Puys, and on the border of a lake which was actually formed by the damming up of a stream by one of the most recent of the lava-currents) to Mamertus, Bishop of Vienne, in which he speaks of the earthquakes that had occurred in the neighbourhood of Vienne; of fire issuing from the earth and wild beasts taking refuge in cities; and the Rogation Homily of Alcimius Avitus, the successor to Mamertus, which mentions the same catastrophes.

Now in the first place Vienne is more than seventy miles in a direct line from the more recent Auvergne volcanoes; in the next, Sidonius himself makes no mention in his writings of any eruptions having taken place in his neighbourhood, although he wrote poems describing the beauty of the scenery; and lastly Auvergne is not mentioned by any ancient writer, neither by Cæsar, who encamped there and laid siege to Gergovia, a city situated on a table-land, with craters close at hand in almost every direction; nor by Pliny, who gives a list of all the then known volcanic countries, including some very out-of-the-way ones; nor by Strabo, nor by any of the poets, as a country where volcanoes were ever known to have been in action.

For these reasons, and because no volcano could have burst out near Vienne without leaving some traces of its existence, Dr. Daubeny concluded that the bishops of Gaul alluded to earthquakes; especially as "the underground thunder, the opening of fissures in the ground, the bursting out of flames and gases, the projection of water and of stones, the smell of sulphur, the alarm evinced by the animals of the spot and neighbourhood, the elevation or depression of the land, noticed by Sidonius and by Avitus in the passages referred to by Sir Francis Palgrave, are all reported as concomitants of the great earthquakes which have occurred in more recent times." Geologists have since accepted this conclusion as the correct one, in opposition to what I may call the theological position.

There was, however, a volcanic region which had not been visited by any English geologist, and which had not been described, viz., the basin of Montbrison, through which the Loire flows. Of this Mr. Scrope says in his work (2nd Ed., p. 28), "a further examination of this basin seems very desirable;" now as this district lies about half way in a direct line between the "Puys," about Clermont Ferrand and Vienne, it occurred to Dr. Daubeny that the disturbances spoken of as in the neighbourhood of Vienne, might have taken place around Montbrison, and accordingly in the autumn of 1866 he visited that locality, and I had the honour of accompanying him on the occasion. We examined carefully the volcanic hills of the neighbourhood, and could find no trace of recent volcanic eruptions; in his own description of this expedition published in the *Quarterly Journal of Science* for January 1867, and republished in his "Miscellanies" (vol. i. p. 74), just before his death, he says:—

"I am now prepared to say that, without pretending to have surveyed the entire district, I saw enough to convince me that no volcanic disturbance which had occurred within this area at so late a period as that alluded to could have escaped our notice, and that every indication of igneous action which presents itself throughout the country, bears marks of a much greater antiquity.

"Thus much, at least, I can venture to affirm, namely, that neither, craters, streams of lava, scorix, nor even cellular trap, are to be met with anywhere within the limits of this district. On the contrary, the only igneous rocks which came under our observation consisted of a compact basalt, containing nests of olivine, a material which could only have been elaborated by the aid of great pressure, and under a different configuration of the surface from that now existing."

The Doctor therefore reiterated his statement that "the lively picture drawn by Sidonius" should not "be regarded in any other light than as the offspring of a lively

imagination, dwelling upon reports which had reached the author with respect to some fearful earthquake which may have occurred in the neighbourhood of Vienne."

I will conclude by advising those who wish to study volcanic phenomena to go to Auvergne, they can do so at almost any time of the year, mid-winter, when it is far too cold for comfort, being the exception; they will there see results of volcanic action far more varied and instructive than at Vesuvius or even at Etna, and they will also be able to study the effects of denudation on a gigantic scale. Few geologists seem to appreciate the fact that within 24 hours of London is one of the largest, richest, and most beautiful of the volcanic countries in Europe.

W. H. CORFIELD

PHOTOGRAPHY AS AN AID TO SCIENCE

THE applications made of photography now-a-days are as various as they are numerous. Irrespective of the ordinary every-day uses to which the art is put in reproducing scenes and objects, or pandering to human vanity, there are, as we know, numberless ways in which it is constantly being employed as a faithful handmaiden to science. To the chemist, the surgeon, the engineer, and others, its aid is frequently of considerable importance, while to the astronomer and physicist the assistance it renders is at times indispensable. The accuracy and fidelity with which the pencil of light performs its functions, combined with the facility with which such reliable records are obtained, make photography indeed one of the greatest boons at the disposal of scientific men.

Let us take, for example, the solar records which are daily secured at the Kew Observatory. These photographs of the sun's disc, taken whenever practicable at a certain fixed period in the day, are often of considerable value, and form illustrations, as it were, of other scientific observations made at the same time. A series of prints of this kind, secured day after day, afford, in truth, a most interesting and instructive lesson to the student of astronomy, for the characteristics exhibited by the various photographs may serve as a corroboration, or otherwise, of scientific theories based upon other data and results. The nature and luminosity of the markings, or spots, upon the disc are rendered with unerring fidelity, and the way in which these are continually modified in shape and intensity, as likewise the rapidity with which they are seen to travel across from the east to west limb of the sun, to reappear again some twelve days afterwards upon the eastern edge, is all clearly and distinctly shown.

Again, another interesting application of photography to astronomic purposes is to be found in the reproduction of the stars as recently undertaken by Prof. Rutherford. In this instance the objects to be secured are so minute that special precautions are necessary in depicting them upon the sensitive film, so that their impressions may be distinguishable from accidental specks in the collodion plate. To prevent any such chance of mistake, Prof. Rutherford secures a double image of each luminary, the moving telescope to which the miniature camera is attached being halted for a short time (half a minute) between a first and second exposure of the plate, so that each star is represented by a double speck, so to speak, upon the negative, and is clearly to be distinguished therefore, from any accidental defect in the film; moreover, by stopping the telescope again after the period necessary for the second exposure, the professor is enabled to demonstrate the direction in which the stars are moving, for the brightest of them produce a tiny streak of light during the time that the camera remains perfectly still. A map or plan of the heavens is in this

* Those who wish for further information will find the whole subject discussed in Dr. Daubeny's classical work on Volcanoes, and in his papers in the *Quarterly Journal of Science* for April 1866 and January 1867.

way secured, very slight and delicate in its nature, it is true, but yet one upon which implicit reliance can be placed when undertaking astronomical measurements. To those more particularly interested in operations of this kind, we may mention that a total exposure of six minutes sufficed for the depiction of these heavenly bodies in the camera.

Turning to another branch of the subject—micro-photography—we find the camera used for several purposes as important almost as those to which we have just referred. In the study of medicine, for instance, and the many sections of Natural History, photography lends a helping hand, so firm and true that we are at once guided to our destination. The large, clearly-defined diagrams of microscopic objects and medical preparations, which we are wont to see at many schools and colleges, cannot be prized too highly, forming as they do the best and most reliable proofs in support of facts and data, and being indeed of value alike to the professor as the student. And perhaps while treating on this particular subject, we may be allowed to refer also to the use made of the micro-camera during the siege of Paris for conveying news from and to that city. We have all heard how batches of private letters and whole sheets of newspapers have been reduced by means of photography to within the most insignificant limits, and produced upon a transparent pellicle, of which a pigeon might without inconvenience carry several under its tail, and how these precious films, on arrival at their destination, were forthwith placed in an enlarging apparatus or under a microscope, to be amplified to their original dimensions. Paris, it is said, contained upwards of a thousand pigeons qualified to act as messengers, and when it is asserted that on one occasion one of these birds arrived at Tours with several thousands of private messages and despatches, we ought by no means to be surprised that the communications between the French metropolis and the provinces were so numerous and frequent.

In the chemical, physical, and meteorological sciences, and even in that of war, photography aids in many ways, and thus helps to the advancement and progress of our knowledge of these matters. But the art, or art-science, as we may call it, has in several instances done something more than render yeoman's service to higher attainments; it has also been the means of discovering phenomena which could by no other means have been ascertained. In illustration of this may be mentioned the recent researches of Dr. Ozanam, undertaken for the purpose of defining the character of the pulsations of the heart; an investigation which has brought to light facts of considerable physiological importance. The instrument used by Dr. Ozanam was a thin India-rubber reservoir of mercury, having a glass tube attached, in which the quicksilver mounted to a certain height; the reservoir, on being placed in the vicinity of the patient's heart, was influenced by the beating of the latter, and the rise and fall of the mercury in the tube was thus made to indicate the ebb and flow of the blood, precisely in the same manner as a barometer registers the variations of the atmosphere. Behind the tube was arranged, by means of clockwork, a moveable strip of sensitive paper, or other suitable material, and this, as it ran along, was impressed by light, and received, in the form of an undulating line, a register of the fluctuations of the mercury column. The sensitive film passed along at the uniform rate of a centimetre per second, so that, presuming there to be one pulsation in that period of time, the wavy line representing a single beat would occupy the space of one centimetre. Of course, by enlarging the result to ten or twenty diameters, it was then, as may be supposed, easy to see what had taken place during the hundredth or thousandth part of a second, or beat, and the knowledge thus acquired, Dr. Ozanam believes, will be highly useful in preparing the diagnosis of a patient. One fact, of itself very important, has

already been discovered by the aid of this ingenious instrument, viz., that not only as Dr. Maurey had before asserted, there exists dicrotism, or a double beat, in the normal pulse, but that the pulsation is even triple and quadruple in its action. The photographic line showed indeed that the column of mercury (representing of course, the blood in the arteries) bounded with one leap to the top of the scale and then descended again to its original level by three or four successive falls. Four descriptions of dicrotism have in this way been proved to exist, the fall of the pulse sometimes taking place in successive horizontal lines and sometimes in ascendant lines, the column reascending two or three times before falling altogether.

Another instance of scientific discovery by aid of photography is afforded in the observations of the spectrum by means of the camera. In Rutherford's picture of the solar spectrum obtained in this manner, there are many portions and lines shown (the ultra-violet for instance) which, while imperceptible to the retina of the eye, impress themselves very distinctly upon the sensitive film; and thus the presence of phenomena is proved of which but little was previously known. Of course the eye again descries certain lines, the yellow ones, which are without action upon the negative plate, and are not, therefore, recorded in the photograph, and thus it is only by carefully noting the results of both methods of observation that a true reproduction of the spectrum is obtainable. As a fact, we may mention, that single lines which are but faintly rendered in the Angström and Kirchhoff tables have been recorded by photography as well-marked double lines, while in some instances actually Rutherford shows indications by means of the camera of which there appears no vestige whatever in the records of other scientific men. In certain spectroscopic observations therefore, where special reliance is required to be placed upon the results, not only must an ocular observation be made, but the photographer's evidence must also be taken before any conclusions can be drawn from the aspect of the spectrum.

And before concluding we must not forget to refer to a still more recent instance in which photography has befriended the scientific investigator; we allude to the successful, although perhaps somewhat imperfect attempt which has been made by Prof. Young, to photograph the protuberances of the sun in ordinary daylight. A distinct reproduction of some of the double-headed prominences on the sun's limb has thus been obtained by the Professor; and although as a picture or mathematical record the impression may be of little value, still there is every reason to believe, now that the possibility of the operation is known, that with better and more suitable apparatus an exceedingly valuable and reliable record may be secured. Prof. Young employed for the purpose a spectroscope containing seven prisms, fitted to a telescope of $6\frac{1}{2}$ inch aperture after the eyepiece of the same had been removed; the miniature camera, with the sensitive plate, was attached to the end of the spectroscope, the eyepiece of which acted in the capacity of a photographic lens, and projected the image on the collodion film. The exposure was necessarily a long one, amounting to three minutes and a half, and for this reason, as likewise on account of the unsteadiness of the air and the mal-adjustment of the polar axis of the equatorial, causing the image to shift its place slightly, the details of the image were somewhat blurred and destroyed. Moreover the eyepiece of the spectroscope was unsuitable for photographic purposes, and only in the centre yielded a true reproduction of the lines free from any distortion. A larger telescope will be required to secure a more defined image, and then, if more strict attention is paid to the clock-work arrangements and to the chemical manipulations, we may anticipate that a really valuable and important result will be obtained by this novel mode of observation.

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