limits of existence of the following hydrates within $-33°{\cdot}6$ C. and 186° C. (the temperature at which water begins to decompose magnesium chloride) have been investigated :—

$MgCl_2.12H_2O$, $MgCl_2.8\alpha H_2O$, $MgCl_2.8\beta H_2O$, $MgCl_2\,6H_2O$, $MgCl_2.4H_2O$, $MgCl_2.2H_2O$.

It is impossible within the limits of this notice to discuss the details of the investigation, but the brief indication here given of the nature and scope of the inquiry may serve to direct attention to a research which is obviously of wide interest.

THE NATURAL HISTORY OF CORDIERITE AND ITS ASSOCIATES.[1]

THE last quarter of the present century has witnessed an extraordinary outburst of petrological activity, due, in a large measure, to the application of precise mineralogical methods to the study of the constituents of rocks. The petrologist, and through him the geologist, owes, therefore, an enormous debt of gratitude to the mineralogist ; at the same time, the benefits have not been wholly one-sided. Mineralogy is becoming something more than a mere catalogue of the crystallographic, chemical and physical characters of museum-specimens, and this is largely due to the influence of petrology. It may end in breaking down the artificial systems of classification which are in vogue, and introducing others more in accordance with genetic principles.

A good illustration of the advantage of studying minerals from the natural history point of view may be obtained by considering some facts relating to the modes of occurrence and origin of corundum, spinelle, sillimanite and cordierite—four minerals which are so frequently found together that they have been called the "faithful companions." Corundum is crystallised alumina (Al_2O_3), true spinelle is an aluminate of magnesia ($MgO.Al_2O_3$), sillimanite is the silicate of alumina ($Al_2O_3.SiO_2$), and cordierite is a silicate of alumina and magnesia ($2MgO.2Al_2O_3.5SiO_2$). The mutual replacing properties of ferrous oxide and magnesia, and of ferric oxide and alumina complicate the composition of the spinelles and cordierite. All the minerals contain alumina, and it is this fact which determines their paragenesis. They occur, usually in combinations of two or more, under the most diverse geological conditions :—

(1) As the constituents of foliated crystalline rocks of more or less doubtful origin.

(2) As the products of contact-metamorphism round plutonic masses.

(3) As the constituents of inclusions in plutonic rocks, dykes, lavas and agglomerates.

(4) As the direct products of the crystallisation of igneous magmas.

(5) As the direct products of the crystallisation of artificial silicate-magmas.

Cordierite-gneisses are found in many parts of the world in association with biotite-gneisses and other foliated crystalline rocks. Various views have been expressed as to their origin. Some petrologists are content to refer them to the Archæan system ; others regard them as due to the contact or thermodynamic metamorphism of ordinary argillaceous sediments ; and others as rocks of mixed origin, containing both igneous and sedimentary material. The last view, as applied to certain members of the group but not to all, derives support from the fact that where cordierite-rocks occur as contact products, they always belong to the inner zone, and sometimes give distinct evidence of the intimate intermixture of igneous and sedimentary material.

Cordierite-rocks, often containing sillimanite and a green spinelle, have been recognised, during the progress of the Geological Survey, at many points in the Southern Highlands of Scotland, in the counties of Aberdeen, Banff, Forfar and Argyle, and quite recently corundum has been detected in some of these ; so that the list of the "faithful companions" is now complete so far as Scotland is concerned. It is doubtful at present whether all the Scottish cordierite-rocks are of the same age and mode of origin. Some are contact-rocks, but others may, for the present at least, be more safely classed with the older crystalline-schists. All are undoubtedly the result of the metamorphism of highly aluminous rocks.

[1] Abstract of the presidential address delivered to the Geologists' Association, by J. J. H. Teall, F.R.S., on February 3.

A very interesting case of the occurrence of all four minerals in rocks due to contact-action has been described by Salomon. It occurs in the southern part of the Eastern Alps round the great mass of tonalite, of which Monte Adamello forms the culminating point.

Inclusions, derived either from a contact-zone or from the crystalline-schist formation, containing two or more of the minerals in question, have been observed in igneous rocks occurring under the most diverse conditions in many parts of the world. They have been found, for example, in the tonalite of Monte Aviolo ; in the kersantite-dyke of Michaelstein in the Hartz ; in the andesitic lavas of the Eifel, the Siebengebirge and the south-east of Spain ; and, finally, amongst the ejected blocks of the Laacher See and Asama Yama in Japan. There is evidence, moreover, that in most of these cases the minerals, or some of them, occur not only as constituents of the inclusions, but also as the direct products of crystallisation from the igneous magmas. Thus, in the mica-andesite of Hoyazo (Cabo di Gata) cordierite occurs in two forms : (1) as irregularly bounded grains up to the size of a hazel-nut, and (2) as sharply defined idiomorphic crystals in a glassy base. The former are inclusions ; the latter are crystals which have separated from the magma. Rock-fragments, consisting very largely of a cordierite-gneiss from which the isolated grains of cordierite have been derived, are also very common in this andesite. Osann, who has described this very interesting case, points out that the abundance of indigenous cordierite, coupled with the presence of numerous inclusions of cordierite and cordierite-gneiss, points to the conclusion that portions of the foreign rock have been dissolved, and that a magma of exceptional composition has thus been formed, out of which cordierite has crystallised. Many other cases are known in which the solution of foreign aluminous material has so modified a magma that members of the group under consideration have crystallised out of it. Moreover, it is not necessary that the minerals should be present in the foreign material. It is sufficient that the necessary chemical constituents should be present. Thus a basalt from Köllnitz in Carinthia has involved fragments of an argillaceous rock, and partially dissolved them. The normal basalt is holocrystalline, but in the neighbourhood of the inclusions it becomes glassy, and crystals of spinelle and cordierite, which are absent, both from the basalt and the inclusion, occur. The partial solution of the fragments evidently modified the composition of the basalt, so that it cooled as a glass after cordierite and spinelle had separated out. It is interesting to note, in passing, that the addition of alumina to the basaltic magna has tended to prevent crystallisation. This effect of alumina is well known to glass-makers.

The formation of corundum in an igneous rock as the consequence of the solution of argillaceous material is well illustrated by the case described by Prof. Busz. The mineral occurs round inclusions of clay slate in a felsite from South Brent. Many cases of the presence of corundum in igneous rocks under conditions which prove that it must have crystallised out of the magma, are now well known ; and amongst the most interesting are those recently found in Hastings County, Canada, where the mineral occurs in dykes of syenite. In these, however, there appears to be no evidence that the excess of alumina is due to the solution of argillaceous rocks.

The remarkable synthetic experiments of Dr. Morosewicz give a complete and satisfactory account of the chemical and physical conditions under which corundum, spinelle, sillimanite and cordierite separate out of alumo-silicate magmas ; and, therefore, of many of the natural occurrences above referred to. Alumina is soluble in magmas agreeing in composition with albite, nepheline and anorthite, or with mixtures of these, and crystallises out as corundum on prolonged cooling at high temperatures. If both silica and alumina are present in excess of that necessary to form felspar, sillimanite is formed until the excess of silica is used up, and then the remaining excess of alumina crystallises out as corundum. The presence of magnesia determines the formation of spinelle, or of cordierite, or of both, according to the excess of alumina and silica above that necessary to form felspar with the soda, potash and lime present. All these phenomena may be verified within the range of temperature in a Siemens' furnace, such as that used in glass-works. The minerals obtained are in every way similar, except as regards size, to those which occur in nature.

It thus appears that the "faithful companions" may be formed either by the metamorphism of sedimentary deposits, or

as the result of the crystallisation of igneous magmas of exceptional composition. In many cases, if not in all, the presence of these minerals in igneous rocks is the result of the solution of argillaceous material. It seems fair to conclude, from their general absence from masses of granite and other igneous rocks, that the absorption of argillaceous sediments has not taken place on any large scale. But in drawing this inference caution is necessary because, under plutonic conditions, the presence of water may lead to the formation of micas instead of them. Fused biotite gives rise to spinelle, and fused muscovite to sillimanite and corundum.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Dr. G. Sims Woodhead has been appointed professor of pathology in succession to the late Prof. Kanthack.

The Balfour studentship, of the annual value of 200*l.*, for original research in biology, especially animal morphology, has been awarded to Mr. J. Stanley Gardiner, Fellow of Gonville and Caius College, for three years from March 25, 1899. Grants from the Balfour fund of 50*l.* each have been made to Mr. J. S. Budgett, of Trinity College, in aid of his researches on the development of polypterus, and to Mr. L. A. Borradaile, of Selwyn Hostel, in aid of the expenses of his proposed journey in company with Mr. Gardiner, the Balfour student.

DR. H. E. ANNETT has been appointed demonstrator of tropical pathology in the newly-founded school of tropical diseases in Liverpool.

WE are asked to state that the offices of the National Association for the Promotion of Technical and Secondary Education have been removed from 14 Dean's Yard to 10 Queen Anne's Gate, Westminster, S.W.

AT the annual meeting of the shareholders of the Patent Nut and Bolt Company (Limited), held on Monday at Birmingham, it was resolved that the company should contribute 5000*l.* to the fund which is being raised for the establishment of a University in Birmingham.

THE London School Board have strongly protested against the application of the London County Council to the Science and Art Department to be recognised as the organisation responsible for science and art instruction in the County of London. A memorial has been drawn up and presented to the Lord President of the Council, asking him not to assent to the application of the County Council, and giving reasons why the Board should be largely represented upon whatever authority was given control over science and art instruction in London.

A COPY of the address delivered at the recent annual meeting of the Association of Technical Institutions, by Earl Spencer, has been received. In the address, the importance attached to a thorough system of technical instruction in America and Germany is pointed out, and the intimate and necessary relations which exist between technical and secondary education are mentioned. Just as it is difficult to give technical instruction without a foundation of good secondary education, so secondary education is retarded and often completely stopped by the poor education of pupils who come from the primary schools to seek it. Earl Spencer made special reference to this lack of system in educational efforts, and remarked that in order to secure sound and good technical education for the population as a whole, many defects of primary education will need to be remedied.

THE Calendar of the Department of Science and Art has been issued. As in former years, the volume contains a history and general description of the Department, with a summary of the rules, and a list of the science and art schools and classes. The total number of individual students who presented themselves for examination in science subjects of the Department in 1898 was 157,306. The six subjects in which the most students were examined are—mathematics (stages 1, 2, 3), 35,945; physiography, 24,877; inorganic chemistry, 23,966; practical plane and solid geometry, 20,238; machine construction and drawing, 18,073; building construction, 13,653. Of the subjects in which practical examinations were held, the first four are—inorganic chemistry, 15,012; magnetism and electricity, 2550; organic chemistry, 1195; sound, light and heat, 1141.

SOCIETIES AND ACADEMIES

LONDON.

Royal Society, January 26.—"On the Structure and Affinities of Fossil Plants from the Palæozoic Rocks. III. On *Medullosa anglica*, a new Representative of the Cycadofilices." By D. H. Scott, M.A., Ph.D., F.R.S., Hon. Keeper of the Jodrell Laboratory, Royal Gardens, Kew.

The existence of a group of fossil plants, combining in their organisation certain characters of the Ferns and the Cycads, has been recognised, of late years, by several palæobotanists. The convenient name, Cycadofilices, has recently been proposed to designate the group in question, which now includes several, somewhat heterogeneous, genera, among which *Lyginodendron*, *Heterangium*, and *Medullosa* may be mentioned.

No stem of a *Medullosa* has hitherto been recorded from this country, though specimens of *Myeloxylon*, now known to have been the petioles of *Medullosa*, are frequent in the calcareous nodules of the Lower Coal-measures.

The author has recently had the opportunity of investigating several excellent specimens of a new species of *Medullosa* from the Ganister Beds of Lancashire. These fossils are of special interest on several grounds; they are considerably more ancient than any members of the genus previously described, they are the first English specimens recorded, they are preserved in a more complete and perfect form than any others at present known, and lastly, the greater simplicity of their structure causes the essential characters of the genus to stand out with greater clearness than in the more complex species. The specimens were discovered by Mr. G. Wild and Mr. J. Lomax, in material from the Hough Hill Colliery, Stalybridge.

The species, which is very distinct from any form previously described, will be known as *Medullosa anglica*.

The most complete specimen of the stem has a mean diameter of rather more than 7 cm., including the adherent leaf-bases, which, to judge from the most perfect specimens, almost completely clothed the surface of the stem. The arrangement of the leaves was a spiral one, and in the only case where the phyllotaxis could be determined, the divergence proved to be 2/5.

In two of the specimens the external characters of the fossil are well shown. The habit of the stem, clothed with the long, almost vertical, overlapping leaf-bases, may have been not unlike that of some of the tree-ferns, such as *Alsophila procera*.

The vascular system of the stem consists of three (or locally four) steles, anastomosing and dividing at long intervals.

Each stele of *Medullosa anglica* is surrounded by a zone of secondary wood and bast, and shows the closest agreement in structure with the single stele of a *Heterangium*, so that the stem of this *Medullosa* might well be concisely described as a polystelic *Heterangium*.

The course of the leaf-trace bundles was followed very completely in consecutive series of transverse, and in longitudinal, sections. On becoming free the trace is a large concentric bundle; as it passes obliquely upwards through the cortex, the trace loses its secondary tissues, and undergoes repeated division into a number of smaller bundles, each of which has collateral structure. These collateral strands have in all respects the same arrangement of their elements as the well-known bundles of *Myeloxylon*.

The base of the leaf received a large number of bundles, consisting of the ultimate branches derived from the subdivision of several of the original leaf-traces. This distribution of the bundles is peculiar and unlike that in any known plants of Cycadean affinities.

The petioles branched repeatedly, the finest ramifications of the rachis having a diameter of about 1 mm. only, but retaining in essentials the "*Myeloxylon*" structure. The leaf was thus a highly compound one; the structure of the leaflets associated with the rachis, agrees well with that of the *Alethopteris* leaflets, figured by M. Renault.

The roots, never previously observed in any species of *Medullosa*, were of triarch structure, with abundant formation of secondary wood, bast, and periderm. The author is indebted to Mr. J. Butterworth and Mr. G. Wild, for specimens which have thrown important light on the connection between root and stem.

While *Medullosa* combines, in a striking manner, the characters of Ferns and Cycads, the author is not disposed to regard it as having lain very near the direct line of descent of the latter group. It is more probable, as Count Solms-