and Archdeacon Maples (he was then), both of whom had travelled a good deal in Africa—Maples more especially—and had seen something of the habits of lions.

Bishop Smythies defended the former theory; Archdeacon Maples—a most talented and entertaining man—the latter, saying he had known instances of lions killing porcupines, and adding that he believed the porcupine to be specially endowed with the power to propel his quills into his assailant when so attacked.

At this juncture, Bishop Smythies generally lost patience and declined to continue the argument.

Had Bishop Smythies lived, it would have interested him, as it may interest some of NATURE'S readers, to know that in March last, at the Salt Stream, two days' march N.W. of Kibwezi, I shot a fine old lion in whose left fore-paw were deeply buried the tips of three porcupine quills.

These are in my possession at the present time: the longest measures exactly 1 inch; another is almost as long, and measures $\frac{15}{16}$ of an inch. How long he had been afflicted with these painful appendages I could not say—months at any rate, or may be years; since the paw was not inflamed, and from constant friction and pressure in using it the cartilage surrounding the quills had become callous.

There is no immediate reason for supposing that in this case the lion killed the porcupine acting on the impulse of inordinate hunger: the Salt Stream country teems with game—such as rhinoceros, zebra, hartebeeste, gnu, gazelles, and ostriches; it is also just such a country for cover as lions habitually frequent, and *do* frequent in numbers, as may be judged from the fact that in two days I saw them on three occasions.

Leopards, I was already aware, prey freely on porcupines. But this is the first instance which has occurred—in my own experience—of a lion's doing so. RICHARD CRAWSHAY.

Neugia, Kitwi, British East Africa, February 6.

Precipitation of Gold by Charcoal.

IN your "Notes" this week, the use of charcoal as a precipitant for gold from solutions is mentioned as being pretty largely applied in Australia, and that the cause of precipitation is not understood.

I venture to put it this way: that by some process, accelerated no doubt by surrounding physical changes, there is formed within the charcoal carbon *mon*oxide (and also carbon dioxide), which is a precipitant for gold. The difficulty of ridding charcoal of oxygen without chemical combination is well known.

I may mention that I am now using carbon monoxide as an industrial precipitating agent in gold-winning.

JAMES C. RICHARDSON.

19 Claremont Square, London, March 29.

IT is an old idea that carbon monoxide is the real agent in the precipitation of gold from solutions of the chloride by means of charcoal. An objection to Mr. Richardson's suggestion, that the same view may be taken in the case of cyanide solutions, lies in the fact that, according to my own experiments, carbon monoxide does not appear to precipitate gold under ordinary conditions from these solutions.

The main objection, however, to all the theories put forward to account for the precipitation of gold by charcoal is that they are not supported by the results of any published experiments.

THE WRITER OF THE NOTE.

Instincts of Wasps.

PERHAPS it may interest your reviewer of Dr. and Mrs. Peckham's work "On the Instincts and Habits of the Solitary Wasps," to learn that one of the main results in question has been already arrived at in a paper by the late Prof. Schiff, of Geneva, in *Mémoires de la Soc. de Physique et d'Histoire naturelle de Genève*, vol. xxviii., 1882-3. I quote the following passage, as in some way complementary to the observations of Dr. Peckham:

"D'ailleurs, un examen microscopique approfondi du système, nerveux des animaux intoxiqués par les guêpes n'a pas revélé la moindre lésion dans les nerfs et les ganglions de ces animaux."

Freiburg, Badenia, March 18. DAVID WETTERHAN.

CORUNDUM AND ITS USES.[1]

THE three works cited below give much new and valuable information concerning the mode of occurrence, the processes of mining, and the uses of corundum. As the mineral is of growing economic value, and is every day finding fresh applications in the arts, it seems desirable to call attention to some of the facts which are for the first time made accessible to the public in these works. We may exclude from view, for our present purposes, the clear and brightly coloured varieties of corundum, so much prized as gem-stones (ruby, sapphire, &c.), and also the composite material known as emery. The latter substance should be regarded not as a mineral, but as a rock—one in which the mineral corundum is a predominant constituent, though always mixed with magnetite, tourmaline, and many other minerals.

Among the works of which the titles are given below, precedence may be fairly conceded to that which deals with Indian corundum. Corundum is a distinctively Indian mineral; its name is of Indian origin, and its recognition as a distinct mineral species was the result of the study of Indian specimens. The plan, now adopted by the Director of the Geological Survey of India, of republishing the "Manual of Economic Geology" in a series of separate memoirs, each dealing with a particular mineral, or group of minerals, is one which must commend itself to every one as being calculated to furnish us with the most complete and exact information from the pens of the best qualified authorities. It is fortunate that the writing of the memoir on corundum has fallen into the hands of so competent a mineralogist and geologist as Mr. Holland.

The first nine pages of the memoir are devoted to a condensed, but very clear and exact, account of the mineralogical characters of corundum. The next ten pages contain an admirable discussion of the geological relations of corundum. Mr. Holland's studies of the famous corundum-yielding rocks of Southern India have furnished him with much fresh material bearing on the mode of occurrence and association of the mineral. In the work before us only a brief sketch can be given of these, and of the theoretical questions upon which they throw much new light. It is to be hoped that the present short memoir will be followed by detailed accounts of the geology of Salem and other districts in Southern India, where Mr. Holland and several of his colleagues have had the opportunity of re-examining the rocks made known to us by the travels of Leschenault de la Tour, and the petrographical researches of Prof. Lacroix.

The larger portion of the memoir is occupied by detailed accounts of the exact distribution of corundum throughout the Indian Empire, and a discussion of the uses of corundum. In this latter part of the work much valuable information, carefully collected from a number of trustworthy sources, has been brought together; and the reader cannot fail to find much that is new, and also has important bearings on the economic uses and the manufacture of the various varieties of corundum as known in the markets of the world.

While the corundum of India has been sought for from the earliest times for use in grinding gems, and other purposes in which abrasive materials of the greatest hardness are required, the rich deposits of the same mineral in the Eastern United States have only been worked for similar purposes during the last twenty years.

[1] "A Manual of the Geology of India.—Economic Geology." By the late Prof. V. Ball, C.B., LL.D., F.R.S. Second edition revised in parts. Part I. Corundum. By T. H. Holland, A.R.C.S., F.G.S. (Calcutta, 1898.)

"Mineral Resources of the United States: Seventeenth Annual Report of the U.S. Geological Survey: Corundum Deposits of the Southern Appalachian Regions." By J. A. Holmes. (Washington, D.C., 1896.)

"Economic Geology of Eastern Ontario: Corundum and other Minerals." By Willet G. Miller. Report of the Bureau of Mines. Vol. vii. Pl. 3. (Toronto, 1898.)

Corundum deposits are known to occur all along the southern flanks of the Appalachian Chain, from the State of New York to that of Alabama, but it is in only a few localities, principally in North Carolina and Georgia, that the corundum has been extracted on any considerable scale. In 1871 attention was first drawn to the deposits in North Carolina as a possible source of gems, and in 1878 mining operations were commenced to extract the abundant corundum of the district as an abrasive material. A great deal of secrecy has been maintained respecting the nature and extent of the corundum industry in the United States; but there appears to be no doubt that since 1878 a steady increase in the output of the corundum mines has been maintained.

The discovery of valuable deposits of corundum in the third of the localities noticed above, that of British Ontario, dates only from 1896. But already there seems to be promise that the counties of Hastings, Renfrew and Peterborough in Eastern Ontario, may, at no distant date, yield large supplies of corundum to the manufacturer.

The Indian corundum is usually found among the gneissose and schistose rocks; the exact conditions under which the mineral makes its appearance will be better understood when the investigations, upon which Mr. Holland has been engaged for some years, are fully published. He has already shown that in some cases the corundum is found in connection with nepheline-bearing rocks, and a precisely similar association has been demonstrated for the corundiferous deposits of Eastern Ontario. The corundum of the Appalachian belt of the United States, however, as shown by Dr. J. H. Pratt, would appear in all cases to occur in the Peridotites (Dunites, Serpentine, &c.), which are intrusive in crystalline schists, and especially in the zones of contact on the outer limits of those intrusive masses.

Corundum, the crystallised oxide of aluminium, has been prized from the earliest times on account of its hardness—which exceeds that of all other natural substances, with the exception of the diamond. In India, blocks of corundum and fragments mounted in tools have been used for grinding, perforating and engraving gems. For general abrasive purposes elsewhere, the rock emery (especially that of Naxos and the adjoining islands and mainland of Asia Minor) has long been preferred to corundum itself. The reason of this is that although emery has a far less "effective hardness," or power of abrading hard materials, than pure corundum, yet the ease with which it can be reduced to powder greatly facilitates its use.

Pure corundum, when freed from its adhering matrix of softer materials (mica, chlorite, &c.), is crushed between rollers and sifted, the "corundum sand" thus formed having far more abrasive power than crushed emery. The chief use of corundum sand is for making corundum wheels; the cementing materials employed in making these wheels seem to be very varied. Shellac alone, or with the so-called "oxidised linseed oil," is one of the commonest materials employed, as in the so-called "red wheels." Silicate of soda is employed in the "silicate wheels," and india-rubber and other substances in the "vulcanite" or "black wheels"; while the cementing material in the "union wheel" is oxychloride of magnesia, and in the "tanite wheel" some form of a so-called "solution of leather," the process of manufacture being kept secret.

Pure corundum wheels are said to be at least twice as effective and durable as emery wheels. Corundum wheels are made in India, with the lac-resin as the cementing material.

Emery and corundum wheels may be regarded as rotary files, whose cutting points never grow dull. They are rapidly replacing files for cutting down metal surfaces, and taking the place of grindstones for sharpening tools. The corundum grains throughout the wheel retain their cutting power, so that it can be worked until quite 90 per cent. of its weight has been worn off, while a file is useless before it has lost 5 per cent. of its weight. It has been estimated that to remove one pound weight of iron with a file costs 2*s.* 6*d.*, while the same amount of work can be done with an emery or corundum wheel in about one-eighth of the time and at one-seventh of the cost. Compared with grindstones in grinding tools, experiments by some English firms show that the cost of the emery wheel is about one-fifth, and the time only one-half of that required by the use of the old grindstone, and at the same time the danger of bursting during rapid revolution, which is such a common accident with the latter tool, is practically abolished.

The corundum wheel is said to be twice as effective as the emery wheel, while its cost is only 15 per cent. more.

It will be seen from these statements that there cannot fail to be a great future for wheels made from corundum and similar materials.

As is pointed out by Mr. Holland, corundum is the richest ore of the valuable metal aluminium. So long, however, as abundant supplies of bauxite (impure hydrated oxides of aluminium) can be obtained, it is scarcely likely that the hard and intractable corundum will be used for the extraction of the metal. The time may, however, come when such a use will be made of the material, which is now almost wholly sought for abrasive purposes.

MULTIPLE VISION.

IT is well known that, owing to what is termed irregular astigmatism, a small bright object, for which the eye is not accommodated, often presents a multiform appearance, the number of separate images perceived varying in different cases from about six to fifteen.

Irregular astigmatism, to which every one is in some degree a victim, can be easily demonstrated in the following manner. With the point of a fine needle a very small hole is pricked in a sheet of tin-foil; this is held up to the light, and the hole is looked at with one eye, the other being closed. Even at the distance of most distinct vision—ten inches, or thereabouts—there will probably be a ragged appearance about the perforation, as if it were not perfectly round. But if the tin-foil be brought an inch or two nearer to the eye, the perforation will not seem to be even approximately circular; it will generally assume the form of a little star with six or more pointed rays. The form of the star is not often the same for the right eye as for the left; but if several holes be pricked in the tin-foil, all the stars as seen by the same eye will appear to be formed after the same model, though some may be larger or brighter than others.

If the luminosity of the source of light is sufficiently diminished by screening with a coloured glass, or otherwise, the star will be seen to consist of several distinct images of the hole superposed upon an irregular nebulous patch. Seven such images can generally be perceived—a central one surrounded by six others, but sometimes there may be more. This and other allied phenomena exhibited by a healthy eye are commonly attributed to the fact that the crystalline lens is composed of several sections connected by radial sutures, six or more in number, which occur upon the two surfaces of the lens.

Some observations described in a recent communication to the Royal Society (*Proc. Roy. Soc.*, January 1899) indicate that under certain conditions the number of independent images due to a single luminous point is far greater than could be accounted for in this way; there may, in fact, be several hundreds, and their formation probably arises from the cellular structure of the transparent media of the eye.