Colville III ’16 (TAN1611) Cruise Report Wellington – Auckland, September 26–October 16, 2016

C. Timm
S. Woelz
J. Whattam
F. Caratori Tontini
T. J. Stewart
T. Kane
R. Barrett

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C. Timm, GNS Science, PO Box 30368, Lower Hutt 5040, New Zealand

F. Caratori Tontini, GNS Science, PO Box 30368, Lower Hutt 5040, New Zealand

T. Kane, NIWA, 301 Evans Bay Parade, Hataitai, Wellington 6021, New Zealand

S. Woelz, NIWA, 301 Evans Bay Parade, Hataitai, Wellington 6021, New Zealand

T. J. Stewart, GNS Science, PO Box 30368, Lower Hutt 5040, New Zealand *

R. Barrett, Victoria University of Wellington, PO Box 600, Wellington 6140. New Zealand

J. Whattam, Victoria University of Wellington, PO Box 600, Wellington 6140. New Zealand

* Now at Beca, PO Box 6345, Wellesley Street, Auckland 1141, New Zealand

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Report compiled by Tineke Stewart, GNS Science, t.stewart@gns.cri.nz.

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CRUISE SYNPOSIS

This research voyage successfully acquired geophysical data and rock samples from the northern part of the Colville Ridge, within New Zealand's Exclusive Economic Zone (EEZ). The main output of this voyage is providing data and fundamental base maps for future regional prospectivity surveys, tectonic plate reconstructions, and general understanding of the architecture of the Kermadec backarc.

The *Colville III* '16 voyage builds on two previous voyages to the southern and mid Colville ridge in 2013 and 2015 respectively and completes a comprehensive and dataset that extends unbroken for over 1000 km along the Colville Ridge. In 2013 and 2015 voyages acquired a suite of geophysical (gravity, magnetic, bathymetry and backscatter) data and rock samples (de Ronde et al 2016a & de Ronde et al 2016b).

The 21 day *Colville III* '16 cruise was successful in acquiring gravity and magnetic measurements, along with bathymetry and backscatter data, during 18 days of surveying, over an area of ~21,815 km^2. Dredge sites were selected from features and anomalies shown in the newly acquired geophysical data, 47 rock samples were obtained from 11 successful dredge deployments.

Combined with *Colville I* and *Colville II* voyage data, the data collected from *Colville III* '16 are crucial for our ability to understand the evolution of New Zealand's on and offshore territory. These data are required to identify prospective sites to carry out more focused, follow-up surveys by AUVs, ROVs, and possibly manned submersibles along the Colville Ridge. The results from this survey will be published as maps and papers in international journals and will become publicly accessible online at GNS.

KEYWORDS

Colville III '16, TAN1611, Colville Ridge, gravity, magnetics, bathymetry, backscatter, rock dredge, U00061

1.0 CRUISE PARTICIPANTS

N=7 Science personnel

Table 1 Cruise participants and contact details

Fabio Caratori Tontini (Co-Chief Scientist)	GNS Science 1 Fairway Drive, Avalon PO Box 30368 Lower Hutt New Zealand	Tel: +64 (4) 570-4760 Fax: +64 (4) 570-4600	F.Caratori.Tontini@gns.cri.nz
Christian Timm (Co-Chief Scientist)	GNS Science 1 Fairway Drive, Avalon PO Box 30368 Lower Hutt New Zealand	Tel: +64 (4) 570-4391 Fax: +64 (4) 570-4600	c.timm@gns.cri.nz
Rachel Barrett	Victoria University PO Box 600 Wellington 6140 New Zealand	Tel: +64 (22) 1676244	rachel.barrett@vuw.ac.nz
Tim Kane	NIWA 301 Evans Bay Parade, Greta Point, Wellington 6021, New Zealand	Tel: +64 (4) 386-0300 Fax +64 (21) 065-1152	tim.kane@niwa.co.nz
Tineke Stewart	GNS Science 1 Fairway Drive, Avalon PO Box 30-368 Lower Hutt New Zealand	Tel: +64 (27) 349 2603 Fax: +64 (4) 570-4600	t.stewart@gns.cri.nz
Jack Whattam	Victoria University PO Box 600 Wellington 6140 New Zealand	Tel: +64 (22) 1157385	j.whattam@gmail.com
Susi Woelz	NIWA 301 Evans Bay Parade, Greta Point, Wellington 6021, New Zealand	Tel: +64 (4) 386-0490 Fax: +64 (21) 065-1152	susi.woelz@niwa.co.nz

Figure 1 The R/V *Tangaroa* at sunset (top left), Crew deploying gear (top right), Jack splitting rock samples (bottom left), and crew deploying the magnetometer (bottom right).

2.0 BACKGROUND TO CRUISE

The Colville and Kermadec ridges are prominent submarine features up to 1.5 km high that extend northward for over 1300 km from the Bay of Plenty, New Zealand. The intraoceanic Kermadec arc system of volcanoes lies on top of the Kermadec Ridge. Volcanism results from westward subduction of the Pacific Plate beneath the Indo-Australian Plate and extends ~1,300 km northward from the Bay of Plenty. To the south the Kermadec arc transitions into the Taupo Volcanic Zone and into continental New Zealand. The Kermadec arc consists of 33 volcanoes up to ~2,500 m high, most of which are hydrothermally active. The Havre Trough lies between the Kermadec and Colville ridges, and is made up of a series of basins up to 4,000 m deep.

Prior to the RV Tangaroa Colville surveys, carried out since 2013, little was known about the Colville Ridge. Most of the seafloor exploration in the region focused on the hydrothermally active Kermadec arc volcanoes. Maps derived from satellite altimetry provided only a first order visualisation of the seabed of the region and there was limited knowledge of seabed morphology and its geological structure, including volcanic edifices. In addition, only widely-spaced ship track geopotential data has been recorded over the region, and few rock samples had been recovered from the Colville Ridge. Surveying the Colville Ridge (and westernmost Havre Trough) therefore provided new data to help understand the tectonic history, geology and potential mineralisation of the ridge as well as the distribution of biological habitats.

Comprehensive surveys of the southern to mid-section of the Colville Ridge were completed during the 15 day 2013 OS2020 *Colville '13* cruise (*Colville I*) and 21 day 2015 OS2020 *Colville '15* cruise (*Colville II*) which collected a suite of geophysical data and rock samples (Figure 2). Together these two earlier cruises produced the first complete maps of detailed bathymetry, backscatter, magnetics and gravity over an area totalling 38,800 km^2 on the southern and mid Colville Ridge. Rocks were also collected from 33 separate dredge stations.

The 21 day *Colville '16* cruise (*Colville III*) adds to the data set collected during the *Colville I* and *Colville II* cruises, by acquiring data from an area along the Colville Ridge adjoining and north of the earlier cruises (Figure 1). The combined data sets from these three cruises now form the first comprehensive geophysical data set for the Colville Ridge region (Figure 3). Combined, this new geophysical dataset and dredge samples will provide new knowledge about this geologically highly dynamic region, its ancient volcanism, and the potential presence of seafloor mineral accumulations.

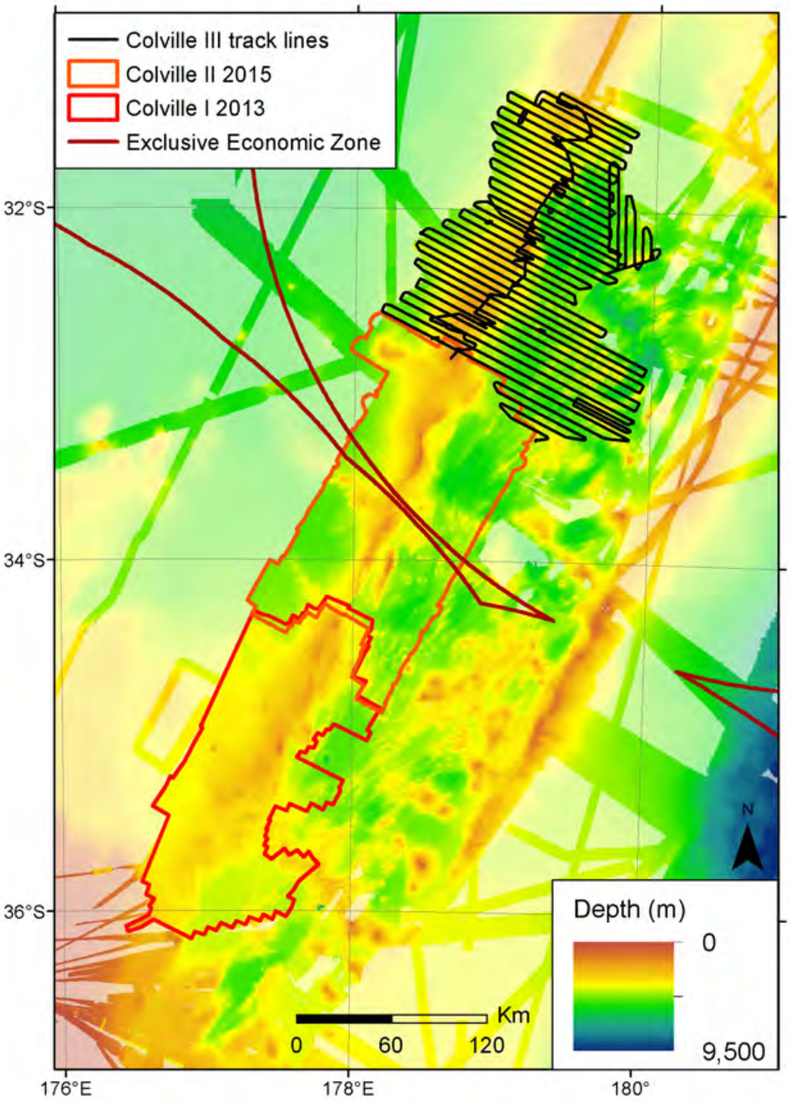


Figure 2 Track lines from the *Colville III* voyage (black lines) and data collected during both the *Colville I* and *Colville II* cruises (bound by red and orange polygons) overlain on low-resolution bathymetry from satellite altimetry (GEBCO 08 Grid).

The area covered in *Colville III* was surveyed in lines spaced ~5–6 km apart (Figure 3). This ensured an overlap of ~10% for bathymetric swath lines, and provides sufficient coverage of the seafloor for magnetic and gravity anomalies at a regional scale.

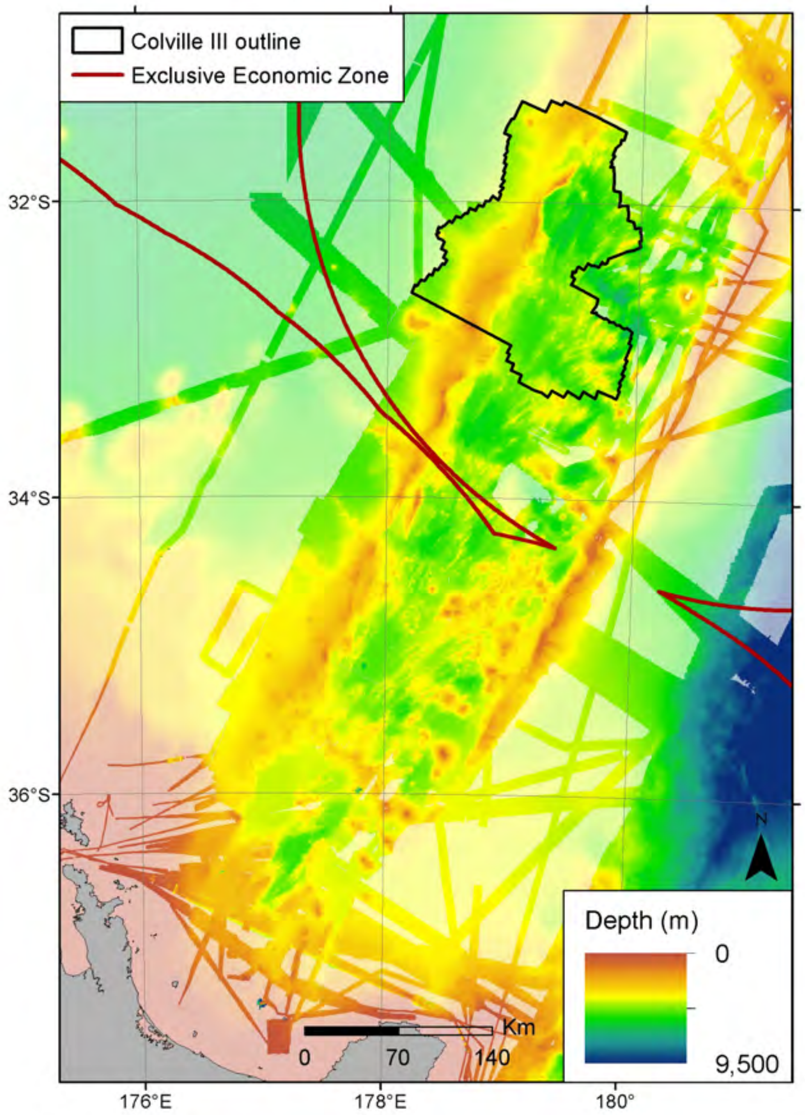


Figure 3 Map displaying the combined bathymetric data collected from *Colville I, II* and *III* voyages. The black polygon delineates the area of the Colville III voyage. Overlain on low-resolution bathymetry from satellite altimetry (GEBCO 08 Grid).

2.1 OBJECTIVES

The primary objectives of the *Colville III* voyage were:

1. To swath map with EM302 multibeam, the northern portion of the Colville Ridge, ensuring 100% coverage of the seafloor at a resolution of ≤35 m,
2. To acquire gravity data for the same area,
3. To acquire magnetic data for the same area, and
4. Conduct dredging operations on select locations in an attempt to recover rocks and mineralized samples.

The Colville III survey provides the first comprehensive map of the seafloor together with geophysical maps of the northern Colville Ridge within New Zealand's extended economic zone (EEZ).

These maps from the survey provide the framework to underpin research on seafloor mineral deposits and tectonic models of arc volcanism in the Kermadec backarc region. Also, proposed cruises with GEOMAR in 2016–2017 will utilize the maps created during this voyage to target areas of interest for more selected sampling. Bathymetric maps are used for defining the geometry and structure of the seafloor, and geophysical data provide information on the geology and structures on, and below, the seafloor. Rock samples recovered from the survey region will be used to determine the seafloor age and composition of this large part of our sovereign estate.

2.2 INSTRUMENTATION/EQUIPMENT USED DURING VOYAGE

- GPS navigation (R/V *Tangaroa*)
- EM302 multi-beam (R/V *Tangaroa*)
- SeaSPY magnetometer (GNS)
- Lacoste & Romberg S-80 gravimeter (GNS)
- Rock dredges (NIWA)

2.3 PERSONNEL RESPONSIBILITIES

Table 2 Task and personnel responsibilities

Team leaders for the various operations	
Fabio Caratori-Tontini	Geophysics (magnetics and gravity)
Christian Timm	Petrology
Tim Kane	Bathymetry and backscatter acquisition

2.4 VESSEL AND NAVIGATION

The vessel R/V *Tangaroa* was used for the survey (Figure 4). This is a 70-metre-long, 2,291 tonne oceanographic research and survey vessel. It is well equipped with laboratory space, hoisting facilities and winches with a cruising speed of 11 knots; she generally carries a crew of 14 and up to 26 survey personnel. For general specifications for R/V *Tangaroa*, see https://www.niwa.co.nz/vessels/rv-tangaroa.

Figure 4 The NIWA vessel R/V Tangaroa

2.4.1 Equipment

The Kongsberg EM302 multibeam echo-sounder, centred on 30 kHz, was used throughout the survey. The multibeam was operated to obtain the maximum swath width with maximum beam angles of 60°/60°. This echo-sounder was used in combination with Seafloor Information System (SIS) software during data acquisition. The EM302 multibeam worked very well during the survey, with swath widths within the expected ranges for the water depths encountered in the survey area.

Any unmeasured change in sound speed through the water column is unpredictable and can potentially result in significant depth and positioning errors. This error source is mitigated by continual monitoring of the bathymetry data for evidence of sound speed artefacts during sounding operations. The ocean surface sound speed is continuously measured and used to calculate departure angles at the transducer and are also used as an indicator of sound speed changes throughout the water column. Sound Velocity Profiles (SVPs) were required to adjust for velocity errors caused by changes in water temperature, details for the three SVPs undertaken during the cruise are included in Table 3. A fourth SVP conducted during the voyage was not usable due to technical difficulties reading data from the SVP unit.

Table 3 Details relating to SVPs undertaken during *Colville III.*

SVP No.	Date (UTC)	Time (UTC)	Lat (S)	Long (E)	Water depth (m)	Profile depth (m)
160928a	28/09/16	1451	-33 18.30	179 13.56	2756	1974
161003a	03/10/16	2119	-32 41.06	179 13.844	2996	1921
161006a	06/10/16	1446	-32 04.165	178 53.125	2631	2046

Vessel heave and attitude were provided by an Applanix POS/MV 320 motion sensor on the R/V *Tangaroa*. The POS/MV generates attitude data in three axes. Measurements of roll, pitch and heading are accurate to 0.02º or better (manufacturer's specifications) regardless of the vessel's latitude. Heave measurements supplied by POS/MV maintain an accuracy of 5% of the measured vertical displacement or ± 5cm (whichever is the larger) for movements that have a period up to 20 seconds (manufacturer's specifications). No significant heave artefacts were observed in the processed data aided by the good weather experienced for most of the survey.

2.4.2 Acquisition

The Kongsberg EM302 multibeam echo-sounder and SIS software (V.4.2.1) were used in tandem for data acquisition. SIS was used to display the previous sounding coverage as well as the current sounding coverage, and was used to provide planning and navigation for the data acquisition and bridge personnel. Raw data files were then exported into CARIS (V.9.1.7) for processing and cleaning.

Survey speed was kept to around 8 knots to ensure the data resolution remained high over the full range of depths experienced during the survey. This speed was reduced in higher sea states to ensure the data quality remained high.

All data collected by R/V *Tangaroa* were transferred to hard drives and taken by the science party on departure from the vessel. A full set of all the multibeam data also resides aboard the R/V *Tangaroa*.

The survey datum for the bathymetric data is Mean Sea Level (MSL). While the raw data is stored in geographic coordinates in reference to the WGS84 datum, data processing outputs are in UTM zone 60 South projection with WGS84 datum.

2.4.3 On-board processing

The raw Kongsberg EM302 data were imported into CARIS HIPS software for initial processing.

The bathymetric data were examined and cleaned using CARIS HIPS initially, with the swath editor, surface 2D and 3D editor then gridded using the CUBE algorithm tool and finally completed using the CARIS subset editor. The amount of cleaning necessary varied with the sea state during acquisition of the bathymetric data.

The bathymetry grid data of 35 m resolution was then exported in ESRI ascii grid format. This can be read in ESRI ArcMap (V.10.3.1) and was used for plot production during the survey and in this report.

Backscatter data (i.e., the strength of the return signal) were imported into FM Geocoder Toolbox software (V.7.6.3). The data were processed and displayed as a mosaic.

3.0 RESULTS

3.1 SWATH MULTIBEAM DATA

Multibeam and backscatter data was collected in a systematic fashion over the survey area, largely along lines oriented NW-SE with a line spacing of 5–6 km (see Figure 2), data was also collected on part of the transit to and from the survey area. In total an area of ~21,815 km^2 was covered by swath mapping, with both multibeam and backscatter data collected and gridded at a resolution of 35 m (Figure 5 and Figure 6) during the Colville III survey. Water column data were also recorded on all lines concurrently with the bathymetry, the data were viewed briefly on-board and no significant water column features were seen. The collected data were logged in a .wcd file format for later land based examination.

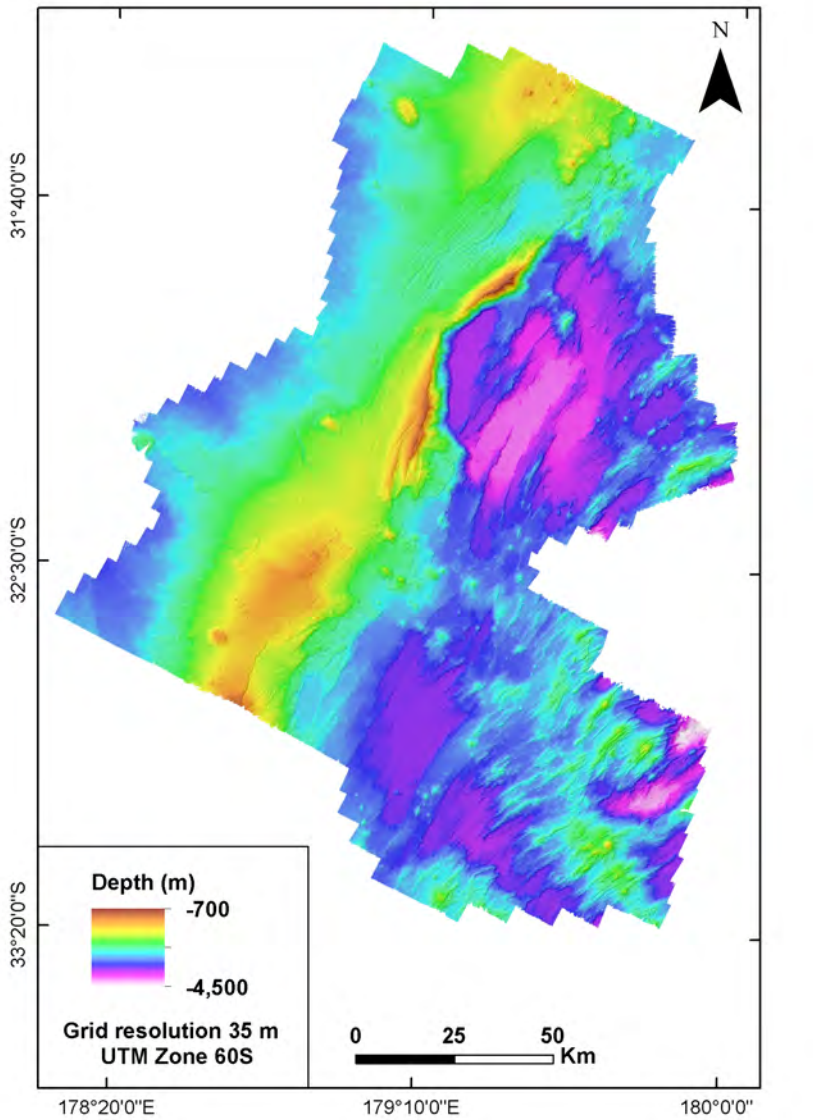


Figure 5 Map displaying full extent of multibeam data collected during *Colville III*.

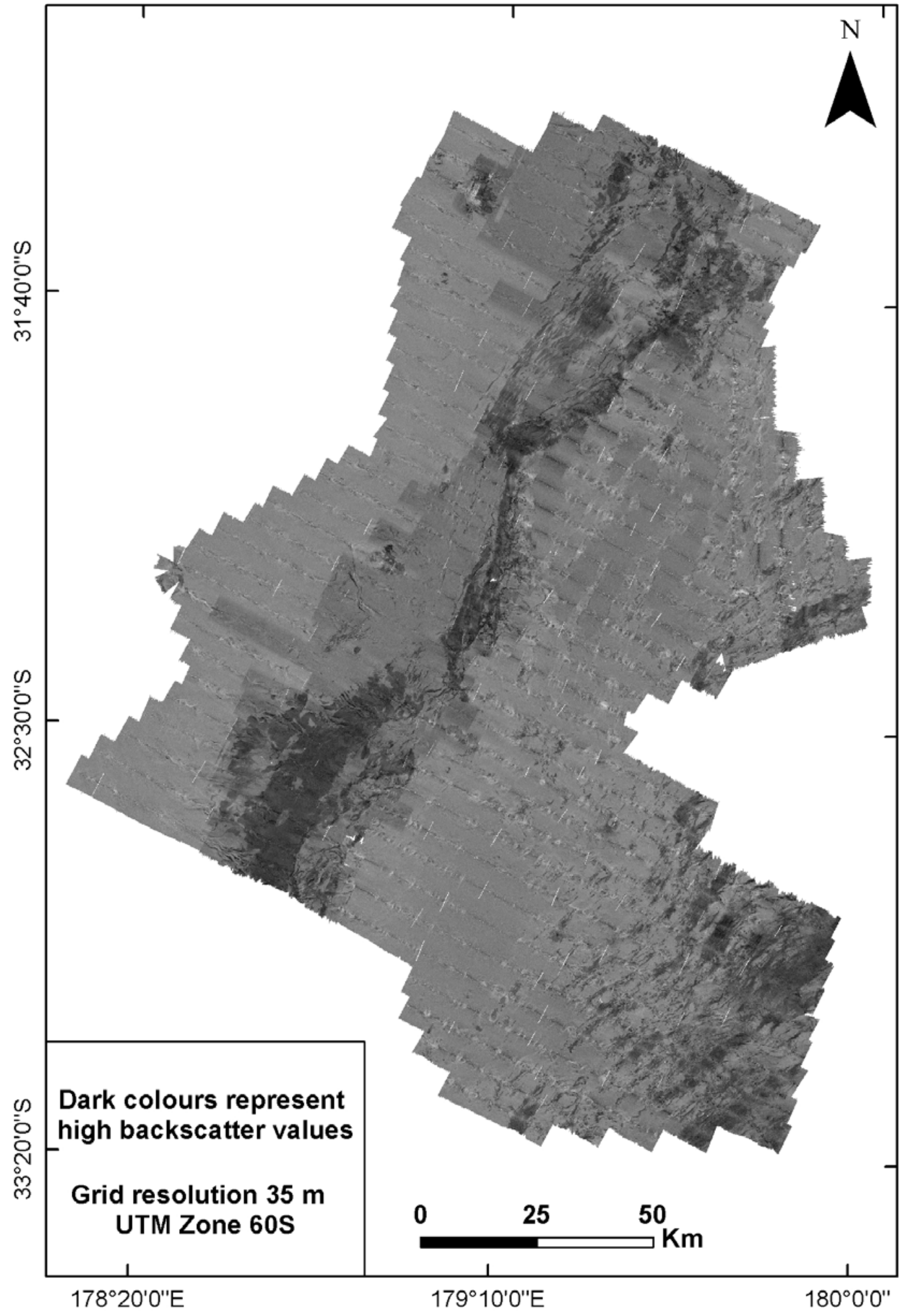


Figure 6 Backscatter data collected during *Colville III*.

3.2 DREDGE OPERATION

Rock sampling during the Colville III cruise was done with a rock dredge.

Seabed rock samples were recovered from 65% of the dredge deployments (11 out of 17; Figure 7). In total, 47 rock samples were collected, with rock types ranging from lava to pumice to altered sedimentary rocks (Figure 7 and Figure 8). Most samples are covered by a few cm thick manganese oxide crusts.

Most samples retained from the dredge hauls were cut with a portable rock saw to allow macroscopic examination, including degree of alteration, mineral content and vesicularity for a preliminary classification (see Table 4). The freshest parts were cut into a thin section stub and a specimen for onshore geochemical analyses. After cleaning the sample exterior from biological residues all samples were photographed (Figure 8), labelled and bagged.

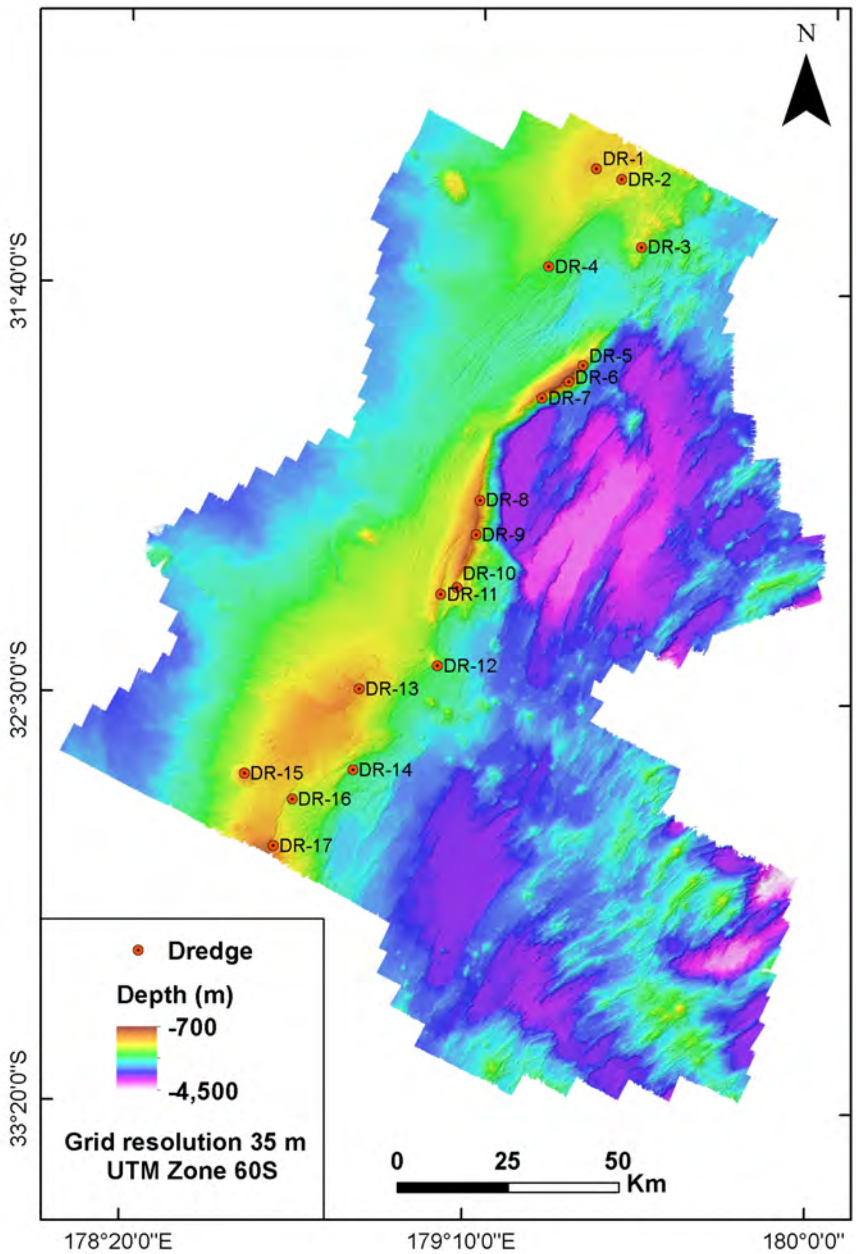


Figure 7 Map displaying dredge sites visited during *Colville III* overlain on bathymetry data.

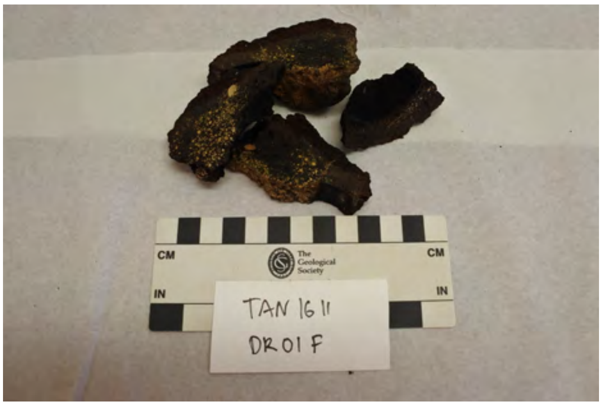

TAN 16 11
DR 1 A


TAN 16 11
DR 01 B


TAN 16 11
DR 01 C


TAN 16 11
DR 01 D


TAN 16 11
DR 01 E


TAN 16 11
DR 01 F


TAN 16 11
DR 02 B


TAN 16 11
DR 02 C


TAN 1611
DR02D


TAN 1611
DR02E


TAN 1611
DR02F


TAN 1611
DR03A


TAN 1611
DR03B


TAN 1611
DR04A


TAN 1611
DR04B


TAN 1611
DR04C


TAN 16 11
DR 04 D


TAN 16 11
DR 05 A


TAN 16 11
DR 05 B


TAN 16 11
DR 05 B


TAN 16 11
DR 05 D


TAN 16 11
DR 06 B


TAN 1611
DR 06 C


CM
IN
TAN 16 11
DR 06 D


CM
IN
TAN 16 11
DR 06 E


CM
IN
TAN 16 11
DR 08 A


CM
IN
TAN 1611
DR08 B


TAN 1611
DR08 C

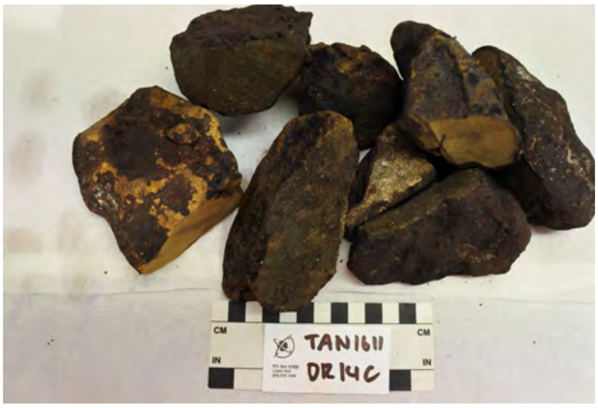

CM
IN
TAN 1611
DR08 E

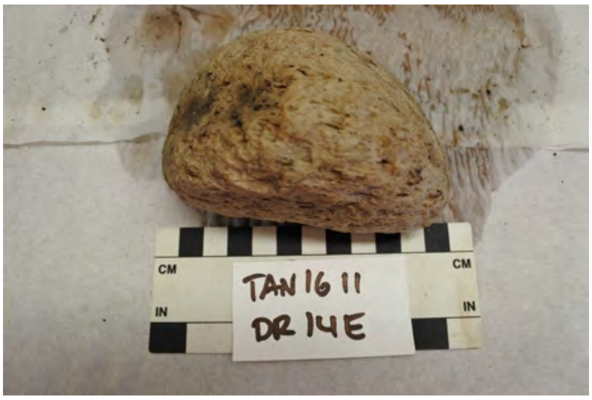

CM
IN
TAN 1611
DR 08 F


TAN 1611
DR 13 A


TAN 1611
DR 14 A


TAN 1611
DR 14B


TAN 1611
DR 14C


TAN 16 11
DR 14E


TAN 16 11
DR 16


TAN 1611
DR 17A

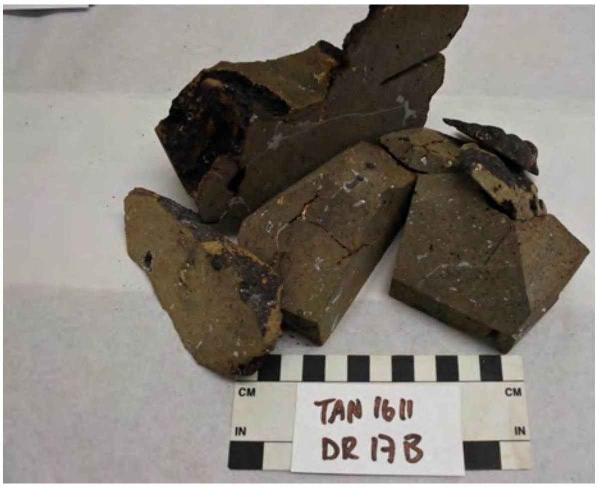

TAN 1611
DR 17B

Figure 8 Rock samples obtained from dredging during *Colville III*.

Table 4 Dredge schedule, including petrographic details for *Colville III*.

Sample No.	Weight (g)	Colour	Angularity	Alteration	Mn coat (mm)	Glass rim (mm)	Vesicles (%)	Texture	Notes
DR01A	6640	Dark grey-black	Subangular to angular	Moderate to fresh	>1mm	-	c.5%	Fsp (<1%) and px (trace; ≤1mm across)-bearing lava; vesicles partly filled with foram ooze or silicified limestone-like material	Pillowlava; Original sample size 25*15*18 cm; cut; GC and TS
DR01B	1260	Dark grey-black	Angular	Fresh	>1mm	-	c.5%	Similar to DR01A, but with smaller vesicles	Pillowlava; Original sample size 10*8*8 cm; cut; GC and TS
DR01C	5180	Dark grey-black; brown	Subangular to angular	Moderate to fresh	>1mm	-	c.5%	Similar to DR01A, and DR01B	Pillowlava; Original sample size 20*17*12 cm; cut; GC and TS
DR01D	980	Brownish-Dark grey-black	Subangular to angular	Moderate to fresh	>1mm	<1mm altered	2–5%	Black lava with brownish rim towards outside; 1–2% fsp and px ± ol	Pillowlava; Original sample size 10*8*7 cm; cut; GC and TS
DR01E	400	Brownish-Dark grey-black	Subrounded	Moderate to fresh	>1mm	-	2–3%	Black lava with brownish rim towards outside; 1–2% fsp and px ± ol; vesicles mostly filled with cemented foram ooze?	Pillowlava; Small sample; cut; TS
DR01F	160	Brownish-Dark grey-black	Subrounded	Moderate	>1mm	<1mm altered	2–3%	Black lava with brownish rim towards outside; 1–2% fsp and px ± ol; vesicles mostly filled with cemented foram ooze? Scoreacous - flow top?	Pillowlava; Original sample size 10*8*6 cm; cut; GC and TS
DR01G	520	Pale grey	angular	Moderate to fresh	-	-	-	pumice (from Havre?)	8 fragments; uncut
DR02A	1280	Dark grey-black	Angular	Fresh	>1mm	-	2–5%	olivine-bearing lava; ≤2mm across; contains crustal xenolith c.2cm across	Pillowlava; Original sample size 12*10*9 cm; cut; GC and TS
DR02B	3260	Dark grey-black	Angular	Fresh	>1mm	-	5–10%	Fsp, px ±ol (<1mm across)-bearing lava; vesicularity gradually decreases from centre (>1cm across) to rim (<1mm across)	Pillowlava; Original sample size 22*12*12 cm; cut; GC and TS
DR02C	2720	Dark grey-black; brown	Angular	Moderate to fresh	>1mm	c.1mm altered	c.2%	Fsp, px ±ol (<2mm across)-bearing lava; vesicle size of <1mm across	Pillow lava; Original sample size 20*12*13 cm; cut; GC and TS
DR02D	2020	Dark grey-black; brown	Subangular	Moderate to fresh	>1mm	c.1mm altered	c.2%	sample similar to DR02C	Pillowlava; Original sample size 18*13*10 cm; cut; GC and TS
DR02E	2060	Red Brownish-Dark grey-black	Angular	Moderate to fresh	>1mm	c.1mm altered	c.20%	Scoreaceous; flow top breccia containing fsp and px?	Pillowlava; Original sample size 22*17*10; cut; TS
DR02F	760	Dark grey-black; brown	Subangular	Moderate	>1mm	c.1mm altered	c.2%	sample similar to DR02C and DR02D, but no olivine?	Pillowlava; Original sample size 12*10*8 cm; cut; GC and TS
DR03A	360	Black	Rounded		MnOx	-	-	Mn-crust; maybe covering some dark grey lava	8 small pieces; uncut
DR03B	780	Pale grey; brown	Subrounded	Moderately to fresh	-	-	-	pumice	10 pieces ≤10 cm across; uncut
DR04A	4540	Crème-beige; black	Rounded	Moderate	c.5mm	-	-	Relatively hard, calcerous sediment; veins of Mn; shell	Original sample size 32*25*18cm; cut
DR04B	1440	Brown-black	Rounded	Strong	5–8mm	-	-	Heavely altered, Mn encrusted sediment?	Original sample size 12*15*8cm; cut
DR04C	720	Brown-black	Rounded	Strong	5–8mm	-	-	Heavely altered, Mn encrusted sediment; similar to DR04B	Original sample size 13*8*9cm; cut
DR04D	3680	White-pale grey	Subrounded to angular	Fresh	-	-	-	Pumice	6 pieces bagged
DR05A	900	grey-pale green	Rounded	Moderate to strong	<1mm	-	-	Dense, heavy lave with >20% fsp and large (>2mm across) px. Fine cracks with Mn infill	Original sample size 12*10*8cm; cut; TS and GC
DR05B	80	Olive green	Rounded	Moderate to strong	<1mm	-	<0.5%	Less dense lava than DR05A; fsp (c.10%) and px-bearing (<2mm across)	Original sample size 8*6*7cm; cut; GC only
DR05C	60	Olive green	Rounded	Moderate to strong	<1mm	-	<1%	Similar to DR05B, less crystal-rich; small vesicles; <1mm iddigsite	Original sample size 5*4*3cm; cut; GC only
DR05D	720	yellow-brown	Rounded	Strong	5mm	-	-	Volcaniclastic breccia; heavy; dense, contains <0.5cm fragments of fsp-bearing lava	two pieces; c.12*10*8 each; uncut
DR06A	3080	Olive green	Rounded	Moderate to strong	<1mm	-	1–3%	Dense lava with c.5% fsp and large (>1mm across) px. Mn vesicle infill	Original sample size 16*15*12 cm; cut; TS and GC

Sample No.	Weight (g)	Colour	Angularity	Alteration	Mn coat (mm)	Glass rim (mm)	Vesicles (%)	Texture	Notes
DR06B	900	Olive green	Rounded	Moderate to strong	<1mm	-	2–4%	More vesicular than DR06A, but less abundant fsp and px; vesicles calcite filled	Original sample size 12*11*9cm; cut; GC and TS
DR06C	1880	Multiple	Rounded	Strong	<1mm	-	-	Volcaniclastic breccia containg large dense greenish lava fragment; Zeolites in lava	Original sample size 23*18*15 cm; cut; GC and TS out of lava fragment (10*5*7 cm
DR06D	1580	Multiple	Rounded	Strong	5mm	-	-	Volcaniclastic breccia; heavy; dense, contains <5cm fragment of fsp-bearing lava	two pieces; c.12*10*8 each; uncut
DR06E	1220	Multiple	Rounded	Strong	5mm	-	-	Similar to DR06D	uncut
DR08A	4160	Olive green; grey	Subrounded	Moderate to strong	≤1cm	-	<1%	Relatively dense, heavy lava containing fsp, px ±ol?.	Original sample size 60*30*28 cm; cut; TS and GC
DR08B	3880	Olive green; grey	Subrounded	Moderate to strong	≤1cm	-	<1%	Relatively dense, heavy lava containing fsp, px ±ol?. Similar to DR08A	Original sample size 25*18*12 cm; cut; TS and GC
DR08C	3100	Olive green; grey	Rounded	Strong	-	-	-	Similar to DR08A and B, but more altered	Original sample size 20*13*12 cm; cut; TS and GC
DR08D	2540	Olive brown; green	Rounded	Strong	<1mm	-	-	Fine grained sedimentary rock with chert-like bands	Original sample size 28*15*12 cm; cut
DR08E	1400	Pale brown-yellow	Rounded	Strong	≤1cm	-	-	Fine grained volcaniclastic rock or heavely altered lava?	Original sample size 14*12*15 cm; cut
DR08F	2520	Multiple	Rounded	Strong	≤5mm	-	-	Heavy and dense volcaniclastic breccia, silica cemented?	Original sample size 18*15*10 cm; cut
DR13A	3240	Multiple	Rounded	Strong	≤1cm	-	-	Volcaniclastic breccia containing large fragments ≤5 com across;	Original sample size 24*16*12 cm; cut; separated xenoliths - gabbroic?
DR14A	180	dark-grey; black	Rounded	Moderately	<1mm	-	1–2%	Small piece of lava; fsp-rich (incl xenocrysts ≤0.5cm across) ±px	Original sample size 7*6*5 cm, edges cut
DR14B	2260	Olive green-brown	Rounded	Strong	≤1 cm	-	-	Sedimentary rocks; silt-sandstones, variably altered	10 pieces bagged
DR14C	2080	Multiple	Rounded	Strong	≤5 mm	-	-	volcaniclastic breccias; different degrees of alteration	6 pieces bagged
DR14D	1040	Multiple	Rounded	Strong	≤2 cm	-	-	Highly altered greenish volcanic breccia with thick Mn crust	Original sample size 22*12*11 cm
DR14E	420	Pale grey -brown	Rounded	Moderately	-	-	-	Piece of rounded pumice	Original sample size 12*10*8 cm, uncut
DR16A	140	Multiple	Rounded	Moderately to strong	<1cm	-	-	few small pebbles of yellow-brown and dense sediment and Mn crusts	-
DR17A	1440	brownish-grey	Rounded	Moderately to strong	<1mm	-	1–2%	relatively dense lava, brown altered px and few fsp; some vesicles and cracks filled with zeolites and calcite	Original sample size 18*15*12 cm; GC and TS; cut
DR17B	1700	brownish-grey	Rounded	Moderately to strong	<1mm	-	1–2%	Similar to DR17A	Original sample size 19*14*10 cm; GC and TS; cut
DR17C	1160	brownish-grey	Rounded	Strong	<1mm	-	1–2%	Similar to DR17A, but less vesicular and denser	Original sample size 12*12*11 cm; GC and TS; cut
DR17D	720	brownish-grey	Rounded	Moderately to strong	<1mm	-	1–2%	Similar to DR17C	Original sample size 12*10*8 cm; GC and TS; cut
DR17E	620	brownish-grey	Rounded	Moderately to strong	<1mm	-	1–2%	Similar to DR17A	Original sample size 10*9*9 cm; GC no TS; cut
DR17F	120	Yellow brown	Rounded	Strong	<1mm	-	-	Sedimentary rock; unstratified siltstone	Original sample size 8*6*5 cm; cut

3.3 MAGNETIC DATA

A total of 21,815 km² of magnetic data was recorded with a line spacing of 5–6 km (Figure 2 and Figure 9). Magnetic data were collected with a GNS Marine Magnetics Seaspy magnetometer (Figure 1), towed 300 m behind the stern of the R/V *Tangaroa*. The data were processed for heading and lag errors, and the anomaly field was obtained by subtracting the 2015 International Geomagnetic Reference Field. Data were processed using Oasis Montaj Geosoft.

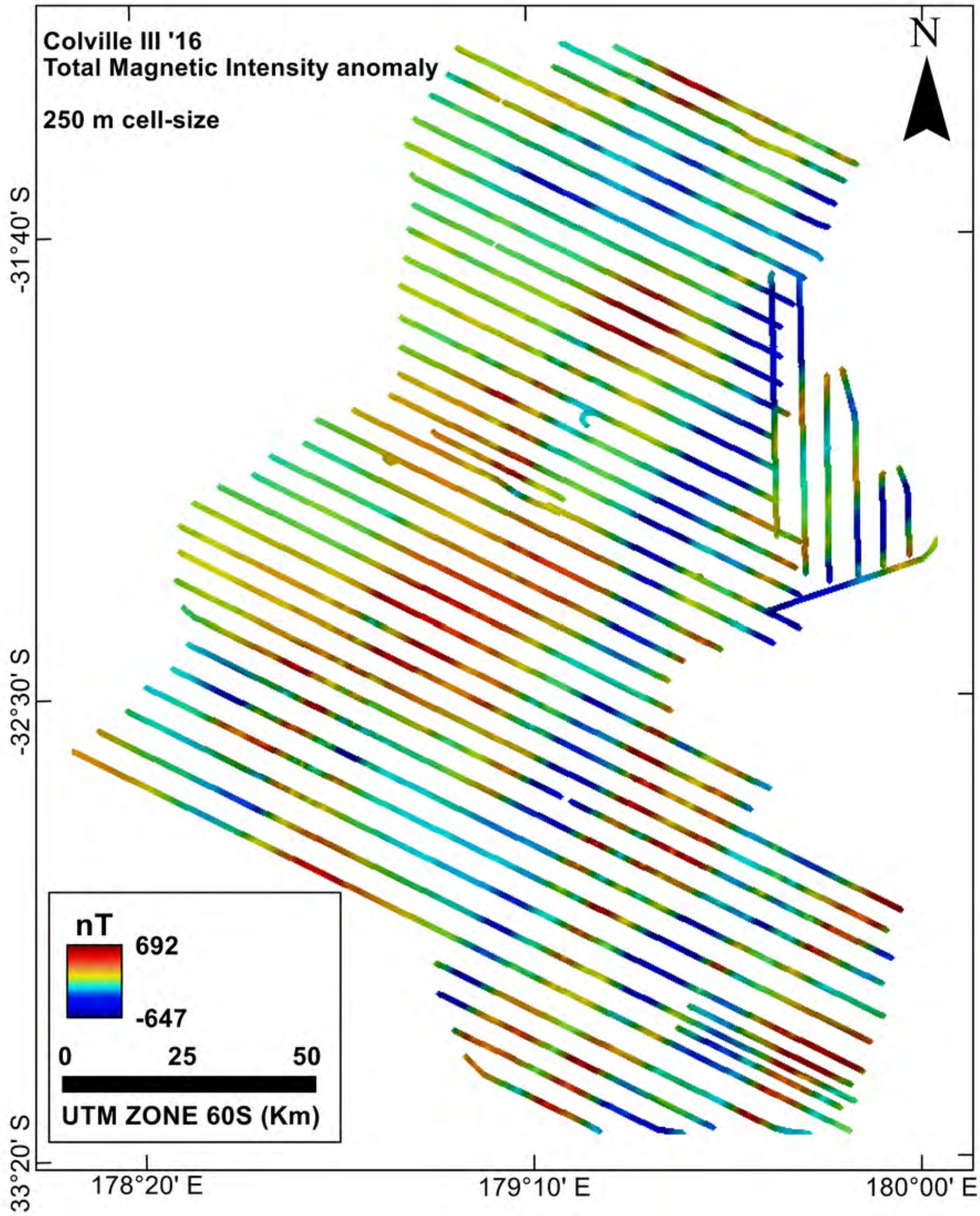


Figure 9 Magnetic data (Total Magnetic Intensity anomaly) collected during the Colville III cruise, underlain by the bathymetric data. Magnetic data grid cell size is 250m.

3.4 GRAVITY DATA

Gravity data were collected using a GNS Lacoste & Romberg S-80 dynamic gravity meter upgraded to a ZLS Ultrasys control system. Data was sampled by using the ZLS Ultrasys software at 1 Hz and stored on two acquisition laptops. The GPS positioning data was stored on a third computer and merged with the gravity data in post-processing. Relative gravity was tied to a base station in Aotea Quay (Wellington) prior to the voyage, and to Wynyard Wharf post voyage to check for meter drift (<3 mGals/month). Data were corrected for drift and Eotvos effects and processed with a Bspline low-pass filter along the survey lines to produce a free air anomaly grid.

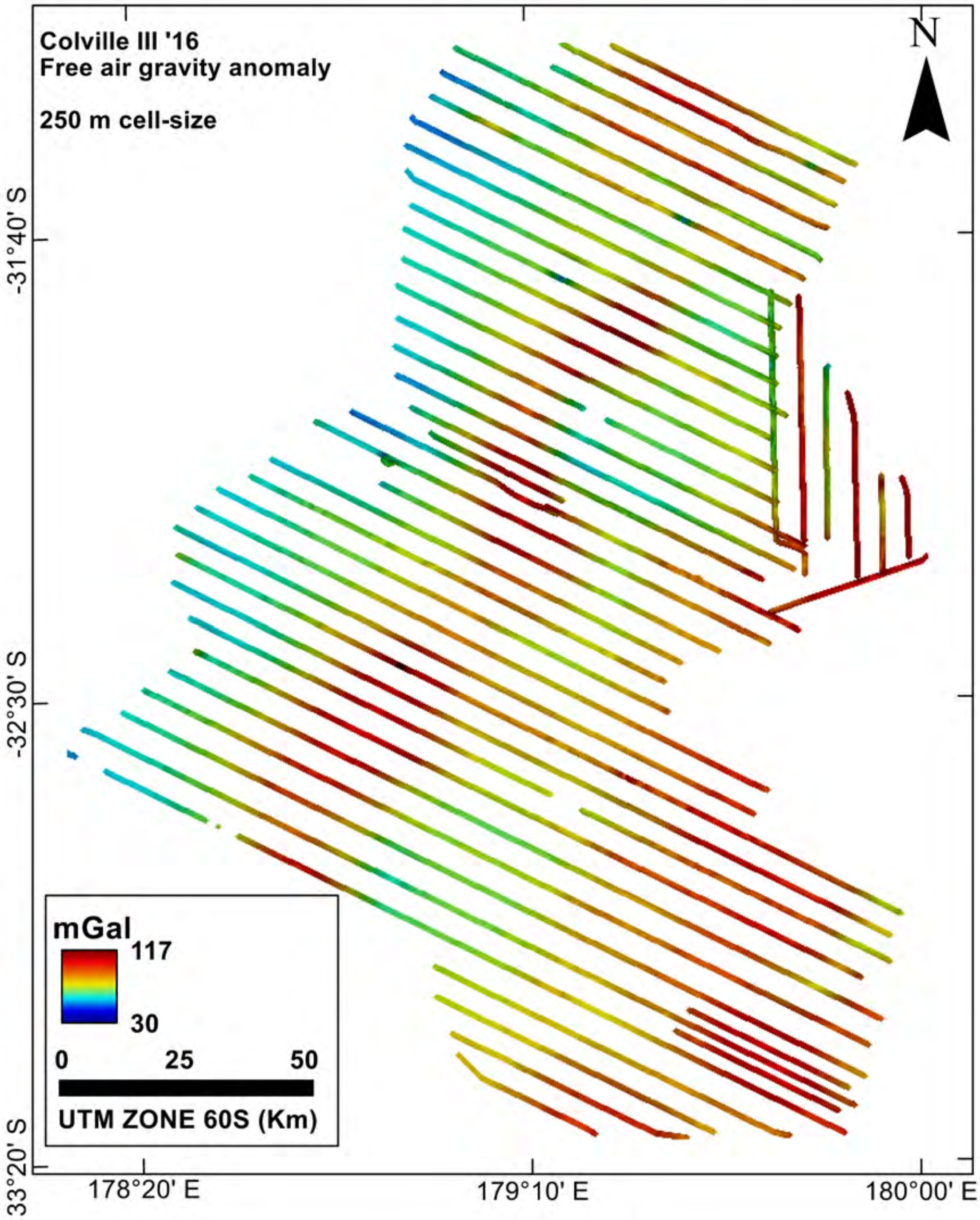


Figure 10 Gravity data (free air Anomaly) collected during the *Colville III* cruise underlain by the bathymetric data. Gravity data grid cell size is 250m.

3.5 Outreach Activity

A GNS Science media release has been published on the day of departure (26.09.2016). The media release can be found here: https://gns.cri.nz/Home/News-and-Events/Media-Releases/Colville.

As a further outreach initiative, an online blog was run by Jack Whattam, a student on-board the voyage. The blog recorded the major scientific objectives and various day-to-day activities that took place on-board. The aim of the blog was to communicate scientific research in the Colville Ridge region and the importance of the work. Each blog post focussed on one specific aspect of the science or general life on-board a research vessel and was accompanied with a series of photos to illustrate points. In total there were six blog posts covering research aims, sound velocity profiles, multi-beam bathymetry mapping, geophysical measurements, ship life on a research vessel, and seabed sampling using a rock dredge.

Read the blog here: http://colville-ridge-marine-expedition.blogspot.co.nz/

3.6 Biological Sampling

Although the rock dredging is not designed to retrieve biological samples from the Colville Ridge the method proved to be successful in recovering a selection of biology from all 17 dredge sites. A representative range of the recovered biology has been sampled and deep frozen for conservation. All biological samples have been passed on to NIWA for further examination.

Table 5 Dredge stations and associated biological samples collected

Date (NZST)	Dredge location	Dredge Station Number	No of large bags	No of small bags	Box	Latitude (S)	Longitude (E)	Depth of gear (m)
12/10/2016	A	DR-1	1	2	1/2	31.42	179.4383333	1100
12/10/2016	B	DR-2	1	2	1/2	31.441389	179.4994444	1249
12/10/2016	C	DR-3	1	2	1/2	31.578333	179.5497222	1435
13/10/2016	D	DR-4	1	2	1/2	31.621944	179.3302778	2130
13/10/2016	E	DR-5	1	2	1/2	31.821667	179.4166667	1209
13/10/2016	F	DR-6	1	2	1/2	31.855	179.3841667	834
13/10/2016	G	DR-7	1	4	1/2	31.89	179.3208333	1130
13/10/2016	H	DR-8	1	4	1/2	32.100556	179.1769444	1200
13/10/2016	I	DR-9	1	3	2/2	32.170833	179.1694444	1970
13/10/2016	J	DR-10	1	2	2/2	32.278611	179.1261111	1368
13/10/2016	K	DR-11	1	1	2/2	32.293611	179.0883333	1397
14/10/2016	L	DR-12	1	-	2/2	32.437778	179.0833333	1550
14/10/2016	M	DR-13	1	1	2/2	32.488056	178.8963889	1220
14/10/2016	N	DR-14	1	1	2/2	32.653333	178.8847222	1945
14/10/2016	O	DR-15	1	4	2/2	32.663611	178.6236111	1400
14/10/2016	P	DR-16	1	3	2/2	32.715	178.7397222	1840
14/10/2016	Q	DR-17	1	7	2/2	32.810278	178.6955556	1160

4.0 VOYAGE SUMMARY

This survey was successful in providing the first comprehensive map of the seafloor together with a geophysical grid of the north-Colville Ridge area covering 21,815 km². Data collected on this cruise includes bathymetry, backscatter, magnetics, gravity and rock samples. Prior to this voyage, no comprehensive data set existed for either bathymetry or geophysical data in the northern Colville Ridge area.

This voyage, combined with data collected from *Colville I* and *Colville II* voyages completes a 4-year project to survey the Colville Ridge with New Zealand's EEZ. These data will be used to underpin basic research on seafloor mineral deposits, New Zealand's tectonic history and related arc volcanism.

The combination of data collected during *Colville III* with data from *Colville I* and *Colville II* means we now have 100% coverage of bathymetry, magnetic and gravity data over a significant area (60,640 km^2) immediately offshore New Zealand. This data has hitherto not been collected in a consistent way over the Colville Ridge. Cruises with GEOMAR in 2017 will utilize the maps created during this voyage and previous Colville voyages to target areas of scientific interest for more selected seabed sampling. The data furthermore provide the framework for further focussed surveys using AUVs or ROVs to further understand the geology of the region. Thus, the three *Colville I, Colville II* and *Colville III* expeditions have ensured this part of our sovereign estate has appropriate resolution maps for years to come in utilization of regional prospectivity surveys, tectonic plate reconstructions, and general understanding of the architecture of the Kermadec backarc.

5.0 ACKNOWLEDGEMENTS

We would like to acknowledge and thank the captain and crew of the R/V *Tangaroa* for a successful and enjoyable voyage. The voyage was fruitful in various operations and the crew worked efficiently and safely to accommodate our sampling requests. GNS Science would like to acknowledge funding for the expedition from the Ministry of Business, Innovation and Employment through the MFARG contract.

6.0 REFERENCES

de Ronde, C.E.J., Caratori Tontini, F., Timm, C. and Merle, S.G., 2016, Colville ’15, OS2020 cruise to the southern Colville Ridge, 5–25 September, 2015, Wellington to Auckland, New Zealand. GNS Science Report 2016/73, 20 pp.

de Ronde, C. E. J.; Caratori Tontini, F.; Timm, C.; Merle, S. G. 2016. Colville I ’13 OS2020 cruise to the southern Colville Ridge, 17 November–1 December 2013, Auckland to Wellington, New Zealand. GNS Science Report 2016/72. 27 p.

The GEBCO_08 Grid, version 20091120, http://www.gebco.net