

Logging of the Rus Formation, Qatar

One Year Later

Sallie Vest

CH2M HILL



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“The cornerstone of any practical rock mechanics analysis or rock engineering is the geological database upon which the definition of rock types, structural discontinuities and material properties is based....even the most sophisticated analysis can become a meaningless exercise if the geological information on which it based is inadequate or inaccurate.”

-Evert Hoek, 1986



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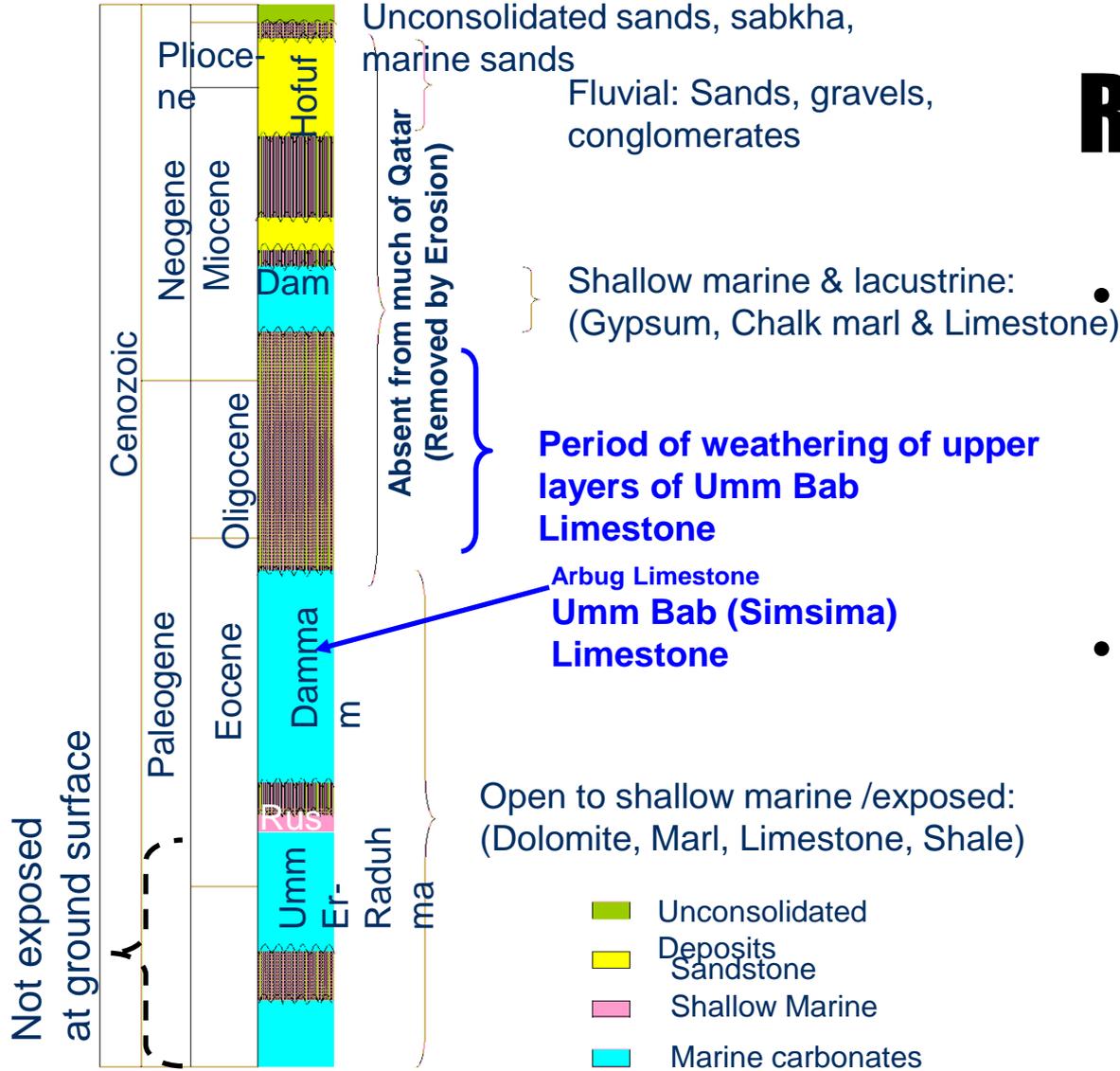


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Rus Formation



- Deposited Regionally throughout the Arabian Gulf Basin
- Sabkha and Salina Soils including thick layers of evaporatic soils deposited between two transgressive sequences.

After Sharland et al 2004 & Sadique & Nasir 2002

Logging of Rus Formation - 2012

- Very thick sequences (19 to 50m) with single description, no detailed description and no description of discontinuities.

- Recommendations included detail on the material and strength changes, and weathering – move to two column system of logging.

19.6 to 50.0 - Moderately weathered, off-white, weak CALCISILTITE, with undifferentiated interbedded yellowish brown to dark grey, weak clayey CALCILULITE, with very close to closely spaced fractures:

21.7



43.5



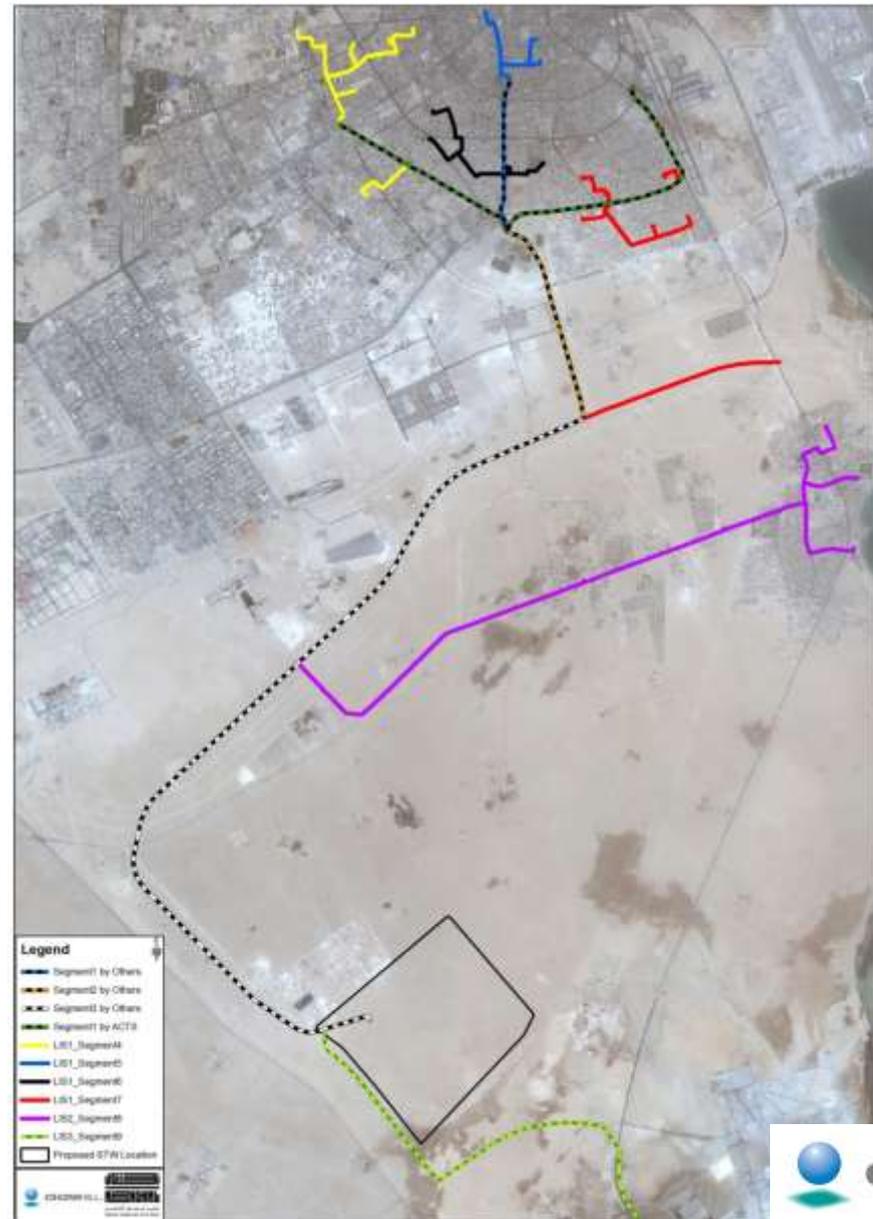
GROUND INVESTIGATION FOR IDRIS

3 GROUND INVESTIGATION CONTRACTS:

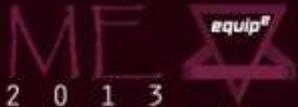
GSI-01 – GEOTECHNICAL INVESTIGATION FOR MAIN TRUNK SEWERS

GSI-02 - GEOPHYSICAL SURVEYS (MASW AND REFRACTION MICROTREMOR)

GSI-03 – GEOTECHNICAL INVESTIGATIONS FOR LATERAL INTERCEPTOR SEWERS



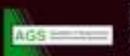
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PROJECT SPECIFICATION

Logging to BS EN 14689-1:2003 (as per EC7) Or US Bureau of Reclamation Standards

Also specified the need to log and describe each core run and each of the discontinuities.

Minimum of 1 site geologist to every 2 rigs



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Logging of Rus Formation – IDRIS Programme

CHALLENGES:

8 DIFFERENT GEOLOGISTS FROM TWO
DIFFERENT CONTRACTORS (11 TO 12
RIGS WORKING)

LIMITED SUPERVISION BY ENGINEER'S
REPRESENTATIVE

LIMITS OF RISK:

EVERYONE USING THE SAME LOGGING
TEMPLATE AND TERMINOLOGIES

USE OF CLARK AND WALKER, 1977 FOR
ROCK CLASSIFICATION

TRAINING BEFORE AND DURING
INVESTIGATION



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LOGGING SHEET

Strength, structure (bedding thickness / angle), color, **ROCK TYPE**, Weathering, carbonate content, discontinuity angle, spacing, and description. Comments on secondary constituents **Formation Name**

Rock Core logging in accordance with BS EN ISO 14689-1:2003 incorp corrigendum no 1

Strata Classification – Rock Type [After Clark and Walker, 1977]:

INCREASING GRAIN SIZE OF PARTICULATE DEPOSITS →

Degree of Induration	Total Carbonate Content	Not Discernable		Biolastic	Oolitic	Shell Coral Algal	Pisolite
Non-Indurated	90%	CARBONATE MUD	CARBONATE SILT	CARBONATE SAND	CARBONATE GRAVEL		
	50%	Clayey CARBONATE MUD	Siliceous CARBONATE SILT	Siliceous CARBONATE SAND	Mixed Carbonate and non-carbonate GRAVEL		
		Calcareous CLAY	Calcareous SILT	Calcareous Silica SAND			
10%	CLAY	SILT	Siliceous SAND	GRAVEL			
Slightly Indurated	90%	CALCILLITITE (Carb claystone)	CALCISILTITE (carb siltstone)	CALCARENITE (carb sands)	CALCIRUDITE (carb conglom or breccia)		
	50%	Clayey CALCILLITITE	Siliceous CALCISILTITE	Siliceous CALCARENITE	Conglomeratic CALCIRUDITE		
		Calcareous CLAYSTONE	Calcareous SILTSTONE	Calcareous SANDSTONE			
10%	CLAYSTONE	SILTSTONE	SANDSTONE	CONGLOMERATE OR BRECCIA			
Moderately Indurated	90%	Fine grained LIMESTONE	Detrital LIMESTONE	Conglomeratic LIMESTONE			
	50%	Fine grained Argillaceous LIMESTONE	Fine grained Siliceous LIMESTONE	Siliceous detrital LIMESTONE	Conglomeratic LIMESTONE		
		Calcareous CLAYSTONE	Calcareous SILTSTONE	Calcareous SANDSTONE			
10%	CLAYSTONE	SILTSTONE	SANDSTONE	CONGLOMERATE OR BRECCIA			

Weathering (Table 13 14689-1):

Term	Description	Grade
Fresh	No visible sign of weathering/alteration of the rock material	0
Slightly Weathered	Discoloration indicate weathering of rock material and discontinuity surfaces	1
Moderately weathered	Less than 1/4 of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as a continuous framework or as core stones	2
Highly weathered	More than 1/4 of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as a discontinuous framework or as core stones	3
Completely Weathered	All rock material is decomposed and/or disintegrated to soil, the original mass structure is still largely intact	4
Decomposed / Residual Soil	The rock material is weathered by the chemical alteration of the mineral grains to the condition of a soil in which the original material fabric is still intact, some or all of the mineral grains are decomposed	5

Discontinuity for joints that are not drilling breaks

- Depth (center of joint or if very long near vertical joint the top and bottom)
- Angle (degrees from vertical – measured by protractor)
- Aperture (see previous sheet)
- Joint-Face description – weathering / discoloration / mineralization
- Roughness (Figure 2 – 14689-1):

	Rough (regular)	Smooth
Stepped	1 	2
	3 	4
Planar	5 	6

- Key**
- 1 stepped rough surface
 - 2 stepped smooth surface
 - 3 undulating rough surface
 - 4 undulating smooth surface
 - 5 planar rough surface
 - 6 planar smooth surface

LOGGING IMPLEMENTATION

EACH GEOLOGIST WAS PROVIDED WITH THE TOOLS

CONSTANT REVIEW OF THE PRELIMINARY LOGS AS THEY WERE PROVIDED

FEEDBACK TO THE OFFICE AND TO THE SITE

DEFINED FOR EACH SAMPLE (CORE RUN)

Project	Depth	Sample ID	Core ID	Depth (m)	Soil Type	Color	Moisture	Plasticity	Grain Size	Notes	Soil Name	Soil Type	Soil Color	Soil Moisture	Soil Plasticity	Soil Grains	Soil Notes	Soil Name	Soil Type	Soil Color	Soil Moisture	Soil Plasticity	Soil Grains	Soil Notes	Soil Name	Soil Type	Soil Color	Soil Moisture	Soil Plasticity	Soil Grains	Soil Notes
500650	C	6	weak	Thick	light	greyish	off	fine	granular	slightly	Unconsolidated	fresh	calcareous	stable	Four units up to 10m occasional patches of gypsum	SL	148	148	148												
650800	C	7	weak	Thick	light	grey	off	fine	granular		Unconsolidated	fresh to desiccated	calcareous	stable	Four units up to 10m occasional patches of gypsum	SL	150	150	150												
800950	C	8	weak	Thick	light			fine	granular		Unconsolidated	fresh to desiccated	calcareous	stable	Four units up to 10m occasional patches of gypsum	SL	150	145	145												
901100	C	9	weak	Thick	light	brn	off	fine	granular		Unconsolidated	fresh to desiccated	calcareous	stable	Four units up to 10m occasional patches of gypsum	SL	150	150	150												
1101200	C	10	weak	Thick				fine	granular		Unconsolidated	fresh	calcareous	stable	Four units up to 10m occasional patches of gypsum	SL	100	85	85												

RESULTS – FIELD REVIEW LOG

- REVIEW OF FIELD LOGS INCLUDED CHECK OF THE STRATA LOG, DETAIL LOG, WEATHERING AND DISCONTINUITIES
- DIFFERENTIATION OF DIFFERENT TYPES OF DISCONTINUITIES



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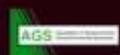
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Graphic Symbol	Depth (m)	Geological Unit	Strata Description	Sample Description	Sample No.	Sample Type & Depth (m)	Rock Core Quality			Weathering Grade
							TCR	SCR	RQD	
	41	RUS	35.50m - 42.70m : Very weak to weak light greyish brown fine grained LIMESTONE interbedded with very weak light yellowish brown to dark pinkish brown calcareous siltstone . Calcareous, fresh to slightly weathered. Occasional medium bedded chert and gypsum nodules. Very closely to closely spaced fractures, generally 0 to 30 degrees. (RUS CALCAREOUS) <i>(As previous sheet)</i>	39.5 - 41m: Very weak, light greyish brown, fine-grained LIMESTONE. Fresh, calcareous (As previous sheet)	C35	41.00	100	100	100	1
			41 - 42.5m: Very weak, light greyish brown, fine-grained LIMESTONE. Fresh, calcareous	C36			100	100	100	
	42		... From 41.70m to 42.25m : very weak calcareous fine grained debital limestone.							
			... From 42.50m to 42.70m : very weak dark pinkish brown calcareous siltstone.	42.5 - 44m: Very weak, light greyish brown, fine-grained CALCARENITE. Fresh, calcareous	C37	42.50				
	43		42.70m - 45.50m : Very weak light greyish brown fine grained CALCARENITE occasionally intercalated with very weak light yellowish brown to dark pinkish grey calcareous siltstone. Calcareous, fresh to slightly weathered. Occasional gypsum nodules. Closely spaced fractures, generally 0 to 30 degrees. (RUS CALCAREOUS)					100	100	
			... From 43.65m to 44.00m : very weak dark greyish green calcareous siltstone.	44 - 44.5m: Very weak, light greyish brown, fine-grained CALCARENITE. Fresh, calcareous	C38	44.00				
	44							100	100	
			... From 44.55m to 44.65m : very weak dark greyish grey calcareous siltstone.	44.5 - 45.5m: Very weak, light greyish brown, fine-grained CALCARENITE. Fresh, calcareous	C39	44.50	97	97	97	
	45									



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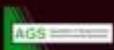
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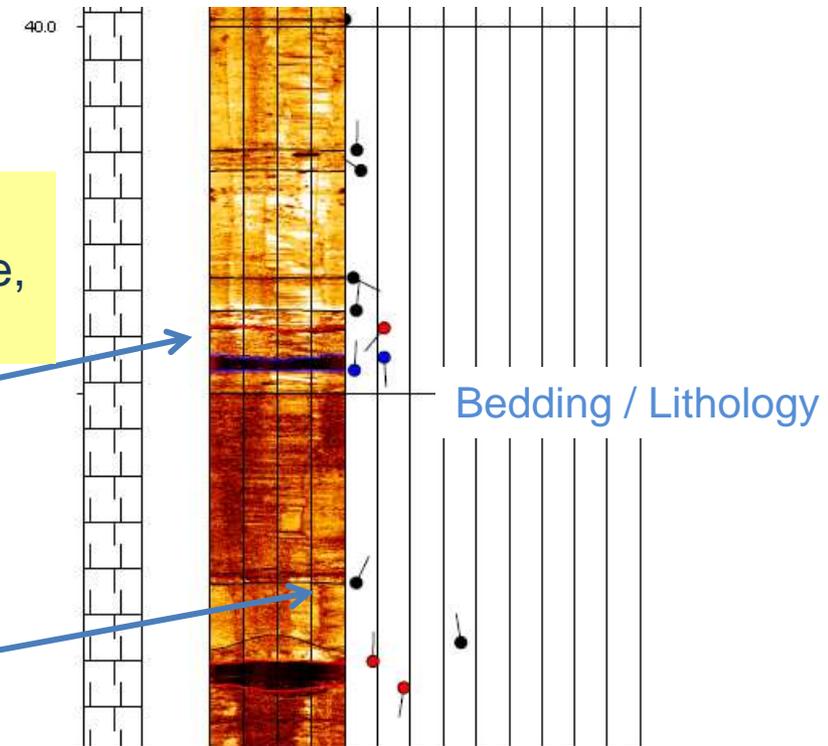
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DISCONTINUITIES

FIELD LOGS / DISCONTINUITY LOGS

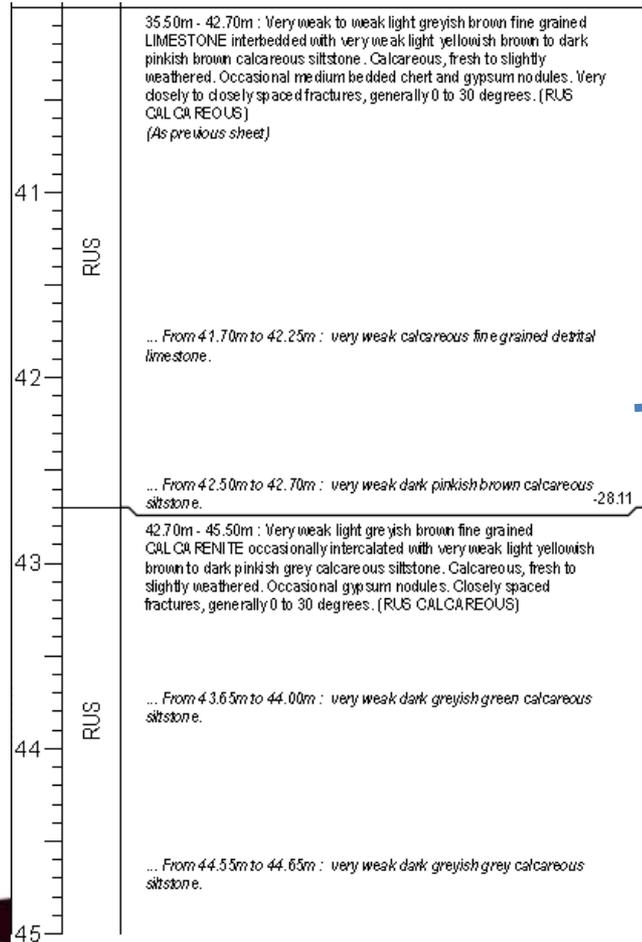
ACCOUSTIC TELEVIEW LOGS – ID-TS-261 (40 to 45m)

41.40	41.55	RUS	Joint Set 1 - 15°degrees, close spaced, planar rough, tight aperture, Slightly weathering
41.55	41.65	RUS	Induced fracture - 15°degrees
41.65	41.75	RUS	Induced fracture - 15°degrees
41.75	41.85	RUS	Induced fracture - 15°degrees
41.85	41.95	RUS	<div style="background-color: yellow; padding: 5px;"> <p>Joint set 1, 15deg, very closely spaced, planar, rough, tight aperture, slight weathering.</p> </div>
41.95	42.05	RUS	
42.05	42.15	RUS	
42.15	42.20	RUS	
42.20	42.30	RUS	Joint Set 1 - 15°degrees, close spaced, planar rough, tight aperture, Slightly weathering
42.30	42.50	RUS	Joint Set 1 - 15°degrees, medium spaced, planar rough, tight aperture, Slightly weathering
42.50	42.70	RUS	Joint Set 1 - 15°degrees, close spaced, planar rough, tight aperture, Slightly weathering
42.70	43.25		Induced fracture - 15°degrees
43.25	43.35	RUS	Induced fracture - 15°degrees
43.35	43.45	RUS	Induced fracture - 15°degrees
43.45	43.65	RUS	Joint Set 1 - 15°degrees, medium spaced, planar rough, tight aperture, Slightly weathering

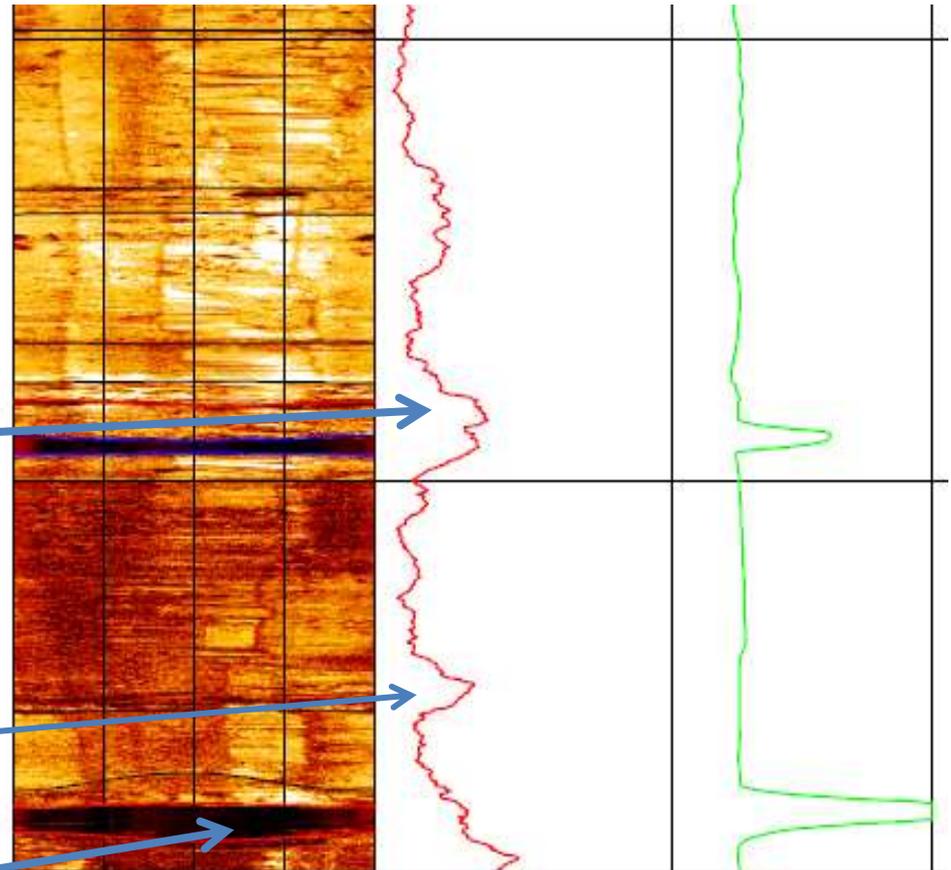


INTERBEDS OF CLAYSTONE AND SILTSTONE

BOREHOLE LOGS



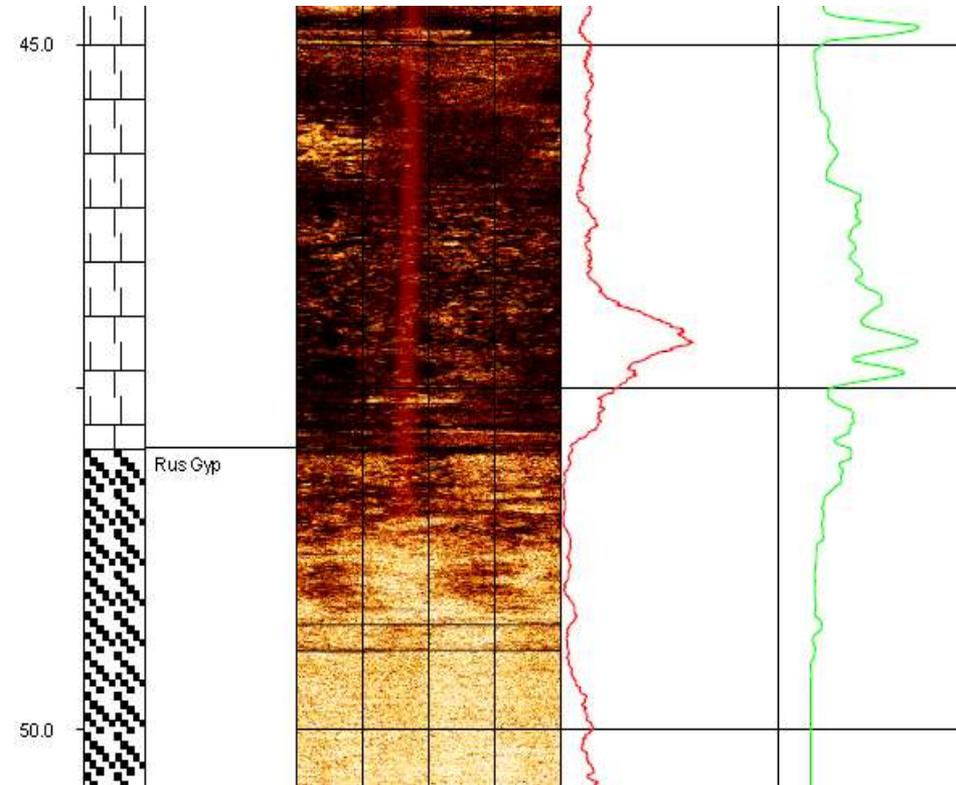
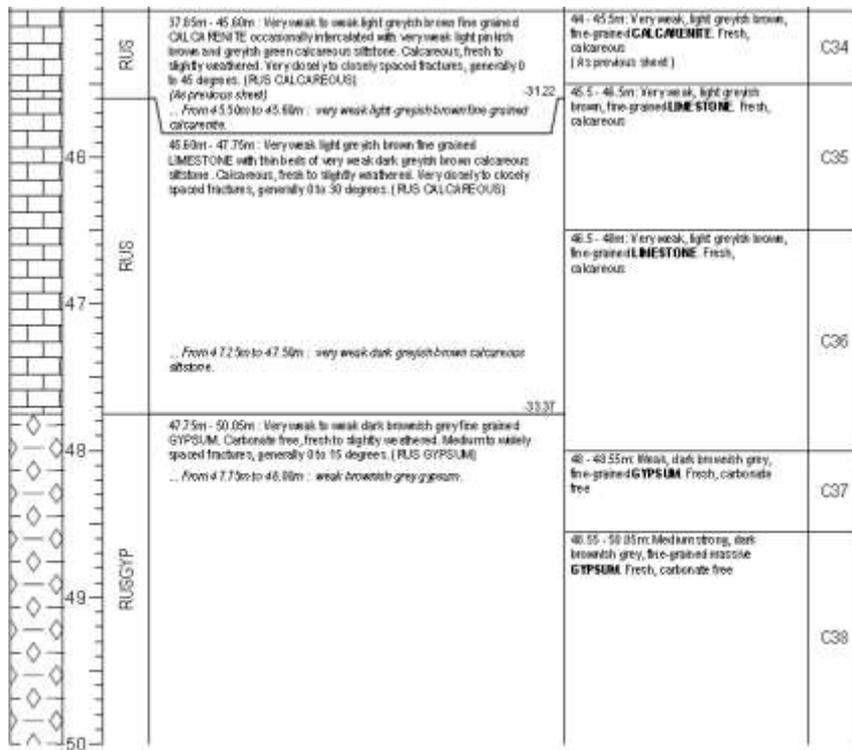
GAMMA – GAMMA LOGS



INTERBEDS OF CLAYSTONE AND SILTSTONE

BOREHOLE LOGS

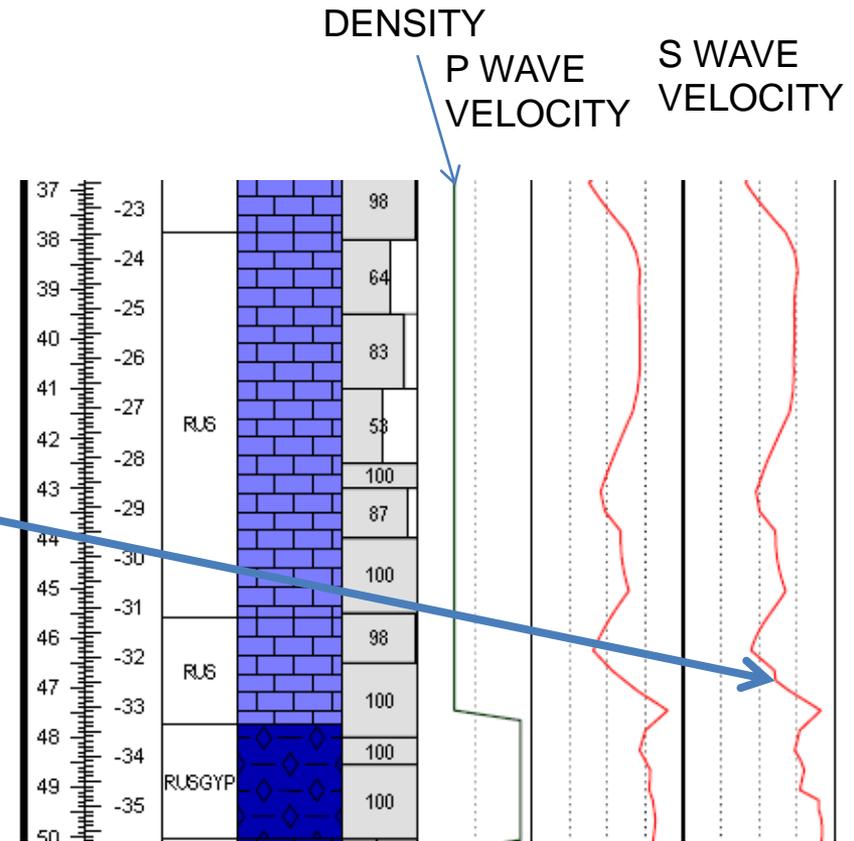
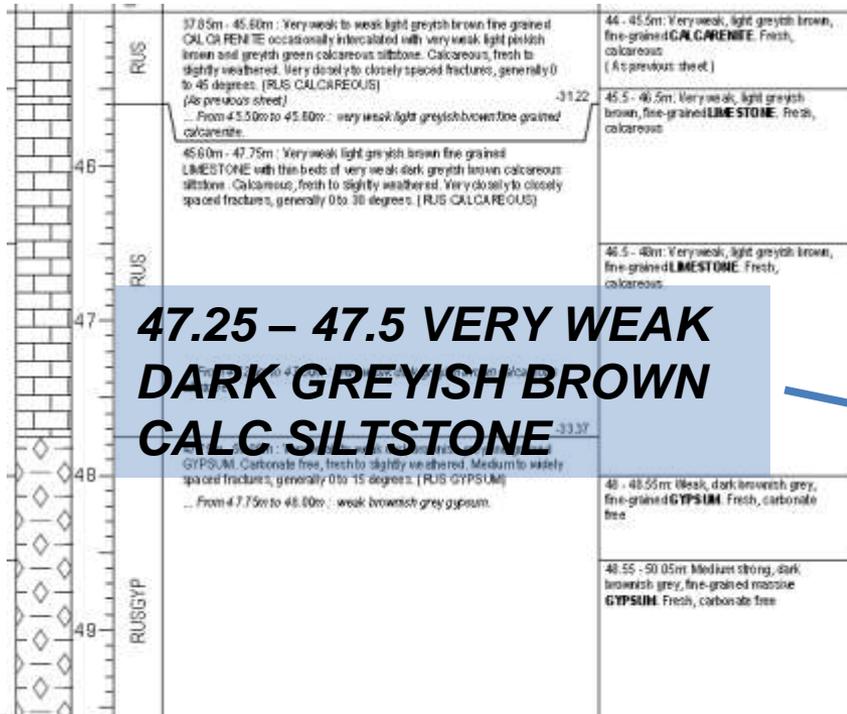
GAMMA – GAMMA LOGS (ID-TS-266 45 TO 50M)



STRENGTH OF INTERBEDS

BOREHOLE LOGS (ID-TS-266)

GEOPHYSICAL SURVEY (FULL WAVE SEISMIC)

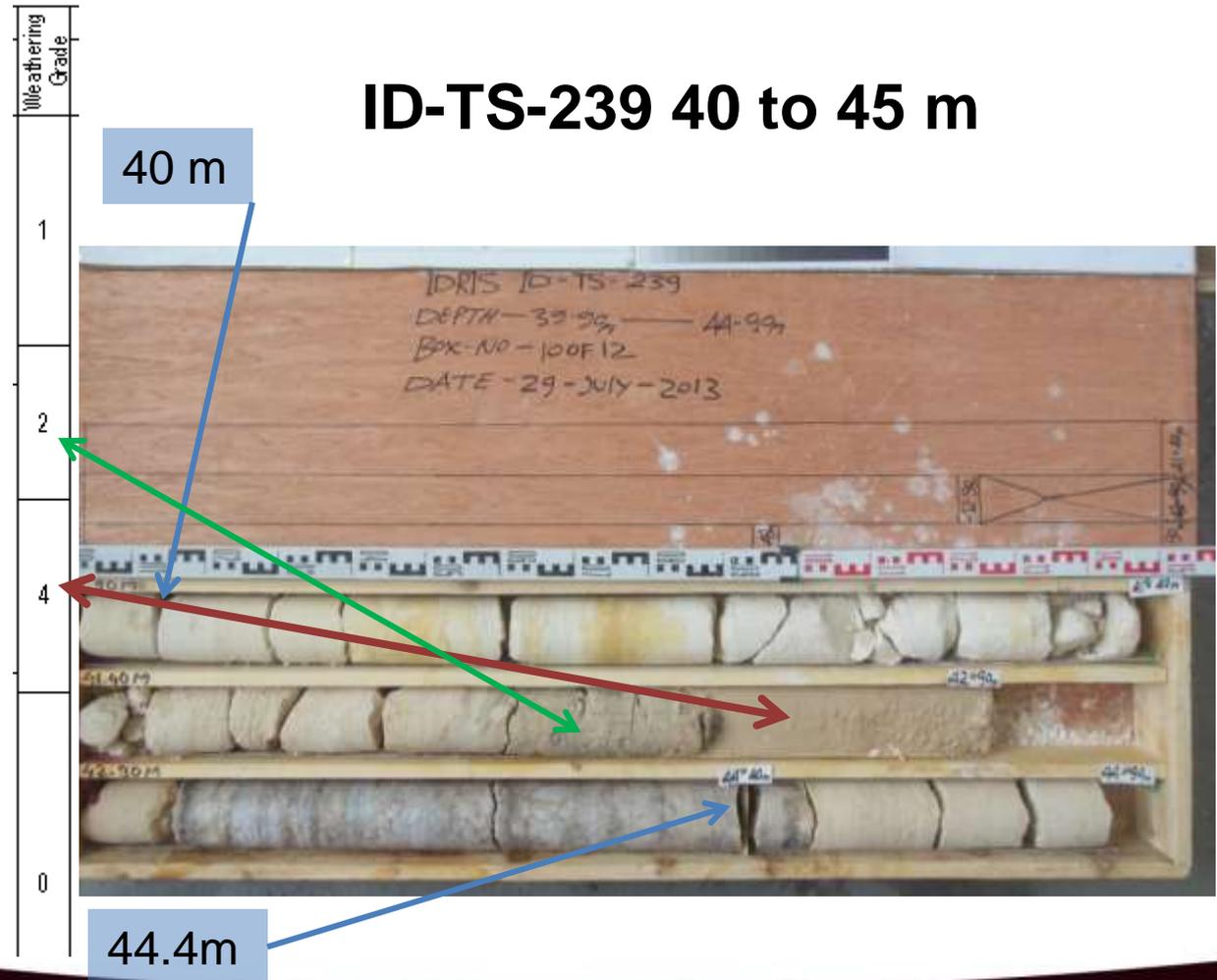


WEATHERING OF INTERBEDS

BOREHOLE LOGS

WEATHERING IN THE TEXT AS PART OF THE SAMPLE AND THE STRATA DESCRIPTION

ALSO PROVIDED AS OVERALL ROCK MASS WEATHERING (SEPERATE COLUMN)



CONSISTENCY IN LOGGING

30.65m - 42.05m : Very weak to weak light greyish brown fine grained LIMESTONE occasionally interbedded with very weak light yellowish brown to light greyish brown calcareous siltstone. Calcareous, fresh to slightly weathered. Occasional thin beds of medium strong dark greyish brown chert. Occasional weak thin gypsum veins. Very closely to closely spaced fractures, generally 0 to 30 degrees. (RUS CALCAREOUS)

... From 37.50m to 37.85m : intercalated with very weak yellowish brown siltstone.

... From 37.85m to 38.00m : medium strong dark greyish brown chert.

36.00m - 42.50m : Weak light yellowish brown fine grained LIMESTONE Fresh, calcareous. Close to medium spaced fractures, joints are generally 5 - 10 degrees. Occasional voids up to 10 mm, occasional veins of gypsum, thin beds of calcilutite and nodules of chert (RUS FORMATION)



OVERALL RESULTS

FOR THE IDRIS PROGRAMME THE SPECIFICATION AND OVERSIGHT RESULTED IN HIGH QUALITY DESCRIPTIONS AND LOGS

STRATA DESCRIPTIONS INCLUDING SAMPLE AND DETAIL DESCRIPTIONS CORRELATE WITH OTHER DOWNHOLE LOGGING PERFORMED.

TEAM WORK BETWEEN THE CONSULTANT AND CONTRACTOR IS REQUIRED TO INSURE A CONSISTENT AND HIGH QUALITY LOG AT THE END OF THE PROJECT.

SUMMARY

- THE RUS FORMATION, AS SEEN IN CORES, IS A COMPLEX SEDIMENTARY SEQUENCE.
- LOGGING IN ACCORDANCE WITH BS 14689-1:2003 REQUIRES NOT ONLY THE OVERALL STRATA DESCRIPTION BUT ALSO DETAILS ON DISCONTINUITIES AND WEATHERING
- FULL LOGGING IS NEEDED FOR THE UNDERSTANDING OF THE ROCK MASS BY ENGINEERS AND GEOLOGIST WHO MAY NOT BE ABLE TO HANDLE THE CORES THEMSELVES IN THE FUTURE.