Edwin A. Walford, F.G.S.

SOWERBY, in vol. i *Mineral Conchology*, describes a Brachiopod now known as *Rhynchonella concinna*. It is figured on T. lxxxiii, 6 from Aynhoe in Northamptonshire. A note on a quarry in the Great Oolite made by the writer in 1883 fixes probably the source of Sowerby's shell—

Aynhoe Allotments Quarry.

	ft.	in.
1. Humus	1	3
2. Whitish Marl	1	3
3. Marl crowded with *Rhynchonella concinna, Ostrea Sowerbyi, Natica, Modiola, Pholadomya*	2	6
4. Shelly Limestone, false-bedded	1	9
5. Grey Marl	2	1
6. Limestone, whitish: top course	1	6

The Geological Survey found its stratum to be a convenient line of demarcation, as it rested upon a base of limestone graduating into the Stonesfield Series.

The discovery of other strata on the borders of East Oxfordshire and West Oxfordshire necessitates the division of the Great Oolite and the separation of the new beds proposed to be classed as Sub-Bathonian. The old survey lines are thus sustained. The sequence suggested is as follows :—

Upper Great Oolite.—1. *Terebratula maxillata* beds. 2. *Calcaire à Echinodermes.*

Lower Great Oolite.—1. Striped Limestones. 2. *Rhynchonella concinna* beds. 3. Stonesfield Slate.

Sub-Bathonian.—1. Striped Limestone and Crinoid beds. 2. Neæran Series. 3. Striped Crinoid Marls. 4. Chipping Norton Limestones.

The new railway (Aynhoe and Ashendon) is cut along the divide between the Cherwell and Ouse Rivers. The missing Sub-Bathonian Series of the West lands were brought to view. Prominent there were White Calciferous Limestones and Striped Marls and Limestones. The author found the chalk-like limestone to be crowded with the decayed heads of large crinoids of which it was made. Above it passed into a blue crystalline limestone, here and there; a packed mass of the brachial joints of the crinoids. At the base of all was the stratum of black vertical stripes (the striped beds), the place of crinoid column and rootlets filled with carbonaceous granules from dark beds above. The beds are now known to be marine, not estuarine, as previously described. Sections of the chalk-like limestone showed a pavement of discs of the crinoid (*Apiocrinus*) calyx.

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(8) On the Structure of the Lias Ironstone of South Warwickshire and Oxfordshire. By Edwin A. Walford, F.G.S.

THE ironstone of South Warwickshire and North Oxfordshire is got wholly from the Middle Lias. The Northamptonshire ironstone of the Inferior Oolite may be traced in the Burton Dassett Hills, where it passes into a useless sandstone.

Beds of the Middle Lias stone are seen in the quarries packed with curved and interlacing stems something like masses of annelid tubes. They lie upon the bedding plane. Other beds of the fine pentangular and smaller ossicles of the Crinoidea range between. More rarely the round columnar stems of forms like *Apiocrinus* are found.

The author infers that the sea floor of the Middle Lias was a tangle of crinoid growth, stage above stage. The Crinoid sea appears to have spread through the Midlands into Yorkshire. Occasionally are phases of invasion or dominance of shells of Brachiopoda. Beds of *Rhynchonella tetrahedra* and *Terebratulæ* are interspersed in the 25 feet of the ferro-crinoid rock-bed.

The quarries and sections in the neighbourhood of Banbury show the several phases described.

In the Nodule Bed at the base of the Ironstone Series (zone of *Spirifer oxygona*) crinoidal conditions appear in segments and stem casts, mingled with large mollusca. Microscopic sections present plates and segments of Crinoidea mingled with ferruginous Oolitic grains of large size and fox-brown colour.

The superimposed bed, the Best Rag, has in sections smaller Oolitic grains of olive-green iron carbonate with ovoid calicular plates of crinoids.

The Top Rag, a grey-green compact stone, is a tangle of crinoidal and other remains more or less broken and converted into Oolitic iron granules.

The Road Stone, the higher beds, shows its organic structure mainly destroyed and converted into the ordinary red oxide.

In 1896 I placed a short study on the making of the Middle Lias Ironstone of the Midlands before the Iron and Steel Institute, which appeared in their *Proceedings*.

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(9) Notes on the Flora and Fauna of the Upper Keuper Sandstones of Warwickshire and Worcestershire. By L. J. Wills, M.A., F.G.S., and W. Campbell Smith, M.A., F.G.S.

A GROUP of sandstones associated with green shaly marls have been shown by Dr. C. A. Matley to form a more or less continuous belt in the Keuper Marls in Warwickshire, and to lie about 120 to 160 feet below the Rhætic. At the same horizon similar beds form an almost unbroken outcrop through Ripple, Longdon, Pendock, and Eldersfield in South-West Worcestershire, and were probably once continuous with the sandstones of Inkberrow and Callow Hill, near Redditch.

Of the constituents, the thin-bedded sandstones are fine-grained, ripple-marked, and characterized by the presence of much calcareous matter and abundant rhombs of dolomite. The thicker-bedded sandstones consist mainly of grains of quartz, with felspar and the usual assemblage of heavy minerals in well-rounded grains; of these garnet is the most conspicuous. Close to the base of the group there is frequently a conglomeratic bed ('bone-bed'), composed of fragments of green marl, plants, bones, and teeth. Shales and steinmergel may occur with the sandstones.

We are able to describe for the first time from the English Trias examples of the foliage and scales of the female cone of a *Voltzia*, closely resembling *V. heterophylla*, of the Bunter of the Vosges, and to record new occurrences of *Voltzia*, *Schizoneura*, *Carpolithus*, and, possibly, *Yuccites*.

The plants are associated with indeterminable teeth and bones of Labyrinthodonts, and with fish-remains, which are abundant in the 'bone-bed' and very rare at higher horizons.

Fish-teeth, hitherto described as *Acrodus? keuperinus*, are widely distributed, and prove, on microscopic examination of their internal structure, to be referable to *Polyacrodus* (Jaekel). Dorsal-fin spines and cephalic spines associated with these teeth probably belong to the same genus.

Teeth similar to *Phœbodus brodiei* have been found at Knowle. *Phœbodus*, *Semionotus*, and *Ceratodus* have all been previously described from these beds.

Cestraciont remains allied to *Polyacrodus keuperinus* are especially abundant in 'bone-beds' at the base of the Lettenkohle in Germany, and its presence may be regarded as evidence of estuarine conditions. *Ceratodus*, on the other hand, occurs frequently in the Rhætic, a deposit usually accepted as marine, but its only living ally inhabits some rivers in Queensland.

We have found *Thracia? brodiei* at Shelfield. This lamellibranch was described by Mr. R. B. Newton as a truly marine form, but it is only represented by rather obscure casts.

Estheria minuta, a form that is probably never truly marine, is practically ubiquitous, and occurs in both shales and sandstones.

The fauna and flora is thus seen to be a restricted one, though many specimens have been found, and their testimony on the origin and age of the deposit is inconclusive.

If we may judge from the lithology, the conditions which governed the formation of the 'skerry-belts' of Nottinghamshire and Leicestershire—namely, the arrival of floods of fresh water—probably acted more persistently in the area under consideration, as a result of its greater proximity to land. For not only are the beds very similar to the 'skerries', but in the 'bone-bed' or marl conglomerate we have positive evidence of littoral conditions.

Thus we are not dealing with a pre-Rhætic incursion of the sea, but with a littoral facies of the Keuper Marls, formed where the water was at times sufficiently fresh to support a small fish-fauna and in sufficient motion to move coarse sediments.

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(10) On the Fossil Floras of the South Staffordshire Coal-field. By E. A. Newell Arber, M.A., Sc.D., F.G.S.

THE rich series of floras of the South Staffordshire Coal-field has suffered much unfortunate neglect in the past. Several collections have, it is true, been made from time to time, but with very few exceptions they have never been described, and some of them are without proper records of locality and horizon. For such trustworthy records as exist we are chiefly indebted to Dr. Kidston and to his memoir published as far back as 1888. The number of species, the exact locality and horizon of which are recorded, is at present as follows:—Keele Series 16, Halesowen Sandstone Series 0, ? Brick Clay Series (Old Hill Marls) 8, Productive Measures 27.

For some time past I have been endeavouring to extend our knowledge of the fossil floras of this coal-field, and I have been fortunate in receiving the active co-operation of several geologists resident in Birmingham and the neighbourhood, who have most kindly formed collections from particular areas, and forwarded the specimens to me for examination and description. In this way the material which I have myself been able to collect has been greatly extended. My thanks are in particular due to Mr. H. Kay, F.G.S., Mr. W. H. Foxall, F.R.G.S., Mr. W. H. Hardaker, M.Sc., and Mr. L. Jackson for their enthusiastic co-operation.

Attention has been chiefly concentrated so far on the floras of the Brick Clays, and of the lowest beds of the Productive Measures on or about the horizon of the Bottom Coal. A considerable number of species have been obtained from both horizons, of which some are new records both to the coal-field and to Britain. This work is still in progress. Information has also been obtained as to the horizon and localities in which the petrified specimens, long known from this coal-field, occur, such information having been lost for many years past.

In addition the first fossil plants from the Halesowen Sandstone Series have been unearthed by Mr. Kay, and here again both petrifactions and impressions occur.

It is hoped that in course of time it will be possible to trace the floras systematically from the lowest to the highest beds of the Coal-measures of this coal-field. The material, however, has to be obtained as opportunity offers, and this preliminary note is intended merely to indicate the present progress of the work.

(11) On Systems of Folding in the Palæozoic and Newer Rocks. By G. Barrow, F.G.S.

IN a paper published by the Geologists' Association the author has given a brief outline of the nature of the crystalline area of the Highlands and shown that it consists of three great lenticular masses of thermally altered rocks. It is further shown that the outer and uncrystalline margins of these masses all trend roughly north-east and south-west. The best known is that forming the south-eastern margin of the crystalline area, which the author has followed, where present at the surface, almost the whole distance from Stonehaven, on the east coast of Scotland, to Omagh in the north of Ireland. Recent work suggests that this margin is also present on the west coast of Ireland.

This outer margin of crystallization is not confined to Scotland; it is also present in Anglesea, where the margin of the crystalline massif is seen along a portion of the Menai Straits. It also occurs in the Isle of Man, where the old rocks are identical with those of the lower aureoles of thermometamorphism in the Southern Highlands. In both cases the trend of this outer margin is the same—north-east and south-west. Wherever this margin can be examined it has been found to be a great line of resistance, and the folding in the adjacent palæozoic, and, at times, even newer rocks, is found to be parallel to it; it is in fact the cause of the strike of the folding; under earth-stresses the softer rocks have buckled up against a great resisting crystalline mass.

Thus, strictly speaking, there is no such thing as a Caledonian Movement; there are a series of resisting masses with parallel margins; the folding in North Wales is determined by the Anglesea Archæan Rocks; Caledonia has nothing whatever to do with it.

If, now, we turn to the area in the south of Britain, we find another system of folding; this, too, the author believes to be due to a similar cause. The outer margin of the old crystalline rocks in Cornwall seems to be roughly east and west; it certainly is not north-east and south-west. It now remains to do in the north-west of France what the author has done in North Britain—i.e. to trace out the outer margins of crystallization and prove that the so-called Hercynian system means simply that the boundaries of the resisting crystalline masses, against which the newer rocks buckle up, now trend east and west. If these facts are once grasped we have an explanation of the local departure of the strike of the folding in the north of England; the lines of resistance locally depart from their usual trend and the subsequent folding does the same.

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(12) On the Spirorbis Limestones of North Warwickshire. By G. Barrow, F.G.S.

THE typical Spirorbis limestone is a rather compact rock, usually grey and generally containing the small fossil *Spirorbis carbonarius*. The number of these varies greatly; at times several specimens may be seen in one fragment; often it is difficult to find any, and, so far as experience has gone at present, they are never

abundant in this area. Though the dominant colour is grey, the rock is often buff and occasionally almost white.

The purest form of Spirorbis limestone occurs in masses of very variable size. The largest and most persistent bed is the Index limestone, which occurs roughly about 100 feet down in the Halesowen or Newcastle Group. This has often been confused with another and less persistent bed, lying about 100 feet further up and close to the base of the Keele Group. Other and less persistent bands have been met with in the Keele Group, notably by Mr. Cantrill. In addition to these distinct beds, which can often be traced for some distance at the outcrop, if the ground be free of drift, there are lenticles varying in length from a few yards to a few inches, and at times only scattered nodules. These smaller patches were found during the great drought, when the old marl pits in the Halesowen Group were completely dried up. Advantage was taken of this to clean the pits out, laying the rock sides bare, when these minor occurrences of the limestones were exposed.

The limestones seem to have been built up of a series of films or layers, resulting from the evaporation of shallow sheets of lime-bearing water. When dried the film appears to have been cracked and more or less broken up, but re-cemented by later deposits of identical material; this in turn became broken up and re-cemented. The process was repeated till a bed several feet thick was at last accumulated. The whole rock thus comes to have a clean sharp fracture, though its fragmental character is easily seen on a freshly fractured face. In this form, best shown by the Index limestone, there is a minimum of material other than lime brought into the deposit. A rough test of the brecciated original fragments shows the limestone to be nearly pure and containing about 95 per cent of carbonate of lime.

From this we pass to the type containing small fragments of other material, such as marl, and the cementing matrix is not merely calcite, a considerable proportion of mud and sand being present. In this the limestone fragments are somewhat rounded, having been transported for short distances. At times the fragments are locally heaped up and the bed attains a quite abnormal thickness. The band at or near the base of the Keele Group shows this character in the cutting of the mineral railway above Kingsbury; the fragments have been heaped up till it has locally attained a thickness of 10 feet.

The extreme type is really a cornstone, or a sandstone more or less crowded with rolled fragments of Spirorbis limestone. It is doubtful in this case if any of the rounded fragments are formed in situ; the whole rock seems to have been the result of flood action tearing up a deposit cracked by drying and transporting the fragments for some distance.

There is strong evidence to support the view that two at least of these limestones were formed over a large area; the Index has rarely been removed completely by this process; the one next above often has. How far the less persistent beds have been locally removed by subsequent erosion is at present an open question.

This mode of origin of the more impure, possibly of all the

limestones, is supported by the character of the sandstones. These at their base often contain abundant pellets of marl, which from their form appear to have been sun-dried and so rendered sufficiently coherent to be capable of transportation for short distances without losing their cuboidal form. The phenomena suggest formation in shallow water, during a dry epoch, subject to sudden or periodical floods.

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(13) The Geology of the District between Abereiddy and Pencaer, Pembrokeshire. By A. Hubert Cox, M.Sc., Ph.D., F.G.S., and Professor O. T. Jones, M.A., D.Sc., F.G.S.

In an introductory paragraph the authors referred to the work of previous observers, namely, Hicks, Reed, Elles, and Elsden, and to the visit of the Geologists' Association during Easter, 1910, when results were obtained which suggested that this area required re-investigation. Examination by the authors has proved that the apparent sequence is extremely complicated by strike-faulting, and instead of Llandeilo and Bala rocks as previously supposed, Arenig and even Cambrian rocks form large areas of the coast.

Part I. Abereiddy Bay to Pwll Strodyr (A. H. Cox).

The ground is occupied by the under-mentioned beds, the stratigraphical order of which is, so far as known, as follows:—

Bala	Limestone of Eastern Quarry, Abereiddy = Mydrim Limestone of Carmarthenshire.
Llandeilo	Lower Dicranograptus Shales = Hendre Shales of Carmarthenshire.
Llanvirn	Didymograptus Murchisoni Shales. Didymograptus Murchisoni Volcanics (including the Abereiddy Ash, and Llanrian lavas). Didymograptus bifidus Shales.
Arenig	Tetragraptus Beds—dark slates. Porth Gain Beds—grits and slates with *Orthis calligramma*, var. *proava*. Abercastle Beds—sandy mudstones with *Ogygia selwyni*, etc.
	? gap.
Doubtful Age	Castell Coch Beds—cleaved blue-black mudstones. Ynys Castell Beds—siliceous mudstones and cherts. Ynys Castell grit and breccia.
	? break.
Lingula Flags	Flags and laminated quartzites with *Lingulella davisii*.
Doubtful Menevian.	Slates near Abercastle with *Agnostus* sp.

The 'Middle Llandeilo' of Hicks' classification has been found to include the Lower Dicranograptus Shales and the succeeding limestone; that is, actually more than the Llandeilo formation as now defined. The 'Upper Llandeilo' includes various Lower Llanvirn and Arenig beds; the affinities of the other rock-groups are briefly discussed in the paper. Lingula flags occupy much of the adjoining inland district.

References are made to certain "intrusive rocks and their relation to the adjoining sediments". The detailed mapping of the area is now in progress.

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References are made to certain "intrusive rocks and their relation to the adjoining sediments". The detailed mapping of the area is now in progress.

Part II. Pwll Strodyr to Pencaer (O. T. Jones).

The following rock-groups are represented in probable descending order :—

LOWER OR MIDDLE ARENIG	Pwll Deri Slates . . .	Cleaved dark slates with extensiform graptolites.
? LOWER ARENIG . .	Aberbach Quartzite Group probably equivalent to the quartzites of Trwyn Llwyd and possibly of Pwll Strodyr.	Quartzites with thin dark shales.
LINGULA FLAGS . .	Mynydd Morfa Group.	
DOUBTFUL AGE . .	Pwll Crochan Group . .	Dark slates with obscure fossils probably Menevian or Upper Lingula Flags.
? SOLVA	Llech Dafad Group . .	Quartzites, green and purple sandstones ; obscure fossils.

The age and relationships of the various groups are briefly discussed, and reference is made to certain intrusive rocks which occur among the lower groups.

In view of the great thickness of some of the groups and of the bearing of their age upon the igneous rocks of Pencaer and Strumble Head it is proposed to map the area in detail.

REVIEWS.

I.—SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN AND THE MUSEUM OF PRACTICAL GEOLOGY FOR 1912. 8vo; pp. iv, 101, with 1 plate and 4 text-illustrations. London: printed for H.M. Stationery Office, 1913. Price 1*s*.

IN this memoir, as usual, there will be found much to interest all geologists, whether their special studies are among the Archæan schists or on succeeding geological systems up to the time when Palæolithic Man occupied the country. In England and Wales field-work has been carried on in three districts: Denbighshire, Warwickshire and Staffordshire, and London with the south-eastern counties. In Scotland the districts comprise the West Highlands, North and Central Highlands, Kilmarnock in Ayrshire, and South Lanarkshire.

Attention is called to the occurrence in Ben Armine Forest, Sutherland, of an altered peridotite, which is in contact with gneisses of Lewisian type and granite intrusions, and was probably intruded prior to the movements which caused the schistosity of the rocks. The subsequent remarkable effects of granitization are described.

The mapping of some of the older Palæozoic rocks on the western borders of the Denbighshire Coal-field has been revised, and it has been found that the Tarannon Shale does not rest unconformably upon the Ordovician, but that the Llandovery Beds are present, and no evidence