

## APPLICATION FOR CONSENT TO CONDUCT MARINE SCIENTIFIC RESEARCH

### 1. General Information

1.1 Cruise name and/or number:	F2023-096-IMPULSE
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1.2 Sponsoring institution(s):		
Name	Address	Name Of Director
LDEO /Columbia University	LDEO/Columbia University 61 Rt. 9W Palisades, NY 10964	Sean Higgins

1.3 Scientist in charge of the project:	
Name:	Mark Landow
Country:	United States
Affiliation:	LDEO/Columbia University
Address:	United States
Telephone:	914-275-3918
Email:	captain@ldeo.columbia.edu

1.4 Entity(ies) /Participant(s) from coastal State involved in the planning of the project:	
Name:	See Section 6.2
Country:	
Affiliation:	
Address:	
Telephone:	
Fax:	
Email:	
Website (for CV and photo):	

1.5 Submitting officer:	
Name:	Sean Higgins
Affiliation:	Lamont-Doherty Earth Observatory of Columbia University , Office of Marine Operations
Address:	61 Rt. 9W Admin Bldg. Rm.102-104 Palisades, New York 10964 US
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### 2. Description of Project

2.1 Nature and objectives of the project:
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The project is called "IMPULSE: Taking the Pulse of the Icelandic Mantle Plume". It will be delivered between 2024 and 2027 by an international consortium of UK, US and Icelandic scientists, supported by the UK Natural Environment Research Council and US National Science Foundation.

IMPULSE will make the first definitive test of the Thermal Plume Pulsing (TPP) model, which has been suggested as a primary driver of some of the most remarkable perturbations to global climate, ecosystems and the carbon cycle in Earth's history.

In the TPP model, patches of hotter mantle rise up a mantle plume conduit and travel radially outward within the plume head beneath the lithosphere. To verify TPP, IMPULSE will measure thermal fluctuations within the head of the Icelandic Mantle Plume, Earth's most vigorous mantle convection cell. IMPULSE will then collaborate with international partners to test the hypothesis that thermal pulsing of the Icelandic Mantle Plume is a viable mechanism to explain the Paleocene-Eocene Thermal Maximum global climate change event.

The North Atlantic V-Shaped Ridges (VSRs) are the basis for the TPP model. However, the TPP model is not universally accepted for the Icelandic and other major mantle plumes because of the lack of critical data from the VSRs. Proving TPP requires co-located measurements of both the thickness and the composition of oceanic crust. A high-quality geochemical survey of the active VSRs is available in our study area, from previous dredging along the spreading axis and IODP Expedition 395 drilling off axis. Yet no full crustal wide-angle seismic survey of a complete VSR cycle has ever been made.

IMPULSE has four scientific objectives (O1–4).

O1. Acquire the first full crustal seismic profiles across multiple complete VSR cycles. The data acquisition objectives for the IMPULSE cruise on R/V Charles Langseth are:

(i) an ocean bottom seismometer (OBS) + multi-channel seismic (MCS) profile along a plate spreading flowline coincident with IODP Expedition 395 boreholes (P-Fe).

(ii) an OBS + MCS profile along the plate spreading flowline conjugate to P-Fe (P-Fw).

(iii) an OBS + MCS profile along the Reykjanes Ridge spreading axis coincident with an existing set of dredged mid-ocean ridge basalt samples (P-A).

O2. Generate the first true record of magma productivity fluctuations that built the VSRs by correcting crustal thickness for the effect of tectonic "noise" from crustal accretion processes.

O3. Model co-located records of magma productivity and composition to verify the TPP model.

O4. In collaboration with international partners, test the relationship between transient mantle convection and global environmental change during the Pliocene onset of the Northern Hemisphere Glaciation and the Paleocene/Eocene Thermal Maximum events.

## 2.2 Relevant previous or future research projects:

### PAST RESEARCH FUNDING

2006–2013. Investigation of Reykjanes Ridge Evolution Near Iceland. NSF OCE-0452132. \*Hey R (SOEST Hawaii), PI; \*Höskuldsson Á (SOEST Hawaii), \*Martinez F (SOEST Hawaii), Co-Is. Supported RV Knorr KNO/07/24 cruise to Reykjanes Ridge in 2007.

2008. Detailed Bathymetric Mapping and Seabed Sampling of North Atlantic V-Shaped Ridge VSR-2W: Constraints on Temporal Variation in Mantle Convection. Celtic Explorer cruise CE0806. Irish National Ship Time Programme 2008. \*Jones SM (Trinity College Dublin), PI and chief scientist; Fitton JG (Edinburgh), Murton BJ (Southampton), \*White N (Cambridge), partners. Seabed Sampling Site Survey for IODP Expedition 395.

2008. Site Survey for IODP Proposal 646-Full: Icelandic V-Shaped Ridges. NERC NE/G001251/1. Murton BJ, PI. Supported mobilization of cruise CE0806 led by \*Jones SM

2009–2012. IODP Site Survey of V-Shaped Ridge Features, North Atlantic Ocean. NE/G007632/1. \*White NJ (Cambridge), PI; \*Henstock TJ & Murton BJ (Southampton), Co-I; \*Jones SM (Trinity College Dublin), Partner. Seismic Site Survey RRS James Cook JC50 for IODP Expedition 395.

2010–2011. Measuring the pulse of the Iceland Plume. NERC Small Grant NE/H011986/1. Fitton JG. Supported geochemical analysis of basalt samples from cruise CE0806 led by \*Jones SM.

2021–2023. International Ocean Discovery Program Expedition 395 "Reykjanes Mantle Convection and Climate", drilled June–August 2021 and July–August 2023. \*Parnell Turner RE (Scripps), co-chief scientist; \*White N (Cambridge), onboard science party member.

2023. Quantitative Analysis of Neogene Sedimentary Fluxes and Plume Temperatures from Basalt Geochemistry (IODP Leg 395). NERC NE/Y002377/1. \*White NJ (Cambridge), PI.

### CURRENT RESEARCH FUNDING

2021–2024. PORO-CLIM: Deep Structure of Porcupine and Rockall Margins: Did the North Atlantic Igneous Province alone cause the Paleocene/Eocene Thermal Maximum? Funded jointly by EuroFleets+/EU Horizon 2020 EFP\_SEA01-022, PIPCO-RSG IS19/06, and . \*Jones SM (Birmingham, PI), O'Reilly B (Dublin Institute of Advanced Studies, Co-I), Hopper JR (Geological Survey of Denmark and Greenland, Co-I). Formally partnering IMPULSE.

2022–2023. Geochemical Analysis and Integrated Modelling of Basalt Samples from V-Shaped Ridges of North Atlantic Ocean. NE/W007150/1. \*White NJ, PI. Supported participation in IODP Expedition 395.

2022–2027. C-FORCE: Carbon cycle Feedbacks from Response to Carbon Emissions. Joint NERC-NSF Large Grant NE/W009625/1. Greene (Birmingham), \*Jones (Birmingham), co-PIs; Foster (NOCS), Kirtland Turner (UC Riverside), Meredith (Nottingham), Ridgwell (UC Riverside), Schofield (Aberdeen), Snape (Nottingham), Zachos (UC Santa Cruz), Co-Is. Formally partnering IMPULSE.

2024–2027. IMPULSE: Taking the Pulse of the Icelandic Mantle plume. NERC NE/V012878/1. \*Jones SM (Birmingham), PI; \*Henstock TJ (Southampton), \*White (Cambridge), Co-Is; \*Höskuldsson Á (Iceland), \*Hey R (SOEST Hawaii), \*Martinez F (SOEST Hawaii), \*Parnell Turner RE (Scripps), Partners. Supports IMPULSE cruise on RV Langseth via UK/US barter agreement, and subsequent data work-up.

### FUTURE RESEARCH APPLICATIONS

ARCTIC-PULSE: V-Shaped Ridges in the Icelandic Sea: Implications for mantle plume pulsing and oceanic circulation. For submission 2025.

## 2.3 Previous publications relating to the project:

#### Previously Published Research

Geophysical and tectonic studies of North Atlantic ridge-plume interaction and V-Shaped Ridge formation: Martinez et al. (2020), Parnell Turner et al. (2017), Hey et al. (2015), Parnell Turner et al. (2014), Parnell Turner et al. (2013), Benediktsdóttir et al. (2012), Hey et al. (2010), Poore et al. (2009), Jones (2003), Jones et al. (2002).  
Geochemical studies of North Atlantic ridge-plume interaction and V-Shaped Ridge formation: Jones et al. (2014), Walters et al. (2013), Poore et al. (2011), Shorttle et al. (2010).  
Links between V-Shaped Ridges / thermal plume pulsing, ocean circulation, climate change, and sedimentation patterns: Parnell Turner et al. (2020), Jones et al. (2019), Parnell Turner et al. (2015), Robinson et al. (2011), Poore et al. (2006), White & Lovell (1997).

IMPULSE Project Co-Investigators and Partners marked with asterisks below.

Benediktsdóttir Á, \*Hey R, \*Martinez F, \*Höskuldsson Á. Detailed tectonic evolution of the Reykjanes Ridge during the past 15 Ma. *G3 Geochemistry Geophysics Geosystems* 3 (2012) Q02008, doi:10.1029/2011GC003948.  
\*Hey R, \*Martinez F, \*Höskuldsson Á, Benediktsdóttir Á. Propagating rift model for the V-shaped ridges south of Iceland. *G3 Geochemistry Geophysics Geosystems* 11 (2010) 10.1029/2009GC002865.  
\*Hey R, \*Martinez F, \*Höskuldsson Á, Eason DE, Sleeper J, Thordarson S, Benediktsdóttir Á, Merkurjev S. Multibeam investigation of the active North Atlantic plate boundary reorganization tip. *Earth and Planetary Science Letters* 435 (2016) 115–123, 10.1016/j.epsl.2015.12.019.  
\*Jones SM, \*White NJ, Maclennan JC. V-shaped ridges around Iceland: implications for spatial and temporal patterns of mantle convection. *G3 Geochemistry Geophysics Geosystems* 3 (2002) 101029/2002GC000361.  
\*Jones SM. Test of a ridge-plume interaction model using oceanic crustal structure around Iceland. *Earth and Planetary Science Letters* 208 (2003) 205–218.  
\*Jones SM, Hoggett M, Greene S, Dunkley Jones T. Large Igneous Province thermogenic greenhouse gas flux could have initiated Paleocene-Eocene Thermal Maximum climate change. *Nature Communications* 10, 5547 (2019) <https://doi.org/10.1038/s41467-019-12957-1>.  
\*Jones SM, Murton BJ, Fitton JG, \*White NJ, Maclennan J, Walters RL. A joint geochemical-geophysical record of time-dependent mantle convection south of Iceland. *Earth and Planetary Science Letters* 386 (2014) 86–97, 10.1016/j.epsl.2013.09.029.  
\*Martinez F, \*Hey R, \*Höskuldsson Á. Reykjanes Ridge evolution: Effects of plate kinematics, small-scale upper mantle convection and a regional mantle gradient. *Earth Science Reviews* 206 (2020) 10.1016/j.earscirev.2019.102956.  
\*Parnell-Turner R, Briais A., LeVay L. Expedition 395 Scientific Prospectus: Reykjanes Mantle Convection and Climate. *International Ocean Discovery Program* (2020) 10.14379/iodp.sp.395.2020.  
\*Parnell-Turner RE, \*White NJ, Maclennan J, \*Henstock TJ, Murton BJ, \*Jones SM. Crustal Manifestations of a Hot Transient Pulse Beneath the Mid-Atlantic Ridge. *Earth and Planetary Science Letters* 363 (2013) 109–120, 10.1016/j.epsl.2012.12.030.  
\*Parnell-Turner RE, \*White NJ, \*Henstock TJ, Murton BJ, Maclennan J, \*Jones SM. A continuous 55 million year record of transient mantle plume activity beneath Iceland. *Nature Geoscience* 7 (2014) 914–919, 10.1038/NGEO2281.  
\*Parnell-Turner RE, \*White NJ, \*Henstock TJ, Murton BJ, Maclennan J, \*Jones SM. Architecture of North Atlantic contourite drifts modified by transient circulation of the Icelandic mantle plume. *G3 Geochemistry, Geophysics, Geosystems* 16 (2015) 3414–3435, 10.1002/2015GC005947.  
\*Parnell-Turner RE, \*White NJ, \*Henstock TJ, \*Jones SM, Maclennan J, Murton BJ. Causes and Consequences of Diachronous V-Shaped Ridges in the North Atlantic Ocean. *Journal of Geophysical Research* 122 (2017) 8675–8708 10.1002/2017JB014225.  
Poore HR, R Samworth, \*White NJ, \*Jones SM, McCave IN. Neogene Overflow of Northern Component Water at the Greenland-Scotland Ridge. *G3 Geochemistry, Geophysics, Geosystems* 7 (2006) Q06010, 1029/ 2005GC001085.  
Poore HR, \*White N, \*Jones SM. A Neogene chronology of Iceland plume activity from V-shaped ridges. *Earth and Planetary Science Letters* 283 (2009) 1–13.  
Poore H, \*White N, Maclennan J. Ocean circulation and mantle melting controlled by radial flow of hot pulses in the Iceland plume. *Nature Geoscience* 4 (2011) 558–561, 10.1038/NGEO1161.  
Robinson MM, Valdes PJ, Haywood AM, Dowsett HJ, Hill DJ, \*Jones SM. Bathymetric controls on Pliocene North Atlantic and Arctic sea surface temperature and deepwater production. *Palaeogeography, Palaeoclimatology, Palaeoecology* 309 (2011) 92–97, 10.1016/j.palaeo.2011.01.004.  
Shorttle O, Maclennan J, \*Jones SM. Spreading ridge geometry controls the symmetry of plume-ridge interaction. *G3 Geochemistry Geophysics Geosystems* 11 (2010) 10.1029/2009GC002986.  
Walters RL, \*Jones SM, Maclennan J. Renewed melting at the abandoned Húnaflói Rift, northern Iceland, caused by plume pulsing. *Earth and Planetary Science Letters* 377–378 (2013) 227–238, 10.1016/j.epsl.2013.06.040.  
\*White N, Lovell B. Measuring the pulse of a plume with the sedimentary record. *Nature* 387 (1997) 888-891.

### 3. Geographical Areas

3.1 Indicate geographical areas in which the project is to be conducted (with reference in latitude and longitude, including coordinates of cruise track/ way points):

Track line for seismic and ocean bottom seismograph deployment lie along two main lines. One profile lies along axis of Reykjanes Ridge from ~56N 34W to 63N25W and another profile that runs perpendicular to the first from 60N33W to 60N25W. There are two smaller connector lines that lie slightly to E and N of 60N25W. See attached cruise track map for layout.

3.2 Attach chart(s) at an appropriate scale (1 page, high-resolution) showing the geographical areas of the intended work and, as far as practicable, the location and depth of sampling stations, the tracks of survey lines, and the locations of installations and equipment.

Chart provided - see Section 10.1.

### 4. Methods and Means to be Used

4.1 Particulars of Vessel:

Name:	MARCUS G. LANGSETH
Type/Class:	Ship : R/V
Nationality (Flag state):	United States
Identification Number/Lloyds #/MMSI #:	6203283
Owner:	Columbia University
Operator:	Mark Landow/Lamont-Doherty Earth Observatory
Overall length:	72.00 m
Maximum draught:	6.00 m
Displacement/Gross tonnage:	3,834.0
Propulsion:	2 x Bergen BRG-6 2650kw /3550 hp (each); 1 x Tunnel 590 kw/ 800 hp bow thruster
Cruising:	10.00 km/h
Maximum speed:	11.00 km/h
Call sign:	WDC6698
INMARSAT number and method and capability of communication (including emergency frequencies):	INMARSAT 150-0231
Name of master:	Capt Mark Landow of Lamont-Doherty Earth Observatory (LDEO)
Number of crew:	20
Number of scientists on board:	25

4.2 Other craft in the project, including its use:

No

4.3 Particulars of methods and scientific instruments:

Types of samples and measurements	Methods to be used	Instruments to be used
1) Multi-Channel Seismic (MCS) reflection data. 2) Ocean Bottom Seismometer (OBS) refraction data. 3) Expendable BathyThermograph (XBT)	1) For MCS data -Acquired along 2 primary transects (P-F, PA) using streamer and airgun array both towed at 12 m depth. See attached cruise track map. 2) For OBS data -Acquired along 3 transects (P-Fe, P-Fw, PA), each acquired by deploying OBS on seabed, shooting at 60s interval, and then retrieving OBS from seafloor. 3) For XBTs: For sound velocity profiles in water column to constrain multi beam profiling data	1) For collecting MCS data: Towed 15 km long hydrophone streamer and 6600 cu in airgun array as standard on Langseth 2) For collecting OBS data: 50 OBS instruments supplied by UK national Ocean Bottom Instrument Facility; 3) For XBTs: : XBT-5 and XBT-7 probes supplied by Lockheed Martin Sippican, and BTP-7 probes supplied by Swale Technologies

4.4 Indicate nature and quantity of substances to be released into the marine environment:

No

4.5 Indicate whether drilling will be carried out. If yes, please specify:

No

4.6 Indicate whether explosives will be used. If yes, please specify type and trade name, chemical content, depth of trade class and stowage, size, depth of detonation, frequency of detonation, and position in latitude and longitude:

No

4.7 Indicate whether protected species be studied. If yes, please specify:

No

## 5. Installations and Equipment

5.1 Details of installations and equipment (including dates of laying, servicing, method and anticipated timeframe for recovery, locations and depth, and measurements):

No

## 6. Dates

6.1 Estimated overall project start and end dates:

Project Start Date: 7/25/2024
Project End Date: 9/5/2024

6.2 Coastal State-specific details:	
<b>Coastal Area</b>	Iceland
Estimated Entry Date:	7/25/2024
Estimated Departure Date:	9/5/2024
Estimated Research Start Date:	7/25/2024
Estimated Research End Date:	9/5/2024
Explanation of multiple entries:	N/A
Research will be performed:	Between 12-200 nm, Beyond 200 nm
Extent to which Iceland will be enabled to participate or to be represented in the research project:	TBD
Name, affiliation and contact information for all participants from Iceland:	N/A

#### 7. Port Calls

7.1 List of Port Calls				
Port	Arrival Date	End Date	Special Logistical Requirements	Shipping Agent
Reykjavik	7/25/2024	7/27/2024	N/A	N/A
Reykjavik	9/3/2024	9/5/2024	N/A	N/A

#### 8. Participation of the representative of the coastal State

8.1 Modalities of the participation of the representative of the coastal State in the research project:
See Section 6.2
8.2 Proposed dates and ports for embarkation/disembarkation:
See Section 6.2

#### 9. Access to Data, Samples and Research Results

9.1 Expected dates of submission to coastal State of preliminary report, which should include the expected dates of submission of the data and research results:
No more than 3 months from the end date of the research as provided in Section 6.1.
9.2 Anticipated dates of submission to the coastal State of the final report:
No more than 2 years from the end date of the research as provided in Section 6.1.
9.3 Proposed means for access by coastal State to data (including format) and samples:
Data will be provided through official channels at no cost to the coastal State(s). Samples will be provided upon request.
9.4 Proposed means to provide coastal State with assessment of data, samples and research results:
Assessment of data, samples and research results will be provided at no cost to the coastal State(s).
9.5 Proposed means to provide assistance in assessment or interpretation of data, samples and research results:
Assistance in further assessment or interpretation will be provided upon request.
9.6 Proposed means of making results internationally available:

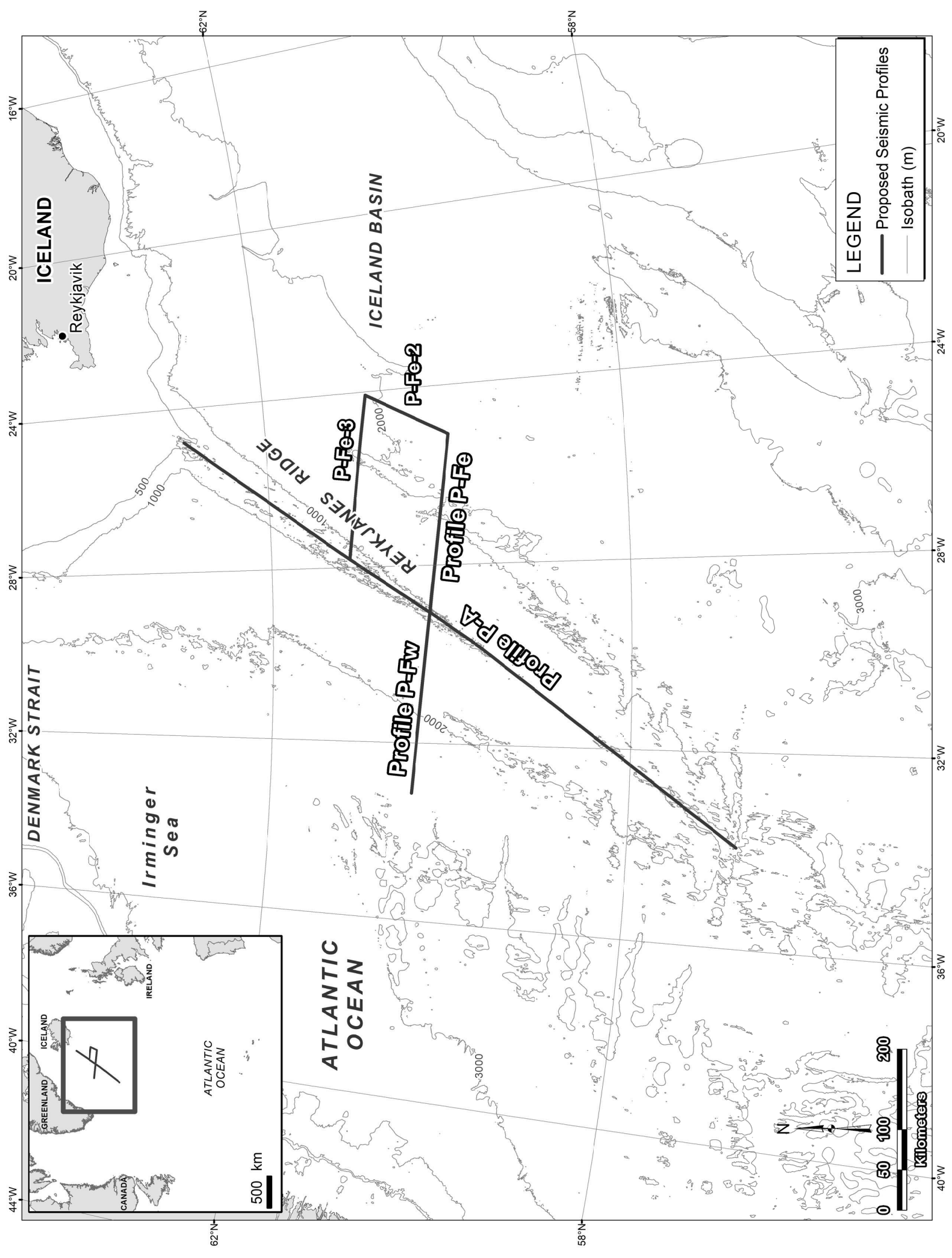
The relevant data centers in the US and the UK National Geophysical Data Centre. To avoid duplication of large-volume datasets, the seismic dataset itself will be provided to one data center, and at the same time a meta-dataset pointing to the seismic dataset will be provided to the other data centre. Underway data from ship's systems, and raw MCS, OBS and XBT data will be supplied to the data centers within 1 month from the end of the cruise. Processed MCS, OBS and XBT data will be provided to the data centers within 6 months of the end of the cruise. Underway data will be made open access upon deposit. The MCS, OBS and XBT dataset will be embargoed to 2 years before being made open access, to allow the funded investigators to complete the IMPULSE project.

Scientific results, including interpretations derived from the MCS, OBS and XBT data, will be published in peer-reviewed journals. All results and publications from the IMPULSE project will be made gold open access, following UK NERC requirements.

10. List of Supporting Documentation

10.1 List of attachments, such as additional forms required by the coastal State, etc.:			
Attachment Type	Description	Attachment	Submission Date
Proposed Cruise Track	Iceland -Draft Cruise Track Map	FA0280_IODP_Iceland_Overview_Simple.png	12/20/2023 10:43 AM

Executed: 12/21/2023 10:55:04 PM (Coordinated Universal Time)



**LEGEND**

- Proposed Seismic Profiles
- Isobath (m)

DENMARK STRAIT

Irminger Sea

ATLANTIC OCEAN

ICELAND BASIN

ICELAND

Reykjavik

REYKJANES RIDGE

Profile P-Fw

Profile P-A

Profile P-Fe

P-Fe-3

P-Fe-2

500 km

GREENLAND

ICELAND

IRELAND

ATLANTIC OCEAN

CANADA

N

0 50 100 200

Kilometers