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AUTHORS: F. H. Brown

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UNIVERSITY OF UTAH SALT LAKE CITY, UTAH 84112

ATTEMPT AT PALEOMAGNETIC DATING OF OPAL, ROOSEVELT HOT SPRINGS KGRA

by

F. H. Brown

Introduction

One of the objectives of our research at Roosevelt Hot Springs KGRA was to drill a core in the Opal Dome for paleomagnetic investigation. This has been accomplished. The results of studying that core are reported here.

Description of the core:

The total length of the core drilled on the opal dome is 16.8 meters. Coring began just below 1.5 m. The first 7 meters consists dominantly of massive or banded opal with some clay interbeds, which become more abundant near the bottom of this section of the core. From 7 to 10 meters the core consists mainly of silicified sediment with minor opal layers. Below this to the bottom the core is made of cemented alluvium, either brown or light green, and varying considerably in its coherence. A detailed log is given in Figure 3.

Paleomagnetic work:

Initial investigation of the opal was done on three oriented blocks collected from surface outcrops of the opal. These blocks were cut into slabs and two adjacent sets of samples were cut from these slabs (Figure 1). The samples were numbered as follows. First a number was assigned to each slab, secondly a letter designation was applied to each set of samples within each slab and a final numerical designation was applied to each cube to designate its vertical position within the sample set. Thus 1N1 is from slab 1, north sample set, uppermost sample in the slab. Each sample was demagnetized at intervals of 50 gauss, and measured immediately following demagnetization. The results were plotted stratigraphically and the data from the two sample sets were compared. These results are set out in Figure 2.

There are two observations to be made about these data, and those are that while fidelity is not particularly good, the general forms of the two curves are quite similar, and thus are thought to record real variations in the geomagnetic field. Second, it should be noticed that while the inclinations remain positive for all samples the declinations make a vast swing to values near 180 degrees, and then return to more normal values. It appears that the variation is sytematic, more or less approximating a smooth curve. The possible significance of this is discussed below.

The samples from the core were labeled as follows. Each piece of core large enough to yield a sample was labeled with a number. If more than one sample could be derived from the piece of core a second number was applied. The smallest number in each set is nearest the top of the core. The largest number of cubes which could be cut from a single piece of core was ten. Table 1 lists the pieces of core along with the depth of each piece in centimeters, and the number of samples cut from each piece. The lithology of the core is described in Figure 3.

Paleomagnetic measurements were made on each of the samples cut from the core. Because of the close sample spacing, measurements were averaged for each piece of core. These are plotted in Figure 4. Because it was not possible to control the declination of the core, and because the core was so badly fragmented, only inclinations were considered. There is a marked difference in the scatter of measurements above about 5 meters, and below that depth, the upper part of the core having greater scatter than the lower. This corresponds roughly to the lithologic transition from the part of the core mainly composed of opal (upper) to the part of the core which has a greater admixture of detrital sediment.

There is a difference in demagnetization behavior within the samples which are predominantly opal. Those above about 3 meters have more stable magnetism than those between 3 and 5 meters. Typical demagnetization curves are shown in Figure 5. NRM intensities for the opal samples range from 6.11×10^{-6} gauss to about 1×10^{-7} gauss, the mean and standard deviation for 31 samples being $1.63 \pm 1.53 \times 10^{-6}$ gauss. The mode lies below 1×10^{-6} gauss as is shown in Figure 6.

One might reasonably ask what the carrier of the magnetism of the opal samples is mineralogically, but a satisfactory answer cannot be given. Because the coercivity of the magnetization is rather small, it is certain that hematite is not the dominant magnetic mineral. Detrital magnetite is a possible carrier, and the difference between the near surface opal and slightly deeper opal samples may be due to finer grained magnetite in the samples nearest the surface. It is also possible that an iron hydroxide such as geothite is partially responsible for the magnetism of the samples, as some of the opal has a yellowish brown cast.

Perhaps it should be pointed out that despite the relatively low intensity of the samples, they are often quite stable with regard to direction; more stable than was expected. Directional changes upon demagnetization are plotted for some samples in Figure 7. Declination is meaningful with respect to north for samples 1N1, 1N4, and 2S2 only. For the other samples, only relative changes in direction can be seen as declination was not controlled in the core. Samples 1N1, 1N4, 14-2, and 1-1 (core) are typical, and demonstrate that directional changes on demagnetization are in general small. Data for samples 2S2 and 31-9 are included to demonstrate that occasionally large changes in declination, inclination, or both are observed.

Chronologic interpretation of the paleomagnetic data:

At first sight, the only bit of geochronologic data that would appear to be forthcoming from the paleomagnetic results is that the opal was all deposited during the Brunhes epoch, that is during the last 690,000 years. This was expected, and may be considered confirmed by this study. It should also be noted that the alluvium underlying the opal is also of normal polarity, and as it is involved in the faulting along the dome fault, the dome fault was active more recently than 690,000 years.

One further bit of data regarding the time over which the opal was deposited is also present from the magnetic data without straining ones credulity too far. This is found in the great swing in both declination and inclination shown in Figure 2.

A number of magnetic excursions have occurred during the Brunhes Epoch, and these are as follows with their respective ages in years following the name of the excursion in parentheses: Biwa II (295,000), Biwa I (181,000), Blake (111,000), Mungo (30,000), and Laschamp (12,100). A further, poorly documented excursion may have taken place about 2800 years ago, and is tentatively named the Stärnö event by Noel and Tarling (1975).

It is felt that because the opal is banded, deposition of the opal took place under surface conditions, and was sequentially deposited, rather than deposited by volume precipitation. Thus increasing depth is correlated with increasing age of the opal. The changes in declination and inclination observed with depth from the block samples of opal are thus thought to record a series of magnetic directions at the site distributed in time.

Were we to correlate the change in declination and inclination with one of the known excursions (or events) listed above, we could set a minimum time for the activity of the deposition of opal on the Opal Dome. The best known, recent, well documented excursion is called the Laschamp event, and supposing that the correlation be made with this event sets a minimum time of ca. 12,000 years on the activity of the Roosevelt Geothermal system. There is, of course, the possibility that a later excursion took place locally, in which case the minimum estimate for the length of activity would have to be correspondingly shortened.

The duration of magnetic excursions is short, being approximately 1000-2000 years. Using these rough estimates, and noting that the excursion which is believed to have been recorded is confined to about 20 cm. of opal leads to an estimate of the rate of deposition of opal of about 1m/5000 years or 1m/10,000 years. Applying the slower rate to the observed thickness of opal (ca. 7m) results in an estimate of ca. 70,000 years for opal deposition on this part of the opal dome, although it may have taken only half that long. Even if the excursion is to be correlated with the Biwa II event, the length of activity on the opal dome would thus be confined to the last 350,000 years or so. The estimate is gross, but better than no estimate at all.

Figure Captions

Figure 1. Schematic drawing of opal block (left) and slab (right), showing the numbering system used.

Figure 2. Plot of declination and inclination measured in samples cut from blocks of opal. Open circles are for the north sample set; filled circles, for the south sample set. All samples demagnetized at 100 gauss.

Figure 3. Depth (left column), schematic lithology (center column) and piece numbers of the core drilled on the opal dome. Summary lithologic description is on right of column.

Figure 4. Inclination plotted vs. depth for the core drilled on the opal dome. Surface samples plotted at the top. The depth is exaggerated for these samples. All samples were demagnetized at 100 gauss. The vertical line at 56° is the theoretical site inclination for a centered dipolar field, and is provided for reference.

Figure 5. Demagnetization curves for shallow (A) and deeper opal (B).

Figure 6. Histogram of NRM intensities for 31 opal samples.

Figure 7. Directional changes in some opal samples with demagnetization.

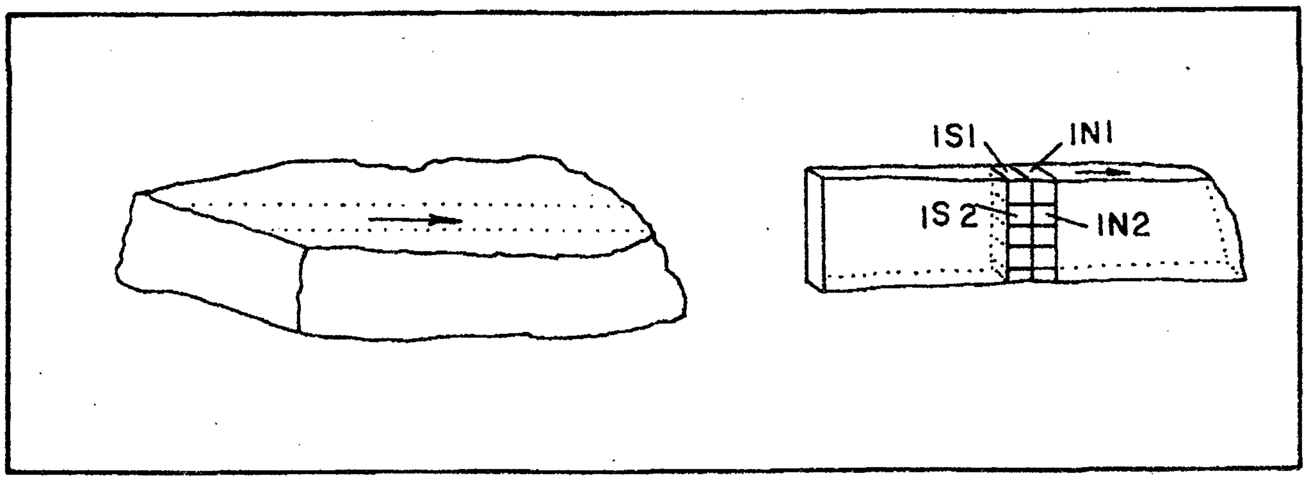
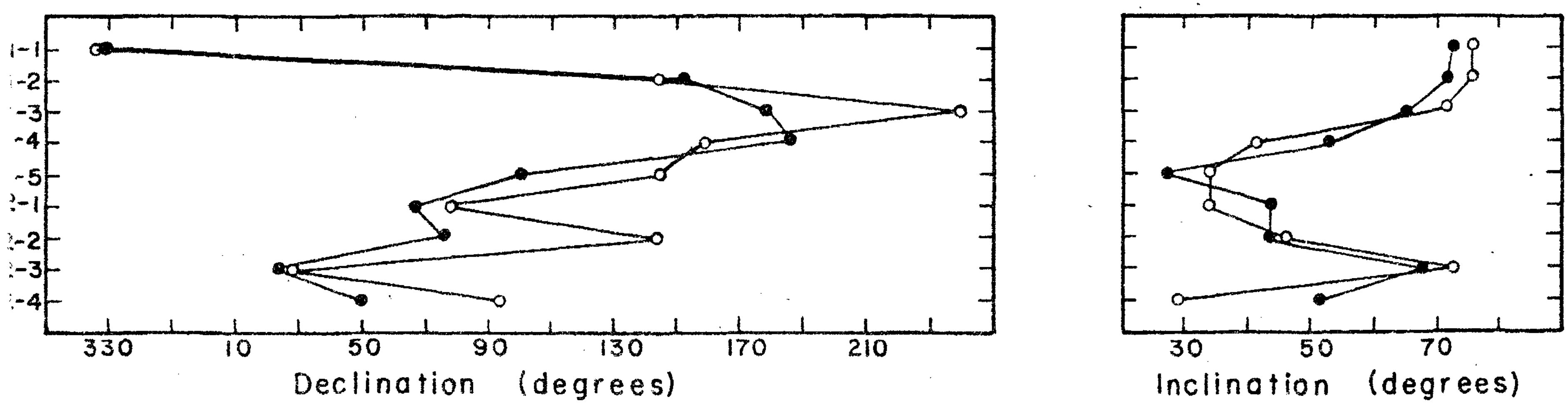


Figure 1



-1
-2
-3
-4
-5
-1
-2
-3
-4
330
10
50
90
130
170
210
Declination (degrees)
30
50
70
Inclination (degrees)

Figure 2

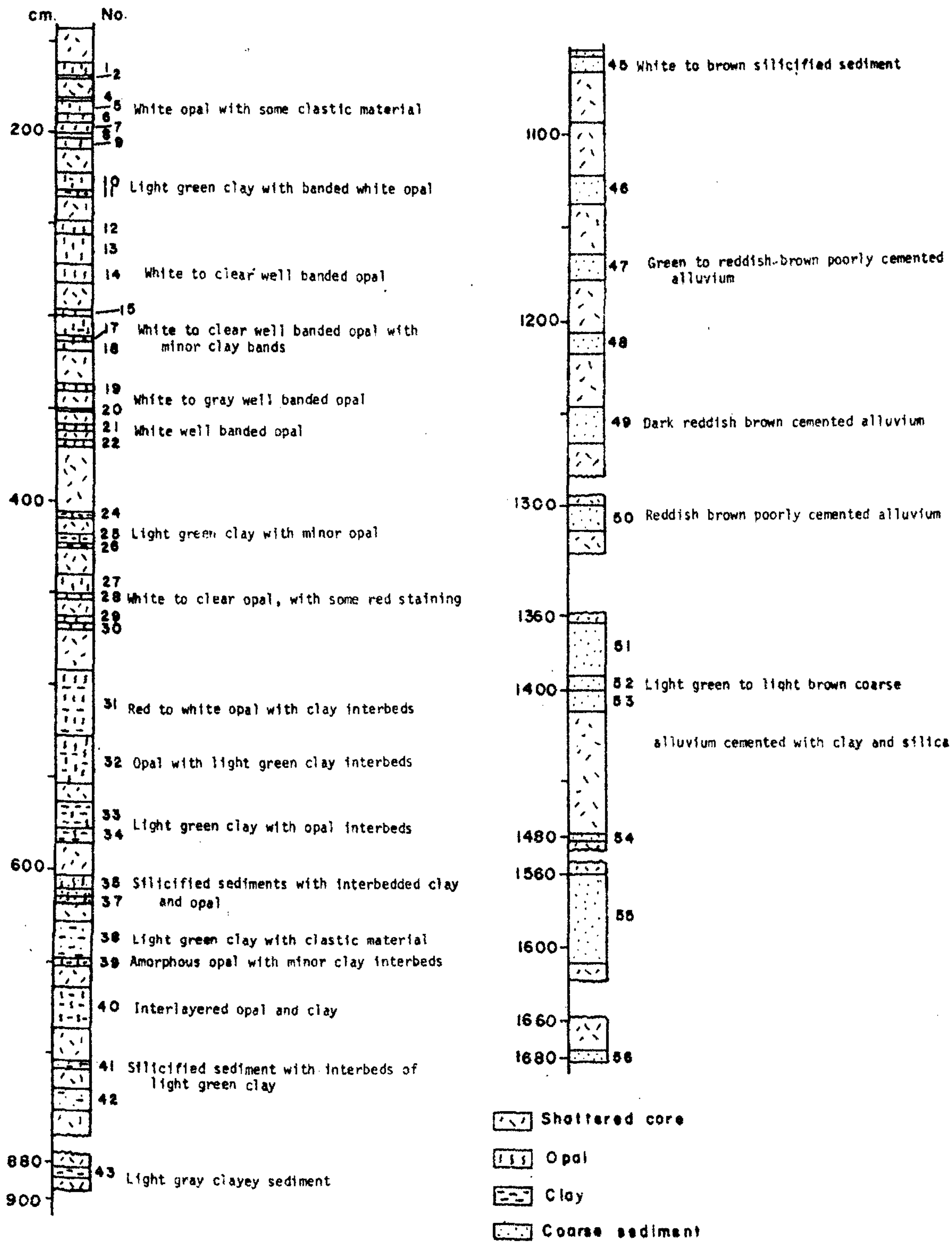

cm.
No.
White opal with some clastic material
Light green clay with banded white opal
White to clear well banded opal
White to clear well banded opal with minor clay bands
White to gray well banded opal
White well banded opal
Light green clay with minor opal
White to clear opal, with some red staining
Red to white opal with clay interbeds
Opal with light green clay interbeds
Light green clay with opal interbeds
Silicified sediments with interbedded clay and opal
Light green clay with clastic material
Amorphous opal with minor clay interbeds
Interlayered opal and clay
Silicified sediment with interbeds of light green clay
Light gray clayey sediment
White to brown silicified sediment
Green to reddish-brown poorly cemented alluvium
Dark reddish brown cemented alluvium
Reddish brown poorly cemented alluvium
Light green to light brown coarse alluvium cemented with clay and silica
Shattered core
Opal
Clay
Coarse sediment

Figure 3

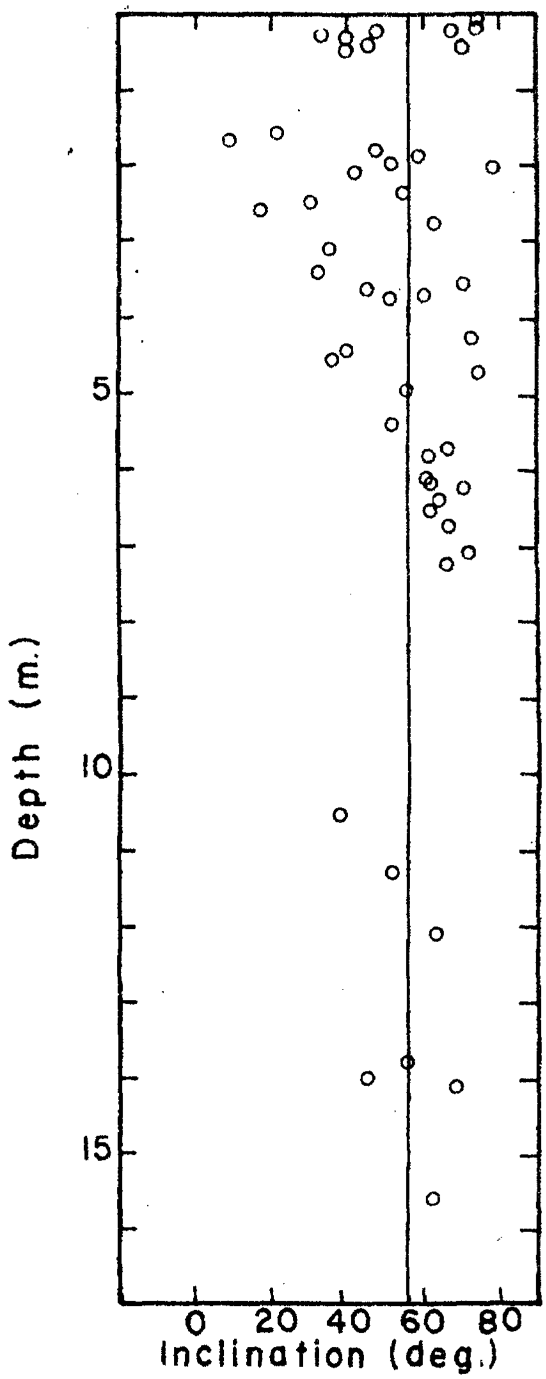


Figure 4

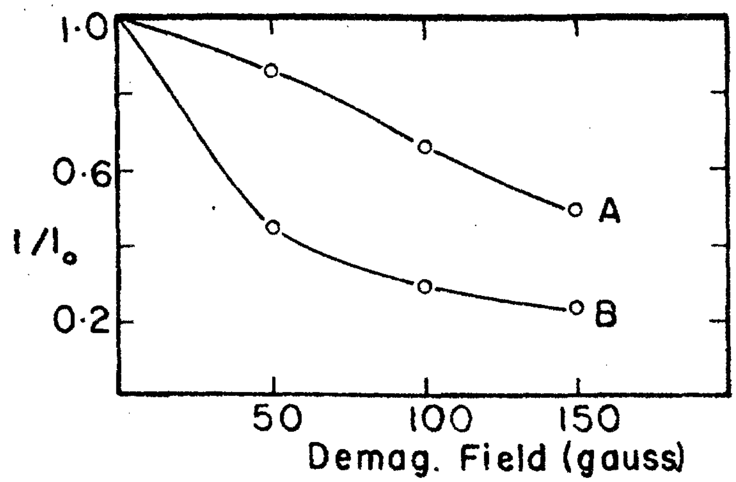


Figure 5

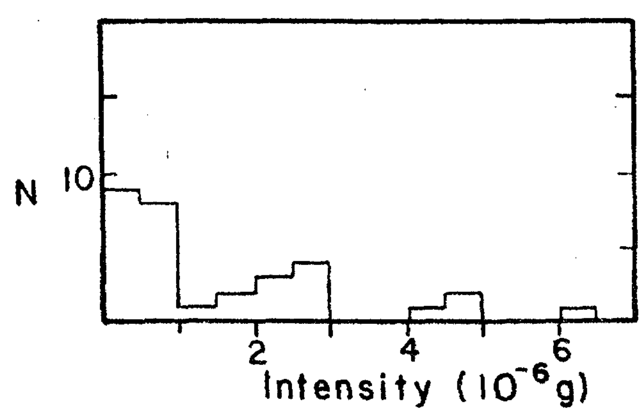


Figure 6

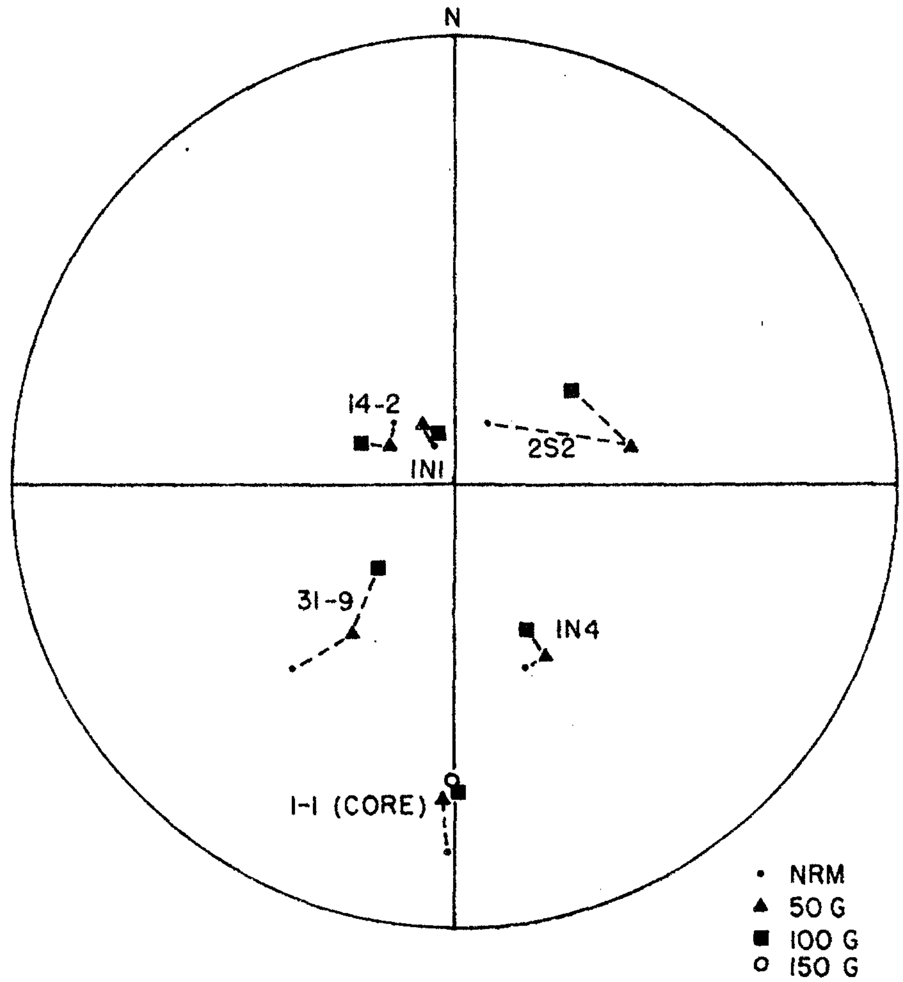


Figure 7

TABLE 1

Piece No.	Depth (cm)	# Samples	Piece No.	Depth (cm)	# Samples
1	161-169	3	29	464-467	0
2	169-171	1	30	467-471	1
4	181-182	1	31	494-528	8
5	182-191	3	32	528-554	6
6	191-195	2	33	564-578	4
7	195-201	1	34	578-586	1
8	201-204	1	35	604-611	2
9	204-210	1	36	611-615	1
10	224-233	0	37	615-619	1
11	233-236	1	38	629-648	6
12	249-256	2	39	648-652	1
13	256-273	3	40	664-687	6
14	273-284	3	41	704-709	1
15	297-300	1	42	721-732	5
16	300-311	0	43	884-889	0
17	311-312	0	44	1055-1058	1
18	312-318	2	45	1058-1066	0
19	337-341	2	46	1123-1137	1
20	351-354	1	47	1165-1180	0
21	359-362	1	48	1207-1218	2
22	368-370	1	49	1246-1266	0
23	370-371	1	50	1294-1314	0
24	406-409	0	51	1370-1393	10
25	419-424	0	52	1393-1401	3
26	424-427	1	53	1401-1412	5
27	442-452	3	54	1480-1482	1
28	452-454	1	55	1560-1608	7
			56	1676-1682	0