Waste Isolation Pilot Plant

Compliance Certification Application

Reference 231

Elliot, C.L., 1976.
A Preliminary Geophysical Study of a Trachyte Dike in Close Proximity to the Proposed Los Medaños Nuclear Waste Disposal Site, Eddy and Lea Counties, New Mexico, Tucson, AZ, Elliot Geophysical Company.

Submitted in accordance with 40 CFR §194.13, Submission of Reference Materials.

ELLIOT GEOPHYSICAL COMPANY

A Preliminary Geophysical Study of a Trachyte Dike in Close Proximity to the Proposed Los Medaños Nuclear Waste Disposal Site, Eddy and Lea Counties, New Mexico

LONG-TERM REGULATORY COMPLIANCE

for

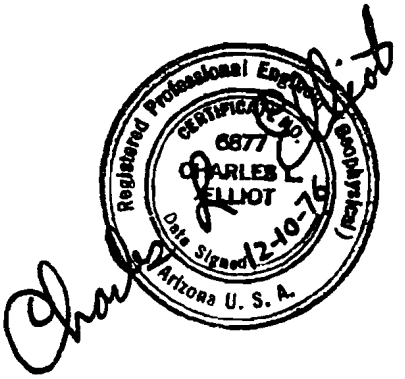
Waste Isolation Pilot Plant Program

Sandia Laboratories, Inc.

Albuquerque, New Mexico

December 10, 1976

Ref: SL1



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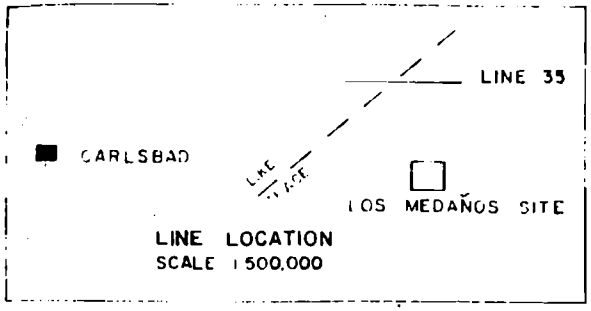
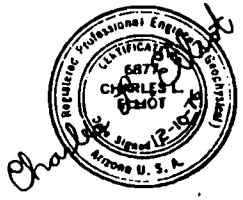




ELLIOT GEOPHYSICAL COMPANY
Mining Geophysical Engineers
Tucson, Arizona

AIRBORNE MAGNETIC PROFILE
USGS SURVEY
LINE 35
for
SANDIA LABORATORIES INC.
ALBUQUERQUE, NEW MEXICO

Scale 1:125000	Date 12-10-76	Ref SLI

A long linear magnetic feature that has been geologically interpreted as a dike of Tertiary age has been well known by petroleum and potash explorations for many years. This long linear feature strikes approximately N 50° E across the northwestern part of the Delaware Basin in southeastern New Mexico. This structural feature has been intercepted by many petroleum exploratory wells and potash test drill holes and it or related material outcrop in several areas south-southwest of the Carlsbad Caverns.

The trace of this dike is located approximately nine miles northwest of the Los Medaños Nuclear Waste Disposal Site that is currently under investigation. At this distance, the dike itself may possibly present a geologic hazard to the selection of Los Medaños as a viable site for a nuclear waste disposal pilot plant. Further, the dike may be, as is often the case, part of a swarm of en echelon dikes and, therefore, a parallel dike or dikes could exist closer to or beneath the Los Medaños site, and, therefore, a definite geologic hazard to site selection would be present. As a result, it seems pertinent to study this dike in detail in order to ascertain its possible significance, genetic origin, age, and any signs of structural movement in the last several million years. In that this dike is only exposed in one area, a long way from

the Los Medanos site, then geologic study by itself cannot adequately define some of the parameters of interest. Fortunately, the dike material has relatively strong magnetic properties and, therefore, the dike can be mapped and studied in part, at least, by geophysical techniques.

The purpose of this preliminary geophysical study of this trachyte dike is to identify the dike, its geometric parameters, as well as its physical property parameters to determine if geophysical techniques can adequately map this dike and search for and delineate any possible parallel features of similiar extent and source material that may exist near the Los Medaños site. Such a geophysical study would be in cooperation with other geophysical studies for other purposes; in the broadest sense, studying the geologic hazards that may effect the selection of an appropriate site for a nuclear waste disposal pilot plant.

References to this report that are pertinent to the data presented and form a intergal part there of are the following:

Pratt, W.E., 1954, Evidences of Igneous Activity in the Northwestern Part of the Delaware Basin, Publication in the New Mexico Geologic Society, 5th Field Conference Southeastern New Mexico, pp. 143-147.

Kelley, V.C., 1971, Geology of the Pecos Country Southeastern New Mexico, New Mexico State Bureau of Mines and Mineral Resources, Memoir 24.

Semmes, D.R., 1920, Notes on the Trachyte Intrusives of the Lower Pecos Valley. American Journal of Sciences, Ser. 4, Vol. 50, pp. 415-413.

Elliot, C.L., 1976, A Laboratory Investigation of Magnetic Physical Properties of Igneous Dike Samples from Kerr-McGee Hobbs Plant, Section 31, T 20 S, R 32 E and Surface Outcrop, Section 31, T 25 S, R 25 E for Waste Isolation Pilot Plant Program, Sandia Laboratories, Inc., Albuquerque, New Mexico, ELLIOT GEOPHYSICAL COMPANY, Reference SL1E, December 1, 1976.

U.S. Geological Survey, Geophysical Investigations Map GP-861, Aeromagnetic Map of the Carlsbad Area, New Mexico and Texas, 1973, including selected aeromagnetic profiles privately obtainable from the U.S. Geological Survey, Regional Geophysics Branch.

Aeromagnetic Contour Map, Total Intensity, Delaware Basin and Portions of Sheffield Channel and Val Verde Basin, Texas-New Mexico, Aero Service Library NO. 43-6, flown by Fairchild Aerial Surveys, Project 26040, November, December 1963 and January, February, March 1964. Sheets 5, 6, 8, and 9; scale 1:96000.

Aeromagnetic Interpretation, Delaware Basin, Texas and New Mexico, Sheets 5, 6, 8, and 9, Gravity Meter Exploration Company, Houston, Texas, November 1964, with revision by Geophysical

Exploration Company, May 1976 with attached maps of second vertical derivative and contour of magnetic basement.

Attached to this report and forming a part thereof is one table and two drawings as follows:

Table I - Reported Dike Intercepts or Surface Exposures

Airborne Magnetic Profile, USGS Survey Line 35, for Sandia Laboratories, Inc., Albuquerque, New Mexico, Scale 1:250000.

Airborne Magnetic Interpretation and Well Intercepts of Dike for Sandia Laboratories, Inc., Albuquerque, New Mexico, Scale 1:250000.

Based on all information presently at hand, the dike structure is very linear and strikes generally N 50° E with a strike length in excess of 75 miles from surface outcrop exposure south-southwest of Carlsbad Caverns to the northeasterly most exploratory well intercept. This extent is shown on the attached Airborne Magnetic Interpretation and Well Intercepts of Dike Map. There is reservations as to whether the surface outcrop exposures near Carlsbad Caverns are indeed part of the dike system or merely genetically related to it. As there are no well intercepts or magnetic indications of the dike for a hiatus of the order of 27 miles from the most southwesterly magnetic indication of the dike to the surface outcrop exposures, that is, with the exception of one questionable magnetic response as shown on the attached map. If one is

willing to accept the conclusion that the surface exposures are not part of the dike, per se, but only fortuitously lie on strike then still from the northeasterly most well intercept to the southwesterly most magnetic indication, the dike still has a linear strike length of 45 miles, a most pronounced feature.

Southwesterly, the dike terminates approximately at the Pecos River. Of coincidence, this is also the approximate western delineation of the extent of the Salado formation, that is the dissolution front. It is questionable if this relationship has any geologic meaning. In vertical extent, the dike is believed to extend upward from the basement the order of 12,000 feet below surface. Intercepts of the dike material have been noted from 790 feet to 13,350 feet within four miles of each other respectively in the underground exposure in International Minerals and Chemical Corporation Mine and in the Perry R. Bass, Big Eddy No. 44 drill test (see Table I). Therefore, it seems realistic to assume that the dike does extend upward from basement and tops out within the Salado formation. This is supported by the International Minerals and Chemical Corproation underground exposure where it has been reported that the underground workings went over the top of the dike and, of course, no exposures at surface are known of the dike material in this section of the Delaware Basin.

The width of the dike is not easy to determine, Near its top, or assumed top, as exposed underground both at the Hobbs Plant of Kerr-McGee Chemi-

cal Corporation and at International Minerals and Chemical Corporation the width is reported to be the order of 15 to 30 feet. On the other hand, the airborne magnetic data suggested a width to the dike grossly in excess of this, probably measured in terms of miles at least at basement level. Therefore, one can reasonably assume at the upper extremity that the dike has severely narrowed and the narrow magnetic response is from the distal ends of a possible major dike swarm or system (See figure on page 15).

Of interest too, are the various reports, sample logs, and well logs mainly from the deep well tests performed by many oil exploration organizations. Invariably, the intercept reports are multiple per well scattered over a significant vertical distance. For example, Stanolind, U.S. Duncan No. 1, showed eight intercepts from 470 to 2,710 feet (see Table I). Also it is the conclusion of several petroleum explorationists, for example W. Ford of Bass Enterprises, Midland, Texas, that whenever the dike rock was intercepted it was a bed-for-bed replacement suggestive of a sill rather than a dike.

The age of the dike is definitely Tertiary having been age dated at 32 million years as reported by C.L. Jones of the U.S. Geological Survey. Its composition as reported by Pratt (see references) is an alkali-trachyte; whereas C.L. Jones considers it a lamprophyre.

This trachyte dike may have a genetic or structural relationship or as-

sociation that deserves more than a passing interest. A foremost importance is the fact that it is closely parallel to the major structual direction of southeastern New Mexico. Many other structural breaks have been reported by Kelley and readers are referred to the Kelley reference for more details. In particular, plate 5 of Memoir 24 is of significant interest. This drawing shows many structural buckles with strikes varying from N 40° to N 50° E, such as the Serano Buckle, Border Buckle. Six-Mile Buckle, Y-O Buckle, K-M Fault, etc. Unfortunately, the work of Kelley does not extend far enough southeasterly into the Delaware Basin to cover the area surrounding the Los Medaños site. If his work had been more extensive, he would undoubtedly have reported the dike of interest here. He does show on plate 5 the outcrops of the dike with the same strike along Highway US 180 south-southwest of the caverns, but does not show the well intercepts and airborne magnetic response of the dike in the area of interest which falls just within the eastern boundary of plate 5.

Two other structural features of significance on plate 5 are the Railroad Mountain Dike and the Camino del Diablo Dike which are east-west dikes that exist in the Tatum Basin, the major structural basin north of the Delaware Basin. Kelley reports these dikes to be long linear features but fairly narrow with surface exposures. More specifically, the Railroad Mountain Dike is 31 miles long in an east-west direction but only 100 feet wide and has an olivine gabbro composition. The Camino del Diablo Dike, on the other hand, is 25 miles long east-west

but is reported to be only 50 feet wide and of andesitic to basaltic diabase composition. Of the two dikes that are both of relatively basic composition one would expect to have a magnetic expression and likely stronger then the dike of interest in the Delaware Basin. This is indeed true from personal observations of proprietary airborne magnetic data in which these dikes are clearly indicated. Of interest, both of these dikes nose out in both an easterly and westerly direction so that from a magnetic point of view one would assume their centers exist somewhere in the middle of Tatum Basin and are not long dikes that extend from the El Capitan Stock well to the west as some have previously assumed.

Therefore, the Railroad Mountain Dike and the Camino del Diablo Dike structures are quite comparable to the narrow dike structure in the Delaware Basin of interest except for strike direction. However, when one realizes that east-west is a second order major structural direction of New Mexico then this does not present any severe conflict. Of particular interest is the nosing out east and west with the center likely within the basin, very comparable to the Delaware Basin Dike which there appears to be a northeast and southwesterly limit clearly defined magnetically and geologically from well intercepts. This is an important point.

A second relationship of the Delaware Basin Dike is its obvious parallelism to the topographic slump structure known as Nash Draw. The dike

occurs not only parallel to but concomitant with the northwest side of Nash Draw. Nash Draw is well known to be due to salt dissolution of the Salado and its preference to the northeasterly-southwesterly direction may be associated with the dike in question. This has been proposed by several people including Griswold.

From a geophysical point of view, the most important aspects of the dike are its magnetic properties. A study of these physical properties has been done by ELLIOT GEOPHYSICAL COMPANY and the results were presented in the referenced report. For completeness sake here, the physical property data is summarized in the following table:

TABLE OF AVERAGE MAGNETIC PROPERTIES

Volume Magnetic Susceptibility 10^{-6} cgs units	Natural Remanent Magnetization Magnitude in Gammas	Koenigsberger Ratio for F = 52000 Gammas	Declination Degrees	Inclinatic Degrees
Outcrop 2690	5130	35.0	Not Determinable	
Underground Kerr-McGee Hobbs Plant 2840	1044	7.2	35.1	57.0

For the underground samples the total intensity of magnetization has a magnitude of 1188. gammas at a declination of 32.5° E and an inclination of 58° (below the horizontal).

Perusal of the above suggest that there is undoubtedly a genetic rela-

tionship between the surface outcrop south-southwest of Carlsbad Caverns and the dike as intercepted in the Kerr-McGee Hobbs Plant. But there are some differences in magnetic properties. This is not probably significant and, therefore, one would expect the surface exposure to be reflecting the same major structure as the dike located high within the Salado section near the Los Medaños site. A summary of all the reported dike intercepts and surface exposures is presented in the attached Table I. In this table the reference number refers to the plot of these intercepts on the attached drawing: Airborne Magnetic Interpretation and Well Intercept of Dike at a scale of 1:250000. By a perusal of this drawing, one can readily see the long linear relationship of the well intercepts of the dike and the magnetically indicated position of the dike from the several airborne magnetic surveys of the data that were available to Sandia Laboratories. At the northeast extend of the dike trace, the wells (reference numbers 1 and 2) seem to be off the linear axis of the dike and there may be cross faulting at this point, but there is insufficient data to ascertain exactly what is transpiring. Except for these two well intercepts, the linear relationship is excellent and all magnetic indications and well intercepts are within one mile of a straight line as shown on the attached Airborne Magnetic Interpretation and Well Intercepts of Dike drawing.

The magnetic data available to interpret the dike is from two sources:

1. Survey purchased by Sandia Laboratories from Aero Service, Division of Western Geophysical Company of America. This data was available

TABLE I

REPORTED DIKE INTERCEPTS OR SURFACE EXPOSURES

REFERENCE NUMBER	WELL OR DRILL HOLE NAME	LOCATION	INTERCEPT DEPTHS IN FEET
1	Humble Oil & Refining; State "BO"#3	SE 1/4 Sec. 12, T18S-R34E	8745
2	Continental; Forest #1	Sec. 22, T18S-R34E	7210-8640
3	International Minerals Corp.; ConcDale#95	NW 1/4 Sec. 12, T20S-R32E	2239
4	Noranda; HB-10	SW 1/4 Sec. 14, T20S-R32E	1700
5	Texaco; Moore#1	SW 1/4 Sec. 21, T20S-R32E	2115
6	Kerr-McGee; Mine	Sec. 31, T20S-R32E	1530
7	Perry R. Bass; Big Eddy#44	SE 1/4 Sec. 25, T22S-R28E	12120-13330
8	Stanolind; U.S. Duncan#1	SW 1/4 Sec. 30, T21S-R30E	470-2710(8 Intercepts)
9	International Minerals Corp.; Mine	Sec. 36, T21S-R29E	790
10	H & W Drilling; Danford#1	SE 1/4 Sec. 9, T22S-R29E	2210
11	Perry R. Bass; Big Eddy#43	SE 1/4 Sec. 25,T22S-R28E	940-2050
12	Outcrop	Sec. 31, T25S-R25E	Surface
13	Outcrop	Sec. 11, T26S-R24E	Surface
14(?)	Amoco; Teledyne Gas#1	Sec. 13, T23S-R28E	Rumor?
15(?)	Unknown	Sec. 25, T22S-R28E	1880-1900 (γ Ray Response)

in the Aero Service Library, reference number 43-6 as originally flown by Fairchild Aerial Surveys for a private petroleum company November, December 1963 and in January, February, March 1964. This survey was flown with a flight line spacing of one mile with east-west lines at a flight altitude of 5000 feet above sea level or on average 1500 to 2000 feet above mean terrain. The data is total magnetic intensity obtained with a fluxgate type of magnetometer with a resolution of approximately $\pm$ 1 gamma. The survey is of excellent quality and Sandia Laboratories received excellent maps and copies of all magnetic profiles. Maps were at a scale of 1:96000 and the magnetic profiles were at a vertical scale of approximately 1 inch = 30 gammas and a horizontal scale of approximately 1 inch = 3500 feet, subject to variation due to change in air speed of the aircraft. An aeromagnetic interpretation of the Delaware Basin by Dr. Nelson C. Steenland of Gravity Meter Exploration Company was included as part of the package purchased by Sandia Laboratories. This report is basically concerned with basement topography as a speculative interpretation of the Fairchild Survey for petroleum purposes.

2. U.S. Geological Survey Investigations Map GP-861 published in 1973 of the area in question. The data is total magnetic intensity obtained with a fluxgate type of magnetometer with a resolution of the order of $\pm$ 2 gammas. This survey was flown by the USGS at 500 feet above mean terrain in 1960. The published map is at a scale of 1:250000. The line spacing in the central part of the area of interest to us is in a one mile line spacing with east-west lines.

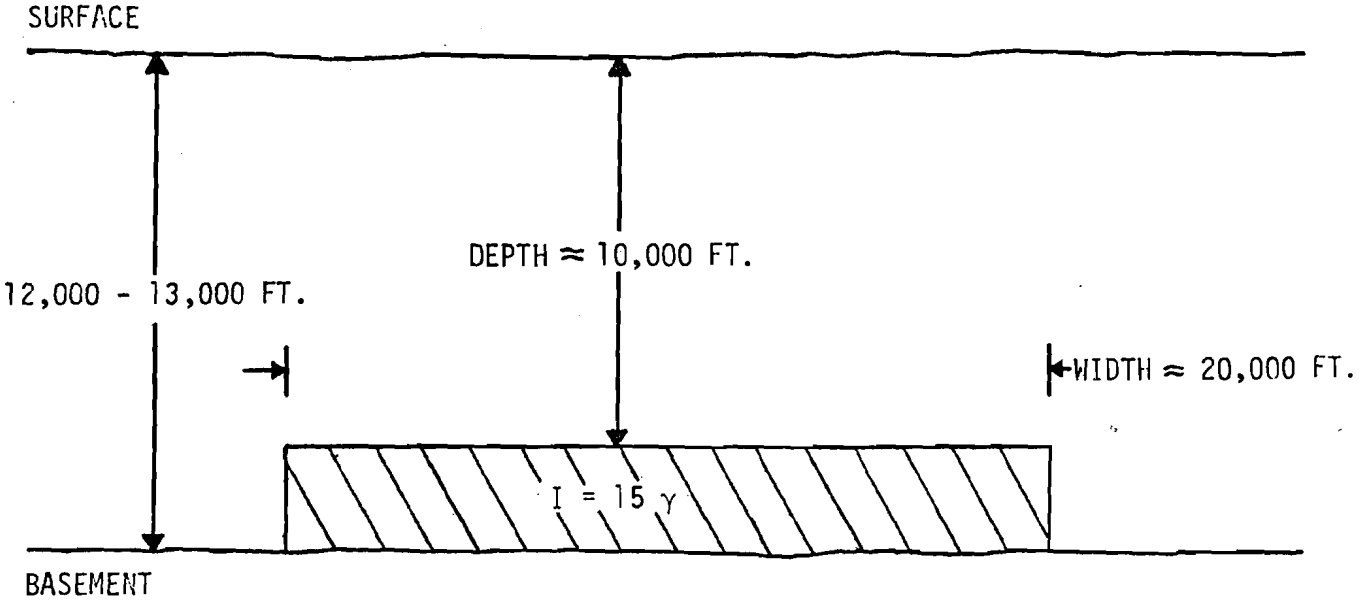
North of the central zone and south of the central zone the line spacing increased to two miles. Respective zones are shown on the attached Airborne Magnetic Interpretation and Well Intercepts of Dike drawing. In addition to the published map, some of the flight line records were obtainable from the U.S. Geological Survey, Regional Geophysics Branch, but the set was not complete. For the most part, all of the profiles were available across the Los Medaños site and immediate surrounding area.

Both of the available airborne magnetic surveys are of comparable quality and areal extent. Both were flown with east-west lines, and in the central area of interest surrounding the Los Medaños site the line spacing was identical at one mile. The two sets of data complement each other and no major discrepancies between the data sets were noted. The principal difference of interest in the study of the trachyte dike is that the USGS Survey was flown at a 500 feet mean terrain clearance versus 1500 to 2000 feet for the Fairchild Survey. Consequently, the USGS data offers a much better means to recognize and map the known narrow dike high within the Salado formation. A representative airborne magnetic profile is shown on the attached drawing for USGS Survey Line 35. On this profile is shown a shallow near surface dike response as a small protuberance on the broader basement source response which is indicated all along the dike trace. On the other hand, for the Fairchild Survey flown at a higher elevation the narrow near surface dike response for the most part is not distinguishable in the noise of the magnetic records.

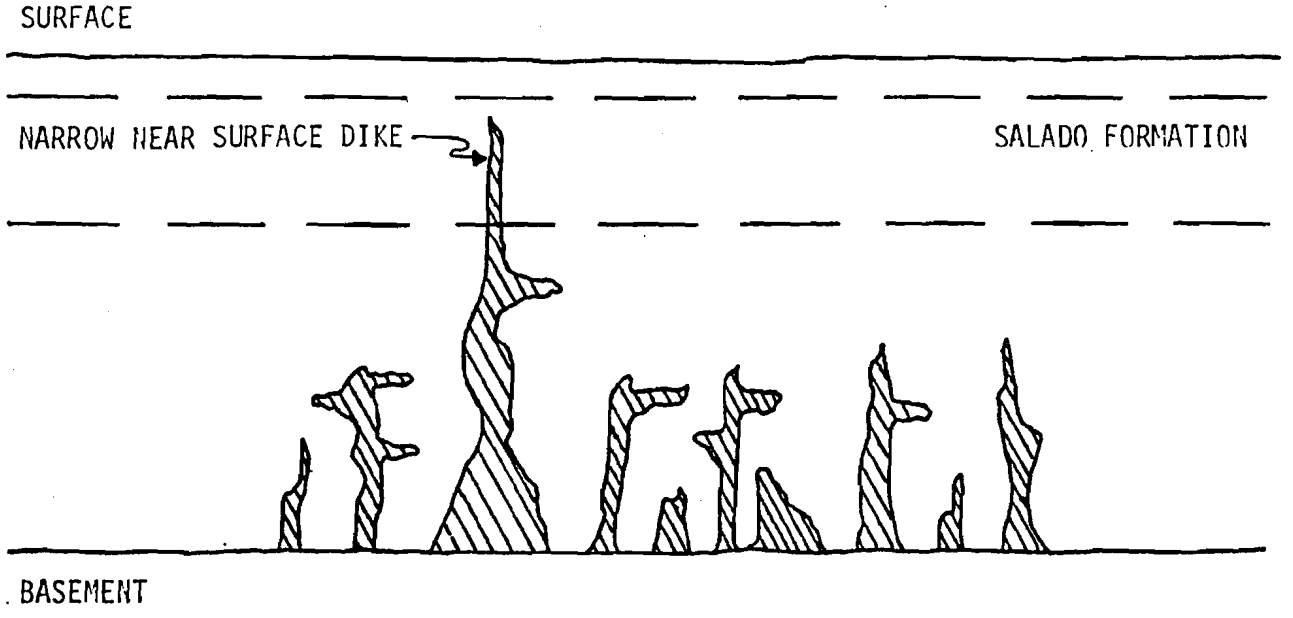
Both surveys are old data flown in the 1960's, and today modern techniques of magnetic exploration utilizing new types of magnetometers can much better map narrow features such as this trachyte dike. Therefore, it has been strongly recommended to resurvey the Los Medaños site area and immediate surroundings and particularly along the dike trace as delineated in this old data. Such a resurvey with modern tools can more than likely map not only this major dike but any en echelon dikes that may form part of a dike swarm system.

The composite picture as presented for USGS Survey Line 35 as shown on the attached profile clearly indicates the narrow dike forming an upper distal end of a much wider feature that is deeper near the precambrian basement at 12,000 to 13,000 feet. For illustrated purposes, Line 35 was interpreted for the broad basement source response following standard means of quantitative geophysical interpretation of magnetic dike (two dimensional) features. The solution from an interpretation of the broad basement source is shown on the figure on page 15.

In the upper part of the figure is shown the direct mathematical solution for the geometry of a possible dike source body rising above basement and its probable average intensity of magnetization. The solution intensity of magnetization is only 15 gammas or little more than 1 percent of the intensity of magnetization as measured for the samples obtained from the Hobbs Plant of Kerr-McGee Corporation (1188 gammas). The depth to the source is the order of 10,000 feet suggesting that dike material extends



MATHEMATICAL SOLUTION



POSSIBLE GEOLOGIC SOLUTION

USGS LINE 35

upward from the known basement level at this location which is the order 12,000 to 13,000 feet. Dike response suggests an integrated width of dike material of the order of 20,000 feet.

More then likely, because of the low suggested intensity of magnetization and the corespondingly great width of indicated magnetic material then a more probable geologic solution is diagrammatically illustrated at the bottom of the figure. Here it is suggested that there is a multiplicity of en echelon dikes forming a swarm which rise generally vertically from the basement and pinch out in an upward direction. Small sill-like protubrances probably extend outward from the main vertical source as diagrammatically shown. One of the dikes may extend upward into the Salado formation which is the one that has been uncovered in the potash mines. All of the dikes may be fairly narrow in extent except for a main feeder for the one that extends up into the Salado formation. Magnetically at the level of the airborne magnetic surveys and within the limits of resolution of the magnetic data of the order of $\pm$ 1 gamma them such a dike swarm would have an integrated effect giving rise to an apparent single broad anomaly.

This illustrates the importance of a reflight of the dike trace by modern techniques of airborne magnetics with a much higher resolution greater then $\pm$ 0.05 gammas or 20 times the resolution of the magnetic instruments of the 1960's. Thereby there would be a chance to differentiate separate magnetic features which would confirm that a dike swarm does exist and

what the width of such a swarm might be which may well come very close to the Los Medaños site. Also, parallel to this dike may be other singularly and narrow dikes that could exist closer to or beneath the Los Medanos site that might be hazards to the selection of this site as a nuclear waste repository.

In conclusion, the trachyte dike that has been uncovered both geologically and magnetically may be a hazard to the Los Medaños site. Therefore, it must be studied adequately, thoroughly, and carefully in order to ascertain its extent and importance to selection of the Los Medaños site or alternate sites that may be proposed in the northern part of the Delaware Basin. Fortunately, this dike appears to have relatively strong magnetic properties and modern tools of high resolution airborne magnetic surveying offer a convenient and relatively inexpensive method to map the dikes and to differentiate parallel dikes that are in close proximity to each other. The dike that has been uncovered is parallel to the one of the major structural directions of southeastern New Mexico, and many other dikes, buckles, and structural features to the north and northwest particularily in Tatum Basin are well known.

Some other factors need to be considered as being of more then passing interest. One is the parallelism of the dike to the general northeasterly strike of Nash Draw and the fact that the dike in a southwesterly direction appears to terminate at the present dissolution front of the Salado formation near the Pecos River. This would suggest that perhaps the

dike might be a source of fresh water extending southwesterly from the Capitan Reef which the dike cuts based on the magnetic information and may be in general associated with dissolution of the Salado formation and the topographic slump known as Nash Draw. This apparent coincidental relationship meeds further study and investigation. Airborne magnetics can supply some of the data crucial to such a study and should be accomplished at first opportunity.

It is thereby strongly recommended that a high resolution airborne magnetic survey with modern magnetic instrumentation be conducted. Such a survey should concentrate on multi-level perpendicular flight lines perpendicular to the known strike of the dike and thoroughly cover the Los Medaños site and immediate surrounding areas. Also, if alternate sites are under consideration in the event that the Los Medaños site does not have the necessary criteria as a nuclear repository, then such alternate site areas should also be flown with the same high resolution magnetic survey. Such a program has been recommended, and it is strongly recommended at this time that it be implemented as soon as possible.

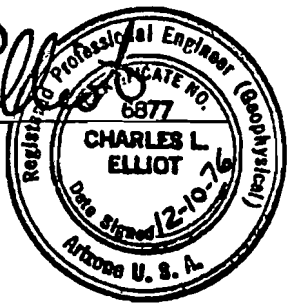
The trachyte dike, as it is presently known and partially understood, should be considered as a major structural feature and should not be discounted lightly. Based on all information at hand, the narrow dike material recognized well within the Salado formation within a few hundred feet of surface is apparently associated with deep basement sources suggestive of a parallel dike swarm with a deep precambrian source. If

it can be resolved from the pre-ent data at hand, then the concentrated basement source of the dike is likely centered near the present Los Medaños site and only a few miles from it. Therefore, this feature deserves a major geophysical/geological study and investigation.

December 10, 1976
Tucson, Arizona

Respectfully submitted,
ELLIOT GEOPHYSICAL COMPANY

Charles L. Elliot



Attachments: Listed on Page 4
Distribution: Dr. George B. Griswold (3 copies)