Dedicated Diffraction Imaging for Sub-Seafloor Object Detection

Viola Bihler

Dr. S. Wenau, Dr. B. Preu, N. Römer-Stange, Dr. H. Keil, Dr. V Spiess, C. A. Ramos Cordova

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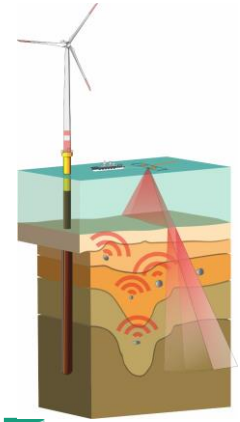

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Our solutions are designed to enhance the quality of life – by supporting the further expansion of wind energy and creating far-reaching synergies through systematic research into the interaction between wind energy and hydrogen generation, reverse power generation and grid integration.

We seize the opportunity.

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Fraunhofer Gesellschaft

No. 1 for applied research in Europe

29.000
employees in total

75
institutes and research facilities

65%
revenue gained from direct industry assignments and acquired third-party funds

32 m €
operating budget / year

2.8 bn €
research volume / year

83 m €
investment in test infrastructure

300
employees

50
publicly funded research projects since 2018

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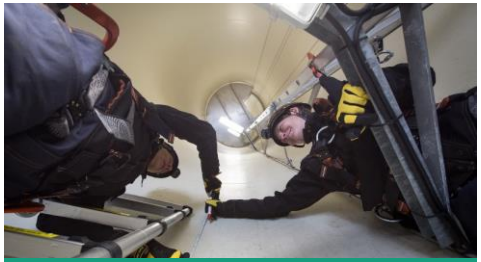
Research and Service Spectrum of IWES

Supporting the Wind Energy Sector in all aspects

Site Assessment and CFD

Nacelle Testing and System Reliability



Field Tests

Qualification of Composite Materials and Parts

Testing of Drive Components and Large Bearings

Certification of Electrical Characteristics

Hydrogen System Performance and Reliability

Validation of Support Structures

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Fraunhofer IWES - Sub-Surface Investigation

Say Hello!

Link: SSI website

Visit us at our stand (booth 7)

Rouven Brune	Viola Bihler
Geophysicist	Geophysicist
Scientific associate	Scientific associate
Integrated Site Characterization	Unconventional geophysical imaging
UHR 2D/3D Seismics	Object Detection

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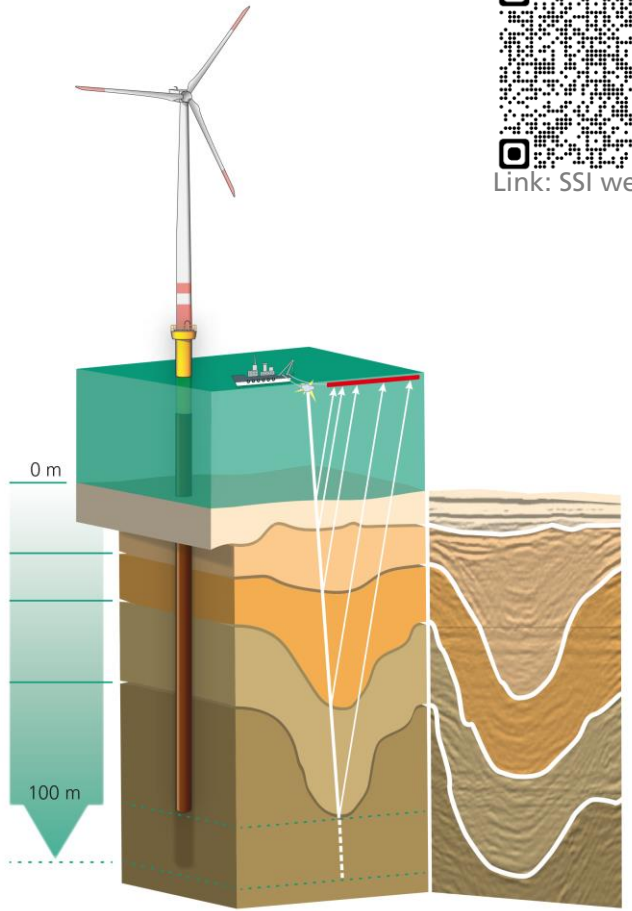
Sub-Surface Investigation (SSI)

Main activities

- Offshore geophysical site characterization
- Integration of geophysical and geotechnical data in geological models
- Sub-seafloor object detection

Link: SSI website



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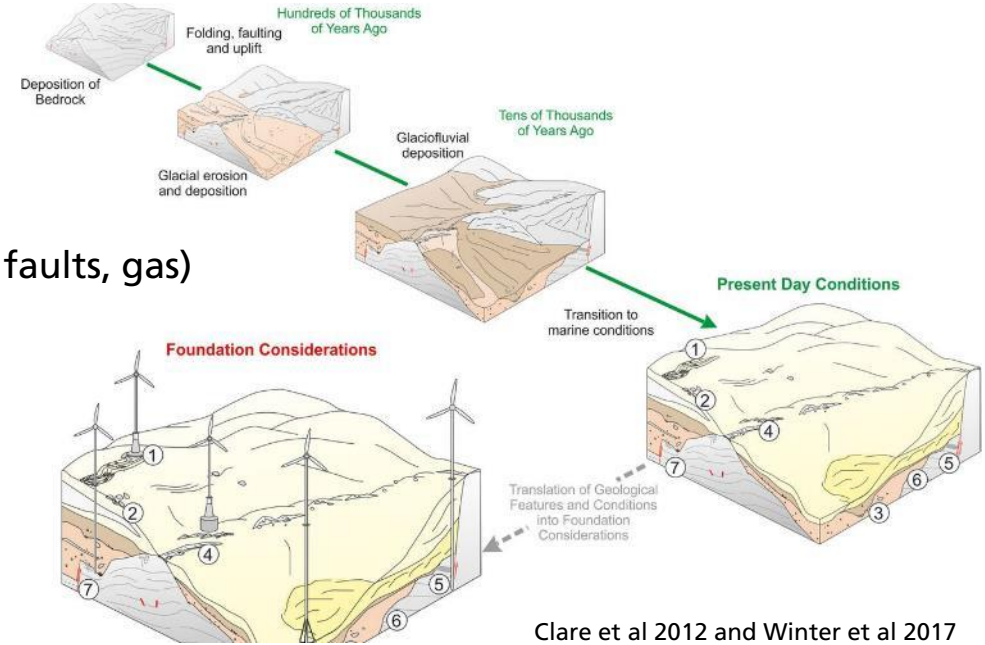
Offshore Site Characterization

Integrated soil model

- **Geophysical site characterization**
  - Subbottom profiler
  - Single-/Multichannel Seismics
  - Geological model
  - Geological hazard identification (boulders, faults, gas)
  - Anthropogenic (UxO, Cables)
- **Geotechnical site characterization**
  - Cone Penetration Tests (CPT)
  - Bore holes
  - Soil model

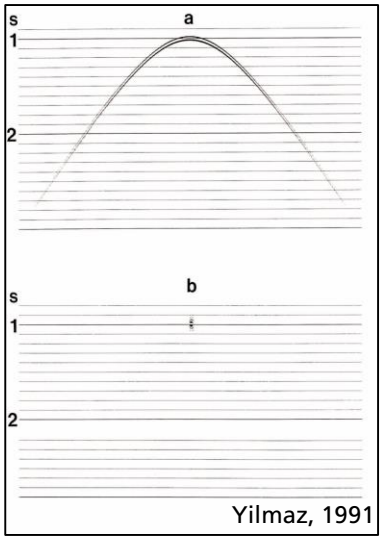


Clare et al 2012 and Winter et al 2017

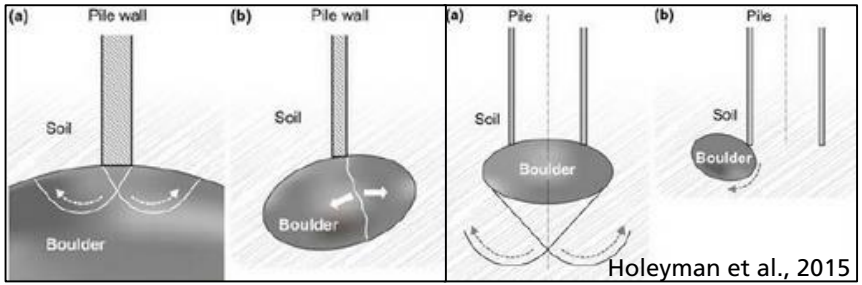
Object Detection in Seismic Data

- **Conventional reflection seismic data**
  - Optimized for structural/stratigraphic imaging
  - Diffraction energy treated as noise

- **Sub-seafloor objects**
  - Hazards for infrastructure installation
    - Boulders
    - UxO
  - Cables
    - Power export
    - Communication



Yilmaz, 1991



Holeyman et al., 2015

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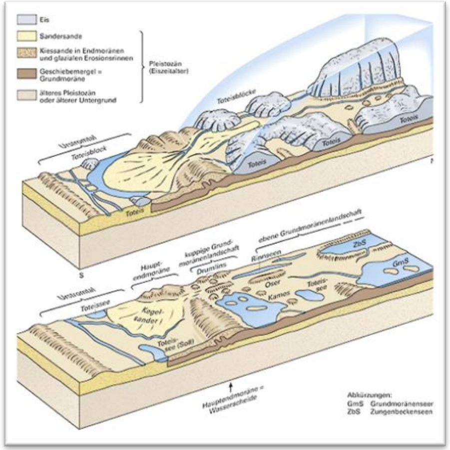
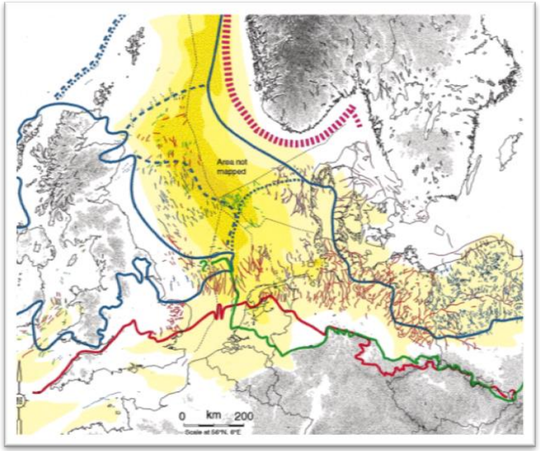
Boulder Occurrence

- Variable sizes < 1 m – 10 m
- Glaciated margins
  - Till units, outwash plains, moraines
- Random distribution & difficult to include in ground models



Koppe, 2003


Huuse and Lykke-Andersen, 2000

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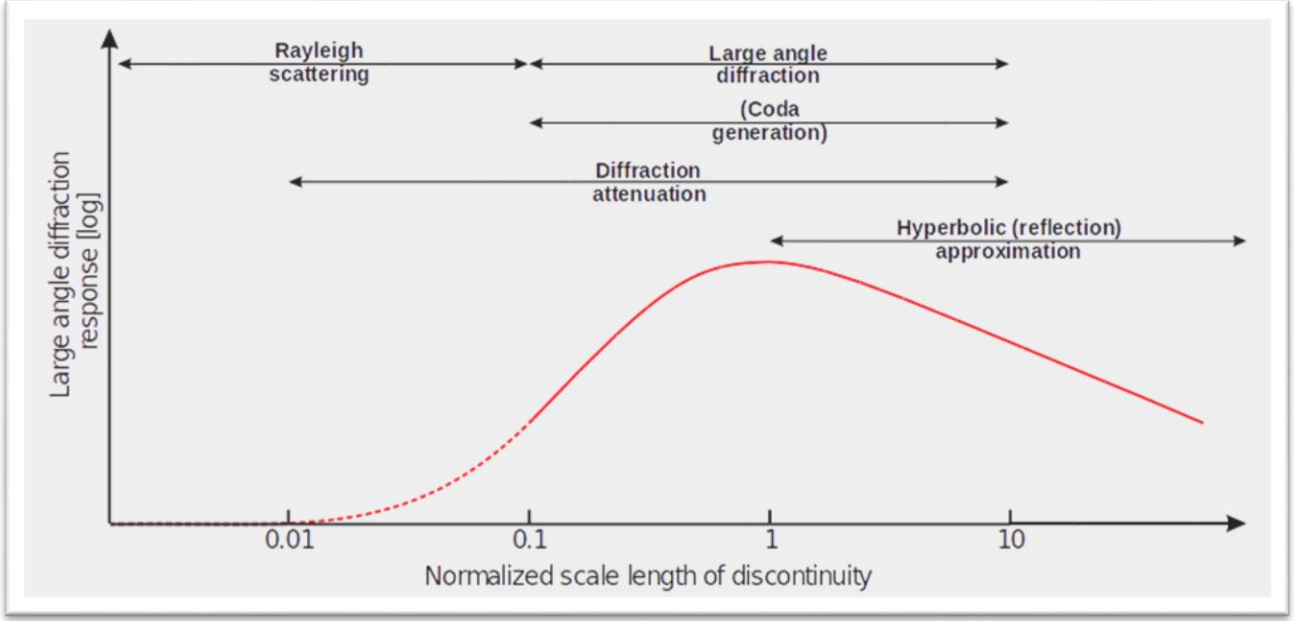
Diffraction responses

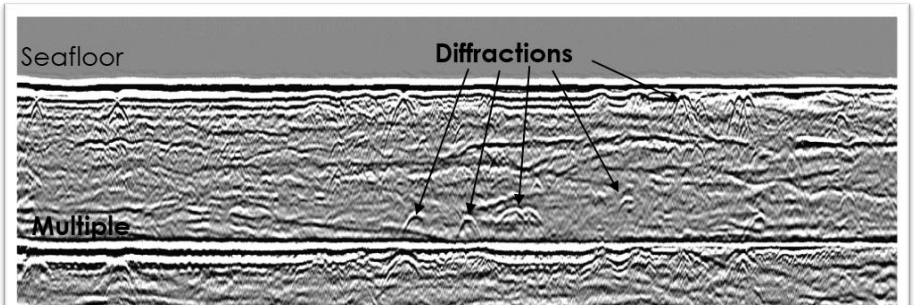
- Strong diffractions if signal wavelength ~ object size
- Balance diffraction resolution and signal penetration



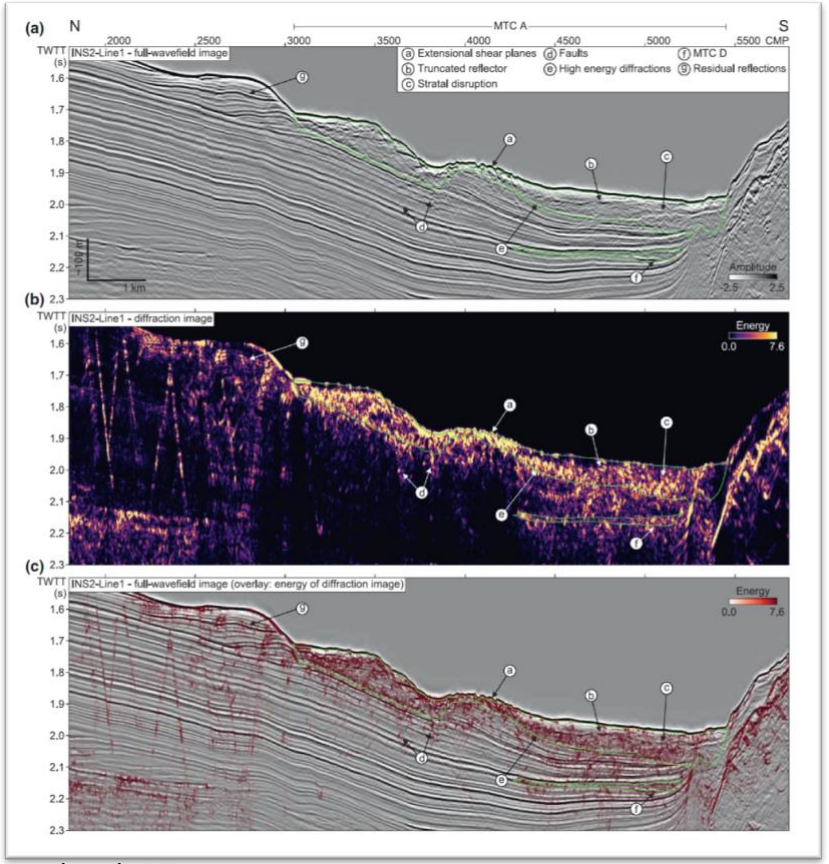
Modified from Wu and Aki (1985, 1988)

Diffraction Imaging

- Diffractions are treated as signal, not as noise as in conventional reflection seismics
- Localization ambiguities in 2D
- Recent advances in diffraction imaging
- Geo-Hazard object identification, cable detection, UXO detection
- Non-magnetic objects can be detected



North Sea stacked seismic section



Ford et al., 2021

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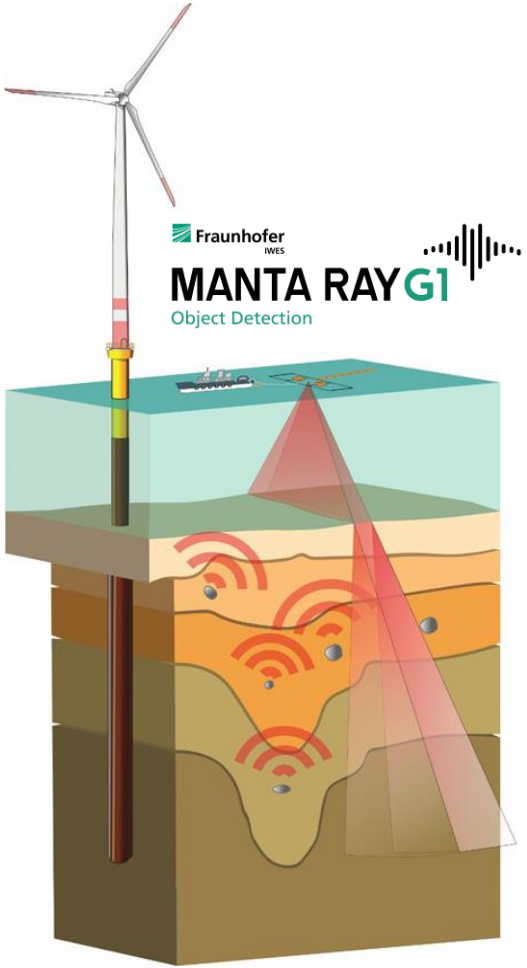
Diffraction Imaging

Manta Ray G1 Object Detection

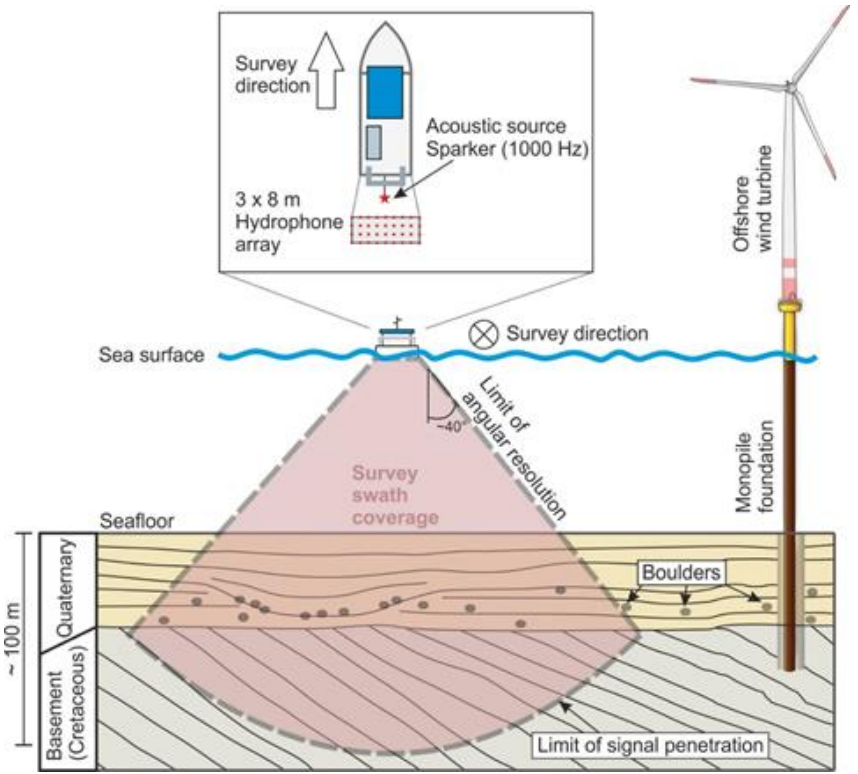
- Tailored data acquisition and processing for sub-seafloor diffraction imaging
  - Diffraction response from small objects sizes > 0.5 m to ~100 mbsf
  - Objects act as secondary sources
- Wave field recording at sufficient resolution & appropriate processing allows diffractor localization
- Fit-for-purpose risk assessment for WTG foundation planning
- Secondary high-resolution 2D/3D site survey data



Diffraction Imaging

Manta Ray G1 Object Detection

- Seismic source
  - Appropriate bandwidth for expected target sizes
  - Sufficient signal penetration
- Hydrophone tow-array
  - Ensure sufficient resolution
    - Array aperture & synthetic aperture
  - Swath imaging
    - Beamforming
- Time-efficient surveying
  - Swath-surveying
  - Combination with other methods

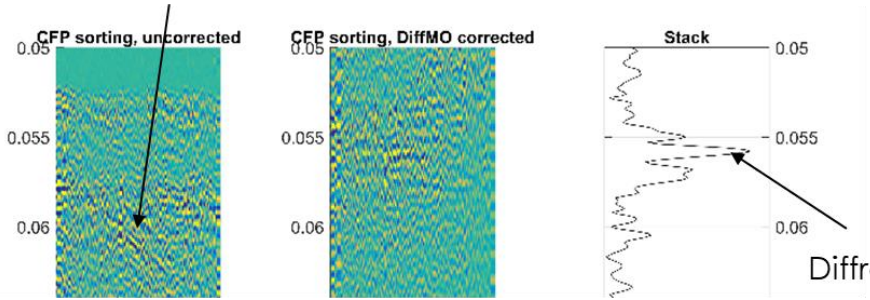


Diffraction Data Processing

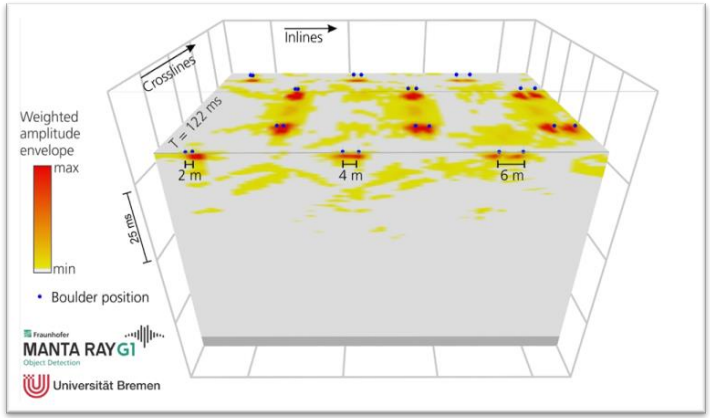
Manta Ray G1 Object Detection

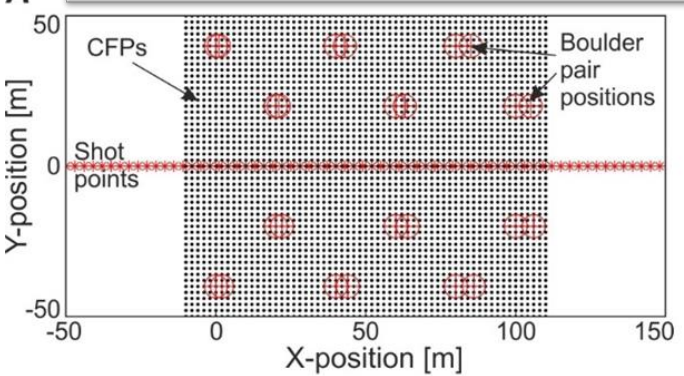
- Reflection-Diffraction separation
- Data processing at pre-defined grid points
- Summation of diffracted energy within grid cells
- 3D diffraction energy volume result

Diffraction hyperbola



Diffraction energy maximum

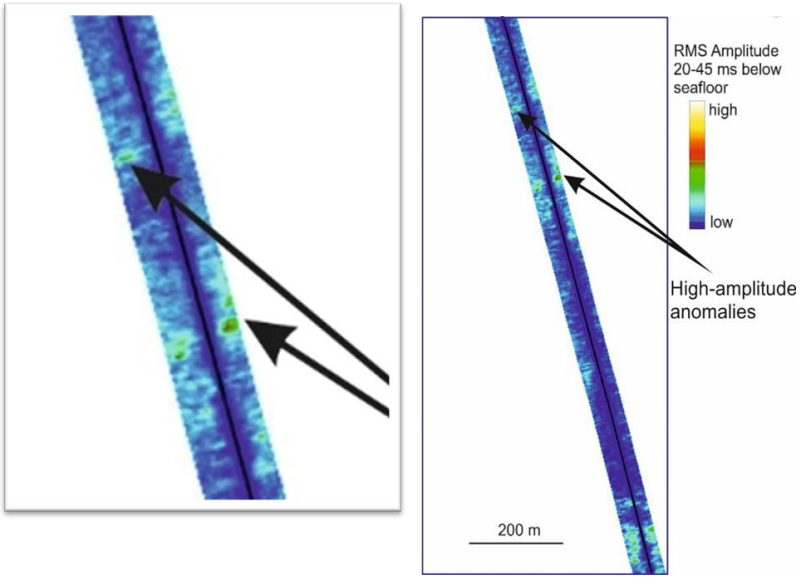




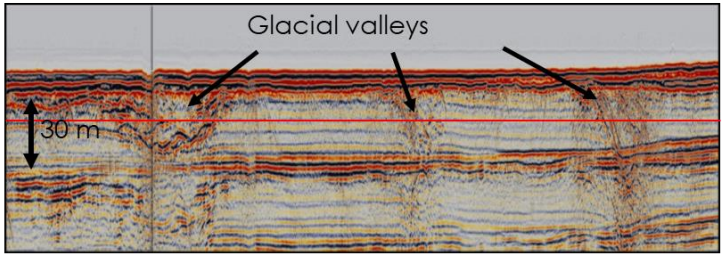
Diffraction Data Results

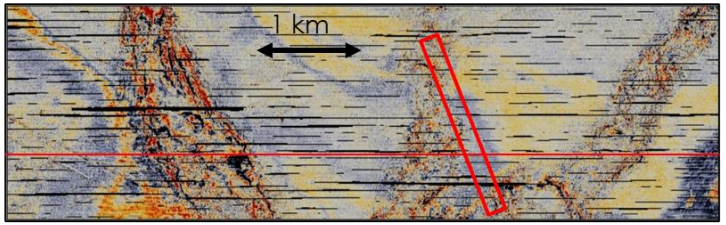
Manta Ray G1 Object Detection

- Baltic Sea trials
- Single-swath diffraction imaging shows maxima in glacial valleys

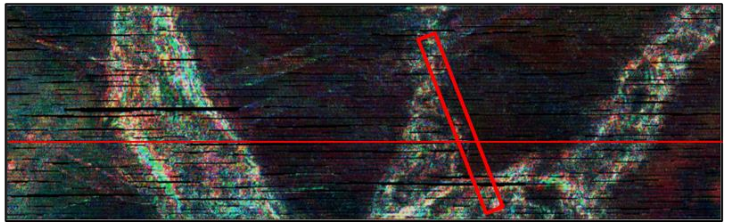


Stacked section





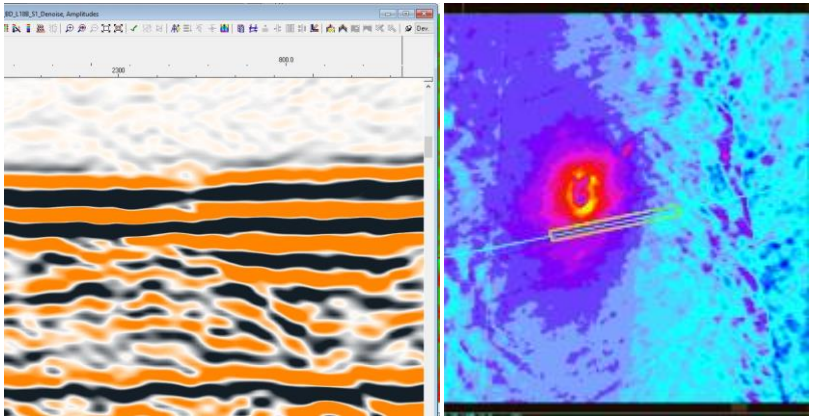
Spectral decomposition

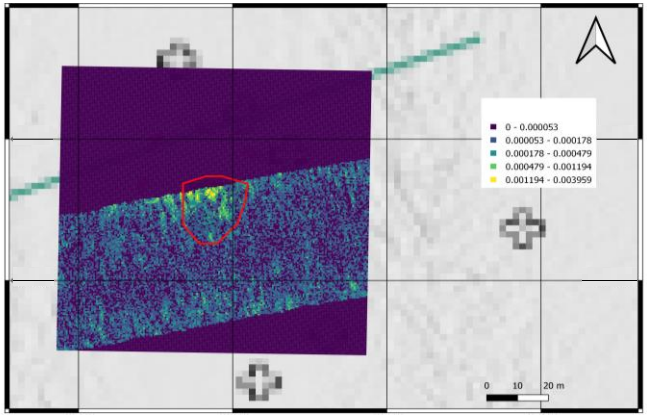


Diffraction Data Validation

Manta Ray G1 Object Detection

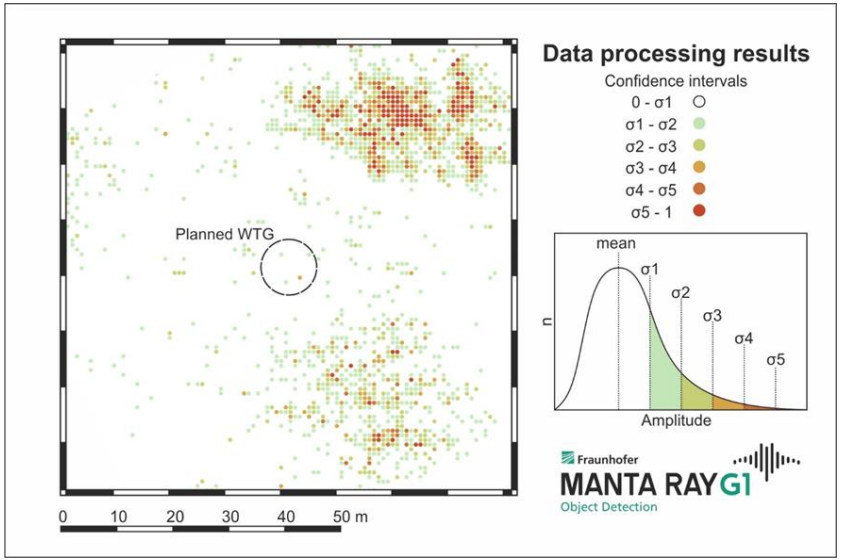
- MBES seafloor targets imaged using seismic beamforming
- Efficient reflection suppression
- Off-Track target identification



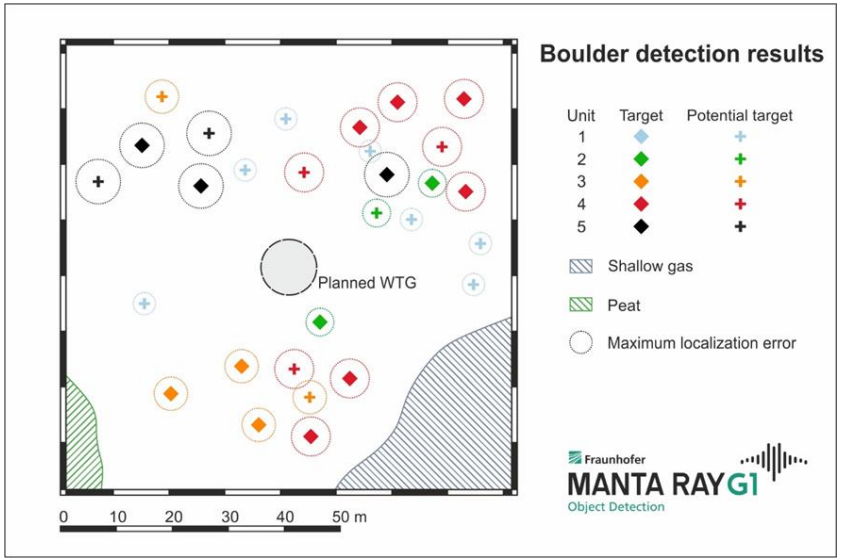


Diffraction Data Interpretation

Manta Ray G1 Object Detection



- Statistical evaluation of diffraction amplitudes for anomaly recognition



- Integrated target interpretation with local geology for foundation micro-siting

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Thank you for the attention!

Unconventional seismics

- Diffraction imaging
- Object detection
- Soil monitoring (4D)
- Technology development
- MantaRay System

Site characterization

- UHR seismic (2D/3D)
- Survey Planning
- Tailored MCS processing solution
- Geological model building
- Proprietary software solution

Geotechnic & Rock physics

- Geotechnical data integration
- Synthetic CPT
- Deriving Geophysical properties from seismic inversion

Contact

SSI Contact

Viola Bihler
Geophysicist
Unconventional geophysical imaging
Department for sub-surface investigation
viola.bihler@iwes.fraunhofer.de

Gino Frielinghaus
gino.frielinghaus@iwes.fraunhofer.de

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MANTA RAY G1
Object Detection

Facing future challenges together

We cooperate with the best players from industry and research in order to tackle challenges concerted and focused.

This approach allows us to handle research projects of any complexity. And to improve our methodological competence further in a systematic manner.