CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

Title of Experiment:

Stratigraphic, sedimentologic, and structural characterization of the alluvial basins in the Yucca Mountain Region, especially those down gradient from the potential repository.

Names of Individuals Performing the Activity:

Dr. John A. Stamatakos, CNWRA Senior Research Scientist (PI)
Dr. Kenneth Ridgway, Consultant, Professor of Geology, Purdue University
Dr. David A. Ferrill, CNWRA Senior Research Scientist
Dr. Darrell Sims, CNWRA Research Scientist
Dr. H. Lawrence McKague, CNWRA GLGP Element Manager

Description of the Objectives:

The aim of this research is to define the stratigraphic, sedimentologic, and structural elements of the alluvial basins in the Yucca Mountain Region, especially those down gradient from the potential repository. These geologic elements will be important for developing a 3D model of the alluvium as input for groundwater flow characteristics in the saturated and unsaturated zones.

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Scientific Notebook 312

Entry: Kenneth D. Ridgway
Project: Stratigraphic, Sedimentologic, and Structural Characterization Experiment: Stratigraphic, sedimentologic and structural characterization of the Yucca Mountain alluvium.

Purpose: Description of first subtask of the experiment

The first subtask of this project is to define the stratigraphic, sedimentologic, and structural characteristics of the alluvium in Forty Mile Wash and Jackass Flats near Yucca Mountain. Alluvium is often characterized by extreme variations in texture and sorting that create complex permeability relationships and groundwater flow paths. Data collected during the first subtask will provide information on the lateral continuity of individual lithofacies, horizontal and vertical barriers to flow, and permeability and porosity properties of specific lithofacies. Understanding the heterogeneity of the alluvium will help delineate aquifers, aquitards, and aquicludes. By defining the basic geologic elements of the alluvium, a framework will be established that will permit realistic hydrogeologic modeling of the behavior of groundwater and contaminants in the Yucca Mountain area. Data collection will involve samples from outcrop and from subsurface well cuttings and cores. The work will include both field observations and detailed examination of well data. Field observations will be initially documented in standard geological field notebooks. Pertinent observations from those notes will be copied into this scientific notebook, conforming to CNWRA QA guidance QAP-001. Sample collection and analysis will follow standard geological practices and procedures under the supervision of Dr. Ken Ridgway. On the test site, sample collection will follow DOE sample regulations in accordance with YAP-S11.4Q. The Collection, Submission, and Documentation of Non-core and Non-cuttings Samples to the Sample Management Facility for Site Characterization. Observations from those analyses will also be entered in this notebook in accordance with CNWRA QA guidance QAP-001.

5/3/99

Date: June 21, 1999

Participants: Theodore Ressler and Peter LaFemina

Subject: Field reconnaissance of Fortymile Wash.

Purpose: The upper and mid-fan regions of the alluvial fan associated with Fortymile Wash are entrenched by the modern Fortymile Wash channel. Steep slopes and cliff faces along the entrenched channel provide exposures of the near-surface alluvium of Fortymile Wash. These exposures of alluvium provide insight into the type and nature of the sediment comprising the alluvial fan and the sedimentary structure present within the sediment. The purpose of the field reconnaissance was to locate outcrops of alluvium within the entrenched channel for later investigation and description. This work is performed under project 20-01402-471 as part of the structural deformation and seismicity KTI.

Results:

Field Identification: FWBIG Subsequent Name Modification: 40MBIG[1]

Large, extensive outcrop of alluvium
Approximately 20 m in height and 500 m in length
Approximate location[2]: Northing 4073645, Easting 0553657
Cased well present on upper surface of the fan near the center of the outcrop
UE25-UZN-85 (Northing 4074130, Easting 0553324)
A stream gaging station is located at the southern end of the outcrop
No identification except for the (possible?) date of installation: 11/16/83

Field Identification: FWSouth1 Subsequent Name Modification:

Large, extensive outcrop of alluvium several hundred meters south of 40MBIG
Approximately 20 m in height and several hundred meters in length

Field Identification: FWS2 Subsequent Name Modification: 40DIST

Smaller exposure of alluvium, several kilometers south of 40MBIG
Max height 10 m and only 10-15 m in length
There is another small outcrop several hundred meters to the south of this outcrop - designated 40DIST2

Field Identification: PR1 Subsequent Name Modification: PORTAL1

Along the west side of the paved road to the portals, several hundred meters north of where the road cuts across the modern Fortymile Wash channel.

Field Identification: PR2 Subsequent Name Modification: PORTAL2

Along the west side of the paved road to the portals, several 10s of meters north of PR1
Cased well UE25-WT13 is directly across the road

Field Identification: FWN1 Subsequent Name Modification:

Located a hundred meters of so north of where the paved road to the portals crosses the modern Fortymile Wash channel.

[1] 40MBIG – Fortymile Wash big outcrop
[2] UTM locations obtained using Garmin handheld GPS unit (locations accurate within ±40 meters)

Theodore R. Ressler 6/16/00

Date: June 22-26, 1999

Participants: Theodore Ressler and Deborah Waiting

Subject: Detailed description of outcrop 40MBIG

Purpose: Initiate detailed descriptions of exposure of near-surface alluvium within the entrenched channel of Fortymile Wash: 40MBIG. The goal is to determine the types of sediment present within the exposed alluvium, the characteristics of the sediment (grain size, sorting, cementation, sedimentary structure, etc.), and how the different types of sediment present within the alluvium are associated with each other (depositional arrangement). The task will be complete using stratigraphic sections measured from the outcrop, outcrop sketches, and detailed photosequences of the described outcrop for assistance in correlation of sedimentary units between measured stratigraphic sections. The stratigraphic sections will include grain size, sedimentary structure, sorting, cementation, caliche development, and lateral continuity of delineated sedimentary units.

Methods:

Stratigraphic sections were completed approximately at a scale of 1:4 beginning at the bottom of the outcrop and working upward. The stratigraphic sections were measured approximately every 100 meters along the outcrop. The exposed sediments were broken into 'sedimentary units' based upon the composition and characteristics of the sediment. These sedimentary units are not interpretive subdivisions of the alluvium, but were devised only for describing packages of sediment similar enough to share a detailed description. Photographs of the alluvium described in the stratigraphic sections were incrementally taken during the completion of stratigraphic sections. The photographs provide a visual picture of the sediments described in the stratigraphic sections. An aluminum extension ladder was for access to portion of the outcrop inaccessible by climbing up the talus accumulations along the base and margins of the outcrop.

Maximum particle size analysis: Develops a quantitative value for the maximum particle size of a defined sediment unit. The analysis was completed by measuring and recording the long axis of the ten largest clasts in a defined sedimentary unit. The clasts chosen were ten of the largest clasts within the near vicinity (within arms reach) of where the stratigraphic section was measured. The clasts were not removed from the outcrop, so the measured long axis length may only be the apparent long axis length. The stratigraphic level within the outcrop at which the analysis was completed is noted on the completed stratigraphic section. **NOTE: It was decided in-field that the collection of maximum particle size data could provide useful information, but that the resulting information would not be relevant to the projected goals of the current research. Consequently, the completion of additional and/or more detailed maximum particle size analyses was not completed.**

Clast imbrication: Where noticeable clast imbrication was present within the alluvium, the orientation of the imbrication was measured. Imbrication measurements were completed on ten clasts and documented. The stratigraphic level within the outcrop at which the analysis was completed is noted on the completed stratigraphic section. **NOTE: Due to time constraints, it was decided in-field that sediment showing imbrication would be noted in the stratigraphic columns, but measurements of the orientation of imbrication would not be made. Consequently, only a few measurements of imbrication orientation were completed.**

Nomenclature on stratigraphic sections: The simple letter code described by Miall (1978) with slight modification was utilized for lithofacies descriptions in the stratigraphic sections. The first capitalized letter indicates whether the sediment is gravel (G), sand (S), or silt to mud (F). The second and third letters describe the texture (Table 1).

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Table 1: Lithofacies codes used in stratigraphic sections (from Miall, 1978)

Facies Code	Lithofacies	Sedimentary structures	Interpretation
Gms	massive, matrix supported gravel	none	debris flow deposits
Gm	massive or crudely bedded gravel	horizontal bedding, imbrication	longitudinal bars, lag deposits, sieve deposits
Gt	gravel, stratified	trough crossbeds	minor channel fills
Gp	gravel, stratified	planar crossbeds	linguoid bars or deltatic growths from older bar remnants
St	sand, medium to v. coarse, may be pebbly	solitary (theta) or grouped (pi) trough crossbeds	dunes (lower flow regime)
Sp	sand, medium to v. coarse, may be pebbly	solitary (alpha) or grouped (omicron) planar crossbeds	linguoid, transverse bars, sand waves (lower flow regime)
Sr	sand, very fine to coarse	ripple marks of all types	ripples)lower flow regime)
Sh	sand, very fine to very coarse, may be pebbly	horizontal lamination, parting or streaming lineation	planar bed flow (l. and u. flow regime)
Sl	sand, fine	low angle (<10°) crossbeds	scour fills, crevasse splays, antidunes
Se	erosional scours with intraclasts	crude cross-bedding	scour fills
Ss	sand, fine to coarse, may be pebbly	broad, shallow scours including eta cross-stratification	scour fills
Fl	sand, silt, mud	fine lamination, very small ripples	overbank or waning flood deposits
Fsc	silt, mud	laminated to massive	backswamp deposits
Fcf	mud	massive, with freshwater mollusks	backswamp pond deposits
Fm	mud, silt	massive, desiccation cracks	overbank or drape deposits
Fr	silt, mud	rootlets	seatearth
C	coal, carbonaceous mud	plants, mud films	swamp deposits
P	carbonate	pedogenic features	soil

All sediments observed in outcrop are unconsolidated, but the degree of sediment cementation varied. The in field degree of cementation of the sediments was described by the amount of sediment able to be removed by hand abrasion on the outcrop exposure of the sediment (Table 2).

Table 2: Nomenclature used to describe the in-field degree of cementation of sediment.

Degree of cementation	Description
Well	No significant amount of sediment grains are removed by hand abrasion of outcrop
Moderately well	Small amounts of sediment are removed by hand abrasion of outcrop, but sediment is mostly solid
Moderate	Small amounts of sediment are removed by hand abrasion of outcrop
Poor	Large amounts of sediment grains are removed easily upon touch

Results:

Two stratigraphic sections were completed: 40MBIG-A and 40MBIG-B (Figure 1). Stratigraphic section 40MBIG-A was developed from the southern most end of the outcrop. Section 40MBIG-B was developed from the outcrop approximately 120 meters north of 40MBIG-A (Figure 2).

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Table 3: Maximum particle size analyses completed.

Nomenclature: Abbreviation indicates type of test completed, test number, and location. For example, A-MPS1 indicates maximum particle size analysis 1 on stratigraphic section A. The stratigraphic location at which the test was completed is indicated on the completed stratigraphic section.

Clast long-axis dimension is given in millimeters

A-MPS1	A-MPS2	A-MPS3	A-MPS4	A-MPS5	B-MPS1	B-MPS2
160	170	160	140	130	60	230
130	150	120	160	175	50	120
150	190	150	70	110	60	100
95	190	100	65	80	100	120
90	290	110	70	165	50	90
85	190	80	100	160	110	100
60	160	90	60	90	80	90
90	150	85	75	90	No others within reach	80
80	120	80	50	65		100
85	140	85	100	75		120
A-MPS1 and A-MPS2 were obtained from the same stratigraphic interval (a laterally grading bed) with A-MPS2 from the coarser portion and A-MPS1 from the finer portion.						

Table 4: Clast imbrication measurements.

Nomenclature: Abbreviation indicates type of test completed, test number, and location. For example, A-I1 indicates imbrication orientation measurement 1 on stratigraphic section A. The stratigraphic location at which the test was completed is indicated on the completed stratigraphic section.

A-I1		A-I2		B-I1	
Strike	Dip	Strike	Dip	Strike	Dip
050	23°NW	082	40°NW	105	15°NE
070	29°NW	088	50°NW	090	23°N
052	11°NW	080	25°NW	095	11°NE
064	18°NW	080	45°NW	095	16°NE
085	11°NW	065	20°NW	095	21°NE
076	23°NW	083	14°NW	105	12°NE
098	20°NE	090	12°N	100	16°NE
077	26°NW	095	12°NE	90	16°N
061	25°NW	080	12°NW	85	12°NW
081	29°NW	084	14°NW	90	12°N

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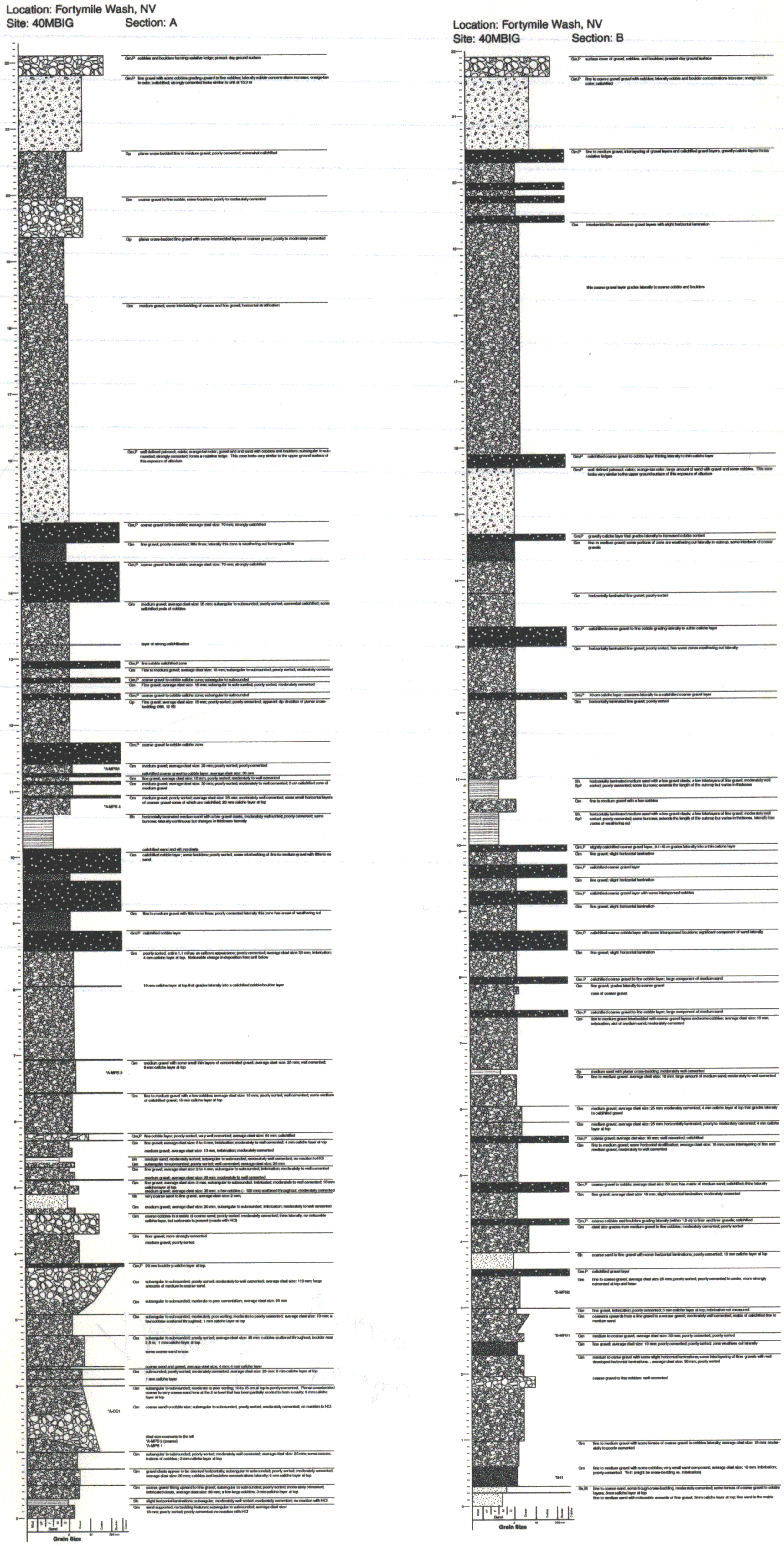
Figure 1: Developed stratigraphic sections 40MBIG-A and 40MBIG-B.



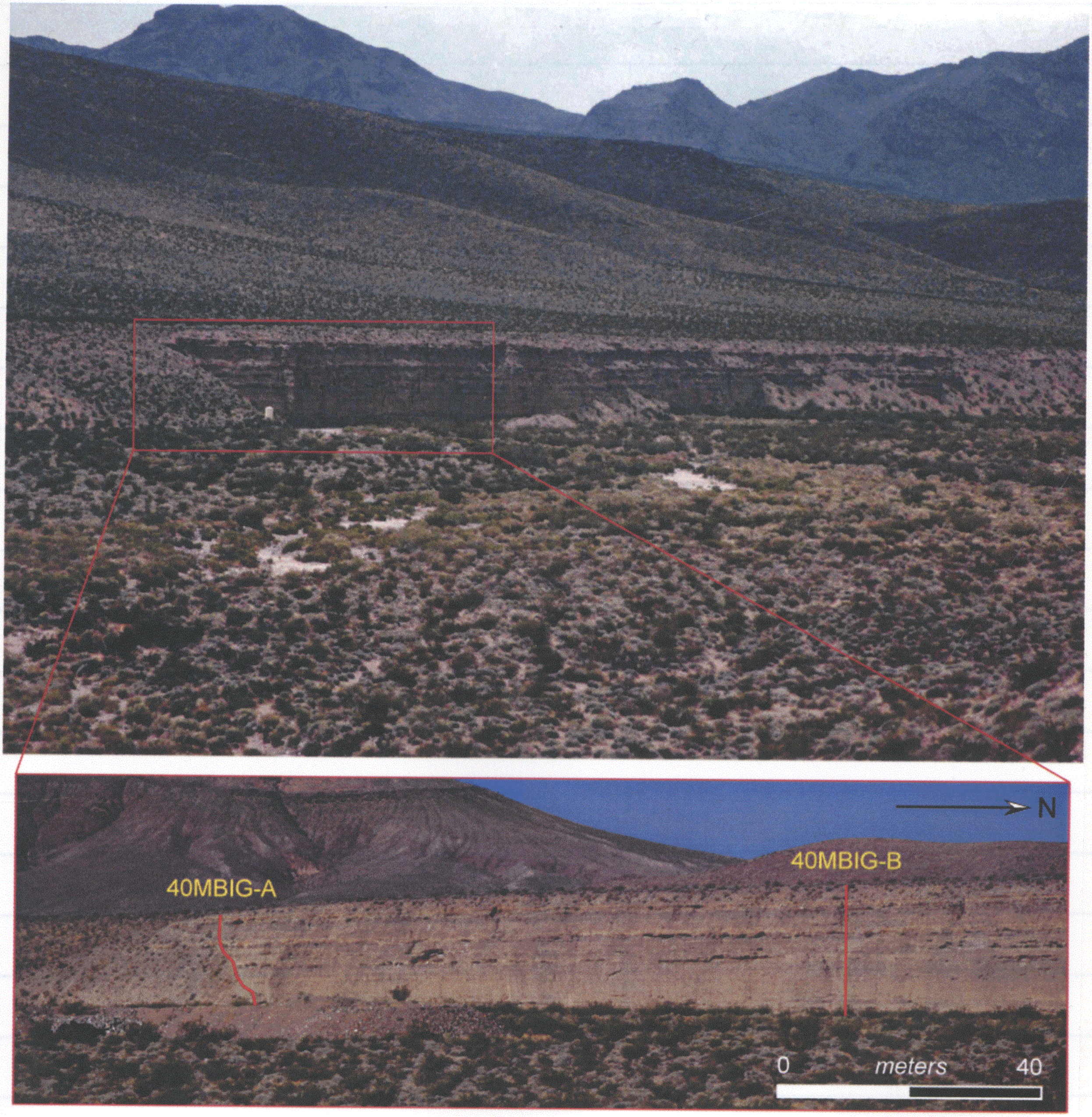


Figure 2: Overall photograph of the investigated outcrop of alluvium, 40MBIG, showing the location where the two stratigraphic sections were described.

Theodore R. Ressler 6/16/00

Date: June 26-27, 1999

Participants: Theodore Ressler and Deborah Waiting

Subject: Permeability sediment sample collection

Purpose: To examine the hydraulic conductivity (K) variations within the near surface alluvium, representative sediment samples of the near surface alluvium within Fortymile Wash were collected from the 40MBIG outcrop for laboratory permeability tests. As the goal of this preliminary sampling is to provide an overview of the permeability variations within the alluvium, sediment samples were taken from visually differing sediment types exposed in 40MBIG.

Methods: As the majority of the exposed alluvium is poorly cemented and consists of large clast sizes, the removal of undisturbed sediment samples would be quite difficult. Due to logistical constraints, only disturbed samples of the alluvium were collected. As the goal of these sediment samples is to provide an overview of the permeability variations within the alluvium, sediment samples were taken from visually differing sediment types exposed in 40MBIG (Table 5 and Figure 3). All of the sediment samples were taken from the southernmost end of the outcrop (the location where 40MBIG-A was described), as the entire sequence of sediment was easily accessible at this location (Figure 3). The methodology used in the collection of the sediment samples is as follows. A portion of sediment was removed from the outcrop face using a masonry trowel and a collection container beneath the excavation. The sediment was carefully removed so no significant amount of removed sediment was lost. The sediment was troweled from the outcrop face in as near to a rectangular shape as possible. The volume of the created rectangular void in the outcrop (from the removal of the sediment sample) was then estimated. As the mass of sediment removed came from this volume of space in the outcrop, the field bulk density of the sediment can be estimated. The estimated field bulk density will be used to constrain the re-packing of the sediment for laboratory permeability tests; thereby reducing the uncertainty associated with the permeability test results. The permeability sediment sampling sites will be photographed to document the excavation and the sediment characteristics.

Results:
Twelve permeability sites were initially identified. Upon subsequent sediment sampling, two sediment samples were not collected: 40MBIG-P4 because a representative sediment sample was not unattainable due to the large clast size component of the sediment, and 40MBIG-P10 due to similarity to the sediment of 40MBIG-P7. Additional details regarding the collected sediment samples are provided in the Sample Custody Log (TOP-004).

Table 5: Description of permeability sediment samples collected.

Nomenclature: Abbreviation indicates the outcrop and permeability sediment sampling site.			
Permeability sediment sampling site	Stratigraphic location (in references to stratigraphic section 40MBIG-A)	Volume of sediment sample (cm^3)	Sediment description
40MBIG-P1	Between 1.5 m	3150	fine to medium gravel with little to no sand
40MBIG-P2	Just below 2 m	1960	fine to medium gravel with sand
40MBIG-P3	2 m	1512	cross-bedded medium to coarse sand
40MBIG-P4	Just above 1 m	Did not collect	coarse gravel to cobble with large amount of medium to coarse sand
40MBIG-P5	Between 5.1 m and 5.6 m	Not determined – could not remove a 'definite' volume of sediment.	fine to medium gravel with sand
40MBIG-P6	Between 5.1 m and 5.6 m	1526	coarse sand to fine gravel
40MBIG-P7	Just below 6.4 m	Undisturbed sample collected, due to amount of cementation	clayey medium sand
40MBIG-P8	Just above 6.9 m	2000	fine to medium gravel
40MBIG-P9	8.6 m	2772	fine to medium gravel with little sand
40MBIG-P10	10.6 m	Did not collect	fine to medium sand
40MBIG-P11	Just above 15.1 m	Undisturbed sample collected, due to amount of cementation	calichified gravel
40MBIG-P12	Just above 15.1 m	Undisturbed sample collected, due to amount of cementation	paleosol

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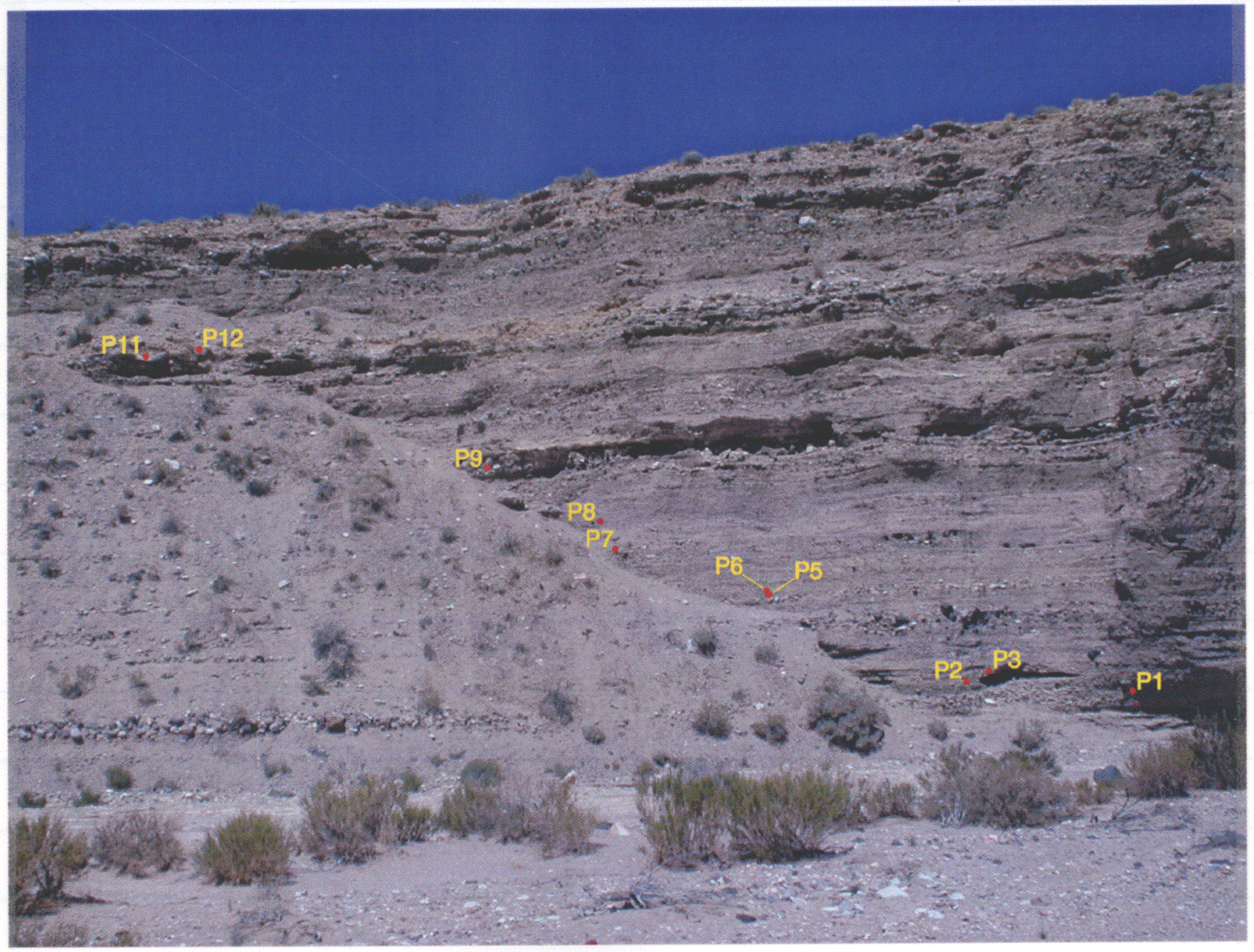

Figure 3: Permeability sediment sampling sites on the southern end of the 40MBIG outcrop in Fortymile Wash.

Theodore R. Ressler 6/16/00

Date: June 27-28, 1999

Participants: Theodore Ressler

Subject: Photomosaics

Purpose: Sequences of photographs will be taken of the 40MBIG outcrop for later assembling of mosaics of the outcrop. These photomosaics will provide assistance in correlation of sedimentary units between measured stratigraphic sections as well as providing information for subsequent offsite investigations.

Theodore R. Ressler 6/16/00

Date: July 14, 1999

Participants: Theodore Ressler

Subject: 40MBIG permeability samples

Purpose: Laboratory permeability tests of the collected representative sediment samples of the near surface alluvium within Fortymile Wash were collected from the 40MBIG outcrop. The results of the permeability tests will be used to examine the hydraulic conductivity (K) variations within the near surface alluvium. Provided that the near surface alluvium exposed within the entrenched channel of Fortymile Wash can be used as an analog to the alluvium at depth, the hydraulic properties and characteristics of the alluvium at depth can be interpreted as similar to that of the near surface alluvium.

Methods: Laboratory permeability tests were completed using a constant pressure permeameter. All sediment samples tested were disturbed sediment samples, and therefore had to be packed for testing. A split-barrel mold was used to create test specimens. Each test specimen was re-packed to its approximate in-field bulk density. The in-field bulk density was calculated from the mass of sediment removed from the outcrop and the volume of the 'space' created by the removal of the sediment. The test specimen can be re-packed to its in-field bulk density using the estimate in-filed bulk density and the known volume of the split-barrel mold.

$$\text{approximate in - field bulk density} = \left(\frac{\text{mass of sediment removed from outcrop}}{\text{volume of void created by the sediment removal}}\right)$$

$$\text{mass of sediment to pack into the mold} = (\text{estimated in - field bulk density} * \text{volume of split - barrel mold})$$

The procedure for creation of test specimens from unconsolidated sediment is a follows. Refer to permeameter schematic provided in Figure 4.

A 2" x 8" latex membrane is attached to the base pedestal of the bottom plate of the permeameter. The membrane is doubled-over on itself, just enough to have 'two layers' along the height of the base pedestal. An O-ring is then placed over the latex membrane, fitting into the grove around the circumference of the base pedestal. A 2" diameter, two-piece cylindrical mold is placed around the latex membrane and base pedestal, resting on the bottom plate of the permeameter. The rigid mold is used to allow the packing of the unconsolidated sediment into the latex membrane. The excess latex membrane extending above the mold is rolled down around the top of the mold. A vacuum is applied via a small pressure valve on the side of the mold to pull the membrane tightly against the inside of the mold.

Because the permeability of the collected sediment samples was anticipated to be quite high, a 2" diameter sandwich of filter paper, fine mesh screen, and filter paper was used in place of a porous stone between the sediment and the base pedestal and between the sediment and the top cap. The appropriate amount of sediment (to achieve the desired bulk density) is added to the mold a little at a time in between which the sediment in the mold is moistened with water and tamped 10-15 times with a 1733 gram stainless steel cylinder. For those test specimens that could not be repacked to the in-field bulk density, the test specimens were packed as dense as possible and the density achieved was determined as follows. After the permeability test was completed, the sediment from the test cylinder was carefully emptied into a sample tray and was placed in an oven at 90°F to dry. The achieved density of the test specimen was determined using the total (dry) mass of sediment that was packed into the test cylinder.

Another 2" diameter sandwich of filter paper and fine mess screen is placed between the packed sediment and the top cap. The latex membrane that was rolled down around the top of the mold is rolled up around the top cap. An O-ring is fixed around the top cap in a similar fashion to the base pedestal. The excess latex membrane extending above the top cap is rolled down over the O-ring and top cap. Vacuum grease is applied to the grooves on the bottom and top plates of the permeameter. The cell wall cylinder is inserted into the groove on the bottom plate and the top plate is placed in a similar fashion onto the top of the cell wall cylinder. The top and bottom plates and the cell wall cylinder are clamped together with the clamping rods. A 0.01% solution of degassed sodium hypochlorite

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was used to saturate the specimen and was used in the permeability tests. The mild solution of sodium hypochlorite was to keep any organisms from growing in the permeameter tubes.

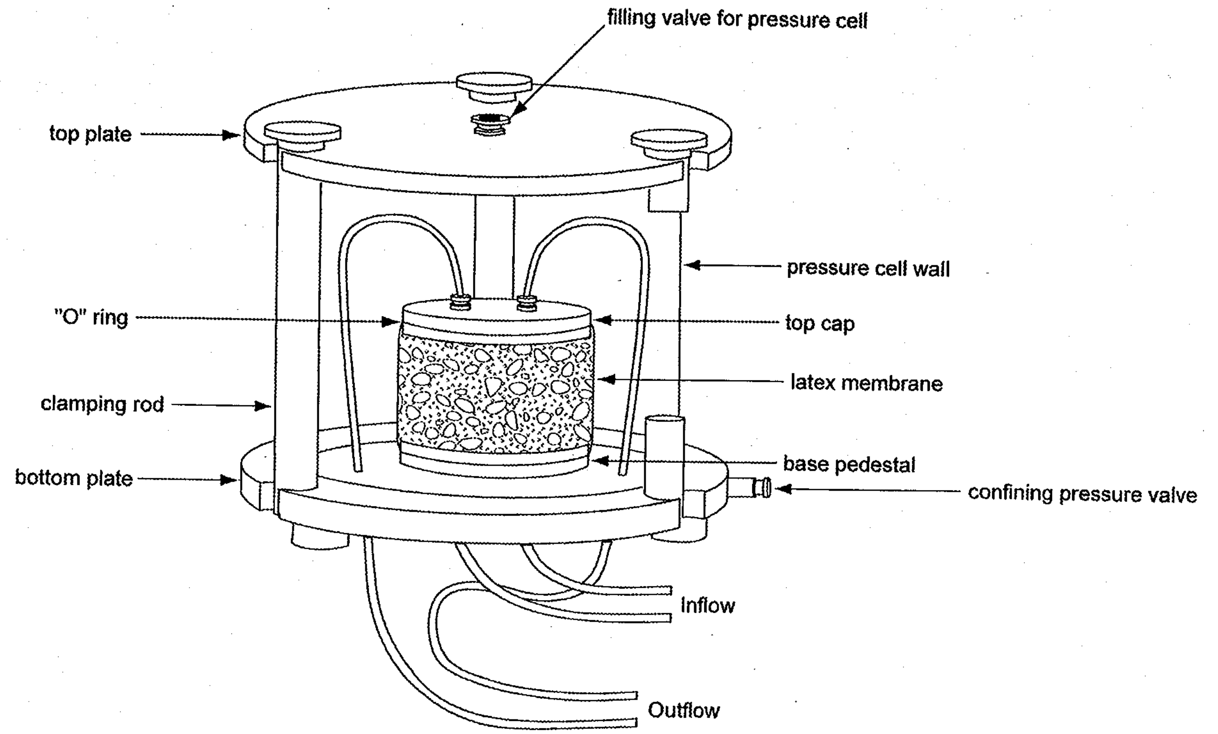

Figure 4: Schematic illustration of constant pressure permeameter used in laboratory permeability tests.

Three different re-packed test specimens were created from each sediment sample and tested to examine the consistency of the permeability test results and of the variation between repacked specimens created from the same sediment sample. For the most part, 6 test runs were preformed on each test specimen at the following pressure cell specifications: confining pressure = 20 psig, outflow pressure = 2 psig, and inflow pressure = 6, 7, and 8 psig each at 2 times. The confining pressure of 20 psig is equivalent to the pressure exerted by a 6.1 meter vertical column of alluvium (overburden) assuming an average density of 2.3 g/cm³ for the alluvium.

$$20 \text{ psi} \cong 137895.145863 \text{ KPa}$$

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Assuming an area of 1 m² and a density of 2.3 g / cm³ for the alluvium,

$$\text{Equivalent overburden} = \frac{\left(137895.145863 \, {}^{N}\!/_{m^2} * 1m^2\right)}{9.81 \, {}^{m}\!/_{s^2} * \left(2300 \, {}^{kg}\!/_{m^3} * 1m^2\right)} \cong 6.1m$$

This low confining pressure was considered appropriate for the testing of near surface unconsolidated sediment samples. Several of the more impermeable sediment samples were run with higher inflow pressures (8, 9, and 10 psig each at 2 times) to facilitate the timely completion of the permeability tests. The saturated hydraulic conductivity (K_{sat}) is calculated using Darcy's Law. The average saturated hydraulic conductivity (K_{sat}) for each of the re-packed specimen was compared to that of the other specimens for that particular sediment sample; thereby evaluating some of the variability possible between test specimens repacked to approximately the same bulk density.

Re-packed sample permeability tests will also run on undisturbed sediment samples, namely 40MBIG-P7 and 40MBIG-P12. The bulk density of the undisturbed sample was determined by determining the mass and volume of

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a small piece of the undisturbed sample. The small piece was weighed, coated in a thin coat of wax, and then submerged in water; giving the mass and volume of the small piece of undisturbed sample from which the bulk density of the sediment sample can be determined. Once the bulk density of the sediment is determined, the appropriate mass of sediment to be packed into a test specimen is obtained, smashed, and then re-packed into a test specimen for testing. In addition, permeability tests on undisturbed portions of these sediment samples will also be attempted. The completion of both types of permeability tests will allow an evaluation of how accurately re-packed permeability samples can estimate the permeability of undisturbed sediment.

Nomenclature for permeability test specimens: Test specimen ID indicates permeability sediment sample ID and test specimen number. For example, 40MBIG-P1 S1 indicates test specimen 1 from permeability sediment sample 40MBIG-P1.

Results:

Table 6: In-field bulk density of collected permeability sediment samples.

Sediment sample	Mass of sediment (g)	Volume of sampling void (cm³)	In-field bulk density (g/cm³)
40MBIG-P1	4570.8	3150	1.451
40MBIG-P2	4076.0	1960	2.080
40MBIG-P3	3842.8	1512	2.542
40MBIG-P5	3087.3	Not determined	Used 1.50
40MBIG-P6	3369.4	1526	2.208
40MBIG-P7	3628.7	Used a portion of undisturbed sample	1.65
40MBIG-P8	3017.9	2000	1.509
40MBIG-P9	3728.6	2772	1.345
40MBIG-P11	6456.7		
40MBIG-P12	2539.7	Used a portion of undisturbed sample	1.7

Hypothesis: Most of the re-packed permeability measurements will be an overestimate of the in-field (i.e., undisturbed) permeability due to the grain reorientation and cementation break-up inherent in the collection of disturbed sediment samples, accuracy of in-field estimates of bulk density, and the inability to re-pack (in some instances) test specimens to the estimate in-field bulk density.

Theodore R. Ressler 6/16/00

Date: July 15, 1999

Participants: Theodore Ressler

Subject: 40MBIG permeability samples

Purpose: Continuation of laboratory permeability tests

Results:

Completed permeability tests on 40MBIG-P1 S3; 40MBIG-P2 S1, S2, and S3 (see permeability test summary sheets).

Date: July 16, 1999

Participants: Theodore Ressler

Subject: 40MBIG permeability samples

Purpose: Continuation of laboratory permeability tests

Results:

Completed permeability tests on 40MBIG-P3 S1 and S2 (see permeability test summary sheets).

Theodore R. Ressler 6/16/00

Date: July 19, 1999

Participants: Theodore Ressler

Subject: 40MBIG permeability samples

Purpose: Continuation of laboratory permeability tests

Results:

Completed permeability tests on 40MBIG-P3 S3; 40MBIG-P6 S1, S2, and S3 (see permeability test summary sheets).

The flow through 40MBIG-P6 moved noticeably faster than that of 40MBIG-P3 although the overall texture and appearance of the two sediment samples were similar. There were noticeably less fines in 40MBIG-P6 compared to 40MBIG-P3 (very evident during the unpacking of the test specimens following the completion of the permeability tests: 40MBIG-P3 had noticeable amounts of fines accumulated on the filter paper while 40MBIG-P6 had little to no fines accumulated on the filter paper following testing).

Hypothesis: Could the build-up of fines on the filter paper be the reason for the decrease in K_{sat} over time (during successive test runs) as seen during some of the test sequences (e.g., the test runs of 40MBIG-P3). Or alternatively, could some of the decrease in K_{sat} with time result from grain reorientation during flow through the test specimen, which is supported by an observed decrease in K_{sat} during successive tests of 40MBIG-P6 which contained little to no fines.

Date: July 20, 1999

Participants: Theodore Ressler

Subject: 40MBIG permeability samples

Purpose: Continuation of laboratory permeability tests

Results:

Completed permeability tests on 40MBIG-P8 S1; 40MBIG-P9 S1 and S2 (see permeability test summary sheets).

Theodore R. Ressler 6/16/00

Date: July 21, 1999

Participants: Theodore Ressler

Subject: 40MBIG permeability samples

Purpose: Continuation of laboratory permeability tests

Results:

Completed permeability tests on 40MBIG-P8 S2; 40MBIG-P9 S3; 40MBIG-P5 S1, S2, and S3 (see permeability test summary sheets).

Due to the difficulty in the removal of the 40MBIG-P5 sediment sample from the outcrop, no direct estimate of the in-field bulk density is possible. The appearance and texture of 40MBIG-P5 is similar to that of 40MBIG-P1 and 40MBIG-P8 (i.e., loose gravel) so the target density used for the packing of the 40MBIG-P5 test specimens was chosen to be 1.50 g/cm^3.

Date: July 22, 1999

Participants: Theodore Ressler

Subject: 40MBIG permeability samples

Purpose: Continuation of laboratory permeability tests

Results:

Completed permeability tests on 40MBIG-P8 S3 (see permeability test summary sheets).

Theodore R. Ressler 6/16/00

Date: July 23, 1999

Participants: Theodore Ressler

Subject: 40MBIG permeability samples

Purpose: Continuation of laboratory permeability tests

Results:

Completed permeability tests on 40MBIG-P7 S1, S2, and S3 (see permeability test summary sheets).

There was noticeable variation in the K_{sat} between test specimens. This particular sediment sample consists of relatively loosely packed sand and gravel, consequently the bulk density is rather low compared to the other sediment samples. As a result, there was not much difficulty in re-packing the samples (i.e., fitting all the necessary sediment into the mold); on the contrary, the difficulty lay in not packing the sample too much (more than was necessary). This may have given rise to the variability observed in the permeability test results.

40MBIG-P7 had noticeable amounts of fines (clay), which was clearly evident by significant accumulations of fines on the filter paper following the completion of a test run. Additional support for the hypothesis that the build-up of fines on the filter paper results in a decrease in the K_{sat} calculated by successive permeability test runs.

Date: July 26, 1999

Participants: Theodore Ressler

Subject: 40MBIG permeability samples

Purpose: Continuation of laboratory permeability tests

Results:

Completed permeability tests on 40MBIG-P12 S1, S2, and S3 (see permeability test summary sheets).

Theodore R. Ressler 6/16/00

Date: July 27 through August 6, 1999

Participants: Theodore Ressler

Subject: 40MBIG photomosaics

Purpose: assembled photomosaics of 40MBIG outcrop for offsite analyses

Methods:

The sequences of photographs taken of the 40MBIG outcrop during the June 21-28 field period were assembled into large, detailed mosaics. These photomosaics will be used for offsite reference and investigations. The photos were arranged and joint using Adobe Photoshop.

Results:

Assembled 6 photomosaics of different portions of the 40MBIG outcrop.

Files

mBIG A.psd	Portion of 40MBIG outcrop where section 40MBIG-A was measured
mBIG A-B.psd	Portion of 40MBIG outcrop between stratigraphic sections 40MBIG-A and 40MBIG-B. Outcrop length between sections is approximately 150 m.
mBIG B.psd	Portion of 40MBIG outcrop where section 40MBIG-B was measured
mBIG B-C.psd	Next ~150 m of outcrop north of outcrop photographed in A-B
mBIG C-D.psd	Next ~150 m of outcrop north of outcrop photographed in B-C
mBIG E-F.psd	Next ~150 m of outcrop north of outcrop photographed in C-D

Theodore R. Ressler 6/16/00

Date: August 6-17, 1999

Participants: Theodore Ressler

Subject: 40MBIG photomosaics

Purpose: delineation of sedimentary units exposed in 40MBIG outcrop

Methods:

Using the developed photomosaics of the 40MBIG outcrop, the observation made during the June 21-28 field period, and the developed stratigraphic sections of the 40MBIG outcrop, the sedimentary units exposed in the 40MBIG outcrop were delineated. Drawing and illustrating was completed using Adobe Illustrator.

Results:

(Preliminary observations and thoughts)

The observed near surface sediments are predominantly characterized by a constant repetition of sand and gravel layers tens of centimeters to hundreds of centimeters in thickness with lateral extents of meters to hundreds of meters. Coarse gravel to cobble layers several tens of centimeters in thickness have a matrix of coarse to very coarse sand and are typically calichified. The coarse gravel to cobble layers grade laterally to thin caliche layers millimeters in thickness extensive for meters to tens of meters. These thin but extensive caliche layers are quite numerous in outcrop and are characteristically separated by intervals of sand and gravel tens of centimeters in thickness. These thin caliche layers are interpreted as the upper surface of a deposited package of sediment exposed to the environment during periods of non-deposition or periods of deposition on other portions of the wash.

Several distinct, laterally continuous layers tens of centimeters in thickness and extending laterally for hundreds of meters were observed in the investigated outcrop. Along the top of the outcrop, an approximately 1 meter thick unit (unit A) is interpreted as a developing soil of the uppermost surface of Fortymile Wash (Figure 5). Another sedimentary unit (unit B) of similar dimension and appearance is located several meters below the upper surface of the outcrop. Unit B is interpreted to be a paleosol. According to Lundstrom, who has investigated the development of alluvial soils in the Yucca Mountain region (Lundstrom et al., 1995), properties suggestive of a buried soil are increases in the fine fraction, increases in clay or silt content, and/or a redder color. Unit B has a substantial increase in sand content, development of a significant gravelly caliche layer near the base of the unit (possible K horizon), and a distinctly reddish-orange color. Thus, the interpretation of unit B as a paleosol seems reasonable. Unit C is a nearly continuous unit varying in thickness from a few centimeters to tens of centimeters. This unit consists of several elongate lenticular to tabular sand bodies at the same stratigraphic level. The sand bodies of unit C are interpreted as deposits of primary distributary channels of the wash. There are several other associations of sand bodies much like unit C within the outcrop at other stratigraphic levels. These are interpreted as smaller secondary distributary channels of the wash. A 3-D block diagram illustrating the interpreted structure of unit C is presented in Figure 6.

The two developed stratigraphic sections were superimposed upon a photomosaic of the outcrop between sections 40MBIG-A and 40MBIG-B to facilitate correlation of sedimentary units. The large laterally extensive units (aforementioned as A, B, and C) are easily correlated between the two stratigraphic sections. The majority of thin caliche layers and gravel layers are not laterally extensive enough for correlation between the stratigraphic sections. The gravel layers tend to form lenses extending for less than 100 meters laterally across the outcrop. The thin caliche layers are at the detectability limit of the outcrop photomosaic, making correlation and estimation of lateral extent difficult. Field observations support the lateral extent of the thin caliche layers for tens of meters, but none of these thin caliche layers were observed to laterally extend the entire distance between the two stratigraphic sections. There are several zones of intense caliche development that do laterally extend between the two stratigraphic sections, but none of the individual caliche layers are directly traceable across this distance.

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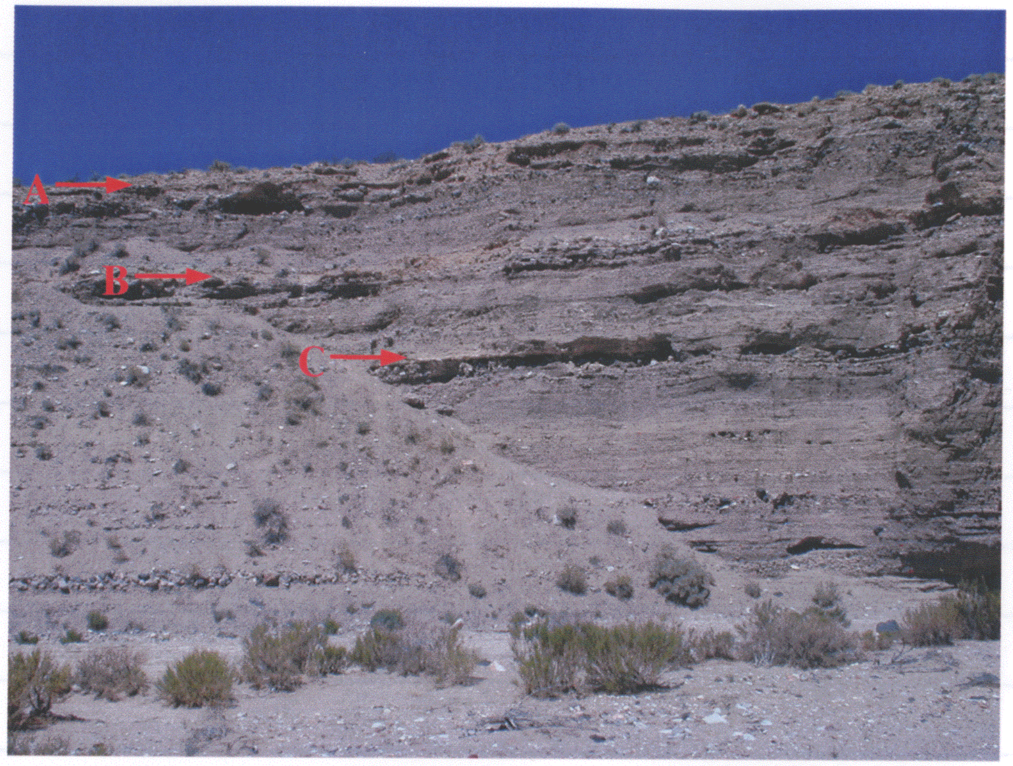

Figure 5: Southernmost end of outcrop 40MBIG. Stratigraphic section A was developed from description of this portion of the outcrop. The laterally extensive units A, B, And C are shown in the photograph.

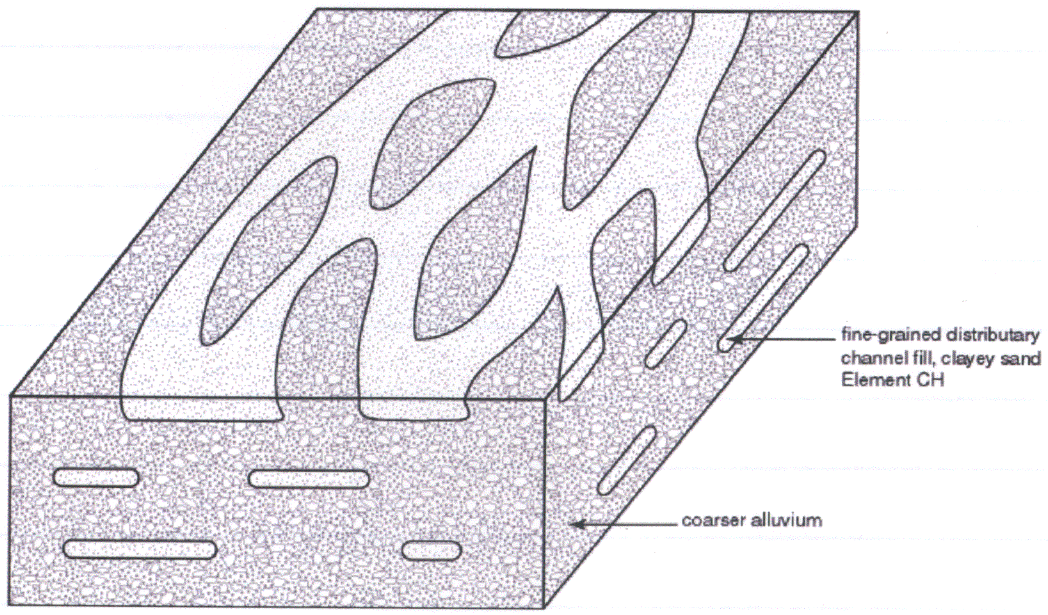

Figure 6: Interpreted sedimentary structure of lenticular sand bodies observed in near surface alluvium.

Theodore R. Ressler 6/16/00

Date: September 30, 1999

Participants: Theodore Ressler and Kenneth Ridgway

Subject: 40MBIG

Purpose: 1) Discuss work T. Ressler completed during June 21-28 field period, and preliminary interpretations made, 2) discuss objective of future field work.

Results:

The 40MBIG outcrop can be divided into 5 overall zones (Figure 7)

Upper surface of outcrop	Developing soil horizon of upper surface of Fortymile Wash fan (previously referred to as unit A)
Zone 1	Sand and gravel; layers of coarse gravel to cobbles in fine-medium sand matrix (calichified), some sand layers
Zone 2	Laterally extensive sand units (previous referred to as unit C)
Zone 3	Zone of large caliche layers with loose gravel between
Zone 4	Paleosol (previously referred to as unit B)
Zone 5	Sand and gravel similar to zone 1

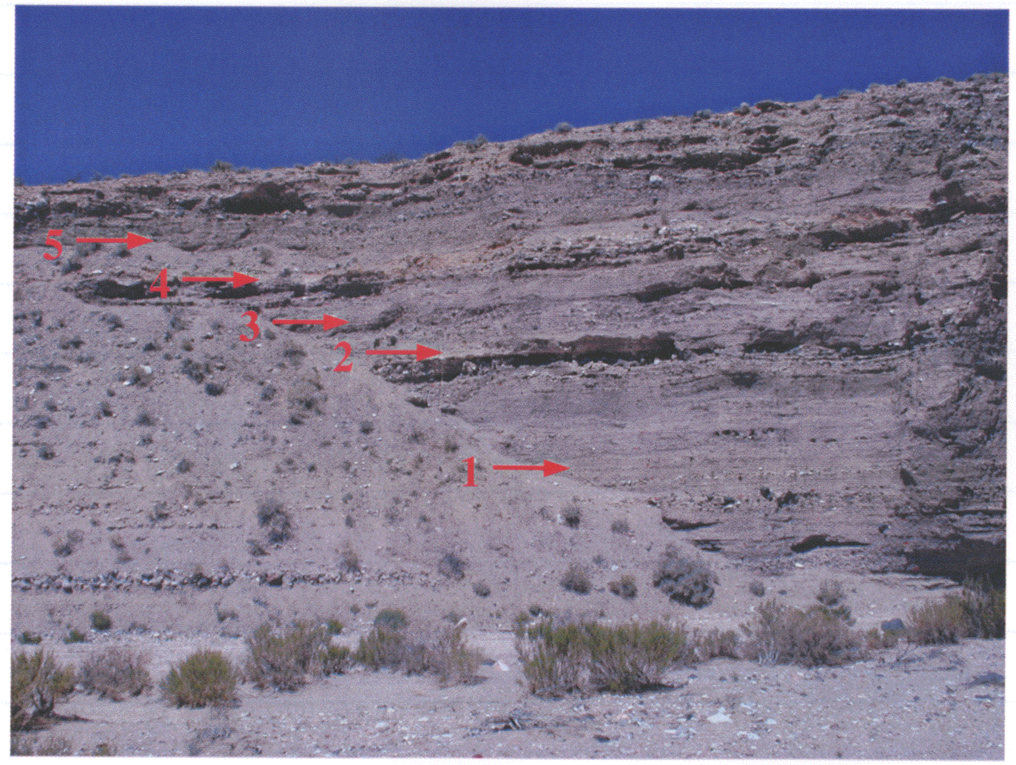

Figure 7: Southernmost end of outcrop 40MBIG showing the 5 gross zones of differing sediments. Stratigraphic section A was developed from a description of this portion of the outcrop

Theodore R. Ressler 6/16/00

Date: Jan 11, 2000

Participants: Theodore Ressler

Subject: Nye County Early Warning Drilling Program (NC-EWDP) wells

Purpose: Use available lithologic and geophysical logs to observe if similar sediments (to those observed in outcrop) are present throughout the fan and especially in stratigraphically deeper portions of the fan.

Methods:

The available data for the NC-EWDP wells will be compiled and plotted using EarthVision to develop summary plots of lithology and geophysical data. These summary plots will be used to attempt correlations of geophysical response with lithologic descriptions and to interpret structure within the alluvium.

Results:

Began input of wireline geophysical data from well NC-EWDP-2D (from Phase 1 FY 1999 Data Package)

Available data for NC-EWDP-2D includes lithology (drilling logs) and gamma, density, and neutron wireline logs.

Date: Jan 12, 2000

Participants: Theodore Ressler

Subject: Nye County Early Warning Drilling Program (NC-EWDP) wells

Purpose: Use available lithologic and geophysical logs to observe if similar sediments (to those observed in outcrop) are present throughout the fan and especially in stratigraphically deeper portions of the fan.

Results: Continued work with EarthVision and NC-EWDP-2D

Theodore R. Ressler 6/16/00

Date: Jan 13, 2000

Participants: Theodore Ressler

Subject: Nye County Early Warning Drilling Program (NC-EWDP) wells

Purpose: Use available lithologic and geophysical logs to observe if similar sediments (to those observed in outcrop) are present throughout the fan and especially in stratigraphically deeper portions of the fan.

Results:

The completed wire-line plots were imported into Adobe Illustrator where lithologic annotations and descriptions were added.

Date: January - February, 2000

Participants: Theodore Ressler

Subject: Nye County Early Warning Drilling Program (NC-EWDP) wells

Purpose: Use available lithologic and geophysical logs to observe if similar sediments (to those observed in outcrop) are present throughout the fan and especially in stratigraphically deeper portions of the fan.

Results:

Data was compiled for NC-EWDP-5S, NC-EWDP-Washburn1X, and NC-EWDP-1D and wireline plots were developed. Lithologic annotations and descriptions were added to the wireline plots using Adobe Illustrator.

Date: Feb 22, 2000

Participants: Theodore Ressler

Subject: Permeability sampling

Purpose: Experiment with obtaining undisturbed (relatively) sediment samples using 2” diameter aluminum cylinders.

Methods:

Attempts will be made to 1) drill cylinders into moderately cemented, coarse sediments (alluvium) and 2) hammer the aluminum cylinders into the sediment. If successful, the sediment filled aluminum tubes can be directly inserted into a constant head permeameter for permeability testing.

Testing site: coarse alluvium exposed in a dry stream bed along route 151 east at the intersection of 151 east and Pinn Road.

Results:

No success in obtaining undisturbed sediment samples in either of the two attempted methods.

Theodore R. Ressler 6/16/00

Date: Feb 22, 2000

Participants: Theodore Ressler

Subject: Permeability sampling

Purpose: establish accuracy of disturbed sediment permeability tests completed during summer 1999

Methods:

Encase undisturbed 'chunks' of alluvium obtained from the 40MBIG outcrop during the June 21-28, 1999 field period. Disturbed sediment samples of these same sediments were also obtained during the same field period: 40MBIG-P7 and 40MBIG-P12.

The undisturbed samples of alluvium were encased in plaster of paris. The plaster encased undisturbed samples will be cored to obtain undisturbed cores on which permeability tests can be completed. The results of the undisturbed permeability tests will be compared with the results of the disturbed permeability tests completed on the same sediments; thereby indicating the accuracy of the undisturbed permeability testing method.

Results:

Encased one undisturbed sample of 40MBIG-P7 and two undisturbed samples of 40MBIG-P12. No coring was completed at this time.

Theodore R. Ressler

Date: March 23, 2000

Participants: Theodore Ressler

Subject: Permeability sampling

Purpose: establish accuracy of disturbed sediment permeability tests completed during summer 1999

Methods: Used a floor mounted drill press with water coring apparatus to drill plaster encased sediment samples. A 1" diamond studded drill bit was used.

Results: Only one usable core was obtained from sample 40MBIG-P7. No cores were obtained from 40MBIG-P12. The coarser gravel contained in the 40MBIG-P12 sediment prevented the obtainment of intact cores.

Date: April 18, 2000

Participants: Theodore R. Ressler

Subject: establish accuracy of disturbed sediment permeability tests completed during summer 1999

Methods: permeability tests completed using a constant pressure permeameter (Figure 4).[1] As indicated in previous entry, one useable core was obtained from coring plaster encased undisturbed sediment samples. Since a useable core was not obtained from 40MBIG-P12 via coring, a undisturbed ~~chunck~~ 'chunk' was trimmed into a cylinder shape by hand. The chunk was shaped by scraping with a putty knife and the ends were

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over →

trimmed flat with a small rock saw.

Results:

[Tests were completed only on 40MBIG-P12 sample]

The permeability of 40MBIG-P12 (intact sample) was between 2×10^{-4} to 4×10^{-4} cm/s (details of each test are provided in permeability test summary sheets). These permeabilities are higher than those obtained from the re-packed sediment sample permeability tests. The tests ran very well and all tests gave values that were similar to each other. In the July 19 entry, it was noted that there was a decrease in permeability with each successive permeability test run (on the disturbed or repacked test specimens). This was explained by a progressive buildup of clay and fine material on the filter paper. No such trend was seen in the undisturbed sample of 40MBIG-P12.

Hypothesis:

Perhaps these intact sample permeabilities are higher because: (1) the repacked specimens were overpacked (density estimates used in packing were overestimates of true density), (2) grains were rearranged in repacking which removed preferential pathways of flow, or (3) cracks or fractures in the undisturbed sediment were removed by repacking.

These effects will most likely be less significant in the coarser ~~material~~ sediment samples.

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1 Ten test runs were completed. The runs were completed at a confining pressure of 20 psi, an outflow pressure of 2 psi, and inflow pressures of 3, 4, 5, 6, 7, 8, 9, 10, and 11 psi.

40MBIG-P1

Sediment Sample											
Repacked Sample		S1				S2				S3	
Estimated in-field density (g/cm³)		1.451				1.451				1.451	
Amount of sediment added (g)		299				299				299	
Repacked density (g/cm³)		1.45				1.45				1.45	
Area, A (cm²)		20.3				20.3				20.3	
Height, dL (cm)		10.16				10.16				10.16	
Test date		7/14/99				7/14/99				7/15/99	
Test Run	1	2	3	4	1	2	3	4	1	2	3
Elapsed Time (sec)	11.65	16.00	17.45	15.70	15.82	17.52	17.51	17.89	17.00	15.59	14.74
Pressure (psig) Confining	20.0	20.0	20.1	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig) Inflow	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Pressure (psig) Outflow	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Differential, dH (cm H_2O)	281.2	281.2	281.2	281.2	281.2	281.2	281.2	281.2	281.2	281.2	281.2
Fluid Levels (ml) Initial Confining											
Fluid Levels (ml) Initial Inflow	3.0	0.0	0.2	1.9	1.0	1.0	1.0	1.0	1.0	0.8	0.9
Fluid Levels (ml) Initial Outflow	20.0	21.7	22.7	21.9	23.0	23.0	23.0	23.0	23.6	21.4	19.6
Fluid Levels (ml) Final Confining											
Fluid Levels (ml) Final Inflow	18.0	20.0	22.3	21.8	21.9	22.6	22.4	22.8	23.4	20.2	18.8
Fluid Levels (ml) Final Outflow	6.0	1.8	0.5	2.1	2.5	1.6	1.7	1.5	0.3	1.0	0.6
Δ Fluid Level (ml) Confining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ Fluid Level (ml) Inflow	15.0	20.0	22.1	19.9	20.9	21.6	21.4	21.8	22.4	19.5	17.9
Δ Fluid Level (ml) Outflow	14.0	19.9	22.2	19.8	20.5	21.4	21.3	21.5	23.3	20.5	19.0
Volume change	14.5	20.0	22.2	19.9	20.7	21.5	21.4	21.6	22.9	20.0	18.4
Discharge, Q (ml/sec)	1.24	1.25	1.27	1.26	1.31	1.23	1.22	1.21	1.34	1.28	1.25
Saturated Hydraulic Conductivity, K_{sat} (cm/sec)	2.22E-03	2.22E-03	2.26E-03	2.25E-03	2.33E-03	2.18E-03	2.17E-03	2.15E-03	2.39E-03	2.28E-03	2.22E-03
Minimum		2.22E-03				2.15E-03				2.22E-03	
Maximum		2.26E-03				2.33E-03				2.39E-03	
Mean		2.24E-03				2.21E-03				2.30E-03	
Median		2.23E-03				2.18E-03				2.28E-03	
Std. Deviation		2.20E-05				7.99E-05				8.56E-05	
Notes	First run, some of the discrepancies in fluid level changes may be due to the sample not being completely saturated prior to the intiation of the test								The discrepancy if fluid level changes may be due to an air bubble seen in the outflow tube – sample was not completely saturated.		

Summary statistics	
Number	11
Minimum	2.15E-03
Maximum	2.39E-03
Mean	2.24E-03
Std Dev	7.04E-05
Confidence (95%)	4.16E-05

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Sediment Sample — 40MBIG-P2

	Parameter	S1						S2				S3			
	Repacked Sample	S1						S2				S3			
	Estimated in-field density (g/cm^3)	2.080						2.080				2.080			
	Amount of sediment added (g)	386						368				381			
	Repacked density (g/cm^3)	1.87						1.78				1.85			
	Area, A (cm^2)	20.3						20.3				20.3			
	Height, dL (cm)	10.16						10.16				10.16			
	Test date	7/15/99						7/15/99				7/15/99			
	Test Run	1	2	3	4	5	6	1	2	3	4	1	2	3	4
	Elapsed Time (sec)	344.59	567.85	657.09	805.39	912.52	418.69	129.07	91.11	69.11	87.95	144.63	163.44	132.55	120.38
Pressure (psig)	Confining	20.0	20.0	20.1	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig)	Inflow	6.0	6.0	6.0	6.0	6.0	10.0	6.0	6.0	8.0	10.0	6.0	6.0	8.0	10.0
Pressure (psig)	Outflow	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Pressure (psig)	Differential, dH (cm H_2O)	281.2	281.2	281.2	281.2	281.2	562.5	281.2	281.2	421.8	562.5	281.2	281.2	421.8	562.5
Fluid Levels (ml) Initial	Confining	4.0	4.0	4.0	4.0	4.0	4.0					9.5	9.5	9.6	9.6
Fluid Levels (ml) Initial	Inflow	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fluid Levels (ml) Initial	Outflow	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Fluid Levels (ml) Final	Confining	4.0	4.0	4.0	4.0	4.0	4.0					9.5	9.5	9.6	9.6
Fluid Levels (ml) Final	Inflow	21.1	21.0	20.0	19.4	18.2	17.3	21.5	21.8	22.3	20.9	21.1	18.9	21.6	20.6
Fluid Levels (ml) Final	Outflow	2.7	3.0	4.2	4.6	4.8	6.7	3.0	2.2	2.3	2.2	3.2	5.3	3.5	3.6
Δ Fluid Level (ml)	Confining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ Fluid Level (ml)	Inflow	20.1	20.0	19.0	18.4	17.2	16.3	20.5	20.8	21.3	19.9	20.1	17.9	20.6	19.6
Δ Fluid Level (ml)	Outflow	20.3	20.0	18.9	18.5	18.3	16.3	20.0	20.9	20.7	20.8	19.8	17.7	19.6	19.4
	Volume change	20.2	20.0	18.9	18.4	17.7	16.3	20.3	20.8	21.0	20.4	20.0	17.8	20.1	19.5
	Discharge, Q (ml/sec)	0.06	0.04	0.03	0.02	0.02	0.04	0.16	0.23	0.30	0.23	0.14	0.11	0.15	0.16
	Saturated Hydraulic Conductivity, $K_{sat\ (cm/sec)}$	1.04E-04	6.26E-05	5.13E-05	4.07E-05	3.45E-05	3.46E-05	2.79E-04	4.07E-04	3.61E-04	2.06E-04	2.45E-04	1.94E-04	1.80E-04	1.44E-04
	Minimum	3.45E-05						2.06E-04				1.44E-04			
	Maximum	1.04E-04						4.07E-04				2.45E-04			
	Mean	5.47E-05						3.13E-04				1.91E-04			
	Median	4.60E-05						3.20E-04				1.87E-04			
	Std. Deviation	2.66E-05						8.88E-05				4.20E-05			
	Notes	New sleave membrane was used begining with Run 1-- small leak was found in old sleeve (large decrease in donfining pressure water level when the test was initiated, perhaps the inconsistencies in the inflow/outflow fluid level changes were due to the beginings of the hole. Could not pack the sample to the desired density						Could not pack the sample to the desired density				Could not pack the sample to the desired density			

Summary statistics

Number	14
Minimum	3.45E-05
Maximum	4.07E-04
Mean	1.67E-04
Std Dev	1.23E-04
Confidence (95%)	6.43E-05

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Sediment Sample — 40MBIG-P3

	Parameter	S1					S2					S3							
	Repacked Sample	S1					S2					S3							
	Estimated in-field density (g/cm^3)	2.542					2.542					2.542							
	Amount of sediment added (g)	366					371					406							
	Repacked density (g/cm^3)	1.77					1.80					1.97							
	Area, A (cm^2)	20.3					20.3					20.3							
	Height, dL (cm)	10.16					10.16					10.16							
	Test date	7/16/99					7/16/99					7/19/99							
	Test Run	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	6	7	8
	Elapsed Time (sec)	691.41	640.56	1303.46	1734.16	1247.82	629.22	609.52	680.78	532.72	384.02	700.84	776.83	620.83	609.34	613.44	614.20	683.31	664.71
Pressure (psig)	Confining	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig)	Inflow	8.0	10.0	7.0	6.0	8.0	6.0	6.0	6.0	7.0	8.0	6.0	6.0	7.0	7.0	8.0	8.0	6.0	7.0
Pressure (psig)	Outflow	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Pressure (psig)	Differential, dH (cm H_2O)	421.8	562.5	351.5	281.2	421.8	281.2	281.2	281.2	351.5	421.8	281.2	281.2	351.5	351.5	421.8	421.8	281.2	351.5
Fluid Levels (ml) Initial	Confining	3.5	3.6	4.5	4.7	4.7	4.7	4.7	4.7	4.6	4.6	9.0	9.0	9.1	9.1	9.2	9.2	9.2	9.2
Fluid Levels (ml) Initial	Inflow	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fluid Levels (ml) Initial	Outflow	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Fluid Levels (ml) Final	Confining	3.6	3.6	4.5	4.7	4.7	4.7	4.7	4.7	4.6	4.6	9.0	9.0	9.1	9.1	9.2	9.2	9.2	9.2
Fluid Levels (ml) Final	Inflow	17.2	17.3	16.2	15.4	16.3	22.0	19.2	19.3	21.5	21.5	20.0	19.8	18.3	15.9	16.9	14.9	10.4	12.3
Fluid Levels (ml) Final	Outflow	6.8	6.8	7.5	8.3	7.7	1.6	4.8	4.8	2.8	4.0	3.9	4.1	5.7	8.0	7.1	9.0	13.5	11.7
Δ Fluid Level (ml)	Confining	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ Fluid Level (ml)	Inflow	16.2	16.3	15.2	14.4	15.3	21.0	18.2	18.3	20.5	20.5	19.0	18.8	17.3	14.9	15.9	13.9	9.4	11.3
Δ Fluid Level (ml)	Outflow	16.2	16.2	15.5	14.7	15.3	21.4	18.2	18.3	20.2	19.0	19.1	18.9	17.3	15.0	15.9	14.0	9.5	11.3
	Volume change	16.2	16.3	15.4	14.6	15.3	21.2	18.2	18.3	20.4	19.8	19.1	18.9	17.3	15.0	15.9	14.0	9.5	11.3
	Discharge, Q (ml/sec)	0.02	0.03	0.01	0.01	0.01	0.03	0.03	0.03	0.04	0.05	0.03	0.02	0.03	0.02	0.03	0.02	0.01	0.02
	Saturated Hydraulic Conductivity, $K_{sat\ (cm/sec)}$	2.78E-05	2.26E-05	1.68E-05	1.49E-05	1.45E-05	6.00E-05	5.31E-05	4.77E-05	5.44E-05	6.10E-05	4.84E-05	4.32E-05	3.97E-05	3.49E-05	3.08E-05	2.69E-05	2.46E-05	2.42E-05
	Minimum	1.45E-05					4.77E-05					2.42E-05							
	Maximum	2.78E-05					6.10E-05					4.84E-05							
	Mean	1.93E-05					5.52E-05					3.41E-05							
	Median	1.68E-05					5.44E-05					3.28E-05							
	Std. Deviation	5.72E-06				532.72	5.42E-06					9.01E-06							
	Notes	Could not pack the sample to the desired density					Could not pack the sample to the desired density					Could not pack the sample to the desired density							

Summary statistics

Number	18
Minimum	1.45E-05
Maximum	6.10E-05
Mean	3.59E-05
Std Dev	1.55E-05
Confidence (95%)	7.16E-06

Sediment Sample

40MBIG-P5

	S1						S2						S3					
Repacked Sample	S1						S2						S3					
Estimated in-field density (g/cm^3)																		
Amount of sediment added (g)	309						309						309					
Repacked density (g/cm^3)	1.50						1.50						1.50					
Area, A (cm^2)	20.3						20.3						20.3					
Height, dL (cm)	10.16						10.16						10.16					
Test date	7/21/99						7/21/99						7/21/99					
Test Run	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Elapsed Time (sec)	36.45	30.32	26.45	27.84	35.24	43.36	55.56	46.38	42.12	45.43	59.16	74.75	55.61	42.92	37.24	42.77	58.81	71.29
Pressure (psig) Confining	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig) Inflow	6.0	7.0	8.0	8.0	7.0	6.0	6.0	7.0	8.0	8.0	7.0	6.0	6.0	7.0	8.0	8.0	7.0	6.0
Pressure (psig) Outflow	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Differential, dH (cm H_2O)	281.2	351.5	421.8	421.8	351.5	281.2	281.2	351.5	421.8	421.8	351.5	281.2	281.2	351.5	421.8	421.8	351.5	281.2
Fluid Levels (ml) Initial Confining	5.2	5.2	5.3	5.3	5.3	5.3	5.7	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
Fluid Levels (ml) Initial Inflow	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fluid Levels (ml) Initial Outflow	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Fluid Levels (ml) Final Confining	5.2	5.2	5.3	5.3	5.3	5.3	5.7	5.7	5.7	5.7	5.8	5.8	5.8	5.8	5.8	5.8	5.8	5.8
Fluid Levels (ml) Final Inflow	22.5	22.7	22.6	22.8	22.5	21.8	22.7	22.4	22.6	22.3	21.8	21.7	22.5	22.5	22.5	22.3	22.9	21.4
Fluid Levels (ml) Final Outflow	1.5	1.5	1.6	1.3	1.5	2.3	1.4	1.7	1.6	1.8	2.1	2.4	1.5	1.6	1.7	1.7	1.9	2.5
Δ Fluid Level (ml) Confining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ Fluid Level (ml) Inflow	21.5	21.7	21.6	21.8	21.5	20.8	21.7	21.4	21.6	21.3	20.8	20.7	21.5	21.5	21.5	21.3	21.9	20.4
Δ Fluid Level (ml) Outflow	21.5	21.6	21.4	21.7	21.5	20.8	21.6	21.3	21.4	21.2	20.9	20.6	21.5	21.4	21.3	21.3	21.1	20.5
Volume change	21.5	21.6	21.5	21.8	21.5	20.8	21.6	21.4	21.5	21.3	20.9	20.7	21.5	21.5	21.4	21.3	21.5	20.5
Discharge, Q (ml/sec)	0.59	0.71	0.81	0.78	0.61	0.48	0.39	0.46	0.51	0.47	0.35	0.28	0.39	0.50	0.57	0.50	0.37	0.29
Saturated Hydraulic Conductivity, K_{sat} (cm/sec)	1.05E-03	1.02E-03	9.64E-04	9.27E-04	8.69E-04	8.53E-04	6.93E-04	6.55E-04	6.06E-04	5.55E-04	5.02E-04	4.92E-04	6.88E-04	7.12E-04	6.82E-04	5.91E-04	5.20E-04	5.11E-04
Minimum	8.53E-04						4.92E-04						5.11E-04					
Maximum	1.05E-03						6.93E-04						7.12E-04					
Mean	9.65E-04						5.84E-04						6.17E-04					
Median	9.46E-04						5.80E-04						6.36E-04					
Std. Deviation	7.87E-05						8.19E-05						8.89E-05					
Notes	Could not pack the sample to the desired density						Could not pack the sample to the desired density						Could not pack the sample to the desired density					

Summary statistics	
Number	18
Minimum	4.92E-04
Maximum	1.05E-03
Mean	7.16E-04
Std Dev	1.86E-04
Confidence (95%)	8.58E-05

Sediment Sample

40MBIG-P6

	S1						S2						S3					
Repacked Sample	S1						S2						S3					
Estimated in-field density (g/cm^3)	2.208						2.208						2.208					
Amount of sediment added (g)	342						348						355					
Repacked density (g/cm^3)	1.66						1.69						1.72					
Area, A (cm^2)	20.3						20.3						20.3					
Height, dL (cm)	10.16						10.16						10.16					
Test date	7/19/99						7/19/99						7/19/99					
Test Run	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Elapsed Time (sec)	88.06	72.49	51.19	53.74	69.88	103.35	110.42	92.45	77.30	82.28	104.74	131.35	95.73	79.75	70.89	78.37	91.81	130.88
Pressure (psig) Confining	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig) Inflow	6.0	7.0	8.0	8.0	7.0	6.0	6.0	7.0	8.0	8.0	7.0	6.0	6.0	7.0	8.0	8.0	7.0	6.0
Pressure (psig) Outflow	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Differential, dH (cm H_2O)	281.2	351.5	421.8	421.8	351.5	281.2	281.2	351.5	421.8	421.8	351.5	281.2	281.2	351.5	421.8	421.8	351.5	281.2
Fluid Levels (ml) Initial Confining	9.7	9.8	10.0	10.0	10.1	10.1	5.6	5.6	5.6	5.6	5.6	5.6	8.0	8.0	8.1	8.1	8.1	8.1
Fluid Levels (ml) Initial Inflow	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fluid Levels (ml) Initial Outflow	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Fluid Levels (ml) Final Confining	9.7	9.8	10.0	10.0	10.1	10.1	5.6	5.6	5.6	5.6	5.6	5.6	8.0	8.0	8.1	8.1	8.1	8.1
Fluid Levels (ml) Final Inflow	22.5	22.5	22.4	22.4	21.3	22.2	22.2	22.3	21.9	21.8	21.4	19.5	22.5	22.5	22.6	22.5	19.4	19.6
Fluid Levels (ml) Final Outflow	1.6	1.6	1.8	1.6	2.8	1.9	1.8	1.7	2.3	2.3	2.6	4.6	1.7	1.6	1.6	1.7	4.8	4.5
Δ Fluid Level (ml) Confining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ Fluid Level (ml) Inflow	21.5	21.5	21.4	21.4	20.3	21.2	21.2	21.3	20.9	20.8	20.4	18.5	21.5	21.5	21.6	21.5	18.4	18.6
Δ Fluid Level (ml) Outflow	21.4	21.4	21.2	21.4	20.2	21.1	21.2	21.3	20.7	20.7	20.4	18.5	21.4	21.4	21.4	21.3	18.2	18.5
Volume change	21.5	21.5	21.3	21.4	20.3	21.2	21.2	21.3	20.8	20.8	20.4	18.5	21.4	21.5	21.5	21.4	18.3	18.6
Discharge, Q (ml/sec)	0.24	0.30	0.42	0.40	0.29	0.20	0.19	0.23	0.27	0.25	0.19	0.14	0.22	0.27	0.30	0.27	0.20	0.14
Saturated Hydraulic Conductivity, K_{sat} (cm/sec)	4.33E-04	4.21E-04	4.94E-04	4.72E-04	4.13E-04	3.64E-04	3.42E-04	3.28E-04	3.19E-04	2.99E-04	2.77E-04	2.50E-04	3.98E-04	3.83E-04	3.60E-04	3.24E-04	2.84E-04	2.52E-04
Minimum	3.64E-04						2.50E-04						2.52E-04					
Maximum	4.94E-04						3.42E-04						3.98E-04					
Mean	4.47E-04						3.03E-04						3.33E-04					
Median	4.27E-04						3.09E-04						3.42E-04					
Std. Deviation	4.59E-05						3.43E-05						5.73E-05					
Notes	Could not pack the sample to the desired density						Could not pack the sample to the desired density						Could not pack the sample to the desired density					

Summary statistics	
Number	18
Minimum	2.50E-04
Maximum	4.94E-04
Mean	3.56E-04
Std Dev	7.22E-05
Confidence (95%)	3.33E-05

Sediment Sample

40MBIG-P7

Repacked Sample	S1					
Estimated in-field density (g/cm^3)	1.650					
Amount of sediment added (g)	317					
Repacked density (g/cm^3)	1.54					
Area, A (cm^2)	20.3					
Height, dL (cm)	10.16					
Test date	7/23/99					
Test Run	1	2	3	4	5	6
Elapsed Time (sec)	1041.51	945.06	798.91	987.49	1050.50	1322.28
Pressure (psig) Confining	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig) Inflow	6.0	7.0	8.0	8.0	7.0	6.0
Pressure (psig) Outflow	2.0	2.0	2.0	2.0	2.0	2.0
Differential, dH (cm H_2O)	281.2	351.5	421.8	421.8	351.5	281.2
Fluid Levels (ml) Initial Confining	9.3	9.3	9.3	9.3	9.3	9.4
Fluid Levels (ml) Initial Inflow	1.0	1.0	1.0	1.0	1.0	1.0
Fluid Levels (ml) Initial Outflow	23.0	23.0	23.0	23.0	23.0	23.0
Fluid Levels (ml) Final Confining	9.3	9.3	9.3	9.3	9.3	9.4
Fluid Levels (ml) Final Inflow	14.1	16.8	18.7	18.9	15.2	14.0
Fluid Levels (ml) Final Outflow	9.9	7.3	5.4	5.3	8.7	9.9
Δ Fluid Level (ml) Confining	0.0	0.0	0.0	0.0	0.0	0.0
Δ Fluid Level (ml) Inflow	13.1	15.8	17.7	17.9	14.2	13.0
Δ Fluid Level (ml) Outflow	13.1	15.7	17.7	17.8	14.4	13.1
Volume change	13.1	15.7	17.7	17.8	14.3	13.1
Discharge, Q (ml/sec)	0.01	0.02	0.02	0.02	0.01	0.01
Saturated Hydraulic Conductivity, $K_{sat\ (cm/sec)}$	2.24E-05	2.37E-05	2.62E-05	2.14E-05	1.93E-05	1.76E-05
Minimum	1.76E-05					
Maximum	2.62E-05					
Mean	2.26E-05					
Median	2.19E-05					
Std. Deviation	3.08E-06					
Notes	Could not pack the sample to the desired density					

Repacked Sample	S2					
Estimated in-field density (g/cm^3)	1.650					
Amount of sediment added (g)	322					
Repacked density (g/cm^3)	1.56					
Area, A (cm^2)	20.3					
Height, dL (cm)	10.16					
Test date	7/23/99					
Test Run	1	2	3	4	5	6
Elapsed Time (sec)	1483.13	1200.50	1200.20	1200.81	1200.76	1200.45
Pressure (psig) Confining	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig) Inflow	7.0	8.0	9.0	10.0	10.0	9.0
Pressure (psig) Outflow	2.0	2.0	2.0	2.0	2.0	2.0
Differential, dH (cm H_2O)	351.5	421.8	492.2	562.5	562.5	492.2
Fluid Levels (ml) Initial Confining	7.0	8.5	8.5	8.6	8.7	8.7
Fluid Levels (ml) Initial Inflow	1.0	1.0	1.0	9.0	6.0	6.0
Fluid Levels (ml) Initial Outflow	23.0	23.0	23.0	12.0	20.0	20.0
Fluid Levels (ml) Final Confining	7.1	8.5	8.6	8.6	8.7	8.7
Fluid Levels (ml) Final Inflow	9.0	8.8	8.4	15.7	11.3	11.2
Fluid Levels (ml) Final Outflow	15.0	15.2	15.6	5.4	14.6	14.7
Δ Fluid Level (ml) Confining	0.1	0.0	0.1	0.0	0.0	0.0
Δ Fluid Level (ml) Inflow	8.0	7.8	7.4	6.7	5.3	5.2
Δ Fluid Level (ml) Outflow	8.0	7.8	7.4	6.6	5.4	5.3
Volume change	8.0	7.8	7.4	6.7	5.4	5.3
Discharge, Q (ml/sec)	0.01	0.01	0.01	0.01	0.00	0.00
Saturated Hydraulic Conductivity, $K_{sat\ (cm/sec)}$	7.68E-06	7.71E-06	6.27E-06	4.93E-06	3.96E-06	4.45E-06
Minimum	3.96E-06					
Maximum	7.71E-06					
Mean	5.83E-06					
Median	5.60E-06					
Std. Deviation	1.63E-06					
Notes	Could not pack the sample to the desired density					

Repacked Sample	S3					
Estimated in-field density (g/cm^3)	1.650					
Amount of sediment added (g)	321					
Repacked density (g/cm^3)	1.56					
Area, A (cm^2)	20.3					
Height, dL (cm)	10.16					
Test date	7/23/99					
Test Run	1	2	3	4	5	6
Elapsed Time (sec)	200.27	241.23	282.92	234.61	305.34	373.99
Pressure (psig) Confining	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig) Inflow	10.0	9.0	8.0	10.0	9.0	8.0
Pressure (psig) Outflow	2.0	2.0	2.0	2.0	2.0	2.0
Differential, dH (cm H_2O)	562.5	492.2	421.8	562.5	492.2	421.8
Fluid Levels (ml) Initial Confining	6.9	7.0	7.0	7.0	7.0	7.0
Fluid Levels (ml) Initial Inflow	1.0	1.0	1.0	1.0	1.0	1.0
Fluid Levels (ml) Initial Outflow	23.0	23.0	23.0	23.0	23.0	23.0
Fluid Levels (ml) Final Confining	6.9	7.0	7.0	7.0	7.0	7.0
Fluid Levels (ml) Final Inflow	22.0	19.4	17.4	18.3	18.5	17.6
Fluid Levels (ml) Final Outflow	2.2	4.6	6.6	5.8	5.4	6.4
Δ Fluid Level (ml) Confining	0.0	0.0	0.0	0.0	0.0	0.0
Δ Fluid Level (ml) Inflow	21.0	18.4	16.4	17.3	17.5	16.6
Δ Fluid Level (ml) Outflow	20.8	18.4	16.4	17.2	17.6	16.6
Volume change	20.9	18.4	16.4	17.3	17.5	16.6
Discharge, Q (ml/sec)	0.10	0.08	0.06	0.07	0.06	0.04
Saturated Hydraulic Conductivity, $K_{sat\ (cm/sec)}$	9.29E-05	7.76E-05	6.87E-05	6.54E-05	5.84E-05	5.26E-05
Minimum	5.26E-05					
Maximum	9.29E-05					
Mean	6.92E-05					
Median	6.70E-05					
Std. Deviation	1.44E-05					
Notes	Could not pack the sample to the desired density					

Summary statistics

Number	18
Minimum	3.96E-06
Maximum	9.29E-05
Mean	3.23E-05
Std Dev	2.89E-05
Confidence (95%)	1.33E-05

Sediment Sample

40MBIG-P8

Repacked Sample	S1					
Estimated in-field density (g/cm^3)	1.509					
Amount of sediment added (g)	311					
Repacked density (g/cm^3)	1.51					
Area, A (cm^2)	20.3					
Height, dL (cm)	10.16					
Test date	7/20/99					
Test Run	1	2	3	4	5	6
Elapsed Time (sec)	51.44	41.15	35.09	34.55	42.87	49.79
Pressure (psig) Confining	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig) Inflow	6.0	7.0	8.0	8.0	7.0	6.0
Pressure (psig) Outflow	2.0	2.0	2.0	2.0	2.0	2.0
Differential, dH (cm H_2O)	281.2	351.5	421.8	421.8	351.5	281.2
Fluid Levels (ml) Initial Confining	5.9	6.0	6.0	5.1	6.1	6.2
Fluid Levels (ml) Initial Inflow	1.0	1.0	1.0	1.0	1.0	1.0
Fluid Levels (ml) Initial Outflow	23.0	23.0	23.0	23.0	23.0	23.0
Fluid Levels (ml) Final Confining	5.9	6.0	6.0	5.1	6.1	6.2
Fluid Levels (ml) Final Inflow	22.5	22.6	22.8	22.6	22.7	22.9
Fluid Levels (ml) Final Outflow	1.7	1.5	1.3	1.6	1.5	1.2
Δ Fluid Level (ml) Confining	0.0	0.0	0.0	0.0	0.0	0.0
Δ Fluid Level (ml) Inflow	21.5	21.6	21.8	21.6	21.7	21.9
Δ Fluid Level (ml) Outflow	21.3	21.6	21.7	21.4	21.6	21.8
Volume change	21.4	21.6	21.8	21.5	21.6	21.9
Discharge, Q (ml/sec)	0.42	0.52	0.62	0.62	0.50	0.44
Saturated Hydraulic Conductivity, $K_{sat\ (cm/sec)}$	7.40E-04	7.46E-04	7.35E-04	7.38E-04	7.17E-04	7.81E-04
Minimum	7.17E-04					
Maximum	7.81E-04					
Mean	7.36E-04					
Median	7.39E-04					
Std. Deviation	2.10E-05					
Notes						

Repacked Sample	S2					
Estimated in-field density (g/cm^3)	1.509					
Amount of sediment added (g)	311					
Repacked density (g/cm^3)	1.51					
Area, A (cm^2)	20.3					
Height, dL (cm)	10.16					
Test date	7/21/99					
Test Run	1	2	3	4	5	6
Elapsed Time (sec)	126.22	95.41	81.23	79.27	109.39	121.10
Pressure (psig) Confining	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig) Inflow	6.0	7.0	8.0	8.0	7.0	6.0
Pressure (psig) Outflow	2.0	2.0	2.0	2.0	2.0	2.0
Differential, dH (cm H_2O)	281.2	351.5	421.8	421.8	351.5	281.2
Fluid Levels (ml) Initial Confining	7.4	7.4	7.5	7.5	7.5	7.6
Fluid Levels (ml) Initial Inflow	1.0	1.0	1.0	1.0	1.0	1.0
Fluid Levels (ml) Initial Outflow	23.0	23.0	23.0	23.0	23.0	23.0
Fluid Levels (ml) Final Confining	7.4	7.4	7.5	7.5	7.5	7.6
Fluid Levels (ml) Final Inflow	22.0	22.5	22.0	22.4	22.3	22.4
Fluid Levels (ml) Final Outflow	2.1	1.6	2.0	1.6	1.8	1.6
Δ Fluid Level (ml) Confining	0.0	0.0	0.0	0.0	0.0	0.0
Δ Fluid Level (ml) Inflow	21.0	21.5	21.0	21.4	21.3	21.4
Δ Fluid Level (ml) Outflow	20.9	21.4	21.0	21.4	21.3	21.4
Volume change	21.0	21.5	21.0	21.4	21.3	21.4
Discharge, Q (ml/sec)	0.17	0.22	0.26	0.27	0.19	0.18
Saturated Hydraulic Conductivity, $K_{sat\ (cm/sec)}$	2.95E-04	3.20E-04	3.07E-04	3.20E-04	2.77E-04	3.14E-04
Minimum	2.77E-04					
Maximum	3.20E-04					
Mean	3.06E-04					
Median	3.11E-04					
Std. Deviation	1.70E-05					

Repacked Sample	S3					
Estimated in-field density (g/cm^3)	1.509					
Amount of sediment added (g)	311					
Repacked density (g/cm^3)	1.51					
Area, A (cm^2)	20.3					
Height, dL (cm)	10.16					
Test date	7/22/99					
Test Run	1	2	3	4	5	6
Elapsed Time (sec)	30.81	27.50	22.84	24.22	29.59	36.84
Pressure (psig) Confining	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig) Inflow	6.0	7.0	8.0	8.0	7.0	6.0
Pressure (psig) Outflow	2.0	2.0	2.0	2.0	2.0	2.0
Differential, dH (cm H_2O)	281.2	351.5	421.8	421.8	351.5	281.2
Fluid Levels (ml) Initial Confining	5.5	5.8	6.0	6.1	6.1	6.1
Fluid Levels (ml) Initial Inflow	1.0	1.0	1.0	1.0	1.0	1.0
Fluid Levels (ml) Initial Outflow	23.0	23.0	23.0	23.0	23.0	23.0
Fluid Levels (ml) Final Confining	5.6	5.9	6.0	6.1	6.1	6.1
Fluid Levels (ml) Final Inflow	22.8	23.3	22.8	22.9	22.9	22.9
Fluid Levels (ml) Final Outflow	1.2	0.8	1.3	1.3	1.1	1.1
Δ Fluid Level (ml) Confining	0.1	0.1	0.0	0.0	0.0	0.0
Δ Fluid Level (ml) Inflow	21.8	22.3	21.8	21.9	21.9	21.9
Δ Fluid Level (ml) Outflow	21.8	22.2	21.7	21.7	21.9	21.9
Volume change	21.8	22.3	21.8	21.8	21.9	21.9
Discharge, Q (ml/sec)	0.71	0.81	0.95	0.90	0.74	0.59
Saturated Hydraulic Conductivity, $K_{sat\ (cm/sec)}$	1.26E-03	1.15E-03	1.13E-03	1.07E-03	1.05E-03	1.06E-03
Minimum	1.05E-03					
Maximum	1.26E-03					
Mean	1.12E-03					
Median	1.10E-03					
Std. Deviation	7.95E-05					

Summary statistics

Number	18
Minimum	2.77E-04
Maximum	1.26E-03
Mean	7.23E-04
Std Dev	3.45E-04
Confidence (95%)	1.60E-04

Theodore R. Resler 6/16/00

Sediment Sample

40MBIG-P9

Sediment Sample	S1						S2						S3					
Repacked Sample			S1						S2						S3			
Estimated in-field density (g/cm^3)			1.345						1.345						1.345			
Amount of sediment added (g)			277						277						277			
Repacked density (g/cm^3)			1.34						1.34						1.34			
Area, A (cm^2)			20.3						20.3						20.3			
Height, dL (cm)			10.16						10.16						10.16			
Test date			7/20/99						7/20/99						7/21/99			
Test Run	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Elapsed Time (sec)	133.32	112.01	93.88	100.98	114.05	147.31	44.52	36.20	30.77	32.91	44.52	54.69	92.34	76.15	63.53	70.34	89.26	118.24
Pressure (psig) Confining	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig) Inflow	6.0	7.0	8.0	8.0	7.0	6.0	6.0	7.0	8.0	8.0	7.0	6.0	6.0	7.0	8.0	8.0	7.0	6.0
Pressure (psig) Outflow	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Differential, dH (cm H_2O)	281.2	351.5	421.8	421.8	351.5	281.2	281.2	351.5	421.8	421.8	351.5	281.2	281.2	351.5	421.8	421.8	351.5	281.2
Fluid Levels (ml) Initial Confining		3.5	3.6	3.7	3.8	3.9	4.5	4.5	4.5	4.5	4.5	4.5	5.2	6.6	8.0	8.0	8.0	8.0
Fluid Levels (ml) Initial Inflow	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fluid Levels (ml) Initial Outflow	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Fluid Levels (ml) Final Confining		3.5	3.7	3.7	3.8	3.9	4.5	4.5	4.5	4.5	4.5	4.5	5.2	6.6	8.0	8.0	8.0	8.0
Fluid Levels (ml) Final Inflow	21.8	22.0	22.0	22.3	20.3	20.6	22.3	22.5	22.5	22.5	22.5	22.6	22.7	22.3	22.5	22.4	21.4	21.4
Fluid Levels (ml) Final Outflow	2.3	2.1	2.1	1.7	3.8	3.5	1.6	1.6	1.6	1.5	1.5	1.4	1.2	1.8	1.6	1.6	2.6	2.7
Δ Fluid Level (ml) Confining	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Δ Fluid Level (ml) Inflow	20.8	21.0	21.0	21.3	19.3	19.6	21.3	21.5	21.5	21.5	21.5	21.6	21.7	21.3	21.5	21.4	20.4	20.4
Δ Fluid Level (ml) Outflow	20.7	20.9	20.9	21.3	19.2	19.5	21.4	21.4	21.4	21.5	21.5	21.6	21.8	21.2	21.4	21.4	20.4	20.3
Volume change	20.8	21.0	20.9	21.3	19.3	19.6	21.4	21.5	21.5	21.5	21.5	21.6	21.8	21.3	21.5	21.4	20.4	20.4
Discharge, Q (ml/sec)	0.16	0.19	0.22	0.21	0.17	0.13	0.48	0.59	0.70	0.65	0.48	0.39	0.24	0.28	0.34	0.30	0.23	0.17
Saturated Hydraulic Conductivity, $K_{sat\ (cm/sec)}$	2.77E-04	2.66E-04	2.64E-04	2.50E-04	2.40E-04	2.36E-04	8.53E-04	8.44E-04	8.27E-04	7.75E-04	6.88E-04	7.03E-04	4.19E-04	3.97E-04	4.01E-04	3.61E-04	3.25E-04	3.06E-04
Minimum			2.36E-04						6.88E-04						3.06E-04			
Maximum			2.77E-04						8.53E-04						4.19E-04			
Mean			2.60E-04						7.82E-04						3.68E-04			
Median			2.57E-04						8.01E-04						3.79E-04			
Std. Deviation			1.61E-05						7.23E-05						4.52E-05			
Notes							Could not pack the sample to the desired density						Could not pack the sample to the desired density					

Summary statistics	
Number	18
Minimum	2.36E-04
Maximum	8.53E-04
Mean	4.69E-04
Std Dev	2.37E-04
Confidence (95%)	1.10E-04

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Sediment Sample

40MBIG-P12

Sediment Sample	S1						S2						S3					
Repacked Sample			S1						S2						S3			
Estimated in-field density (g/cm^3)			1.700						1.700						1.700			
Amount of sediment added (g)			340						350						350			
Repacked density (g/cm^3)			1.65						1.70						1.70			
Area, A (cm^2)			20.3						20.3						20.3			
Height, dL (cm)			10.16						10.16						10.16			
Test date			7/26/99						7/26/99						7/26/99			
Test Run	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Elapsed Time (sec)	622.34	793.26	1026.12	795.41	851.41	864.64	568.82	797.56	829.34	688.60	798.02	906.88	387.87	579.07	543.16	424.65	602.06	654.15
Pressure (psig) Confining	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Pressure (psig) Inflow	10.0	9.0	8.0	10.0	9.0	8.0	10.0	9.0	8.0	10.0	9.0	8.0	10.0	9.0	8.0	10.0	9.0	8.0
Pressure (psig) Outflow	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Differential, dH (cm H_2O)	562.5	492.2	421.8	562.5	492.2	421.8	562.5	492.2	421.8	562.5	492.2	421.8	562.5	492.2	421.8	562.5	492.2	421.8
Fluid Levels (ml) Initial Confining	5.1	5.1	5.2	5.2	5.2	5.2	4.5	4.5	4.6	4.6	4.7	4.7	5.8	5.9	6.0	6.1	6.1	6.1
Fluid Levels (ml) Initial Inflow	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fluid Levels (ml) Initial Outflow	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Fluid Levels (ml) Final Confining	5.1	5.1	5.2	5.2	5.2	5.2	4.5	4.5	4.6	4.6	4.7	4.7	5.9	6.0	6.0	6.1	6.1	6.1
Fluid Levels (ml) Final Inflow	18.8	16.4	15.4	17.0	13.7	10.9	18.9	17.7	13.6	15.5	13.3	12.0	22.6	21.5	14.3	16.0	15.8	12.9
Fluid Levels (ml) Final Outflow	5.4	7.4	8.5	7.4	10.2	13.2	5.2	6.3	10.2	8.8	10.6	12.0	1.1	2.2	9.6	8.4	8.0	10.8
Δ Fluid Level (ml) Confining	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Δ Fluid Level (ml) Inflow	17.8	15.4	14.4	16.0	12.7	9.9	17.9	16.7	12.6	14.5	12.3	11.0	21.6	20.5	13.3	15.0	14.8	11.9
Δ Fluid Level (ml) Outflow	17.7	15.6	14.5	15.7	12.8	9.9	17.8	16.7	12.8	14.2	12.4	11.0	21.9	20.8	13.4	14.6	15.0	12.2
Volume change	17.7	15.5	14.4	15.8	12.7	9.9	17.8	16.7	12.7	14.4	12.4	11.0	21.8	20.7	13.3	14.8	14.9	12.1
Discharge, Q (ml/sec)	0.03	0.02	0.01	0.02	0.01	0.01	0.03	0.02	0.02	0.02	0.02	0.01	0.06	0.04	0.02	0.03	0.02	0.02
Saturated Hydraulic Conductivity, $K_{sat\ (cm/sec)}$	2.53E-05	1.99E-05	1.67E-05	1.77E-05	1.52E-05	1.35E-05	2.79E-05	2.13E-05	1.81E-05	1.85E-05	1.57E-05	1.44E-05	4.99E-05	3.63E-05	2.91E-05	3.10E-05	2.52E-05	2.19E-05
Repacked sample statistics																		
Number			6						6						6			
Minimum			1.35E-05						1.44E-05						2.19E-05			
Maximum			2.53E-05						2.79E-05						4.99E-05			
Mean			1.90E-05						1.93E-05						3.22E-05			
Median			1.72E-05						1.83E-05						3.00E-05			
Std. Deviation			4.18E-06						4.82E-06						9.97E-06			
Confidence (95%)			3.34E-06						3.86E-06						7.98E-06			
Notes	Could not pack the sample to the desired density						Could not pack the sample to the desired density						Could not pack the sample to the desired density					

Summary statistics	
Number	18
Minimum	1.35E-05
Maximum	4.99E-05
Mean	2.32E-05
Std Dev	9.19E-06
Confidence (95%)	4.25E-06

HLMcK 7/13/00

I have reviewed scientific notebook 312 and find it in compliance with QAP-001. There is sufficient information regarding procedure used for conducting the research and acquiring and analyzing the data so that another qualified scientist could repeat the activity or activities recorded in this scientific notebook

H. Lawrence McKague 7/13/00

H. Lawrence McKague
GLGP Element Manager

HLMcK 7/13/00

Date: September 27, 2000

Location: Fortymile Wash, Nevada Test Site, Southwestern Nevada (unless otherwise noted)

Participants: Theodore Ressler, Kenneth D. Ridgway, John Stamatakos, John M. Sharp

Subject: Investigations of nearsurface alluvium in Fortymile Wash

Purpose: To evaluate uncertainties associated with flow and transport of groundwater in the valley-fill aquifer, the SDS KTI and USFIC KTI initiated a joint project in 1998, as part of the Structural Effects on Groundwater Flow Working Group. The goal of the project was to refine concepts about structural and sedimentological controls on groundwater flow in the valley fill aquifer, which will underlie independent assessments of DOE data and analyses regarding the performance of the proposed repository. The work focused on investigations of valley fill sediments exposed in Fortymile Wash, specifically to: (1) delineate sedimentary structure in the near surface alluvium; (2) determine if the near surface alluvium can be used as an analog of the alluvium in the saturated zone; (3) estimate values for the hydraulic properties and the distribution of these hydraulic parameters within the alluvium; and (4) develop a 3D conceptual model of the stratigraphic and structural framework. This entry provides the procedures and results used in the analysis presented in the milestone deliverable "Preliminary hydrostratigraphy of the valley-fill aquifer in Fortymile Wash and the Amargosa Desert". Conclusions (to-date) resulting from the work are presented in the report.

1. Additional outcrops

Listed below are additional outcrops located in or near Fortymile Wash that were not listed on page 6. A map providing the location of all of the outcrops utilized in the investigation to-date, is provided in Figure 8.

Field Identification: 40mPROX   Subsequent Name Modification:
Northern most outcrop of the alluvium within the entrenched channel of Fortymile Wash
Approximate location[1]: Northing 4083182, Easting 0555066

Small outcrops in alluvial fans rimming Fortymile Wash were also visited. No official name designation is given to these outcrops.
- Outcrop beneath Jake Ridge
  Approximate location: Northing 4082149, Easting 0554511
- Outcrop beneath Calico Hills
  Approximate location: Northing 4081459, Easting 0555245

2. Lithofacies

Purpose: Delineate sedimentary structure in the near surface alluvium. These observation will assist in the development of a conceptual model of the sedimentary structure within the near surface alluvium, which can be used to improve the understanding of how the sedimentary structure of the valley-fill may influence groundwater flow.

Methods: Based on grainsize, sedimentary features, and deposit geometry, the alluvium was subdivided into seven diagnostic sedimentary facies. Descriptions of the seven delineated lithofacies along with the interpreted depositional process(es) are provided in the following paragraphs.

The nomenclature used in the alluvium descriptions was modified slightly, superceding Table 1 on page 8. The revised nomenclature is provided in Table 7. The degree of in-field cementation was unchanged, so Table 2 stands as is. The grain size scale used in the investigations and subsequent descriptions is provided in Table 8.

[1] UTM locations obtained using Garmin handheld GPS unit (locations accurate within ± 40 m)

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Table 7. Lithologic codes used in sediment descriptions and stratigraphic sections

Lithologic code	**Description**
Gravel and coarser	
Gcm	clast supported, massive
Gcmi	clast supported, massive, imbricated
Gch	clast supported, horizontal stratification
Gchi	clast supported, horizontal stratification, imbricated
Gcp	clast supported, planar cross stratification
Gct	clast supported, trough cross stratification
Gmm	matrix supported, massive
Sand	
Sm	massive
Sh	horizontal stratification
Sp	planar cross stratification
St	trough cross stratification

Table 8. Grain size system utilized in alluvium descriptions (modified Wentworth scale)

Sediment grain size	**Size range (mm)**
clay	$<{}^{1}/_{256}$
silt	${}^{1}/_{256}$–${}^{1}/_{16}$
sand	${}^{1}/_{16}$–2
gravel	2–64
cobble	64–256
boulder	>256

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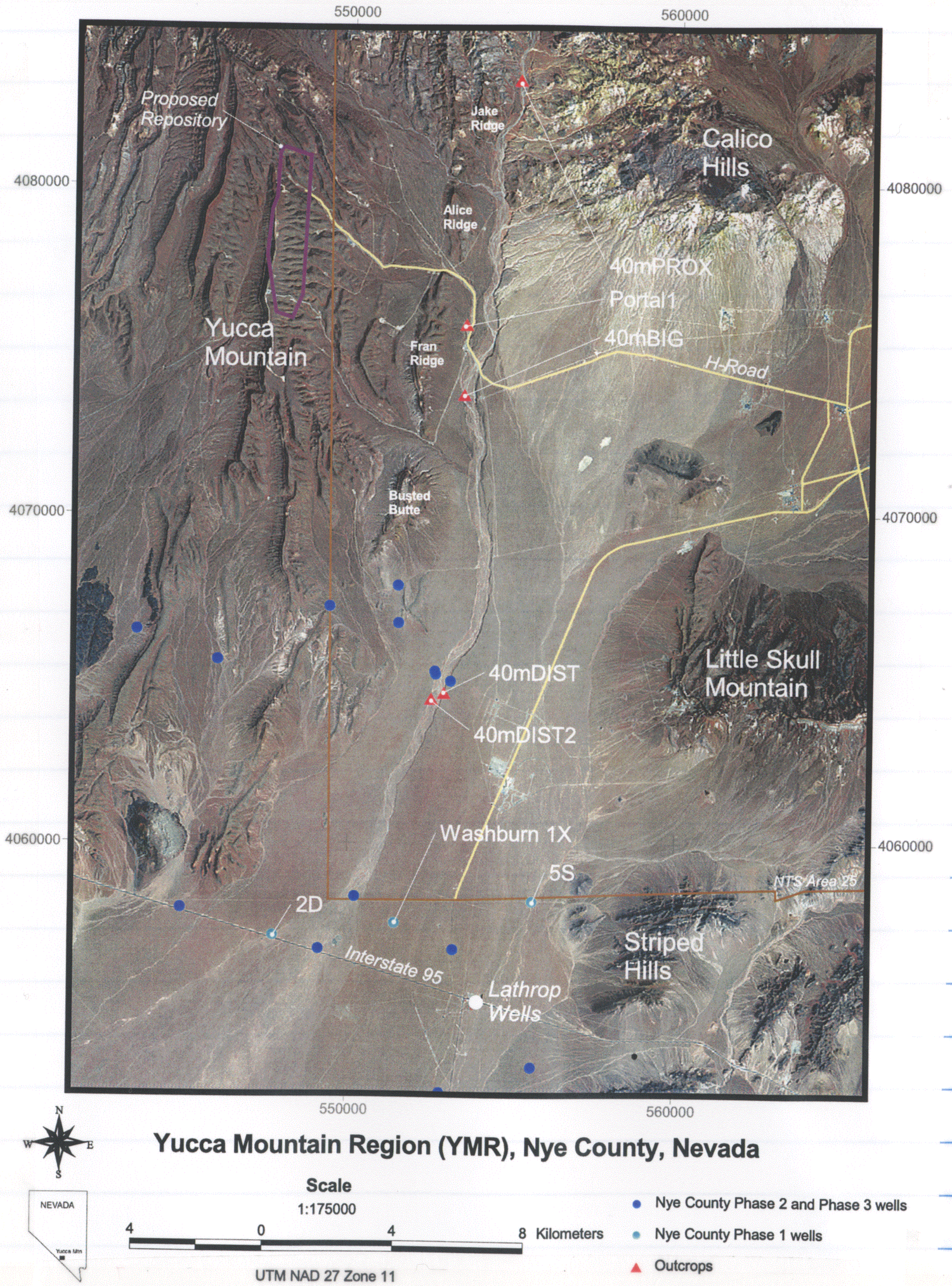

Figure 8. Location of investigated outcrops within the entrenched channel of Fortymile Wash.

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Results:

Facies F1 (Gcm to Gcmi)

Description Facies F1 is characterized by clast-supported, well sorted cobble to boulder conglomerate with a matrix of well cemented medium to coarse sand (figure 9). This facies typically has a distinct bimodal grain size consisting of cobbles to boulders, and medium to coarse sand. Some clasts are imbricated. Scattered outsized boulder clasts in the range of 60 cm occur. This facies has lenticular geometries with lengths of 10 to 50 m 10 to 50 cm thick. Facies F1 occurs as isolated lenses within Facies F2. The lenticular geometries are best developed perpendicular to the longitudinal axis of the wash (perpendicular to the flow direction). Facies F1 is common in occurrence and remains fairly consistent in character in the investigated outcrops.

Interpretation Facies F1 is interpreted as channel deposits that formed between longitudinal bars in a braided stream system (Miall, 1977). Facies F1 is always found in close association with Facies F2 and both facies are interpreted to have formed by similar depositional processes.

* see pages 70–73
T. Kessler 2/1/01

Figure 9. Facies F1: Elongate to lenticular units of clast-supported, well sorted pebble to boulder conglomerate with a matrix of medium to coarse sand.

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Facies F2 (Gch/Sh to Gchi/Sh)

Description

The most common facies within the alluvium is horizontally stratified gravel and sand, which is here defined as Facies F2. The characteristic feature of the facies is the portioning of grain sizes, forming gravel-sand couplets (figure 10). The coarse component consists of clast-supported medium gravel to fine cobble. In some exposures, the coarse component has a distinctive bimodal grain size content consisting of gravel to fine cobble and medium to coarse sand; while in other exposures, portions of the coarse component have open framework. The fine component of the gravel-sand couplets consists of interlayered medium to coarse sand and fine gravel. The sand layers tend to be more strongly cemented than the gravelly layers and stand out in relief, highlighting the stratification present. These gravel-sand couplets vary in thickness, but are typically less than 50 cm in thickness. Imbrication of clasts is common, and is particularly evident in the coarser, elongate clasts. Numerous thin (millimeters in thickness) but laterally extensive sandy caliche layers are commonly present within the facies and are characteristically separated by intervals of tens of centimeters. These thin caliche layers are concentrated within the sandier component of the facies, and commonly cap the gravel-sand couplets. Facies F2 was consistently observed throughout the various outcrops, though the grain size varied slightly. In the proximal regions, the grain size is more coarse but the couplets of coarser and finer clast sizes are still clearly observable. In the same manner, Facies F2 has a finer grain size content in the distal outcrops, but retains the other sedimentary features of the facies. Lenticular units of cross bedded gravel are locally present within the horizontally stratified gravel. The lenticular units are on the order of 5 to 15 m in length. Stratification within the lenticular units varies from stratification parallel to the base of the lense, to cross stratification that is tangential to the bottom of the channel, to more planar-like cross stratification. A coarse gravel to cobble lag is commonly developed along the bottom of the channel (figure 11).

Interpretation

The formation of gravel-sand couplets (sometimes referred to as gravel couplets) is attributed to the migration of gravel bedforms on the channel bottom. These gravel-sand couplets have been attributed to the migration and destruction of antidunes (Blair, 1987) in sheetflood flows on alluvial fans and the bar-front migration of submerged gravel bars in braided stream environments (Carling and Glaister, 1987; Carling, 1990). The bar-front migration mechanism of Carling and Glaister (1987) is favored for the interpretation of the gravel-sand couplets in Facies F2. This mechanism not only accounts for the gradation of grain size, but also the bimodal sediment content of the coarse fraction and the open-framework gravels that were observed within the gravel-sand couplets. The cross-stratified gravel locally present within the horizontally stratified gravel is similar to structures observed by Siegenthaler and Huggenberger (1993) in their investigations of Pleistocene braided stream deposits in Switzerland. These lense shaped units of cross-stratified gravel were interpreted by Siegenthaler and Huggenberger (1993) as scour pools developed at the convergence of two channels. A simple geometric model of pool migration with time and orientation of cross sectional view provides an explanation for the differing styles of cross-stratification observed within the lense shaped units (Siegenthaler and Huggenberger, 1993 Figure 12). Near identical cross-stratification was observed in the lense shaped gravel units within Facies F2 (figure 11). Currently, the cross-stratified gravel is included in Facies F2, though this sediment association may be subsequently identified as a separate facies.

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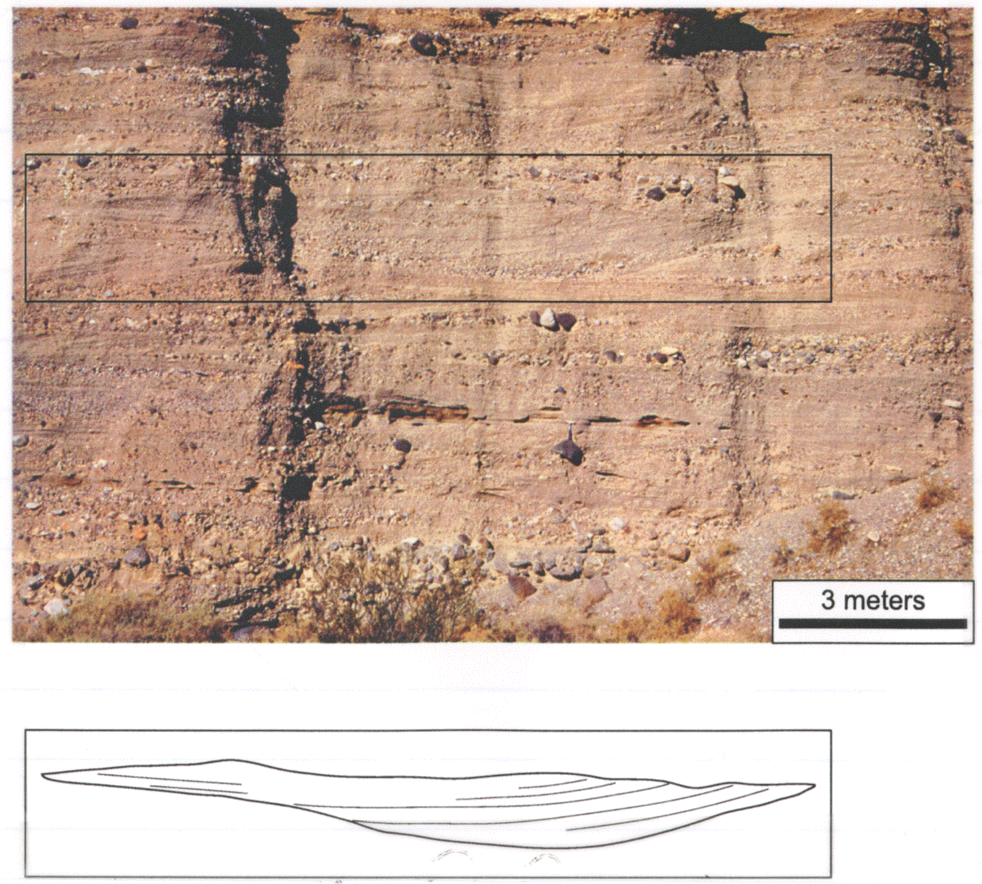
* See pages 70-73 T. Roessler 2/1/01

Figure 10. Facies F2: Alternating layers of gravel and coarse sand with fine gravel, forming gravel-sand couplets. Arrows highlight a single gravel-sand couplet. Numbers correspond to position on stratigraphic section 40mBIG.



* See pages 70-73 T. Roessler 2/1/01

Figure 11. Lenticular units of cross-stratified gravel within horizontally stratified gravel; interpreted as scour pools at the confluence of two braid channels.

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Facies F4 (Gcm to Gcmi, Gch, and Sh)

Description — Facies F4 consists of poorly sorted, clast-supported conglomerate that contains a wide range of clast sizes ranging from sand to boulders, with coarse gravel to fine cobbles predominating. Imbrication of clasts is common. The facies exhibits crude horizontal to subhorizontal stratification due to partitioning of coarser and finer grain sizes into crude gravel couplets 40 to 50 cm thick (figure 12). The finer portions consist of sand to gravel and the coarser portions consist of sand and cobbles. In some exposures the cobble layers are strongly cemented and may have significant caliche development. These coarse layers stand out in relief within the facies. Small lenses of sand to fine gravel, typically less than 30 cm in thickness, are variably present within the facies. The available exposures of Facies F4 are limited, but the facies appears to be laterally continuous tabular units on the order of 1–2 m thick. Channelized fine to medium gravel and sand is commonly present at the top of the facies (figure 13).

Interpretation — The poor sorting and organization of the facies indicates a more turbulent depositional process than that which deposited the other facies. The crude stratification and clast imbrication indicate tractive transport processes. This facies is interpreted as deposits of turbulent flood flows containing extremely high sediment concentrations. Similar poorly sorted and poorly organized deposits have been described by Nemec and Steel (1984) and have been attributed to 'fluvial sediment flows.' Terminology regarding these deposits and this realm of fluid flow is not well defined and according to Nemec and Steel (1984) these types of flows have also been referred to as hyperconcentrated flows, intermediate-type flows, streamfloods, and sheetfloods. The channelized gravel and sand commonly present atop the facies is interpreted as erosion and deposition by lower discharge channelized flows following the flood flow.

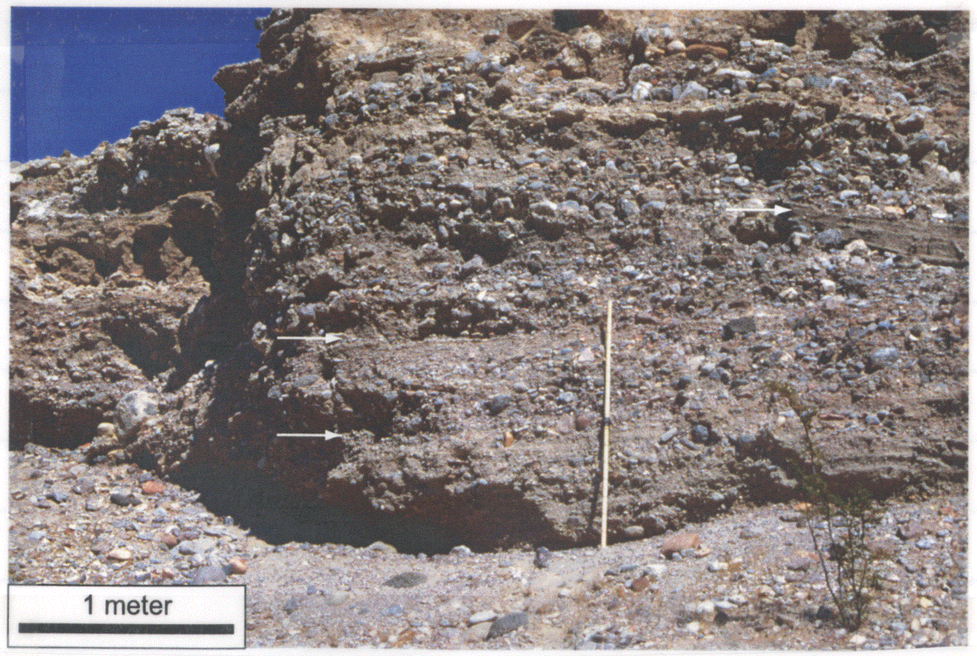

Figure 12. Facies F4: Poorly sorted, coarse alluvium displaying crude horizontal stratification. Arrows to the left of the Jacob staff highlight coarse layers in crude gravel couplets. The single arrow to the right highlights a small lens of fine gravel and sand within the facies.

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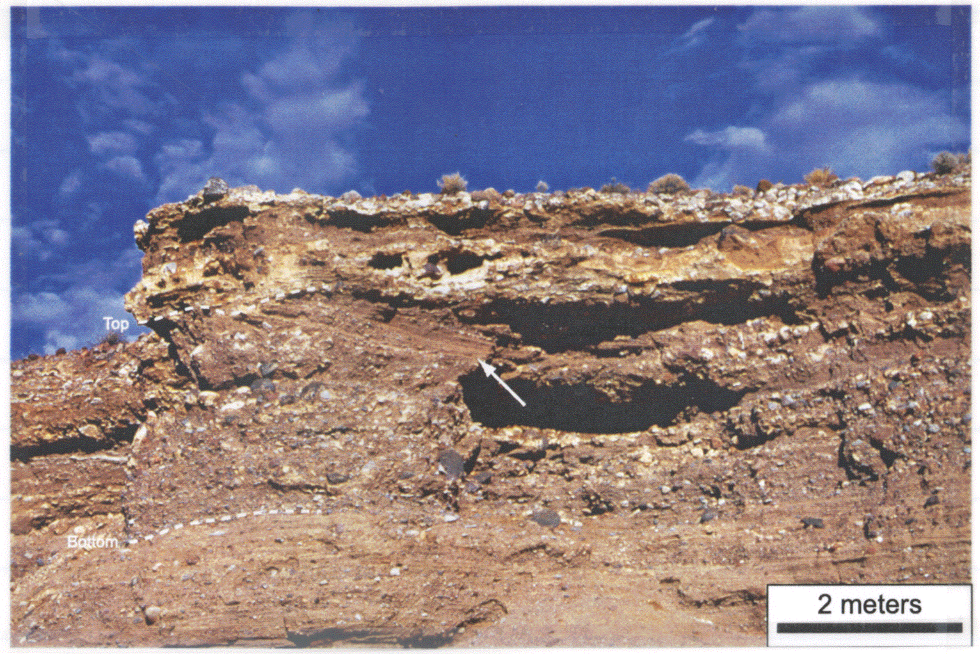

Figure 13. Channelized fine to medium gravel and sand at the top of Facies F4, indicated by arrow. The bottom and top of Facies F4 are indicated by the dashed lines.

Facies F5 (Gmm to Gcm)

Description — Facies F5 is a clast-supported, distinctly disorganized deposit consisting of angular gravel to boulders with a matrix of medium to coarse sand (figure 14). The facies has a distinct bimodal sediment content, and the angularity of the particles strongly contrasts with the predominant rounded to well rounded nature of the majority of the alluvium. The facies is distinctively almost monolithologic in clast content. Some clasts of differing lithology are present in the deposit, though in minor amounts, and have the more rounded texture characteristic of the Fortymile Wash alluvium. Only a single exposure of Facies F5 was observed within the Fortymile Wash valley fill, in Portal 1. In this exposure, the facies is variable in thickness but always less than 50 cm, and is laterally extensive for 10 to 15 m.

Interpretation — On the basis of the extreme angularity of the clasts, the dominant monolithologic clast content of the sediment, and the disorganized arrangement of the clasts, Facies F5 is interpreted as a rock slide or debris flow deposit. The more rounded clasts of differing lithologies contained in the facies are interpreted as Fortymile Wash alluvium that was entrained by the sediment gravity flow. The monolithologic clast content of Facies F5 is thought to be characteristic of the facies, but the lithology of the clasts in a particular exposure of the facies is dependent of the sediment source of the sediment gravity flow. The facies is limited in outcrop exposure and is volumetrically minor in the areas of the wash where outcrops are available. However, this facies is interpreted to be more expansive and volumetrically larger toward the margins of Fortymile Wash where mountains rim the wash—localities with steep slopes where these types of flows commonly occur and where relict deposits are present. Upon deposition, Facies F5 is reworked by subsequent water flows in Fortymile Wash. This is illustrated by the incorporation of scattered angular clasts identical to those observed in Facies F5 into subsequent deposits of Facies F2 (figure 14). Deposits similar to Facies F5 were observed in outcrop in the slopes beneath Jake Ridge (figure 8). These deposits, also interpreted as deposits of sediment gravity flows, are poorly sorted, poorly organized, and consist predominantly of angular monolithologic clasts..

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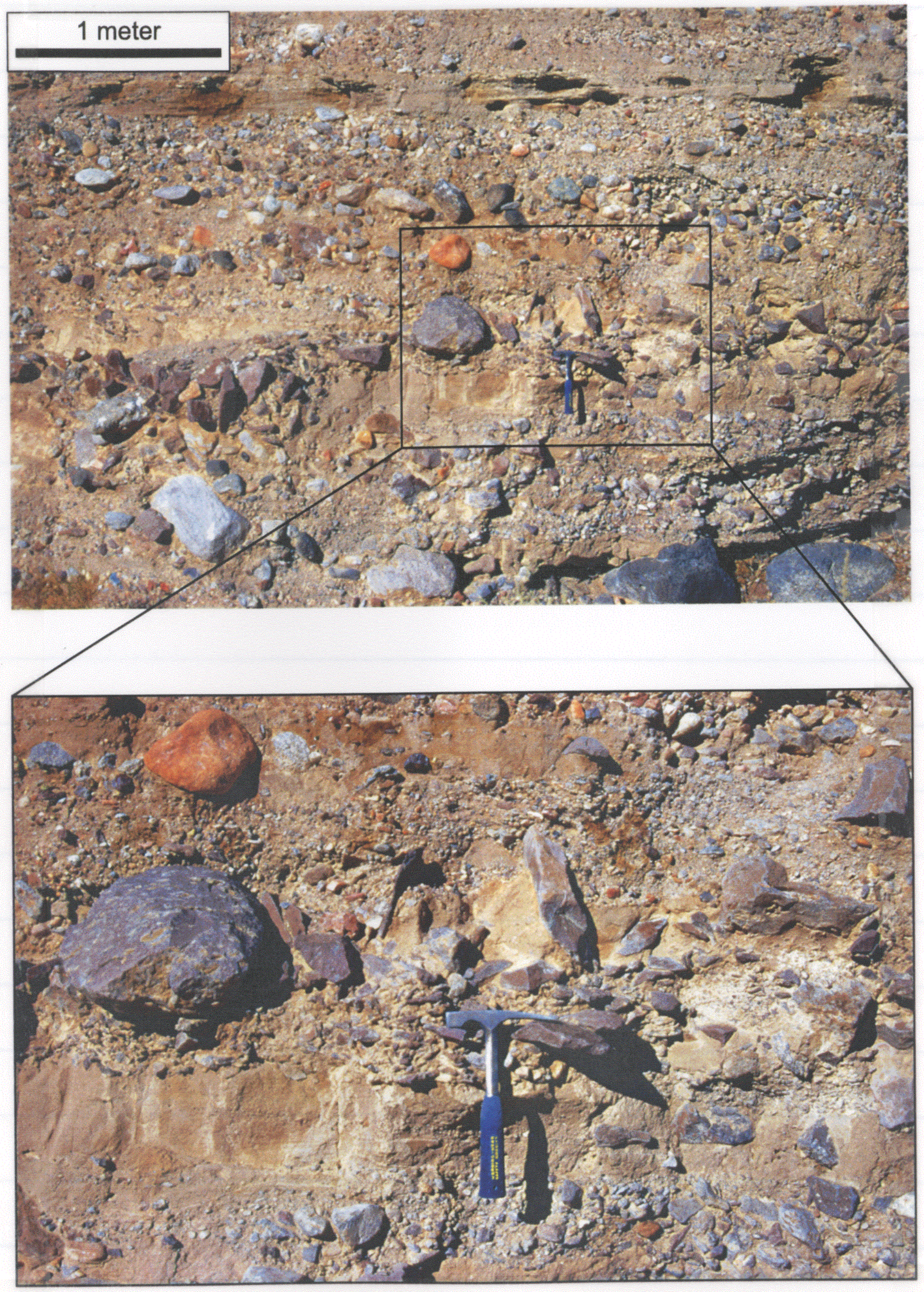

Figure 14. Facies F5: Clast-supported, distinctly disorganized deposit consisting of dominantly monolithologic angular gravel to boulders with a matrix of medium to coarse sand. Note the incorporation of angular clasts identical to those observed in Facies F5 into subsequent deposits of Facies F2.

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Facies F6 (Gcm)

Description

Facies F6 consists of gravel to boulder conglomerate with well developed calcrete cement (figure 15). The facies varies from 5 to 30 cm in thickness, though typically not exceeding 20 cm. The facies is laterally extensive for 100s of meters, but over that length the thickness varies, and in some cases the facies is discontinuous. Facies F6 is commonly present stratigraphically below paleosols (Facies F7). These gravelly calcrete horizons stand in relief and form resistive ledges in outcrop.

Interpretation

Facies F6 is commonly developed beneath paleosols. These calcrete horizons are interpreted as pedogenic carbonate associated with paleosols.

Figure 15. Layers of Facies F6 developed beneath a paleosol. Arrows highlight individual gravelly calcrete horizons.

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Facies F7 (Sm to Sh)

Description

Facies F7 consists of medium to very coarse sand with well developed calcite cement. The facies contains varying concentrations of gravel to cobbles, is mildly to heavily bioturbated, and commonly contains small caliche layers within the unit as well as an exposure of Facies F6 at its base. The internal stratification of the facies is complex. In many exposures, the internal stratification resembles that of one of the other delineated facies except for the increased sand content, increased cementation and caliche formation, and the reddish coloration. In other exposures, the facies appears more massive in appearance. Bed thickness typically range from 50 cm to 2 m in thickness, and the facies may be scoured out by overlying units. In one exposure, the units appear lenticular in shape, ranging in thickness from 50 cm to 1 m and extending laterally 10 to 40 m (figure 16a). In this exposure, the facies is predominantly sand, is mildly bioturbated, and tends to show horizontal to subhorizontal stratification and does not contain substantial amounts of gravel or outsized boulders. Some of these sand units appear to be arranged in groups, where several of the sand bodies are located laterally adjacent to each other at the same stratigraphic level. In other exposures, the facies is 1 to 2 m in thickness and extends laterally for 100s of meters. In general, these thicker units tend to be highly bioturbated, completely homogenized (no stratification), and contain scattered gravel clasts (figure 16b). In some instances, the facies contains outsized cobble and boulder clasts. A gravelly caliche layer (Facies F6) typically 10–30 cm thick is commonly developed near the base of the unit.

Interpretation

The increased fine component content, intensive caliche development, bioturbation, and orange-red coloration make a strong argument that these units are the result of pedogenic processes. This facies is interpreted as paleosols in various stages of development. The varying internal stratification and grain size content of this facies reflects the different sediment deposits in which soil development took place.

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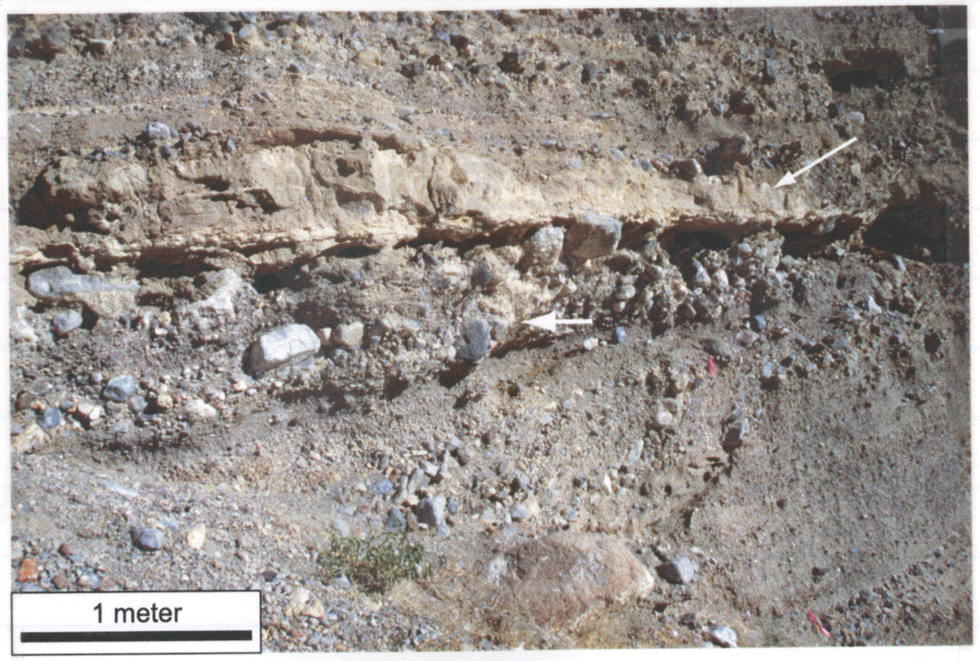
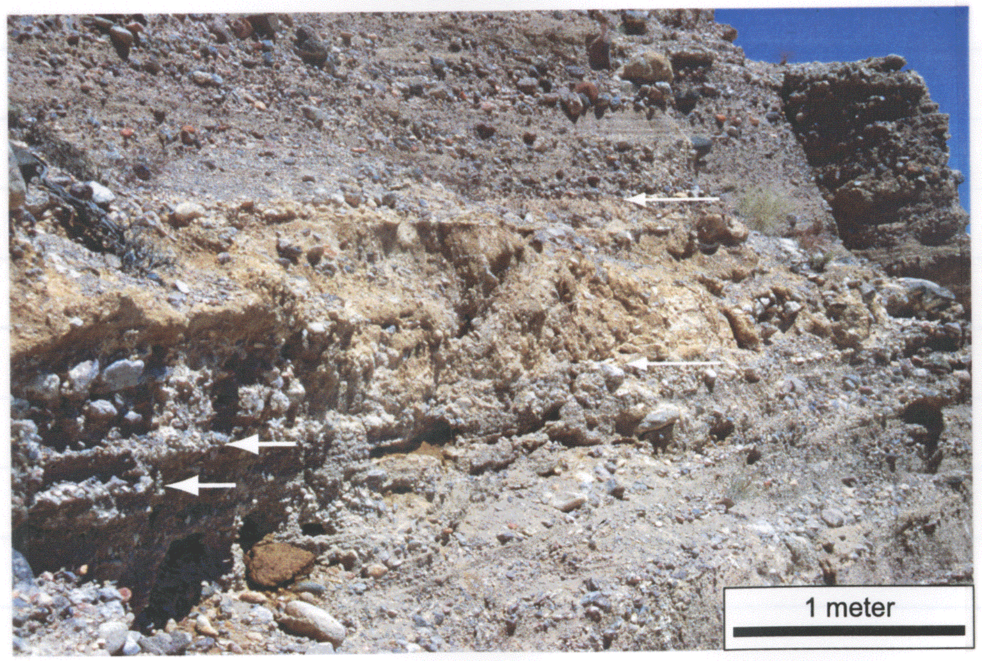


a)



b)

Figure 16. Facies F7: Paleosols in various stages of development. (A) Lenticular shaped sand body consisting of medium to coarse sand. Sand is bioturbated, calcite cemented, and has a distinctive orange-tan color. Thick, short arrows indicate gravelly caliche layers. (B) Laterally extensive, heavily bioturbated coarse sand with scattered gravel and cobbles to boulders. Thin, long arrows highlight top and bottom of the paleosol. Thick, short arrows indicate gravelly caliche layers.

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Facies F8 (Sh)

Description

Facies F8 is the only sand dominated facies present within the alluvium. This facies consists of well sorted, medium to coarse sand that variably contains scattered fine gravel clasts (figure 17). The sand typically displays horizontal stratification, but appears almost massive in some exposures. In some instances, the sand is mildly bioturbated, limited mostly to scattered burrows. Facies F8 occurs as lenticular shaped sandstone drapes, typically found in association with bimodal gravel units (Facies F1 or coarse fractions of gravel couplets in Facies F2). The facies is typically less than 30 cm thick and is laterally continuous for only about 1 m. Facies F8 is not volumetrically significant within the outcrops investigated.

Interpretation

The sand composing Facies F8 appears similar to the sand found in the matrix of Facies F1 and the coarse fraction of the gravel couplets in Facies F2. The fine grain size content of this facies stands in contrast to the predominantly coarse grain size content of the alluvium. Facies F8 is interpreted as concentrations finer sediment deposited during waning flow.

Figure 17. Facies F8: Lenticular shaped sandstone drapes composed of well-sorted, medium to coarse sand.

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3. Outcrop density profiles

Date(s): Collected during May 7, 2000 through May 12, 2000 and during August 14, 2000 through August 16, 2000.

Participant(s): Theodore R. Ressler, Kenneth D. Ridgway, Deborah Waiting

Purpose: Preliminary analysis of the lithology logs from the NC-EWDP wells indicate the alluvium at depth generally shows similar sediment types and 'bed' thickness to those sediments observed in outcrop: predominantly sand and gravel with some intervals of increased/decreased gravel, sand, silt, and/or clay content. Based solely upon the lithologic data, the types of sediment present at depth that were not observed in outcrop were reworked tuff (or bedded tuff or fine sandstone) in NC-EWDP-5S at 750 m and 728 m AMSL, and several thin intervals (< 1 m) of predominantly clay in NC-EWDP-2D at 739 m AMSL and in NC-EWDP-5S in the interval 744–751 m AMSL. A more detailed description of the subsurface alluvium can be developed by augmenting the available lithology logs with interpretations made from the collected geophysical wireline logs. Due to the problems discussed previously, only a portion of the collected geophysical logs are available for this task. To assist in the interpretation of the geophysical logs, simulated density and gamma ray wireline logs (i.e. outcrop profiles of density and gamma radiation) were developed at several of the exposed outcrops. The purpose of the outcrop profiles is to investigate whether particular facies have a distinctive geophysical response or 'signature', which can be used to further constrain lithologic interpretations of the Nye County wells.

Background: Two borehole methods for determining bulk density are sonic velocity and neutron logs. Neutron logging tools measures bulk density by emitting neutrons into the formation and measuring the backscatter of electrons. The backscatter of electrons is a function of the rock (or sediment) and the fluid contained in the formation. The bulk density of the formation, also a function of the rock (or sediment) and the contained fluid, can be related to the amount of backscattered electrons. Sonic velocity logging tools operate by emitting a compressional wave (P-wave) and recording the travel time through a fixed length of the formation. The velocity of the emitted P-wave through the formation depends on the rock (or sediment) and fluids contained in the formation. The calculated P-wave velocity through the formation can be related to the bulk density of the formation through an empirical relation.

Neutron density and sonic velocity were variably utilized in the geophysical logging of the NC-EWDP (Phase I) wells. In all of the wells located within Fortymile Wash, neturon density logs were run. Due to problems with borehole collapse upon removal of the drill string, the neutron density logs were completed in the drill string. The effects of the drill string could not be compensated for, so the neutron density measurements were left as count rates (CPS). Accordingly the density logs only provide qualitative density information (R. Federwisch of Geophysical Logging Services, personal communication). Some additional density logging (sonic) was completed once the drill string was removed, but in many cases these logs only provide truncated data sets as a result of borehole collapse during logging. The logs available for the NC-EWDP wells in Fortymile Wash are provided in Table 9.

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Table 9: Geophysical logs for available NC-EWDP wells located in Fortymile Wash.

Well	Total depth (ft)	Logs available	Logged interval (ft)
2D	1618	neutron density gamma	0 to 440 0 to 440 0 to 440
5S	1200	neutron density gamma e-logs caliper deviation	0 to 1160 0 to 1160 0 to 1160 500 to 950 500 to 690 0 to 1160
Washburn 1X	658	neutron density gamma e-logs deviation	0 to 657 0 to 657 0 to 657 340 to 511 0 to 657

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Methods: Field determination of rock density is limited to three methods: (1) collection of rock/sediment samples for laboratory determination of density, (2) use of nuclear density devices, and (3) use of sonic velocity devices. The collection of rock/sediment samples is a simple, well-established method; unfortunately, in our study intact samples could not be removed from the outcrop due to the nature of the sediment investigated. Nuclear density devices see widespread use for density determination, but unfortunately require a trained technician to operate them because of the radioactive source utilized in its operation. The density measurements described in the following paragraphs were made using a small hand-held ultrasonic velocity probe developed by Batzle and Smith (1992). The instrument operates much like a borehole sonic probe: emits a P-wave and records the arrival time of the P-wave at two locations separated by known distance. Obviously, the fixed separation distance of the hand-held probe is quite small (1 inch) and the penetration depth of the P-wave is only a few millimeters. A detailed explanation of the hand-held velocity probe is provided in the paper by Batzle and Smith (1992).

Several aspects of the hand-held velocity probe must be considered before the interpretation of the collected measurements or comparison to borehole sonic logs. The investigation volume of the velocity probe is limited to the surface of the material; therefore, weathering and surface roughness will affect the velocity measurements (Batzle and Smith, 1992). Attempts were made to minimize or standardize these effects by preparing a fresh surface on the outcrop at each measurement location. The outcrop velocity measurements were made in unsaturated media and at zero effective pressure (on the outcrop face), conditions that will differ in the subsurface. Accordingly, the outcrop measured velocities should be systematically lower than the same material at subsurface conditions (Batzle and Smith, 1992). As alluded to earlier, the volume of investigation of the hand-held scope is much smaller than that of a borehole instrument (transmission of a P-wave over 1 inch of formation as compared to 1 ft of formation). According to the designers, "probe measurements are primarily for comparison of one location to another, of one lithology to another, or of property changes within a single lithology" (Batzle and Smith, 1992). The velocity measurements are not absolute values, rather the measurements provide information on the relative changes in velocity (i.e., changes in apparent velocity). Finally, many of the available density logs from the NC-EWDP wells were developed using neutron or gamma logging tools; consequently, the hand-held velocity measurements will not be directly comparable to wireline density logs. As a result of these factors, only qualitative comparisons of the outcrop density profiles and the borehole density wireline logs will be possible.

Despite the 'relative' nature of the outcrop velocity measurements, Batzle and Smith (1992) provide several examples of how outcrop velocity profiles were successfully used as simulated wireline logs for assistance in reservoir characterization.

[Special notes: After the construction of the velocity probe, the Vp velocity of a standard was measured by Batzle and Smith and was provided with the instrument. The calibration and correct operation of the velocity probe was periodically checked to the standard. In addition, it should be noted that the instrument is designed for investigating relative changes. The apparent density obtained from the analyses is based on an empirical relation as was only developed to display the relative density changes in familiar units.]

The outcrop density profiles were developed following the basic methodology utilized by Ahmadi and Coe (1998); except that whereas Ahmadi and Coe obtained their point bulk density measurements from laboratory analyses of rock samples removed from outcrop, the density measurement in my study were collected using a hand-held ultrasonic velocity probe. The apparent density values were calculated using Gardner's velocity/density model (Mavko et al., 1998):

$$\rho_b = a*V_p^2 + b*V_p + c$$

where,

ρ_b = bulk density (g/cm^3)

V_p = p-wave velocity (km/s)

a, b, c = empirical coefficients

The sandstone model was chosen for the velocity-density calculations since the observed P-wave velocities ($0.6 \le V_p \le 6.4$ km/s) closely approximated the model V_p range ($1.5 \le V_p \le 6.0$ km/s). The empirical coefficients for the sandstone model are : a = -0.0115, b = 0.261, and c = 1.515 (Mavko et al., 1998).

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The density profile of the outcrop was generated by plotting the measured densities at the stratigraphic interval at which they were sampled. Both a raw and adjusted density profile were developed. The adjusted density profile is the raw density profile was adjusted to compensate for the limited number density measurements that could be collected from each bed and for beds that were not sampled. These adjustments consisted of: (1) assigning the single density measurement for a particular bed to the entire bed thickness, (2) assigning and average density value determined from the measurements made within a particular bed to the remainder of the bed thickness that was not sampled, and (3) assigning an average density (typical for the particular sediment) to beds that had no density measurements. Ahmadi and Coe suggest the application of a moving average filter to the developed density "box curve" to account for the 'moving average' effect of wireline density logging (i.e., consecutive readings overlap portions of the sampling volume of previous readings.)

[Special notes regarding the adjusted density profiles: If data were collected from a facies, that data was used. If the precise stratigraphic location was available, the measurements were put in their precise location. If an approximate stratigrahic location was available (e.g., 5.2 - 5.4 m) then the measurement was placed in the middle (e.g., 5.3 m). If multiple measurements were made in a single occurrence of a facies, all the data values were used at the collected stratigraphic position. The only exception was Facies F1 and F6. Due to the coarse nature of these units, the bulk Vp velocity was estimated using a weighted average of the clasts and the matrix, the weights determined by the clast to matrix ratio. In these units, the multiple measurements were combined to develop one estimate of the sonic velocity of that occurrence of the facies. This single value was placed at the middle of the facies. For units with a single measurement, the single measurement was applied to the total thickness of the unit. For units with multiple measurements, and average of those values was used at the top and bottom of the unit if needed to 'box out' the thickness of the unit. For units with no measurements, and average density (typical for the particular sediment) was applied to the total thickness of the unit.]

Results: The variations in density observed in the alluvium are illustrated in figure 18. The coarse units have higher densities than the finer grained units. This arises from the larger clasts contained in the coarser units. An average density range for the volcanic rocks in the area is 1.8–2.45 g/cm^3 (Brocher et al., 1998) and an average bulk density range for sand is 1.44–2.40 g/cm^3 (Carmichael, 1989). The large cobbles and boulders in the coarse units have a higher density than a sand or a sand and fine gravel unit; consequently, a unit containing a large percentage of large clasts should have a higher bulk density than a sand or sand and fine gravel unit. Our density values compare favorably with values used by Brocher et al. (1998) for the alluvium in Crater Flat (1.8–2.2 g/cm^3). An outcrop density profile was also developed from 40mDIST; displaying similar facies responses as seen in the Portal 1 density profile (figure 19).

Limited success was obtained in identifying unique geophysical 'signatures' for the different delineated facies. The outcrop density profiles were found to be primarily a function of the clast content of the valley fill. The profiles clearly identify the cobble and boulder layers: Facies F1, Facies F4, Facies F6, and in some instances the coarse fraction of the gravel-sand couplets in Facies F2.

Theodore R. Pessh
9/28/00

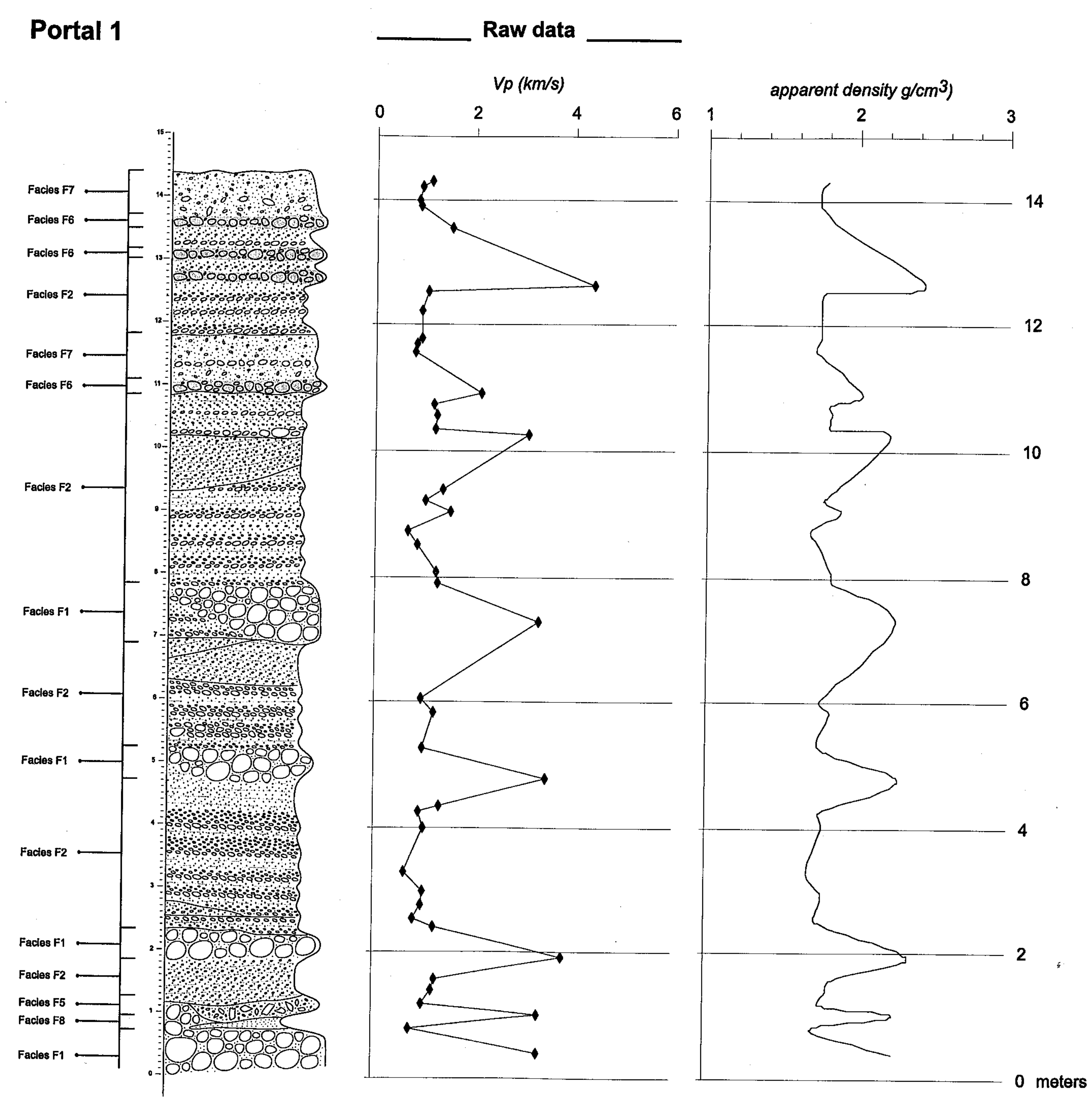

Figure 18. Outcrop density profile of Portal 1.

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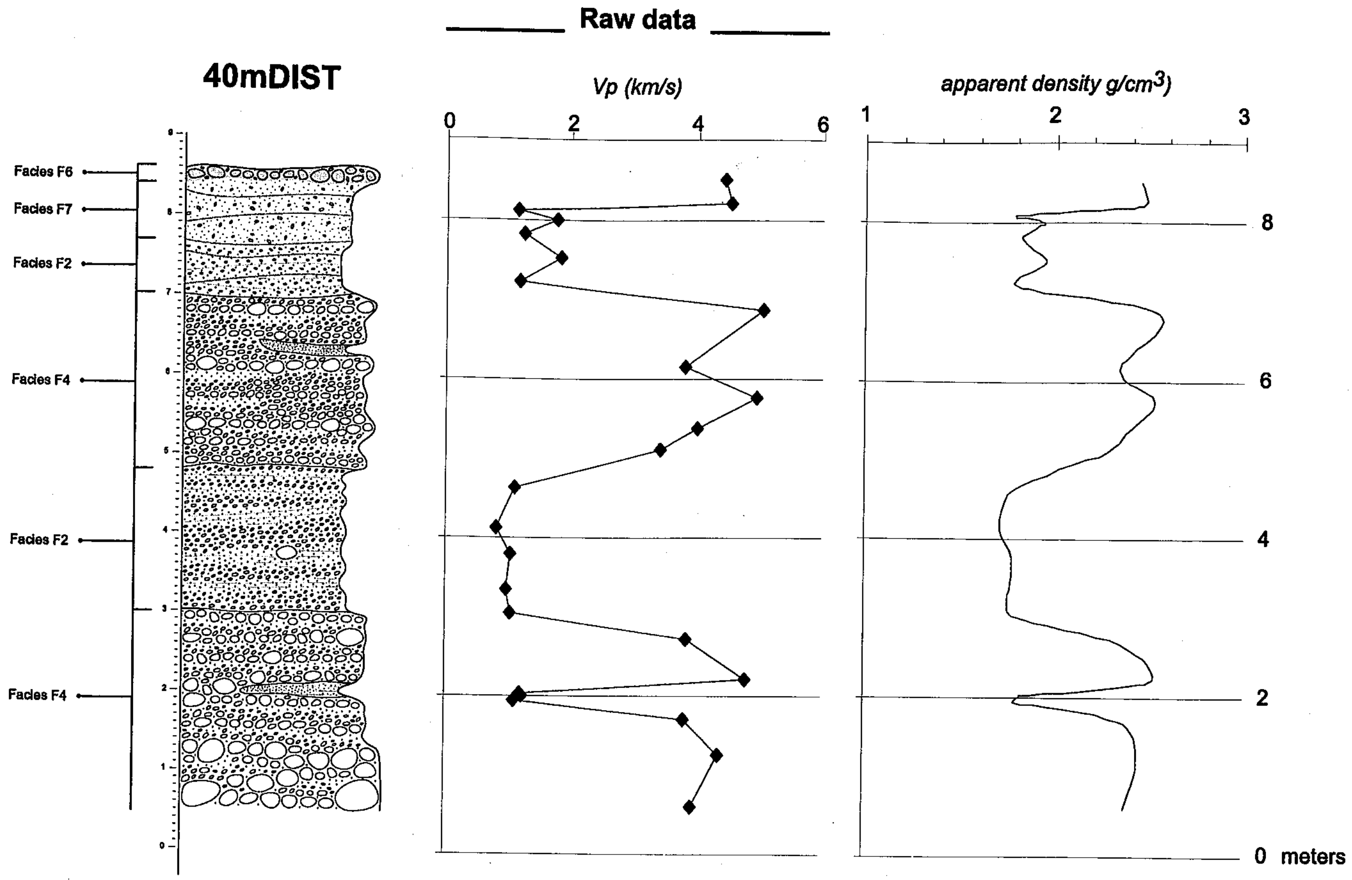

Figure 19. Outcrop density profile of 40mDIST

References:

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Theodore R. Ressler 9/28/00

4. Laboratory test of gamma ray spectrometer

Date: July 14, 2000 (refers to date of laboratory test of spectrometer) T. Ressler 9/28/00

Location: Bureau of Economic Geology, Pickle Research Center, Austin, TX

Participant(s): Theodore R. Ressler

Purpose: Test effectiveness of gamma ray spectrometer (Exploranium GRS-256 with GPS-21 dectector) in reproducing a gamma log from associated core. The gamma ray spectrometer was subsequently used on outcrops in Fortymile Wash to establish geophysical signatures for the delineated facies (if possible).

Methods: A gamma ray wire line log was obtained for an available core. An interval of the core was selected for logging, based on noticeable response on the gamma ray wireline log (an appropriate site for trying to reproduce the observed signal). Measured the gamma ray response over the chosen interval with the gamma ray spectrometer. Compared the measured results with the wireline log.

Core used: C-04618
well name: E.A. Barker No. 1
field name: Wildcat
county: Jasper
state: Texas
Section of core examined: 10375 to 10590 ft; sections were missing at 10375-10391 ft, 10435-10492 ft, and 10570-10590 ft.

Spectrometer was set at
time period of count: 100s
reference channel: 0 (no source)
ROI (energy range of total count window): 10-255
Collected gamma ray measurements at 1 ft increments

Results: Two of the logged sections compare well with the wireline log (figure 20). The signatures are similar, though the count rates are different. This is not unexpected due to the relative nature of gamma ray measurements and the different volume of investigation for the handheld spectrometer and the borehole tool. There is some offset between the wireline and the logged core. This is probably due to inaccuracies in the depth marking of the core.

The spectrometer response of the top section of the core is anomalous. I'm a bit suspicious that this section of the core may have been mislabeled as this section of the core was a different diameter than the rest of the core.

The spectrometer was operating correctly, and was able to reproduce from the core a comparable signal to that obtained during the wireline logging of the borehole.

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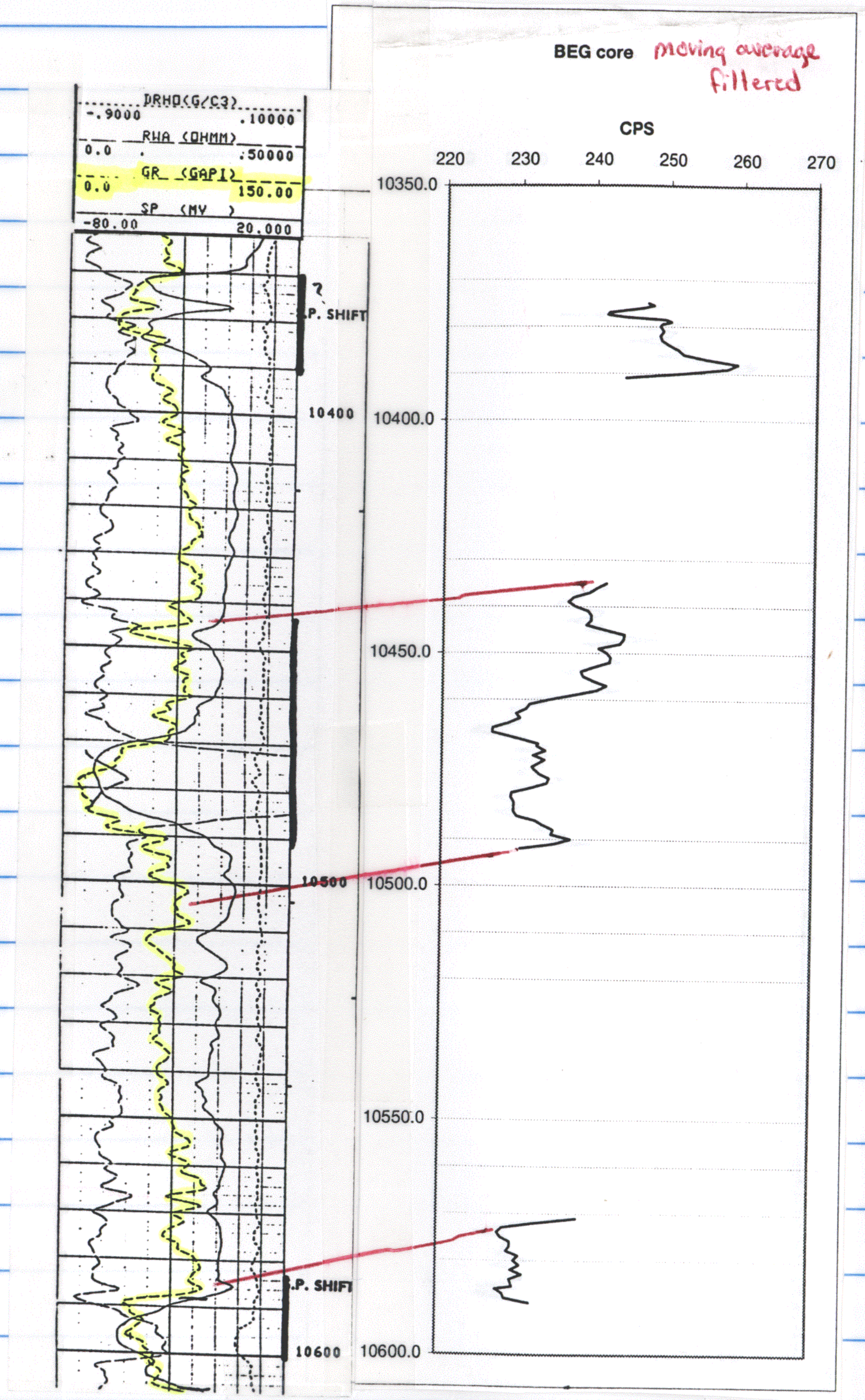

Figure 20. Gamma ray wireline log and response from spectrometer logged core sections.

Theodore R. Ressler 9/28/00

5. Outcrop gamma ray profiles

Date: Collected during August 16, 2000 through August 21, 2000

Participant(s): Theodore R. Ressler, Deborah Waiting, Melissa Hill

Purpose: Preliminary analysis of the lithology logs from the NC-EWDP wells indicate the alluvium at depth generally shows similar sediment types and 'bed' thickness to those sediments observed in outcrop: predominantly sand and gravel with some intervals of increased/decreased gravel, sand, silt, and/or clay content. Based solely upon the lithologic data, the types of sediment present at depth that were not observed in outcrop were reworked tuff (or bedded tuff or fine sandstone) in NC-EWDP-5S at 750 m and 728 m AMSL, and several thin intervals (< 1 m) of predominantly clay in NC-EWDP-2D at 739 m AMSL and in NC-EWDP-5S in the interval 744–751 m AMSL. A more detailed description of the subsurface alluvium can be developed by augmenting the available lithology logs with interpretations made from the collected geophysical wireline logs. Due to the problems discussed previously, only a portion of the collected geophysical logs are available for this task. To assist in the interpretation of the geophysical logs, simulated density and gamma ray wireline logs (i.e. outcrop profiles of density and gamma radiation) were developed at several of the exposed outcrops. The purpose of the outcrop profiles is to investigate whether particular facies have a distinctive geophysical response or 'signatures', which can be used to further constrain lithologic interpretations of the Nye County wells.

Background: Two basic types of borehole gamma ray logging tools exist: scintilometers and spectrometers (spectral scintilometers). Both instruments measure the amount of natural gamma radiation emitted by the formation, only a spectrometer allows more detailed processing of the measurements. Only the total amount of gamma radiation is measured by a scintilometer, while a spectrometer is capable of partioning the measured gamma radiation according to the frequency of the gamma rays. Different radioactive isotopes emit radiation at different frequencies, so the proportion of the measured radiation arising from a particular isotope can be determined. The natural gamma radiation arises from radioactive isotopes naturally present in rock (or sediment). Both instruments detect the level of gamma radiation by measuring the rate of gamma ray interaction with a Sodium Iodide (NaI) crystal that is contained in the detector. The specifics of the instruments' operation are not explained further in this document, but are available in Ahmadi and Coe (1998) or in any basic wireline interpretation text.

These instruments provide the level of gamma radiation in terms of a rate, typically expressed as counts per second (CPS). The count rate obtained from an instrument is not an absolute rate, rather it is a relative rate that is dependent on several factors. The radioactivity detected by a scintilometer (or spectrometer) is dependent on the size of the crystal used in the detector, the distance between the detector and the gamma ray source, and the angle between the detector and the gamma ray source (Ward, 1982). In addition, the observed rate is dependent on the background radiation setting of the instrument. Consequently, the count rates the same material obtained using different instruments may differ.

The majority of the gamma ray logging of the NC-EWDP (Phase I) wells was completed in the drill string. Some gamma ray logging was completed after removal of the drill string, but in many cases only truncated data sets are available due to borehole collapse. As mentioned in the preceding paragraph, gamma ray logs record the relative changes in the emitted gamma radiation from a formation; thus the running of the gamma logs in the drill string is less of an issue than in density logging.

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Methods: The outcrop gamma ray measurements were collected using and Exploranium GR-256 spectrometer with a GPS-21 detector. The GPS-21 utilizes a thermally insulated and ruggedized 21 in^3 sodium iodide (NaI) crystal coupled with a photomultiplier tube for gamma ray detection. The GR-256 is a 256 channel spectrometer that allows the measured gamma ray to be partioned into a max of eight user chosen isotopes. The spectrometer utilizes a small radioactive reference source (Cs 137 at 0.5 mC) for automatic gain stabilization (i.e, the frequency peak of the reference isotope is kept at the correct channel of the spectrometer) to correct for temperature and humidity effects.

Count rates from a borehole gamma ray tool will differ from that of a hand-held instrument due to the aforementioned differences between instruments, as well as because of sampling volume differences between borehole and hand-held instruments . A borehole gamma ray tool has a roughly spherical volume of investigation, while a hand-held instrument on an outcrop has rough hemispherical or Gaussian shaped volume of investigation. The differences yield differences in count rates, but as gamma ray logs provide relative changes in gamma radiation, these differences do not hinder comparisons.

Gamma ray measurements were collected at a sampling interval of 20 - 30 cm. The collected data from the outcrops is provided in Table 10. At this sampling interval, the investigation volume of consecutive measurements will overlap each other, which is analogous to borehole gamma logging. The NC-EWDP gamma ray logs were collected every 0.10 ft (~ 3 cm). The spectrometer (Exploranium GRS-256 and GPS-21 detector) was set at the following settings for the collection of the field data.

time period of count: 200s
reference channel: 55 (Cs 137 source)
ROI(s)

1	Total count energy window	60 - 255
2	Potassium (K)	111 - 125
3	Uranium (U)	132 - 150
4	Thorium (Th)	197 - 219

Natural radioactivity in igneous rocks primarily arises from the contained potassium, mainly in the form of feldspar. In sedimentary rocks, the highest natural radioactivity is associated with clays, specifically the radioactive elements present in the crystal lattice of the clay (Ward, 1982). In the study area, a change in gamma ray response is assumed to be related to these two components: the contained clasts of igneous provinance and the clays contained in the matrix.

[Special notes: Gamma ray logs provide qualitative information that is used to investigate relative changes in gamma radiation. The total gamma ray count is not a standardized measurement and is dependent on several factors which more or less amounts to a DC shift. When comparisons are made between gamma ray logs there are done so qualitatively. A reference source was used with the instrument when spectral gamma ray measurements were recorded. Spectral measurements provide the amount of gamma radiation arising from particular isotopes, usually Potassium (K), Thorium (Th), and Uranium (U). Each isotope gives off radiation at a particular frequency. The isotope used in the reference source (Cs 137) is programed into the instrument, and before each measurement is made the instrument refers to this known isotope and makes sure the frequency of this radiation in the correct channel of the spectrometer.]

The use of outcrop gamma ray profiles as simulated wireline logs is more established in published literature than is outcrop density profiles. Aigner et al. (1995), Thomas (1998), and Ahmadi and Coe (1998) provide published examples of how outcrop gamma ray profiles are developed and Aigner et al. (1996) and Aigner et al. (1999) demonstrate how gamma ray profiles can be utilized in outcrop analog studies to assist in formation characterization. Further references of additional studies utilizing outcrop gamma ray profiles are provided in these cited papers.

The methodology for developing the outcrop gamma ray profiles was much simpler than that used in the construction of the density profiles. Unlike the density sampling, the gamma ray sampling is not restricted by outcrop quality for sample placement. Thus measurement can be taken at any chosen sampling interval, simplifying the later construction of the outcrop gamma ray profile. The outcrop gamma ray profile was generated by plotting the gamma ray measurements at the stratigraphic interval at which they were recorded. The overlapping of the gamma ray measurements imparts a moving average effect on the results, consequently a moving average filter was not applied to the developed gamma ray profiles.

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Results: Analyses of the gamma ray logs are not yet complete.

Table 10. Gamma ray measurements obtained from Portal1 and 40mDIST

Portal1					40mDIST				
m	counts/200s				m	counts/200s			
strat pos	TC	K	U	Th	strat pos	TC	K	U	Th
0.2	19886	4354	938	621	8.6	19575	4146	935	605
0.4	21702	4686	1047	732	8.4	18767	4007	936	598
0.6	21095	4627	967	687	8.2	20932	4458	1062	676
0.8	23294	5109	1094	846	8	22167	4664	1057	673
1.0	21266	4676	990	738	7.8	21293	4518	1022	673
1.2	22419	4860	1062	803	7.6	23176	4872	1106	733
1.4	21162	4503	1043	741	7.4	25433	5394	1139	773
1.6	20833	4473	984	686	7.2	24137	5053	1134	757
1.8	21207	4501	891	761	7	24673	5258	1125	748
2.0	21500	4648	1052	724	6.8	23671	5032	1131	750
2.2	20228	4435	934	626	6.6	24772	5348	1210	748
2.4	21563	4658	1035	738	6.4	24452	5303	1182	786
2.6	21926	4683	1078	756	6	23015	4985	1158	721
2.8	21454	4612	1048	735	5.8	22041	4723	1058	769
3.0	21299	4561	1010	767	5.6	22682	4801	1113	801
3.2	21321	4601	1037	738	5.4	21780	4626	1100	736
3.4	22108	4717	1074	784	5.2	21464	4459	1048	747
3.6	22368	4916	1031	759	5	22033	4692	1137	748
3.8	22897	4982	1154	820	4.8	21912	4657	1020	754
4.0	21934	4740	1066	751	4.6	21695	4715	1048	758
4.2	21433	4582	1059	764	4.4	22650	4962	1110	785
4.4	22595	4747	1055	794	4.2	22490	4954	1127	695
4.6	23099	4944	1159	830	4	21820	4816	1025	745
4.8	23679	5285	1103	838	3.8	21413	4586	1041	784
5.0	22111	4722	1049	803	3.6	22335	4887	1110	789
5.2	22367	4800	1123	804	3.4	19304	4140	955	703
8.0	22407	4836	1055	813	3	20910	4406	1000	746
8.2	23080	5011	1080	788	2.8	21533	4610	993	764

*Table 10 cont'd on next page

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Table 10 cont'd (from previous page)

8.4	23751	5163	1145	814	2.6	20730	4390	1046	723
8.6	23849	5246	1105	829	2.4	20484	4542	972	674
8.8	24107	5155	1124	880	2.2	19259	4136	946	694
9.0	23385	5105	1130	817	2	20158	4346	921	684
9.2	23965	5160	1134	829	1.8	20893	4504	1041	732
9.4	22743	4921	1113	767	1.6	21117	4545	1006	748
9.6	23528	5073	1064	824	1.4	19535	4345	907	662
9.8	23139	5012	1162	788	1.2	19349	4140	958	689
10.0	22571	4837	1107	791	1	19364	4193	980	704
10.2	23661	5133	1178	839	0.8	19985	4411	930	658
10.4	22332	4851	1115	715	0.6	20273	4319	900	701
10.6	21889	4645	1089	787					
10.8	21829	4728	1045	770					
11.0	20930	4603	1044	721					
11.2	19910	4461	911	655					
11.4	19810	4339	845	673					
11.6	19696	4330	912	659					
11.8	21235	4706	930	712					
12.0	22666	4913	1069	757					
12.2	24200	5369	1176	878					
12.4	24666	5301	1151	835					
12.6	23325	5065	1125	782					
12.8	21851	4736	1060	809					
13.0	22204	4783	1108	764					
13.2	24637	5447	1198	824					
13.4	25004	5625	1229	866					
13.6	20748	4389	970	740					
13.8	21973	4790	1035	769					
14.0	20682	4401	1065	735					
14.2	20431	4396	960	728					
14.4	17558	3774	855	585					

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I have reviewed scientific notebook _____ and find it in compliance with QAP-001. There is sufficient information regarding procedure used for conducting the research and acquiring and analyzing the data so that another qualified scientist could repeat the activity or activities recorded in this scientific notebook

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