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Interpretation of Core and Well Log Physical Property Data from Drill Hole UPH-3 Stephenson County, Illinois

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Jeffrey J. Daniels, Gary R. Olhoeft, and James H. Scott
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Abstract

Laboratory and well log physical property measurements show variations in the mineralogy with depth in UPH-3. Gamma ray values generally decrease with depth in the drill hole, corresponding to a decrease in the felsic mineral components of the granite. Correspondingly, an increase with depth in mafic minerals in the granite is indicated by the magnetic susceptibility, and gamma ray measurements. These mineralogic changes indicated by the geophysical well logs support the hypothesis of fractionation during continuous crystalization of the intrusive penetrated by UPH-3.

Two fracture zones, and an altered zone within the granite penetrated by drill hole UPH-3 are defined by the physical property measurements. An abnormally low magnetic susceptibility response in the upper portion of the drill hole can be attributed to alteration of the rock adjacent to the sediments overlying the granite.

Fracture zones can be identified from the sonic velocity, neutron, and resistivity measurements. A fracture zone, characterized by low resistivity values and low neutron values, is present in the depth interval from 1150 to 1320 m. Low magnetic susceptibility and high gamma ray values indicate the presence of felsic-micaceous pegmatites within this fracture zone. An unfractured region present from a depth of 1380 m to the bottom of the hole is characterized by an absence of physical property variations. The magnetic susceptibility and gamma ray measurements indicate a change in the amount of mafic minerals at the base of this otherwise homogenous region of the drilled interval. Abrupt changes and repeated patterns of physical properties within the drill hole may represent interruptions in the crystalization process of the melt or they may be indicative of critical temperatures for specific mineral assemblages within the intrusive.

Introduction

Geophysicists often consider a granitic intrusive to be a fairly homogenous medium in terms of its physical properties, consequently they often assign constant values for various physical parameters of granite when surface geophysical measurements are interpreted over a granitic intrusive. However, the physical properties of granite reflect textural and mineralogical variations that depend upon the emplacement history and post-emplacement deformation of the rock. The literature on the physical properties of granite is primarily confined to tabulated values in various handbooks (Clark, 1966, Touloukian and others, 1981, Carmichael, 1982). These publications give a generalized view of the nature of the physical properties of granite, but do not provide insight into the relationship between the physical properties and associated variations in the mineralogy of the granite. Nowhere is a detailed interpretation of the physical properties of granite from geophysical well logs given.

Drill hole UPH-3 is located near Winslow, in Stephenson County, Illinois. The hole was cored to a depth of 1607 m, penetrating granite in the lower 944 m of the drill hole. The development history of the scientific investigations conducted in the drill hole have been described by Haimson and others (1980). Physical property information obtained from drill hole UPH-3 illustrates that detailed information on fracture zones, alteration zones, and geochemical variations can be obtained from a complete suite of geophysical well logs combined with laboratory analysis of the physical properties of the core.

Laboratory physical property measurements on 65 core samples from UPH-3 included specific gravity, dry bulk density, wet bulk density, magnetic susceptibility, resistivity, induced polarization (IP), and sonic velocity. Helium accessible porosity, water accessible porosity, and the total porosity of the samples were calculated from the density and specific gravity measurements (Daniels and others, 1982). Resistivity, gamma ray, neutron, IP, self potential (SP), magnetic susceptibility, gamma-gamma-density, sonic velocity, temperature, and nonlinear complex resistivity well log measurements were also made in drill hole UPH-3. The SP and temperature logs are not included in this discussion, but they have been presented in a previous report (Daniels, 1981a). The gamma ray, neutron, magnetic susceptibility,and gamma-gamma density were recorded digitally at 15 cm intervals, and the electrical measurements were recorded digitally at approximately 35 cm intervals.

Variations in Mineralogy

Variations in physical properties in UPH-3 can be divided into four distinct zones: (A) and upper altered zone, (B) a zone with moderate fracturing, (C) a zone of high fracturing, and (D) a zone of devoid fractures. Superimposed on these four zones is a general trend of physical property variations that reflect changes in the mineralogy of the granite body. The mineralogic variations are best illustrated by the gamma ray and magnetic susceptibility measurements shown in Figure 1.

Gamma ray well log measurements were made in UPH-3 using a total count scintillation detector. The probe measures the total gamma radiation emitted by the rocks surrounding the borehole, and does not discriminate between various energy levels (Pirson, 1963). The principle gamma ray emitting isotopes in UPH-3 are from the uranium and thorium decay series. Schulz (1981) found that the trace element distribution from 26 core samples indicated uranium content ranging from 15-70 ppm and thorium content ranging from 39-183 ppm in UPH-3. Uranium and thorium values measured by Rosholt (John Rosholt, U.S. Geological Survey, personal communication, October, 1981) are shown with the gamma ray well log in Figure 1, and show a general correspondence with the variations in the amplitude on the gamma ray log.

Each of the four zones (A-D) discussed previously are distinguished by a change in the gamma ray response. These zones represent variations in the uranium and thorium bearing minerals that are related to the grain size and mafic mineral content of the rock (where the term "mafic" refers to an increase in the ferromagnesian silicates; Hatch, 1973). Increases in some felsic mineral components (e.g., orthoclase, and muscovite) increase the potassium-40 content of the rock and also result in an increase in the gamma ray response, but the high gamma radiation from the uranium and thorium isotope series masks the smaller contribution from potassium-40. Fortunately, uranium and thorium are also assoicated with muscovite, resulting in an additional increase in the gamma ray response with increasing muscovite. Vitaliano and others (in this volume) noted a general increase in grain size with depth in UPH-3. Fine grained granite and micaceous pegmatites yield high gamma ray response values, while coarse grained rocks yield lower gamma ray response values. The gamma ray log and other logs indicate that some pegmatites are present that are not indicated on the field lithologic log shown in Figure 1. This discrepancy may be due to core loss.

A change with depth in the felsic mineral content of the drilled interval, shown by the gamma ray log, is supported by the magnetic susceptibility measurements in Figure 1. The magnetic susceptibility well logging probe has been described by Scott and others (1981). Magnetic susceptibility values for all rock types are a function of the grain size, grain distribution, and the amount of ferromagnetic minerals contained in the rock (Daniels and others 1981b; Hagstrum and others, 1980). Mineralogic analysis of core samples is not available to establish the relationship between the various characteristics of the magnetite and the magnetic susceptibility values in UPH-3. However, an interpretation that attributes an increase in magnetic susceptibility to increasing ferromagnesium minerals is consistent with the interpretation given previously for the gamma ray response values.

Inspection of the magnetic susceptibility log shows that the values for zone A are generally low, implying alteration of magnetite to maghemite or hematite. A sharp increase in magnetic susceptibility values at a depth of 735 m corresponds to the mafic concentration indicated on the lithology log. Intermediate values of magnetic susceptibility dominate the well log response in zone B. A mafic region at a depth of 910 m results in intermediate-to-high magnetic susceptiblity values, while the quartz pegmatite at a depth of 990 m has a low magnetic susceptibility response. The fractured and altered zone C

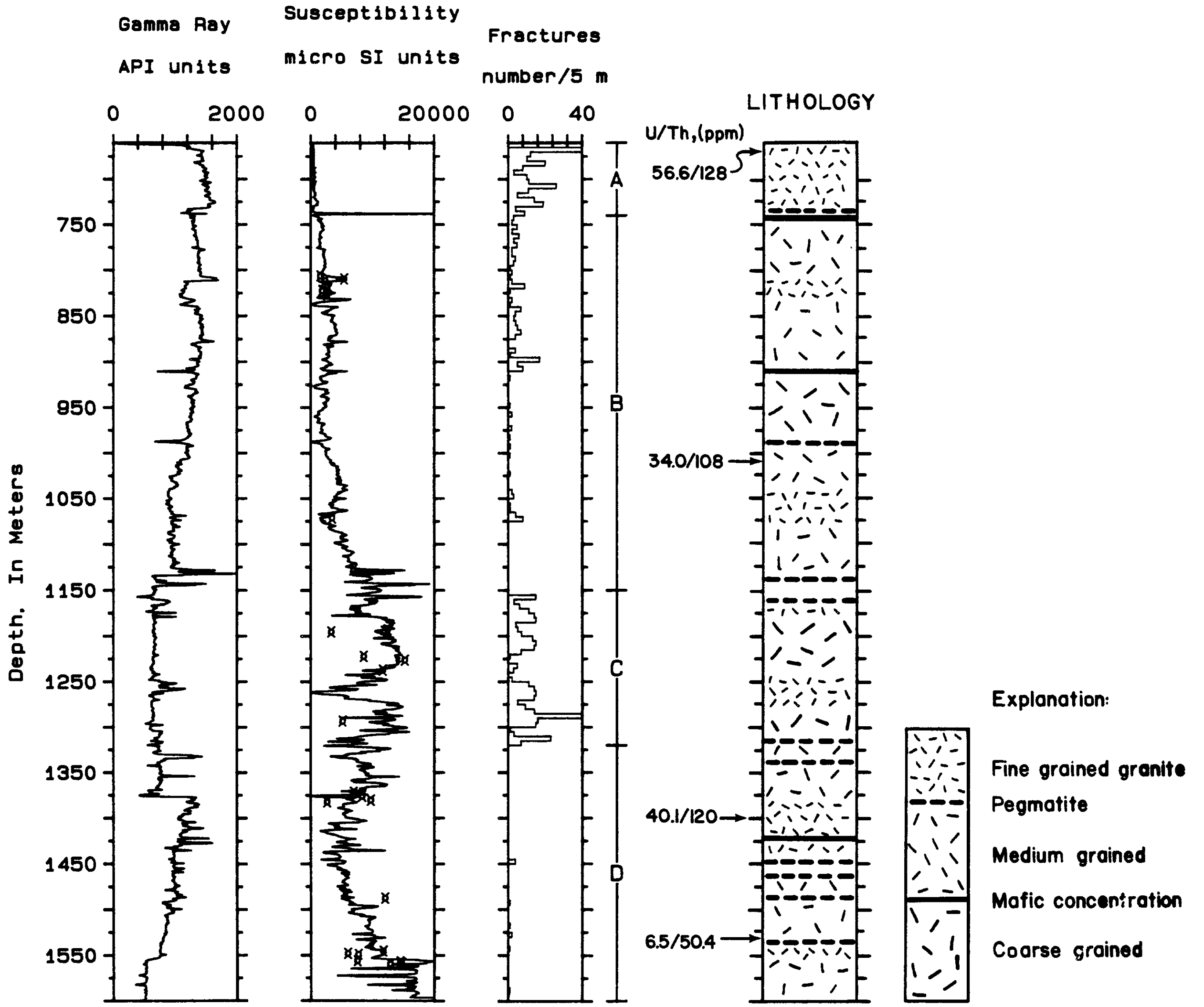

Figure 1. Total count gamma ray, magnetic susceptibility, fracture-count, and field lithologic well logs for UPH-3. Laboratory magnetic susceptibility values are plotted with the well log values. U/Th values from Rosholt (U.S. Geological Survey, personal communication, October, 1981) are shown on the right side of the figure. Values for the fracture-count histogram are from Haimsom (personal communication, U. of Wisconsin, May, 1982). The field lithologic log information was obtained from Mary Sue Coates (Harza Engineering, August, 1981).

has a high magnetic susceptibility response, with the exception of the fine-grained region between depths of 1250 and 1275 m. This high magnetic susceptibility response may be the result of concentrations of magnetite in the fracture zones. Pegmatites that are indicated on the lithology log, also have a low-to-intermediate magnetic susceptibility response in zone C. Zone D has low-to-intermediate magnetic susceptibility values at the top, and high values at the bottom (between depths of 1550 and 1600 m). The upper section of zone D contains many pegmatite regions as indicated on the lithology log, that are predominantly felsic and low in magnetite content.

Vitaliano and others (this volume) state that "the samples from the upper part of the core are fine grained and are richer in muscovite", and "the deeper the rocks in the core, the higher the Mg content of the biotite it contains". The Fe/Mg ratio was found to be greater than one in all samples, and the SiO_2 values were the lowest in samples from the bottom of the hole. All of these findings are consistent with the gamma ray and magnetic susceptibility measurements in UPH-3.

Fracture and porosity variations

Variations in porosity in UPH-3 are principally due to fracturing, with porosity values for selected core samples generally low for the granite (Daniels and others, 1982). Higher average porosity values were measured for samples from zones A and C (with average porosity values of 2.15 and 1.92 percent, respectively) than for samples from zones B and D (with average porosity values of 1.42 and 1.81 percent, respectively). The regions containing higher porosity values represent the altered and fractured regions of the drill hole.

The neutron log response is principally a measure of the water content of the rock (Pirson, 1963, Nelson and Glenn, 1975). The neutron probe consists of the neutron source and a neutron detector. A neutron detector measures the thermal neutrons scattered by the rocks surrounding the borehole. The number of neutrons counted by the detector is an inverse function of the hydrogen content of the rock surrounding the borehole, and is generally a measure of the amount of water contained in the rock. The neutron log response is affected by both chemically bound water and pore water, and in rocks containing abundant micaceous and clay minerals the neutron log is not a good indicator of porosity (Nelson and Glenn, 1975). Fractures in granite commonly contain hydrated clay and micaceous minerals that combine with the free water in the open region of the fractures to yield a low neutron response compared to the unfractured regions.

There is no definite correlation between the neutron log response in Figure 2 and grain size variations that are indicated by the field lithologic log in Figure 1. The neutron log shows anomalously low values in zone A and zone C that are indicative of fractures. This interpretation is substantiated by higher laboratory porosity values obtained for these intervals. Zone B shows a slight increase in the neutron response with depth that corresponds to an increase in density and probably represents decreasing porosity with depth.

The highly fractured zones A and C are also characterized by cycle skipping on the acoustic log (Figure 2). However, the anomalies on the acoustic log are not as consistent, or pronounced, in the fracture zones as the related anomalies on the neutron log. The acoustic log is a measure of the compressional velocity of the rock wall as measured between two detectors

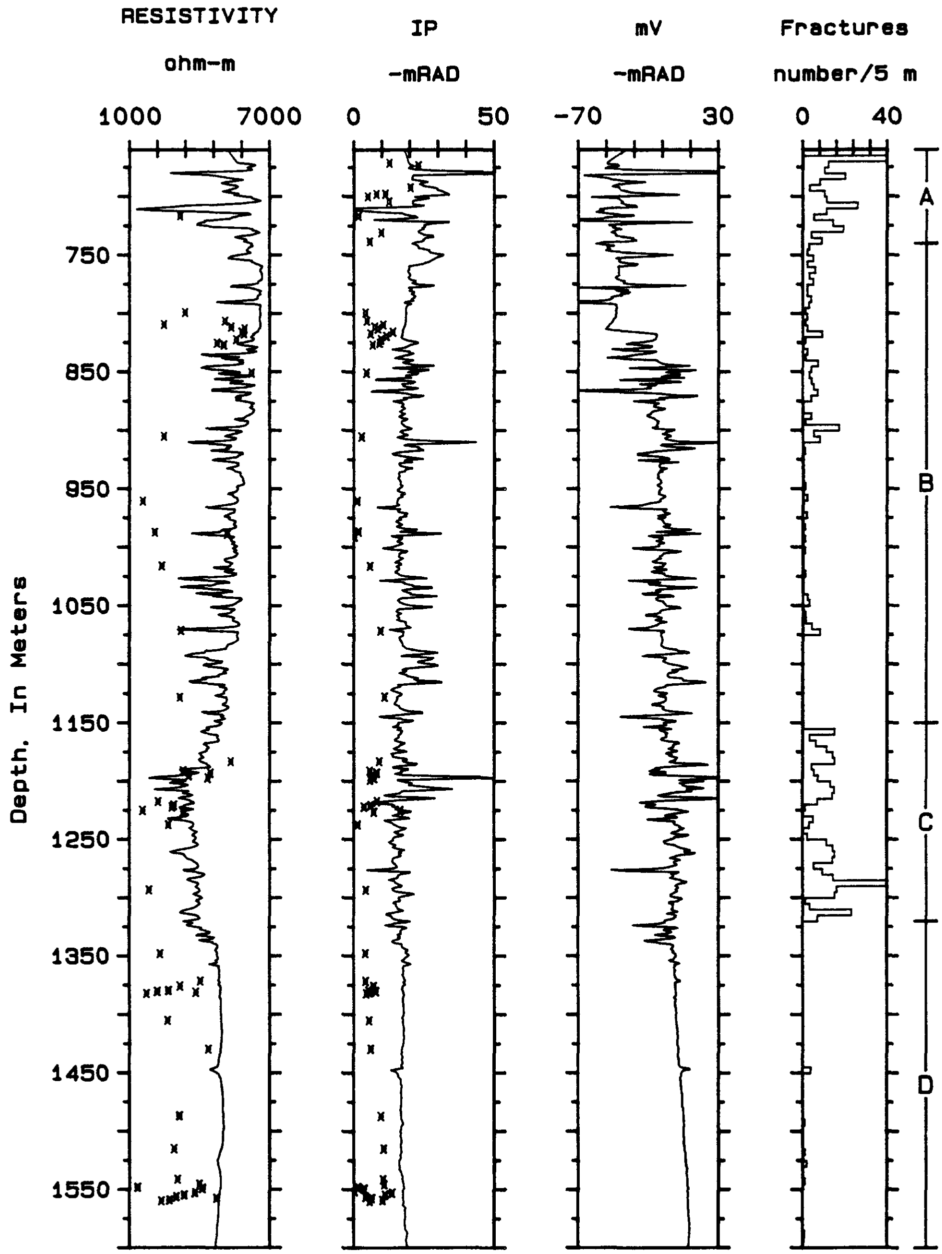

Figure 2. Acoustic velocity (Acoustic), Density, Neutron, and fracture-count well logs for UPH-3. Laboratory p-wave velocity values, and laboratory density values are plotted on the acoustic and density well log, respectively. Values for the fracture-count histogram are from B. Haimson (personal communication, U. of Wisconsin, May, 1982).

spaced .3 m apart. When fractures are present along the borehole wall, the signal received by the detectors is distorted, and the first compressional arrival is often weak. This results in an arrival other than the compressional arrival being picked as the first arrival, and the resulting recorded acoustic velocity is in error with the recorded anomaly being called a cycle skip. These high amplitude cycle skips are often indicative of fractures, and a comparison of cycle skips on the acoustic log with the fracture log illustrates this correspondence. Cycle skips only occur for the larger fractures or sets of fractures and do not appear to be a reliable indicator of all fractures.

The laboratory velocity values that are plotted on the acoustic log (Daniels and others, 1982) are generally lower than the recorded log values, with the difference increasing with depth. This is probably due to the fact that the laboratory measurements were made at 1 atomsphere of pressure, rather than at a pressure equal to the depth of burial of the core sample. The log velocity values of approximately 6km/s are consistent with values obtained from granite samples by other investigators.

Continuous in-situ gamma-gamma density log measurements and laboratory density measurements on 65 core samples were made in UPH-3. The laboratory wet bulk density measurements (Daniels and others, 1982) are plotted on the density well log in Figure 2. The in-situ gamma-gamma density measurements were made by measuring the radiation emitted from a Cs-137 gamma ray source located on the density probe. Gamma rays emitted by the source are Compton-scattered by the rock, and the gamma radiation measured at two detectors (located on the Probe) decreases with increasing electron density of the rock. The density probe is calibrated so that the electron density is equivalent to the bulk density when the average Z/A ratio of the rock is

0.5. The effects of borehole rugosity on the apparent bulk density measurement is compensated by using two detectors (Scott, 1977). The natural background radiation in the drill hole was subtracted from the countrate logs before the apparent density calculation was made. The error range for the density well log measurements is approximately 0.02 g/cm^3, with most of the laboratory sample values within the error range for the well log measurements.

There is no detectable change in density in the fractured zones (A and C), but there is a trend towards a slight increase of density values with depth. This trend may be caused by increased pressure with depth, combined with the presence of higher density minerals. The range of this trend is barely within the error limits of the measurements and is not considered to be of major significance to the analysis of the physical property data from UPH-3.

The interconnected porosity is generally low in UPH-3, resulting in high apparent resistivity values measured in-situ with the well logging probe when compared to values measured in the laboratory (Figure 3). Figure 3). The abnormally low values for most of the laboratory resistivity measurements may be caused by microfractures in the core created by the coring process. Resistivity values in rocks are a function of the porosity, fluid resistivity, and grain resistivity of the rock (Keller and Frischknecht, 1966). Low resistivity values on the well log are primarily caused by fractures, and there is no apparent correlation in UPH-3 between the resistivity values, recorded by the well log, and the grain size as indicated by the field lithologic log shown in Figure 1. The resistivity log is sensitive to microfractures in the rock in addition to larger fractures that affect other

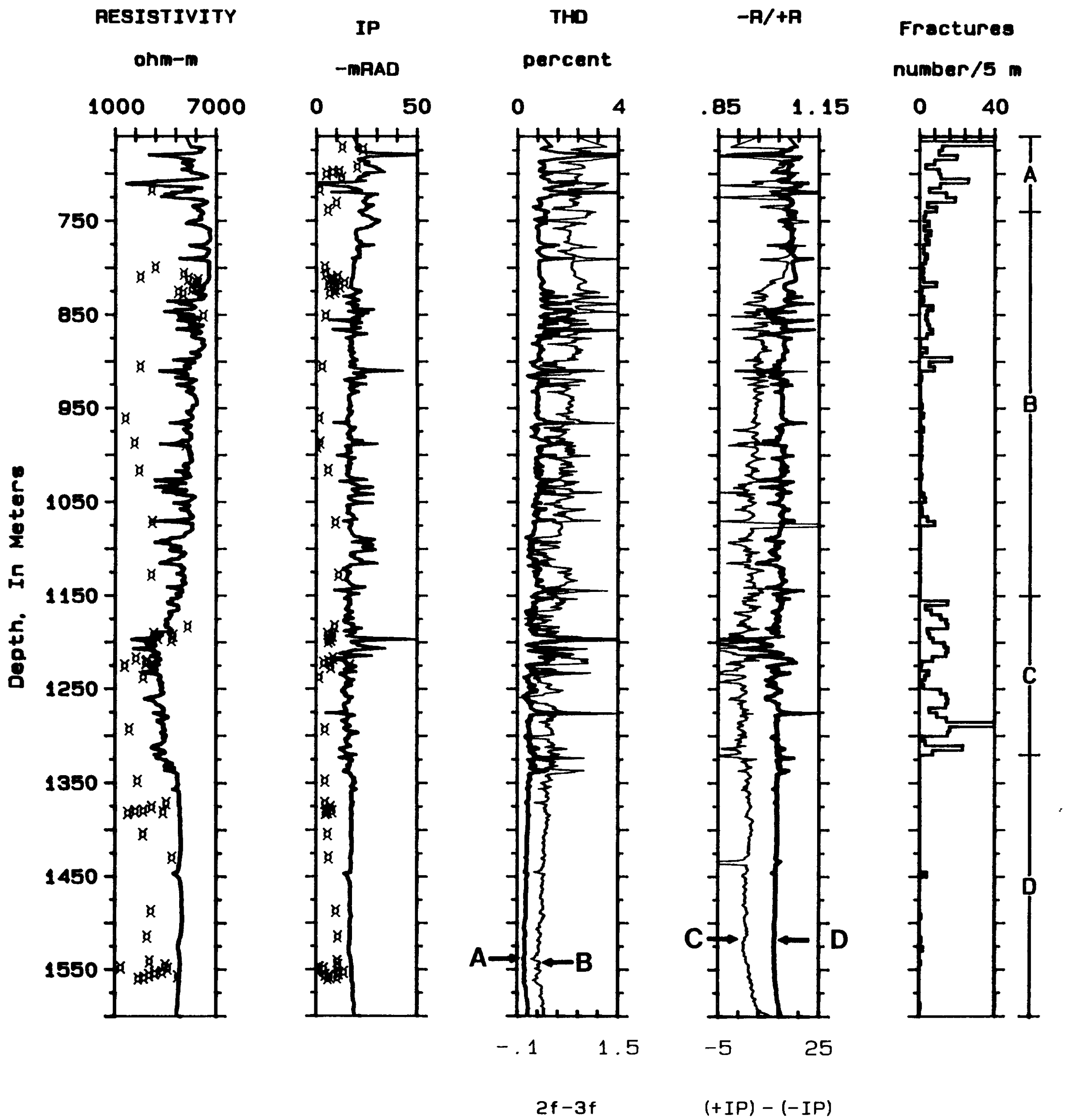

Figure 3. Electrical and fracture-count well logs for UPH-3. Laboratory resistivity and IP values are shown plotted on the resistivity and IP well logs. Traces A and B, correspond to total harmonic distortion (THD), the third harmonic minus the second harmonic (2f-3f), respectively. Trace C is the ratio of the resistivity computed from the negative portion of the waveform to the positive portion of the waveform (-R/+R). Trace D is the difference between the induced polarization (IP) computed from the negative and positive portions of the waveform [(+IP)-(-IP)]. Values for the fracture-count histogram are from B. Haimson (U. of Wisconsin, personal communication, May, 1982).

logging devices. The highly fractured zone (C) generally has lower resistivity response values than the other zones, while the non-fractured zone D is characterized by uniform resistivity values when compared to the remainder of the the log. The mafic region (as shown by the magnetic susceptibility log) below a depth of 1550 m has the same resistivity values as the overlying felsic rocks, showing that variations in mineralogy have very little influence on the resistivity values in this granite.

The induced polarization log response is indicative of the presence of electrically polarizable minerals (Keller, 1968; Snyder and others 1977). Polarizable minerals in UPH-3 include clay minerals (as alteration products), magnetite, and hydrated minerals (e.g., amphiboles). Polarizable minerals must be open to the flow of electric current in order to respond to the electrical polarization measurement, resulting in higher IP well log values in fractured or altered regions of the drill hole. Large IP anomalies are present in zone A, indicating extensive alteration in this zone. Zones B and C both contain numerous IP anomalies that are principally related to polarizable minerals in fractures. The IP response for the lower portion of zone C and the entire length of zone D is uniform, indicating unfractured rock (or sealed-fractures) with low electrical access to polarizable minerals.

Laboratory resistivity and IP measurements for 65 core samples are given by Daniels and others (1982) and are plotted on the well logs in Figure 3. The discrepancy between lab values and well log values may be due to the difference in volume measured with the logging device compared with the small sample volume measured in the lab, or by a high background IP response in the drill hole due to the presence of polarizable clay minerals in the drilling fluid.

Nonlinear complex resistivity (NLCR) is a measure of the nonlinearity of the output electric potential with respect to the input current. Measures of nonlinearity in UPH-3 include the total harmonic distortion (THD) between the input sine wave and the measured potential waveform, the difference between the deconvolved first and second harmonic (2f-3f), the ratio of the negative partial waveform resistivity to the positive partial waveform resistivity (-R/+R), and the difference between the IP phase angles of the positive waveform polarity [(+IP)-(-IP)]. The principles of nonlinear complex resistivity logging have been described in detail by Olhoeft and Scott (1980), Daniels and others (1981b), and Olhoeft (1979).

Chemical reactions that can cause nonlinear electrical polarization behavior include oxidation-reduction reactions (redox) involving magnetite, maghemite, and metallic sulfides, and ion-exchange reactions (ionex) involving chlorite, clays, and some other hydrated minerals (e.g., amphiboles). Studies with sulfides and other types of minerals show that when redox reactions dominate the NLCR response, there is an increase in the (2f-3f) and (-R/+R) values and a decrease in the [(+IP)-(-IP)] values. Studies have not been extensive enough to firmly establish the causal relationship between the mineralogy and NLCR response in granite and the following interpretation is somewhat speculative.

The resistivity, IP, and NLCR well logs for UPH-3 are shown in Figure 3. The upper altered zone (zone A) generally shows an increase in redox reactions that may be caused by magnetite or maghemite. The magnetic susceptibility log shows that zone A contains only small amount of magnetite, but mineral alteration may increase the electric accessibility of the zone resulting in a high NLCR response. An alternate interpretation is that the magnetite has been altered to hematite, or maghemite, resulting in a low magnetic susceptibility response, and a high NLCR-redox response.

Zones B and C exhibit NLCR responses that are indicative of both redox and ionex reactions. The redox reactions (increasing 2f-3f values, increasing -R/+R values, and decreasing [(+IP)-(-IP)] values) are interpreted to be predominantly caused by the presence of magnetite. These responses do not correlate perfectly with the magnetic susceptibility well log response, since not all of the magnetite is accessible to the electric current. Significant ionex reactions are indicated on the NLCR logs between depths of 1175 and 1200 m, which may be caused by the presence of chlorite, or another clay, in the fractures. Electrical properties within Zone D are extremely uniform, with a total variation of less than three percent. This absence of electrical properties anomalies is caused by low electric current penetration in the unfractured (or sealed-fractured) rock. The anomaly just above 1450 m is caused by an abrupt change in the speed of the logging tool, and is not due to a change in the granite.

Composite Interpretation

Individual well logs illustrate the major zonations and some of the individual anomalies in UPH-3, but a detailed interpretation of the data can only be made by simultaneously considering all of the data. A composite interpretation of geophysical well logs can often be accomplished by automated assignment of lithologies to depth intervals where the geophysical well log measurements are within specified value ranges (Daniels and others, 1981b). However, the nature of the anomalies on the well logs for UPH-3 does not lend itself to this type of interpretation. Instead, we must interpret anomalies on an individual basis, using the following guidelines and assumptions:

(1) Magnetite is the dominant magnetic mineral present in the section.

(2) High gamma ray response indicates the presence of U and Th, which is usually associated with felsic micas. The effect of potassium is negligible.

(3) A low gamma ray response, and a high neutron response in an unfractured region is indicative of quartz pegmatites.

(4) A low gamma ray response, and a high magnetic susceptibility response indicates the presence of a mafic region.

(5) Low apparent resistivity values are indicative of macrofracturing, or microfracturing.

(6) Low neutron values are indicative of brecciated, or fractured regions.

The detailed logs for zones A-D are shown in Figures 4-7. Each of these figures contains selected anomalies which have been assigned the numbers appearing to the right of the fracture-fill log.

The characteristics for each of these anomalies is summarized in Table 1. The interpretation of the indicated anomalies for zone A shows the presence of microfractures within the upper altered region. The presence of alteration is confirmed by the occurrence of hematite in the fracture fill as shown by Haimson (in this volume) and plotted with the other logs. The low mafic content of this zone is shown by the low magnetic susceptibility response and high gamma ray response for the selected anomalies. The analysis for zone B (Figure 5, Table 1) indicates the presence of numerous fractures and microfractures that are shown by the fracture-fill analysis of the core to be principally filled with chlorite. However, these microfractures in zone B do not yield a very substantial neutron anomaly even with the presence of the hydrated mineral chlorite. The trend towards increasing mafic minerals with depth is confirmed by increasing magnetitic susceptibility values with depth

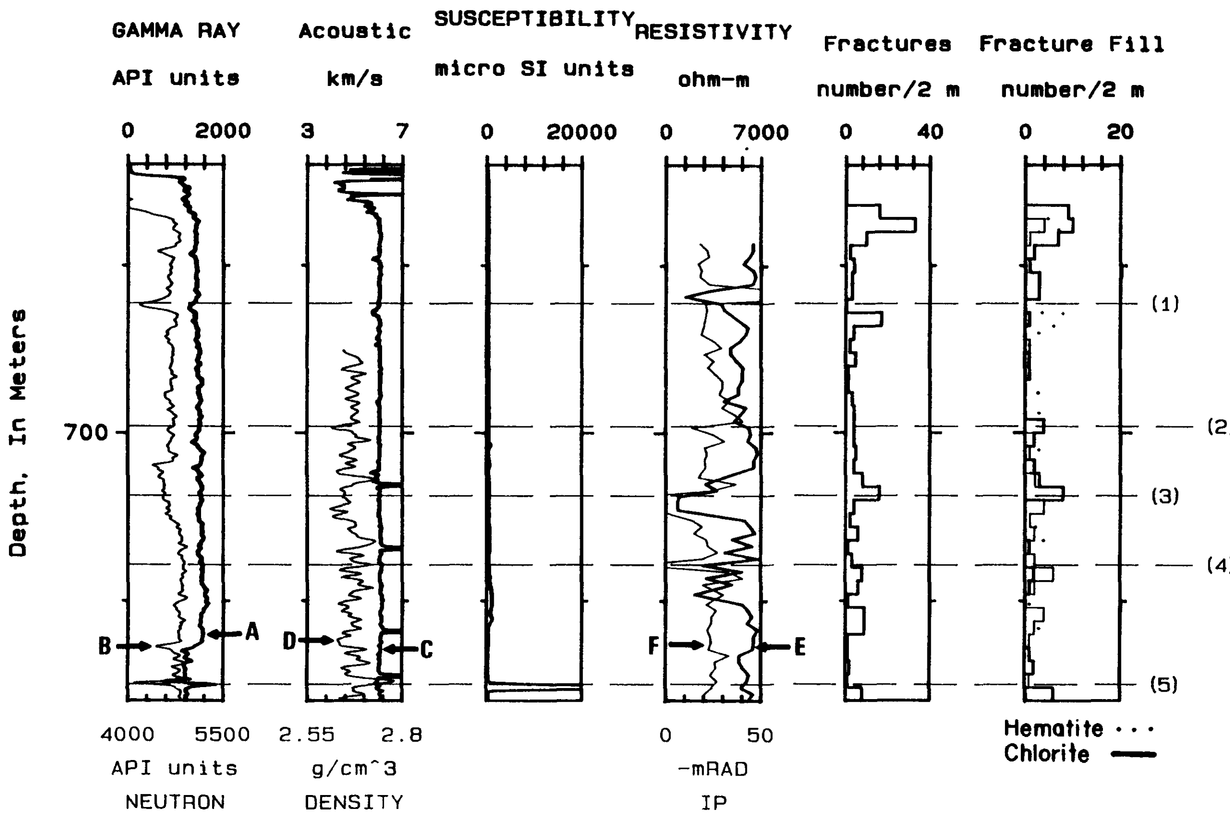

Figure 4. Composite well logs for zone A of UPH-3. Numbers to the right of the well logs explained in Table 1.Data for the fracture and fracture-fill logs were obtained from Haimson (personal communication, 1982). Trace -A, -B, -C, and -D correspond to the gamma ray, neutron, acoustic and density well logs, respectively. Traces E, and F correspond to the resistivity and induced polarization well log.

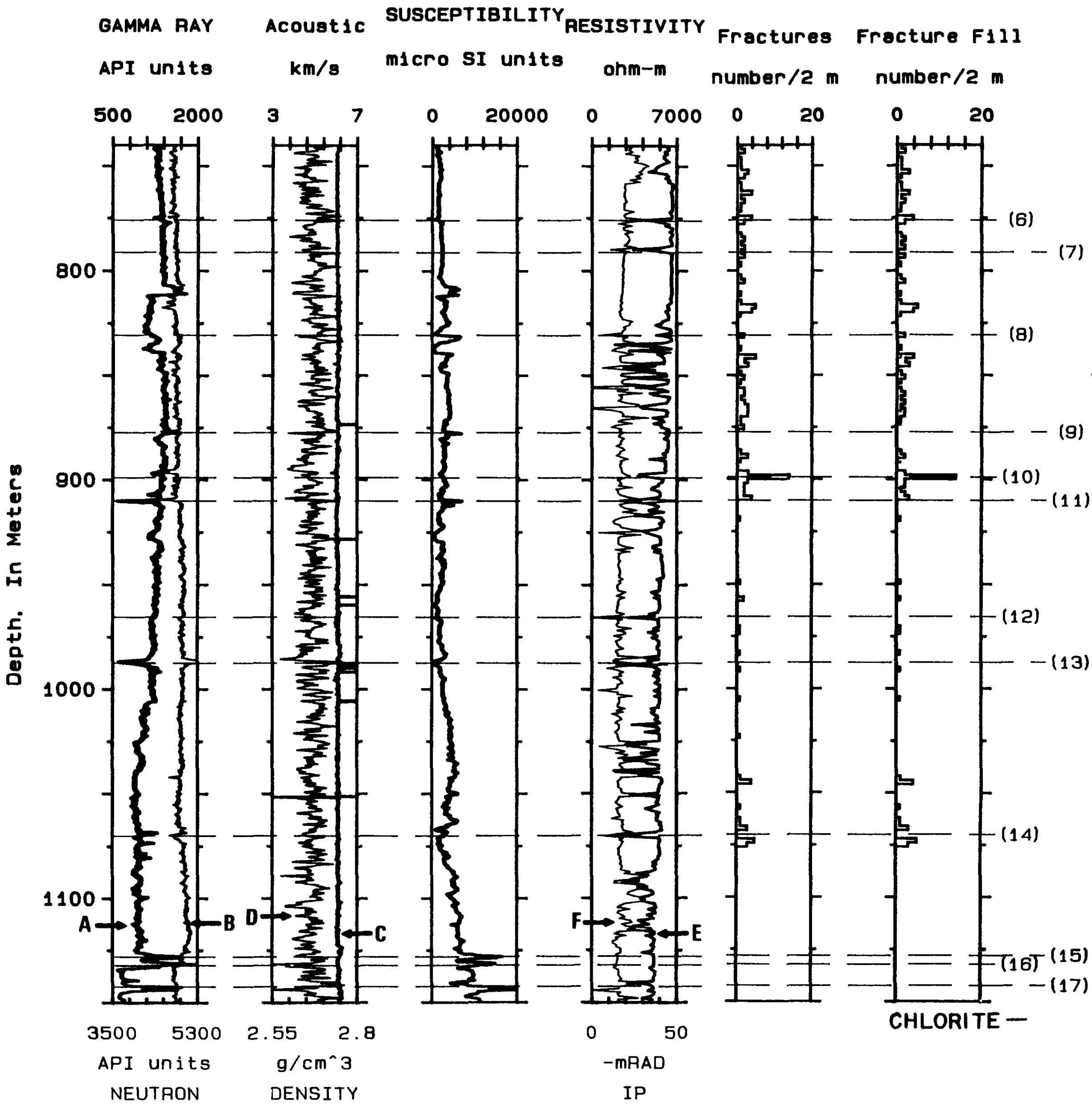

Figure 5. Composite well logs for zone B of UPH-3. Numbers to the right of the well logs are explained in Table 1. Trace -A, -B, -C, and -D, correspond to the gamma ray, neutron, acoustic and density well logs, respectively. Traces E, and F correspond to the resistivity and induced polarization well log.

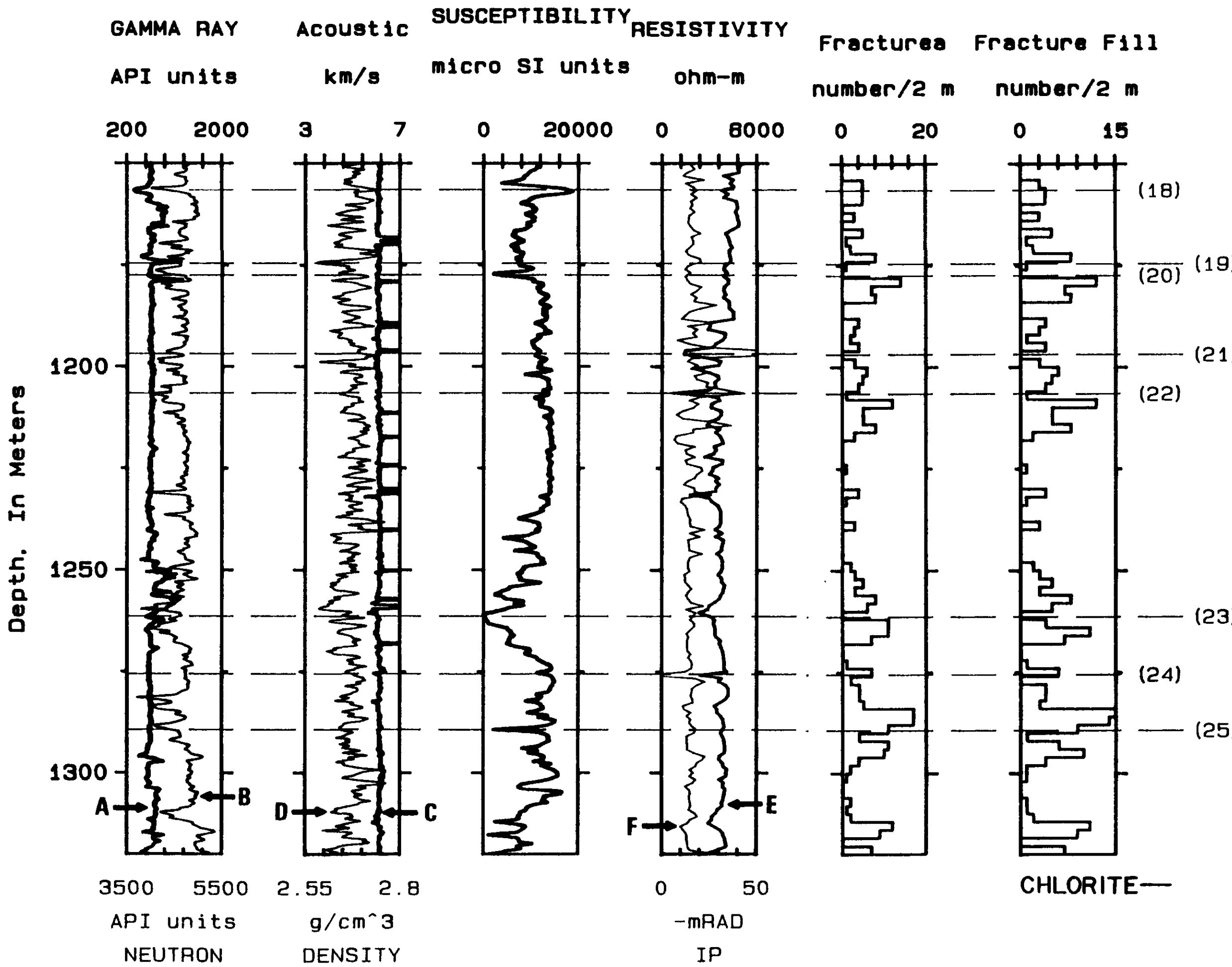

Figure 6. Composite well logs for zone C of UPH-3. Numbers to the right of the well logs are explained in Table 1. Trace -A, -B, -C, and -D correspond to the gamma ray, neutron, acoustic and density well logs, respectively. Traces E, and F correspond to the resistivity and induced polarization well log.

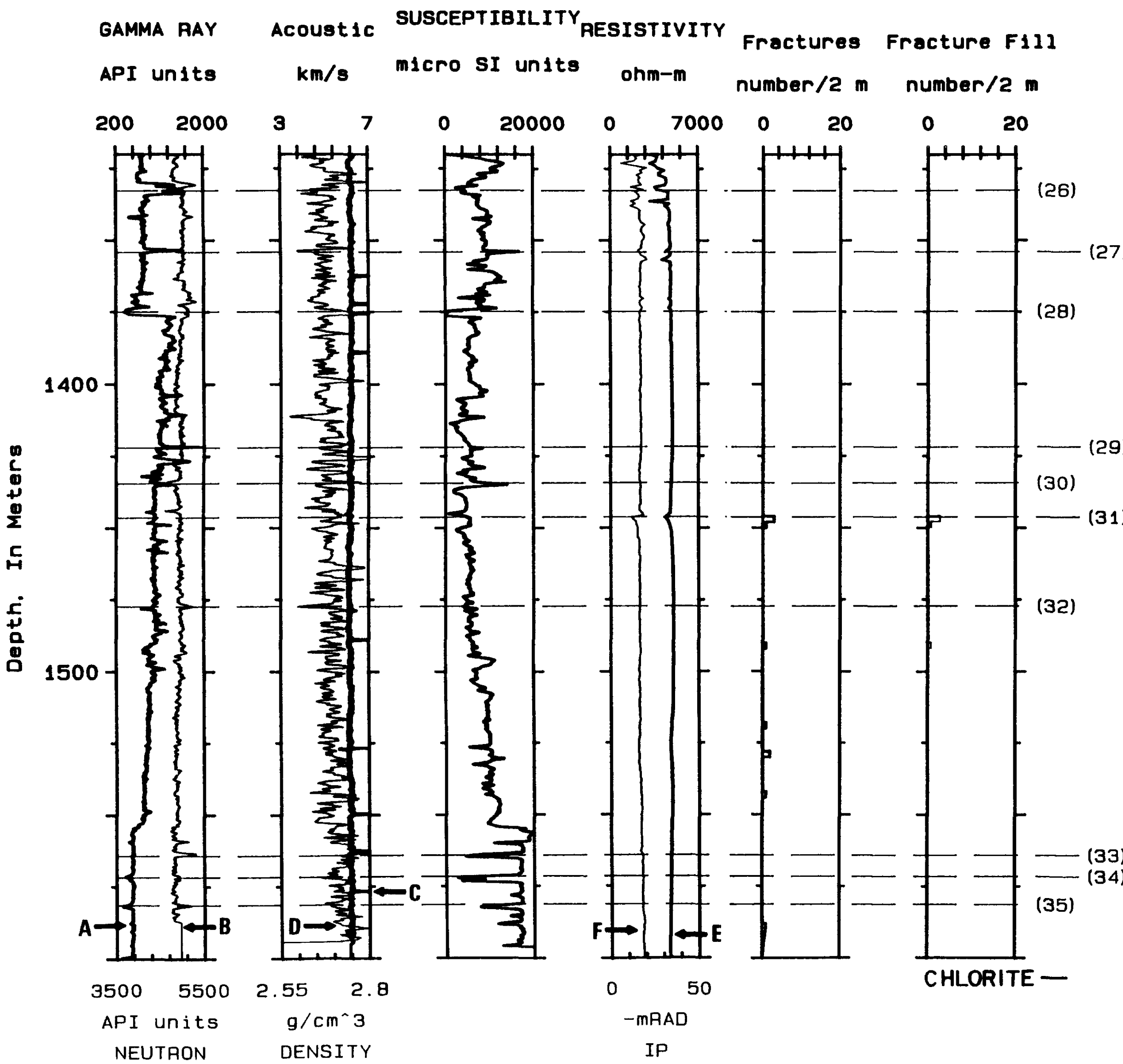

Figure 7. Composite well logs for zone D of UPH-3. Numbers to the right of the well logs are explained in Table 1. Trace -A, -B, -C, and -D correspond to the gamma ray, neutron, acoustic and density well logs, respectively. Traces E, and F correspond to the resistivity and induced polarization well log.

and decreasing gamma ray values with depth. Anomalies 15, 16, and 17 (Table 1) are anomalous in that they contain both high gamma ray response and a high magnetic susceptibility response. The depth of these anomalies represents a transitional break between the highly fractured and mafic zone C and the relatively unfractured zone B. The anomalies in this depth region may represent a change in the fundamental compostion or a change in the rate of crystalization of the igneous body. The selected anomalies in zone C (Figure 6, as analyzed in Table 1) illustrate the high concentration of fractures and mafic minerals in this zone. The high concentration of mafic minerals continues into the unfractured zone D (Figure 7). Zone D contains two abrupt changes in the gamma ray and magnetic susceptibility measurements that may be indicative of changes in the characteristics of the original melt. The upper change occurs at anomaly number 28, while the lower change occurs approximately 5 m above anomaly 33. The amplitudes of the gamma ray and magnetic susceptibility logs for anomalies 33, 34, and 35 are nearly the inverse of anomalies 15, 16, and 17 and these anomalies may represent significant phases in the crystalization process above and below the fracture zone.

Conclusions

The physical properties in UPH-3 show variations that are caused by changes in the mineralogy throughout the depth of the hole, alteration at the top of the hole, and regions containing numerous fractures. A steady increase in the mafic mineral components with depth, and a corresponding decrease in the felsic mineral components with depth, is clearly shown in the total count gamma ray and magnetic susceptibility measurements. Therefore, these physical property measurements support the hypothesis of fractionation during crystalization of the magma that formed the granite intrusive which is penetrated by the UPH-3 drill hole.

A major fracture zone, located between the depths of 1150 and 1370 meters, is clearly defined by the magnetic susceptibility, gamma ray, acoustic p-wave velocity, and resistivity measurements. Distinct physical property signatures at the top of this fractured interval suggest that this zone may be caused by an interuption of the normal cooling history of the intrusion, or by super-enrichment of some mineral components in the melt.

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Table 1. Analysis of individual anomalies from Figures 4-7. The logs used to analyze the feature are indicated by the numbers 1, 2, 3, 4, and 5 for gamma ray, neutron, acoustic, susceptibility, resistivity, respectively. Fractures that are indicated by the core fracture analysis are assigned the letter "F", while fractures that are interpreted from the well logs in a region of high core loss are assigned the letter "CL". The relative amount of mafic and micaceous material for the anomaly (interpreted from the logs) is denoted as "L", "M", or "H" for low, medium, or high amounts. The dominant type of fracture fill material from core analysis in the vicinity of the anomaly is denoted by the symbols "hem" and "ch" for hematite, and chlorite.

Feature	Fracture	Micro-Fracture	Fracture Fill	Micaceous (felsic)	Pegmatite	Magnetite	Mafic
1	CL,2	5	ch,hem	H,1	---	L	L
2	---	5	ch,hem	H,1	---	L	L
3	2	5	ch,hem	H,1	---	L	L
4	---	5	hem	H,1	---	L	L
5	CL,2	---	ch	H,1	---	H	M,1,4
6	F	5	ch	H,1	---	L	L
7	F	5	ch	H,1	---	L	L-M
8	F	5	ch	M,1	---	M	M,1,4
9	F,2	---	---	H,1	---	M	L-M,1,4
10	F	---	ch	M,1	---	L	L
11	F,2	5	ch	L,1	---	M	H,1,4
12	---	5	---	M,1	---	L	L
13	---	5	---	L,1	1,2,4	L	L
14	2	5	---	M-H,1	2,4	L	L
15	---	---	---	H,1	---	H	---
16	---	---	---	H,1	---	H	---
17	---	5	---	H,1	---	H	---
18	F,2	---	ch	L,1	---	H	H,1,4
19	F,CL	---	ch	M-H,1	2,4	M	M-H
20	F?,CL	---	ch	M-H,1	1,2,4	L	M-H
21	CL,2,3	5	---	L,1	---	M	M-H
22	F,2	5	ch	L,1	---	M	M
23	CL,2	5	---	M,1	---	L	L
24	CL	5	---	L,1	---	L-M	M-H
25	CL,F,2	---	ch	L,1	---	L	M
26	---	5?	---	H,1	1,2,4	L	L
27	---	---	---	H,1	---	H	M,1,4
28	---	---	---	L,1	1,2,4	L	M-H
29	---	---	---	H,1	---	M	M
30	---	---	---	L,1	---	H	M,1,4
31	---	---	ch	L,1	---	L	M,1,4
32	---	---	---	L,1	---	M	M
33	---	---	---	L,1	1,2,4	L	L
34	---	---	---	L,1	1,2,4	L	L
35	---	---	---	L,1	1,2,4	L	L