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YOKOSUKA Cruise Report

YK10-08

Eastern margin of Japan Sea

July 10th, 2010 – July 26st, 2010

Japan Agency for Marine-Earth Science and Technology
(JAMSTEC)

Contents

1. Cruise Information

Cruise number: YK10-08

Ship name: R/V *Yokosuka*, AUV *Urashima*, AUV *TunaSand*

Title of the cruise:

Joetsu Basin, Eastern margin of Japan Sea

Title of proposal:

Analysis and acquisition of high resolution map data of the accumulation and auto-collapse processes of the sea-floor gas hydrates

Cruise period: July 10^{th}, 2010 – July 26^{th}, 2010

Port call: July 10^{th}	Departure	JAMSTEC, Yokosuka, Kanagawa Prefecture
July 26^{st}	Arrival	Matsugae Pier, Nagasaki, Nagasaki Prefecture

Research area: Eastern margin of Japan Sea (Fig. 1)

Joetsu Basin, Umitaka Spur and Joetsu Knoll (Figs. 2A and 2B)

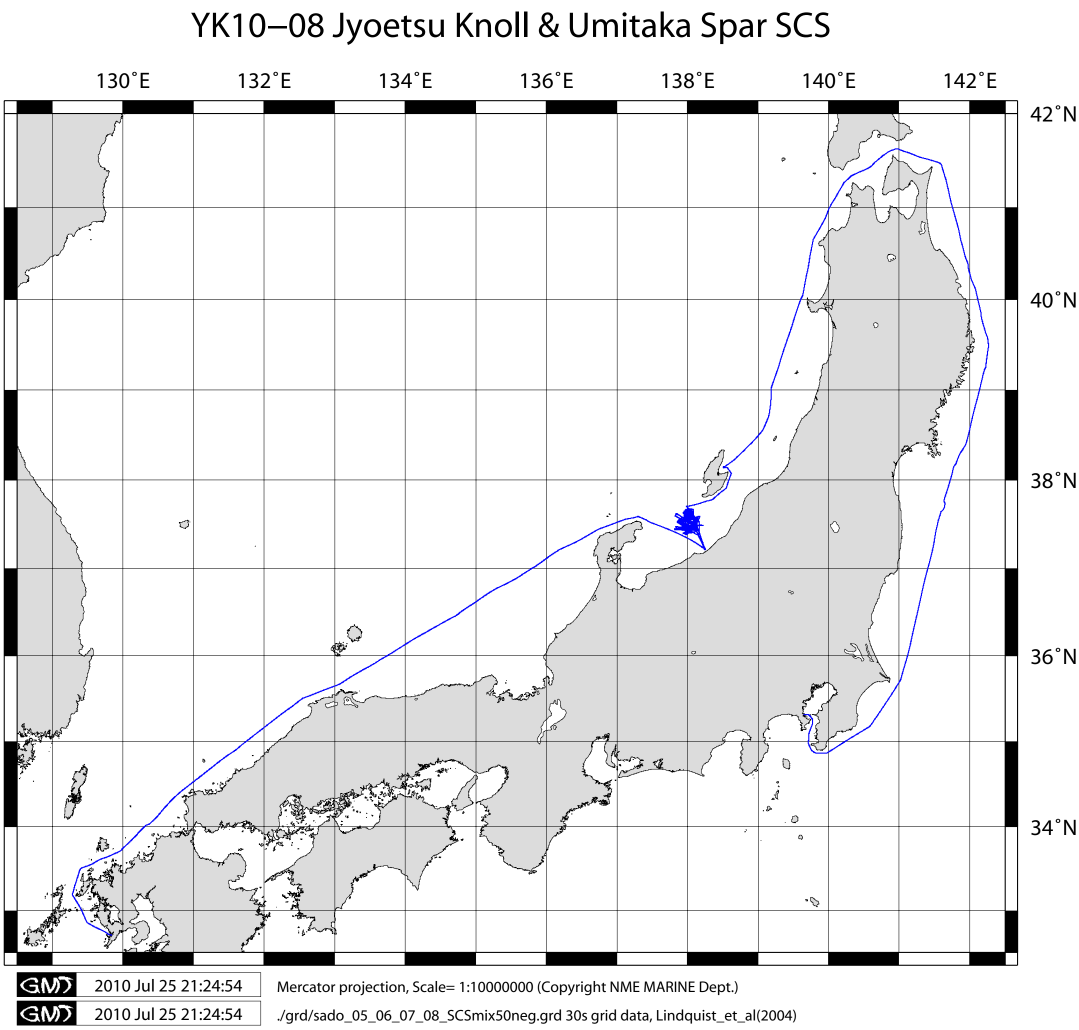

Fig. 1. Ship track of the YK10-08 Cruise.

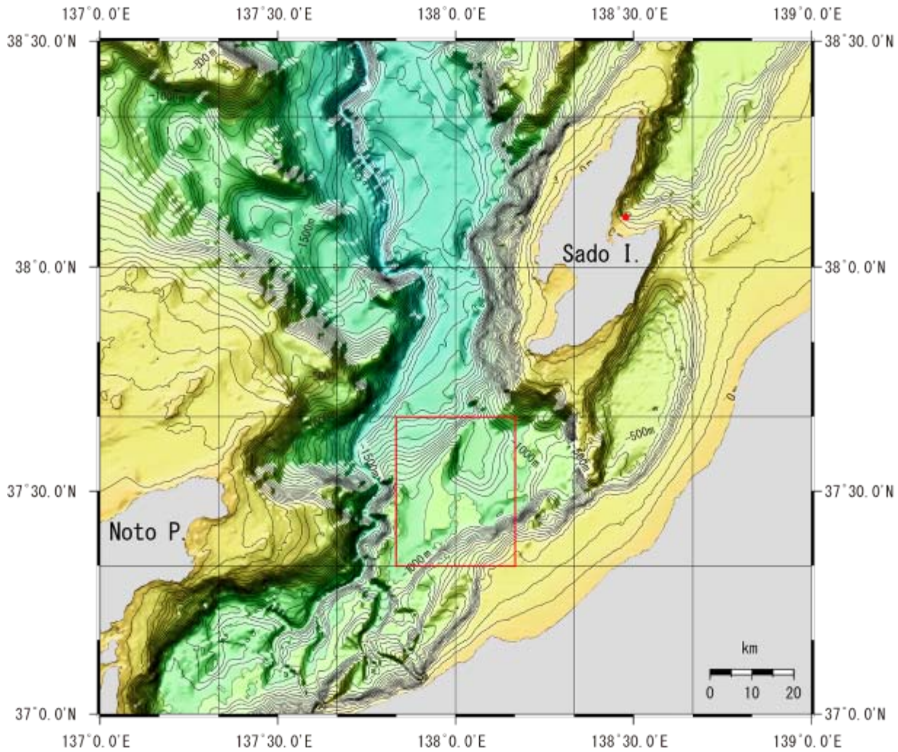

Fig.2A. Bathymetry and research area, Joetsu Basin, SW of Sado island.

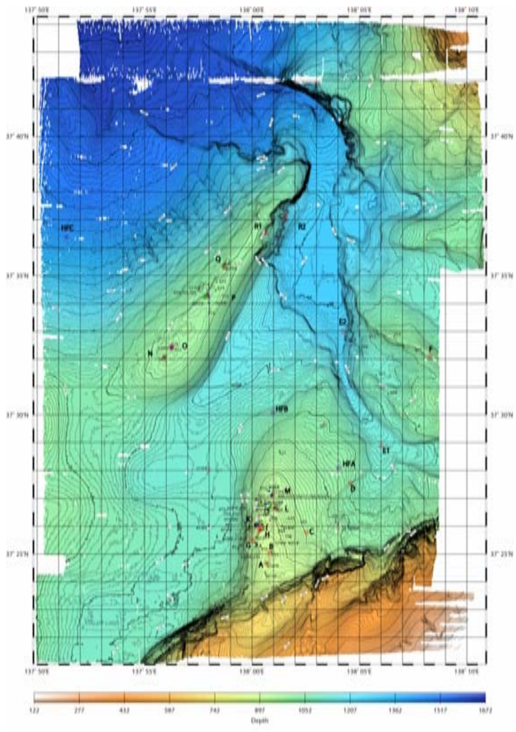

Fig.2B. Joetsu knoll and Umitaka Spur of the Joetsu Basin.

2. Researchers (Science Party)

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Yamano, Makoto (Earthquake Research Institute, University of Tokyo)

Yanagawa, Katsunori (University of Tokyo)

3. Research Summary

3.1 Background and Overview

Gas hydrates accumulate in shallow sediments on the mounds, 300m to 500m in diameter and 30m to 40m high, on the Umitaka spur and Joetsu knoll in Joetsu basin, at the depth of water of 880m to 1200m, Japan Sea. All of the hydrate mounds develop on gas chimneys as observed by single channel seismic profiles. Some of the mounds are associated with active methane plumes, 600m to 700m high.

During the R/V Yokosuka YK10-08 cruise in July 2010, we conducted (1) Multi Beam Echo Sounder (MBES), Side Scan Sonar (SSS) and Sub-Bottom Profiler (SBP) by means of AUV URASHIMA, (2) mosaic photo survey by AUV Tuna Sand of the Institute of Industrial Science and Technology, Tokyo University, and (3) Single Channel Seismic surveys.

(1) The AUV operated geophysical surveys have revealed ultra-high resolution topographic features and subsurface structures of the mounds and adjacent areas. AUV URASHIMA ran over the spur and knoll at 50m to 80m above seafloor at a cruising speed of 2.4 knots. MBES and SSS discriminated two types of mounds; one is a low swell with smooth surface and weak reflections, while the other is characterized by rough and uneven topographic features with strong SSS images, probably due to incrustation by methane-induced carbonate concretions and gas hydrates. SBP penetrated down to 50 mbsf to 80 mbsf and recognized three stratigraphic units: I upper massive unit (5-10m thick), II middle evenly bedded unit (15-25m thick) and III lower slightly bedded unit (> 15-25m thick). Deep gas chimneys grow up toward the seafloor through the lithologic Units III, II, and I. When the ceiling of gas chimney stays within Unit III or II, the mounds above are either low swell or nearly flat, while the ceiling reaches up to Unit I or seafloor, mounds grow up high. Finally, the ceiling breaks through the seafloor and protrudes to form gas hydrate mound. The mounds continue to grow up to 40m to 50m high, and then start to decay due to mechanical collapse and chemical dissolution of gas hydrates. The protruded mounds with uneven rough surface and strong SSS images correspond to this stage. The ceiling of gas chimneys is often represented by high amplitude, uneven acoustic reflectors on SBP, even within the sediments.

(2) We conducted 5 dives of AUV Tuna Sand over active methane seep sites, gas hydrate exposures, and bacterial mat zones. We had identified high concentration of snow crab on and around gas hydrate mounds, which seemed to suggest that snow crabs depend on chemosynthetic community. AUV Tuna Sand took about 600 high resolution photos during her 7 to 8 hours dive, covering about 20m x 40m area. The resolution of the photos is a few mm or less, enabled to identify very small crabs, and discriminate male and female, and old and young ones. Highest concentration (“population”) was 2945 female crabs and 416 males in about 800 m2 area. This means that about 4 crabs in 1 m2. This population is 100 times high than average crab population in Japan Sea. Crabs tend to concentrate around high methane concentration area, however, the direct relation between the chemosynthetic communities was not recognized. Lithology and micro-topography may also control the population of snow crabs.

(3) Single Channel Seismic profiles were taken for about 20 track lines over the Umitaka Spur and Joetsu Knoll. We had already revealed the structure and distribution of the bottom simulating reflectors on the knoll and spur, but the stratigraphic relation between the knoll and spur was not fully understood. 2010 SCS surveys were focused on the connection between the knoll and spur. We confirmed that the Joetsu knoll is younger than the Umitaka spur.

3.2 Cruise Log

Date	Activity & Operation	Area
July 10	Embarkation/Departure	JAMSTEC Pier, Yokosuka
	Brifing	
July 11	Transit	
	Science Talk and Science Meeting	
July 12	Transit	
	Turnout at Ryotsu harbor due to high waves	
July 13	Transit	
	Embarkation of 3 scientists	Naoetsu port

	Site survey for crab-fishing	
	XGT/Bathymetry (MBES)	
	SCS on the Umitaka Spur	
July 14	AUV Urashima dive#114(150m interval)	Umitaka spur
	SCS on the Umitaka spur	
July 15	AUV Urashima dive#115(75m interval)	Umitaka spur
	SCS on the Umitaka spur	
July 16	AUV Tuna Sand dive#46 & #47	Umitaka spur
	SCS on the Umitaka spur to the Un-named ridge	
July 17	AUV Tuna Sand dive #48 & #49	Umitaka spur
	SCS on the Umitaka spur to the Un-named ridge	
July 18	AUV Tuna Sand dive #50 & #51	Umitaka spur
	Science meeting	
July 19	AUV Urashima dive#116 (75m interval)	Joetsu knoll
	SCS on the Umitaka spur	Umitaka spur
July 20	AUV Tuna Sand dive #52 & #53	Umitaka spur
	SCS on the Umitaka spur and Joetsu knoll	
July 21	AUV Tuna Sand dive #54 & #55	Joetsu knoll
	SCS on the Umitaka spur and Joetsu knoll	
July 22	AUV Tuna Sand dive #56 & #57	Joetsu knoll
July 23	AUV Urashima dive #117 (75m interval)	Joesu knoll
	Disembarkation of 3 scientists	Naoetsu port
	Transit to Nagasaki	
July 24	Transit	off Shimane-Torrori
	Science meeting	
July 25	Transit	Genkai nada
July 26	Disembarkation	Matsugae Pier, Nagasaki

3.3 AUV (Autonomous Underwater Vehicle) Dives

(A)　AUV Urashima

Multi Narrow Beam Echo Sounder (MBES), Side Scan Sonar (SSS) and Sub-Bottom Profiler (SBP) surveys were conducted by AUV Urashima about 80 to 100 meters above seafloor at cruising speed of 2.4 knots. Urashima also carried 24 Niskin bottles to collect seawater samples during the cruise.

AUV Urashima:

Max. detph	3500m
Max. cruising range	300km (by fuel cell)
Cruising speed	2.0 to 4.0 knots
Length	10 m
Width	1.3 m
Height	2.4 m

Fig. 3. AUV Urashima onboard R/V Yokosuka in Joetsu Basin, Japan Sea.

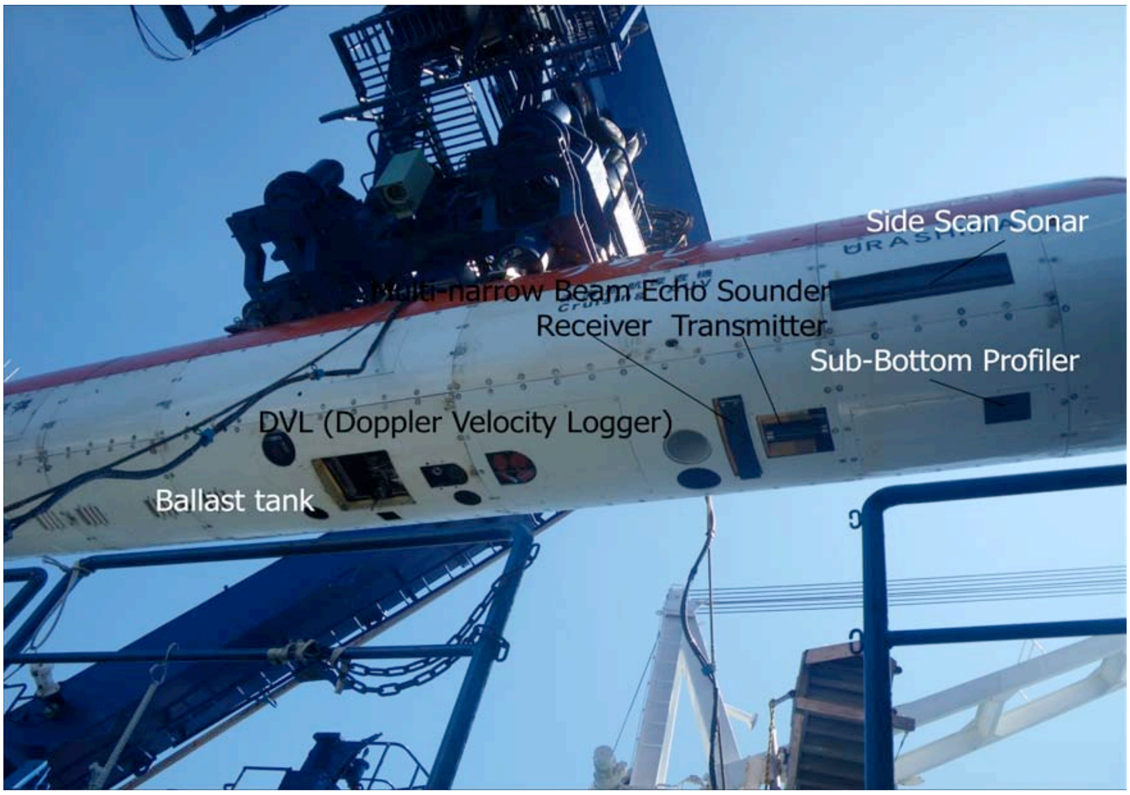

Fig. 4. MBES, SSS, SBP, and other instruments below the Urashima.

Fig. 5. Niskin bottles onboard AUV Urashima.

(B) AUV Tuna Sand

Hovering type AUV Tuna Sand was used for close observation and photo-imaging of gas hydrate bearing, methane venting sea-floor. Basin dimension of Tuna-Sand is,

Length	1.1 m
Weight	250kg (in the air)
Max depth	1500 m

Tuna Sand is specially designed for taking high resolution photographs of the seafloor from about 2.2 m above seafloor. The vehicle can dive into depression and rise up cliff guided by its forward laser sensor. For 7 to 8 hours dive, it takes 600 shots covering 20m x 40m area. These photos are to be compiled to construct a mosaic photo soon after the recovery onboard.

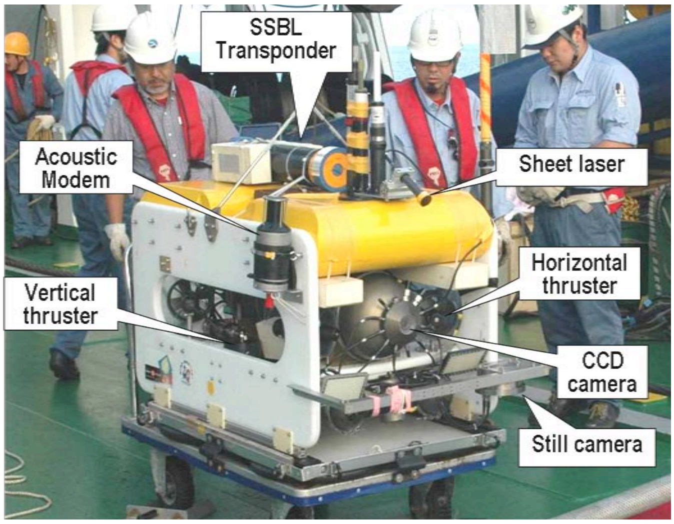

Fig. 6. AUV Tuna-Sand onboard R/V Yokosuka in Joetsu Basin.

3.4 AUV Dive Summary

3.4.1 AUV Urashima Dives

AUV Urashima conducted 4 dives (Dive#114, #115, #116 and #117) over the Umitaka spur and Joetsu knoll, and collected high resolution data for bathymetry mapping (MBES), surface expression (reflection profiles/SSS), and sub-seafloor imaging (SBP). Among these mapping and imaging, MBES has revealed a series of evolution of gas hydrate mounds from smooth domed swell with gentle slope to unusual mound with central crater-like depressions, valleys and rough and irregular surface. Evolved mounds are also characterized by high reflections on SSS images. SBP has revealed high resolution acoustic stratigraphy down to 40 meters below seafloor. Track lines of the dives are shown in Figs. 7 to 10.

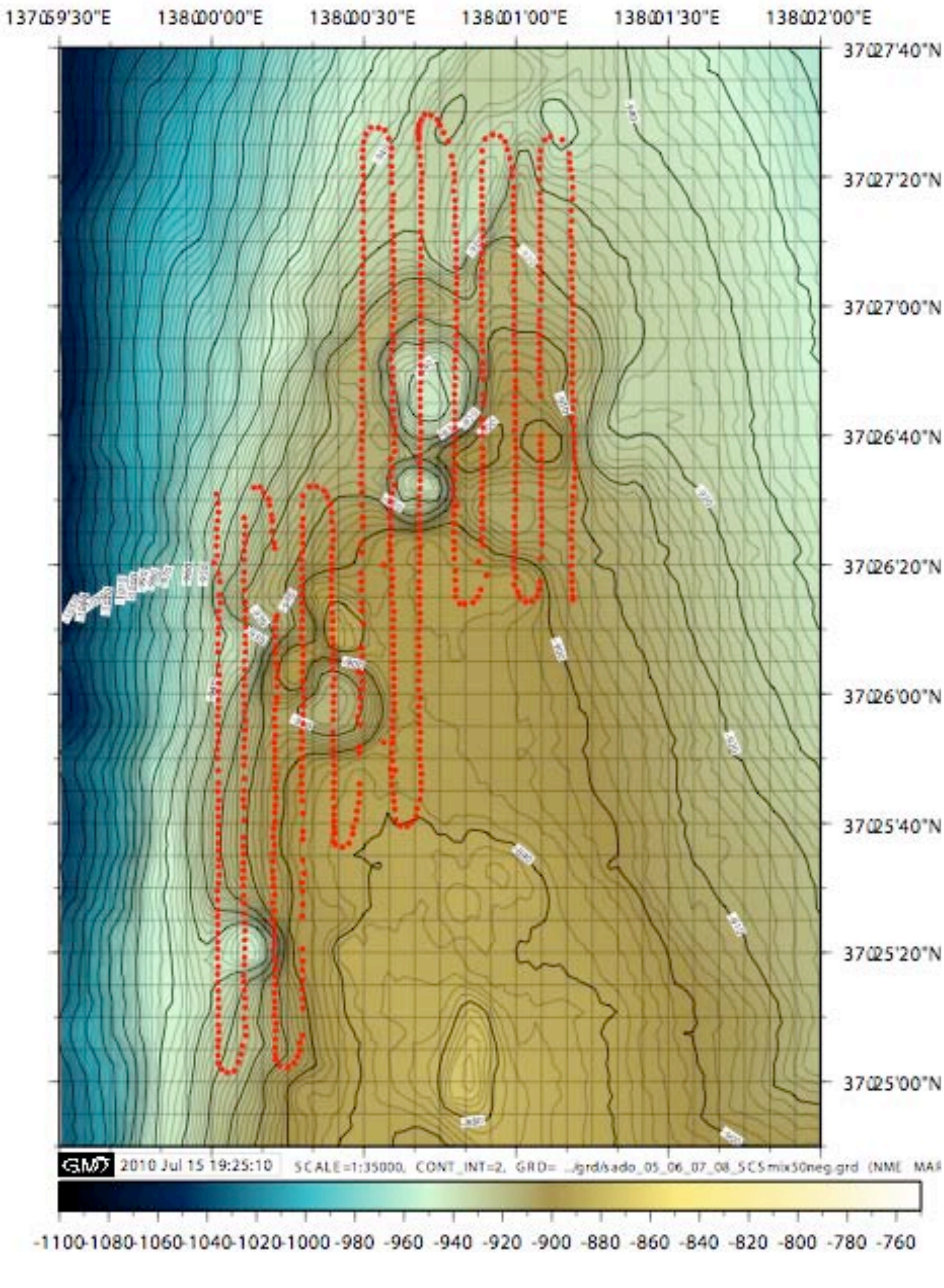

Fig. 7. SSBL track lines of AUV Urashima dive #114 on the Umitaka spur

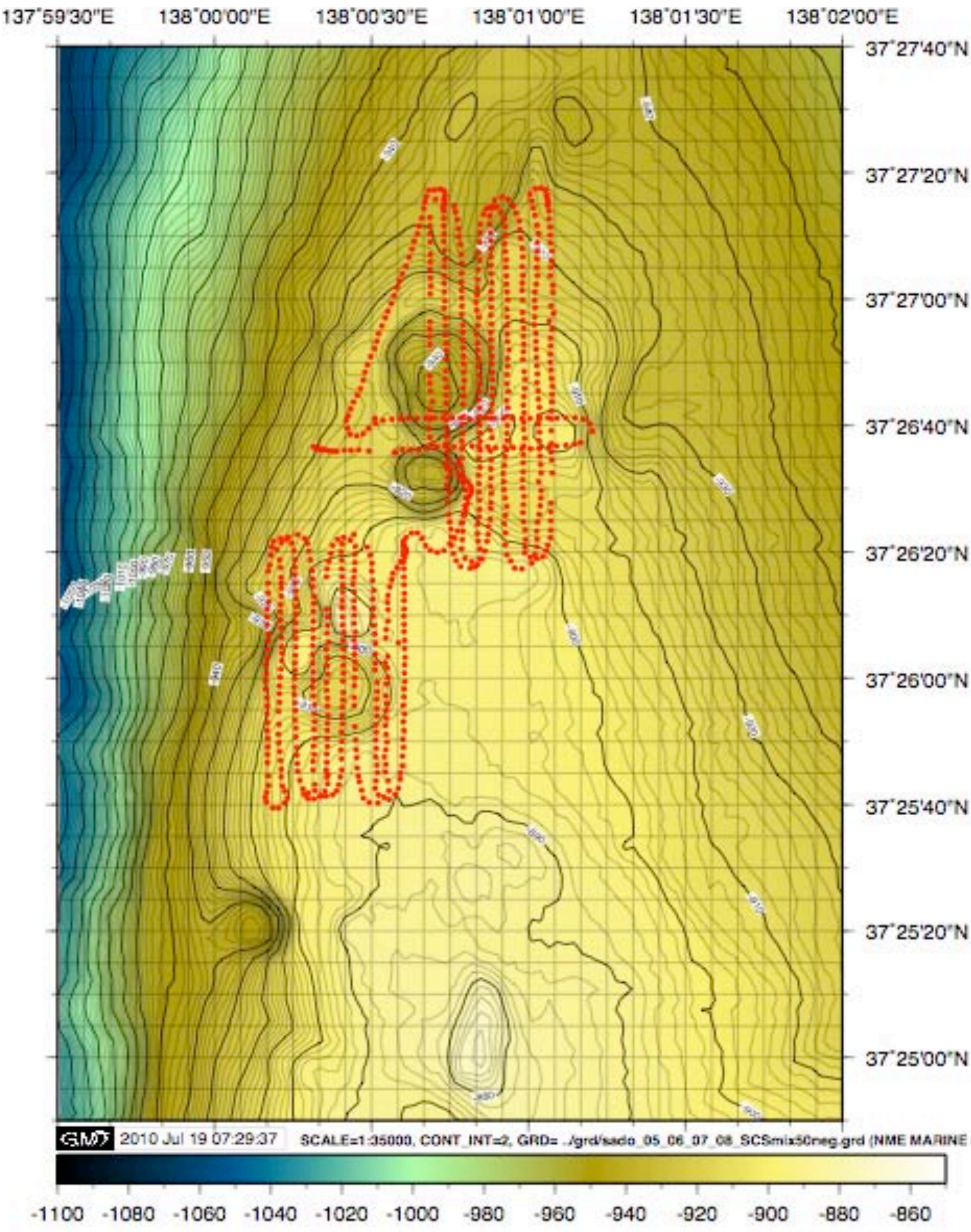

Fig. 8. SSBL track lines of AUV Urashima Dive #115 on the Umitaka spur.

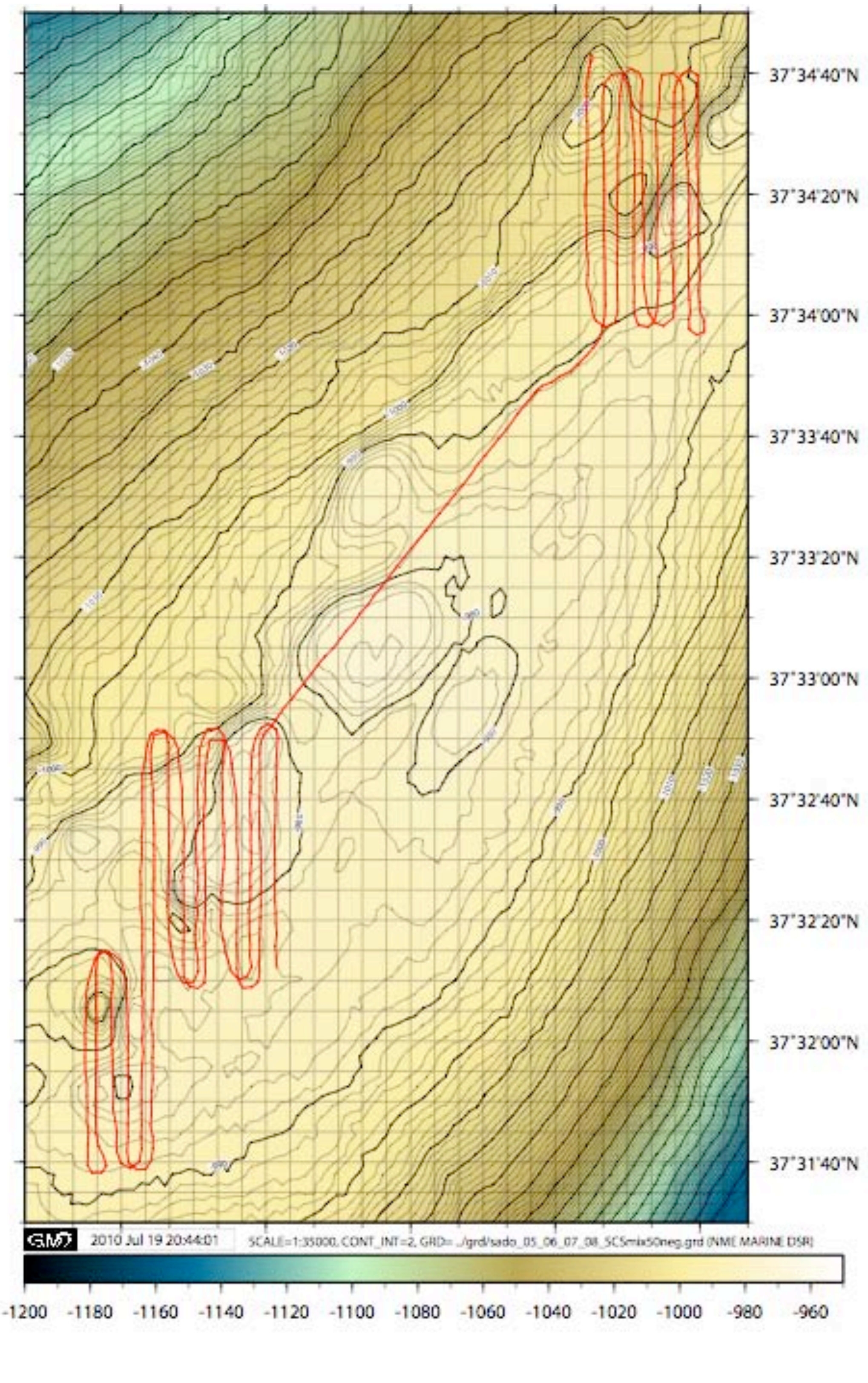

Fig. 9. SSBL track lines of AUV Urashima Dive #116 on the Joetsu knoll.

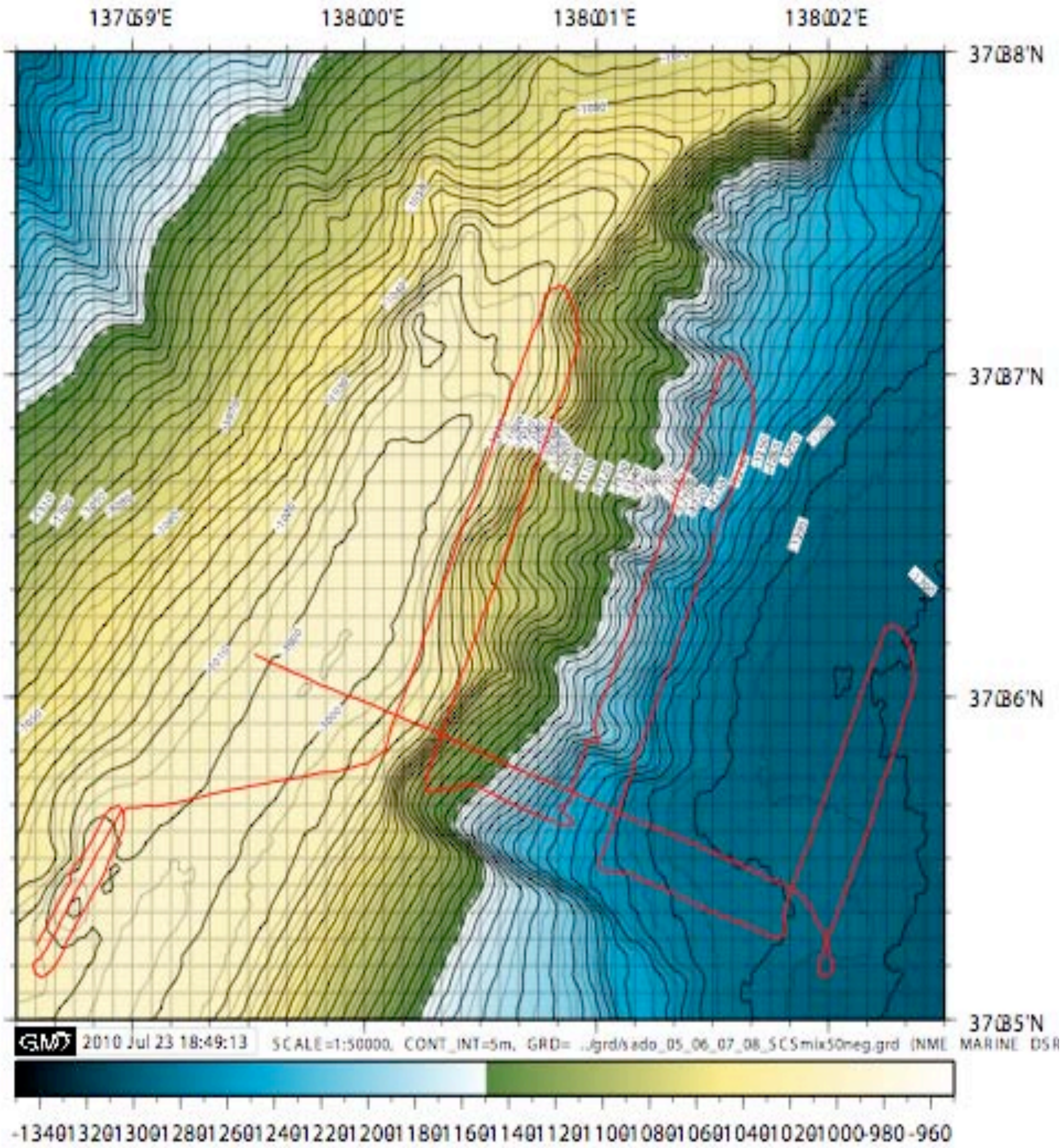

Fig. 10. SSBL track lines of AUV Urashima Dive #117 on the Joetsu knoll.

(A) MBES High Resolution Bathymetry

Gas hydrate occurs in and on mounds of the Umitaka spur and Joetsu knoll. The mounds are often observed as simple swell or oval shaped mounds. However, the Urashima MBES has revealed that most of gas hydrate mounds have central crater-like depressions with rough surface.

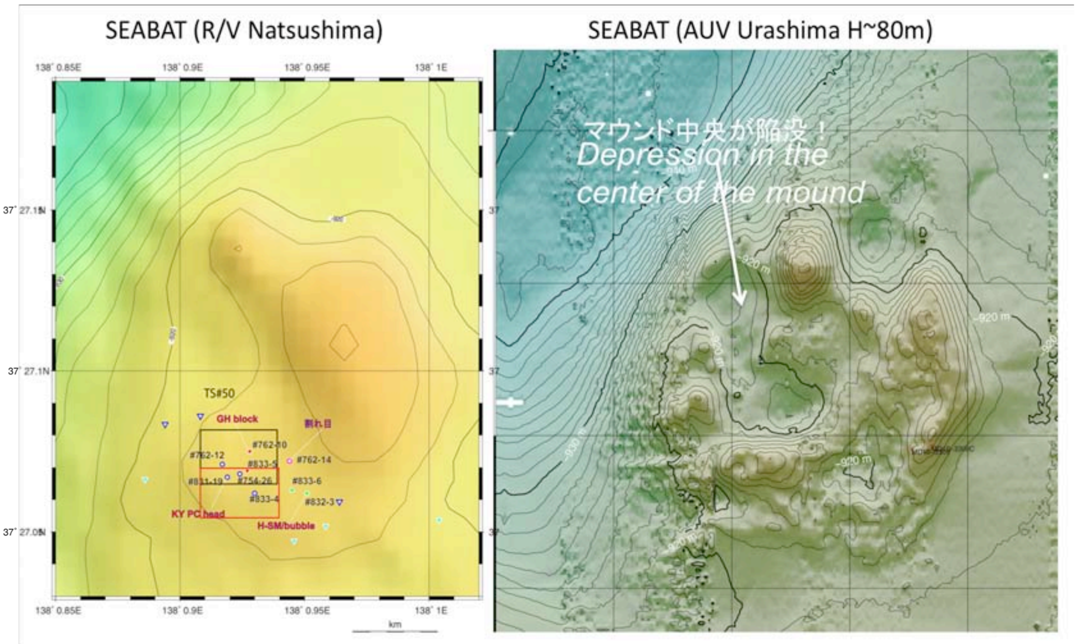

Fig. 11. MBES mapping by R/V Natsushima (left) and AUV Urashima (UT spur).

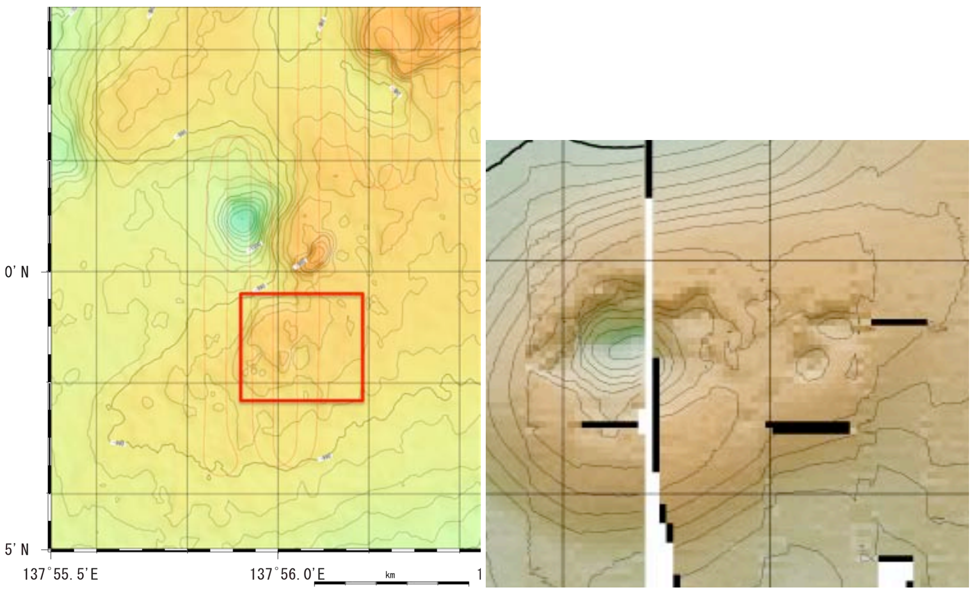

Fig. 12. MBES mapping by R/V Natsushima (left) and AUV Urashima (JE knoll).

(B) Sub-Bottom Profiles

SBP has revealed acoustic blanking structures below gas hydrate mounds and high resolution stratigraphy around the mounds. SBP penetrated about 40 mbsf. Mounds are observed as exposed/extruded hard ceiling of gas chimney structures. SBP has also revealed hidden mound under the seafloor.

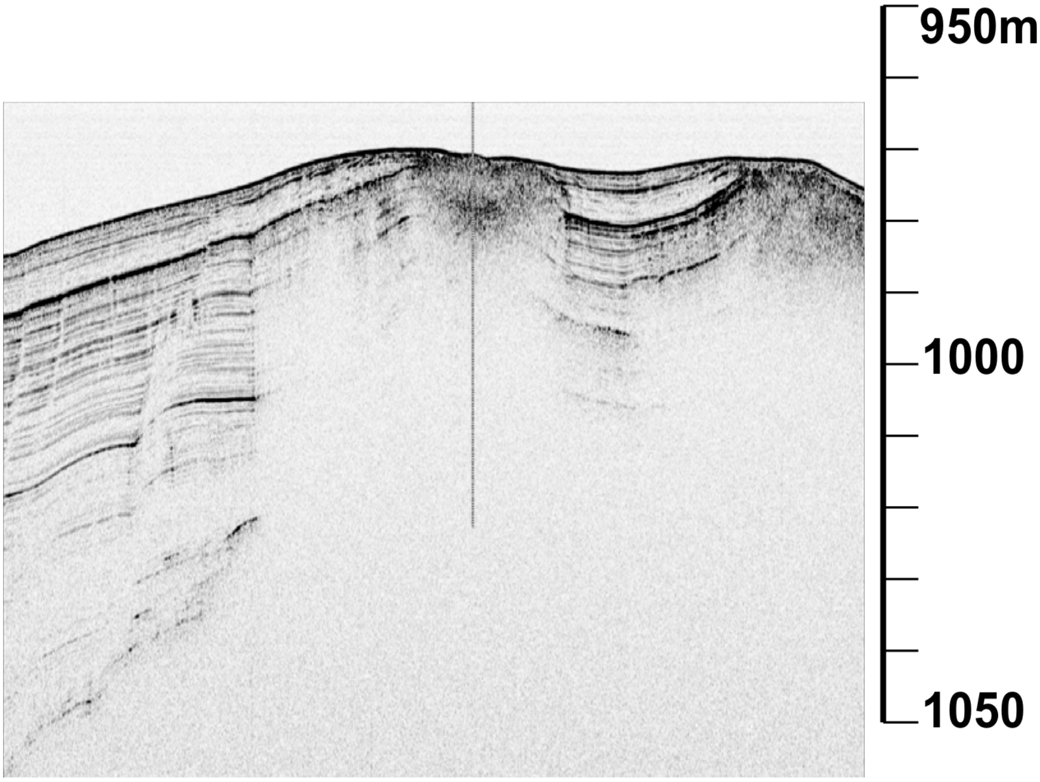

Fig. 13. SBP showing exposed gas chimneys. Gas hydrate and carbonate concretions have been recovered from the top of the mounds.

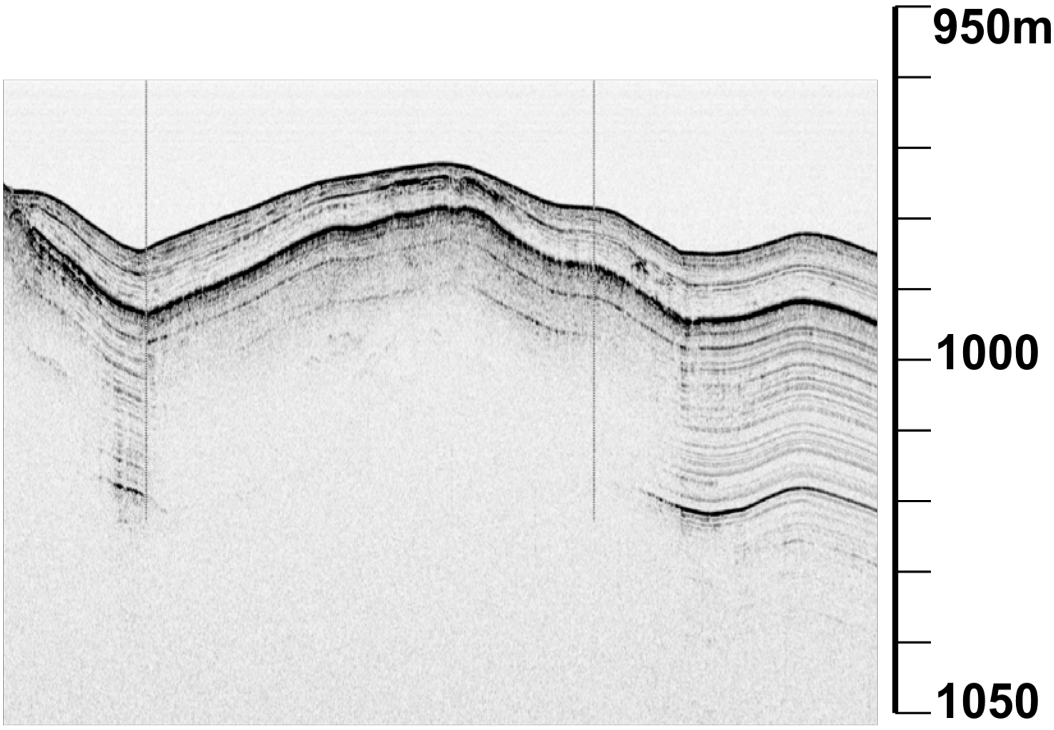

Fig. 14. SBP showing hidden mound under the seafloor. Blanking zone indicates extensve distribution of free gas while strong reflectors seem to correspond carbonate and gas hydrate mixed hard cap of gas chimney structure.

3.4.2 AUV Tuna-Sand Dives

Main objectives of the Tuna Sand Dives were to take high resolution photos of seep sites and gas hydrate exposures. According to high resolution mapping of the Urashima, 12 dives were conducted on the selected sites of the mounds. Mosaic photos have clearly revealed 3 to 6 m , circular depressions on the outer ridge of mounds. This type of depressions are considered to represent initial phase of the collapse of gas hydrate mounds. Unexpectedly, large number of snow crabs were observed on mounds, in particular, around carbonate concretions and depression areas. No crabs were found on mud flat far away from gas hydrate mounds, whereas, high concentration of crabs are common on the mounds, in particular, well developed mounds with rough surfaces. Number of crabs seems to be related with bacterial mat as well as carbonate hard-ground and seep sites.

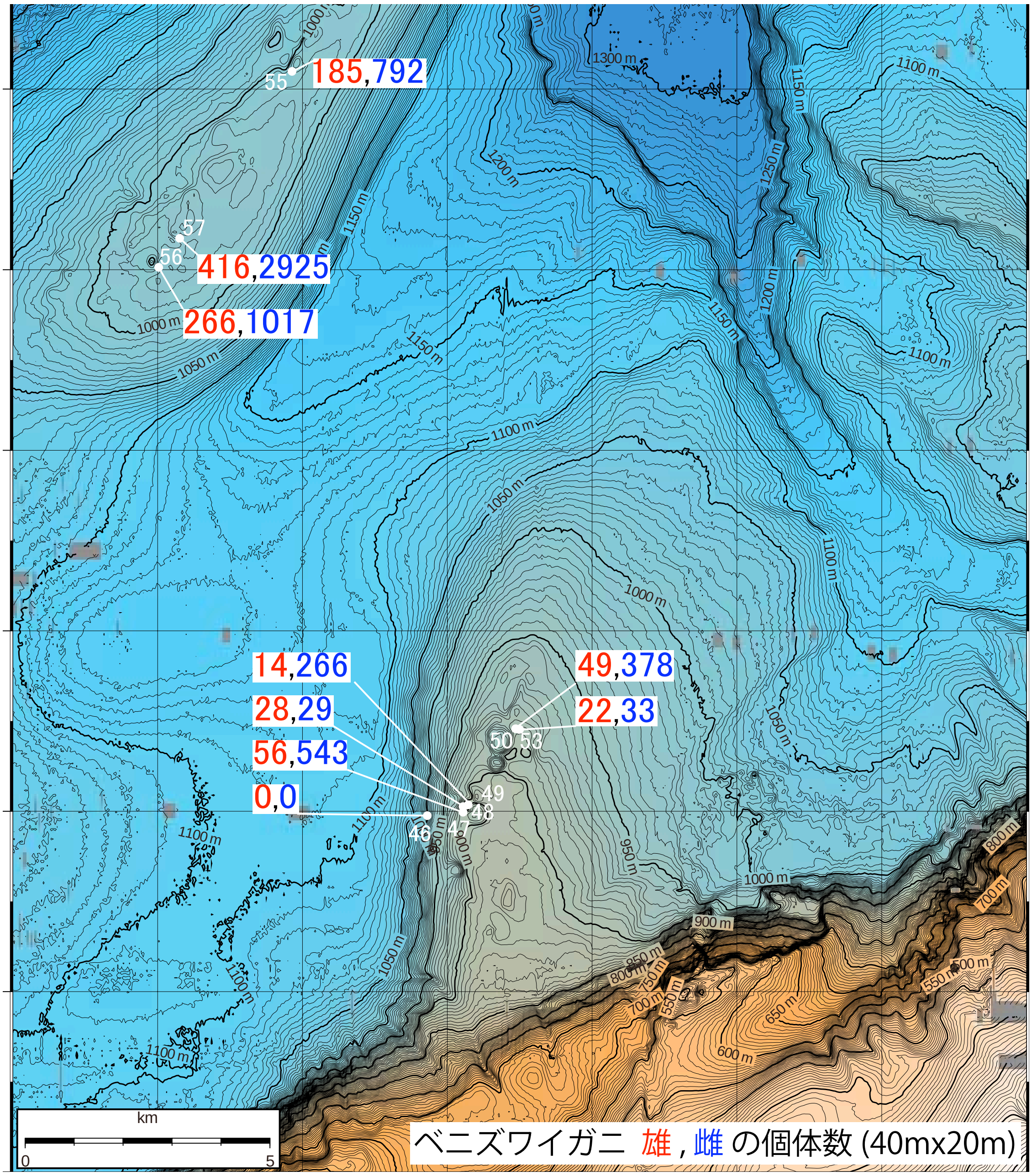

Fig. 15. Number of snow crabs in 800 m2 on and around gas hydrate mounds. No crabs were recognized at Site 46, which is more than 1 km away from active seep sites.

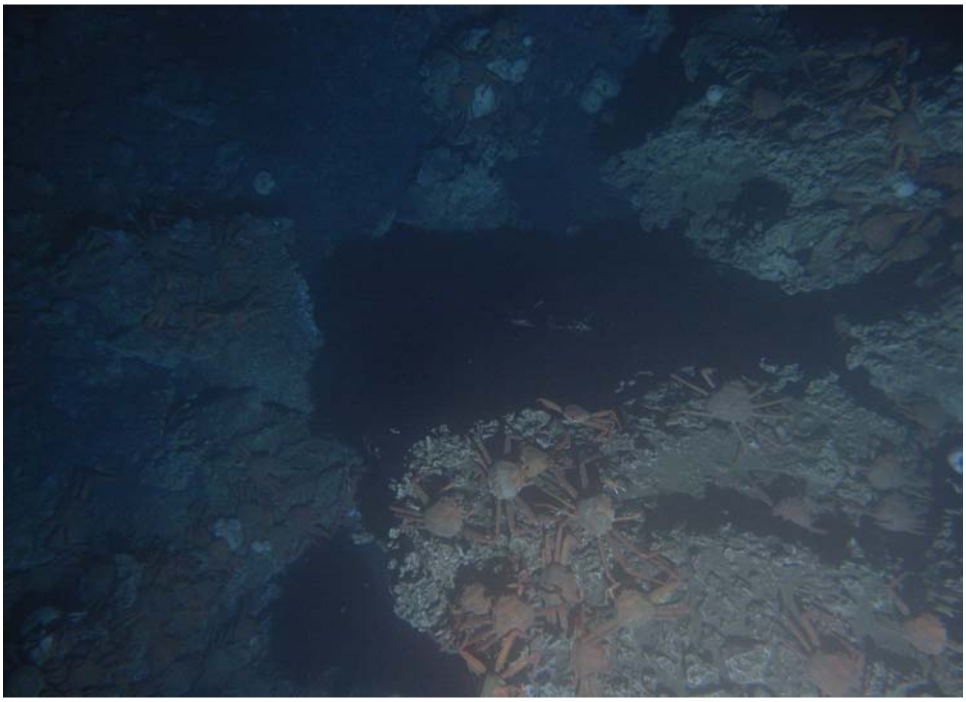

Fig. 16. Snow crabs on carbonate concretions near CH4 seep sites on the Joetsu knoll.

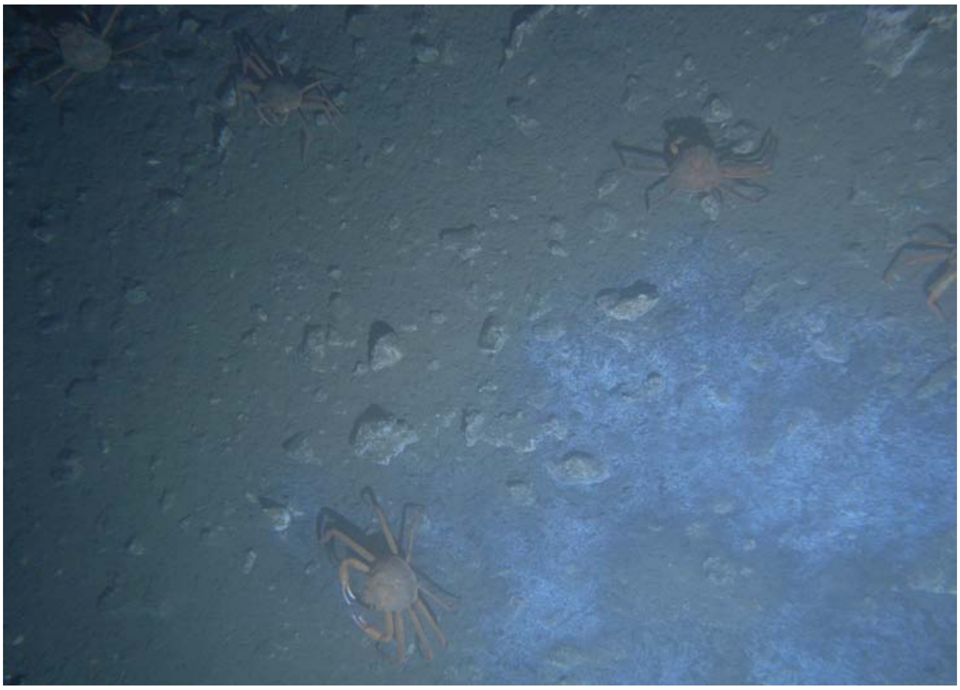

Fig. 17. Snow crabs on bacterial mat, central mound of the Umitaka spur.

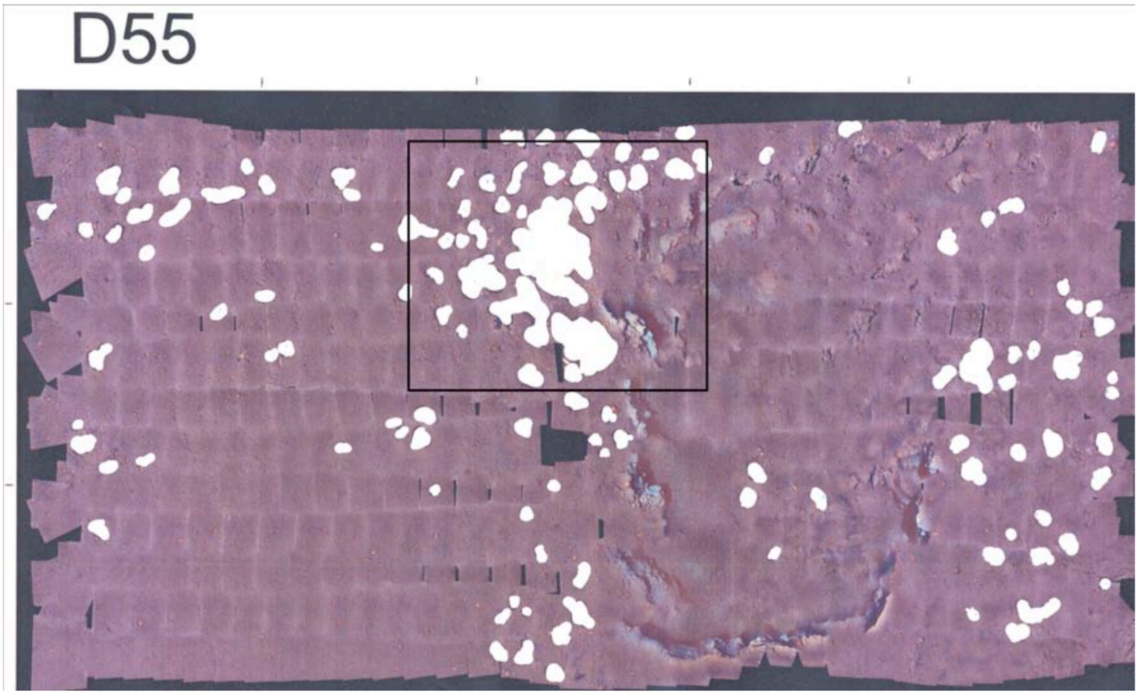

Fig. 18. Mosaic photo of gas hydrate mound on the Joetsu knoll. 10m x 20m oval shaped depression is found on the right of the survey area. White zone indicates bacterial mats.

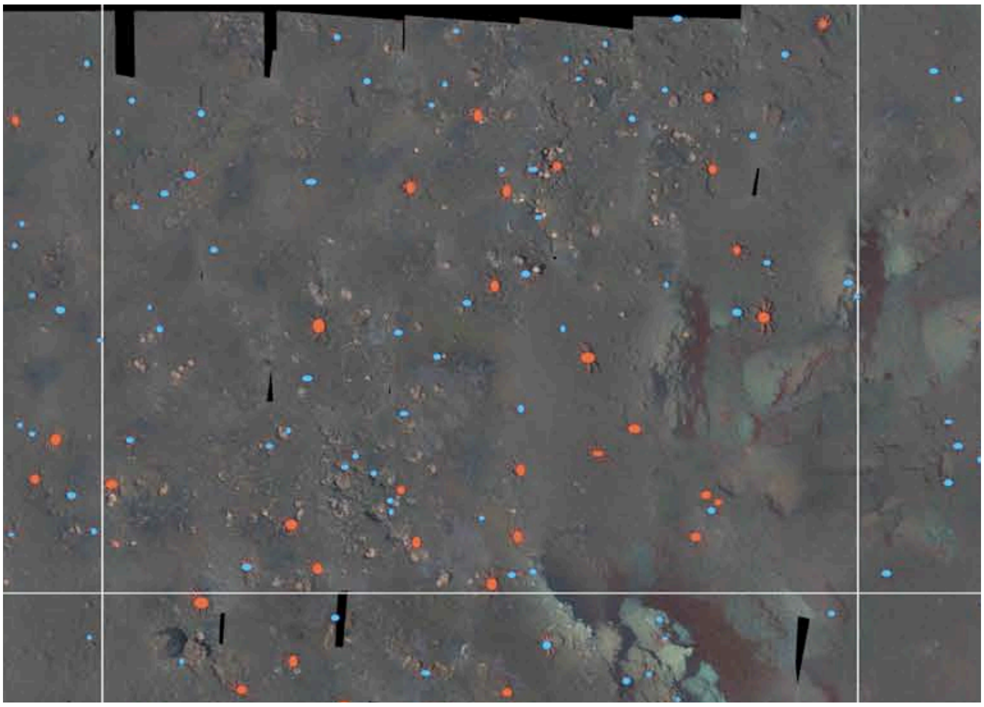

Fig. 19. Distribution of snow crab (orange dot = male, blue=female) in the upper center area of Fig. 18.

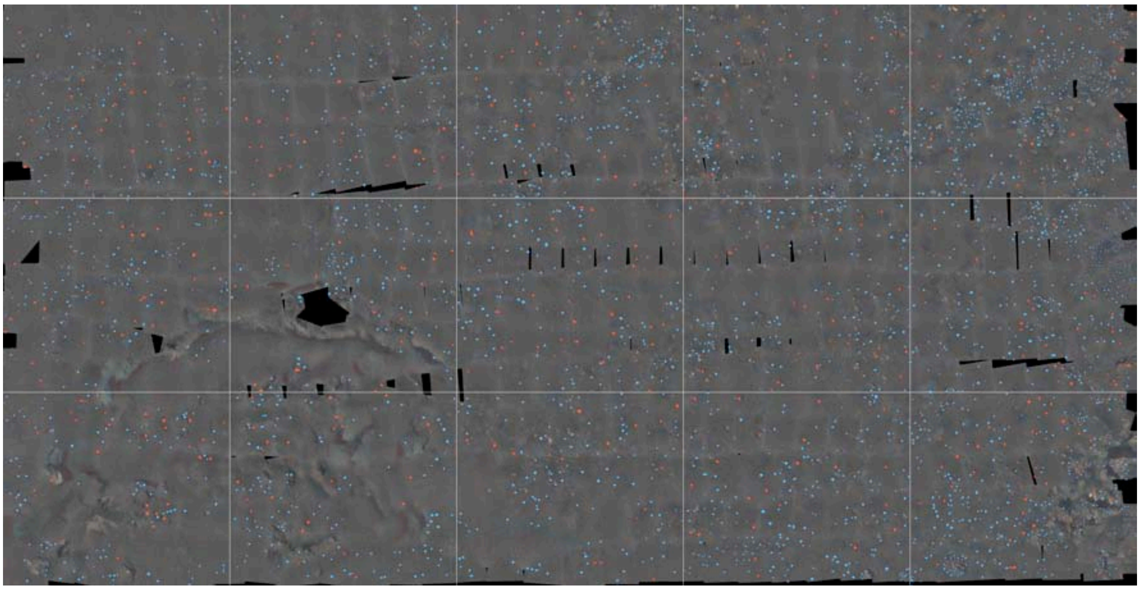

Fig. 20. Densely populated area at Site 57 on the Joetsu knoll.

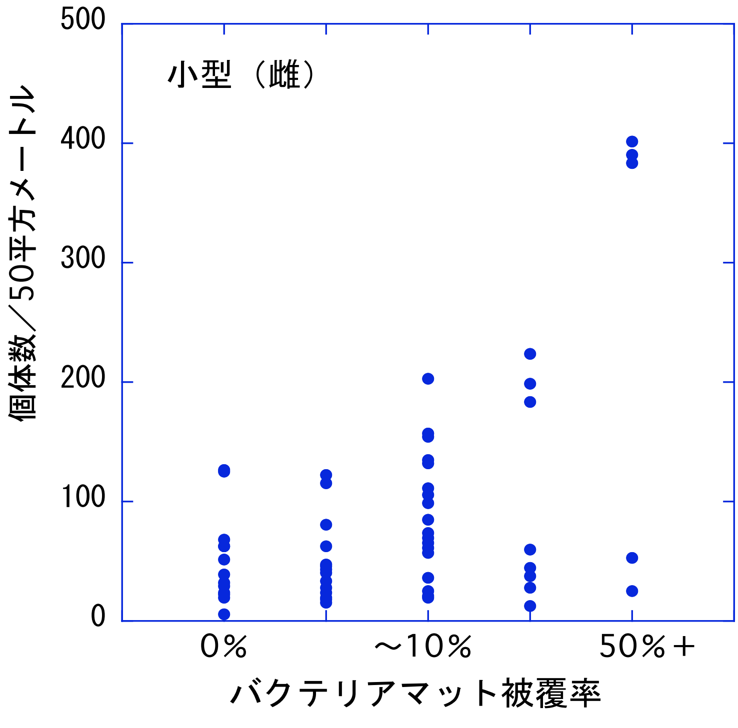

Fig. 21. Relation between the coverage of bacterial mat and number of snow crabs.

3.5 SCS survey

SCS survey has clearly indentified different history of evolution between the Umitaka spur and Joetsu knoll. Also, the profiles has revealed wide distribution of debris flow deposits. Considering the structures observed by SBP, gas chimneys are playing a critical role to carry gas and gas-bearing fluid to the surface. SCS survey lines are shown in Fig. 22.

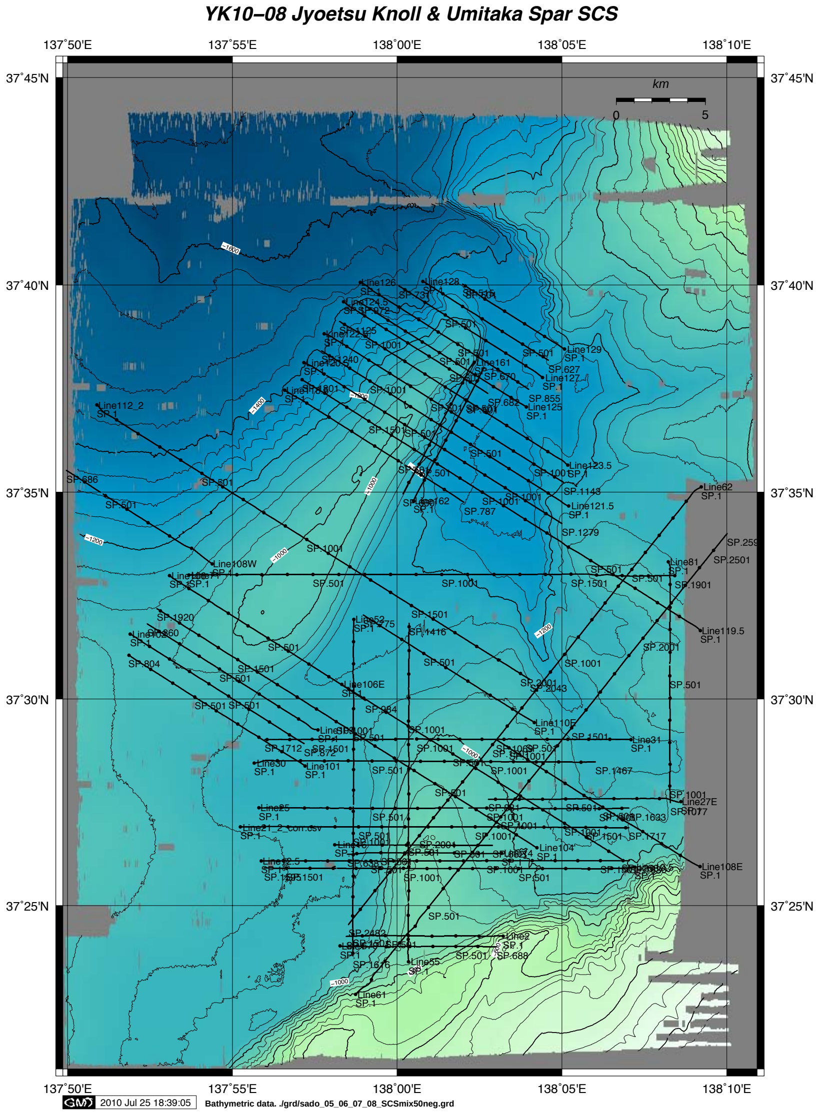

Fig. 22. SCS track lines conducted during the YK10-08 in the Joetsu basin.

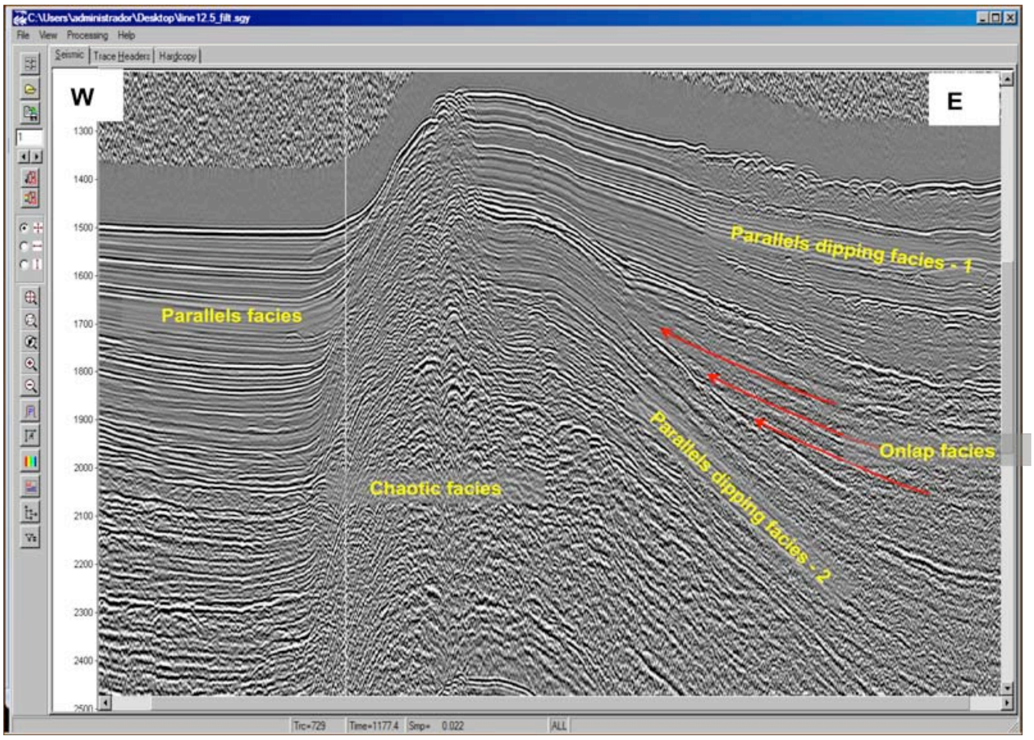

Fig. 23. W-E seismic section of the Umitaka Spur showing distinct 5 seismic facies.

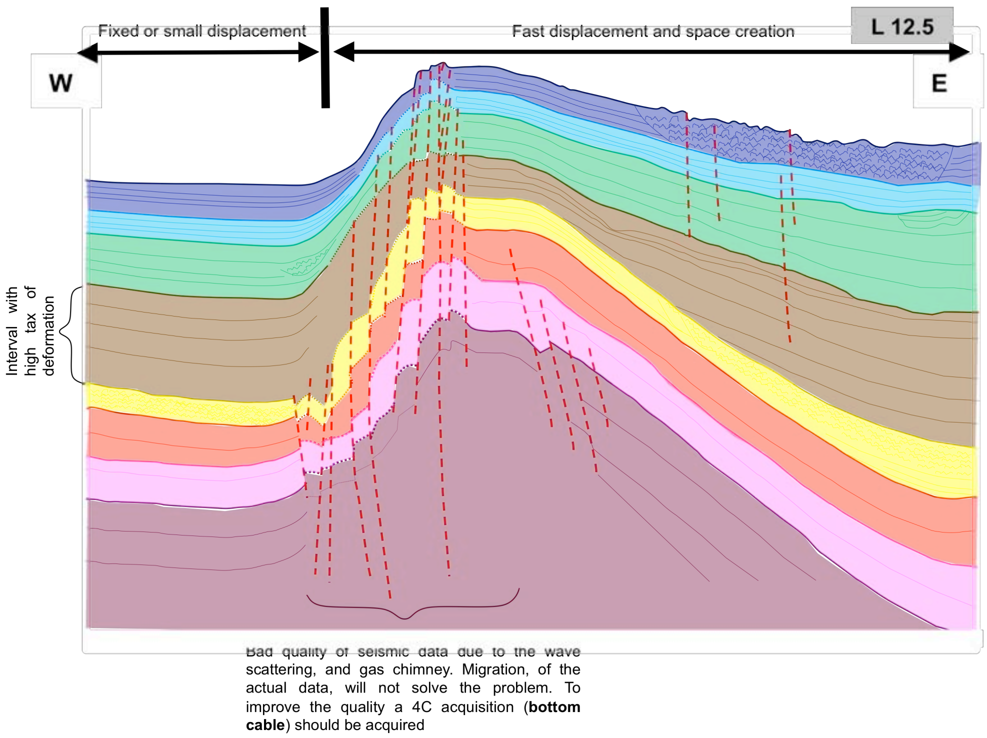

Fig. 24. Interpretation of Seismic section L12.5 (above).

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Acknowledgements

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