dure, involving the removal of paraffin and the running of the slides down the graded alcohols to water. A slide is then flooded with a few drops of mordant, used full strength. After five minutes the slide is rinsed for a few seconds in tap water and flooded with ready stain. Staining begins at once and is complete in ten minutes or less. After rinsing the slide is differentiated in 0.1 to 0.4 per cent. hydrochloric acid in water. When differentiation has reached the desired point the slide is transferred without rinsing to a jar of water containing one or two drops of ammonium hydroxide. As soon as the blue color has appeared in the sections the slide is removed, counterstained with erythrosin, passed up the graded alcohols to xylol and mounted in balsam. The final mount shows nuclear material in deep blue and cytoplasmic material in pink. The results are comparable to those obtained with the use of Delafield's haematoxylin, followed by erythrosin.

The color of the ready stain gives a clue as to the color of the nuclear material in the final preparation. Freshly prepared aqueous ready stain is deep purple in color, with a strong tint of blue. It will stain nuclear material a deep blue. After about an hour the ready stain has lost most of its blue tint and is a red orange in color. It will then stain nuclear material a bluish black. Still older stain will give a black nuclear stain. In other words, as oxidation of the ready stain proceeds the color changes from brilliant blue-purple to purple to orange-red to orange brown, and the color of the nuclear stain secured progresses from brilliant blue to blue-black to black. When the stain has reached the orange brown stage its staining power is largely gone and its use will give an undesirable yellow-brown nuclear staining but little stronger than the color imparted to the cytoplasm. The black nuclear stain resulting from the use of the orange-red ready stain is comparable to that secured by the use of Heidenhain's iron haematoxylin.

The ammonium hydroxide used as a "bluing" agent has the most powerful action on the color of sections stained with fresh stain, and least with those stained with the old stain. While there is a considerable amount of haematoxylin dissolved in the ammonia of the ready stain the nuclear stain resulting will be distinctly blue; as more and more of the haematoxylin becomes converted into haemateïn-ammonia and further oxidation products the resulting nuclear stain tends more and more toward black.

The best way to secure a blue nuclear stain is to use a freshly prepared ready stain. If an aqueous one, it should be used for this purpose within a half hour; if an alcoholic solution, within eight or ten hours. There are several ways in which to secure a black nuclear stain. First, use old ready stains; second, add two or three drops of ammonia in the preparation of the ready stain; third, flood slides with either fresh or old ready stain, and add a drop of dilute ammonium hydroxide to each slide. In any case the desired results will have been secured when the stain flooded on the slide has become orange brown in color. Contrary to expectations, the use of ammonium hydroxide as described in these three variations does not appear to injure the tissues. The third method is, perhaps, the easiest and best. As soon as the flooded stain has become orange brown in color the slide may be rinsed in tap water, counterstained, dehydrated, cleared and mounted in balsam. It must be admitted that there is still some question as to the permanence of the stain, but a number of slides stained by the methods given above show no signs of fading, although exposed for several months to ordinary daylight. Further study is being made along these lines and results will be reported at the appropriate time.

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SPECIAL ARTICLES

THE EFFECT OF PRESSURE ON THE MAGNETIZATION OF MAGNETITE

AMONG the interesting properties of magnetite, $FeO.Fe_2O_3$, is that of being oxidizable to Fe_2O_3 without loss of its ferro-magnetism and without a change in its cubic crystal structure. A closer study of this phenomenon and of hysteresis in magnetite reveals the following three facts which clearly suggest that hydrostatic pressure should increase the permeability:

(1) Magnetite oxidized to Fe_2O_3 is even more magnetic than before oxidation.[1] In one sample the maximum permeability increased 16 per cent. and the position of the maximum was shifted from a magnetizing field of 85 to 65 gausses.

(2) On annealing magnetite at 1000° C. the permeability maximum is shifted from 85 gausses to about 350.[2] Since annealing implies the removal of strains, the shift from 85 gausses to 65 produced by oxidation means that any existing strains were then increased.

(3) A consideration of the inter-atomic distances in magnetite[3] shows that the free unoccupied radial distance is 0.55Å, whereas the oxygen radius is usually found to be 0.65Å. The oxygen which enters on oxida-

[1] *Phil. Mag.*, 1925, 1, 403.
[2] *Phil. Mag.*, in press.
[3] *Phil. Mag.*, 1925, 1, 406.

tion, therefore, fits in rather tightly and acts in such a way as to compress the structure.

Through the courtesy of the physics department of Cornell University I was enabled, during a brief stay there the past summer, to study the effect of pressure on magnetization. The magnetite tested was of the variety lodestone from Alameda County, California, and was used in the form of a cylinder 3.3 cm long and of 1.1 cm diameter cut approximately parallel to the original direction of magnetization. It was demagnetized in a gradually decreasing alternating field. It appears from the magnetometer readings that the specimen was still "biased," since they are not symmetrical about the zero.

The pressure chamber was a cylinder of manganese bronze. The lower part of an axial hole was just large enough to accommodate the specimen contained in a thin brass cup to facilitate handling. The upper part of the hole was of 1.9 cm (three quarter inch) diameter. Into this was fitted a manganese bronze plunger, the clearance allowed being one one thousandth inch. The compression fluid used was a motor oil of the grade "extra heavy." A hydraulic press forced the plunger into the oil. Owing to the high viscosity the leak of oil past the plunger was slow and it was not difficult to reach the desired pressure. The chamber was wound with a magnetizing coil along practically its entire length. The field as calculated by the solenoid formula requires correction for the increase due to the iron of the press. It was found to be 6.1 per cent. and is included in the fields recorded.

The data obtained pertain only to the permanent magnetism. The procedure adopted when the effect of pressure was sought was to leave the magnetizing field on while the pressure was brought to the desired value and then back to atmospheric pressure. A United States engineers' compass was used as a magnetometer. The deflections were small enough so that the moments are considered to be proportional to the angles themselves.

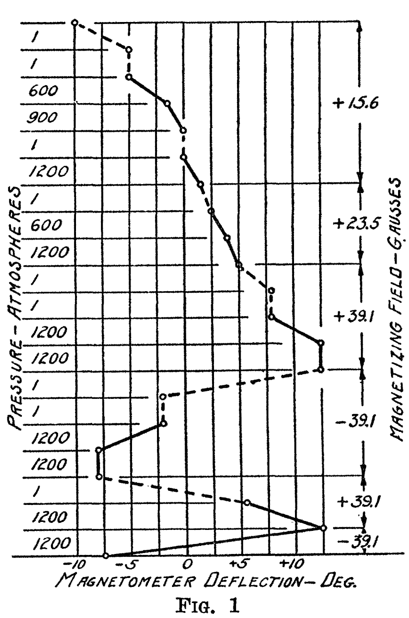

FIG. 1

A typical set of observations is shown in Fig. 1. Reading downward, each step represents an operation, with the field shown on the right at the pressure indicated on the left. Operations carried out at atmospheric pressure are indicated by broken lines. The deflections are magnetometer readings after the indicated operation. The qualitative nature of the effect is brought out in the upper part of the figure. The three complete reversals shown in the lower part give us a quantitative measure at that particular magnetizing field and pressure. It is, evidently, either of the ratios

$$\frac{\Delta\,\theta_{p\,=\,1200}}{\Delta\,\theta_{p\,=\,1}} \text{ or } \frac{\Delta\,\theta_{p\,=\,1} + \Delta\,\theta_{p\,=\,1200}}{\Delta\,\theta_{p\,=\,1}}$$

since we may perform the reversal directly at the higher pressure or we may perform part of it at atmospheric pressure and then the remainder at the high pressure. The three reversals shown in the figure give for the ratio the average value 1.45. A similar and more extended series of observations contains four complete reversals and yields as an average

$$\frac{\Delta\,\theta_{p\,=\,1200}}{\Delta\,\theta_{p\,=\,1}} = 1.51.$$

We may, then, state the results in the form: At a pressure of 1,200 atmospheres and with a magnetizing field of 39.1 gausses the change of magnetic moment in magnetite is from 45 to 51 per cent. greater than the corresponding change at atmospheric pressure.

Pressures exceeding 1,200 atmospheres could not be reached with the bronze plunger on account of the danger that it would swell permanently and stick in the hole. A steel plunger was then made and a pressure of 1,900 atmospheres was reached. At that pressure the chamber stretched and began to leak around the plunger. The steel plunger increased the magnetizing field by an unknown amount and the results are not free from the additional objection that the steel's disturbing influence on the field might depend on the pressure.

A series of observations made while using the steel plunger contains three reversals and the average ratio at 1,900 atmospheres was

$$\frac{\Delta\,\theta_{p\,=\,1900}}{\Delta\,\theta_{p\,=\,1}} = 2.3.$$

It should be pointed out that these ratios are in the nature of minimum values and that the true effect of pressure on the permanent magnetization is really greater. The reason is that the specimen was short, with a large demagnetizing factor which interfered with the full development of the pressure effect. It should also be stated that the effect of pressure on the temporary magnetization should be relatively greater since it is known from our work on artificial magnetite[4] that strains of the compression type decrease the remanence.

The bearing of the present results on the general problem of ferro-magnetism is not clear. It is in their relations to other questions that they are of interest. First is the question of the origin of lodestone. It is manifestly impossible to imagine any magnetizing field of natural origin sufficiently large to give to lodestone its marked magnetic moment.[5] Unless one assumes some entirely unfamiliar process of magnetization one is forced to admit that the magnetic characteristics of magnetite are enormously magnified under pressure and, perhaps, temperature conditions such as found at great depths. The results herein described scarcely do more than show that the pressure effect is of the required sign. They represent a mere beginning in the attainment of the desired result, as is shown by the fact that the original natural moment of the specimen employed was 130 times the moment observed after magnetizing with a field of 39.1 gausses at 1,200 atmospheres pressure.

The other question is that of the contribution of the earth's material to its magnetic field. Much of the earth's crust is iron oxide. More specifically,[6] six per cent. of the outer ten miles is made up of the oxides of iron in their various forms. It is evident, if this material plays any part whatever in the earth's magnetic phenomena, that the contribution is larger than one would suppose from a study of magnetite under ordinary conditions. In any event, local magnetic anomalies which are known to be due to deposits of iron ore appear in an exaggerated form.

Several lines of research suggest themselves here. It would be interesting to see if the pressure effect is itself a function of the temperature. It would be of particular importance to learn if the critical temperature of magnetization is increased by pressure, not only in magnetite but in iron and nickel as well. It is strange, indeed, often as the suggestion has been made in the literature of the earth's magnetism, that no experiments in this direction have yet been made. Perhaps the difficulty of the large demagnetizing factor for a spherical body like the earth is considered to be so decisive and so insurmountable that a study of earth materials, under pressures and temperatures approaching as far as possible those existing in the earth, would be of no value to our knowledge of terrestrial magnetism.

Finally, it may be suggested that the property of magnetite herein described might be used, in principle at least, as a high pressure gauge.

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September 27, 1926

[4] *Phil. Mag.*, in press.

[5] Since writing this article it has occurred to me that such a field would exist in the neighborhood of a lightning flash. On looking through the literature I find that Pockels made use of this fact to measure the maximum current during the discharge. See *Phys. Zeit.*, 1901, II, 306 and III, 22.

[6] Proc. Nat. Acad. Sci., 1920, vi, 592.

PRELIMINARY NOTE ON THE EGG AND LARVA OF THE AMERICAN EEL (ANGUILLA ROSTRATA)

Four eggs provisionally identified as those of the American eel, *Anguilla rostrata,* were taken while on the *Arcturus* Oceanographical Expedition on July 16, 1925. The catch was made on the edge of the Challenger Bank, a shoal about ten miles southwest of Bermuda (Lat. 32°02′N, Long. 65°00′W), in a Petersen trawl towed at five hundred fathoms below the surface. The depth increases very rapidly from the banks, a sounding made just before the trawl giving 505.7 fathoms, and one not long after 2,116 fathoms.

The eggs closely resembled those of the few species of eels and eel-like fishes which are known. They were highly transparent, colorless except for a slight yellowish tinge of the yolk, and measured 3.3 mm in outside diameter. No oil globules were present. They were further characterized by a very wide perivitelline space, the diameter of the yolk measuring 1.7 mm. A very early stage of development had been reached, for the germinal disc was defined without evidence of cleavage. As development progressed the posterior extension of the vesicular yolk into a narrow stalk below the intestine nearly to the region of the vent was typical of a muraenoid embryo.

After an incubation of approximately seven days a ribbon-shaped, transparent prelarva emerged. It was 9 mm long, colorless except for ocular pigment, and provided with three pairs of very large teeth in the upper jaw, and four pairs in the lower. The anterior upper teeth were enormous fangs. When the eel was living there appeared to be a very few black chromatophores on the caudal portion of the