EVALUATION OF THE

APACHE LEAP SITE, ARIZONA

FOR POTENTIAL PROTOTYPE DRILLING,

YUCCA MOUNTAIN PROJECT

November 1989

Prepared by
Field Operations of Sample Management
Technical and Management Support Services Contractor
Yucca Mountain Project

ENCLOSURE B

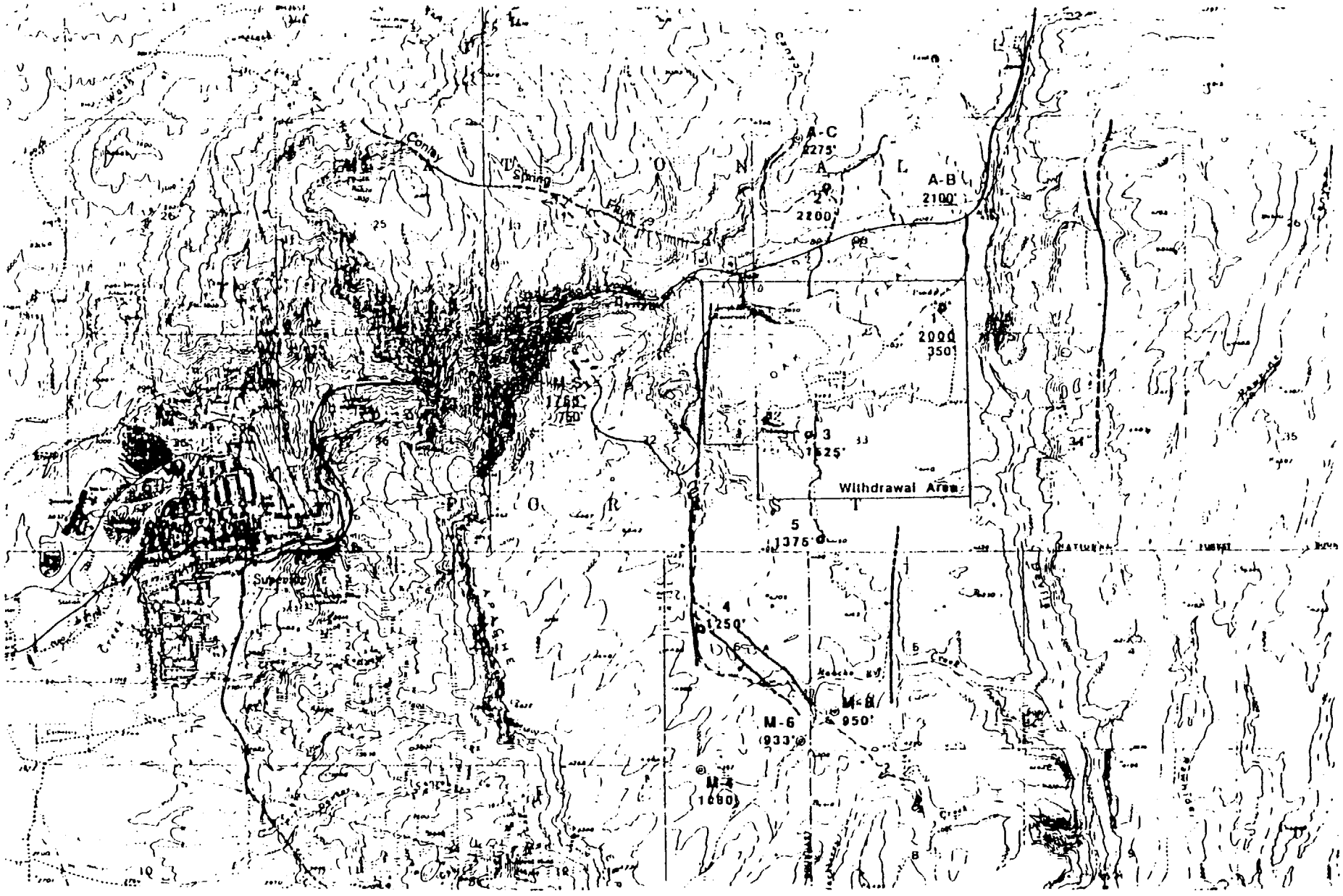
INTRODUCTION

In early October 1989, Field Operations of Sample Management was asked to identify potential drilling sites where the feasibility of continuous wireline coring could be tested using air rather than foam or mud to depths exceeding 1000'. Using guidelines developed from conversations with the Yucca Mountain Project Office (Project Office), sites were evaluated for (1) volcanic rocks similar to those at Yucca Mountain (e.g., moderately to densely welded rhyolitic ash flow tuffs); (2) a minimum of 1600' of volcanic rock, mostly welded tuff; (3) an unsaturated zone deep enough to continuously core 1600' of welded tuff; (4) less than 300' of non-volcanic rock above the welded tuff; (5) accessibility to the LM 120 drill rig and sufficient space for a drill pad; and 6) permittability. In early November 1989 a report was submitted to the Project Office which summarized preliminary evaluations of 23 sites for suitability for prototype drilling. In light of the geology, hydrology and access, the Apache Leap site east of Superior, Arizona, appeared to be the most promising of the sites investigated.

This report contains detailed site information and identifies five potential drilling locations in the Oak Flat area (Fig. 1). Based on existing drill hole information, the site appears to be underlain by a northward thickening wedge of moderately to densely welded dacitic tuffs, the Apache Leap Tuff, similar in composition and welding to the Paintbrush Tuff at Yucca Mountain. A mine shaft and several drill holes in the area are reported to have been either dry or to have encountered at shallow depths perched water that was controllable. Access to the area is good.

GEOLOGY

Apache Leap is a high escarpment which trends north-south along the western side of an extensive upland of volcanic tuff. Elevations are around 4700-4800' along the crest of the escarpment and are 4000-4400' over much of the upland. Bedrock is exposed over most of the area, and soil cover everywhere is less than 10-20' thick. The Tertiary-aged Apache Leap Tuff is a massive sequence of dacitic welded tuffs which thickens northward across the area from about 1000 feet to about 2300 feet. It unconformably overlies a very complex sequence of Precambrian through early Tertiary age sedimentary and metamorphic rocks. The following brief rock descriptions are based on observations made on a traverse along the type section of the Apache Leap Tuff in Queen Creek Canyon. Along the canyon the tuff dips eastward at low angles between 8 and 15 degrees. These descriptions were fitted into D. Peterson's informal stratigraphic subdivisions of the Apache Leap Tuff that were measured in the nearby Magma #9 shaft (1500' south of the canyon). The basal portion of the tuff begins about 200 feet west of the west portal of the tunnel for route 60 east of Superior. Fragmental material in these tuffs includes juvenile ejecta (generally pumice derived from the erupting magma), cognate ejecta (derived from volcanic rocks from previous eruptions of the same volcano) and accidental fragments from the subvolcanic basement. Lithic as used here covers cognate and accidental



3 – Map #
2000' – Thickness of fill
350' – depth to perched water, if known

0 Scale: 1

Miles

N

Figure 1. Location map of existing boreholes and potential prototype drilling sites.

material. The basal 30 feet of nonwelded tuff and all but the upper 20 feet of the overlying "black vitrophyre unit" (80 feet thick) are covered by talus here. This vitrophyre is a densely welded crystal-lithic vitrophyre with lapilli-size and larger fragments making up about 10 to 15 % of the rock. The overlying "brown inclusion unit" is about 275 feet thick and is a gray-brown, densely welded crystal lithic tuff . Most of this unit is masked by the tunnel. The overlying "gray unit" (1000 feet thick) is a partially welded pinkish gray crystal rich lithic tuff. The dominant type of fragmental material is a cream colored crystal "tuff" that was formed by the compaction of the original crystal bearing pumice fragment (juvenile ejecta). Accidental and possibly some cognate ejecta make up a small amount of the fragmental material. Flattening ratios are generally less than 6:1. Lapilli size fragments and larger make up less than 10 % of the rock in the lower portions of this unit, but appear to increase in size and amount (on the order of 25%) higher in the "gray unit". The "white unit" (600 feet thick) consists of partially welded to nonwelded, light pinkish gray to white crystal-lithic to pumice-block lithic tuff. Lapilli size and larger pumice fragments with minor amounts of cognate and accidental fragments make up as much as 60% of some intervals. The upper 100 feet of the "white unit" is composed of nonwelded, white crystal tuff, gray pumice-block lithic tuff, and white to tan reworked tuff (characterized by thin beds, cross bedding and thin channel structures). The pumice-block tuff contains a few cognate and accidental fragments. Pumice fragments weather out to give these rocks a vuggy appearance. This uppermost (100 foot) unit may be unconformable on the older Apache Leap units. North of the highway in the area of the second drill site the bedded tuffs abut directly against the older partially welded tuff without a change in attitude. Although this relationship could be interpreted as being due to faulting the lack of deformation near the contact (actual contacts are covered) suggests that the upper tuffs were deposited in a topographic low and are in depositional contact with the sides of a paleovalley. A few thin beds of silicified tuff along with associated veinlets of blue-white chalcedony occur in this upper unit.

Field time was not adequate for a detailed study of the fracturing in the Apache Leap Tuff. High angle joints (dips generally >75 degrees) with northeast, northwest, and east-west strikes are common throughout the unit. Low angle joints (dips generally < 45 degrees) are also present. Through at least the lower half of the tuff strong partings or joints parallel to the compaction foliation are well developed. Combinations of closely spaced high angle joints and joints or partings along the foliation lead to highly fractured masses of tuff within the Apache Leap unit. No evidence of springs or seeps along these fractures was observed in the canyon. Zones of tight, bleached granulated to brecciated tuff occur along shear zones examined in the vicinity of the canyon. Although some zones are silicified most of those observed were not.

Drill site 1 south of the highway is a large area of nearly flat topography with excellent road access. A borehole here would spud in the upper nonwelded white tuff (upper 100 foot unit). One small silicified breccia zone (N-S,80E) lies about 100 feet west of this site. The second site, north of the highway would require more site preparation, but has good road access. A borehole here would also spud in the upper white tuff. There is a minor amount of silicification in this area.

Several exploratory coreholes have been drilled in the area by Magma Copper Co. and ASARCO Inc. (Table 1). The tuff thickness increases northward from 933' in hole # M-6 to almost 2300' in hole # A-C. Unfortunately, little more than the thickness of the tuff was recorded during drilling of these coreholes. The most reliable information is from the sinking of the Magma #9 Shaft (map # M -S), which penetrated 1765' of dacite tuff closely matching the description of the type section. The Apache Leap Tuff is expected to equal or exceed that thickness over most of the area to the east and northeast of the shaft.

A number of faults have been mapped in the area (Fig. 1). One north-trending fault parallels the western edge of the withdrawal area. Two other north-trending faults are mapped about one and two miles to the east. A northwest-southeast trending horst passes between boreholes M-6 and M-8. Several other apparently discontinuous faults are mapped beyond the locations of the existing boreholes. Field observations suggest that there are probably numerous small faults and crushed zones present in addition to the major ones shown.

Table 1. Drill holes in the vicinity of potential prototype drilling sites.

Map #	Hole #	Location		Thick. of tuff	Depth to water
		Section	T., R.		
A-A	ASARCO A	SW1/4 SW1/4 sec. 27	T. 1 S., R. 13 E.	1975'	400'
A-B	ASARCO B	SE1/4 NE1/4 sec. 28	T. 1 S., R. 13 E.	2100'	360'
A-C	ASARCO C	NW1/4 NW1/4 sec. 28	T. 1 S., R. 13 E.	2275'	-
M-S	Magma #9 Shaft	NW1/4 NW1/4 sec. 32	T. 1 S., R. 13 E.	1765'	750'
M-4	Magma 4	NE1/4 NW1/4 sec. 7	T. 2 S., R. 13 E.	1080'	-
M - 6	Magma 6	SE1/4 SE1/4 sec. 6	T. 2 S., R. 13 E.	933'	-
M - 8	Magma 8	SW1/4 SW1/4 sec. 5	T. 2 S., R. 13 E.	950'	-

HYDROLOGY

Very little published information is available on the surface and subsurface conditions at the Apache Leap site. Only one spring is mapped about two miles to the north of the area, and no indications of surface water were seen in Queen Creek or Devils Canyons. Rainwater has been impounded in small ponds on the upland surface. There does not appear to be any published information relating to the subsurface hydrologic conditions in the tuff section.

Magma mine records and personnel indicate that the Magma #9 Shaft was dry to 750' where a fracture aquifer was penetrated. The zone was grouted, shutting off the flow, and sinking continued, reportedly dry, to total depth. Mining ceased in 1982 and the shaft was allowed to flood. Maximum static level is reported to have been at about the 3550' level or only about 600 feet above sea level and well below the base of the tuff section. Water-supply wells were later drilled into the perched zone and have provided mine water at about 60 gallons per minute for nearly 20 years. If this perched water is found to be largely confined to a relatively isolated fracture zone, this could be advantageous for the purpose of closely simulating hydrologic conditions at Yucca Mountain (perched water and flow through fractures are included as part of the conceptual model of ground-water flow at Yucca Mountain). In addition, many of the rocks at Yucca Mountain are believed to have relatively high saturation levels (>50%). Drilling through a wet fracture zone at Apache Leap could simulate the conditions of perched or fracture water and water contents approaching saturation, similar to those that might be encountered at Yucca Mountain.

ASARCO has drilled a few coreholes in the area with air circulation and reported having encountered water zones similar to that in the Magma #9 Shaft at depths of 350-400'. Apparently no increases in volume were noted with depth, suggesting zones of limited vertical extent. Later, holes drilled with mud lost circulation at similar depths, indicative of possible low-pressure aquifers. These intervals were successfully plugged off, and drilling continued without problems.

LAND OWNERSHIP

Magma, ASARCO and probably others hold unpatented mining claims on a considerable portion of the area. However, most of the area of interest is controlled by the Forest Service of the U.S. Department of Agriculture as National Forest land. An area about one mile square around the Oak Flat campground has been withdrawn from mineral entry (Fig. 1). But permits for exploratory or scientific drilling can be obtained, even in the withdrawal area.

ROAD ACCESS

U.S. Highway 60 climbs Queen Creek Canyon just to the north of the area of interest, and there is limited access over fair to good roads within the area. Magma has a paved road to the Magam #9 Shaft near the crest of the Apache Leap escarpment, and there are a few forest service roads and trails across other parts of the area. The terrain along the crest is developed on bedrock and is very rough, and grading roads and a drill pad would be very difficult. A mile or so eastward the surface flattens, and several areas would provide good drill sites. A field examination was made of access routes into the southern part of the area. Generally these are impassable for the larger drill rigs without substantial upgrading. A newly-graded dirt road leads northward from the highway.

RECOMMENDED DRILL SITES

Based on geologic and hydrologic data and field examination of the area, three sites were selected for permitting. Two other sites were suggested by Magma as potential drilling sites. Table 2 lists the locations of these five sites. The map number indicates the Project Office's order of drill site preference.

Table 2. Locations of potential prototype drill sites.

Map #	Location	Elev.	Remarks
1	SE1/4 SE1/4 sec. 28, T. 1 S., R. 13 E.	~4075'	~600' from south & east lines
2	SE1/4 NW1/4 sec. 28, T. 1 S., R. 13 E.	~4070'	~1700' from north line ~1980' from west line
3	SE1/4 NW1/4 sec. 33, T. 1 S., R. 13 E.	~4015'	~2500' from north line ~1300' from west line
4	SW1/4 NW1/4 sec. 6, T. 2 S., R. 13 E.	~4120'	~1850 from north line ~800 from west line
5	SE1/4 SW1/4 sec. 33, T. 1 S., R. 13 E.	~4150'	~200' from south line ~1700' from west line

SUMMARY

A summary of selection parameters for each of the five sites is presented in Table 3. Thickness of the tuff may range from 1250 to 2200'. Site 4 is located between two faults. Perched water will probably be encountered between 350' and 1000' below the surface in the area but is reportedly controllable by grouting. Accessibility varies to the sites. The roads to sites 1 and 2 are in excellent condition. The road to sites 3 and 5 will require some upgrading at the beginning of the road and major upgrading to reach site 5. The road to site 4 needs major upgrading. Permitting of any site is likely to be relatively easy but could require as long as 45 days. These factors indicate that site 1 is recommended as the primary site, and sites 2 and 3 are the secondary selections.

Table 3. Selection parameters for potential prototype drilling sites.

Hole #	Est. tuff thickness	Est. depth to perched water	Access	Land Ownership
1	2000'	350'	excellent	Forest Service (Withdrawal)
2	2200'	*	excellent	Magma unpatented claims
3	1625'	*	needs upgrading	Forest Service (Withdrawal)
4	1250'	*	major upgrading	Magma unpatented claims
5	1375'	*	major upgrading	Magma unpatented claims

* insufficient information

REFERENCES

Flores, F., 11/89. Magma Copper Co., Superior, AZ, Pers. Comm.

Gronlund, F., 11/89. Magma Copper Co., Superior, AZ, Pers. Comm.

Hammer, D.F. and D.W Peterson, 1968. Geology of the Magma Mine area, Arizona: *in* Ridge, J.D., ed., Ore Deposits of the United States, Part 9, Chap. 61, Graton-Sales Volume, Am. Inst. Mining, Metal, and Pet. Eng., Inc., pp. 1282-1310.

Peterson, D.W., 1969. Geologic map of the Superior quadrangle: USGS Geologic Quadrangle Map GQ-818.

Sell, J.D., 11/89. ASARCO Inc., Tuscon, AZ, Pers. Comm.

Short, N.M., 1943. Geology and ore deposits of the Superior mining area, Arizona: Arizona Bureau of Mines, Ser.16, Bull. 151, 159 p.

Field Operations of Sample Management, T&MSS Contractor, 1989. Evaluation of some potential sites for prototype drilling on the southeastern U.S., Yucca Mountain Project: T&MSS Contractor, Yucca Mountain Project, Las Vegas, NV, 33 p.

Various well records, misc. dates. Ariz. Dept. Water Resources, Phoenix, AZ.

Webster, R., 11/89. Magma Copper Co., Superior, AZ, Pers. Comm.

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ISS CORE LOGGER

ologic Section of Apache Leap Tuff

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Scale: 1" = 200'

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ded Tuff

ded Tuff

Log Sources:

Magma Copper Co.

D. Peterson/USGS

J. Kepper/T&MSS

J. Moyer/T&MSS

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erived from the Magma shaft which collars in Petersons
cated just south of Route 60. Thickness of upper most
eld data. Rock descriptions based on field observations

black: lithics
han 6:1.

but not exposed on

EXHIBIT C

FSN

YMP RECORD OF VERBAL COMMUNICATION

Time: 3:55 P.M.

FS-YRVC-00054

FROM Roy Long of DOE/YMPO

TO Eddie [illegible] of FSN

☒ By Telephone
☐ By Radio
☐ In Person

SUBJECT: DRY DRILLING AND CORING EQUIPMENT PROGRAM - PHASE 1e

☒ Received the following
☐ Issued the following

☒ INSTRUCTIONS ☐ AUTHORIZATION ☐ INFORMATION

The Dry Drilling and Coring Equipment Program - Phase 1e shall be revised from Rev. #6 dated 10/10/89 to Rev. #7 dated 12/04/89. This Revision #7 shall change the USW UZPSI-2 and USW UZPSI-3 bore hole programs to reflect a cementing/grouting operation for perched water.

The statement "If water is encountered..." will be changed to "If perched water is encountered prior to reaching total depth, the bore hole will be grouted.

ACTION COPIES		SIGN OFF & DATE
	U. Clanton, DOE	
	B. B. Grams, FSN	DOE [signature] 12/4/89
	R. L. Bullock, FSN	USER
DISTRIBUTION	FSNRC	REECo
C. Mason, REECo		FSN [signature] 12/4/89
J. Peck, SAIC		

FORM LV-186C

EXHIBIT D

FENIX & SCISSON OF NEVADA
ENGINEERS-CONTRACTORS

WBS 1.2.3.5.3
QA

TO: REECo DRILLING

W.O.: #3404-502

RE: DRY DRILLING AND CORING EQUIPMENT DEVELOPMENT PROGRAM-PHASE 1e
USW UZPSI-2
USW-UZPSI-3
USW UZP-4
USU UZP-5
REVISION #7

CRITERIA LETTER:
Phase 1 of Unsaturated Zone Drilling and Coring Equipment Development, 04-10-89

LETTER:
Gertz/Carter, 04-10-89

LETTER:
Bullock/Gertz, 04-11-89

VERBAL:
Clanton/Wright, 10-06-89
Long/Wright, 12-04-89

DATE: December 4, 1989

LOCATION: To Be Determined

APPROVED BY:

12/4/89
FSN Drilling Engineer

12/4/89
FSN Quality Assurance

12-4-89
SAIC

12/4/89
DOE/YMPO

All work described in this program is QA Level III. Unless specified otherwise Lang will furnish services, permits, materials, and equipment under a subcontract to REECo for all work described in this work program.

Drill site selection is under study and all drilling equipment required for this program shall be available by November 20, 1989.

PROGRAM - PHASE 1e

USW UZPSI-2

1. Move in a Lang drill rig and necessary equipment on the proposed location. Rig up and drill a nominal 6-1/2 inch diameter hole to a maximum depth of 1700 feet using dry air and an air hammer. If perched water is encountered prior to reaching total depth, the hole will be grouted. The hole shall be plugged and abandoned according to state requirements.

2. Demobilize the drilling rig and equipment.

FSN Sr. Drilling Engineer Date

USW UZPSI-3

1. Move in a Lang drill rig and necessary equipment on the proposed location. Rig up and drill a nominal 6-1/2 inch diameter hole to a maximum depth of 1700 feet using dry air and an air hammer. If perched water is encountered prior to reaching total depth, the hole will be grouted. The hole shall be plugged and abandoned according to state requirements

2. Demobilize the drill rig and equipment.

FSN Sr. Drilling Engineer Date

USW UZP-4

1. Move in the LM-120 drill rig, 9-5/8 in. O.D. dual-wall drill pipe, CHD-134 coring equipment, compressors, and dust collector. Drill 20 inch hole to solid bedrock. Run 16-inch O.D. surface casing open-ended belled to bedrock and cement casing. Weld 16 inch flange to top of 16-inch casing and install drilling head.

2. With a 12-1/4 inch open-centered roller-cone bit on bottom, continuously wireline core with air below surface casing using the CHD-134 coring system and direct circulation.

3. At intervals to be determined the coring tools will be removed from the hole and the hole will be advanced to the bottom of the core hole using the 12-1/4 inch open-centered bit.

4. The hole shall be continuously wireline cored to the standing water level or to 1100 feet. Hole may be terminated at a shallower depth as determined by the User.

5. Drilling and coring parameters shall be closely monitored and documented to determine coring and drilling penetration rates.

6. At total depth run geophysical logs and surveys as specified by the User.

7. At total depth plug and abandon the hole as required.

FSN Sr. Drilling Engineer Date

USW UZP-5

1. Move in the LM-120 drill rig, 7 inch O.D. dual-wall drill pipe, CHD 101 coring equipment, compressors, and dust collector. Drill a nominal 14-3/4 inch hole to bedrock using air. Run 10-3/4 inch O.D. casing open-ended belled and cement casing. Weld 10-3/4 inch flange to top of 10-3/4 inch O.D. casing and install drilling head.

2. Using an 7 7/8 inch roller-cone bit, drill to 30 feet, trip out and run a tungsten carbide open-centered bit. Pick up CHD-101 coring tools and continuously wireline core to 1700 feet. Hole may be terminated at a shallower depth as determined by the User.

3. At intervals to be determined the coring tools will be removed from the hole and the hole will be advanced using the open-centered tungsten carbide bit or another type of bit as required.

4. Drilling and coring parameters shall be closely monitored and documented to determine coring and drilling penetration rates.

5. At total depth run geophysical logs and surveys as specified by the User.

6. At total depth plug and abandon the hole as required. Demobilize rig and equipment.

FSN Sr. Drilling Engineer Date

ADDITIONAL EQUIPMENT REQUIREMENTS

1. 600 FT. OF 7" X 4-1/2" Continuous Sample Recovery (CSR) Dual Wall Drill Pipe in 20 ft. lengths with thread protectors. This drill pipe must be compatible with the existing drill string purchased from Drill Systems, Inc. through Lang Exploratory Drilling for prototype drilling and coring tool development.

2. One set of pony subs with thread protectors for the 7" x 4-1/2" CSR Dual Wall Drill Pipe in lengths of 2-1/2 ft., 5 ft. and 10 ft. This drill pipe must be compatible with the existing Drill Systems, Inc. drill string.

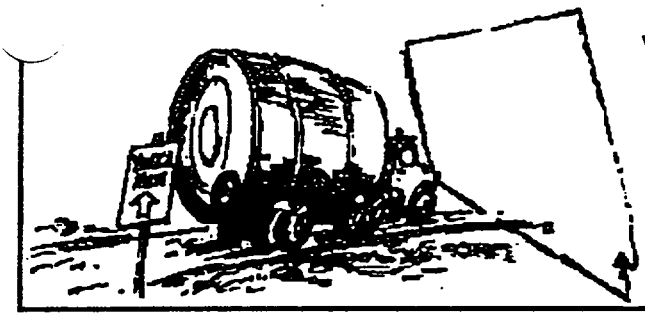
3. One set of pony subs with thread protectors for the 9-5/8" x 6" CSR Dual Wall Drill Pipe in lengths of 2-1/2 ft., 5 ft. and 10 ft. This drill pipe must be compatible with the existing Drill Systems, Inc. drill string.

4. 600 ft. of Longyear CHD 101 core rod in 3 meter lengths with thread protectors. This core rod must be compatible with the existing coring string purchased from Longyear through Lang Exploratory Drilling for prototype drilling and coring tool development.

5. Modification of the sample collector to increase efficiency of collecting and disposing of bulk cuttings samples. FSN will provide the design for this modification.

FSN Sr. Drilling Engineer Date

NEVADA NUCLEAR WASTE NEWS



Vol. 1 No. 1 December 1989

CALENDAR

Dec. 15	NV Commission on Nuclear Projects 10 a.m Las Vegas City Hall
Dec. 18	DOE/BLM Land Withdrawal Meeting 6 p.m. Reno-Sparks Convention Center
Dec. 19	DOE/BLM Land Withdrawal Meeting 6 p.m Henderson Convention Center

Public Meetings Dec. 18-19

DOE Asks for Withdrawal of Public Land

Two public meetings are scheduled in Henderson and Reno concerning 4,300 acres of public land that the U.S. Department of Energy wants to withdraw around Yucca Mountain. The land, currently managed by the Bureau of Land Management, includes part of the proposed site of the national high-level nuclear waste dump.

According to a BLM announcement, "The purpose of these public meetings is to gather information for consideration and incorporation the withdrawal application case record...In r words, the proposed withdrawal will be ely for the purpose of maintaining the physical integrity of the subsurface environment from unplanned or unknown intrusions in order to ensure that scientific studies for site characterization are not invalidated."

"Even though the Department of Energy is saying this is not part of the Site Characterization Plan for Yucca Mountain, Nevadans should attend these meetings," said Judy Treichel, Executive Director of the Nevada Nuclear Waste Task Force.

"Every time a piece of Nevada is chipped away for this project, we are getting closer to a time when Nevadans may not have the option of accepting or denying this project. We cannot allow government bureaucracies to have the final word on Yucca Mountain. Nevadans need to speak up at public meetings like this."

The meetings are scheduled for:

Dec. 18	Reno - 6 p.m. Reno- Sparks Convention Center 4950 So. Virginia St.
Dec. 19	Henderson - 6 p.m. Henderson Convention Center 200 So. Water Street

Persons wishing to speak at these meetings should pre-register by calling (702) 646-8800 in Las Vegas; and (702) 328-6330 in Reno. They may also register at the door prior to the meeting. Persons who cannot attend the meetings can submit written comments until Dec. 29, 1989. Written comments should be addressed to State Director (NV-943), Bureau of Land Management, 850 Harvard Way, P.O. Box 12000, Reno, NV 89520.

For more information about these meetings call the Nevada Nuclear Waste Task Force at 1-800-227-9809 or (702) 878-0832, or Mary Clark at the BLM in Reno, (702) 328-6330.

Yucca Mtn Budget Cuts

The Administration's multibillion-dollar War on Drugs took its toll last month on the DOE's budget for the civilian high-level nuclear waste program, and DOE has announced the layoff of 200 workers from the already stalled Yucca ntain site characterization work.

Congress recently appropriated $346 million from the utility customer-funded Nuclear Waste Fund for DOE work during fiscal 1990, beginning on October 1 of this year.

(Cont'd on back page)

DOE Delays Yucca Mtn Again

Gov. Bob Miller has told the U.S. Department of Energy he will not bend to threats of a lawsuit to force Nevada to allow testing for siting the national high-level nuclear repository at Yucca Mtn. "We're not going to be influenced by threats when we have already taken conclusive and decisive action in expressing our opposition to the dump," Miller said.

He reacted forcefully after DOE Deputy Energy Secretary W. Henson Moore announced on Nov. 28 the federal government would sue Nevada to force issuance of permits for the project. Speaking at a nuclear industry convention in San Francisco, Moore said Nevada has 30 days to "decide to cooperate." If the state does not issue permits for more tests at Yucca Mtn., Moore said the Justice Department "will file suit in January, and we will get on with the program."

The threat of lawsuits is part of a DOE reorganization plan to get the Yucca Mtn. project back on track, according to John Tuck, the DOE Undersecretary of Energy. Tuck told reporters that Secretary of Energy James Watkins is "dissatisfied with earlier assessments," and the department never had "a good scientifically sound plan" after two years of study costing $500 million.

Last month Miller called on Watkins to abandon Yucca Mtn. because of numerous technical flaws and errors in the study of the site. Citing the state's legislative veto (see back page) in a letter and supporting documents, Miller said, "Even though the site is legally dead, this additional technical information is again offered to the Secretary so he,himself, can realize that he has the ability to stop the project."

Miller closed his letter saying Nevadans "are firmly resolved to oppose" the dump and that "such unwanted federal intrusion is without precedent in our nation's history."

Watkins has refused to kill the project, saying Congress has directed DOE to conduct studies solely at Yucca Mtn. But the reorganization plan is seen as an admission the Yucca Mtn. proposal is off-track for completion by 2003. In addition to the lawsuits, the new plan calls for completion by 2010; delays in test shafts until late 1992; cutbacks in contractors working on the project; speedy nomination of a nuclear negotiator and director of the Office of Civilian Radioactive Waste Management; and immediate work on siting for temporary nuclear waste storage: The so-called monitored retrievable storage (MRS) could be ready by 1998, according to DOE. (see back page)

O-1347

YUCCA MOUNTAIN UNCERTAINTY BURDENS NUCLEAR UTILITIES

A Presidential Commission has reported to Congress that a Monitored Retrievable Storage facility for commercial nuclear reactor spent fuel, as proposed to the U.S. Department of Energy and authorized in the federal Nuclear Waste Policy Act, is not justified and should not be built. So far, it is unclear how Congress and the DOE will respond to this recommended reversal in interim storage planning.

The MRS Review Commission, established by the 1987 waste act amendment that also singled out Yucca Mountain as the sole high-level nuclear waste disposal site for study, ditched the MRS proposal because of its linkages in the law to progress on the Yucca Mountain disposal site.

"Because of delays already experienced in the repository schedule, and continued uncertainty surrounding the repository's (Yucca Mountain) location and date of operation, the value of the MRS would be greatly diminished if its construction were tied to the schedule of the repository," the report said. Meanwhile, the review commission did point out that most, if not all of the nation's 111 commercial reactors will run out of space in on-site spent fuel storage pools before any disposal facility could become available.

To meet this storage capacity need the Commission said that aside from utilities installing on-site dry spent fuel storage casks or vaults, the federal government should provide additional limited off-site storage capacity for utilities with special needs. One of the off-site approaches recommended would be for immediate acceptance of spent radioactive fuel if needed because of a safety emergency at a reactor. This facility is proposed to be paid from the Nuclear Waste Fund, which now charges utility ratepayers a fee for the DOE's nuclear waste disposal program.

The report also recommends that DOE build a small interim storage facility for spent fuel from reactors that cannot otherwise meet their on-site storage needs and continue to generate electricity. This facility would be paid for by the individual utilities when they use the storage service.

The report does not say how the government should decide where to locate these nuclear waste storage facilities, but the federal nuclear waste act prohibits placing an MRS facility in Nevada. In addition, Energy Secretary James Watkins has assured Governor Bob Miller, and the Nevada Congressional delegation, that Nevada would not be considered for interim storage of spent nuclear fuel.

FOR MORE INFORMATION ABOUT YUCCA MOUNTAIN

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4550 W. Oakey Blvd. Suite 111
Las Vegas, NV 89102
(702) 878-1885
TOLL FREE 1-800-227-9809

Budget Cuts *(Cont'd from front page)*

Congress earlier had cut this year's program funds from a $500 million Administration proposed budget. But, when the White House went looking for money in the federal budget to fund its new anti-drug initiative, it singled out the DOE nuclear waste program to ante up another $6 million in spending authority.

Nevada's $23 million requested grant from the Waste Fund to oversee DOE's Yucca Mountain project was cut to $5 million in the Congressional appropriation to DOE. Another $6 million was authorized to be released to Nevada at the discretion of the Energy Secretary, but that money has not been offered yet. Last year's Nevada funding was a full $11 million. The $46 million reduction for DOE is not expected to further lower Nevada's grant funding.

AG Agrees: Site Vetoed

A formal legal opinion from Nevada Attorney General Brian McKay reinforces the state's ability to veto the DOE Yucca Mountain proposal, according to Gov. Bob Miller.

"Federal law allows Nevada to veto the dump, and we have done that," Miller said. "Congress failed to override the veto. Our message to the Department of Energy has been delivered: Find someplace else besides Nevada."

The federal nuclear waste law, which singled out Yucca Mountain as the sole proposed site, allows Nevada to file a notice of disapproval with Congress, and the notice stands as a veto unless overridden by Congressional vote within 90 days of receipt.

The Legislature approved, and Gov. Miller signed, Assembly Joint Resolution 4 and 6 and forwarded them to Congress in mid-April.

Miller asked for a legal opinion from the Attorney General to determine whether the DOE's pending State permit applications for work at Yucca Mountain are valid, given the fact that the State had successfully vetoed the site.

According to the opinion, the applications for an air quality permit, an underground injection permit, and a water appropriation are invalid, since Nevada has followed the legal process for vetoing the site.

"Nevada has followed the law, so should the DOE," Miller said. "Nevadans have said no. We have legally rejected the dump."

The Nevada Nuclear Waste News is prepared for the Nevada Nuclear Waste Project Office by the Nevada Nuclear Waste Task Force, Inc., funded through U.S. DOE grant #DE-FG08-85NV10461

Nevada Nuclear Waste Project Office
Agency for Nuclear Projects
Capitol Complex
Carson City, NV 89710
(702) 885-3744

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Office of Resource Mgt.
Nuclear Reg. Comm.
1050 E. Flamingo Rd., Suite 319
Las Vegas, NV 89109

ACTIVITY TO EVALUATE PRIORITIZATION OF SURFACE-BASED TESTING

- GUIDANCE RECEIVED FROM DOE/HQ ON OCTOBER 31, 1989

- PURPOSE OF TASK IS TO ENSURE THAT EARLY TESTING IS PRIORITIZED TO PROVIDE DATA NEEDED TO EVALUATE POTENTIALLY ADVERSE CONDITIONS

- GUIDANCE SUGGESTS LINK FROM THIS TASK TO MORE GENERAL EVALUATION OF SITE SUITABILITY SHOULD BE CONSIDERED

  -- CONSIDER FEASIBILITY OF DEVELOPING EVALUATION CRITERIA FOR POTENTIALLY ADVERSE CONDITIONS

  -- CRITERIA SHOULD LINK PRESENCE OF POTENTIALLY ADVERSE CONDITION TO POTENTIAL FOR NON-COMPLIANCE WITH PERFORMANCE OBJECTIVES

IMPLEMENTATION OF GUIDANCE BY YUCCA MOUNTAIN PROJECT

- INFORMAL DISCUSSIONS WITH YMP MANAGEMENT HAVE BEEN HELD TO DETERMINE AVAILABILITY OF KEY STAFF

- DOE/HQ GUIDANCE TRANSMITTED TO YMP TECHNICAL PROJECT OFFICERS WITH REQUEST FOR STAFF SUPPORT FOR TASK FORCE

- PROJECT OFFICE VIEWS THIS TASK AS PRIMARILY A REVIEW OF EXISTING INFORMATION, WITH DEVELOPMENT OF RECOMMENDATIONS AND OPTIONS FOR CONSIDERATION BY DOE MANAGEMENT

GENERAL ASSUMPTIONS USED IN SCOPING THE TASK

- TASK WILL UTILIZE ABOUT 5-7 FTE FOR ABOUT 10 MONTHS

- TASK IS TO BE GIVEN HIGH PRIORITY IN RESPONSE TO REQUESTS FROM THE NUCLEAR REGULATORY COMMISSION, ADVISORY COMMITTEE ON NUCLEAR WASTE, STATE OF NEVADA, AND EDISON ELECTRIC INSTITUTE TO PLACE EARLY FOCUS ON POTENTIALLY ADVERSE CONDITIONS

- LIMITED OR NO NEW EVALUATIONS/ANALYSES WILL BE PERFORMED; HOWEVER, AVAILABLE INFORMATION MAY BE REANALYZED OR REINTERPRETED

- A SMALL CORE TEAM WILL HAVE PRIMARY RESPONSIBILITY FOR CONDUCTING THE TASK

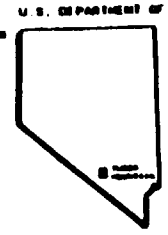
GENERAL ASSUMPTIONS USED IN SCOPING THE TASK (CONTINUED)

- A DECISION ANALYST WILL SERVE AS A MEMBER OF THE CORE TEAM TO ENSURE THAT STATE-OF-THE-ART TECHNIQUES FOR EVALUATING SUBJECTIVE/HIGHLY UNCERTAIN INFORMATION ARE USED

- AN INDIVIDUAL FROM EDISON ELECTRIC INSTITUTE'S SITE SUITABILITY TASK FORCE WILL SERVE AS AN ADVISOR TO THE CORE TEAM

- A YMP INTEGRATION TEAM WILL SERVE AS AN "EXPERT POOL" FOR THE CORE TEAM, PROVIDING EXPERTISE ON SITE, PERFORMANCE ASSESSMENT, AND ENGINEERING

- DRAFT IMPLEMENTATION PLAN IS IN REVIEW BY CORE TEAM AND IS DUE AT DOE/HQ ON DECEMBER 15, 1989



YUCCA
MOUNTAIN
PROJECT

ESF ALTERNATIVES STUDY

T. O. HUNTER

12-7-89

Sandia
National
Laboratories

ESF ALTERNATIVES STUDY

YMPO HAS ESTABLISHED AN EVALUATION TO INTEGRATE REPOSITORY AND ESF CONFIGURATION

- PROVIDE A CONSISTENT DESIGN BASIS UNDER CURRENT REQUIREMENTS AND QA PROGRAM

- REMOVAL OF NRC OBJECTIVES

  1. NEED FOR DOE TO DEMONSTRATE THE ADEQUACY OF BOTH THE ESF DESIGN AND THE DESIGN CONTROL PROCESS

     RECOMMENDATION: "The Title II design should ensure that... the number of shafts and their locations in the final repository contribute to reduce uncertainty with respect to waste isolation."

  2. NEED TO IMPLEMENT A BASELINED QUALITY ASSURANCE PROGRAM BEFORE STARTING SITE CHARACTERIZATION

- NUCLEAR WASTE TECHNICAL REVIEW BOARD

  - "Re-examine the proposed ESF configuration, incorporating the use of an SBM to construct ES-1"

  - "Re-examine the incorporation of a ramp in the proposed ESF configuration, excavated by the use of the TBM..."

U.S. DEPARTMENT OF ENERGY

YUCCA MOUNTAIN PROJECT

ESF Alternatives Study

Chronology of Implementation Plan

8/25/89	Alternative Strategies Meeting, LV
10/5/89	Planning Meeting at DOE/HQ
10/18/89	Verbal assignment of task to SNL
11/7/89	Informal review of Plan
11/21-27/89	Technical, Management, and QA Review Plan
11/27/89	Comment Resolution Meeting
11/30/89	Plan Approved by SNL, Submitted to YMPO

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U.S. DEPARTMENT OF ENERGY

YUCCA MOUNTAIN PROJECT

ESF Alternatives Study

Tasks

1. Plan Management & Implementation
2. Develop Methodology/Rules for Evaluations of Options
3. Identify Requirements Basis for Evaluations
4. Identify Options to be Evaluated
5. Selection of Preferred Option
6. Prepare Study Report
7. Revise SDRD for Resumption of Design
8. Identify Revisions to RDR

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U.S. DEPARTMENT OF ENERGY

YUCCA MOUNTAIN PROJECT

ESF Alternatives Study

Tasks

1. Plan Management & Implementation
   - Develop and Approve Task Plans
   - Schedule/Budget
   - Records Management
   - Training

2. Develop Methodology/Rules for Evaluations of Options
   - Repository Options
   - ESF Options

3. Identify Requirements Basis for Evaluations
   - Requirements for Repository
   - Requirements for ESF
   - Testing Requirements

4. Identify Options to be Evaluated
   - Repository UG Configurations and Accesses
   - ESF Options

5. Selection of Preferred Option
   - Application of Methodology/Rules

6. Prepare Study Report
   - Prepare Text for Each Task
   - Graphics/Editorial Support
   - Independent Technical Review
   - Management Approval/Acceptance

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U.S. DEPARTMENT OF ENERGY

YUCCA MOUNTAIN PROJECT

ESF Alternatives Study - Con't

Tasks

7. Revise SDRD for Resumption of Design
   - Establish Quantitative PA Requirements, As Required
   - Update Repository and Testing Interface Requirements, as Necessary
   - Verify Requirements
   - Prepare/Submit CR to CCB

8. Identify Revisions to RDR

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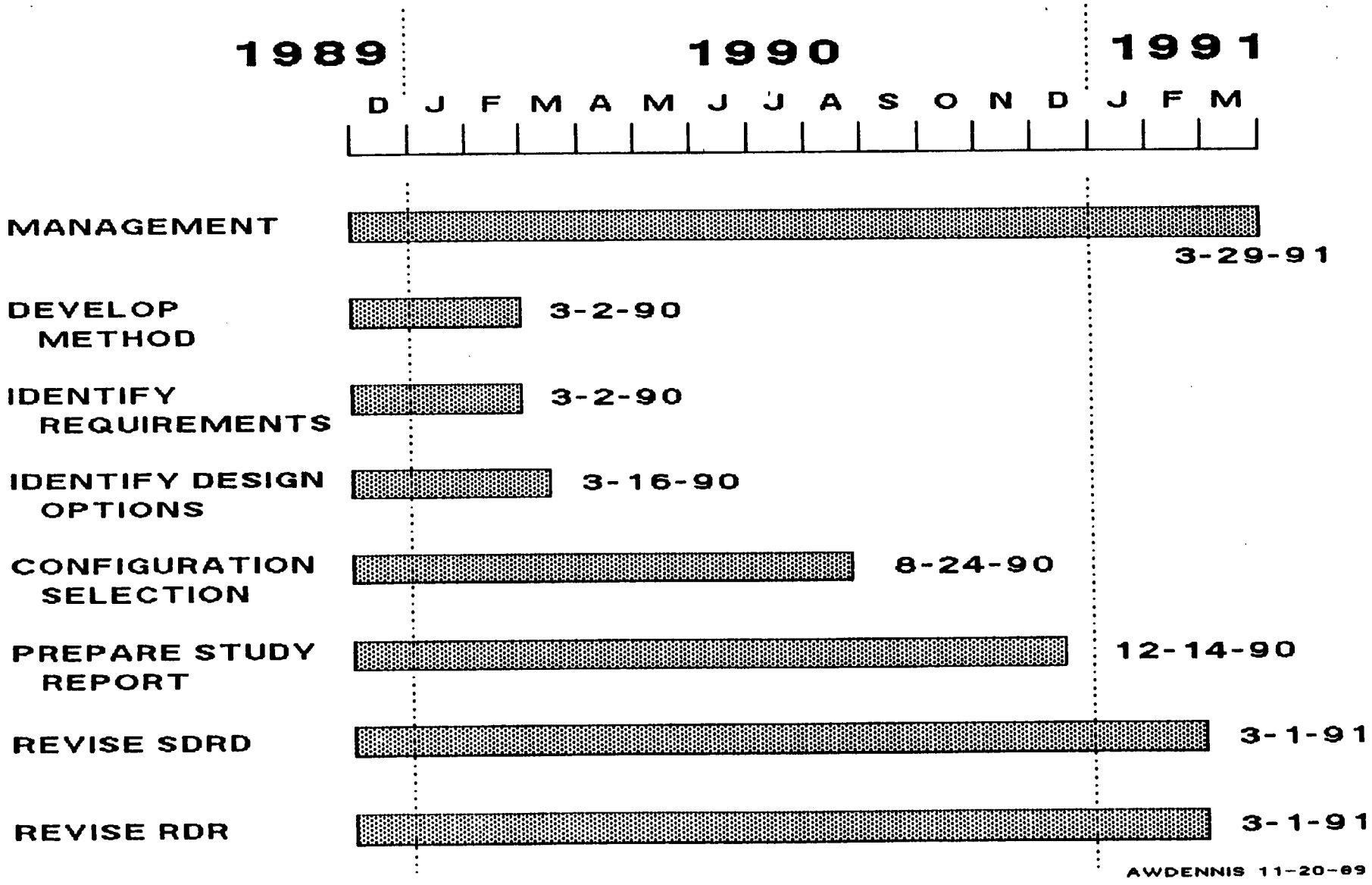
ESF ALTERNATIVE STUDIES SCHEDULE



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YUCCA MOUNTAIN PROJECT

ESF Alternatives Study

QA

Basis for QA Program is SNL QAPP and Procedures

- Those "participants" with an "approved" QA Program will operate under their own program and interface with SNL through AP-5.19Q, Interface Control.
- Those "participants" without an "approved" QA Program will operate under SNL QA procedures.

First Time Application of Subpart G under NNWSI 88-9

- Work/Task Plans with QALAS and Grading
- Software QA
- Use of Data
- Formal Plans

  - Personnel Certification and Training
  - Implementing Instructions
  - Records
  - Peer Review
  - Document Preparation and Review
  - Audits & Surveillances

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YUCCA MOUNTAIN PROJECT

ESF Alternatives Study

Options

Repository/ESF Layout

- Access (Shaft-Ramp)
- Location of Access

Construction Method

- Drill & Blast
- Mechanical
  - TBM
  - V-Mole
  - Raise-Borer
  - etc

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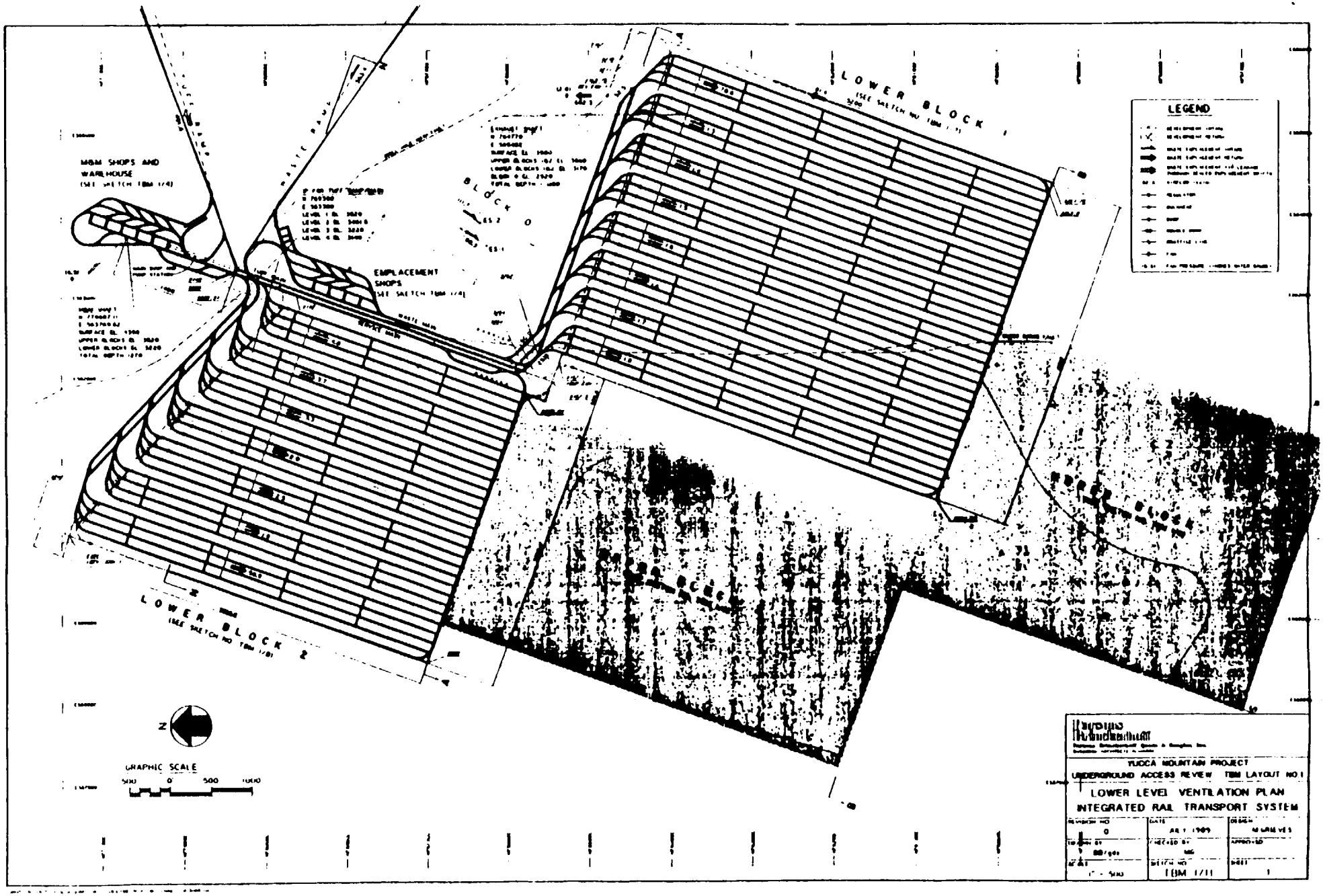
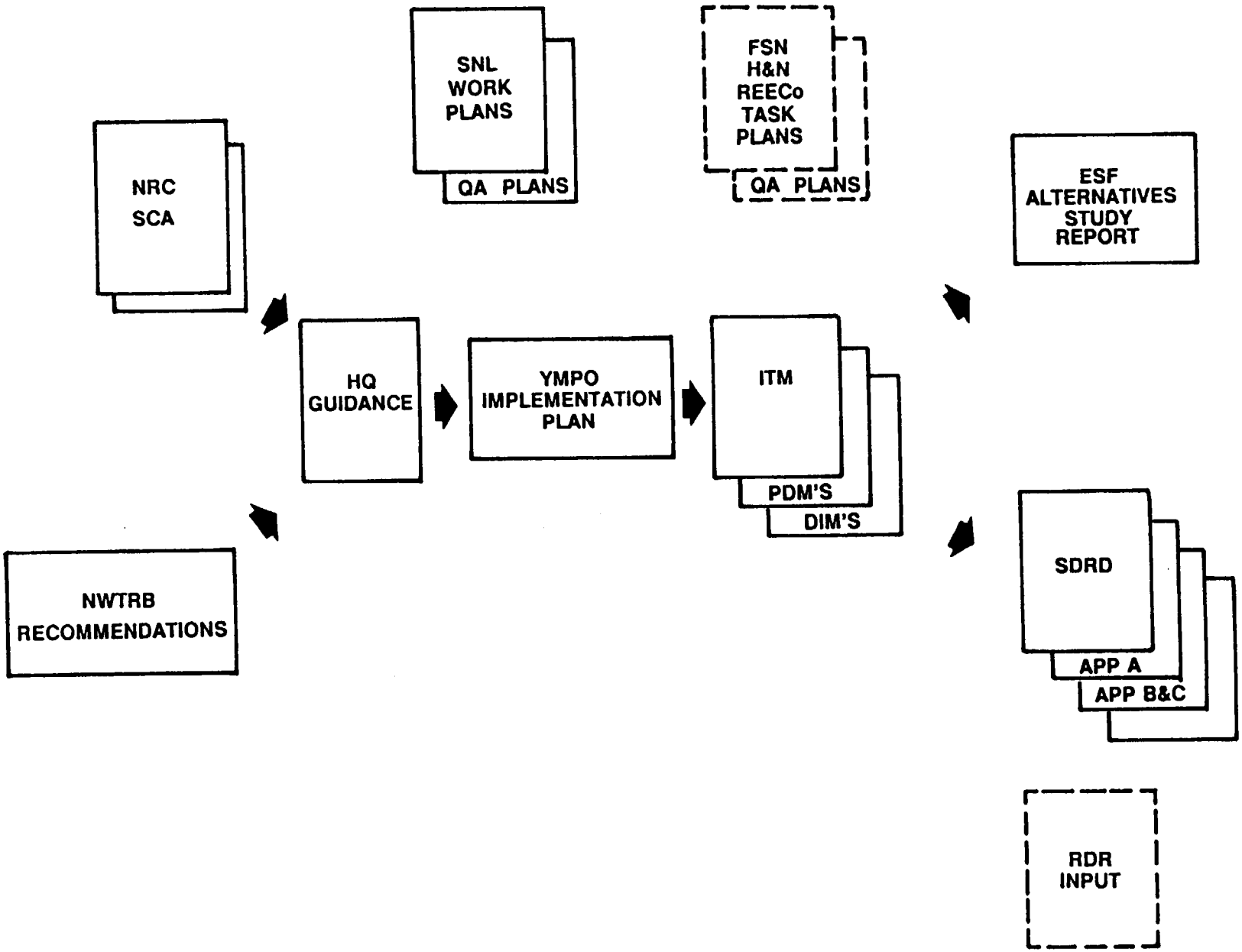
REQUIREMENTS

ALL REQUIREMENTS
10 CFR 60
SCA COMMENTS
NWTRB
FUNCTIONAL REQUIREMENTS

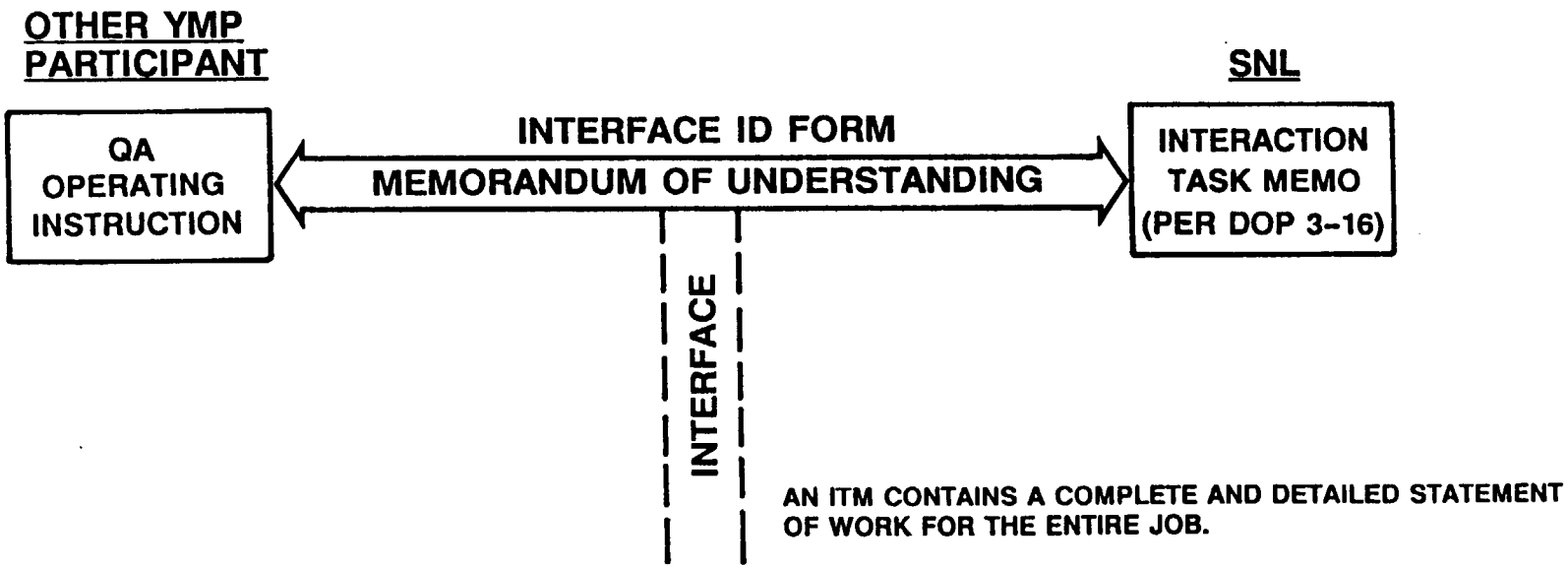
KEY REQUIREMENTS
(IMPACT ON OPTIONS)


LOWER BLOCK 1
(SEE SKETCH NO TBM 1/3)
LOWER BLOCK 2
(SEE SKETCH NO TBM 1/3)
MGM SHOPS AND WAREHOUSE
(SEE SKETCH TBM 1/4)
EMPLACEMENT SHOPS
(SEE SKETCH TBM 1/4)
BASTILE WASH
LEGEND
N
GRAPHIC SCALE
500 0 500 1000
Kaiser Engineers
YUCCA MOUNTAIN PROJECT
UNDERGROUND ACCESS REVIEW TBM LAYOUT NO 1
LOWER LEVEL VENTILATION PLAN
INTEGRATED RAIL TRANSPORT SYSTEM
TBM 1/11

ESF ALTERNATIVES STUDY



YMPO
AP-5.19Q
INTERFACE CONTROL



U.S. DEPARTMENT OF ENERGY

YUCCA MOUNTAIN PROJECT

ESF Alternatives Study

Task	Lead	Participant Lead
1. Plan Mgmt	Al Dennis (SNL)	
1.1 QA		- Richards (SNL
		- Heaney (SAIC)
1.2 Dev/Approve		- Dennis (SNL)
		- Dokuzoguz (SAIC)
1.3 Records		- Sharpton (SNL)
1.4 Training		- Tang (SNL)
2. Methodology	Costin (SNL)	- Voegele (SAIC)
		- Kalia (LANL)
		- Stanley (FSN)
		- Harig (PB)
		- Deklever (H&N)
		- Grams (REECO)
3. Requirements	Davenport (SAIC)	- Parsons (SAIC
		- Morales (SNL)
		- Hill (SNL)
		- Foster (SAIC)
		- Oliver (LANL)
		- Mirza (FSN)
		- Schreiner (H&N)
		- Schepens (REECO)

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U.S. DEPARTMENT OF ENERGY

YUCCA MOUNTAIN PROJECT

ESF Alternatives Study

Task	Lead	Participant Lead
4. Options	Wavrik (SNL)	- Chytrowski (FSN) - Graves (PB) - Musick (H&N) - Elkins (LANL) - Luke (SNL) - Koss (REECO) - Gardiner (SAIC)
5. Selection	Bauer (SNL)	- Hinkebein (SNL) - Peterson (SNL) - Hardin (SAIC) - Grenia (FSN) - Mrugala (FSN) - Kalia/Elkins (LANL) - McNeely (H&N) - Gardella (Reeco)
6. Report	Dennis (SNL)	All task leaders Reviewers (all part.)
7. SDRD	Morales (SNL)	- Smith (SAIC) - Milligan (LANL) - Kennedy (FSN) - Brake (H&N) - PA Staff (SNL)
8. RDR	Hill (SNL)	- Standish (SAIC) - (TBD) (PB)

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U.S. DEPARTMENT OF ENERGY

YUCCA MOUNTAIN PROJECT

ESF Alternatives Study

Current Status:

ESF Alternatives Study Implementation Plan	Approved by SNL Accepted by YMPO Submitted to DOE/HQ
QA training of participant personnel	Training on 12-6-89 Video tapes available at YMP Training Center
SNL Work Plans and Grading Package	Submitted to YMPO on 12-8-89
SNL Interaction Task Memo	Transmitted to Participants 12-12-89

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U.S. DEPARTMENT OF ENERGY

YUCCA MOUNTAIN PROJECT

ESF Alternatives Study

IMPACTS

Possible major revisions to test program

Title II Design restart moved to March '91

Construction dates estimated to be

Site prep 6-92
Collar 11-92

Repository configuration may change

Surface based testing Program may change

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8.3.1.5.2.1 CHARACTERIZATION OF QUATERNARY REGIONAL HYDROLOGY (PALEOHYDROLOGY)

.1 -- Regional paleoflood evaluation

.2 -- Quaternary unsaturated zone hydrochemical analysis

.3 -- Evaluation of point discharge areas

.4 -- Analog recharge studies
a) chloride ion model
b) arid zone geochemistry

.5 -- *Studies of calcite and opaline silica vein deposits (Hydrogenic Deposits)*

CONTRIBUTING ORGANIZATIONS TO PALEOHYDROLOGY

A. USGS/WRD
   1. NHP
   2. Nevada District
   3. CSM
   4. UNM

B. USGS/GD
   1. BIG
   2. BP&S
   3. BRG

C. LANL

SCIENTIFIC APPROACH

a) Field work

b) Mineralogy

c) Geochemistry

d) Fluid inclusions

e) Geochronology

f) Tracer isotopes

g) Stable isotopes

h) Paleontology

i) Hydrology

j) Data integration

STATEMENT OF PROBLEM

1. Do any hydrogenic deposits or hydrothermal data have significant implications for repository performance?
   A) Stability of waste package?
   B) Travel time to biosphere?

2. Do any hydrogenic deposits have potential economic implications?

HYDROGENIC DEPOSITS

1. Minerals and mineraloids precipitated from water.

2. Types identified around Yucca Mountain:
   a) Calcite and opaline silica
   b) Bedrock breccias
   c) Drusy quartz and other vug fillings

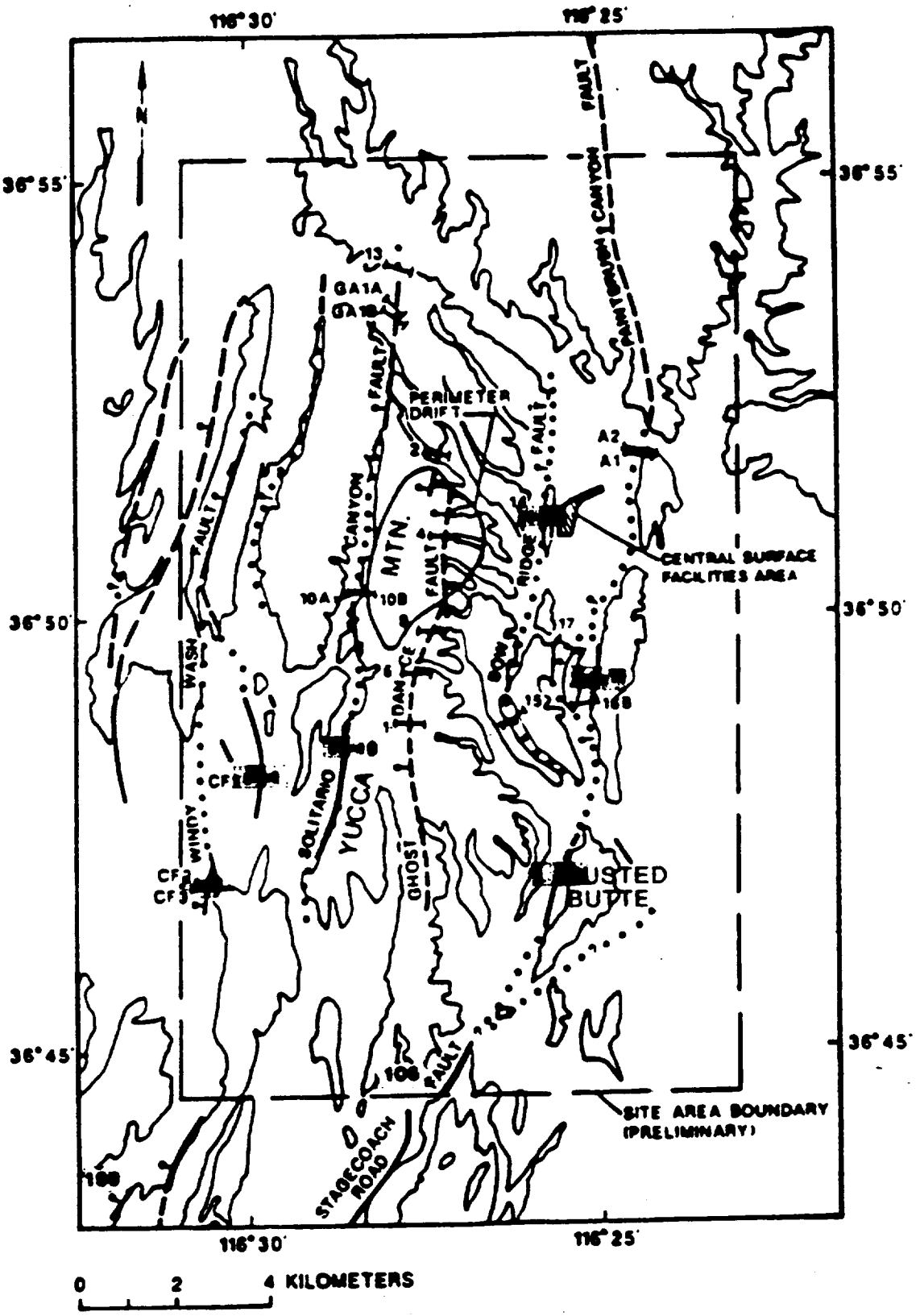
MODES OF ORIGIN FOR HYDROGENIC DEPOSITS

1. **Pedogenic:** Deposited by meteoric waters as part of the soil-forming process.

2. **Cold springs:** Groundwater of deep or shallow origin moved along fractures.

3. **Hydrothermal springs:** Water heated by any of several mechanisms & moved up fractures.

4. **Seismic springs:** Hot or cold waters moved along faults as a direct result of faulting.



[PICTURE OF SOUTH WALL OF TRENCH 14 FOLLOWS.]

BEDROCK BRECCIAS

2 Categories:

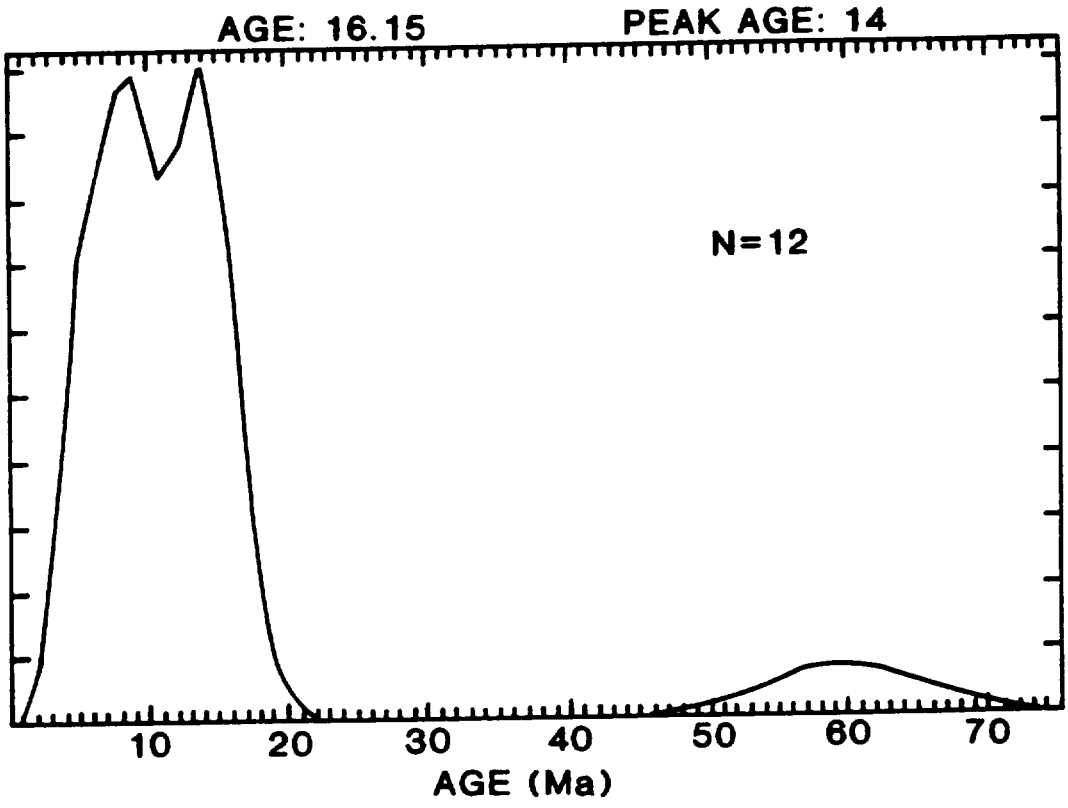
1) Crushed-tuff-matrix breccia

2) Authigenic mineral-cemented breccia

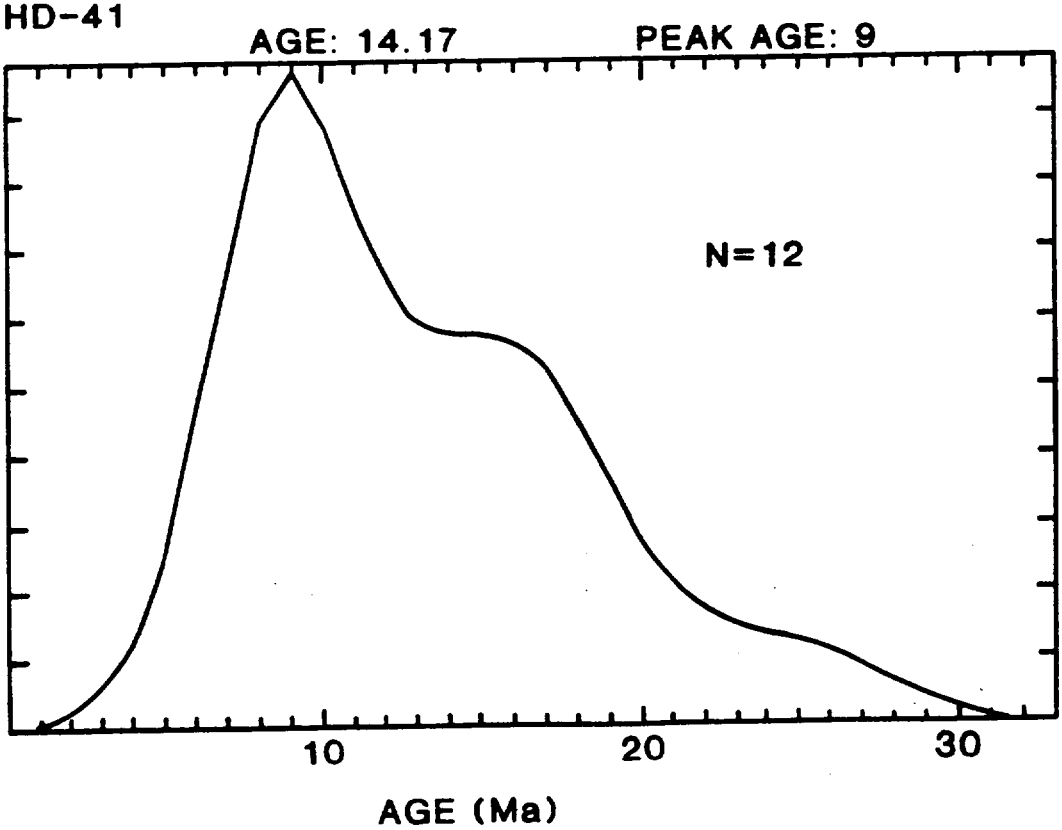
[PICTURE OF CRUSHED-TUFF-MATRIX BRECCIA FOLLOWS.]

BEDROCK BRECCIAS
FISSION-TRACK ZIRCON AGES

BUSTED BUTTE HD-74

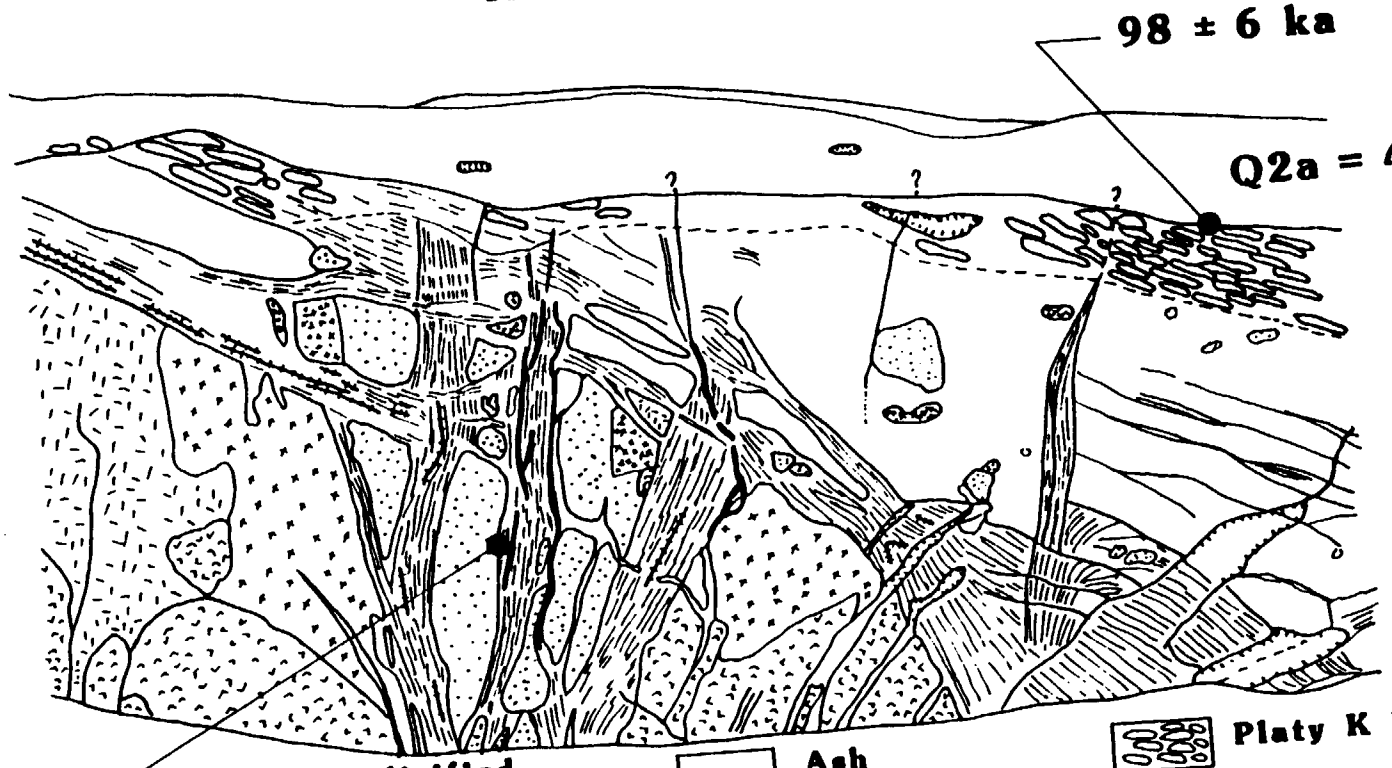


TRENCH 14
HD-41



DEC - 8 1989

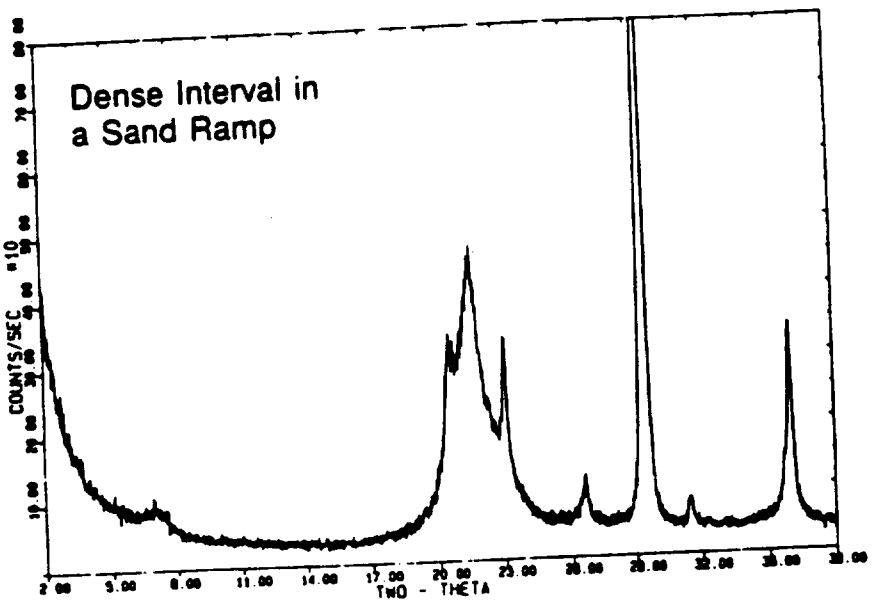
Trench 14, South Wall

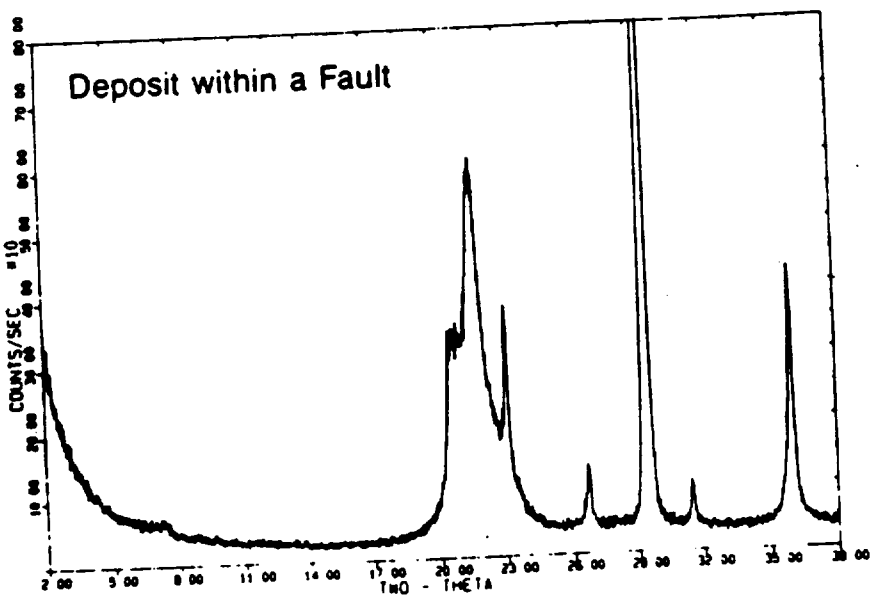


From E.M. Taylor

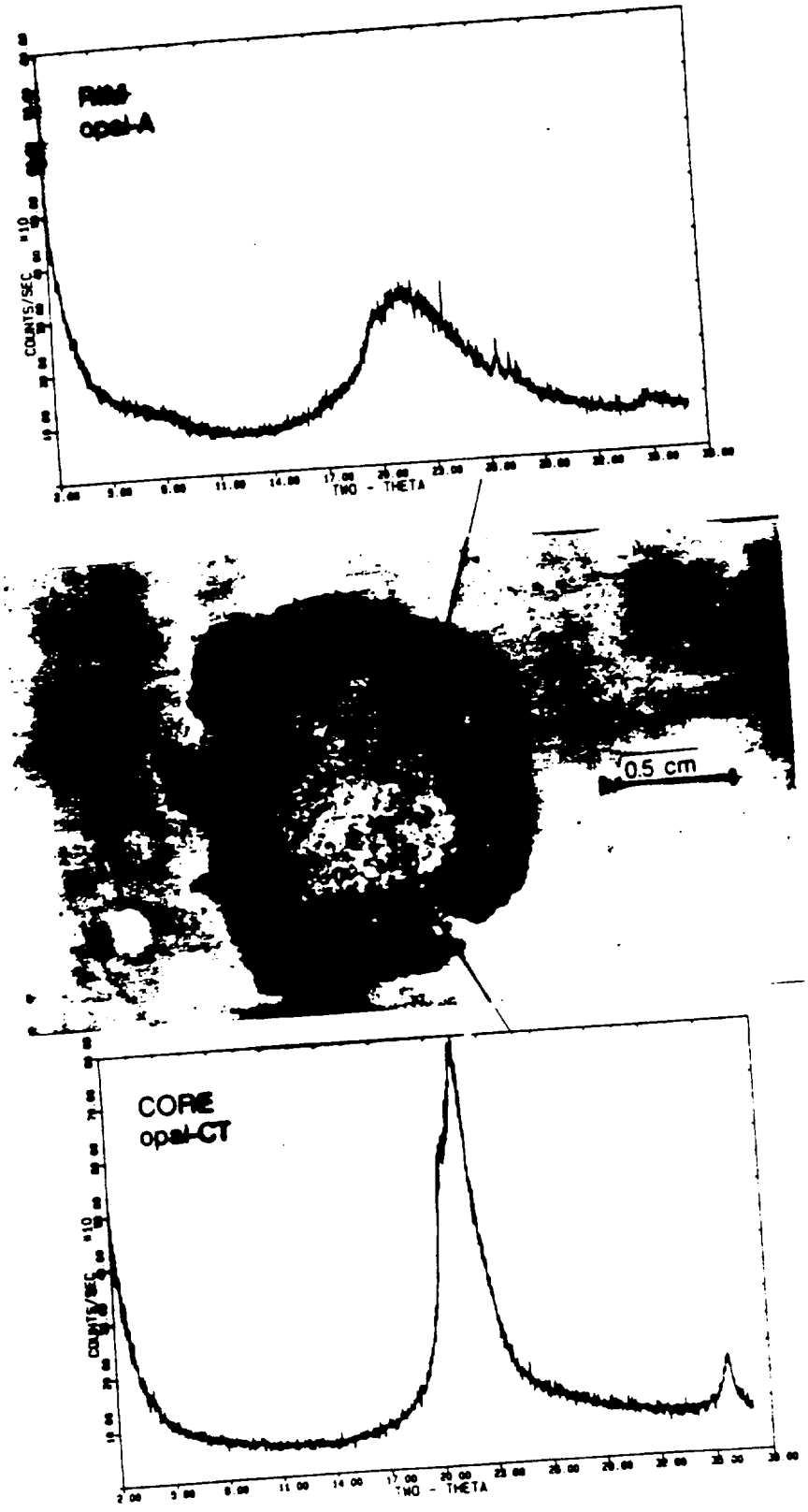
ASSOCIATIONS AND ASSEMBLAGES

	CALCITE	OPAL A	OPAL CT	OPAL C	QUARTZ	SEPIOLITE	CRYPTOMELANE	SULFUR PHASES
HYDROTHERMAL VEINS	X			X	X		X	
WARM SPRINGS		X						X
COLD SPRINGS AND SEEPS	X		X		X	X		
SOILS	X		X					
SAND RAMPS	⊗	⊗	⊗			⊗		
FAULTS	⊗	⊗	⊗			⊗		





[DETAILED PICTURE OF LAMINATED VEIN SHOWING AREAS STUDIED BY THIN SECTION AND PHOTOMICROGRAPH OF ROOT CROSS SECTION FOLLOW.]


opal-A
COUNTS/SEC
TWO - THETA
0.5 cm
opal-CT
COUNTS/SEC
TWO - THETA

OSTRACODE STUDIES

- Two soil and six vein samples of carbonate from Trench 14 are apparently devoid of ostracodes and mollusks
- Two samples from Busted Butte yield same preliminary results
- Saturated residence time for the area of carbonate deposition must have been less that 2 months.
- Need to look for horizontal areas within veins at Trench 14 and Travertine Point

[PICTURE OF OSTRACODA FOLLOWS.]

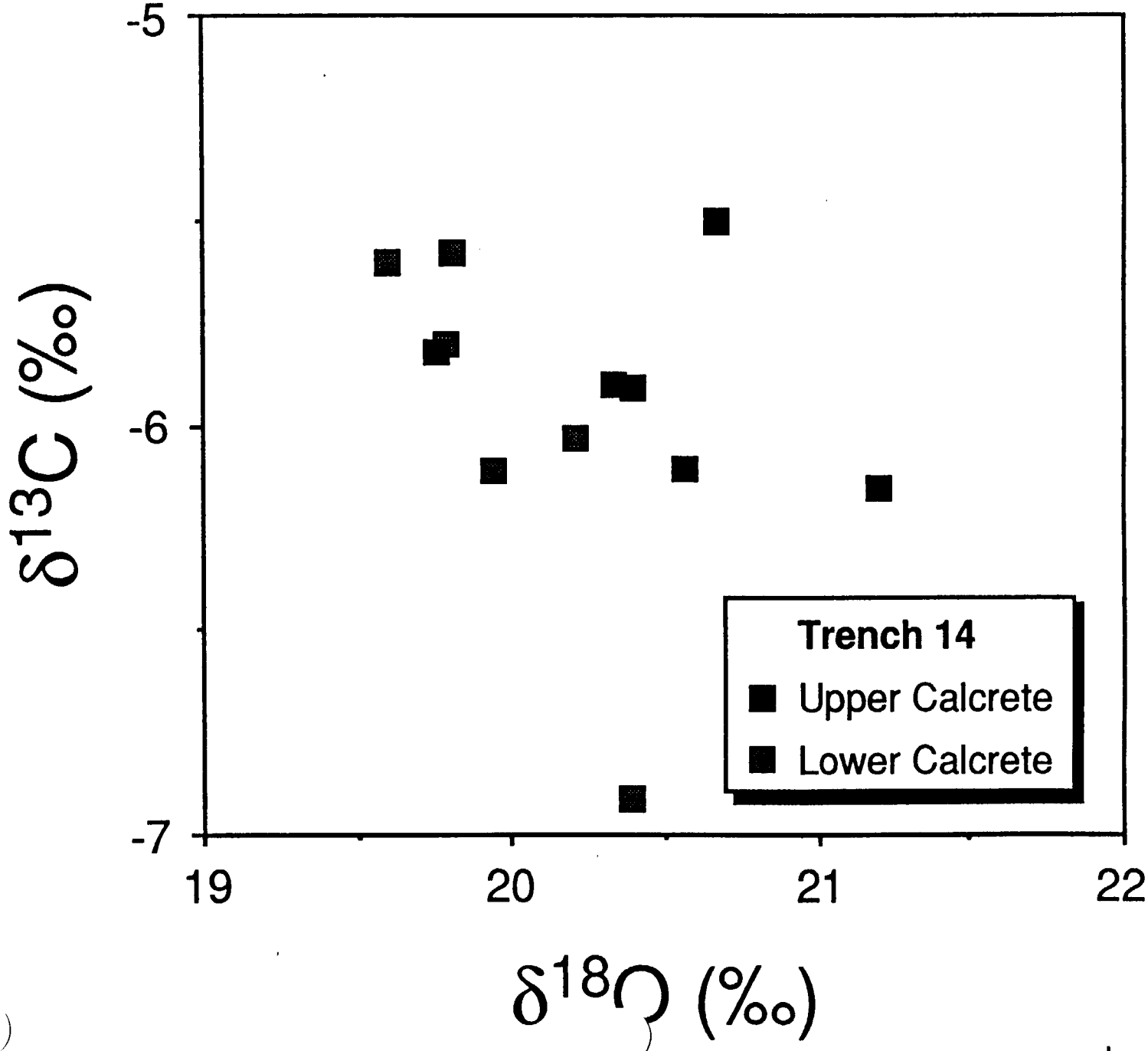
CHRYSOPHYTE CYSTS

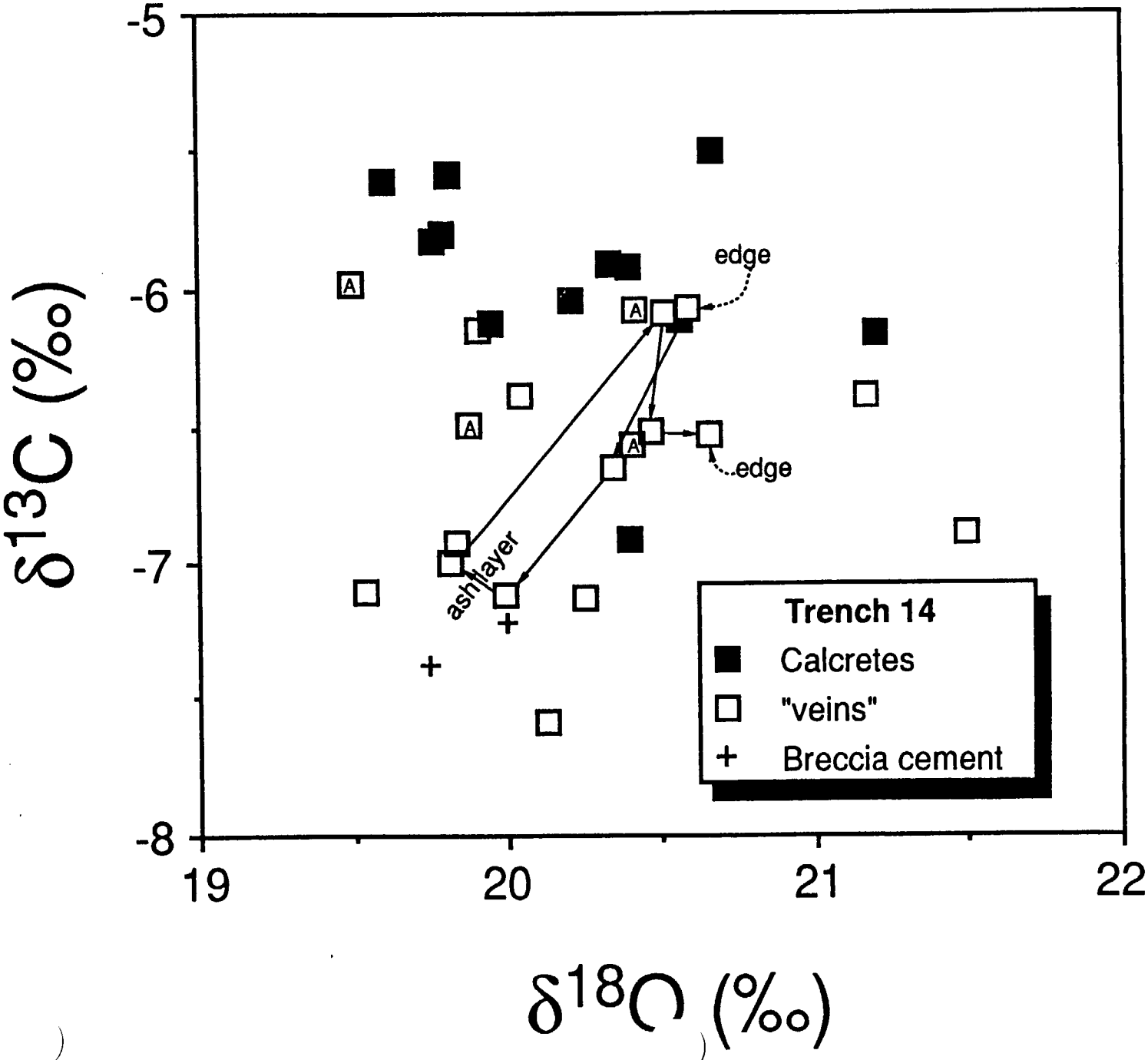
- Opaline silica
- Resting stages of certain chrysophyte algae
- Quite small (2.5-2.0 μm in diameter)
- Wide morphological range
- Hundreds of different forms
- In the modern environment, cysts are far more common in places where relatively dilute surface waters are entering the hydrologic system (recharge areas) than in places where relatively concentrated groundwater is emerging from the hydrologic system (discharge areas).

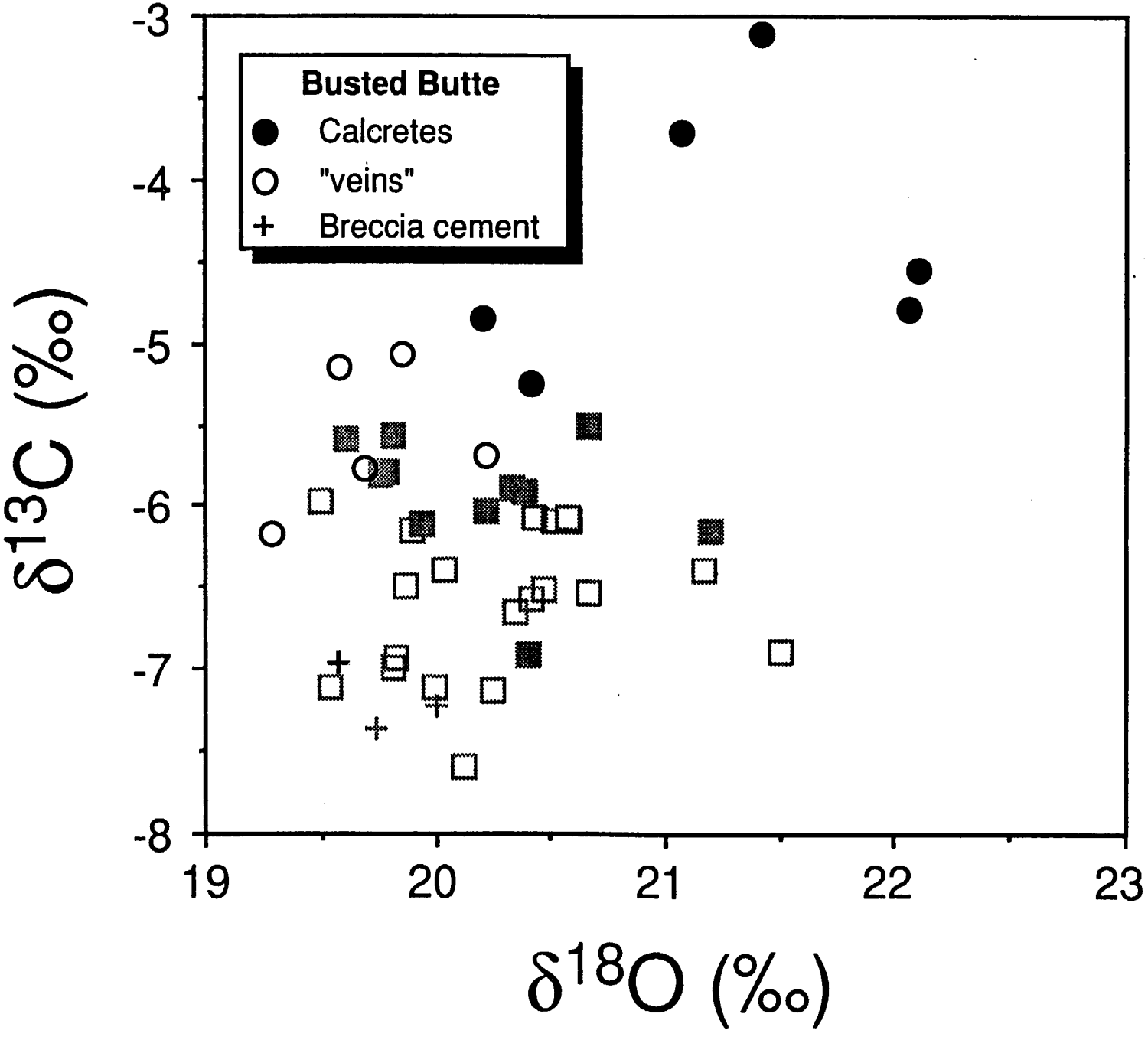
[TWO PICTURES OF CHRYSOPHYTE CYSTS FOLLOW.]

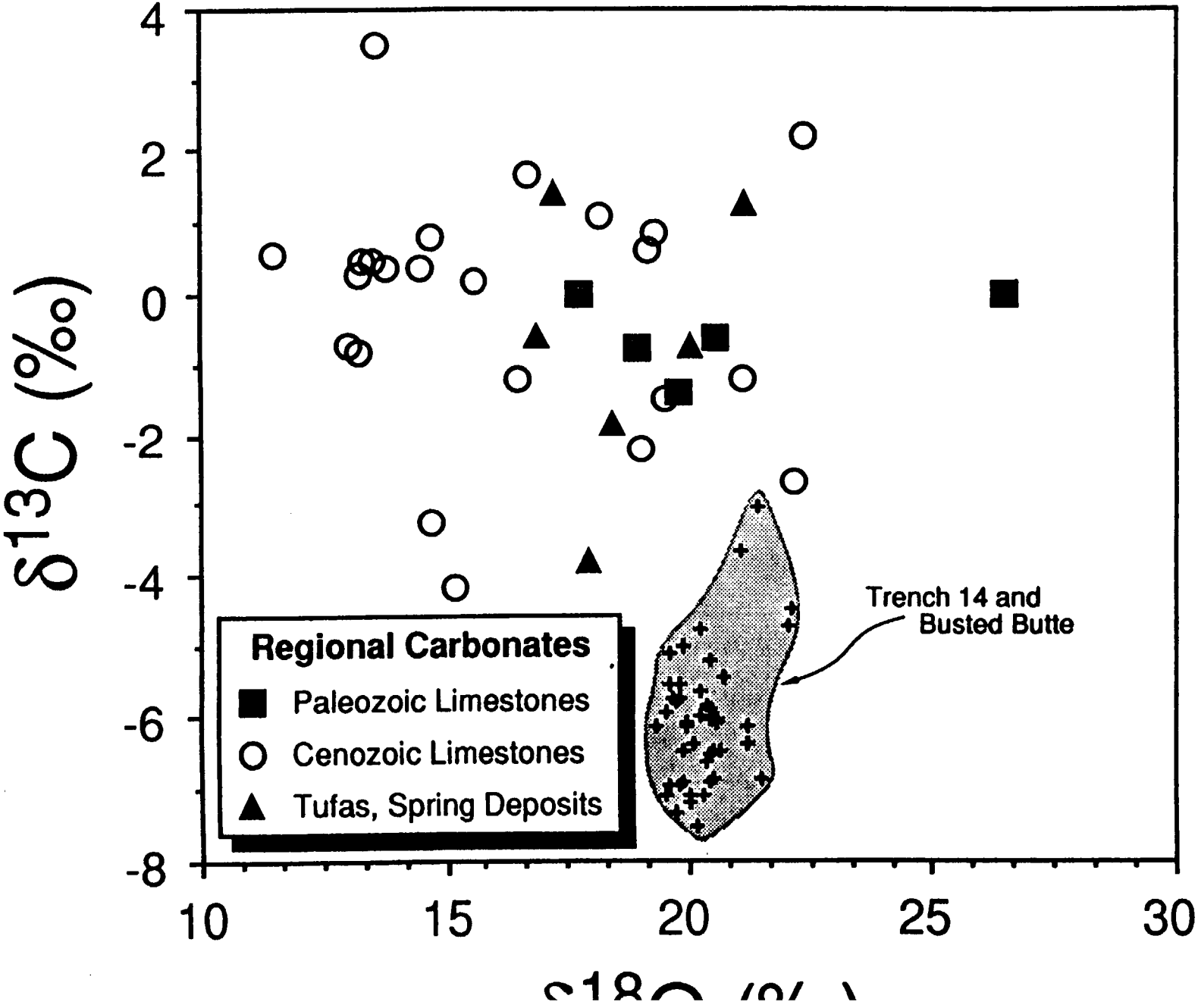
CHRYSOPHYTE CYSTS

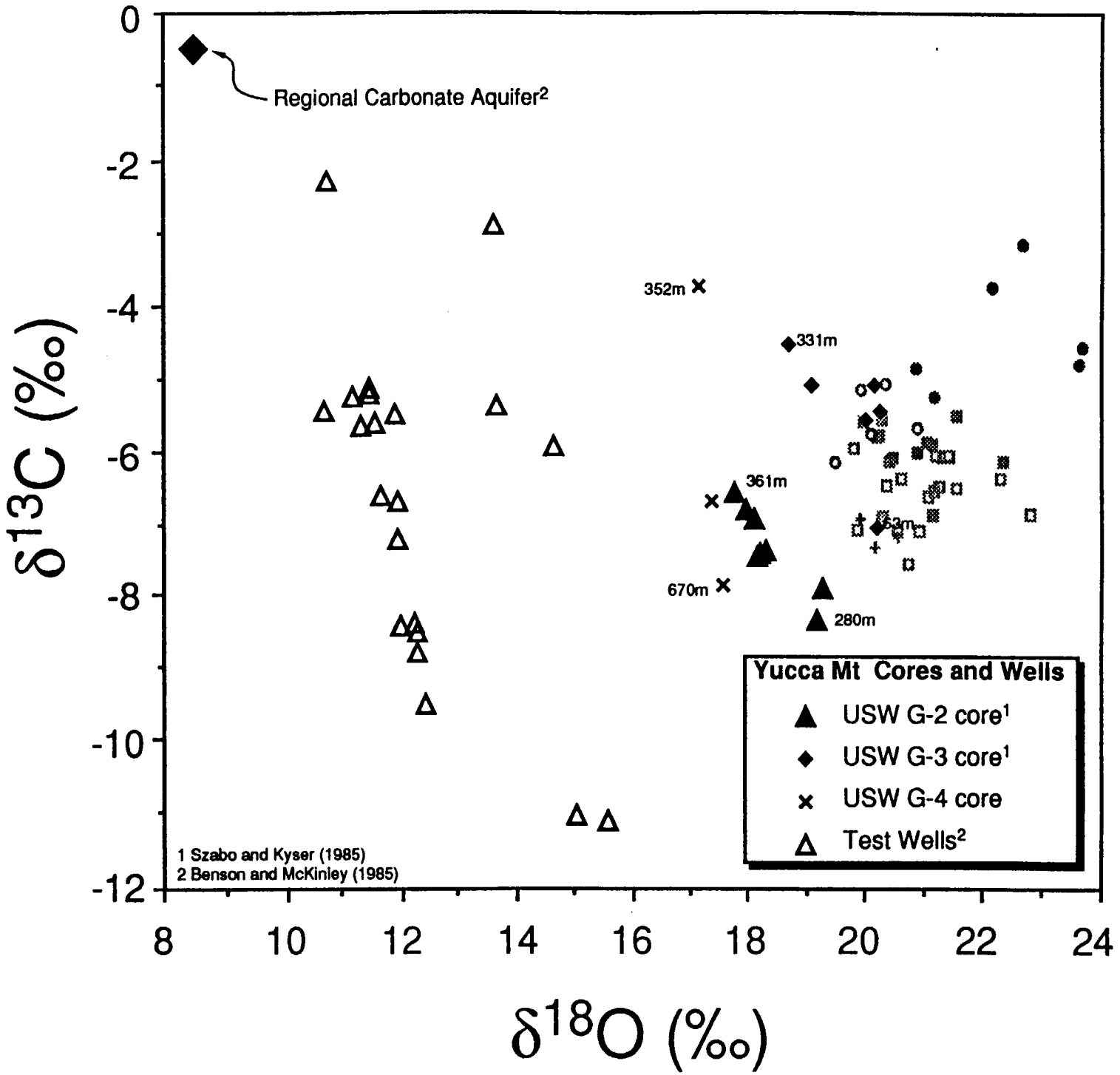
- None found in 4 samples of soil
- None found in 4 samples of calcite-silica veins and 1 sample of volcanic ash.
- Two samples of calcite-silica veins have rare cysts
- Rare cysts have been found in dried mud from Trench1.

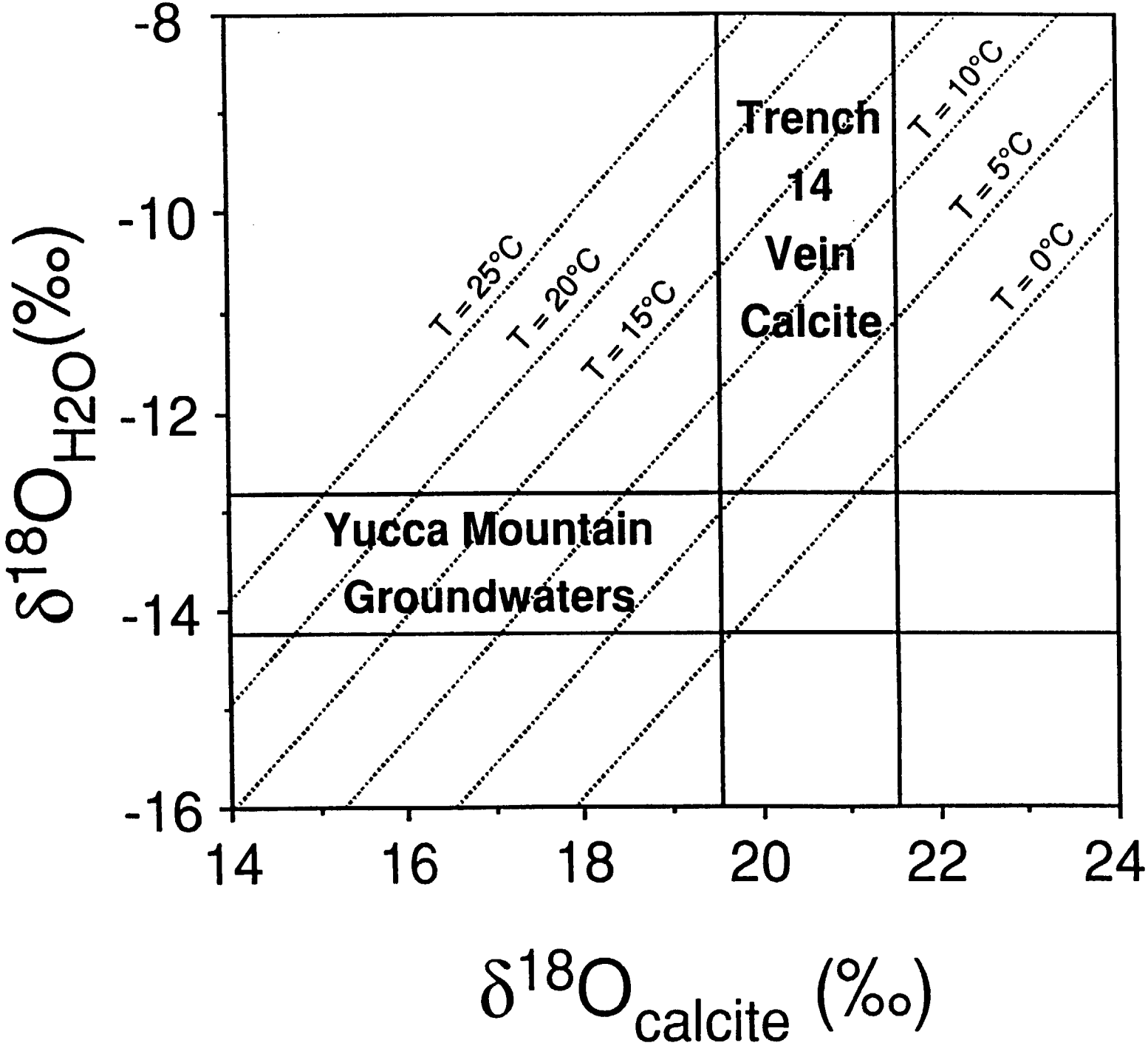

-5
-6
-7
19
20
21
22
δ13C (‰)
δ18O (‰)
Trench 14
Upper Calcrete
Lower Calcrete


-5
-6
-7
-8
19
20
21
22
δ13C (‰)
δ18O (‰)
edge
edge
ash layer
A
Trench 14
Calcretes
"veins"
Breccia cement

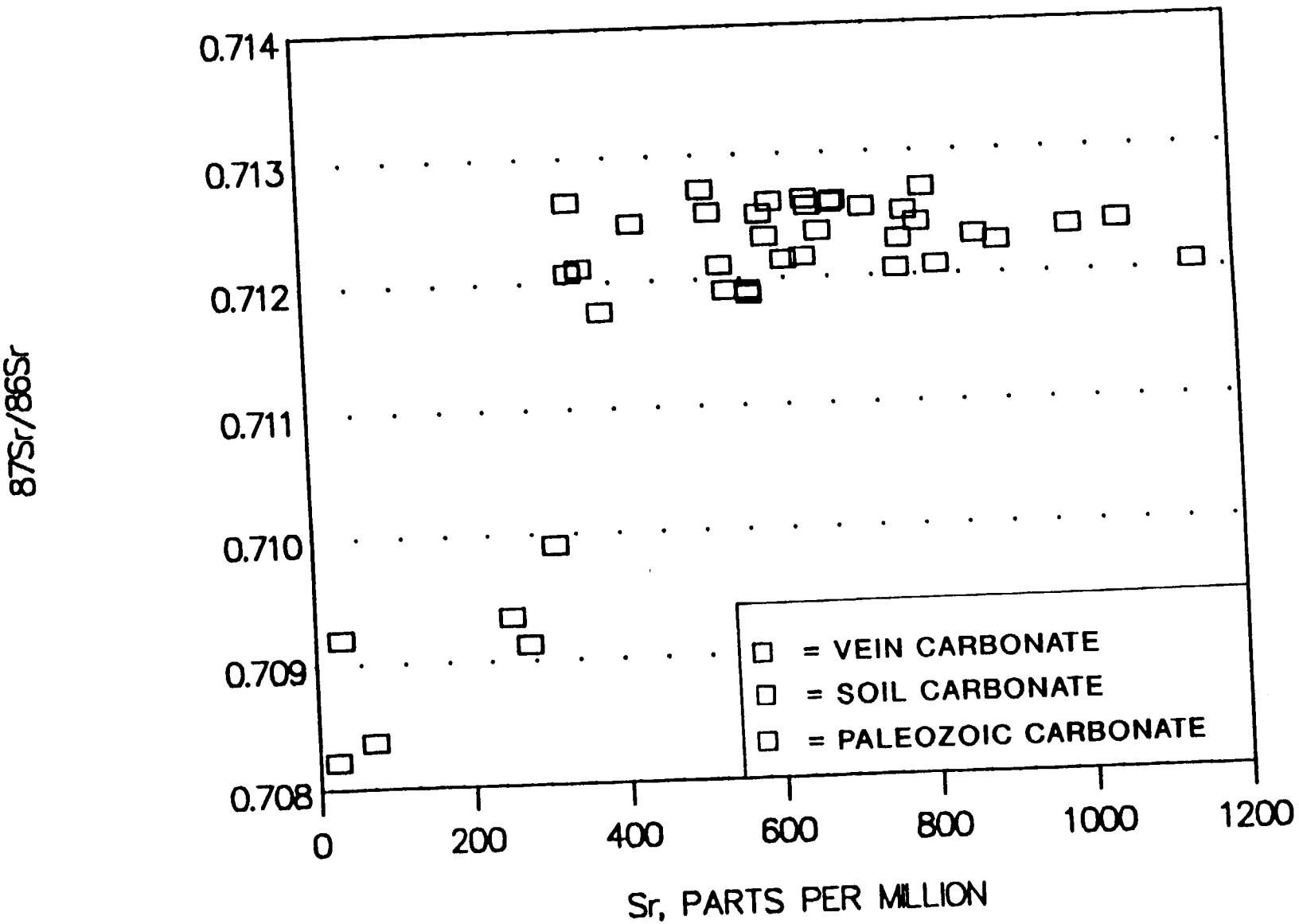

Busted Butte
Calcretes
"veins"
Breccia cement
-3
-4
-5
-6
-7
-8
19
20
21
22
23
δ13C (‰)
δ18O (‰)


4
2
0
-2
-4
-6
-8
10
15
20
25
30
δ13C (‰)
Regional Carbonates
Paleozoic Limestones
Cenozoic Limestones
Tufas, Spring Deposits
Trench 14 and
Busted Butte

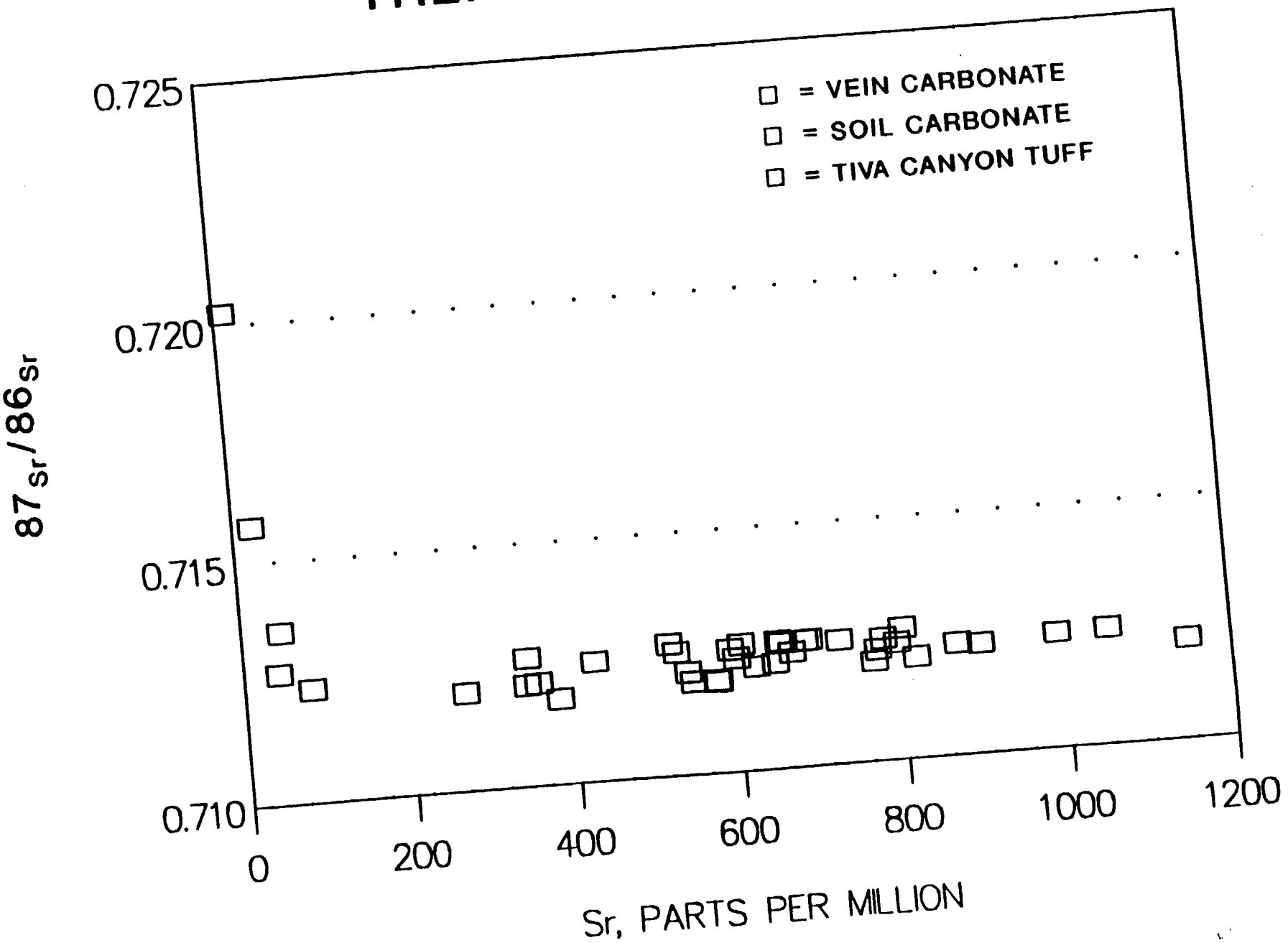

Regional Carbonate Aquifer2
352m
331m
361m
670m
280m
Yucca Mt Cores and Wells
USW G-2 core1
USW G-3 core1
USW G-4 core
Test Wells2
1 Szabo and Kyser (1985)
2 Benson and McKinley (1985)
δ13C (‰)
δ18O (‰)
0
-2
-4
-6
-8
-10
-12
8
10
12
14
16
18
20
22
24

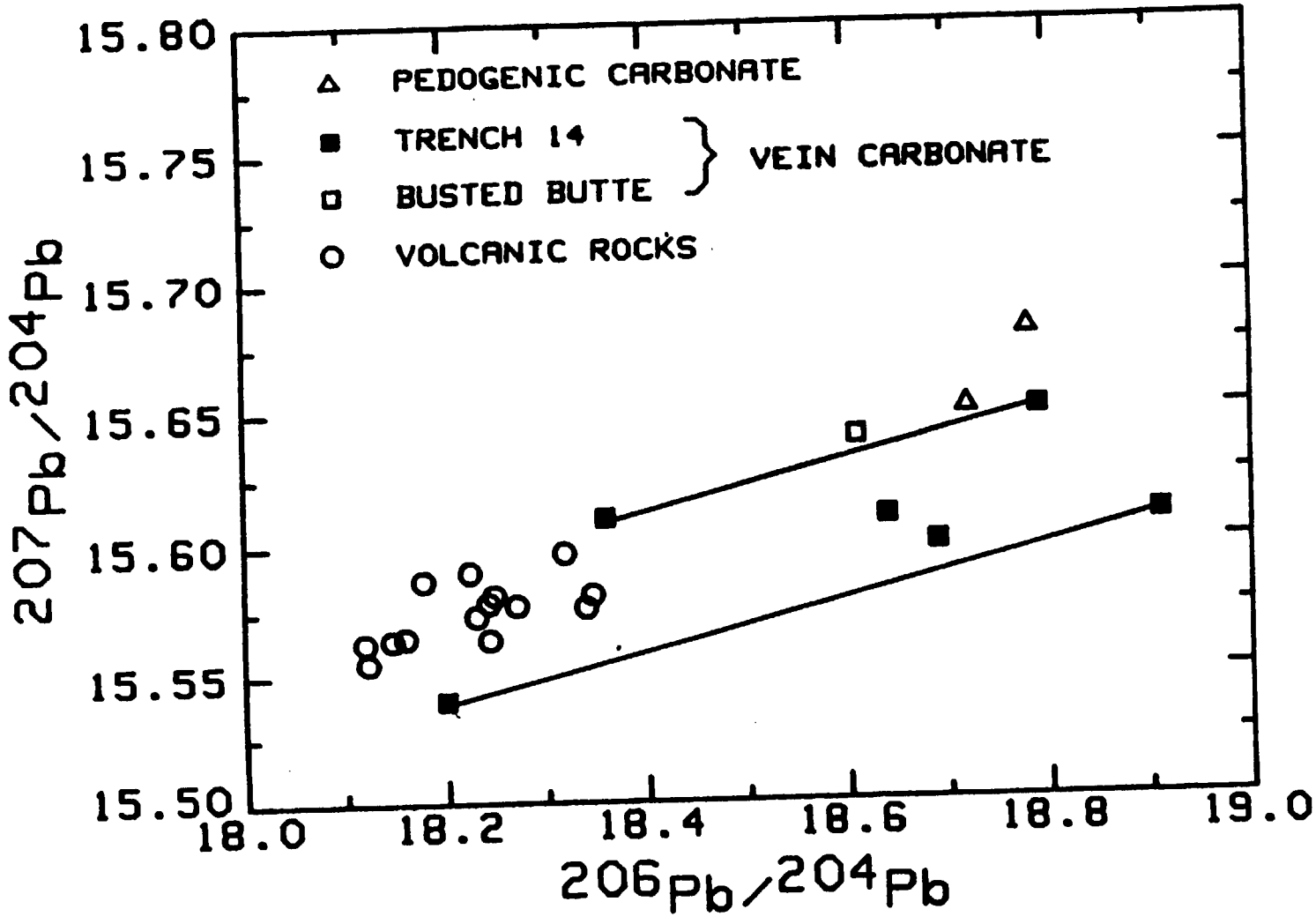

-8
-10
-12
-14
-16
14
16
18
20
22
24
δ18OH2O(‰)
δ18Ocalcite (‰)
T = 25°C
T = 20°C
T = 15°C
T = 10°C
T = 5°C
T = 0°C
Trench
14
Vein
Calcite
Yucca Mountain
Groundwaters

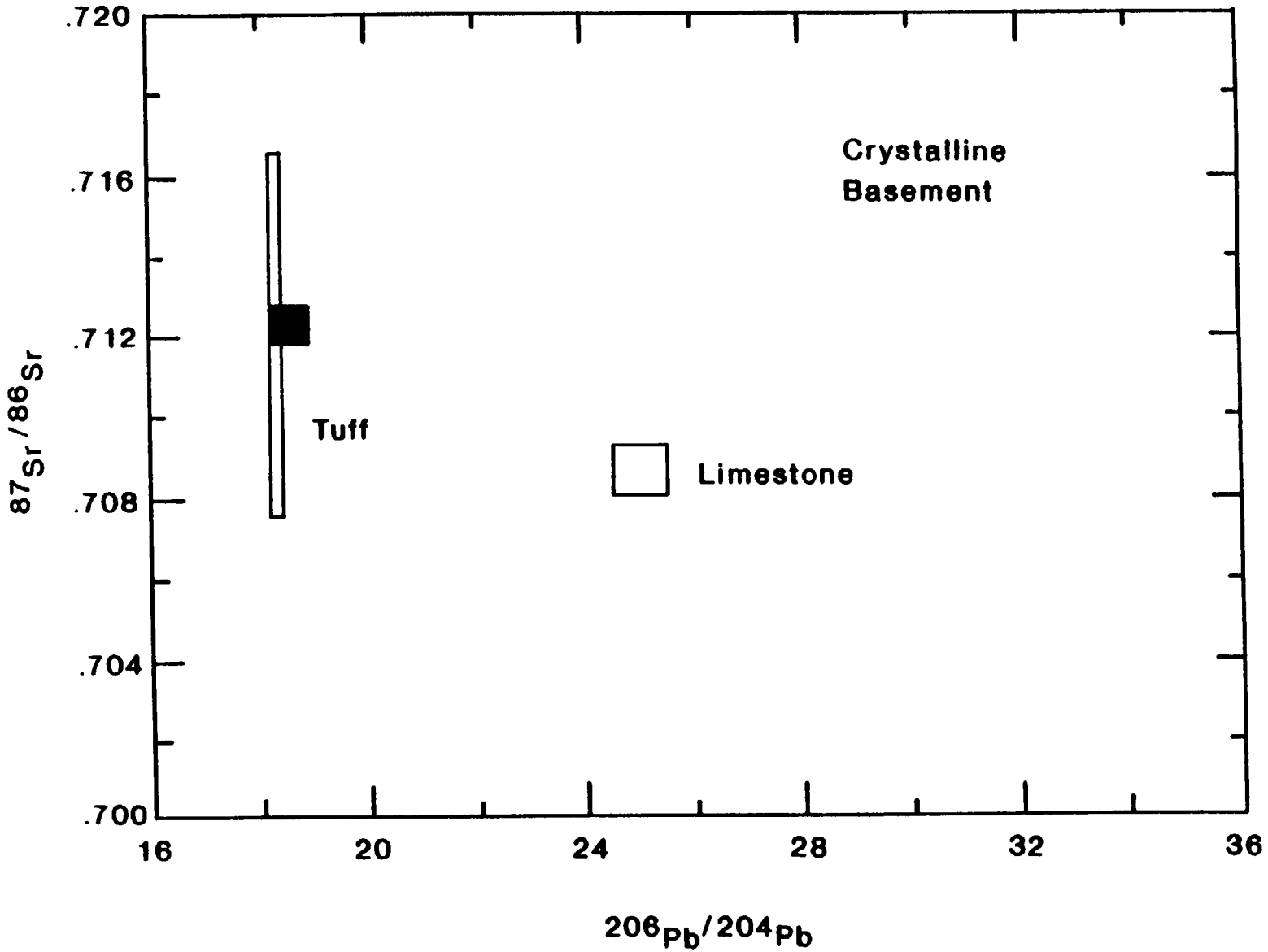
TIVA CANYON TUFF
TRENCHES 14 AND 14A



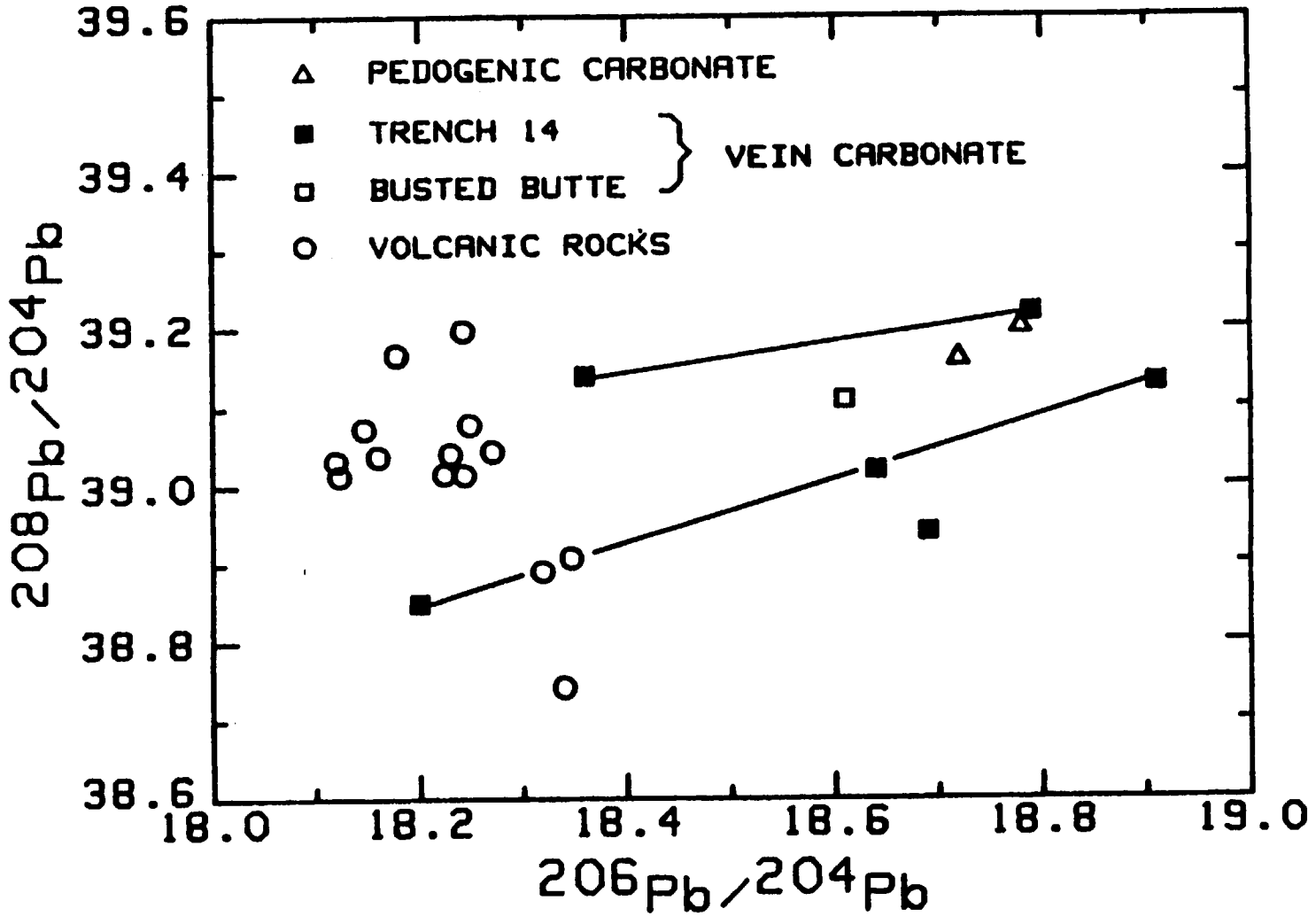
TRENCHES 14 AND 14A

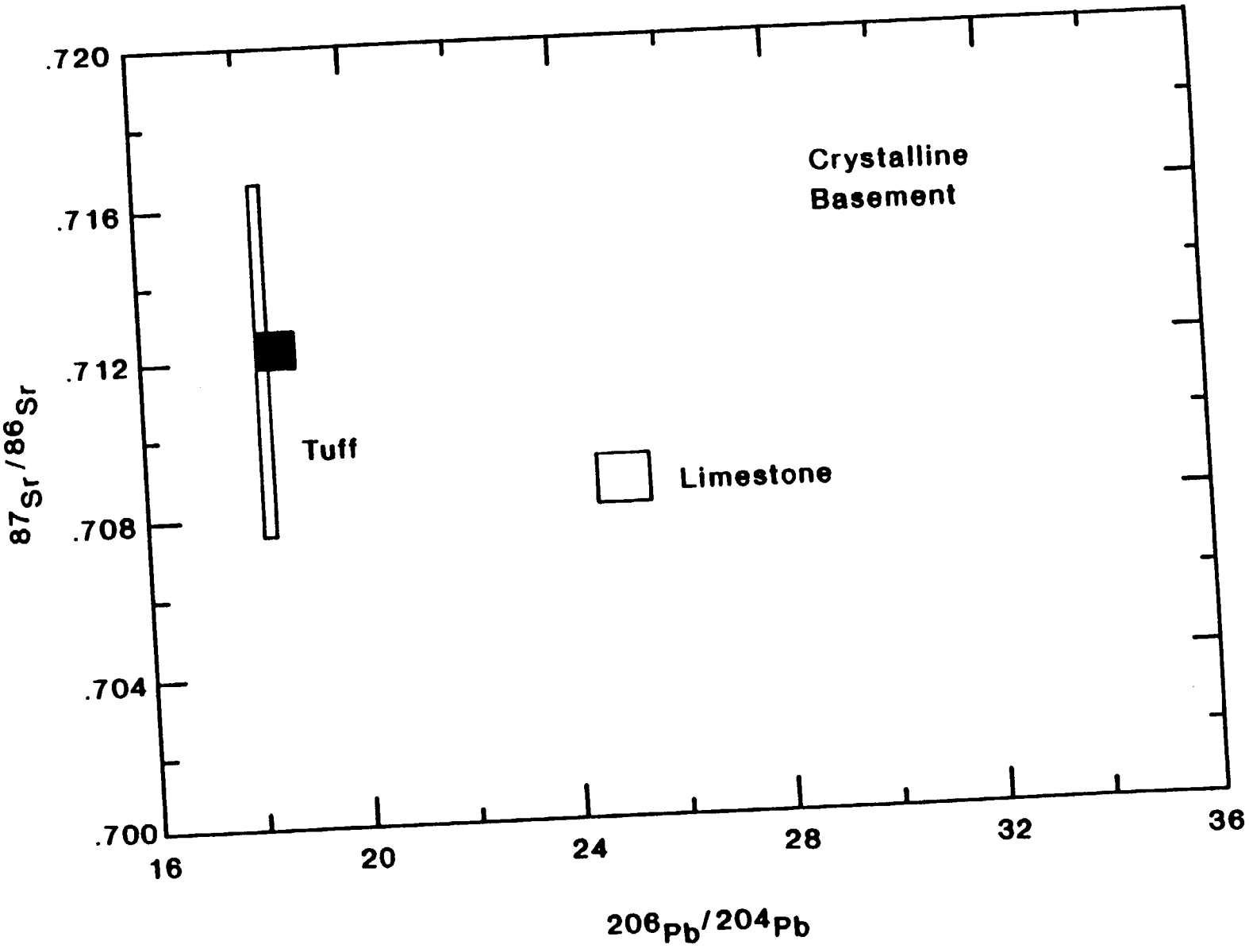


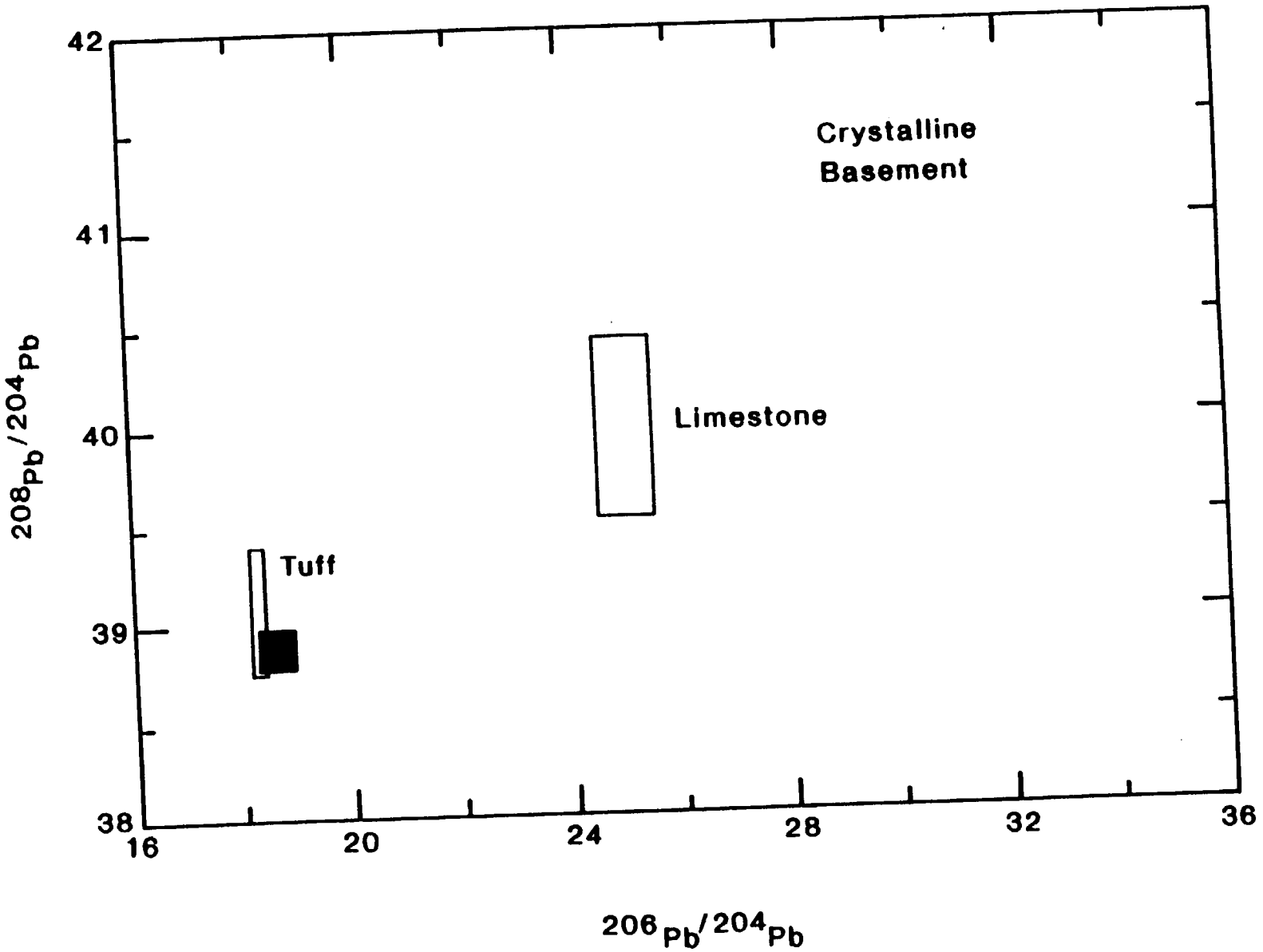

15.80
15.75
15.70
15.65
15.60
15.55
15.50
18.0
18.2
18.4
18.6
18.8
19.0
207Pb/204Pb
206Pb/204Pb
PEDOGENIC CARBONATE
TRENCH 14
BUSTED BUTTE
VEIN CARBONATE
VOLCANIC ROCKS

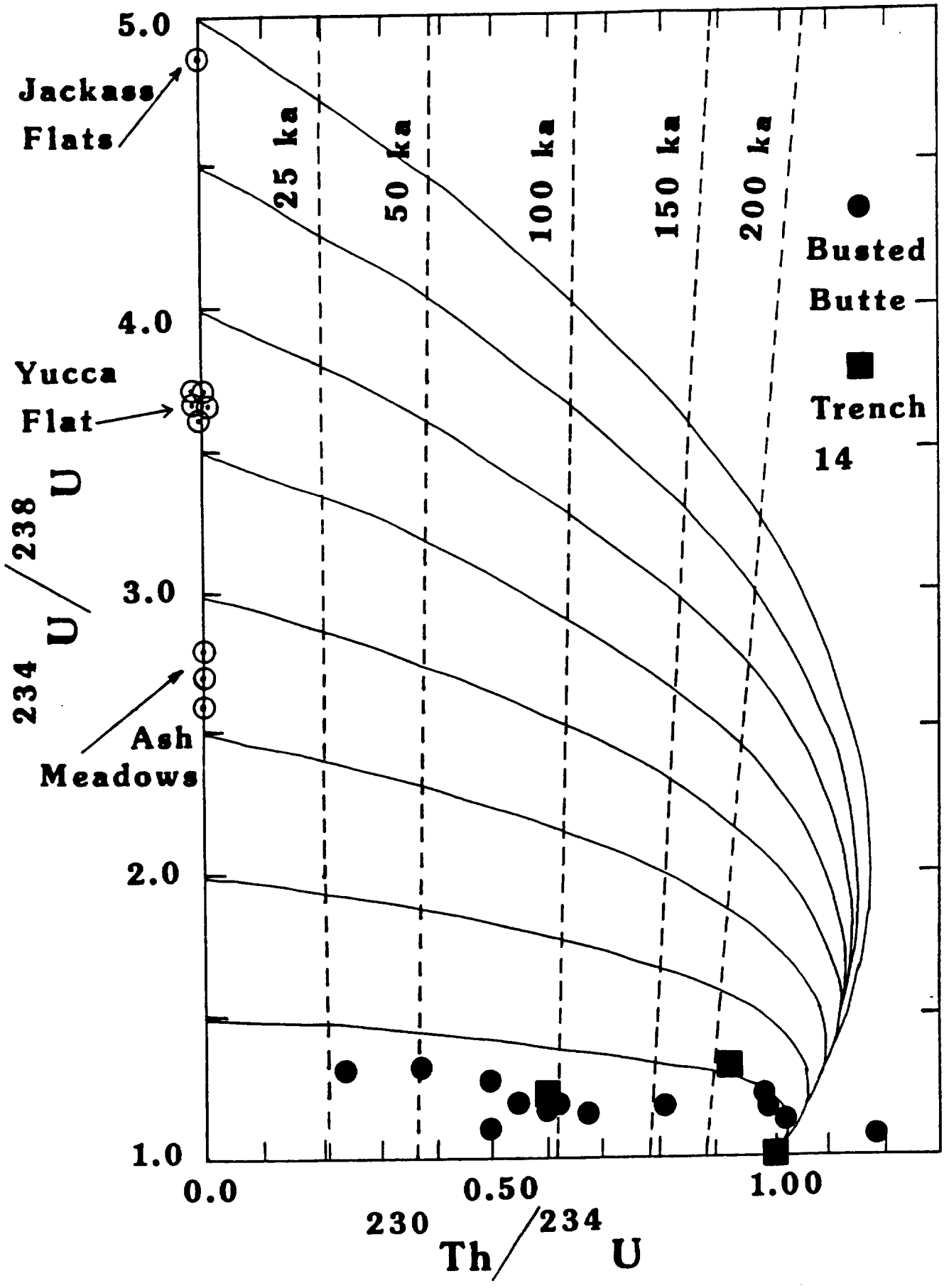

.720
.716
.712
.708
.704
.700
$^{87}Sr/^{86}Sr$
16
20
24
28
32
36
$^{206}Pb/^{204}Pb$
Crystalline
Basement
Tuff
Limestone

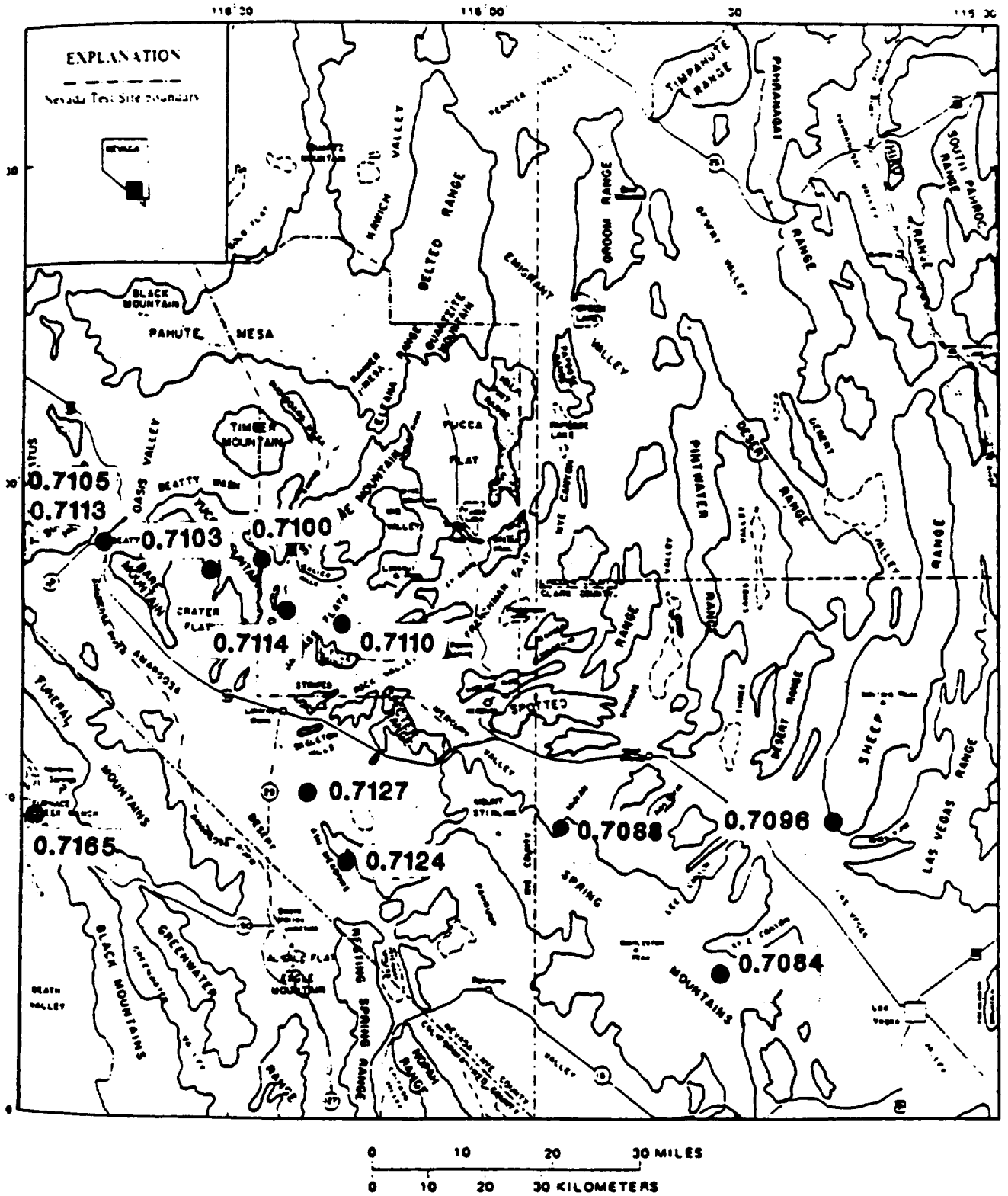
DEC 7 0 1989


PEDOGENIC CARBONATE
TRENCH 14
BUSTED BUTTE
VEIN CARBONATE
VOLCANIC ROCKS
39.6
39.4
39.2
39.0
38.8
38.6
18.0
18.2
18.4
18.6
18.8
19.0
208Pb/204Pb
206Pb/204Pb


.720
.716
.712
.708
.704
.700
87Sr/86Sr
Crystalline
Basement
Tuff
Limestone
16
20
24
28
32
36
206Pb/204Pb


Crystalline
Basement
Limestone
Tuff
42
41
40
39
38
16
20
24
28
32
36
$^{208}Pb/^{204}Pb$
$^{206}Pb/^{204}Pb$


5.0
4.0
3.0
2.0
1.0
0.0
0.50
1.00
Jackass Flats
Yucca Flat
Ash Meadows
25 ka
50 ka
100 ka
150 ka
200 ka
Busted Butte
Trench 14
234U/238U
230Th/234U


EXPLANATION
Nevada Test Site boundary
0.7105
0.7113
0.7103
0.7100
0.7114
0.7110
0.7127
0.7165
0.7124
0.7088
0.7096
0.7084
BLACK MOUNTAIN
PAHUTE MESA
TIMBER MOUNTAIN
YUCCA FLAT
CRATER FLAT
BARE MOUNTAIN
OASIS VALLEY
BEATTY WASH
AE MOUNTAIN
QUARTZITE MOUNTAIN
BELTED RANGE
KAWICH VALLEY
GROOM RANGE
TIMPAHUTE RANGE
PAHRANAGAT RANGE
SOUTH PAHROC RANGE
PAHUTE MESA
PINTWATER RANGE
DESERT RANGE
SPOTTED RANGE
SPRING MOUNTAINS
LAS VEGAS RANGE
SHEEP RANGE
FUNERAL MOUNTAINS
BLACK MOUNTAINS
GREENWATER RANGE
RESTING SPRING RANGE
NOPAH RANGE
DEATH VALLEY
0 10 20 30 MILES
0 10 20 30 KILOMETERS