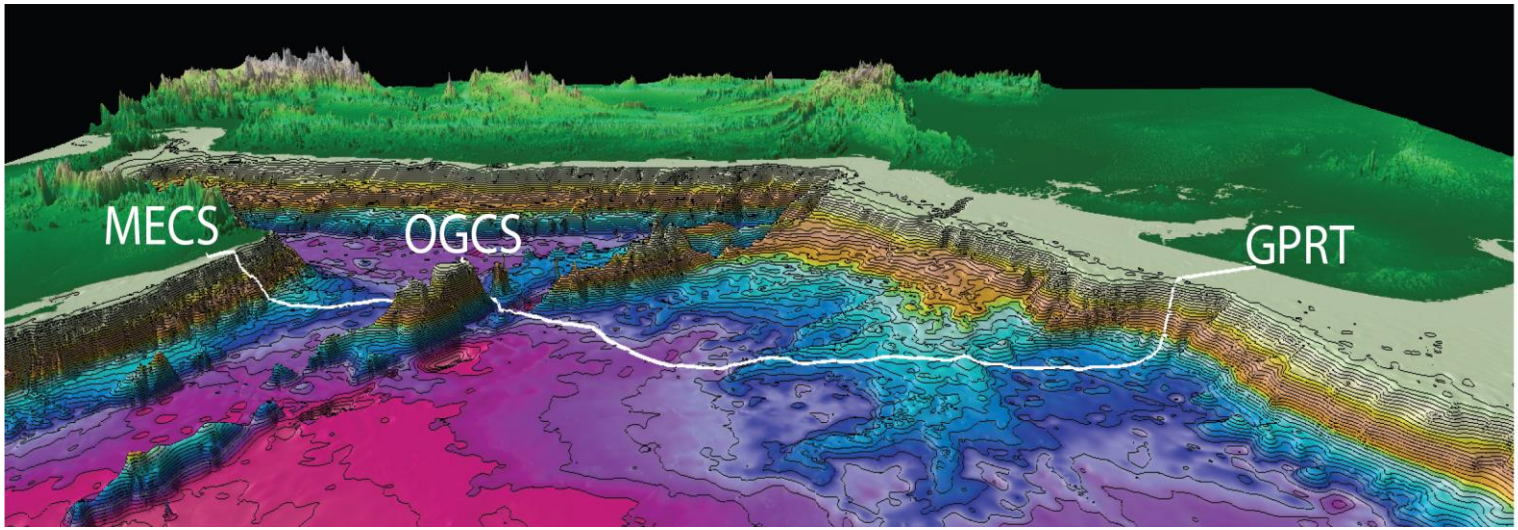
SAGE

Middle East India Deepwater Pipeline (MEIDP) – findings and implications of the 2013 reconnaissance survey



Project Summary

1. Introduction to MEIDP
2. MEIDP Project Features
3. Reconnaissance Survey Scope
4. Oman Continental Scope
5. Qalhat Seamount
6. Owen Fracture Zone
7. Indus Fan
8. Indian Continental Slope
9. Geohazard Features
10. Summary and Conclusions

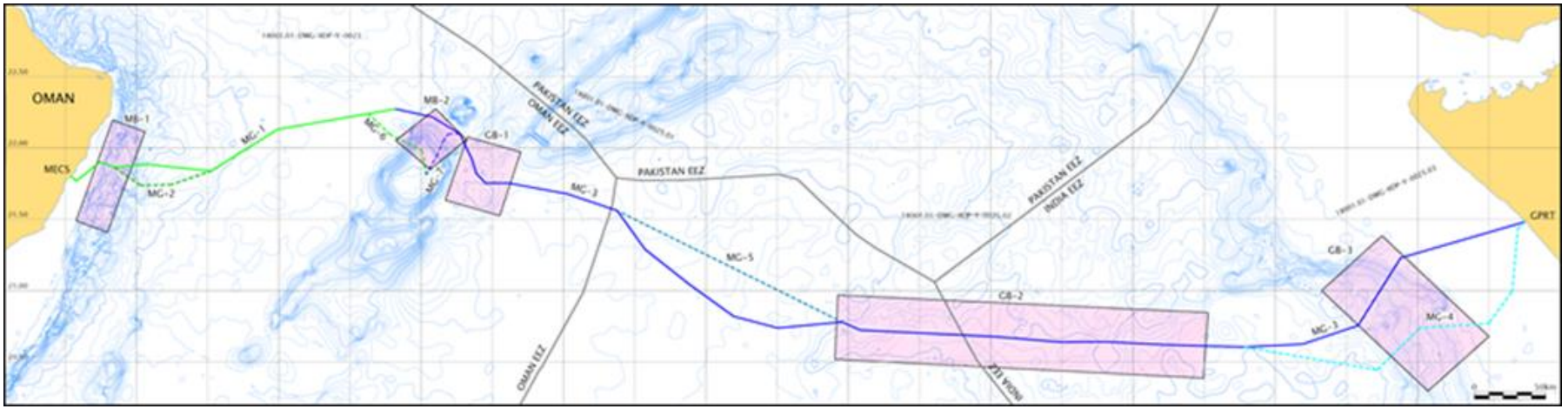
The Project

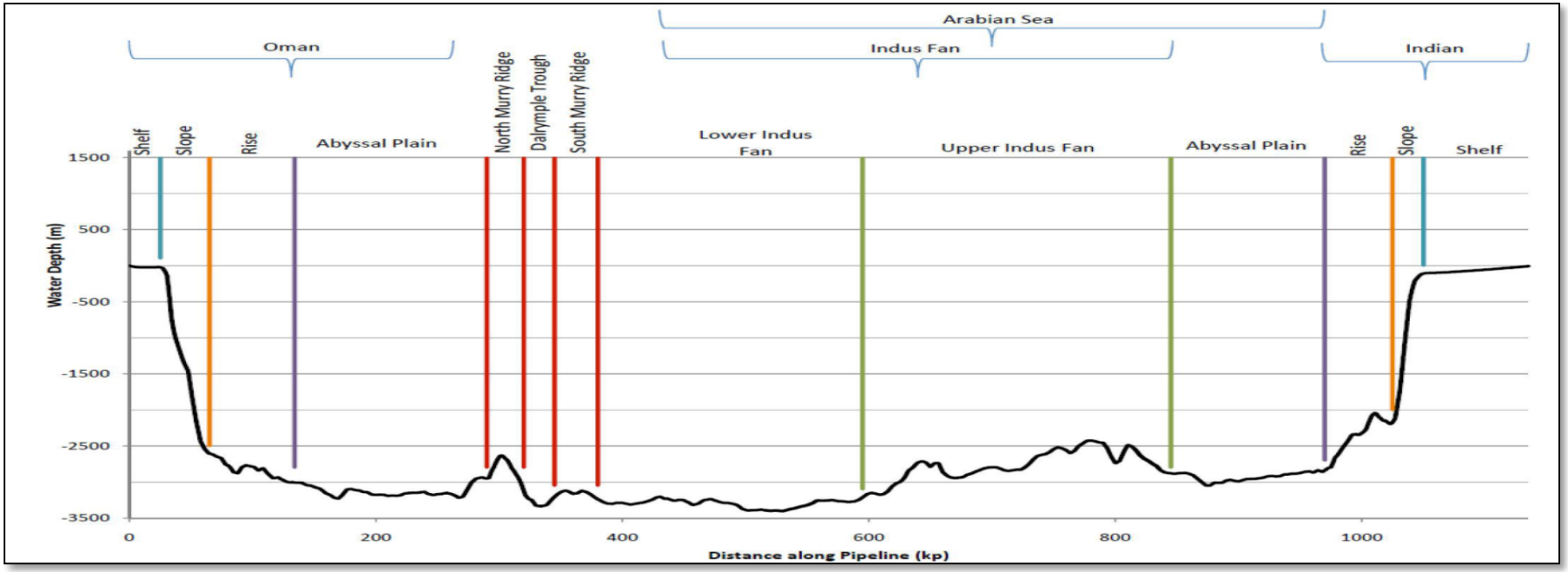
- MEIDP 1 will be the first in a series of pipelines supplying gas to the Gujarat coast of India, from the vast available resources in the Middle east, by the **safest, most economic** and **reliable** means
- The SAGE MEIDP Project is envisaged as an transmission pipeline **Infrastructure project** allowing transportation of multiple sources of Middle East Gas to the West Coast of India
- In June 2012 SAGE commissioned Fugro to perform a multi-million $ Geophysical Survey of the pipeline route across the Arabian Sea
- The reconnaissance Survey was completed on 21st June 2013

MEIDP Project Features

- Potential Start Points
  - Chabahar, Iran
  - Ras al Jafan, Oman
- End Point- South Gujarat
- Diameter 27.2”, 32.9-40.5mm WT (DNV OS-F101)
- Flowrate 1.1BSCFD (31.1mmscmd)
- Maximum Depth- 3,450 meters
- Length- 1,200- 1,300 kilometers
- Fast Track Project can be executed over 5 year period
- Pipeline Construction over 2 years

2013 Reconnaissance





Survey Vessel MV Gauss

Survey Awarded to Fugro OSAE June 2012

MV Fugro Gauss is equipped with multibeam systems for both shallow and deep waters:

- Kongsberg EM 710
- EM 122

MV Fugro Gauss Mobilised from Mumbai on 14th April 2013

Survey to be completed before the SW Monsoon In June

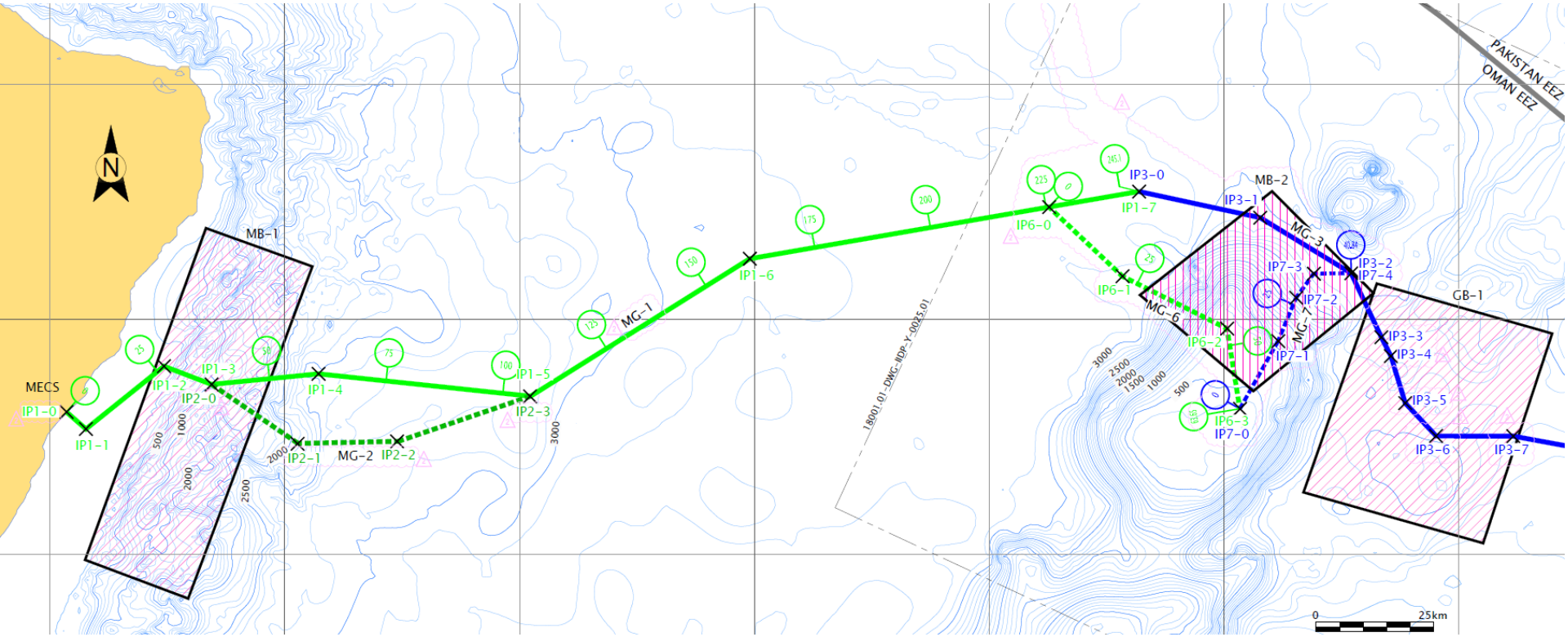
Objective of Survey

Survey objectives include the acquisition, processing, interpretation and reporting of appropriate hydrographic, geophysical, geological and geotechnical data as required to:

- Establish seabed topography
- Evaluation of seabed and shallow sub seabed geological and geotechnical parameters
- Identify and map potential geological features, geotechnical phenomena and environmental constraints that may have the potential to influence the pipeline routing, construction or operation of the proposed pipeline development.

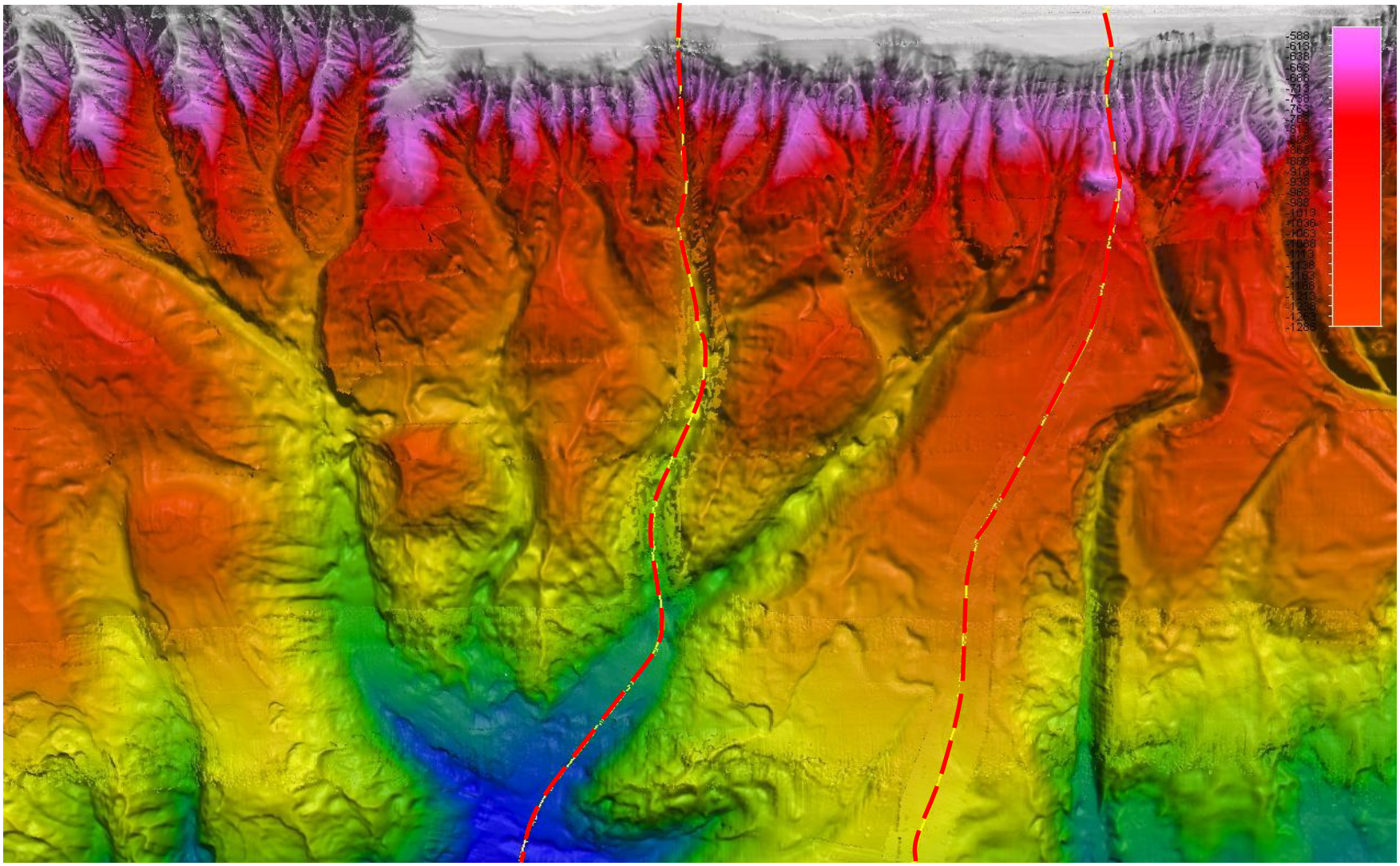
Task		Water Depth	Survey Scope
Block:	Reconnaissance Surveys	100m-3500m	Swath bathymetry, sub-bottom profiler
Corridor:	Reconnaissance Surveys	20m-200m	Swath bathymetry, sub-bottom profiler, backscatter. Minimum corridor width 2 km (Bathy)
		200m-500m	Swath bathymetry, sub-bottom, backscatter. Minimum corridor width 5 km (bathy)
		500m-2000m	Swath bathymetry, sub-bottom, backscatter. Minimum corridor width 10 km (bathy)
		2000m-3500m	Swath bathymetry, sub-bottom, backscatter. Minimum corridor width 25 km (bathy)

Survey – Oman EEZ

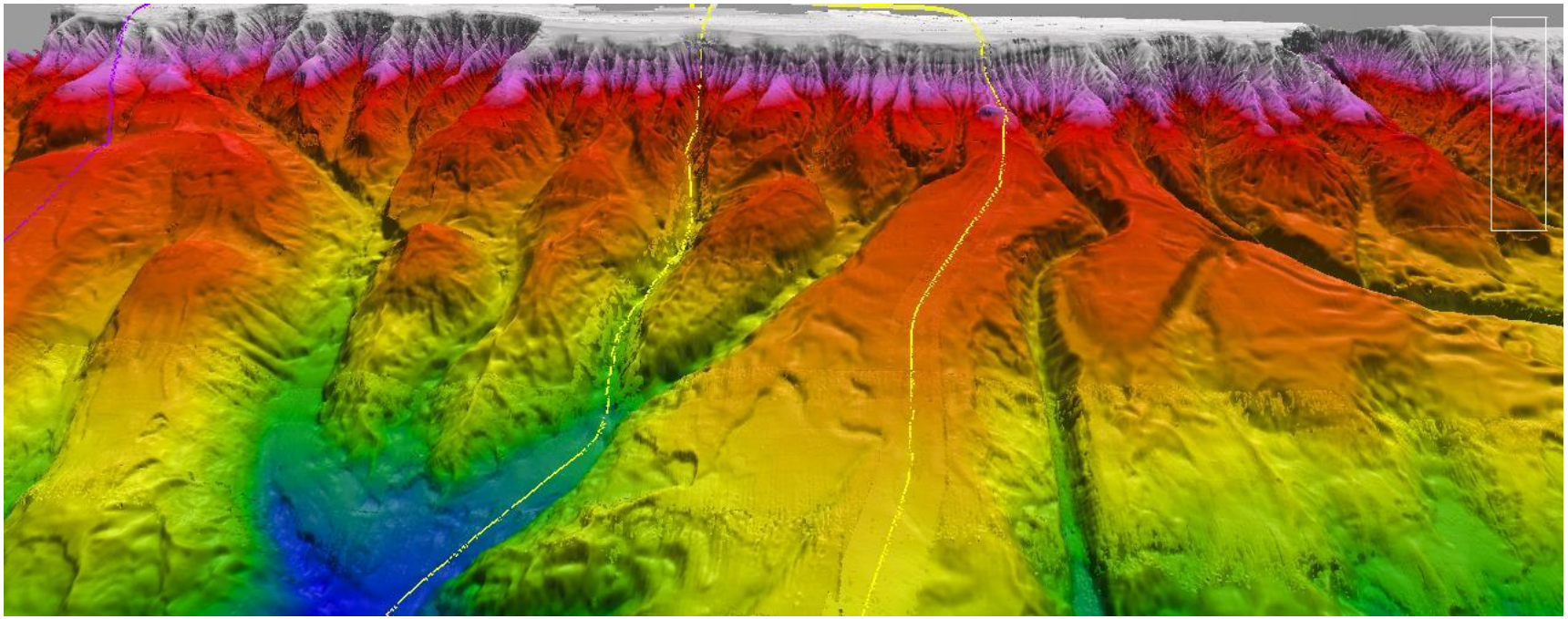


- Oman Continental Slope
- Route to Owen Fracture Zone
- Qalhat Seamount

Omani Continental Slope



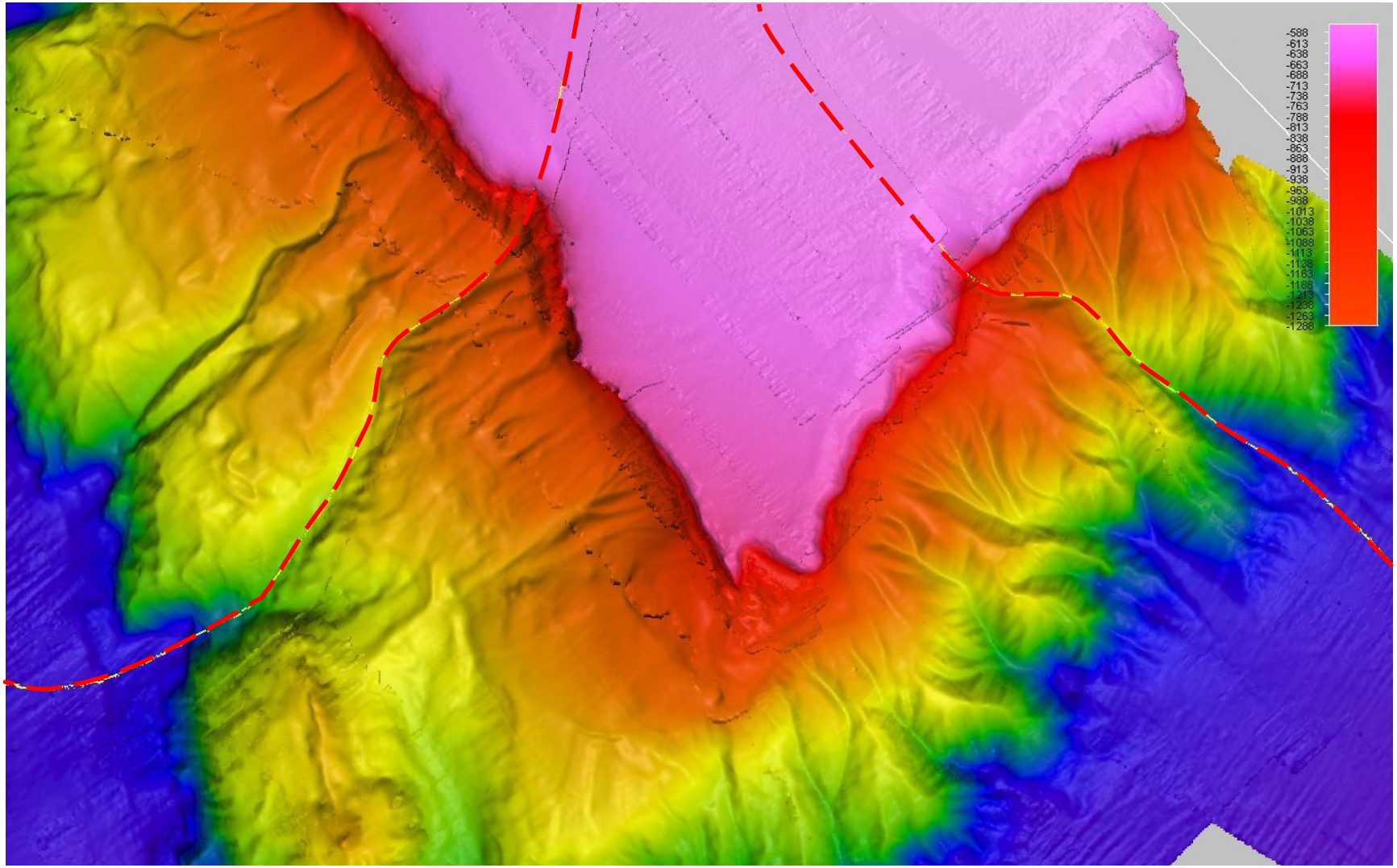
Omani Continental Slope



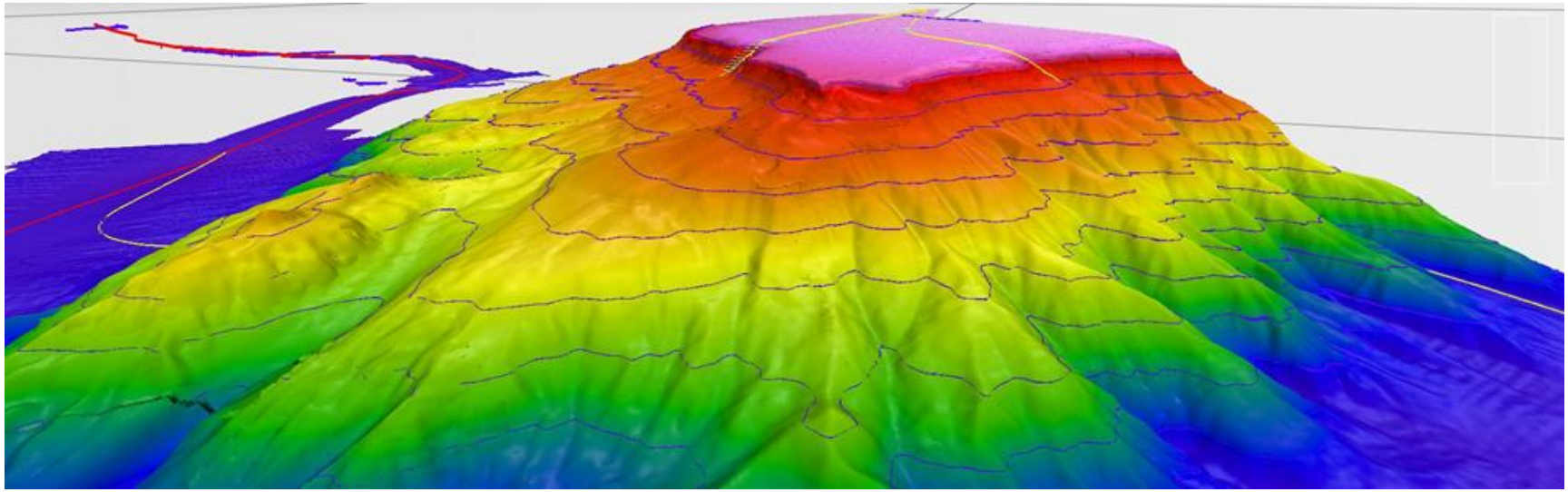
The slope is dominated by large canyons and channels descending the slope seawards from the shelf.

- Water depth at the shelf break is approx. 100m with many small channels
- Channels merge to form canyons and at the foot of the slope (4 major canyons)
- Largest canyon complex, three large tributaries (almost 6km wide @2900m WD)
- There is evidence of slumping and sliding mainly within the channel walls
- The shelf and slope show homogeneous sediments between canyons which contain various amounts of coarser sediment
- On the shelf, there are outcropping rock and hard ground (sediments < 2m)

Qalhat Seamount



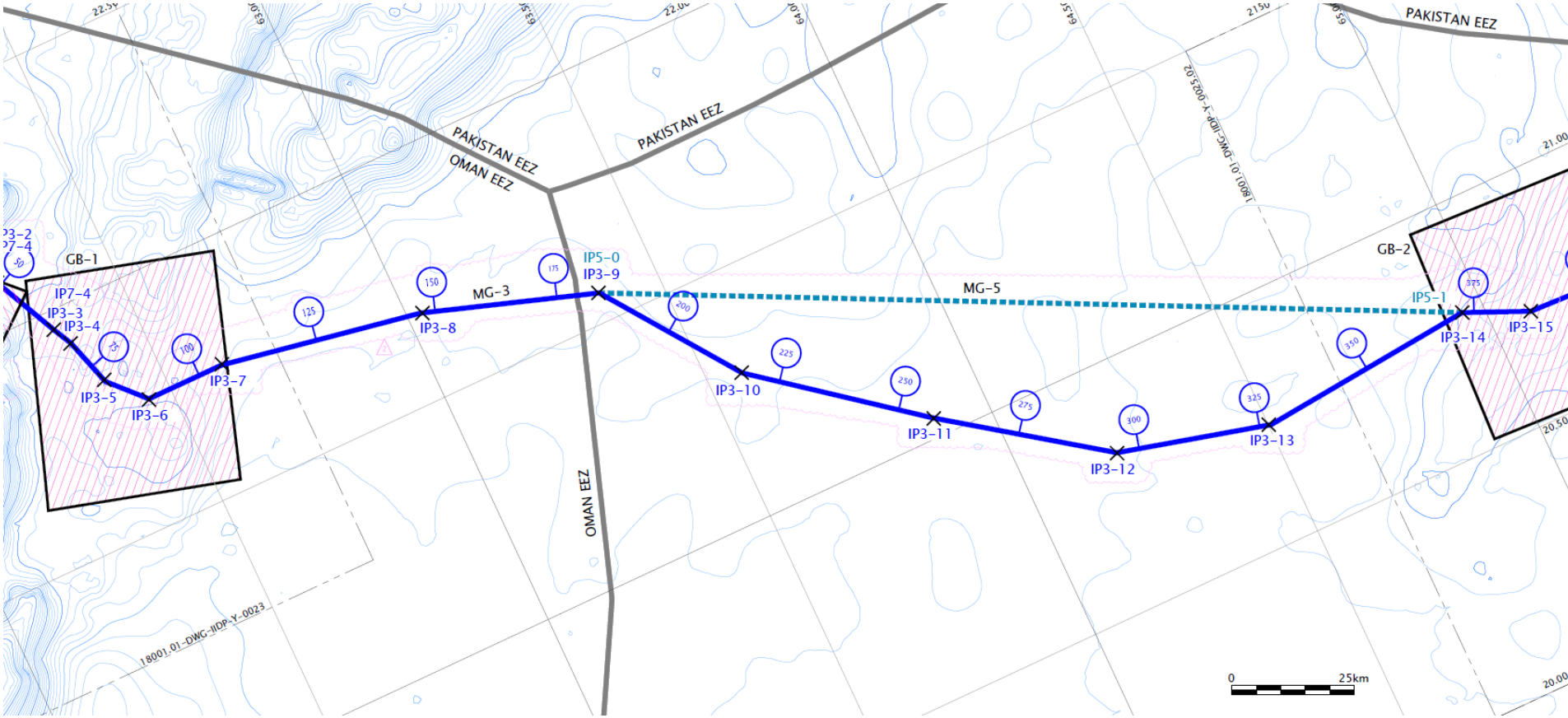
Qalhat Seamount



Only the Northern corner of the plateau was covered by this survey,

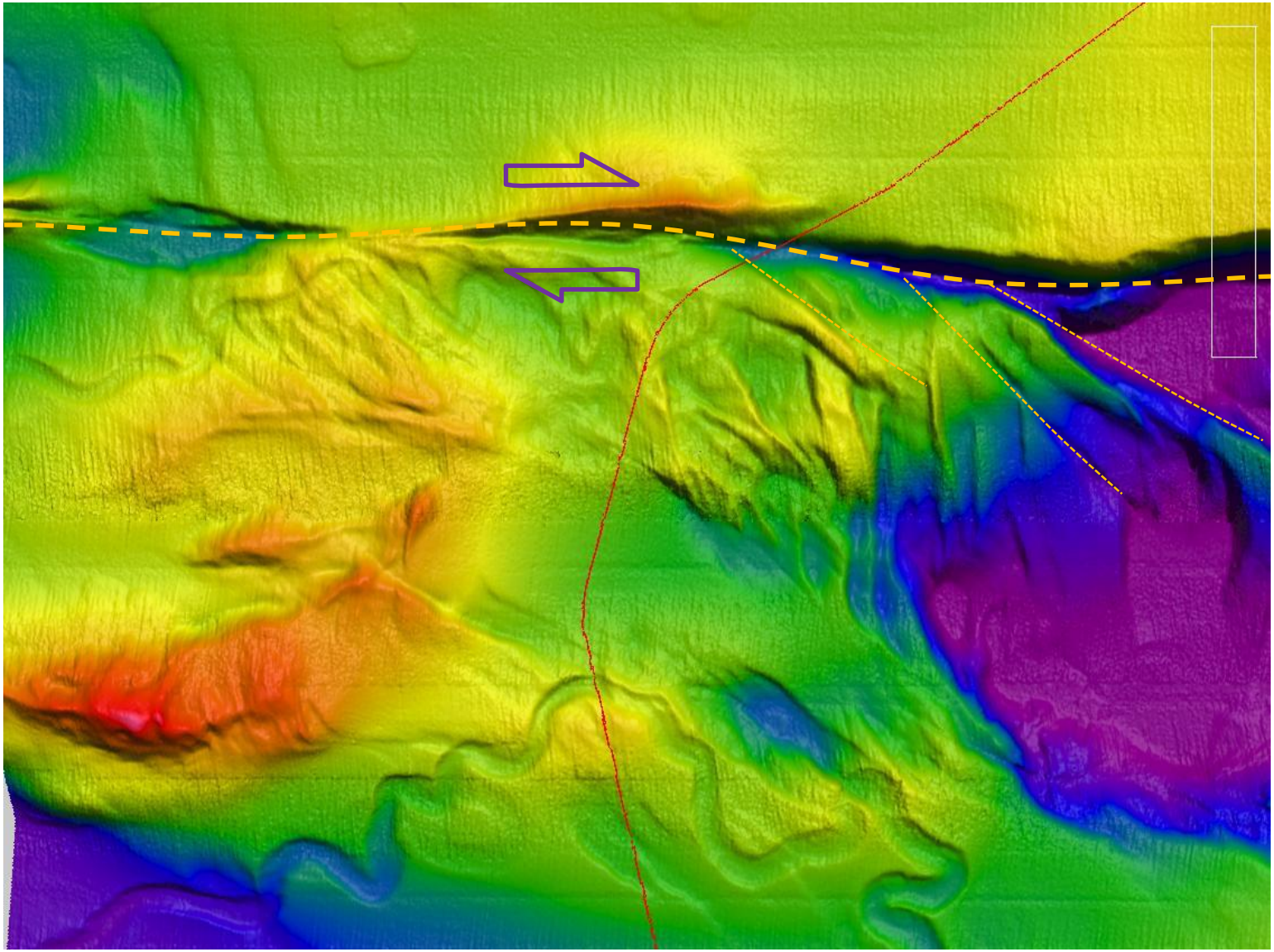
- Shallowest part of the Plateau is around 350m
- Plateau dips slightly towards the north with the plateau break occurring at between 650m and 700m water depth.
- Gradients are around 20˚ in the lower part
- Gradients between 25˚ and 29˚ in the upper slope area
- Deep canyons and gullies dissect the slopes containing courser materials
- There is some evidence of slumping and sliding along the slopes

Survey – International Water



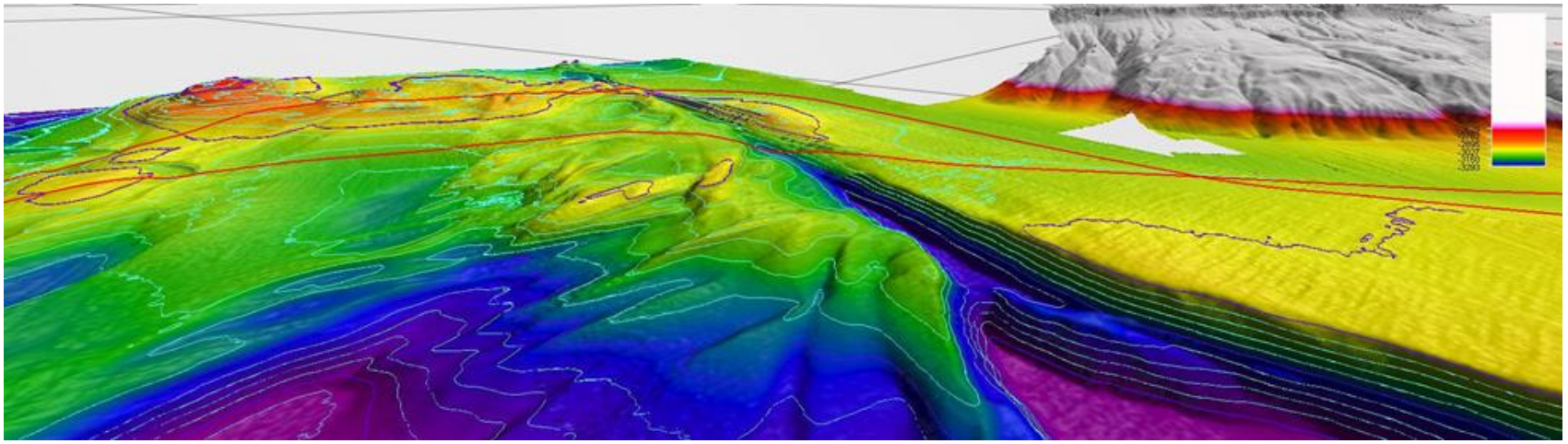
- Owen Fracture Zone
- Dalrymple Trough
- Lower Indus Fan

Owen Fracture Zone



[IN1]Add reference for movement rate

Owen Fracture Zone



Block GB-1 block is characterized by two main structures:

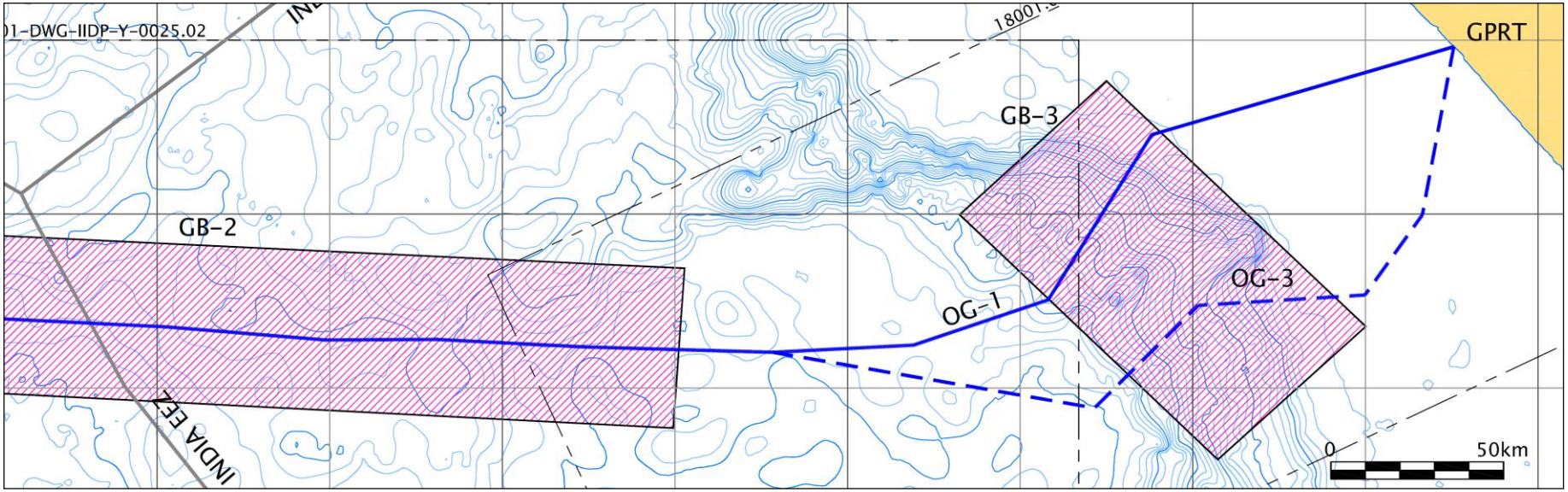
- The deep basins of the Dalrymple Trough and horsetail in the north
- An arch formed bathymetrical high in the south

This fault is the tectonic plate boundary of the Indian and Arabian plates.

- A strike-slip right lateral fault
- Moving at a slip rate of 2mm/year (7mm/yr max).
- Fault forms a 200m deep canyon 1.3km wide at MEIDP crossing

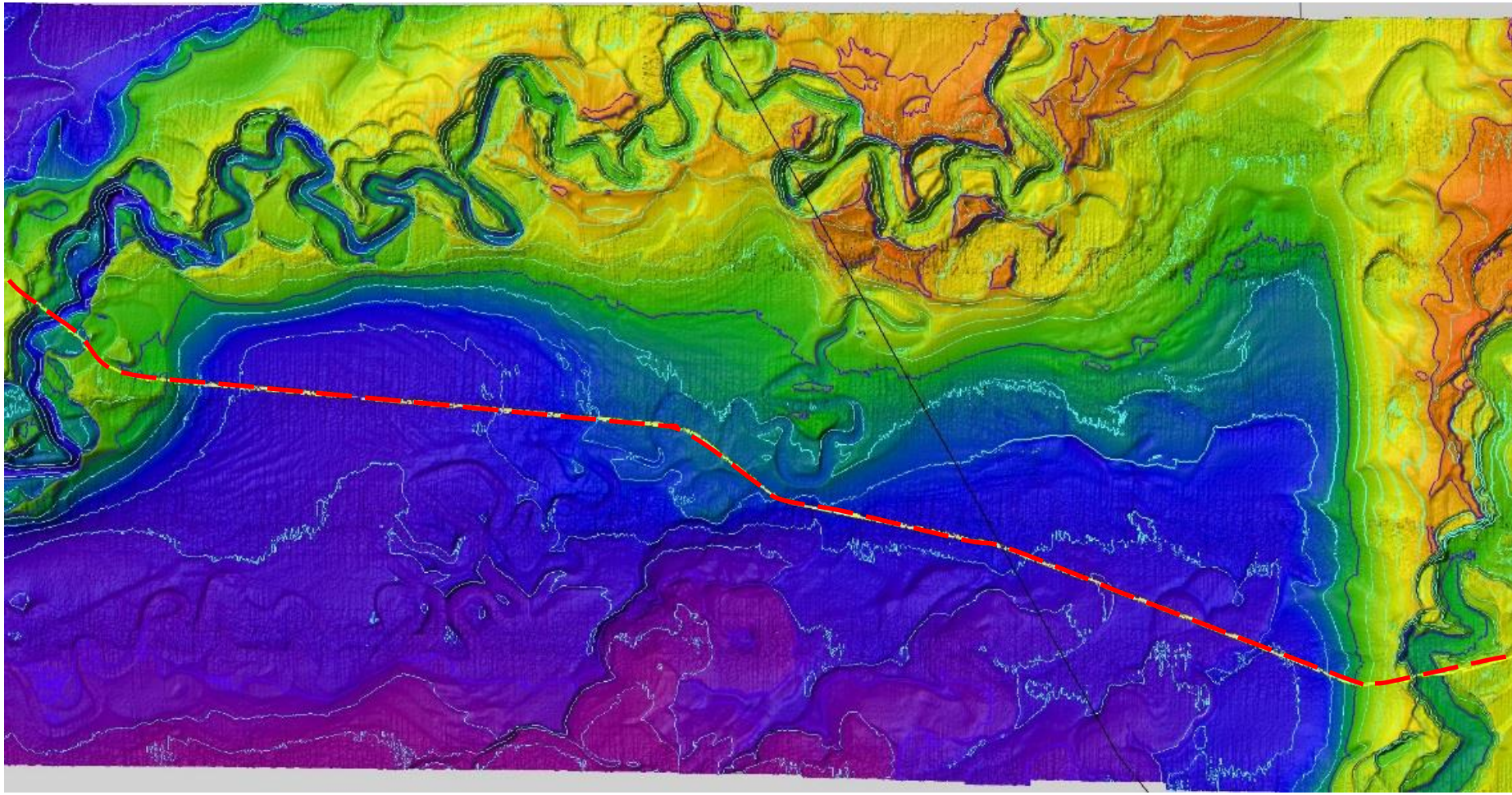
The bathymetric high is about 6km wide and approx 19km long, rising to 2630m water depth at its shallowest part.

Survey – Indian EEZ

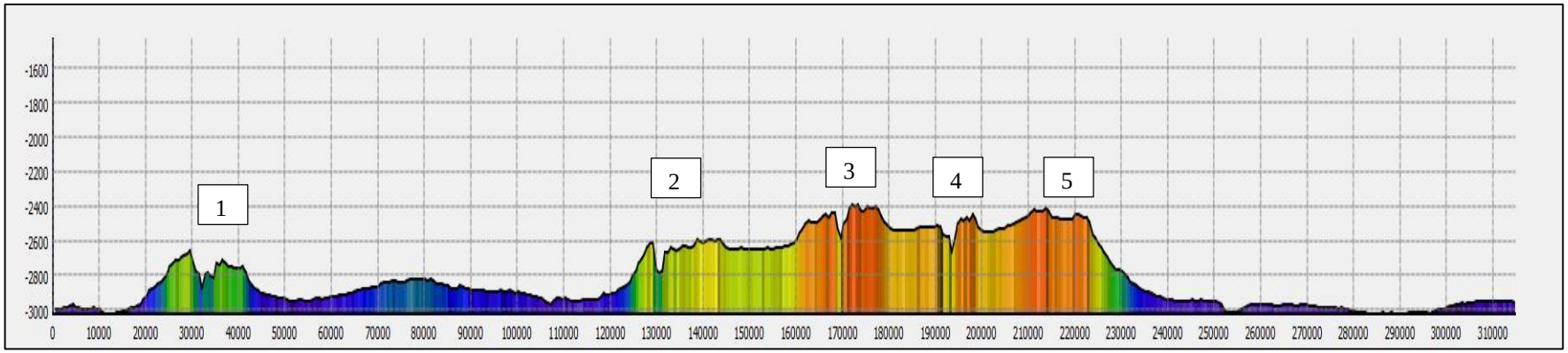


- Middle Indus Fan
- Indian Continental Slope
- Route to Gujarat Landfall

Indus Fan (GB2)



Indus Fan (GB2)



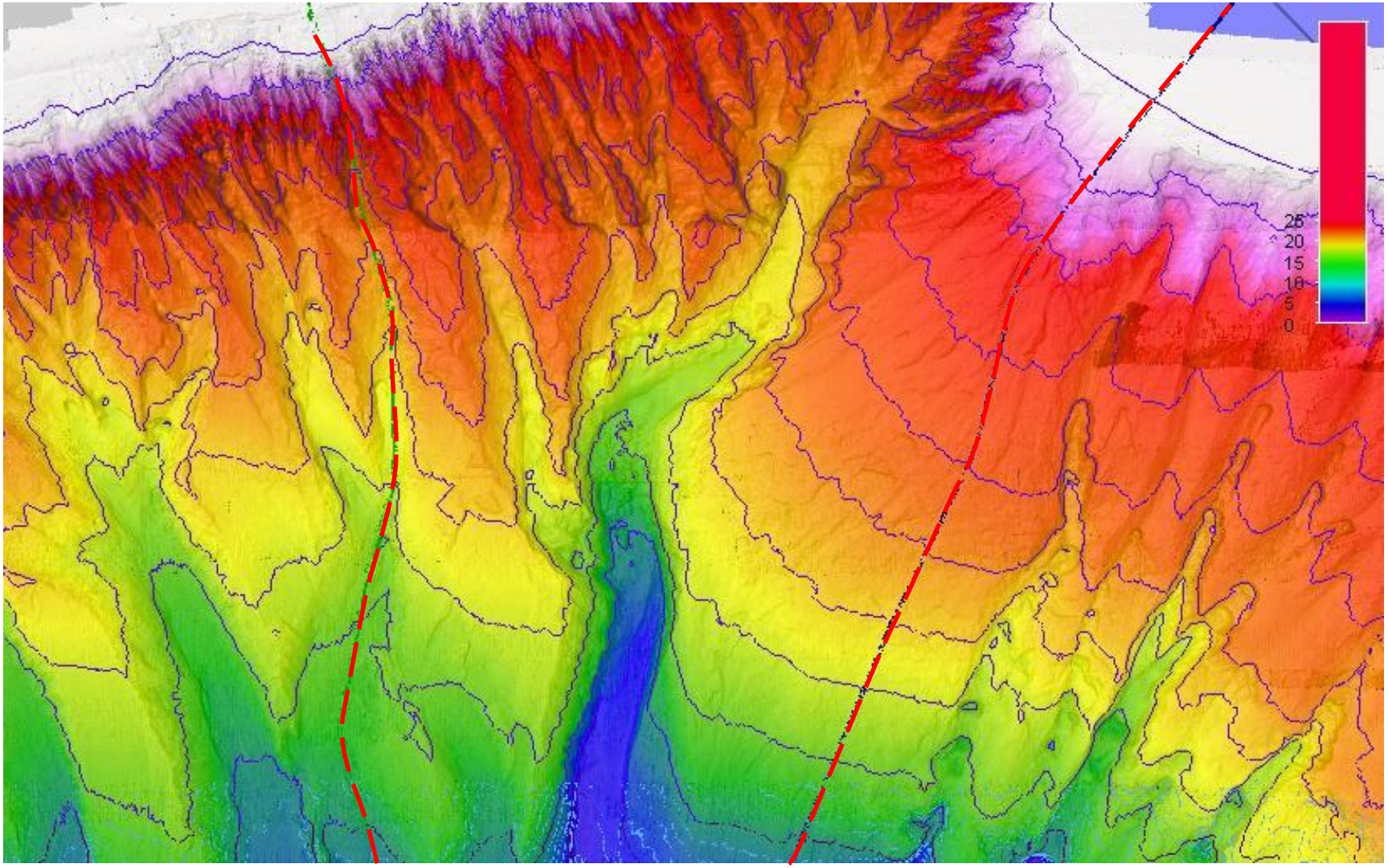
Block GB-2 is characterized by two topographical main structures in water depths between 2100m – 3200m:

- Channel/levee systems dominating the central part
- Deep sea basins in the easterly and westerly sections

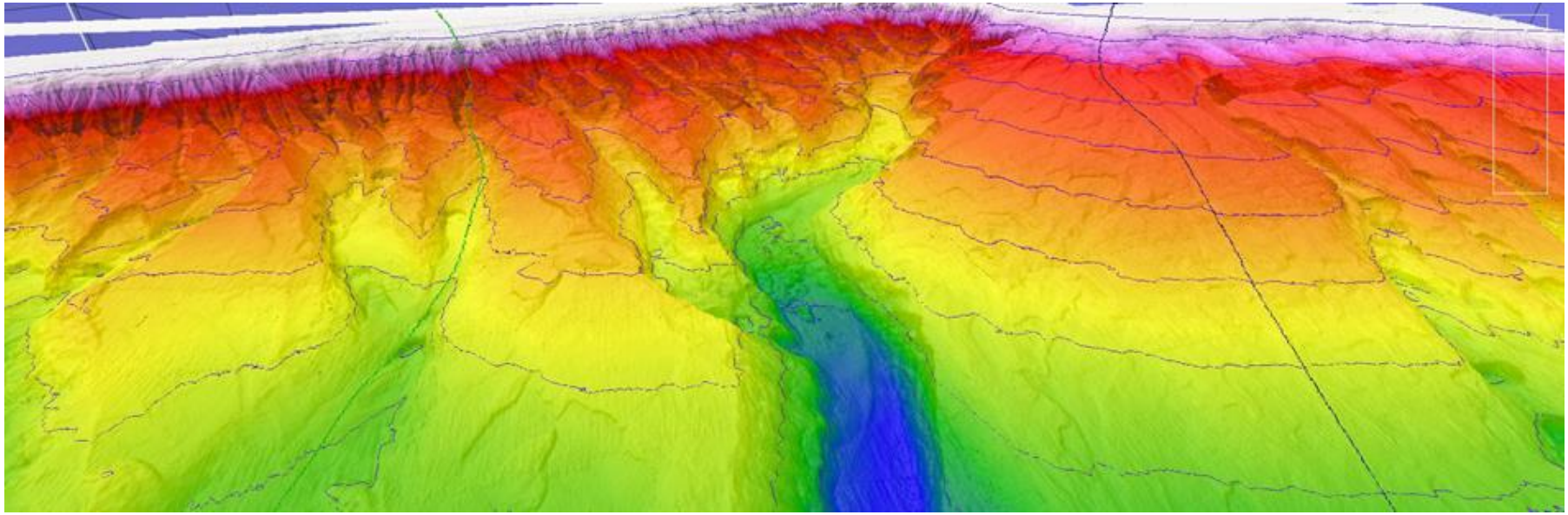
The channel/levee system is characterized by central channels with a series of adjacent terraces and numerous abandoned channel loops

- The pipeline route crosses five turbidity current Channels
- up to 200m high with up to 25˚ side slopes
- Generally in a meandering flow pattern with general N-S direction
- Generally covered by a fine grained soft to very soft clay

Indian Continental Slope (GB3)



Indian Continental Slope (GB3)



The Indian shelf break occurs between 100m to 150m water depth with the slope decending to 2500m at its base. The upper slope area is dominated by numerous steep incised gullies

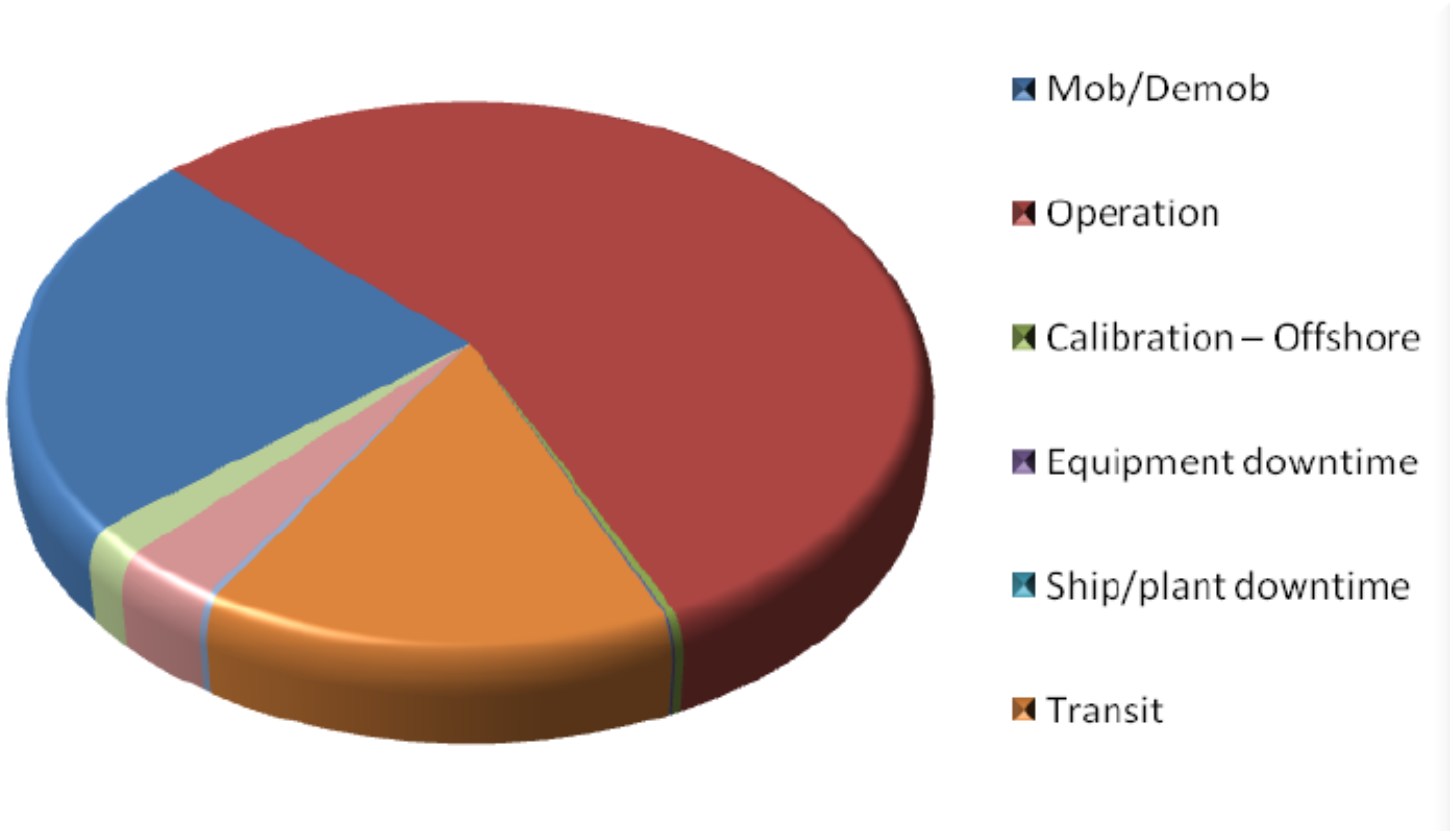
- Slopes of up to 30 ˚ observed near the shelf break
- Bullies join to form smaller then large canyons
- Between the canyons sediment ridges/mounts are developed
- Slump deposits are evident especially at the base of the slope (within canyon walls)

Geological Route Hazards

Geological Hazard	Survey Block				
	MB-1	MB-2	GB-1	GB-2	GB-3
Faults	✓	✓	✓		✓
Slope instability	✓	✓	✓	✓	✓
Debris Flows	✓	✓	✓		✓
Slumps/Slides	✓	✓	✓		✓
Turbidity Currents			✓	✓	
Scour	✓				✓
Rock Outcrop	✓	✓	✓		✓
Hardground	✓	✓			
Corals	✓				✓
Shallow Gas					✓
Variable Soil Conditions	✓	✓	✓		✓

Statistics

- Route Corridor Survey 1,779.8 km
- Block Survey 26,206.5 km^2



The Middle East to India Deepwater Pipeline Reconnaissance Survey

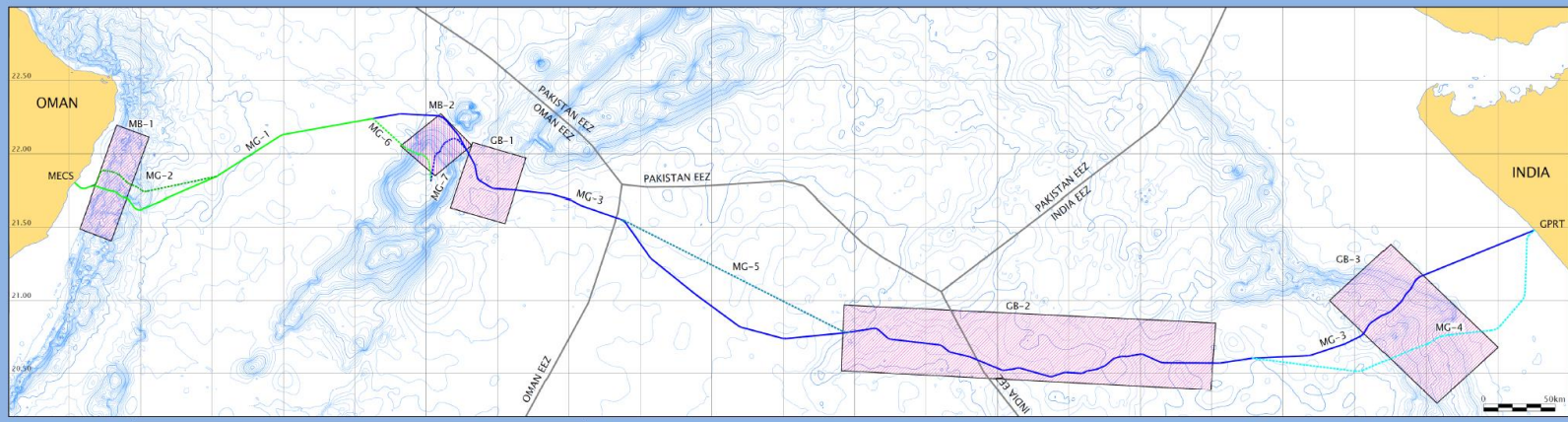
By Ian Nash

1 Objectives

The MEIDP Reconnaissance Survey combines Area/Block route corridor surveys of critical areas of the pipeline route including the Omani and Indian continental slopes, the Arabia-India plate boundary and associated features such as the Qalhat Seamount, Murray Ridge and Dalrymple Horsetail, Indus river abyssal fan.

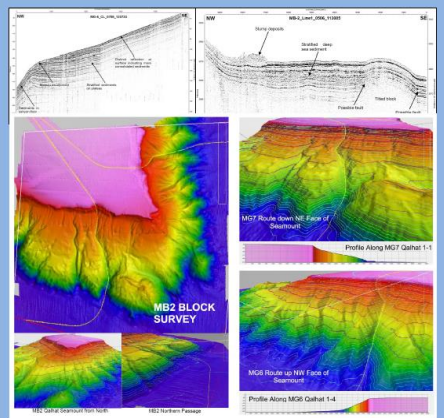
In May and June 2013 the MV Fugro Gauss performed the geophysical survey including:

- Multibeam echo sounder (12kHz - EM122 & 70kHz -EM710)
- Backscatter imagery
- 35kHz & 2-7kHz sub-bottom profiler (SES-2000 Deep)



2 Projection Parameters

Projection	Lambert Conformal Conic with 2 standard parallels (LCC2SP)
Hemisphere	North
Latitude of Origin	20° N
Longitude of Origin	66° E
Latitude of 1st Parallel	21° N
Latitude of 2nd Parallel	22° N
False Easting	800,000m
False Northing	0m

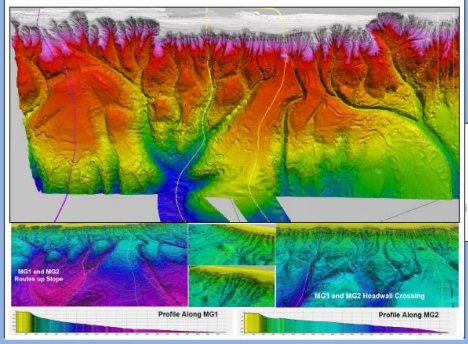


4 Qalhat Seamount – Block MB2

The high Qalhat Seamount located approximately 280km east of the Oman coast within the Omani EEZ and could potentially be used to locate floating compression facilities should a route direct from the Persian gulf be adopted. The seamount rises from a water depth of 3000m in the deep sea area to about 300m at the shallowest point on the plateau, a rise of 2700m. In order not to lose the opportunity of collecting geophysical data on the seamount, the survey included the most likely routes up the eastern slope and down the northern slopes, together with parts of the plateau area. The history of the Qalhat Seamount is not completely known however the presence of a strong magnetic anomaly in the vicinity of the seamount and a typical flat morphology. Evidence suggest that the Qalhat Seamount is a volcanic guyot. The general gradients of the eastern slope are around 20' with the upper slope area having gradients between 25° and 29°. Deep canyons and gullies dissect the slopes and there is frequent evidence of slumping and sliding along the slopes.

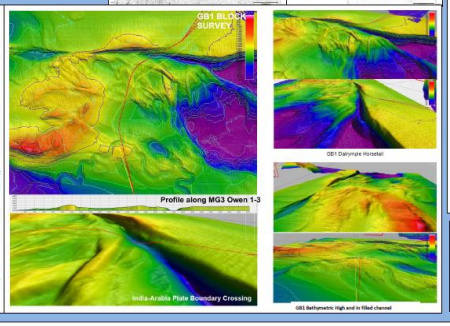
3 Omani Continental Slope – Block MB1

The seabed in Box MB-1 is dominated by large canyons and channels coming down the slope and extending seawards from the continental shelf. The water depth at the shelf break is aprox 100m. a large amount of small channels and gullies at the shelf break. As the channels continue down the slope, they merge into larger channels and canyons and at the foot of the slope, the majority of them have merged into four major canyons. One of the largest canyon complex is seen in the south. It comprises three large tributaries at the foot of the slope and is almost 6km wide. The water depth at the canyon mouth is 2900m. Along the slope there are several evidences of slumping and sliding, however slump scars are almost entirely found within the channel walls. No slump scars have been detected in the areas in between the canyons and channels. The shelf and slope show homogeneous sediments on the slope between the canyon complexes. On the shelf, there are outcropping / sub-cropping rock and hard ground. The soft seabed sediments are of varying thickness on the shelf but generally less than 2m. The canyons and channels on the slope appear to contain various amounts of coarser sediment.



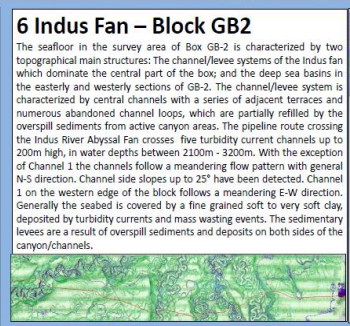
5 Owen Fracture Zone – Block GB1

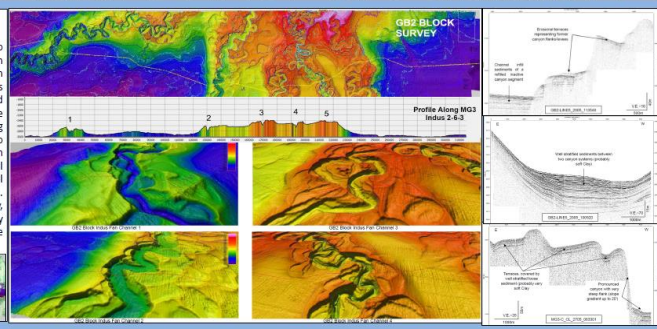
The GB-1 block is characterized by two main structures, a central part which comprises the westernmost extension of the Upper Indus Fan complex as well as the east flank of the Qalhat Seamount, and the deep basins of the Dalrymple Trough in the north. A distinct fault crosses the area in an almost north-south direction into the southernmost end of the pull apart basin of the Dalrymple trough at the Dalrymple Horsetai. This fault is the tectonic plate boundary between the Arabian and Indian plates that extends over 800km in 5 main fault segments of up to 220km length. At the MEIDP crossing point of the Dalrymple Horsetail the Owen Fracture Zone takes the form of a strike-slip right lateral fault. The best estimate for slip rate along this fault is 2mm/year (7mm/yr max). On entering the Dalrymple trough the fault line breaks up into a series of spreading normal faults. At the location of the pipeline crossing, the surface relief of the fault forms a 200m deep canyon, 1.3km wide and water depth of 3200m. Another distinct feature in the area is a bathymetrical high in the south, at the top of the slope to the deep Arabian Abyssal Plain basin. The high is about 6km wide at its widest point and approximately 19km long. The shallowest part, 2630m, is found on the southern part of the high.
To the east of the bathymetric high, there is a 1km wide, approximately 40m deep meandering channel. Parts of the channel are almost entirely in filled by pelagic sedimentation and barely visible in the seafloor.

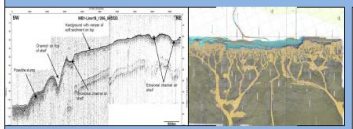


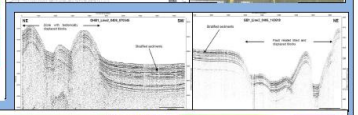
6 Indus Fan – Block GB2

The seafloor in the survey area of Box GB-2 is characterized by two topographical main structures: The channel/levee systems of the Indus fan which dominate the central part of the box; and the deep sea basins in the easterly and westerly sections of GB-2. The channel/levee system is characterized by central channels with a series of adjacent terraces and numerous abandoned channel loops, which are partially refilled by the overspill sediments from active canyon areas. The pipeline route crossing the Indus River Abyssal Fan crosses five turbidity current channels up to 200m high, in water depths between 2100m - 3200m. With the exception of Channel 1 the channels follow a meandering flow pattern with general N-S direction. Channel side slopes up to 25° have been detected. Channel 1 on the western edge of the block follows a meandering E-W direction. Generally the seabed is covered by a fine grained soft to very soft clay, deposited by turbidity currents and mass wasting events. The sedimentary levees are a result of overspill sediments and deposits on both sides of the canyon/channels.



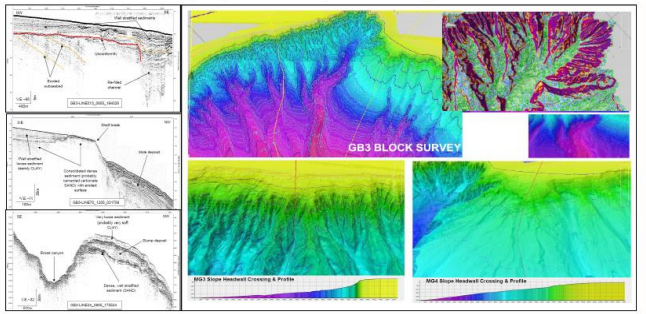






7 Indian Continental Slope – Block GB3

The seabed in the survey area of Box GB-3 consists of a narrow shelf section at the eastern edge of the box and a broad area covering the continental slope in the middle and western part of the survey area. The water depth ranges from 70m at the East to around 150m at the shelf break. The water depth ranges from 150m at the shelf break to around 2500m at the base of the slope. The upper slope area is dominated by numerous steep incised gullies with slopes of up to 30 ° observed near the shelf break (see slope map below). Down slope, most of the gullies join together to form smaller canyons, which then form major canyons. Between the canyons sediment ridges/mounts are developed. Slump deposits can be observed in MBES data which usually end up at the base of the slope contained within canyon walls



8 Conclusion

The survey must be seen to be a great success for all concerned. The next stage of the project is to finalise of the route. The data will allow the detailed assessment of the 5 critical route areas (Indian Slope, Indus Fan, Owen Fracture Zone, Qalhat Seamount and Omani Slope), which will in turn allow a full definition of the intervention works required to safely install the MEIDP. This assessment is very important in order to allow the project to move forward to remove any doubts that remain about its technical viability.