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KAIREI CRUISE
KR06-11
CRUISE REPORT

1st ~ 11th September, 2006

at

Southern Mariana Trough

KR06-11 Preliminary Report

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1. Introduction

1.1 Purpose of the study

Our targeted area is the southernmost part of the Mariana back-arc basin located in the west from the Guam (Figure 1-1). The Mariana area is one of the best fields in the world to study on the formation and differentiated evolution of the arctic and oceanic crusts in the back arc region and associating material circulation in convergent plate margins. In the southeastern part of the Mariana Trough area, fast-spreading ridge and associating active volcanisms and hydrothermal venting were found adjacent to the active arc volcanic zone in the decade. The previously obtained geophysical and geochemical data suggested that the history of back-arc evolution of the targeted area; the spreading started between the Mariana and West Mariana ridges as a fast spreading in the northern segments (N1 in Fig. 1-1) and amagmatic spreading in the southern segment (R), then the spreading centers jumped to the east leaving two fast spreading ridges in the center of the trough (N2 and S2). The spreading ridges jumped again to the east and the remnant spreading ridges were left in the eastern part adjacent to the arc volcanic zone (N3 and S4). New segments of the spreading ridge would be formed on the extent of the southern spreading ridge segment (S5) and also in the southern end of the basin (W1, W2 and W3). This cruise is planed to verify our hypothesis.

The objectives and the tusks during the cruise are as follows.

1. The volcanic rocks will be dredged from the presumed old spreading and arc volcanic ridges.
2. Detailed bathymetric survey will be done on the western half of the Mariana Trough shown in Figure 1-1. The obtained map will be used for the accurate interpretation of the back-arc basin history.

1.2 Background

Study on the Mariana Trough has long history, and it started in the late 1960's. The Mariana Trough is located on the southeastern edge of the Philippine Sea, and it is an active backarc basin formed in association with the subduction of Pacific plate beneath the Mariana arc. The early study was targeted on the middle part of the trough around 18°N, where the backarc is most extended. Second stage of the study moved to the northern part at 20~22°N, where the Mariana active arc and West Mariana remnant arc converge to extent to the Izu-Ogasawara arc. Southern part of Mariana Trough has not been systematically studied until 1990's except a few studies mainly along the ocean floor cable lines. It is because the bottom of the southern part of the trough, south from 14°N, is 1000m shallower than the other area of the trough, and it was thought to be magmatically inactive.　Thus, the area has been actively studied since 1990's.

The scientific cruises held in this area by the research vessels belonging to JAMSTEC is as follows; YK05-09 Leg 2/ KR03-11/ KR00-09 Leg 2/ YK99-11/ YK93-03/ YK92-05.

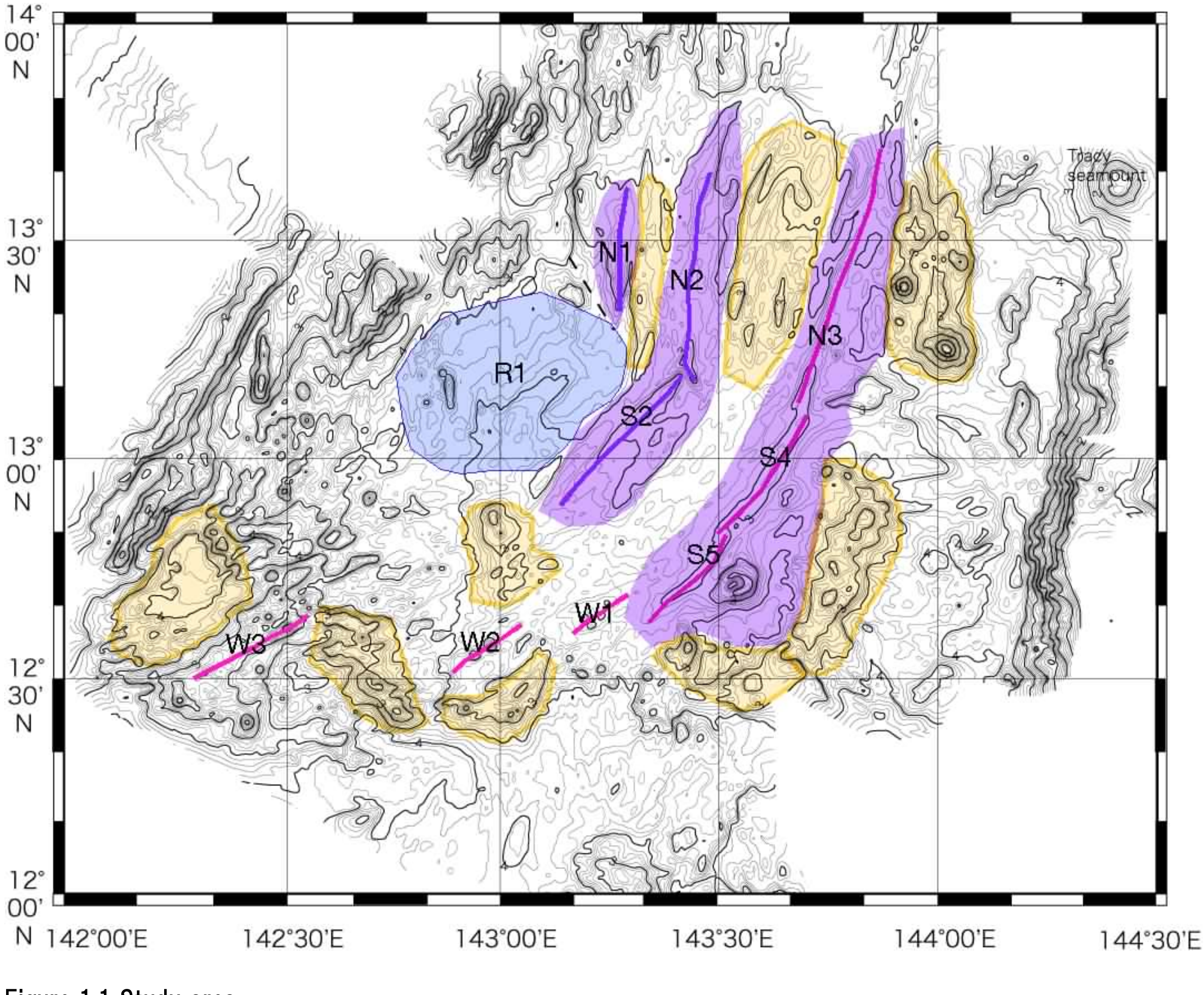


Figure 1.1 Study area

2 Results

2.1 Dredge

2.1.1 Site description

The selection of dredge sites followed the prime directives outlined in the expedition proposal. As additional detailed bathymetry and sidescan sonar data became available, slight modification of the originally proposed sites was done in order to increase the probability of achieving the research objectives. The general strategy for site selection was to sample the steepest slope up to the apex of a selected seamount or mound, while considering morphological evidence as to where outcrops may occur. Additionally, locations were added or omitted due to time constraints or difficulties in recovering samples from particularly resistive surfaces. Both proposed and achieved dredge sites are presented (Figure 2.1.1.1) in order to highlight the site selection strategy and display possible targets for future expeditions.

Sites 1 and two were proposed as the locations of the oldest spreading axis and adjacent rifted arc material respectively. This spreading segment is referred to as N1 in the initial proposal (hereafter IP-N1). Sites 3 and 5 were located along the next oldest presumed spreading center IP-N2, with Site 5 sampling a larger seamount at an apparent triple-junction. Site 4 was proposed to sample the adjacent rifted volcanic arc, but was omitted due to lack of time. Sites 6 and 7 were proposed to sample the southern extension of IP-N2, a relict spreading ridge referred to as IP-S2, but we were only able to sample at Site 6. Site 14, also not sampled due to time limitations, is of interest because it may contain older volcanic arc material that now lies between the remnant spreading center and the currently active system.

The next group of dredge sites represent young and possibly active volcanic complexes from the arc and backarc systems. Sites 12 and 13 lie at the southernmost tip of the known volcanically active backarc (IP-S5). Evidence from sidescan sonar imaging suggests that Site 12, in particular, may be the location of a hydrothermal mound or recent volcanic activity. Site 13 is a larger feature that could be composed of fresh backarc volcanic material, but was not sampled on this expedition. Sites 10 and 11 were initially proposed to sample a small segment of the predicted current backarc spreading axis, IP-W1. Sampling at the summits of the two conical features proved challenging, so an additional site, 22, was added along the flank of the seamount at Site 11. This dredge produced a large volume of fresh volcanic material and so sites 23 and 24 were added on the adjoining seamounts to thoroughly investigate the history of this rift segment. Sites 8 and 9 were two small seamounts located along another short hypothetical spreading axis, IP-W2.

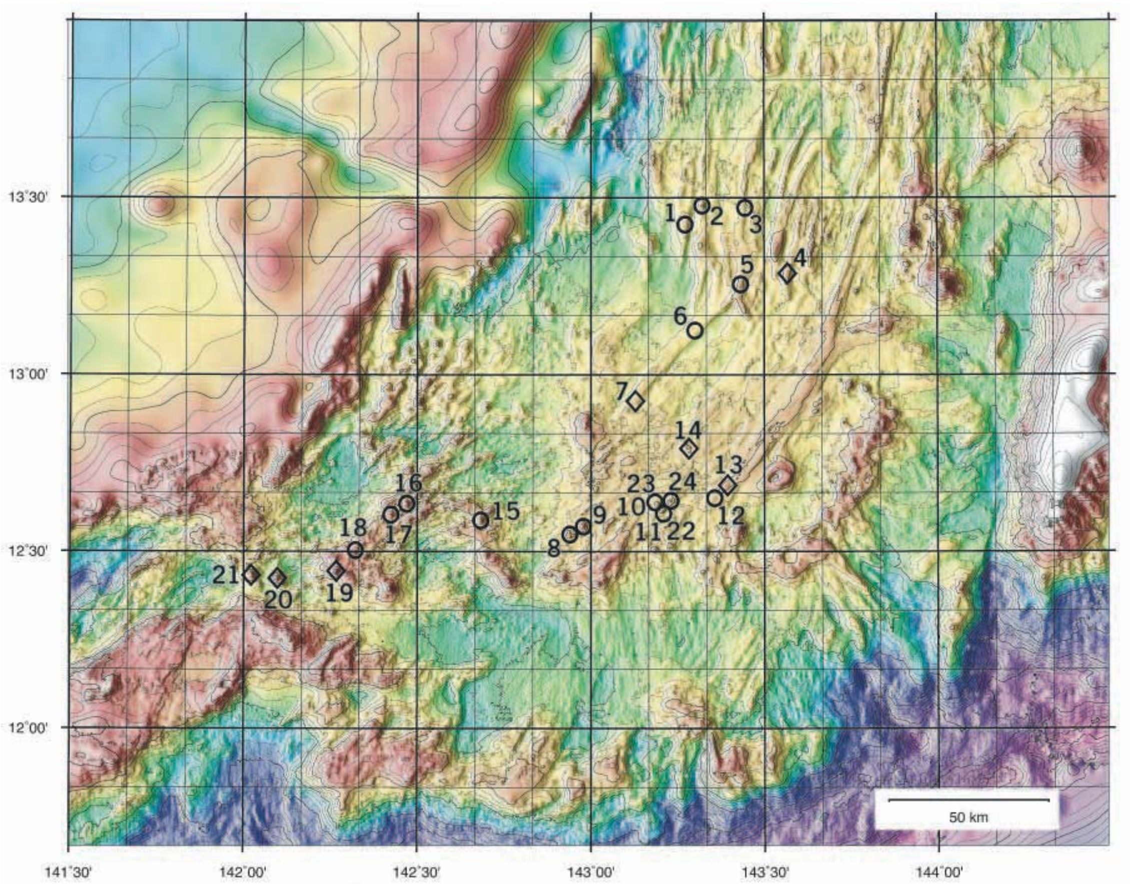


Figure 2.1.1.1 Locations of prospective (diamonds) and completed (circles) dredge sites. Contours every 250m

The final group of dredging targets were located along the axis of the westernmost theoretically active backarc spreading fabric, as well as two volcanic cones to the southwest, and one to the east. Site 15 was situated in the northern extent of a transitional zone between IP-W2 and IP-W3. Because of the seamount's proximity to IP-W3, high backscatter, and extreme conical morphology, its origin as a recently active arc volcano was highly speculative and deserved investigation. Sites 16, 17 and 18 were selected to comprehensively sample this large area of spreading fabric and to look for temporal and compositional trends along stike of the axis. Sites 19, 20 and 21 were omitted from the cruise itinerary due to time considerations (Site 19) and because of possible political complications of sampling outside of the U.S. EEZ (sites 20 and 21). Fortunately, Dr. P. Fryer (University of Hawaii) has previously sampled at sites 19 and 21 and has offered to collaborate on the future analysis of the sample collection.

For a detailed view of the site bathymetry and dredge tracks, please refer to Appendix E.

2-1-2-1 Sample description

Rocks

aphyric basalt

Aphyric glassy basalts are dredged at D01, D02, D03, D05, D06, where are located at spreading ridge in northern part in this survey. These are blocks from ropy lava surface, where quenched glassy rim (5-10mm thick) are usually covered by loosely aggregated Mn crust. The lavas contain abundant minute cavities (< 10%).

porphyritic basalt

Plagioclase and olivine phenocrysts are contained in basalts from D06, D10, D22, D23, D09, D08, D15, D16, D17, D18, D12 and D24.

Basalt from D12, where is located at the southern end of the northeastern ridge in this survey, is very fresh, and has lustrous quenched glass rim (5-8mm thick) and fresh and compact inner part. It contains plagioclase (<5mm, <3%) and a small amount of olivine (<1mm) phenocrysts. On the contrary, quenched glass (<1cm thick) from basalt from D24, which contains sparse olivine and plagioclase phenocrysts, has partly altered to thin gray colored layers of clay(?) minerals (<3mm thick).

Basalts from the southeastern part in this survey, are commonly porphyritic. Amounts of phenocrysts range from less than 5% (D10, D22) to more than 10% (D09).

The largest plagioclase phenocrysts (5-9mm in length) are contained in D15, D16, D17. Basalts at D18, D23 are abundant olivine (<<1mm) phenocrysts. Most of samples are from parts of lava surface with quenched glassy rim. Some of them are large blocks (20-<40cm in length) from large pillows of lava with cooling joints (>20cm in length) developing perpendicular to quenched glassy rim (D08, D22, D23-01, -04). The rind of quenched glass rim is sometimes brown colored by weathering. Some of D23 has fresh quenched glassy rim (D23-02, 03, 05, 06, 07).

others

A fragment of rounded fresh white pumice is dredged at D05 (sp D05-010).

D06-004 basalt contains phenocryst of augite (?) and abundant (3%) long prismatic plagioclase.

Sample D01-03 is a group of small balls (3-5 cm in diameter) composed of loosely aggregated Mn particles.

2-1-2-2. Characteristics of sediment samples

Sept. 5th.

D01-S001

Brown-colored mud was recovered from this site. This mud probably deposited on the flat area at the foot of the surveyed peak. Foraminifera sand and Mn-oxide blocks were mixed with mud samples. Notable feature of the S001 is a unique occurrence of spherical nodules. The diameters of nodules are uniform ranging from ca. 3 to 4 cm. These nodules are most likely composed of fragments (a few mm in size) of Mn oxides cemented by carbonate.

D02-S001

Large quantities of light brown colored lime mud were recovered from this site. Lime mud was coated by a black Mn-oxide layer which thickness is ranging from 1 to 3 cm. Mn-oxide layers are fragile and porous.

Sept. 6th

D05-S001

Small amount of foraminifera sand was recovered. This will be used to identify foraminifera species. Volcanic rocks were extensively altered probably right after the eruption. Red-orange nontronite are common in these altered part.

Sept.7th

D09-S001

Only small quantity of sediments was recovered from this site. This sample consists of brown color pelagic sediment with a portion of foraminifera sands. This foraminifera will be used for age constrain.

D08-S001

Foraminifera sand, mixed with pelagic components, was attached on the pillow lavas.

Sept. 8th

D15-S001

Small foraminifera sand was attached on the surface of collected rocks.

Sept. 9th

D18-S001

Foraminifera sand, mixed with pelagic components, was attached on the pillow lavas.

2-2.Bathymetry Survey

Bathymetric data were collected by the SEA BEAM 2112 (Sea Beam Instruments, USA) multi-beam system. The SEA BEAM 2112 is a survey system which makes wide-swath counter maps and backscattering data.

The system operates under condition of up to 7.5 degrees of pitch and 20 degrees roll. Positioning of depths data on the seafloor is based on GPS and ship motion input from the vertical reference unit (VRU). The VRU supplies digital roll, pitch, and digitally filtered heave data to the receiver of the SEA BEAM 2112.

The obtained raw data includes data records of each ping (bathymetry, backscattering, position, nautical information, and correction parameters such as sound velocity profile.

Table. 2-2 SEA BEAM 2112.004

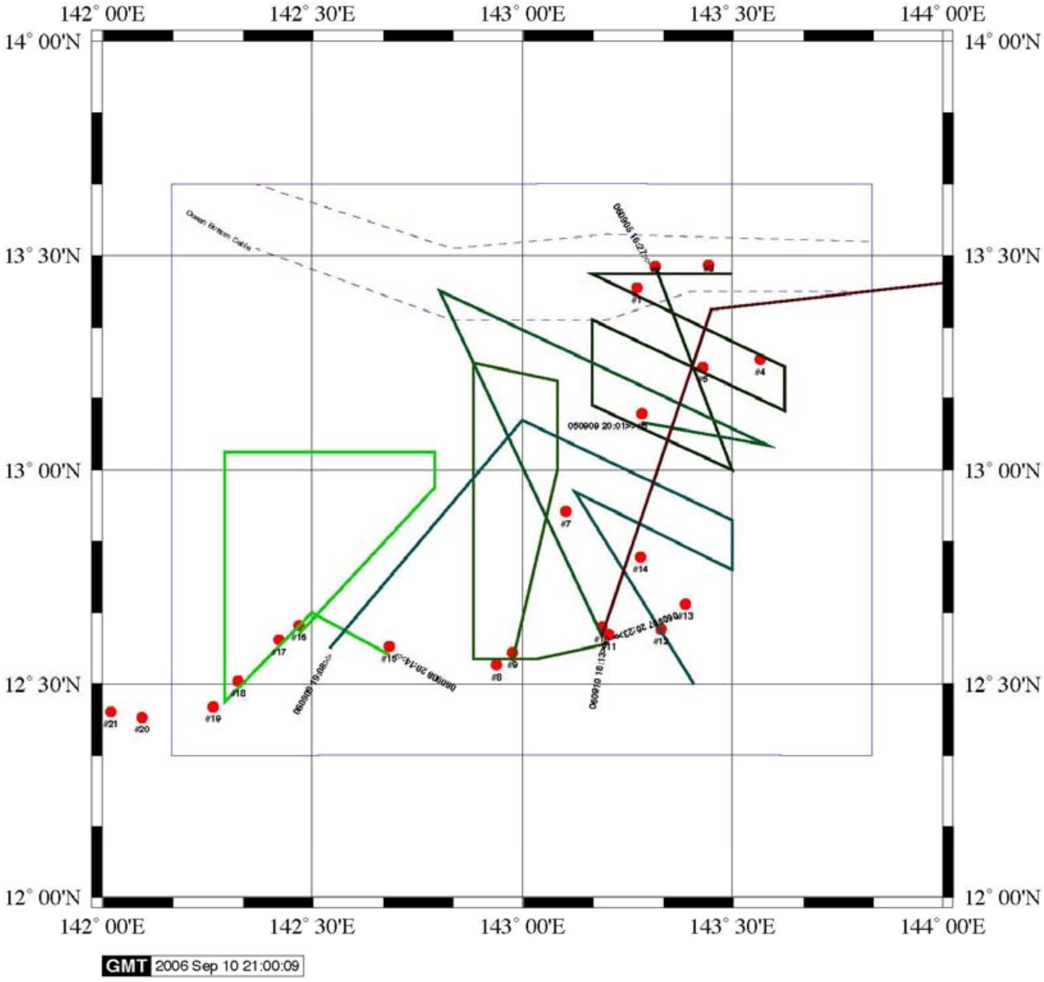
Bathymetry and backscattering	frequency : 12 kHz detecting depth : 50 - 11,000m beam angle : 2 x 2 degrees (fore/after) beam number : 151 (interval 1 degree) swath width : 120 degrees (50 - 4500m), 90 degrees (4500 – 11000m) accuracy : -0.5% of water depth
Sub-bottom profiler	frequency : 4 kHz /chirp

2-2. Bathymetry survey

2-2-1. Survey Lines

Bathymetric survey was carried out during the night time from 5th Sep. to 10th Sep. 2006. About 732 nautical miles of bathymetric survey were completed. See Figure 2-2-1 as the track lines and Table 2-2-1 as list of the survey lines.

Figure 2-2-1. KR06-11 Batymetric Survey Lines



2.2.2 Summary of Bathymetry Mapping

Seafloor surveying of the Southern Mariana Trough during the course of this expedition focused on filling holes in and complimenting existing data sets. The Mariana trench, forearc, and active backarc region had previously been surveyed in great detail; however scant data existed for the westernmost portions within areas of previous volcanic and tectonic activity. Therefore, extensive nightly surveys attempted to thoroughly map remnants of previous volcanic arc formation and rifting events related to the formation of the Southern Mariana Trough (Figure 2.2.1). In addition to satisfying this overall mapping objective each dredge site was mapped prior to dredging, thus enabling precision guidance of the dredge for pinpoint selection of sample targets (Appendix. E).

3. Discussion

We proposed the hypothesis concerned with the history of backarc spreading in the southern Mariana Trough described in Introduction. We have to wait to argue the hypothesis precisely until laboratory works will be improved, however, we will give the perspectives of the results.

3.1. Magmatism of the center of trough

We could obtain the rocks only from the presumed back arc spreading ridges in the center of the trough except one (site #2). The rocks from Site #1 seemed to be older than the rocks from the Sites #3, 5 and 6, implying that the spreading ridge jumped toward east. Among the rocks from Sites #3, 5 and 6, where the presumed spreading center on the middle part of the southern Mariana Trough, those from #5 looked most fresh. This site is on the triple junction of the ridge and the shallowest among those three sites. Thus, the spreading volcanism would terminate earlier in the Sites #3 and 6 than in Site #5. The shallowest peak means the largest volume of the produced magma, implying the most active volcanism among this spreading ridge.

3.2. Diffusive and migrating rifting in the southern end of the trough

The southern end of Mariana Trough is located at about 12°30’N, where rifting is presumed to occur in the arc crust. We dredged rocks from three presumed rift zones (Sites #16, 17 and 18; Sites 9 and 10; Sites #10, 11, 23, and 24 from west to east), a remnant arc (#15) and southern tip of the presently active spreading ridge ((#12). All rocks from the presumed rift zones contain much amount of phenocryst, plagioclase and/or olivine. Thus, the magma chamber must be present beneath each seamounts. It means that the volcanic activity along those rift zones is similar to those of slow spreading center.

Among the rocks from the same presumed rift zone, the rocks seemed to become younger toward south. Comparing the rocks from the three rift zones, those become younger toward east. Also, the freshest rocks were recovered from the southern tip of the presently active spreading ridge (Site #12). Those observation facts imply that the rifting has migrated toward south, and rifting zone jumped toward east before terminating the volcanic activity. Volcanic activities of northern part of each rift zone is inactive at present, however, those of southern end would be still active at the three rift zones.

4. Future studies

4.1 Future Studies proposed by OCU (Osaka City University)

1 In order to discuss the history of tectonics and magmatism associating with backarc basin spreading in the southern part of Mariana Trough, we will analyze the fresh volcanic rocks including quenched glass rim and sediments for the following compositions.

Optical observation of thin sections:

Major and minor compositions of bulk rocks, quenched glass and phenocrysts: XRF, EPMA, SEM-AES

Isotope analyses of quenched glass (Rb, Sr, Nd, Sm, Pb): Collaborating with Dr. Y. Tatsumi.

Age determination of the volcanic rocks (bulk rocks and phenocrysts) by K-Ar (and if possible Ar-Ar): AAS (for K) and gas masspectrometer, collaborating with Prof. J. Matsuda, Osaka University.

Age determination of the volcanic rocks (bulk rocks and phenocrysts) by U-Th decay series elements by neutron activation method: Collaborating with T. Noguchi.

Age determination of foraminifera in the sediment:

2 Mineralogical study on the altered glass will be done for observing the clay mineral formation process using XRF and TEM.

4.2 Future studies at Tohoku University

(1) Concentration and isotope analyses of volatile elements

Many lava samples collected from this cruise contain abundant vesicles. This suggests the high concentrations of volatiles in the original magma. Concentrations of volatile elements and their isotope compositions are highly likely reflecting source conditions of magma. In addition, it may be possible to distinguish back-arc type magma from arc-like magma using the volatile geochemical data, because arc-like magma may have more contribution from subduction slabs containing more volatile elements.

In particular in this study, sulfur (hydrogen sulfide) and carbon (carbon dioxide) are major targets for analyses in addition to hydrogen and nitrogen species. These volatiles are often trapped and preserved in volcanic glasses. Concentrations of hydrogen sulfide and carbon dioxide will be determined on roughly crushed glass samples using elemental analyzer (approximately 30 mg for each; Carlo Elba EA1800). Analyses of hydrogen and nitrogen concentrations will be attempted by the same method: note that the hydrogen and nitrogen concentrations in the examined samples are not likely below the detection limit.

4.3 Future studies at UH

The studies conducted at University of Hawaii will focus upon the chemical composition of the glassy portions of the rock samples. This will be done in order to constrain the magmatic sources of the sampled extrusives. Initially, electron microprobe analysis of the major and minor elements in glass sections of the rocks will be done. Elements analyzed will include Si, Fe, Mg, Ca, Na, Al, and Ti. The variability of Ti in the samples will be used as an initial estimate of the degree of alteration in the glasses for sample selection.

Subsequent trace element analyses of the glasses will be conducted by LASER ablation high-resolution inductively-coupled-plasma mass-spectrometer (LA-HR-ICP-MS) at the University of Hawaii. The analysis system comprises a New Wave 213 nm UV laser coupled with a Finaggin Element2 HR-ICP-MS. Elements analyzed by this method will include Sr, Rb, Y, Zr, Nb, Cs, Ba, REE, Hf, Ta, Pb, Th, and U.

The results of these analyses will be compiled with those done by Masuda et al. in order to accurately describing the past and present mass transfers between the subducting slab, volcanic arc, backarc, and the underlying mantle components. Additional analysis of the long-lived Sr, Nd, and Pb isotopes may be conducted at UH by ion microprobe analyses in order to detail mantle dynamics beneath the southern Mariana arc and backarc system.

KR06-11 D01								
date	9月5日							
sample No	size(cm)	sample description	remarks	distribution				
S001				TH,OCU				
001	20×16×5	basalt breccia covered by Mn with 8mm thick, ellipsoidal cavity<5% max10mm	glassy	distribution				
002	12×19×5	irregular shaped basalt, aa cavity rich(10%) max 20mm, basalt	glassy,fluidal surface	UH,OCU,JAM	TH	OCU	JAM	
003	ϕ1.5〜4	ball (loosely aggregated of Mn particles)		TH,OCU,JAM				
004	12×18×5	basalt breccia coated by Mn with 3mm thick, elongate cavity<3% max15mm	glassy	UH,OCU				
005	2×2〜5×5	Mn conting rock fragments		UH,OCU,JAM				
006	1×1	Mn conting rock fragments		UH				
D02								
date	9月5日							
sample No	size(cm)	sample description	remarks	distribution				
S001				TH,OCU				
001	5×9×3	basalt, breccia, glassy rim<10mm, aa cavity(10%)<5mm		UH,OCU				
002	3×3×2	basalt, breccia, glassy rim<5mm, aa cavity(5%)<0.5mm		UH,OCU				
003	3×4×3	basalt, breccia, glassy rim<8mm, aa cavity(5%)<0.1mm		UH,OCU				
004		max20cm, a lot of Mn aggregates		UH,TH,OCU,JAM				
005	5×4×2	basalt, breccia without glass rim, Mn coated		OCU,JAM				
006	2×2×2	basalt, breccia with glass part, Mn coated		OCU				
D03								
date	9月6日							
sample No	size(cm)	sample description	remarks	distribution				
001	12×10×8	basalt, breccia, cavity, 10mm Mn coated	partly glass rim	UH,TH,OCU,JAM				
002	10×12×6	basalt, breccia, aa cavity<10%(average1mm max10mm), 10mm Mn coated	no glass	UH,TH,OCU,JAM				
003	5×5×5	basalt, breccia, cavity<10%(average3mm max5mm), 10mm Mn coated		OCU				
004	5×5×5	basalt, breccia, cavity<10%(average2mm max3mm), 8mm Mn coated		OCU				
005		basalt, breccia, aa cavity<1mm, 5〜8mm Mn coated		TH,OCU				
D05								
date	9月6日							
sample No	size(cm)	sample description	remarks	distribution				
S001				TH,OCU				
001	40×25×13	salt ,block of ropy lava surface (ex.ϕ40mm(with ϕ15mm hollow), 10mm thick Mn co	glassy	UH,OCU				
002	20×11×7	asalt, cavity(average1mm, max8mm), shrinked lava surface part, 5mm thick Mn cote	glassy rim	OCU,JAM				
003	20×14×9	basalt, cavity(average1mm max8mm), shrinked lava surface part, 5mm Mn coted	glassy rim	TH,OCU				
004	18×14×8	basalt shrinked lava surface part, 5mm Mn coted	glassy rim	TH,OCU,JAM				
005	14×12×9	basalt, aa cavity(average1mm max10mm), shrinked lava surface, 5mm Mn coted	glassy rim	UH,OCU				
006	15×10×8	basalt, aa cavity(average1mm max10mm), shrinked lava surface	glassy surface, altered inside	UH,TH,OCU,JAM				
007	ϕ3〜ϕ10	basalt breciated lava surface	3piecies	OCU				
008	13×7×6	basalt, breciated lava surface, aa cavity(average1mm max10mm), 1mm Mn coated		UH,OCU				
009	ϕ3〜ϕ8	Mn coted fragments	a lot of pieces	TH,OCU,JAM				
010	ϕ2	dacite or rhyolite, white pumice	without Mn coating	OCU				
D06								
date	9月6日							
sample No	size(cm)	sample description	remarks	distribution				
001	8×6×3	basalt, breccia, aa cavity<10%(average1mm max3mm), Mn coated		UH,OCU,JAM				
002	ϕ4	aggregates of Mn	2pieces	OCU				

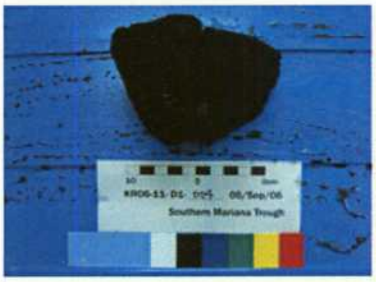
003	φ1	basalt, glassy lava fragment	glass	UH			
004	2×1×1	basalt long prismatic pl and augite? phenocrysts, aa cavity (<<1mm, 3%)	porphyritic	OCU			
D10							
date	**9月7日**						
sample No	**size(cm)**	**sample description**	**remarks**	**distribution**			
001	φ±1	basalt fragments	quench glass matrix pl,(ol)phenocrysts	UH,OCU			
D22							
date	**9月7日**						
sample No	**size(cm)**	**sample description**	**remarks**	**distribution**			
001	23×38×20			UH,TH,OCU			
002	25×20×20			UH,TH,OCU			
003	20×18×15			UH,TH,OCU,JAM			
004	20×15×15			TH,OCU			
005	25×20×20			UH,TH,OCU,JAM			
006	28×15×15			UH,TH,OCU			
007	12×10×5			UH,OCU			
008	20×15×12			UH,OCU			
009	20×15×8	basalt, aa cavity(5%. average5mm), cooling joint	quenched glass rim pl>>ol phenocrysts	UH,OCU			
010	15×13×13			UH,OCU			
011	10×10×10			UH,OCU			
012	10×5×4			UH,OCU			
013	8×8×8			UH,OCU			
014	16×13×12			UH,OCU			
015	5×5×3			UH,OCU			
016	4×4×3			UH			
017	a lot of rocks			TH,OCU,JAM,H			
D09							
date	**9月8日**						
sample No	**size(cm)**	**sample description**	**remarks**	**distribution**			
S001				OCU			
001	15×15×6			UH,TH,OCU			
002	10×5×4			UH,TH,OCU			
003	14×8×4			UH,TH,OCU			
004	16×8×4			UH,TH,OCU			
005	10×10×8	basalt, aa cavity, block of lava surface	quenched glass rim(<10mm) ol phenocrysts	UH,TH,OCU,JAM			
006	10×5×5			TH,OCU			
007	10×5×5			UH,TH,OCU			
008	φ5			UH,OCU			
009	a lot of rocks		fragments	OCU,JAM			
D08							
date	**9月8日**						
sample No	**size(cm)**	**sample description**	**remarks**	**distribution**			
S001							
001	20×10×10			UH,OCU			
002	30×30×25			UH,TH,OCU			
003	20×15×15			UH,TH,OCU			

004	25×20×20			TH			
005	25×25×20			UH,OCU,JAM			
006	10×5×3			UH			
007	15×10×10			UH,OCU			
008	35×15×10		ol and pl phyric, phenocryst 10%	UH,TH,OCU			
009	15×15×5	basalt block of lava surface, with cooling joint		OCU			
010	15×8×5			UH,OCU			
011	10×10×8			UH,OCU			
012	10×10×5			UH,OCU			
013	10×5×5			UH,OCU			
014	10×5×5			TH			
015	8×8×5			TH			
016	15×10×8			TH			
017	a lot of rocks			UH,JAM			
D15							
date	**9月8日**						
sample No	**size(cm)**	**sample description**	**remarks**	**distribution**			
S001							
001	28×25×20	basalt, aa cavity(max 10mm)	quenched glass rim,	OCU			
002	20×10×10	basalt	ol and pl phyric(max2mm, 5%)	UH,TH,OCU			
003	20×15×10	basalt	〃	OCU			
004	15×10×10	basalt	〃	OCU			
005	φ3	basalt	quenchd glass fragments	UH,TH,OCU			
006	<φ5	basalt	small fragments	UH,TH,OCU,JAM			
007	φ3	porpyritic basalt	quenched glass rim,	OCU			
			ol and pl phyric(max2mm), chi				
D16							
date	**9月9日**						
sample No	**size(cm)**	**sample description**	**remarks**	**distribution**			
001	40×20×17			UH,OCU,JAM			
002	25×20×15			UH,TH,OCU,JAM			
003	30×15×15	basalt, block of pillow lava, ol<<pl (max8mm,≤15%), joint	weathered quench glass	TH,OCU			
004	20×13×10			OCU			
005	15×10×10			OCU			
006	10×5×5			OCU			
D17							
date	**9月9日**						
sample No	**size(cm)**	**sample description**	**remarks**	**distribution**			
001	15×9×6	basalt, pl phyric	quenched glass	UH,TH,OCU			
002	9×9×3			UH,OCU			
003	5×5×2	basalt fragment, glassy surface		UH,OCU			
004			3piecies	OCU			
005	φ5,length10	basalt, cylindical		TH			
006		basalt fragments, quenched surface		OCU,JAM			
D18							
date	**9月9日**						
sample No	**size(cm)**	**sample description**	**remarks**	**distribution**			
S001				TH,OCU			

001	25×25×20	basalt,quenched glass		UH,TH,OCU			
002	25×2518×	basalt,aa cavity, jointing 5cm		OCU			
003	28×18×18	basalt		OCU			
004	30×20×18	basalt	ol＞pl (＜3%)	UH,OCU,JAM			
005	20×20×16	basalt		OCU,JAM			
006	35×12×10	basalt		UH,TH,OCU			
007	15×13×5	basalt, quenched glass rim ＜1cm	pl＞ol (＜3%)	UH,TH,OCU			
008	25×15×12	basalt, quenched glass rim ＜1cm		UH,TH,OCU			
009	20×20×12	basalt,lava ropy surface, quenched glass rim ＜1cm	ol≒pl (＜3%)	OCU			
010	φ20	basalt, blocks, quenched glass rim	ol＞pl (＜3%)	UH,TH,OCU,JAM			
011	φ20	basalt,blocks, jointings		OCU			
012	5×3×2	basalt,altered		TH			
013	23×15×12		ol≒pl (＜2%)	UH,TH,OCU			
D12							
date	**9月10日**						
sample No	**size(cm)**	**sample description**	**remarks**	**distribution**			
001	10×10×8	basalt, quenched glass(5-10mm)	pl ＞＞ ol (2%), fresh quenched glass	UH,TH,OCU			
002	10×8×8			UH,TH,OCU			
003	11×8×8			UH,TH,OCU			
004	10×4×4			UH,OCU			
005	11×5×5			UH,OCU			
006	φ2	basalt fragments		UH,TH,OCU,JAM			
D23							
date	**9月10日**						
sample No	**size(cm)**	**sample description**	**remarks**	**distribution**			
001	30×20×10	basalt, ava surface, large cavity(φ1cm)		TH,OCU			
002	18×15×15	basalt, cooling joint	quenched glass	OCU			
003	18×15×15			OCU			
004	30×20×20	basalt		OCU			
005	14×10×10	basalt	quenched glass	UH,OCU			
006	10×10×5	basalt, small pillow(φ30cm)		UH,TH,OCU			
007	10×3×5			UH,OCU			
008	10×10×8	basalt	4pieces	TH			
009	a lot of rocks	basalt		JAM			
D24							
date	**9月10日**						
sample No	**size(cm)**	**sample description**	**remarks**	**distribution**			
001	20×20×20	basalt, cooling joint	quenched glass	UH,TH,OCU			
002	20×15×10	basalt		UH,OCU			
003	18×18×10	basalt,pale green, altered block		OCU			
004	15×8×8	basalt,sporadic ol,pl phenocrysts	quenched glass	UH,OCU			
005	25×20×20	basalt, pale green, altered block ,jointing	quenched glass(altered)	TH,OCU			
006	25×25×20		2piecies	OCU			
007	20×10×10	basalt, altered quench glass	many piecies	UH,TH,OCU			
008	5×5×5	basalt, pale green		TH,OCU,JAM			

Table 2-2-1. List of SEA BEAM survey lines
KR06-11 Southern Mariana Truogh

Line No.	Date Time Local Tima (UTC+10h)			Start		End		Total
				Latitude	Longitude	Latitude	Longitude	732.2n. mile
SB-0	5-Sep-06	06:36-07:15		13-27.5'N	143-14.0'E	13-27.5'N	143-28.0'E	13.6n. mile
SB-1	5-Sep-06	16:27	IN	13-28.5'N	143-19.0'E	13-00.0'N	143-30.0'E	148.4n. mile
SB-2				13-00.0'N	143-30.0'E	13-07.0'N	143-10.0'E	
SB-3				13-07.0'N	143-10.0'E	13-20.0'N	143-10.0'E	
SB-4				13-20.0'N	143-10.0'E	13-08.0'N	143-37.5'E	
SB-5				13-14.0'N	143-37.5'E	13-27.5'N	143-10.0'E	
SB-6	6-Sep-06	5:20	OUT	13-27.5'N	143-10.0'E	13-27.5'N	143-32.0'E	
SB-7	6-Sep-06	20:01	IN	13-07.9'N	143-17.1'E	13-03.5'N	143-35.0'E	81.5n. mile
SB-8				13-03.5'N	143-35.0'E	13-25.0'N	143-48.2'E	
SB-9	7-Sep-06	5:30	OUT	13-25.0'N	143-48.2'E	12-38.0'N	143-11.4'E	
SB-10	7-Sep-06	20:23	IN	12-38.0'N	143-11.4'E	12-33.5'N	142-02.0'E	111.4n. mile
SB-11				12-33.5'N	143-02.0'E	12-33.5'N	142-53.0'E	
SB-12				12-33.5'N	142-53.0'E	13-15.0'N	142-53.0'E	
SB-13				13-15.0'N	142-53.0'E	13-12.5'N	143-05.0'E	
SB-14				13-12.5'N	143-05.0'E	13-00.0'N	143-05.0'E	
SB-15	8-Sep-06	5:25	OUT	13-00.0'N	143-05.0'E	12-34.4'N	142-58.6'E	
SB-16	8-Sep-06	20:14	IN	12-40.0'N	142-30.0'E	12-27.5'N	143-17.5'E	170.7n. mile
SB-17				12-27.5'N	143-17.5'E	13-02.5'N	143-17.5'E	
SB-18				13-02.5'N	143-17.5'E	13-02.5'N	142-47.5'E	
SB-19	9-Sep-06	6:06	OUT	13-02.5'N	142-47.5'E	12-38.2'N	142-28.1'E	
SB-20	9-Sep-06	19:08	IN	12-35.0'N	142-32.0'E	13-07.0'N	143-00.0'E	138.2n. mile
SB-21				13-07.0'N	143-00.0'E	12-53.0'N	143-30.0'E	
SB-22				12-46.0'N	143-30.0'E	12-57.0'N	143-07.5'E	
SB-23	10-Sep-06	5:36	OUT	12-57.0'N	143-07.5'E	12-30.0'N	143-24.5'E	
SB-24	10-Sep-06	18:13	IN	12-38.5'N	143-13.9'E	13-22.5'N	143-27.0'E	68.4n. mile
SB-25			OUT	13-22.5'N	143-27.0'E	13-23.0'N	143-50.0'E	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05/Sep/06
Southern Mariana Trough


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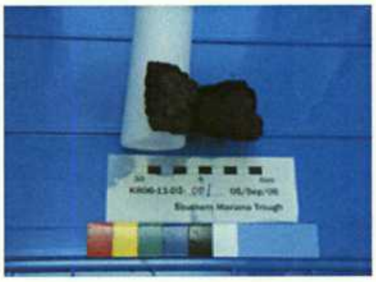
KR06-11-D1-
05/Sep/06
Southern Mariana Trough


Southern Mariana Trough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KR06-11-D2-
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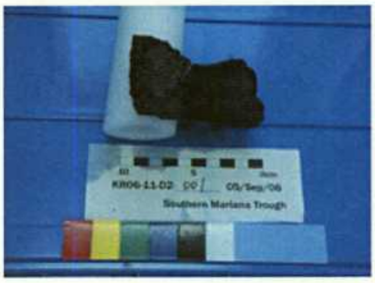
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Southern Mariana Trough


KR06-11-D2-
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KR06-11-D2-
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Southern Mariana Trough


5 0cm
KR06-11-D2-
05/Sep/06


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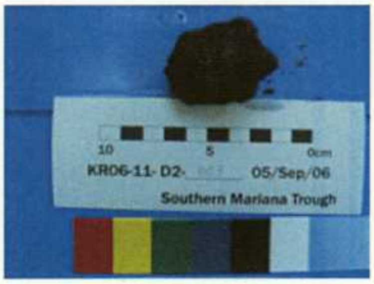
Southern Mariana Trough

060905


KR06-11-D2-
05/Sep/06
Southern Mariana Trough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05/Sep/06
Southern Mariana Trough


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05/Sep/06
Southern Mariana Trough


KR06-11-D2-005
05/Sep/06
Southern Mariana Trough


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KR06-11-D2-005
05/Sep/06
Southern Mariana Trough


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KR06-11-D2-006
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Southern Mariana Trough


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Southern Mariana Trough

























10 5 0cm
KR06-11- D5-
06/Sep/06
Southern Mariana Trough











10 5 0cm
KR06-11- D5-
06/Sep/06
Southern Mariana Trough

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060908
































S001 S001
















10 5 0cm
KR06-11-D17-
09/Sep/06
Southern Mariana Trough











KR06-11-D17-
09/Sep/06
Southern Mariana Trough


060909

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10 5 0cm
KR06-11-D23-004 10/Sep/06


10 5 0cm
KR06-11-D23-007 10/Sep/06
Southern Mariana Trough


Southern Mariana Trough

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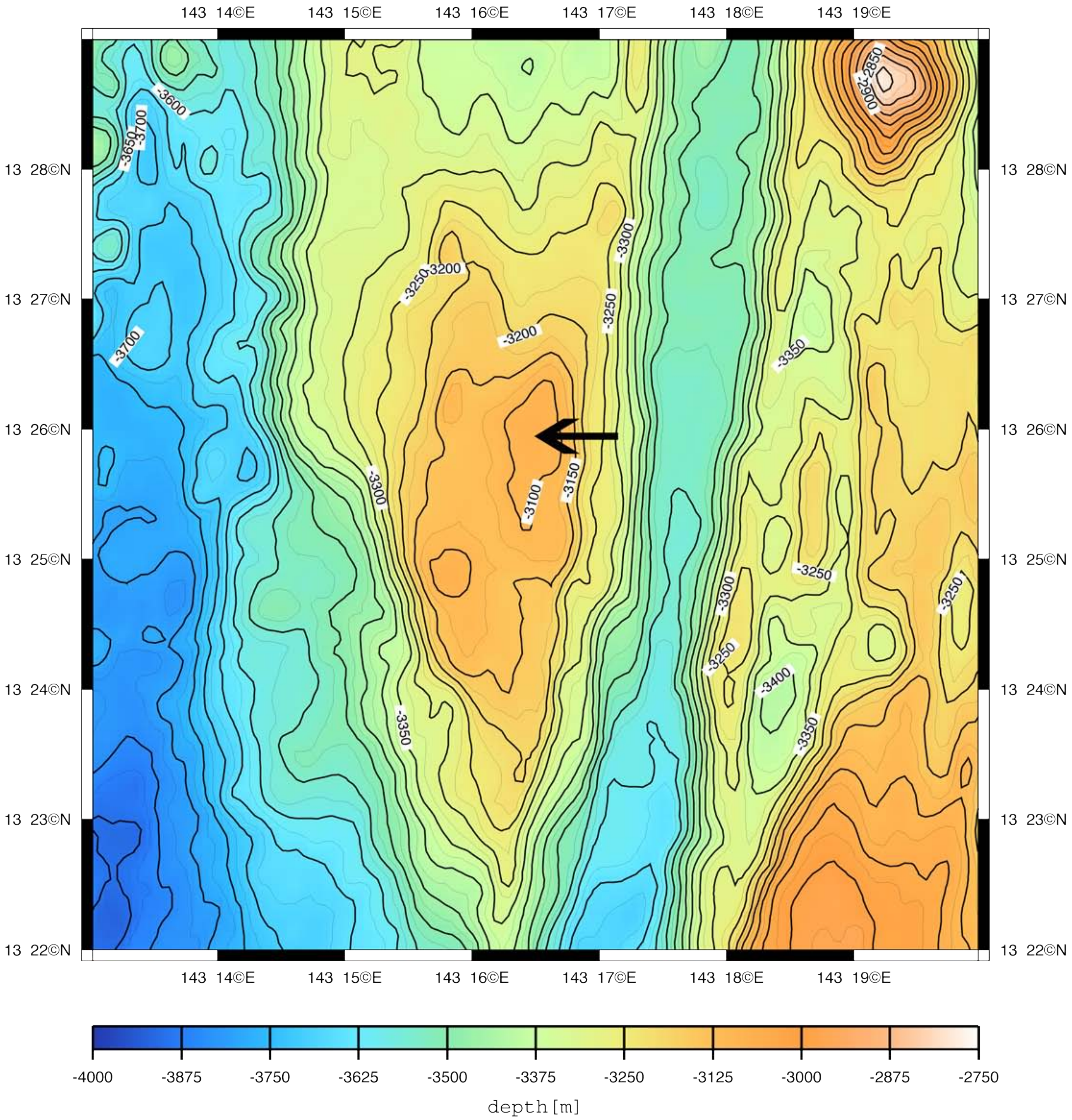

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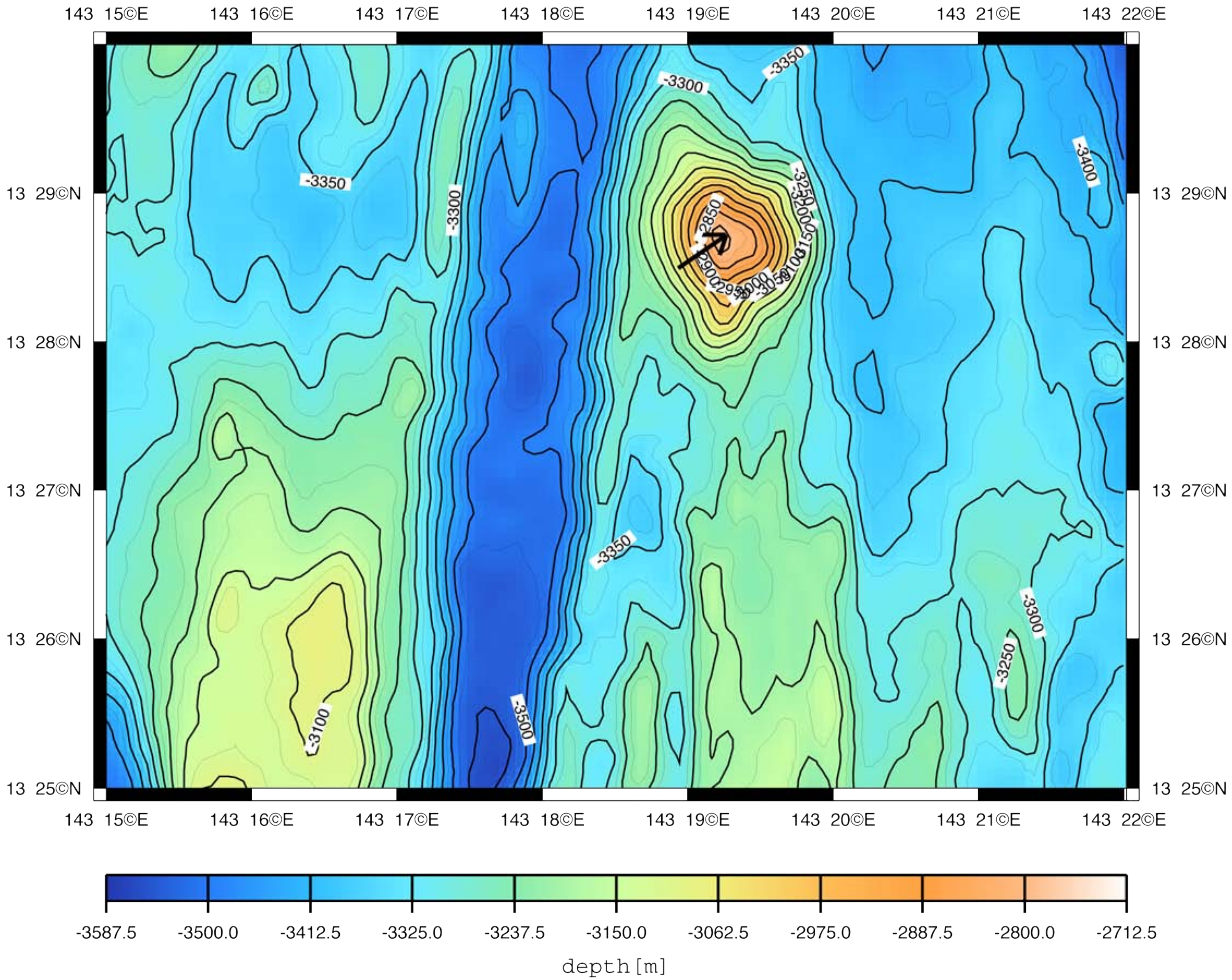
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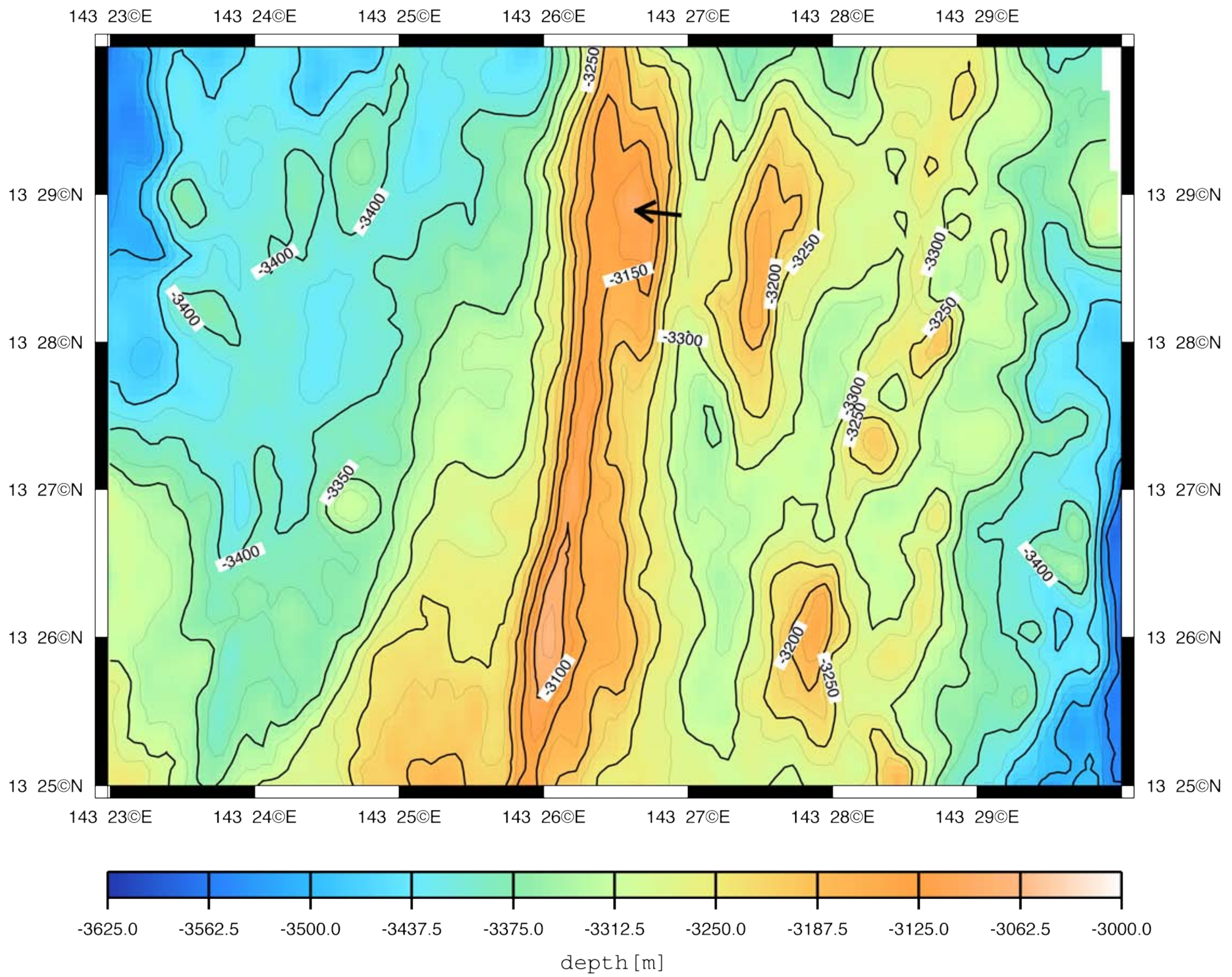

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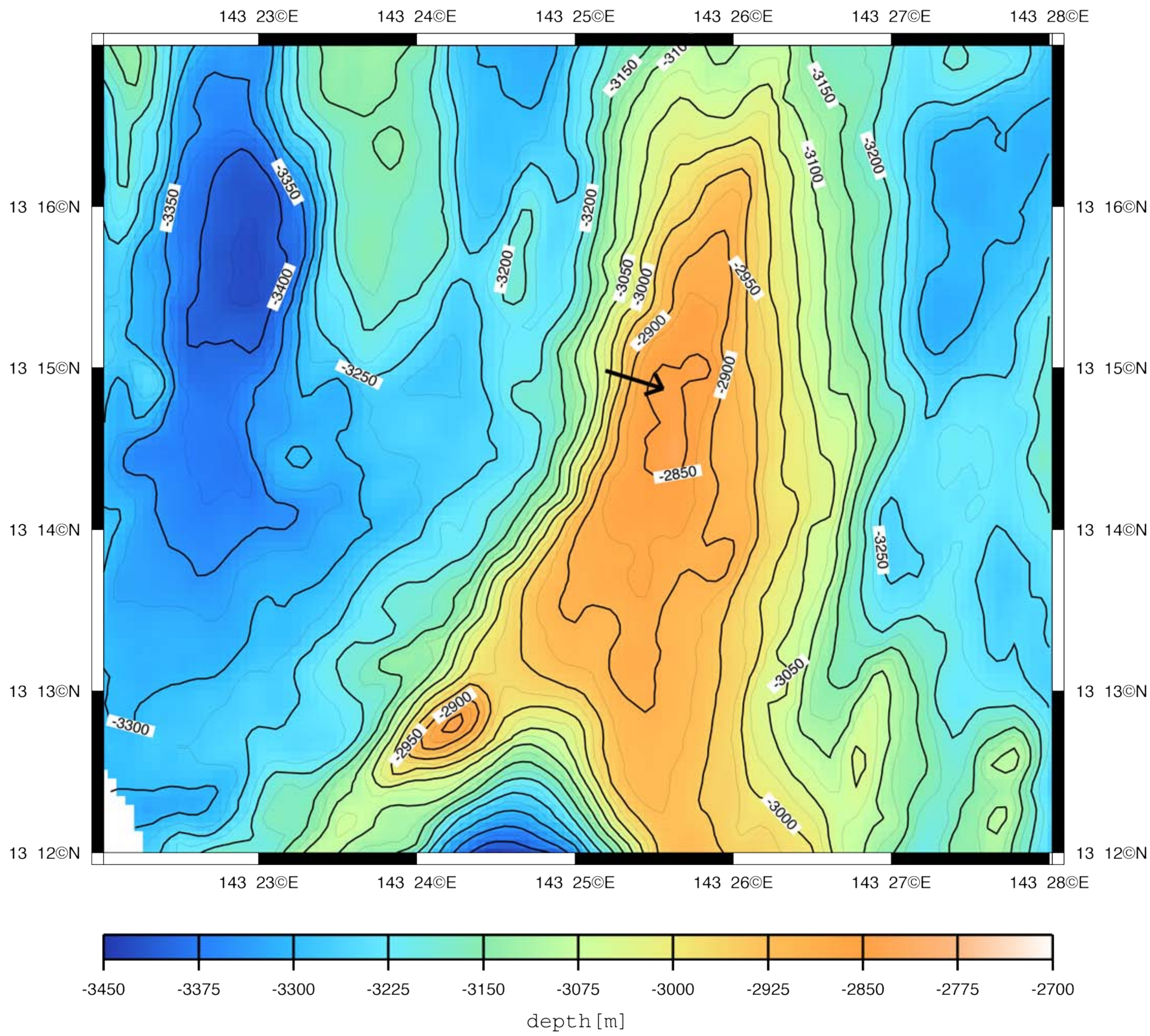

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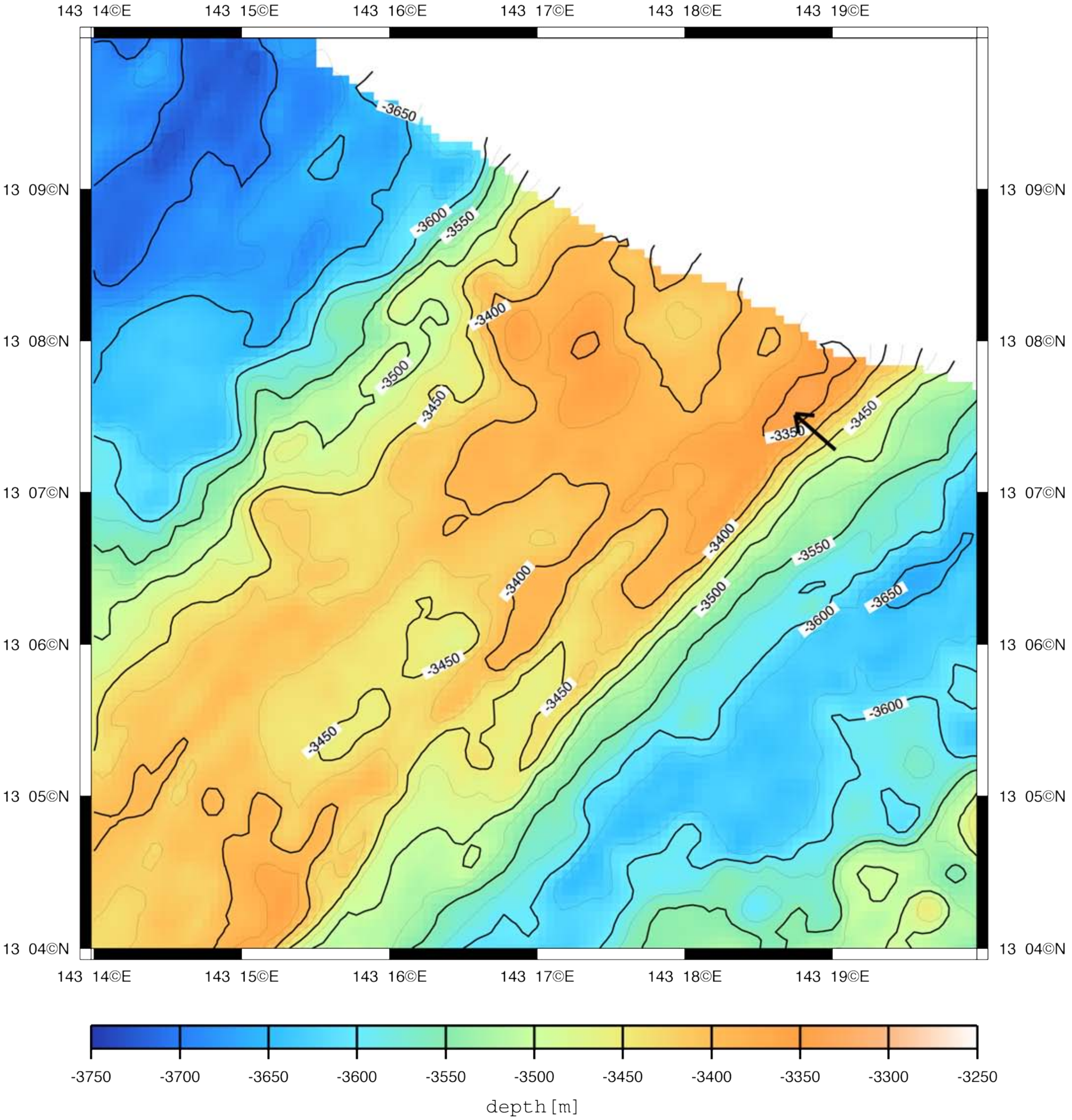
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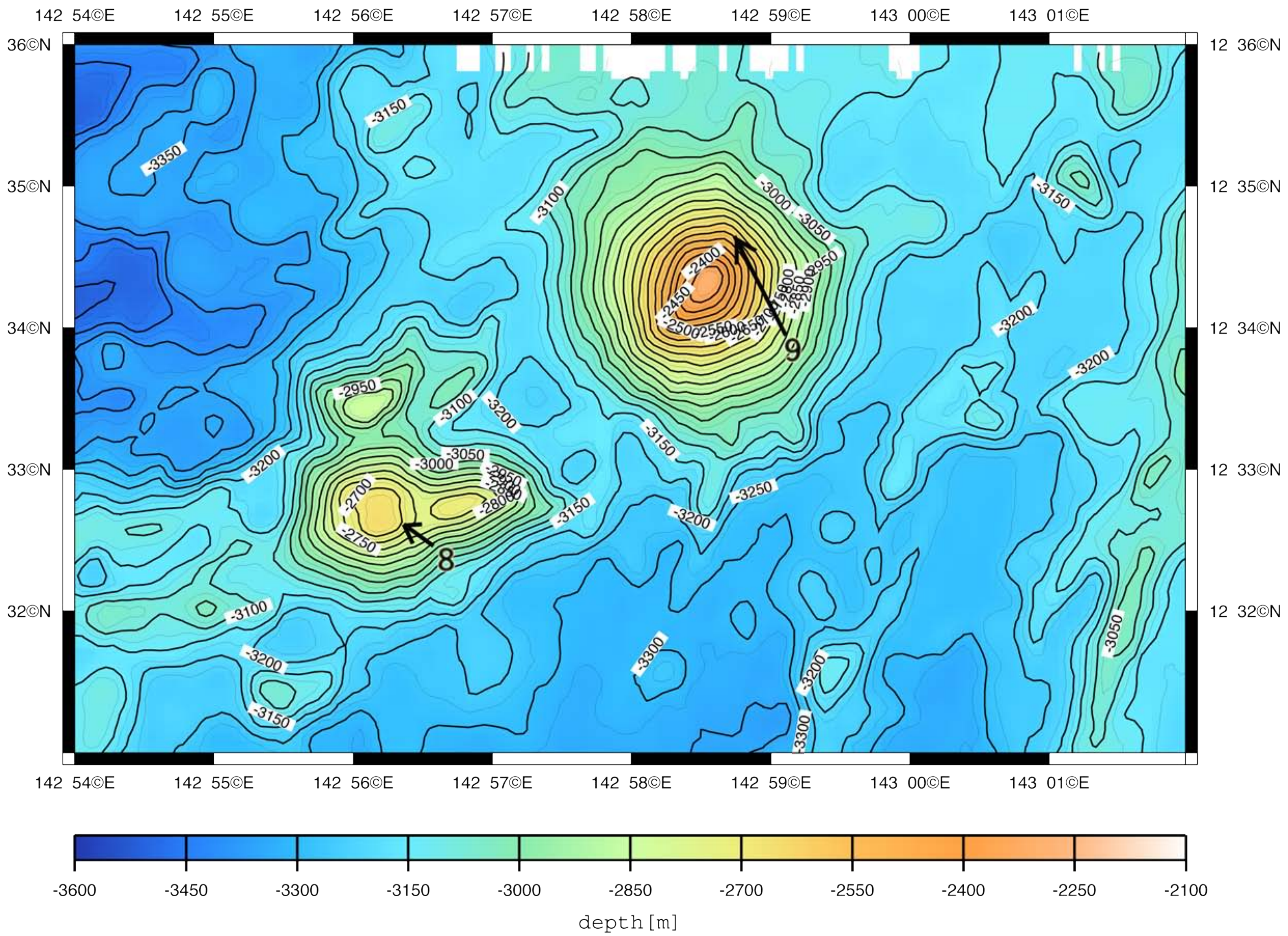

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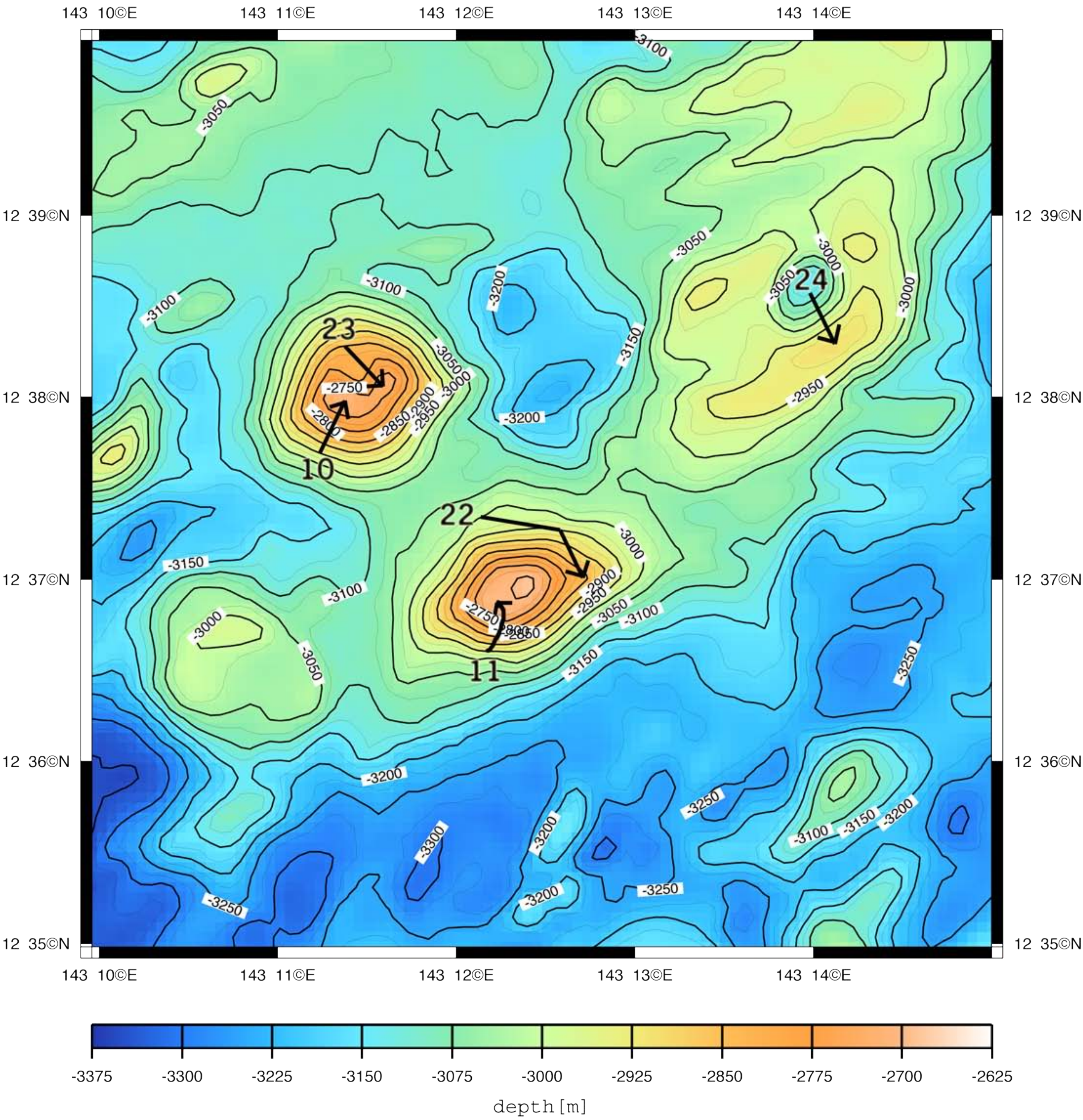

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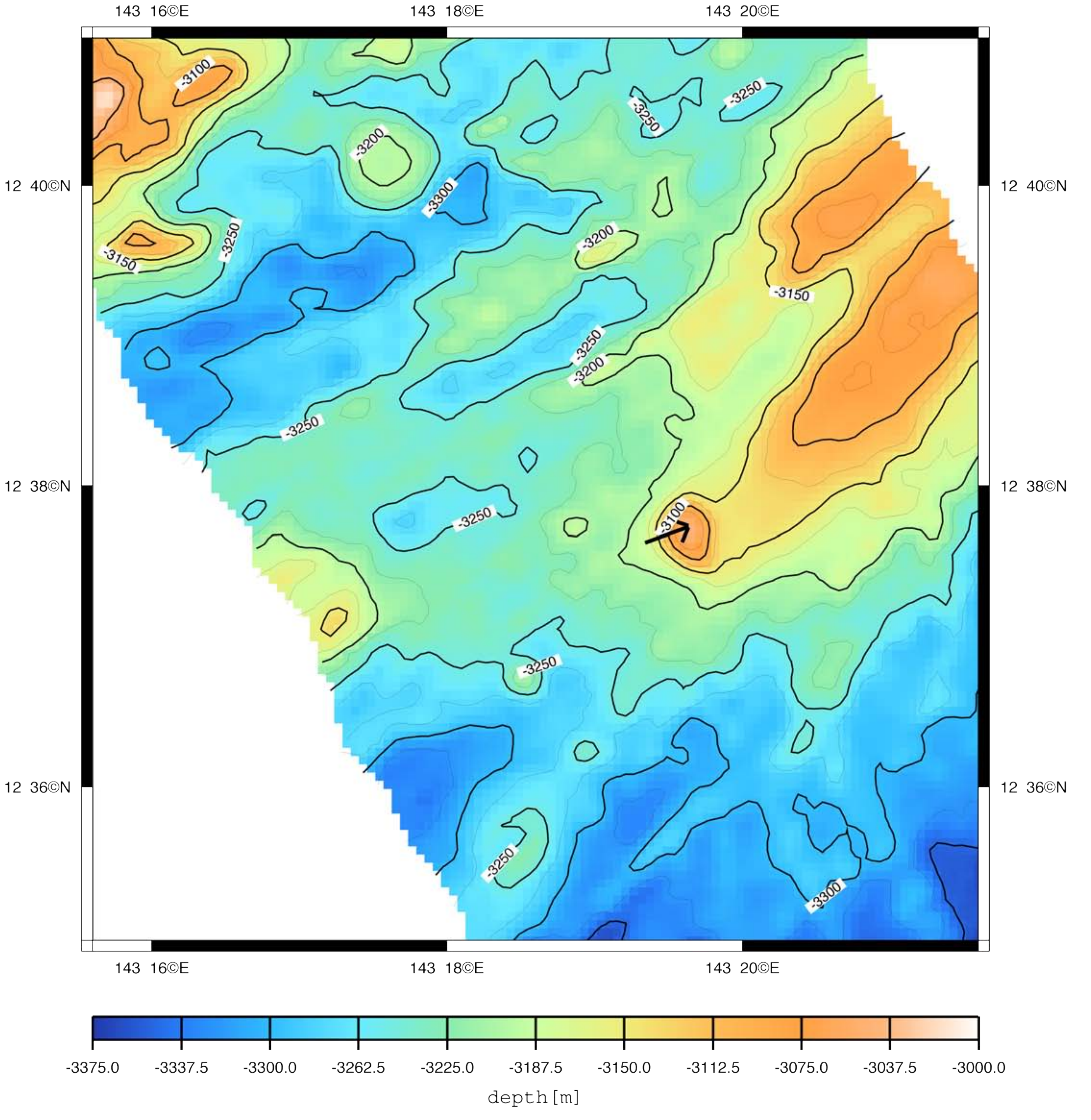

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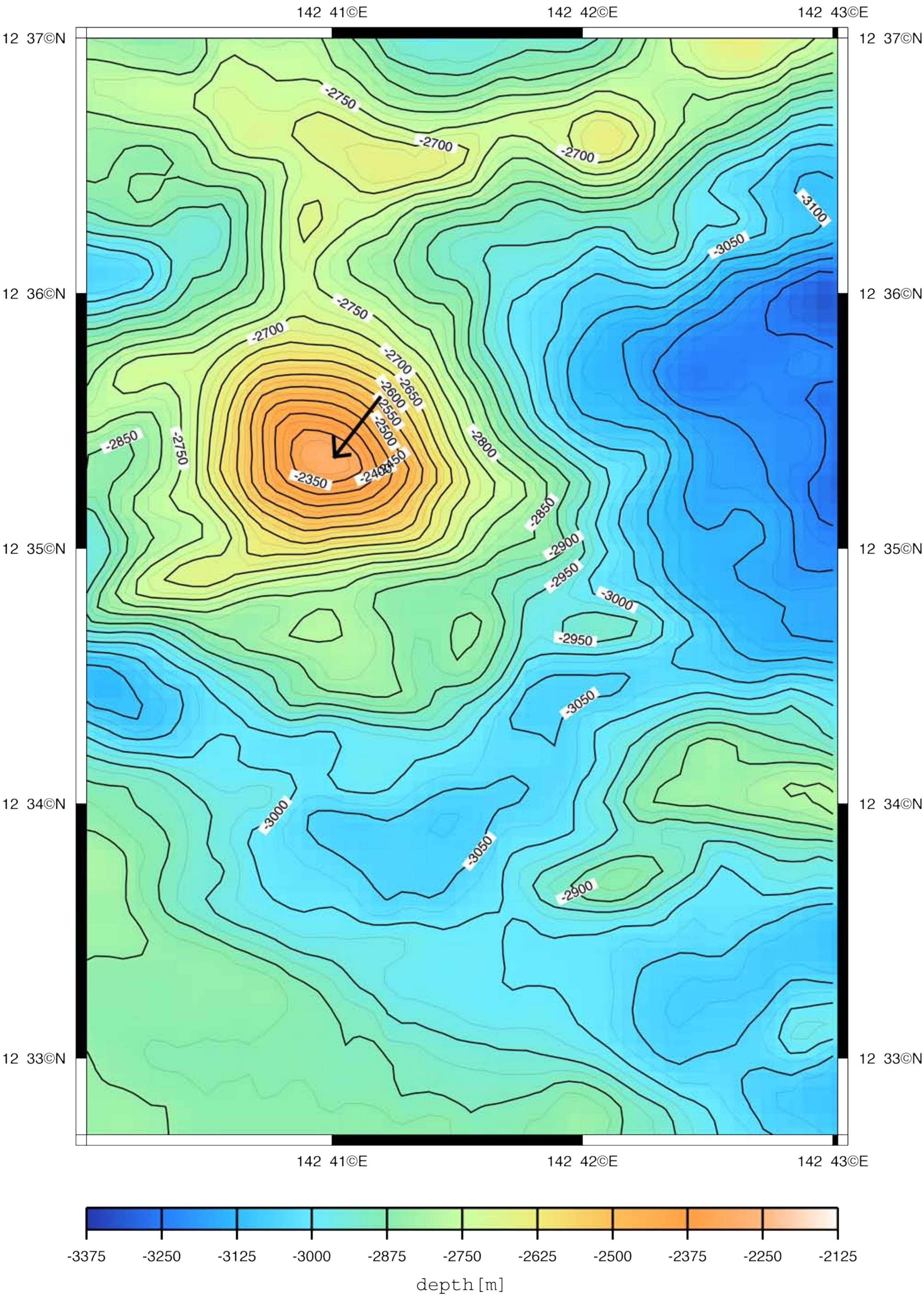
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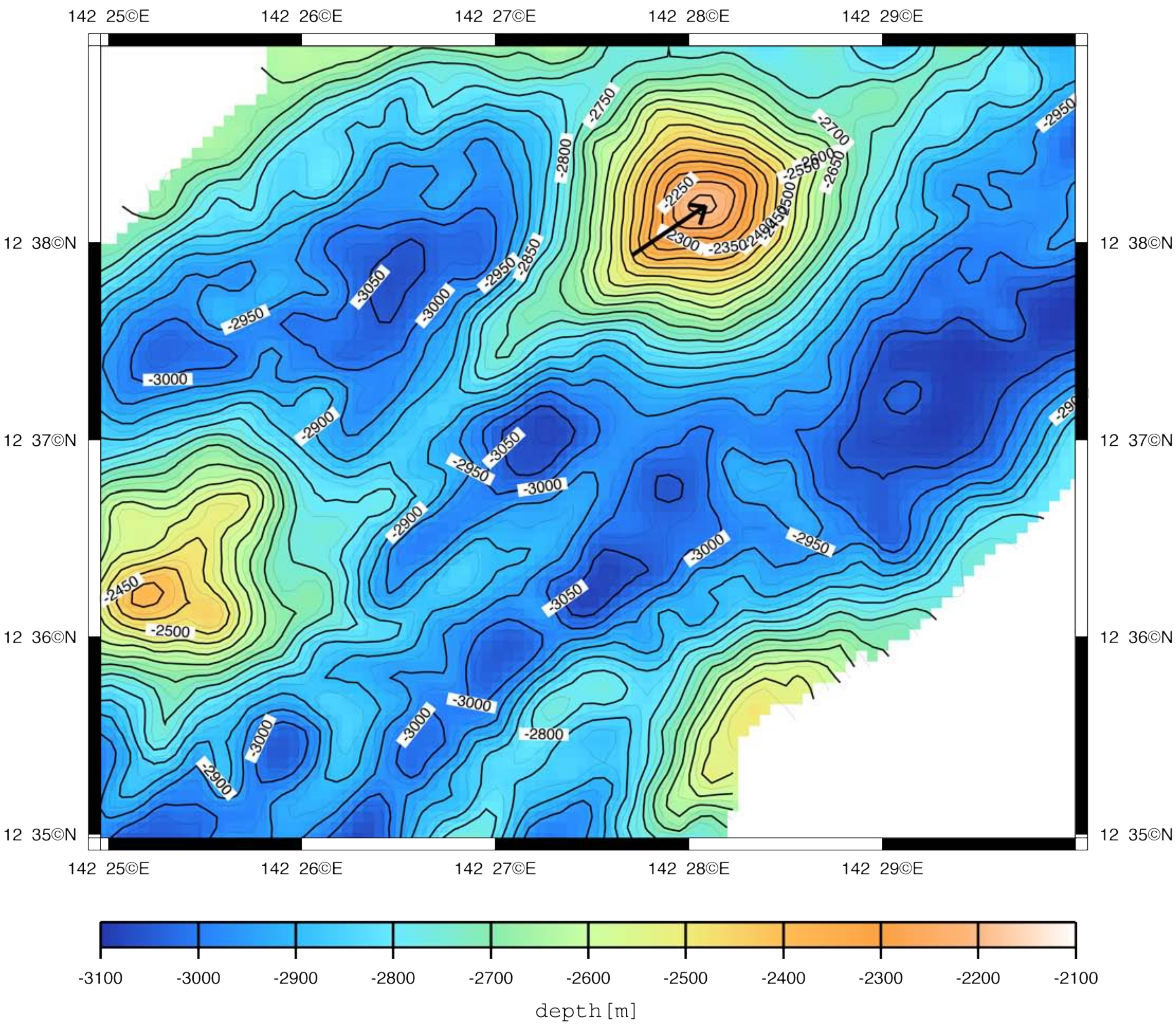

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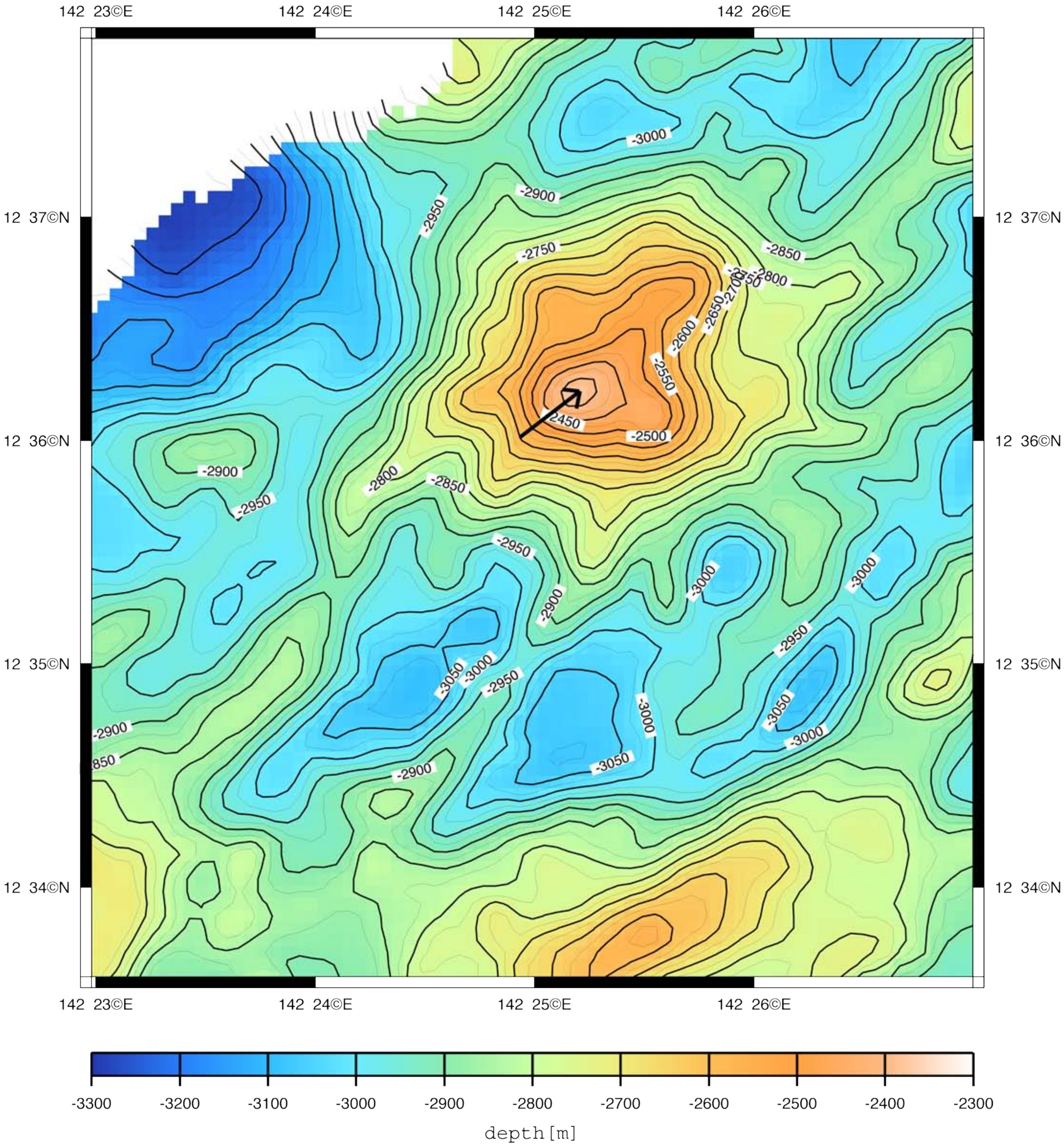
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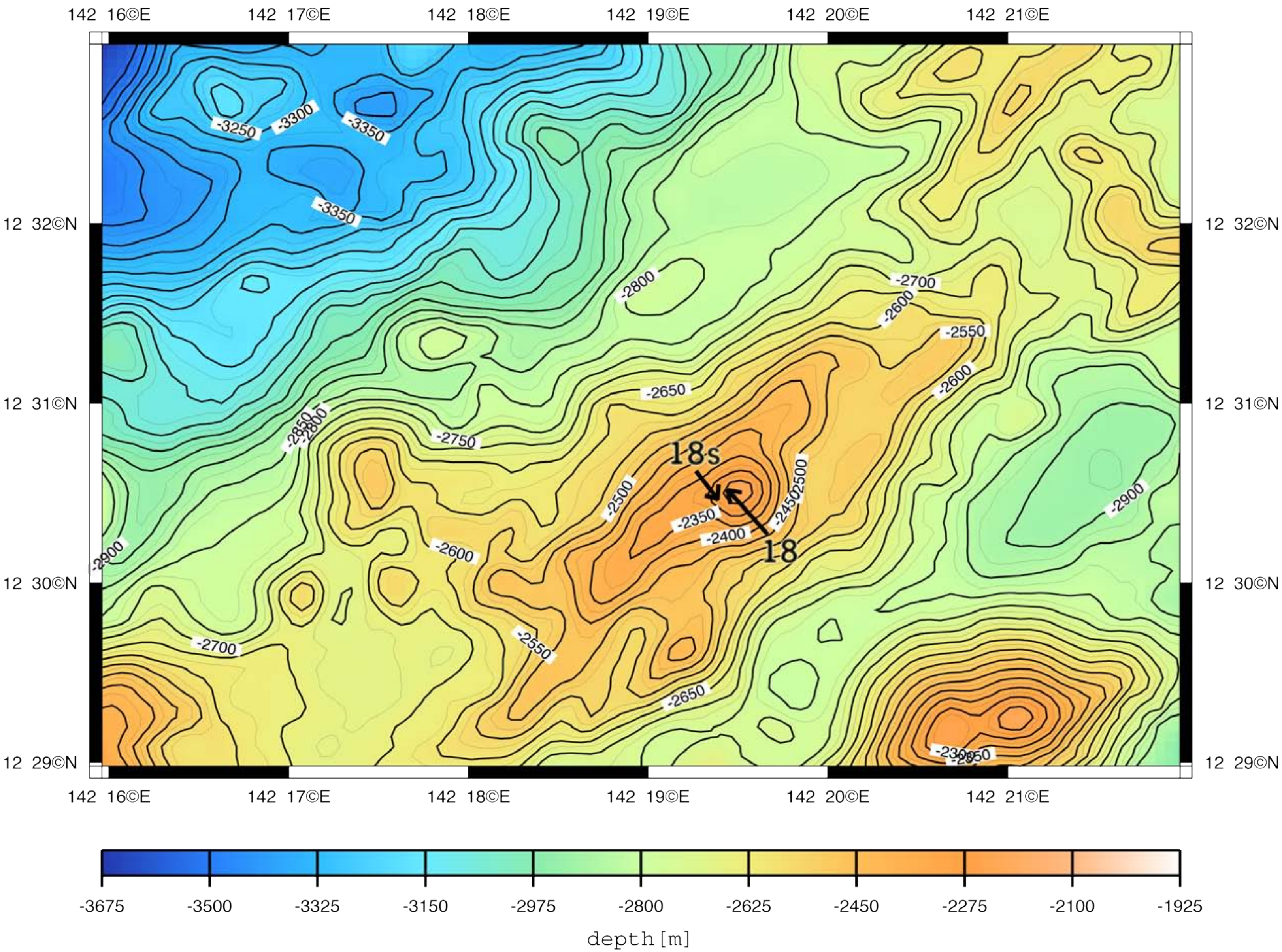

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