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Scientific Notebook #22 on
Geochemical Analog Research
Project

RECORD

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CNWRA
CONTROLLED
COPY 22

April 18, 1991

McDermitt Caldera Field Trip

Geochemical Analogs
Research Project

Field Book Prepared by

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WMM is
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4-18-91

Peña Blanca trip Sept. '91 starts page 17.
Santorini page 36. WMM 6/21/92

Field trip participants:

William Murphy
English Pearcy
Ronald Green
(Principal Investigators, CNWRA)

William Ott (USNRC)

Steve Castor
Nevada Bureau of Mines

Sept. 1, 1992: Peña Blanca
on page 73
WMM 9/16/93

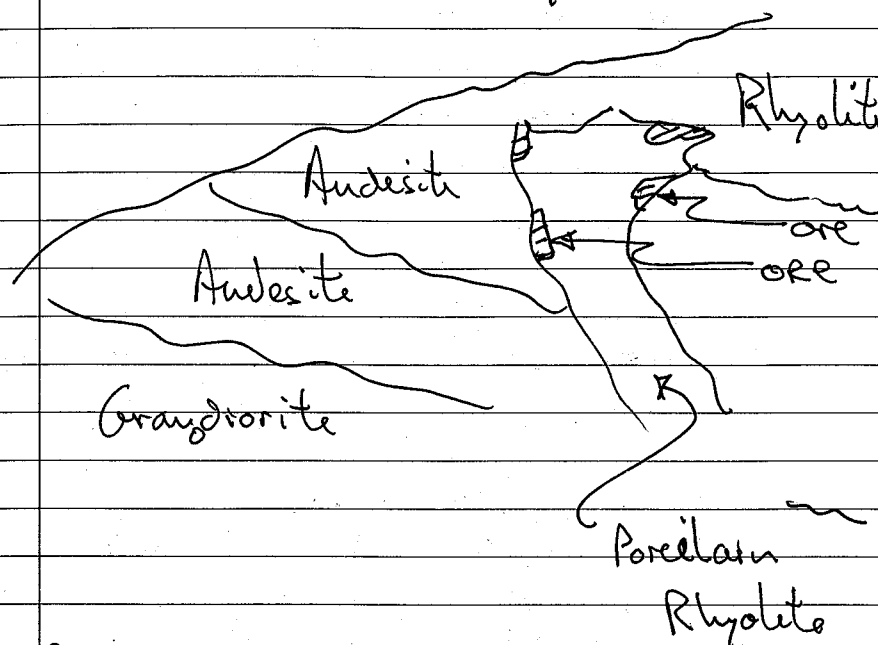
August 30, 1993 Santorini
on page 86
WMM 9/16/93

Meeting with Jim LaBrett,
Oravada, Nevada
Horse Creek controller (claims)
(Kings River Evaluations Area)
5 miles of Chevron core
Several volumes of well logs
Lithologic descriptions of core and cuttings
Assay data

Stratigraphic section generalization (from Chevron work)

	Colluvium	unconformity
Tertiary	Caldera Lake Sediments Ash flow tuffs Lathy Diabase / Andesite Porcelain Flowed-Tuff Black Felsic / Porcelain Rhyolite / Sugary Porcelain Rhy.	
	Kings River Rhyolite	unconformity
	Andesite	unconformity
	Lathy diabase	unconformity
	Andesite Conglomerate	
	Hornblende Felsite / Basalt	unconformity
Cretaceous	Granodiorite / Granite / Quartz Diorite	

Uranium associated with contacts between intruding Porcelain Rhyolite / Black Felsic and Andesite / Lathy Diabase and Kings River Rhyolite



Cross Section
Generalized from
Chevron summary cross section

Report may be available from
Castor

Observations of core
South drill area of
Horse Creek

Ore material in breccia associated with sulfides (pyrite) and veins of silica (?) and clay (?)
Few ore core is preserved, ~1 box, most has been ground for analysis.

Caster took ½ of this core for study (a split)

Much core in boxes is stored at LaBrett's yard

Many chip boards of rotary drilled holes are prepared; chips glued to wooden boards

Also many bags of cuttings are stored outdoors

Information and materials described above in possession of LaBrett

stop 1

On hillside in Horse Creek Claim area. South side of Horse Creek above Chevron hole 57. According to Castor this is stratigraphically below the ore zone in the andesite/dacite unit of Chevron. Rock is a welded tuff with phenocrysts by observation. Brecciated zones are slightly radioactive. Sample taken labelled HC-WMM-1 consists of welded tuff samples and breccia sample showing radioactivity. WMM 4-18-91

WMM 6/20/94

stop 2

East of stop 1 a few hundred yards at the base of a prominent cliff-forming unit, possibly mapped as porcelain rhyolite by Chevron.

Sample HC-WMM-2 comprises three rocks illustrating different characteristics of the rock: a green mineral that oxidizes, a finer grained variety, and a sample with oxidation along fractures.

Just under this unit is a zone where brecciated, strongly oxidized - even gossan-like rock showed strong radiation but not much extent when explored. Sulfides are associated with silica and fine uraninite is reported by LaBrett to have been identified.

Stop 3

Following the cliff former around to the west and then south along the east escarpment of the King River Valley, this cliff former is roughly continuous, not indicating intrusive or fault juxtapositions, in this superficial observation. An area explored on this escarpment also at the base of the cliff former, yield some radioactive rocks. The general rock type is a porphyritic rhyolite, occassionally brecciated, sometimes with oxidized sulfides.
Sample HC-WMM-3 consists of fragments of a silicified rhyolite porphyry showing radioactivity.
This stop is slightly north of a major point along the east escarpment

Stop 4

Moonlight Mine

Similar setting to previous locations near base of cliff-forming rhyolite, but at a lower elevation relative to King River Valley.

Sample MM-WMM-1
Brecciated Rhyolite, altered, oxidized sulfides (?), matrix of black quartz. Radioactive. Some yellowish oxidation: uranyl silicates (?). Sample taken from exposed wall just south of inclined adit without wooden frame or door.

Sample MM-WMM-2
Small samples of brecciated rock especially rich in iron oxides.

Information including descriptions of LaBrett's data, stops 1 to 4 and samples taken at those stops entered by Murphy
4-18-91 William M Murphy

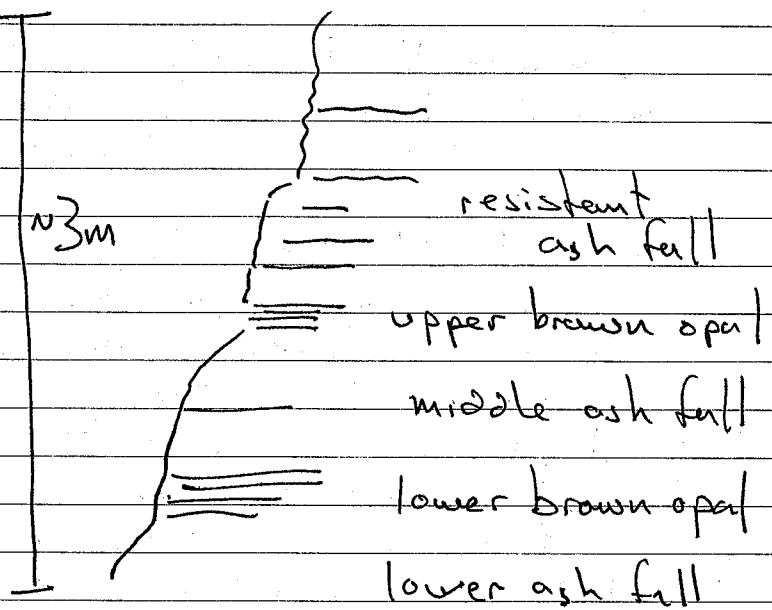
AMY 6/20/94

4.19.91

Virgin Valley: Airfall and water worked tuffs contain beds of opal which is locally uraniferous.

Stop 5

Section sampled across "brown opal beds" of Castor up to "resistant air fall tuff" of Castor.



Location: a small cliff on the west side of Virgin Valley, a kilometer or two north of Virgin Valley Ranch. North of an intersection with a road that heads east.

About 250 meters north of this road to the Royal Peacock Mine.

Sample VV-WMM-1
Taken from lower ash fall: gray, medium grained containing some pumice fragments and glass.

Sample VV-WMM-2
Taken from lower brown opal. Opal tends to break in angular fragments. Sample includes a fine grained water or air-fall tuff.

Sample VV-WMM-3
Taken from middle ash fall Similar to lower ash fall

Sample VV-WMM-4A
Taken from upper brown opal Similar to lower brown opal. Beds contain a thin ~ 2cm clay(?) rich horizon that is the most radioactive part of the section. Portions of this have a green-yellow surface painting that is radioactive and could be a uranyl silicate or carnotite.

Sample VV-WMM-4B
Chips from the upper brown opal layer containing the yellow-green uranium staining.

Sample VV-WMM-5
Taken from the resistant ash fall tuff. Similar to other air fall tuffs, but slightly whiter.

Lower in the section about 8 to 10 meters below the brown opal is the "green bed" of Castor. It has been identified as a uraniferous ash fall with alteration to clinoptilolite.

Sample VV-WMM-6 is a sample of the radioactive material. It is poorly lithified gray-brown ash.

Sample VV-WMM-7 is from a better lithified ash flow (?) tuff immediately underlying the "green bed".

Sample VV-WMM-8

At the split in the valley that cuts the west wall of Virgin Valley about 200 m north of the previous sampling site is a prospect. A sample was taken of green fine grained tuffaceous material. This type of rock is reported to be rich in clinoptilolite by Castor. Stratigraphically it probably corresponds to the "green beds" sampled at VV-WMM-6

WMM 6/20/94

Sample VV-WMM-9

Taken from a tuffaceous bed, contains some possibly charcoalized material, and some greenish minerals and coatings which may be carnotite. Sample taken from a prospect upstream from the previous location approximately 50 meters.

Sample VV-WMM-10

Uphill from the tuffs and tuffaceous sediments described above is a heavily silicified, much harder rock, reported to be rhyolite flow rock. A spot in it, about 20 meters vertically above the break in slope marking the contact, and at the head of the northern fork of the small valley, is very radioactive and containing an abundant yellow mineral. Fragments of this material was collected. Castor speculates that this is the source of the

uranium in the sedimentary units, which may be younger and deceptively below the rhyolite flows.

Notes on pages 11-16 including sample descriptions VV-WMM-1 through VV-WMM-10 by WMM 4-19-91.

Pena Blanca Trip 9-23-91

Readings from Murphy's personal dosimeter prior to arrival in field:

Friday 9-20-91	@ SwRI	9 mrem
9-22	in airplane	20 mrem
9-23	AM	27 mrem
9-24	AM	31 mrem

WMM copied from my notes 9-30-91

Peña Blanca Trip Sept. 23, 1991

Water chemistry for pH buffers prepared by William Murphy and Ron Green:

4.01 Buffer prepared according to instructions on packet, 200 ml (Orion Research # 910004 dated June 18, 1986. "Distilled water" supplied by Philip Goodell.

7.00 Buffer prepared in the same manner, 200 ml (Orion Research # 910007 dated Feb. 13, 1989)

Eh buffers A and B also prepared with "Goodell water"

A: 0.0885 g $K_4Fe(CN)_6 \cdot 3H_2O$ + 0.6585 g $K_3Fe(CN)_6$ in 200 ml volumetrically

B: 0.8848 g $K_4Fe(CN)_6 \cdot 3H_2O$ + 0.0659 g $K_3F(CN)_6$ in 200 ml

The "First Need" water purification device was used to filter some tap water. In its initial use a lot of the charcoal filtering material was exhausted (which is normal for the unit). It successfully passed the blue food coloring removal test - making a blue solution clear. It was finally rinsed with previously filtered water.

This device has a fairly large filter unit e.g. 100+ ml and it is probably impossible to completely purge it of water. Several filter volumes should be passed through it for each sample taken in the field, before the samples to be analyzed are taken.

Another concern is that the literature that comes

with the filter indicates that the filter removes materials by adsorption and specifically notes Cl^-, I^-, ...

Notes above on Peña Blanca water chemistry preparation by WMM 9.23-91

9.24.91 WMM Arrival by east side to Napal I, access by foot from base of canyon ~45 minute walk after 2 hour drive from Chihuahua.

Murphy's personal dosimeter reading is 32 mrem at 12:30 PM at arrival at the -100 adit opening. Background radiation is close to zero.

In the canyon to the east of Napal I water was observed seeping at several points from limestone outcrops. At one spot a small rivulet may be samplable.

Murphy's
Personal dosimeter @ 33⅓
leaving the -100m @ 1:45 PM

O Level γ scintilometer survey

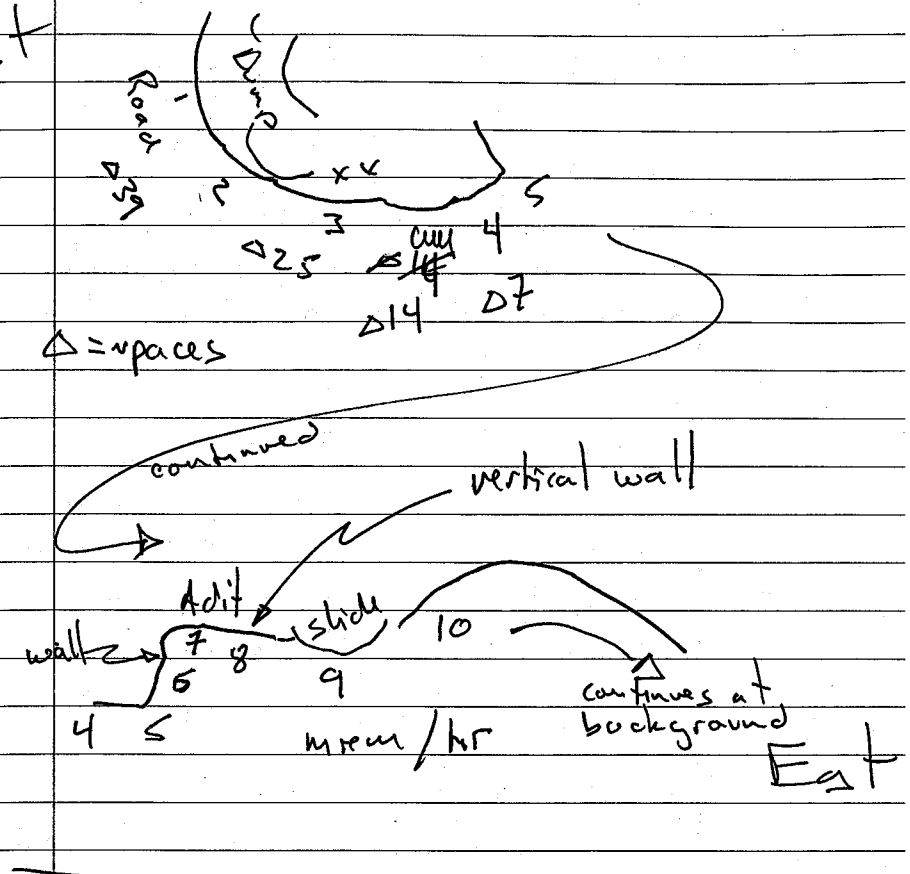
1. 1/10 mrem/hr
2. Nose of dump ½ mrem
3. Edge of outcrop ½ mrem
4. Before corner 1 mrem
5. At corner 1.75 mrem
6. At slickensides 5 mrem
7. Face of adit 4 mrem
8. On small pile 9 mrem right of adit
9. Nose of shale 1 mrem
10. Right of shale 1/10 mrem

Inside adit at juncture of tunnels ~ 3 or 4 meters inside 20 mrem/hr.

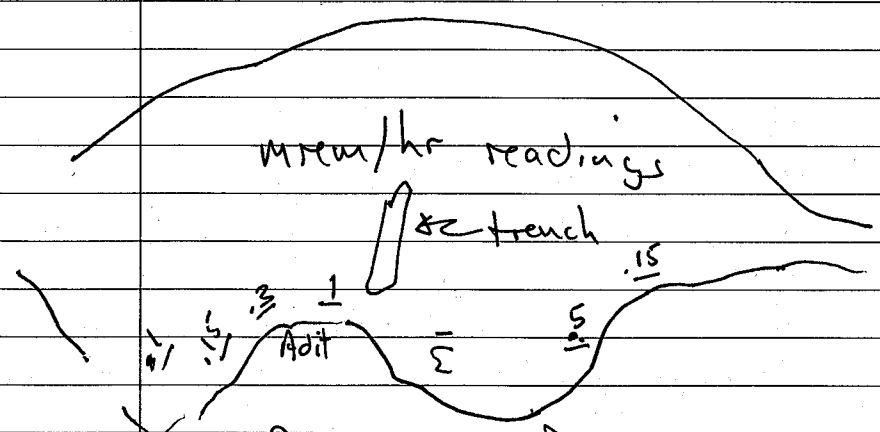
Measurements on this and facing page were taken 1 to 3 meters from rock surfaces

WM 9-24-91

O Level



+10 Level



Readings by Pearcy
Notes by Murphy WM 9-24-91

3:00 PM after X survey of 0 and +10 levels and discussion of vegetation and cleaning of surface and mapping, Murphy's personal dosimeter @ 37 mrem.

Goodell noted that plants do not grow over mineralized breccia zone on +10 level. Small bushes and sparse grasses grow elsewhere

4:05 PM exiting mine area Murphy's dosimeter @ 37 mrem

Notes on 9-24-91 by WMH

9-25-91
Murphy's dosimeter at departure from vehicles: 41 mrem

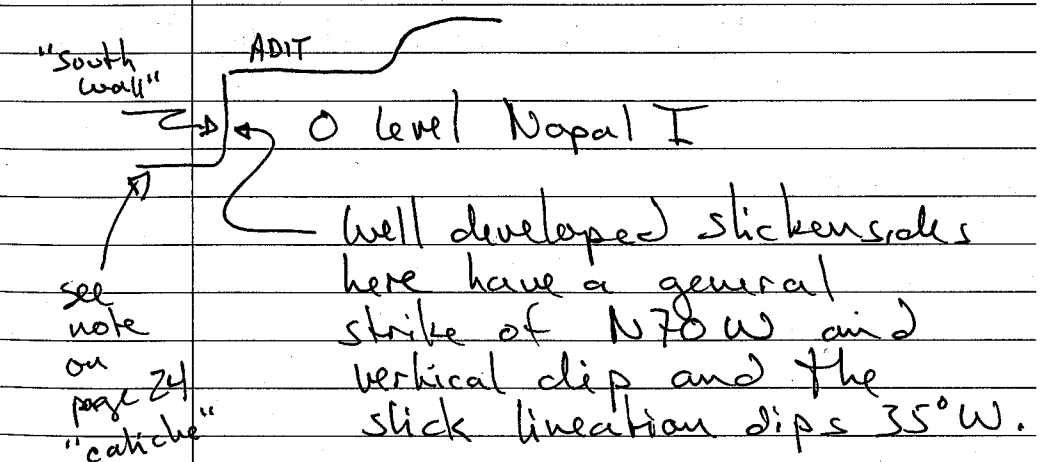
Arrival at Napal I 0 Level @ 11:50 AM
Murphy's dosimeter @ 41 mrem.

(well from which sounding at 281 feet was taken on 9-24-91 (see Ron Green's notebook) was located on 1:50,000 topographic field map at 1340 meters

$281' \times 12'' \times 2.54\ cm/'' \times 1\ meter/100\ cm$

281
12
562
281
3372
2.54
13488
16860
6744
8564.88

Napal I @ ~1500 m
well @ 1340
160
well depth 86
246



"caliche" observed coating vertical fractures 1 to 2 meters below the present surface in the road cut on the east facing side (see note on previous page). Caliche is up to 1 cm thick, chalky, laminated texture, in places it is porous. This has a completely different texture than calcite in veins in the core of bleached zones in the Coloradas fm. especially from the -100 level. Several fragments of the caliche collected. as NOPI-ECP-17. 9.25.91

1:30 PM departed from Nopal I, Murphy's dosimeter @ 43 mrem

Calibration of Eh. pH electrodes.

Goodell's millivoltmeter and electrodes were used. The meter has a pH scale which was calibrated with the pH 4 and 7 standards: pH 7 standard was used — meter was calibrated, and pH 4 standard gave a reading of 4.0.

With the Eh standards
A gave a reading of +200 mV
B gave a reading of +83 mV

Water discovered at El Mesquite a 3x4 meter shallow well surrounded by a rock wall up to ground surface.
(continued next page)

Alkalinity #10
Silica #13
Anions #22
Dissolved metals #27
Total Metals #31
} Bottles for Green/Murphy analyses.

Water level is about 2½ meters below groundsurface. Small green floating plants cover the surface. The water is very clear, one can see several feet deep in places where the sun shines.

pH meter w/ 7.0 buffer still yields 7.0.
4.0 buffer yields 3.8

Sample 7.2 pH

Eh calibration A 209 mV
B 89 mV

Sample 138 mV

Alkalinity, silica, anions, and dissolved metals samples were filtered with paper filter to remove plants. Charcoal camper filter was not used. Water is very still and clear. No inorganic material was noted in single filter used for all filtered samples.
4.8 ml conc. nitric acid added to #27
10.0 ml conc. nitric acid added to #31
Sampling completed at 2:45 PM.

Notes on Reyes Analyses of El Mesquite water - Ward's kit

13 ppm CO_2 from titration with Ward's kit supplies

Nacho notes that "water tastes good, better than ~~Chihuahua~~ El Paso water." 9-25-91

Dissolved oxygen measured @ 2 ppm

Dissolved silica > 15 ppm

Reyes collected no samples

Contrary to instructions provided by Bret Leslie for water sampling, bottles were not rinsed with a small amount of sample prior to filling.

Thermometer broke prior to
El Mesquite sampling
Air T estimated at 25°C
Water T @ 17°C

Previous notes taken at
"El Mezquite" spring on
1:50,000 field map (not Mesquite)

The water was taken from ~~at~~ [illegible] 9-25-91
a well in La Mesa Formation:
red laminated ignimbrite.

On departure from Nopal I
for the day Murphy's
dosimeter is at 47 mrem

Notes taken starting on page
22 on 9-25-91 by [illegible]

9-26-91 Murphy's dosimeter begins
the day at 51 mrem

Murphy's dosimeter on arrival
at Nopal I at 300 PM.
@ 52 mrem

Departure from Nopal I @ 430 PM
dosimeter @ 53.

Examination of upper El Tigre
drainage for seeps:
At a point 1 km WNW from
the Nopal Camp there are minor
seeps from Coloradas bedrock
near the dry stream bottom:
they would be impossible to
provide more than a few
milliliters of water over
a days time.
Another of similar size in the
bottom of a minor tributary
1/2 km north of the Nopal I Mine
at the break of slope about 200 m
upstream from El Tigre.
Also near the base of this
minor stream valley there are
seeps of smaller volume. The small
~~rig~~ [illegible] 9-26-91 ridge that makes the
east divide of this
small tributary catches much
of the drainage from the
Northwest flank of the Nopal
Cuesta.
No apparent water was
observed in small tributaries
other than the above on the
north and northwest side of
the cuesta around to the east
side of the 1400 meter promentary
on the north side of the cuesta.

Near the sommit of the Nopal cuesta toward the northe end a drill pad is cleared and a drillhole has a concrete cover (abelled 813. Where the soil has been removed caliche occurs covering fairly unaltered Nopal formation blocks. Caliche is not generally observed at the undisturbed surface or under surface rocks - there is a thin brown soil zone. But below the root zone caliche is probably abundant A sample of caliche encrusted rock from the drill pad was collected. Together with this rock is some additional caliche encrusted rock fragments from the cuesta top just above the Nopal I mine. These samples are collected as NOPI-ECP-27.

WMM 9-26-91

One additional seep noted at junction of streams draining west side of Nopal Cuesta, just at point where main stream turns from flowing WSW to NW.

Water sampling and chemistry at BH 12 drill hole at rear of +10 level, near the back and center of the level. See notes in Ron Green's book concerning water level.

Water sampling done with PVC pipe and brass check valve constructed in Chihuahua. It is lowered in the drill hole on a thin cord.

Air T = 24-26°C

Failure of pH/eH meter to operate (low battery) forces delay until tomorrow.

Notes taken 9.26.91 on pages 28-31 by WMM

9-27-91 On arrival at water sampling site (BH 12 hole) Murphy's dosimeter reads 59 mrem.

Resumption of sampling and analysis:
Bailer lightly rinsed with distilled water.

Air temp. 22°C
Water temp. 24°C

First bottle extracted is turbid yellowish-brown. Second bottle is orange brown and much more turbid. Third liter is like second. - One liter per bail extracted
First liter filtered for dissolved metals in bottle 26. 5.0 ml conc. HNO_3 added to bot. 26. Sample contaminated by dirt/soil from sides of borehole, especially 2nd and 3rd liter.
Bottle 19 taken for alkalinity from first collected liter. It was filtered through filter paper

Results from I. Reyes field analyses
pH 7.5
CO_2 20 ppm
Dissolved oxygen 3 ppm
Silica > 15 ppm

(Goodell meter fails to work.)

Bottle 7 collected for anions from first liter collected. It was paper filtered.

Bottle 18 collected for silica from first liter. Paper filtered.

Additional samples were paper filtered from second collected liter and given to I. Reyes for independent analysis. The remainder of the second liter was also given to Reyes, unfiltered.

The third collected liter was allowed to settle for about 1 hour. Then it was decanted into the 1 liter bottle labelled 101.37 g. 10.0 ml of conc. HNO_3 was added to this unfiltered sample.

Limestone sample taken from bedrock cropping out ~2 km SW of Nopal I. Taken from mound between two small drainages just south of a predominant bedded limestone outcrop. Rock is light gray, sparkles on fresh surfaces, occassional Fe-oxide stained concretions resist weathering. Sample bagged as KL-WMM-1.

Murphy's dosimeter @ 60 at departure from Nopal at 3:15 PM

Notes on pages 32-34 taken 9-27-91 by WMM

9-28-91 WMM Boarding plane in El Paso Murphy's dosimeter reads 66 mrem

Blank WMM 6/21/92

6/21/92 Notes by Murphy on Santorini

Arrival as planned yesterday on Santorini. Green and Peard are scheduled to arrive on 6/22.

Acquired vehical and started island reconnaissance and familiarization with geologic formations.

Most of the island is covered by the Minoan deposits which are generally light colored poorly consolidated ash which often contains large dark colored breccia fragments.

Attempt to visit the Akrotiri site failed because it was closed to the general public and also closed on Mondays. I will await arrival of the rest of the team to contact Doumas.

6/21/92

6/22/92

Reconnaissance of north end of island reveals an apparently clear contact between Minoan ash and the Megalo Vouno Complex which is composed of dark colored pumice. Access to thermal areas of the island(s) adjacent to the main island is provided by tours from Oia.

Most of the landscape is covered by dry (post-season) grasses or unirrigated vineyards. Everything is very dry.

The massif of Messa Vouno is a dominant feature - composed of pre-volcanic rocks.

Peary and Green fail to arrive as scheduled.

Section to Athenios explored: schists and carbonates of the basement provide support for the road. Overlying ash is often thin and deposited on a steep slope.

6/22/92

6/23/92

Rod English arrived yesterday evening.

Field:

Paid tourist admission to visit the Akrotiri archeological site. Public access is limited to a tour of the excavated area within strict limits.

Key ideas with regard to analogs
- Interiors of dwellings are filled with ash - probably the Rose Ash - the lower Minoan unit.
- Excavations have concentrated on the dwellings, exposures of fresh ash occur on the margins and inside unexcavated rooms.
- The Rose Ash contains xenoliths, usually on the scale of 1-5 cm that have reacted to produce an iron oxidation halo and a clay zone. These show precisely (trace) element migration for about 3600 yrs.

WM 6/23/92

- Dumas and no other researchers are at the site (or on Santorini) at present. We will try to contact him.
- Most of the materials used in construction of the houses is tuff.

On the road from the town of Akrotiri toward the tip of the Akrotiri Peninsula the Rose Tuff is well exposed. Many examples of Fe-oxide halos were observed. They are generally about 1 cm or 1/2 cm distant from the xenoliths. Sometimes asymmetrically disposed.

A road branching from this road and returning to a small group of houses on the hill overlooking Akrotiri the contact between the Minoan tuff and the underlying paleosol and tuffs is well exposed.

WM 6/23/92

At the tip of the Akrotiri peninsula a small remnant of Minoan tuff has remained uneroded. The underlying tuff is fractured and sloping, and caliche has been deposited in the fractures which can be traced upward into the Minoan tuff in fractures. - Fracture flow and deposition over 3600 years.

A key consideration is that the well constrained timing of the eruption is the key. ~~Are there~~ 10,000 year

WM 6/23/92

Are there 10,000 year old welded rhyolitic tuffs containing zeolites, xenoliths, fossils? Perhaps a xenolith with Eu^{2+} oxidized to Eu^{3+} and transported in an unsaturated/arid environment. would make an excellent analog.

WM 6/23/92

6/24/92 Contact with Doumas in Athens revealed his intent to arrive on Santorini on Sunday 6/28. He was to call the site guard to inform him that we would have access to the site.

On arrival, with the aid of a tour guide's translation, we talked our way onto the premises with permission to meander about in areas off limits to tourists. Little work appears to have been done for a long period, judging from the accumulation of dust and rare footprints. Our tentative explorations are well recorded by fresh footprints.

The interiors of rooms that are partially excavated are filled with rocks of collapsed walls and fine dry dust material that may be the mortar remains or material from soil roof tops.

Pottery sherds in partial excavation in a room on the northeast corner of the House of the Ladies (room 2)

cont. WM 6/24/92

are being excavated from this powder material. Many are intact and fine details of their design are visible.

A reasonably water-tight roof of corrugated fiberglass (?) with plastic (?) skylights and walls of stone and the same materials keep the site fairly well protected. Everything is very dry.

There are no apparent signs of weathering subsequent to the burial of the site within the excavated areas. Much of the mortar/roof material appears to be mud-based. Additional weathering would be difficult to discern. Pottery is qualitatively dull in color and dusty, but not knowing its original condition makes it hard to discern weathering. Pottery is commonly fractured and the fracture surfaces appear fairly sharp - not crumbling. These delicate edges would possibly show the earliest signs of weathering.

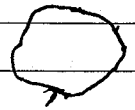
WWM 6/24/92

At the northeast corner of the large excavation shelter a vertical face has been excavated in the Rose Tuff. It is light cream colored, to red hematitic colored on and around oxidized clasts. The ash is poorly sorted with clay sized cream colored matrix and pumice fragments of the same color ranging up to a few centimeters in diameter but mostly less than 1 cm.

Clasts with hematitic coatings are denser than the pumice fragments but generally of the same size range. Zones with more coarse grained fragments are interbedded with zones of fine material with fewer clasts. Cross bedding is apparent. Strata with generally recognizable features are 10's of centimeters to meters thick.

WWM 6/24/92

Fragments developing hematitic stains:

1) Rock fragment with black matrix, phenocrysts up to 1 mm of plagioclase (?) and olivine (?). The hematitic rim has a thickness observable with a hand lens, but is less than 1/10 mm. There is a sharp front between the clast and the hematite alteration, but a fainter hematite staining occurs along fractures in the rock fragment interior. The fragment is this big:  .

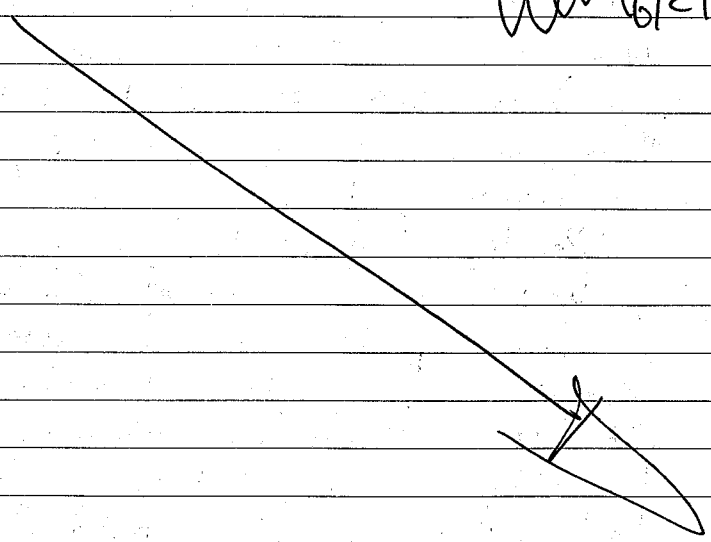
It is notably magnetic.

Most hematitic fragments - and especially the reddest ones - appear to be this basaltic material. It's necessary to crack them open to tell.

WM 6/24/92

Other hematite/limonite stained fragments are highly altered - chalky - chalcedony. The alteration zone is somewhat thicker, up to a millimeter and a diffuse zone somewhat thicker into the fragment which is oranger - rustier and follows fractures. This fragment is much more porous and less dense than the basalt fragments. Original lithology is difficult to tell because of extensive alteration, but it could be a schist or a silicic igneous rock.

WM 6/24/92



6/25/92

Rocks of Minoan eruptions and underlying rocks were observed in a large quarry just south of Thera (Thera Quarry by field nomenclature).

The underlying rocks are black to reddish brown pumaceous deposits stratified on a meter scale. This is the phreatomagmatic interbedded tuff at the top of the middle tuff sequence of Heiken and McCoy: (JGR, v. 89 B10, p. 8441-8462; 1984).

The pre-Minoan topography was highly irregular with hundreds (at least approaching 100) meters of relief between the quarry and the city of Thera visible to the north.

On top of this tuff is a paleosol with variable thickness ranging up to over 1 meter composed of weathered rocks of the underlying pumice (mostly) in a matrix of brown to tan colored fine grained baked mud. There's no evidence

of organic matter apparent in the paleosol (- not grossly apparent)

A pumice fall is the most common first layer of the Minoan tuff, but locally - e.g. on the residual mesa in the center of the quarry, the first Minoan tuff is a heterogeneous tuff with mixed dark blocks of older volcanics. Also on this mesa is are rip up clasts of paleosol near the contact.

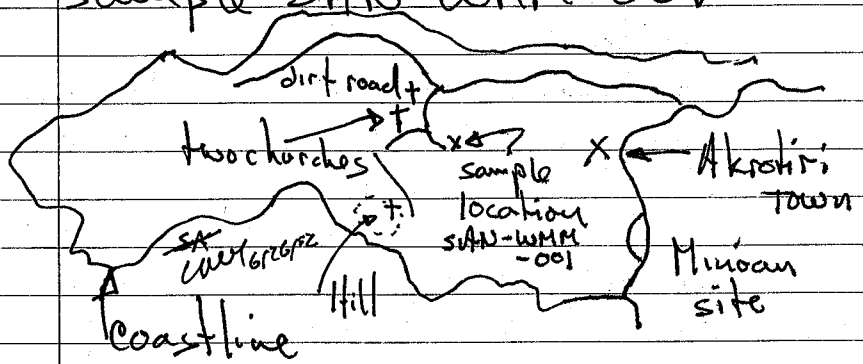
Following Heiken and McCoy: the phase 1 Minoan tuff observed in the quarry is a pumice unit with a few percent lithic clasts. Many clasts are altered hematitic and have stained aureoles indicating transport on a scale of 1 to 2 cm or less. Transport away from clasts is asymmetric and tends to be downward.

Heiken + McCoy's phreatomagmatic transition observed as alternating pumice and ash beds. Phase 2 - phase 3 transition noted speculatively in the wall. JJM/6/25/92

6/26/92

Examination of the dacite pumice tuff underlying the Minoan volcanics referred to as the Lumaravi-Archangelos pyroclastics by Tsolis-Katagas and Katagas (TKK Clays and Clay Min., v. 37, p 497-510, 1989) which is described as a zeolitized (clinoptilolite) tuff by these authors.

Sketch map to site of sample SAN-WMM-001



Akrotiri Peninsula

Along the trail that follows the base of hill, which connects to a dirt road leading to a farm is a pit below a small artifical cave.

The contact between the pumiceous Minoan tuff and the underlying altered zeolitic tuff is exposed in the pit (photographed and recorded by Ron Green). The contact is very irregular: on one side of the pit there is a significant paleosol 10's of cm's thick; two paleo meters away there is no soil. The Minoan pumice dips at 20-30°. In the cave which is above the pit the zeolitized tuff is well exposed and from here sample SAN-WMM-001 was taken.

It's white and chalky in appearance with slightly altered (greenish) black hornblende and β-quartz(?) phenocrysts. Matrix is very fine grained.

Near the bottom of a prominent dome shaped hill between the former sample site and the coast a church is built into the base of the hill. This hill is mapped by TKK as the same Lumaravi-Archangelos pyroclastics.

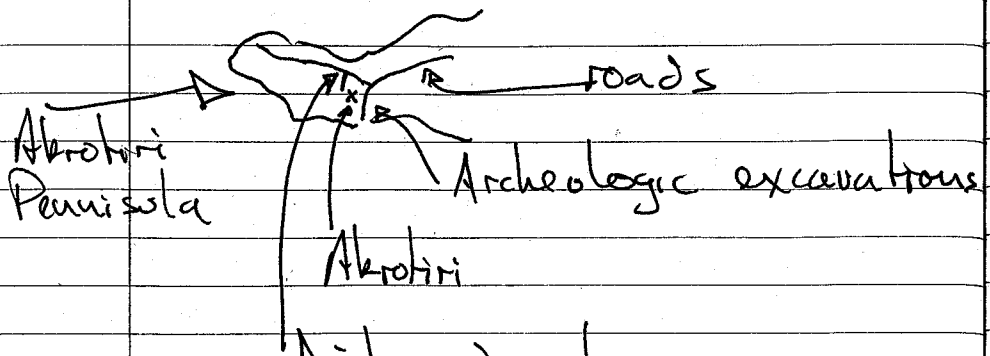
Just below the church a road/terrace cut exposes a heterogeneous section of the zeolitized tuff. Within five meters there are ten or more detailed lithologies on a hand specimen scale. Generally a white matrix with hornblende phenocrysts is common. Some zones are blocky - a silica rich white volcanic breccia. Some zones have many small (2-5 mm) lithic fragments of a darker color, and there are occassional large 30-40 cm lithic blocks that tend to be rounded. Some small faults show offset and evidence of fluid flow. The matrix here tends to develop a green color. Laminations and bedding marked largely by lithic-rich zones show a roughly 30° dip toward the north. Other similar 6/26/92 rocks, but more homogeneous and similar to the sample SAN-WMM-001 are located

in the vicinity of the church and are very green. Just above the church a sample of this material was taken which is SAN-WMM-002. It's fairly hard/silicified with a pale green matrix with few small dark green vug-like holes and dark hornblende (?) pheno's.

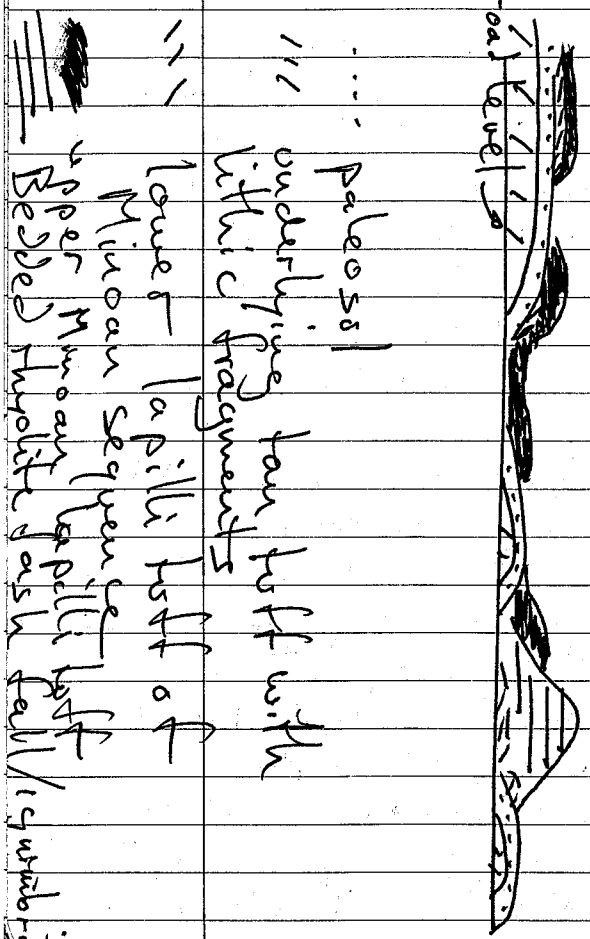
Examination of rocks underlying the excavations at Akrotiri reveal them to be tan pyroclastic rocks of Heiken and McCoy's Middle Tuff Series, and not the clinoptilolite-bearing rocks of the zeolitized dacite. 6/26/92

The section examined on 6/23/92 was reexamined - that is the road cut of the dirt road branching off toward the top of the town of Akrotiri from the dirt road toward the tip of the Akrotiri peninsula. A schematic section along this road cut is presented on the next page.

Sketch map



Dirt road section



Two layers of lapilli tuff, i.e. pumice fragments in beds overlie the paleosol of the Minoan age. An archeo stone wall is preserved under this tuff. A white cross bedded - ignimbritic(?) tuff occurs massively between the two lapilli layers near the road junction with the road toward the tip of the Akrotiri peninsula.

Notes on pages 48-53 by [illegible] 6/26/92.

6/27/92, 6/28/92

Visit to archaeologic museum at Thera: a few pots and pithoi from Akrotiri; some of the artifacts were imported from Greet and elsewhere; one, no two, small bronzes were well corroded with copper carbonate type alterations. Other materials mostly from Ancient Thera.

Contact made with Floyd McCoy acquiring a geologic map.

Visit to Ancient Thera: everything in limestone.

Walk down to Athornia Beach revealed a thick sequence of volcanics over a limited exposure of pre volcanic basement, mostly schists. These have been locally altered extensively with probably copper and metal sulfide mineralization which is now largely oxidized. Some exploration pits were observed. No current hot spring activity was noted. Mineralization was apparently before volcanism.

6/29/92

Summary of discussions with Dumas Monday morning 6/29/92.

① Clearing of site following the earthquake the people apparently piled material outside room Δ15 outside another building * as indicated by the upstanding leg* of an overturned bed. The bed is buried in pumice. Other materials buried here could also be in pumice (rather than in building debris as most artifacts discovered. Also the point is well suited for geophysical testing for buried material

*West of Δ15 north of Mill house square.

* As indicated by a cavity (mold) filled now by a cast.

② A torrent eroded part of the archeologic materials flowing from south of building 15 toward the north. It deposited alluvium among the building remains. It flows and continued to flow intermittently until diverted to preserve the site. When it flows it flows

for a short period (hours? days?) during rainfall.

(3) Roots of vines were discoved up to 8 6/29/92 7 (seven) meters below the ground surface indicating the hygroscopic nature of the pomice permits useable water at that depth. When originally excavated there is no dust associated with the materials - i.e. it is moist - once excavated it dries and becomes dusty. Other effects of water were not noted, but metallic artifacts are oxidized - some completely - and some building stones are very punky - disintegrated by water weathering in my estimation.

(4) On the west wall of 6/29/92 door room 37 casts of original wooden planks are preserved in volcanic deposits and in alluvial gravels. This indicates alluviation while the wood was intact, and that the temperature of the

volcanic deposits was low - the wood did not burn. 6/29/92 It rotted in place leaving the casts.

(5) lead weights were found in room Δ8, a second storey room. Bronze artifacts were found in the first storey room north of Δ8. They were perhaps wrapped in straw and lying on the bedrock floor. They were perhaps 1/2 meter from the wall of the torrent and 2 meters below the ground surface. The torrent passed just east of this room.

(6) Slopes of the tops of the standing walls indicates the topography generated by the torrent erosion.

The torrent eroded lapilli-ash tuff of the Minoan sequence cutting a gully 3-4 meters deep and 4-6 meters wide in the stretch above (north) of the older structure protecting the excavations. In this gully on the west wall about 3 meters north of an old stone bridge that crosses it a pit was dug in the wall. roughly hemispherical in shape and ½ meter in radius. The 10 cm of material at the surface was dry and created clouds of dust on digging with a rock pick. Inside this limit the very friable rock was darker in color, cooler to feel and penetrated by numerous roots.

One sample of the unconsolidated mixed lipilli-ach was collected in a small aseptic plastic bag which was closed and enclosed in a larger zip-lock bag, removing as much air as possible. A

gross estimate of moisture content could possibly be obtained from this sample. It is numbered SAN-WMM-003.

The horizon dug out also contains red oxidized samples and pumice fragments mostly 1-2 cm in diameter or less. Several of the iron-stained samples and one pumice fragment showing fine delicate glassy textures were collected together as sample SAN-WMM-004. Not all iron stained material surrounding each nodule was collected, as it is too friable.

The small pit is about 2 meters from the ground surface and one meter from the gully floor level and two meters horizontally from the center line of the gully. Photographed by Ron Green.

Notes on pages 55-59 taken by Willy on 6/29/92

6/30/92 -Αλεξάνδρα Αϊβεροπούλου

Alexandra Avieropoulou
Archaeologist assisting at the site provided information from old field notes dated Sept. 1, 1970 locating the top of the bronze artifacts in room Δ 3 at 325 cm from the west wall, 80 cm from the north wall, and 185 cm down from the top of the west wall. This point is about 80 cm above the present floor of room Δ 3. At this point about 5-10 cm of "packed earth" with (WMM 6/29/92) which according to Doumas could have been a constructed floor, overlying the bedrock off tuffs underlying the Minoan sequence.

WMM 6/30/92

Sample SAN-WMM-005 is 100-200 grams of earth collected from loose material that was directly below the estimated discovery point. It consists of fine material swept off the packed earth surface and is likely to

consist of the packed earth and material slumped/fallen off the nearby north wall and from elsewhere.
(WMM 6/30/92

Clearing the surface of the packed earth and bedrock of dust exposed the contact and a linear vertical trench more or less parallel to the west wall. Near the contact with the earth the material in the trench is whiter than the slight purple tinge of other material. 10-15 grams of this white material was collected as sample SAN-WMM-006.

Floyd McCoy (Univ. of Hawaii) arrived at the site and has tentatively identified the underlying material, referred to previously as bedrock, as chaotic collapse debris from a destruction of the city in earthquakes several generations before the final destruction.
See correction below: it is rock.

Sample SAN-WMM-007 is an 800-1000 gram sample of several fragments ~~of the "collapse debris"~~ bedrock 6/30/92 under the "packed earth". It has a purplish tinge. In hand specimen and with hand lens it looks very much like a tuffaceous rock. In outcrop it is continuous over several meters, and I am returning again to the impression that it is a rock. It's a chaotic mixture of crystals pumice fragments up to cm's long, ash matrix, and lithic fragments. It fractures easily. Perhaps it's a volcanic mudflow deposit.

The site archetect who has extensively studied the site has confirmed that the underlying material - briefly referred to as collapse debris, - is indeed bedrock. Clairey (Claire) Palyvou is the archetect.

60 cm west of the ground surface below the artifact discovery point and 50 cm down the face of a vertical shaft built to access an older, and reoccupied archeological cavern another sample of the bedrock very similar to the previous one was collected. It is SAN-WMM-008. This was taken from the east wall of the pit.

A sample of the packed earth floor was taken from a similar location as the first but 115 cm west of the point below the artifact discovery point. It's mostly crumbled fragments but up to a few centimeter pieces. This is SAN-WMM-009 ~ 1kg of material. Its brown with variable clasts. Some larger clasts were excluded.

Notes from description of volcanism at the site given in the tour by Floyd McCoy: Chronology

Early occupation.
Seismic destruction.
Minoan rebuilding on debris, etc.
Seismic disruption.
Incipient clearing.
Phase I volcanism, a few centimeters of fine ash. Some of this was collected into piles before the final evacuation.
Phase II volcanism: pumice fall buttressing walls, entering structures through doors and windows, cool temp. On the order of meters thick.
~~Phase III~~ WEL 6/30/12
Phase II was a phreatomagmatic violent eruption associated with the opening of a vent in the sea. There are well developed bed forms. It violently cleared off any remaining structural walls, so the surface defined by the

tops of walls is the bottom of the phase II deposit.

Phase III: was probably deposited but then completely eroded.

Phase IV: Another violent and extremely erosive deposit [associated with the collapse of the caldera (or was that phase III?)]. It eroded Phase III deposits completely and also much of Phase II and also some Phase I deposits especially at the south of the excavations. Phase IV rocks are lithic rich and dark colored compared to earlier deposits.

Field notes from Sept. 1, 1970 indicate that alluvial type material was found associated with the bronzes. The descriptions recall the alluvial sands in the rooms across the torrent from Δ rooms. Alexandra Avieropoulou is preparing a copy of the field notes for us.
Notes on page 60 to this point by [illegible] 6/30/92

July 1, 1992

Discussions with Avieropoulou and Doumas:

Transcription of field diaries provided by Avieropoulou, Alexandra
Π refers to pottery
X refers to bronze

Alex. Avieropoulou
Dikeoiou 6 Athens 11741
→ 5 Hyderabad Rd Alexandra Park
Singapore 0511

Alexanda's addressed are noted above.

Photographs of the bronzes in place and as excavated are in

Excavations at Thera IV
(1970 Season) (1971)
by Spyridon Marinatos
Athens Archaeological Society,
Athens

Plate 23 a. shows
"A hoard of bronze vessels under the slabs of Δ3"
Plate shows 2 ewers and one baking tray.
Text describes 3 ewers and two baking trays. (p. 16-18)
One baking tray was 1.5 m from the center of the north wall. (from field notes).
Notes also describe artifacts at the height of the top of the east wall.
A goblet (plate 91 a) was the first find "at the level of the pavement". This is the position from which we worked at the site.

The five bronzes are described in the Excavations book as being found under the stone floor, which was preserved only in the NE corner of the room Δ3. The stream may have flowed over this point because the field notes describe mud in one ewer and sand and allusion to the stream is made in the excavations book.

At the level of the floor (probably on it) were a smaller bronze goblet, a lead weight, a stone stopper and other things found in the "aspra".

Making the assumption that the most decorative of the ewers is the "large" one, the maximum ewer size is about ~~39 cm~~ WMM 7/1/92 2.5 × 14.5 = 36.25 cm tall from a plate (photo) with a scale (assumed to be centimeters) in the excavations book. Much of the space below the stone floor and above the packed earth floor must have been filled with the bronzes.

McCoy has published a magazine article on his Akrotiri work in

Earth Watch
Watertown, MA
ask for Emilie Snodgrass
re: McCoy's recent article on GPR.
or ask for David Silverberg
"Site Unseen"
Earth Watch Magazine

Also, an article in
ref: Archaeology Magazine
May-June 1991 article
by McCoy + Heiken

*series B or C

Bedrock at the site may the upper scoria II*, i.e., the material under the packed earth floor in Δ3 according to McCoy. He is going to explore this further.

A sample of the flagstone flooring (a local phyllite?) was taken from the box of such material in room Δ3. It is a gray triangle about 12 cm on each edge and 1-2 cm thick ≈ 300 grams. This is SAN-WMM-010.

Further observations in and around Δ3.

Holes in the north and south walls are indicative of the casts of wood planks. They occur in the south wall about at the level identified as the discovery point of the goblet. This could make the level to which the flagstone floor fell. The casts are higher by 20-30 cm on the north wall.

Discussions with C. Palyvouis indicate that the floor had not collapsed (much). The space in which the bronzes occurred was about a meter tall, it seems. (She had not previously noted this.) Dumas indicates that the floor could have collapsed enough such that the room was tall enough for access.

Dumas also noted that the odd 1-2 cm wide fracture from which SAN-WMM-006 was taken may be continuous with a clear (obvious) fracture that crossed the area now excavated (by prehistoric people) to the north of Δ3.

According to A. Hyperopoulou the Cappadoccia site in Turkey about 300 km from Ankara is a site where early Christian churches are built in volcanic rocks.

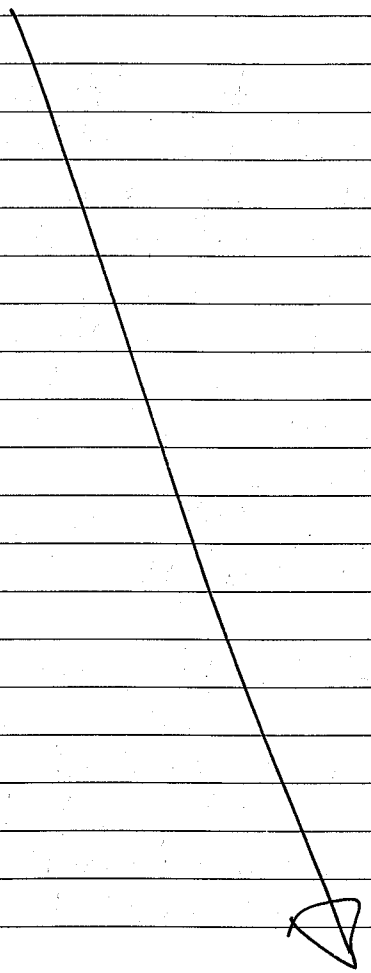
Pompeii south of Rome is a Roman City buried by volcanic rocks.

The flow path for transport may have been other than vertical, e.g. parallel to the stream direction. It might be interesting to look in material of the wall (e.g. the clay mortar) on the south end of the room Δ3 — or on the north. (Without permission I won't sample this now.

The wall on the west side of Δ3 has fallen, rather its base appears to have been pushed out toward the cellar cavity. Material behind it could be similar

to material that enclosed the bronzes. It's a hetero-geneous muddy mixture of debris. In contrast the orginal field notes from 53 refer to sand and mud.

Notes starting mid page 66 to here by [illegible] 7/1/92



Sept 1, 1992

Peña Blanca

Nopal 2x2 km map by Reyes - field checking by William M. Murphy ([illegible]) and Linda Kovach.

The steep part of the valley that runs down SE from the Nopal Camp (located SW of Nopal I mine) has a fault mapped. The area around the 1420-1425 m counter shows a resistent unit that holds up the head of the valley. It can be visually traced around the head of the valley with no evidence of faulting. It dips generally to the (S) West. This seems to be the general attitude, rather than the east dip mapped along the road.

The big cliff that the valley falls over at about the 1400-1410 m elevation looks from a distance to be continuous. Again the fault mapped in this

valley is dubious.

There is good evidence for the east-west fault mapped about 300-400 meters south of the Napal Camp. The massive unit forming the cliff in the valley at 9400-1400 meters is offset. Lithology changes across it, where the road crosses it at an east-west valley - as the main road goes generally south.

However, if the southern block is downthrown as mapped, then the section of Napal Fm above the vitrophyre is very thin - the lucassive Napal units such as the cliff formers are absent. It seems possible that the throw is in the opposite direction. The massive Napal then, capping the resistant hilltop south of the fault.

Coloradas and Pozos Fms observed well as mapped in the SW corner of the 2x2 km map.

The NW striking fault whose existence is questioned would seemingly rationalize the mapped offset of the Napal - Coloradas contact to the south of the mine. However the direction of throw on the fault, (assuming a normal fault with downdropped hanging wall is wrong to explain the offset. In contrast, the north-south fault, whose northern projection goes between the mine and the camp could also explain the Napal - Colorados offset - with throw on the fault as mapped with the east side dropped.

The vitrophyre mapped to the north of the main stream separating volcanics from limestone is correct, although it appears to pinch out in the extreme west edge of the mapped area. Where mapped as outcrop it is better exposed than I have previously seen, blocks of gray rock with

light gray small lithophysae can be extracted that are 3-5 cm across. Vitrophyre sample taken NOPI-ECP-45.

Good evidence in the form of slickensides supports the existence of the east-west fault as mapped on the ridge 200 m south of the large dump west of the mine.

No good evidence could be found for the north-south fault south of the east end of the large dump noted above.

Air photo observations confirm good evidence for the east-west faults WMM 9-1-92.

Mapping on the NW side of the Napal Cuesta was field checked with Nacho and Linda and found to be correct.

Note on pg. 73-76 by WMM
9/1/92

to the east of the dubious faults near their intersection and south of the Napal I mine area

9/2/92 WMM

Field checking faults with Nacho: the dubious N-S "fault" south of the camp appears to be a gentle syncline with no off set.

No clear evidence such as slickensides or juxtaposed rocks or attitudes could be found for the second N-S "fault" to the east of that noted above. The best evidence for faulting is the offset of the Napal-Coloradas contact near the bottom of the big valley north of the limestones!

Near the base of the Napal Fm crapping out near the base (to the south) of the ridge WMM 9/2/92 ~~between the two dubious faults~~ WMM 9/2/92 a roughly 10x10x10 cm sample was taken of typical unaltered Napal Fm for Ron Green's hydrologic testing. It's purple with sanidine pheocrysts altered pumice fragments and clay-coated fracture surfaces.

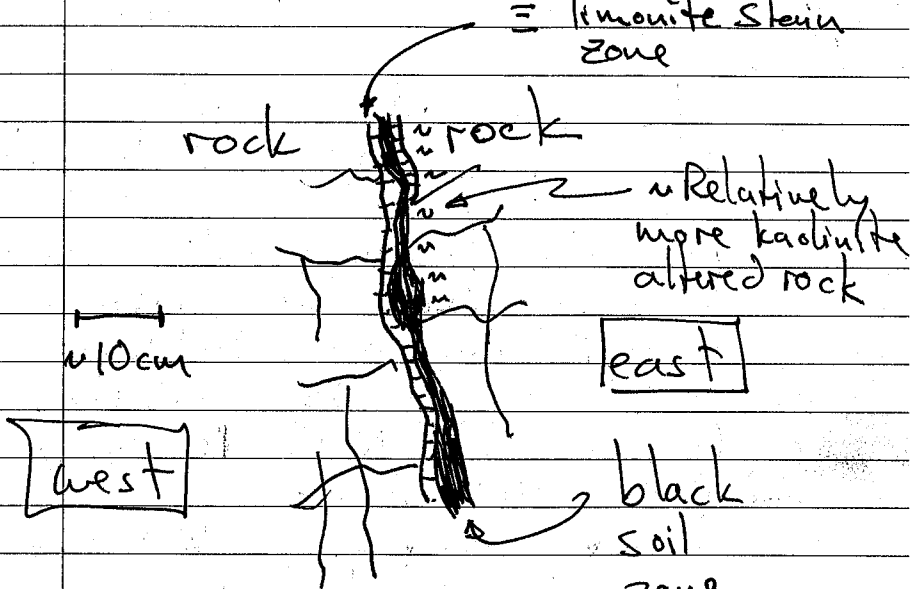
A second set of 3 samples of relatively fresh Napal Fm was taken from the base of the cliff on the west side of the well indicated fault that runs N-S to the east of the Napal I Mine area. These samples are similar, but somewhat fresher than the previous one. Some pomice inclusions are intact.

These two samples are labelled NOPI-ECP-43 and NOPI-ECP-44, respectively. 9-2-92

Plus 10 meter level.

Near-vertical, N-S trending faults with small displacement exposed in the +10 m headwall appear to be late features. One of them coincides with the limonite zone of the cleared area.

Excavation by rock hammer ~40 cm into one of these fractures on strike with the west end of the cleared area exposes



This is an open system.

Two photos were taken of the excavated zone just described. Roll WMM1 frame 1 and 2.
Five rock samples were taken
① Black central material
② Limonite stain zone on west side
③ Limonite stain zone on east side
④ Kaolinite altered zone on east side
⑤ Relatively fresh rock on east side
They are called:

NOPI-10-18/2	A	⑤
"	B	④
"	C	③
"	D	②
"	E	①

The eighteen refers to reference point 18 on the +10 m level headwall.

A similar fracture/fault zone was sampled. The center material was a red-black plastic gouge-like material (2 samples): NOPI-10-25/2A, and 2B, on WMM 9/2/92
A third sample is kaolinized rock adjacent to the gouge. NOPI-10-25/2C.
Locations are given in Jim Prokopiuk's book as for those noted above.

Photos from roll WMM frames 3,4,5,6,7 were taken from above the cleared area within a meter of concrete post PNI 62. This point is just at the summit of the excavated headwall of the Napali Mine. The photos were taken of the cleared area on the +10 level with ribbons delineating the surveyed grid.

Photo frame 8 was taken of Pearcy and Reyes at a lower level.

Photo frame 9 was taken with a maximum angle to include area on the +10 level that may be cleared in the future.

Photo frame 10 was taken from the +30 meter ledge of the cleared area.

The fracture near reference point 18 on the +10 m headwall was located on the +20 m headwall between reference points 19 and 20. Here there is no black soil, a 1-2 cm wide red hematitic central zone with clasts of Nopal rocks surrounded by a kaolinite bleached/altered zone. Three samples were taken.

NOPI-20-19/3A The hematitic material
/3B The kaolinized rock
NOPI-20-20/0 Fresh (relatively) Nopal fm rock approximately 1.5 meters east of the fracture.

Photos (WMM roll Frame 11 and 12 were taken here on the +20 level of the fracture. + Jim Prikryl.

Notes on pages 77 to 82 by WMM 9/2/92.

Borehole locations on +10 level

Location: 7m E, 25.65 m N
direction N50E, dip 47°
(bearing) (A)

Location: 6.3 m E, 25.2 m N
bearing N53E, dip 68° (B)

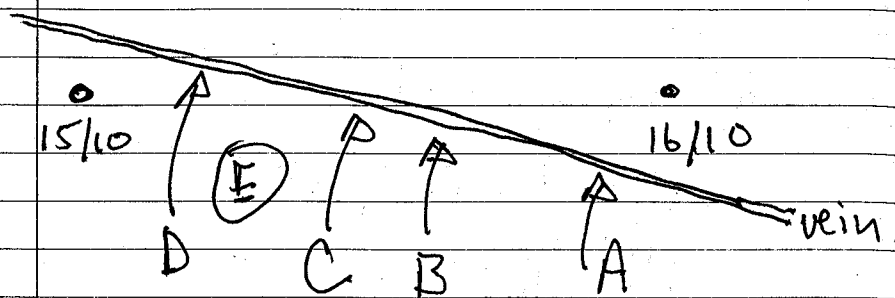
Canoe caps are labelled

(A) N52E, 50°

(B) N52E, 70°

WMM 9/3/92 Postulating that the yellow (limonite) N-S zone at the ~~ele~~ center of the ore zone on the +10 m level represents a late alteration (like the 18/20 vein/fracture in the +10/+20 m headwall), and that uranophane-bearing E-W veins are being altered by this action on the NW axis, a series of samples is taken.

Between the 15/10 m nail and the 16/10 m nail is an E-W fracture with limonite (?) and calcite (?). Between the nails it is bleached and there is a N-S fabric.



A. Uranoplane-limonite rich material around the vein - rock red-yellow

B. Black (calcite?) material around the vein - rock bleached

C. Bleached area near intersection of vein w/ N-S fracture

D. Reddish rock on vein where vein minerals appear to have been leached.

E. Rock ~5 cm from the vein in zone of N-S fractures.

Samples labelled

(A) NOPI-ECP-15.9/9.95

(B) NOPI-ECP-15.7/10

(C) NOPI-ECP-15.6/10

(D) NOPI-ECP-15.2/10.1

(E) NOPI-ECP-15.4/9.9

Notes on pages 83-85 by [illegible]

9/3/92

SANTORINI CONTINUES
(notes by Murphy)

Arrival in Athens 8/30/93
Pearcy and Green pass through Athens airport and are met on 8/31/93.

Primary efforts devoted to obtaining meteorological data and maps. The tourist police at the west airport terminal identified the National Meteorological Service, which is near the airport east terminal, and the Army Geographic Service as the responsible organizations.

By phoning 9612800 at the National Meteorological Service I learned that statistical monthly data can be obtained for a thirty year period. Data include wind, rainfall, pressure, and temperature (mean, maximum average, minimum average, absolute maximum, and minimum absolute). A tax must be paid in advance at the bureau of taxes.

WM 9/1/93

The tourist information service provided a phone number (8842811) and a map location (a (military?) complex of buildings north of Athens on EVELPIDON) for the Army Geographic Service. This may be a general reference to the Army or Army Services.

The National Library had no subject index entries for weather or climate, and one entry for Santorini, a book written ~1865 in German.

The Natural Science Museum is closed for renovations.

The national archeological museum was visited and the Akrotiri and Δ3 artifacts were viewed. I will return with a ruler and a camera and attempt to estimate masses (volumes) and dimensions and describe alteration.

WM 9/1/93

Archeological Museum
Notes on large frying pan in separate case number BE 1974.42
Circular, 52 cm outside diameter 7 cm outside depth.
Opposing handles 12-13 cm wide, extending 3 cm below the pan lip and 4 and 5 cm above the pan lip. Handles are 1 3/4 to 2 cm in diameter and connected by four brackets of the same diameter. Pan lip is 1 cm wide and hangs over outside and inside. Detailed ribbing is shown on handles - grooves with a depth 1/2 mm or less. (grooving not ribbing)

Broken pot/ewer on facing wall: BE1974.48
28 cm tall from lip to broken tip. Walls are partly folded inside the ewer, so the minimum wall length is approximately 15 cm from lip to (unfolded) end. Lip is 6-7 cm in diameter (outside) and 3 cm above the ewer body top. The keepering handle attaches to the body ~7 1/2 cm from the lip, vertically and

WM 9/11/93

extends 2 1/2-3 cm outward from the lip. Delicate spiral ribbing has an amplitude up to 1 to 2 mm. Wall thickness where exposed is ~ 1 1/2 mm and fairly uniform. The lip is rolled to a ~3 mm thickness

Returning to the large pan its wall thickness is estimated by estimating the difference between the lip width and the sum of the lip over hangs which are each ~3 mm. Therefore the pan wall width is ~ ~~4~~ mm 9/11/93
~ 10 - 6 = 4 mm. The pan bottom may be the same, but can't be seen/measured.

The small pan on the bottom shelf of the multiple item case: BE1974.47 is by construction a smaller version of the large pan. 29 cm outside diameter, 6 cm depth (outside). Lip ~ 7mm wide. Handles ~ 5-7 mm wide and 3-4 cm across, and 3 cm tall.

WM 9/11/93

The small ewer on the lower shelf BE 1974.44 is built like the one described. Both have small brackets connecting the handle to the lip area. It's 26 cm tall, and 17 cm wide at its widest, although it is badly dented and reconstructed with a green cement. (The broken ewer with the spiral design is ~27 cm at its widest point.)

The big ewer BE1974.46 has the same construction as the others with an additional handle below the lip handle and about 1/3 of the way up from the base. 48-50 cm tall, 32-38 cm wide at the widest point. The lip on the little ewer and the big ewer are not rolled or rounded as on the ewer with the spiral design. They are each ~ 1-2 mm thick, which may be a good representation of the wall thickness. The handles on these two are ~3-4 mm thick.

MM 9/11/93

The bases of the small and big ewers are ~~8~~ 7 and 12 cm, respectively. The big ewer has a broadened base ~1 cm larger than the minimum diameter.

The small cup BE 1974.43 has a construction like the ewers but with 3 brackets holding the handle. It's 7-8 cm in diameter, but not very round, and 3-4 cm tall. All wall thicknesses are ~2 mm, the handle ~3 mm.

Alteration has produced a foliated character on the bronzes of different dimensions. On a larger scale, exterior gray material resembles ash. This is underlain by many colored layers that alternate among themselves. Prominent ones are dark/dusty green, red green, malachite, and dull red. Lesser amounts of azurite, red or orange Fe-oxides, and in one cleaned spot on the large ewer a spot of polished copper/bronze.

MM 9/11/93

The heterogeneous pattern of alteration is due partly to varying degrees of cleaning. Clearly, though the alteration, and surely the materials properties are not homogeneous or uniform. Preservation of delicate features suggest no large scale general corrosion

2011 Broken ewer with spiral decoration
Photo 1 viewed from the broken side
Photo 2 Ensemble of broken ewer, large ewer and cup.
Photo 3 View down the throat of the broken ewer.

A hole has corroded through the bottom of the smaller pan. Material exposed in the sides of the hole is strongly laminated parallel to the pan bottom. Similarly the bracket of the smallest ewer and its handle show partings and laminations parallel to the structural material.

Photo 4 Side of large ewer showing second handle

WM 9/1/93

This handle side of the large ewer has a striated material plastered on it. This may correspond to literature references to straw matting, but it looks much like ash material except for the long continuous striations.

Observations and measurements made at the archeological museum were conducted by looking through glass cases. All measurements are approximations with significant error, and dimensions varied on each old, worn artifact.

Notes on pages 86-93

by William M. Murphy

9/1/93

WM

9/2/93

Inquiry at the tourist information desk at Syndagma Square revealed that a tax bureau is located at 42 EOLOU (also spelled AILOU). It is open only in the mornings. I found it on the 6th floor of that building. I had prepared a list of climatological data to be obtained according to the instructions of the woman at the National Meteorological Service. With much consternation 6 women in the tax office agreed to accept a 12,500 GDRS fee from me, plus a small fee for services, giving me a receipt.

I took my list and receipt to the National Meteorological Service (NMS). It is located in a large building separate from the International air terminal about 1 km to the north? Presenting my

WLM 9/2/93

business card I obtained a visitor's badge at the gate and found the woman to whom I had talked on the second floor. I did not get her name, but I believe she is the director of the climatological division. She took me to a statistician who promptly provided a computer printout of data for 1974-1991 for Santorini.

notes on 9/2/93 by WLM

9/3/93

At Akrotiri at the ravine above the archeological site, where the sample was taken for moisture content in '92, Green made dielectric potential measurements for water content and inserted gypsum blocks for water potential measurements in fine Minoan ash.

Roll 1 Photos 5 and 6 record augering of a hole for a gypsum plug and placement of the plug.

WLM 9/3/93

In a lecture given by Doumas to a group of archaeologists (?) he (and they) provided the following information in response to my questions:

1) Based on the location of a harbor to the west of the excavated site, sea level has risen 1 meter since the eruptions - due either to water level or subsidence changes.

2) A consensus - or at least a majority opinion - among researchers is that the date of the eruption is 1645 ± 7 years B.C. New ice core data tend to confirm this. Tephra, chemistry in ice core would be the best evidence, but has not been reported.

Photos 7 and 8 are roughly perpendicular views of the reference lines for mapping Δ3.

notes on 9/3/93 by WM

9/4/93

Hole dug in test area ravine above the archaeological site for lysimeter placement.

Roll 1
Photo 9 mm 9/4/93 8' Measurement of time domain reflectometry (for dielectric constant in hole to be used for lysimeters.

Photos 10 mm 9/4/93 11 ~~9 and 10~~. Hole w/ auger for lysimeter.

Photo 12 Lysimeter apparatus prior to insertion at 10:15 AM.

Photo 13 Moisture content measurement at site of future infiltration study. Ref. Green's notebook.

Comparison of the Nat'l Geographic photos, archive photos belonging to the local archaeologists demonstrate conclusively the original location of the artifacts! They were along the low remaining wall on the east side of Δ3 in the WM 9/4/93

hollow below and south of the area where they were previously believed to be. The area is now covered by the flag shows that once formed the first floor.

Photos 14, 15, and 16 show photographs of the artifacts roughly located in △3 at the points where the artifacts were found.

Photo 17. Moisture content measurement at hydrologic site Akrotiri 2 well 2. Ref. notebook by Green. Guelph MM 9/5/93

Photos 18. and 19 Filling infiltration device with water and use of permeameter in Akrotiri 2 well 2. ref. Green notebook. (CNWRA controlled copy 23). Guelph MM 9/5/93

Photo 20 View of △3 before movement of floor tiles overlying ground below artifacts.

MM 9/4/93

9/5/93

Slate floor stones and dust were removed from the area where the bronzes were taken from △3. The packed earth under the artifacts was mostly removed, probably by the original workers in 1970, so there is now about a 1 x 1 m depression corresponding to the artifact location.

There is a hole to the south of the depression which is an extension of the major N-S trending fracture described in the NE corner of △3. Another similar major fracture with a roughly EW strike is clearly exposed in the wall of the basement on the W side of △3. Its projection goes through the artifact-depression and intersects the NS fracture in the depression, although it's not visable there.

MM 9/5/93

There appears to be some packed earth remaining in the depression. It has no obvious sign of discoloration. Some bedrock also crops out from the floor where it forms slightly elevated mounds.

The following is a list of constraints on location of the bronzes deduced from the photos and the site.

1) An excavation trench existed in 1970 that was parallel to the east wall 0.58 meters inside D3. The large ewer, crushed spiral decorated ewer, both flat pans, and most of a large ceramic jug were within the space of this trench. The small ewer lip was exposed in the trench.

WMM
9/5/93

At Ron Green's hydrologic site the tension infiltrometer is functioning at site TI 1.

Photos Three photos, numbers roll 1 photos 21, 22, and 23 were taken of the general set up, a close up of an infiltration front on the ground surface, and a close up of the bubbler tube, respectively.

Photos 24 and 25 also show the general arrangement of apparatus, techie, and tourists.

notes by Murphy 9/5/93

9/6/93

A major discovery and object of excavation and research this season was three bed frames in the area explored last year by Green et al. using a magnetometer. One frame is inverted over another; its leg (s?) was exposed as a hole last year. The other frame is adjacent.

WMM 9/6/93

Attached to the inverted frame is a cord lattice work, e.g. a support lattice which is being preserved by glue (epoxy?) impregnation. The bed frame is preserved by filling the holes with a gypsum epoxy. A small amount of wood was preserved and Alexandra is interested to identify the type of tree to discover trade processes.

Also, a small piece of metal was taken and another remains plastered to a horizontal frame piece of the inverted bed. It's about 4 mm across and 1 mm to 2 mm thick. It is non magnetic, though there is discussion of it's being anomalous iron in the bronze age.

Photos Roll 2 Frames 1 and 2 are general views of the inverted bed. Frames 3, 4 and 5 attempt to show the small embedded

WM 9/6/93

It's rock.
WM 9/7/93

piece of metal. Photo frame 6 shows the bedding and the conservator who is impregnating the cord.

Photo 7 is an overview of Δ3 after cleaning the area where the artifacts were taken showing the string lines used to prepare our map. The weather is cloudy and it is not very light in the site under the roof, so exposure times are long, and photos may be poor.

Sample SAN-020 is a piece of the Cape Riva toff extracted by hand from the wall on the west side of the basement on the west half of Δ3 behind the metal roof-supporting frame. It is about 20 x 7.5 x 7 cm, light purple in color, with many lithic fragments, and significant heterogeneous porosity.

WM 9/6/93

Sampling of packed earth in SE quarter of △3 under the artifact location. Alexandra Avieropoulou is taking notes of our activities.

Sample SAN-021 is packed earth material from an area 15 cm west of the inside of the east wall and 34 cm south along the wall from the northern tip of the last rock of the wall. 3-6 cm deep to bedrock, 10-15 cm in diameter Sample SAN-022 is similar material centered on 20 cm west of the wall and 65 cm south along the wall from its northern remaining tip. SAN-021 and SAN-022 are each ~ 1kg in mass light brown color with included rock fragment. And mostly unconsolidated earth. SAN-022 is 5 to 7 cm deep to bedrock; 10-15 cm in diameter

WM 9/6/93

SAN-023 is 13 cm west of the wall and 97 cm in a southerly direction from the north tip of the remaining wall. It is from an area ~ 20 cm in diameter and ~0 to 4 cm deep to bedrock. It is similar packed earth. ~ 700 g.

SAN-024 starts a new line of samples from the north; i.e. 34 cm south along the wall and 52 cm west of the wall, 3-4 cm deep to bedrock; ~ 1 kilogram. of packed earth.

SAN-025: 65 cm south; 54 cm west; ~0 to 4 cm deep to bedrock; ~ 1kg. Similar packed earth material.

WM 9/6/93

SAN-026 is a bedrock (Cape Riva) taken from the west side of the major N-S fracture. It is purple, rich in lithic fragments and porous. The top surface and the fracture surface are weathered to a whiter color. The fracture surface was marked with marker pen. The sample is fragmented and fragmenting. It was located by east wall coordinates at 80 cm west and ~~80~~ 90 cm South.

WWM 9/6/93.

SAN-027 is a weathered crust of the bedrock located 1 meter south and 40 cm west by east-wall-coordinates (EWC). Nearly 2 kg it is mostly powdered weathered rock; light brown to light purple, with some poorly consolidated chunks.

SAN-026 and SAN-027 are approximately 4 and 3 cm deep from the rock surface respectively.

WWM 9/6/93

Photos of roll 2 numbers 8 and 9 show the floor of Δ3 after collection of SAN-027

Sample SAN-028 is bedrock in many chunk's, one up to 8 cm across, collected immediately under neath the point where SAN-021 was taken. It's 34 cm south 13 cm west, centered by EWC from an area about 17 cm in diameter and up to 5 cm deep below the bedrock surface. It contains minor contaminating material (dust) from the overlying packed earth. It's typical purple Cape Riva tuff ~1.5 kg.

Sample SAN-029 is bedrock taken below the site of sample SAN-022. ~1 kg of rock fragments up to ~6 cm. Centered on 68 south, 20 west EWC from an area up to 9 cm deep below the bedrock surface. A square area about 15 cm across.

WWM 9/6/93

SAN-030 is the bedrock sample from below SAN-023 in chunks up to 10 or 12 cm across; located 102 cm S 13 cm W by EWC and up to 7 cm deep below bedrock surface. It's typical Cape Riva - taken from an oval area about 20 cm in diameter.

SAN-031 is bedrock from under SAN-024; centered at 14 S, 54 cm W by EWC it is up to 8 cm deep. It's the same tuff in chunks up to 5 cm across. Some surfaces are notably weathered to a whiter material. Taken from a rectangular area ~15 x 20 cm.

SAN-032 continues the saga under the point where SAN-025 was taken. A bedrock sample in chunks. Taken from a rectangular area ~ 15 x 20 cm centered on 60 W, 68 south by EWC. The sample was collected from an

WM 9/6/93

area up to ~ 7 cm deep below the upper surface of weathered bedrock

SAN-033 is bedrak taken underneath the sites of SAN-027. It's generally the same as the other bedrock samples of this series. Centered on about 50 cm W, ~~91~~ 100 cm S 9/6/93 by EWC. The hole area is a rectangle ~15 x 20 cm and up to 5 cm deep.

026 WM 9/6/93

The hole where SAN-~~027~~ was extracted was enlarged and deepened to a roughly uniform depth corresponding approximately to the maximum depth of material in SAN-~~027~~. WM 9/6/93

026

SAN-034 is (orginally) two bedrock fragments taken below the site of sample SAN-~~027~~ -026 WM 9/6/93. Each has one surface with

WM 9/6/93

a white coating. This is the west surface of the major N-S fracture. SAN-035 is ~400 g of bedrock from the rest of the enlarged area under the site of sample SAN-026. The site of samples SAN-034 and SAN-035 is now a hole centered 83 W, 100 cm S by FWC and 17 x 15 cm in cross section and ~12 cm deep maximum.

WMM 9/6/93

9/7/93

Following removal of the second layer of samples from the array of seven sites the were all cleaned to a depth corresponding to approximately the base of the last sample material.

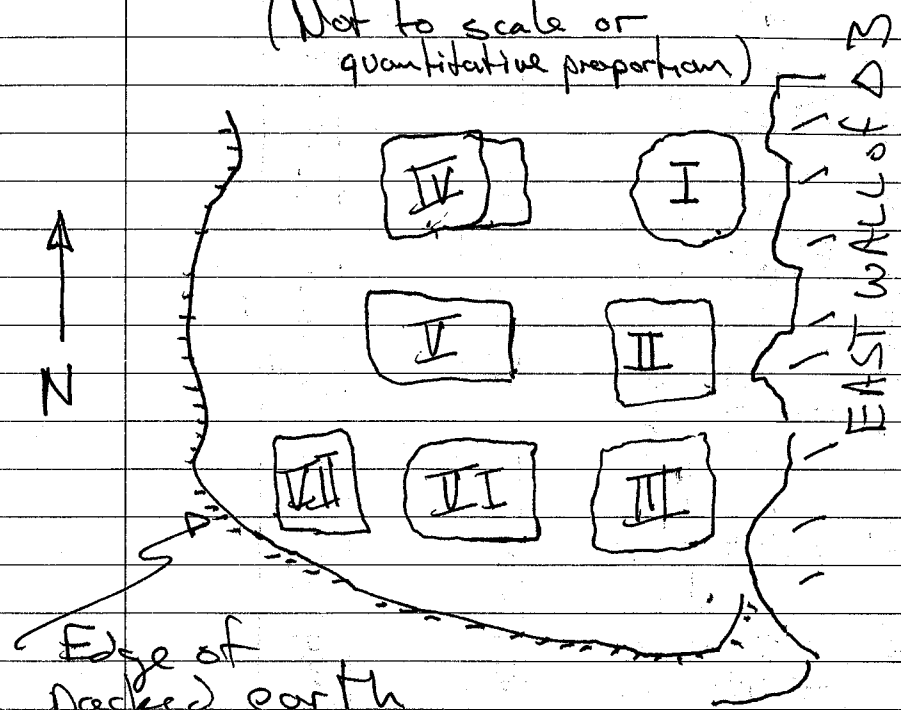
Roll 2 photos 10 and 11 are of the floor of Δ3 after two levels of samples were taken and holes were levelled and swept.

WMM 9/7/93

Photo 10 without flash has a long exposure time. Photo 11 used the flash with a low (?) battery.

The holes now have the following configuration:

(Not to scale or quantitative proportion)



WMM 9/7/93

Matrix of samples from floor of Δ3

(from sketch on page 111)

Hole	I	II	III	IV	V	VI	VII
Horizon 1	SAN-021 P.E.	SAN-022 P.E.	SAN-023 P.E.	SAN-024 P.E.	SAN-025 P.E	SAN-027 W.B.R.	SAN-026 B.R. w/ F.
Horizon 2	SAN-028 B.R.	SAN-029 B.R.	SAN-030 B.R.	SAN-031 B.R.	SAN-032 B.R.	SAN-033 B.R.	SAN-034 B.R. w/ F. SAN-035 B.R.
Horizon 3	SAN-036	SAN-037 B.R.	SAN-038	SAN-039	SAN-040	SAN-041 B.R. w/ F. SAN-043 B.R.	
Horizon 4	SAN-044	SAN-045	SAN-046	SAN-047	SAN-048	SAN-049	SAN-050 B.R. w/ F. SAN-051 B.R. w/ F. SAN-052 B.R.

B.R. Bedrock
P.E. Packed Earth
W.B.R. Weathered Bedrock
B.R. w/ F. B.R. with fracture

LLM 9/7/93

Samples SAN-036 through SAN-03-041 is a series of
LLM 9/7/93
samples from holes I to VII, respectively. All are typical purple Cape Riva tuff with pumice and rock fragments in fragments up to 10 cm in maximum dimension. All samples were taken from horizon 3 according to the table on page 112. Depths from the interpolation of the bedrock surface in each hole to the approximate maximum dept of the hole after removal of these samples are: 10 cm for all.

From hole VII in horizon 3 two samples were taken. SAN-042 consists of (orginally) 3 fragments of bedrock each with one weathered surface corresponding to west surface of the major N-S fracture. SAN-043 is additional material from this hole. The maximum depth of the hole is ~ 15 cm after sampling.

LLM 9/7/93

All seven holes were deepened to approximately the level of the deepest part of the hole and debris and most dust were removed by hand. Thus the ground was prepared for a fourth horizon of samples.

Photos 12 and 13: Pictures of Pearcy taking samples from horizon 4. Flash appears to be working well.

The controversy yesterday (9/6/93) concerning the metal fragments associated with the bed was resolved when I looked at one that Alexandra had removed. It was non-magnetic, oxide stained, and had a quartz phenocryst. Conclusion: it's a rock fragment.

Photos 14 and 15. Views of two fragments taken from horizon 4 of hole VII. Both have surfaces that show weathering along perpendicular surfaces N-S and E-W. The samples are from the NW quadrant of the

WMM 9/7/93

intersection of these fractures. Photo 14 is a view from the south looking at the E-W fracture surface. Photo 15 is a view from the SE looking obliquely at both surfaces.

Hand lens examination of the surfaces showed nothing exceptional. Some filaments could be calcite. Some darkly red/brown stained material could be oxidized rock fragments.

The longer fracture edge of both is the EW fracture. A mark TOP1 is written and TOP2 is written on the top SE corner of the upper and lower sample respectively.

The upper and lower of these fracture wall samples are recovered as SAN-050 and SAN-051, respectively.

Samples SAN-044 through SAN-049 and SAN-052 are unremarkable samples of bedrock from sites I to VII, respectively, on horizon 4.

WMM 9/7/93

After horizon 4 sampling: maximum depths from bedrock surface to hole bottoms are given approximately in the following table:

Hole	Max. Depth (cm)
I	14
II	14
III	13
IV	12
V	14
VI	15
VII	20

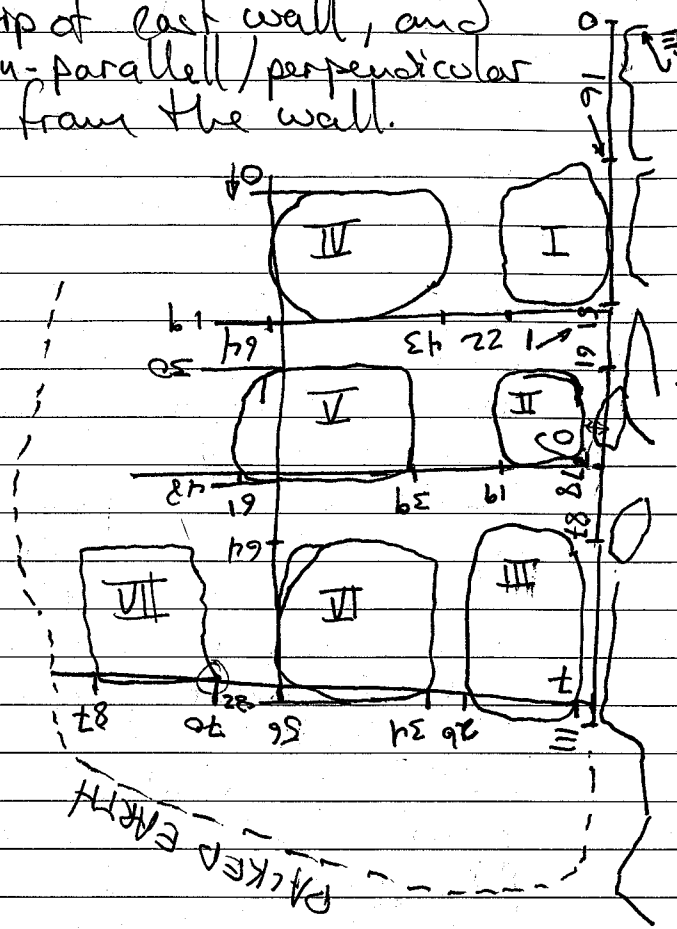
Photos 16 and 17 of tension infiltrometer test of Cape Riva tuff in the area just east of the east wall.

Photos 18 and 19 are a view from Δ3 from the south after horizon 4 samples were taken and holes cleaned, and a view of Δ3 and the tension infiltrometer test.

WWW 9/7/93

(Semi-) Quantitative Map of Sample Holes After 4th horizon sampling (Marked dimensions are correct - Drawing distorts scale)

Values in CM from north tip of east wall, and in non-parallel/perpendicular lines from the wall.



The southeast corner of hole VII is directly under the high, roughly N-S reference line 1.26 meters south of the intersection of that line and the lower E-W reference line. Ref. map + notes by Pearcy. WWW 9/7/93

Data on preceding page was incorporated in Pearcy's map.

Photos 20 and 21 were taken of a worker carrying out a cast of a skull found two rooms south and one room east of △3.

Based on the Nat'l Geographic photographs, particularly the one, taken early with a single worker brushing the large pan, the pan elevation appears to be within 10 cm of the top of the angled rock. The top of the large ewer appears to be about the angled rock in the east wall. In contrast the photocopied image of KR35F23 (?) seems to show the large ewer below the smaller rock which is N and lower than the angled rock. Probably the ewer had been moved down at the time of the latter photo - there is considerably more excavation.

WW 9/7/93

Eyeball placement of the two large pan photos from Nat'l Geographic indicates the apex of the bottom of the inverted pan was roughly centered on the angled rock and ~10.5 cm below the crossed-string reference frame (see notes by Pearcy).

The big ewer appears to angle upward at about 30°, so its projected cross section in the plane of the figure drawn by Pearcy is approximately 40 cm.

WW 9/7/93

9/8/93

Depths in sample holes relative to ground surface. A reference point is associated with the SW corner of each hole measurements relative to that point of the top of the bedrock and bottom of the hole are taken.

WW 9/8/93

Hole	Ref. SW Corner Ground Surface* (cm)	Top of Bedrock** (cm)	Bottom of Hole**
I	144	3	17
II	150	1	15
III	151	0	13
IV	140.5	1	13
V	146	0.5	16
VI	149	0	17
VII	148	0	23

* These values are measured down from the cross horizontal reference lines which Peary refers to as 23.97 m (above sea level reference) to archeologist survey point (see notes by Peary.

** Relative to reference corner downward.

All measurements are approximate.

JLL 9/8/93

Considerable erosion of the packed earth cover occurred during mining of the holes, so the surface of the packed earth is now lower than when originally measured.

Data in the table on page 120 are similar to, but differ from data in the table on page 116 for the following reasons. The first set is the difference between the bedrock surface, interpolated over the hole to a rough maximum depth. For the "top of bedrock" measurement on page 120, the point was near the SW corner of the hole, not interpolated. Nevertheless, the difference between "bottom of hole" and "top of bedrock" in page 120 should generally correspond to the independently measured numbers on page 116, which they do. Slightly deeper maximum depths measured in the latter data set are the main reason for small discrepancies. JLL 9/8/93

Photos 22 and 23 show the positions of two tension permeameter positions ~~west~~ east of Δ3, and relative to Δ3. WM 9/8/93

Photo 24 shows Green and Pearcy with gear east of Δ3.

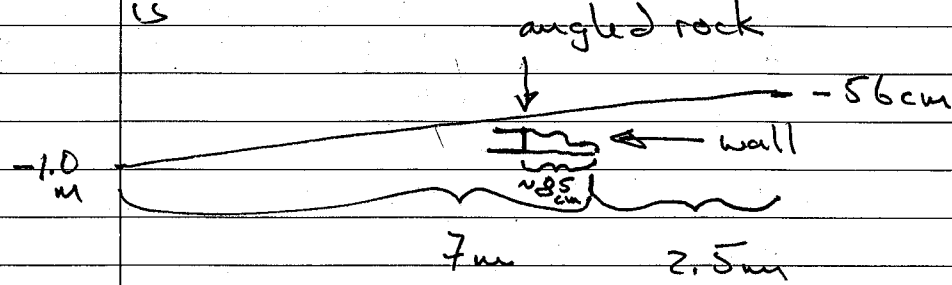
This ends roll 2 of Santorini '93 slides.

Examination of sediments associated with the "torrent" and the stream bed that existed prior to excavation.

Field notes and reports of the 1970 investigations indicate that the east wall of Δ3 was below the level of the stream prior to excavation. A reasonable lower limit to the stream bed is provided by the top of a preserved wall 7 meters south of the north end of the east wall of Δ3. It is about 1 meter below the 23.97 meter above sea level reference plane. The top of the

WM 9/8/93

angled rock is 90 cm below this plane. The minimum elevation of the former (and likely excavated) stream bed to the north of Δ3, approximately at the north side of its north wall, ~2.5 m north of the north end of the east wall of Δ3, is 56 cm below the 23.97 reference. By rough linear interpolation, the minimum stream bed is



$$-.56 - \frac{3.35}{9.5}(1.0 - .56) = -71.5\text{cm}$$

Thus I estimate at least ~20 cm of cover over the angled rock.

Roll 3 photos 1 and 2 of Guelph permeameter study east of Δ3 (w/ tourist cadre).

WM 9/8/93

Photo archives were reviewed with help from Annie

The photo labelled 85/1456 in the archives of the site is labelled "Section Δ entrance Δ5." It shows the area of Δ5, Δ4, the staircase behind Δ3, and probably Δ8A, early during excavation. Walls were generally buried. The torrent path and area of Δ3 are just outside the view. 75/882 is another early photo; it is labelled "South part of bldgs B and F from east".

Photo 85/1654 shows an early view of Δ3
"Sector Δ, Δ3, picture from east to west"

Photo 85/1657 a photo that is even earlier shows the collapsed upper floor + hole of the cellar

Photo 76/25 shows more or less the present excavation of Δ3

WM 9/8/93

Photo 85/1663 is a view downward on the original bronze configuration in Δ3

Devetzi, Tania

Photos listed above and a copy of the site map in sizes of approx. 20 x 30 cm and 1 m x 0.5 m were requested from Tania Devetzi who has responsibility for archives.

WM 9/8/93

9/9/93

Gypsum block water pressure blocks are in place in the west wall of the ravine (#2) and under the roof near the south-east end of the excavation, #3 to the north and #4 to the south of the hydrology study area of Green. These are monitored by measuring resistance with a meter connected to two wires.

WM 9/9/93

The vacuum lysimeter is in place near the site of gypsum block #3. It has Tesco hoses. It is pressurized and pressure is measured with a pump and guage using the hose with no coupling. If water is collected in the lysimmeter it can be extracted from the tube with the fitting which goes to the bottom of the lysimeter. Water can be pumped out with the same pressorizing pump into an erlinmeyer flask. the lysimeter is ~10 inches tall and its bottom is ~2 feet deep at this site.

Near the southeast corner of the roofed area a vertical wall of Minoan tuff is exposed. It is the air fall pumice rich light gray tuff of phase 2 (?) of the eruptive sequence. It is stratified with individual layers having more or less and larger and smaller pumice lapilli. Here Ron Green is collecting short

WM 9/9/93

core samples from the vertical wall by hammering a copper pipe with one end taped closed into the wall.

SAN-COR-001 was collected from a zone of pumice lappilli ~2 to 3 mm in diameter in a matrix of very fine ash. This horizon is about 50 cm below one containing abundant clasts that have oxidized to a hematite-colored oxide stain. This is the intermediate size core.
SAN-COR-002 was collected from the same horizon ~15 cm away from the former sample. This is the large size core.
SAN-COR-003 was collected ~20 cm from SAN-COR-002 from the same horizon about 5 cm lower in the section. This is the small size core.

Units with coarser pumice lapilli are too coarse for representative samples to be taken in the cores, although they make up most of the stratigraphy.

WM 9/9/93

A hole was dug in the hydrology study area near the infiltration study sites at a depth of 60 cm the ash is a very fine grained matrix with rock clasts up to 1 cm across, but mostly < 2 mm. SAN-COR-004, a large diameter core sample was taken here. SAN-COR-005 and SAN-COR-006 were also taken from the bottom of this hole, intermediate and small size cores respectively. The ash is is notably moist due to color and absence of dust.

Photos 3 and 4 of roll 3 are of the hole from which core and TDR data were collected, and the wall from which core were collected, respectively. In the latter the core samples were taken from the area adjacent to the hammer near the bottom of the frame.

WM 9/11/93

Photos 5, 6, and 7 are progressively closer views of the east wall of Δ17 which is east and ~~west~~ south of Δ3 and east of Δ8 across the ravine. At the south side of this east wall alluvial deposits occur interbedded mainly with building debris. There are pot sherds among the debris. Sediments are a heterogeneous mixture. A dominant component is dark colored sand with grains up to 1 mm. Larger light colored lithic fragments are mostly less than 5 mm but rarely up to 2 or 3 cm. The sherd is at least 3 cm in its flat dimension. Above a sand and lithic fragment set is fine light brown sand or silt with a limited interbed of pumice mostly 2 to 5 mm across. Above this is more dark sand and lithic fragments.

WM 9/9/93

Photos 8 and 9 are of Green's infiltration test in the cellar of Δ3

WM 9/9/93

Above the upper sand is a thin mud-like layer which is at the level of the neck of the hammer in the photos. This layer is ~5 mm thick and dips steeply, e.g. up to 30° to the east. Elsewhere beds dip in the opposite direction or are flat.

All material is very friable and easily dislodged by gentle brushing.

A slightly more resistant but highly friable fine grained mud occurs in a vertical plane striking ~ perpendicular to the wall. It rises from the lower sand and lithics unit through the fine sand unit and terminates at the pumice and dust which overlies the mud-like layer. It could be a water escape structure.

ARI KAMBOURIS

a photographer who works for Doumas and the British School at Athens is photographing the consequences of the work at Δ3. We supplied two rolls of color slide film. He is using a blue filter to compensate partially for the yellow roof. Development could also partially compensate. Half the photos will go to Doumas and the site files. He will also take some black and white photos and provide us negatives.

9/9/95

Photos 10 and 11 are of a room well illuminated showing some sediments and holes casts of building logs.

MM 9/9/95

Photos 11, 12, and 13 and 14 are of Ari taking photos of Δ3 from the rafters.

9/10/93

English and Ron leave on separate airplanes in the morning. I retain equipment for monitoring the gypsum block water pressure devices, and for checking and extracting water from the lysimeter

Date	Lysimeter pressures (centibars) initial	pumped	time
9/10/93	72	85	12:22
9/12/93	69	~80	11:38
9/13/93	74	84	9:30
9/14/93	75	86*	11:23
9/16/93	72		11:08

*after sampling see pg 142

Data recorded on these pages represent by Ron Green prior to his departure field book CNWRA 23. Refer the semiannual research report a discussion of data and

Gypsum Block Water Pressure Measurements with Model 5910A. Soilmoisture Meter adjusted to 100.

Date	Time	Reading	Site
9/10/93	11:41	54	#2
	11:52	61	#3
	11:53	60	#4
9/12/93	11:28	55	#2
	11:35	60	#3
	11:36	62	#4
9/13/93	8:53	55	#2
	9:28	59	#3
	9:28	62	#4
9/14/93	10:47	56	#2
	11:01	59	#3
	11:01	62	#4
9/16/93	10:58	56	#2
	10:43	58	#3
	10:44	61	#4

a continuation of data being collected on 9/10/93 as described in his to Ron Green's field notes and CNWRA 93-025 chapter 5 for results. 6/20/94

Nicolas Vasalos a farmer owns? farms 26 stramata (an area) with grapes, etc. Thanks to a translation by Ari I obtained anecdotal information on the small stream that once traversed the site. The following is basically the information he provided without much interpretation. The last five years, preceeding the 92-93 winter were very dry. The stream did not flow. This past winter there was a first heavy storm to the east that caused landslides and mudflows, but it did not rain hard at Akrotiri. The second storm was hard at Akrotiri and the stream cut some new channels. Water flows after heavy rains for a short time to the sea, then the ground remains moist. The water depth in the stream can be waist deep (≈ 35 cm). The

WM 9/10/93

water depth and flow in the stream to the east can be greater. It has a larger basin area.

Slate floor stones that were removed from the area east of the east wall of △3 were placed over the sample holes I – VII, which are well hidden. Photograph 15 documents the covered holes. Moving the rocks was sweaty work and the bottom of page 134 suffers as a consequence. Photograph 16 additionally shows the covered holes and placement of a large rounded boulder over the auger hole for the infiltration study. This rock was moved about 1/2 meter to the west.

WM 9/10/93

I approached the office at the study area near the back gate. Annie had just opened a bag.

" Δ3 9/9/70

X 4

Daybook 5 page 93"

was on the ~~table~~ label. It contained fragments of bronze collected from Δ3 on 9/9/93 ~~70~~ from the ewer X4, which by deduction is either the large ewer or the small one; not the spiral ewer and probably the large one. She gave me numerous fragments of it, perhaps weighing 100 mg. They're mostly green corrosion products and a few grains of ash, but two larger pieces are about 1 mm thick and probably have relatively fresh bronze at their centers.

This sample is called Δ3 X4 for now. MM 9/10/93

The remainder of the day was first spent identifying rocks for Annie. They were mostly obsidian ropy flow rocks, and one spherical (~ 30-40 cm diameter) block of (probably) cerrusite. It was dense. - Probably lead ore from Siphenos (?), imported by the Minoans.

I reported Cretes hole in the bottom of the cellar of Δ3 to Alexandra, and I made an appointment to meet with Doumas on Monday to discuss examination of sediments in the site.

In wrapping things up w/ Doumas these are issues:
- Photos
- Letter announcing collaboration and priveledge
- Continued interest, particularly to be notified when metallic artifacts are extracted.
- Status of Δ3 and samples

MM 9/10/93

9/13/93 Measurements for hydrology were taken on 9/12 and 9/13 (see pages 132 and 133.

Three photos were given to Doumas with notification that they are for our research purposes. He was duly thanked, and he particularly expressed his interest in our work and recognition of our respect for the archaeology and the ruins. He granted permission to examine the sediments in the site.

The whole roofed site was explored for the sediments. They occur in thick deposits extending to the ground surface around the margins of the site, i.e. in the walls of the excavation. The most northerly exposure under the roof is of this form and occurs at the level of the roof in the east wall east of the house of the ladies.

Deposits on the east wall of room Δ17 were described previously. These can be traced all along the east wall of Δ17 and continuously along the south wall where they become thinner and dip generally (the bed, not the bed structures) to the west. They occur again on the outside of the east wall of Δ8 where they are thin, e.g. 30 cm and overlain by building debris. It appears that a mixture of these sediments and building debris is exposed on the east facing termination of the north wall of Δ3, but sedimentary structures are hard to detect here.

Sediments can also be seen in the east facing window of Δ17. Although material seen by looking in the east windows and door of Δ18 and 19 is a dirty ash.

Then looking in the north window door of Xesté 2, which is near the NW corner of the building,

NMM 9/14/93

and only a meter east and 2 meters south of Δ19, sediments are observed overlying clean fine ash. The half meter of section observed through the window grades strongly to fine material upwards.

However, the sediments appear to fill this room at its north end, which may be a thickness of 5 meters +. Although the ground surface is covered with fine ash dust, digging into it reveals it to be dust covered coarse gravels of the sedimentary type. The gravels also appear in the tops of walls that are incompletely excavated to the east, and a scoured channel of gravels is revealed in the east wall of excavation.

WM 9/14/93 ~~Nevertheless, a pilon is burr~~

Nevertheless, a pilon 10 meters south is in a hole dug completely in ash. In the hole of the next pilon to the west gravels are exposed scoured into ash up to the excavated

WM 9/13/93

surface.

On the east facing wall surfaces on the east side of room B1 and the wall between B8 and B6 sand has been deposited on ash and has clearly filled in around holes that were structures for the rooms. Above the sands is a second (?) story wall.

Photos 17 and 18 of sediments on the NE corner of Δ17 and the outside of the east wall of Δ8, respectively.

Photo 19 of scoured deposit in east wall of excavation east of Xesté 2.

Review of volcanic stratigraphy suggests that the massive, widespread "gravel" deposits are the phase of mudflow (?) of the volcanic Minoan eruption. I postulate that the finer materials resembling these deposits were deposited in

WM 9/13/93

cavities remaining in the buildings at the time of phase 4.

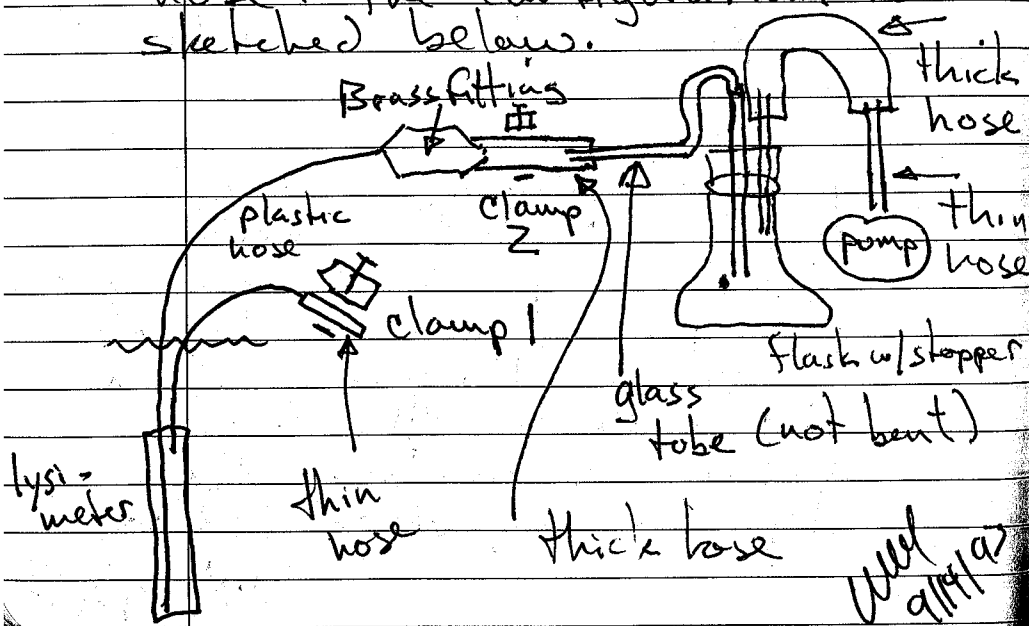
WMM 9/13/93

Sediments were also observed in a room in the house of the ladies. WMM 9/13/93

9/14/93

Water sampling was accomplished.

To place a vaccum on the erlinmeyer flask a short section of the small hose was inserted in the end of the big hose. The pump works only on the small hose. The configuration is sketched below.



WMM 9/14/93

The erlinmeyer flask was evacuated to about 75 centibars suction which is equivalent to the value measured in the lysimeter (page 132). Clamp 2 was openned, then clamp 1 was openned, then the pump was used to pull water into the flask. Approximately 40 to 45 ml was collected. About 40% of this was decanted from the flask to bottle A1 OCL 8-26. The remained was decanted into a 9/14/93 bottle labelled C1-SAN 9/14/93. The flask and attached tubes were rinsed with DI water and placed in a sunny spot to dry.

The water is very clear although a few fine sand grains and a few fragments of rubber hose were left in the flask after decanting.

Clamps were replaced and the lysimeter was (un)pressurized again to 86 centibars.

WMM 9/14/93

Photos 20 and 21 of roll 3 were taken of the flask and pump set up with water in the flask.

I took a long walking tour around the inside of the site fence. A second small drainage drains the area east of the site. The larger stream further east drains only from the top of the cliff on its west side adjacent to the site, but it has a large basin to the north. The boundary between the two smaller drainages is vague because the land is under cultivation. The two smaller streams converge just below the site. Below the site the drainage system bottom has been occupied by the road to the beach, i.e. it's paved. Above the site the small stream has been mostly under cultivation. No semi-natural stretch of this stream exists.

WMM 9/14/93

WMM 9/14/93

The major stream ~~north~~ east of the site appears to have been graded or channelized artificially. It is straight and of a roughly constant width. Nevertheless there are sediments along its channel in a somewhat braided configuration. These sediments are mostly sand to small gravel sized, dark lithic fragments, sometimes with finer white ash as matrix. There are also occassional large blocks/ 9/14/93 boulders up to 30 cm ~~stream~~ or greater. Excavating into one braid deposit I found a zone of fairly well sorted sand in a horizon <1 cm thick. Most sediments are poorly sorted. The stream is actively eroding its channel, and there are no bank deposits. The sediments in this channel bed resemble those deposited near Δ3 in Δ17 generally.

WMM 9/14/93

To get a better idea of the geographic orientation of S3 I took a Brunton compass reading of the line of pilons that we used as our E-W reference line at S3. I'm unaware of the magnetic declination so a correction may be required. The compass is set 11° E (magnetic north relative to true north). Is this Texas? Peña Blanca? With this setting the line of pilons is S 86° E. That is relative to magnetic North the pilon line is N 83 W. (mag)

Another small drainage exists to the west of the site at the base of the hill on which (modern) Akrotiri is built.

Comparing my visual inspection of the landscape with the travel map obtained on the island which has topography, it appears that

WM 9/14/93

the map gives a remarkably good representation of topography. This map is made by

DOURAKOS
ATHENS: THA. 6924712

of Santorini. I sketched the outline of the small drainage that fed the stream through the site (and S3) on this map.

WM 9/14/93

9/16/93

Return to Akrotiri for final visit of the trip. Having returned the car, transit was by bus, taking 1 hour from Kamari with transfer in Thira.

Gypsum blocks were monitored and data recorded on page 133.

The flask and tubes contraption pictured on page 142 was reconfigured. Pressure on the lysimeter was 72 centibars suction. The flask was evacuated to about this suction

WM 9/16/93

The clamp between it and the lysimeter was opened, then the clamp at the other (air) line was opened and air was pumped out of the flask. One drop of water was extracted into the flask and not collected.

By hand and with a garden trowel the auger hole in which the lysimeter was placed was laboriously re-excavated. The top of the lysimeter entry (initial 9/16/93 corrections) was found a a depth of 41 cm below the ground surface. It became evident that to extract the lysimmeter a rather large hole would have to be dug adjacent to the auger hole. This was also achieved laboriously with the use of a trail shovel, the spade/trowel and hands. The lysimeter was removed and dusted off by hand and by blowing. Pressure was restored by

WWW 9/16/93

opening the clamp on the air (top) hose. Then the hoses were disconnected from the lysimeter and a few milliliters of water was decanted from it into a bottle labelled AZ OCL 8-26.

The lysimeter is 25 cm long and the tube connectors are about 2 cm tall. The bottom of the lysimeter was then 68 cm below the ground surface. The center of the lysimeter hole was 50 cm south of the gypsum block location #3.

The hole was refilled with cash.

WWW 9/16/93

of this notebook
Pages 1-149 were reviewed for compliance with QAP-001 in response to CAR 94-02. Corrections and clarifications were made as appropriate.

Verified by: Randy Folck
SWRI-QA
7/12/94

The Natural Analogs Project has been terminated.

This scientific notebook is complete.

WEL 3/12/96