Seabed preparation on Edradour Glenlivet project 2014-2015 campaigns

Loic Delebecque, TOTAL E&P





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EDRADOUR GLENLIVET PROJECT

- Edradour and Glenlivet are gas condensate fields located approximately 100km North West of the Shetland Isles, in water depths ranging from 300m to 430m
- Subsea development, tied back to existing Laggan-Tormore system and installation of a Condensate Mercury Removal Unit at Shetland Gas Plant
- Two 12" production flowlines of 17km and 35km, with design capacity up to 200MMscfd with associated condensate
- Edradour and Glenlivet are planned to come on-stream in 2017 and 2018 respectively







EDRADOUR GLENLIVET PROJECT OVERVIEW





~150 km of pipelines and umbilicals overall

SEABED CONDITIONS WEST OF SHETLANDS

• Seabed boulders (glacial dropstones) prevalent offshore West of Shetlands

Glacial dropstones, involving rocks falling out of icebergs, are one of the most common types of **dropstone** preserved in the geological record, particularly when deposited in low-energy deep sea or lake environments.



Dropstone - Wikipedia, the free encyclopedia https://en.wikipedia.org/wiki/Dropstone

- Surface boulders are a constraint for pipeline and umbilical installation (risk of overstressing/damaging product)
- Sub-surface boulders are a constraint for trenching installed pipelines (risk of damaging plough/trenching equipment)



SEABEAD PREPARATION TIMELINE ON EDRADOUR GLENLIVET

	May – June 2014	Geophysical and geotechnical early survey on Glenlivet MBES, SSS, CPT, core samples				
		Kommandor Calum				
	July 2014	Geophysical and geotechnical pre-engineering survey MBES_SSS_CPT_core samples				
		Siem Daya 2				
	July 2015	Boulder removal Viking Neptun				
	September 2015	Pre-lay rock carpet installation Stornes				
	August – October 2016	Post lay rock installation (pipelines, umbilicals) Stornes and/or Nordnes				
	July 2017	Post lay rock installation (GRP covers, spools, well jumpers) Stornes and/or Nordnes				
-	MBES – Multi Beam Echo Sound SSS – Side Scan Sonar CPT – Cone Penetration Test	ler				

BOULDER REMOVAL – INITIAL ROUTE SURVEYS

20 May - 26 June 2014

Kommandor Calum surveys, Glenlivet

Siem Daya 2 surveys, Edradour – ILT3 – Laggan

2 - 21 July 2014



Contact	Position X	Position Y	Length m	Width m	Height m	Burial %
MB677	516536,7400	6754785,4400	0,9	1	0,5	0,05
VI067	516577,8000	6754776,2800	1	0,8	0,5	0,1
MB702	515199,8800	6755043,1100	0,8	0,6	0,5	0,3
SC553	515212,8300	6755050,7500	0,6	0,9	0,5	0,3
VR068	517635,7500	6754567,1200	0,7	0,9	0,5	0,4
MB640	518367,0900	6754420,5700	0,6	0,7	0,5	0,4
MB672	516642,1400	6754766,3600	0,7	0,9	0,5	0,2
MB670	516707,9900	6754749,0400	0,6	1,2	0,5	0,2
MB841	505850,5000	6756617,2000	0,8	1,1	0,5	0,1
MB804	510709,7000	6756253,5000	0,8	1	0,5	0,1
MB883	508661,0900	6756840,8000	0,6	0,6	0,5	0,3
SC591	509663,3000	6756666,9000	0,9	0,7	0,5	0,2
MB748	512672,7000	6755541,8000	1	0,9	0,5	0,3
MB716	514360,7000	6755213,3000	1	. 1	0,5	0,4
SC578	511218,6000	6756009,9000	0,8	0,9	0,5	0,2
MB764	512044,4000	6755690,1000	1,3	1	0,5	0,5
SC476	522590,1700	6753593,1400	0,8	0,7	0,5	0,5
SC474	522847,7300	6753537,3600	1	0,9	0,5	0,4
VI069	518648,1200	6754367,5700	0,9	0,9	0,5	0,1
MB611	522102,6800	6753688,7000	0,7	0,8	0,5	0,2
MB591	524920,0000	6753162,0000	1,2	0,6	0,5	0,5
MB605	522965,4700	6753515,0000	0,9	1,1	0,5	0,4

Laser sizing of boulders (green lines set to 0.5m separation)

BOULDER REMOVAL – TARGET ASSESSMENT

Initial assessment (20m corridor) (Multi Beam Echo Sounder + Side Scan Sonar + laser sizing)

Corridor refinement

Boulder size criteria (prop height) > 0.5m Reduction of installation tolerances (corridor width)



1692 targets

1414 targets

204 targets

OFFSHORE OPERATIONS

28 June – 4 July 2015 Viking Neptun – confirmation survey & boulder removal



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ROV ruler used to measure boulder height (0,5m critical height)

OFFSHORE OPERATIONS – SUMMARY

Total of **199 boulders** moved to disposal corridor in just over **4 days** (4.2days) offshore on location $\rightarrow \sim 2$ boulders / hour







PRE-LAY ROCK DUMPING

• Specific foundation (rock carpet and large mudmats) required on 6 off FLETs and 1 off ILT due to soft seabed conditions (soft clay overlaid by veneer of silty sand)



• Rock carpet required below Edradour production pipeline cooling section (~1.5km long) to limit embedment of pipeline and ensure required gas cooling



ROCK CARPETS DESIGN

- Geotechnical calculations performed to design required design of rock carpet
 - Subsea structures weight
 - Pipeline/spool loads
 - Fishing design loads (overtrawlability)





ROCK DUMPING OFFSHORE OPERATIONS







Accurate placement of rock on seabed using fall pipe diverters and live multi beam echo sounder survey Height tolerance [0; +0.1m]



ROCK CARPET INSTALLATION



 Typical outcome from rock dumping campaign ⇒ DTM (Digital Terrain Model) survey charts

Orange lines ⇒ FPROV track whilst filling boxes to target height

Yellow \Rightarrow target height



Blue ⇒ low spots needing filling

SUMMARY AND CONCLUSIONS

- Importance of high quality initial geophysical surveys
- **Boulder relocation campaign** successfully completed by Viking Neptun in just over 4 days in July 2015
 - Boulder grab method proved adequate for the scope
 - Initial project assessment/alternative using seabed scar plough was forecasted to last ~30days with no guarantee on effectiveness
- **Pre-lay rock dumping campaign** successfully completed by Van Oord Stornes in September 2015
 - Very accurate rock placement (actual seabed height accuracy down to 0.05m) with the state-of-the-art MBES data processing capability
- Special thanks to Technip Norway for the performance of this successful offshore works and thanks to our partners DONG Energy and SSE for all their contribution

