General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Produced by the NASA Center for Aerospace Information (CASI)

RADIOACTIVE AND MAGNETIC INVESTIGATIONS

D. Heye and H. Beiersdorf

Translation of "Radioaktive und Magnetische Untersuchungen,"
Source unknown, pp 716-725 (without references)

1. Report No. NASA TM-75508	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle	5. Report Date
RADIOACTIVE AND MAGNETIC INVESTIGATIONS	JULY 1979
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
D. Heye and H. Beiersdorf	
	10. Work Unit No.

9. Performing Organization Name and Address	11. Contract or Grant No. NASw-3199
Leo Kanner Associates Redwood City, California 94063	13. Type of Report and Period Covered Translation

12. Sponsoring Agency Name and Address	
National Aeronautics and Space Administration, Washington, D.C. 20546	14. Sponsoring Agency Code

15. Supplementary Notes

Translation of "Radioaktive und Magnetische Untersuchungen," Source unknown, pp 716-725, (without references)

16. Abstract

The article concerns age determination and growth pattern determination of manganese nodules. Two methods are discussed: the first involves measurement of the presence of radioactive iodine isotopes, and is effective only up to $3 \cdot 10^5$ years. An attempt was made to measure the paleomagnetic effect in order to determine greater ages, but the particular approach pursued by the investigators evidently failed.

17. Key Words (Selected by Author(s))	18. Distribution Statement
	Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	14	

RADIOACTIVE AND MAGNETIC INVESTIGATIONS

D. Heye and H. Beiersdorf

Rate and Conditions of Growth in the Investigated Nodules

Radiation measurements were compiled and evaluated for five nodules (Figs. 1-3). Two of the nodules BP1 (Blake Plateau, Atlantic Ocean) and the nodule M1 (east of Madagascar, Indian Ocean) showed no heightened radioactivity near the surface. As was mentioned above, in such cases one assumes that the nodules have not grown for the last $3 \cdot 10^6$ years, or have even decreased in size. In the case of the nodule in the Blake Plateau, this result is in agreement with results of Ku and Broecker [1969], who came to the same conclusion for this region. The results for the other nodules will be discussed individually.

Nodule J1

This nodule is probably located in the central Pacific Ocean; similar nodules are known to exist there. (For competitive reasons, the corporations who own the rights to most of the useable nodules do not give their location with any greater precision.) It has grown around a core (Fig. 3) and has a maximum diameter of 6 cm. The nodule has a layered structure, and the individual lines are fairly easily distinguishable in cross sections of the nodule. The background radioactivity due to the presence of U and Th in the nodule is low, amounting to about 10 tracks/mm^2 per month.

The evaluation of data for regions 1-4 resulted in the determination of median growth velocities s = 10.7, 14.3, 4.0,

---

* Numbers in the margin indicate pagination in the foreign text.

and 15.1 mm/10^6 years, respectively (see also Table 1). It is apparent from a visual inspection of the growth lines on the investigated section surface that the nodules in regions 1 and 4 grew at approximately equal rates, in region 2 at a somewhat faster rate, and in region 3 at only about 1/3 of the rate of regions 1 and 4. If one now takes into account the possibility of error in the individual results of Table 1, then the relative relationship of the determined growth rates is in good agreement with the picture of the visible layer formation. For the various axes one thus arrives at various growth rates, and for the whole nodule one can extrapolate an age of about $(2.3\pm.3)\cdot10^6$ years.

Nodule H1d

This nodule from the Pacific Ocean also exhibits easily discernible growth lines, and grew around a large core. For the outer layers, one obtains the same growth rates for both region 1 and region 2, within allowable margins of error; this is in good agreement with visual observation. The median growth rate <u>/717</u> is s = 6.8 mm/10^6 years. For this nodule, one can extrapolate a total age of between 1.5 and 2 million years. In both regions, a varying degree of U or Th activity was noted.

Nodule G1d

This nodule also is located in the Pacific Ocean, and the visible growth lines suggest a complex growth history. One can clearly see that a smaller nodule grew into the structure a longer period of time ago (i.e. t > $3\cdot10^5$ years) and that one should expect evidence for a diversity of growth environments. The U <u>/720</u> and Th concentration also varies greatly throughout the nodule, and in comparison to the other nodules, is quite high (Figs. 1, 2 and Table 1).

In region 1, there was no difficulty with the evaluation of data, and a growth rate of s = 3.6 mm/10^6 years was ascer-

2
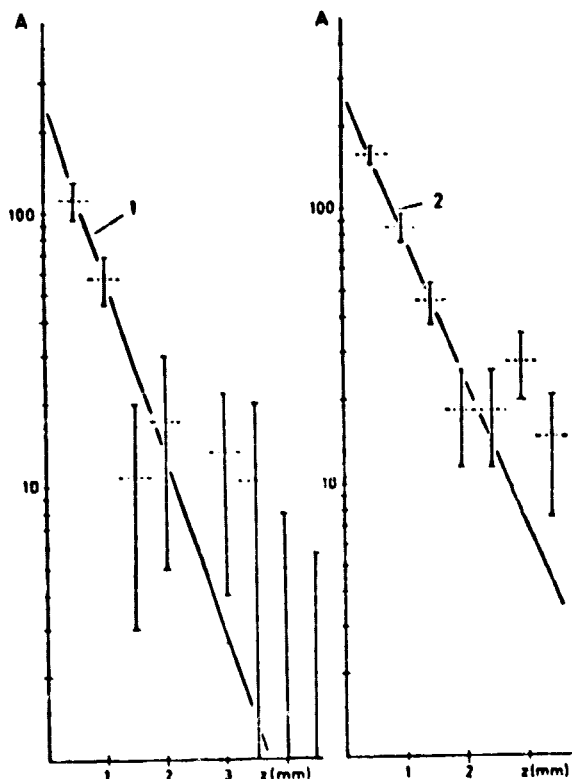
Figs. 5, 6, and 7: Corrected distribution of α-traces in the examined nodules as a function of the depth.

tained. For region 2, we suspect a possible change in the growth rate (the exterior 1.7 mm with s = 5.6 and then with s = 22 m/10^6 years). In the graphical approximation for background N_1(U, Th), these two lines remain invariant through several approximation steps. Based on the initial growth rate, the intersection of the two lines occurs at an age of $3 \cdot 10^5$ years, so that at this depth all but 6% of the Io must already have disintegrated. In this connection, the frequency of radioactive traces at greater depths of the nodule was also

3

taken into account, and this showed clearly the pure coincidence of this series of data points. Therefore only the value of s = 5.6 mm/10^6 years is valid.

For region 3, there were similar difficulties; it at first appeared that there was a change in the growth rate (slow on the outside, rapid on the inside). These two lines again remained invariant during the evaluation of the data, and therefore region 4 was introduced into the evaluation as a control. In evaluating the data for region 4, there was at first again the suspicion of a change in growth rates, but with opposite sequencing (fast on the outside, slow on the inside); but the second line disappeared upon successive approximations for N_1(U, Th). For region 4 then we conclude that there is a constant growth rate of s = 7.4 mm/10^6 years. But since regions 3 and 4 are directly adjacent, and the growth lines through both regions are sufficiently traceable, one should also assume constant growth for region 3. The calculation then yields a value s = 10.3 mm/10^6 years. On the whole, the varying results in the 4 evaluated regions confirm the observable differences within this nodule. Unfortunately, for large regions of the nodule the layer lines cannot be sufficiently well traced so as to enable one to read the relative growth rate changes off directly. Because of this irregular growth, it does not seem to make sense to extrapolate an over-all age for the nodule.

In summary, with these investigations it was possible to determine the growth rate of 3 out of 5 nodules with a relative error, in the most favorable case, of 7.3%. In these 3 cases, the surface of the nodule was recent, and the over-all age of the nodule could be extrapolated with an accuracy of better than 30%.

4

Magnetic Investigations of Manganese Nodules

As mentioned at the outset, the Io dating procedure for manganese nodules is only applicable up to a limit of about $3 \cdot 10^5$ years. Occasionally possible K/A age determinations in the core of the nodule, and Be/Al dating, which is feasible but requires great experimental effort, do not seem suitable as a general method for bridging this gap at greater ages. The goal /721 of the measurements that were conducted within the framework of this investigation then was to determine whether paleomagnetic reversals were observable in these manganese nodules, and useable for purposes of dating.

When these investigations were planned at the end of 1970, this question was completely unclarified. In addition, it remains an open question whether during the time of formation the nodules have always remained in the same position on the ocean floor, and whether therefore it is even possible for a magnetic polarity change to 'grow in' in a regular manner at all. In these investigations, correct results are obtained only if the assumption of constant position of the nodule is accurate. All that is known is that the nodules contain relatively large quantities of iron, and that the mineral Goethit has been found [Hering, 1971].

In addition, successful attempts have been made to extract meteorite particles from ground-up manganese nodules by means of a hand magnet [Finkelmann, 1970]. All of the to us available nodules were located in low latitudes, and it therefore made sense to investigate the horizontal magnetic components. Before artificial resin was poured around the nodules, their magnetic properties were measured, in order to determine, if possible, the north-south magnetic axis. Later, for purposes of magnetic investigation, an about 5 mm thick slice perpendicular to this axis was cut out of the nodule. That is,

the sliced was sawed so that any natural residual magnetism in the north-south direction would lie perpendicular to the plane of the slice.

Because of the low growth rate of the nodules, it became clear that the zones of varying magnetic polarity, if they are in fact present, are arranged in very fine layers, and therefore one should strive to develop a measuring procedure of high resolution.

Measuring Procedure for Magnetic Investigation

Within the confines of a magnetic shield, the nodule slice to be measured is placed between the sensors of a saturated core magnetometer, and the vertical field components are measured at numerous points. A photograph or diagram of the sample, with a pointer, positioned outside of the magnetic shield permits a precise orientation of the sensors with respect to the sample slice. The sensors and the pointer can be positioned at various heights, so that the entire surface of the slice can be measured (see Fig. 8). Because the measured values are very low (fields $< 10^{-6}$ Oersted), before and after each measurement the sensors were removed from the measuring region, and the zero setting checked. By means of Helmholtz coils, one can use this arrangement to undertake demagnetization by means of alternating fields, up to a maximum of 250 Oersted.

The two sensors of the saturated core magnetometer are arranged symmetrically about the sample at a distance of 2mm and are switched so that in this position a field measurement can be carried out. With this arrangement, only that component of the field that is perpendicular to the plane of the slice is measured. Magnetization components directed parallel to the plane of the slice are not measured, since the field component /722
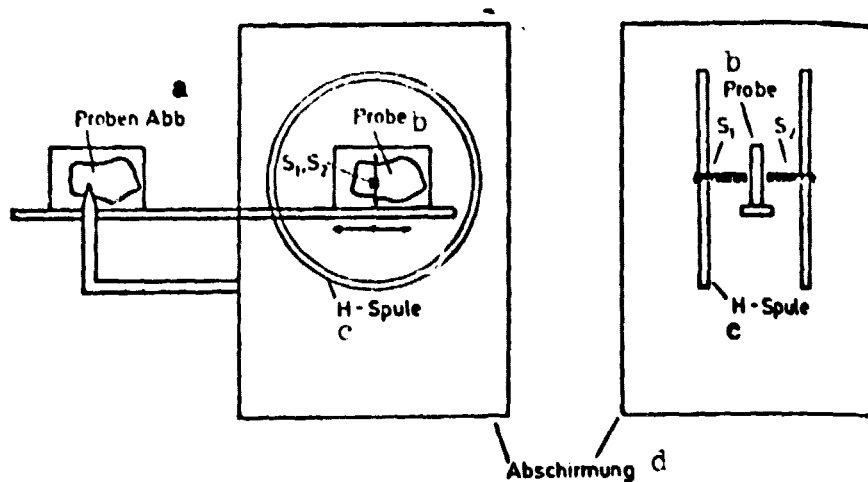
6

Fig. 8: Sketch of the magnetic measurement system for small slices of manganese nodules with the sensors S_1 and S_2, the sample and the Helmholtz coil system H.

Key: a diagram of sample   c H coil
      b sample   d shielding

since in this symmetric arrangement such field components act on each of the two sensors with the same magnitude but with opposite sign, and therefore cancel each other out. Even in cases in which there are inhomogeneities in such magnetization components, these can have an effect only if they disturb this symmetry. And even if this is the case, the disturbance remains small, because in such cases the nature of the maximal asymmetry from 2.5 mm (slice surface) to the medium measuring height of the sensors, about 20 mm, becomes a factor.

If in slices that are taken from manganese nodules the residual magnetism is not oriented precisely perpendicularly

7

to the plane of the slice, then the magnitude of the measured effect is merely lowered. The relation between the perpendicular magnetization components in the slice and the measured field remains the same, so that variations in magnetic intensity or polarity among the layers of the nodule lead to changes in the measured magnetic field at the appropriate points. If one neglects the degree of resolution possible with the measuring apparatus, one also obtains a one-to-one relationship in the opposite direction, that is, between the measured field changes /723 and the here relevant magnetization components.

These claims were subjected to scrutiny and substantiated by means of experiments with especially constructed control samples. These samples were made from pourable resin and fine iron filings, in a thickness of 5 mm, and were magnetized perpendicularly (and at other angles) to the surface to be measured. In the case of a wedge-shaped sample, for example, which was measured at points of various thicknesses, a resolution capacity (half value width) of 11 mm was determined (Fig. 9).

In simulations of regions of varying polarity, it can be   /724 seen that zones of a width greater than 6 cm register as changes in the polarity of the magnetic field, while smaller zones can be measured only as intensity changes. For nodules of low growth rate (s < 10 mm/10^6 years), this means that any zones of reversed polarity that might exist appear in the measurements not as a change in sign, but as a change in the intensity of the measured magnetic field. In order to conclusively resolve such cases, it has proven advisable to prepare and measure small samples of only a few millimeters in size.

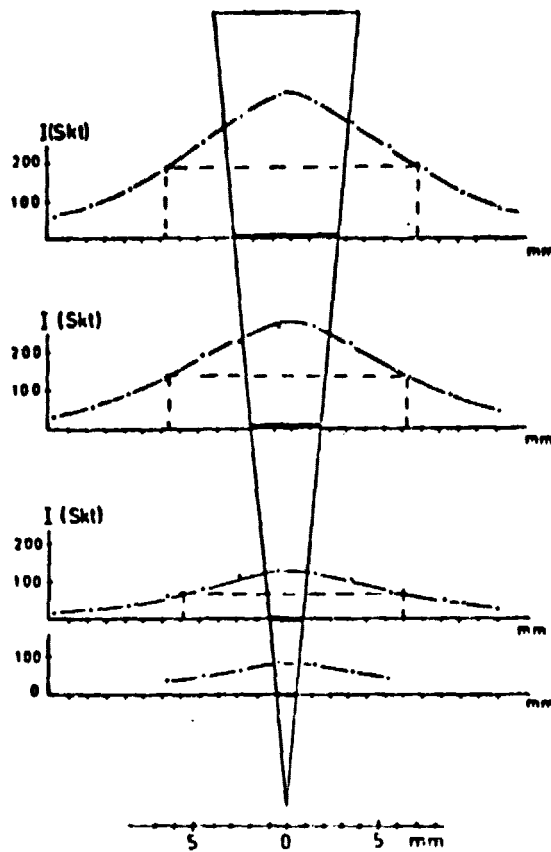By means of comparative measurements of synthetic samples

Fig. 9: Magnetic measurements of the perpendicular component at various positions over wedge-shaped sample in order to determine the resolving power. The sample was magnetized perpendicularly to the plane of the above diagram. (Thickness of the slices 5 mm)

inside and outside of the shielding, it was determined that at certain points there is considerable divergence between the measurements in the two cases, for example in the case of large plates, and at the edges of plates. The probable explanation is that the long measuring sensors, made of highly permeable material, apparently lead the field lines in part in

9

the direction of the shielding, where the lines close off. This does not affect the possibility of establishing a one-to-one relationship between residual magnetism and field changes, and vice versa, but a comparison with theoretical models is therefore not possible.

In this connection, it should be mentioned that for magnetic fields of varying gradients, as is always the case here, the medium measuring height in the long sensors of about 20 mm changes somewhat, and is in any case by no means constant.

Experimentally, measurements of the induced magnetization (relative susceptibility) were made for various nodules. For this purpose, a constant magnetic field was created by means of the Helmholtz coils. A more detailed description of these results will be omitted, since no changes were found within the investigated nodule slices.

Measurements of Residual Magnetism in Manganese Nodules

In addition to the five nodules whose radioactive properties were investigated, one additional nodule was measured. For three of these six nodules, the magnetic measurements yielded regions of varying sign; however, these could not be sensibly correlated to the growth pattern of the nodule. In the case of one nodule, the magnetization was so 'soft' that after demagnetization with an alternating field of 3 Oersteds, the sign change disappeared.

As an instance of these investigations, the results for nodule M1 are given. The nodule has a maximum diameter of 10 cm, grew around a stone splinter, and grew together with a smaller nodule. Fig. 10 represents the results diagrammatically, and it is clear that the regions of varying polarity
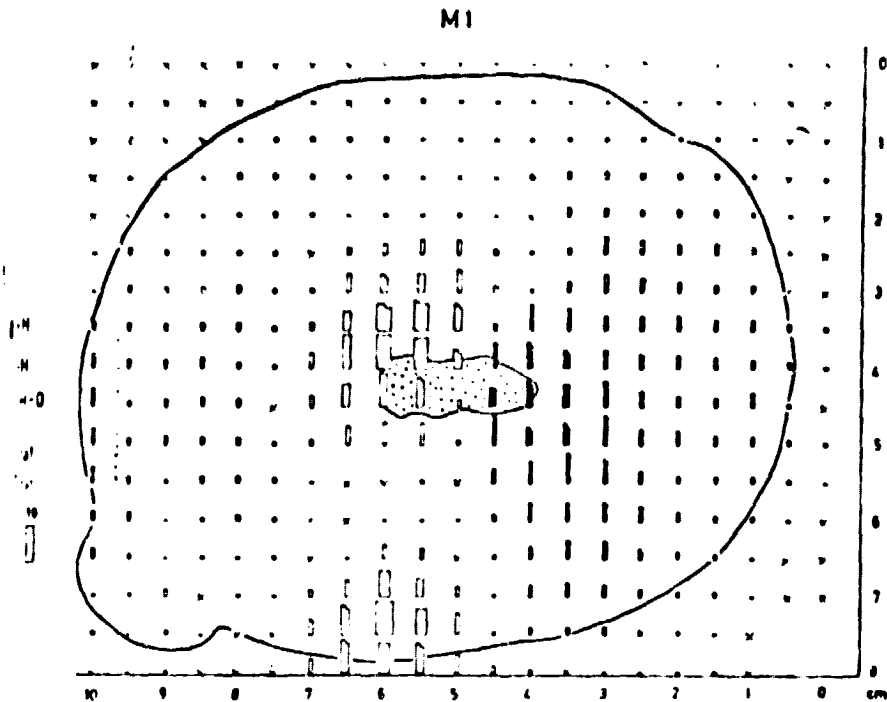
M1

Fig. 10:   Results of the magnetic measurements on a slice of
the manganese nodule M1. The intensities and the measured
changes of sign are represented.

are not centrally located. After demagnetization in an alter-
nating field, there was no fundamental change. A better rela-
tionship between regions of varying polarity and the direction
of growth did n⌐⁺ result.

In conclusion, the results of the magnetic investigations
of the manganese nodules indicate that the measured sign chan-
ges cannot be interpreted as paleomagnetic reversals. Further
investigations are planned in this direction, during which
other approaches will also be tried.

11