And besides, the effect of changes of temperature upon the spectroscopic portion of his apparatus, and the difficulty of securing nights on which the atmosphere would not cut off the actinic rays to an unusual degree, not to mention the fact that the observatory was more than two miles distant from his residence, — these and many other conditions hindered the progress of the work. Spectrographic operations are, as Professor Young well says, much more sensitive to atmospheric conditions than are visual observations.

As regards the spectroscopic apparatus, a great many forms were employed, the first of which has already been mentioned. Later, direct-vision prisms were used in the same way, and spectroscopes made up of such prisms, some with a slit, some without, and some with a cylindrical lens to give necessary width to the spectrum. In the definitive arrangement of the apparatus, with which all the plates measured by Professor Pickering were made, a remodelled form of Browning's star-spectroscope formed the basis of the instrument; the telescope and collimator each having a focal length of six inches, and an aperture of 0.75 of an inch. The eye-piece and micrometer being removed, a block of hard wood was fitted on in such a way as to carry the photographic plate (a small piece of glass about an inch square); and a small positive eye-piece was mounted on the block, so that the yellow and red portions of the spectrum, projected beyond the sensitive plate into the field of view, could be examined at pleasure. It was thus possible to be sure that the driving-clock was running properly, and that all the adjustments remained correct. The whole apparatus weighed less than five pounds, and could be screwed on the eye-end of whichever telescope it was desirable to use it with. The development of the plates was usually by ferrous oxalate, though the alkaline development and pyrogallic acid were both used on some occasions. The pictures were about half an inch long, and one-sixteenth of an inch in width, extending from a point between the Fraunhofer lines *F* and *G* to a point near *M*.

Professor Pickering divides his work on these plates into three parts: first, the determination of the relative positions of the lines in the various spectra in terms of any convenient unit of length; second, from the known spectra of the moon and Jupiter, a determination of the relation of these measures to wave-lengths; third, a reduction of the measures of the stellar spectra to wave-lengths, and a discussion of the results. The stars whose spectra have been measured are *α* Aquilae, *α* Lyrae, *α* Aurigae, *α* Boötis, and *α* Scorpii. The spectrum of the first of these stars is remarkable for containing, in addition to the intense broad hydrogen-bands which characterize the spectrum of *α* Lyrae and similar stars, a multitude of very fine lines, which are easily seen between *G* and *H* in several of the plates, but are too delicate to be satisfactorily measured. Dr. Draper considered these fine lines very important as showing that Altair should be regarded as a sort of intermediate link between *α* Lyrae and Sirius on the one side, and Capella and the sun on the other.

On the plates of the spectra of *α* Aurigae and *α* Boötis, not only do the lines appear to coincide in position with those of the sun, but their relative intensity seems to be nearly the same. Of the twelve lines seen in at least seven of the nine spectra of the moon and Jupiter, every one is contained in the spectra of both *α* Aurigae and *α* Boötis. Of the fifteen lines which are so faint as to be contained in but one or two of the spectra of the moon or Jupiter, only four are contained in the spectrum of *α* Boötis, and but one in that of *α* Aurigae. There is therefore no room for doubt of the correctness of Professor Pickering's conclusion that the evidence afforded by these photographs is very strong indication of the sameness of their constitution with that of our sun.

Professor Pickering's method of deriving his results from these plates is worthy of note here, as indicating the great degree of confidence to which they are entitled. To secure entire independence in the results, the measures were completed before the reductions were begun. The lines in each plate were measured without comparison with any map, and no search was made for lines which appeared to be wanting. When two similar spectra were photographed side by side, care was taken to cover one when measuring the other. Under these circumstances, the agreement in the measures of several plates is strong evidence of the identity of the spectra.

Appended to this monograph are three of the papers of Dr. Draper, reprinted from the *American journal of science:* 1°, On photographing the spectra of the stars and planets (December, 1879); 2°, On photographs of the spectrum of the nebula in Orion (May, 1882); and, 3°, Note on photographs of the spectrum of comet *b* 1881 (August, 1881). The first of these papers gives, in brief form, a very lucid statement of the conditions of the problem of celestial spectrum-photography, as well as the obstacles which he had, up to that time, overcome in solving it.

DAVID P. TODD.

THE GEOLOGY OF THE ASTURIAS AND GALICIA.

Recherches sur les terrains anciens des Asturies et de la Galice. Par CHARLES BARROIS, docteur ès-sciences. Lille, *Six-Heremans*, 1882. 630 p., 20 pl. 4°.

IT was the good fortune of one of the writers of this review to see this work in process of evolution in the workshop and study of its hospitable author in Lille; but much as he admired the indomitable energy and patience which were presiding at its birth, as well as the copious notes and experience which were being assimilated into this monograph, the result is a surprise. How much more must it surprise those who are unacquainted with Dr. Barrois, to learn that he is but little past his thirtieth year; that this is but one of several important memoirs which he has begun and

completed alone; and that he has been able to do this while his chair in the faculty of science at Lille (Academy of Douai) was demanding the constant and fatiguing work of lectures and preparation, and his arduous labors in Brittany under the geological survey of France suffered no interruption!

Without the experience which he gained, both in the field and in the art of publishing, by his important and now often quoted "Recherches sur le terrain cretacé supérieur de l'Angleterre et de l'Irlande," which won him his doctorate from the University of France, he would hardly have been so successful in this last book. Both works begin with historical notices and bibliographies; but in the latest the first four pages are devoted to a veritable history of the labors of his predecessors, rather than to a mere list of their books. At the end of this, however, there are nearly four pages of titles rained upon the reader, as if Dr. Barrois were anxious to terminate this part, and get at his subject.

Accompanying this large and handsome quarto is an atlas in the same form, which contains twenty plates reproduced in the best style of art at the present day. The first three of these are colored plates, representing ten thin sections of rocks under the microscope and in polarized light. Each plate is conveniently covered by a thin tissue sheet containing the outlines of the constituent minerals, with the letters and figures necessary for indentifying them. Following these are fourteen plates of fossils, of which four are from the hand of the author; nine were drawn by the lithographer, Mr. C. Rogghé; and one is a phototype from the *Ateliers de reproductions artistiques* in Paris. The last three plates are in order: one of vertical sections, one of section sketches, and one of pure sketches, on which latter interesting and important geological phenomena have been marked. Viewed as a whole, the artistic work is as perfect as any set of illustrations of scientific matter which the writer remembers to have seen. Where fault is so hard to find, he may be pardoned here for mentioning the only additions which it seems to him could have made the plates clearer; viz., a note of the amount of enlargement of the figures of plates ii. and iii., on the pages opposite those plates. Plate i. is thus provided.

The first part of the subject of this review (161 p.) is devoted to lithology. It is interesting and valuable, and will do much to increase the reputation of the author. It treats of the general and microscopic characters of the sedimentary rocks, including schists, phyllites, quartzites, limestones, and mimophyres; and the crystalline massive rocks, comprising granite, quartz porphyry, diorite, diabase, and recent quartz-bearing kersantite. The schists are of every age, from the Cambrian to the carboniferous; and he divides their mineral ingredients into two classes, — those which were clastic, and prior in origin to the consolidation of the rocks; and those which were secondary, or crystallized out during the consolidation. The first class includes quartz, felspar, and white mica; the second, quartz, rutile, tourmaline, white mica, and chlorite. The term 'mimophyre' is given by Barrois to a series of felspathic, porphyritic, and schistose rocks, which he thinks were formed from volcanic ashes and detritus, — the same as most poroditic felsites are known to have been formed. The mimophyres are found associated with the sedimentary schists, quartzites, and phyllites, and belong to the Cambrian, Silurian, and Permian.

Of the plates, it is sufficient to state that they were made by Jacquemin, who prepared those for Messrs. Fouqué and Lévy's 'Minéralogie micrographie.'

The second part treats of the paleontology of the Cambrian and Silurian (chap. i.), and of the Devonian and carboniferous (chap. ii.), and occupies 217 pages of very interesting matter; to which, however, it will be impossible here to make more than the briefest allusion. We learn from a prefatory note, that Dr. Barrois has succeeded in collecting three hundred and eighty-five species of fossils from the field of his labors in this part of Spain. Of these, thirty-nine are new species, which we owe to his research; viz., three in the Cambrian and Silurian, twenty in the Devonian, and sixteen in the carboniferous. The syllable 'Barr.,' affixed to many others, is apt to lead the hasty reader to ascribe these also to him; but the abbreviation is for Barrande, and not Barrois. The author's note (p. 177) on the right of precedence of Professor Haldeman's Scolithus over Ronault's Tigillites is a model of impartial justice and scholarly treatment of the subject.

Following the detailed description is a *résumé* (pp. 359 to 385) containing considerations by Dr. Barrois on the genera and species just referred to, with special regard to their parallelisms; and the chapter is concluded by speculations on the conditions under which the deposits have been formed. In the following chapter (ii.) the same method is applied to the fossils of the Devonian and carboniferous.

The third part is devoted to the stratigraphy, including, of course, the description of cross-sections. It is no fault of the author that this

portion of the work is more difficult to follow, owing to the necessity of subdividing the cross-sections, like the previous parts of the book, in accordance with the limits of the great formations. This difficulty is inherent in the case, and lies in deciding how to put the diverse phenomena before the mind in 'natural order' (much-abused phrase). If we follow the geographical divisions, there must be a continual interruption and resumption of the same geological horizon; whereas, if the geological boundaries are alone regarded, the geographical continuity is broken. Of the two solutions, perhaps the second is the better. The first of these subdivisions (chap. i.) is the 'primitive terrane' (used by de Castro to imply nearly what is meant by the archaean of Dana). It is very interesting in this connection (and not unexpected), to find that the upper division of the 'primitive' consists of the *roches vertes* which occupy this position in South Wales, the Appalachian belt, and in so many other places. They are mingled with chlorite schists and talc schists overlying the mica schists of Villalba, which latter contain biotite, muscovite, orthose, plagioclase, and two kinds of quartz; with garnet, zircon, sphene, and oligiste as accessories. Gneiss has been observed by Dr. Barrois only in subordinate thin layers intercalated among the mica schists.

The same is true of the garnetiferous amphibolites; but the difference between this Spanish stratigraphy, and that of those regions where similar rocks have been observed in America and in Europe, is, that the series in the former case are concordant. The Laurentian would appear, from Dr. Barrois' conclusions, to be wanting in the outcrops of Galicia, and the above-mentioned measures to represent a great development of the Huronian. The succession of Cambrian beds, both in the Asturias and in Galicia, he finds perfectly in accordance with Barrande's views of this part of Europe. From a fossil of Archaeocyathus (Billings), characteristic of the Potsdam sandstone, found in the limestones of El Pedroso, MacPherson forms a column in which he thinks that possibly the Laurentian is represented at the base by mica and talc schists, with intercalated limestones of various colors, and sometimes filled with actinote (actinolite), and, more rarely, intercalated beds of felspathic grauwacke. On this rest argillaceous, splendent, siliceous talc schists, sometimes containing chiastolite; and on these, three benches of conglomerates, tuffs, and argillaceous schists and limestones, which he refers to the Potsdam sandstones.

Following this are details of the sections in the Devonian and carboniferous. The sixth chapter treats of the phenomena which have modified the position of the paleozoic strata since these latter have been deposited. His conclusion is, that the Cantabrian Mountains owe their origin to two distinct lines of pressure; the one acting along east and west, and the other along north and south, lines. The former occurred between the carboniferous and Permian ages; and the latter, between the eocene and miocene.

The last subjects treated are the effects of denudation and the details of the actual surface-relief.

The work has been built on strong and sure foundations, and will long be cited as an authority. It is full of new facts and suggested analogies, and is characterized by thoughtfulness, industry, and modesty.

LOCKWOOD'S ELECTRICITY.

Electricity, magnetism, and electric telegraphy: a practical guide and handbook of general information for electrical students, operators, and inspectors. By THOMAS D. LOCKWOOD. New York, *Van Nostrand*, 1883. 377 p., illustr. 8°.

As indicated in its preface, Mr. Lockwood's unpretending book is not primarily intended for those having any considerable previous knowledge of the subject of electricity, but for the large number of persons who have not had the advantage of a scientific education, and yet find themselves in the employment of telegraph, telephone, or electric-light companies in various subordinate positions. To this class of persons the information contained in the work will doubtless be of great value; and, indeed, we do not recall any one book, of moderate size and price, in which so many of the different applications of electricity are considered in an elementary manner. To one familiar with the subject, the treatment of the more important topics must, of course, seem brief and occasionally superficial; but, recollecting the design of the work, it can hardly fail to win commendation, even from those who most clearly recognize its deficiencies.

The chapters on line-construction, office arrangements, and the adjustment and care of instruments, are excellent: and a very clear description of the principles of duplex and quadruplex telegraphy is given. There is also a good account of Mr. Gray's interesting harmonic multiple telegraph. Mr. Delany's ingenious multiplex synchronous telegraph is not described, probably because it did not