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Standard for geological seabed mapping offshore

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REPORT

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Standard for geological seabed mapping offshore

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Summary:

This report gives specifications and requirements for geological seabed mapping in the offshore region. The work was initiated by needs in the MAREANO-programme to document procedures. The report summarizes the work flow from collected data, through processing and interpretation to final products available/published on web map services, e.g. www.mareano.no.

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Backscatter	Sampling	Seabed sediment

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1. INTRODUCTION

This report gives specifications and requirements for geological seabed mapping in the offshore region. The report summarizes the work flow from collected data, through processing and interpretation to final products available/published on web map services, e.g. www.mareano.no.

2. DATA COLLECTION FOR GEOLOGICAL MAP PRODUCTION

2.1 Reference systems and timing

The horizontal reference system shall be the EUREF89. All data are to be UTC. In MAREANO, all map products are presented in UTM Zone 33 (WGS 84).

2.2 Multibeam bathymetry

Bathymetric data are to be collected using multibeam echosounder according to NHS (2010) "Technical specifications Seabed Mapping - MAREANO-programme" published on www.mareano.no.

2.3 Multibeam backscatter

Backscatter data are to be collected using multibeam echosounder according to NHS (2010) "Technical specifications Seabed Mapping - MAREANO-programme" published on www.mareano.no.

2.4 Seabed video data

Seabed video data are to be collected using towed HD video equipment and digital storage. All data are collected according to Norsk Standard (2009) "Visuelle bunnundersøkelser med fjernstyrte og tauede observasjonsfarkoster for innsamling av miljødata", NS 9435.

2.5 Seabed sediment samples

Seabed sediment samples are collected by various sampling devices according to guidance on sampling in marine sediments (Standard Norge 2004).

Grabs are used to take sediment sample up to a few kilos of the uppermost c. 10 cm of the seabed. In case of gravelly seabed it may be impossible to obtain samples. Visual description of sediment samples is done onboard according to SOSI-classification (Appendix 1), and subsamples are preserved in plastic bags for grain size and other analyses.

Boxcorers are used to obtain sediment samples of the uppermost c. 50 cm of the seabed. In case of gravelly seabed it may be impossible to obtain samples. Visual description of the sediment surface is done onboard according to SOSI-classification (Appendix 1). Boxcores are subsampled with plastic tubes to obtain cores for grain size and other analyses.

A multicorer (KC Denmark AS Model 73.00) (www.kc-denmark.dk) is used to obtain up to 6 clear plastic tubes of undisturbed sediments of the uppermost c. 50 cm of the seabed for geochemical studies. Multicorer is only used where the seabed is fine grained. Visual description of sediment cores is done onboard according to SOSI-classification (Statens kartverk 2006).

A Niemistöcorer (a small gravity corer) is used to obtain undisturbed sediment cores up to 75 cm long for geochemical studies. Description and subsampling is done post cruise.

Gravity corers, piston corers and vibrocorers are used to obtain sediment cores up to several metres long for stratigraphic studies. Description and subsampling for various purposes is done post cruise.

All samples and cores are carefully labelled and documented in a station journal.

Post-cruise grain-size analyses on subsamples from plastic bags and tubes is performed by wet sieving and Laser Coulter Counter (http://www.beckmancoulter.com/coultercounter/product_LS2Series.jsp).

2.6 Shallow seismic data

Shallow seismic data (pinger, TOPAS, boomer, airgun, sleevegun) data are collected on cruises where equipment is available. A TOPAS PS018 (www.kongsberg.com) parametric sub-bottom profiler is used for collecting high-resolution seismic data on G.O.Sars (http://www.imr.no/om_havforskningsinstituttet/fasiliteter/fartoy/g_o_sars/en). Data are stored in TOPAS raw format for later processing.

3. DATA PROCESSING, INTERPRETATION AND REPORTING

3.1 Multibeam backscatter processing

Multibeam backscatter data are processed by NGU from raw multibeam data. Processing software employed is either:

(a) Custom backscatter processing software developed and provided by Robert Courtney, Geological Survey of Canada, or
(b) Poseidon software (Kongsberg Maritime) (www.kongsberg.com)

These produce a raster grid of backscatter amplitude in decibels (dB).

Processed data are converted to ArcGIS format and archived in NGU's Marine Geology database (MGDB). To overcome differences in backscatter (dB) levels between surveys each dataset are also levelled as far as possible to a common standard using calculations performed using Spatial Analyst extension for ArcGIS. These levelled data are also archived in NGU's MGDB.

Levelled backscatter data are published on www.mareano.no.

3.2 Bathymetric terrain modelling

Terrain modelling is used to produce quantitative descriptors (e.g. slope) of the seabed from bathymetry data. Many descriptors are calculated at multiple spatial scales. Softwares employed are:

(a) Spatial Analyst extension for ArcGIS (www.esri.com), and
(b) Landserf software (www.landserf.org)

Quantitative descriptors are used in the production of landscape and nature type maps among others.

3.3 Compilation of existing geological data

NGU uses existing geological ground truthing information, both published and unpublished where permitted. This may include samples from grabs, boxcorers, gravity corers, vibrocorers and drill cores as well as video data and photos. NGU also uses available seismic data for mapping stratigraphic units and unit boundaries at the seabed.

Existing geological information is translated or transformed to formats that can be stored in the MGDB and used for interpretation and map production.

3.4 Compilation of preliminary maps as basis for cruise planning

Preliminary maps are compiled prior to the combined geology/biology/pollution mapping cruises. Preliminary maps are based on multibeam bathymetry and backscatter data as well as existing geological information, and are used for planning the location of ground truthing stations (video, grab, boxcorer, multicorer) and shallow seismic profiles.

Preliminary maps include bathymetry, backscatter, various terrain indices (e.g. slope), geology and predicted nature types. By combining the information from these preliminary maps it is possible to select typical and special bottom types and features for ground truthing in order to make the sampling representative and therefore provide the best data for the production of accurate final maps.

3.5 Processing and interpretation of shallow seismic data

Topas Aquisition and Processing software (www.kongsberg.com) is used for processing raw data files. Custom software developed at NGU is used for preparing SEGY files for use in SeisVision (http://www.halliburton.com/ps/default.aspx?pageid=3847&navid=1708&prodid=MSE::1055451444053286) and Petrel (http://www.slb.com/content/services/software/geo/petrel/) interpretation software.

Seismic data are stored in raw format. Seismic data are also stored in processed SEGY format and SeisVision format with extracted position data on txt-files.

3.6 Marine Geology DataBase (MGDB)

MGDB is an ArcSDE-database with datasets on bathymetry, backscatter, shaded relief, shallow seismic, seabed samples, videos and photos, and geochemistry. A description of and user manual for the database will be developed later.

The database stores metadata and interpreted data. Raw data and large shallow seismic and batymetry datasets are stored separately on servers for open and confidential (bathymetry with resolution better than 50 m within 12 nautical miles) data.

Geological interpretations are done according to the SOSI standard for superficial deposits (Statens kartverk 2006).

Sediment grain size maps are made according to the classes in Appendix 1.

Sediment genesis maps (comparable with Quaternary geology maps on land) are made according the the classes in Appendix 2.

Sedimentary environment maps (recent/present sedimentary environment) are made according to the classes in Appendix 3.

Landscape maps are made according to Erikstad et al. (2009) (Appendix 4). The nature type "landscape" is one of five hierarchical levels in the nature type classification system "Naturtyper i Norge" (Halvorsen et al. 2008).

3.7 Data interpretation and compilation of geological maps

ArcGis from ESRI (www.esri.com) is used for interpretation and compilation of geological maps. ER Mapper (www.erdas.com) is used for visualizing bathymetric data (shaded relief).

Digitizing of geological boundaries and features is done at a scale of 1:50 000 to make maps to be presented in scale 1:100 000. Distance between data point for lines and geological boundaries is set to 125 m. Only objects larger than 250 m in length/diameter are digitized.

3.8 From database to web map services

Interpreted geological data stored in MGDB are made accessible for users through several map services, and are published on thematic maps on the MAREANO web site (www.mareano.no).

Map services are developed using ArcGIS (www.esri.com) and built on the ArcIMS platform. The map services are made WMS compliant, which makes it possible for users of various GIS-software to use these maps in their own GIS projects and applications.

In order to keep the services manageable the WMSs are compiled on thematic principles and each data set is used only once. Creating complex maps using layers from different map services is enabled through the functionality of a map database and a web map application, both specially developed for publishing marine data on www.mareano.no.

All web map services from NGU based on marine data are registered with metadata on www.geonorge.no as required by the agreement of Norway Digital co-operation.

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5. APPENDICES

Appendix 1. Sediments (grain size). Classification according to SOSI (Statens kartverk 2006).

Symbol	Grain size	Abbr.	Definition/description	Code
	Clay	C	Clay:silt ratio >2:1 and clay+silt >90%, sand <10%, gravel <2%	10
	Organic mud	-	Clay:silt ratio from 1:2 to 2:1 and clay+silt >90%, sand <10%, gravel <2%. High content of organic material.	15
	Mud	M	Clay:silt ratio from 1:2 to 2:1 and clay+silt >90%, sand <10%, gravel <2%	20
	Sandy clay	sC	Clay:silt ratio >2:1 and clay+silt >50%, sand <50%, gravel <2%	30
	Sandy mud	sM	Clay:silt ratio from 1:2 to 2:1 and clay+silt >50%, sand <50%, gravel <2%	40
	Silt	Z	Clay:silt ratio <1:2 and clay+silt >90%, sand <10%, gravel <2%	50
	Sandy silt	sZ	Silt:clay >2:1 and clay+silt >50%, sand <50%, gravel <2%	60
	Clayey sand	cS	Sand >50%, clay:silt ratio >2:1 and clay+silt <50%, gravel <2%	70
	Muddy sand	mS	Sand >50%, clay:silt ratio from 1:2 to 2:1 and clay+silt <50%, gravel <2%	80
	Silty sand	zS	Sand >50%, silt:clay ratio >2:1 and clay+silt <50%, gravel <2%	90
	Fine sand	-	Sand >90%, includes fine and very fine sand (Wentworth, 1922)	95
	Sand	S	Sand >90%, clay+silt <10%, gravel <2%	100
	Coarse sand	-	Sand >90%, includes medium, coarse and very coarse sand (Wentworth, 1922)	105
	Gravelly mud	gM	Sand:silt+clay ratio <1:9, gravel 2-30%	110
	Gravelly sandy mud	gsM	Sand:silt+clay ratio from 1:9 to 1:1, gravel 2-30%	115
	Gravelly muddy sand	gmS	Sand:silt+clay ratio from 1:1 to 9:1, gravel 2-30%	120
	Gravelly sand	gS	Sand:silt+clay ratio >9:1, gravel 2-30%	130
	Muddy gravel	mG	Sand:silt+clay ratio <1:1, gravel 30-80%	140
	Muddy sandy gravel	msG	Sand:silt+clay ratio from 1:1 to 9:1, gravel 30-80%	150
	Sandy gravel	sG	Sand:silt+clay >9:1, gravel 30-80%	160

	Gravel	G	Gravel >80%	170
	Gravel, cobbles and boulders	GB	Dominant grain sizes are gravel, cobbles and boulders.	175
	Cobbles and boulders	B	Dominant grain sizes are cobbles and boulders.	180
	Sand, gravel and cobbles	SGB	Dominant grain sizes are sand, gravel and cobbles.	185
	Sand and boulders	SB	Dominant grain sizes are sand and boulders.	190
	Diamicton	D	Sediment containing particles of a wide range of sizes. Unsorted or very poorly sorted.	200
	Compacted sediments or sedimentary bedrock	-	Submarine outcrop of compacted sediments or sedimentary bedrock.	300
	Thin or discontinuous sediment cover on bedrock. Sediments with varying grain size.	-	Lateral variation of small basins with sediments and exposed bedrock, and/or bedrock with thin/discontinuous sediment cover. Sediments in small basins may have varying grain size.	1
	Exposed bedrock	-	Areas without sediment cover.	5
	Unspecified	-	Grain size is not specified.	0

Appendix 2. Sediments (genesis). Classification according to SOSI (Statens kartverk 2006).

Symbol	Sediment genesis	Definition/description	Code
	Suspension deposit	Fine grained sediments (mainly clay and silt) transported by and deposited from suspension.	200
	Glaciomarine deposit	Mostly fine grained sediments (clay and silt) deposited in the ocean from suspension in the vicinity of glaciers. Can be influenced by bottom currents. Occur in great thickness on the continental shelf, along the coastline and in fjords.	202
	Beach deposit	Deposits reworked by waves and currents in the beach zone. The material is often well rounded and sorted. Grain size varies from sand to boulders, but sand and gravel are most common. Mapped where thicker than 0.5 m.	42
	Shallow marine deposit	Sediment deposited in turbulent shallow marine environment. Consists of sand, gravel and cobbles.	210
	Bedload (traction) deposit	Sediment transported by and deposited from bottom currents. Consists of sand and gravel. Bedload deposits may occur in submarine channels and shallow marine areas, and has often characteristic cross-bedding and lenticular bedding.	201
	Contourite	Sediment body deposited by a permanent ocean current (contour current) along the continental margin. Consists of fine grained, well sorted material (mainly clay and silt, but also sand).	211
	Channel deposit	Sediments deposited in a channel. Consist usually of coarse grained particles (sand, gravel).	215
	Till, unspecified	Unsorted glacial sediment consisting of material ranging in size from clay to boulders.	10
	Till, continuous cover	Unsorted glacial sediment consisting of material ranging in size from clay to boulders. Locally of great thickness and with sporadic patches of lag.	11
	Terminal moraine	Linear or slightly curved ridge of unconsolidated and unsorted debris deposited at the front or the sides of a glacier. Locally, sorted glacio-fluvial deposits may occur.	15
	Mass movement deposit, continuous cover, locally of great thickness	Continuous cover of sediments deposited by mass movements such as rock avalanches, rock falls, snow avalanches, landslides and mudflows from steep valley sides/fjord sides/slopes. Locally of great thickness.	81
	Mass movement deposit, thin or discontinuous cover	Thin and/or discontinuous cover of sediments deposited by mass movements such as rock avalanches, rock falls, snow avalanches, landslides and mudflows from steep valley sides/fjord sides/slopes.	82

	Slide deposit, continuous cover, locally of great thickness	Unspecified slide deposit, locally of great thickness.	86
	Debris flow deposit	Sediment deposited by a fast moving, liquefied landslide of unconsolidated, saturated debris. Consists of material ranging in size from clay to boulders.	213
	Lag deposit	Sediment consisting of sand, gravel and/or coarser material left behind when smaller particles are washed away by waves or currents. Thickness ranges from a few centimeters to a few decimeters.	204
	Exposed bedrock	Areas without sediment cover.	130
	Thin or discontinuous sedimentary cover on bedrock	Lateral variation of small basins with sediments, exposed bedrock and/or bedrock with thin/discontinuous sediment cover. Sediments in small basins may have varying grain size.	140
	Unspecified marine deposit	Marine deposit of unknown origin.	219

Appendix 3. Sedimentary environment. Classification according to SOSI (Statens kartverk 2006).

Symbol	Sedimentary environment	Code
	Deposition from suspension, mainly mud.	1
	Deposition from suspension, mainly mud. Local erosion of fine-grained sediment.	2
	Deposition from bottom currents, mainly sand.	3
	Erosion, local deposition of silt and sand in depressions.	4
	Erosion	5
	Lag deposit	6

Appendix 4. Landscapes and landforms. Classification according to Erikstad et al. (2009).

Symbol	Landscape	Definition/description	Code
	Strandflat	A relatively flat crystalline bedrock platform, partially submerged. The strandflat consists of hilly plains or platforms with distinct boundaries to mountains/highlands on the landward side, and continental shelf on the seaward side.	1
	Smooth continental slope	Areas of continental slope between canyons and between the continental shelf break and the deep sea plain.	21
	Marine canyon	Deep gorge with steep margins incised into the continental slope.	22
	Marine valley	Trough on the continental shelf, at places cutting into the strandflat, with a relative relief of >200 m and a width of >1 km.	31
	Open fjord	Wide fjord of moderate depth (<200 m) with fjord sides rising <200 m above sealevel. Fjord slopes are relatively gentle (10º to 15º). *See footnote.	32
	Deep-cut fjord	Deep fjord (water depths >200m) with fjord sides rising to more than 200 m above sealevel. Fjord slopes are relatively steep (>15º), in places with cliffs and crags along most of the valley's length. Fjords of this type are usually isolated from the sea by well-defined thresholds. *See footnote.	33
	Deep sea plain	Deep ocean floor below continental slope comprising both abyssal plain and continental rise. Relative relief is typically low (<50 m).	41
	Continental slope plain	Plateau on the continental slope where the seabed has minor relief variations (relative relief <50 m) and usually a thick sediment cover.	42
	Continental shelf plain	Plain on the continental shelf forming a relatively flat (relative relief <50 m) platform between the continental slope and the strandflat/coast.	43
	Shallow marine valley	Trough on the continental shelf, with relative relief of 100-200 m.	431
	Marine hills and mountains	Area of the seabed with relative relief >50 m within a square of 1 km^2, but without well-defined valleys. **See footnote.	51
	Archipelago (islands and straits)	Coastal landscape, both below and above the sea level, which is not part of the strandflat. Relative relief >50 m within a square of 1 km^2. Numerous small islands separated by straits make archipelagos a distinctive landscape type. **See footnote.	52

* Landscape types defined by NiN. In the MAREANO programme, no distinction has been made between open and deep-cut fjords.
**NiN landscape types outside MAREANO-area.