National Reservoir Inundation Study Research at Round Spring and Alley Spring

National Park Service, Southwest Cultural Resources Center, Santa Fe

Round Spring Oblique View

NATIONAL RESERVOIR INUNDATION STUDY RESEARCH
at
ROUND SPRING AND ALLEY SPRING
OZARK NATIONAL SCENIC RIVERWAYS, MISSOURI

by

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National Reservoir Inundation Study,
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ABSTRACT

The National Reservoir Inundation Study, in cooperation with Archeologists from the University of Missouri Columbia, American Archaeology Division, spent 3-1/2 days at Ozark National Scenic Riverways collecting data on Round Spring and Alley Spring and setting up a field experiment to test the impacts of freshwater immersion on archeological materials. During this visit an archeological site was discovered in Round Spring Grotto under 10 feet of water. This report discusses the field experiment initiated, documentation of the Round Spring Grotto Site (23SH96), results of analysis of the materials collected from the site, geologic and floral data gathered from both Round Spring basin and grotto and Alley Spring basin and cave, and the underwater archeological field methods employed to map both the basin and grotto at Round Spring and to gather data from both sinks. A one-half hour edited video tape supplements this report; it is available from the Submerged Cultural Resources Unit, Southwest Cultural Resources Center, National Park Service, Santa Fe, New Mexico.

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A number of individuals contributed to the successful completion of the intense research work undertaken at Round Spring and Alley Spring between September 18 and September 21, 1978. It goes without saying that without the contributions of each person on the field crew as well as the Park staff, it would not have been possible to accomplish as much as we did within such short period of time.

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Toni L. Carrell

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I. INTRODUCTION

The National Park Service's Southwest Cultural Resources Center in Santa Fe, New Mexico, houses the coordinating office for a multiphase study designed to determine the effects of freshwater inundation on archeological sites. The National Reservoir Inundation Study is jointly funded by the U.S. Army Corps of Engineers, Water and Power Resources Service, Soil Conservation Service and the National Park Service.

Focus for the study is the examination of sites prior to inundation, while flooded, and during periods of drawdown in order to assess the impacts on: data retrieval potential; the degree of preservation or destruction of archeological remains; and the efficacy of salvage operations versus direct protective measures. Laboratory experimental research and a reservoir modelling program are also being employed in the study. The long range goal of the project is the development of a management-oriented document which will contain predictive models for anticipating impacts of inundation and a discussion of methods of site protection and preservation.

Field research has been undertaken at over 50 reservoirs or other freshwater areas around the United States in order to obtain a balanced sample of impacts and environments. Karst areas have also been included in the research program because sites containing well-preserved organic and inorganic remains dating to 10,000 B.P. have been located in such geologic features in the past. A

one-to-one correlation between spring-sink features and cultural activity has been noted in recent Florida surveys (Murphy, personal communication). Similar data are currently not available for the Missouri Karst; however, there are reports describing prehistoric and historic cultural activity in the karst area of southeast Missouri.

The Ozark National Scenic Riverways in Southeast Missouri was selected for a combined research effort between personnel from the American Archeology Division, University of Missouri and the National Reservoir Inundation Study. Alley Spring and Round Spring were the two areas examined between September 18 and September 21, 1978.

II. RESEARCH ORIENTATION AND GOALS

The reservoirs which have been included in the ongoing inundation research (e.g., Palmetto Bend, Texas; Glen Canyon, Utah; Saylorville, Iowa; Table Rock, Missouri; Lake Mendocino, California; Blue Stone, West Virginia) contain sites which represent a diverse range of cultural manifestation. In none of the reservoirs examined or considered for inclusion, however, has the study team been able to retrieve archeological materials from previously excavated sites which have undergone long periods of immersion.

A major portion of the Inundation Study includes comparisons between pre- and post-inundation cultural remains to determine changes in data-retrieval and analytic potential. The criteria for site selection, including detailed information on sample collection, retention of adequate comparative materials, and site location informaton, is of critical importance. In many cases, however, these criteria have not been met.

The Inundation Study, in order to obtain some of the needed materials under the criteria previously listed here and in the Preliminary Report of the National Reservoir Inundation Study (Lenihan, et al., 1977:123-182), has contracted with individuals and institutions across the United States to prepare sites currently under excavation in reservoirs according to the guidelines for data collection and site preparation outlined in the above document.

These contracted situations will be examined prior to the end of the study; however, they will only be able to provide information on relatively short periods of inundation. In order to assess the long-term effects of freshwater inundation, the karst areas of

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the United States have also been included in the study.

Wakulla Cave (Olson 1958), Silver Springs (Martin 1966), Warm Mineral Springs (Cockrell 1973, 1974), and Little Salt Springs (Clausen 1972a, b), in Florida, to name but a few, have all yielded cultural and non-cultural organic materials which have been submerged for thousands of years and are in excellent states of preservation. These materials can be used to answer the following question: What are the beneficial effects of immersion found in karst features which preserve rather than destroy cultural remains?

Selection of Round Spring and Alley Spring for inclusion in the inundation research was based upon four factors:

(1) Round Spring was used both historically and prehistorically by local inhabitants. Archeological investigations in the immediate area yielded several prehistoric human burials, pottery and numerous lithic and ground stone artifacts (23SH19).

(2) Alley and Round Springs have relatively constant temperatures which vary seasonally only slightly; a phenomenon shared by the springs in Florida which have yielded well preserved cultural material. This permits the isolation of the temperature variable in preservaion.

(3) Alley and Round Springs have water chemistry values suitable for comparison to an ongoing laboratory experiment being conducted at the University of New Mexico.

(4) The Alley Spring area has experienced a long historic occupation period. Prehistoric use of the spring area has been substantiated through surface collections and testing (Bonn and Chapman 1972) and there exists the possibility of use of the basin and cave area as well.

Three specific goals were outlined for the research to be undertaken at the two springs:

(1) preliminary examination of the Alley Spring cave feature and Round Spring basin for cultural remains;

(2) placement of buckets containing archeological materials in both sinks for the field phase of the water chemistry laboratory experiment; and

(3) general environmental survey and mapping of Round Spring basin.

III. BACKGROUND RESEARCH

Environmental Setting

The springs examined by this study are located in the southeastern Missouri portion of the Ozark uplift. This portion of the uplift is characterized by deep, narrow valleys and sharp ridges of the Salem Plateau region (McCracken 1971:3). Springs occur in all sections of Missouri but the dolomitic rock of the Salem Plateau has the greatest number as well as the largest of them. The mass of from 1000 to 2000 foot thick dolomitic rock present in this area allows tremendous storage for precipitation. The mean annual precipitation for the area is 42 inches (data from National Weather Service) with the preponderance falling in early spring and late fall. Evopotranspiration over the state averages about 28 inches leaving a 14 inch residual to fill the dolomite aquifers that have carved large vadosic and phreatic zone karst features most notably of which is the springs.

Meinzer (1972:2) employs a classification of springs according to their yield or discharge as follows:

Magnitude	Discharge
1st	100 cfs (cubic feet per second)
2nd	10-100 cfs
3rd	1-10 cfs
4th	1 cfs - 100 gpm (gallons per minute)
5th	10-100 gpm

Following this classification, Alley Spring (125 cfs, average flow) is a 1st magnitude spring and Round Spring (41 cfs) is a second magnitude spring. By comparison Big Spring located 90 km south, is measured at 427 cfs (average flow) which classes it among

the ten largest springs in the world. Of the U.S. springs, Silver Springs (Fla., est. 1000 cfs) and Rainbow Springs (Fla., 700 cfs) are the largest 1st magnitude springs in the western hemisphere.

Fauna within the Missouri springs is limited to species that are found in temperatures remaining near 58° Fahrenheit year-round. Although not diverse, the species present are markedly abundant (Pflieger 1974:33). Flatworms, amphipods, isopods, snails and certain insects are the dominant invertebrates while fish and salamanders are the dominant vertebrates.

The flora of Ozark Springs is dominated by distinctive species of spermatoplytes, bryophytes, and algae (Liscomb 1974:45-50). Water cress (Nasturtium sp.) is the most frequently observed plant but deeper water plants include Potomogeton species and Sparganium. Aquatic mosses and filamentous algae also dominate in spring basins.

Archeological Overview

A review of published and unpublished archeological sources reveals a long sequence of occupation for areas within and adjacent to the Ozark National Scenic Riverways. Surveys and excavation reports have delineated a cultural sequence that includes technological traditions of the Paleo-Indian, Archaic, Woodland, Mississippian, Proto-historic, and Historic Periods. Within this report, technological traditions are defined as classes of material objects with definable attributes that extend through time and space (Chapman 1975:23). Chronological periods will be individually identified and follow the generally accepted time spans outlined by Willey (1966) and Chapman (1975:27). Each of these periods (Table 1) and the pertinent reports are briefly discussed below. Because of the lack of information on complete technological assemblages within the study area, information about technological traditions outside of the area will be used for tentative typological and chronological ordering.

TABLE 1
CULTURAL SEQUENCE OF OZARK NATIONAL SCENIC RIVERWAYS
(After Chapman 1975:30)

Tradition	Period
Village Farmer	Late Mississippian A.D. 1450-1700 Early Mississippian A.D. 900-1450
Prairie-Forest Potter	Late Woodland A.D. 400-900 Middle Woodland 500 B.C.-A.D. 400 Early Woodland 1000-500 B.C.
Forager	Late Archaic 3000-1000 B.C. Middle Archaic 5000-3000 B.C. Early Archaic 7000-5000 B.C.
Hunter-Forager	Dalton 8000-7000 B.C.
Early Hunter	Paleo-Indian 12,000-8000 B.C.

Paleo-Indian (12,00-8,000 B.C.)

Little information is available in the study area about the Early Hunter Tradition, but fluted points have been collected from sites 23CT2 and 23CT5 in Carter County along the Current River (Garrison et al. 1976:16). These sites consist of surface lithic scatters without any depth of cultural deposits. Fluted forms have been reported to the north in the Meramec River Basin (Chapman 1975:75), therefore it is possible that large game hunters may have camped near Round and Alley Springs.

Dalton (8,000-7,000 B.C.)

Chapman (1975:99) notes that Dalton Serrated type lithic artifacts have been collected from the surface of sites along the Current River in Shannon County. These finds are the only basis for assuming that Hunter-Foragers occupied the area during the Dalton period (Chapman 1975:71). Outside of the area to the northwest in the lower Osage River drainage is located Rodgers Shelter which has produced Dalton, Plainview, and fluted points from the lowest level (Chapman 1975:73). Radiocarbon dates from this level were from 8500-8000 B.C., i.e., 10,530 ± 650 B.P. [ISGS48] and 10,200 ± 330 B.P. [M-2333] (Chapman 1975:74 after McMillan 1971:81). McMillan (1971:186) suggests that both hunting and gathering were important subsistence activities. Dalton points are known from the Round Spring area and a site near the southern border of Shannon County (23SH1) (Garrison et al. 1976:16).

Archaic (7000-1000 B.C.)

The Archaic period adaptations in the study area may be summarized as a shift from mainly hunting subsistence patterns to one of mixed hunting and gathering with an emphasis on smaller game and greater vegetal variety (Chapman 1975:127).

The Early Archaic (7000-5000 B.C.) has not been reported in the study area (Chapman 1975:129) but has been described by Bray

(1956) at the Rice Site (23SN200) in the Table Rock Reservoir area to the West. McMillan found an Early Archaic complex at the Tick Creek Cave site consisting of Rice Lanceolate, Rice Lobed, Graham Cave Notched, snubbed-end flake scrapers, and split-bone awls (McMillan 1965:69). Marshall (1956:30-118) also noted Early Archaic materials in VerKamp shelter in the Meramec basin north of the study area.

Middle Archaic (5000-3000 B.C.) cultural materials have not been described in the literature of the study area but radiocarbon dates at Jakie Shelter have indicated that the complex was present just prior to 5000 B.C. (Chapman 1975:159). McMillan (1956:57) also noted a Middle Archaic component of chipped and groundstone artifacts and bone tools from Tick Creek Cave in the Gasconade River drainage. Chapman (1975:172) also notes the presence of a Middle Archaic Component in Stratum 2 of Rodgers Shelter.

The period defined as Late Archaic (3000-1000 B.C.) is not well studied in the project area. Chapman (1975:229) indicates there are no data on this period from the Current-Eleven Point drainage. To the west in the White River drainage Late Archaic period assemblages have been called the James River complex (Chapman 1975:229). This complex is characterized by Smith Basal Notched, Stone Square Stemmed, Table Rock Stemmed, Afton Corner Notched, triangular bifaces, chipped stone notched axes, hafted and straight sided drills, flake tools, scrapers, and chert core hammerstones (Chapman 1975:186). Garrison et al. (1976:17) reports Late Archaic type artifacts in the Current River area based on examinations of private collections. Finally, Born and Chapman (1972:45-49) conclude, based upon excavation and surface collections, that tested areas around Alley Spring were occupied primarily during the entire Archaic period. Garrison also suggests a possible Middle-Late Archaic period occupation for 23SH70 (area slightly east of spring) (Garrison et al. 1976:86, Chapman 1978 personal communication).

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Early Woodland (1000-500 B.C.)

Within the context of Missouri prehistory the Woodland Period begins about 1000 B.C. and concludes about A.D. 900 (Chapman 1975-30). In many respects the artifact assemblages of the Early Woodland period are similar to assemblages of the Late Archaic. However, it is generally accepted that the end of the Archaic and the beginning of the Woodland is characterized by the presence of ceramic remains (Jennings 1974:213), but there were no immediate changes in the overall technological assemblages. There is no evidence at present to indicate an Early Woodland occupation either at Round or Alley Springs. This does not mean that this area was not occupied from 1000 to 500 B.C. It is quite possible that people with a pre-ceramic technology continued to occupy the area until Middle Woodland times when contact with Ozark Highland populations was possible.

Middle Woodland (500 B.C. - 400 A.D.)

Garrison states that projectile points similar to Middle Woodland forms and corner-notched Hopewell forms are common along the Current River and Round Spring (Garrison et al. 1976:18, 34). Garrison also suggests (1976:18) that a cache of blades found at Round Spring are probably from the Middle Woodland period. A generalized Woodland projectile point was described from Alley Spring excavations (Born and Chapman 1972:49); they were unable to make a closer affiliation, however. To the north there is some evidence for a Middle Woodland intrusion into the Gasconade drainage at Tick Creek Cave (McMillan 1965:74). This evidence consists of a few grit tempered sherds with dentate stamping and a few Snyder-like points. Similar sherds were found by Wood (1961:90) in Stratum 4 of Blackwell Cave in the Pomme de Terre drainage in western Missouri.

Late Woodland (400 - 900 A.D.)

Within the study area much of the literature describes ceramics and projectile points that are associated with Late Woodland

times. Born and Chapman (1972:50) describe Late Woodland material from a terrace overlooking Alley Spring Branch. Also possible Late Woodland material including flakes, a single pottery sherd, and a single projectile point came from sites 23SH58 and 23SH61 near Alley Spring (Born and Chapman 1972:52). Pottery sherds from the Round Spring Grotto Site (23SH96) have been tentatively identified as Late Woodland and Mississippian (Chapman 1979 personal communicaton). Garrison (1976:32,34) reports four small clay tempered, plainware body sherds from 23SH70 (near Round Spring) in association with diagnostic projectile points typical of the Early-Middle Woodland Periods.

Outside of the study area toward the north in the Maramec River drainage Marshall (1965) has described and defined the Maramec Spring Focus. Cultural materials included in this focus were first described by Chapman (1948:100-110) as the Highland Aspect; traits representative of the Central area of the Ozarks. Most of the artifacts identifed with this focus are usually identified with Late Woodland complexes (McMillan 1965:60). McMillan also notes the presence of this focus in the Gasconade drainage (1965:60). The pottery of the Maramec Spring Focus is Maramec Cord Marked and Maramec Plain types. The only real difference between these two types is surface treatment. Both types are made with paddle and anvil during final processing, temper is finely crushed limestone with some sand inclusions, texture is usually compact and hard (average 3, calcite) and dark brown or black to reddish buff on exteriors. Shell tempered pottery may also occur in the latter periods of this focus (McMillan 1965:60).

Mississippian Period (900-1700 A.D.)

Shell tempered pottery associated with burials of ca. AD 1100-1350 was found at Round Spring (23SH19) but construction has destroyed much of this site (Chapman 1979 personal communication, Garrison et al. 1976:180). McMillan (1965:77) suggests that people

who were producing Maramec Cord Marked pottery in the Gasconade drainage may have had contact with Mississippian populations from Cahokia. It is not unreasonable to suggest possible contacts between people in the Middle Mississippi Valley and people living in the Round Spring-Alley Spring areas.

Historic Period (A.D. 1700-present)

Traditionally the study area was assigned to the historic Osage Indians but it may be east of the area actually occupied by that tribe (Garrison et al. 1976:19). Shawnee and Delaware Indians were invited to the vicinity by the Spanish (Chapman and Chapman 1965:113). By 1830 all Indian tribes that had previously occupied this area had been moved out (Garrison et al. 1976:19).

Permanent Euro-American settlement began in the early part of the 19th Century. Prior to this period the majority of activities by Europeans centered around the fur trade (Garrison et al. 1976:19). The topography of the area is an inhibiting factor in the development of agriculture, but commercial lumber and mining activities occured during the latter half of the 19th Century (Garrison et al. 1976:19). Saltpeter deposits, necessary for the production of gunpowder, were also exploited commercially in the Current River drainage at least as late as the Civil War (Sauer 1920:154). Excavations at both Round and Alley Spring yielded historic ceramics, nails, glass, and lead (see Born and Chapman 1972 and Garrison et al. 1976 for a description of historic materials).

In summary, an examination of published and unpublished archeological reports for the Current River drainage and surrounding areas outline a series of occupations from perhaps as early as 8000 B.C. to the present. Much of the information concerning relative chronology and the dating of archeological materials from the Ozark National Scenic Riverways, Missouri comes from the outside of the research area, but continued interest and work in this area will change that situation.

IV. A FIELD EXPERIMENT AT ALLEY SPRING AND ROUND SPRING

One of the stated research goals of the National Reservoir Inundation Study is to address the problems of chemical and biological impacts (Lenihan et al. 1977:11). What are the impacts which result from water chemistry changes and the introduction of new biological forms on those classes of cultural remains that are usually subjected to attribute analysis (i.e., ceramics, wood, bone, glass, shall, lithics, etc.)?

Questions regarding water chemistry and biological impacts are being addressed by the Inundation Study through two avenues of research: a water-chemistry laboratory experiment and associated field phases which include both chemical and biological effects research, are now in progress.

> "Although water quality is a variable considered in the context of various hypotheses advanced in this research design, it should receive special attention due to its subtle and complex nature. It is known that industrial wastes and runoff from agriculturally developed areas seriously affect the biosphere in aquatic environments. However, virtually nothing is known about the potential impacts . . . on cultural resources." (Lenihan et al. 1977:12).

The laboratory experiment being conducted at the University of New Mexico is directly confronting the problem of differential impacts from water chemistry variables on cultural remains. Efforts have been made to select those chemicals present in reservoirs which occur in the greatest quantities or were assumed to have the greatest potential impact upon cultural remains (Fosberg 1978:3).

Nine chemicals along with pH have been selected for testing including calcium (Ca), magnesium (Mg), sodium (Na), carbonate (CO_3), bicarbonate (HCO_3), chlorine (Cl), sulfate (SO_4), dissolved silica (SiO_2), and dissolved oxygen (O_2) (Fosberg 1978:3). Chemically inert containers hold the chemical mixtures; one half having concentrations reflecting the median values of the 10 chemicals, generated from reservoir information from throughout the country. The remaining containers hold highly concentrated (20X) solutions of the chemicals in an "attempt to accelerate rates of . . . impact in order to simulate extended periods of immersion time" (Fosberg 1978:3).

Various classes of artifactual material have been placed into the solutions (Plate 1). Periodically, the materials were removed to measure rates of deterioration or change. Results of measurements and tests conducted on the controlled materials prior to immersion and at regularly scheduled removal intervals will, hopefully, provide linear or exponential rates of deterioration for particular artifact types in specific water chemical environments (Plate 2).

A critical aspect of the laboratory experiment is the careful control and monitoring of the chemical solutions. Predicted rates of decay from the simplified laboratory experiment must also be tested against real world conditions. Therefore, Brady Reservoir, Texas, was selected for inclusion because it matches very closely the water chemistry values used in the laboratory phase (Table 2). Lake Powell, Utah, and Amistad Reservoir, Texas, have been included because they do deviate from the median and the buckets of materials could be monitored by local Park personnel.

Alley Spring and Round Spring were selected for inclusion in the field phase because:

Plate 1: A variety of cultural materials are being immersed in specially prepared chemical solutions in an experiment being conducted at UNM.

Plate 2: Careful measurement, weighing and handling of the experimental materials during each of the scheduled removal intervals is critical.

TABLE 2
WATER CHEMISTRY VALUES
(Milligrams per Liter)

Element	Laboratory (median)	Alley Spring (range)	Round Spring (range)	Brady Reservoir (range)
Silica (SiO_2)	8.8	3.2 - 9.9	1.6 - 9.0	.9 - 12.0
Calcium (Ca)	38	18 - 40	20 - 48	29 - 65
Magnesium (Mg)	11	9.3 - 20	11 - 23	2.8 - 31
Bicarbonate (HCO_3)	131	101 - 205	111 - 238	105 - 184
Sodium (Na)	19.0	*	*	13. - 140
Carbonate (CO_3)	.03	*	*	0.00- 5.0
Chloride (Cl)	16.0	*	*	12 - 240
Sulfate (SO_4)	39	*	*	7.4 - 110
Dissolved Oxygen (O_2)	9.3	8.1 - 8.8	8.1 - 9.4	*
pH	5-8	6.8 - 8.0	7.2 - 8.1	6.8 - 8.5
Temperature	18°C	13 -14.5°C	12 -14.5°C	*

Note: Water quality data on Round Spring and Alley Spring after Barks 1978.
Water quality data on Brady Reservoir obtained from U. S. Geological Survey
Laboratory medians based on NASQAN network.

*Not available

(1) their water chemistry closely correlates with the water chemistry values used in the laboratory phase and therefore, relate well to those values present in reservoirs across the U.S.;

(2) their water temperatures are relatively constant, varying seasonally only 2.5° centigrade; and

(3) both had areas where buckets of materials could be placed in total darkness to factor out certain biological impacts.

The following methods were employed in preparation of the materials and placement in the two springs. Chemically inert polyethelene plastic buckets were purchased to hold the experimental materials. Locally available artifacts, contributed by the American Archeology Division, University of Missouri, Columbia, were used in the experiment. Only bone, lithics and sherds from excavations conducted at Round Spring (23SH19) in 1959 were available. These do not represent all of the classes of material used in the laboratory phase, but are typical artifactual remains in Missouri and other areas of the United States.

Human bone as well as animal bone was used. Each piece was carefully cut in half and numbered correspondingly. One piece of each was used in the buckets, the other being retained in the National Reservoir Inundation Study office in Santa Fe, as a control for later comparison. Lithics and sherds were broken in two with pliers and numbered (Plate 3). In each case a control sample has been retained (Plate 4).

Two buckets were placed in Alley Spring and one was placed in Round Spring. In order to provide a statistical sample and permit correlation of results with the laboratory experiment, a minimum of

Plate 3: Sherds, lithics and bone were used in the Ozark National Scenic Riverways test buckets. A control piece for each sample was retained for later comparison.

Plate 4: Experimental materials are being numbered and a notation of the bucket and level recorded by C. B. Ratchford and Alan May.

10 samples of each artifact class (i.e., bone, pottery, lithcs) were placed in each of the buckets.

Bucket number one was placed at 25 feet in Alley Spring basin in an area of high light penetration. It was also within the well defined vegetation zone of the spring. A wide variety of flora is present in this zone as well as a species of freshwater snail, crayfish, and at least two species of fish. It is suspected that materials placed in this area will undergo quantitatively greater attack from macro- and microbiological activity than those in the second bucket placed in the total darkness of the cave deep in the spring.

Bucket number two was taken approximately 150 feet back from the cave entrance and was placed at a depth of 100 feet (Figure 1). This area is in total darkness and has a more limited macrobiological expression than does the basin; it is not known what the potential microbiological differences are between the two areas.

Alley Spring may undergo greater chemical variation than Round Spring due to run-off and differences in their ground water recharge systems. While the research team was conducting work at the two springs, heavy rainstorms north of the Riverways area were occurring. It was not until the final day of the investigations that local showers were experienced at the two springs. Visibility at Round Spring did not vary measurably; however, the water clarity at Alley Spring deteriorated continuously during this time. It turned from a very light, slightly milky, blue to a beige tint, reminiscent of the darker tannic acid conditions which alter water clarity in the Florida karst.

In Round Spring a single bucket was placed at a depth of 50 feet (15.24m) in the small room in the deepest area of the basin. Its location on the north side of the room is one of total darkness.

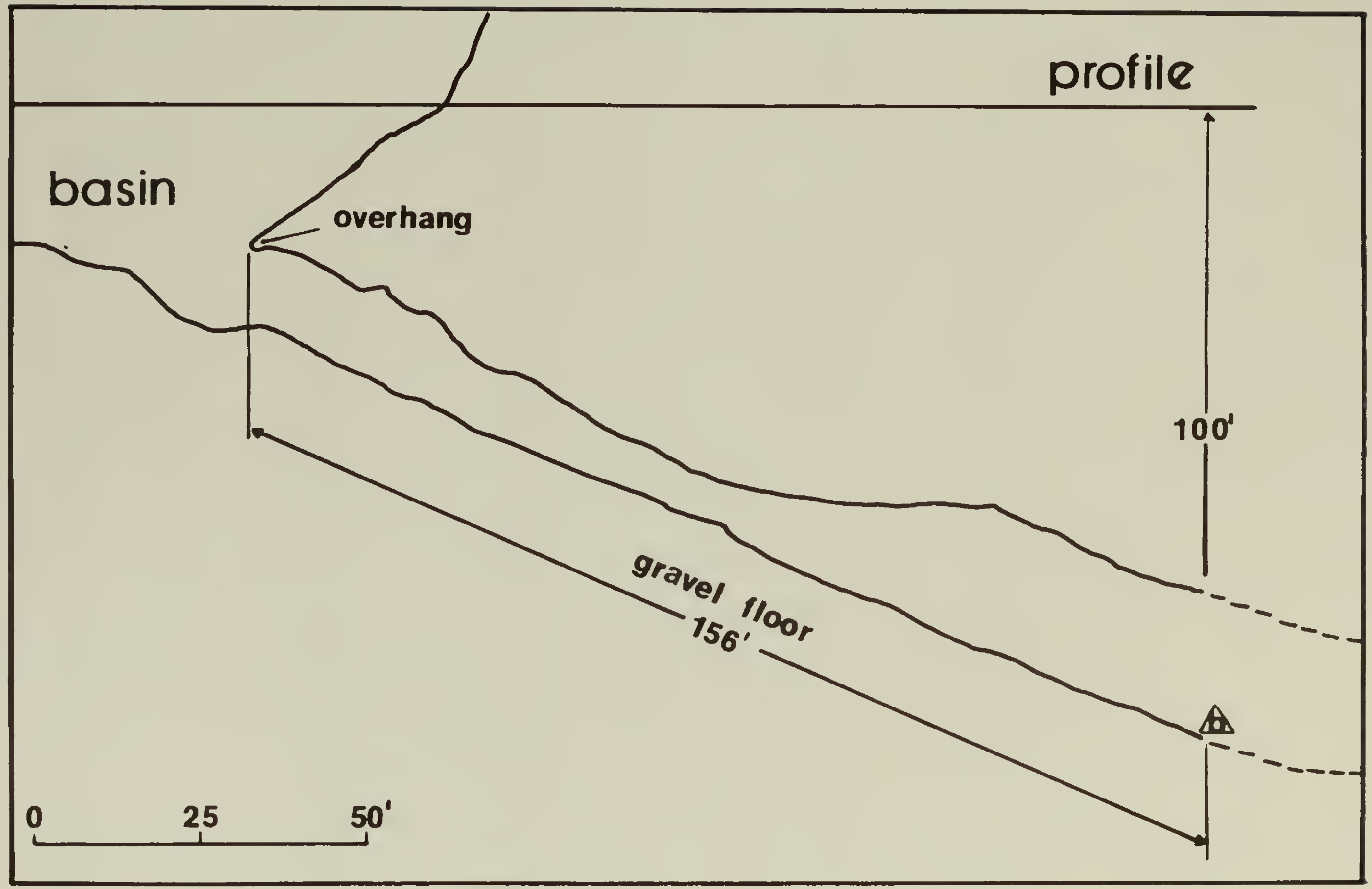

fig.1 alley spring cave

(after Vineyard & Feder 1974)

bucket location

These buckets will remain submerged for a period of one year. After that time they will be retrieved and a comprehensive testing program undertaken on the inundated and the non-inundated control samples.

The isothermal conditions (i.e., constant temperatures) of springs is not usually encountered in a reservoir situation. Temperature variability is suspected to be a factor in material deterioration, and is one for which it is difficult to determine a precise cause-effect relationship. This variable has been eliminated in Alley and Round Spring; chemical and biological activity will, presumably, be the primary agents affecting the experimental materials.

Biological impacts on cultural remains is a little understood phenomenon. An attempt is being made by the Inundation Study team working in conjunction with researchers at Virginia Polytechnic Institute and State University to isolate some of these factors (Fosberg 1979:2). Sampling of artificial substrates in reservoirs for macro- and microbiological organisms is one of the areas of research undertaken by Virginia Polytechnic Institute. A cooperative field sampling program is now underway at Brady Reservoir, Texas. This field program will utilize a wide variety of cultural materials (bone, shell, ceramics, lithics, wood, etc.) which will be placed in glass containers at different localities in the reservoir where there is suspected variation in biological activity or water chemistry.

These chemical and biological field data will be used to test predictions generated in the laboratory experiment phase. An understanding of both the chemical and biological factors which influence artifact preservation and deterioration will aid in the development of comprehensive management and planning programs for cultural resources in freshwater areas.

V. RESEARCH RESULTS

Alley Spring

Archeological surface collections were made in three areas in and adjacent to the spring. Initially the area of the mill turbine was surveyed, video taped and photo documented. In this area field samples 1 to 4 were collected (Appendix I). Sample 01 is a cut nail possibly lost when the mill was being built. Samples 02 through 04 consist of an iron nut, spike and wire nail that could have associated with initial mill construction or maintenance activities during actual operation. Sunglasses and other items associated with visitors to the mill were found in the turbine well and spring branch.

The most interesting object located in this area was field sample 05, a concretion of iron, glass, sand and the basal end of a projectile point (Plate 5). The portion of the projectile point that is exposed measures 2.2 cm wide at the shoulders and 6 to 7 mm thick. Side notches below the shoulders are fairly deep and the base is concave with basal grinding or is water worn. Chapman (personal communication 1979) suggested that this projectile point is similar to a Jakie Stemmed point or may grade into a Big Sandy Notched. Without a complete series of projectile points and associated materials it is difficult to make a positive identification but a tentative date for this point may be Middle Archaic (5000-3000 B.D.). Little else can be said about this projectile point but Born and Chapman (1972:47) did note that sites adjacent to the spring contained mostly Archaic Period materials. No ceramic materials were found in the spring or mill area during the present survey.

Plate 5: An unusual encrustation, Field Sample 05, collected from below the mill wheel at Alley Spring contained a projectile point.

Plate 6: Philamentus algae (center) and potomegetum (right) are two of the floral species identified in Alley Spring basin.

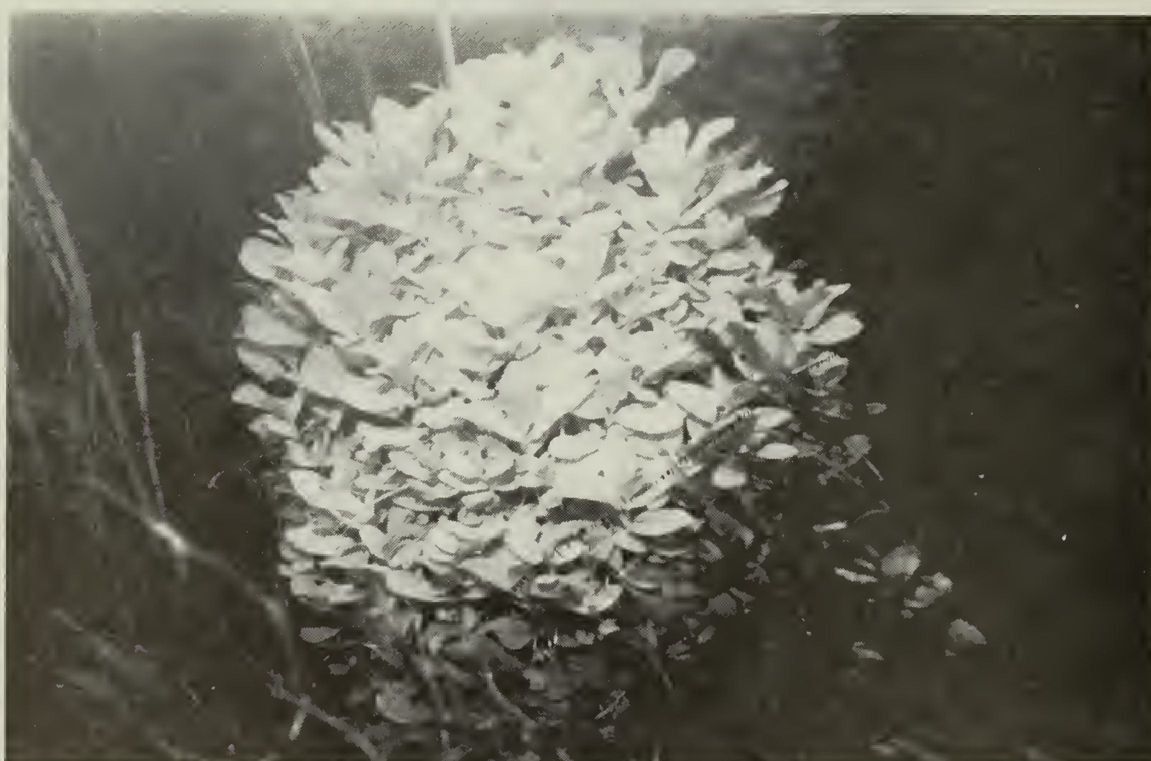

Plate 7: The wide variety of floral species in Alley Spring Basin were videographically and photographically documented.

The variety of flora to be found in Missouri springs has been reported elsewhere (Liscomb 1974; Redfern 1972; Steyermark 1941). A number of mosses and liverworts have been identified in Alley Spring basin (Redfern n.d.) and include Amblystigium laxirete, A. noterophilum, A. riparium, A. tenax, Brachythecium rivulare, Fissidens fontanus, F. grandifrons and others.

A limited floral collection, made by the research team during their brief visit, was sent to Dr. Redfern at Southwest Missouri State University for identification (Plates 6 and 7). The results of his analysis is presented in Table 3. Of particular interest was the tentative identification of specimen number 5 as Potomogeton zosterifolius Schum or P. epihydrus. This specimen, if correctly identified, is several hundred miles south of its previously known range of Michigan, Minnesota, etc.

A preliminary survey of Alley Spring cave was undertaken for the purpose of evaluating the cave for placement of a bucket containing materials for the water-chemistry field experiment and to seek evidence of prehistoric human use. An area at the base of the gravel slope on the west wall was selected as the location for the bucket. No evidence of early human use was seen during several dives in the cave to a maximum horizontal penetration of 450 feet and a depth of 135 feet.

During the survey divers noted the presence of a species of crayfish which appears to have adapted to the total darkness of the cave environment by losing all pigmentation. These troglobitic crayfish were seen beginning at a depth of 100 feet in an area 150 feet to approximately 250 feet from the entrance. Two varieties of blind crayfish from Missouri caves have been identified by Hobbs and Barr (1960); Cambarus hubrichiti Hobbs and Cambarus setosus Faxon. No attempt was made to either collect or identify the crayfish in Alley Cave,

TABLE 3
FLORAL COLLECTIONS AT ALLEY SPRING

List of Specimens

Specimen	Location	Taxonomic Classification
Collection #1	Alley Spring	Myriophyllum heterophyllum Michx
Collection #2	Alley Spring	Potomogeton pectinatus filiformis var. borealis (need fruiting material for positive i.d.)
Collection #3	Alley Spring	Sparganium americanum Nutt?
Collection #4	Alley Spring	Moss - no i.d.
Collection #5*	Alley Spring	Potomogeton zosterifolius Schum or P. epihydrus (need fruiting material for positive i.d.)

*Specimen has spicules at nodes characteristic of this variety but if so the specimen is far south of its known range (Minnesota, Michigan, etc.).

The cave environment from the entrance to a depth of 100 feet and an approximate 150 feet horizontal distance closely resembles the description given in Vinyard and Feder (1974:81):

> " . . . the deepest part of the spring basin [is] 32 feet deep. At this point they [Saint Louis Underwater Recovery Team] found an opening to the spring conduit and were able to descend to a depth of 100 feet in a horizontal distance of about 150 feet. The opening to the spring conduit was measured as 15 feet wide and 10 feet high; it is floored by well-worn chert gravel. The tubular channel descends at an angle of about 25 degrees."

From the base of the gravel slope, beyond the area investigated by the Saint Louis team, the angle of descent lessens to nearly horizontal. The cave continues in this manner for an additional 300 feet following what appears to be a bedding plane. The nature of the cave floor also changes abruptly from the clean chert gravels found on the slope, to heavily silted limestone.

As a result of this preliminary cave exploration, some discrepencies were noted between the plan drawing in Springs of Missouri (Vineyard and Feder 1974:80) and the findings of the Inundation Study team:

(1) The tubular channel does not appear to curve as abruptly to the west as is indicated by the map. Rather it is a gentle north-westerly trending tube to the base of the slope; and

(2) The area beyond the slope opens up into what appears to be a large room rather than continuing as a narrow channel or tube.

It is difficult to be more specific at the present time since the research team was under severe time constraints and was ham-

pered by 10 to 15 foot visibility during the exploratory dives in Alley Cave.

Round Spring Grotto (23SH96)

A surface collection within Round Spring Grotto (Fig. 2) produced three categories of cultural materials: bone, ceramics, and lithics. No prehistoric artifacts were found in Round Spring basin. A brief description and provenience of the materials collected is in Appendix I.

Lithic materials were examined under low (30X) magnification and Dr. Carl H. Chapman, Professor North American Archeology, University of Missouri-Columbia was consulted for information about these materials. Possible cultural affiliation and chronological determinations of the specimens collected are made on the basis of a comparison with materials from sites outside of the project area.

Five pieces of pottery were recovered from Round Spring grotto. All five of the sherds have the same temper, paste and surface treatment. A detailed description of the sherds can be found in Appendix II. It is probable that they are fragments of the same vessel. The portions of a conical shapped vessel represented are: 1 rim sherd, 1 rim with lip missing and 3 body segments. The conical vessel was tempered with fine crushed limestone. The temper density is about 30% and the paste is generally hard and compact.

Although the exterior surface has reddish brown areas, the interior and exterior surfaces are predominately dark reddish brown. The interior of the vessel has been smoothed while the exterior has been cord impressed (Plate 8). The cord markings on two of the sherds, worn very smooth by water action, are not very distinct. On the lip, rim and body sherd, however, the cord marking is clear. A laytex mold of this sherd was made to examine the

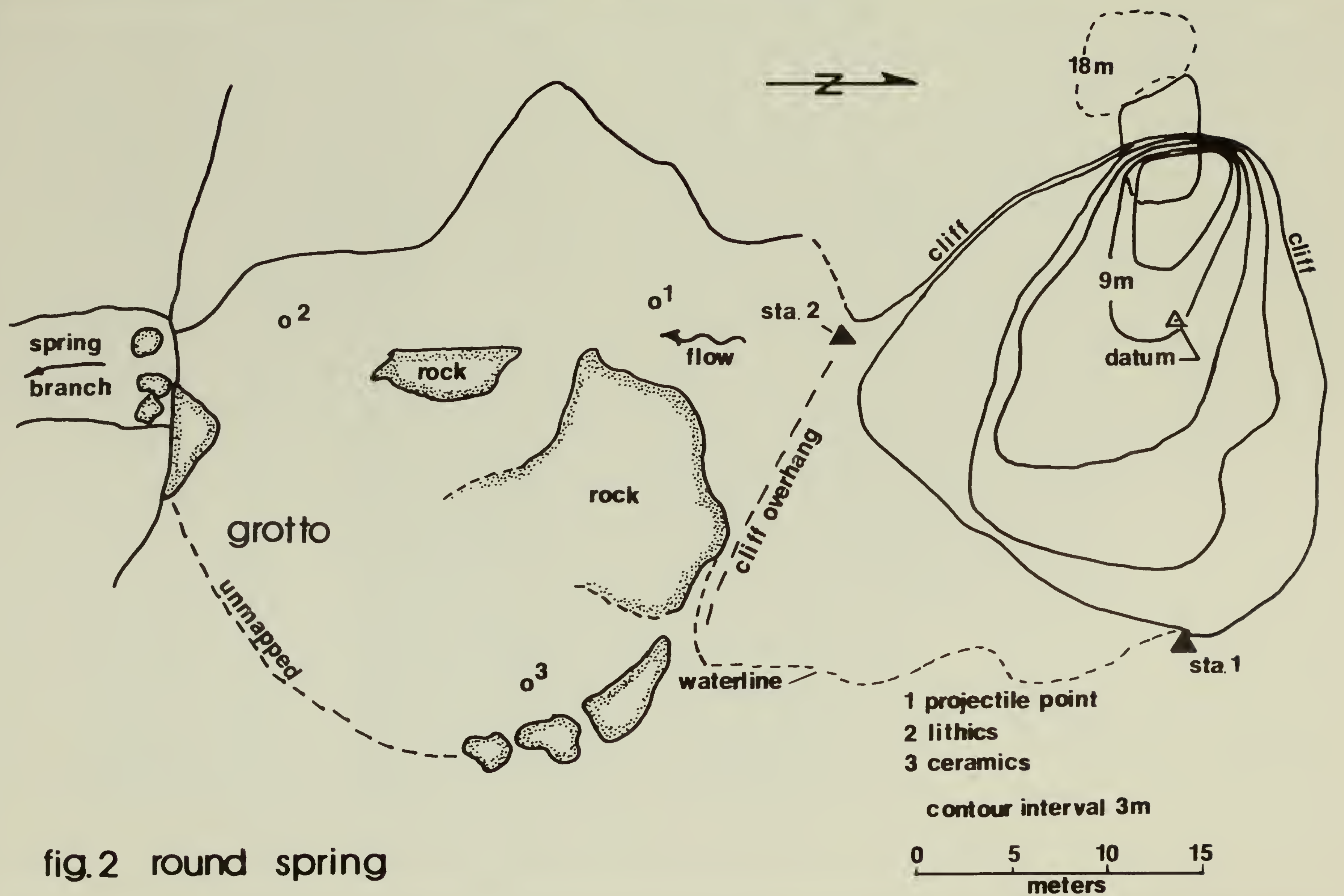

fig. 2 round spring

structure of the cords. Cords of both the "s" and "z" twist variety, two-strand, are present. The diameter of the cords is about 2mm, and run perpendicular to the rim. There is some crossing of impressions on the lower portions and bottom of the vessel (FS-20-G) (Plate 9).

The temper, paste and surface treatment of these five pieces of pottery fit the type description of Meramec Spring Cordmarked by Marshall (1963:17). The lip shape and overall vessel shape are common ceramic forms in the Meramec Spring Focus.

The Late Woodland culture in the southern and central Ozark Highland was outlined by Chapman and is dated roughly at A.D. 400-900 (Chapman 1975:30). In 1948 Chapman tentativey labelled the Late Woodland culture in the southern and central Ozark Highland as the Highland Aspect (1948:100-109). There are many close parallels between Meramec Spring Focus and Highland Aspect and the Meramec Spring Focus can be considered a re-definition of the Highland Aspect in central Missouri (McMillan 1964:94).

The Meramec Spring Focus is found primarily in the Meramec and Gasconade drainage basins and along several of the southern tributaries of the Osage River (1964:96). According to McMillan "it is also probable that on the northern most reaches of the Upper Current River drainage components of the Meramec Spring Focus will be found" (1964:96). Therefore, the vessel fragments found within the grotto can be roughly dated to 400-900 A.D., based upon the above typological and cultural affiliations.

Examination of the lithic materials revealed utilization of six of the seven flake tools collected (Plate 10). Two cores, FS-07-G and FS-11-G, may have also been used (Plate 11). Chapman (personal communication) tentatively identified FS-12-G as a possible Late Woodland adz. Water rolling and smoothing of the edges makes positive identification impossible (Plate 12).

Plate 8: Field Sample 19-G, collected from Round Spring Grotto, was in an excellent state of preservation. This is a section of the lip, rim and body of a conical vessel, ca. 400-900 A.D.

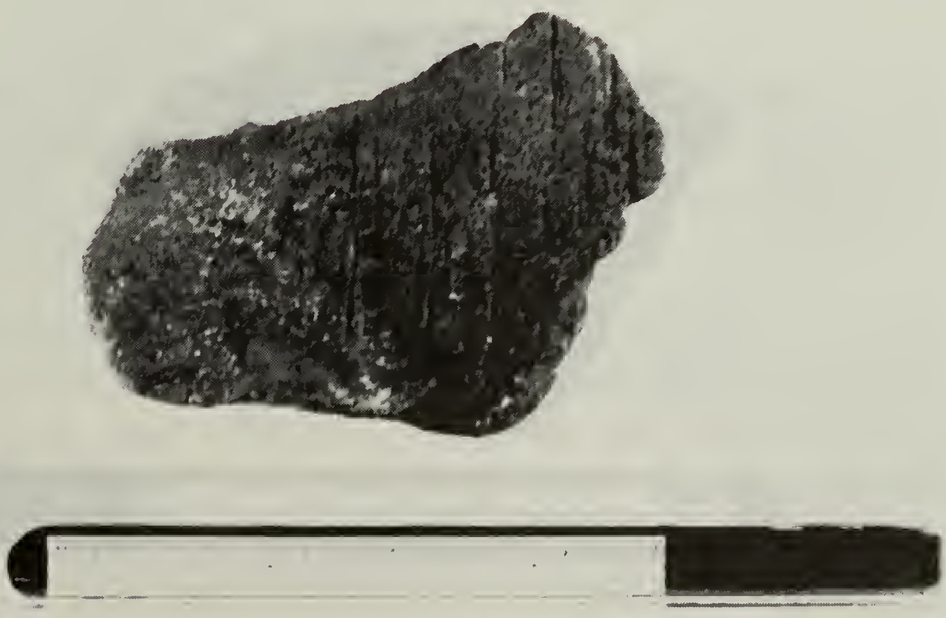

Plate 9: Analysis of FS-20-G suggested that this was a portion of the lower section of a vessel; thickness and crossing of cord markings supports this conclusion.

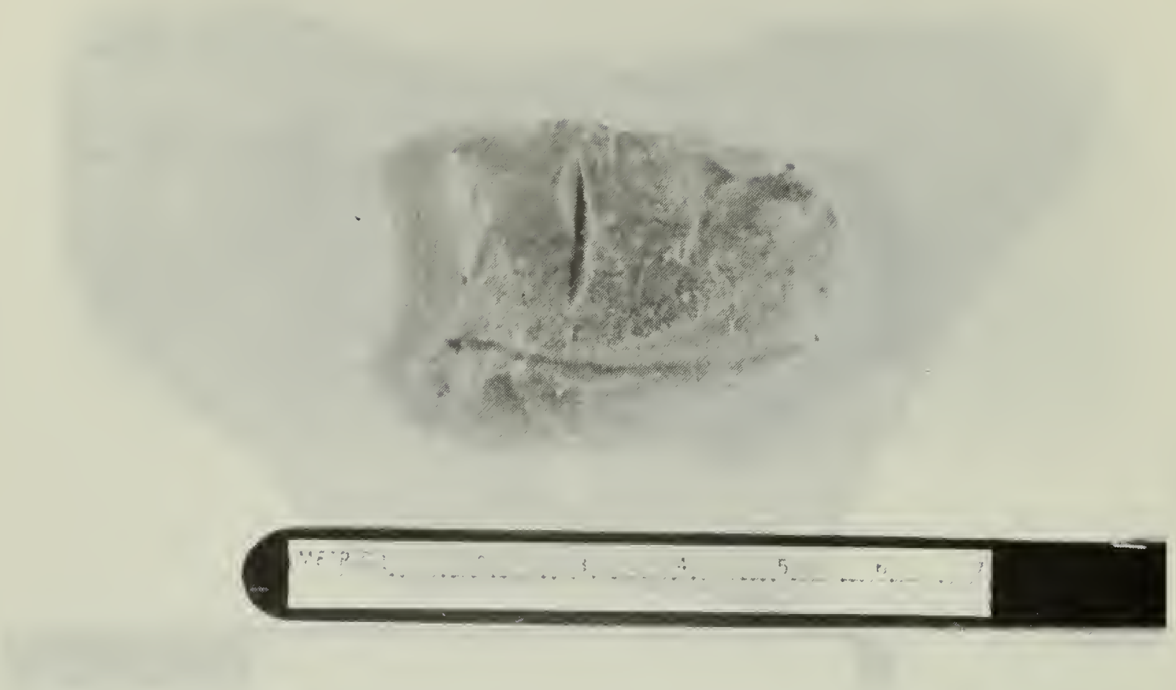

Plate 10: Field Sample 04-G. Six of the seven flakes collected from Round Spring Grotto showed signs of utilization.

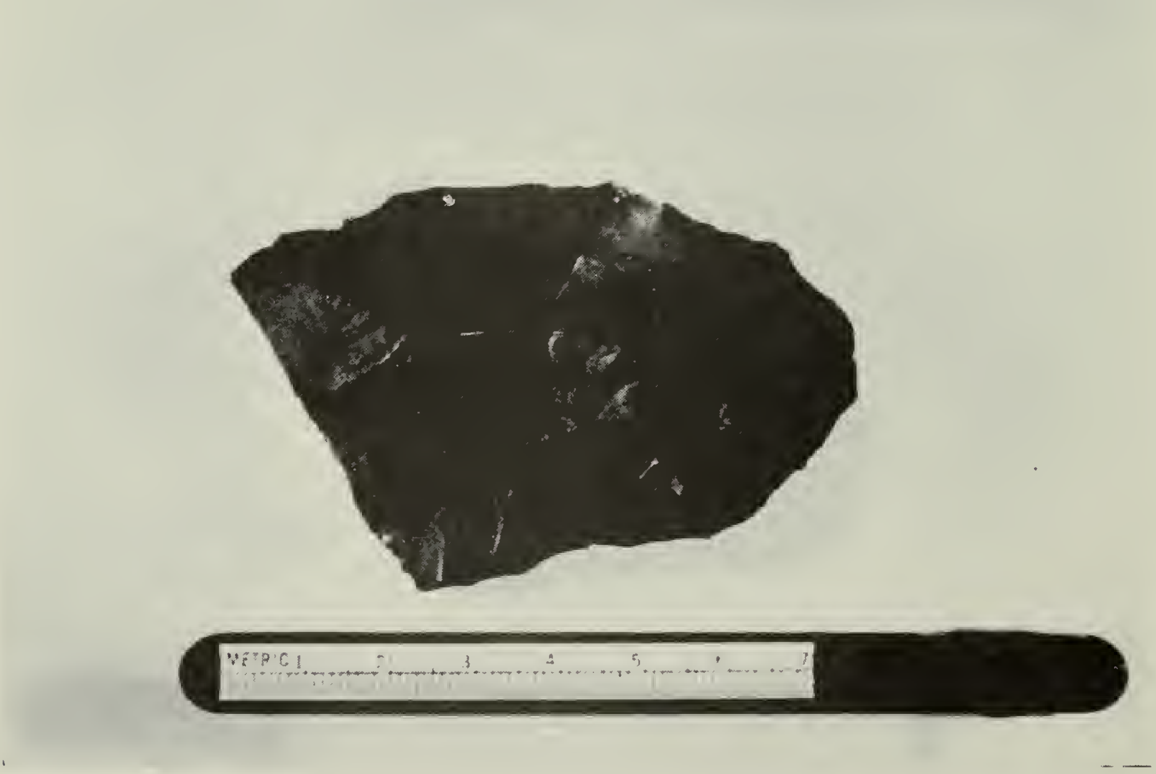

Plate 11: Field Sample 11-G, a large bifacial core, was collected from Area 2 in the Grotto.

Two biface specimens, FS-14-G and FS-13-G, were also collected (Plates 13 and 14). FS-13-G is a corner notched projectile point or "knife" form found in the upper levels of sites within the Meramec, Current and White River drainages. This artifact may be Late Woodland, ca. 400-900 A.D., and therefore associated with the ceramic material found in the grotto. The absence of its direct association with the ceramics precludes a positive identification.

The underwater portion of the sink was mapped by a team of three divers, discussed elsewhere in this report. The deepest portion of the basin was found to be 18 meters (60 feet). This depth is reached in a small room where two historic wagon wheels were found.

This room was formed as a result of the solution activity of the limestone, which is typical of karst formations. The video tape which supplements this written report documents the physical features of the room. Although it was the probable source of the spring flow at one time no discernible flow from the room was noted by the research team; rather the spring flow now seems to be emanating from several smaller fissures and cracks in other areas of the basin.

Large angular rocks predominate in the lower portion of the sink; resulting from the breakdown when the dome collapsed and the sinkhole was formed. Due to reduced water flow in the lowest areas of the sink, a layer of fine silt is also present.

Round Spring grotto is located adjacent to the spring basin in a limestone bluff (Plate 15) within the Eminence dolimite formation (Vineyard and Feder 1974:111). The grotto was formed during a period of higher water level, when solution activity carved through the limestone creating the grotto and establishing a spring branch. Since its initial formation, water levels have receded, leaving an

Plate 12: Field Sample 12-G is possibly a Late Woodland adz; water smoothing of edges precludes positive identification.

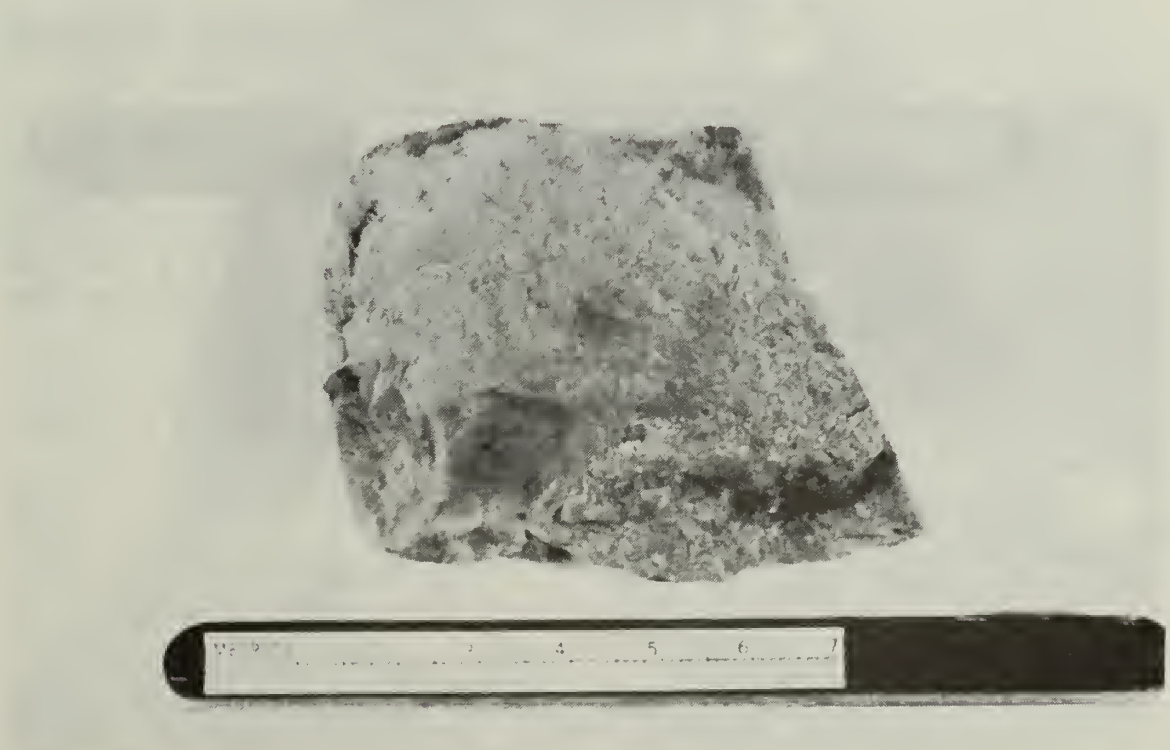

Plate 13: Field Sample 14-G, a large bifacial tool possibly a knife, was collected from Area 2 of the Grotto.

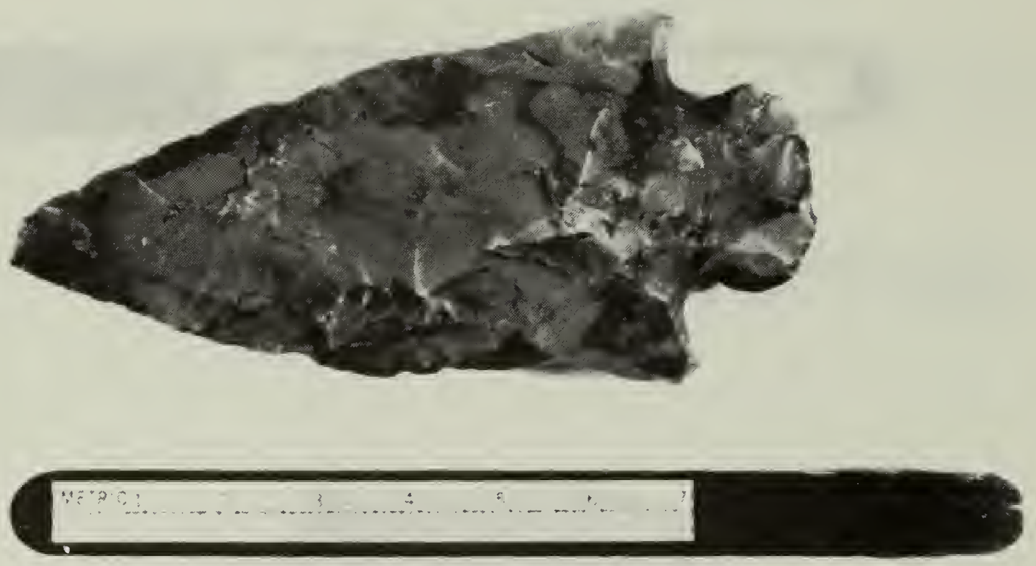

Plate 14: Field Sample 13-G. This projectile point or knife has been tentatively identified as Late Woodland, ca. 400-900 A.D.

Plate 15: Round Spring carved its way out of the Eminence Dolomite formation, eventually creating the bluff, basin and run seen today by Park visitors.

Plate 16: A closer look at the Grotto entrance at Round Spring. The spring flow exits through the Grotto.

Plate 17: Moisture on the ceiling of the Grotto and the formation of stalactites is evidence of the continued activity of this karst feature.

air/water interface passageway (Plate 16). Stalactites can be seen in the grotto; evidence of the continued activity of this feature (Plate 17).

Water depths in the grotto vary from 50 cm (20 inches) at its juncture with the basin pool to over 2.5 meters (8 feet) in the main corridor and side rooms. Discussion with residents indicates that the grotto has been underwater as long as the area has been settled, but records on spring levels and flow are non-existent before the 20th Century. Debris typical of any state or federal park was encountered in the main corridor and it was learned that walkthroughs by spelunkers and the curiosity-minded have been prevalent in the past. No such debris was seen off the main corridor; only prehistoric materials.

Inundation Study Hypotheses

The discovery of prehistoric cultural materials in Round Spring grotto provided the Inundation Study an opportunity to test selected hypotheses on artifacts which have, presumably, undergone a long period of inundation. These hypotheses along with generating data and numerous test implications, in some cases, have been previously presented in The Preliminary Report of the National Reservoir Inundation Study (Lenihan et al., 1971).

That report provides hypotheses on the general categories of mechanical impacts, differential preservation of common cultural materials, impacts on analytical techniques, impacts on dating techniques, loss of qualitative data relating to strata and features, and faunal impacts. The context in which the grotto artifacts were found and the nature of the materials precluded consideration of all but three of the six general areas in which hypotheses were presented in the preliminary report. Differential preservation, impacts on analytical techniques and impacts on dating techniques each contained hypotheses applicable to the grotto artifacts.

The three classes of artifactual remains collected from the grotto are stone, ceramics and bone. The following text presents the general category, i.e., differential preservation, followed by the hypothesis and test implications selected for each class of material. Results from analysis and testing of the materials, in some cases are not included in this report due to time constraints. The information resulting from the analysis of the grotto materials will be incorporated into the final report of the National Reservoir Inundation Study to be published in mid-1980.

Stone

Differential Preservation - Hypothesis:

> "The differential preservation of inundated stone artifacts will be dependent upon the chemical composition of the artifact in question. Destruction of the artifact will increase with the quantity and distribution of impurities and the relative amounts of feldspar, silica, and carbonates contained within the specimen and the nature of the inundation, i.e., periodic or continuous, to which it is subjected. Preservation and destruction will also depend upon the pH of the water or soil within which the stone is located. Increased amounts of acid in solution will directly affect the rate of mineral dissolution and the loss of structural integrity of the stone specimen" (Lenihan et al. 1977:37).

Test Implication:

> "Stone artifacts which have a high ratio of silica and a low proportion of water-soluble or unstable impurities to other minerals and are exposed to continuous inundation will deteriorate at a faster rate than artifacts which have a similar chemical composition and are exposed to periodic inundation" (Lenihan et al. 1977:30).

Test Methodology: Undertake comparative examination of specimens of similar chemical composition and age taken from a non-inundated context (23SH19) and specimens collected from an inun-

dated context, i.e., Round Spring Grotto (23SH96), for structural integrity, exfoliation, severe patination and/or chemical dissolution and loss of morphology.

Test Results and Commentary: The development of a patina is the most characteristic change that flint, chert, quartzite, and similar stone undergo through natural causes in an inundated environment.

As a result of the patination process the stone is dehydrated, and the coloring matter is broken up. The susceptibility of any particular rock type to patination depends upon their chemical composition and texture. Shallow patination will not change the relief of the stone surface; however, severe patination can cause deterioration of the surface, destroying signs of use.

Various quantities of quartz feldspar or carbonate compounds can be found in virtually all rocks. Natural weathering processes act upon these chemicals to eventually bring about exfoliation, crumbling and general deterioration of the rock structure. Highly acidic environments will tend to accelerate the weathering processes (Press and Siever 1974).

The lithics collected from areas one and two (Fig. 2) in Round Spring grotto were compared to a random sampling of lithic materials from the associated Round Spring dry site (23SH19). This site, located at the edge of the basin pool, has been subjected to periodic flooding. It was during one such flooding period that human skeletal material was exposed, precipitating excavations at the site (Garrison, personal communication). There are no records that detail the number of periodic flooding events that have occurred since original occupation of the site, ca. 900-1200 A.D; It is assumed, however, that there has been more than one such occurrence.

The test implication presented above, from The Preliminary Report of the National Reservoir Inundation Study (Lenihan et al. 1977), states that in comparisons of like materials (i.e., stone artifacts with a high ratio of silica and a low proportion of water-soluble or unstable impurities to other minerals) of the same age, those materials undergoing continuous inundation would deteriorate at a faster rate than those only periodically inundated.

The lithic materials from the grotto, high in silicates, have probably undergone continuous inundation for a period of, at minimum, 1000 years. They showed no loss of structural integrity, exfoliation or loss of morphology. Patination has been minimal; relief on all surfaces of the specimens being quite obvious, with the exception of one, questionable artifact. The alkaline environment at Round Spring, pH 7.2 to 8.1 (Barks 1978), may have enhanced preservation of the stone artifacts, although conclusive evidence to this effect has not been demonstrated.

Comparisons between the periodically inundated materials and the continuously inundated materials, in this instance, showed no readily identificable differences in preservation.

Based on this limited finding, a tentative re-structuring of the foregoing test implication could be: the preservation of stone artifacts which have a high ratio of silica and a low proportion of water-soluble or unstable impurities to other minerals, whether exposed to periodic or continuous inundation in an alkaline environment will not be adversely affected. It is not known what effect periodic or continous inundation in a highly acidic environment will have on preservation of these artifacts.

Analytical Techniques (microscopic analysis) - Hypothesis:

> "The potential for microscopic analysis for wear patterns and plant and animal residues on stone

will be adversely impacted by inundation. The degree of impact will depend upon the state of preservation of the stone; the extant chemical environment; and the direct mechanical action to which the specimen has been subjected. Analysis of inundated specimens will not yield data of quality comparable to that of similar specimens that have not been subjected to inundation. Only the special circumstances of anaerobic conditions or burial in stable soils (that is, soils not subject to erosion, scour, or currents) and very cold temperatures will act to preserve the wear-patterns and residues" (Lenihan et al. 1977:68).

Test implications: (Note: Of eleven test implications presented in the Preliminary Report, only numbers 1, 2, and 8 are applicable):

"(1) Stone artifacts that exhibit patination as a process of weathering will patinate at a faster rate as a result of inundation; examination of inundated specimens for microscopic wear will not yield data of quality comparable to non-inundated stone. The length of time required to destroy traces of tool use will depend on the chemical composition of the specimen.

(2) Stone artifacts that exhibit the patination as a process of weathering, and are exposed to mechanical abrasion through wave-action, surge, or scour by coarse gravels, will lose traces of tool use. Analysis of mechanically abraded inundated specimens will not yield data of a quality comparable to inundated stone not subjected to this action . . ." (Lenihan et al. 1977:69).

"(8) Animal and plant residues on stone artifacts will be destroyed if the stone specimen has been subjected to inundation and mechanical abrasion, through wave-action, surge, or scour. Microscopic analysis for residues will not yield data of quality comparable to specimens that have not been inundated and subjected to this mechanical action" (Lenihan et al. 1977:70).

Test methodology: Undertake comparative examination of specimens of similar chemical composition and age taken from a non-inundated context (23SH19) and specimens collected from an inundated

context, i.e., Round Spring grotto, for microscopic wear analysis and animal and plant residues.

Test Results and Commentary: The susceptability of various rocks to patination depends upon their chemical composition and texture, i.e., ratio of silica to other materials, stability and distribution of impurities, and granular structure. Rocks that are composed of pure silica, for example, will not patinate regardless of grain size or texture (Hurst and Kelly 1961). Shallow patination will not change the relief of stone surface, but advanced patination can cause loss of visible and microscopic wear patterns (Semenov 1973).

Chemical composition of a stone artifact will also affect its potential for microscopic wear analysis if it is high in soluble feldspar and/or carbonates. Constant inundation, if combined with wave action, surge, and scour by coarse gravels will act to destroy visible and microscopic wear patterns.

Examination of non-inundated samples from 23SH19, discussed previously, and samples from the grotto 23SH96 for indications of severe patination, evidenced by destruction of wear patterns, yielded no difference in the ability to detect visible use and manufacture patterns on either group of specimens. Further examination of both groups under a 30X microscope resulted in identification of step fracturing, microflaking and rounding, indicating use after manufacture of 90% of the inundated samples. All of the non-inundated samples had microscopic edge damage resulting from use. Abrasion from water flow and movement of fine silt or gravels over the inundated artifacts had not appreciably affected the preservation of microwear patterns.

The corollary of test implication number 1 above (Lenihan et al. 1977:69), i.e., that stone artifacts that either do not pati-

nate or patinate only slightly, regardless of period of inundation, will yield data from microscopic wear analysis of a quality comparable to non-inundated specimens, appears to be true. Specimens which resist patination, that is those high in silicates, will be more resistant to mechanical abrasion due to their higher overall hardness. The duration and severity of mechanical abrasion will remain a critical factor, however, in the ability to obtain data for microwear analysis from inundated specimens (test implication number 2, above).

Microscopic traces of vegetal and animal residues have been found on unwashed tools from the arid Southwest (Briuer 1976). In more humid areas of the United States, such as in Missouri, chemical and bacterial activity may act to destroy these residues. Washing also removes microscopic residues; the inundated environment combined with wave-action, surge, and scour may "wash" the specimens to such an extent that microscopic residue analysis is impossible.

Microscopic analysis of specimens from Round Sping grotto to determine the presence or absence of residues is being undertaken. Due to the rate of water flow (45 cf/s, mean) from Round Spring which exists through the grotto where the lithics were located, it is anticipated that no residues will be found on any of the stone tools. The preservation of animal and vegetal remains in an alkaline environment (pH above 5) is also contraindicated (Dowman 1970); Round Spring is alkaline and ranges in pH from 7.2 - 8.1 (Table 1). Determination of the validity of test implication number 8 (above) to the materials collected from Round Spring grotto will have to await results of analysis, and will be reported on at a future date.

Ceramics

Dating Techniques - Hypothesis:

> "Samples that have been inundated for 20% or more of their archeological lives will be adversely affected, and will not yield data [from thermoluminescence dating] comparable to that yielded by samples that have not undergone such long-term immersion" (Lenihan et al. 1977:103).

Test Implication:

> "Samples taken from an inundated site will show anomalous results when subjected to thermoluminescence dating analysis after a period of immersion in excess of 20% of their archeological life, as determined by other standard dating techniques, which is not correctable during analysis, and will not be comparable to a given number of similar samples that have not undergone such long-term immersion" (Lenihan et al. 1977:103).

Test Methodology: Subject inundated ceramic samples collected from the Round Spring Grotto Site (23SH96) to thermoluminescence dating. Ceramic samples from a non-inundated context, e.g., 23SH19, similar in age, temper and method of manufacture to be subjected to the same dating technique.

Test Results and Commentary: A major source of error in thermuluminescence dating is the shielding effect that groundwater has on the annual rate at which gamma, beta and alpha decay produce carriers in any given specimen to be dated. These charge-carriers are the key to age determination by the thermoluminescence technique. It is suspected that shielding for more than 20% of the life of the specimen will exceed the acceptable limits of error for this technique (Lenihan et al. 1977:103).

It is tentatively hypothesized that the grotto was permanently flooded sometime between 700 A.D. and 900 A.D. The ceramic samples collected from Round Spring grotto, tentatively identified as Late

Woodland (ca. 400 to 900 A.D.) may have undergone inundation for as long as 1,000 years.

The exact archeological age of the inundated specimens is open to question as of this writing. Woodland occupations in the Ozarks are in evidence by 500 A.D., although earlier occupation to 200 B.C. in the once dry grotto, as well as other locales that may now be flooded cannot, of course, be completely ruled out. If early manufacture dates are assumed for the specimens, 400 A.D., or as recent as 900 A.D., the hypothesized length of inundation is, at minimum, 1000 years. This is well beyond the suspected acceptable limits for correction by thermoluminescence.

The uppermost limit for groundwater shielding, and presumably any form of flooding, of 20% of the archeological life of the specimen has not been confirmed. Additionally, typological identification of the sherds as Late Woodland, ca. 750 A.D., has provided an age range for the specimens that may aid in determining the correctable capabilities of the thermoluminescence method. For this reason it is felt that an attempt should be made to subject the materials to thermoluminescence testing. Results of this testing are not yet available; a follow-up statement of results will be provided at a later date.

Differential Preservation - Hypothesis:

> "The basic ceramic structure of ware from an inundated archeological site will be affected by water saturation in a ratio directly proportional to its porosity, permeability and strength" (Lenihan et al. 1977:32).

Test Implication:

> "Ceramic samples of low porosity and permeability and high strength (that is, stable) taken from an inundated context will be in a state of preservation

comparable to ceramic samples of a similar nature taken from non-inundated context" (Lenihan et al. 1977:32).

Test Methodology: Inundated ceramics collected from the Round Spring Grotto Site (23SH96) are to be subjected to porosity testing, analysis of temper and hardness. If feasible, given the small sample of sherds collected, a strength test will be performed. Shepard (1956:125-136) presents a discussion of the test procedure for porosity and strength testing.

Test Results and Commentary: The resistance of any piece of pottery to deterioration is dependent upon a number of factors, including strength, porosity, hardness and temper. Shepard states:

> "Strength is not a simple property, for it is influenced by many conditions: texture of the paste, particle size and composition of the clay, method of preparing the paste, technique of building the vessel, and alteration after discard" (1968:131).

The ratio of the volume of the pores to the volume of the mass of a piece of ceramic material, or its porosity, is one of the basic properties of ceramics. Porosity affects "... density, strength, permeability, degree of resistance to weathering and abrasion, extent of discoloration by fluids, and resistance to thermal shock" (Shepard 1968:126). The porosity of the Round Spring sherds ranged from 15.27% to 15.42%. This was determined after Shepard (1968:127) where:

$$P = \frac{Sf - Wf}{Vf} \times 100$$

P = per cent apparent porosity

Sf= weight of saturated test piece in gm

Wf= weight of dry test piece in gm

Vf= volume of fired test piece in gm

As porosity decreases, density increases, and the overall strength of the vessel increases.

Uniformity of grain size results in higher porosity than mixed grading because fine grains pack between coarse ones; the Round Spring sherds exhibited a grain size of less than 1mm, with occasional pieces 2 - 3mm in diameter. Under Wentworth's size classification the particle sizes range from coarse to silt, with very coarse inclusions (Shepard 1968:118).

Temper, as conditioned by the size and shape of grain size, is a primary cause of variability in the strength of pottery. In general, the greater the amount of temper, the weaker the vessel. Particle density in the Round Spring Grotto sherds was 30%. Rough surfaced grains will form a better bond with the clay then smooth ones (Shepard 1968:131). Crushed limestone, a rough surfaced material, was the primary tempering constituent of the inundated sherds.

Hardness is one of the specifications by which the serviceability of pottery is judged, i.e., the likelihood of its being broken or marred. Both composition of the paste and firing conditions are determinants of hardness (Shepard 1968:114). Wares that are 2½ to 3 in Moh's scale may have high luster, but are not considered highly from the standpoint of the technologist. "Pottery that is 5 to 6 in hardness ... is good service ware..." (Shepard 1968:114). The Round Spring Grotto sherds could be considered soft at 3 on Moh's scale.

Overall the Round Spring Grotto sherds are not technically of the highest quality. Softness is somewhat offset by their low porosity and generally fine grain size; increasing the strength and durability of the pieces recovered. Crushed limestone as the tempering material has also contributed to the overall durability of the sherds. Vessels have been retrieved after as long as 1,000

years of freshwater inundation (Marden 1959:110-129) and the Round Spring Grotto environment, stable year round, presumably contributed to the preservation of these materials.

It would appear, then, that the test implication presented above is true, at least insofar as the Round Spring Grotto sherds tend to support this conclusion.

Bone

Differential Preservation - Hypothesis: Osteological remains subjected to inundation will exhibit differential preservation depending upon the condition of the specimen at the time of inundation; pH, degree of aeration, bacterial action and movement of the water; structure and seasonal properties of the soil; and variability of inundation.

Test Implications:

> "1) In an inundated context, dense and impervious osteological materials are less susceptible to crushing and water logging, and will therefore, be more suitable for identification and analysis even after inundation than less dense and porous materials.
>
> "2) In an inundated context, osteological materials in an alkaline environment will be well-preserved after inundation" (Lenihan et.al. 1977:27).

Test Methodology: Obtain water quality data on Round Spring to determine pH, aeration, bacterial action and water flow rates. Photograph and examine specimens to document physical integrity after removal from the Grotto and after drying.

Test Results and Commentary: The preservation of osteological material in an archeological site is dependent upon two factors: 1) the physical integrity of the specimen at the time of disposal, and 2) the nature of the depositional environment.

Bones that have greater surface area and porosity, such as cranial bones and ribs, are more susceptible to destruction than are those which are more dense, i.e. long bones and teeth. Bone surfaces which have been rubbed or worked tend to have a more compressed texture than unworked bone, and therefore are more likely to be preserved (Semenov 1973).

The bones from Round Spring Grotto have been tentatively identified as White tailed deer and appear to be sections of long bone. Their condition when collected and later after drying, was excellent. They did not appear to be worked and were not charred; no warping, cracking or other deformation occurred. Water smoothing may have contributed to their preservation, although there is no direct evidence to support this hypothesis.

Osteological remains are best preserved in an alkaline environment (Dowman 1970). The pH of Round Spring ranges from 7.2 - 8.1 (Barks 1978); a pH of 5.6 or below is generally not condusive to preservation of bone (Dowman 1971). Dissolved-solids concentrations, representing the total mineralization of the water, ranged from 105 - 215 mg/L at Round Spring (Barks 1978:12). Hardness ranged from 95 - 197 mg/L as $CaCo_{3,}$ and averaged 145.5. A reading above 180 is considered to be Very Hard water, 121 - 180 is considered Hard (Barks 1978:12). The combination of alkalinity, mineralization and hardness of the water have preserved faunal remains for thousands of years in the Florida karst (Olsen 1958, and others). Presumably these are also factors contributing to the excellent state of preservation of the specimens from Round Spring Grotto.

> "Until recent years little consideration was given to the bacterial content of spring water in the Ozarks. The clear, cold water which issued from the ground was assumed to be 'pure'. However, recent interest has been generated by a greater awareness of the potential for spring contamination

from surface sources and by high fecal coliform and fecal streptococcus densities observed in some Ozark springs.... The main sources of the bacteria are sewage effluents, septic tanks, landfills (especially in sinkholes) and high livestock concentrations" (Barks 1978:17).

The role that the bacterial content of water, such as that found in reservoirs and sinkholes, plays in the preservation or deterioration of archeological bone can only be surmised at this point. An ongoing field experiment, at Brady Reservoir, Texas, discussed in an earlier chapter of this report, is attempting to address this problem. Presumably, however, the higher the bacterial activity the greater is the potential for deterioration of archeological specimens. Fecal coliforms and fecal streptoccoci were found in Round Spring, as well as six other springs in the Ozark Riverways system tested by Barks. The origin of contamination can be interpreted from coliform to streptococcus ratios; ratios at nearly all seven springs, including Round Spring, were below .06, indicating animal wastes as the primary source (Barks 1978:17). "Because the Current River basin is mostly undeveloped, the springs ... are relatively unaffected by the activities of man" (Barks 1978:37).

The water flow from Round Spring is 41 cfs, classifying it as a 2nd magnitude spring (Meinzer 1972:2). Water flow rates cannot be assumed to have been constant hundreds of years in the past. However, variations in the water flow, if they have occured, have not adversely affected the preservation or overall condition of the osteological specimens.

Based upon this limited analysis, the test implications and hypothesis presented above appear to be valid, at least insofar as this karst feature is representative of similar features in central Missouri and the specimens collected representative of archeological bone. How the test implications will stand up when tested against the Brady Reservoir results, remains to be determined.

Dating Techniques (amino acid racemization) - Hypothesis:

> "A sample taken from an inundated context will prove suitable for amino acid racemization dating except in reservoirs where it will be exposed to intermittent periods of wetting and drying, and the associated significant wet-dry cycles. A sample taken from a Karst-spring will prove more reliable for amino acid racemization analysis" (Lenihan et.al. 1977:98).

Test Implications:

> "1) Inundated samples will yeld corrected dates comparable to similar samples from a non-inundated context.
>
> "2) Samples taken from a Karst-spring formation where environmental conditions have remained constant for thousands of years will yield results comparable to or better than like samples taken from a non-inundated context" (Lenihan et.al. 1977:98).

Test Methodology: Subject inundated bone specimens to amino acid racemization analysis. Specimen has been tentatively dated by association with Middle Woodland artifacts collected in the same area.

Test Results and Commentary:

> "Chemical dating techniques are based upon the testable assumption that after human or animal bones have been buried, sequential chemical reactions result in a continuous accumulation or depletion of some substance within the bone. Dates can be obtained when analysis of the chemical reactions supplies a continuous set of data that can be equated to the specific times" (Lenihan et. al. 1977:96).

Environmental variables such as ground water, temperature, and pH in both soil and water will affect the decay rate of the amino-acids within bone specimens, and this in turn may skew dates obtained from amino-acid racemization analysis. The occur-

rance of a constant environment is problematical in most situations, the variables of rainfall, temperature and soil pH will all affect the relevant environment of an archeological site. These climatic changes can also alter the chemical reactions taking place during bone degradation, and therefore must be understood and corrected for in the analysis process.

The karst features of the Southeast, noted for their constant temperatures and relatively unchanging aqueous environments, have yielded well-preserved osteological materials (Olsen 1959, and others). The suitability of these materials to amino-acid racemization analysis is not known, although it has been assumed by the National Reservoir Inundation Study that a constant environment over thousands of years would make results from this type of analysis reliable.

The same holds true, potentially, of materials from the Missouri karst. The temperature of Round Spring varies seasonally only 2.5°c, and its pH ranges from 7.2 to 8.1; two variables known to affect amino-acid dating results. Presumably this environment has remained constant for several hundred years, at minimum, although no data are available to positively confirm this. Some water level fluctuations must have occurred in the past, the exact time of flooding of the grotto, and inundation of 23SH96, is unknown. Long term stabilization of the environment, similar to that seen today by Park visitors to Round Spring, is assumed to increase the potential reliability of dating results. The bone collected from the grotto is currently undergoing analysis; results will be reported on at a later date.

VI. DATA COLLECTION TECHNIQUES

The nation-wide research undertaken by the National Reservoir Inundation Study has been designed with a cultural resource management orientation. Within a total resource management program there also exists the need to understand what data-retrieval methods can best be used to extract information, upon which sound management decisions can be made. Therefore, one of the expressed research objectives of the National Reservoir Inundation Study is:

> ". . . to determine to what degree state-of-the-art underwater archeology data-retrieval methods can produce information from inundated sites comparable to information produced by land archeology techniques. . . ." (Lenihan et al. 1977:13).

A brief overview of the data recording procedures and collection techniques employed during a 3½ day research period follows.

<u>Mapping Technique</u>

One of the research objectives was a general environmental survey and mapping of Round Spring basin and grotto. As a part of this activity a datum was installed (Plate 18), temperature readings in the basin recorded, and general environmental photography undertaken.

Standard land mapping techniques usually employed by archeologists include a surveyor's transit and stadia rod. The particular equipment used to map the surface area of the sink, in this case, was loaned to the research team for testing by Hewlett-Packard (Plate 19). The transit used an infra-red beam, rather than sighting through an eyepiece, to get distance measurements. The beam is directed toward a special rod containing a prism beam reflector. The beam is deflected back to the transit which automatically provides the distance measurement in a digital readout. This equipment permitted quick, accurate mapping of the surface area of the sink.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Plate 18: A datum was installed in Round Spring basin prior to mapping.

Plate 19: A Hewlett-Packard infra-red beam transit was used to quickly map the dry portion of Round Spring basin.

Plate 20: Bob Goodman is moving along the sink walls during mapping of Round Spring basin. Measurements were taken from the datum to the walls.

Underwater mapping of an area is a difficult task at best. The particular methods used in any given locality may not be applicable in another situation. A simple, yet effective, method was used to map the basin at Round Spring. An azimuth ring and tape measure were used; one diver took measurements at predetermined degree intervals around the ring, a second diver moved along the basin walls with the tape (Plate 20), and a third diver recorded the data.

This process was repeated at predetermined depths relative to the underwater datum until the entire basin was measured. In this manner a 3 meter contour interval map was produced (Figure 2).

In order to map the grotto at Round Spring a north-south baseline was installed in the main corridor, and was tied in to the primary datum in the basin. Distance measurements from this baseline to the perimeter of the grotto were recorded by a three diver team in a manner similar to that used in the sink. It was during the mapping activity that the archeological site was located in the grotto under approximately 10 feet of water.

Archeological Data Recording

All activities during the 3½ day research were manually and photographically recorded. In addition, videotaping both on land and underwater documented all procedures used and materials examined.

Prior to collection of selected artifacts from the Round Spring grotto, a video survey was conducted along the mapping baseline to document the location of materials *in situ*. Specific areas of cultural activity were carefully measured in (Plate 21) and later plotted onto the Round Spring contour map. Both black and white photos and color slides were taken of archeological materials collected from the grotto.

Numerous historic artifacts were found beneath the mill wheel at Alley Spring. Due to the confined quarters, videotape was the data recording tool used to document both the presence of these artifacts and the collection of an unusual conglomerate containing an unidentified metal mechanism and a prehistoric projectile point.

Preparation of the artifacts and the placement of the buckets, for the water-chemistry field experiment, was done both photographically and with a video tape. The unedited video tapes provide a permanent record of these activities; field notes supplement these tapes.

Environmental Data Recording

Since little was known about the environment of the Round Spring grotto, the room at the deepest portion of the basin, and the cave in Alley Spring, these areas were video taped and photographed.

Floral species, discussed elsewhere in this report, were of particular interest and an effort was made to visually document the variety of plant life present in both Alley Spring and Round Spring (Plate 22). Samples collected and placed in plastic ziplock bags were carefully labeled and later analyzed at the University of Missouri. Sample collection procedures were also documented.

The geologic formations of the Round Spring grotto, the deep room in the basin and Alley Spring cave were photographed and videotaped. The deep room in the basin at Round Spring was the probable source of the spring at one time. The solution activity of the limestone is evident in this room by the rippling effect and ledges formed in the rock matrix. This phenomena was permanently recorded on video tape; a small segment of this environmental survey is on the data tape which supplements this written report.

Plate 21: All material collected from the Grotto was carefully mapped and photographically and videographically recorded in situ. Following discovery of this site a special site designation was given; it is now listed as 23SH96 and is officially the Round Spring Grotto Site.

Plate 22: Coon's Tail or myriophyllum, often used in freshwater aquariums, was one of a wide variety of flora present at Round Spring.

A similar video survey of the grotto environment below the water level was also undertaken. Many smaller solution cavities were found as well as the submerged remains of a tree; probably hauled in by a beaver which was in residence in the grotto.

The deep cave environment at Alley Spring was also videotaped. This activity represents the deepest underwater cave penetration known to date with video recording equipment. The video tape and photographs of the cave entrance area, gravel slope and base extending to a depth of 100 feet and 150 feet back from the cave mouth provides a permanent analog record of this portion of the cave and the environment.

Traditional methods of data recording in archeology include photography and hand written notes. These procedures are extremely time consuming and are frought with problems of subjectivity, faulty equipment, loss of data, etc. The Inundation Study has attempted to improve these data recording procedures by expanding them to include video taping both on land and underwater.

The use of this approach has increased the capabilities of the research team to record a wide variety of information very quickly and provides the team with a permanent record that can be viewed at a leisurely pace later. Written notes, environmental data, floral identification, sample collection, and additional mapping information can all be generated from the videotapes.

A great advantage that live video tape has over photography is the assurance of usable results immediately. During archeological excavation the site or feature being photo documented is destroyed as a part of the data retrieval process. Weeks may pass before photos or slides are developed and returned. If for some reason they are inadequate, the information being photographically recorded is lost.

The Inundation Study team was only able to allocate a very short period of time at both Alley Spring and Round Spring. The video tape insured the complete documentation of all of the activities undertaken and materials examined during the brief stay. An ancillary benefit of video tape is the ability to provide park managers with supplemental information about submerged resources within the park, possibly not otherwise available.

VII. SUMMARY AND RECOMMENDATIONS

The archeological survey of Round Spring basin and grotto and the discovery of a site under 10 feet of water is of importance not only to an understanding of the cultural history of the Riverways, but also to the hydro-geological and paleo-climatological changes the Riverways may be experienced. If flooding of Round Spring Grotto was prehistoric, i.e., post 900 A.D., as hypothesized, then further study of variables indicative of spring level fluctuations in the past should be undertaken. When combined with relevant archeological data, a better understanding of the role of large freshwater spring features in past cultural systems would result.

The Round Spring Grotto Site, 23SH96, should be completely surveyed, and the location of other artifacts noted. If the long-term management plan and regional research strategy for the Ozark National Scenic Riverways warrants it, materials could be collected for analysis at a later date. Spelunkers or casual visitors to the area should continue to be discouraged from walking through the grotto. Damage to both fragile stalactites and artifacts can easily occur.

The Alley Spring cave should be mapped by a team of trained cave divers who specialize in mapping. Information gathered from such an activity would contribute to an understanding of ground water recharge systems in that area and the source of the Alley Spring's flow.

A complete floral collection from Alley Spring basin is recommended. A random sampling undertaken by the National Reservoir Inundation Study revealed the presence of at least one

anomolous specimen. Collection should be timed so as to gather the fruiting materials needed for a positive botanical identification.

An effort should be made to identify the species of troglobitic crayfish observed by the research team during their brief stay. A team of trained cave divers, working closely with Park personnel, could be used to gather baseline data on the numbers and variety of cave fauna in Alley Spring cave.

Other springs within the Ozark National Scenic Riverways system should be systematically investigated for similar cultural and environmental data. What are the effects of increased visitation and development on the Ozark springs; are seasonal variations in fish populations occurring; are there other, very early, archeological sites underwater in the Park; how can they contribute to an enriched cultural history of the Ozarks? These and other questions could be addressed. The complete picture of the Ozark National Scenic Riverways role in the cultural and environmental history of the Ozarks would emerge from further investigations and the mission and story of the Park would, ultimately, be enhanced.

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APPENDIX I

ROUND SPRING AND ALLEY SPRING, OZARK NATIONAL SCENIC RIVERWAYS
Collection Inventory

Site: 23SH96 - Round Spring Grotto

Field Sample #	Provenience	Collection Date	Description of Material
01-G	Surface collection Locus #2-N/S Baseline between 25-29M	09/20/78	Chert, Flake, utilized, retouch left lateral margin
02-G	Surface collection Locus #2-N/S Baseline between 25-29M	09/20/78	Chert, Flake, bifacial, utilized retouch both lateral margins
03-G	Surface collection Locus #2-N/S Baseline between 25-29M	09/20/78	Chert, Flake, cortex, possible use
04-G	Surface collection Locus #2-N/S Baseline between 25-29M	09/20/78	Chert, Flake, unifacial, utilized, retouch distal end and left lateral margin
05-G	Surface collection Locus #2-N/S Baseline between 25-29M	09/20/78	Chert, Flake, unifacial, utilized notch distal margin
06-G	Surface collection Locus #2-N/S Baseline between 25-29M	09/20/78	Chert, Flake, unifacial, cortex, utilized both lateral margins
07-G	Surface collection Locus #2-N/S Baseline between 25-29M	09/20/78	Chert, Core, bifacial, possible use, step fracturing dorsal side
08-G	Surface collection Locus #2-N/S Baseline between 25-29M	09/20/78	Chert, Flake, unifacial, utilized both lateral margins
09-G	Surface Collection Locus #2-N/S Baseline between 25-29M	09/20/78	Chert, Core, possible use one edge, step fracturing
10-G	Surface collection Locus #2-N/S Baseline between 25-29M	09/20/78	Geologic Specimen
11-G	Surface collection Locus #2-N/S Baseline between 25-29M	09/20/78	Chert, Core, bifacial, possible use proximal end

Site: 23SH96 - Round Spring Grotto con.

Field Sample #	Provenience	Collection Date	Description of Material
12-G	Surface collection, Locus #2-N/S Baseline between 25-29M	09/20/78	Chert, possible Late Woodland adz. water worn
13-G	Surface collection, 2.4m west of 10m point on N/S baseline Locus #1	09/20/78	Chert, corner notched proj. pt. or knife, possible Late Woodland
14-G	Surface collection, exact location unknown - general N/E Area of Grotto	09/19/78	Chert, biface, possible knife
15-G	Surface collection, exact location unknown - general N/E Area of Grotto	09/19/78	Bone
16-G	24.4m, 50° E/N from south end N/S baseline in Grotto Locus #3	09/20/78	Sherd, upper portion of vessel
17-G	24.4m, 50° E/N from south end N/S baseline	09/20/78	Limestone, geologic specimen
18-G	24.4m, 50° E/N from south end N/S baseline	09/20/78	Bone
19-G	24m, 50° E/N from south end N/S baseline	09/20/78	Sherd, section of lip
20-G	24m, 50° E/N from south end N/S baseline	09/20/78	Sherd, body section
21-G	24m, 50° E/N from south end N/S baseline	09/20/78	Sherd, body fragment
22-G	24m, 50° E/N from south end N/S baseline	09/20/78	Sherd, body fragment

Site: 23SH83 - Alley Spring

Field Sample #	Provenience	Collection Date	Description of Material
01	Under turbine well	09/21/78	Square nail
02	Under turbine well	09/21/78	Nut section
03	Under turbine well	09/21/78	Spike
04	Under turbine well	09/21/78	Wire nail
05	Under turbine well	09/21/78	Encrustacian w/proj. point

APPENDIX II

ANALYSIS OF SHERDS FROM ROUND SPRING GROTTO (23SH96)

Field Sample 16 - Grotto (FS-16-G)

Thickness	Temper	Paste	Surface Treatment	Section of Vessel
6 mm	Fine crushed limestone with occasional inclusions of sand and larger pieces of limestone. Particle size less than 1 mm; occasional pieces are 2-3 mm Particle density 30% Condition: Most of the temper particles have been leached from the exposed surfaces producing a porous appearance; the interior surface exposed along the breaks is more porous than the exterior; the temper material in exposed surfaces shows almost no reaction to HCl, however, temper material exposed by a new break reacts quickly to HCl.	Texture generally hard and compact Hardness 3 MOH's Color 5 yr. 2.5/2; both exterior and interior are dark reddish brown	Interior-smoothed Exterior-cord marked Condition-surfaces and edges are very smooth; probably due to water action	This sherd is from the upper part of a conical vessel; although the lip is missing, the sherd can be identified as the lower part of the rim and a section of the body as it begins to curve outward.

Field Sample 19 - Grotto (FS-19-G)

Thickness	Temper	Paste	Surface Treatment	Section of Vessel
6 mm	Fine crushed limestone with occasional inclusions of sand and larger pieces of limestone. Particle size less than 1 mm; occasional pieces are 2-3 mm Particle density 30% Condition: Most of the temper particles have been leached from the exposed surfaces producing a porous appearance; the interior surface exposed along the breaks is more porous than the exterior; the temper material in exposed surfaces shows almost no reaction to HCl; however, temper material exposed by a new break reacts quickly to HCl.	Texture generally hard and compact Hardness 3 MOH's Color 5 yr. 2.5/2 and 5 yr. 4/4. The exterior surface varies from dark reddish brown to reddish brown across the exterior surface; the interior surface is dark reddish brown. The core is dark brown.	Interior-smoothed Exterior-cord marked Condition-surfaces and edges are very smooth; probably due to water action	This sherd represents a section of the lip, rim and body of a conical vessel.

Field Sample 20 - Grotto (FS-20-G)

Thickness	Temper	Paste	Surface Treatment	Section of Vessel
6.5 mm	Fine crushed limestone with occasional inclusions of sand and larger pieces of limestone. Particle size less than 1 mm; occasional pieces are 2-3 mm. Particle density 30% Condition: Most of the temper particles have been leached from the exposed surfaces producing a porous appearance; the interior surface exposed along the breaks is more porous than the exterior; the temper material in exposed surfaces shows almost no reaction to HCl; however, temper material exposed by a new break reacts quickly to HCl.	Texture generally hard and compact Hardness 3 MOH's Color 5 yr. 2.5/2 both the exterior and interior surfaces are dark reddish brown; the core varies from dark brown to reddish orange	Interior-smoothed Exterior-cord marked Condition-surfaces and edges are very smooth; probably due to water action	This sherd is from the body of a conical vessel; the thickness and curvature of the sherd indicate that it was part of the lower section of the vessel. The crossing of cord impressions also indicates placement on the lower portion of the vessel.