



STANFORD RESEARCH INSTITUTE
MENLO PARK, CALIFORNIA 94025
(415) 326-6200

For Fro
January 17, 1973

Dr. Elizabeth K. Ralph
Associate Director
Museum Applied Science
Center for Archaeology
University of Pennsylvania
33rd and Spruce Streets
Philadelphia, Pennsylvania

Dear Dr. Ralph:

Thank you for copies of MASCA Newsletter which you sent. Indeed, this work is of great interest to us.

Since last March we have been developing underground electromagnetic sounders under Institute Research and Development sponsorship. We are interested in applications in archeology, geology and mining.

Ten years ago we began work on a new family of high-powered pulse transmitters which are lightweight, portable, and very inexpensive. We have adapted these novel transmitter techniques to our present sounder program. For example, we can readily generate pulses from 1 to 10 RF cycles in length, at frequencies from 5 to 30 MHz, and peak powers of tens of megawatts.

We also have built and tested a number of antennas for launching the transmitted pulse into the earth and detecting the reflected signals. Care must be taken to prevent air propagated signals which can give spurious returns from mountains, buildings, towers, etc.

Surface moisture in soils and rocks often precludes propagation of radio waves in the earth for distances greater than tens of feet. However, in very dry climates or deep within the earth, longer range propagation is possible. We are familiar with underground propagation problems and dielectric properties of soils and rocks at radio frequencies.

Our sounder is, we believe, well suited to detection of tombs, chambers, walls, tunnels or structures buried beneath desert sands, mounds, or pyramids. Our equipment can be readily adapted to different geometries and different rock and soil media. We would welcome support for field experiments at sites of interest to archeologists.

Sincerely,

Lambert Dolphin

CABLE: STANRES, MENLO PARK / TWX 910-373-1246
LD:hd

Senior Physicist
Radio Physics Laboratory



STANFORD RESEARCH INSTITUTE
MENLO PARK, CALIFORNIA 94025
(415) 326-6200

March 11, 1975

Dr. Elizabeth K. Ralph, Associate Director
Museum Applied Science Center for Archaeology
University of Pennsylvania
33rd and Spruce Streets
Philadelphia, Pennsylvania 19174

Dear Beth,

Roger and I are indebted to you for your generous hospitality during our recent visit. Thank you very much.

Our time in Washington was well spent. It appears probable that we can get an NSF grant under their foreign currency program for sonics measurements in Egypt this fall. We'll take an array of other sensors along also so it will be easy to join the German team for a portion of our time there if that proves feasible.

We are all set for the White Mountains and will share the costs of our participation with you. If you can spare a 3-4k total, that would be satisfactory. We'll plan on a couple of trips over at different phases of the work. It would be helpful to block out some times on the calendar in the next few weeks as we seem to be getting busy.

Roger and I are both intrigued with the book you are planning on Modern Remote Sensors. He and I would be happy to contribute a couple of chapters on subjects such as underground radar or thermal infrared, for example.

We are looking forward to working together with you and your group in the months to come. Thanks again for your encouragements and hospitality.

Cordially,

Lambert Dolphin
Senior Physicist
Radio Physics Laboratory

LD:hd

cc: Roger S. Vickers

Have 2 others
3000 B.C.

Range 200 B.C.
to 3660 B.C.

6136

Acambaro, Mexico
C¹⁴ date = 2110 B.C.
~ TL dates



STANFORD RESEARCH INSTITUTE
MENLO PARK, CALIFORNIA 94025
(415) 326-6200

April 21, 1975

Dr. Elizabeth K. Ralph
Department of Physics, DRL/EI
University of Pennsylvania
Philadelphia, Pennsylvania 19174

Re: Proposal ERC 75-102

Dear Beth,

It will be a great pleasure to apply our underground radars and personal services to the problem of locating Bristlecone Pine stumps buried in alluvial fans in the White Mountains during late May and early June of this year, as we discussed recently in your office. We look forward to working with Henry Michael on this project. It is our plan to make two separate attempts at radar location of buried logs during different phases of Henry's excavation there.

Our participation is to be on a cost plus fixed fee basis not to exceed a total of \$3500. An invoice is enclosed per your request.

This research project will be established at the Institute on receipt of a letter accepting the proposal.

This proposal will remain in effect until 31 July 1975; however, the Institute will be pleased to consider an extension if requested.

Respectfully submitted,

Lambert Dolphin
Senior Physicist
Radio Physics Laboratory

Encl.

LD:hd

Approved:

R. L. Leadabrand, Executive Director
Electronics and Radio Sciences Division



STANFORD RESEARCH INSTITUTE
MENLO PARK, CALIFORNIA 94025
(415) 326-6200

February 23, 1976

Dr. Elizabeth K. Ralph, Associate Director
Museum Applied Science Center for Archaeology
University of Pennsylvania
Philadelphia, Pennsylvania 19174

Dear Dr. Ralph:

Under separate cover last week Lambert Dolphin and I conspired to send along for your reference shelf an in-house reproduced copy of

" Age Dating of Geological Materials, " a compendium of the several useful dating techniques assembled by some of my colleagues at Woodward-Clyde Consultants, as a function of their Professional Development Committee. The attached letter covers their intentions.

When I discussed my thought of making a copy for our own use, and one for your reference as well with Ray Lundgren, my particular associate at Woodward-Clyde, he said "By all means, do so." He then said that they have been pleased to have "good returns" as to the coverage and utility of the book from a limited distribution, and that their appropriation for cost of getting it in present form is well justified; their committee has sponsored several such productions.

He further asked if we would ask that you would provide a short critique as to whether this would be a useful book to have published, and if it is presently in sufficient depth, adequate source back-up, etc. for a reference handbook and text. I told him of the book that you and Henry Michael brought out in 1971 (the MIT Press reference) and he wondered if you might have suggestions as to the right publisher. My own thought here would be W. H. Freeman and Company here in San Francisco as a starter.

Your trouble in these several regards will be appreciated by all parties concerned and your frank appraisal is what is needed. After all you have been in the business and helped make it just that! Please extend my warm regards to Henry Michael. I hope we may again have the pleasure of working together across the coming season as it may work out.

Very truly yours, *W. B. Beatty*
W. B. Beatty, Senior Geologist
Radio - Physics Laboratory

WBB,hd
Enc.

WOODWARD-CLYDE CONSULTANTS

WESTERN REGION

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Suite 700
Two Embarcadero Center
San Francisco, CA 94111
415/956-7070

December 18, 1975

R. Lundgren

RECEIVED

JAN 5 1976

R. LUNDGREN

Dear Colleague:

The accompanying book "Age Dating of Geologic Materials: a Survey of Techniques" was funded by the Woodward-Clyde Consultants Professional Development Committee. It is intended to be an introduction to age-dating techniques; sources of information referenced for each technique can provide more detailed descriptions of various aspects of the technique.

The summary charts and preface at the beginning of the book constitute an "executive summary". The charts concisely summarize specific details of the techniques, such as effective age range, applicable geologic material, and sampling requirements. The preface explains that the age-dating techniques are organized by the parameter measured, such as rate processes, evolutionary changes, or phenomenological events. This organization can provide a framework for viewing the physical and chemical processes occurring within the geologic process. This framework will provide the key to useful applications of creative approaches to age-dating in various geologic and engineering situations.

Your comments, suggestions, and critical review would be greatly appreciated. If interest warrants, it may be possible to publish a slightly expanded second edition in a form that would receive wider distribution.

Sincerely,



Duane R. Packer

May 6, 1976

Dr. W.B. Beatty, Senior Geologist
Radio-Physics Laboratory
Stanford Research Institute
Menlo Park, California 94025

Dear Dr. Beatty:

Many thanks for sending us the personalized copy of Age Dating of Geologic Materials, and please excuse my delay in replying.

It is a useful book, but our overall reaction is that it is too general and in most chapters, nothing new is described. However, it does contain good summaries of the various methods of dating, and excellent references to pertinent articles.

A few specific criticisms and comments are as follows:

<u>page</u>	<u>comments</u>
vii	The use of TL dating for geologic periods greater than 10,000 years has not been successful. Also, people have talked about ERS, but have not had much luck.
viii	Palaeomagnetic dating, as described later, has been used in the range of 1.3×10^4 years as well as greater than 10^5 . <u>The Half-life of ^{14}C</u>
19	5710 years
24	5730 years (The value that I prefer)
27	5570 years (The value used by geologists and in <u>Radiocarbon</u>)
	Henry Michael feels that the illustrations taken from Fritz, pp. 141-143, 1971 are unnecessary. For example, one for narrow rings would have been sufficient.
129	Coeditors of our MIT book are: Michael, H.N. and Ralph, E.K.
42	The explanation of K/A dating is clear and excellent.
113	Good explanation of soils.

In summary, we feel that the chapters are well organized although in parts redundant.

As for publishers, the only one that I know well is M.I.T. How much a need there is for this type of book, I do not know, but I'll try to ask some geologists here.

With best regards,

Elizabeth K. Ralph



MASCA

May 4, 1976

A MOBILE SENSING PLATFORM
FOR ARCHAEOLOGICAL SURVEYING

SRI has recently completed development of a sensing platform for locating subsurface anomalies to aid the archaeologist by rapidly and nondestructively providing maps of buried features in advance of excavation. Traditionally, locating archaeological materials has been a combination of trial and error and the archaeologist's experience and intuition. Survey and excavation are highly labor-intensive methods of obtaining information in which large amounts of time, money, and energy may go into the painstaking excavation of a potential site with disappointingly few results. Indeed, if archaeological materials are found, they may not be what was sought. A single survey or archaeological excavation may cost anywhere between \$10,000 and \$100,000 a year, indicating the advantage of any improvements that would increase the probability of finding the often elusive archaeological objective.

The new SRI platform in use at present consists of a cordless, lightweight, hand-towed cart (Figure 1) to which any type of presently known sensing instrument for subsurface exploration can be readily attached. Such sensors can include ground-penetrating radar, and presently available magnetometers, microgravity meters, or resistivity probes. Since radar is not universally applicable to use in archaeological exploration, other complementary sensors including a high-frequency acoustic sounder are under development at present at SRI. Output from the sensing instrument is automatically transmitted by a radio link to a receiver located in a mobile vehicle parked at some convenient distance where the data are processed by a small computer, printed out within a few seconds, and digitally tape-recorded for permanent record. Simultaneous with the sensor operation, a position-location system (Figure 2) records the cart position on the horizontal plane (to an accuracy of approximately ± 1 foot) and plots this information directly on a map or

aerial photograph of the archaeological site. Any detected anomalies can then be superimposed on the map or aerial photograph of the site to give a readily usable presentation to guide the archaeologist in his subsequent exploration and excavation. Working hand in hand with the archaeologist, on site, the survey crew can also provide markers and other on-the-spot information for the archaeologist's immediate use. Where terrain is too rugged for use of the towed cart, the platform can be adapted for backpack operation by one or two men.

The automatic position-detection unit eliminates the need for time-consuming surveys of the site, and the laying out and staking of grids with consequent disturbance of the site. Time and cost requirements for an archaeology survey are therefore reduced, and the site is left undisturbed. Any kind of grid pattern can be chosen, and, since results are available in real time, areas of the site showing unusual subsurface features can be immediately re-explored using a tighter grid spacing to obtain more detail on subsurface features.

Subsurface radar is the most difficult sensor to use and presents the greatest quantities of data to be reduced. Therefore, to qualify for use with the most difficult sensor, the platform was initially built and tested around a family of radars developed at SRI during the past four years. Data processing and recording equipment, electrical power supplies, and cart storage space are at present provided by a mobile laboratory (Figure 3). All equipment can thus be driven to the archaeological site.

The potential usefulness of the platform has been initially demonstrated by a series of field experiments at Chaco Canyon National Monument, New Mexico, where subsurface structural features have been readily mapped by a subsurface radar mounted on the platform (Figure 4).

Archaeologists interested in joint research and cooperation in a survey of their site with this platform should contact Roger Vickers or Lambert Dolphin at [415] 326-6200, Ext. 4422 or 4868. To assist in archaeological evaluation of this technique, SRI is working in cooperation with Professor Ezra Zubrow, Department of Anthropology, Stanford University. Professor Zubrow is available to discuss archaeological applications of the platform and its potential usefulness, at [415] 497-3118.

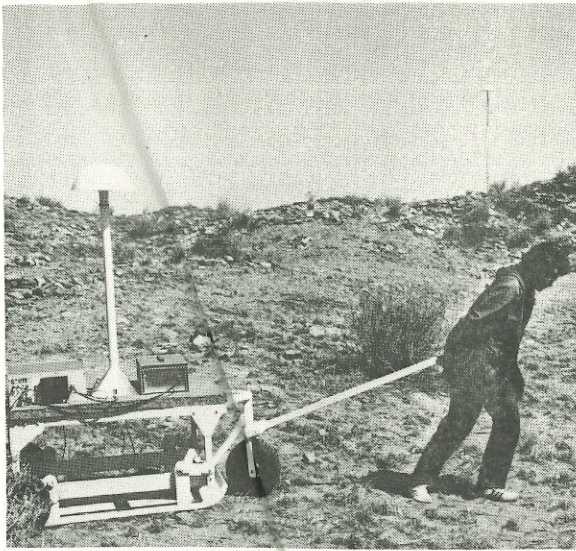


FIGURE 1



FIGURE 2

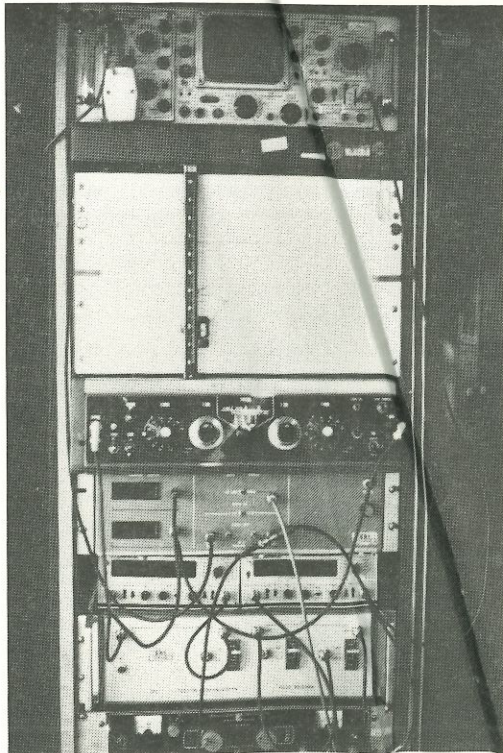


FIGURE 3

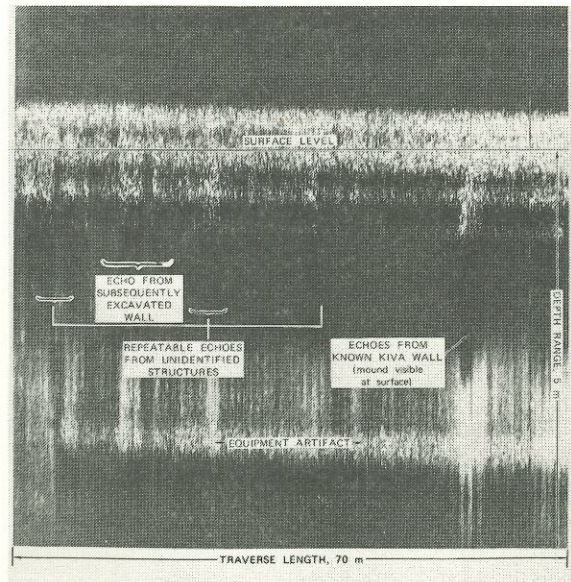


FIGURE 4



STANFORD RESEARCH INSTITUTE
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(415) 326-6200

May 18, 1976

Dr. Elizabeth K. Ralph, Associate Director
Museum Applied Science Center for Archaeology
The University Museum Fl
Philadelphia, Pennsylvania 19174

Dear Friend :

Many thanks for your taking time to provide a short "critique" for the "Age Dating Survey" that was a sort of work-book task of my Woodward-Clyde Consultant associates. I have sent your letter along to them and they should find your notes helpful. I myself think they have provided a useful "overlook" of all the techniques and we found the volume very informative here in our lab at SRI.

In thinking of a publisher, I suggested that they review this possibility with W. H. Freeman Company right there in San Francisco, who have a reasonably fair spread of geology and earth science oriented texts that they maintain in their list. And we hope they may fly it for the "useful spread of knowledge."

And, again, our thanks for your friendly help. And please extend our general regards to Henry Michael, whom we would hope to see again on site at the Bristlecones sometime this summer.

Cordially,

W. B. Beatty, Senior Geologist
Radio Physics Laboratory

WBB.hd

UNIVERSITY of PENNSYLVANIA

PHILADELPHIA 19174

February 4, 1976

Dear Colleague:

At yesterday's meeting of representatives of the departments which expressed an interest in the Research Initiation and Support Program of NSF, it was agreed that interested departments should submit one or two-page proposals to me for consideration by the Committee on Research in developing an institutional response for the University. Because the deadline for submission of the institutional response is March 15, I must ask you to have your proposal in my hands by February 10.

Sincerely,

Bernard Steinberg (ms)

Bernard D. Steinberg
Chairman, Committee on Research

cc: Marilyn E. Hess
Donald N. Langenberg

Application for NSF Consortium grant by Elizabeth K. Ralph (Ph.D. 1973)
(Department of Physics, DRL E1, Tel. 8168)

Submitted to Professor Bernard Steinberg on February, 3, 1976.

The search for bristlecone pines older than 6000 B.C. is described in the attached article from the New York Times. If found, and after they have been cross-dated by the dendrochronological process and C-14 dates have been obtained, they will provide basic information about changes in the Earth's magnetic intensity and climatic changes starting with the Wisconsin glacial period and the subsequent warming of the oceans.

The development and use of our cesium magnetometer (manufactured by Varian Associates) is described in the attached reprint from Geoexploration.



STANFORD RESEARCH INSTITUTE
MENLO PARK, CALIFORNIA 94025
(415) 326-6200

June 26, 1975

Dr. Elizabeth K. Ralph, Associate Director
Museum Applied Science Center for Archaeology
University of Pennsylvania
33rd and Spruce Street
Philadelphia, Pennsylvania 19174

Dear Beth,

Thank you very much for your support of our radar search for Bristlecone pine stumps in the White Mountains alluvial fans. We are sorry not to have pinpointed any logs in our traverses; however, the radar technique did work in that buried boulders were detected,* as well as warping of subsurface strata now filled, in old stream channels, to depths of 30 to 40 feet.

We found it necessary to have our antennas in intimate contact with the ground, so clearing the sagebrush by hand for the 100-200 ft traverses was necessary. We could survey much faster if long swathes could be cut for us by a small bulldozer, and if our equipment were mounted so as to be jeep-towable rather than hand-towed. With manual sagebrush clearing we found we could cover only 400-500 feet a day.

In some applications of subsurface radar we are able to mount antennas off the ground, as we did at Chaco Canyon, but this method proved unsuccessful on the fans.

Optimum frequency for sounding into the fans appears to be in the 70-140 MHz range. At the lowest frequency we have too much dead-time and cannot see objects shallower than about six feet. At the higher frequencies the unwanted scattering (clutter) obscures our radar field of view. The experiments on the fans were mostly conducted at 91 MHz, at which frequency the dead-time accounted for the first 4 feet, and scattering was not prominent. Also, attenuation of the signal rises rapidly above 100 MHz, according to the soil sample measurements shown in Figure 1. The silt, which appears to constitute a good part of the total volume of the fan (over 50 percent in the first trenches opened in Silver Creek Canyon fan), has a low dielectric constant which means that the dielectric contrast between silt and logs is less than that between silt and boulders. However, we feel we could have detected any isolated logs had there been any in the traversed area, subject to a few feet of dead-time, and a maximum depth limitation of 30 or 40 feet. In the case where the log was accompanied by numbers of

* Henry with his backhoe found boulders at each of 8 radar anomaly locations on Silver Creek fan, and in each of 4 anomalies we found on Milner Creek fan.

different rigid boulders, however, individual detection would not be possible, and one would have to be satisfied with delineation of 'zones of deposition' instead.

The fans are highly inhomogeneous, and boulders two to three feet in diameter are common, so there is much clutter in our data. We could thus only make shrewd estimates about the 8 or so anomalies detected. To modify a system specifically for use on the fans would in itself be a six-month project.

In spite of these limitations we gained much valuable experience in subsurface radar technology during our week in Bishop.

Because of the overwhelming number of boulders present, it is far less expensive to rent backhoes and simply trench hundreds of feet of fan blindly than to analyze data from the present radar equipment. Yet, in simpler geologic settings a jeep-mounted radar and advance bulldozing of traverses could make surveying very large areas by radar practical.

We are also continuing work on clutter-reduction techniques so as to enhance our abilities to see desired signals, discriminating against air-propagated echoes and scattering in the surface layer.

From our point of view this was a valuable and instructive exercise. Working with Henry in the field was a distinct professional and personal privilege for us.

Sincerely,



Lambert Dolphin
Senior Physicist
Radio Physics Laboratory

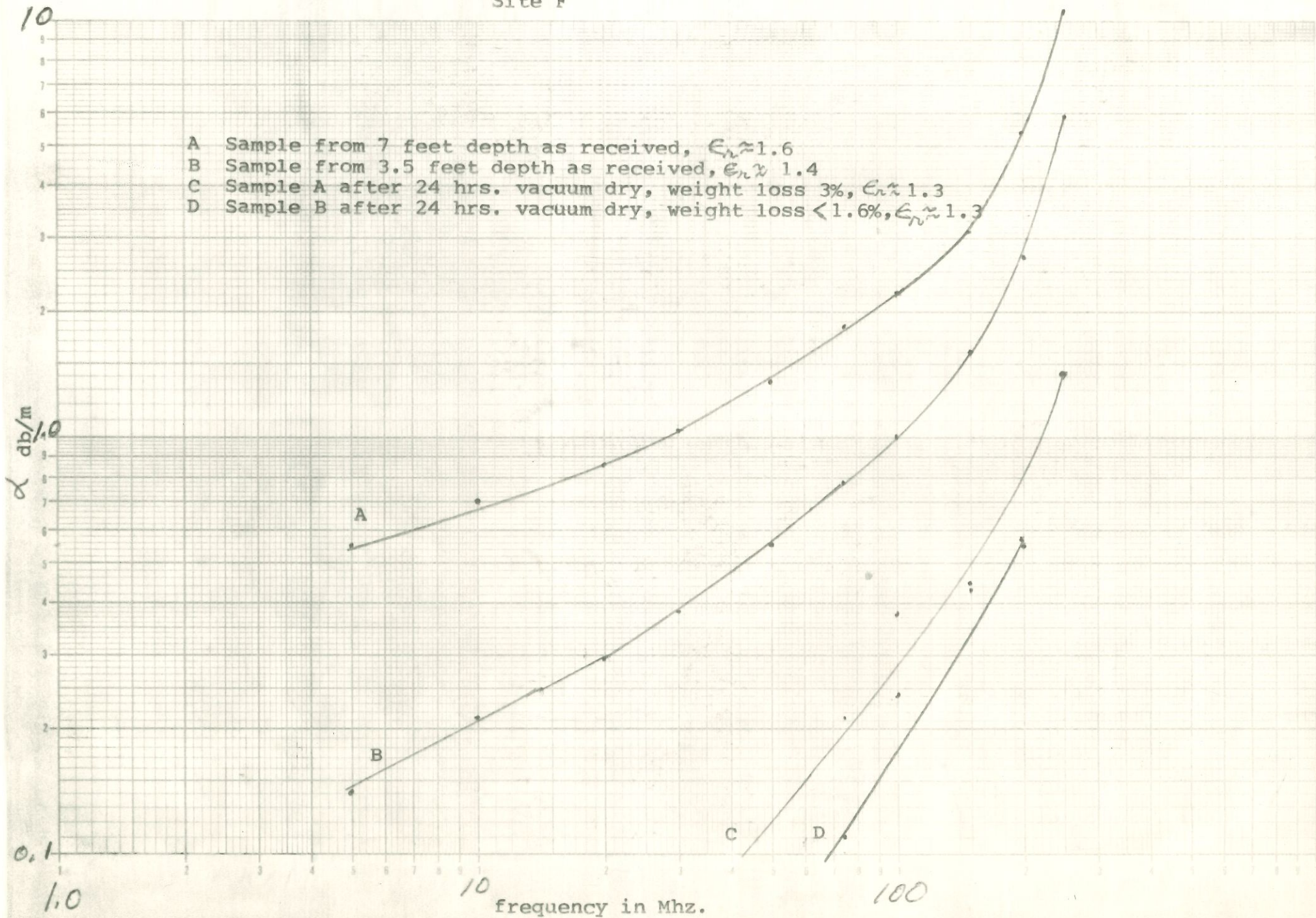
Enclosure: Fig. 1

LD:hd

cc: Dr. Henry Michael, MASCA
Dr. Roger S. Vickers, SRI

RF Losses in Silt From Silver Creek Alluvial Fan
Site F

6/26/75



September 4, 1975

Dr. Roger Vickers
Senior Physicist, Radio Physics Lab.
Stanford Research Institute
Menlo Park, California 94025

Dear Dr. Roger Vickers :

This letter is to serve as an authorization for Dr. Roger Vickers, Dr. Lambert Dolphin, and their colleagues at Stanford Research Institute to assist the Museum Applied Science Center (MASCA) in further exploration.

"Exploration" is defined as the use and improvement of soil-penetrating radar equipment and other apparatus that will improve and expand the techniques for archaeological prospecting.

The next tests are planned to take place at Chaco Canyon, New Mexico in late September or early October, 1975.

MASCA is planning to contribute \$1500.00 toward the cost of the experiments at Chaco Canyon.

Sincerely yours,

Elizabeth K. Ralph