Required Marine Geological, Geophysical and Geotechnical Surveys for Offshore Wind Farm Development in Taiwan

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Outlines

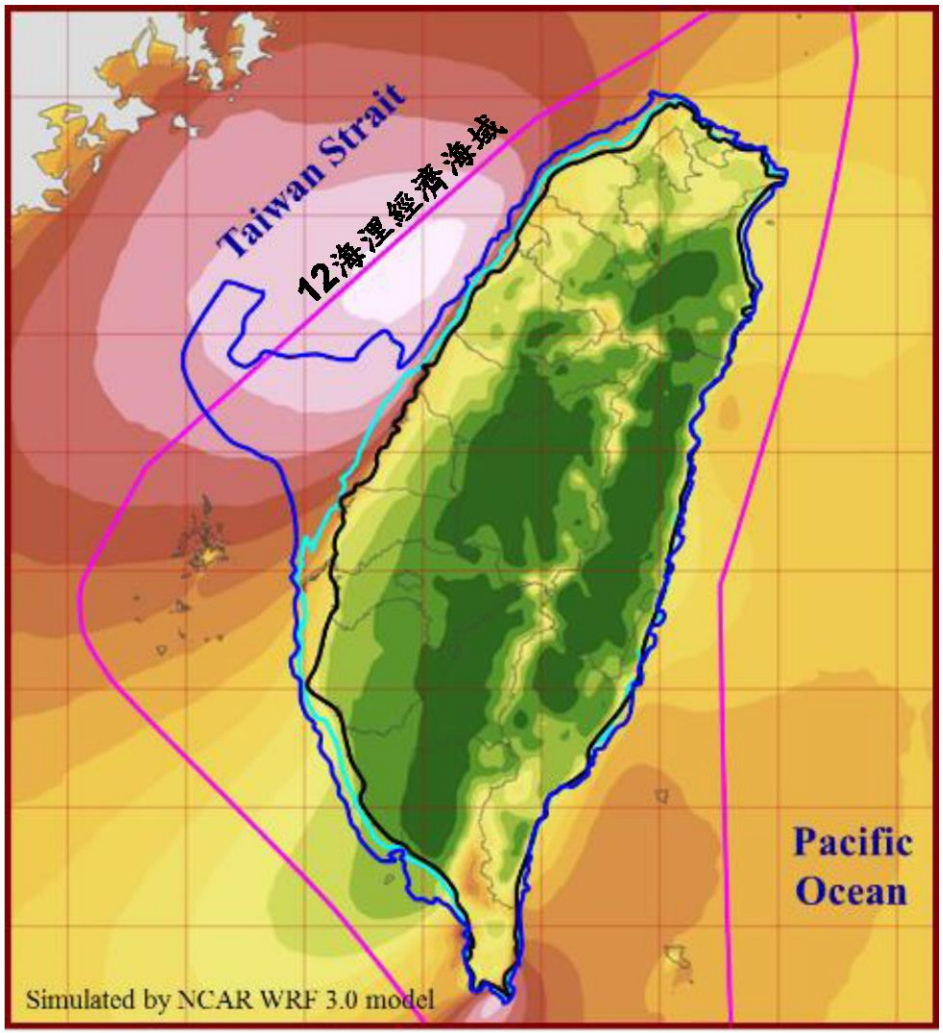
@ Status of Taiwan Offshore Wind Farm (OWF) Development

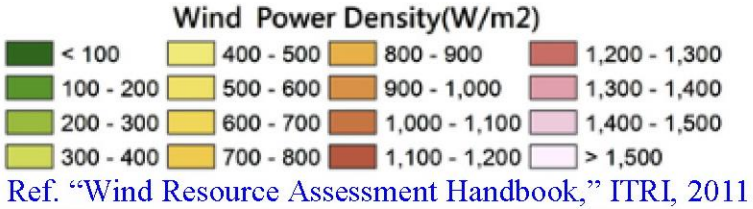
@ Requirements for Taiwan OWF Development

@ Geophysical, geological and geotechnical data to be acquired

@ Potential geohazard risks identified

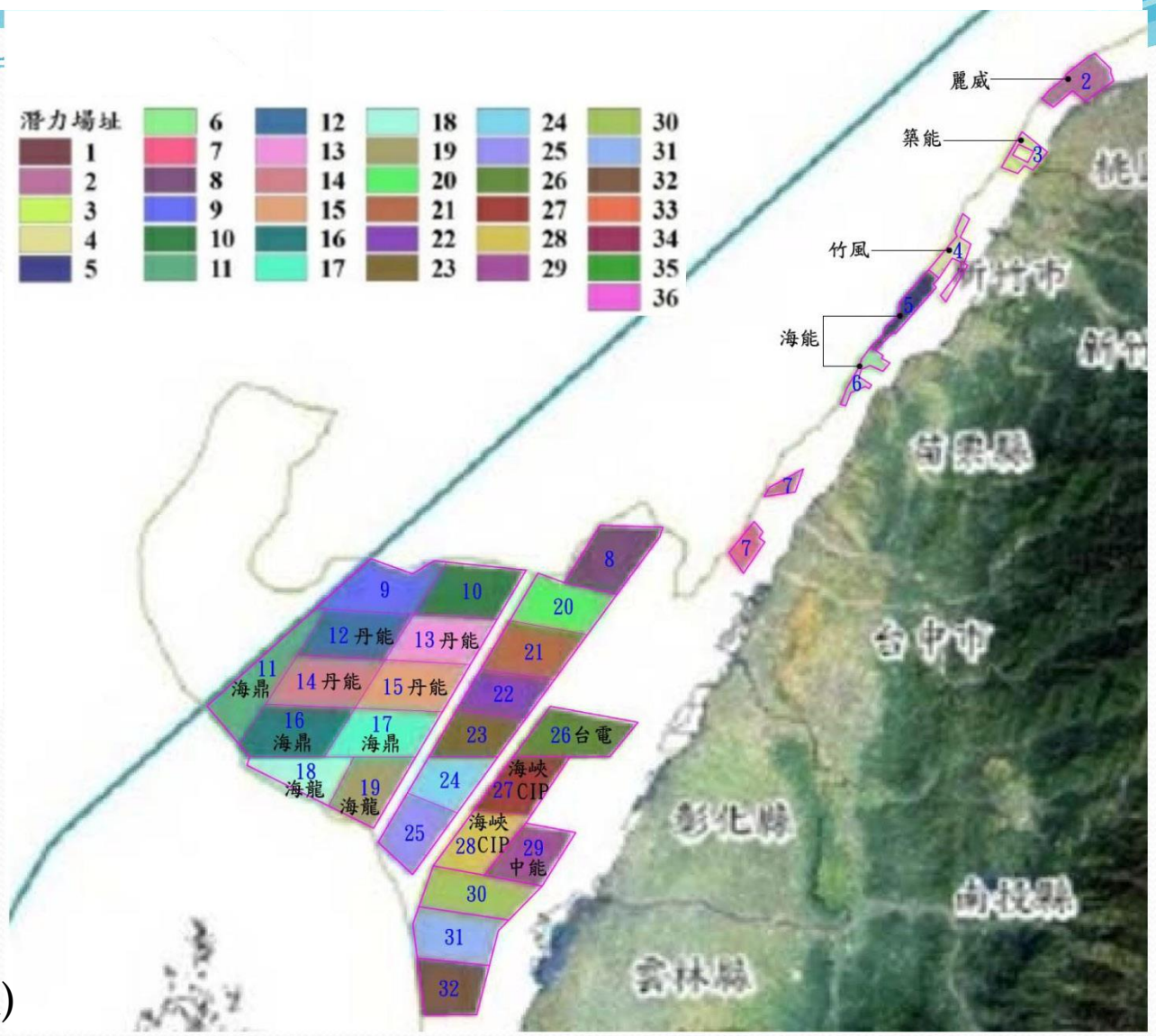
Wind power density map of Taiwan





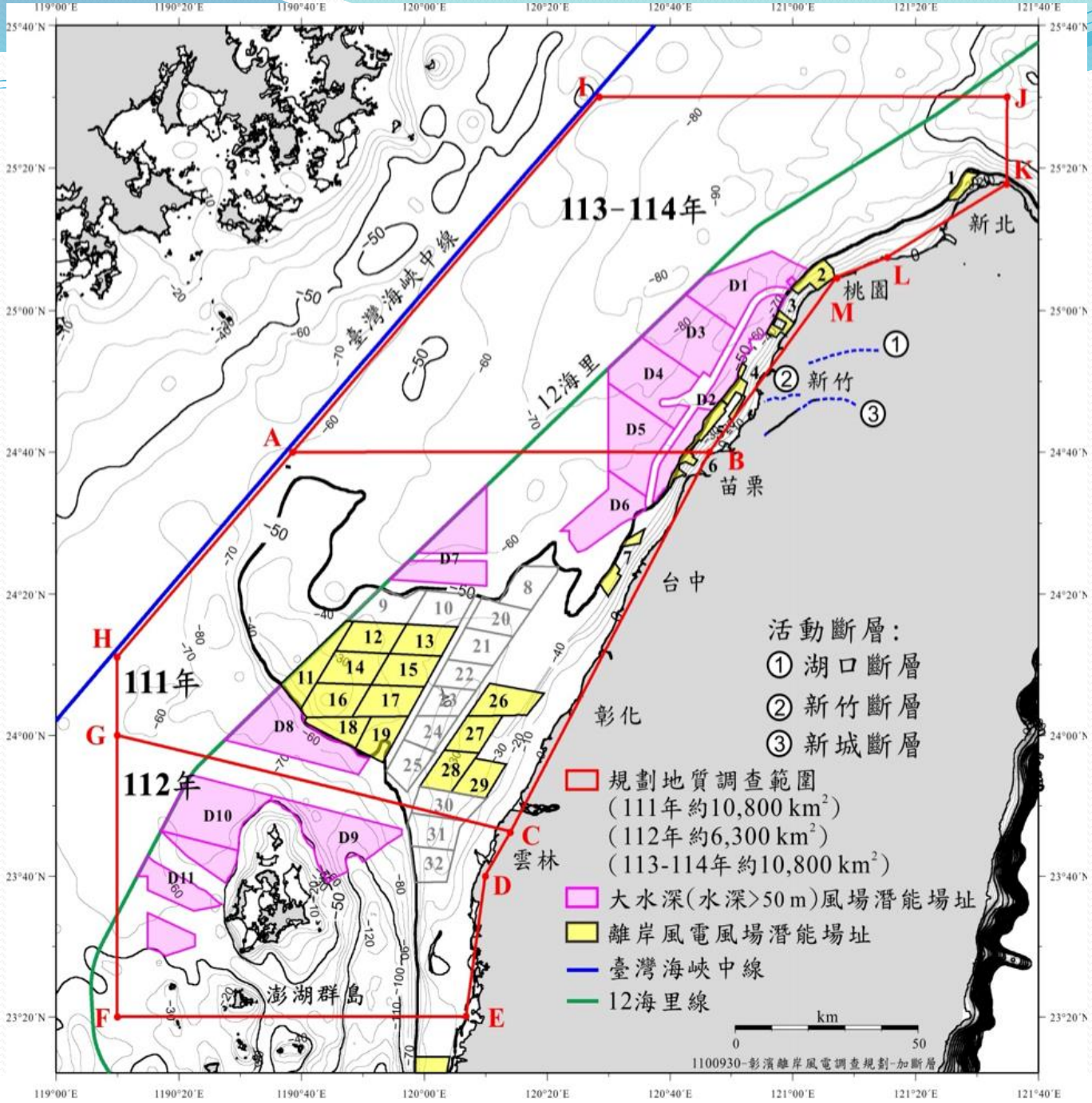
Ref. "Wind Resource Assessment Handbook," ITRI, 2011

OWF blocks released for bidding since 2018
Shallow water potential blocks



(BOE, MOEA)

Deep water OWF blocks (pink color) released for bidding in 2024



(GSMMA, MOEA)

Steps for OWF Development in Taiwan

- Government releases blocks and selection rules for offshore wind farm (OWF) developments
- **Developers prepare required documents and submit their proposals for bidding**
- Government announces bidding/selection results
- **Awarded developers work on WTG sites preparation and engineering design**
- Government approves engineering design and development plans
- WTG and cable installation and OWF in operation

OWF development application needs to meet the following requirements:

- **Environmental Impact Assessment approved**
  - **Low geological hazard risk (Preliminary MGG survey needed)**
  - No interference to aviation safety
  - No interference to military activities
  - No interference to shipping activities
  - No threat to biological/ecological environment
  - Not in potential marine mineral resource zone
  - Agreement from fishery communities
- Local government approved
- Land usage agreement obtained
- Electricity generated to be connected to TaiPower grid agreed
- **No underwater cultural heritage on site (UCH survey needed)**
- **Submarine cable route approved (SCR survey needed)**
- Financial resource secured

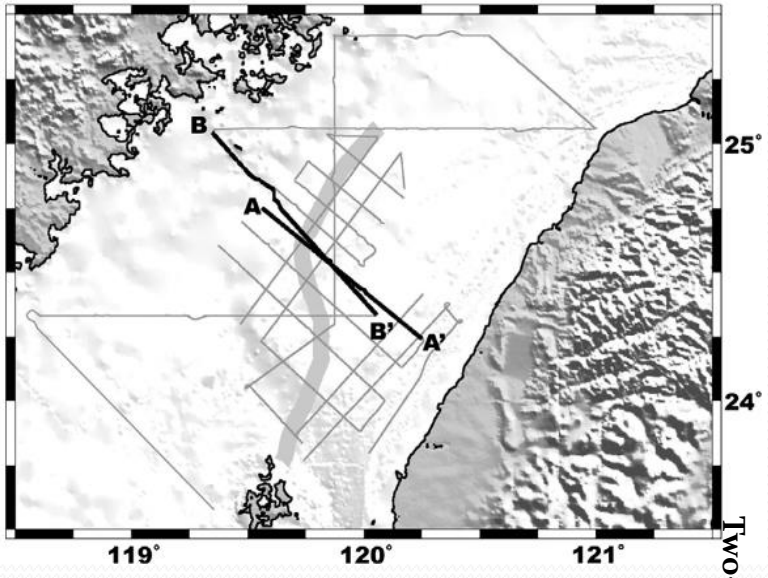
Geological Aspects in EIA Preparation

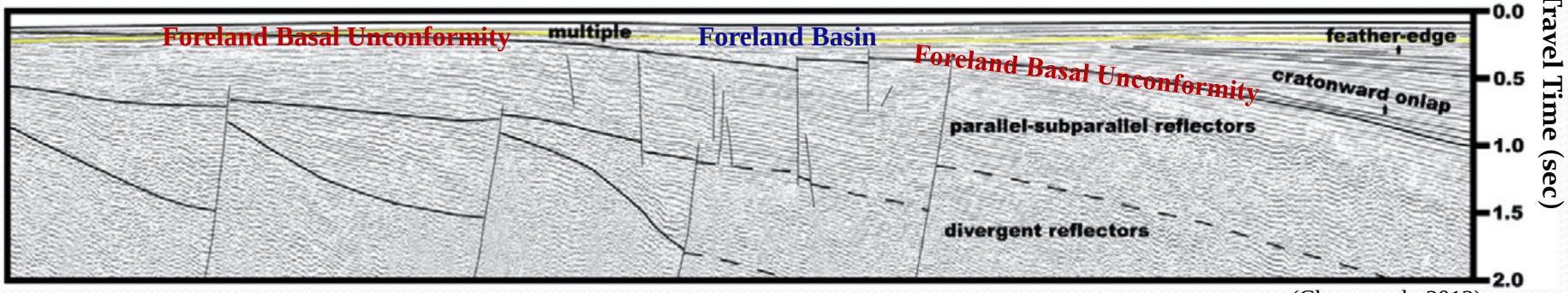
- Desktop study using existing and publically available geological, geophysical and geotechnical information.
- Geophysical surveys to acquire MBES bathymetry and high resolution seismic data (SBP).
- Geological sampling and geotechnical measurements from drilling a few boreholes and several CPT sites.

In the early stage of OWF development (before 2020), not many geological information were available besides regional framework, and no technical guidelines established in Taiwan for OWF surveys.

Regional Geological Framework

- Taiwan Strait is now in a foreland basin setting
  - Normal faults development
    - Old rift margin, rifting
    - Foreland basin formation, bending
- Large amount of sediment deposited in the Strait (Taiwan mountain belt and fast erosion)
  - Fast deposition of sediment strata
- Strong ocean current and tidal current
  - Sand wave movement, submarine erosion, etc.





(Chang et al., 2012)

MG&G Investigations in Taiwan Strait for Offshore Wind Farm Developments

Seismic surveys (OWF in central TS)
Bureau of Energ (BOE), MOEA 2017-2018

Marine geophysical and geological surveys
Geological Survey and Mining Management Agency (GSMMA), MOEA 2022-2025

Factors contributing to potential geohazard risks in Taiwan Strait

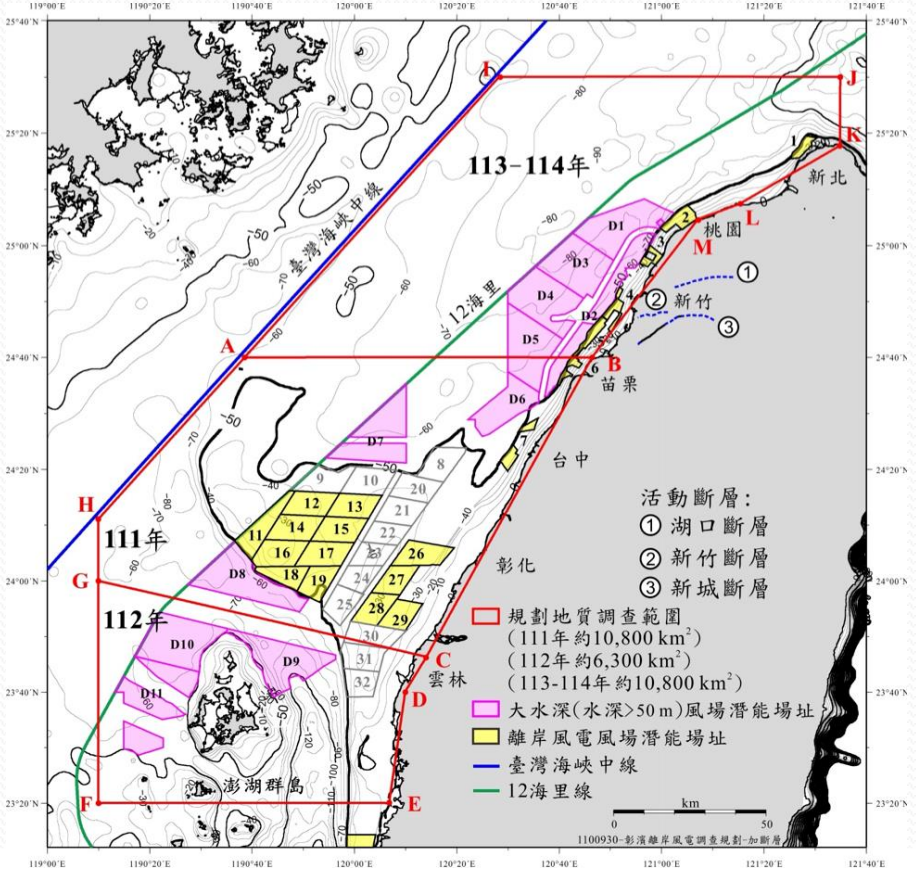
Large variation of metocean conditions

Large seafloor morphologic variations

Fast and dynamic sedimentary processes:

Fast deposition, strong submarine erosion, fluid activities, liquefaction, etc.

Faults, igneous rocks and other geological features.

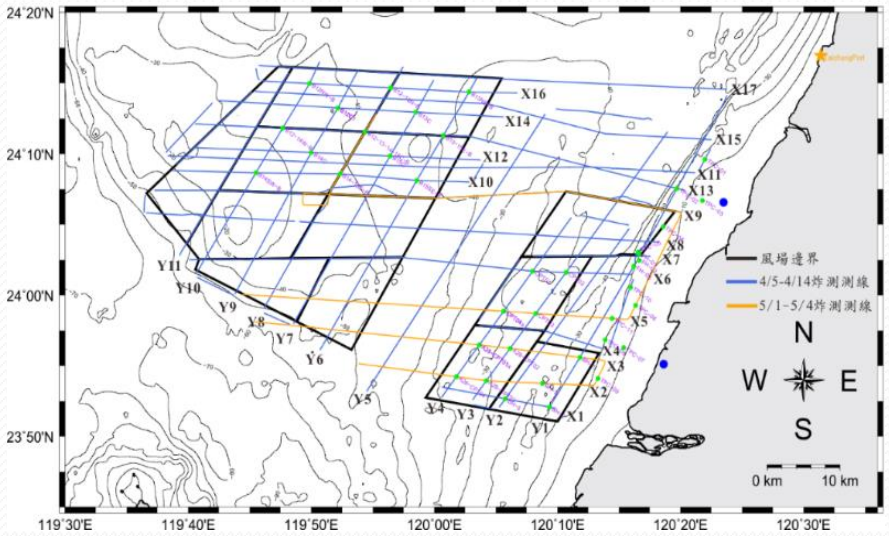


(GSMMA. MOEA)

Marine seismic surveys in Potential OWF Areas

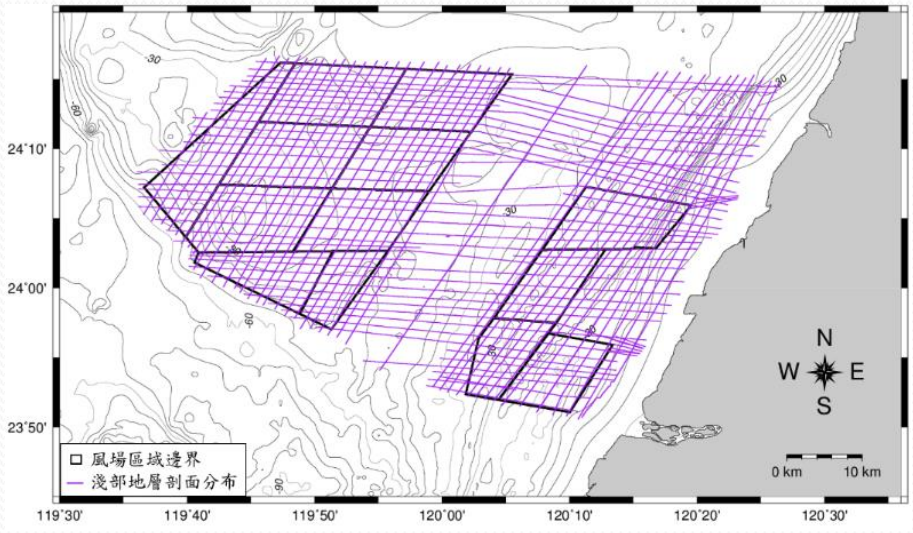
BOE (now Energy Administration), MOEA in 2017

Multichannel Airgun Seismic Lines



2017 BOE multichannel seismic survey line distribution (blue lines)。

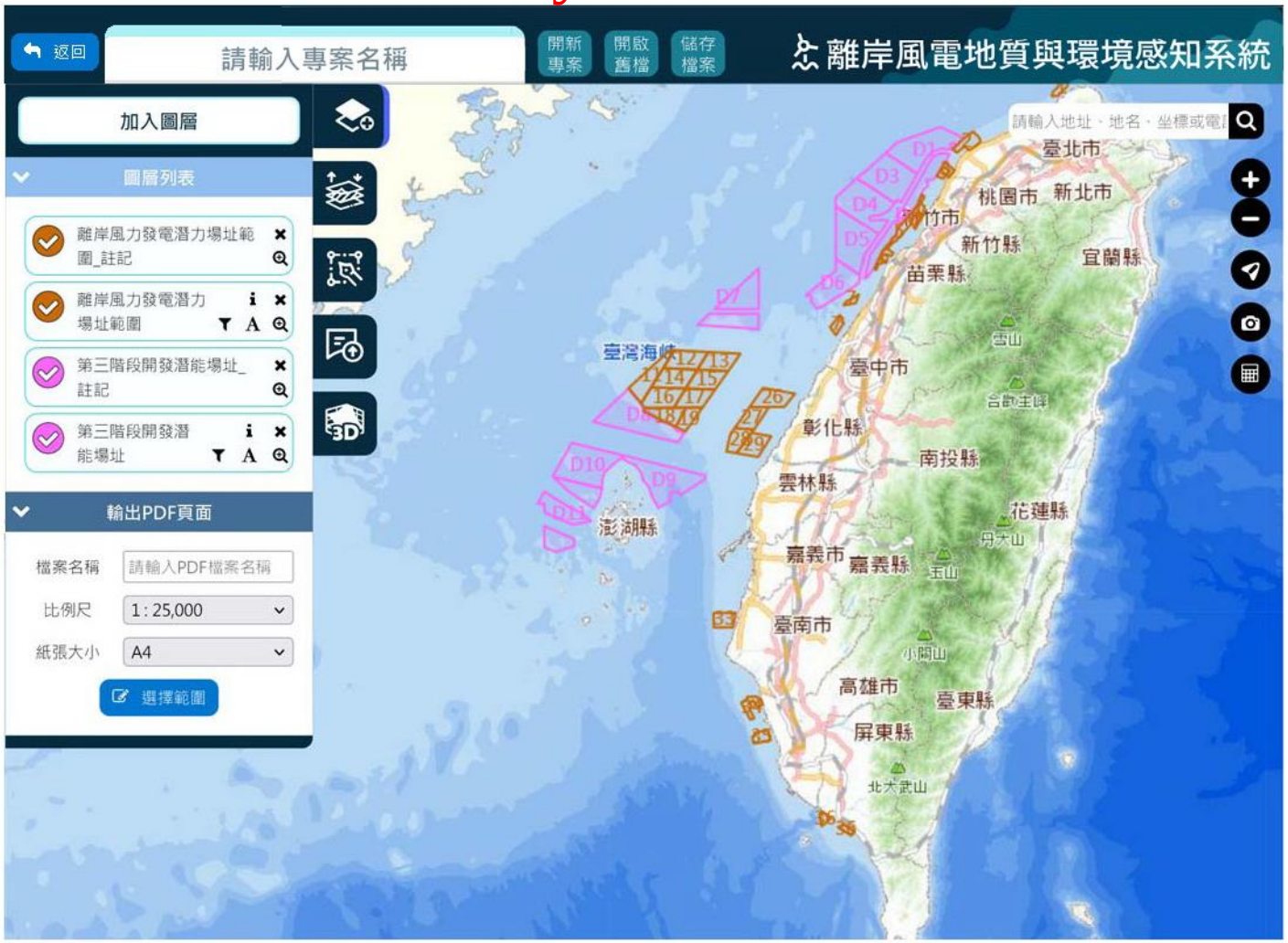
High-Resolution Sparker Seismic Survey



2017 BOE high resolution sparker seismic survey line distribution (purple lines)。

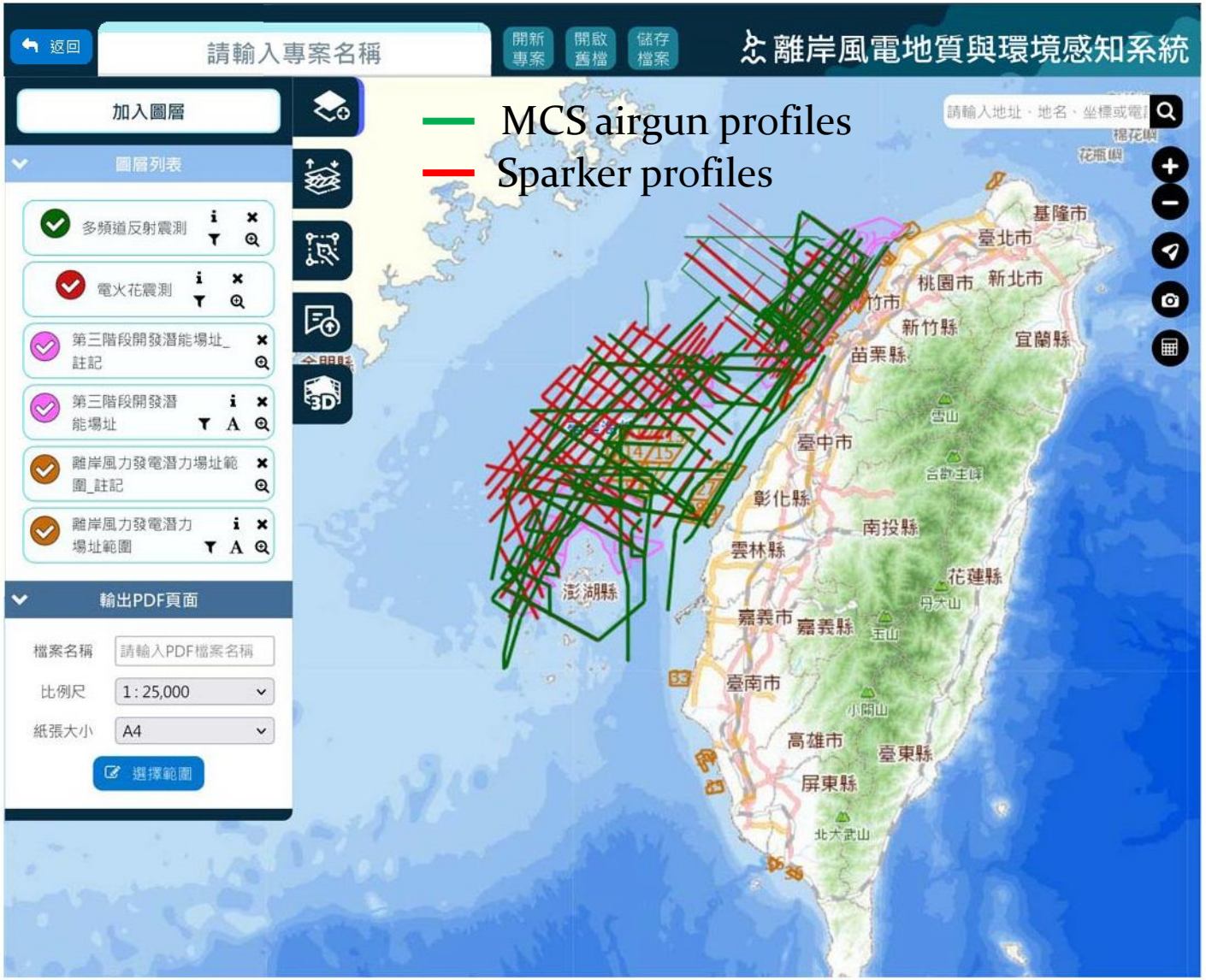
OWF Geological and Environmental Perception System

Established by GSMMA in 2023



https://windpower.geologycloud.tw/

Seismic Track Map from OWF Geological and Environmental Perception System



Three Offshore Wind Farm Technical Guides

Released by Bureau of Standards, Metrology and Inspection (BSMI), MOEA, in 2023

- **離岸風電場址調查及設計技術指引**

  OWF Site Investigation and Design Technical Guide

- 離岸風電發電製造及施工技術指引

  OWF WTG Manufacture and Installation Technical Guide

- 離岸風電運轉及維護技術指引

  OWF Operation and Maintenance Technical Guide

OWF Technical Guide Database and Platform

離岸風力發電技術指引資料庫平台 https://www.owpdb.tw/home

https://www.owpdb.tw/

Technical Guide Documents

Database Search Platform

UCH Survey Data and Report

Requested by Ministry of Culture

For the developer whose proposal has been accepted by EA, MOEA, underwater culture heritage (UCH) surveys will be conducted to see if there is any UCH object present. The survey will acquire the following 4 types of data:

1. Full coverage MBES bathymetry data
2. Full coverage side-scan sonar (SSS) data
3. Sub-bottom profile (SBP) data
4. Marine magnetic survey data

Detail investigation of seafloor features will be conducted and analyzed for possible underwater cultural heritage items.

Marine Cable Route Survey Data and Report

To be approved by Ministry of Interior

For planned cable routes inside the OWF block and the section extended to on shore, marine geophysical surveys along the routes will be conducted to ensure the safety of the cables though their operation life. The survey will acquire the following 4 types of data:

1. MBES bathymetry data extending to a specified width on each side of the planned route.
2. Full coverage side-scan sonar (SSS) data of the route.
3. Sub-bottom profile (SBP) data
4. Marine magnetic survey data

Marine Geophysical Surveys Required for WTG sites Investigation

For engineering design works, seafloor and substrata information are required at each of the wind turbine generator (WTG) sites. Marine geophysical surveys to be conducted for engineering design purpose include:

1. Full coverage of MBES bathymetry of the OWF block.
2. Multichannel seismic reflection data crossing each of the planned WTG sites.
3. SBP data along the seismic profiles

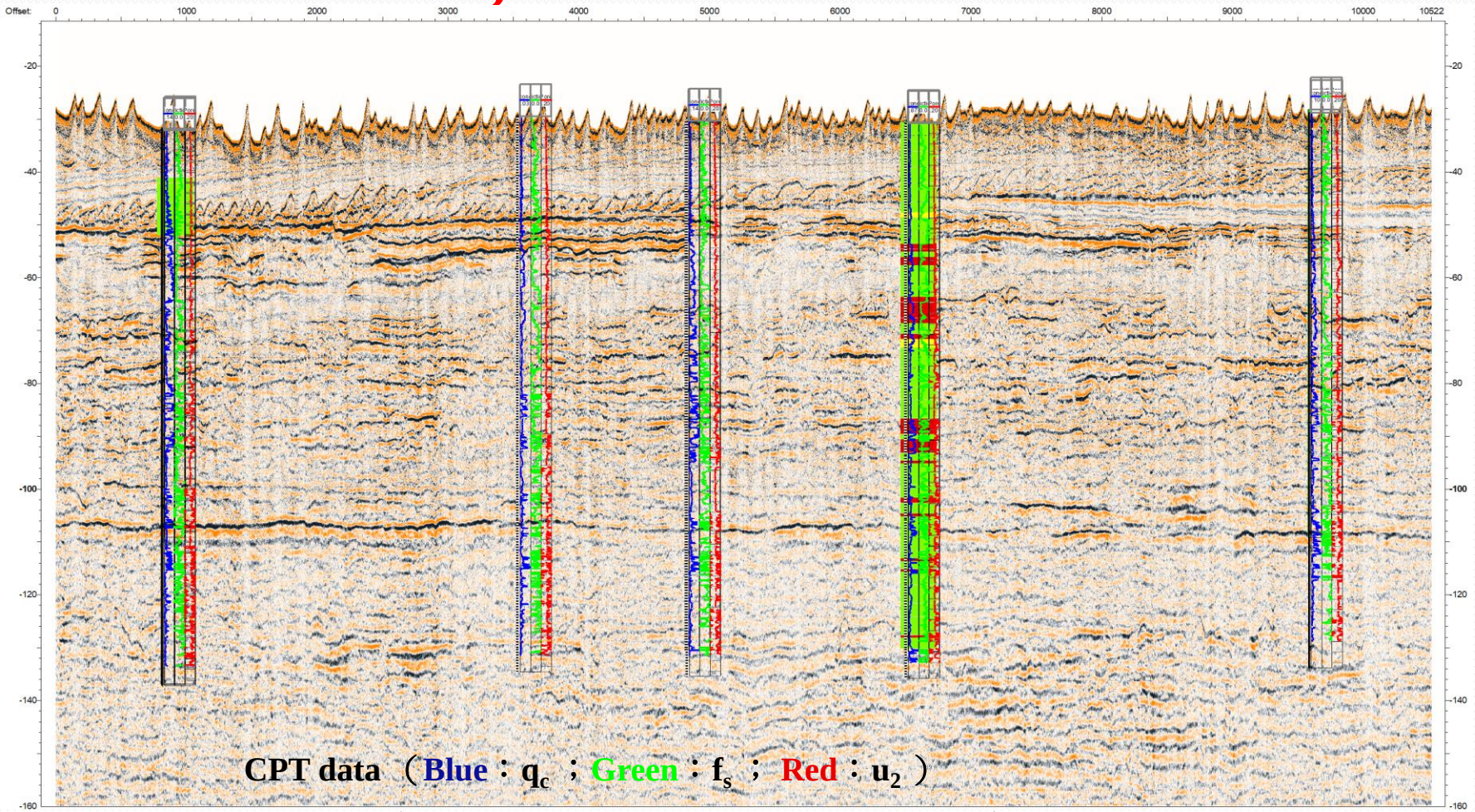
Detail geophysical data analysis will be conducted to reveal the substrata features and to assess possible geohazard risks.

Core Samples and Geotechnical Data to be collected at WTG sites

It is required that geotechnical measurements (CPT) to be conducted at each of the WTG sites to a depth beyond the designed foundation depth, and geological core samples to be collected at selected (representative) boreholes to reveal the soil properties of the substrata.

Lab analyses of the core samples and mechanical property experiments of the core samples are also to be conducted to provide substrata soil properties for engineering designs.

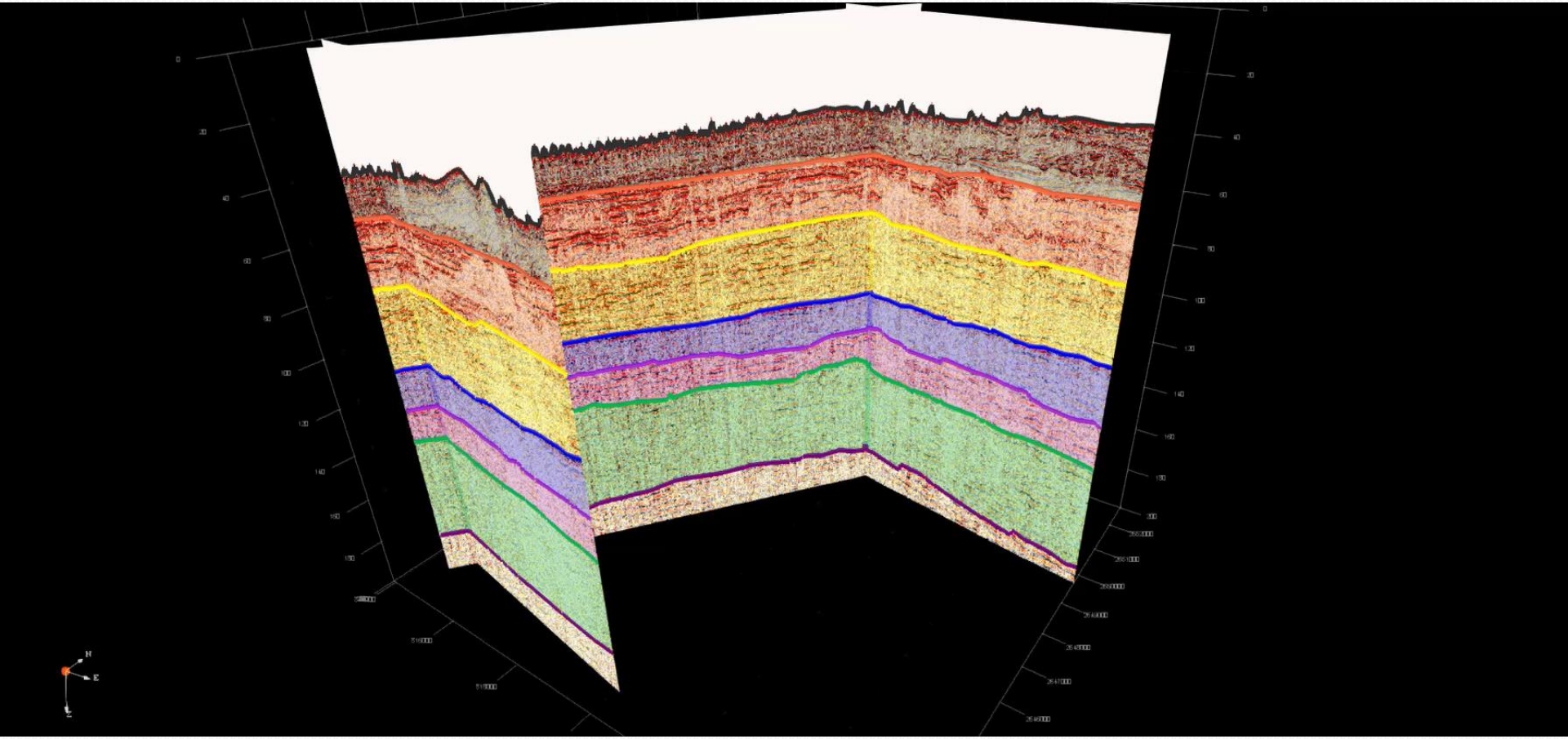
Ground Model Building by Integration of Seismic, Core and CPT Data



CPT data（Blue：q_c；Green：f_s；Red：u_2）

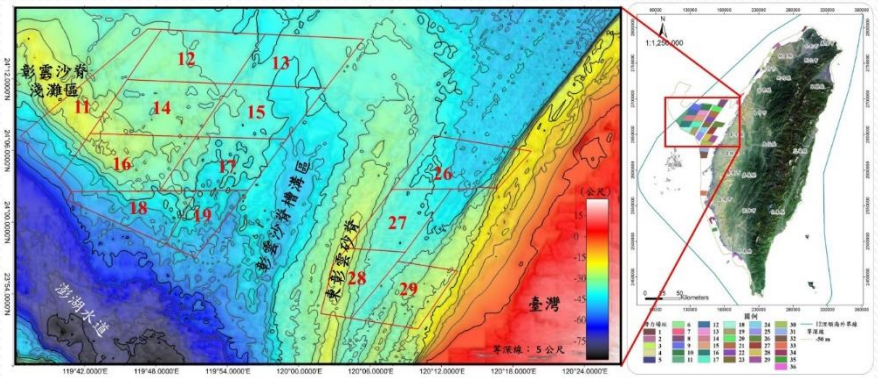
Core data（Green：sand；Yellow：silt；Red：clay）

Ground Model Building

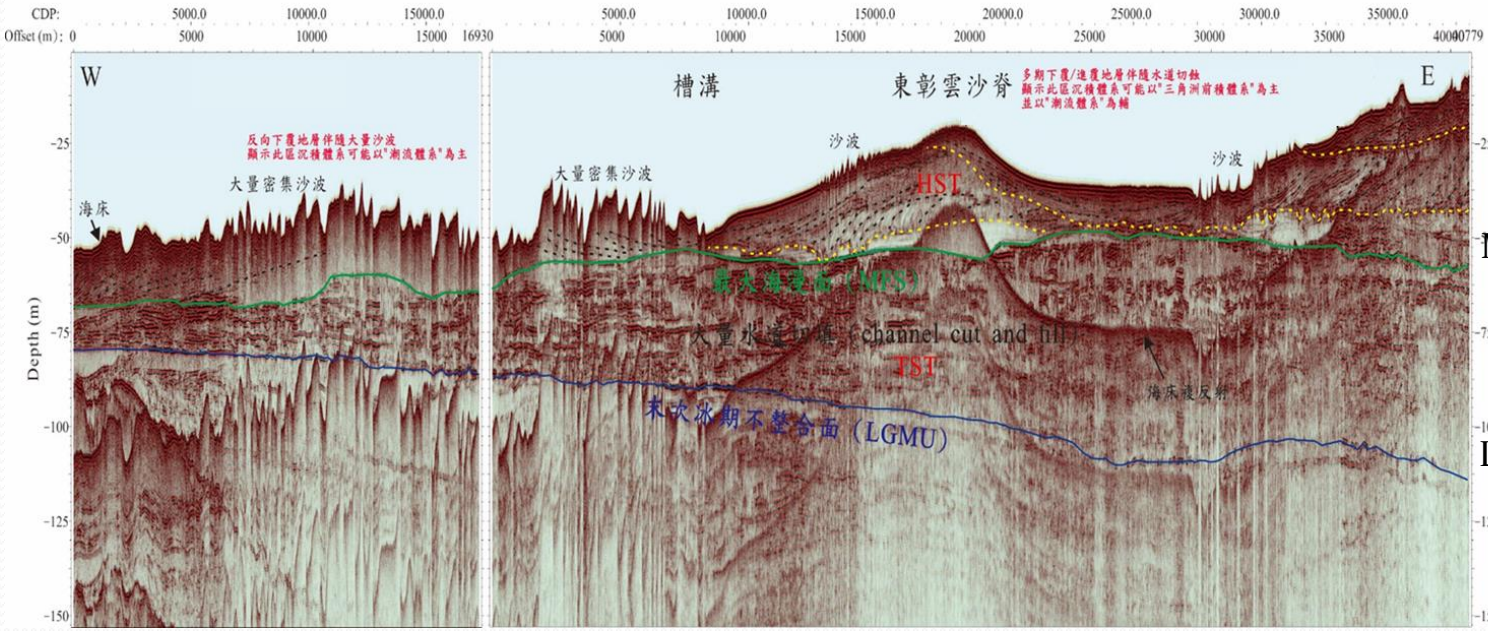


Geological Interpretation and Geohazard Investigation via multiscale geophysical data analyses

Complex sand waves, sand ridges, channel cuts and fills, and fan delta deposits near shore are observed.



最大海漫面(MFS); 末次冰期不整合面(LGMU)

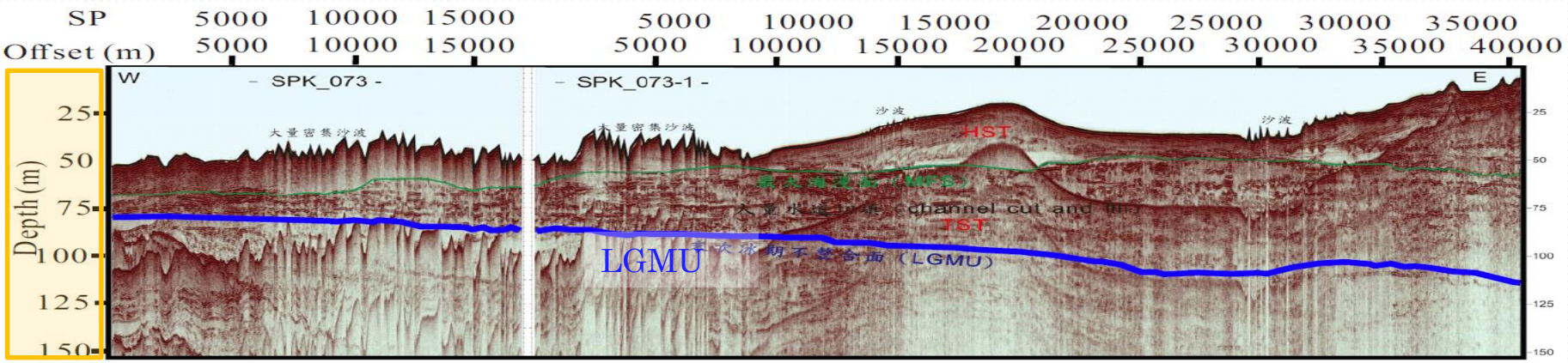


MFS (~6 kybp)

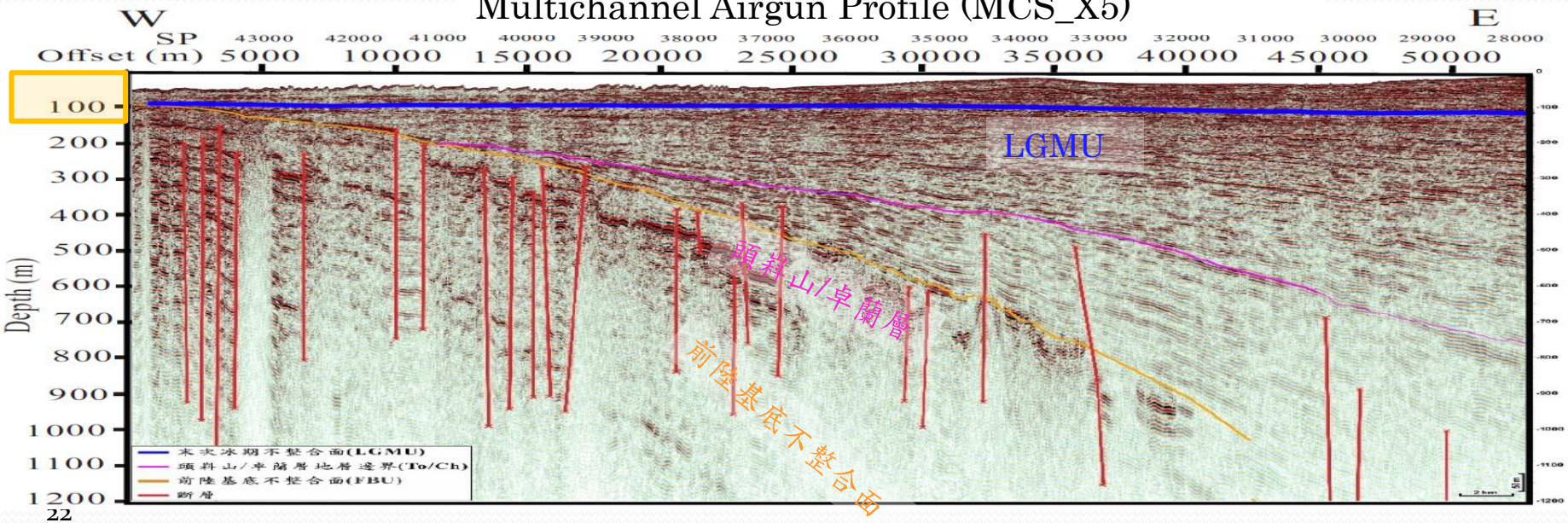
LGMU (~20 kybp)

MCS Seismic vs Sparker HRS Profiles

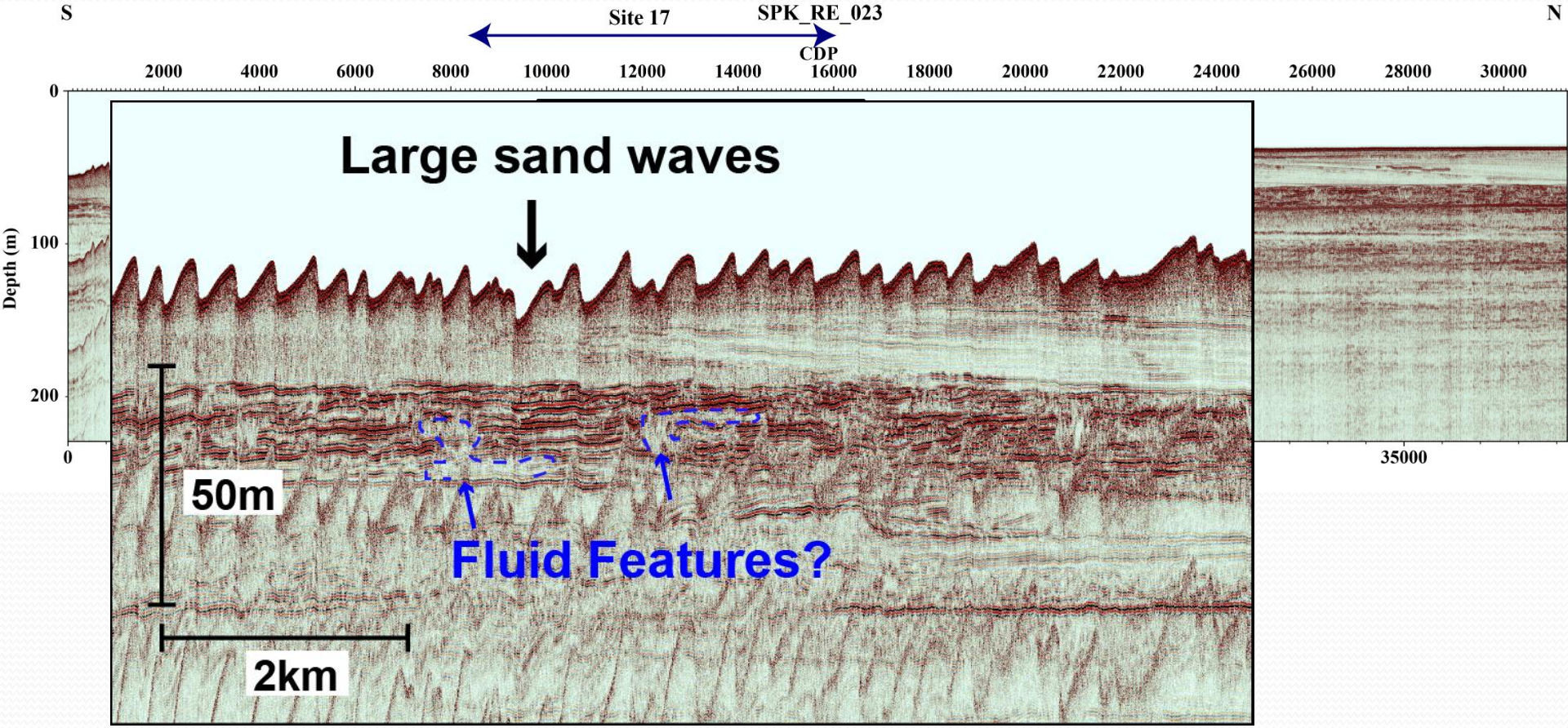
HR Sparker (SPK_073+SPK_073-1)



Multichannel Airgun Profile (MCS_X5)



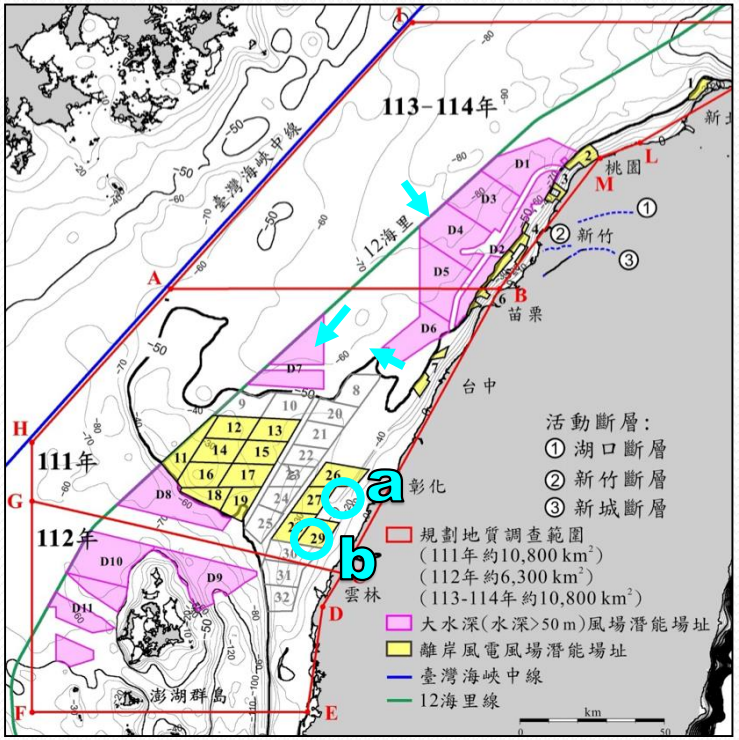
Example of Subsurface Features



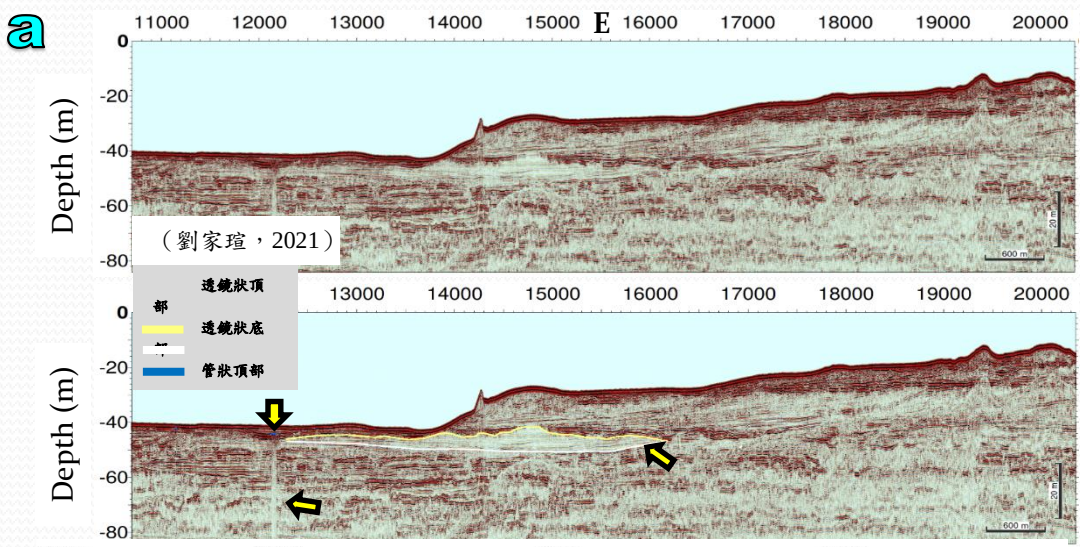
Sparker seismic profile image

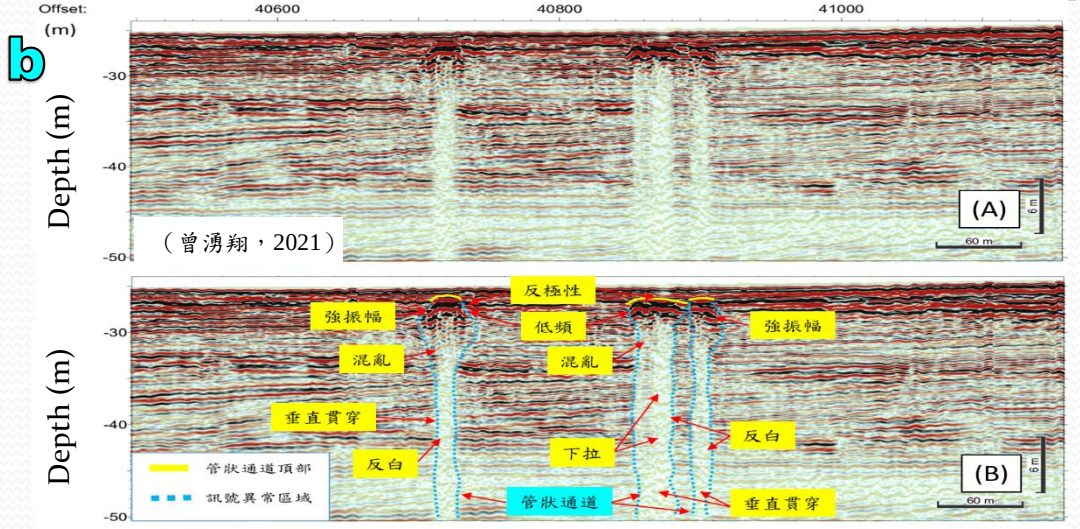
Fluid related features

- Seismic chimmy, pockmark, lenticular white zone, etc. are observered in Taiwan Strait



Horizontal blanking zone

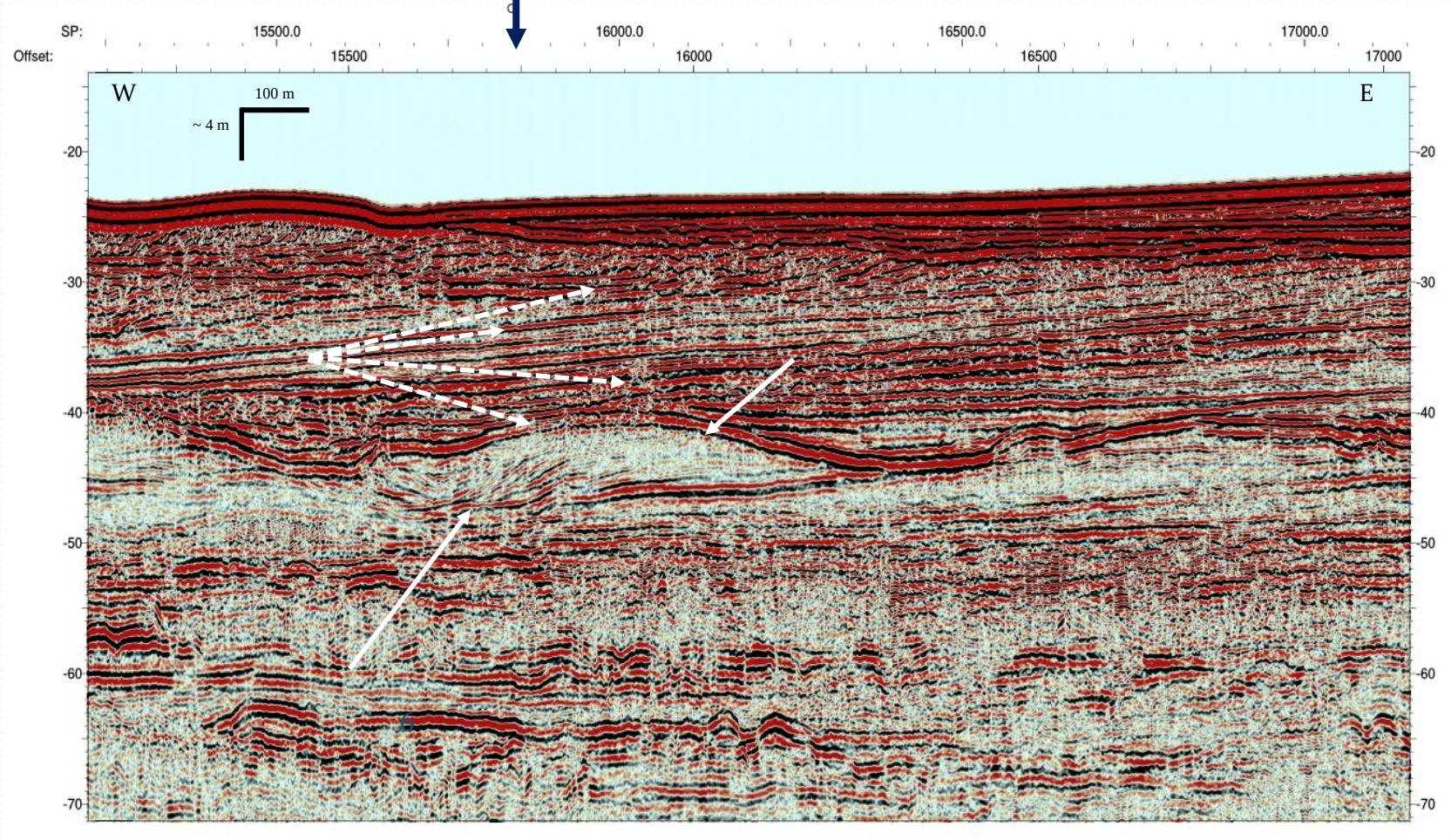




Vertical chimney features

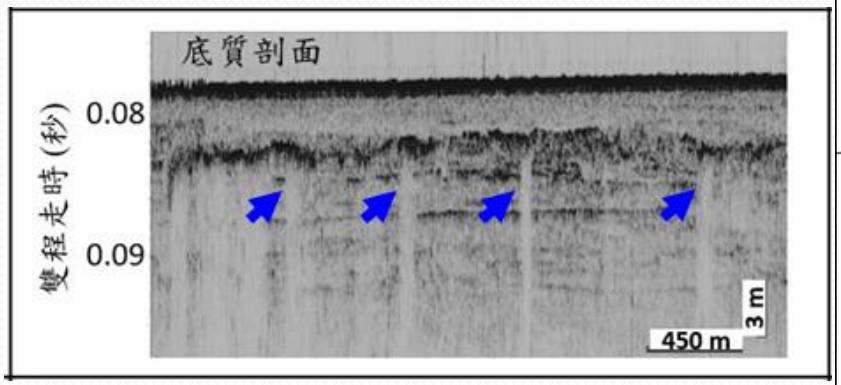
Investigation of weak zone

Pile run location

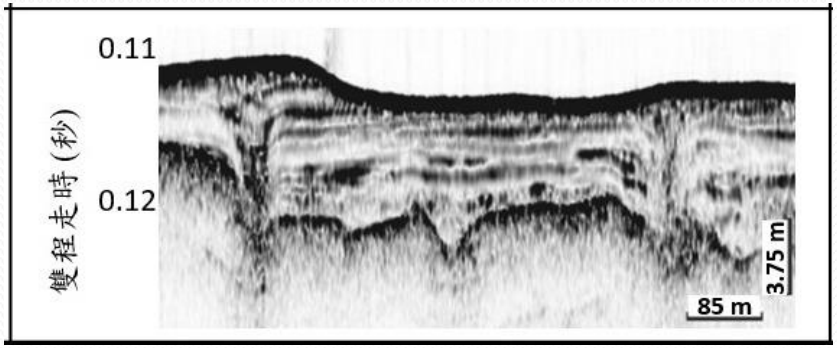


Fluid migration / soft sediment deformation

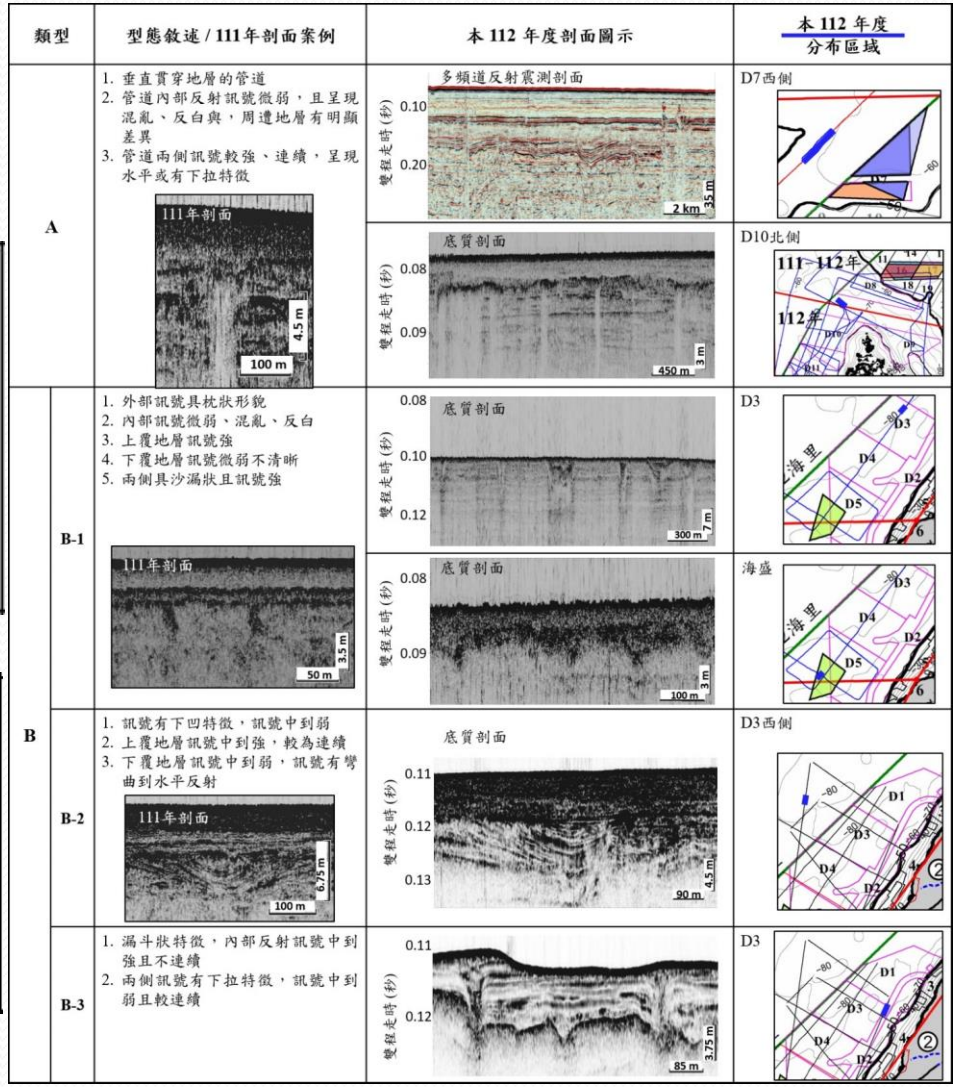
Type A



Type B



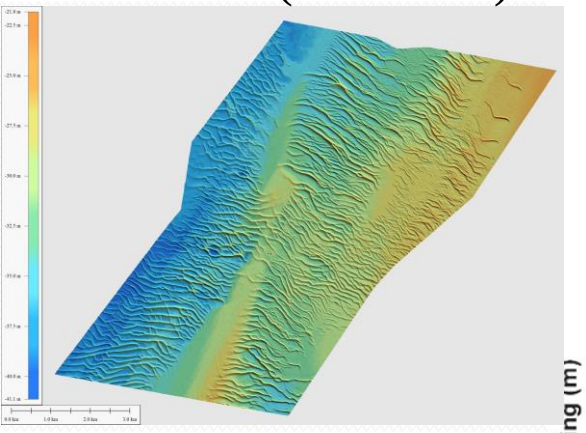
(Hsu, 2023)



Sand wave migration analysis from repeated survey data

Repeated swath bathymetry mappings

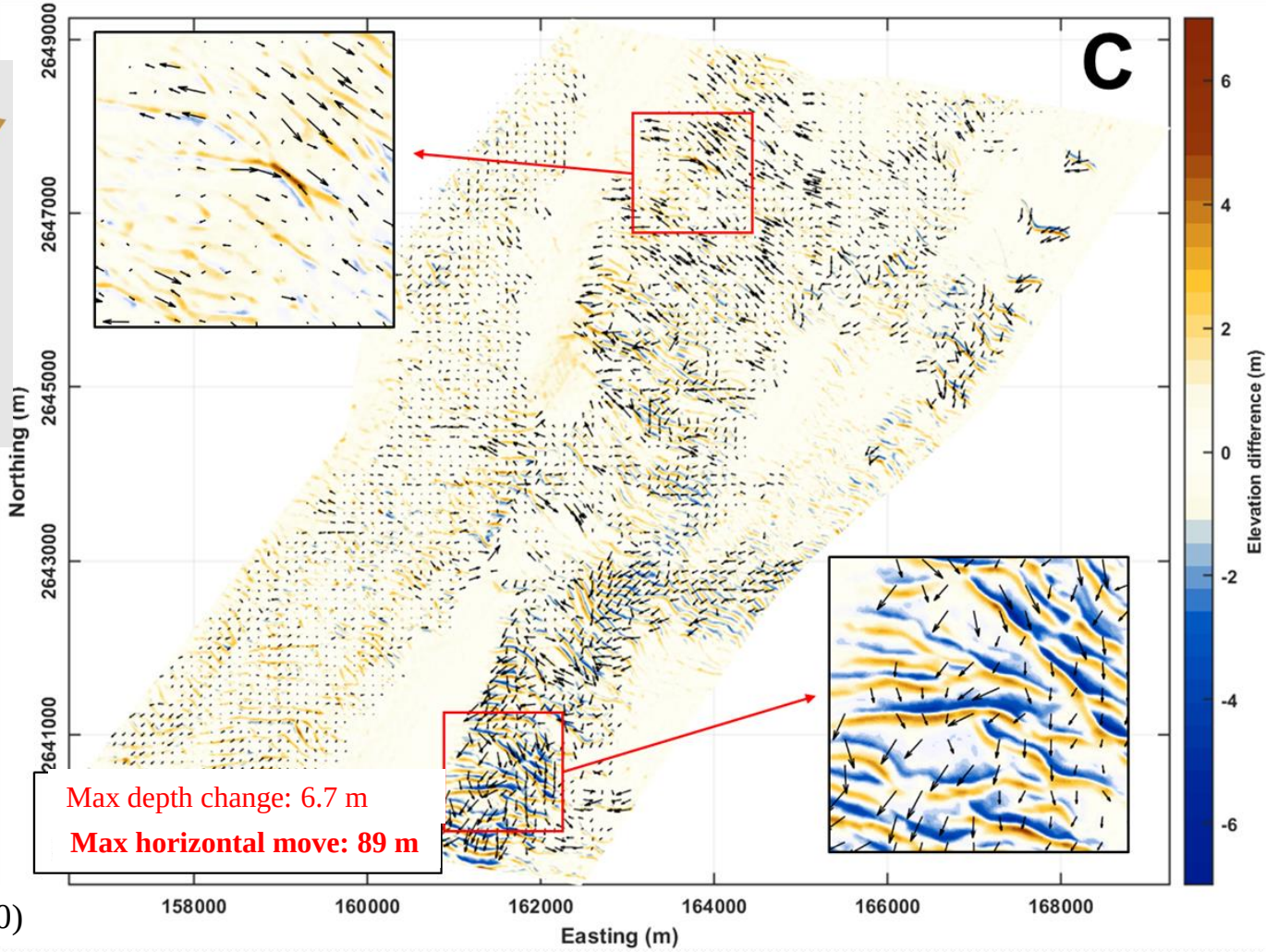
2016-2018 (27 months)



Small area
2018.07-2018.09
2018.11.21-2018.11.23

2D cross-correlation to derive sand wave movements

(Hsu and Liao, 2018; Liao, 2000)

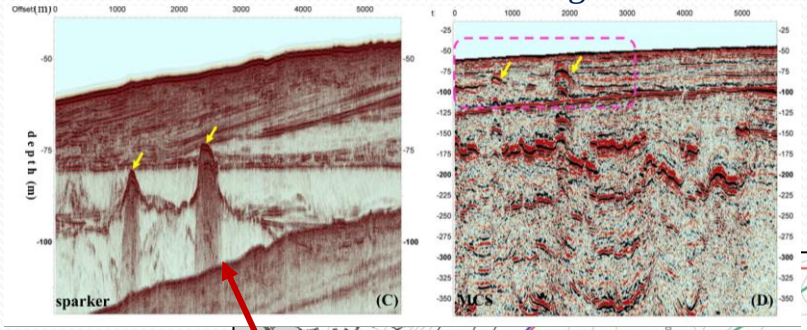


Potential Geohazards for OWF TG Installation

(Shallow hard strata)

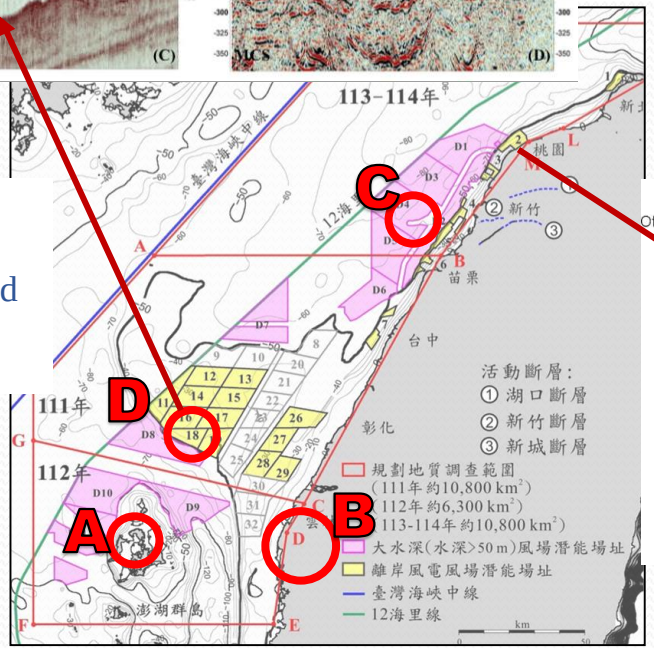
50-80 m below seafloor

Strong reflections



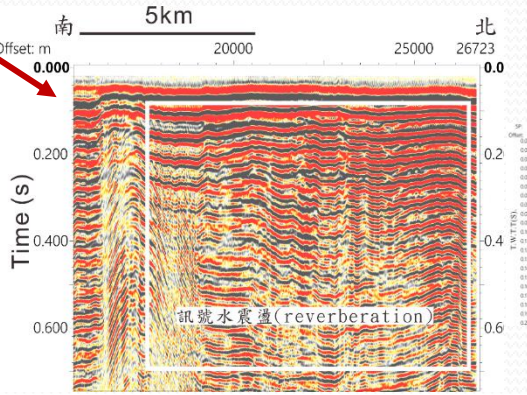
謝欣崧等，2018

Basalt intrusion and extrusions

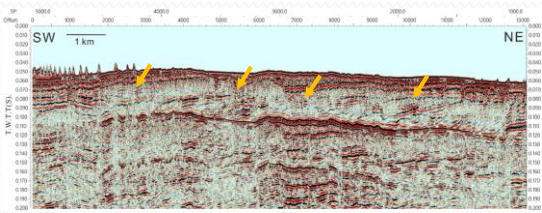


Miocene Basalt Distribution

	Depth	References
A	0至320 公尺	(黃立勝、劉秀邦，1967)
B	1142至1422公尺	(原振維，1981)
C	海床下> 2500至2800公尺	(Lin A. et al., 2021)



Conglomerate layers below seafloor



許鶴瀚等，2020

Summary

1. **Geological background information** of the Taiwan Strait and OWF geophysical and geotechnical **survey requirements and guidelines** have been established.

2. Repeated seafloor MBES mapping provide opportunities to reveal the **morphodynamic processes of the seafloor** and for modeling the maximum seafloor variations.

3. **Multi-scale seismic data** provide substrata images from structural features at depth to detail fluid features and strata deformations at shallow depth, and to reveal the geological processes in the OWF site.

4. **Integration of geophysical, geological and geotechnical data** enable us to build a more realistic ground model, and to better constrain the lateral soil property variations.

Thanks for listening