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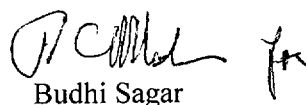
Subject: Submittal of Poster—Preliminary hydrostratigraphic characterization of a valley-fill aquifer: Fortymile Wash, southwestern Nevada

Dear Mrs. DeMarco:

Attached is a poster for presentation at the 2000 National Geological Society of America (GSA) Meeting. This poster is based on work done by Theodore Ressler and John Sharp of the University of Texas, Ken Ridgeway of Purdue University, and John Stamatakos and James Winterle of the CNWRA. The poster describes CNWRA's current ongoing investigations of the alluvium in Fortymile Wash in order to develop a model of the hydrostratigraphy southeast of Yucca Mountain. The abstract for this poster, Hydrostratigraphic characterization of a semi-arid alluvial fan: Fortymile Wash, Nevada, was approved by the NRC in an e-mail (P. Justus to D. DeMarco) dated August 14, 2000, with a copy to B. Sagar. This poster was presented at the GSA National Meeting in November. Submission of this poster was delayed due to printer problems and because the senior author attends the University of Texas and could not return to San Antonio for several weeks to produce the poster.

If you have any questions please contact Dr. John Stamatakos at (210) 522-5247 or me at (210) 522-5252.

Sincerely,


Budhi Sagar
Technical Director

rae

Attachment

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Preliminary hydrostratigraphic characterization of a valley-fill aquifer: Fortymile Wash, southwestern Nevada

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Introduction

Background

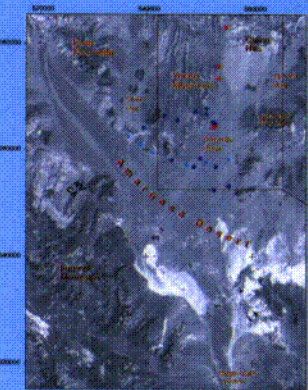
Information on the stratigraphic controls on groundwater flow within alluvium south and southeast of Yucca Mountain is needed for groundwater models to evaluate the performance of the proposed nuclear waste repository at Yucca Mountain. The features observed in the near-surface alluvium are presently the best analogs of the valley-fill material in the saturated zone. The modern entrenched channel of Fortymile Wash, a large desert wash located east-southeast of Yucca Mountain in southwestern Nevada, provides several laterally continuous, well-exposed outcrops of alluvium. A detailed investigation of the outcrops was completed to evaluate the sedimentary architecture and hydraulic properties of the alluvium.

Objectives

1. Delineate characteristic sedimentary associations (lithofacies) in the valley-fill of Fortymile Wash.
2. Delineate the sedimentary architecture within the valley-fill of Fortymile Wash.
3. Estimate values for the hydraulic properties of the different lithofacies.
4. Collect geophysical measurements from outcrop to determine subsurface alluvium properties.

Regional Setting

Yucca Mountain is located in southwestern Nevada, in the Great Basin of the Basin and Range Province of the North American Cordillera. Yucca Mountain is an associated group of north to north-northeast-trending, fault-bound ridges of Miocene tuff. Bounding Yucca Mountain is the Scollario Canyon Fault to the west and Fortymile Wash to the east. Flanking Yucca Mountain further to the east and west are the alluvium-filled basins of Crater Flat and Jockass Flats, respectively. Like that of the rest of the Great Basin, Yucca Mountain is underlain by a thick unsaturated zone, up to 750 m thick (Fleckenstein, 1984).



Yucca Mountain and Amargosa Desert, Nevada
Scale 0 10 20 km
UTM NAD 27 Zone 11

Main Points of Study

The outcrop investigations indicate that the alluvium of Fortymile Wash consists of predominantly conglomerate and sandstone. The majority of the alluvium is well organized and contains relatively small amounts of matrix.

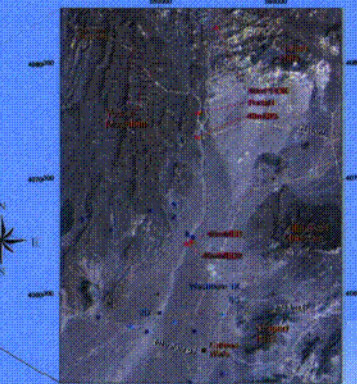
Eight diagnostic lithofacies were identified based on grain size, sedimentary features, and geometry.

Preliminary laboratory results indicate that the permeability between the lithofacies varies over two orders of magnitude, ranging from 10^{-2} to 10^{-4} cm/s.

Gamma ray and density measurements were collected from outcrop to develop simulated wireline logs for comparison to wireline logs from recently completed borehole in Fortymile Wash. This information will assist in the characterization of alluvium in the subsurface.

Study Area

Fortymile Wash is the largest tributary of the upper Amargosa River and is one of the largest alluvial systems in the Southern Basin and Range Province (Lundstrom et al., 1998). The active wash channel is entrenched to depths exceeding 20 m and gently grades into a wide alluvial plain within the Amargosa Desert.



Scale 0 4 8 km
UTM NAD 27 Zone 11

• Nye County Phase 2 and Phase 3 wells
• Nye County Phase 1 wells
• Outcrops

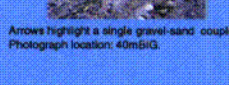
Lithofacies Descriptions

Lithofacies were identified based on grain size, sedimentary features, and geometry.

Facies	Lithologic Codes	Description		Interpreted Depositional
		Sedimentary Features	Observable Geometries	
F1	Gch/Sh to Gch/Sh	- clast-supported, imbrication sand to cobble - primarily horizontally stratified gravel and sand, characterized by gravel-sand couplets - coarse component of gravel-sand couplets may have bimodal sediment content; open framework gravels variably contained within couplets	- most common and volumetrically significant facies - gravel couplets 10-50 cm thick	bar deposits; gravel-sand couplets formed by migration of submerged gravel bars
F2	Gom to Gom	- clast-supported - bimodal grain size consisting of cobbles to boulders and m-c sand	- occurs as lenses within Facies F1 - lenticular for lengths of 10-60 m; 10-50 cm thick; coarser units	channel deposits between longitudinal bars
F3	Gch, Gop, or Gch	- clast-supported - gravel to cobble - lens-shaped units of cross-stratified gravel; internal stratification varies from base parallel stratification to cross-stratification that is planar or tangential to the base	- occurs as lenses within Facies F1 - 10-15 m in length; < 2 m in thickness	pool scours at convergence of two braid channels
F4	Gom to Gom, Gch, and Sh	- clast-supported, poorly sorted, poorly organized, imbrication sand to boulders, coarse gravel to cobbles, coarse - crude stratification to massive - crude gravel couplets - variably contains small lenses of sand - channelized gravel and sand commonly present at top of	- gravel couplets are 40-60 cm thick - lenses of sand < 30 cm thick - facies are 2-3 m thick	deposits of turbulent flood flows/hyperconcentrated flows
F5	Gim to Gom	- matrix-supported, nearing clast-supported in some instances; disorganized - angular clasts; predominant monolithologic clast content - distinct bimodal sediment content consisting of coarse gravel to boulders and m-c sand	- laterally extensive for 10-15 m, variable in thickness, but < 50 cm (Note: based only on a single exposure) - this facies is expected to be volumetrically larger in proximity to the mountain slopes rimming Fortymile Wash	sediment gravity flow; most likely debris flow or rock fall
F6	Gom	- gravel to boulders - calcareous horizons	- 5-30 cm in thickness; laterally continuous for 100s of meters, though facies may be discontinuous over that length	pedogenic carbonate associated with paleosols
F7	Sim to Sh	- matrix-supported, in some instances nearing clast-supported; mild to heavy bioturbation common - medium to coarse sand, with varying concentrations of gravel to cobbles - distinctive reddish coloration and strong caliche development - internal structure complex	- thickness ranges from 50 cm to 2 m; laterally extensive for 10-100s of meters	paleosols
F8	Sh	- horizontal stratification to massive - dominantly well-sorted, m-c sand, some scattered fine gravel clasts	- commonly found in association with bimodal gravel units (Facies F1 or Facies F2) - < 30 cm thick; laterally continuous < 1 m	concentrations of finer sediment deposited during waning flow



Photograph location: 40mBIG



Photograph location: 40mBIG



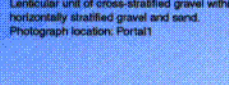
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Photograph location: Portal1



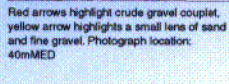
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Lithofacies Associations

Proximal Braided Stream Deposits

Many of the lithofacies present in outcrop are similar to those observed down gradient, though they are coarser grained.

Facies F4 is the dominant lithofacies in the most proximal outcrop (40mPRGX).

Facies F1 becomes more dominant down gradient (Portal1 and 40mBIG). There appears to be a gradation, rather than a distinct textural break, between Facies F4 and F1.

Facies F7 is common in outcrop and in most exposures is laterally extensive across the entire outcrop (10-100s of meters).

Exposures of Facies F5 are limited in Fortymile Wash (Portal1). Deposits similar to Facies F5 are observed in transverse fans rimming the upper reaches of Fortymile Wash.

Medial Braided Stream Deposits

All of the lithofacies, except Facies F5, are observed in the medial part of Fortymile Wash.

In general, lithofacies are finer grained.

Facies F1 and F2 are much finer grained than exposures up gradient.

Facies F1 and F2 are interstratified with much coarser grained deposits of Facies F4 (40mMED).

Larger discharge, more turbulent flood flows (Facies F4) periodically occurred, intervened by lower discharge flows (Facies F1, F2, F3, and F8) and pedogenic processes (Facies F6 and F7).



Photograph location: Portal1



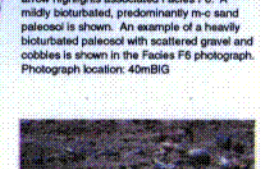
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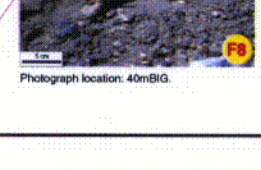
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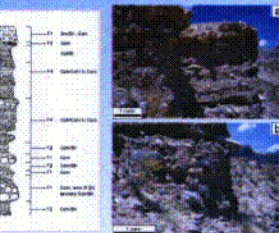
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Photograph location: 40mPRGX



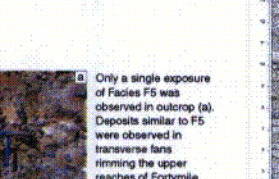
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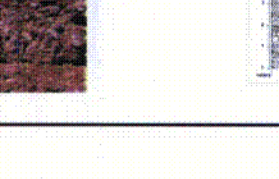
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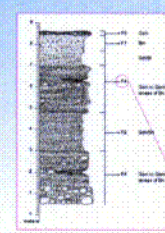
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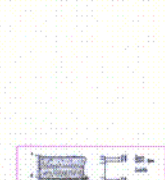
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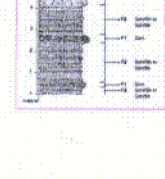
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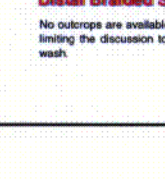
Photograph location: 40mMED



Photograph location: 40mMED2



Photograph location: 40mMED



Photograph location: 40mMED

Distal Braided Stream Deposits

No outcrops are available in the distal reaches of Fortymile Wash, limiting the discussion to the proximal and medial portions of the wash.

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Permeability Measurements

Alluvium samples were collected from outcrop to investigate the variation in permeability between the different lithofacies.

Methods

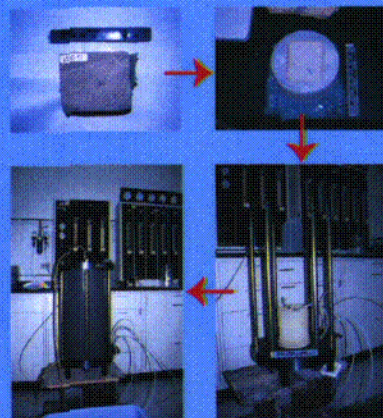
Oriented, undisturbed blocks and grab samples were collected from different lithofacies at several localities. Laboratory permeability tests on undisturbed columns obtained from the intact blocks and on repacked test specimens were completed using a flexible wall permeameter. The coarse, unconsolidated to poorly consolidated nature of the alluvium made permeability sampling difficult. The coarser lithofacies and the less indurated lithofacies are underrepresented in the collected alluvium samples.

Undisturbed columns

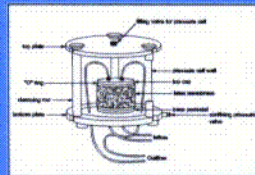
Undisturbed columns were obtained from intact blocks of alluvium collected in the field. The procedure used was patterned after the ASTM standard for flexible wall permeameters (D5084), which was modified to accommodate the poorly consolidated alluvium.

Repacked test specimens

Additional permeability measurements were obtained from disturbed test specimens repacked from grab samples of the alluvium. The repacking was constrained by field estimates of bulk



The flexible wall permeameter accommodates cylindrical samples, but the poor consolidated nature of the alluvium did not allow coring (in most instances). Intact rectangular columns (maximized in size) were obtained from the oriented undisturbed blocks obtained in the field. Cylindrical samples were obtained by encasing the rectangular columns in wax, which were then used in the permeameter.



Flexible wall permeameter

Results

Laboratory results from repacked sediment samples indicate that the permeability between the lithofacies varies over two orders of magnitude, ranging from 10^{-9} to 10^{-5} cm/s. A sample of predominantly fine to medium gravel from a layer of open framework gravel within Facies F1 was found to be the most permeable: K_{sat} of $2.26 \times 10^{-3} \pm 4 \times 10^{-5}$ cm/s. Samples consisting of slightly differing mixtures of gravel and sand were found to have K_{sat} in the range of 10^{-4} cm/s. Samples collected from Facies F6 and F7 were found to be the least permeable: in the range of 10^{-5} cm/s.

Preliminary results from the intact alluvium columns yield K_{sat} values that appear systematically greater than the values obtained from the repacked sediment samples. K_{sat} for Facies F7 and F9 on the order of 10^{-4} cm/s and K_{sat} for sandier units in Facies F1 on the order of 10^{-3} cm/s.

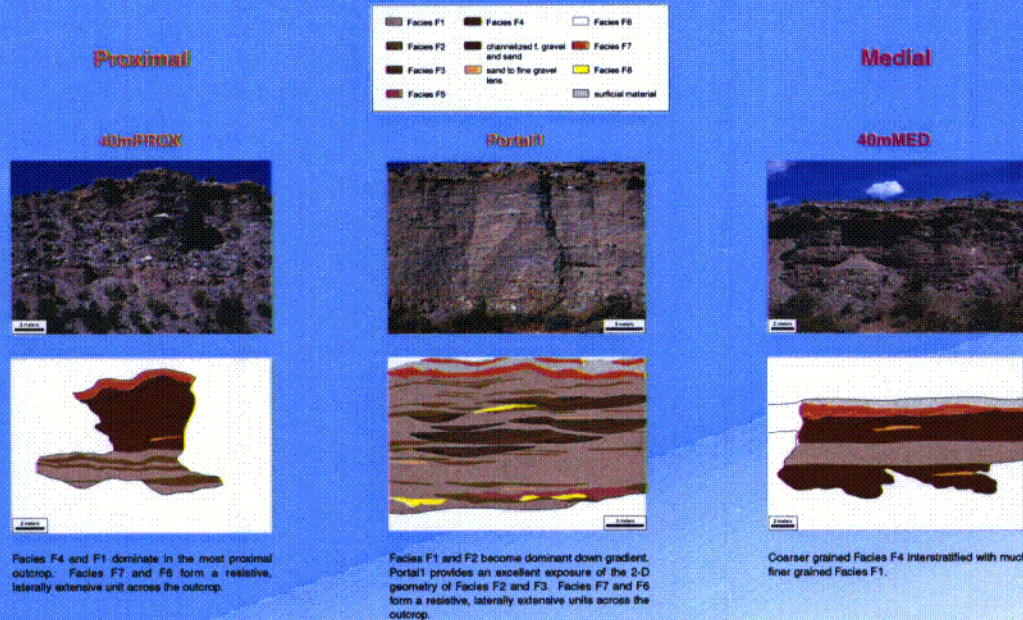
On a larger scale, the interlayering and intergradation of the lithofacies in the alluvium has important implications for groundwater flow. The low permeability and large lateral continuity of Facies F6 and F7 suggest these facies can impart a strong stratification that could affect vertical and horizontal groundwater movement. This conclusion is supported by results of ponding experiments conducted by Guertal et al. (1994), which showed that the paleosol and pedogenic carbonate layers retard the vertical movement of water.

References

Batzle, M.L., and B.J. Smith. Hand-held velocity probe for outcrop and core characterization. Proceedings of the 33rd U.S. Symposium on Rock Mechanics 1992, Santa Fe, New Mexico. J.R. Tillerson and W.R. Wawerski, eds. Rotterdam, Balkema: 649-658. 1992.
 Guertal, W.R., A.L. Flint, L.L. Hofmann, and D.B. Hudson. Characterization of a desert soil sequence at Yucca Mountain, NV. High Level Radioactive Waste Management 4: 2755-2763. 1994.
 Lundstrom, S.C., J.B. Paces, and S.A. Mahan. Late Quaternary History of Fortymile Wash in the area near the H-road crossing. Quaternary Geology of the Yucca Mountain Area, southern Nevada: Field Trip Guide. Friends of the Pleistocene, Pacific Cell. 63-76. 1996.
 Mavko, G., T. Mukerji, and J. Dvorkin. 1998. Part 7.9 Velocity-density relations. The Rock Physics Handbook. New York, NY: Cambridge University Press: 250-254.
 Robinson, J.H. Ground-Water Level Data and Preliminary Potentiometric-Surface Maps: Yucca Mountain and Vicinity, Nye County, Nevada. U.S. Geological Survey Water-Resources Investigations Report 84-4197. 1984.

Aquifer Characterization

Outcrop photographs were used to delineate the 2-D geometry of the lithofacies and to examine the lithofacies associations in the different portions of Fortymile Wash. These observations improve understanding of the sedimentary architecture of the valley-fill alluvium of Fortymile Wash.



Facies F4 and F1 dominate in the most proximal outcrop. Facies F7 and F6 form a resistive, laterally extensive unit across the outcrop.

Facies F1 and F2 become dominant down gradient. Portal provides an excellent exposure of the 2-D geometry of Facies F2 and F3. Facies F7 and F6 form a resistive, laterally extensive unit across the outcrop.

Coarser grained Facies F4 interstratified with much finer grained Facies F1.

Summary

The current investigation demonstrates that the alluvium is heterogeneous, consisting of several different types of sedimentary deposits, some of which have substantially different hydraulic properties.

The low permeability and large lateral continuity of Facies F6 and F7 suggest these facies can impart a strong stratification that could affect vertical and horizontal groundwater movement.

The conceptual model for the sedimentary structure of the valley-fill underlying Fortymile Wash will provide a basis for developing geostatistical descriptions of the distribution of hydrostratigraphic facies. These geostatistical descriptions can be used to assess whether flow and transport models for the region appropriately account for the effects of the heterogeneous flow system.

Outcrop geophysical measurements provide information that can help constrain lithologic interpretation of wireline logs from recently completed boreholes in Fortymile Wash. The outcrop density response was found to be a function of the clast content of the valley-fill. The outcrop gamma ray response appears to be dominantly a function of the potassium contained in the volcanic clasts of the alluvium.

Some paleosols can yield a gamma ray low due to low clay content and low clast content.

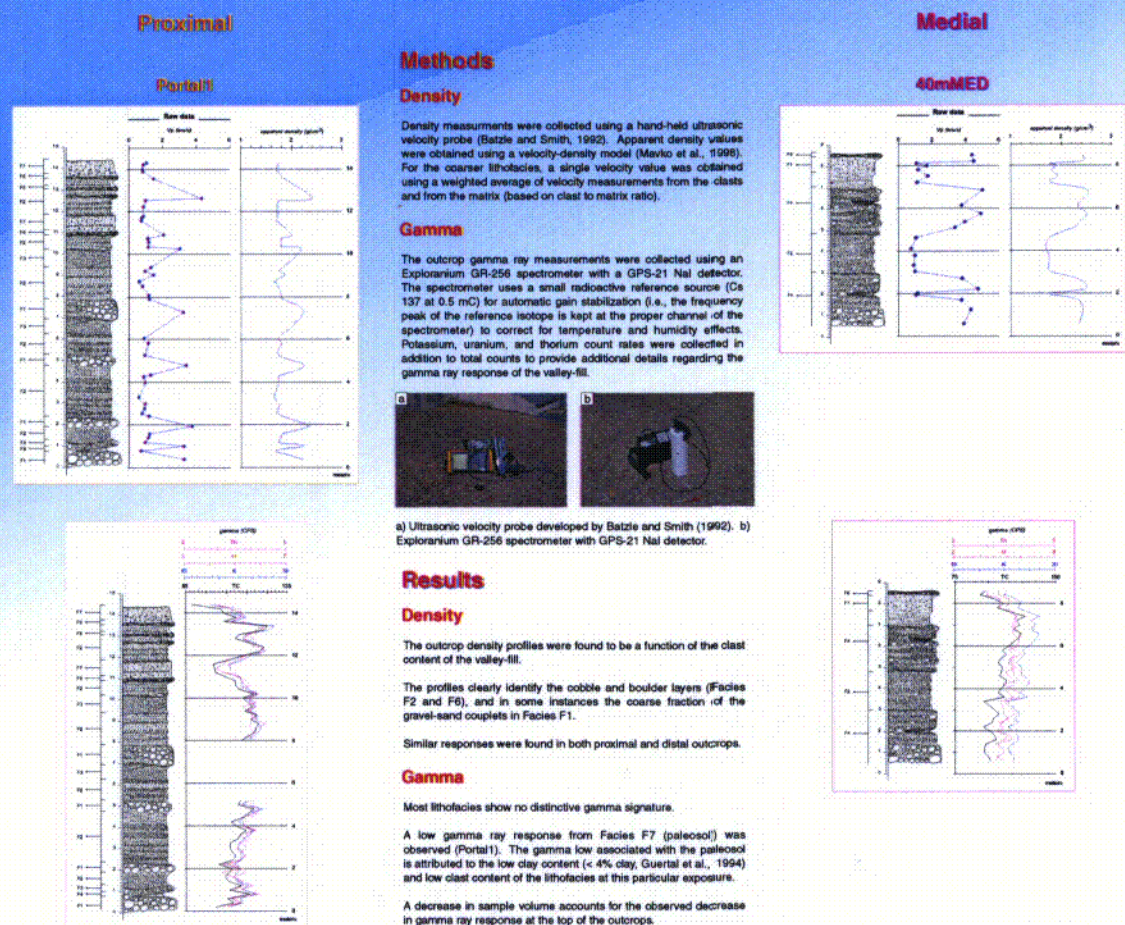
Acknowledgements

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We would like to thank Deborah Walling, Melissa Hill, and Pete La Femina for their assistance in the field. Chad Glenn, John Richardson, Tom Pysto, William Freeland, Loretta Camp, Della Christie, and other YMP personnel for their assistance in coordinating fieldwork activities.

Wireline Logs and Outcrop Profiles

Gamma ray and density measurements were collected from the outcrops to determine if particular lithofacies have a distinctive response or 'signature' that can be used to constrain lithologic interpretation of wireline logs from recently completed boreholes in Fortymile Wash.



Methods

Density

Density measurements were collected using a hand-held ultrasonic velocity probe (Batzle and Smith, 1992). Apparent density values were obtained using a velocity-density model (Mavko et al., 1998). For the coarser lithofacies, a single velocity value was obtained using a weighted average of velocity measurements from the clasts and from the matrix (based on clast to matrix ratio).

Gamma

The outcrop gamma ray measurements were collected using an Explorerium GR-256 spectrometer with a GPS-21 NaI detector. The spectrometer uses a small radioactive reference source (Cs 137 at 0.5 mCi) for automatic gain stabilization (i.e., the frequency peak of the reference isotope is kept at the proper channel of the spectrometer) to correct for temperature and humidity effects. Potassium, uranium, and thorium count rates were collected in addition to total counts to provide additional details regarding the gamma ray response of the valley-fill.



a) Ultrasonic velocity probe developed by Batzle and Smith (1992). b) Explorerium GR-256 spectrometer with GPS-21 NaI detector.

Results

Density

The outcrop density profiles were found to be a function of the clast content of the valley-fill.

The profiles clearly identify the cobble and boulder layers (Facies F2 and F6), and in some instances the coarse fraction of the gravel-sand couplets in Facies F1.

Similar responses were found in both proximal and distal outcrops.

Gamma

Most lithofacies show no distinctive gamma signature.

A low gamma ray response from Facies F7 (paleosol) was observed (Portal). The gamma low associated with the paleosol is attributed to the low clay content (< 4% clay; Guertal et al., 1994) and low clast content of the lithofacies at this particular exposure.

A decrease in sample volume accounts for the observed decrease in gamma ray response at the top of the outcrops.

C02