

MINDeSEA

Seabed Mineral Deposits in European Seas:
Metallogeny and Geological Potential for
Strategic and Critical Raw Materials

Critical minerals in the European seas: The project GeoERA-MINDeSEA

Javier González and the MINDeSEA Team
EGU 8 May 2020



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166



MINDeSEA Consortium (12 Partners)

Project Lead



Instituto Geológico
y Minero de España

WP Leads



Instituto Geológico
y Minero de España



Laboratório Nacional de Energia e Geologia

GEOLOGICAL
SURVEY OF
NORWAY

- NGU -



Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

An Boireann Comhairle, Eanáiríocht ar son na Mairbhí agus Comhairle
Department of Communications, Climate Action & Environment

Partners



SGU

Sveriges geologiska undersökning
Geological Survey of Sweden

(Non-Funded)



instituto português do mar e da atmosfera



science for a changing world



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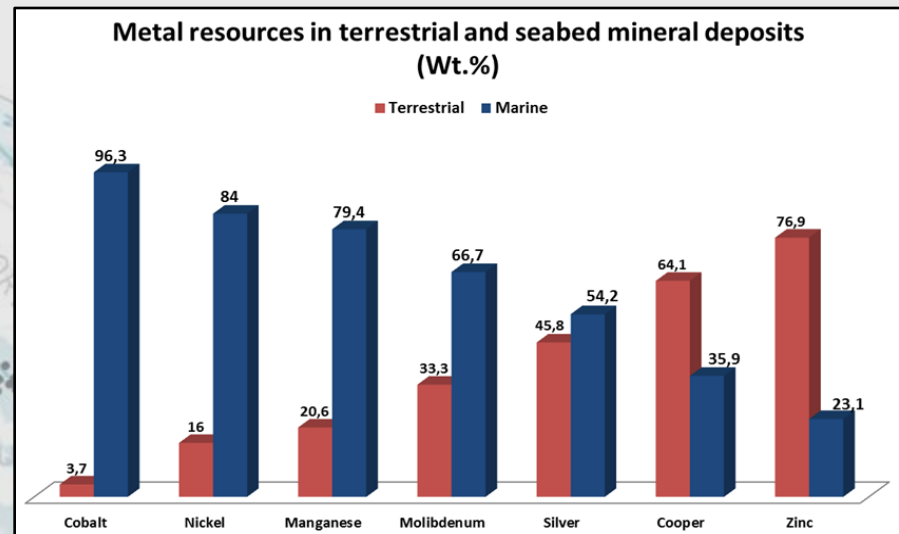
Challenge

Seafloor deposits:

the most important yet least explored resource of CRM

By 2030, 10% of the world's minerals, including cobalt, copper and zinc could come from the ocean floors.

Global annual turnover of marine mineral mining can be expected to grow from virtually nothing to **€10 billion by 2030**.



Source: USGS

2017 CRMs (27)

Antimony	Fluorspar	LREEs	Phosphorus
Baryte	Gallium	Magnesium	Scandium
Beryllium	Germanium	Natural graphite	Silicon metal
Bismuth	Hafnium	Natural rubber	Tantalum
Borate	Helium	Niobium	Tungsten
Cobalt	HREEs	PGMs	Vanadium
Coking coal	Indium	Phosphate rock	

Source: EC



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Workpackages

- **WP1 Project Management and Coordination**
- **WP2 Communication, Dissemination and Exploitation**
- **WP3 Seafloor Massive Sulphide Deposits**
- **WP4 Ferro-manganese crusts, phosphorites and Critical Raw Materials**
- **WP5 Marine placer deposits**
- **WP6 Polymetallic nodules**
- **WP7 Exploration in the Atlantic, Mediterranean, Baltic and Black Sea**
- **WP8 Link to Information Platform**



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MINDeSEA Aim and Objectives

- The **specific aim** of MINDeSEA is to establish the metallogenic context for different seabed mineral deposits with economic potential in the pan-European setting.

Work in progress

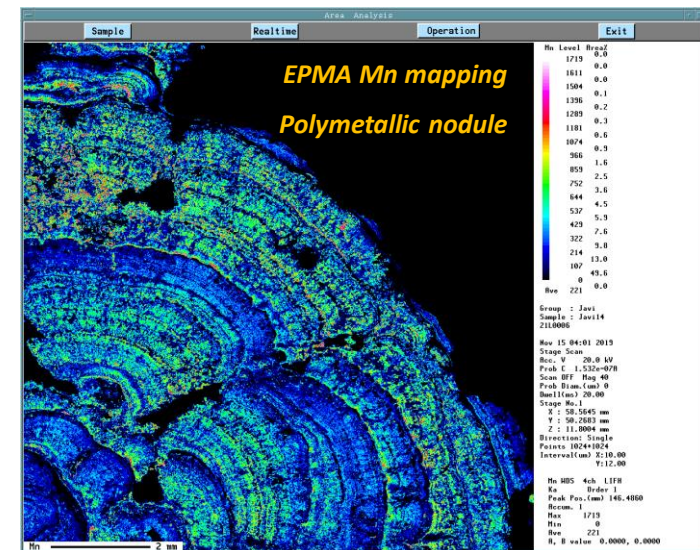
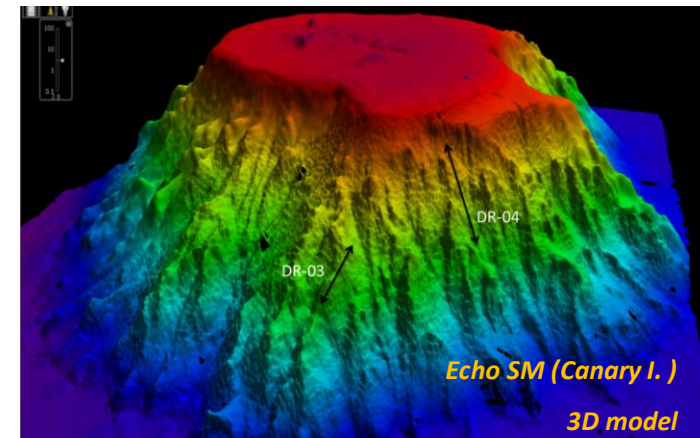
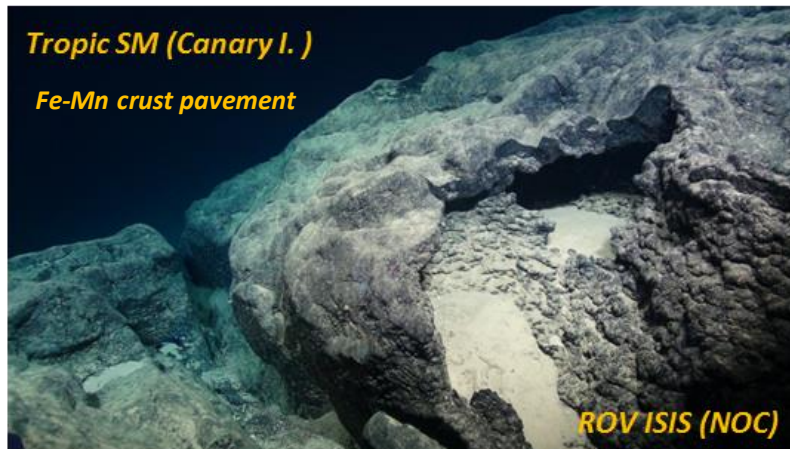


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Characterising the European deposit types and their CRM

- 1- Hydrothermal mineralizations
- 2- Co-rich Ferromanganese Crusts
- 3- Phosphorites
- 4- Polymetallic Nodules
- 5- Marine Placer deposits



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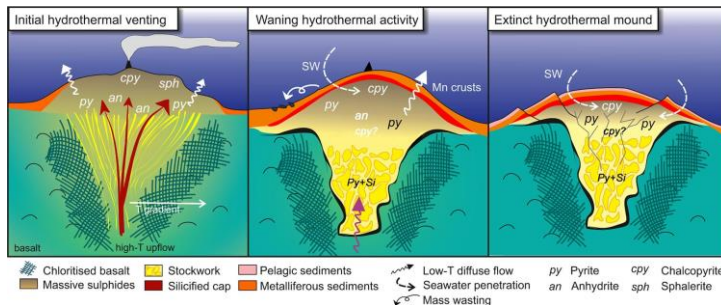
Identifying the principal metallogenic provinces

Mineral assemblages

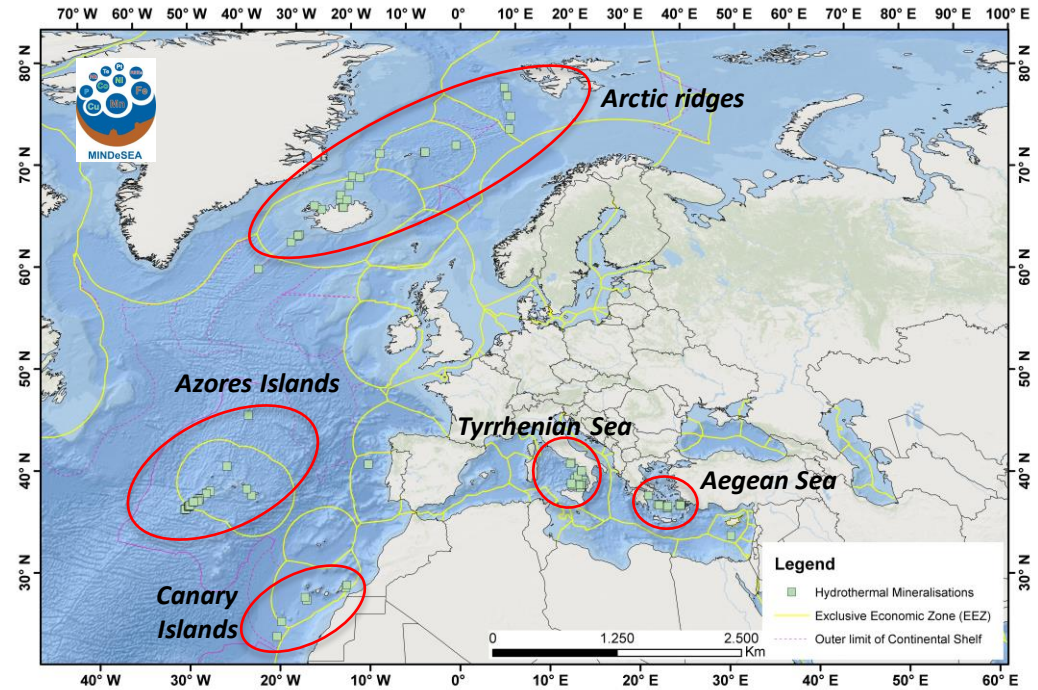
Areas of distribution

Epochs of formation

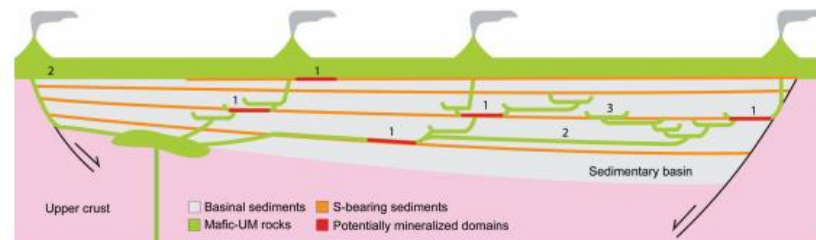
Genetic models



Murton et al., 2019



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Leshner, 2019



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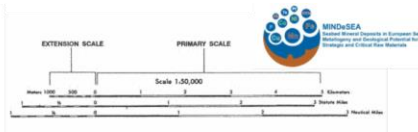
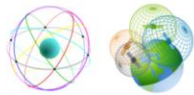
Developing harmonized mineral maps and datasets

Geological Survey Organizations datasets

Mineral potential and prospectivity maps



World Geodetic System (WGS84)



1:250,000 (minimum)
1mm = 250m



Mineral Resources

ISO/TS 19139:2007

Geographic information — Metadata — XML schema implementation

	ATTRIBUTE	FIELDNAME	FORMAT	COMMENT
General Data	OBJECTID	FID	Unique Identifier	Unique Shapefile identifier
	Shape	SHAPE	Geometry	Point
	Longitude	LONGITUDE	Number	reorder as longitude is X, Decimal (5) Degree format
	Latitude	LATITUDE	Number	reorder as latitude is Y, Decimal (5) Degree format
	Country Code	COUNTRY	Text (2)	rename field, ISO 3166 Two Letter Country Code e.g. IE, NO, ES
	Administration	MARITIME_ZONE	Text (24)	Controlled vocabulary
	Geographical Area	SEA_AREA	Text (32)	Controlled vocabulary
	Sector	SECTOR	Text (40)	What is the purpose of this geographical name description?
	Importance	IMPORTANCE	Text (20)	Controlled Vocabulary (Importance)
	Mineral Occurrence Type	MINERAL_OCCURRENCE_TYPE	Text (16)	Controlled Vocabulary (Mineral Occurrence Type)
	Year of discovery	YEAR_DISCOVERY	Date	ISO 8601 four digit year [YYYY]
	Year of Database Entry	CREATION_DATE	Date	ISO 8601 four digit year [YYYY]
	Date of Database Update	UPDATE_DATE	Date	ISO 8601 date format [YYYY-MM-DD]
Metallogeny	Deposit Group	MINERAL_DEPOSIT_GROUP	Text (53)	Controlled Vocabulary (Mineral Deposit Group)
	Deposit Type	MINERAL_DEPOSIT_TYPE	Text (84)	Controlled Vocabulary (Mineral Deposit Type)
	Hydrothermal activity	HYDROTHERMAL_ACTIVITY	Text (8)	Controlled Vocabulary (MINDeSEA)
	Distance from rift or active vent sites	RIFT_DISTANCE	Number	Distance in km
	Age	AGE	Text (250)	Age of the mineral deposit and host rock
	Host rock	HOST_ROCK	Text (250)	Substrate rock or sediment surrounding the ore deposit
	Metallic Commodity	METALLIC_COMMODITY	Text (250)	Controlled Vocabulary (Commodity Code)
	Other metals	OTHER_METALS	Text (250)	
	Commodity Group	COMMODITY_GROUP	Text (250)	Controlled Vocabulary (Commodity Code) duplicate?
	Ore Minerals	ORE_MINERALS	Text (250)	Metal-hosting minerals (see INSPIRE)
	Gangue Minerals	GANGUE_MINERALS	Text (250)	Non-economic minerals (see INSPIRE)
	Ore mineral distribution	ORE_MINERAL_DISTRIBUTION	Text (250)	Controlled Vocabulary (MINDeSEA)
	Alteration	ALTERATION	Text (250)	Alteration minerals formed during/after the process of mineralization
	Structure	STRUCTURE	Text (250)	Controlled Vocabulary (MINDeSEA)
	Morphology	MORPHOLOGY	Text (250)	Controlled Vocabulary (MINDeSEA)
	Texture	TEXTURE	Text (250)	Controlled Vocabulary (MINDeSEA)
	Genetic type	GENETIC_TYPE	Text (250)	
	Geochemistry	GEOCHEMISTRY	Text (250)	Link to Geochemistry table?
Economic Data	Mineral Occurrence Type	MINERAL_OCCURRENCE_TYPE	Text (16)	Controlled Vocabulary (Mineral Occurrence Type)
	Mine Status	MINE_STATUS	Text (28)	Controlled Vocabulary (Mine Status)
	Mining Activity Type	MINING_ACTIVITY_TYPE	Text (36)	Controlled Vocabulary (Mining Activity Type)
	Deposit Size	DEPOSIT_SIZE	Text (40)	Deposit size calculated according to ProMine (small, medium, large)
	Grade	GRADE	Text (40)	
	Resources (total)	RESOURCE	Number	Resources in Mt
	Reserves (total)	RESERVE	Number	Reserve in Mt
	Mined tonnage	MINED_TONNAGE	Number	Tonnage in Mt
	Total tonnage	TOTAL_TONNAGE	Number	Tonnage in Mt
	Remaining tonnage	REMAINING_TONNAGE	Number	Tonnage in Mt
	Resource reporting standard / compliance	STANDARD	Text (58)	Controlled Vocabulary (Minventory)
	Reference for tonnage assessment	REFERENCE	Text (40)	Company ordering the assessment
	Data Scale	SCALE	Text (9)	1:250,000
	Exploration Activity Type	EXPLORATION_ACTIVITY_TYPE	Text (50)	Controlled Vocabulary (Exploration Activity Type)
	Operator	OPERATOR	Text (250)	Research, exploration or operating agency/company
	Cruises	CRUISES	Text (250)	Cruises identification
	Sampling Methods	SAMPLING_METHODS	Text (250)	Sample recovery method controlled vocabulary?
	Data Provider	DATA_PROVIDER	Text (250)	Name of organisation providing the data
Environment	Data Provider Contact	CONTACT_EMAIL	Text (250)	GDPR compliance contact email
	Deposit extent (km2)	DEPOSIT_EXTENT	Number (Double) (11,4)	Area of deposit
	Depth to Deposit (m)	DEPTH_TO_DEPOSIT	Number (Double) (11,4)	Depth to deposit from sea surface
Other Data	Fauna	FAUNA	Text (100)	Controlled vocabulary?
	Description	DESCRIPTION	Text (500)	
	Gallery	GALLERY	Image	Images of the mineralization (geophysical, sampling, textural features, paragenesis, etc)
	References	REFERENCES	Text (250)	Link to bibliographic references (DOI and/or Author, Year & Title if you wish)
	Comments	COMMENTS	Text (250)	Any additional comments or observations



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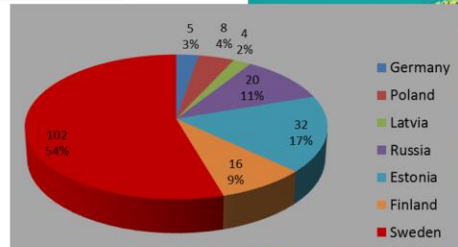


Demonstrating the efficiency of the case study results

Offshore minerals exploration

Critical metals assessment

Baltic Sea



5 DE EEZ

8 PO EEZ

4 LV EEZ

20 RU EEZ

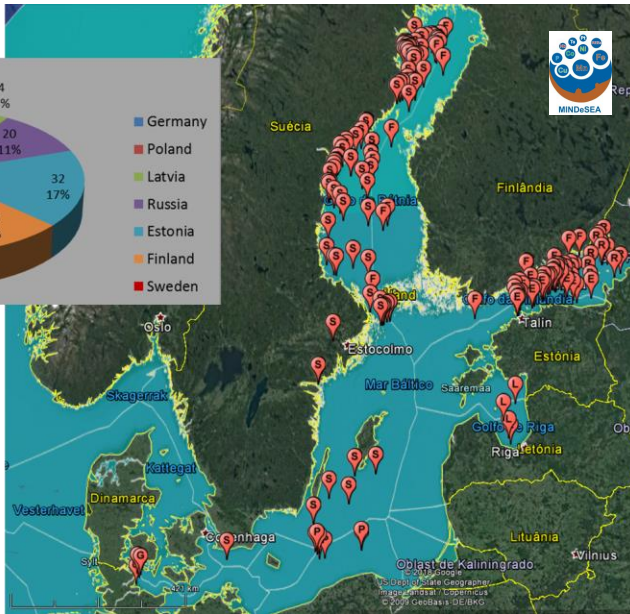
32 EE EEZ

4 FI EEZ

12 FI TS

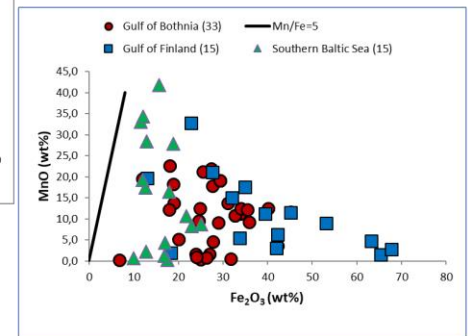
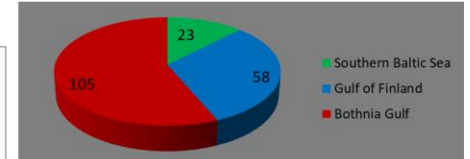
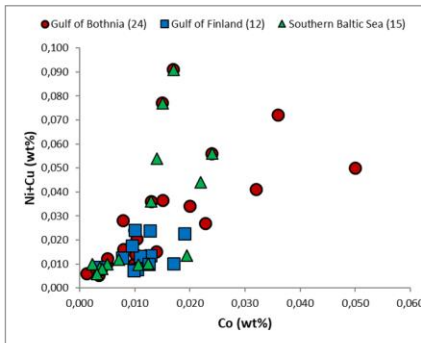
81 SE EEZ

21 SE TS

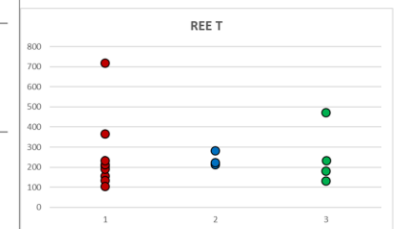
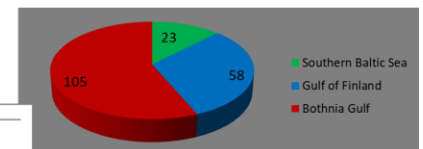
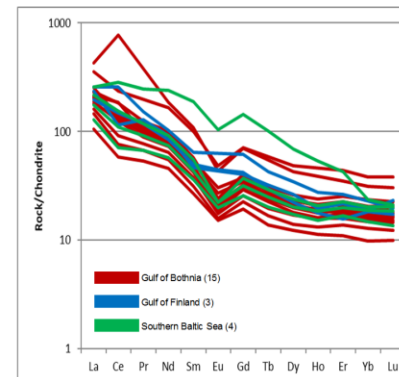


Polymetallic nodule
Baltic Sea

Baltic Sea (all 3 sub-regions)



Baltic Sea (all 3 sub-regions)



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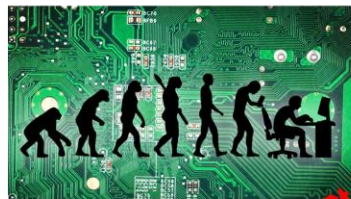
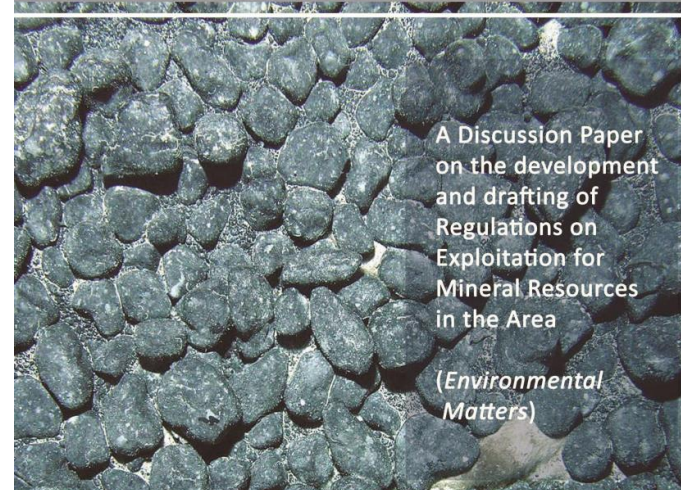
Analysing present-day exploration and exploitation status

Regulation, legislation, environmental impacts, exploitation and future directions



United Nations Convention on the Law of the Sea of 10 December 1982
Overview and full text

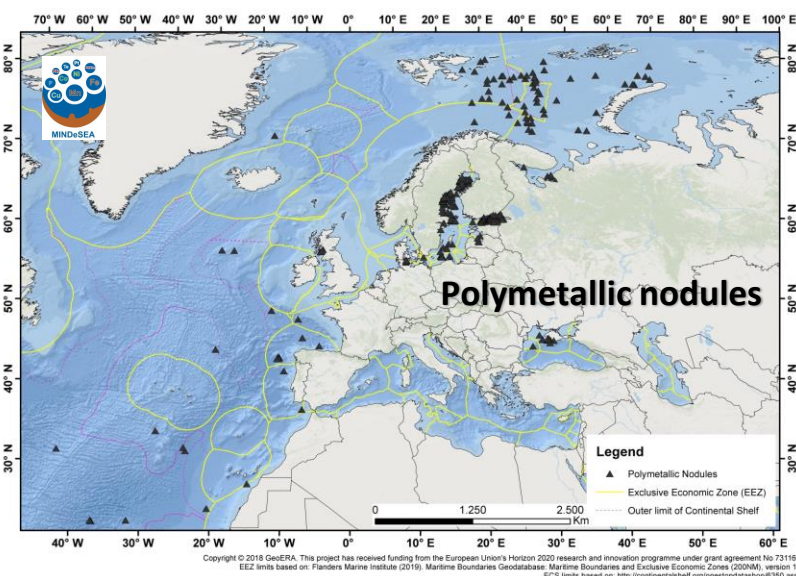
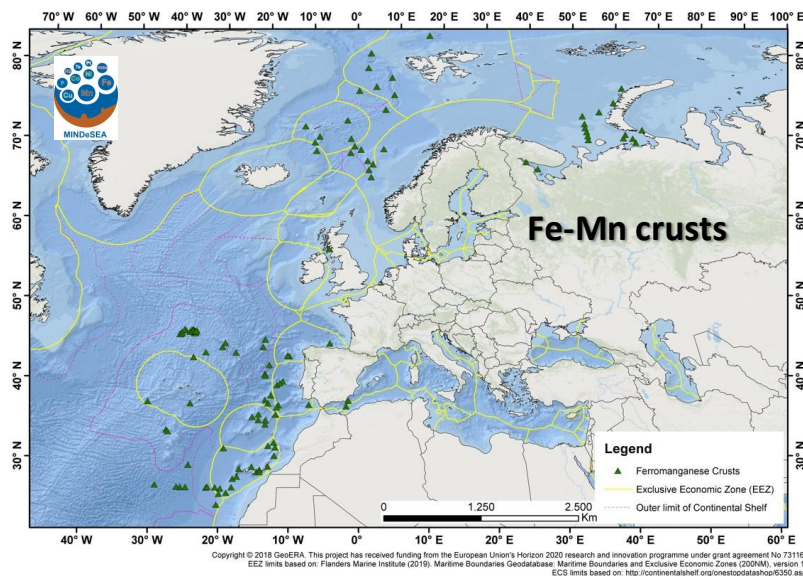
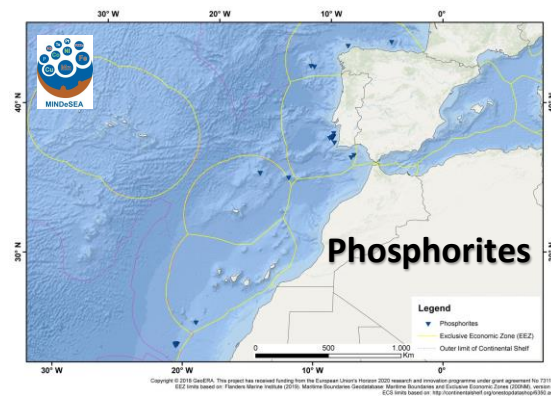
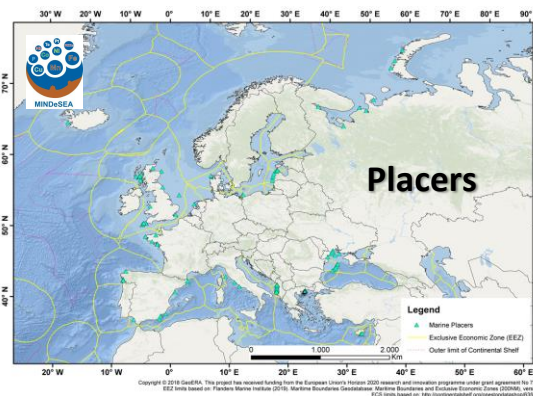
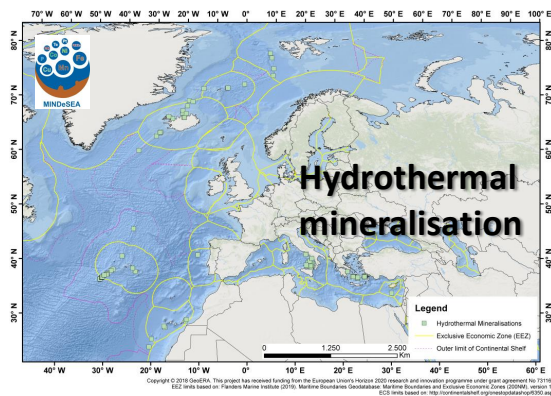
Developing a Regulatory Framework for Mineral Exploitation in the Area



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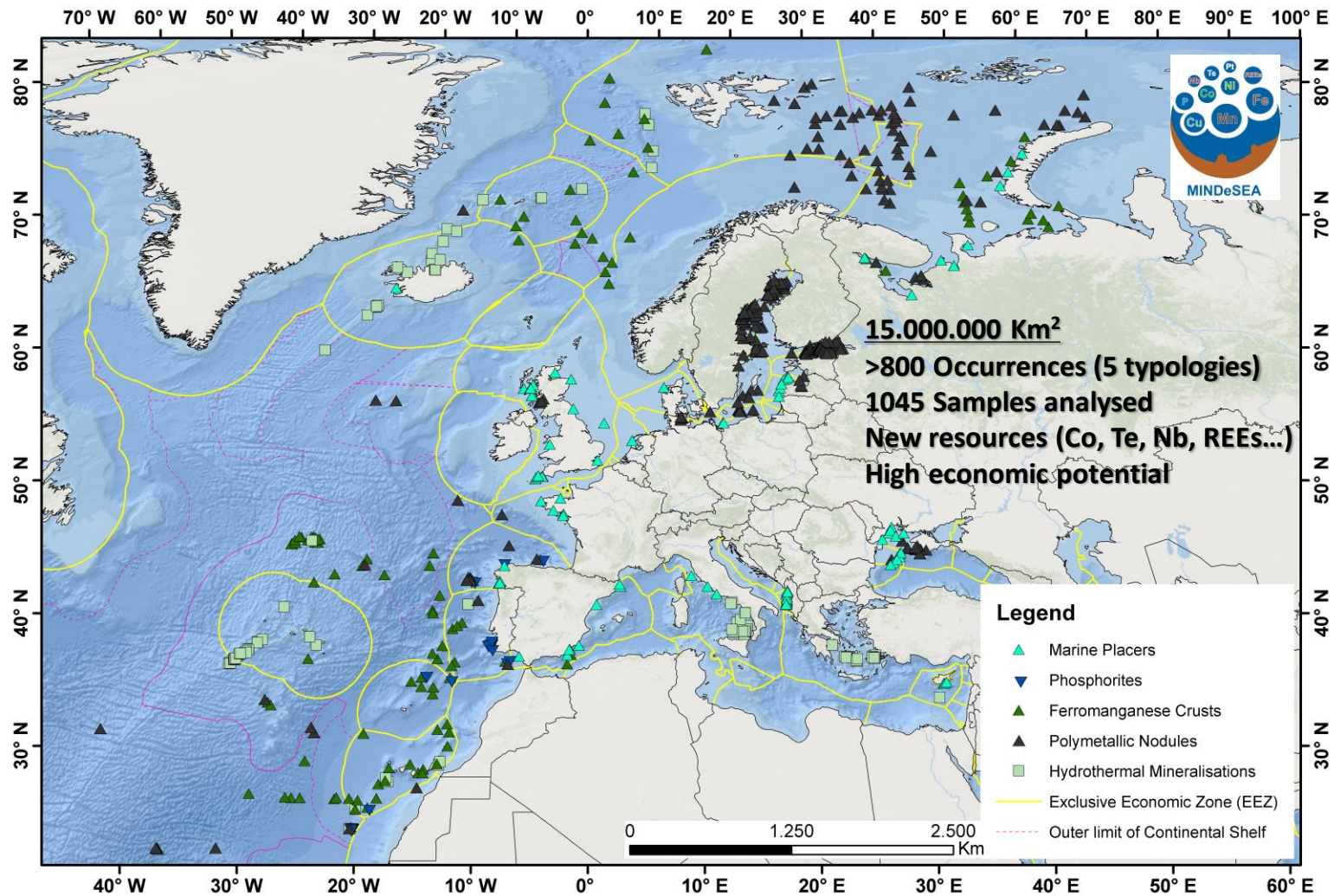
MINDeSEA Preliminary Results

Cartography and Databases



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pan-European research approach for seabed mineral deposits



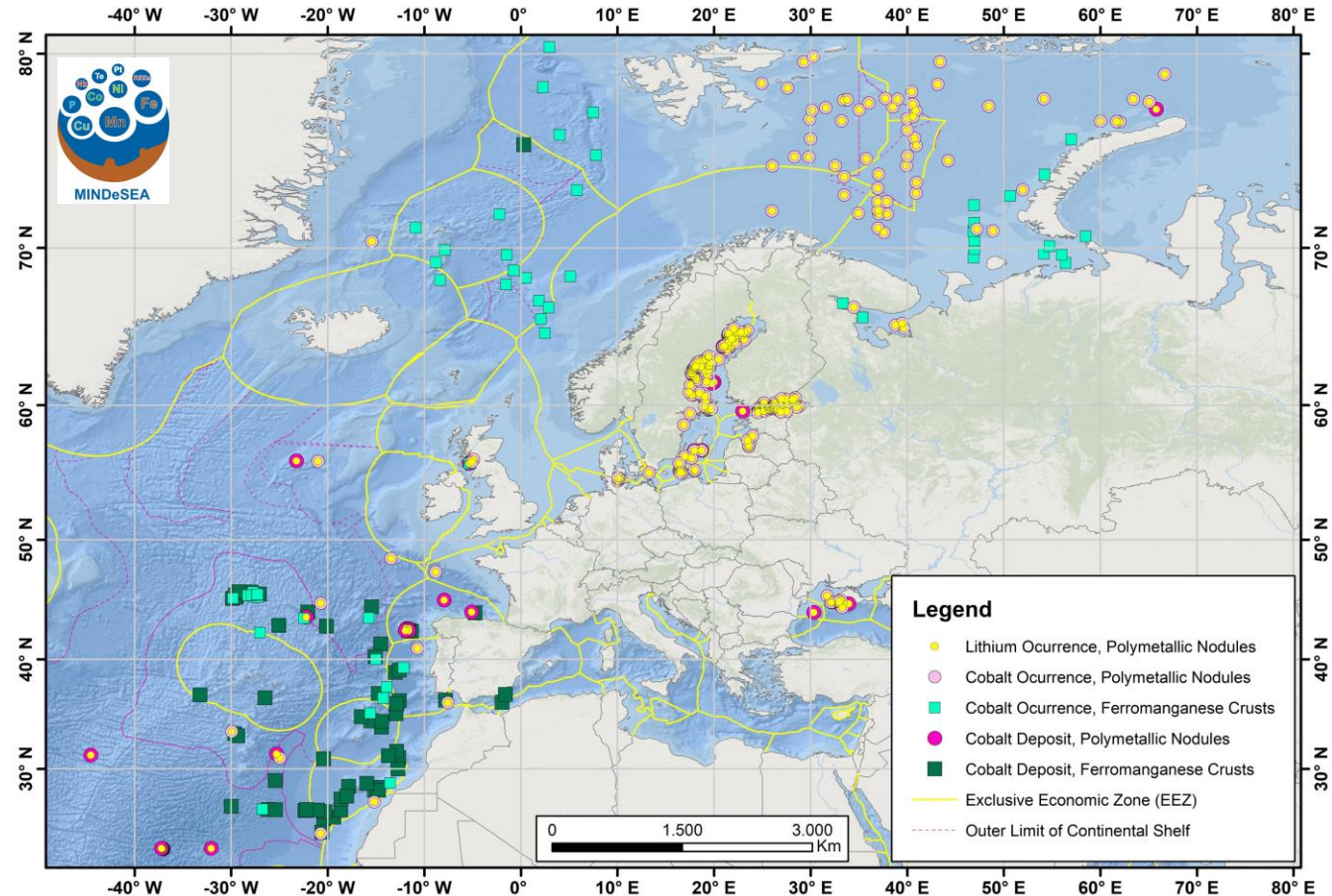
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MINDeSEA Preliminary Results

Pan-European map of Energy-critical elements Co and Li



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ECS limits based on: <http://continentalshelf.org/onestopdatashop/6350.aspx>



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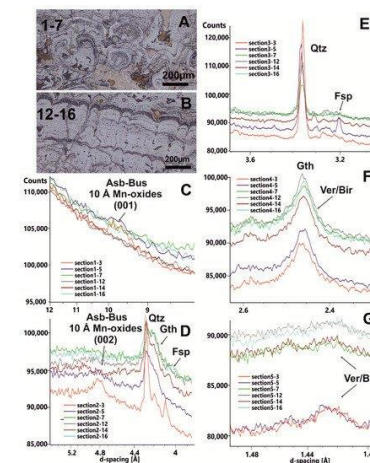
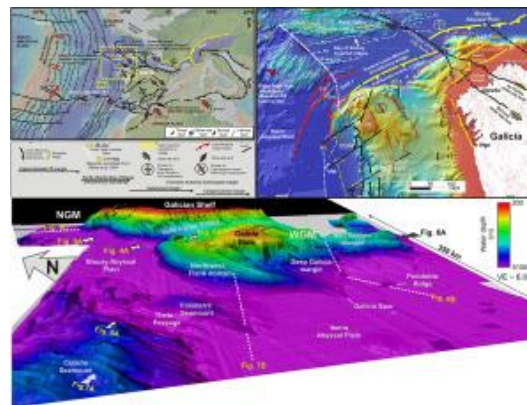
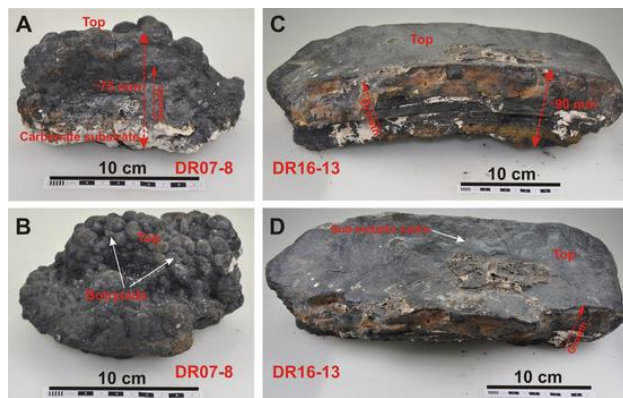
MINDeSEA Preliminary Results-Publications

Exploration and cutting edge technical development for critical raw materials investigation in European seas

Marino, E., González, F.J., Kuhn, T., Madureira, P., Wegorzewski, A.V., Mirao, J., Medialdea, T., Oeser, M., Miguel, C., Reyes, J., Somoza, L., Lunar, R. 2019. Hydrogenetic, Diagenetic and Hydrothermal Processes Forming Ferromanganese Crusts in the Canary Island Seamounts and Their Influence in the Metal Recovery Rate with Hydrometallurgical Methods. *Minerals*, 9(7), 439. <https://doi.org/10.3390/min9070439>

Somoza, L., Medialdea, T., González, F.J., León, R., Palomino, D., Rengel, J., Fernández-Salas, L.M., Vázquez, J. T. 2019. Morphostructure of the Galicia continental margin and adjacent deep ocean floor: From hyperextended rifted to convergent margin styles. *Marine Geology* 407, 299-315. <https://doi.org/10.1016/j.margeo.2018.11.011>

Marino, E., González, F.J., Lunar, R., Reyes, J., Medialdea, T., Castillo-Carrión, M., Bellido, E., Somoza, L. 2018. High-Resolution Analysis of Critical Minerals and Elements in Fe–Mn Crusts from the Canary Island Seamount Province (Atlantic Ocean). *Minerals*, 8(7), 285. <https://doi.org/10.3390/min8070285>



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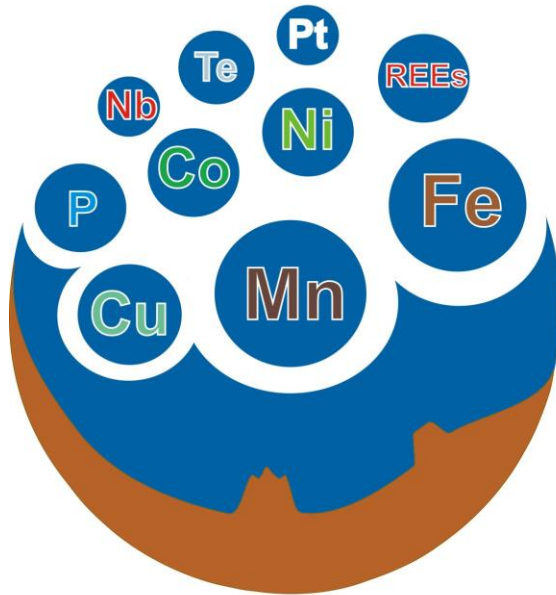
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Thank you!



MINDeSEA

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Metallogeny and Geological Potential for
Strategic and Critical Raw Materials

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