

Recreation Management Tech Tips

United States Department of Agriculture
Forest Service



Technology &
Development Program

August 1999

2300—Recreation 9923 1307—SDTDC

Cryoprobe—A Unique Tool for Archeologists

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INTRODUCTION

Cryogenic technology involves the knowledge and use of very low temperatures for practical results. Archaeologists have used geological coring techniques to obtain soil/sediment samples from sites of interest for many years. A recently developed coring technique that is based on cryogenic technology has been used successfully to extract soil/sediment cores from archaeological sites.

First developed in Europe in the late 1980s, the “cryoprobe” technique uses a steel pipe through which a cryogenic fluid is circulated. After inserting the probe into the soil, the fluid is circulated inside the pipe, and a continuous coating of soil/sediment is frozen along the length of the probe. When extracted, the soil column exposes the depositional record for use in subsequent archaeological study. The frozen column provides an undistorted record of the stratigraphy that can then be used in a variety of geological and archaeological analyses.

During the mid-1990s, archaeologists from the University of Georgia, working in conjunction with Forest Service Cultural Resources staff in the Southern Region, successfully demonstrated soil sampling using cryoprobes. They requested that the Technology and Development Center provide assistance in developing a prototype cryoprobe system for field work. What was desired was a system that would allow them to freeze a small column of soil, extract it, examine it, and accurately record the findings in remote locations.

CRYOPROBE SYSTEM DEVELOPMENT

The first American cryoprobe prototype, developed by the University of Georgia Geology Department, used 1-inch (25.4 mm) diameter pipe that was open at the top and closed on the insertion end. The

cryogenic fluid, such as dry ice, liquid, or gas such as CO₂ or nitrogen, was introduced into the pipe to freeze a portion of the surrounding soil onto the pipe. Liquid nitrogen was the preferred fluid because it is a very low temperature coolant, and decreases freezing time and increases the thickness of the frozen soil. The probe was then extracted using a manual hoist (often called a come-along) hung from a tripod.



Figure 1—Cryoprobe developed at University of Georgia.

This approach was chosen because it provided relatively non-compressed samples in comparison to traditional coring methods and produced more complete or continuous sediment columns, especially in soils where liquefaction and loss of the sample can occur. Ground penetrating radar and magnetic prospecting methods were used to carry out geophysical studies of specific site elements,



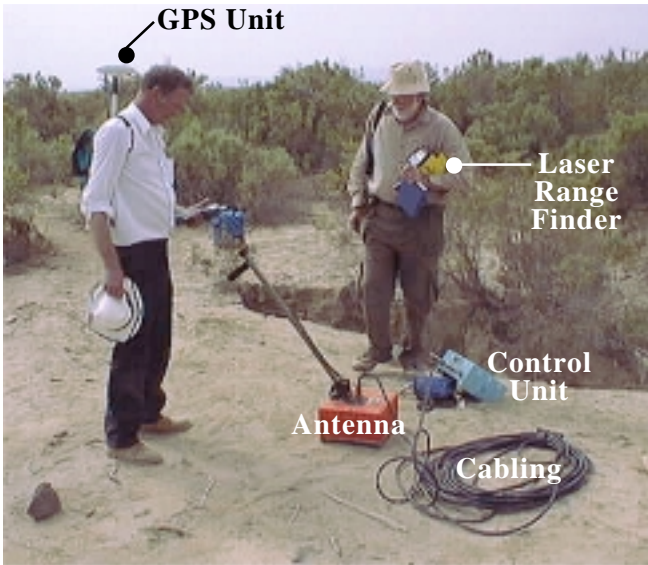


Figure 2—Ground penetrating radar equipment pinpoints key locations to probe.

followed by coring using the cryoprobe (figure 2). The cryogenic soil probing technique provides a new and useful tool that should be incorporated into geoarchaeological methodology designed to characterize archaeological sites. The extracted sediment profiles have also proved to be useful in geochemical and plant macrofossil studies, as well as pedological studies.

Because the results of these initial developmental trials were so encouraging, the Technology and Development Center was asked to continue the development of the cryoprobe and to provide a complete system for archaeological studies at remote sites. The probe and extraction hardware were modified to provide more efficient operation and a trailer to haul the necessary equipment was developed. A digital video camera and a colorimeter were provided to record the significant characteristics of the soil cores.

A driving mandrel that fits inside the post driver and attaches with a coupling (so it can be removed during the freezing and extraction) and a small feeder tube inside the probe were added. This allowed the liquid nitrogen to be introduced close to ground

level and directed towards the bottom of the probe, which increased the efficiency of the operation by decreasing the amount of nitrogen required and shortening the freezing time.

The best manual hoist that could be found was rated at 2000 pounds force (8900 N) and was inadequate for soil samples longer than 1 to 2 feet (0.3 to 0.6 m) in most soils. To provide more pulling power, a hydraulic power pack and cylinder that provided 10,000 pounds of force (44,500 N) were added to the system. The cylinder is supported by a lightweight, portable aluminum tripod (rated to 10,000 pounds) with legs that telescope for transport.

A narrow, lightweight trailer was developed to carry all of the equipment including: probes, liquid nitrogen bottles, hydraulic power pack and cylinder, tripod, post driver, recovery trays, and other accessories. The trailer was designed to be towed behind an all-terrain vehicle to go off-road to the particular archaeological sites. The trailer is approximately 10-foot long and 42-inches wide (3 m by 1 m) and can easily be maneuvered on most trails. Since narrow vehicles are inherently less stable, the trailer is equipped with telescoping axles that when expanded increase the track width by over one foot (0.3 m). This increases the stability of the trailer on rougher trails. The all-terrain vehicle and the trailer should be transported to the off road location on an equipment trailer designed and equipped for highway travel.



Figure 3—ATV and trailer in tow.



Figure 4—Trailer at San Dimas Technology and Development Center.

PROTOTYPE TRIALS

Working in conjunction with archaeologists from the Angeles NF, initial trials were conducted at the Technology and Development Center (SDTDC) in San Dimas, California where the soils are mostly decomposed granite. As one would expect, early experimentation confirmed that the soil characteristics and the amount of moisture present are critical to the cryoprobation success. The decomposed granitic soils were difficult to penetrate with the probe using the post driver, and would not readily freeze using the liquid nitrogen when dry. Trials conducted during the rainy season or after water was added (usually 10 to 20 gallons [37.9 to 75.8 L] of water poured into a

small shovelled-out basin) proved successful. Soils cores ranging from 30 to 48 inches in length (0.8 to 1.2 m) and 7 to 9 inches in diameter (0.2 m) were extracted. In some cases, when the hole left after the first extraction did not collapse in, it was possible to pull out a second core up to 24-inches long (0.6 m).



Figure 5—Liquid nitrogen released to the atmosphere as probe freezes the ground around it.



Figure 6—Come-along used to extract frozen core from its surroundings.



Figure 7—Sample of a frozen undisturbed core approximately 4 foot in length and 4-7 inches in diameter.



Figure 8—Cryoprobe used to extract a core from a streambed.

The first field trial of the prototype cryoprobe system was conducted at Scull Shoals, a significant archaeological site in Georgia on the Oconee NF. Soils there are composed of clay, silt, and sand. A core over 48 inches long (1.2 m) with a diameter ranging from 6 to 10 inches (0.2 to 0.3 m) (with a large bulb on the end) was extracted. It took approximately one hour to set up and extract the core, which included about one-half hour for freezing. The low bearing capacity of the soils showed the need to add “feet” (pads) to the legs of the tripod.



Figure 9—Transporting cryoprobe equipment with small trailer and all-terrain vehicle to remote site.

This and other minor modifications to the cryoprobe system have been made and further trials are expected soon.



Figure 10—Skip Garrett from SDTDC pounds cryoprobe into ground using a post driver.



Figure 11—Once the probe is frozen a hydraulic cylinder is attached to hoist probe out of the ground.

CONCLUSION

Scientists from the University of Georgia and the Forest Service Southern Region have increasingly incorporated technological advancements, such as the cryoprobe, into geoarcheological methodology designed to characterize significant archeological sites. As these techniques are developed and refined, and when combined with established analytical tools, they will provide additional insights for archeologists and geologists in the future.



Figure 12—Archeologists gather around to examine the frozen, intact sample once removed.

CAUTION

Liquid nitrogen, which boils at -320°F (-196°C), is a hazardous substance. If misused it may cause, frostbite, eye damage, torn flesh, or asphyxiation.

FOLLOW THESE SAFETY RULES:

- Wear safety goggles at all times.
- Wear insulating gloves when handling liquid nitrogen or large, cold objects.
- Use liquid nitrogen only in well ventilated places.
- Do not allow any liquid nitrogen to touch any part of your body.
- Items in contact with liquid nitrogen becomes extremely cold. Do not touch any item that has been immersed in liquid nitrogen until it has warmed to room temperature.
- Do not store liquid nitrogen in any container with a tight fitting lid. A tightly sealed container will build up pressure as the liquid boils and may EXPLODE after a short time.
- Substances become brittle and may shatter when cold, sending pieces of the material flying.
- Avoid common glass and large, solid plastics.



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