# VESPA cruise report

Volcanic Evolution of South Pacific Arcs

***n/o L'Atalante,***

**Nouméa – Nouméa, 22 May - 17 June 2015**

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## Abstract

VESPA was a successful 25 day research cruise on R/V l'Atalante that took place in May and June 2015. The main aim was to acquire new rock samples from extinct volcanoes on the Norfolk, Loyalty and Three Kings ridges, which connect New Caledonia and New Zealand. This was in order to test various hypotheses of Late Cretaceous-Miocene SW Pacific tectonic development relating to (i) nature and duration of magmatism on the ridges; (ii) timing of subduction initiation east of northern Zealandia; (iii) postulated subduction polarity changes.

A total of 3400 km of 'sismique rapide' shallow reflection seismic data were acquired and processed onboard. The seismic lines provided a very useful structural-stratigraphic framework for the rock dredging. Combined with multibeam bathymetry data they allowed intelligent targeting of acoustic basement (lavas) and specific seismic reflectors (sedimentary strata) on rocky slopes and fault scarps. Different stratigraphic levels of the Loyalty and Three Kings Ridge volcanic piles were sampled by dredging at different water depths on the Cook Fracture Zone and Cagou Trough fault scarps.

By the end of the cruise, 43 dredges had been attempted and 36 of them yielded igneous or sedimentary rocks potentially useful to the VESPA project. Onboard use of a portable X-ray fluorescence unit confirmed the presence of intraplate (but no arc) volcanoes on the Norfolk Ridge and presence of arc, intraplate and shoshonitic volcanoes on the Loyalty and Three Kings Ridges. A total of 770 kg of rock was retained for post-cruise analysis in New Caledonia, France and New Zealand. Future work will include micropaleontological dating of sedimentary rocks, U-Pb and Ar-Ar isotopic dating of igneous rocks, and whole rock geochemical and tracer isotope analyses. We are optimistic that many of the initial research hypotheses will be able to be tested.

## Acknowledgments

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We are grateful to the Commandant, Jean-René Glehen, and Crew of N/O l'Atalante without whom the VESPA cruise would not have have been so successful and satisfying.

Julien Collot, Rupert Sutherland, Walter Roest and Rick Herzer gave valuable advice during the proposal stage of VESPA.

We thank the DT/INSU for the loan of a clinometer/pressure gauge, and especially Emmanuel de Saint-Léger who did what was necessary for the tool to be available despite our late application.

Finally IFREMER, SGNC and, ADECAL/Zonéco are acknowledged for their continuous support since the beginning of this project.

# I) Introduction

Geologically the SW Pacific is composed of alternating deep basins and shallow ridges spread out between the east coast of Australia and the active plate boundary between the Australian and Pacific Plates along the Tonga – Kermadec subduction zone (Figure 1). From the long and complex geological evolution that resulted in this setting, one stage is of particular interest: the transition from a regime of regional extension to one of regional convergence, compression and subduction initiation.

Much of the Late Cretaceous in the region was dominated by intracontinental (Gondwana) extension, and also by sea floor spreading in the Tasman Sea. Sometime during the Paleogene the geological setting switched to compression and a convergent, subduction zone, boundary initiated between the Pacific and Australian Plates. This convergent regime, with its volcanic arcs and back arc basins, matured and developed into the present day geometry. This Paleogene tectonic change, accompanied by volcanic activity growth of the arcs, is the focus of the 2015 VESPA (Volcanic Evolution of South Pacific Arcs) cruise. The cruise allows us to address outstanding questions of plate tectonics: how does subduction start, and what are its consequences? The VESPA cruise was designed to answer these important issues in the SW Pacific: where and when did Cenozoic subduction start adjacent to Zealandia?

Oligocene subduction related rocks are found along the Three Kings Ridge, in Fiji and in the Vanuatu and Tonga volcanic arcs (Figure 1). So far, Eocene subduction-related rocks have been found only in Fiji, Tonga and on Bougainville Seamount. These are the oldest known, post-Cretaceous, subduction related rocks. Tectonic models predict that subduction should have initiated over a widespread region, with alternative hypotheses predicting an east- or west-dipping subduction zone forming an arc on the Loyalty Ridge (Figure 2). Therefore pre-Oligocene subduction related rocks should be more widespread than their currently known distribution.

To search for these pre-Oligocene volcanic arc rocks and answer the aforementioned questions, the VESPA cruise mapped seabed features and collected volcanic rocks that are expected to be the early manifestations of the arc(s) formed as the new Pacific-Australian plate subduction regime set up. The strategy of the VESPA cruise was first to acquire rapid seismic, sub bottom profiler and multibeam sounding and then dredge for volcanic and sedimentary rocks.

VESPA focused on four areas in succession, the Norfolk Ridge, Loyalty Ridge, South Fiji Basin and Three Kings Ridge (Figure 1). We dredged a line of extinct volcanoes on the western flank of the Norfolk Ridge to establish whether the volcanic line was due to intraplate or to arc volcanism, and to determine how old it was. Then we worked on the Loyalty Ridge as all previous attempts to sample its older arc basement had failed, whereas its morphology and location at the eastern edge of the Gondwana margin makes it a good candidate to be the Paleogene volcanic arc. Fault scarps on the Cook Fracture Zone were used as a 'window' into the deeper basement of the Loyalty Ridge without the need to drill. The next work area was the backarc crust of the South Fiji Basin which lies east of the Loyalty Ridge. There is controversy on the age of opening of the basin and its relationship to the Loyalty Ridge. Finally the Three Kings Ridge was surveyed and dredged, again taking advantage of the Cook Fracture Zone to allow us to dredge the deeper stratigraphic levels of the ridge.

Consequently the VESPA cruise progressed from Noumea southward along the Norfolk Ridge up to the Cook Fracture Zone and return to Noumea. 23 days at sea allowed us to acquire multibeam bathymetry, sub bottom profiling and magnetics, as well as to shoot 3400 km of rapid seismic and to carry out 43 dredging operations.

# II) Geological framework

Subduction in the South Pacific is currently active along the Tonga-Kermadec and Vanuatu trenches (Figure 1). Associated back-arc basins are the Havre, Lau and North Fiji basins. The tectonics, kinematics, petrology and age of these features have been intensely studied and are very well characterised at the regional scale (e.g. Lagabrielle et al. 1997, Pelletier et al. 1998, Ruellan et al. 2003).

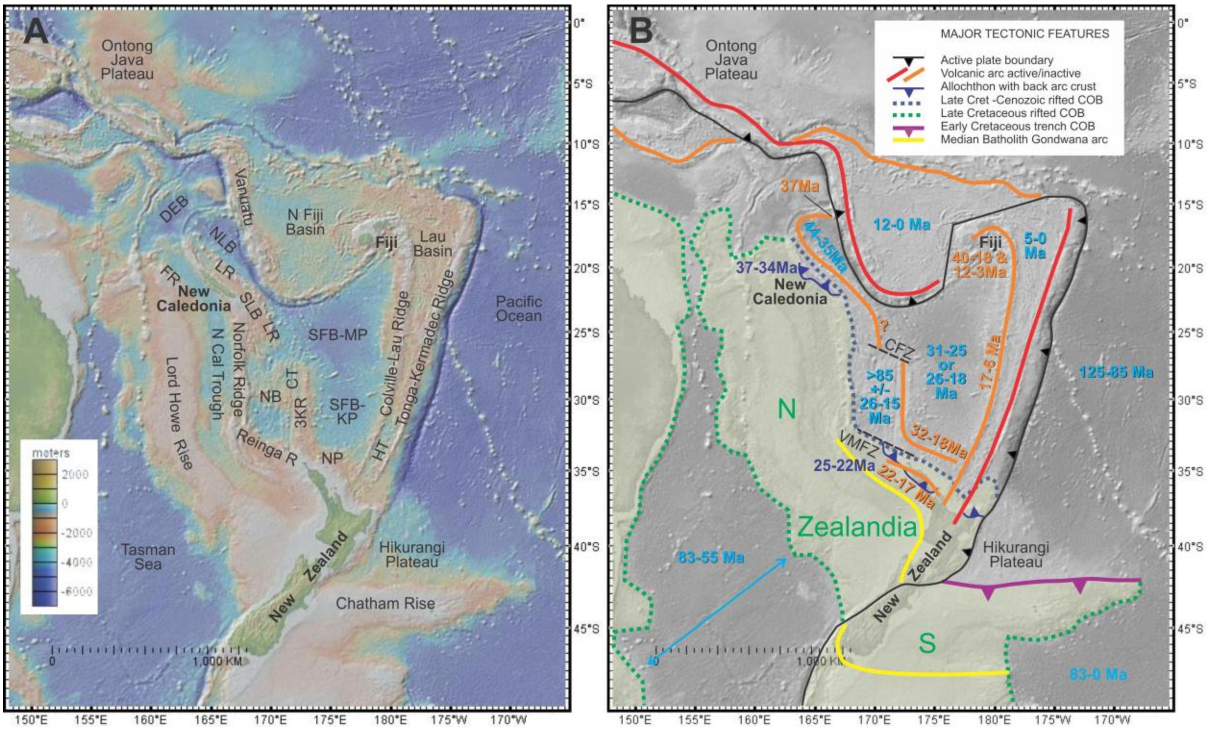

Figure 1 Geography and major tectonic features of the South Pacific area. DEB = D'Entrecasteaux Basin, NLB = North Loyalty Basin, SLB = South Loyalty Basin, FR = Fairway Ridge, LR = Loyalty Ridge, CT =Cagou Trough, SFB = South Fiji Basin, MP = Minerva Plain, KP = Kupe Plain, NB = Norfolk Basin, 3KR = Three Kings Ridge, NP = Northland Plateau, HT = Havre Trough, CFZ = Cook Fracture Zone, VMFZ = Vening Meinesz Fracture Zone, COB = Continent-Ocean boundary. Known and/or inferred ages shown by different coloured letters: volcanic arcs (orange), basins (blue) and allochthon emplacement (violet), S = South Zealandia, N = North Zealandia.

Less well studied in the region is the older subduction history, including time and mode of subduction initiation (Matthew et al. 2015). Subduction tectonics has been continuous since at least the Eocene. In the South Pacific region Cenozoic collisional events and terrane accretions have not progressed to extreme conclusions as they have in many orogenic belts. Thus there is a good chance to be able sort out the tectonic evolution from the array of small collisional orogens, partial terrane accretions, still-open backarc basins, remnant arcs and a preserved continental margin.

A 94% submerged continent called Zealandia (Figure 1, Mortimer 2004) forms the western back-stop to the wider region of active and inactive arcs and back-arc basins. The presence of this long-lived continental platform, with its cover of sedimentary basins provides a separate, far-field, record of subduction-related regional tectonic events that is the topic of investigation by the parallel TECTA cruise. Zealandia, along with Australia and Antarctica, was formerly part of the southern supercontinent of Gondwana. Subduction-related magmatism persisted along Gondwana's Pacific-facing Zealandia-West Antarctica margin until at least 110 Ma. Zealandia started to separate from Gondwana at c. 83 Ma with the formation of the Tasman Sea and Southern Ocean.

The only significant parts of Zealandia that are above sea level are New Caledonia and New Zealand, located at the north and south ends of the Norfolk and Reinga Ridges (Eade 1988). These islands have many continental geological elements in common (Aitchison et al. 1995, Nicholson et al. 2000, 2011; Cluzel et al. 2010): they both consist of a basement of Permian-Early Cretaceous accreted terranes with a cover of <100 Ma nonmarine and marine sedimentary rocks, Late Cretaceous (85-102 Ma) subalkaline arc and/or rift lavas (Diahot-Noumea Volcanics and Houhora Complex), and allochthonous thrust nappes of Late Cretaceous-Paleogene back-arc basin lavas and sedimentary rocks (Poya Nappe, Tangihua Complex-Northland Allochthon). Major differences in the geology are that New Caledonia contains a blueschist-eclogite facies metamorphic core that was overthrust by a mantle peridotite nappe at c. 34 Ma and which contains volumetrically very minor post-emplacement 24-27 Ma subduction-related plutonic rocks (Cluzel et al. 2005). In New Zealand, the Northland Allochthon was emplaced at 22-25 Ma; Northland lacks both the high pressure metamorphic core and peridotite nappe and instead hosts a volumetrically substantial, 500 km long, 17-22 Ma volcanic arc (e.g. Booden et al. 2011).

Despite assertive statements in several papers, the age and mechanism of nucleation and inception of subduction of Pacific Oceanic crust against Zealandia continental crust is both poorly known and ardently disputed (Figure 2). Options include Model 1: induced nucleation by a collisional arc at c. 40-50 Ma and c. 25 Ma, with age of collision getting younger from New Caledonia to New Zealand. Model 2: spontaneous nucleation by resumption of the Mesozoic Gondwana subduction pattern, at c. 90-100 Ma, 40-50 Ma or 25-30 Ma. What is not disputed is that there is a gap in presently sampled record of arc magmatism, between the 105 Ma arc of eastern Gondwanaland (Median Batholith) and the 40-50 Ma magmatism of SW Pacific (IBM, Fiji etc). If such rocks exist in the south Pacific, they probably lie in the deep parts of the Loyalty and Three Kings Ridges.

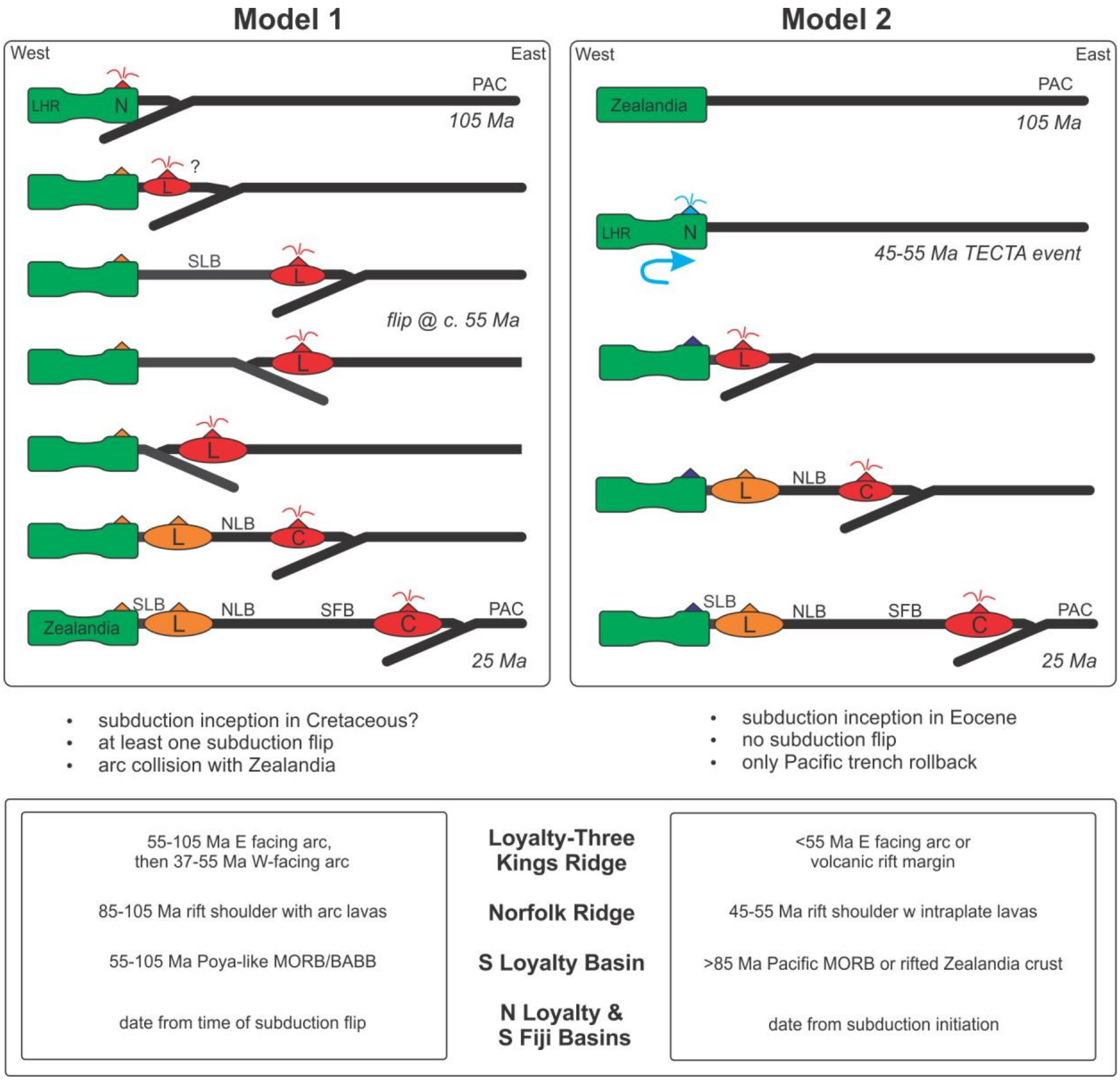


Figure 2 Two very different classes of South Pacific magmatic-tectonic models that will be tested by the VESPA cruise sampling of the Loyalty-Three Kings (L) and Norfolk (N) Ridges. The two models are highly simplified composites of many different models, focus on subduction polarity, and do not attempt to explain the complete tectonic evolution of the region e.g. ophiolite obduction. C = Colville-Lau Ridge, SLB = South Loyalty Basin, NLB = North Loyalty Basin, SFB = South Fiji Basin, LHR = Lord Howe Rise, PAC = Pacific Plate. Model 1 is based on Malahoff et al. (1982), Launay et al. (1982), Cluzel et al. (2001), Meffre et al. (2002, 2006), Crawford et al. (2003), Whattam et al. (2005, 2008) Schellart et al. (2006) and Collot et al. (2009). Model 2 is based on Ballance et al. (1982), Ballance (1999), Mortimer et al. (2007, 2010a) Sutherland et al. (2010) and Bache et al. (2012). Red=active arc, orange=inactive arc, blue=intraplate.

## Polarity Change and Arc Collision

37 Ma boninites, 32-20 Ma normal arc andesites and 20 Ma shoshonites have previously been dredged from different parts of the Three Kings Ridge (Mortimer et al. 1998, 2007; Mauffret et al. 2001, Bernardel et al. 2002, Sdrolias et al. 2004b, Dicaprio et al. 2009). Such distinct rock types are potentially of great use in determining arc polarity as schematized on

Figure 3. However, prior to the VESPA cruise, the number of samples are too few and the ages of, and distances between, samples too scattered to be able to confidently establish the (changing or constant) polarity of the Loyalty-Three Kings Ridge in any one time interval (Figure 2). Furthermore, the only subduction-related volcanic rocks yet to have been recovered from the entire 1600 km long Loyalty Ridge are from its extreme northeastern tip (Figure 1): 37 Ma (Eocene) lavas on Bougainville Seamount (Baker et al. 1994; Mortimer et al. 2014).

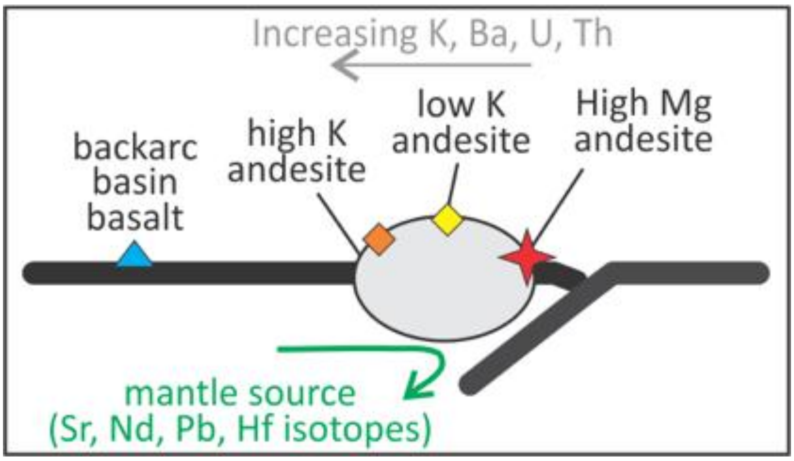


Figure 3 : Expected petrological and geochemical variation of lavas across an idealized volcanic arc.

By dedicating most of the VESPA cruise to the dredging of the Loyalty-Three Kings Ridge we hoped to collect petrological, geochemical, stratigraphic and structural data that bear directly and specifically on the arc polarity (Figure 3).

# III) Survey Description

## *III-1) Onboard scientific team*

| | | | |
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Figure 4 The scientific team plus part of the crew

## *III-2) Progress of the survey*

This is a summary of the chronological progress of the survey in Universal Time (UTC).

Depart Nouméa Friday **22/05/2015 21h** (Saturday 23 May 08h local time)

- 30 mn test of *EM710* in shallow water (lagoon) **22/05 22h**
- start *Rapid Seismic acquisition* off the lagoon **23/05 01h** until **23/05 14h** (SR001 – SR002)
- *Dredge* DR001 **23/05 17h**
- *Rapid Seismic* from **23/05 20h** until **24/05 18h** (SR003 – SR006)
- 2 days of *dredging*, until **26/05 21h** (DR002 – DR007)
- 6 days of *Rapid Seismic* until **01/06 16h** (SR008 – SR018). This included two unplanned profiles to and from to New Caledonia (SR017 & SR018), in order for a crew member to leave the ship because of a family death: the ship transited to Passe de la Havannah (south of New Caledonia) where we met the pilot at **20h** the **01/06** (02/06 7h local time).
- transit back to the working area until **02/06 18h**
- *dredging* until **14/06 02h** (DR008 to DR041)
- *Rapid Seismic acquisition* until **15/06 03h** (SR019 - SR020)
- two last *dredges* (DR042 & DR043)
- transit back to meet the pilot at the lagoon entrance, **16/06 at 03h**

Arrive Nouméa **16/06/2015** c. 0**5h** (Tuesday 16 June 16h local time)

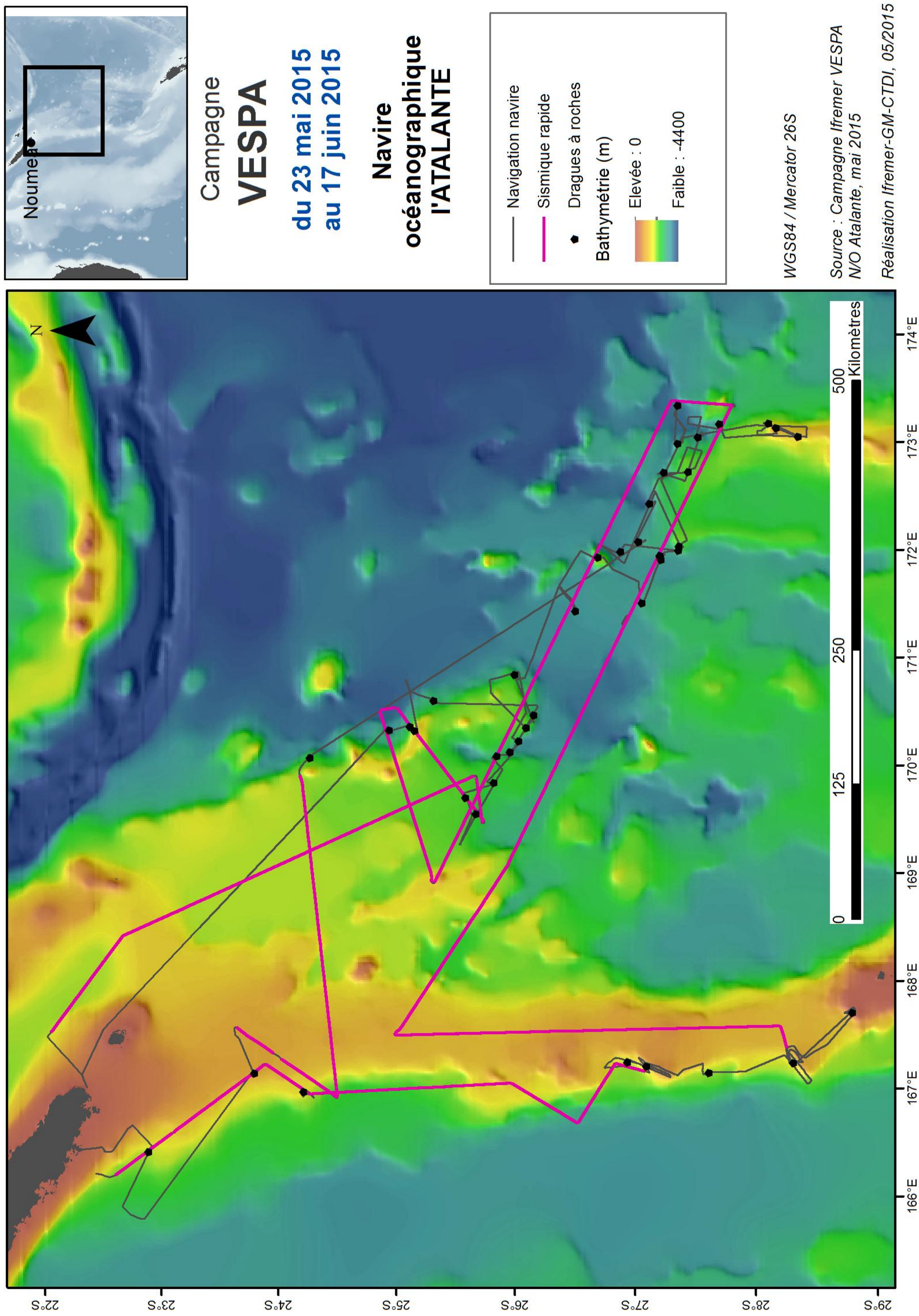



Figure 5 General navigation of the VESPA cruise

# IV) Provisional results

## *IV-1) Seismic data*

### IV-1-1) The "Sismique Rapide" (SISRAP) system

The seismic device deployed during the VESPA voyage was a rapid seismic acquisition system (SISRAP) towed at 10 knots behind the vessel. The active part of the 600 m long streamer is composed of 24 separate channels of 12.5m and 2 auxiliary channels. The sound source is produced by two GI guns forming a total volume of 300 cubic inches towed 25 m behind the ship, and the shooting interval fixed to 10s. The acquisition geometry is summarized in Figure 6.

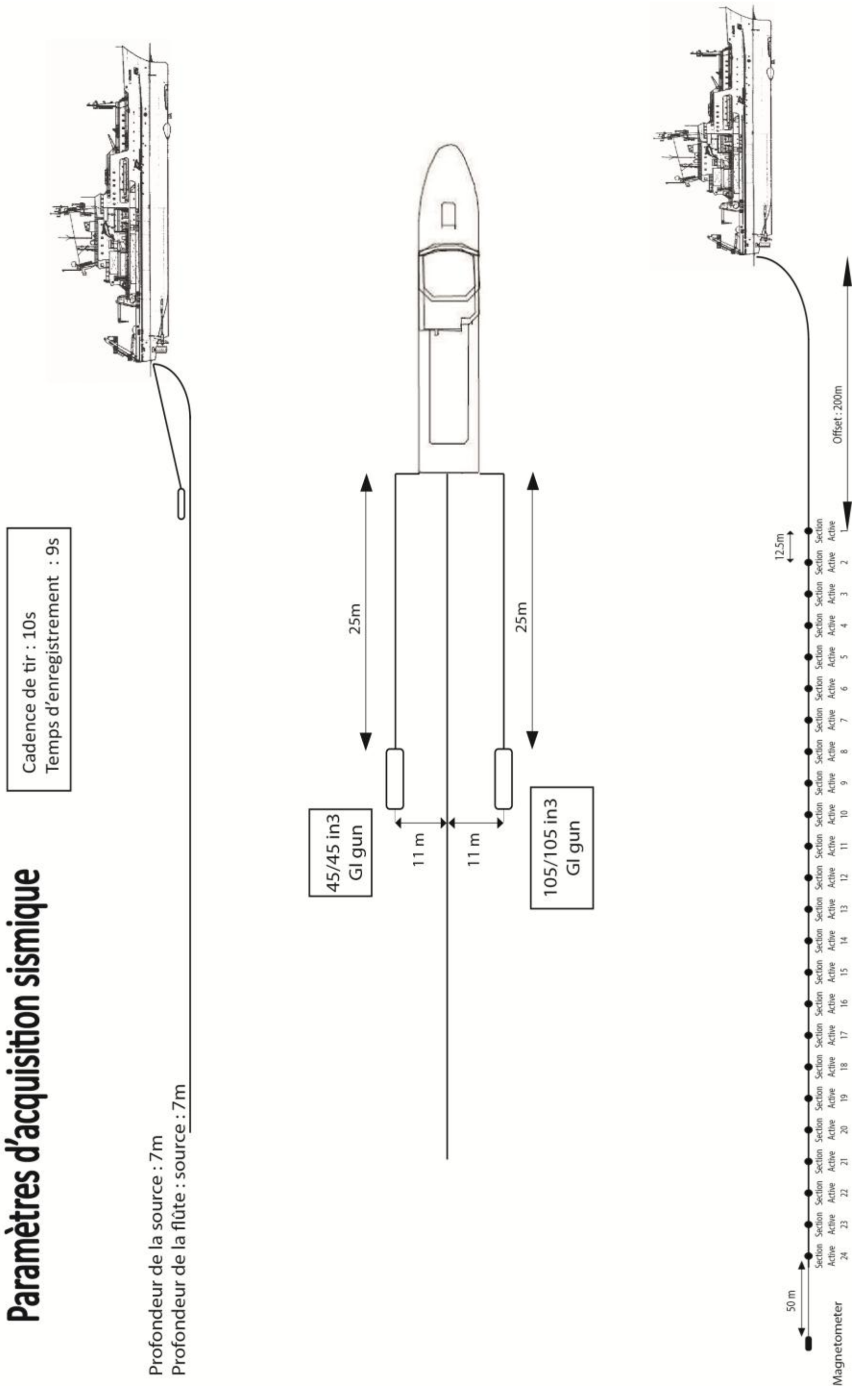



Figure 6 Acquisition geometry of the SISRAP system

## IV-1-2) Seismic impact mitigation measures

Note that in order to limit the impact of seismic sources on marine mammals, an impact study was conducted prior to the voyage and strict mitigation protocols were followed during acquisitions. Two Marine Mammal Observers were onboard. The measures and observations are detailed in ANNEXE 3.

## IV-1-3) SISRAP profiles acquired during VESPA

20 rapid seismic profiles (SISRAP) were acquired during the VESPA cruise, for a total length of about 3400 km (Figure 7). The positioning of the profiles logically focussed on and connected different areas of dredging on both sides of Cook Fracture Zone: Norfolk Ridge, South Loyalty Basin, Loyalty Ridge, South Fiji Basin and Three Kings Ridge. Indeed, besides their regional stratigraphic and tectonic utility, the SISRAP profiles, together with multibeam bathymetry and sub-bottom profiler data, were used to define and refine specific dredge sites. The SISRAP lines imaged the seabed outcropping of geological features of interest such as fault scarps, submarine canyons, stratigraphic units, and volcanoes.

Coordinates of the start and end of each profile and the number of shots are summarized in the Table 1 below.

| Profile | Start of profile (latitude) | Start of profile (longitude) | End of profile (latitude) | End of profile (longitude) | # shots |
|---|---|---|---|---|---|
| 001a | S22°36.371 | E166°11.866 | S23° 5.311 | E166°35.091 | 1244 |
| 001b | S23° 6.250 | E166°35.588 | S23°53.018 | E167°13.665 | 2081 |
| 002 | S23°53.486 | E167°13.508 | S24°14.886 | E166°57.483 | 1068 |
| 003 | S24°15.499 | E166°56.966 | S25°58.009 | E167° 2.944 | 4246 |
| 004 | S25°58.134 | E167° 2.899 | S26°31.516 | E166°40.977 | 1620 |
| 005 | S26°31.584 | E166°41.065 | S26°49.905 | E167°13.887 | 1321 |
| 006 | S26°50.428 | E167°14.076 | S27° 5.004 | E167° 9.508 | 593 |
| 007 | S28°15.049 | E167°22.987 | S28°11.604 | E167°34.782 | 432 |
| 008 | S28°11.474 | E167°34.773 | S24°59.581 | E167°31.100 | 7504 |
| 009 | S24°59.723 | E167°31.229 | S25°55.950 | E169° 3.909 | 3714 |
| 010a | S25°56.027 | E169° 4.027 | S26°55.252 | E171°19.366 | 4865 |
| 010b | S26°55.087 | E171°19.135 | S27°48.196 | E173°20.822 | 4505 |
| 011 | S27°47.781 | E173°20.437 | S27°18.171 | E173°22.938 | 1055 |
| 012 | S27°17.736 | E173°22.588 | S25°19.128 | E168°54.668 | 10 155 |
| 013 | S25°17.754 | E168°55.290 | S24°51.504 | E170°30.200 | 3261 |
| 014 | S24°51.873 | E170°30.791 | S24°59.422 | E170°32.200 | 293 |
| 015 | S25°00.066 | E170°31.966 | S25°44.353 | E169°28.569 | 2724 |
| 016 | S25°43.343 | E169°28.375 | S25°40.446 | E169°52.925 | 794 |
| 017 | S25°38.950 | E169°53.953 | S22°40.025 | E168°25.004 | 7180 |
| 018 | S22°39.942 | E168°24.905 | S22° 2.892 | E167°31.352 | 2365 |
| 019 | S24°10.919 | E169°54.264 | S24°28.663 | E166°55.573 | 6218 |
| 020a | S24°28.556 | E166°55.692 | S24° 1.176 | E167°16.597 | 1279 |
| 020b | S23°57.281 | E167°19.728 | S23°38.524 | E167°33.930 | 844 |

Table 1 : Starts and ends of SISRAP profiles

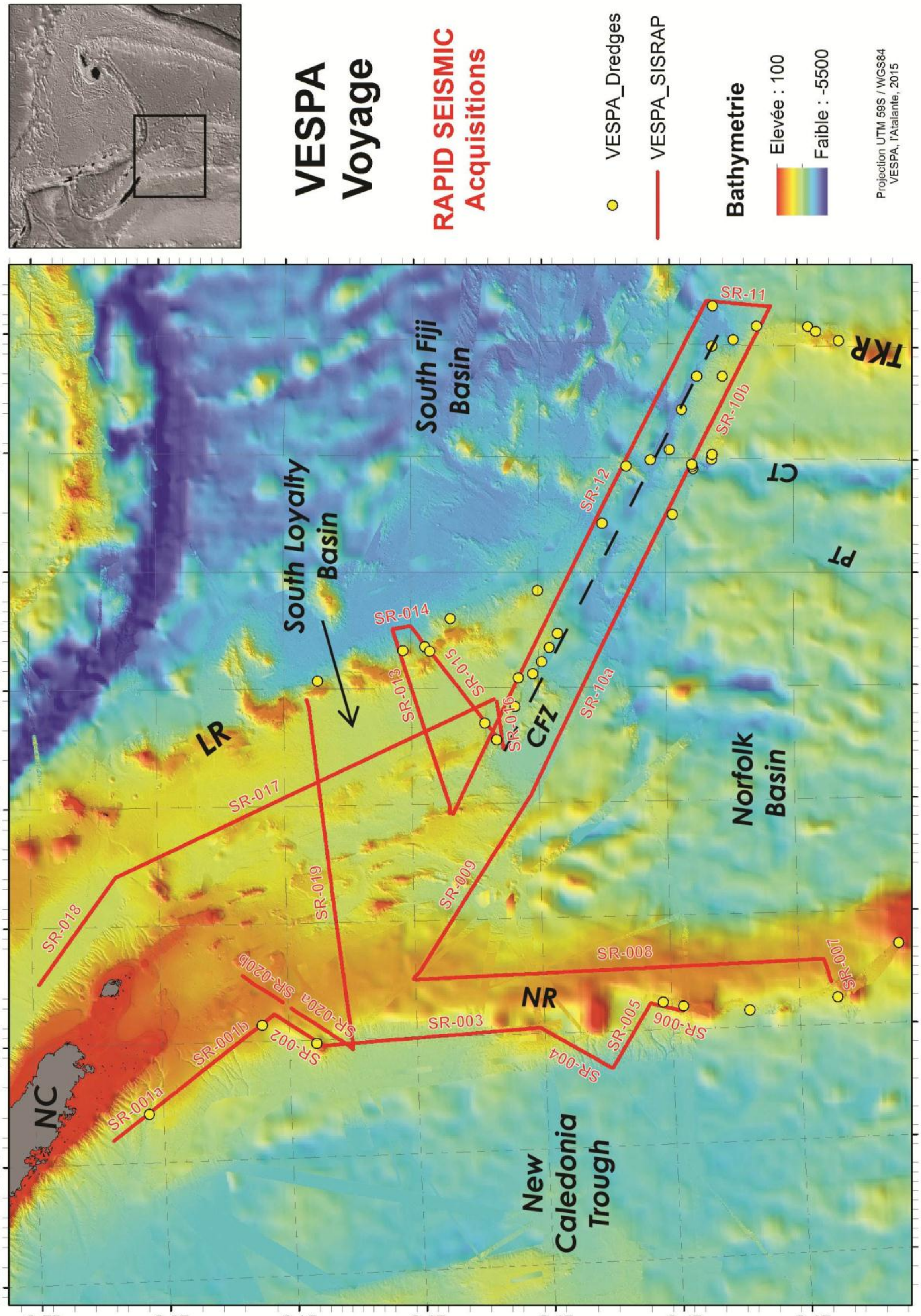


Figure 7 Location of the 20 rapid seismic profiles (SISRAP) acquired during the VESPA cruise.

## IV-1-4) Seismic data processing

Due to the short length of the streamer used on VESPA only basic processing was applied to the seismic data (Figure 8).

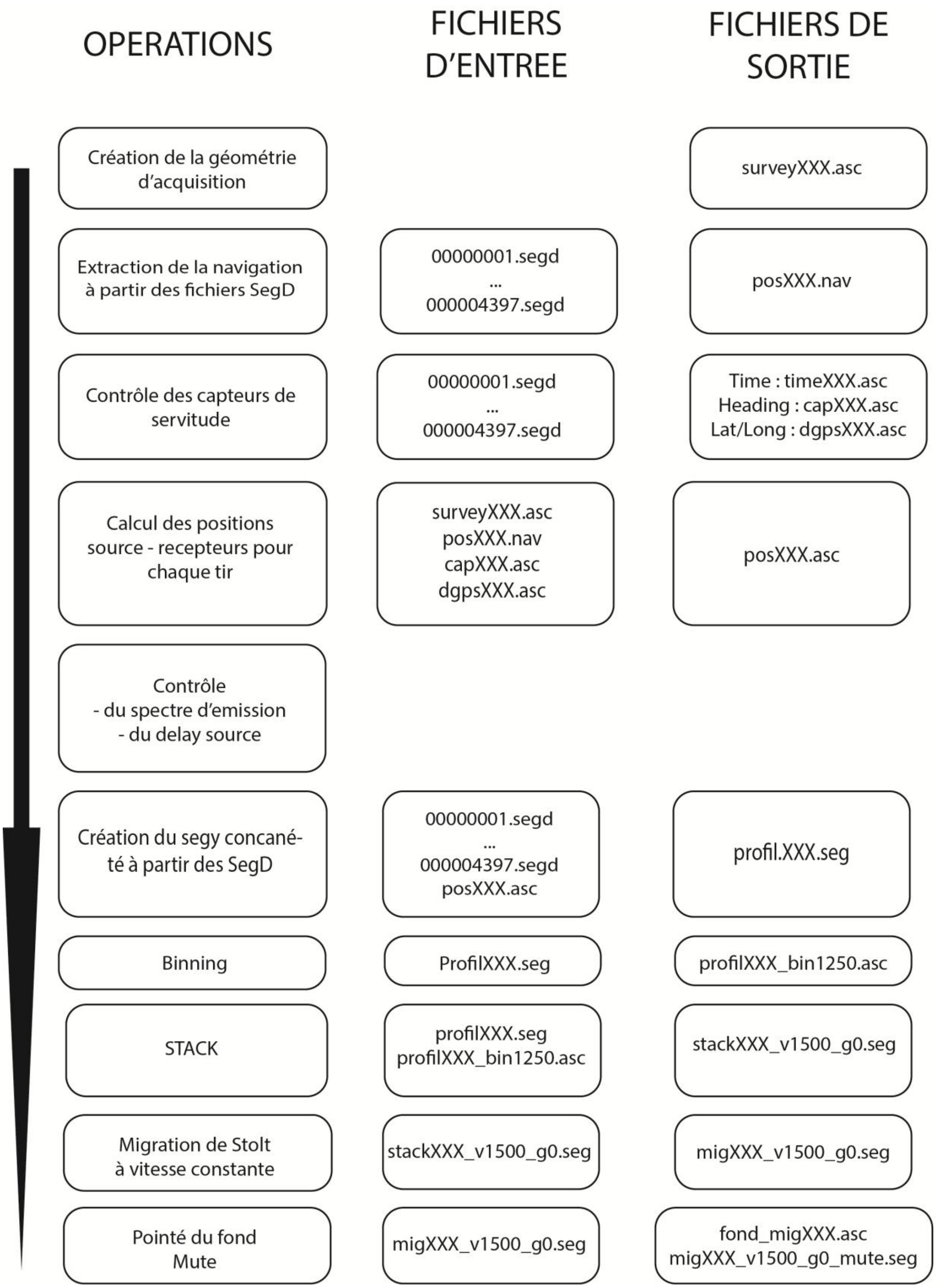



Figure 8 VESPA seismic processing workflow (Sispeed, Ifremer)

The first step of the processing was a rapid quality control assessement of the raw data using the Sispeed software developed by Ifremer. This included a definition of the acquisition geometry containing all device parameters (offsets, inter-traces etc). Navigation was then extracted from the SEGD files and analyzed to determine potential problems due to GPS positioning. The position of each channel for each shot was then recalculated based on the acquisition geometry and the vessel's positions during successive shots. Following this calculation the emission spectrum and the source delay, among others, were checked.

From the above information a SEGY file concatenating all the SEGD was created, in which the positions of all the channels were indicated. A reorganization of these points was established in order to better distribute the CMP and avoid some areas being empty of seismic information (binning step). Blocks of defined size (25 m in this case) followed one another along the profile and made it possible to duplicate or transfer channels having the same characteristics from one block to another and thus replace missing channels.

A stack and a Stolt migration using a constant seismic velocity were then applied to the data. Finally a picking of the seafloor was done followed by a mute operation.

## IV-1-5) Preliminary interpretations

Some preliminary seismic interpretations, based on the work done on board, are presented below, selected among the four major areas investigated with this method during VESPA (Cook Fracture Zone, South Loyalty Basin, Norfolk Ridge and New Caledonia western margin). These interpretations are based on conventional seismic interpretation methods, such as the characterization of seismic reflectors terminations and geometry and the identification of different seismic facies. Under no circumstances they constitute definitive interpretations.

## Cook Fracture Zone

The Cook Fracture Zone area and its adjacent basins (South Fiji, North Norfolk and South Loyalty basins) was the site of two NW-SE long profiles, located just north and south of the fracture zone (SR012 and SR010 profiles, respectively;Figure 9).

Around the Norfolk and South Fiji basins these two profiles show a superficial sedimentary stratigraphic unit, characterized by a continuous and tabular seismic facies with low to average amplitude, lying above an angular unconformity (onlap) on a structurally complex acoustic basement. The basement discontinuities could represent normal faults and fractures affecting an oceanic basement, indicating an extensional regime related to the Cook Fracture Zone and to the opening of the South Fiji Basin in a back-arc position. The upper seismic unit seems to reflect a relatively distal marine sedimentation, whose exact age remains undetermined.

In and around the South Loyalty Basin (Figure 9D), the profiles allowed the distinction of at least three seismic units: (1) a relatively thick upper unit, whose internal seismic reflectors were continuous, tabular, corrugated and medium to low amplitude. This unit locally showed internal unconformities and more chaotic facies. This unit would correspond to hemipelagic sediments alternating with gravity and / or contourite deposits. This unit rests with angular unconformity (onlap; black arrows in Figure 9D) on (2) a unit with average to high amplitude reflectivity, deformed, and locally showing thickness variations which may be interpreted as syn-tectonic fans. The latter ultimately lies on (3) acoustic basement again marked by faults forming important NNW-SSE basement highs, clearly visible in the bathymetry. These basement highs could be interpreted as horsts. In detail (not shown) the eastern part of profile SR010 , west of the Three Kings Ridge and east of the Cagou Trough, has a similar configuration of seismic units. This is not surprising since restoration of sinistral strike-slip faulting on the Cook Fracture Zone places these two basins adjacent to each other.

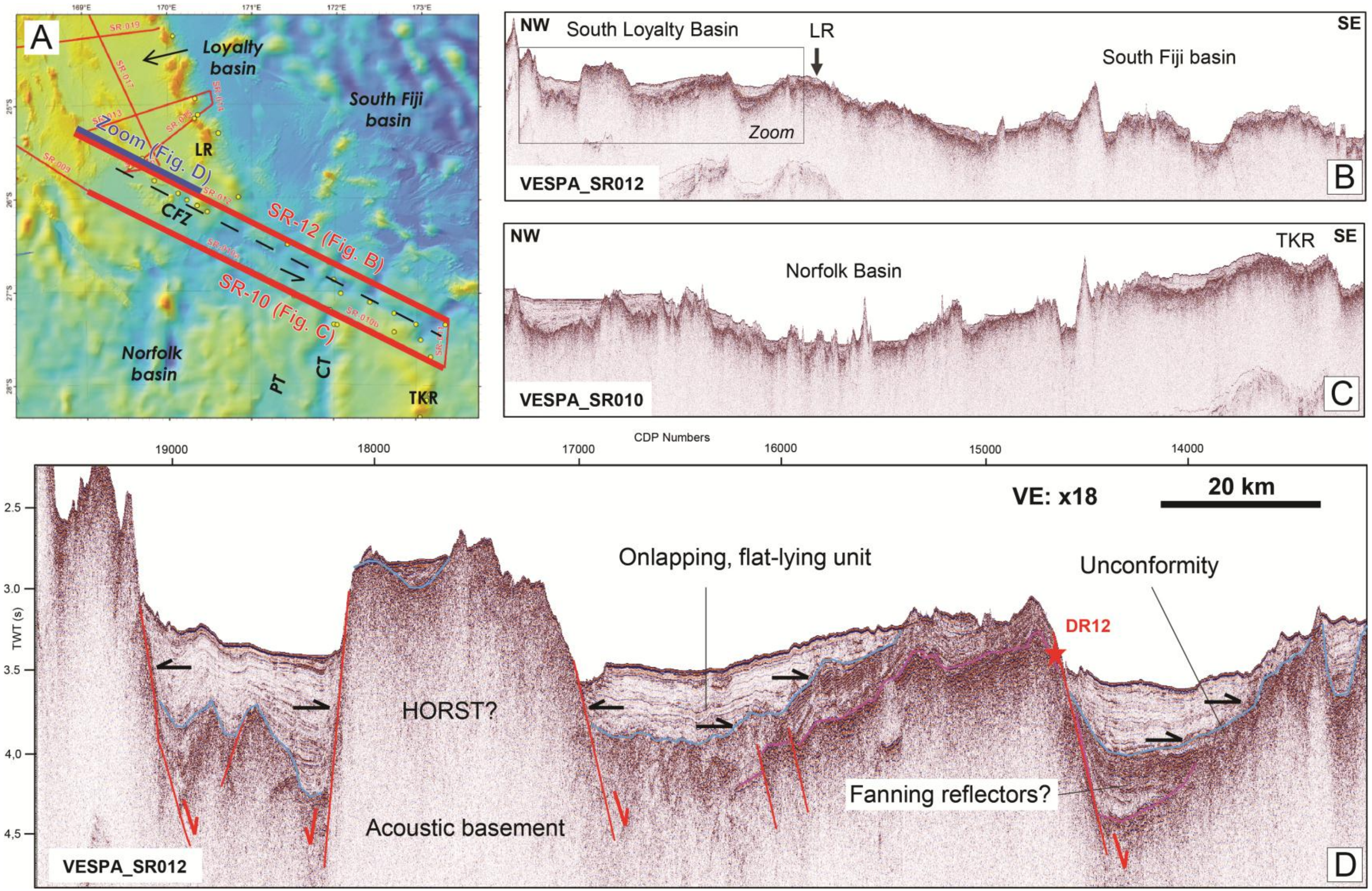



Figure 9 A. Location of the SISRAP profiles near the Cook Fracture Zone (CFZ). B. Profile SR012, north of the CFZ, imaging part of the South Loyalty Basin and South Fiji Basin. C. Profile SR010, south of the CFZ, imaging part of North Norfolk Basin and Three Kings Ridge. D. Focus on SR012 profile at the South Loyalty Basin, showing the geometry of acoustic basement (tilted blocks?) topped by two main sedimentary units separated by an angular unconformity (onlap, shown by black arrows).

## South Loyalty Basin

Several rapid seismic profiles were made across the South Loyalty Basin, especially in its southern part, near where it is bounded by the CFZ, north of the Norfolk Basin. Two profiles are presented here, one along the axis of the basin and the other perpendicular to the basin between the Norfolk Ridge and the Loyalty Ridge (SR017 and SR019 profiles, respectively; Figure 10).

These profiles again show a geometry of acoustic basement marked by structural highs. On profile SR019 these highs are aligned with Grande Terre and are NNW-SSE orientated. Also, thicker sedimentary units are revealed than in Figure 9 around the Cook Fracture Zone, probably related to the proximity of sedimentary sources (New Caledonia, and the Loyalty and Norfolk ridges?).

Around the southern South Loyalty Basin, at least three seismic units are distinguishable and bear some relationship to the three units described for the Cook Fracture Zone region above): (1) an upper unit characterized by continuous seismic facies, with tabular, medium to low amplitude refekectivity. This unit lies through onlap on (2) an unit marked by strong variations in thickness toward the south (syntectonic fans ?), in which the seismic facies is of high amplitude. This second unit itself lies through onlap on series with (3) a unit of discontinuous seismic facies and variable amplitude, potentially affected by numerous (normal?) faults, especially near the Cook Fracture Zone.

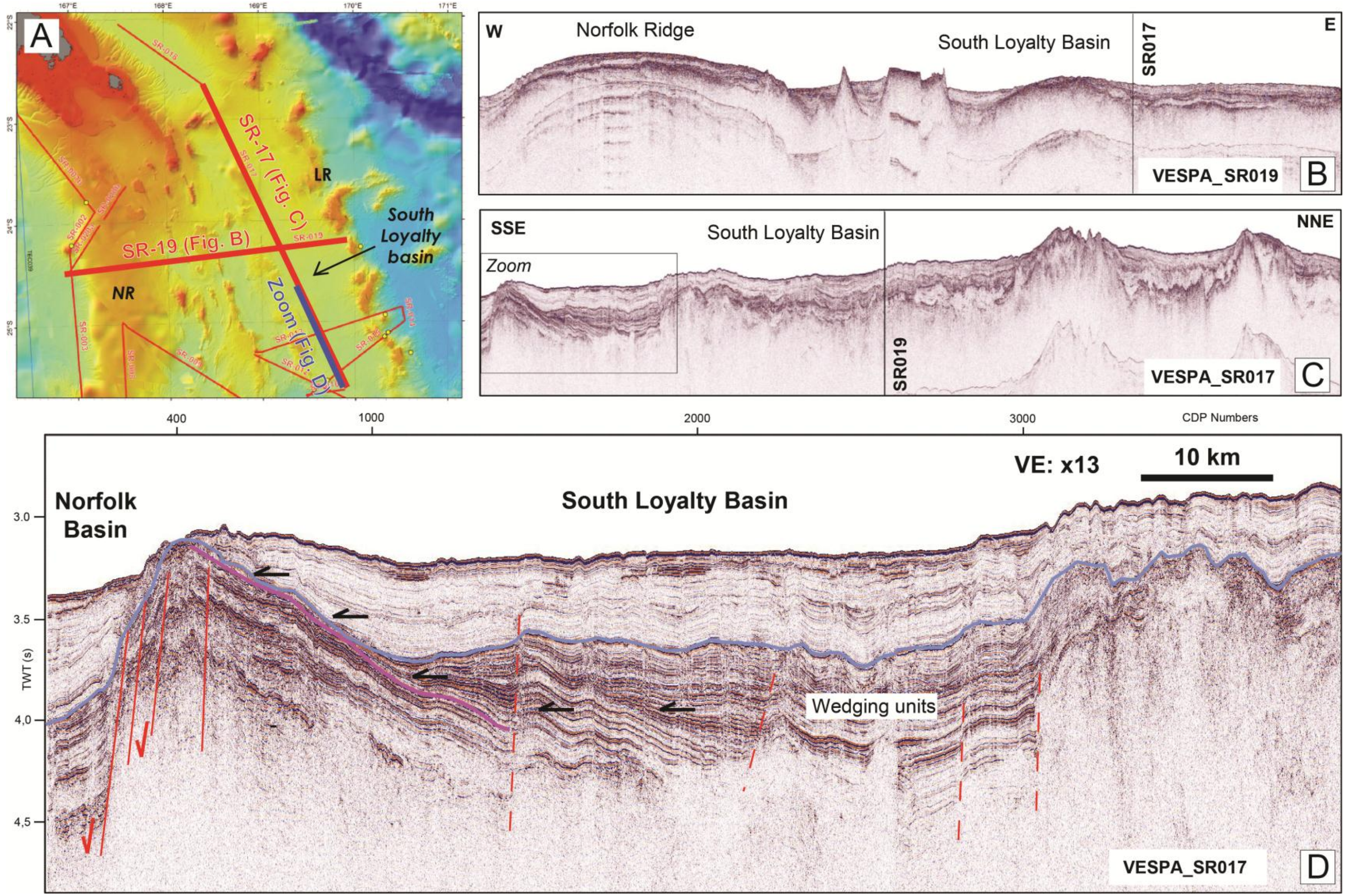



Figure 10 A. Location of the SISRAP profiles in the South Loyalty Basin. B. Profile SR019 perpendicular to the South Loyalty Basin and imaging the Norfolk Ridge in the west. C. Profile SR017, in the axis of South Loyalty Basin. D. Focus on SR017 profile at the southern termination of the South Loyalty Basin (Cook fracture zone delimiting the Norfolk basin) showing at least three seismic units (see text for details).

## Norfolk Ridge and western margin of New Caledonia

The Norfolk Ridge was imaged by several NS profiles (subparallel to the ridge), but the SR019 profile, showed on Figure 11, is perpendicular to the ridge and highlights two major unconformities, that are likely continuous throughout and under the ridge.

The deepest of these unconformities delimits a lower unit with discontinuous and variable amplitude reflectors, tilted to the east; the unconformity erodes the lower unit significantly (erosion suggested by truncatures, ie. toplaps endings reflectors, Figure 11). Toward the New Caledonia Basin, the deeper unconformity seems to be affected by normal faults, with a NS apparent strike. This major unconformity, which could correspond to the TECTA regional event, is topped by a transparent seismic facies unit, bounded at its top by a second (upper) erosive unconformity, locally marked by channelized forms. The latter defines an uppermost sesimic unit on the Norfolk Ridge of high amplitude, marked by nested channelized deposits as well as by gravity destabilization on the slope. Note the presence in Figure 11 of a turbidite channel at the base of the slope, potentially active, flanked by symmetrical levees resulting from the overflow of the diluted part of gravity flows.

Further north, on the slope of the western margin of the Grande Terre, two profiles parallel to the margin (SR001a profile and SR001b Figure 12) again image an unconformity like the lower unconformity of Figure 11, characterized by a continuous and high amplitude reflector, delimiting the top of a poorly-imaged unit whose weak reflections suggest a sedimentary sequence. The unconformity in Figure 12 is topped by a unit with very variable seismic facies, marked by the presence of numerous incisions, which correspond to present day turbiditic current channels visible on bathymetry. These incisions are made in a transparent to weakly laminated seismic facies (hemipelagic deposits?), that is characterized by discontinuous reflections (but parallel and high amplitude at their base, suggestive of coarse filling at channel bases?) and are bounded by nested tabular to oblique units, with low to moderate amplitude (terrraces and / or turibidic levees?).

Locally, these erosional incisions expose the major unconformity and, during the VESPA cruise, were therefore identified as a dredge target (dredge DR43, see Figure 12B). Also, this discontinuity outcrops in the western part of SR001b profile as a terrace only slightly covered by the transparent upper unit (of recent reworked marine sediments?), and was therefore the target of another dredge (Dredge DR42, see Figure 12C).

The imaging of the major unconformity in the VESPA SISRAP profiles and other existing seismic profiles, looks promising for the improving our understanding of the stratigraphy of the Norfolk Ridge and New Caledonia Basin (cf. TECTA voyage). Dating of dredge samples, will provide additional constraints for seismic interpretation.

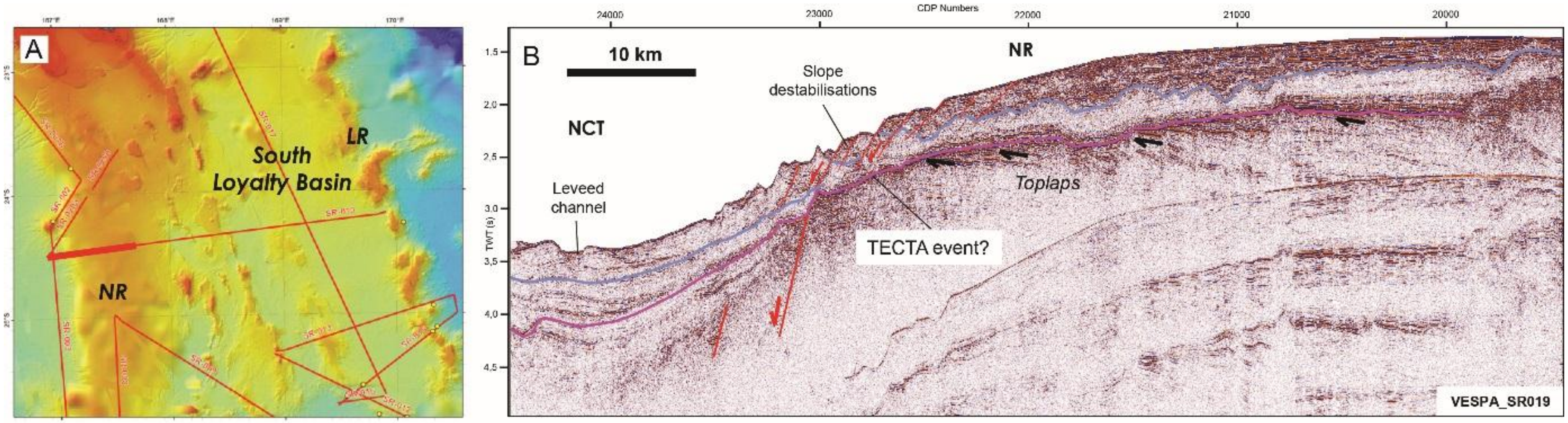



Figure 11 A. Location of the western part of SR019 profile imaging the western part of the Norfolk Ridge (NR) and its extension in the New Caledonia Basin (NCT). B. Profile SR019, showing two major erosive unconformities, the more deeply imaged (purple) can correspond to the regional unconformity TECTA.

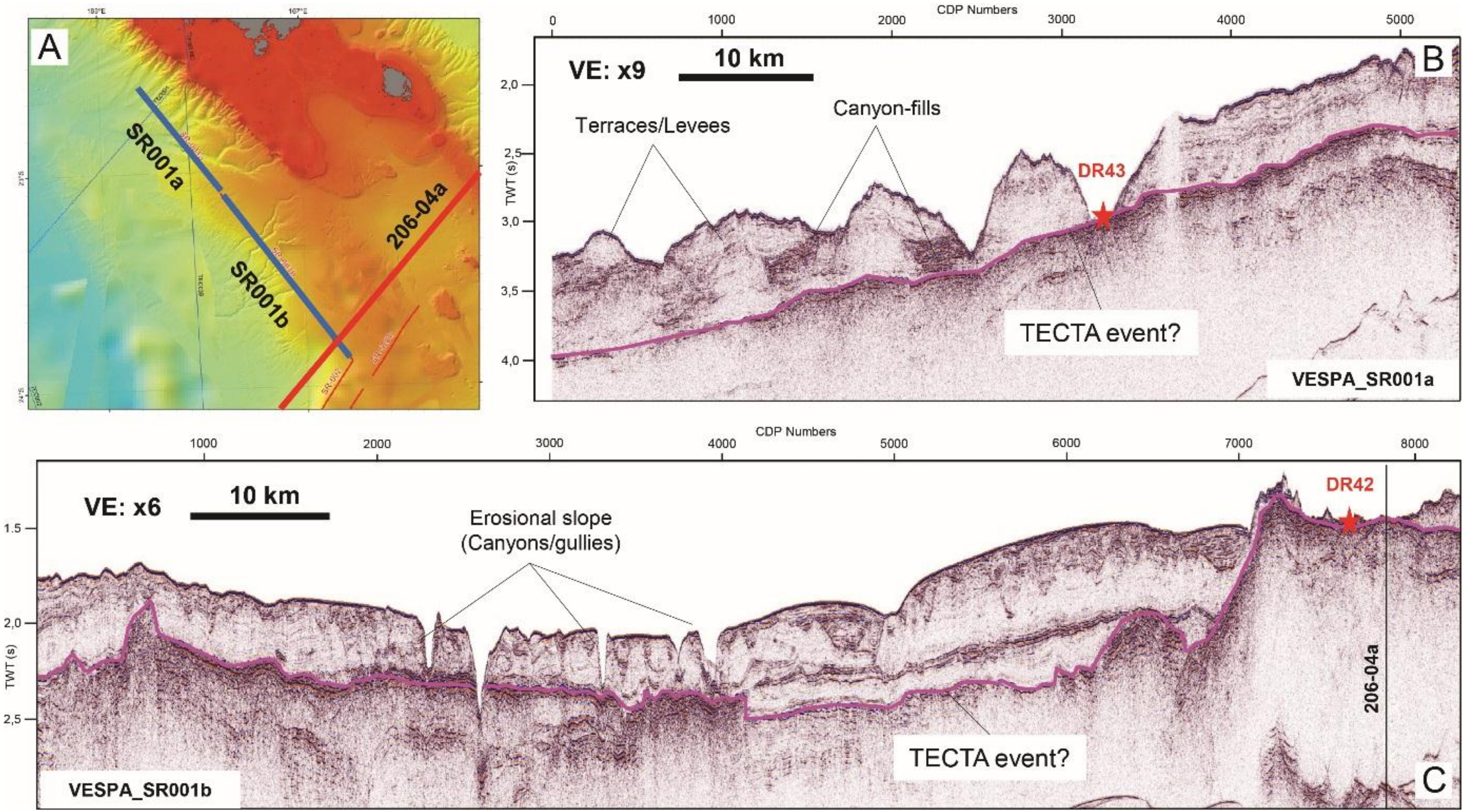



Figure 12 A. Location of SR001a and SR001b profiles, imaging the western slope of the Grande Terre. B. Profile SR001a, imaging architecture of turbidite canyons and channels visible in the bathymetry, and delimited at their base by a discordant continuous surface. C. Profile SR001b, in the continuity of the profile 001a, showing a similar configuration. Note the presence of a structural high on which the unconformity outcrops and was dredged.

## *IV-2) Dredges*

### IV-2-1) Dredging Procedures

#### Site selection

The VESPA cruise had four geologically different work areas for dredging (slightly different from the seismic areas outlined above): Norfolk Ridge, Loyalty Ridge, South Fiji Basin and Three Kings Ridge. Sampling of the latter three successfully exploited exposures in fault scarps on the Cook Fracture Zone. Before the VESPA cruise, dredge targets were selected using several criteria including spatial distribution along east-west and vertical depth profiles, satellite gravity anomalies, and potential dredgable steep slopes and fault scarps as interpreted from existing seismic and multibeam bathymetry data. Five sites on the Norfolk Ridge were dredged for the companion TECTA project, targeting sedimentary rocks. All other targets were intended to sample volcanic rock for VESPA, but with the expectation that associated sedimentary rocks (volcaniclastic rocks and limestones) would also be encountered. In this way, 34 potential dredge sites were identified prior to the voyage.

The resolution of *l'Atalante*'s multibeam system was superior to that of earlier surveys and, inevitably, we conducted our own multibeam survey of prospective dredge targets once we arrived on site.

The crew had a strong preference to dredge into the wind and this commonly governed the choice of dredge site. The steepest slopes were the most preferred dredge targets due to a combination of inferred rocky slopes and low ooze accumulation.

#### Dredging equipment

Three rock dredges were supplied by Genavir and were onboard *l'Atalante* prior to the start of the voyage. These were heavy duty dredges with a round 80 cm diameter mouth constructed of 2cm thick steel, teeth around the circumference, and an 'A' frame yoke made of 3 cm thick steel that was attached to the mouth via a hinge. The chain bag consisted of welded circular large and small links with a mesh size of 7 cm; this meant that only material of this size or larger was retained.

Figure 13 Rock dredge used during the VESPA cruise

Unlike on other ships there was no 'safety' or weak link between the main cable and the dredge bag. On request, the crew made and attached a small pipe dredge to the bottom of the main dredge bag; this was successfully used to collect unconsolidated sediment. At dredge DR05 the main cable broke 150 m above the dredge and the first Genavir dredge was lost. The second dredge was used for the rest of the VESPA cruise; although it progressively departed from a circular shape, and broke two teeth, it performed well. Only on a few occasions did the dredge bag get caught up in the teeth and once a small (easily repairable) hole was torn in the bag.

Figure 14 Rock dredge coming back on deck (note the dredge bag caught up in the teeth of the dredge).

## Dredging procedure

After picking a suitable target spot and an up-slope dredging path on a multibeam bathymetry map, a calculation was made using an Excel spreadsheet of how much cable to pay out and when, in order to land the dredge on the target spot.

We adopted a technique modified after that previously used onboard L'Atalante and described in an internal note (*Instruction N° P.48)*. The main characteristic of our technique is to dredge at constant ship speed of 1.5 knots (ground speed), and cable unwinding rates (0.8 m/s over 500m, and 1.2 m/s during the rest of the dredge). Following this protocol, and if we do not encounter any hydrodynamic issues (strong currents), we were able to:
1: Define a simple cable length – dredging depth relationship.
2: Calculate the distance sailed by the ship while unwinding the cable as a function of the cable length.

There is actually a relatively well-defined empirical relationship between cable length and depth of dredging, based on both former cruise experience and dredging experiments (dredges equipped with positioning (BUC) and pressure sensors). During the VESPA cruise, we combined the two approaches. We based our first dredges on experience of former cruises, and we also performed an instrumented dredge experiment (ANNEXE2). Even though time limitations and bias on the depth gauge did not allow us to fully process the results of the experiment during the cruise, numbers delivered by the BUC allowed us to further define key parameters such as:

- Angle from the horizontal of the ship to dredge vector.
- Length of this vector compared with the cable length.

The subtle difference between these two last parameters comes from the fact that the cable does not follow a straight path from the ship to the dredge. It is actually curved (a catenary) due to chain and dredge weights and lift and the water buoyancy. The length of the ship-dredge vector is therefore shorter that the cable, and the wire apparent angle from the horizontal is not necessarily the same as the one observed from the ship. This angle ⍰ was repeatedly estimated around 65° for cable length longer than 1500m, it rises up, maybe up to ~70°, for shorter cable lengths even though we have less experience on shallow dredges.

We expressed the relationship between vectors and cable actual lengths as percentages of the former. This number "n" increases with cable length and was estimated around 1% for cable lengths up to 1500m and 2% after that.
Practically, we were able to use these parameters in order to define the cable length as a function of the targeted depth following the equation:

$$\text{cable length "}L\text{"} = \frac{\text{targeted depth "}P\text{"}}{\sin(a)} \times \frac{100}{\text{cable-vector length difference "}n\text{"}} \quad (1)$$

Based on the cable rate, we were able to estimate the time « T » necessary in order to reach the targeted cable length « L ». Knowing the ship velocity, we could calculate the distance “D” between the targeted point “C” and the start of unwinding point “B”.
During the VESPA cruise, we could therefore use this technique in the following way:

The targeted point C is selected based on geological and morphological considerations (see chapter “site selection” above). The depth of C allowed us to estimate the cable length as well as the start of unwinding point B. We communicated to the bridge these two points:

Point C = dredge target.

Point B = start of unwinding point (ship position).

We also supplied the two following pieces of information to the bridge:

Point A= beginning of operation (ship position at outboarding of the dredge), estimated 10 minutes (ie: 460 meters at 1.5 knots) before point B.

Point D= distant point (4000 meters away from C) allowing the ship to steer a straight course during dredging.

All these parameters are illustrated on Figure 15.

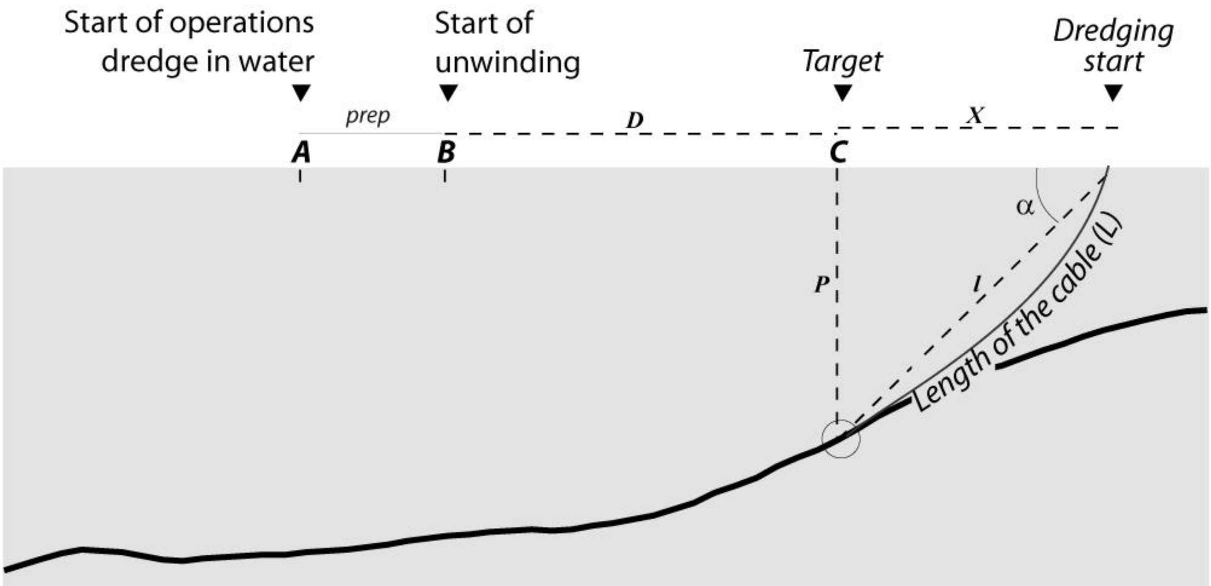


Figure 15 Schematic dredging profile and associated A, B and C points.

It is worth noting that A and B correspond to two actual successive **ship positions** whereas point C describes the **dredge position**, when it reaches the seabed.

In summary:

- Unwinding rate = 0.8 m/s during the first 500m, 1.2 m/s afterward.
- Length of cable is defined considering an angle from the horizontal of 70-65°, and a « vector – cable » difference of 1 to 2%.
- 4 locations are communicated to the bridge:
  - Point A: start of operation, dredge in the water point.
  - Point B: start of unwinding point.
  - Point C: target point.
  - Point D: distant point (to ensure the linearity of the dredging path).

  Points A and B are estimated based on the cable length.

Following this method, we were able to improve the accuracy (remove the guess work) of the dredging location compared to the targeted point. Another benefit of this method was streamlining of the interaction between the scientists and the bridge crew once everyone was familiar with it.

During unwinding of the cable, the tension meter was watched on the bridge for a small drop indicating that the dredge had touched the sea bottom. After this, a further 200 m of cable was paid out and then no more. A dredge typically lasted for no more than 30 minutes in which time it travelled ~ 0.75 nautical miles and then the cable was wound back in. So during the entire operation of unwinding, the ship moved forward at 1.5 knots. During winding in the speed of the boat was less a matter of concern as it did not determine any more the location of the dredge. It stayed around 1.5 knots unless specific needs were expressed, like the will to reduce the length of the dredge profile. After winding in began, the dredge was still on the seabed for a period of time. During this winding in, cable tension peaks of 10-12 tonnes indicated the dredge was biting into rocks; exceptionally 18-20 tonne peaks were recorded. For about half the dredges, the dredge got physically stuck and the ship had to be stopped and manoeuvred to dislodge the dredge.

For the VESPA dredges we additionally estimated the actual path of the dredge on the seabed calculated from the ship's position and other considerations. The setdown and takeoff positions are not known but can be estimated directly from the ship position. When the rock dredge arrives on the bottom a slight but generally clear drop of the cable tension is recorded. From the cable length at that moment and using the parameters described a little above (angle and shortening), it is possible to determine the distance of the dredge behind the ship and therefore its position on the seafloor.

When the rock dredge lifts off the seafloor, the cable tension does not vary significantly, or at least relatively too little with respect to the oscillations of the tension due to the swell. The exact time of take-off is therefore much more difficult to determine. Practically, we considered that, from the moment when the dredge seriously hooked the seafloor, the cable is taut and therefore almost linear. This is particularly the case for the last hooks. The position of the dredge behind the ship corresponds then to the end of a right triangle whose hypotenuse corresponds to the tensioned cable, the small side to the water depth at the rock dredge, and the long side the distance of the dredge behind the ship. Two unknowns remain: the depth and dredge distance behind the ship. But by trial and error, adjusting these parameters to the bathymetric profile which is known, generally results in an unique solution for determining the position of the dredge (using the Pythagorean theorem).

Excel and Arcgis ("Measure" tool) software was used to estimate the path of the rock dredge on the seafloor. While the ship position is known with great precision (uncertainty in the order of a meter), the dredge positions proposed in this report should be taken with caution and have an uncertainty of about 100-200 meters, in particular laterally in relation to the progress of the ship. This uncertainty is primarily related to the fact that the calculations of the position of the drag on the seafloor consider the dredge follows the ship, and that the cable is stretched rearwardly on a straight line in line with the progress of the ship . This is often not the case due to the currents that we have not taken into account in estimating the position of the dredge.

Once back on deck the sailors inverted the dredge bag and dumped the rocks onto plywood sheets on the back of the deck. Once the dredge was secured the geologists were allowed to examine the rocks. A 'deck photo' of each dredge was taken prior to any further action. Hammers, including a large sledgehammer, were used to break rocks. Representative samples were carried to the rock laboratory in boxes where they were rinsed of mud and cut on the rocksaw (supplied by SGNC, Noumea). Both the sledgehammer and the rocksaw were extremely useful items and the geological work would have been a lot harder without them.

Figure 16 Dredge (DR24) on deck

The rocks were further sorted and categorised in the rock laboratory. Usually between one and six (exceptionally more than ten) individual rock types were present in each dredge (see pages later in this section). Brief notes were made on each rock type including quantity in the dredge, hardness, Munsell colour, textures, mineralogy and other notable features. Representative samples of each rock type were assigned to various institutions for post-cruise work (see below).

## IV-2-2) Dredges Results

### Post cruise sample distribution

Subsamples or, in some cases, all samples of rock types from the dredges were sent to five institutions for further work and/or archiving:

- IUEM Brest (contact Arnaud Agranier): mainly fresh volcanic rocks for whole rock geochemistry and isotope work (160 kg)
- GNS Wellington (contacts Hamish Campbell, Nick Mortimer): at least one sample from every dredge for archiving in GNS Petrology Collection and the online Petlab database (http://pet.gns.cri.nz). Fresh and altered volcanic and sedimentary rocks for radiometric and/or fossil dating as appropriate. Includes all the modern foraminifera ooze samples (170 kg)

- SGNC Nouméa (contact Martin Patriat, Julien Collot): main archive of VESPA samples (370 kg)
- IFREMER Brest (contact Yves Fouquet): selection of manganese crusts (13 kg)
- IRD Nouméa (contact Fanny Houlbreque, Riccardo Rodolfo-Metalpa): recent biological samples (2 kg)

A rock sample log book is available and kept, at Ifremer, together with the logbook of the cruise.

## Summary of rock dredging (Table 2)

The dredging component of VESPA was clearly a success. Originally, 34 dredges were planned but in the end 43 were carried out. Of the 43, one dredge was lost because of a severed main cable (DR05), no rock at all was recovered from three (DR09, 32, 35) and only very soft, probably Plio-Pleistocene sedimentary rock, Mn crusts and/or pumice were recovered from three (DR02, 11, 34). This left 31 dredge sites from which igneous or sedimentary rock useful to the VESPA project and 5 to the TECTA project were obtained: 7 from the Norfolk Ridge, 12 from the Loyalty Ridge, 4 from the South Fiji Basin and 13 from the Three Kings Ridge. Modern foram ooze was recovered using the small pipe dredge at 25 dredge sites.

| Dredge | Area | Location | Long | Lat | Depth | kg | Main rock types | Minor rock types (excl. Mn, ooze) |
|---|---|---|---|---|---|---|---|---|
| DR01 | Norfolk Ridge | NE flank volcano, W side of northern Norfolk Ridge | 166.9707 | -24.2118 | 1115 | 5 | Altered olivine basalt | Hyaloclastite breccia, coral pieces |
| DR02 | Norfolk Ridge | Scarp on W side Norfolk Ridge, TECTA site | 167.2416 | -26.9326 | 1702 | 35 | Weakly indurated foram ooze, burrowed | Modern foram ooze |
| DR03 | Norfolk Ridge | Fault scarp on N flank of volcano, Norfolk Ridge | 167.2033 | -27.0919 | 835 | 60 | Volcanic breccia, very altered | Limestone, some fresher lava clasts |
| DR04 | Norfolk Ridge | Canyon, W side Norfolk Ridge, TECTA site | 167.1490 | -27.6086 | 2321 | 100 | Soft ashy mudstone, Mn crusts | Altered olivine basalt, coral pieces |
| DR05 | Norfolk Ridge | N lower flank of volcano, W side of Norfolk Ridge | na | na | na | 0 | Dredge lost | - |
| DR06 | Norfolk Ridge | Fault scarp on NW side platform, TECTA site | 167.7049 | -28.7889 | 707 | 30 | Hard volcaniclastic sandstone | White limestone, foram ooze |
| DR07 | Norfolk Ridge | N lower flank of volcano, W side of Norfolk Ridge | 167.2407 | -28.3018 | 1569 | 60 | Volcanic breccia v altered, Mn crusts | Fresher basalt clasts in breccia |
| DR08 | Loyalty Ridge | Ridge on N side guyot volcano, eastern Loyalty Ridge | 170.3263 | -24.9381 | 2271 | 15 | Aphyric vesicular lava, fairly fresh | Hard breccia-conglomerate with limestone matrix |
| DR09 | Loyalty Ridge | Bottom part of volcano, eastern Loyalty Ridge | 170.3577 | -25.1122 | 2929 | 0 | Empty dredge | - |
| DR10 | Loyalty Ridge | Top half of volcano, eastern Loyalty Ridge | 170.3192 | -25.1513 | 1523 | 50 | Plag-px-ol porphyritic andesite | Limestone hardground, texturally complex |
| DR11 | Loyalty Ridge | Bottom part of volcano, eastern Loyalty Ridge | 170.6015 | -25.3118 | 3152 | 20 | Soft bioturbated siltstone | - |
| DR12 | Loyalty Ridge | E-W fault scarp, possible older seismic unit | 170.0856 | -25.8437 | 2561 | 15 | Slightly hard sandstones & mudstones | Some ss has detrital mica |
| DR13 | Loyalty Ridge | Normal fault scarp at NW end Cook FZ | 169.5488 | -25.6681 | 2731 | 60 | Hard volcanic conglomerate, sst, mudstone | Sanidine-pptic dacite |
| DR14 | Loyalty Ridge | E-W fault across S Loyalty Basin N of Cook FZ | 169.6967 | -25.5786 | 2112 | 200 | Hard volcanic sst, conglomerate, mudstone | Plag-pptic andesites, shoshonitic |
| DR15 | Loyalty Ridge | Cook Fracture Zone northern scarp | 169.8381 | -25.8163 | 2240 | 600 | Hard conglomerate, sandstone | Oliv basalt, plag basalt, bi andesite, quartzite |
| DR16 | Loyalty Ridge | Cook FZ northern scarp, next to pop-up ridge | 170.1202 | -25.9557 | 2791 | 600 | Fairly hard fine grained sandstone and mudstone | Hard volcanic conglomerate |
| DR17 | Loyalty Ridge | Cook Fracture Zone northern scarp | 170.2254 | -26.0258 | 3539 | 75 | Aphyric medium grained basalt | Mod hard interbedded ss and mdst, cataclasite |
| DR18 | Loyalty Ridge | Cook Fracture Zone northern scarp | 170.3474 | -26.0882 | 3457 | 75 | Basalt, basalt breccia | Limestone coating and crack fill |
| DR19 | Loyalty Ridge | Cook Fracture Zone northern scarp, SE site | 170.4683 | -26.1529 | 3028 | 150 | Altd volcanic breccia with large blocky clasts of fresh plag basalts | Moderately hard coloured siltstones, chalky limestone |
| DR20 | Loyalty Ridge | South tip of Loyalty Ridge | 170.8399 | -25.9939 | 2651 | 3 | Mn crusts | Very very altered vesicular olivine basalt |
| DR21 | S Fiji Basin | W seamount in S Fiji Basin N of Cook FZ | 171.4284 | -26.5021 | 3385 | 15 | Vesicular, pillowed aphyric basalts as big boulders and smaller pieces | White cemented breccia-conglomerate |
| DR22 | S Fiji Basin | Large seamount next to S Fiji Basin spreading axis | 171.9271 | -26.6865 | 2849 | 50 | Pillow basalt with fresh glass rinds | Soft carbonate infill |
| DR23 | Three Kings | Fault scarp in terrace west of main Three Kings Ridge | 171.5080 | -27.0537 | 3165 | 250 | Siltstone, mainly non-calcareous | Cataclastic siltstone |
| DR24 | Three Kings | E scarp N Cagou Trough, deep | 171.9098 | -27.2128 | 3660 | 350 | Pillow basaltic andesite with fresh glass rinds | Cumulate gabbro, silty mudstone |
| DR25 | Three Kings | E scarp N Cagou Trough, middle | 171.9309 | -27.2067 | 3002 | 600 | Basalt | Andesite |
| DR26 | Three Kings | E scarp N Cagou Trough, shallow | 171.9461 | -27.2030 | 2419 | 700 | Biotite-bearing andesite | Hydrothermally altered granite |
| DR27 | S Fiji Basin | E side S Fiji Basin spreading axis | 171.9853 | -26.8770 | 3771 | 40 | Sparsely olivine-phyric basalt. Very altered but w thin glassy rinds | - |
| DR28 | Three Kings | E scarp Cagou Trough, middle part | 171.9934 | -27.3573 | 3050 | 250 | Chilled fragmented glassy basalt-andesite | Devitrified ashy hyaloclastite |
| DR29 | Three Kings | E scarp Cagou Trough, shallow part | 172.0336 | -27.3615 | 2145 | 40 | Trachytic/phonolitic lavas, highly altered | Bioclastic limestone adhering to lavas |
| DR30 | S Fiji Basin | SE end of Cook FZ. W edge of Fantail Terrace | 173.3406 | -27.3485 | 3954 | 100 | Fresh plag-ol porphyritic basalts, some with fresh glass rinds | - |
| DR31 | Three Kings | Cook FZ, southern scarp towards eastern | 172.9846 | -27.3491 | 3920 | 50 | Very fresh hard basalt | Soft, muddy calcareous ashy pumiceous |
| DR32 | Three Kings | E side of long guyot, northern Three Kings Ridge | 173.1719 | -28.0982 | 2247 | 0 | Empty dredge | - |
| DR33 | Three Kings | S side of long guyot, northern Three Kings Ridge | 173.0522 | -28.3423 | 1391 | 100 | Hard, fresh andesite and basalt | Limestone attached to outside of andesite |
| DR34 | Three Kings | E side of long guyot, northern Three Kings Ridge | 173.1309 | -28.1611 | 2254 | 70 | Soft pumice breccia cemented and penetrated by Mn oxides | - |
| DR35 | Three Kings | Small scarp low on E- side Three Kings Ridge | 173.1693 | -27.6963 | 2801 | 0 | Empty dredge | - |
| DR36 | Three Kings | Bottom of canyon near E end of Cook FZ | 173.0451 | -27.5167 | 3936 | 100 | Fresh, columnar jointed aphyric basalt | Very soft, pumice-derived calcareous mudstone |
| DR37 | Three Kings | Cook FZ, c. 10km SE of FAUST-2 dredge | 172.7205 | -27.2333 | 4157 | 150 | Fresh, columnar jointed aphyric basalt | Volcanic breccias |
| DR38 | Three Kings | East-west normal fault scarp on Three | 172.7225 | -27.4344 | 2072 | 1 | Very altered hyaloclastite breccia with | - |
| DR39 | Three Kings | Cook Fracture Zone, southern scarp | 172.4261 | -27.1165 | 3957 | 50 | Fresh, columnar jointed aphyric basalt | - |
| DR40 | Three Kings | Cook Fracture Zone, southern scarp | 172.0745 | -27.0257 | 3721 | 250 | Hyaloclastic breccia,sandstone | Aphyric and porphyritic basalts |
| DR41 | Loyalty Ridge | Loyalty Ridge | 170.0669 | -24.2663 | 2861 | 60 | Ol-cpx phyric lavas | White limestone, volcanic breccia |
| DR42 | Norfolk Ridge | Norfolk Ridge, TECTA dredge site | 167.1401 | -23.7897 | 1145 | 30 | Soft mudstone | Hard siltstone, hard limestone, hardground |
| DR43 | Norfolk Ridge | Norfolk Ridge, TECTA dredge of seismic reflector | 166.4114 | -22.8864 | 2299 | 1 | Aphyric andesite | Calcarenite chips |

Table 2 : Synopsis of rock dredges. Latitude, longitude and water depth are calculated mid points of actual dredge on bottom location. See ANNEXE 1 for more detailed dredge descriptions.

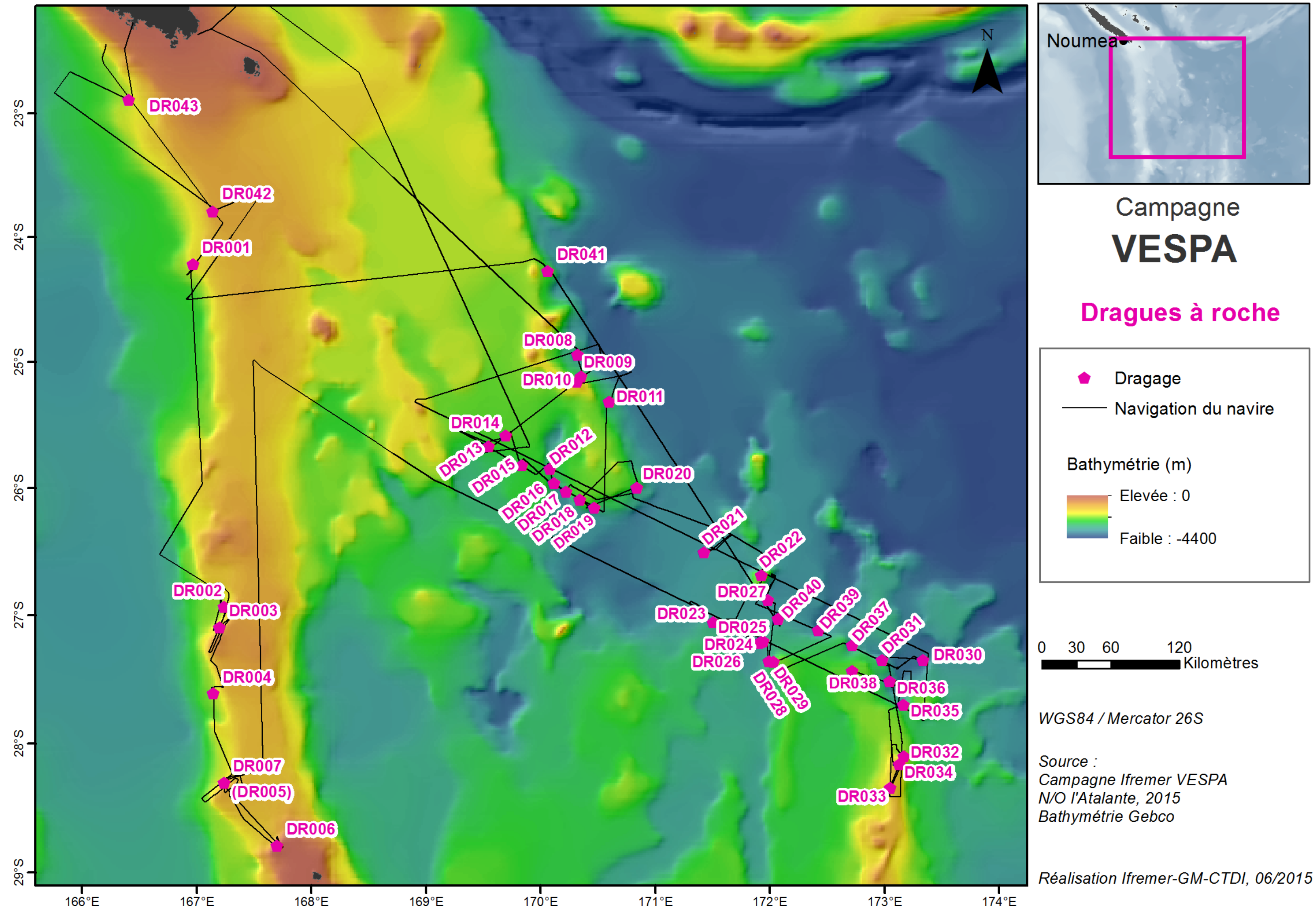



Figure 17 Location of the 43 dredge sites

A total of 770 kg of cleaned and trimmed rock was weighed on scales. This is the quantity of material that was retained for archiving and further analysis. Based on brief visual estimates on the deck, at least 3.5 tonnes of rock was recovered from the sea bed, but this probably is an underestimate and we believe that, in the end, we probably retained c. 10% of the total weight of rocks we dredged.

## Dredge descriptions

A full on-board description of dredges is given in ANNEXE 1
Dredge description”). It is a catalogue of the dredge sites and the different rock types recovered. For each dredge the following information is given:

**Target:** short description of site
**Latitude, Longitude, Depth:** estimated coordinates of dredge position (note: not the ship position) midway between on-bottom and off-bottom locations
**Approx. weight:** visually estimated weight of total dredged rock (perhaps an underestimate)
**Main rock types:** dominant rocks in dredge
**Other rock types:** minor rocks in dredge excluding Mn crusts, pumice and foram ooze
**Dredging notes:** notes on cable tension etc
**Map** of dredge site, ship track and dredge points
**Images** of rocks from the dredge
**DRnnAi:** sample numbers usually, but not always, allocated in order of decreasing abundance or usefulness. A, B, C etc… are usually quite different from each other whereas i, ii, ii etc have similarities and are often separate pieces of the same rock type.
**Subsamples:** location of institution to which samples or subsamples were sent. The largest quantity of rock went to SGNC Nouméa.

## IV-2-3) Portable XRF Analysis

### Portable X-Ray fluorescence unit

The VESPA cruise made use of GNS Science's Olympus Innov-x, Delta series portable X-Ray Fluorescence (pXRF) analyser, model DP-6050-C. This particular pXRF unit is equipped with a silver anode tube, which permits the analysis of light major elements such as Si, Al and Mg. A large suite of major, minor and trace elements can also be detected in one or both of its two operating modes: Geochemistry mode and Soil mode. In Soil mode it operates using up to three X-ray beams operating at 50, 40 and 15 KV whereas in Geochemistry mode it uses two beams operating at 50 and 10 kV. Elements analysed on the VESPA cruise are listed in the following table.

| | Mode | |
|---|---|---|
| **Element** | **Geochem** | **Soil** |
| Al | **YY** | n |
| As | y | **YY** |
| Ba | y | **YY** |
| Ca | y | **YY** |
| Cl | y | **YY** |
| Ce | y | Y |
| Cr | y | **YY** |
| Cu | y | **YY** |
| Fe | y | **YY** |
| K | n | **YY** |
| La | y | Y |
| LE | Y | n |
| Mg | **YY** | n |
| Mn | **YY** | y |
| Nb | y | **YY** |
| Ni | y | **YY** |
| P | **YY** | y |
| Pb | y | **YY** |
| S | n | **YY** |
| Si | **YY** | n |
| Sr | y | **YY** |
| Th | y | Y |
| Ti | y | **YY** |
| U | y | Y |
| V | y | **YY** |
| Y | y | **YY** |
| Zn | y | **YY** |
| Zr | y | **YY** |

Table 3: The two pXRF operating modes and analysed elements. LE = elements lighter than Mg (e.g. mainly Na, C, O, H). **YY**=analysis used in 'best provisional' compilation of Table 4; commonly above detection limit. Y=analysis noted in Table 4 but commonly below detection limit in basalts or otherwise considered unreliable. y=analysis not selected for Table 4. n=not analysable by this mode.

### pXRF set-up

The pXRF unit and charging stand were mounted to a wooden frame made by one of the technicians of *l'Atalante* (Figure 18). The frame was then secured to the counter top using mounting screws. This provided security and stability for the unit on a moving ship between and during analyses. The pXRF was operated using the software interface on the PC laptop screen rather than the smaller screen on the pXRF unit itself. The charging stand was permanently plugged into the 240V mains supply on *l'Atalante* via a simple NZ-European adaptor.

Figure 18 The pXRF shown mounted to a wooden frame and fixed to the counter for stability during the cruise.

## Analytical methods

Between one and three lava samples per dredge were selected for pXRF analysis. Small (c. 7x5x2.5 cm) slabs of these were cut on the rock saw, washed and placed in the oven to dry at 60 °C, after which they were analysed on the flat cut surfaces. The drying is important to prevent attenuation of X-rays during analysis.

The beam area of the pXRF on a flat sample surface is an ellipse c. 1cm$^2$ in area and, wherever possible, the sample was positioned so that areas free of phenocrysts, amygdules and secondary hydrothermal mineralisation were targeted. At least one spot was analysed per sample and this was recorded as the sample name (eg. DR-31Aii-SPOT1). When additional spots were analysed on the same sample analyses were named sequentially (eg. DR-31Aii-SPOT2, 3 etc.). All samples and spot locations were photographed and catalogued on the VESPA data drive.

At the start of each analytical session the pXRF unit was calibrated using the factory provided calibration disk. Following this a number of standards, a blank and a selection of GNS SW Pacific lava reference samples were analysed to check the data quality and to enable post-cruise calibration of the data. All samples were analysed using both modes with all beam times set for 30 seconds. Each spot was analysed three times in each mode and an average of the three measurements were taken as the composition of the sample. Typically one analysis took at least 15 minutes, including sample handling. Following each session, a 'best provisional' composition was selected from elements analysed by soil and geochemistry modes (Table 3). Meta-data captured during each analysis included the date, time, mode, a machine generated reading number, dredge number, sample number, and sample description.

## Results

A total of 1337 analyses were performed on standards, reference materials and lavas from 41 dredges during the VESPA cruise. The 'best provisional' compositions for each sample are shown in Table 4 and Table 5. Because of time constraints, no further refinement of data accuracy (e.g. by re-calibrating against the GNS reference samples) was done onboard. Sample compositions shown in Table 4 and Table 5 and the figures in this section are presented in groups according to their locations within the four main geologically distinct working areas: Norfolk Ridge, Loyalty Ridge (including its Eastern and Southern segments, the South Loyalty Basin and the northern Cook Fracture Zone), the Three Kings Ridge (including the southern Cook Fracture Zone and the Cagou Trough) and the South Fiji Basin.

## Interpretation

Preliminary interpretations and classifications of the lavas were made using a number of geochemical classification diagrams (Figure 19). The variable but generally high degree of alteration in the lavas coupled with the variable accuracy of some elements by pXRF led us to focus on relative differences, trends and groupings of samples in the classification diagrams in order to assign and/or confirm broad rock types and provenance (intraplate versus arc or back arc).

NORFOLK RIDGE: Most Norfolk Ridge lavas (magenta squares in Figure 19) are relatively enriched in Nb implying alkalic affinities typical of intraplate basaltic andesites, andesites and trachy-andesites. Samples from DR07 are problematic from a primary igneous point of view: they have low silica, low totals, high Cl, high Ca and high P. A manganese crust from the Norfolk Ridge has appropriately high trace element concentrations.

LOYALTY RIDGE: If the high $K_2O$ content of some lavas, and low $TiO_2$ and Nb content of others is correct then several of the lavas have either shoshonitic or boninitic characteristics; arc and back arc lava types are also present. This is a satisfying range of compositional variation and suggests that we will have success in testing models of arc polarity, one of the main aims of the VESPA project.

THREE KINGS RIDGE: The lavas from the wider Three Kings Ridge area show a similarly wide range in compositional variation to those from the Loyalty Ridge (Table 4, Table 5, Figure 19). This is not surprising given that the two ridges were formerly contiguous. The only granite dredged on the VESPA voyage, at DR26, has notably high As concentrations in agreement with its hydrothermally altered appearance.

SOUTH FIJI BASIN: the DR21 and DR27 South Fiji Basin lavas plot as backarc basin subalkaline basalts. Intraplate basalt was recovered from a large seamount at DR22.

| Sample number | Rock type and onboard interpretation | SiO2 | Al2O3 | TiO2 | Fe2O3 | MnO | MgO | CaO | K2O | P2O5 | Cl | S | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NORFOLK RIDGE** | | GC | GC | S | S | GC | GC | S | S | GC | S | S | |
| DR-01A SPOT1-2-3 | TRACHY-ANDESITE (SHOSHONITIC?) | 45.5 | 16.3 | 1.0 | 7.1 | 0.0 | 4.8 | 15.9 | 3.9 | 2.0 | 0.1 | 0.1 | 96.7 |
| DR-01A-HBL XENO | HRBND XENOCRYST IN BASALT | 36.3 | 12.9 | 1.1 | 12.0 | 0.2 | 4.4 | 30.0 | 2.1 | 2.3 | 0.5 | 0.2 | 101.8 |
| DR-03A SPOT1-2-3-4 | ALKALI BASALT (INTRAPLATE) | 28.8 | 11.0 | 2.0 | 9.1 | 0.0 | 5.2 | 33.2 | 1.4 | 3.9 | 0.3 | 0.3 | 95.2 |
| DR-04A 125U FRACTION | SANDY MUDSTONE | 26.6 | 8.9 | 0.4 | 4.0 | 0.2 | 2.2 | 45.2 | 1.7 | 1.6 | 0.0 | 0.1 | 91.1 |
| DR-04A SPOT 1 | SANDY MUDSTONE | 21.8 | 7.3 | 0.4 | 4.6 | 0.0 | 2.2 | 24.2 | 1.6 | 1.6 | 10.9 | 1.1 | 75.7 |
| DR-04B SPOT2-3 | ALKALI BASALT (INTRAPLATE) | 27.6 | 10.5 | 1.4 | 11.5 | 0.3 | 3.0 | 20.1 | 1.3 | 6.6 | 3.2 | 0.7 | 86.1 |
| DR-04C SPOT 1 | MANGANESE CRUST | 8.3 | 1.8 | 1.4 | 54.8 | 12.7 | 2.7 | 5.7 | 0.0 | 0.7 | 3.6 | 8.2 | 100.0 |
| DR-07B i SPOT1-2-3-4 | BASALTIC ANDESITE (INTRAPLATE) | 18.6 | 8.3 | 0.7 | 10.2 | 0.1 | 0.8 | 17.7 | 2.3 | 5.2 | 12.4 | 1.6 | 78.0 |
| DR-07C i SPOT1-2-3-4 | BASALTIC ANDESITE (INTRAPLATE) | 25.5 | 10.4 | 1.2 | 12.0 | 0.2 | 2.6 | 15.4 | 0.8 | 2.2 | 6.7 | 0.8 | 77.8 |
| DR-07C ii SPOT5-5R-7 | BASALTIC ANDESITE (INTRAPLATE) | 17.8 | 7.9 | 0.7 | 8.6 | 0.1 | 1.2 | 22.8 | 2.5 | 7.3 | 11.1 | 1.0 | 81.0 |
| DR-07C iii SPOT8-9 | BASALTIC ANDESITE (INTRAPLATE) | 17.9 | 7.8 | 0.5 | 6.7 | 0.0 | 0.9 | 13.7 | 2.6 | 3.8 | 15.7 | 1.1 | 70.7 |
| DR-07C iv SPOT10-11 | BASALTIC ANDESITE (INTRAPLATE) | 12.1 | 5.7 | 0.7 | 8.9 | 0.1 | 0.4 | 17.9 | 1.7 | 3.4 | 17.1 | 1.8 | 69.8 |
| DR-07C v SPOT12-13 | BASALTIC ANDESITE (INTRAPLATE) | 9.6 | 4.9 | 1.1 | 13.4 | 0.0 | 0.8 | 5.5 | 1.0 | 0.2 | 21.9 | 3.4 | 61.7 |
| | | | | | | | | | | | | | |
| **LOYALTY RIDGE** | | | | | | | | | | | | | |
| DR-08A SPOT1 | BASALTIC ANDESITE | 24.1 | 9.3 | 2.0 | 9.9 | 0.2 | 1.7 | 32.3 | 0.8 | 13.5 | 8.1 | 1.0 | 102.9 |
| DR-08Ai SPOT1 | BASALTIC ANDESITE | 35.5 | 12.2 | 1.6 | 7.8 | 0.1 | 2.3 | 19.6 | 1.7 | 7.7 | 4.1 | 0.7 | 93.5 |
| DR-10A SOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 61.9 | 19.4 | 0.9 | 5.9 | 0.1 | 3.4 | 9.9 | 3.0 | 0.4 | 0.1 | 0.0 | 105.0 |
| DR-13Ai SPOT1-2-3 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 53.5 | 28.6 | 1.0 | 4.9 | 0.0 | 3.2 | 8.3 | 4.8 | 0.7 | 0.2 | 0.0 | 105.2 |
| DR-14Ai SPOT1-2 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 58.8 | 17.9 | 1.0 | 5.9 | 0.0 | 4.7 | 6.1 | 5.3 | 1.0 | 0.2 | 0.1 | 101.1 |
| DR-14Ai SPOT3 | PLAGIOCLASE PHENOCRYST | 57.1 | 25.6 | 0.4 | 2.7 | 0.0 | 4.0 | 13.9 | 2.5 | 0.4 | 0.1 | 0.1 | 106.8 |
| DR-14Aii SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 60.1 | 18.0 | 0.8 | 5.0 | 0.0 | 4.1 | 6.6 | 4.9 | 0.9 | 0.1 | 0.0 | 100.6 |
| DR-15A SPOT1 | ARC ANDESITE (BONINITIC?) | 48.1 | 15.7 | 0.6 | 5.2 | 0.0 | 3.6 | 9.0 | 1.2 | 0.1 | 1.9 | 0.5 | 86.0 |
| DR-15B SPOT1-2 | TRACHY-ANDESITE (SHOSHONITIC?) | 50.4 | 14.4 | 0.6 | 3.5 | 0.0 | 2.2 | 3.4 | 5.7 | 0.2 | 0.5 | 1.9 | 82.9 |
| DR-15Ci SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 57.0 | 16.9 | 1.0 | 6.0 | 0.1 | 4.5 | 10.9 | 4.3 | 0.7 | 0.2 | 0.1 | 101.7 |
| DR-15E SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 54.5 | 15.4 | 1.1 | 7.0 | 0.1 | 3.8 | 7.8 | 4.6 | 0.7 | 0.1 | 0.0 | 95.0 |
| DR-15F SPOT1 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 32.2 | 0.4 | 0.0 | 0.2 | 0.0 | 0.5 | 86.2 | 0.2 | 0.1 | 0.2 | 0.1 | 120.2 |
| DR-17Aii SPOT1-2 | ARC BASALT/BABB | 49.6 | 15.4 | 1.6 | 11.7 | 0.1 | 6.8 | 12.8 | 0.1 | 0.2 | 0.0 | 0.1 | 98.5 |
| DR-18Ai SPOT1 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 41.1 | 17.5 | 0.6 | 10.6 | 0.1 | 4.2 | 16.9 | 0.3 | 0.0 | 2.2 | 0.1 | 93.6 |
| DR-18Aii SPOT1 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 40.1 | 16.6 | 0.7 | 11.7 | 0.2 | 3.7 | 15.6 | 0.9 | 0.3 | 2.8 | 0.1 | 92.7 |
| DR-18Aiv SPOT1 | ARC BASALT-BASALTIC ANDESITE | 44.9 | 19.3 | 0.8 | 11.7 | 0.1 | 4.1 | 16.2 | 0.4 | 0.1 | 2.6 | 0.1 | 100.2 |
| DR-18Avi SPOT1 | ARC BASALT-BASALTIC ANDESITE | 38.9 | 14.7 | 0.8 | 12.9 | 0.2 | 4.4 | 17.3 | 0.3 | 0.1 | 1.7 | 0.2 | 91.5 |
| DR-18Avii SPOT1 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 42.9 | 17.7 | 0.6 | 11.1 | 0.1 | 4.8 | 16.5 | 0.5 | 0.3 | 0.5 | 0.6 | 95.7 |
| DR-18Bii SPOT1 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 48.0 | 17.5 | 0.7 | 12.8 | 0.1 | 6.1 | 19.1 | 0.4 | 0.3 | 0.3 | 0.1 | 105.3 |
| DR-19B SPOT1 | ARC BASALT-BASALTIC ANDESITE | 47.5 | 15.8 | 1.4 | 20.2 | 0.2 | 4.8 | 14.3 | 0.4 | 1.2 | 0.4 | 0.4 | 106.6 |
| DR-19B SPOT2 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 45.4 | 15.7 | 0.6 | 11.6 | 0.1 | 6.3 | 16.8 | 0.3 | 0.0 | 0.1 | 0.1 | 97.1 |
| DR-19C SPOT1-2 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 40.3 | 15.1 | 0.6 | 9.7 | 0.1 | 4.1 | 16.1 | 1.7 | 2.9 | 0.4 | 0.3 | 91.5 |
| DR-19D SPOT2 | ARC BASALT-BASALTIC ANDESITE | 47.9 | 16.8 | 0.7 | 12.1 | 0.1 | 6.1 | 13.9 | 0.7 | 0.0 | 0.3 | 0.2 | 98.9 |
| DR-19G SPOT1 | ARC BASALT-BASALTIC ANDESITE | 43.3 | 15.7 | 0.7 | 12.5 | 0.2 | 4.3 | 14.8 | 1.0 | 0.0 | 0.2 | 0.2 | 92.9 |
| DR-20A SPOT1 | BASALT (INTRAPLATE) | 35.2 | 15.4 | 1.9 | 14.4 | 0.2 | 2.7 | 18.2 | 0.2 | 0.9 | 0.3 | 0.4 | 89.6 |
| DR-41Aii SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 45.5 | 15.2 | 0.8 | 9.4 | 0.0 | 5.1 | 17.1 | 2.8 | 1.0 | 0.2 | 0.1 | 97.4 |
| | | | | | | | | | | | | | |
| **THREE KINGS RIDGE** | | | | | | | | | | | | | |
| DR-24B SPOT1 | ARC BASALT/BABB | 54.8 | 17.7 | 1.7 | 7.0 | 0.1 | 5.7 | 14.8 | 0.7 | 0.1 | 0.2 | 0.0 | 102.9 |
| DR-24D spot 1 cum px | PYROXENE CUMULATE | 35.8 | 13.0 | 0.6 | 7.2 | 0.1 | 5.0 | 16.4 | 0.3 | 0.0 | 3.2 | 0.4 | 82.1 |
| DR-24D spot 2 gabbro | GABBRO | 23.7 | 8.1 | 1.1 | 11.9 | 0.1 | 4.6 | 7.4 | 0.6 | 0.1 | 11.8 | 1.3 | 70.6 |
| DR-25Ai SPOT1-2 | ARC BASALT/BABB | 51.2 | 14.3 | 2.8 | 14.7 | 0.1 | 4.1 | 9.2 | 0.7 | 0.4 | 0.1 | 0.3 | 97.8 |
| DR-25Cii SPOT1 | ARC BASALTIC ANDESITE (BONINITIC?) | 53.6 | 13.7 | 0.5 | 6.8 | 0.1 | 3.2 | 6.3 | 0.7 | 0.0 | 0.0 | 0.0 | 84.8 |
| DR-25D SPOT1-2 | ARC BASALTIC ANDESITE (BONINITIC?) | 23.6 | 9.5 | 0.6 | 5.0 | 0.0 | 0.9 | 6.2 | 2.2 | 0.2 | 11.3 | 0.8 | 60.2 |
| DR-26Aii SPOT1-2 | ARC BASALTIC ANDESITE (BONINITIC?) | 64.6 | 16.5 | 0.5 | 3.8 | 0.1 | 3.7 | 9.8 | 2.4 | 0.1 | 0.1 | 0.0 | 101.6 |
| DR-26B SPOT1-2 | ARC BASALTIC ANDESITE (BONINITIC?) | 48.6 | 13.2 | 0.7 | 7.4 | 0.2 | 2.7 | 11.8 | 0.0 | 0.1 | 3.7 | 0.2 | 88.6 |
| DR-26Fii SPOT1 | GRANITE-HYDROTHERMALLY ALTERED | 61.4 | 13.1 | 0.5 | 1.3 | 0.0 | 1.2 | 0.3 | 6.3 | 0.1 | 3.7 | 0.1 | 88.0 |
| DR-28Aiii SPOT1 | ARC BASALTIC ANDESITE | 44.6 | 11.9 | 1.1 | 13.6 | 0.1 | 2.9 | 10.1 | 0.3 | 0.0 | 0.2 | 0.1 | 85.0 |
| DR-28Bii SPOT1 | ARC BASALTIC ANDESITE (BONINITIC?) | 55.5 | 16.0 | 0.8 | 9.6 | 0.0 | 5.1 | 8.4 | 1.8 | 0.1 | 0.1 | 0.1 | 97.5 |
| DR-28Eii SPOT1 | ARC BASALTIC ANDESITE | 43.3 | 15.9 | 1.2 | 13.4 | 0.1 | 4.0 | 10.7 | 0.2 | 0.1 | 0.5 | 0.4 | 89.8 |
| DR-31Ai SPOT1 | ARC BASALT/BABB | 47.7 | 15.4 | 2.1 | 11.9 | 0.1 | 5.8 | 16.1 | 0.2 | 0.2 | 0.2 | 0.1 | 99.8 |
| DR-31Aii SPOT1 | ARC BASALT/BABB | 42.2 | 13.9 | 2.1 | 11.1 | 0.1 | 5.0 | 16.9 | 0.0 | 0.2 | 2.1 | 0.1 | 93.6 |
| DR-33Ai SPOT1 | ARC BASALTIC ANDESITE | 55.1 | 22.8 | 0.7 | 11.4 | 0.1 | 5.4 | 18.2 | 0.4 | 0.1 | 0.1 | 0.1 | 114.1 |
| DR-33B SPOT1 | ARC BASALT | 47.6 | 19.1 | 0.6 | 10.2 | 0.1 | 4.0 | 17.2 | 0.4 | 0.1 | 0.1 | 0.1 | 99.5 |
| DR-33Ci SPOT1 | ARC BASALT | 49.8 | 21.4 | 0.8 | 14.3 | 0.1 | 6.4 | 19.6 | 0.1 | 0.4 | 0.2 | 0.2 | 113.3 |
| DR-36C SPOT1 | ARC BASALT/BABB | 49.5 | 16.2 | 2.3 | 11.6 | 0.1 | 4.5 | 12.7 | 0.8 | 0.4 | 0.2 | 0.0 | 98.4 |
| DR-37Ai SPOT1 | ARC BASALT-BASALTIC ANDESITE | 47.6 | 17.0 | 0.9 | 9.8 | 0.1 | 7.7 | 18.0 | 0.5 | 0.2 | 0.2 | 0.1 | 102.0 |
| DR-37Cii SPOT1 | ARC BASALT-BASALTIC ANDESITE | 45.1 | 13.2 | 0.8 | 7.7 | 0.0 | 4.0 | 4.3 | 2.6 | 0.1 | 0.6 | 1.0 | 79.5 |
| DR-39A SPOT1-2 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 49.3 | 18.3 | 0.8 | 7.3 | 0.0 | 6.7 | 18.5 | 0.0 | 0.1 | 0.1 | 0.0 | 101.2 |
| DR-40Ai SPOT1 | ARC BASALT/BABB | 46.1 | 13.2 | 4.2 | 13.1 | 0.1 | 3.4 | 11.6 | 1.3 | 0.6 | 0.1 | 0.1 | 93.8 |
| DR-40Bi SPOT1 | TRACHY-ANDESITE (SHOSHONITIC?) | 50.8 | 15.8 | 0.9 | 7.3 | 0.0 | 5.1 | 16.2 | 2.6 | 0.5 | 0.3 | 0.1 | 99.6 |
| DR-40Biii SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 55.3 | 16.2 | 0.8 | 7.8 | 0.1 | 5.2 | 11.5 | 3.2 | 0.3 | 0.0 | 0.1 | 100.4 |
| DR-40C SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 47.0 | 17.4 | 0.7 | 4.1 | 0.0 | 3.2 | 8.3 | 3.8 | 0.9 | 2.6 | 0.2 | 88.4 |
| | | | | | | | | | | | | | |
| **SOUTH FIJI BASIN** | | | | | | | | | | | | | |
| DR-21B SPOT1 | BASALTIC ANDESITE | 36.6 | 14.1 | 1.1 | 7.6 | 0.1 | 3.7 | 17.0 | 0.3 | 0.8 | 5.0 | 0.2 | 86.6 |
| DR-21D SPOT1 | BASALTIC ANDESITE | 35.6 | 14.2 | 1.1 | 7.7 | 0.0 | 2.9 | 16.5 | 0.2 | 0.6 | 4.5 | 0.3 | 83.6 |
| DR-22A SPOT1 | ALKALI BASALT (INTRAPLATE) | 45.9 | 16.8 | 2.3 | 8.8 | 0.1 | 4.8 | 16.8 | 0.8 | 1.5 | 0.3 | 0.2 | 98.3 |
| DR-27B SPOT1 | BASALT | 46.3 | 19.4 | 0.8 | 8.0 | 0.1 | 4.6 | 20.1 | 0.1 | 0.2 | 1.1 | 0.2 | 100.8 |

Table 4 : Un-calibrated and un-normalised 'best provisional' pXRF major element analyses of VESPA samples. GC=element from Geochem mode, S=element from soil mode. Concentrations in wt %. Location, dredge and rock type details are given elsewhere in the cruise report.

| Sample number | Rock type and onboard interpretation | V | Cr | Ni | Cu | Zn | As | Rb | Sr | Y | Zr | Nb | Ba | La | Ce | Pb | Th | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NORFOLK RIDGE** | | | | | | | | | | | | | | | | | | |
| DR-01A SPOT1-2-3 | TRACHY-ANDESITE (SHOSHONITIC?) | 163 | 186 | 99 | 58 | 76 | 14 | 40 | 1381 | 29 | 276 | 32 | 955 | 93 | 235 | 11 | 21 | 3 |
| DR-01A-HBL XENO | HRBND XENOCRYST IN BASALT | 150 | 5 | 105 | 66 | 90 | 14 | 29 | 1118 | 37 | 408 | 23 | 781 | 45 | 178 | 9 | 18 | 5 |
| DR-03A SPOT1-2-3-4 | ALKALI BASALT (INTRAPLATE) | 127 | 223 | 246 | 44 | 70 | 15 | 16 | 593 | 28 | 215 | 49 | 289 | 68 | 105 | 3 | 13 | 2 |
| DR-04A 125U FRACTION | SANDY MUDSTONE | 36 | 0 | 121 | 62 | 67 | 4 | 19 | 719 | 16 | 111 | 21 | 181 | 33 | 59 | 6 | 12 | 0 |
| DR-04A SPOT 1 | SANDY MUDSTONE | 40 | 0 | 62 | 92 | 62 | 3 | 24 | 593 | 21 | 119 | 21 | 168 | 43 | 50 | 6 | 8 | 2 |
| DR-04B SPOT2-3 | ALKALI BASALT (INTRAPLATE) | 128 | 295 | 35 | 135 | 126 | 20 | 25 | 839 | 16 | 178 | 57 | 551 | 56 | 94 | 4 | 11 | 3 |
| DR-04C SPOT 1 | MANGANESE CRUST | 606 | 0 | 1845 | 893 | 546 | 171 | 10 | 953 | 61 | 523 | 41 | 1622 | 151 | 832 | 995 | 14 | 16 |
| DR-07B i SPOT1-2-3-4 | BASALTIC ANDESITE (INTRAPLATE) | 75 | 241 | 70 | 92 | 110 | 94 | 29 | 579 | 71 | 98 | 13 | 231 | 94 | 39 | 2 | 8 | 5 |
| DR-07C i SPOT1-2-3-4 | BASALTIC ANDESITE (INTRAPLATE) | 104 | 255 | 98 | 86 | 112 | 59 | 12 | 504 | 65 | 127 | 16 | 236 | 46 | 47 | 7 | 8 | 5 |
| DR-07C ii SPOT5-5R-7 | BASALTIC ANDESITE (INTRAPLATE) | 68 | 96 | 63 | 80 | 109 | 75 | 25 | 638 | 61 | 97 | 12 | 265 | 83 | 63 | 8 | 11 | 6 |
| DR-07C iii SPOT8-9 | BASALTIC ANDESITE (INTRAPLATE) | 60 | 131 | 56 | 64 | 83 | 67 | 37 | 518 | 49 | 76 | 12 | 237 | 84 | 63 | 1 | 8 | 7 |
| DR-07C iv SPOT10-11 | BASALTIC ANDESITE (INTRAPLATE) | 66 | 51 | 115 | 79 | 127 | 82 | 23 | 618 | 55 | 96 | 13 | 240 | 78 | 51 | 3 | 9 | 3 |
| DR-07C v SPOT12-13 | BASALTIC ANDESITE (INTRAPLATE) | 102 | 212 | 77 | 100 | 153 | 108 | 22 | 443 | 30 | 108 | 17 | 191 | 39 | 35 | 2 | 5 | 7 |
| | | | | | | | | | | | | | | | | | | |
| **LOYALTY RIDGE** | | | | | | | | | | | | | | | | | | |
| DR-08A SPOT1 | BASALTIC ANDESITE | 129 | 3 | 56 | 169 | 146 | 67 | 8 | 862 | 46 | 228 | 29 | 697 | 72 | 121 | 15 | 12 | 11 |
| DR-08Ai SPOT1 | BASALTIC ANDESITE | 94 | 19 | 28 | 46 | 139 | 16 | 17 | 650 | 43 | 303 | 33 | 520 | 110 | 79 | 4 | 10 | 2 |
| DR-10A SOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 138 | 11 | 23 | 39 | 51 | 4 | 86 | 389 | 21 | 213 | 15 | 1282 | 29 | 71 | 12 | 12 | 6 |
| DR-13Ai SPOT1-2-3 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 170 | 1 | 7 | 102 | 72 | 3 | 100 | 583 | 15 | 162 | 11 | 1858 | 15 | 81 | 17 | 15 | 2 |
| DR-14Ai SPOT1-2 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 148 | 4 | 8 | 107 | 86 | 3 | 188 | 409 | 16 | 191 | 12 | 1556 | 7 | 92 | 16 | 12 | 5 |
| DR-14Ai SPOT3 | PLAGIOCLASE PHENOCRYST | 76 | 1 | 9 | 43 | 42 | 3 | 92 | 714 | 10 | 138 | 9 | 1456 | 24 | 78 | 10 | 10 | 2 |
| DR-14Aii SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 143 | 2 | 32 | 92 | 66 | 4 | 150 | 435 | 15 | 170 | 11 | 1554 | 4 | 58 | 16 | 11 | 2 |
| DR-15A SPOT1 | ARC ANDESITE (BONINITIC?) | 111 | 13 | 33 | 36 | 57 | 3 | 28 | 373 | 13 | 132 | 16 | 979 | 21 | 99 | 16 | 9 | 4 |
| DR-15B SPOT1-2 | TRACHY-ANDESITE (SHOSHONITIC?) | 128 | 0 | 3 | 16 | 64 | 2 | 111 | 300 | 15 | 264 | 24 | 2086 | 8 | 98 | 35 | 20 | 4 |
| DR-15Ci SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 188 | 157 | 62 | 134 | 67 | 3 | 100 | 386 | 16 | 163 | 12 | 1710 | 10 | 92 | 23 | 11 | 2 |
| DR-15E SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 190 | 6 | 91 | 148 | 65 | 4 | 109 | 401 | 17 | 157 | 10 | 1744 | 4 | 106 | 22 | 12 | 5 |
| DR-15F SPOT1 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 28 | 0 | 3 | 4 | 10 | 1 | 3 | 394 | 2 | 16 | 1 | 914 | 1 | 5 | 3 | 4 | 1 |
| DR-17Aii SPOT1-2 | ARC BASALT/BABB | 92 | 0 | 33 | 24 | 89 | 1 | 5 | 124 | 25 | 109 | 5 | 90 | 9 | 27 | 3 | 3 | 5 |
| DR-18Ai SPOT1 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 92 | 0 | 15 | 38 | 71 | 1 | 8 | 158 | 11 | 28 | 2 | 96 | 12 | 25 | 5 | 5 | 2 |
| DR-18Aii SPOT1 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 97 | 0 | 55 | 35 | 95 | 2 | 17 | 178 | 20 | 35 | 3 | 151 | 8 | 26 | 5 | 5 | 2 |
| DR-18Aiv SPOT1 | ARC BASALT-BASALTIC ANDESITE | 112 | 0 | 12 | 88 | 73 | 2 | 6 | 185 | 15 | 35 | 3 | 180 | 3 | 16 | 3 | 3 | 3 |
| DR-18Avi SPOT1 | ARC BASALT-BASALTIC ANDESITE | 116 | 0 | 12 | 95 | 85 | 2 | 7 | 140 | 13 | 30 | 2 | 72 | 26 | 19 | 4 | 4 | 2 |
| DR-18Avii SPOT1 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 84 | 0 | 19 | 43 | 98 | 1 | 10 | 173 | 13 | 33 | 2 | 113 | 18 | 22 | 4 | 3 | 3 |
| DR-18Bii SPOT1 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 105 | 0 | 5 | 108 | 102 | 7 | 6 | 143 | 11 | 26 | 2 | 70 | 2 | 27 | 4 | 5 | 5 |
| DR-19B SPOT1 | ARC BASALT-BASALTIC ANDESITE | 160 | 0 | 9 | 144 | 159 | 2 | 7 | 169 | 20 | 56 | 3 | 123 | 21 | 45 | 5 | 2 | 5 |
| DR-19B SPOT2 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 95 | 0 | 34 | 63 | 108 | 1 | 4 | 129 | 9 | 20 | 0 | 244 | 9 | 12 | 3 | 2 | 6 |
| DR-19C SPOT1-2 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 76 | 0 | 29 | 105 | 97 | 6 | 20 | 201 | 22 | 33 | 2 | 83 | 26 | 28 | 4 | 3 | 3 |
| DR-19D SPOT2 | ARC BASALT-BASALTIC ANDESITE | 116 | 0 | 7 | 123 | 104 | 1 | 10 | 157 | 12 | 35 | 2 | 278 | 2 | 33 | 3 | 4 | 2 |
| DR-19G SPOT1 | ARC BASALT-BASALTIC ANDESITE | 89 | 0 | 33 | 111 | 94 | 8 | 15 | 115 | 7 | 26 | 2 | 140 | 2 | 13 | 2 | 2 | 6 |
| DR-20A SPOT1 | BASALT (INTRAPLATE) | 133 | 0 | 49 | 67 | 105 | 44 | 5 | 319 | 16 | 138 | 5 | 72 | 20 | 46 | 0 | 6 | 4 |
| DR-41Aii SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 160 | 182 | 60 | 123 | 135 | 11 | 33 | 677 | 15 | 127 | 8 | 1185 | 0 | 49 | 5 | 14 | 0 |
| | | | | | | | | | | | | | | | | | | |
| **THREE KINGS RIDGE** | | | | | | | | | | | | | | | | | | |
| DR-24B SPOT1 | ARC BASALT/BABB | 104 | 15 | 40 | 57 | 78 | 3 | 9 | 194 | 27 | 150 | 8 | 165 | 9 | 42 | 4 | 5 | 3 |
| DR-24D spot 1 cum px | PYROXENE CUMULATE | 50 | 391 | 38 | 59 | 64 | 2 | 16 | 150 | 17 | 81 | 3 | 61 | 11 | 38 | 4 | 3 | 5 |
| DR-24D spot 2 gabbro | GABBRO | 58 | 5 | 93 | 72 | 92 | 5 | 44 | 154 | 20 | 124 | 6 | 78 | 4 | 22 | 3 | 2 | 4 |
| DR-25Ai SPOT1-2 | ARC BASALT/BABB | 170 | 3 | 1 | 21 | 102 | 7 | 8 | 117 | 33 | 134 | 3 | 60 | 15 | 35 | 1 | 3 | 7 |
| DR-25Cii SPOT1 | ARC BASALTIC ANDESITE (BONINITIC?) | 43 | 3 | 1 | 5 | 20 | 2 | 14 | 343 | 22 | 76 | 2 | 23 | 17 | 11 | 1 | 5 | 2 |
| DR-25D SPOT1-2 | ARC BASALTIC ANDESITE (BONINITIC?) | 98 | 3 | 12 | 47 | 47 | 7 | 55 | 418 | 20 | 147 | 17 | 1303 | 20 | 77 | 14 | 9 | 2 |
| DR-26Aii SPOT1-2 | ARC BASALTIC ANDESITE (BONINITIC?) | 101 | 12 | 27 | 19 | 43 | 3 | 87 | 354 | 10 | 122 | 9 | 1285 | 8 | 51 | 15 | 9 | 3 |
| DR-26B SPOT1-2 | ARC BASALTIC ANDESITE (BONINITIC?) | 89 | 3 | 35 | 76 | 110 | 8 | 4 | 145 | 21 | 51 | 2 | 79 | 6 | 31 | 2 | 3 | 2 |
| DR-26Fii SPOT1 | GRANITE-HYDROTHERMALLY ALTERED | 105 | 50 | 2 | 20 | 35 | 79 | 323 | 56 | 5 | 127 | 10 | 1478 | 6 | 41 | 16 | 8 | 3 |
| DR-28Aiii SPOT1 | ARC BASALTIC ANDESITE | 120 | 0 | 3 | 67 | 75 | 2 | 6 | 90 | 16 | 57 | 2 | 41 | 0 | 43 | 1 | 2 | 4 |
| DR-28Bii SPOT1 | ARC BASALTIC ANDESITE (BONINITIC?) | 91 | 0 | 3 | 18 | 60 | 2 | 21 | 124 | 13 | 49 | 1 | 88 | 0 | 16 | 1 | 4 | 3 |
| DR-28Eii SPOT1 | ARC BASALTIC ANDESITE | 125 | 0 | 8 | 83 | 99 | 1 | 6 | 120 | 23 | 60 | 2 | 9 | 0 | 12 | 2 | 2 | 5 |
| DR-31Ai SPOT1 | ARC BASALT/BABB | 122 | 0 | 66 | 66 | 110 | 2 | 7 | 150 | 27 | 123 | 5 | 37 | 32 | 35 | 2 | 2 | 8 |
| DR-31Aii SPOT1 | ARC BASALT/BABB | 133 | 0 | 60 | 58 | 85 | 2 | 4 | 143 | 27 | 126 | 6 | 41 | 32 | 41 | 1 | 1 | 7 |
| DR-33Ai SPOT1 | ARC BASALTIC ANDESITE | 108 | 0 | 11 | 103 | 69 | 2 | 7 | 266 | 12 | 35 | 3 | 398 | 1 | 18 | 5 | 6 | 3 |
| DR-33B SPOT1 | ARC BASALT | 109 | 0 | 12 | 115 | 59 | 2 | 9 | 273 | 11 | 34 | 2 | 358 | 1 | 22 | 5 | 3 | 4 |
| DR-33Ci SPOT1 | ARC BASALT | 120 | 0 | 36 | 101 | 79 | 44 | 3 | 292 | 11 | 36 | 2 | 134 | 23 | 20 | 4 | 7 | 5 |
| DR-36C SPOT1 | ARC BASALT/BABB | 131 | 1 | 9 | 60 | 89 | 1 | 13 | 250 | 33 | 170 | 6 | 189 | 14 | 45 | 5 | 3 | 4 |
| DR-37Ai SPOT1 | ARC BASALT-BASALTIC ANDESITE | 88 | 1 | 48 | 106 | 80 | 4 | 18 | 340 | 12 | 47 | 4 | 78 | 2 | 45 | 1 | 4 | 3 |
| DR-37Cii SPOT1 | ARC BASALT-BASALTIC ANDESITE | 16 | 1 | 29 | 119 | 73 | 1 | 35 | 116 | 3 | 44 | 4 | 48 | 18 | 37 | 1 | 1 | 3 |
| DR-39A SPOT1-2 | ARC BASALT-BASALTIC ANDESITE (BONINITIC?) | 63 | 228 | 191 | 68 | 58 | 1 | 2 | 52 | 17 | 31 | 1 | 3 | 3 | 20 | 1 | 1 | 5 |
| DR-40Ai SPOT1 | ARC BASALT/BABB | 178 | 1 | 3 | 26 | 138 | 2 | 26 | 217 | 40 | 315 | 17 | 322 | 17 | 90 | 7 | 8 | 9 |
| DR-40Bi SPOT1 | TRACHY-ANDESITE (SHOSHONITIC?) | 175 | 170 | 62 | 82 | 71 | 5 | 53 | 659 | 14 | 104 | 16 | 1728 | 16 | 94 | 12 | 13 | 1 |
| DR-40Biii SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 173 | 65 | 61 | 85 | 62 | 5 | 83 | 507 | 14 | 97 | 6 | 1439 | 2 | 51 | 15 | 11 | 2 |
| DR-40C SPOT1 | ARC BASALTIC ANDESITE (SHOSHONITIC?) | 178 | 1 | 9 | 79 | 38 | 3 | 82 | 595 | 14 | 122 | 8 | 1808 | 5 | 68 | 17 | 14 | 1 |
| | | | | | | | | | | | | | | | | | | |
| **SOUTH FIJI BASIN** | | | | | | | | | | | | | | | | | | |
| DR-21B SPOT1 | BASALTIC ANDESITE | 77 | 0 | 32 | 80 | 68 | 4 | 9 | 293 | 39 | 104 | 5 | 82 | 27 | 42 | 3 | 5 | 1 |
| DR-21D SPOT1 | BASALTIC ANDESITE | 81 | 0 | 28 | 81 | 76 | 14 | 6 | 282 | 17 | 108 | 4 | 72 | 11 | 44 | 1 | 6 | 0 |
| DR-22A SPOT1 | ALKALI BASALT (INTRAPLATE) | 161 | 128 | 62 | 68 | 112 | 5 | 9 | 410 | 23 | 221 | 52 | 687 | 30 | 96 | 3 | 6 | 4 |
| DR-27B SPOT1 | BASALT | 63 | 246 | 90 | 98 | 82 | 9 | 4 | 96 | 16 | 45 | 3 | 8 | 14 | 41 | 1 | 4 | 4 |

Table 5 Un-calibrated and un-normalised 'best provisional' pXRF trace element analyses of VESPA samples. All elements from soil mode and in parts per million. '0' = below detection limit. Location, dredge and rock type details are given elsewhere in the cruise report.

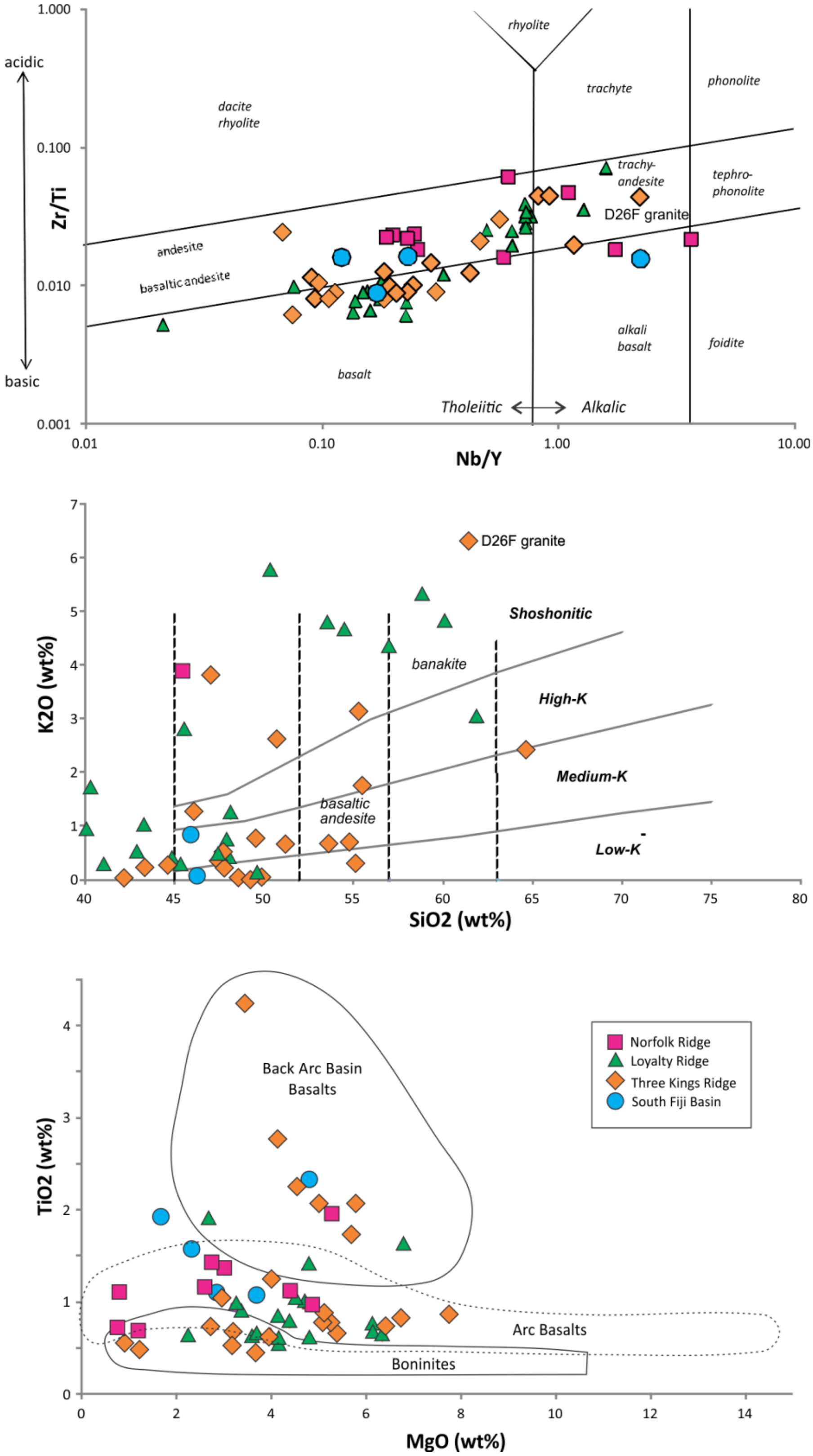



Figure 19 Selected binary geochemical plots of pXRF analyses of VESPA cruise igneous rocks. A wide variation in composition from each of the four work areas is revealed.

## Comments

- the pXRF proved to be a very useful addition to the VESPA cruise. We would unhesitatingly recommend that it be used on future cruises that dredge igneous rocks. The unit arrived at GNS Science only a few days before the departure of VESPA, so we did not have time to make any accurate calibration curves, using in-house reference material, that may have assisted with post-data processing during the cruise.

- based on concentrations of elements such as Si, Mg, K, Ti, Zr, Nb and Y we were able to confirm that we dredged a range of alkaline and subalkaline basalts. In other cases we were able to confirm the presence of andesitic and/or more evolved compositions. Shoshonitic and high-K lavas were also indicated at some dredge sites. Clearly there are as-yet-unresolved issues with some elements. For example Ti contents vary by up to 2x on the same spot depending if Geochem mode or Soil mode is used. This has major implications for e.g. identification of boninitic and intraplate lavas. As expected elements such as La, Ce, U, and Th were largely below detection in these basaltic and andesitic rocks.

- on one occasion the dredging plan was changed as a result of pXRF data. A dredge was made at site DR22 in order to sample the youngest backarc basin lavas adjacent to a South Fiji Basin fossil spreading centre. However the pXRF analysis showed the dredged lava to have Ti and Nb indicative of an intraplate (ocean island basalt) lava, not a backarc basin lava. Consequently, DR27 was planned and a backarc basin lava was successfully obtained from the new site.

- porous rocks (e.g. Norfolk Ridge material) generally gave low silica and high chlorine as analysed by pXRF. Probably this was due to unleached sea salt and/or high modal clay minerals. Because of the high throughput of dredged rocks to sort and describe, there was no time on board to renormalise these data NaCl and light element free nor to properly calibrate or check the accuracy of pXRF data against reference samples. For pXRF use on future cruises we (1) recommend at least some soaking in fresh water to leach salt from porous samples and (2) suggest that plenty of dedicated pXRF analysis time, off-shift from describing rocks, be allocated (while pXRF certainly is more rapid than laboratory XRF, sample preparation, sample analysis and data reduction are collectively fairly time consuming); (3) hope that Olympus will introduce an 'all element' mode in its software package as it was very tedious to have to manually combine elements from Soil and Geochem mode tables to get a 'best provisional' analysis for each sample.

- a sample-by-sample interpretation of the pXRF data is beyond the scope of this cruise report. The onboard pXRF results will, in due course, be compared with post-cruise laboratory grade analyses, and further comments will be able to be made.

## IV-2-4) Fossiliferous material, sea floor sediment pipe samples and living biota

This section presents a summary of activities and findings relating to fossils, living biota and modern sea floor sediments.

## Fossiliferous Material

Observed and/or potentially (micro-)fossiliferous sedimentary rocks were recovered in 28 of the 43 dredges. A total of 47 samples were identified for potential paleontological analysis ('Dredge PAL sample' in Table 6). The rock types included:

- hard micritic limestone
- hard bioclast-bearing micrite
- hard bioclastic calcarenitic limestone
- soft foram limestone
- calcareous mudstone
- carbonaceous mudstone

All fossil-bearing samples have been catalogued and housed at GNS Science in Wellington. In almost all cases, duplicate samples have been stored at SGNC, Nouméa.

The primary objectives of collecting fossil-bearing sedimentary rock samples were: to establish constraining ages on the volcanic history of the area of interest to VESPA; to determine the age of specific rock formations/sequences recognised in key seismic profiles; and to constrain interpretation of depositional environment such as water depth.

It was hoped that by having a paleontologist on board, biostratigraphic ages could be determined for dredged fossil-bearing sedimentary rock samples, based on on-the-spot fossil identifications. This expectation met with mixed success for a number of reasons: 1) we encountered surprisingly few lithologies that were soft or friable enough to easily extract microfossils from without the benefit of a dedicated micropaleontology laboratory; 2) when we did, we found that our binocular microscope did not provide sufficient illumination or magnification to resolve detailed textures and ornament on forams, thus preventing identification to species level; 3) bioclastic limestones that we encountered generally lacked obvious age diagnostic fossils and 4) an on board lack of expertise and hence confidence when it came to identifying planktonic forams.

Despite these handicaps, we were able to make reasonable provisional age pronouncements on some of the sedimentary rock samples that we encountered (see Table 6 :6).

Some weakly indurated lithologies were prepared for post-cruise microfossil identification ('PAL crushed' column in Table 6 :6). These samples were gently crushed with a pestle and mortar, wet sieved to 2000-1000, 1000-500, 500-250 and 250-125 micron fractions; the <125 micron fraction was also retained)), dried in an oven at 60°C, and finally examined under the binocular microscope. In all 10 cases, identification of forams proved difficult due to mineralisation and/or cementation effects. Further laboratory processing will be necessary.

## Post-cruise analysis

All 47 fossil-bearing samples will be re-examined in the paleontology laboratory at GNS Science in Wellington, and a prioritised plan of action for further analysis will be made.

Soft and hard sedimentary rocks will be examined and selected for disaggregation and thin sectioning respectively with identification of the following microfossil groups in mind:

forams, radiolarians, coccolith nannofossils and palynomorphs. GNS Science has significant internal capability in handling all of these fossil groups.

Any macrofossils will be examined and identified.

## Sea Floor Sediment Pipe Samples

Following the first dredge of the cruise, DR01, we requested the crew to attach a steel pipe, closed at one end, to the bottom of the dredge chain bag. This enabled recovery of particles <5 cm in diameter (the finest mesh size of the chain bag) from the sea floor, in particular unconsolidated sea floor sediment (ooze). This duly happened. Once on deck, sea floor sediment pipe samples were emptied into a bucket and taken to the Rock Laboratory.

Sea floor sediment pipe samples were recovered from 37 of the 43 dredges ('Pipe sample' in Table 6 :6). Two pipes were lost, one with the dredge. DR01 had no pipe attached, and in three dredges the pipe was empty.

In the laboratory, the contents of the sediment pipe were wet-sieved into five fractions using four stacked sieves of aperture 1 mm, 500 µm, 250 µm and 125 µm. These separates were then dried in an oven at temperatures no greater than 60° C. They were then examined under the binocular microscope and then bagged in plastic bags and/or plastic bottles. Small bottles of wet, unsieved sea floor mud and/or ooze samples were retained from 25 dredges ('Bottle' in Table 6 :6). All sea floor sediment pipe samples were lodged with GNS Science in Wellington (none at other institutions).

These ‘pipe’ samples are of great scientific interest because they are a record of what clastic and biogenic sediment is accumulating on the sea floor today at each dredge site. Some samples were rich in grains of quartz, pumice and glass, probably relating to distal silicic volcanic eruptions. Others were rich in rock fragments that may relate to the geology of the dredge site.

The biogenic content of the pipe samples was typically dominated by planktonic forams which reflects plankton productivity within the modern water mass. Some benthic forams were also recovered, including a spectrum of agglutinating forms (tubiform and rhizoform), and various worm tubes. For macropaleontologists, material included the shells or shelly elements of molluscs (micro-molluscs in the main and pelagic molluscs), barnacles, brachiopods, bryozoans, echinoderms and corals. Sponge spicules, fish otoliths and shark teeth were also sometimes recovered but no bone was observed.

## Living Biota

Little obvious living and/or recently dead biota was recovered in the dredges ('Living biota' in Table 6). This is probably a combination of the coarse mesh size of the dredge, fragility of organisms, and dredge targets well below the photic zone and away from active hydrothermal vents.

Biota recovered were worms, sponges, corals, one hermit crab, benthic forams (see Table 6 for inventory). Most were preserved in alcohol in small bottles with larger objects (coral, sponge) placed in plastic bags.

Below is a summary of all conspicuous 'living' material found in either the dredge or the pipe. This material was sent to IRD, Nouméa.

- DR01: three bags with coral fragments; one bag with large ?sponge; one bottle with sponge; three bottles with corals
- DR02: one bottle with two 'worms': one large, one very small and thin
- DR04: two bags with large coral fragments
- DR07: one bottle with three brachiopods: two entire specimens plus one crushed specimen (identified by HJC as *Amphithyris comitodentis* Nauendorf, Wörheide & Lüter 2014)
- DR13: coral in bag
- DR15: bag with large coral fragments
- DR16: glass sponge in bag
- DR18: worms & sponges in bottle
- DR33: one bottle with /sponge or bryozoan?; one bottle with hermit crab; two bottles of foram sand fractions: 500µm and 250µm
- DR38: coral debris in small bag; one bottle with a sponge; one bottle with coral

| Dredge | Work area | Depth (m) | Dredge PAL sample | PAL crushed | Pipe sample | Bottle | Living biota |
|---|---|---|---|---|---|---|---|
| DR01 | Norfolk Ridge | 1115 | - | - | - | - | Y |
| DR02 | Norfolk Ridge | 2300 | 2A (Late Neogene?) | 2A | 2B | - | Y |
| DR03 | Norfolk Ridge | 2000 | 3B | - | 3C | - | - |
| DR04 | Norfolk Ridge | 2400 | 4A | 4A | 4G | - | Y |
| DR06 | Norfolk Ridge | 707 | 6B, 6C (Neogene) | - | - | - | - |
| DR07 | Norfolk Ridge | 1569 | - | - | - | - | Y |
| DR08 | Loyalty Ridge | 2271 | 8B | - | 8D | - | - |
| DR09 | Loyalty Ridge | 2929 | - | - | 9A | Y | - |
| DR10 | Loyalty Ridge | 1523 | 10B, 10D | - | 10E | - | - |
| DR11 | Loyalty Ridge | 3152 | 11A, 11B | - | 11D | Y | - |
| DR12 | Loyalty Ridge | 2561 | 12B, 12E | 12B | 12G | Y | - |
| DR13 | Loyalty Ridge | 2731 | 13Eiii, 13I | - | 13H | - | Y |
| DR14 | Loyalty Ridge | 2112 | 14D | - | 14L | Y | - |
| DR15 | Loyalty Ridge | 2240 | 15Hi | - | 15J | - | Y |
| DR16 | Loyalty Ridge | 2791 | 16E, 16G | - | 16H | Y | Y |
| DR17 | Loyalty Ridge | 3539 | 17Ci, 17Cii | - | 17D | Y | - |
| DR18 | Loyalty Ridge | 3457 | 18C | 18C | 18D | Y | Y |
| DR19 | Loyalty Ridge | 3028 | 19Jii, 19Jiii, 19K | - | 19L | - | - |
| DR20 | Loyalty Ridge | 2651 | - | - | 20C | - | - |
| DR21 | South Fiji Basin | 3385 | - | - | 21H | Y | - |
| DR22 | South Fiji Basin | 2849 | 22B | - | 22C | Y | - |
| DR23 | Three Kings Ridge | 3165 | 23A, 23B, 23C, 23E | - | 23H | Y | - |
| DR24 | Three Kings Ridge | 3660 | 24E | - | - | - | - |
| DR25 | Three Kings Ridge | 3002 | - | - | 25H | Y | - |
| DR26 | Three Kings Ridge | 2419 | - | - | 26H | Y | - |
| DR27 | South Fiji Basin | 3771 | - | - | 27D | Y | - |
| DR28 | Three Kings Ridge | 3050 | - | - | 28F | Y | - |
| DR29 | Three Kings Ridge | 2145 | 29C, 29D (Late Eocene) | - | 29H | Y | - |
| DR30 | Three Kings Ridge | 3954 | 30D | 30C | - | - | - |
| DR31 | Three Kings Ridge | 3920 | 31Bi, 31Bii, 31C | 31Bi, 31C | 31D | Y | - |
| DR32 | Three Kings Ridge | 2247 | - | 32C | 32A | Y | - |
| DR33 | Three Kings Ridge | 1391 | 33Ci | - | 33D | - | Y |
| DR34 | Three Kings Ridge | 2254 | - | 34B | 34C | Y | - |
| DR35 | Three Kings Ridge | 2801 | - | - | 35A | Y | - |
| DR36 | Three Kings Ridge | 3936 | 36E | 36E | 36F | Y | - |
| DR37 | Three Kings Ridge | 4157 | 37D | - | 37E | Y | - |
| DR38 | Three Kings Ridge | 2072 | 38A | - | 38D | - | - |
| DR39 | Three Kings Ridge | 3957 | 39G | - | 39I | Y | - |
| DR40 | Three Kings Ridge | 3721 | - | - | 40E | Y | - |
| DR41 | Loyalty Ridge | 2861 | 41Ei, 41Eii | - | 41F | Y | - |
| DR42 | Norfolk Ridge | 1145 | 42A, 42B, 42C, 42D | - | 42F | - | - |
| DR43 | Norfolk Ridge | 2299 | - | - | 43D | Y | - |

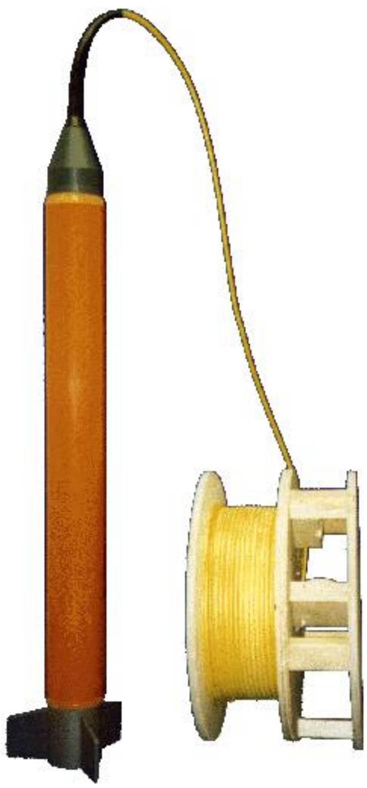
Table 6 : Summary list of VESPA fossiliferous material, sea floor sediment pipe samples and living biota

## *IV-3) Magnetometer*

### IV-3-1) SeaSPY Magnetometer

*Source: GENAVIR/SQAE 01/06/04 Fiche DINES*

A magnetometer measures the magnetic intensity, the measuring unit being Tesla. The earth generates a magnetic field which produces a flux density ranging from 18 microTesla near South America to 60 microTesla around the Arctic Circle. The air in the flux density is directly proportional to the magnetic field, the magnetometer can detect the changes in that field. Dynamic fluctuations in the magnetic field are due to the activity of the Earth's core, to solar activity, or magnetic storms in space. On the other hand, static anomalies are due to the magnetization of different components of the Earth's crust and upper mantle. It is this component that interests us in this particular case. The SeaSPY magnetometer provides a local measure of the intensity of the geomagnetic field. It is based on the principle of the proton precession.



The device consists of a submerged sensor towed behind the vessel, a coaxial cable, a connecting cable "bridge", an RS 232 interface and power supply housing, onnected to a single PC. The sensor towed behind the research vessel so that the influence of the ship's magnetism is negligible as compared to the measurement noise. A rule of thumb is to tow the magnetometer at a distance of at least 3 times the length of the ship. During multi-channel seismic surveys, the magnetometer is towed behind the tail buoy of the streamer, and is, hence, well beyond the minimum required distance from the vessel.

The accuracy of the measurement is of the order of 0.2 Gamma (or 0.2 nanoTesla); 10-9 = 10-5 Tesla Gauss = 10-5 = 10-9 Oersted Webers / m2 = 1 Gamma). The sensor has a measuring range of from 20000 to 120000 Gammas.

← SeaSPY magnetometer and cable

A standard magnetometer uses the property of protons that behave as a magnetic gyroscope (spin). A strong current is applied to a coil in the sensor. The resulting magnetic field polarizes the protons of a liquid (kerosene) in the direction of the axis of the coil. The current is then stopped as is the magnetic field generated: the protons 'gyros' are then subjected to the Earth's magnetic field whose direction is different from that of the initial polarization. This results in a Larmor precession frequency (approximately 2000 Hz for a field of 50000 gammas) proportional to the field strength. The bias coil also serves to collect an induced voltage (through the precession) of low amplitude and rapidly decreasing on which will be made a measure of frequency.

Unlike the standard magnetometer, which uses strong direct current for polarization before each measurement, the Overhauser magnetometer is constantly polarized by a high frequency low power source and it uses the principle of Nuclear Magnetic Resonance. If a material containing protons undergoes a high frequency alternating polarization, protons will precession around the direction of the absolute field at a frequency proportional to the applied field (f = 42.4763751 MHz / T)

The sensor therefore can give valid measurements of the magnetic field while being polarized, allowing a measurement interval ranging from 10 seconds to 1/4 seconds without loss of sensitivity (0.015 nTesla) .The system is entirely numerical and has an omni directional sensor, a pressure sensor and a humidity sensor integrated within the tow-fish.

Characteristics of the measurements
A magnetometer is a rather sensitive device and its measurement can be altered by environmental factors. Among the factors that may influence the quality of the measurements, we can note the electromagnetic environment in which the sensor is placed, and notably the distance to the ship.

On the other hand, the intensity of Earth's magnetic field is subject to various changes over time. These temporal variations include:

- The diurnal variation which can reach 100 nT in amplitude can be observed,
- In addition, at any time of day or night, there are shorter period of microwave pulses that can reach tens of nanoTeslas.
- Solar storms can last one day and cause variations of several hundred nanoTeslas.

A detailed knowledge of the magnetic field would require the registration of these variations by a moored base station in the survey area, in order to correct the ship-borne measurements. Such corrections are often applied on land, during aeromagnetic surveys. However, at sea this is rarely done, and the R/V L'Atalante does not have the necessary instrumentation to have such a reference base station.

The magnetometer has been deployed in two different situations: when seismic data were recorded, and independently. In the first situation, the magnetometer is towed at the very end of the streamer, 653 meters behind the ship. In the second situation, it is towed on an independent cable running starboard and pulled 289 meters behind the boat.

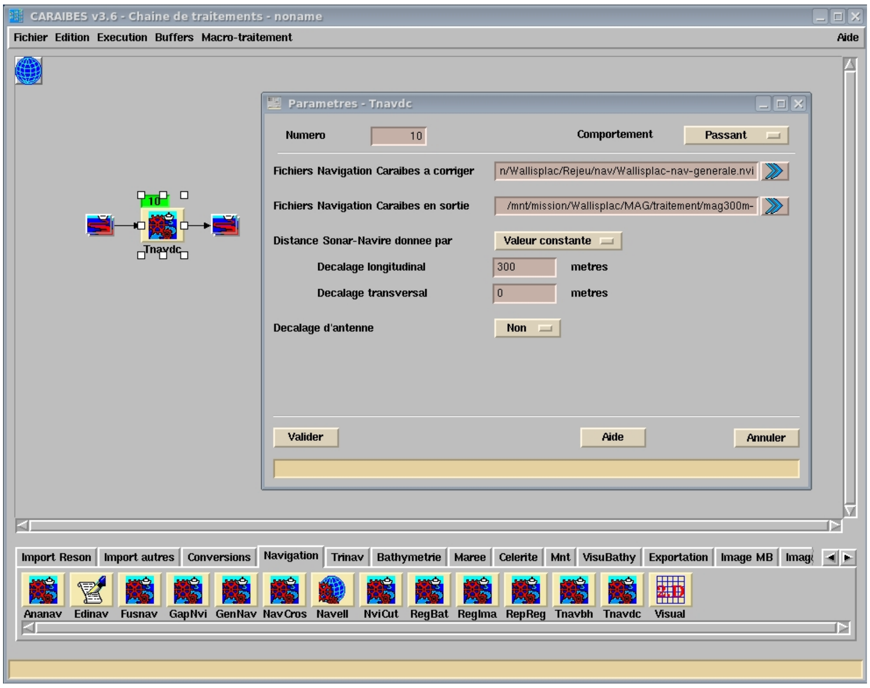
### IV-3-2) Magnetic data

The magnetic data are acquired and backed-up by the Techsas on board system in two formats: NetCDF (*.mag) and ASCII (* .MAGNE). The data need to be combined with the navigation file of the survey (*.nvi) provided by the ship operator Genavir on a daily basis.

## Correction of navigation offset

To correct for the distance between the tow-fish and the vessel, one uses the Navigation/Tnavdc module of Caraïbes

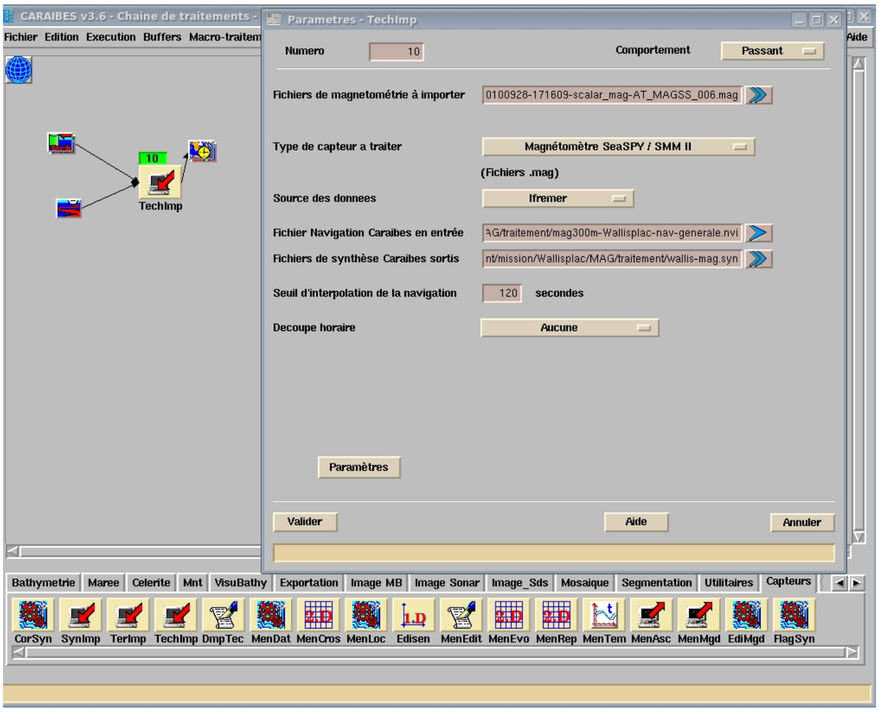
The offset is applied positively from the stern. Depending if the magnetometer was deployed at the end of the streamer or independently, the offset is either 653 or 289 meters from the reference point for the VESPA Cruise.




## Merging data with navigation

2 modules are available depending on the files used:

- import files with file extension .mag: Module Caraïbes / Capteurs / TechImp
- import files with file extension .MAGNE: Module Caraïbes / Capteurs / TerImp

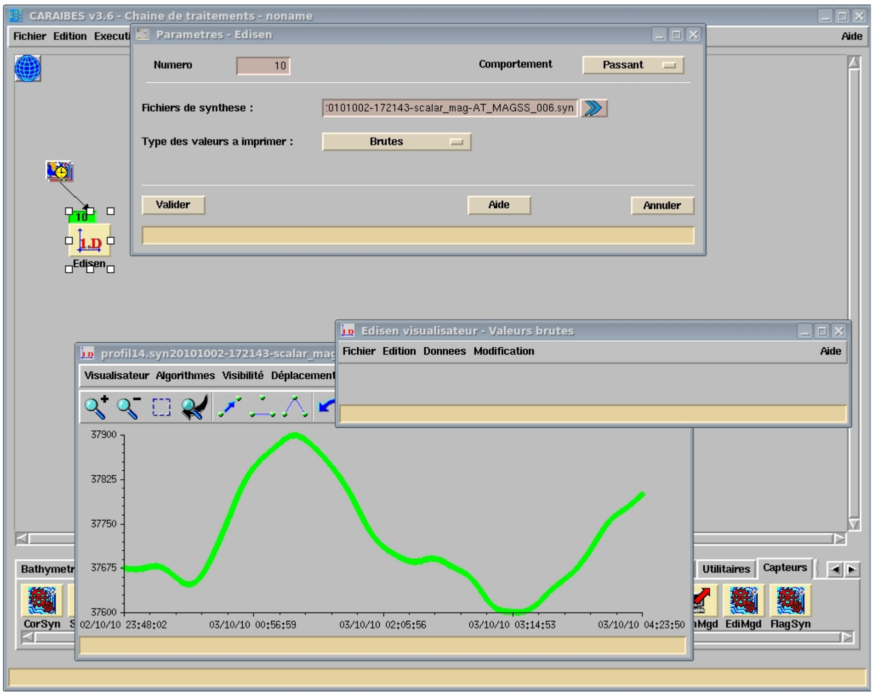



The two modules are fairly similar. During the VESPA Cruise the TechImp module was used primarily.

## Data Correction

The editing of data from the file created above, can be done with Caraïbes Module / Sensor / Edisen.

In the Edisen Module, the total magnetic field and the magnetic anomaly data are displayed independently. Corrections or removal on one of the data sets is not automatically repeated on the other data set. Saving of the editing operations is done by either "*Edisen/Fichier/Enregistrer*" or in the data viewer "*Visualisateur/Enregistrer*"




## Exporting data to ascii

The total field magnetic data and the magnetic anomaly data can be exported in Ascii using the Caraïbes Module / Sensor / Menasc

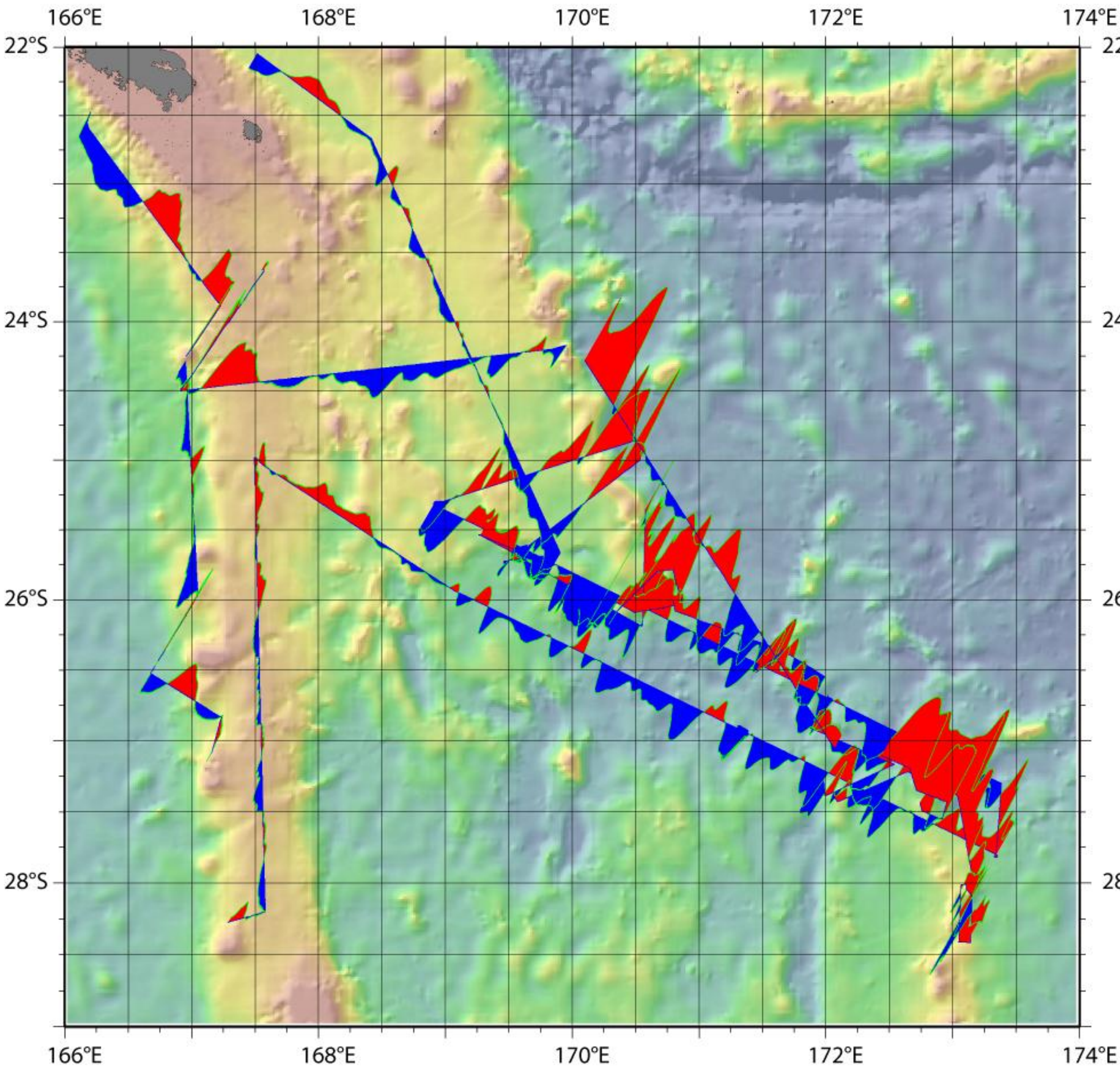



Figure 20 Magnetic anomaly as measured during VESPA

## *IV-4) Sub bottom profiler*

The sub bottom profiler used on board L'Atalante was developed by the Triton-Elics company, in collaboration with Ifremer, Eramer and ENERTEST. During the VESPA cruise it was used almost continuously.

The acquisition of sub bottom profiler data was performed with the SUBOP acquisition system developed by Ifremer.

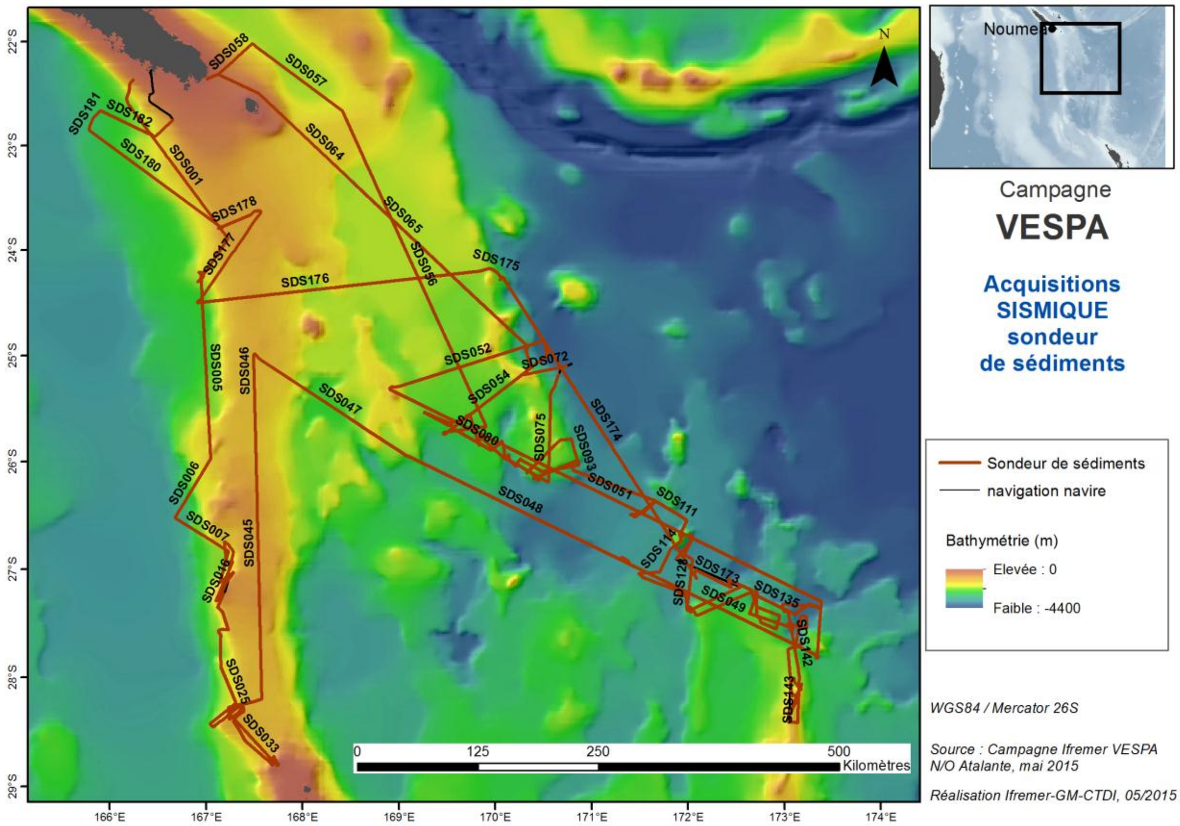



Figure 21 Sub bottom profiler profiles

## *IV-5) Multibeam bathymetry*

During the survey the multibeam sounder (MBS) EM122 ran almost continuously. The EM710 was started when the depths were less than 1000m. 180 profiles were acquired and 47 velocity profiles were conducted throughout the study area.

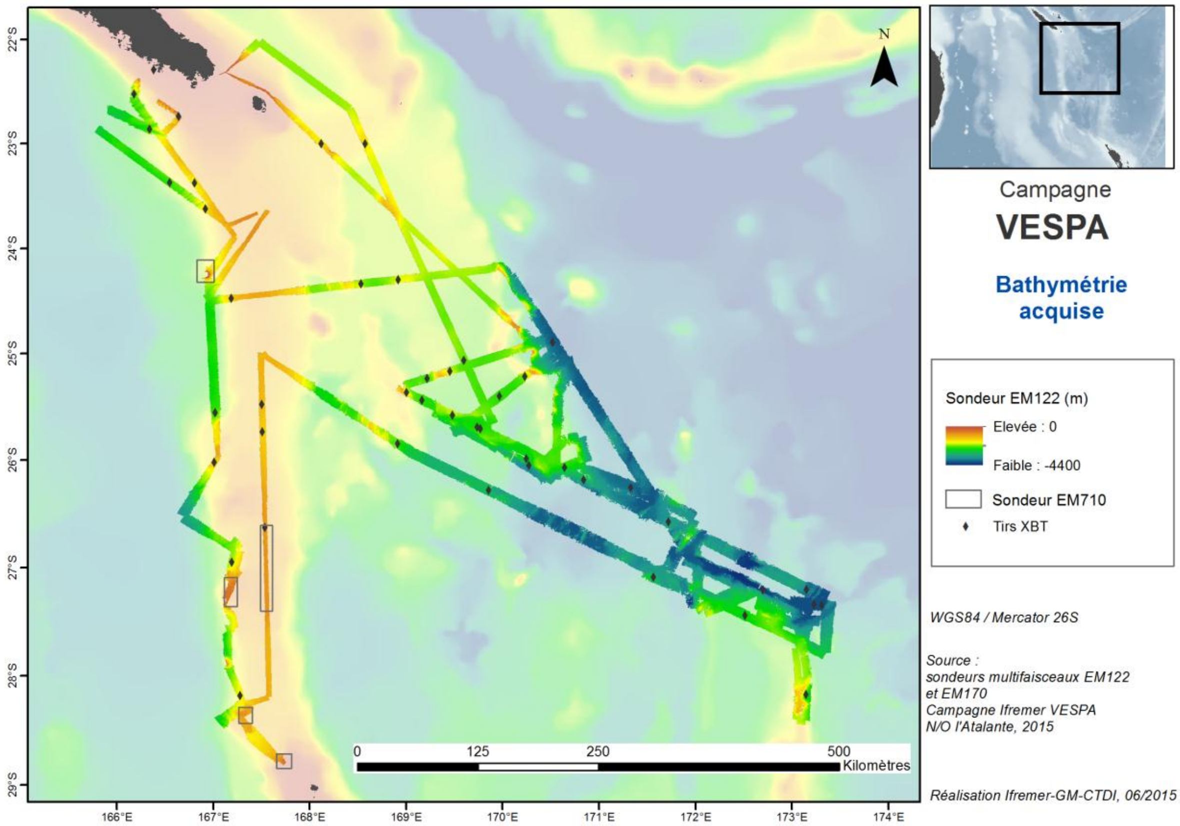



Figure 22 Multibeam bathymetry acquisition

The processing of bathymetry data was achieved with the CARIBBEAN v4.3 software developped by Ifremer. Processing of reflectivity could not be carried out onboard because the Sonarscope software was defective.
The data were corrected for tidal predictions derived from SHOM at:

·23°54.00'S-16°70.00'E,
·25°30.00'S-17°00.00'E,
·27°12.00'S-17°23.00'E,
·27°30.00'S-16°71.00'E,

The navigation and bathymetry files were exported to GIS. Data are in WGS84 and projected to UTM 58S and 59S (2 DTMs were generated).

The weather was relatively mild with a few days a little rough at the beginning of the voyage and the last two weeks. The maximum observed wind was 40kts with a swell of up to 5m.

Sippican soundings were made throughout the study area.

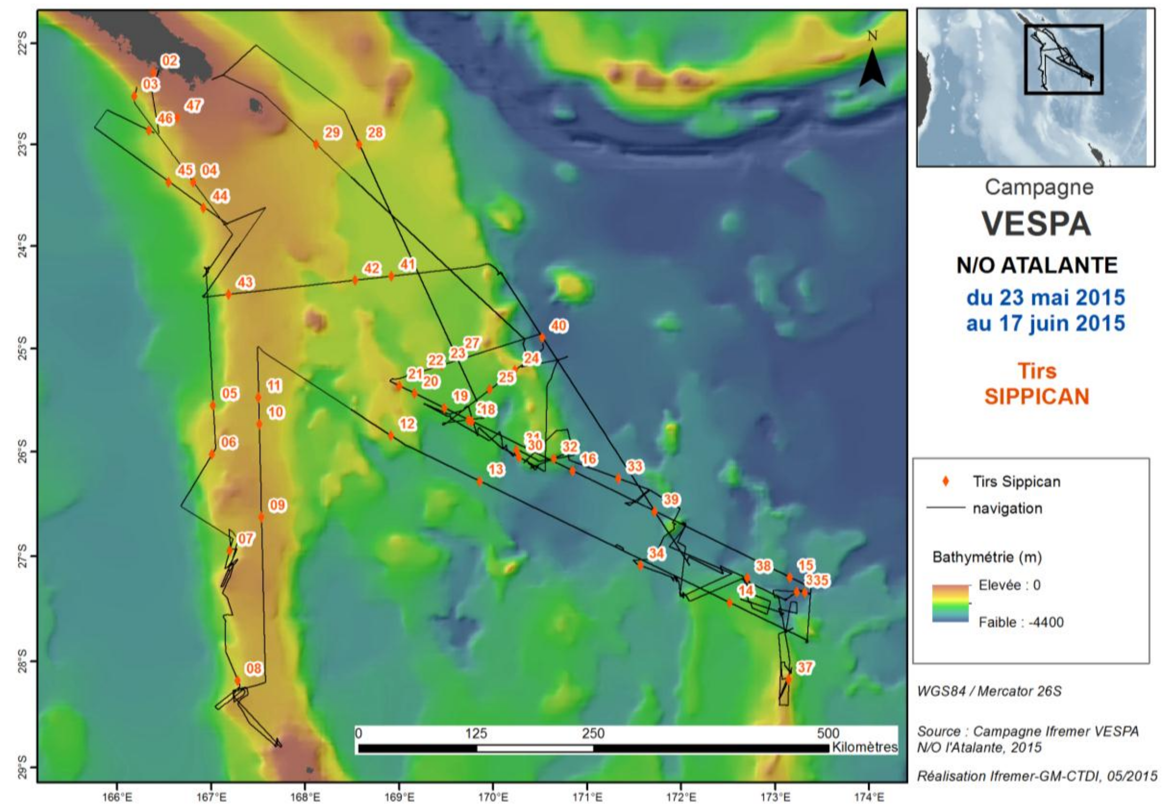



Figure 23 Location of the Sippican soundings

## IV-5-1) EM122

### EM122 configuration

- FM mode active
- Dual swath (dynamic)
-  75°/75°opening
- Acquisition mode « AUTO »
- Attenuation coefficient « salinity »

### EM122 calibration

No calibration was done until the central PHINS attitude broke down (9 June at 5 am). A roll calibration of the EM122 was then made, wired to OCTANS.

A return of twice 15 minutes was done on a relatively flat bottom. After processing the profiles, bias roll of -0.02 ° was observed on the half of the calibration profile and then introduced directly into the SIS acquisition software. This bias is negligible since it represents the level of accuracy of the central.

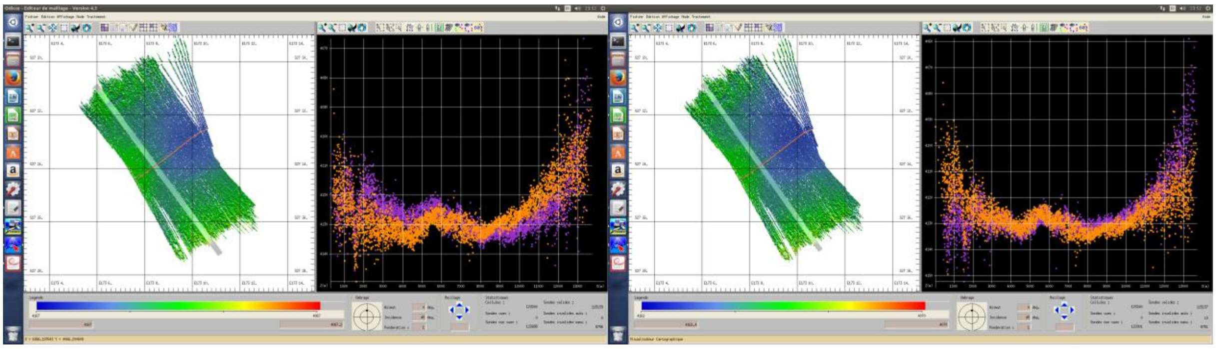


Figure 24 Left window: calibration profile without correction, right window: calibration profile corrected of -0.02 °

The previous integrated bias was + 0.2 °. Bias integrated in SIS with the wired OCTANS is + 0,2-0,02 = + 0.18 °.

### IV-5-2) EM710

### EM710 configuration

- FM mode active
- Dual swath
- 70°/70° opening
- Acquisition mode « AUTO »
- Attenuation coefficient « salinity »

### Vertical detection problem on EM710

Vertical detection problems were observed with EM710. After several tests, it appears that the SIS software with mode "AUTO" has trouble managing the switch from DEEP mode to VERY DEEP (about 500m).

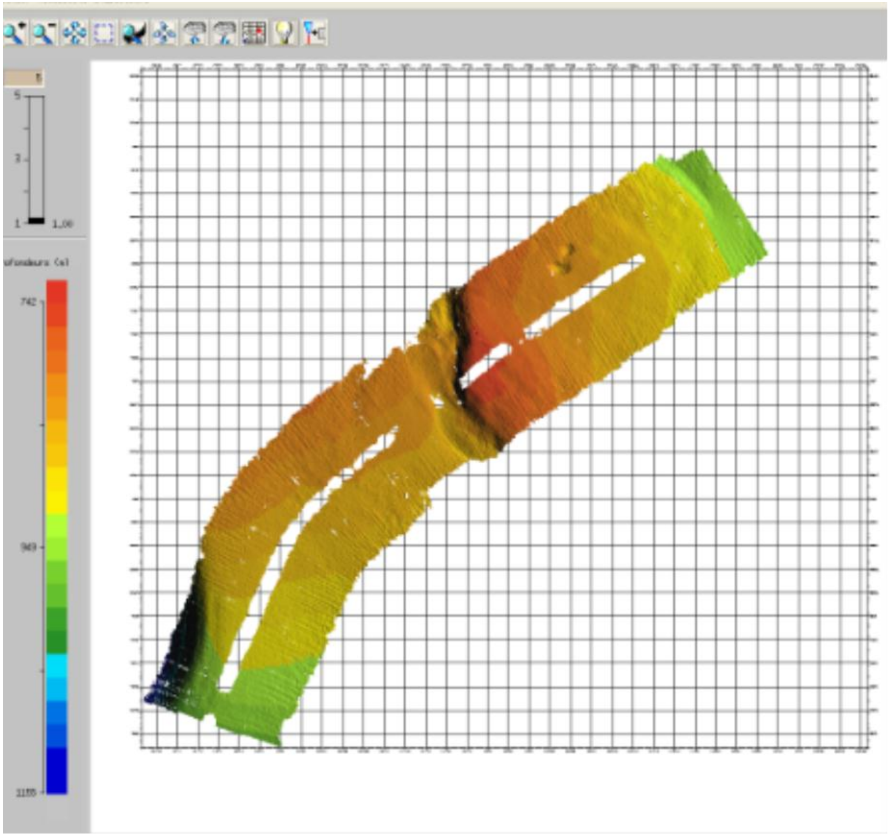


Figure 25 Vertical detection problems on EM710

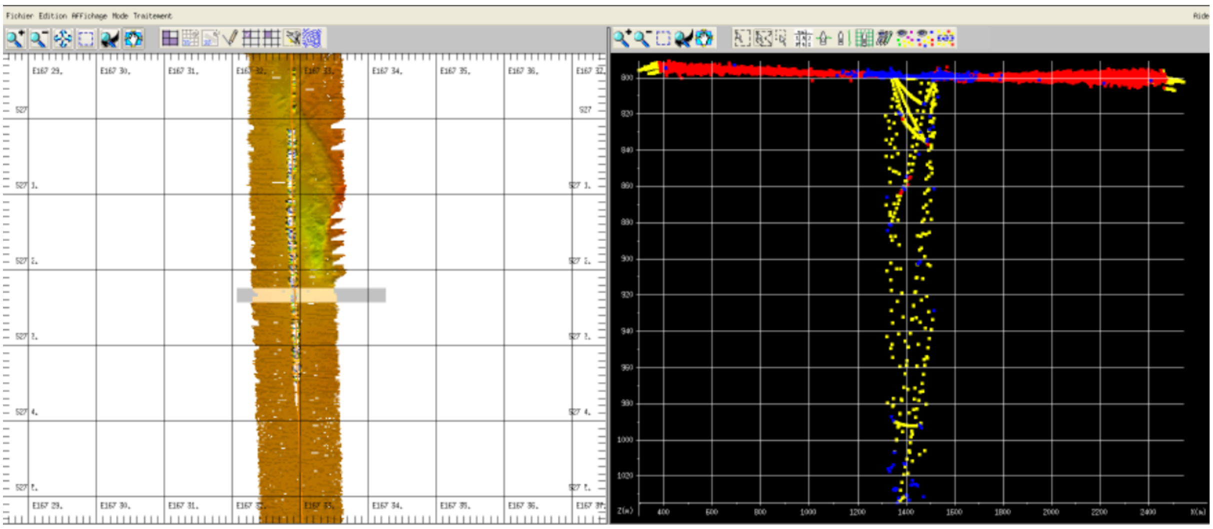


Figure 26 Viewing false detections vertical to the EM710

Vertical false detections should be monitored and switching to DEEP mode manually forced. In addition, the swath is not always optimally detected. To solve this problem you must manually adjust the Z detection window

# V) Conclusions

The answering of the main research questions on the timing of Southwest Pacific subduction inititation and subsequent development must await dating and chemical analysis of the VESPA rocks as well as interpretation of seismic and magnetic data. However, the cruise component of the VESPA project has been an undoubted success and in many cases exceeded our expectations. Some statistics from the voyage:

- 35 crew aboard l'Atalante
- Team of 17 scientists and technicians
- 25 days (23 May-16 June 2015)
- length of cruise 7700 km (@ 13 km/hr)
- 22 lines/190 hours/3400 km of rapid seismic data acquired
- 43 dredges made (36 with useful rock, 29 with (micro)fossils)
- collected an estimated total of c. 8 tonnes of rock (770 kg retained)
- 287 different samples characterised

The quality of the processed rapid seismic lines was very high. The two long magnetic profiles in the Norfolk and South Fiji Basins contain distinct, seemingly normal and reversed polarity high amplitude anomalies. As planned, we profitably exploited the presence of Cook Fracture Zone fault scarps to obtain samples from deep stratigraphic levels of the Loyalty and Three Kings Ridges. Use of the portable XRF instrument on board let us confirm the presence of a range of lava compositions including alkali basalt, high Ti subalkaline basalts, low Ti subalkaline basalts (subduction-related), andesite, shoshonite and possibly boninite. Preliminary geochemical results, chiefly on the basis of K, Ti, Zr, Y and Nb concentrations indicate that the line of volcanoes on the Norfolk Ridge is not subduction-related but is an intraplate chain. Dredges from the Loyalty Ridge were dominated by shoshonites but we have provisionally confirmed the probable presence of subduction-related basalts and andesites on the Loyalty Ridge.

The post-cruise work plan will involve several strands:

- shipping of rock samples to IUEM Brest and GNS Wellington
- screening of the quality and suitability of rocks using thin sections in order to prioritise them for subsequent geochemistry and dating work. This work will be divided between IUEM and GNS.
- seismic interpretation at SGNC Nouméa and IFREMER Brest.
- marine magnetic anomaly interpretation at Victoria University of Wellington, New Zealand
- whole rock geochemistry and isotope chemistry at IUEM.
- possible melt inclusions studies at University of Tasmania.
- preparation and identification of microfossils at GNS Science.
- mineral separation at GNS Science followed by Ar-Ar dating at University of California Santa Barbara and U-Pb isotopic dating at University of Otago, Dunedin, New Zealand.

Realistically, it probably will take at least 2-3 years to complete the planned analytical programme of work. During that time we will present emerging results at conferences.

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# VII) ANNEXE 1

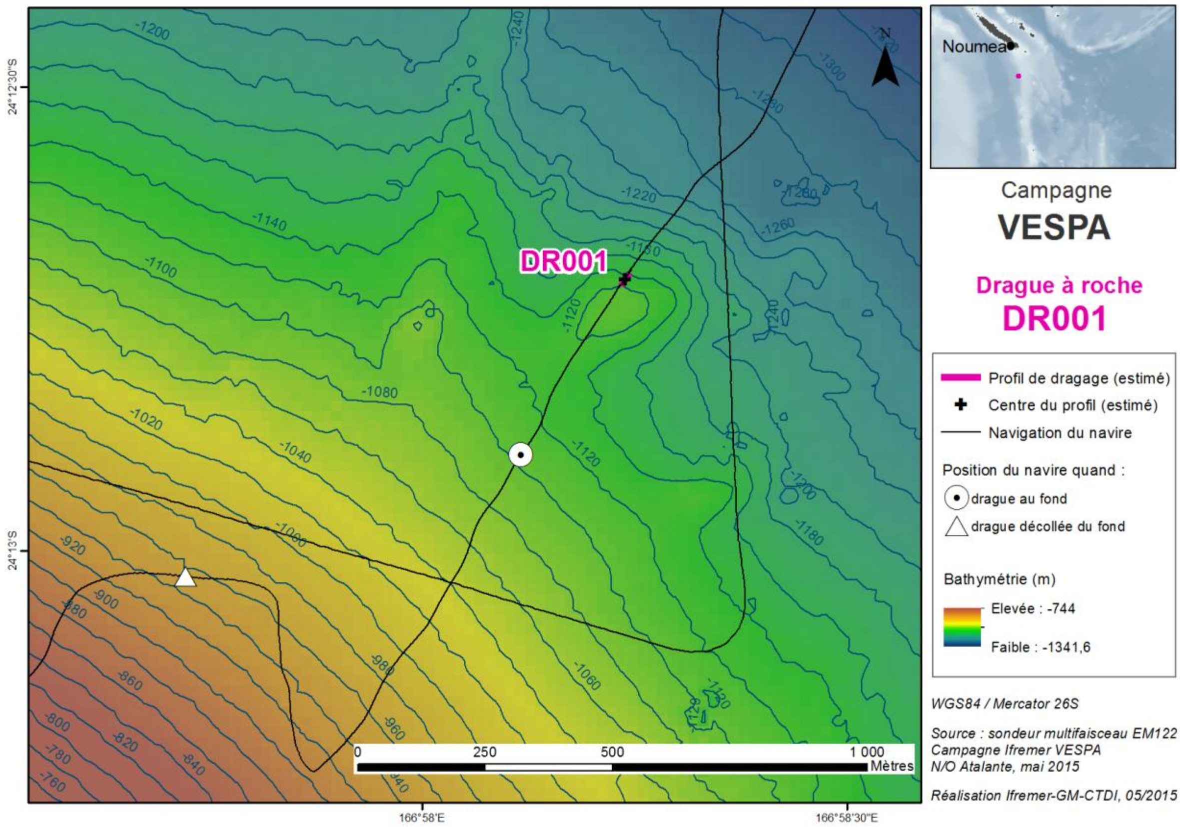
## Dredge description

On the following pages is a catalogue of the dredge sites and the different rock types recovered. For each dredge the following information is given:

**Target:** short description of site
**Latitude, Longitude, Depth:** estimated coordinates of dredge position (note: not the ship position) midway between on-bottom and off-bottom locations
**Approx. weight:** visually estimated weight of total dredged rock (perhaps an underestimate)
**Main rock types:** dominant rocks in dredge
**Other rock types:** minor rocks in dredge excluding Mn crusts, pumice and foram ooze
**Dredging notes:** notes on cable tension etc
**Map** of dredge site, ship track and dredge points (note that positions of the dredge (not the ship) are indicated, that have been estimated in accordance with the method described below (in italic))
**Images** of rocks from the dredge
**DRnnAi:** sample numbers usually, but not always, allocated in order of decreasing abundance or usefulness. A, B, C etc… are usually quite different from each other whereas i, ii, ii etc have similarities and are often separate pieces of the same rock type.
**Subsamples:** location of institution to which samples or subsamples were sent. The largest quantity of rock went to SGNC Nouméa.

## *DR01*

**Target:** Norfolk Ridge area. Gravity anomaly on northern part, west side. Presumed to be a volcano.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 23/05/2015 | 17:06:29 | -24,20102 | 166,9776337 | MISE A L'EAU | Mise à l'eau DR_001, 1129m de la cible |
| 23/05/2015 | 17:19:00 | -24,20551 | 166,9750627 | DEBUT DE FILAGE | Début de filage DR_001, 480m de la cible |
| 23/05/2015 | 17:45:00 | -24,21494 | 166,968609 | AU FOND | Drague au fond, 1250m filés, 640m de la cible |
| 23/05/2015 | 17:51:37 | -24,21729 | 166,9671997 | FIN DE FILAGE | Fin de filage, 1500m filés |
| 23/05/2015 | 17:55:23 | -24,21861 | 166,9662015 | CROCHE | Croche, 1500m filés, 707m de cible |
| 23/05/2015 | 18:05:00 | -24,22014 | 166,9641835 | CROCHE | CROCHE 15T, 1582m filés |
| 23/05/2015 | 18:16:00 | -24,2171268 | 166,9620194 | DRAGUE DECOLLEE | Drague décollée, 1307m filés |
| 23/05/15 | 18:59: | -24,22941 | 166,95151 | A BORD | DR_001 à bord |

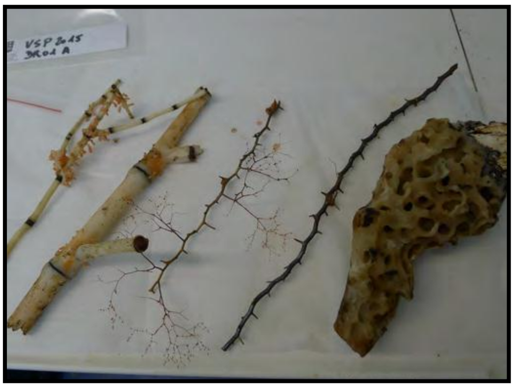
**Approx. weight:** 5 kg
**Main rock types:** Olivine basalt and hyaloclastite
**Other rock types:** Corals and sponges.
**Dredging notes:** Volcanic rocks successfully recovered


DR01


DR01A


DR01A


DR01B



DR01C

**DR01A:** 40x25x30cm piece of olivine basalt partially covered with manganese crust: less than 5% olivine phenocrysts, of maximum size 2mm. Rare black amphibole (hornblende or pargasite?) xenocrysts up to 7mm in size. Calcite amygdules up to 5mm in size.

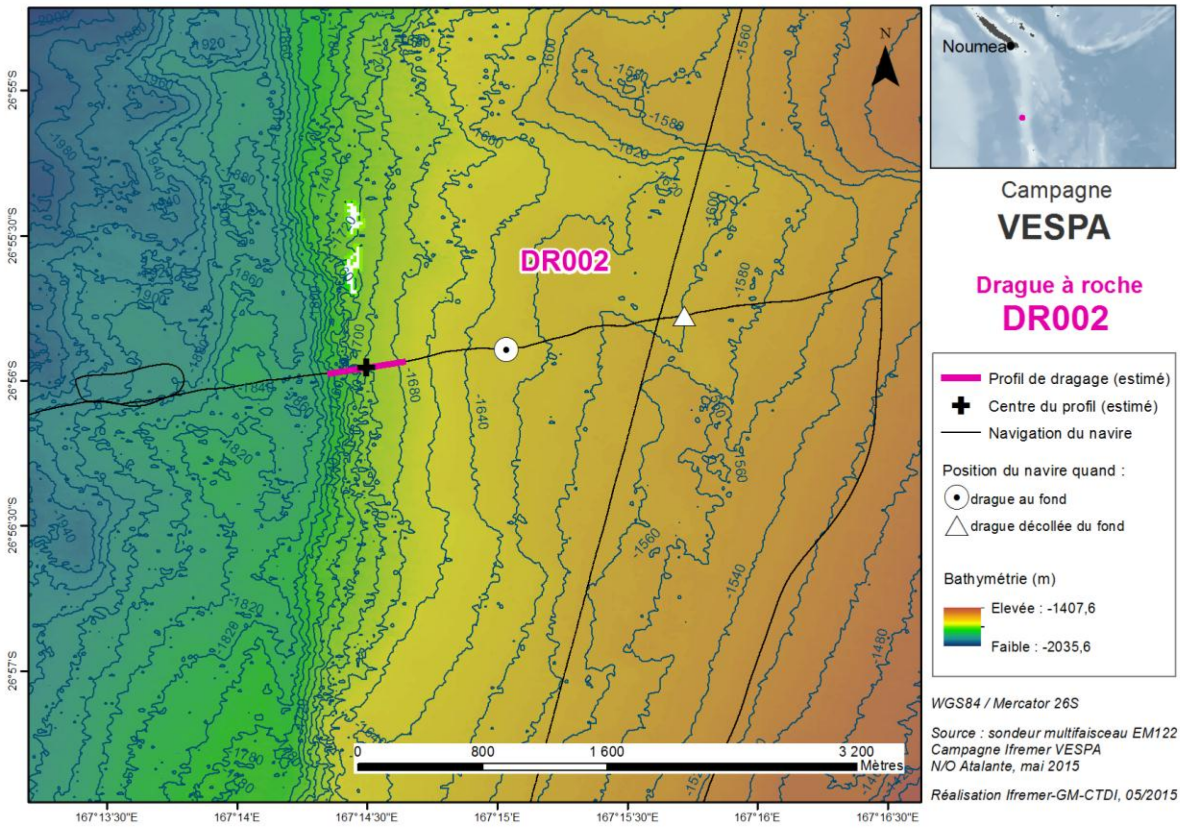
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR01B:** 20x10x10 cm piece of hyaloclastite breccia very altered
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR01C:** Recently dead biological material. Two pieces of black and white coral (25x1cm and 26x0.5 cm), one piece of gold coral, one piece of black coral, one piece of silicified sponge (20x10x10cm).
*Subsamples at IRD Nouméa*

# *DR02*

**Target:** Norfolk Ridge area. Seabed exposure of TECTA seismic horizon on steep, sediment-free slope.

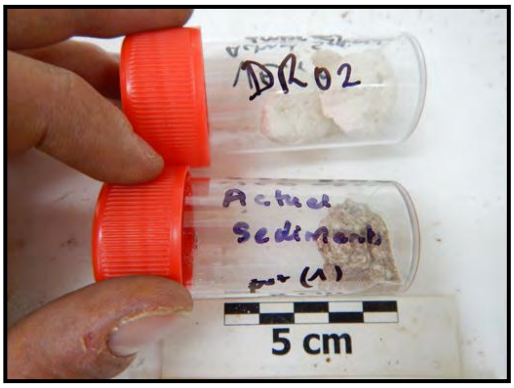



| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 24/05/2015 | 23:36:08 | -26,934560 | 167,2266875 | MISE A L'EAU | Mise à l'eau DR_002, 112m de la cible |
| 24/05/2015 | 23:49:40 | -26,933696 | 167,2328902 | DEBUT DE FILAGE | Début de filage DR_002, 919m de la cible |
| 25/05/2015 | 00:30:00 | -26,931522 | 167,2505763 | AU FOND | Drague au fond 2200m filés, 1200m de la cible |
| 25/05/2015 | 00:40:00 | -26,930656 | 167,2547678 | CROCHE | Croche 7T, 2140m filés, 1677m de cible |
| 25/05/2015 | 00:47:00 | -26,930148 | 167,2573098 | DEBUT VIRAGE | Début de virage, 2108m filés |
| 25/05/2015 | 00:59:00 | -26,929585 | 167,2619908 | DRAGUE DECOLLEE | Drague décollée, 1350m filés |
| 25/05/2015 | 01:44:00 | -26,932721 | 167,2743875 | A BORD | DR_002 à bord |

**Approx. weight:** 35 kg
**Main rock types:** Weakly indurated and burrowed foram ooze
**Other rock types:**
**Dredging notes:** A few dozen pieces of soft material. Unlikely that Paleogene basement was sampled.


DR02

DR02A




DR02B


DR02C

**DR02A:** Very pale orange (10YR8/2) soft, weakly indurated, stiff to crumbly, burrowed foram ooze/ limestone. Fossils identified in washed, sieved and oven-dried separate include forams *Globigerina*, *Globigerinoides*, *Orbulina* and *Globorotalia* species. Care was taken to prepare foram samples from ooze/limestone matrix only (i.e. uncontaminated by obvious burrows and discoloration spots). Possibly of Late Neogene age (to be refined with closer examination of the foram fauna).
*Subsamples at GNS Wellington, SGNC Nouméa*

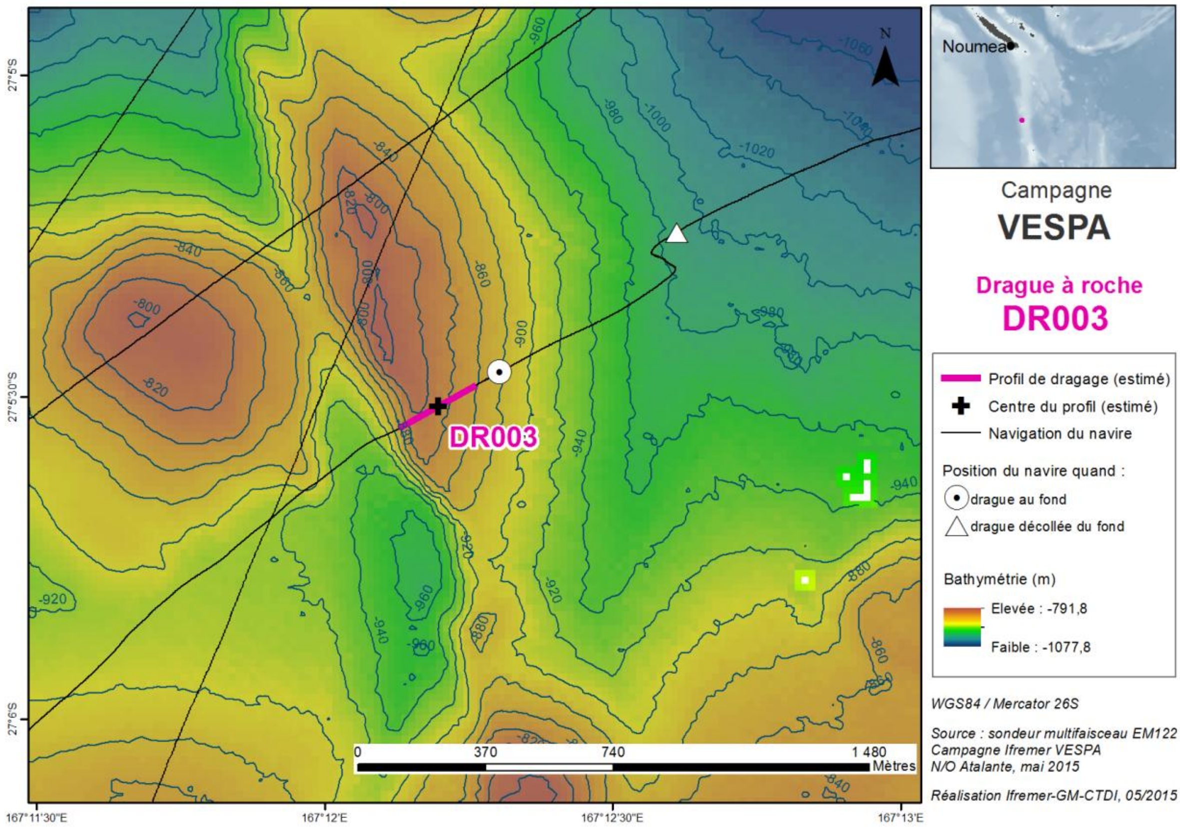
**DR02B:** Brownish coloured infillings of a large worm burrow (a live worm was retrieved from its burrow and preserved in alcohol) was sampled as a proxy for the present day sea floor sediment. From washed, sieved, oven-dried 250 and 125 micron separates this fauna appear to be more diverse than the fossil fauna in DR02A.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR02C:** Two worms were recovered from DR2B and preserved in alcohol. One was a large worm c. 10 cm long, within a white membrane sac, ruptured in places to reveal parts of the worm sporting short stout setae. The other was a very long thin red worm. Burrows of both of these species were conspicuous in blocks (see photos).
*Samples at IRD Nouméa*

**DR02D:** seafloor sediment pipe sample
*Subsample at GNS Wellington*

# *DR03*

**Target:** Norfolk Ridge area. Large round gravity anomaly on west side of Norfolk Ridge, presumed to be a volcano. Based on the multibeam survey, a down-to-the-west fault scarp in the vicinity of some small cones was dredged.

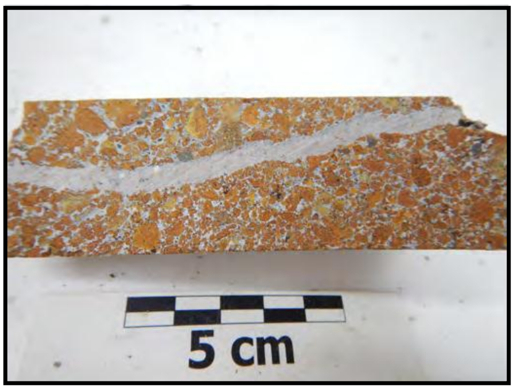



| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 25/05/2015 | 07:13:12 | -27,099422 | 167,1925216 | MISE A L'EAU | Mise à l'eau DR_003, 820m de la cible |
| 25/05/2015 | 07:23:24 | -27,096515 | 167,1959245 | DEBUT DE FILAGE | Début de filage DR_003, 435m de la cible |
| 25/05/2015 | 07:48:18 | -27,091017 | 167,2050526 | AU FOND | Drague au fond, 912m filés |
| 25/05/2015 | 07:58:01 | -27,089000 | 167,2092665 | CROCHE | Croche 1220m filés, 1170m de cible |
| 25/05/2015 | 08:02:27 | -27,088123 | 167,2098449 | DEBUT VIRAGE | Début de virage, 1198m de la cible |
| 25/05/2015 | 08:06:00 | -27,087511 | 167,2099818 | CROCHE | Croche (22T), 1147m filés, 1279m de cible |
| 25/05/2015 | 08:06:30 | -27,087397 | 167,2101777 | DRAGUE DECOLLEE | Chute de la tension (2T), 1122m filés, 1339m de la cible |
| 25/05/2015 | 08:47:00 | -27,080180 | 167,2281818 | A BORD | DR_003 à bord |

**Approx. weight:** 60 kg
**Main rock types:** Volcaniclastic breccia
**Other rock types:** Limestone, some fresher lava clasts
**Dredging notes:**

DR03


DR03A




DR03A


DR03A


DR03B


DR03C

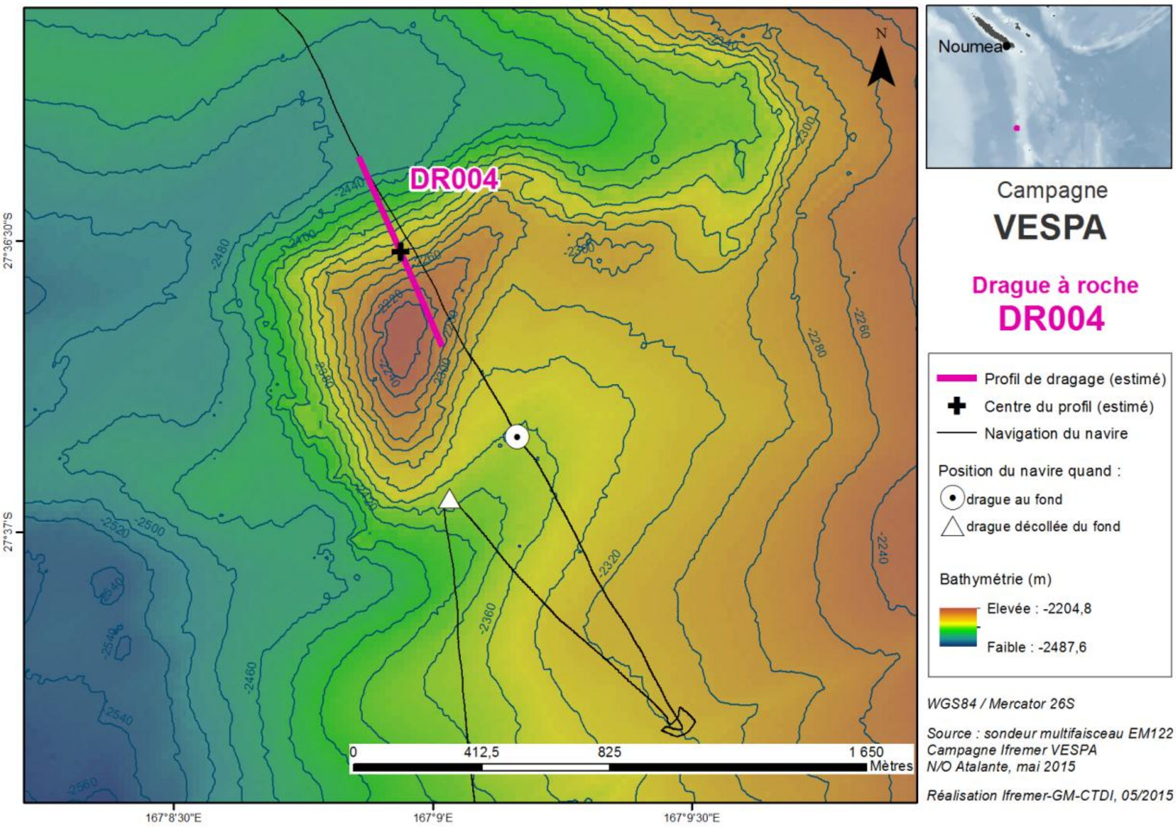
**DR03A:** Less than 20 pieces of hard, light brown (5YR5/6) weakly bedded volcanic breccia with sparse small clasts of relatively fresh basalt. Covered with a thin Mn crust and some encrusting fauna, in particular corals and sponges.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR03B:** One piece of limestone. Attached to one broken angular block of the breccia. A bioclast-bearing micrite interpreted to be a fissure-fill accumulation. Thin (<4mm) micritic limestone 'veins' are present in several other pieces of volcanic breccia. Obvious molluscan (bivalve and gastropod) shells, with echinoderm elements, coral fragments and possible brachiopod shell too. There is potential for microfossils and in particular nannofossils and forams. Possible Paleogene age? A refined age is possible with closer investigation of the fossils.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR03C:** Modern fauna attached to samples. Includes pelagic gastropods: *Cavolinia gibbosa*, *Diacria costata*, *Clio pyramidata lanceolata*, *Limacina leseuri.*
*Samples at IRD Nouméa*

# *DR04*

**Target:** Norfolk Ridge area. TECTA seismic reflector exposed on south side of incised erosional submarine canyon on west side of Norfolk Ridge.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 25/05/2015 | 13:41:24 | -27,5907782 | 167,1381125 | MISE A L'EAU | Mise à l'eau DR_004, 1120m de la cible |
| 25/05/2015 | 13:52:31 | -27,5947213 | 167,140552 | DEBUT DE FILAGE | Début de filage DR_004, 1490m de la cible |
| 25/05/2015 | 14:43:06 | -27,6139407 | 167,1527204 | AU FOND | Drague au fond, 2797m filés, 895m de la cible |
| 25/05/2015 | 14:50:17 | -27,6165759 | 167,1544816 | CROCHE | Croche 5.2T, 2965m filés, 1263m de la cible |
| 25/05/2015 | 14:52:00 | -27,6171393 | 167,1548075 | CROCHE | Croche 6.1T, 1283 m de la cible, 2968m filés |
| 25/05/2015 | 14:53:00 | -27,6175018 | 167,1550011 | DEBUT VIRAGE | 1320m de la cible, 2965m filés |
| 25/05/2015 | 15:01:00 | -27,6201277 | 167,1567402 | CROCHE | Croche 16T. 2800 m filés, 1700 m de la cible |
| 25/05/2015 | 15:46:00 | -27,6157063 | 167,1505387 | DRAGUE DECOLLEE | Drague décollée, 2300m filés, 920m de la cible |
| 25/05/2015 | 17:05:00 | -27,6480992 | 167,1509598 | A BORD | DR_004 à bord |
| | | | | | |

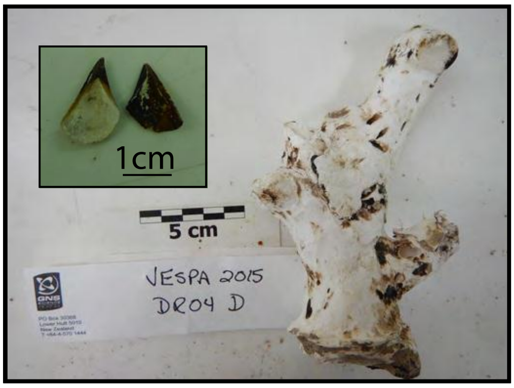
**Approx. weight:** 100 kg
**Main rock types:** Soft ashy mudstone, Mn crusts, olivine basalt
**Other rock types:** Altered olivine basalt, coral pieces
**Dredging notes:** Dredge got stuck on bottom for an hour; pulls of up to 20 tonnes recorded.


DR04


DR04A


DR04B


DR04C




DR04D


DR04E


DR04F


DR04G

**DR04A:** About 60% of dredge comprised a few dozen 20-30 cm cobbles and one boulder 40x30x30cm of a soft, ashy, yellowish grey (5Y 7/2) sandy mudstone. Sand grains were orange sideromelane glass; and variably altered lava. Some forams were visible in matrix (sample was very weakly effervescent). No bedding visible but samples were intensely bioturbated. Based on white colour, the mud content probably was collapsed pumice rather than being epiclastic. Black hornblende was seen in the 125-250 micron sieve separate. This could potentially be Ar-Ar dated. The crushed, washed, sieved and oven-dried separate revealed vast majority of forams to be small, between 125 and 250 microns. Low faunal diversity, dominated by *Globigerina*, *Globigerinoides*, and *Globorotalia*.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR04B:** Half a dozen thickly-Mn coated corestones, up to 15cm across. Rock type in the cores was a hard, brownish grey (5YR 4/1) olivine porphyritic basalt. Olivine phenocrysts (replaced by red clay) were up to 2mm in size and comprise up to 10% of the rock. Lavas also had c. 5% amygdules/vesicles. Amygdules and cracks were infilled by a white microcrystalline ?silica or ?zeolite mineral (not carbonate or phosphate). XRF analysis showed the lava to be an intraplate basalt with high Nb.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR04C:** About 35% of dredge was cobble-sized slabs of Mn crust. Some were attached to volcanic substrate (DR04B) but most were individually plucked samples. Some botryoidal structures on exterior surfaces and some internal layering observed. Maximum thickness of crusts was c. 6 cm.
*Subsamples at IFREMER Brest, SGNC Nouméa*.

**DR04D:** Ten pieces of assorted dead biological material. Pieces of coral and two well-preserved barnacle plates.
*Subsamples at IFREMER Nouméa*.

**DR04E:** One sawn 15x10x8cm piece. Soft, bioturbated mudstone very similar to DR04A but contained a microbed of multicoloured, granule-size, altered vitric clasts.
*Subsample at SGNC Nouméa*.

**DR04F:** One sawn 12x8x6cm piece. Similar to DR04E but contained one large angular altered basalt clast, c. 5cm in size.
*Subsample at SGNC Nouméa*.

**DR04G:** seafloor sediment pipe sample.
*Subsample at GNS Wellington*

## *DR05*

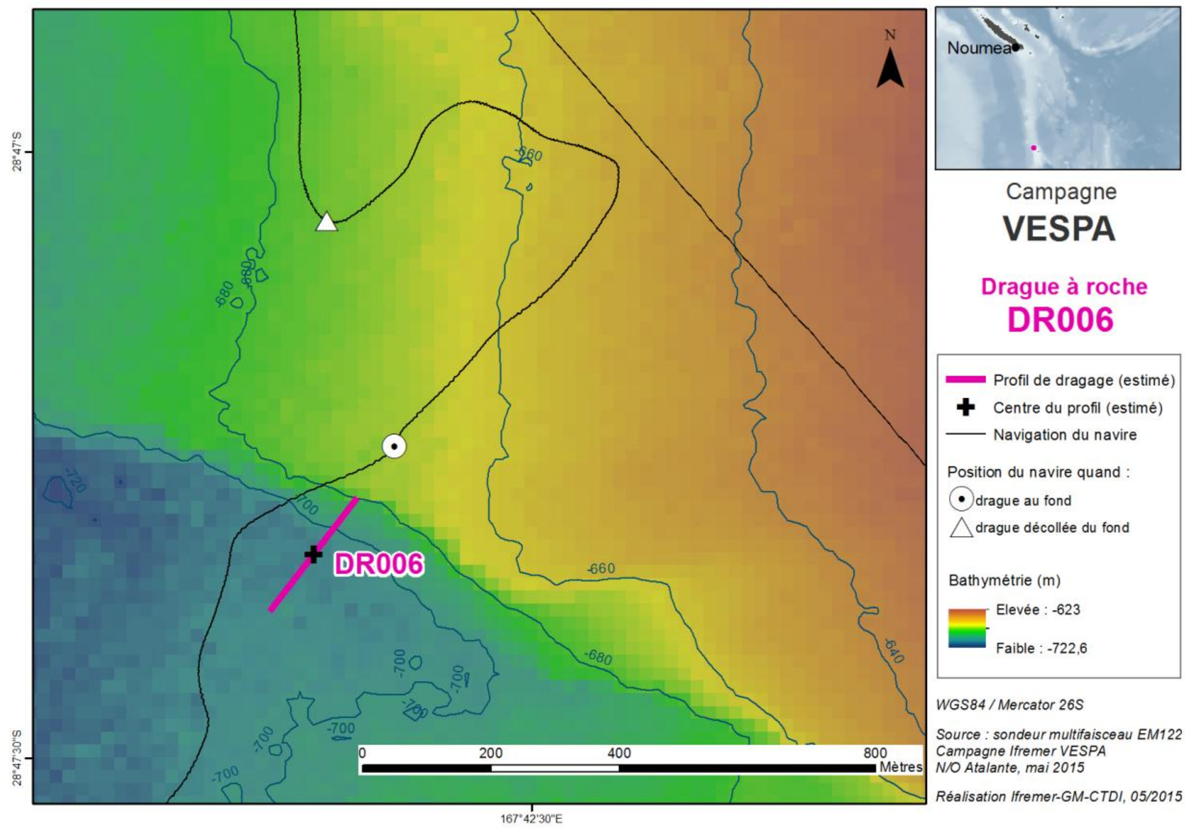
**Target:** Norfolk Ridge area. North lower flank of volcano, W side of Norfolk Ridge near 28°S.

| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 26/05/2015 | 02:55:18 | -28,285543 | 167,2362977 | MISE A L'EAU | Mise à l'eau DR_005, 1318m de la cible |
| 26/05/2015 | 03:06:00 | -28,289826 | 167,2372391 | DEBUT DE FILAGE | Début de filage DR_005, 945m de la cible |
| 26/05/2015 | 03:44:00 | -28,304908 | 167,2408488 | AU FOND | 2060 m filés, 805 m de la cible. |
| 26/05/2015 | 03:54:06 | -28,308646 | 167,2417028 | CROCHE | Croche 6.4T, 2230m filés, 1215m de cible |
| 26/05/2015 | 04:01:01 | -28,310899 | 167,2421557 | CROCHE | Croche 15.5T, 2202m filés, 1460m de cible |
| 26/05/2015 | 04:01:31 | -28,311034 | 167,2421797 | DEBUT VIRAGE | 2202 m filée, 1460m de la cible. |
| 26/05/2015 | 04:02:00 | -28,311201 | 167,2422104 | DRAGUE DECOLLEE | Drague décollée, 2202m filés, 1460m de la cible |
| 26/05/2015 | 05:02:27 | -28,337194 | 167,2474133 | INCIDENT | **Drague perdue** |

**Weight:** 0 kg.
**Main rock types:** none
**Other rock types:**
**Dredging notes:** Main cable was severed about 150 m above the dredge. Dredge and pipe dredge were lost.

## *DR06*

**Target:** Norfolk Ridge area. TECTA seismic horizon on the NW side of the Norfolk Island platform. Given proximity to Norfolk Island (a Pliocene volcano), volcanic/volcaniclastic rocks were expected too.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 26/05/2015 | 10:24:00 | -28,798239 | 167,6958903 | MISE A L'EAU | Mise à l'eau DR_ 006, 1163m de la cible |
| 26/05/2015 | 10:34:38 | -28,794682 | 167,6989635 | DEBUT DE FILAGE | Début de filage DR_006, 691m de la cible |
| 26/05/2015 | 10:54:33 | -28,787377 | 167,7062012 | AU FOND | Drague au fond, 770m filés, 383m de la cible |
| 26/05/2015 | 11:03:26 | -28,784869 | 167,7089663 | CROCHE | Croche 3T, 770m de la cible, 770m filés |
| 26/05/2015 | 11:05:39 | -28,784132 | 167,7095418 | CROCHE | Croche 5,5T à 814m de cible |
| 26/05/2015 | 11:06:15 | -28,783965 | 167,7096448 | CROCHE | Croche 19T à 896 m de cible |
| 26/05/2015 | 11:06:18 | -28,783965 | 167,7096448 | CROCHE | Croche 12T à 900m de cible |
| 26/05/2015 | 11:07:22 | -28,783580 | 167,7096803 | CROCHE | Croche 12T à 930m de cible |
| 26/05/2015 | 11:10:50 | -28,783215 | 167,7088952 | CROCHE | Croche 12T à 900m de cible |
| 26/05/2015 | 11:14:04 | -28,782939 | 167,7082267 | CROCHE | Croche 7T à 905m de cible, 920m filés |
| 26/05/2015 | 11:20:51 | -28,782929 | 167,706757 | DEBUT VIRAGE | Début de virage 900m filés, 855m de la cible |
| 26/05/2015 | 11:29:54 | -28,784280 | 167,7051465 | DRAGUE DECOLLEE | Drague décollée, 734m filés, 663m de la cible |
| 26/05/2015 | 11:49:29 | -28,778401 | 167,7041418 | A BORD | DR_006 à bord |

**Approx. weight:** 30 kg
**Main rock types:** Coarse grained volcanic litharenite with calcareous cement.
**Other rock types:** White bioclastic limestone (packstone).
**Dredging notes:**

DR06

DR06A

DR06B

DR06C

DR06D

**DR06A:** 25x25x10cm piece (the largest in the dredge) of dark yellowish brown 10YR 4/2. Coarse grained volcanic litharenite moderately sorted with subangular lithic clasts. Lithic clasts are mafic lava with crystals of ex-olivine, amphibole and pyroxene. The cement is calcareous. Bioturbation could be present and a weak bedding (grain size change) is visible in one sample.
*Subsamples at GNS Wellington, SGNC Nouméa*

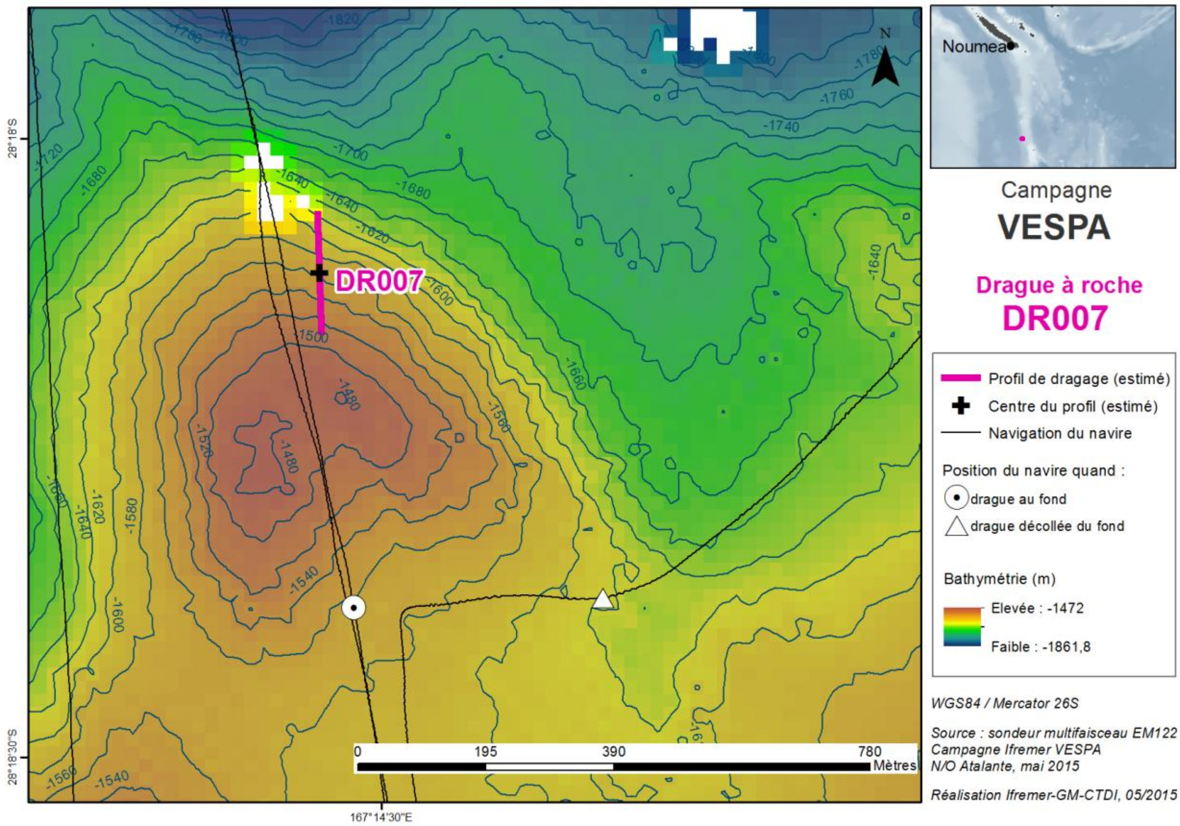
**DR06B:** Same lithology as DR06A but with a finer graded fine to medium sandstone. A cream coloured micritic limestone is attached to one of the DR06B pieces (different from DR06C).
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR06C:** Several small pieces of white (N9) bioclastic limestone (packstone) contains molluscan (bivalve and gastropod) debris, coral debris and algal balls; several conspicuous and well-preserved bivalve fossils are present, including one double-valved and articulated (to be identified). There may be some forams preserved. This limestone is interpreted as a very shallow (<40 m water depth) shell coquina associated with a reef environment. A sample was prepared for forams: gently crushed in a mortar and pestle, washed, sieved and oven-dried. Separates were made using 250 and 125 micron sieves. Only a very few forams were observed, if any. Interpreted age is Neogene. A more refined age should be possible with closer fossil analysis.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR06D:** seafloor sediment pipe sample. Coarser fragments of corals and shells were picked out and stored separately.
*Subsample at GNS Wellington*

# *DR07*

**Target :** Norfolk Ridge area. North lower flank of volcano, W side of Norfolk Ridge near 28°S (repeat of DR7).



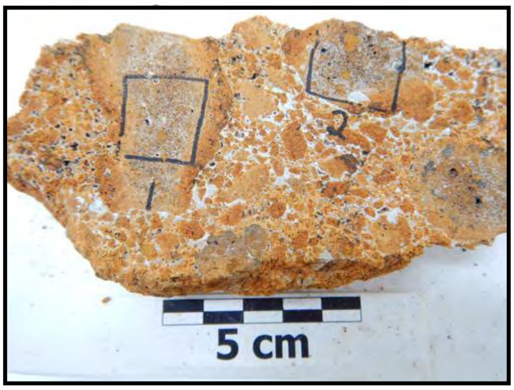

| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 26/05/2015 | 17:49:15 | -28,284324 | 167,2354304 | MISE A L'EAU | Mise à l'eau DR_007 |
| 26/05/2015 | 18:01:50 | -28,289678 | 167,2371018 | DEBUT DE FILAGE | Début de filage DR_007, 1005m de la cible |
| 26/05/2015 | 18:45:09 | -28,306317 | 167,2412439 | AU FOND | Drague au fond, 1780m filés, 933m de la cible |
| 26/05/2015 | 18:53:52 | -28,309886 | 167,2418408 | DEBUT VIRAGE | Début de virage, 1950m filés, 1296m de la cible |
| 26/05/2015 | 18:55:14 | -28,310271 | 167,2419071 | CROCHE | Croche 7T, 1920m filés, 1379m de la cible |
| 26/05/2015 | 19:14:11 | -28,309721 | 167,242241 | CROCHE | Croche 18T, 1706m filés, 1246m de la cible |
| 26/05/2015 | 19:33:14 | -28,306180 | 167,2450329 | DRAGUE DECOLLEE | Drague décollée, 1604m filés, 974m de la cible |
| 26/05/2015 | 20:16:29 | -28,291330 | 167,2562212 | A BORD | DR_007 à bord |

**Approx. weight:** 100 kg
**Main rock types:** Volcaniclastic breccia with olivine-rich basaltic clasts.
**Other rock types:** None
**Dredging notes:** Stuck for 30 mins. Pulls of up to 14 tonnes. Pipe dredge/sediment tube was empty.


DR07

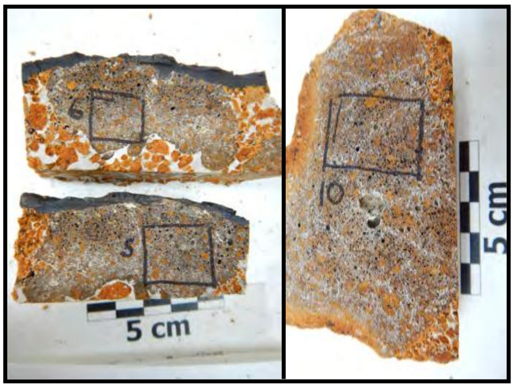

DR07A


DR07B




DR07B


DR07B




DR07C


DR07C, basaltic clasts surrounded by Mn-crust


DR07D

**DR07A:** About 20 pieces, 20kg total weight, of Mn-crust up to 4cm thick.
*Subsample at IFREMER Brest.*

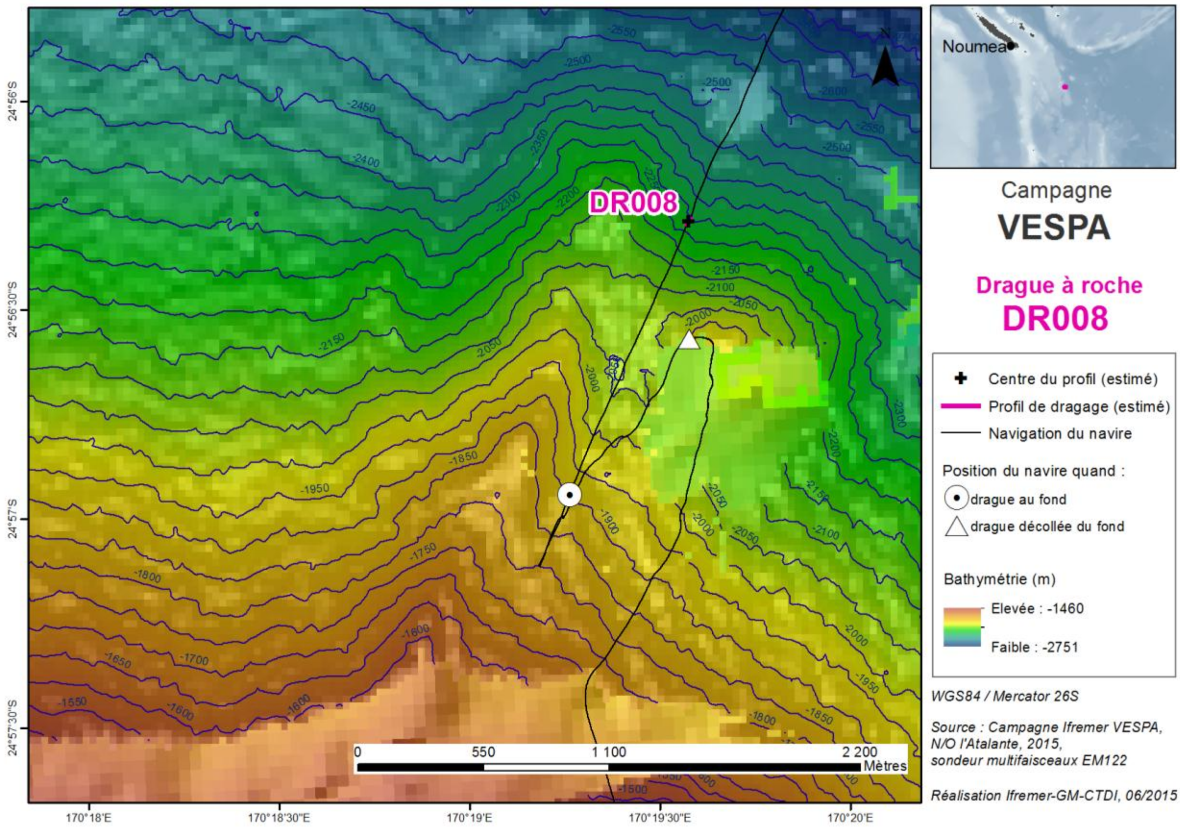
**DR07B:** Two very large (50x50x40cm), one medium (30x30x20cm), and four smaller (20x15x15cm) rocks in dredge. Intensively altered light brown (5 YR 5/6) volcaniclastic breccia with medium to large olivine (?) basaltic clasts.Typical size of clasts 1cm. Olivine replaced by orange clay minerals.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR07C:** One very large (50x40x40cm) piece cut down to 4 subsamples (from 2 to 9cm). Medium to fine grained volcaniclastic breccia similar to DR07B except parts of the sample are finer grained. In the fine grained area are basaltic clasts that are significantly larger than clasts in DR07B (up to 7cm across). Some portions of this sample also contain less altered olivine basalt clasts (pale brown 5 YR 5/2). Individual basalt clasts numbered DR07Ci, ii, iii and iv. Some other basalt pieces are located within a Mn-crust up to 6cm in size.
*Subsamples at IUEM Brest, GNS Wellington*

**DR07D:** Three living brachiopods (one of which was crushed) found on Mn-crust attached by their pedicles. Identified as a species of *Amphithyris*.
*Samples at IFREMER Nouméa*

## *DR08*

**Target:** Loyalty Ridge area. Small volcanic or structural ridge on north side of guyot volcano just north of 25°S, eastern Loyalty Ridge.

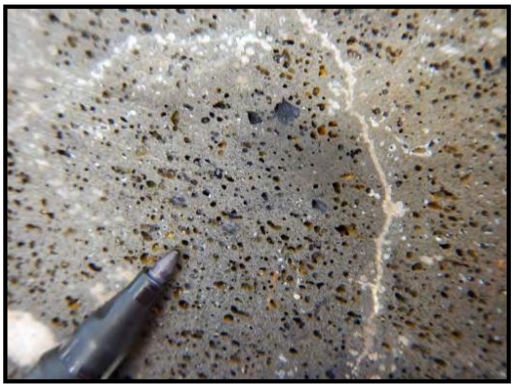



| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 02/06/2015 | 15:07:18 | -24,915665 | 170,3374672 | MISE A L'EAU | Mise à l'eau DR_008, 2334m de la cible |
| 02/06/2015 | 15:18:00 | -24,918820 | 170,3359523 | DEBUT DE FILAGE | Début de filage DR_008, 1954m de la cible |
| 02/06/2015 | 16:38:00 | -24,949036 | 170,321039 | AU FOND | Drague au fond, 1720m de la cible |
| 02/06/2015 | 16:38:46 | -24,949380 | 170,3208896 | CROCHE | Croche à 6.5T, 2684m filés, 1720m de cible |
| 02/06/2015 | 16:46:01 | -24,951858 | 170,3196926 | CROCHE | Croche à 17T, 2750m filés, 2020m de cible |
| 02/06/2015 | 16:47:46 | -24,951821 | 170,3197577 | DEBUT VIRAGE | Début de virage |
| 02/06/2015 | 17:30:00 | -24,942814 | 170,3262707 | DRAGUE DECOLLEE | Drague décollée, 2212m filés, 1650m de la cible |
| 02/06/2015 | 18:33:00 | -24,952085 | 170,3248764 | A BORD | DR_008 à bord |

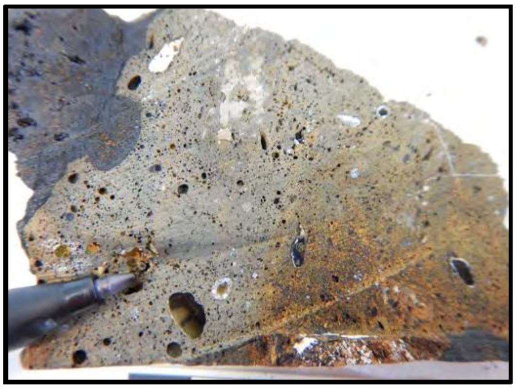
**Approx. weight:** 15 kg
**Main rock types:** Aphyric basalt
**Other rock types:** Hard breccia-conglomerate with limestone matrix
**Dredging notes:**


DR08


DR08A



DR08A



DR08Ai


DR08B


DR08B


DR08B with limestone


DR08C

**DR08A:** Three 20x10x15 cm pieces in dredge of hard, medium light grey (N6) moderately vesicular, aphyric, fine grained lava. Has Mn crust. Is relatively fresh compared to previous dredge. Vesicles are small (round to elongate). Some flow banding evident. Alteration filled vesicles not reactive. Clast observed in lava was analysed by pXRF and catalogued as separate piece (**DR08Ai**)
*Subsamples to IUEM Brest, GNS Wellington, SGNC Nouméa.*

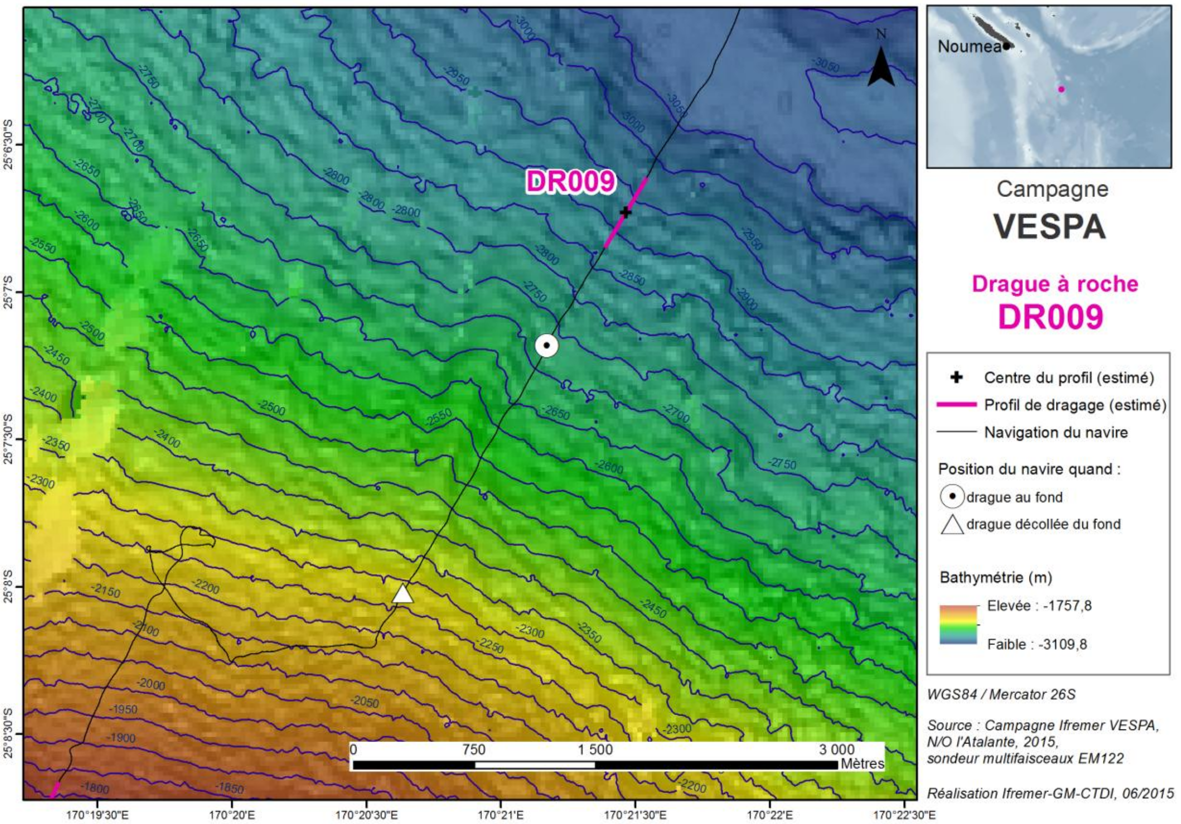
**DR08B:** Breccia-conglomerate of basaltic clasts possibly two types - dark reddish grey (5 YR 3/2) aphyric very weathered and the other medium grey (N5) which looks like lava DR08A. Clasts are angular and vary in size from 0.5-4 cm in diameter. Some clasts have Mn coating inside amygdales. Conglomerate matrix comprises two types of carbonate: one (dominant) a moderately hard sandy limestone with small lava clasts and echinoderm fragments, the other (minor) a very hard, cleaner micrite with visible forams.
*Subsamples to GNS Wellington, SGNC Nouméa.*

**DR08C**: Mn-crust up to 6 cm thick with very minor amount of lava attached
*Subsamples to IFREMER Brest*

**DR08D:** Seafloor sediment pipe sample: sand, foram ooze with bits of broken Mn crust
*Subsample to GNS Wellington*

# *DR09*

**Target:** Loyalty Ridge area. Bottom part of volcano just south of 25°S on eastern Loyalty Ridge. Above South Fiji Basin abyssal plain.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 02/06/2015 | 19:52:00 | -25,097119 | 170,3668172 | MISE A L'EAU | Mise à l'eau DR_009, 1670m de la cible |
| 02/06/2015 | 20:00:00 | -25,099908 | 170,3650873 | DEBUT DE FILAGE | Début de filage DR_009e, 1270m de la cible |
| 02/06/2015 | 20:56:07 | -25,119673 | 170,3528528 | AU FOND | Drague au fond, 1060m de la cible. |
| 02/06/2015 | 21:07:00 | -25,123780 | 170,3500931 | DEBUT VIRAGE | Début de virage, 1625m de la fin du profil. |
| 02/06/2015 | 21:07:00 | -25,123780 | 170,3500931 | CROCHE | Croche 7 T, 3322m filés et 1627.9m de la cible. |
| 02/06/2015 | 21:07:04 | -25,123780 | 170,3500931 | CROCHE | Croche 7T, 3322m filés, 1628m de cible |
| 02/06/2015 | 21:39:00 | -25,133655 | 170,3439122 | DRAGUE DECOLLEE | Drague décollé, 1116.8m de la fin du profil |
| 02/06/2015 | 22:56:28 | -25,135005 | 170,3305862 | A BORD | DR_009 à bord |

**Approx weight:** Main dredge 0 kg, c. 200g in pipe dredge
**Main rock types:** None
**Other rock types:** None
**Dredging notes:** Main dredge empty

DR09, sediments in pipe dredge

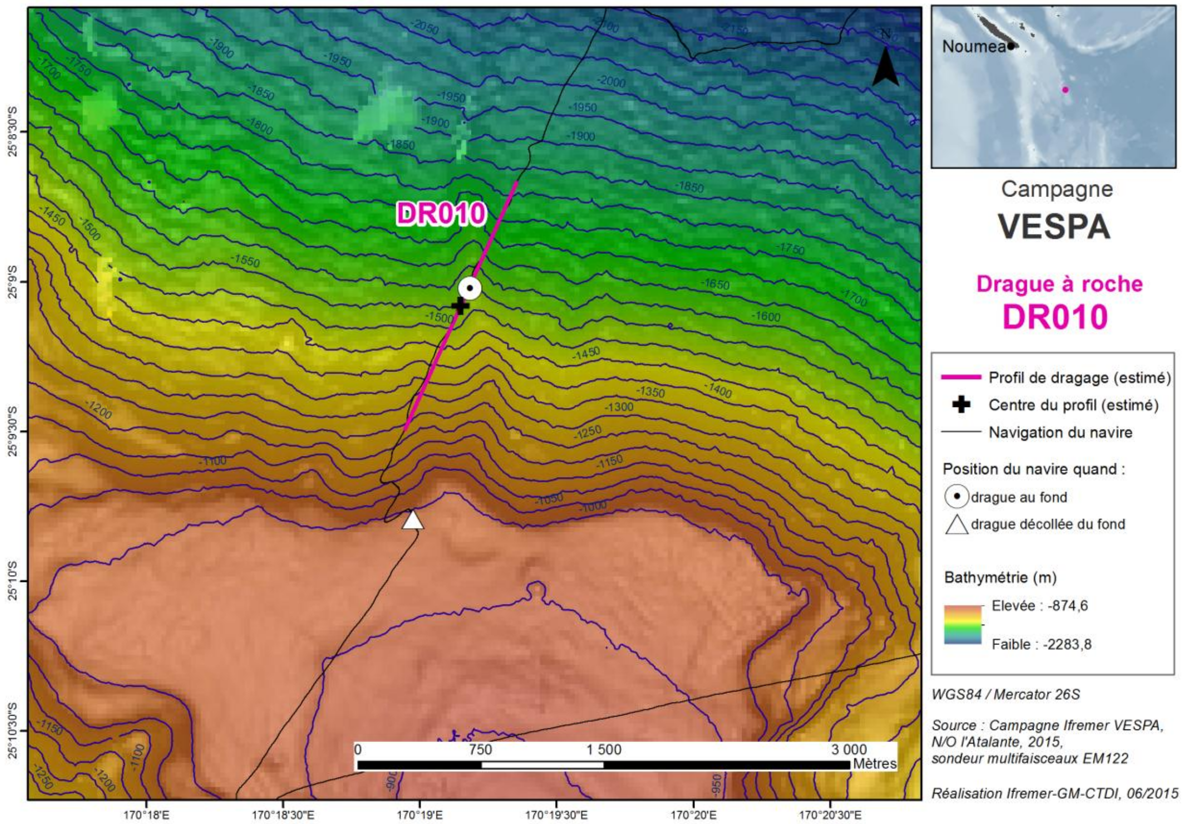

DR09, coarser fractions after sieving


DR09, all fractions after sieving

**DR09A:** Seafloor sediment pipe sample.
*Subsample to GNS Wellington*

# *DR10*

**Target:** Loyalty Ridge area. Top part of volcano just south of 25°S on eastern Loyalty Ridge. Above South Fiji Basin abyssal plain.

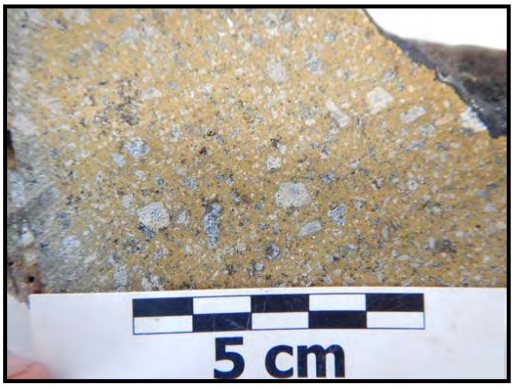



| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 03/06/2015 | 00:00:27 | -25,134215 | 170,3282281 | MISE A L'EAU | Mise à l'eau DR_010, 1302m de la cible |
| 03/06/2015 | 00:08:27 | -25,137515 | 170,3266282 | DEBUT DE FILAGE | Début de filage DR_010, 974.2m de la cible. |
| 03/06/2015 | 00:49:00 | -25,150352 | 170,3197333 | AU FOND | Drague au fond, 1996m filés, 637m de la cible |
| 03/06/2015 | 01:02:00 | -25,154866 | 170,3171923 | CROCHE | Croche 6,9 T, 2181 m filés, 1200 m de la cible |
| 03/06/2015 | 01:03:00 | -25,155156 | 170,3171118 | DEBUT VIRAGE | Début de virage, 2181m filés, 1235m de la cible |
| 03/06/2015 | 01:08:00 | -25,157053 | 170,316003 | CROCHE | Croche 5,8 T, 2085 m filés, 1400 m de la cible |
| 03/06/2015 | 01:10:00 | -25,157772 | 170,3158847 | CROCHE | Croche 6,2 T, 2068 m filés, 1550 m de la cible |
| 03/06/2015 | 01:11:00 | -25,158144 | 170,3157884 | CROCHE | Croche 6,6 T, 2049 m filés, 1590 m de la cible |
| 03/06/2015 | 01:12:00 | -25,158561 | 170,3155566 | CROCHE | Croche 11 T, 2030 m filés, 1650 m de la cible |
| 03/06/2015 | 01:14:00 | -25,159345 | 170,3150515 | CROCHE | Croche 11,4 T, 1998 m filés, 1745 m de la cible |
| 03/06/2015 | 01:32:00 | -25,162695 | 170,314758 | CROCHE | croche 9,5 T, 1564 m filés, 2109 m de la cible |
| 03/06/2015 | 01:34:00 | -25,163134 | 170,3145469 | CROCHE | Croche 8 T, 1500 m filés, 2134 m de la cible |
| 03/06/2015 | 01:35:00 | -25,163285 | 170,314521 | CROCHE | Croche 6 T, 1490 m filés, 2146 m de la cible |
| 03/06/2015 | 01:36:00 | -25,163357 | 170,3145749 | CROCHE | Croche 8,8 T, 1471 m filés, 2146 m de la cible |
| 03/06/2015 | 01:37:00 | -25,163330 | 170,3147418 | CROCHE | Croche 13 T, 1450 m filés, 2137 m de la cible |
| 03/06/2015 | 01:39:00 | -25,163020 | 170,3153324 | CROCHE | Croche 7 T, 1379 m filés, 2070 m de la cible |
| 03/06/2015 | 01:39:01 | -25,163020 | 170,3153324 | CROCHE | Croche 12 T, 1358 m filés, 2052 m de la cible |
| 03/06/2015 | 01:41:00 | -25,162682 | 170,3158729 | CROCHE | Croche 16 T, 1288 m filés, 2026 m de la cible |

**Approx. weight:** 100 kg
**Main rock types:** andesite
**Other rock types:**

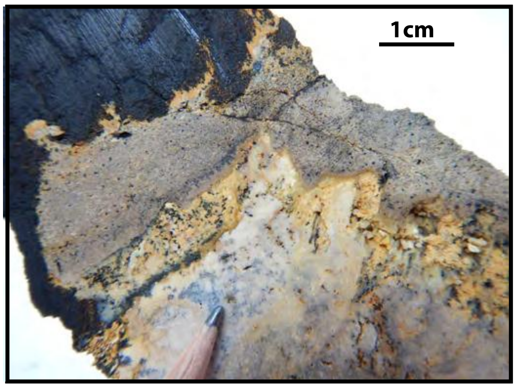
**Dredging notes:**

DR010



DR010A


DR010A

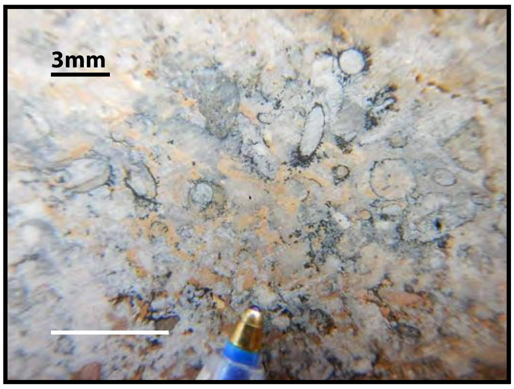


DR010B volcanic ashes and pumices

DR010B limestone, ashes and pumices

DR010B

DR010B layered volcanic ashes



DR010D

**DR10A:** 100x30x30cm piece retained of hard, fresh, medium gray (N5) (but has weathered rind of up to 10cm thick dusky yellow (5Y9/4)) nonvesicular porphyritic andesite. Up to 20% phenocrysts of alkali feldspar, pyroxene, olivine (microphenocrysts) and possibly biotite. Phenocrysts mostly 1-3 mm in size. Possibly a shoshonite. Sample has a 5 mm thick Mn crust.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR10B:** pieces of very orange pale (10YR 8/2) to pinkish gray (5YR8/1) partly ?silicified limestone with pumice fragments, intergrown with Mn crust across distances up to 5 cm. Fossils identified include echinoderm plates (single calcite crystals), forams, brachiopods. 3cm Mn crust.
*Subsamples at GNS Wellington, SGNC Nouméa*

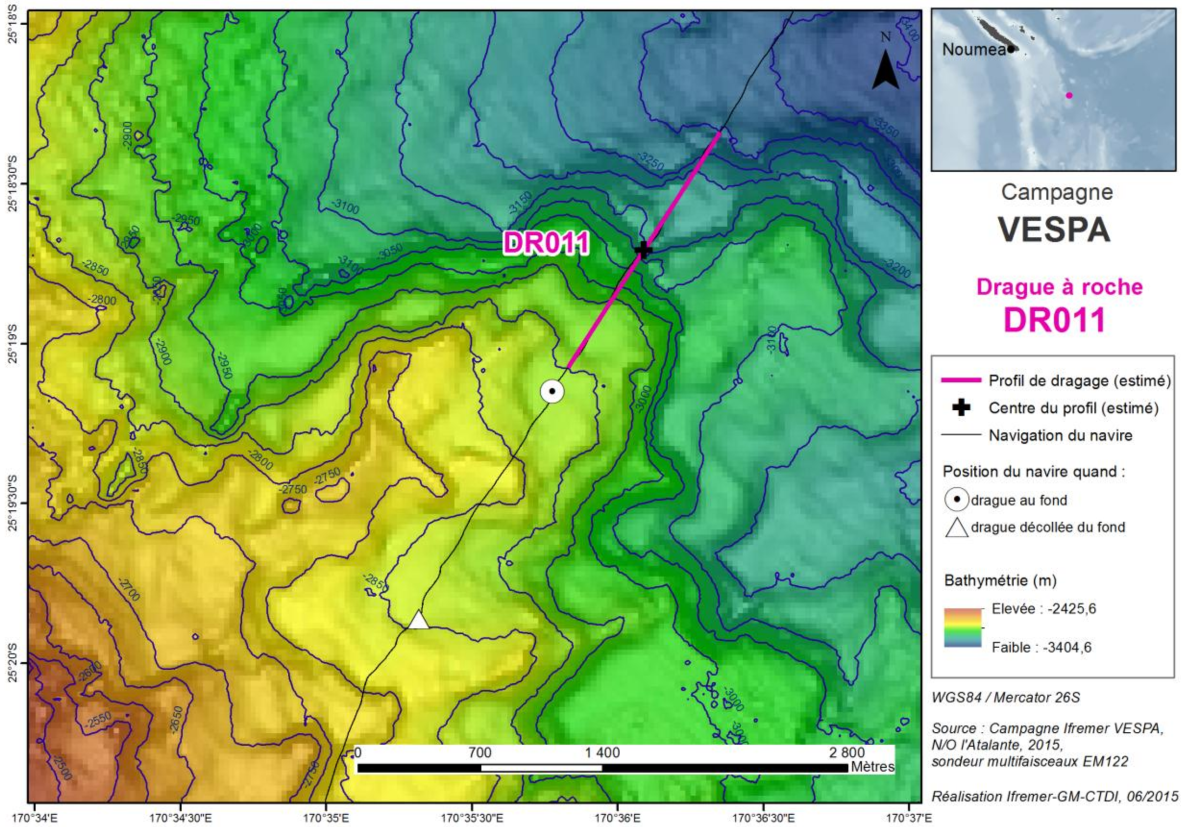
**DR10C:** Mn crust with small amount of limestone attached, contact may be bored**.**
*Subsamples at IFREMER Brest, SGNC Noumea*

**DR10D:** Silicified limetone hardground; intensely modified by worm tubes, other encrusting shelly fauna such as corals
*Subsample at GNS Wellington*

**DR10E:** Seafloor sediment pipe sample.
*Subsample at GNS Wellington*

# *DR11*

**Target**: Loyalty Ridge area. Bottom part of volcano near 25.3°S on eastern Loyalty Ridge. Above South Fiji Basin abyssal plain.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 03/06/2015 | 14:33:00 | -25,294681 | 170,613691 | MISE A L'EAU | Mise à l'eau DR_011 |
| 03/06/2015 | 14:45:00 | -25,298737 | 170,6104819 | DEBUT DE FILAGE | Début de filage DR_011 |
| 03/06/2015 | 15:46:00 | -25,319139 | 170,5962822 | AU FOND | Drague au fond, 3576 m filés, 1531 m de la cible |
| 03/06/2015 | 15:57:00 | -25,322831 | 170,5938486 | CROCHE | Croche de 7 T, 3698 m filés, 2019 m de la cible |
| 03/06/2015 | 15:58:00 | -25,323208 | 170,593555 | CROCHE | Croche de 8 T, 3698 m filés, 2019 m de la cible |
| 03/06/2015 | 16:02:00 | -25,324587 | 170,5924722 | DEBUT VIRAGE | Début de virage, 3698 m filés, 2239 m de la cible |
| 03/06/2015 | 16:06:00 | -25,325877 | 170,5915334 | CROCHE | Croche de 7,2 T, 3602 m filés, 2408 m de la cible |
| 03/06/2015 | 16:07:00 | -25,326182 | 170,5913605 | CROCHE | Croche de 10 T, 3580 m filés, ~2408 m de la cible |
| 03/06/2015 | 16:08:00 | -25,326453 | 170,5912143 | CROCHE | Croche de 13 T, 3566 m filés, 2485 m de la cible |
| 03/06/2015 | 16:12:00 | -25,327648 | 170,5904633 | CROCHE | Croche de 9 T, 3478 m filés, 2660 m de la cible |
| 03/06/2015 | 16:27:00 | -25,331022 | 170,5886236 | DRAGUE DECOLLEE | Drague decolée, 3000 m filés, 3174 m de la cible |
| 03/06/2015 | 17:40:00 | -25,347872 | 170,5803432 | A BORD | DR_011 à bord |

**Approx. weight:** 20 kg
**Main rock types:** Bioturbated siltstone
**Other rock types:** Limestone cemented breccia-conglomerate
**Dredging notes:**


DR011


DR011A


DR011B


DR011C


DR011D

**DR11A:** Four 20x15x10cm pieces of intensely bioturbated soft siltstone
*Subsample at IUEM Brest, GNS Wellington, SGNC Nouméa*

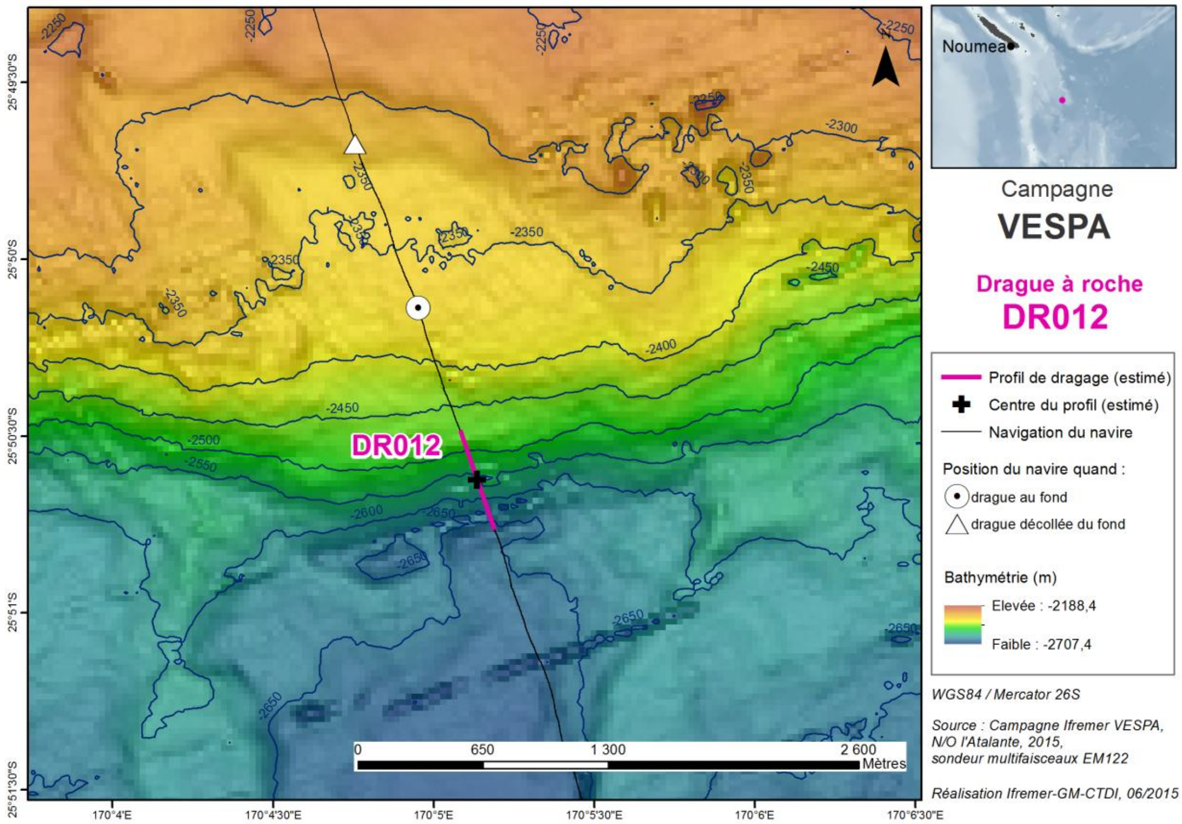
**DR11B:** Glob ooze with. Tube fossils, modern (colour: 10 YR 8/2). 3types of tube fossils:1°broad straight smooth sided tubes,approx. 1-2cm diameter. 2° thin (<1cm) smooth tube with manganese coated walls. 3° very fine (<3mm),"spidery" tubes that are light brownish colour
*Subsample at GNS Wellington*

**DR11C**: About 15-20 10x15x10cm pieces, and one 8x8x5cm piece of moderately phenocryst rich light grey ( N7) pumice.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR11D:** Seafloor sediment pipe sample. *Subsample at GNS Wellington*

# *DR12*

**Target:** Loyalty Ridge area. East-west fault scarp in southern South Loyalty Basin, a possible faulted anticline in older seismic unit




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 04/06/2015 | 02:53:00 | -25,862730 | 170,089652 | MISE A L'EAU | Mise à l'eau DR_012 |
| 04/06/2015 | 03:44:00 | -25,854865 | 170,0897205 | DEBUT DE FILAGE | Début de filage DR_012 à 50 m de cable |
| 04/06/2015 | 04:33:00 | -25,835621 | 170,0825358 | AU FOND | Drague au fond~, 2969 m filés, 1200 m de la cible |
| 04/06/2015 | 04:37:00 | -25,834061 | 170,0818259 | CROCHE | Croche de 4,8 T, 3150 m filés, ~1489 m de la cible |
| 04/06/2015 | 04:42:00 | -25,832192 | 170,0811163 | CROCHE | Croche de 6,5 T, 3150 m filés, 1613 m de la cible |
| 04/06/2015 | 04:42:30 | -25,831958 | 170,0810798 | CROCHE | Croche de 6,6 T, 3150 m filés, 1613 m de la cible |
| 04/06/2015 | 04:44:00 | -25,831401 | 170,0808878 | CROCHE | Croche de 7,6 T, 3150 m filés, 1678 m de la cible |
| 04/06/2015 | 04:48:00 | -25,830003 | 170,0802115 | DEBUT VIRAGE | 3150 m filés, 1850 m distance de la cible |
| 04/06/2015 | 04:49:00 | -25,829602 | 170,0799941 | CROCHE | Croche de 15 T, 3061 m filés, 1934 m de la cible |
| 04/06/2015 | 04:50:00 | -25,829272 | 170,0798142 | CROCHE | Croche de 10 T, 3043 m filés, 1956 m de la cible |
| 04/06/2015 | 04:53:59 | -25,827890 | 170,0792717 | CROCHE | Croche de 7 T, 2988 m filés, 2097 m de la cible |
| 04/06/2015 | 04:54:00 | -25,827890 | 170,0792717 | DRAGUE DECOLLEE | Drague decollée, 2991 m filés, 2111 m de la cible |
| 04/06/2015 | 06:20:00 | -25,811742 | 170,062349 | A BORD | DR_ 012 à bord |

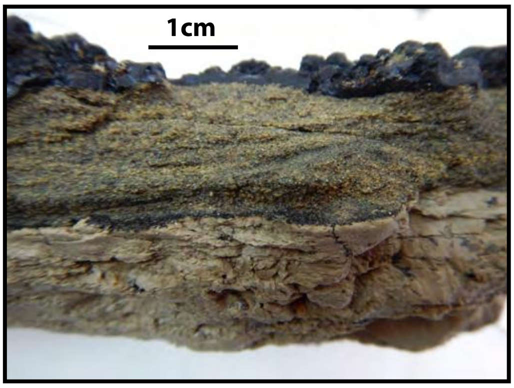
**Approx. weight:** 15 kg
**Main rock types:** mudstones
**Other rock types:** sandstone
**Dredging notes:**

DR012

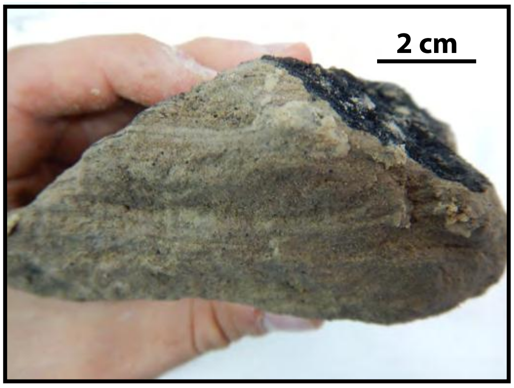

DR012A

DR012A

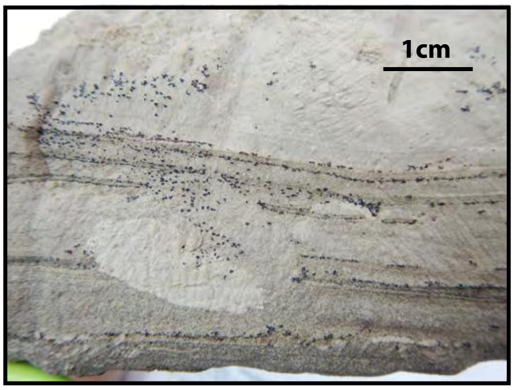
DR012B




DR012C




DR012D




DR012E


DR012F

**DR12A:** Nine 20x10x10cm pieces of granule conglomerate layer in soft but indurated, light olive grey (5Y5/2) mudstone. Coarse clasts are c. 5-15 mm subrounded moderately sorted pumice and assorted other volcanic lithologies. Sample has some additional sandy laminations seen. Resemble "jellystones" (collapsed gel-like pumice of recent origin) previously dredged on the Northland Plateau? Pumice glass may have converted to diagenetic opal?
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR12B:** Six 8x5x5cm pieces of fine to very fine weakly indurated softish, friable but indurated sandstone. Contains rounded, well sorted grains of volcanic lithics as well as quartz, feldspar and micas (both weathered biotite and muscovite identified). A washed sieved separate was bagged separately. Two rock pieces have trace fossils/burrows.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR12C**: Separate piece of composite sample of very fine-grained softish sandstone to mudstone in sedimentary contact. Both are laminated. A fault with a displacement of 15 mm has been seen. Piece is crusted by 5mm of Mn rind.
*Subsample at SGNC Nouméa*

**DR12D:** Five 12x7x5 cm pieces and one 25x10x10 cm piece of soft sandy mudstone with some laminations.
*Subsample at SGNC Nouméa*

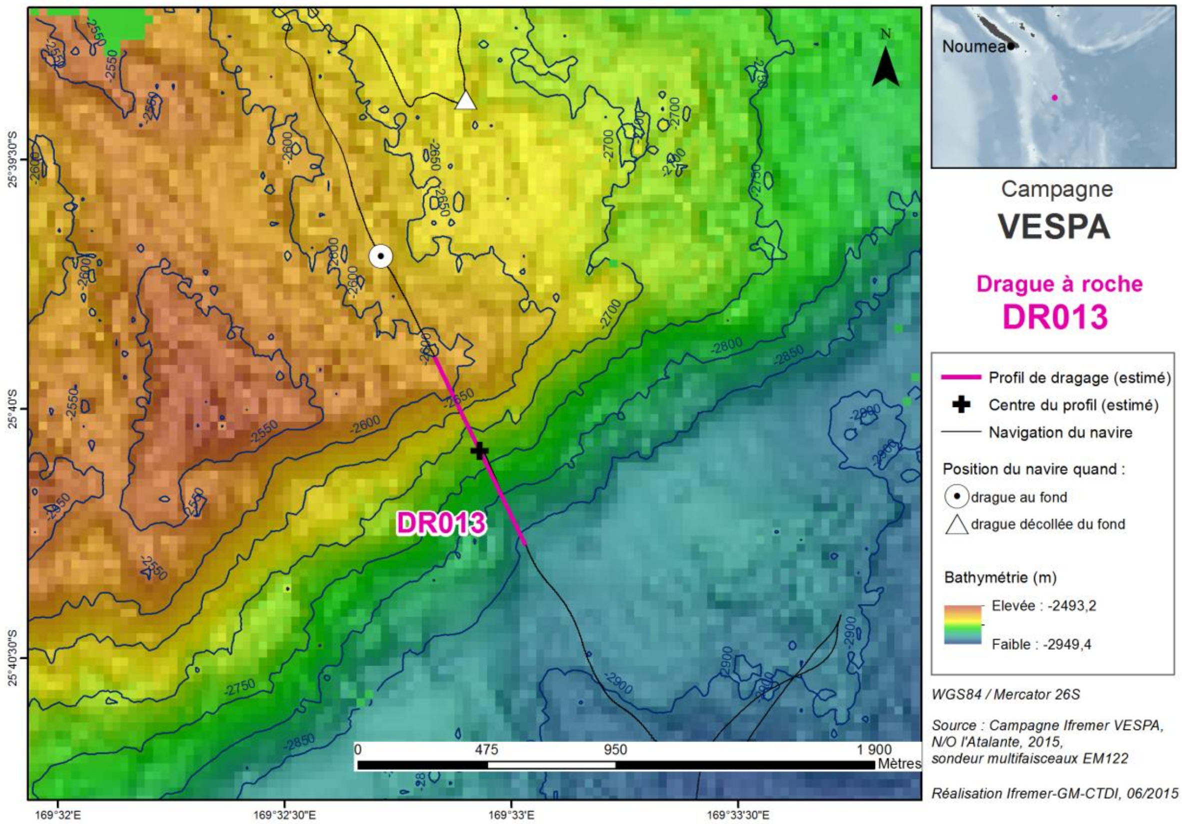
**DR12E:** Five 5x3x2 cm, and four 10x7x5 cm pieces of soft mudstone. Softer than most of the sandy rocks. Could be younger?
*Subsample at GNS Wellington, SGNC Nouméa*

**DR12F:** About twenty five pieces of 15x10x10 cm (some larger) of Mn crusts on rock substrate, up to 1cm thick. Top surface of crust is rough and irregular.
*Subsample at SGNC Nouméa*

**DR12G:** Seafloor sediment pipe sample.
*Subsample at GNS Wellington*

# *DR13*

**Target:** Loyalty Ridge area. Normal fault scarp at northwest termination of Cook Fracture Zone. Inferred to be part of Loyalty Ridge structural block.

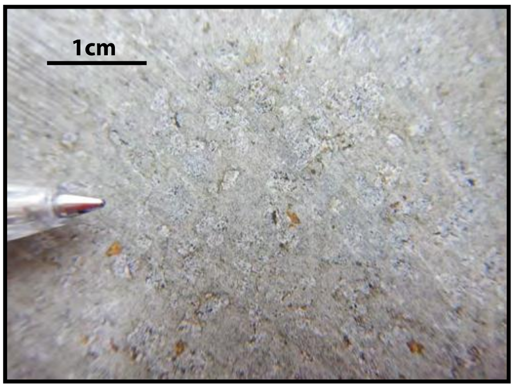



| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 04/06/2015 | 10:20:34 | -25,678680 | 169,5578459 | MISE A L'EAU | Mise à l'eau DR_013, 1153m de la cible |
| 04/06/2015 | 10:24:07 | -25,678111 | 169,5564266 | DEBUT DE FILAGE | Début de filage DR_013 994m de la cible |
| 04/06/2015 | 11:12:22 | -25,661557 | 169,5451981 | AU FOND | Drague au fond, 1161m de la cible |
| 04/06/2015 | 11:24:07 | -25,657344 | 169,5433685 | CROCHE | Croche de 6.5T, 3319m filés, 1676m de la cible. |
| 04/06/2015 | 11:25:16 | -25,656764 | 169,5430192 | CROCHE | Croche de 6T, 3319m filés, 1711m de la cible |
| 04/06/2015 | 11:26:09 | -25,656577 | 169,5429123 | CROCHE | Croche de 8.5T, 3319m filés, 1778m de la cible |
| 04/06/2015 | 11:27:37 | -25,656048 | 169,5427198 | DEBUT VIRAGE | Début de virage, 1790m de la cible |
| 04/06/2015 | 11:28:16 | -25,655763 | 169,5426711 | CROCHE | Croche de 16T, 3319m filés, 1827m de la cible |
| 04/06/2015 | 11:31:06 | -25,655077 | 169,5424547 | CROCHE | Croche de 8T, 3297m filés, 1046m de la cible |
| 04/06/2015 | 11:33:53 | -25,654422 | 169,5416965 | CROCHE | Croche de 9.6T, 3208m filés, 1073m de la cible |
| 04/06/2015 | 11:34:47 | -25,654106 | 169,5417467 | CROCHE | Croche de 10.2T, 1090m de la cible |
| 04/06/2015 | 11:36:30 | -25,653717 | 169,5418268 | CROCHE | Croche de 14.4T, 3156m filés, 1118m de la cible |
| 04/06/2015 | 11:37:32 | -25,653396 | 169,5415735 | CROCHE | Croche de 17.6T, 3152m filés, 1131m de la cible |
| 04/06/2015 | 11:39:23 | -25,652833 | 169,5411775 | CROCHE | Croche de 8.2T, 3100m filés, 2180m de la cible |
| 04/06/2015 | 11:42:07 | -25,652267 | 169,5413164 | CROCHE | Croche de 17T, 3096m filés, 1196m de la cible |
| 04/06/2015 | 12:07:22 | -25,656311 | 169,5483348 | CROCHE | Croche de 16.5 T, 2821m filés, 1663m de la cible |
| 04/06/2015 | 12:07:29 | -25,656311 | 169,5483348 | DRAGUE DECOLLEE | Drague décollée, 1663m de la cible |
| 04/06/2015 | 13:12:45 | -25,651821 | 169,5361884 | A BORD | DR_013 à bord |

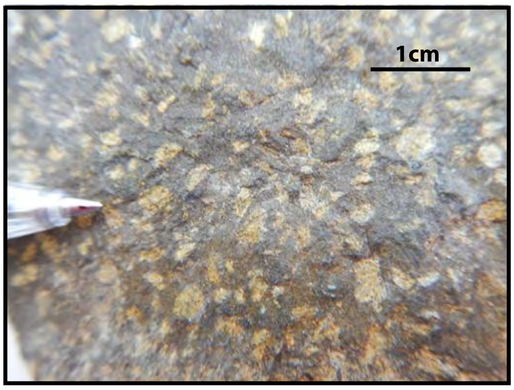
**Approx. weight:** 60 kg
**Main rock types:** Hard volcanic conglomerate, sandstone and mudstone
**Other rock types:** Sanidine-phyric dacite

## Dredging notes:

DR013

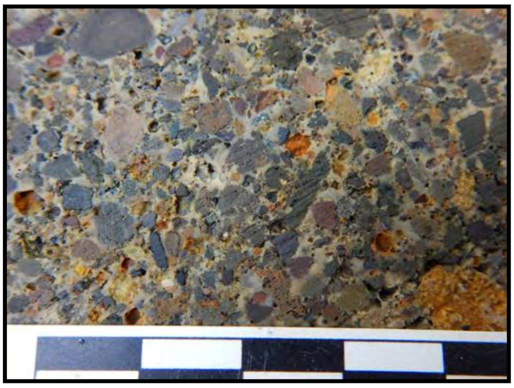


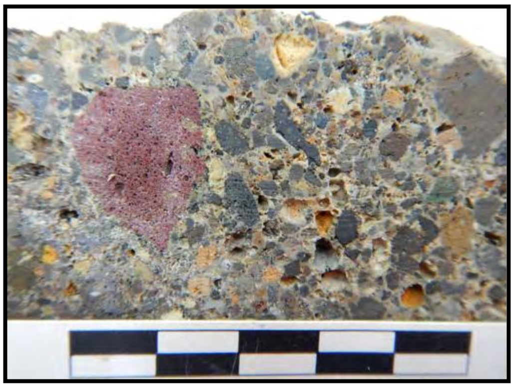
DR013A



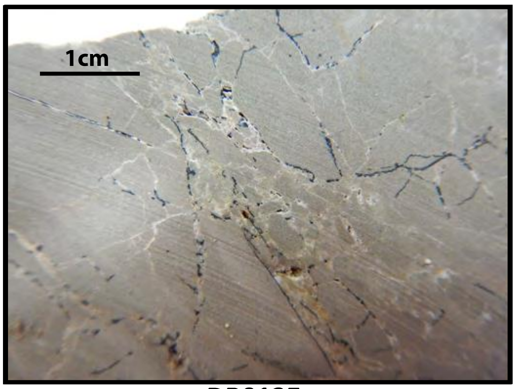
DR013A

DR013B


DR013Ci


DR013Cii

DR013D



DR013E

DR013F


DR013G

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**DR13Ai:** One 30x20x20 cm rounded boulder of hard, medium light grey (N6) porphyritic volcanic rock (dacite). Contains K-feldspar phenocrysts of size >2 mm. Some darker weathered crystals of ~1 mm seen (formerly pyroxene?).
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR13Aii:** Similar to Ai but from a separate 15x10x10 cm boulder.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR13B**: 10x5x5 cm piece of greyish yellow (5Y8/4) bedded sandstone. Grains are rounded. Possible non-volcanic composition indicates it could be coming from a distant source.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR13Ci:** 60x50x40 cm piece of moderate yellowish brown (10YR5/4) matrix-supported volcanic conglomerate-breccia. Clasts are subrounded and mostly c. 0.5 cm in size but range from 0.1 to 1 cm. s are matrix-supported. Brick-red vesicular basalt seen amongst fragments. Mn crust of 1-4 cm.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR13Cii:** Like Ci but coarser: clasts commonly 2 cm but up to 4.5 cm. 1-4 cm thick Mn crusts.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR13D:** Various pieces of manganese crust up to 7 cm thick. Some have mudstone substrate attached to them.
*Subsamples at IFREMER Brest, SGNC Nouméa*

**DR13Ei:** One 15x10x10 cm piece of light olive gray (5Y5/2) mudstone, laminated and brecciated (fluid flow?). Thin Mn veins penetrate sample. Possible detrital mica seen.
*Sample at SGNC Nouméa*

**DR13Eii:** Separate 5x5x3 cm piece of siltstone (definitely not a claystone).
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR13F:** Two 11x7x5 cm lumps of pumice. one piece greyish red (5R4/2), one piece very light grey (N8). Both are rounded and aphyric and contain vesicles of up to 2 cm.

*Subsamples at SGNC Nouméa*

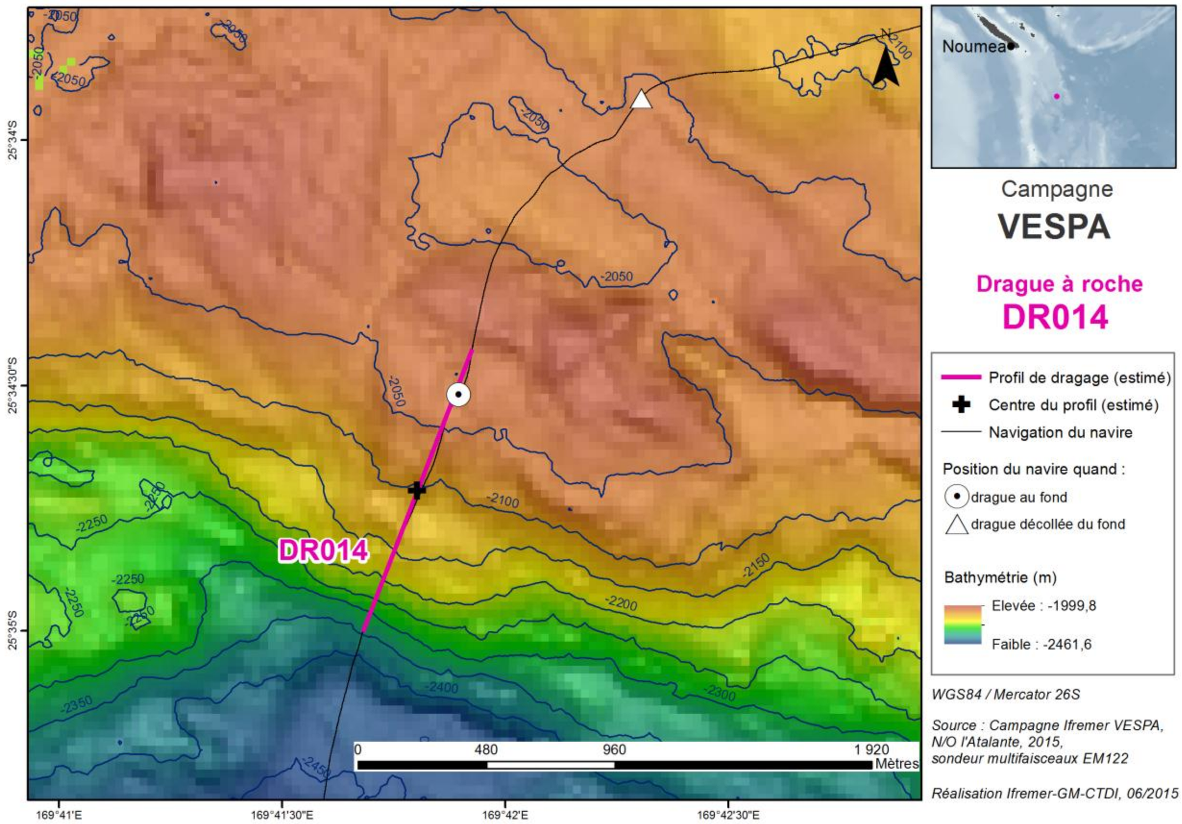
**DR13G:** >10 pieces of dusky yellow (5R6/4) massive sandstone. A few clasts or minerals of up to 8 mm but most are 1 mm. Soft greenish mineral seen.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR13H:** Seafloor sediment pipe sample.
*Subsample at GNS Wellington*

**DR13I:** Two separate c. 10 cm slabs of laminated very fine grained carbonaceous muddy sandstone. Possible plant fragments (1-2 mm size) seen on bedding planes.
*Subsamples at GNS Wellington, SGNC Nouméa*

# *DR14*

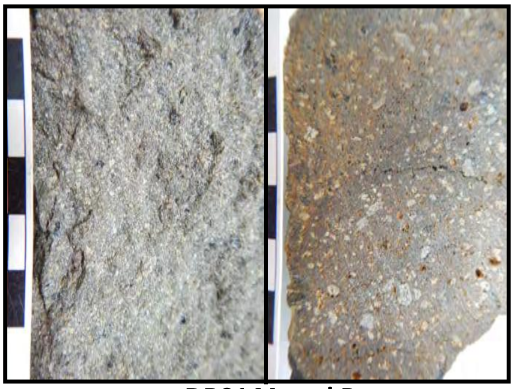
**Target:** Loyalty Ridge area. East-west fault across South Loyalty Basin north of Cook Fracture Zone.



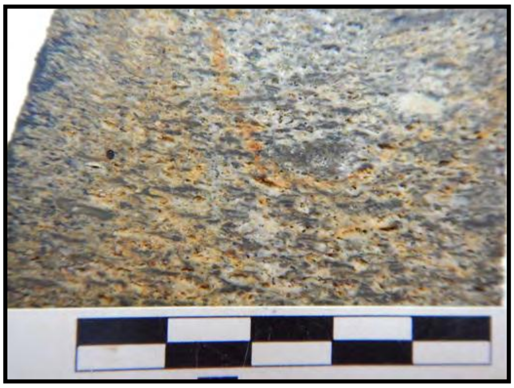

| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 04/06/2015 | 18:01:00 | -25,596048 | 169,6896707 | MISE A L'EAU | Mise à l'eau DR_014, 1200m de la cible |
| 04/06/2015 | 18:09:00 | -25,592732 | 169,6923281 | DEBUT DE FILAGE | 946m de la cible |
| 04/06/2015 | 18:52:00 | -25,575307 | 169,6982602 | AU FOND | 1096m de la cible, 2600m filés |
| 04/06/2015 | 19:03:32 | -25,570626 | 169,6995761 | CROCHE | Croche à 6T, 2800m filés, 1615m de la cible |
| 04/06/2015 | 19:05:00 | -25,570077 | 169,6998719 | DEBUT VIRAGE | 1683m de la cible, 2800m filés |
| 04/06/2015 | 19:12:00 | -25,568126 | 169,7013552 | CROCHE | Croche 15T, 2710m filés, 1943m de la cible |
| 04/06/2015 | 19:29:00 | -25,565239 | 169,7050808 | DRAGUE DECOLLEE | 2371m de la cible, 2116m filés |
| 04/06/2015 | 20:24:00 | -25,558092 | 169,728181 | A BORD | DR_014 à bord |

**Approx. weight:** 200 kg
**Main rock types:** Hard volcanic sandstone, conglomerate, mudstone
**Extra types:** Plagioclase-phyric andesites (probably shoshonitic)
**Dredging notes:**

DR014



DR014A and B



DR014C

DR014D


DR014E


DR014F


DR014G

DR014H

DR014 I


DR014J


DR014K

**DR14A:** Seven pieces (two large angular boulders and five angular cobbles) of hard, medium light grey (N6), porphyritic basalt or andesite. **Ai**: large boulder of plagioclase porphyritic andesite. **Aii:** second large boulder similar to Ai. **Aiii** 20x20x10 cm cobble similar to Ai. All thickly Mn crusted (up to 6cm). Possibly shoshonitic.
*Subsamples at IUEM Brest (I & ii), GNS Wellington, SGNC Nouméa*

**DR14B:** 10x7x5 cm piece from a boulder, of altered moderate brown (5 YR 3/4) lava. Texture and minerals unspecified but noted as similar to A. 15% phenocrysts (plagioclase?) are more visible on weathered part of sample
*Subsamples at SGNC Nouméa*

**DR14C**: 10x10x10cm subangular cobble of hard, light olive grey (5Y 5/2) pumiceous sandstone. Hard but porous in some places. Initially thought ot be an ignimbrite but, because if porosity, more likely to be a compressed Pleistocene tuffaceous sediment in a more advanced state of compaction than DR14I
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR14D:** 5 mm thick skin of hard, moderate yellowish brown (10 YR 8/6) micritic limestone adhering to outside of DR14C. Catalogued separately.
*Subsample at GNS Wellington*

**DR14E:** Dozens of decimetre-size slabs of hard, light olive grey (5 Y 6/1) sandstone. interbedded with conglomerate and muddy sandstone on mm, cm and dm scales. Bedding reveals soft sediment deformation. Sandstone is very poorly sorted and has

grains of fine grained volcanic rocks and sedimentary rocks. Includes a distinctive moderately red colour (5 R 4/6) vesicular lava similar to that seen in DR13C. Thickly Mn crusted.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR14F:** Dozens of decimetre-size slabs of softish, weakly indurated conglomerate, cemented cemented by manganese. Clasts include radiolarian chert, lava, sandstone. and are sometimes well rounded and polished. Matrix is ashy mustone and sandstone. A younger rock than DR14E.
*Subsamples at GNS Wellington (clast), SGNC Nouméa (bulk)*

**DR14G:** Many Mn crusts, up to 5cm thick
*Subsamples at IFREMER Brest, SGNC Nouméa*

**DR14H:** 20x20x10 cm piece of pale greenish yellow (10 Y 8/2) calcareous mudstone. Ashy no obvious forams.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR14I:** 10x10x10 cm subangular cobble of greyish orange (10 YR 7/4) pebbly sandstone. Clasts are mainly porous (= recent) rhyolite. Likely a less compacted version of DR14C.
*Subsamples at GNS Wellington, SGNC Nouméa*

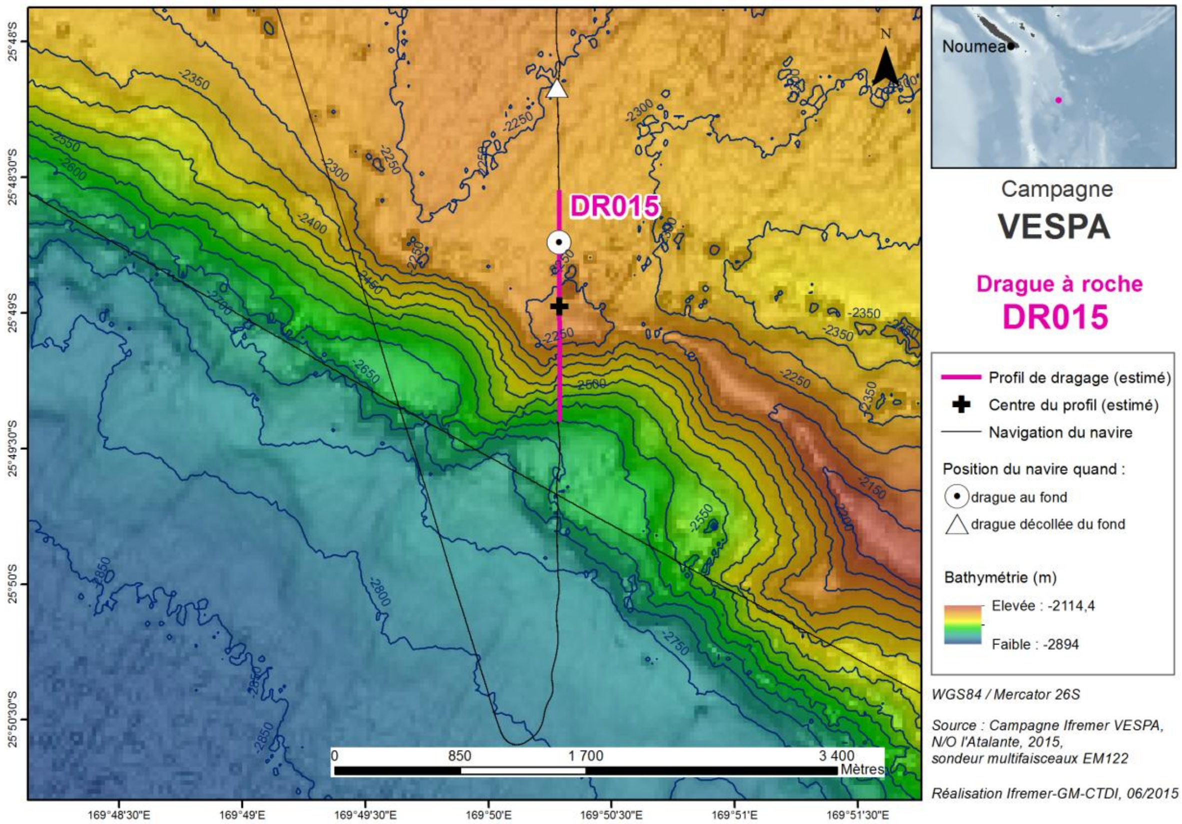
**DR14J:** One 15x7x7 cm Mn crusted micrite. Composite scruffy rock, strongly Mn crusted but otherwise like DR14D.
*Subsample at SGNC Nouméa*

**DR14K:** Half a dozen 1 -3 cm lumps of pumice from the pipe.
*Subsample at SGNC Nouméa*

**DR14L:** Seafloor sediment pipe sample.
*Subsample at GNS Wellington*

# *DR15*

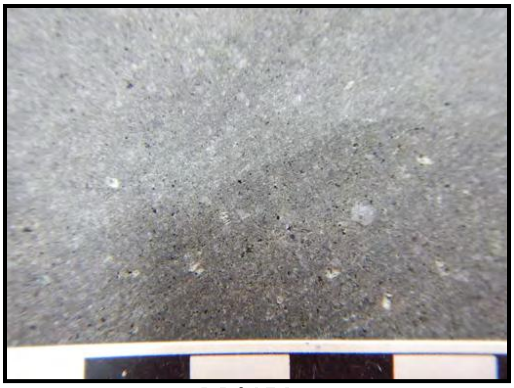
**Target:** Loyalty Ridge area. Cook Fracture Zone scarp near long. 169.8°E.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 04/06/2015 | 22:42:36 | -25,834365 | 169,8380357 | MISE A L'EAU | Mise à l'eau DR_015, 1213m de la cible |
| 04/06/2015 | 22:51:00 | -25,831756 | 169,8380174 | DEBUT DE FILAGE | Début de filage DR_015, 916m de la cible |
| 04/06/2015 | 23:38:28 | -25,812331 | 169,8381188 | AU FOND | Drague au fond, 2955m filés, 1200 m de la cible |
| 04/06/2015 | 23:48:48 | -25,808117 | 169,8380724 | CROCHE | Croche de 6.9T, 3126m filés, 1663m de la cible |
| 04/06/2015 | 23:50:40 | -25,807599 | 169,8380697 | DEBUT VIRAGE | Début de virage, 3119m filés, 1730m de la cible |
| 04/06/2015 | 23:51:05 | -25,807449 | 169,8380712 | CROCHE | Croche de 10T, 3105m filés, 1755m de la cible |
| 04/06/2015 | 23:53:09 | -25,806766 | 169,8380836 | CROCHE | Croche de 8.8T, 3060m filés, 1846m de la cible |
| 04/06/2015 | 23:55:07 | -25,805957 | 169,8380481 | CROCHE | Croche de 8T, 3021m filés, 1924m de la cible |
| 04/06/2015 | 23:57:05 | -25,805495 | 169,838018 | CROCHE | Croche de 9.5T, 2970m filés, 1979m de la cible |
| 04/06/2015 | 23:59:13 | -25,805141 | 169,8380503 | CROCHE | Croche de 10T, 2895m filés, 2031m de la cible |
| 05/06/2015 | 00:00:18 | -25,804829 | 169,8380792 | CROCHE | Croche de 12T, 2882m filés, 2042m de la cible |
| 05/06/2015 | 00:01:18 | -25,804642 | 169,8380705 | CROCHE | Croche de 10.2T, 2840m filés, 2068m de la cible |
| 05/06/2015 | 00:03:22 | -25,804211 | 169,8380402 | CROCHE | Croche de 9.8T, 2795m filés, 2111m de la cible |
| 05/06/2015 | 00:05:21 | -25,803691 | 169,8380257 | CROCHE | croche de 9T, 2725m filés, 2179m de la cible |
| 05/06/2015 | 00:10:00 | -25,802813 | 169,837985 | DRAGUE DECOLLEE | Drague décollée, 2234m filés, 2408m de la cible |
| 05/06/2015 | 01:30:43 | -25,769677 | 169,8467832 | A BORD | DR_015 à bord |

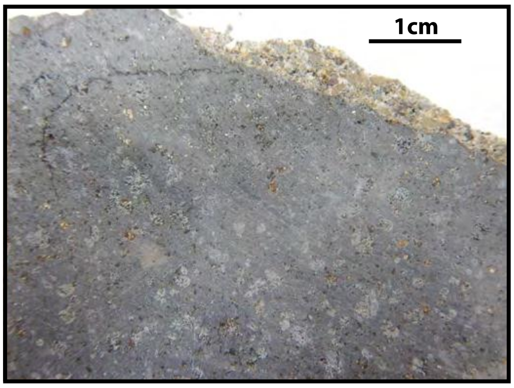
**Approx. weight:** 600 kg
**Main rock types:** Hard conglomerate, sandstone
**Other rock types:** Basalts, biotite andesite, quartzite
**Dredging notes:** dredge full with only thin <5mm rinds on all rocks in the dredge

DR015

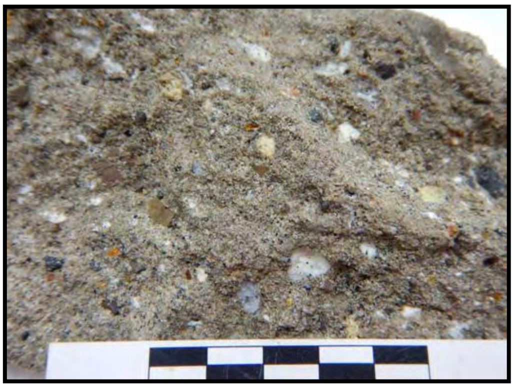


DR015A

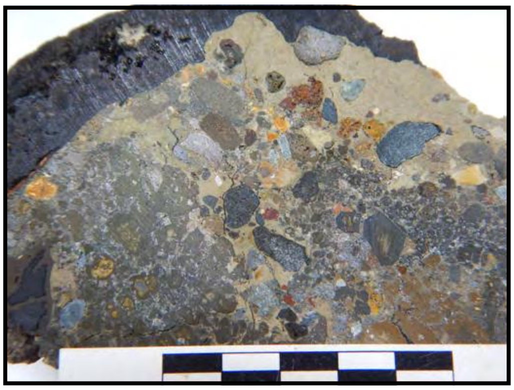
DR015B




DR015Ci

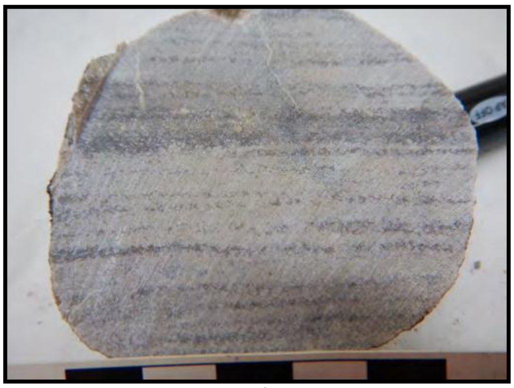


DR015Cii



DR015D

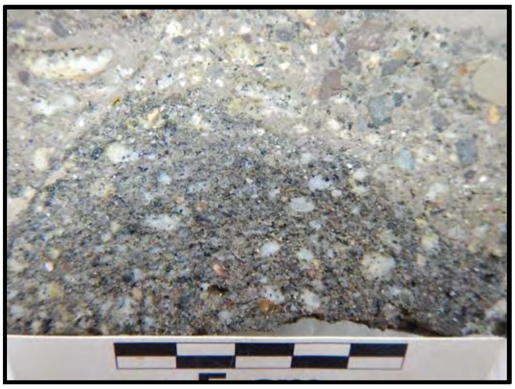
DR015E



DR015F

DR015G

DR015Hi



DR015Hii

DR015I

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**DR15A:** 40 cm diameter boulder (extracted from even larger boulder of pebbly sandstone DR15Cii) of dark grey (N3) slightly vesicular, plagioclase phyric basalt. Olive weathering rind. 5-10% plagioclase phenocrysts c. 1 mm in size.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR15B:** 35 cm diameter boulder (extracted from DR15Cii) of greyish red (5 R 4/2) biotite- and plagioclase-porphyritic andesite. Biotite is fresh, 1mm. Some zeolites in vesicles.
*Subsamples at IUEM Brest, GNS Wellington*

**DR15Ci**: 30 cm diameter cobble (extracted from DR15Cii) of dark grey (N3) porphyritic basalt with weathered phenocrysts of olivine and pyroxene (15%, 1-2 mm in size)
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR15Cii:** 70x70x60 cm boulder that got jammed in the dredge mouth. Varicoloured but overall moderate yellowish (10 YR 4/2) poorly sorted polymict pebbly sandstone. Contains rounded to subrounded boulders, cobbles and pebbles of assorted heterogeneous volcanic and sedimentary rocks inckluding A, B and Ci. Crude bedding noted (grain size change).
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR15D:** c. 50 cm piece (separate from DR15Cii) of pale olive grey (10 Y 6/2) conglomerate. Heterogeneous (size and composition) subrounded clasts of both sedimentary (mudstone) and volcanic origin. Different from DR15Cii in that there are white clasts and higher clast/matrix ratio.

*Subsamples at GNS Wellington, SGNC Nouméa*

**DR15E:** c. 20 5-20 cm pieces of dark grey, blocky, jointed, olivine- and pyroxene-phyric basalt very similar (probably same as) DR15Ci. Noitably porphyritic (2-3 mm size phenocrysts). Because of jointing, probbaky represents the *in situ* basalt at this site, not transported with the (assumed overlying) sedimentary rocks.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR15F:** Individual 10cm diameter light gray (N7) rounded, subspherical quartzite pebble. Slightly banded. Probably a cobble in the main conglomerate DR15Cii. Exotic detrital origin compared with the volcanic and sedimentary clasts.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR15G:** One big piece 30x30x20 cm piece of jointed pale brown (5YR 5/2) siltstone. Some sandy microbeds and layering within siltstone. Has manganese veins as well as nuclei within the rock.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR15Hi:** Many pieces up to 50x30x20 cm size of yellowish grey (5Y 7/2) to pale olive (10Y 6/2) soft to weakly indurated siltstone-mudstone. A few crystals/sand grains noted.
*Subsamples at GNS Wellington, SGNC Nouméa*

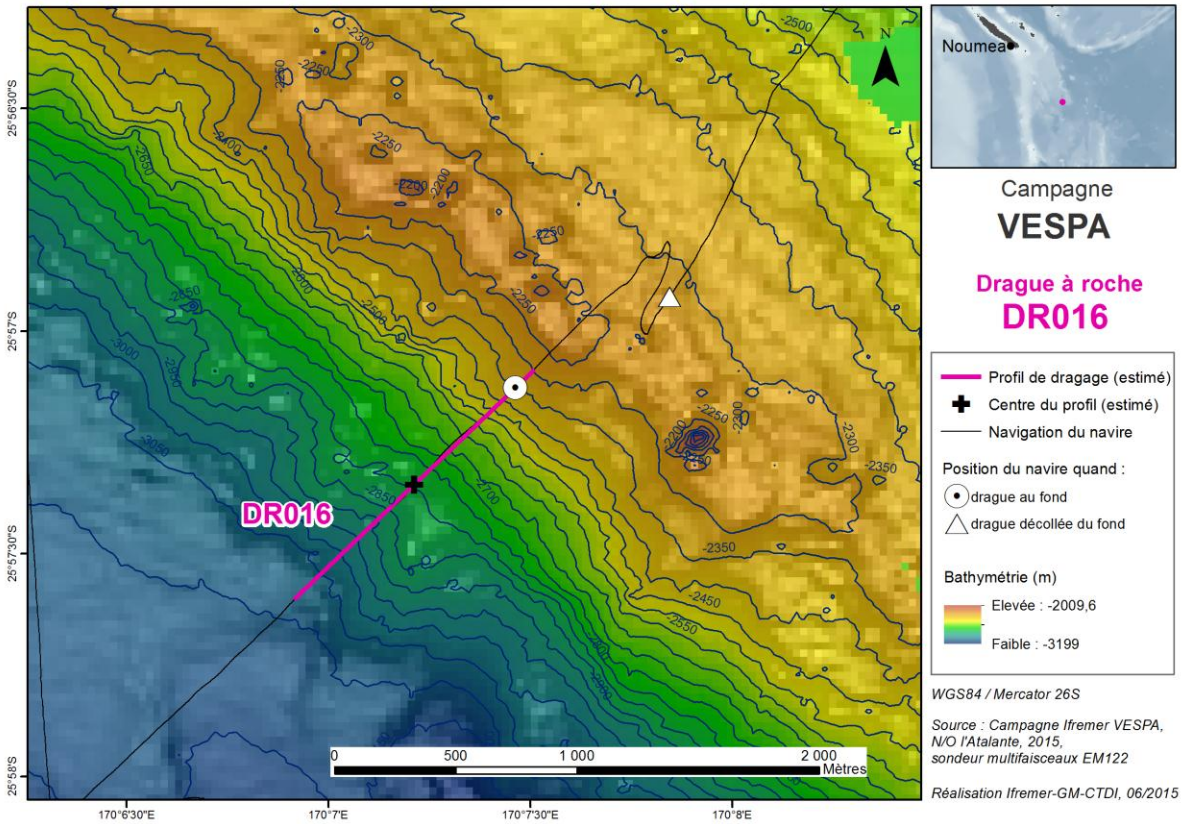
**DR15Hii:** Decimeter sized piece of soft, yellowish grey to light olive grey (5Y 8/1 to 5Y 6/1) matrix-supported conglomerate. Layered with pumiceous volcanic clasts up to 2 cm in size. Possibly young because of soft gel like pumice clasts bluish. Also because it has bits of mudstone DR15Hi stuck to it.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR15I:** Half dozen dm pieces of hard, indurated pale olive 10Y 6/2 silty sandstone. Lithic clasts, poorly sorted. Bedded and laminated on a mm-cm scale. Permeated by Mn-oxide nuclei.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR15J:** Seafloor sediment pipe sample. Sieved glob ooze plus gravel with notable barnacle plates.
*Subsample at GNS Wellington*

# *DR16*

**Target**: Loyalty Ridge area. Cook Fracture Zone scarp near long. 170.1°E.



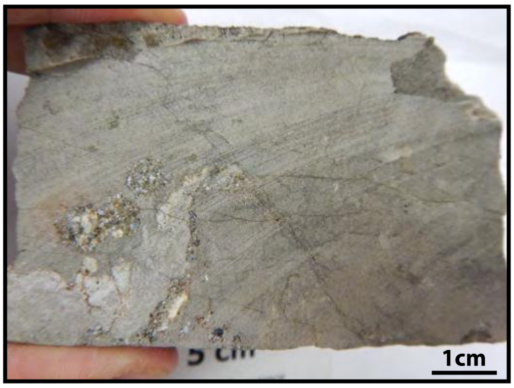

| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 05/06/2015 | 03:27:00 | -25,969022 | 170,1049294 | MISE A L'EAU | Mise à l'eau DR_016 |
| 05/06/2015 | 03:35:00 | -25,966729 | 170,1074635 | DEBUT DE FILAGE | Début de filage DR_016, 1050m de la cible |
| 05/06/2015 | 04:26:00 | -25,952112 | 170,124376 | AU FOND | Drague au fond DR_016, 3400m filés, 1135m de la cible |
| 05/06/2015 | 04:36:00 | -25,949267 | 170,1275137 | CROCHE | Croche à 6T. 1600 m de la cible, 3591 m filés |
| 05/06/2015 | 04:37:00 | -25,948956 | 170,1278688 | CROCHE | Croche 8.5T. 1660 m de la cible, 3580 m filés |
| 05/06/2015 | 04:38:00 | -25,948692 | 170,1282102 | DEBUT VIRAGE | 3580m filés, 1670m de la cible |
| 05/06/2015 | 04:49:00 | -25,947146 | 170,1302347 | CROCHE | Croche 17T. 3370 m filés, 1933m de la cible |
| 05/06/2015 | 05:14:41 | -25,949486 | 170,1301396 | CROCHE | Croche à 15T, 2560m filés, 1750m de cible |
| 05/06/2015 | 05:21:00 | -25,948706 | 170,1307499 | DRAGUE DECOLLEE | Drague décollé, 2284m filés, 1843m de la cible |
| 05/06/2015 | 06:12:00 | -25,938923 | 170,1368419 | A BORD | DR_016 à bord |

**Weight:** 600 kg
**Main rock types:** Fairly hard fine grained sandstone and mudstone
**Other rock types:** Hard volcanic conglomerate
**Dredging notes:** Very full dredge


DR016


DR016A


DR016B



DR016D


DR016E


DR016F

DR016G

**DR16A:** 50x50x50cm boulder-sized piece of polymict, poorly sorted, moderately rounded matrix-supported conglomerate. Clasts consist mainly of varitextured and

varicoloured volcanic clasts: basalt, andesite, rhyolite. Minor mudstone clasts. Sandy and muddy matrix. Typical clast size 10 mm but lavas up to 3 cm in size. Some clasts well rounded and polished.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR16B:** Two-three boulders of 50x40x30 cm greyish olive (10 Y 4/2) moderately sorted, subangular, subrounded coarse sandstone. Some volcanic pebbles up to 1cm in size, some well-rounded and polished. Bedding planes defined by abruptnchanges in grain size. Weak lamination also present. Sandstone bed is at least 10 cm thick (top and bottom contact not seen).
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR16C**: A dozen 30 cm boulders of greyish yellow green (5 GY 7/2) moderately sorted fine grained, lithic volcanic sandstone. Some soft sediment deformation involving siltstone.
*Subsamples at SGNC Nouméa*

**DR16D:** Most of the rock volume in the dredge. Greyish yellow green (5 GY 7/2) very fine grained sandstone. Finer version of DR16C.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR16E:** Several 20-30cm boulders of distinctive pale brown (5 YR 5/2) coloured of non-calcareous uniform unbedded siltstone (coarse)
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR16F:** Two 15x15x10 cm pieces of well bedded carboclastic fine grained sandstone. 1-2 cm bedded layers. Somewhat like C, D and G. Cut by conjugate microfaults including one with a 1 cm gouge zone (Cook Fracture Zone deformation?)
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

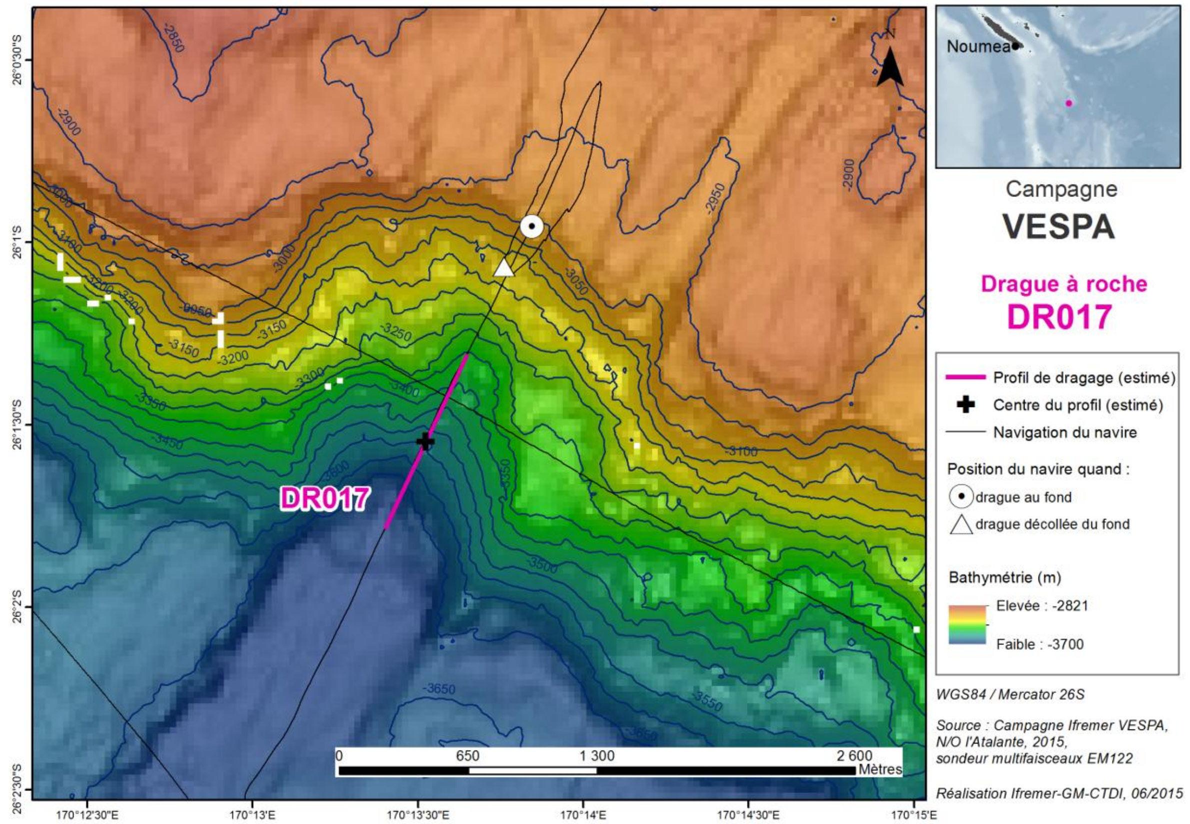
**DR16G:** Several small (10 cm) pieces of soft yellowish grey 5Y 7/2 ashy siltstone (pumiceous?). Not as indurated as other samples, so may be the youngest rock type in the dredge.
*Subsamples at IUEM Brest, GNS Wellington*

**DR16H:** Seafloor sediment pipe sample.
*Subsamples at GNS Wellington*

**DR16Z:** One 7x7x5 cm piece of olivine-clinopyroxene phyric basalt. Similar to DR15E; suspect this might have been left trapped in the chain bag from the previous dredge.
*Subsamples at IUEM Brest, SGNC Nouméa*

# *DR17*

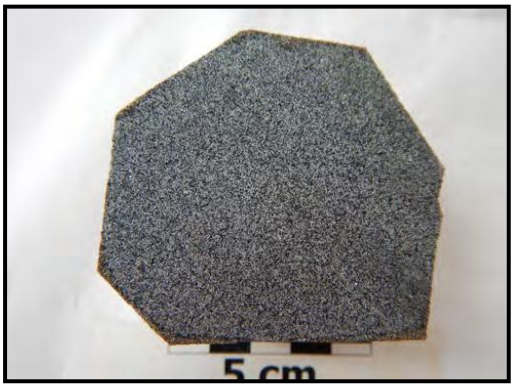
**Target:** Loyalty Ridge area. Cook Fracture Zone northern scarp near long 170.2°E.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 05/06/2015 | 07:38:00 | -26,042053 | 170,2162916 | MISE A L'EAU | Mise à l'eau DR_017 |
| 05/06/2015 | 07:51:50 | -26,037203 | 170,2193297 | DEBUT DE FILAGE | Début filage DR_017, 1261m de la cible |
| 05/06/2015 | 08:49:45 | -26,015928 | 170,2307381 | AU FOND | Drague au fond, 4090m filés, 1450m de la cible |
| 05/06/2015 | 08:57:00 | -26,013191 | 170,2321463 | DEBUT VIRAGE | 4090m filés, 1772m de la cible |
| 05/06/2015 | 09:03:00 | -26,011133 | 170,2330868 | CROCHE | croche à 8T, 4053m filés et 2050m de cible |
| 05/06/2015 | 09:08:19 | -26,009547 | 170,2339572 | CROCHE | croche à 18T, 4025m filés et 2216m de cible |
| 05/06/2015 | 10:04:00 | -26,017530 | 170,2305012 | CROCHE | Décrochage, 3563m filés, 1163m de la cible |
| 05/06/2015 | 10:25:14 | -26,017776 | 170,229333 | DRAGUE DECOLLEE | Drague décollée, 2988m filée, 1194m de la cible |
| 05/06/2015 | 11:25:27 | -26,010982 | 170,2322594 | A BORD | DR_017 à bord |

**Approx. weight:** 75 kg
**Main rock types:** Basalts
**Extra types:** Cataclasite, hard sedimentary rocks
**Dredging notes:**


DR017




DR017Ai

DR017Aiv


DR017B


DR017C

**DR17A (Ai to Ai iv):** 20x20x10 cm blocks of hard, aphyric medium grained equigranular non-vesicular jointed basalt. Fresh colour: medium dark grey (N4) but mostly slightly weathered (olive grey, 5Y4/1). Aiv is slightly more weathered but otherwise is the same as the others.
*Subsamples at IUEM Brest (Ai), GNS Wellington (Aii), SGNC Nouméa (Aiii, Aiv)*

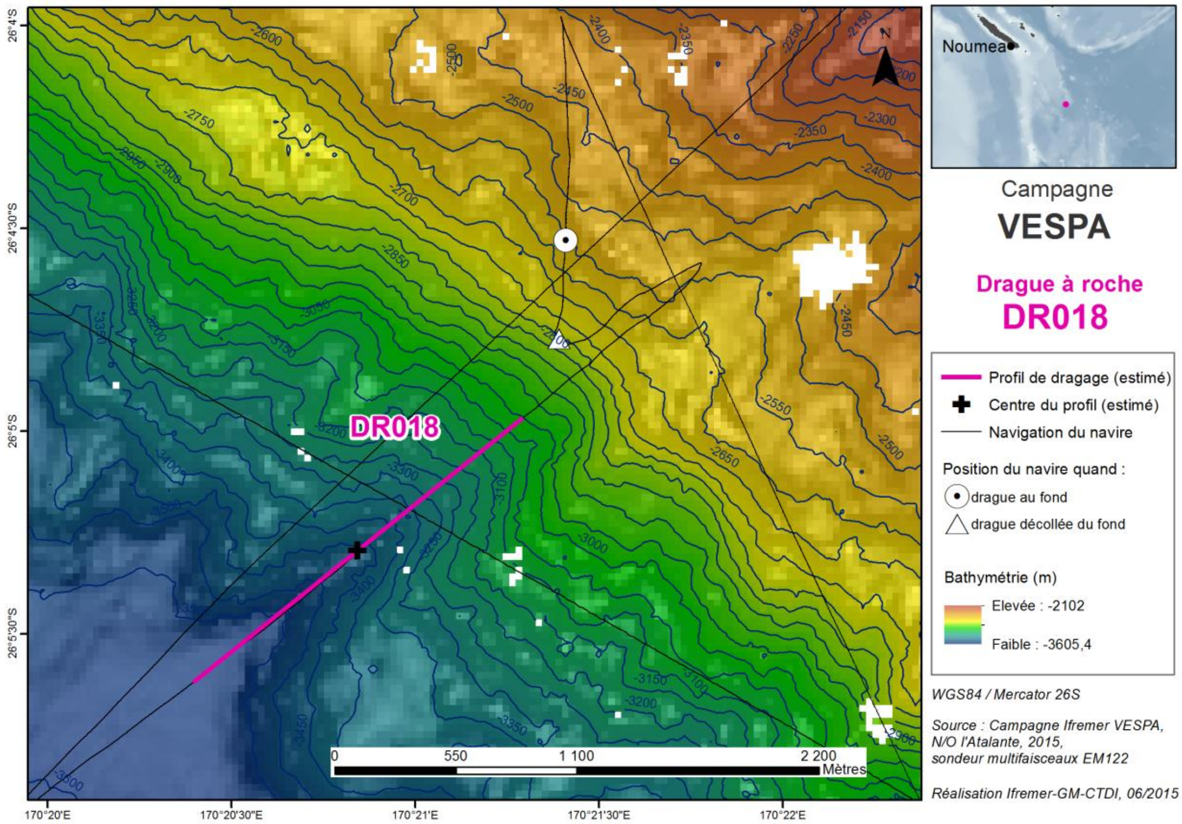
**DR17B:** One 40x40x25 cm boulder of hard olive grey (5 Y 3/2) cataclastic fault breccia of altered basalt of similar protolith to 17A. Many clasts have a chloritic polish. Most of the rock consists of sheared matrix. Probably from Cook Fracture Zone *sensu stricto*.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR17C**: Pieces of hard, light olive grey (5 Y 5/2) bedded mudstone and fine and medium grained sandstone. Trough-cross lamination, current ripples (in medium sandstone) and load casts observed (latter could be differential compaction between siltstone and mudstone). Base of current ripple is erosive with lag in trough (pebbles of mudstone) and normal grading (fining upward). **Ci:** spiculite with fossils in crystal-vitric tuff, **Cii:** trace fossils in siltstone, **Ciii:** slabbed sandstone/siltstone with sedimentary structures. *Subsamples at GNS Wellington, SGNC Nouméa*

**DR17D:** Seafloor sediment pipe sample.
*Subsample at GNS Wellington*

# *DR18*

**Target:** Loyalty Ridge area. Cook Fracture Zone northern scarp near 170.35°E




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 05/06/2015 | 20:20:00 | -26,101715 | 170,3285502 | MISE A L'EAU | Mise à l'eau DR_018 |
| 05/06/2015 | 20:34:21 | -26,097949 | 170,3335545 | DEBUT DE FILAGE | Début de filage DR_018, 1087m de la cible |
| 05/06/2015 | 21:30:17 | -26,075471 | 170,3568286 | AU FOND | 4018m filés, 1442m de la cible |
| 05/06/2015 | 21:41:00 | -26,081198 | 170,3569654 | CROCHE | Croche à 7.2T, 4142m filés, 1904m de cible |
| 05/06/2015 | 21:41:00 | -26,081198 | 170,3569654 | DEBUT VIRAGE | 4149m filés, 1878m de la cible |
| 05/06/2015 | 21:49:00 | -26,080051 | 170,3584622 | CROCHE | Croche à 8.4T 3940m filés, 2095m de cible |
| 05/06/2015 | 22:17:04 | -26,076760 | 170,3628128 | CROCHE | Croche à 15.9T, 3424m filés, 2647m de cible |
| 05/06/2015 | 22:19:43 | -26,076616 | 170,3629069 | CROCHE | Croche à 15,8T, 3408m filés, 2658m de cible |
| 05/06/2015 | 22:20:37 | -26,076581 | 170,3629047 | CROCHE | Croche à 12T, 3393m filés, 2661m de cible |
| 05/06/2015 | 22:55:39 | -26,079749 | 170,3569775 | CROCHE | Croche 20T, 2938m filés, 1980m de cible |
| 05/06/2015 | 22:56:00 | -26,079770 | 170,3569016 | CROCHE | Croche à 9T, 2907m filés, 1965m de cible |
| 05/06/2015 | 22:57:00 | -26,079766 | 170,3567602 | CROCHE | Croche à 8.3T, 2890m filés, 1960m de cible |
| 05/06/2015 | 23:00:00 | -26,079529 | 170,3565131 | DRAGUE DECOLLEE | Drague décollée 2732m filés, 1965m de la cible |
| 06/06/2015 | 00:00:20 | -26,068768 | 170,3568401 | A BORD | DR_018 à bord |

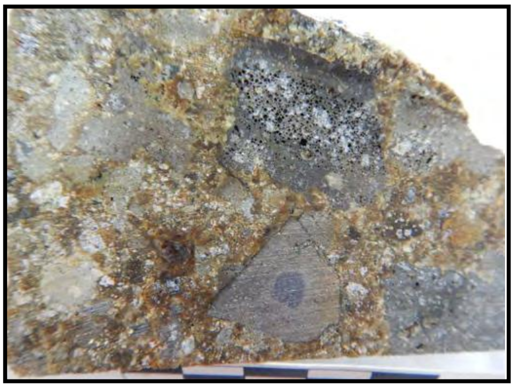
**Approx. weight:** 75 kg
**Main rock types:** Basalt, basalt breccia
**Other rock types:** Limestone

**Dredging notes:**

DR018

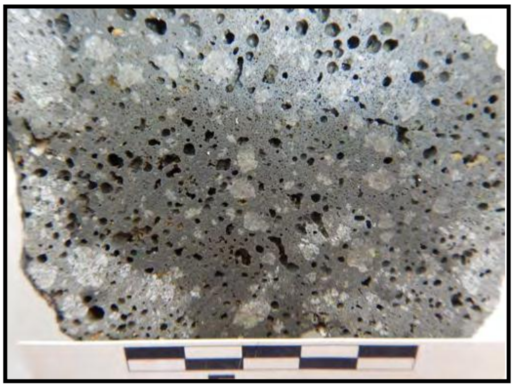
DR018Ai

DR018Aii

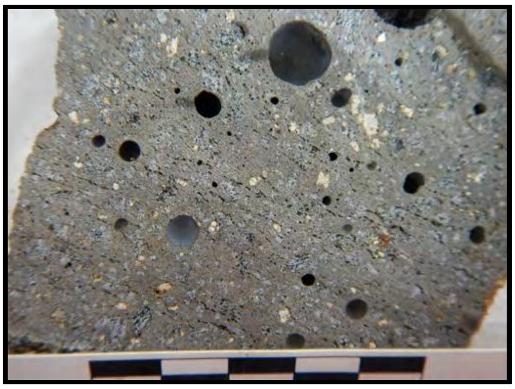


DR018Aiii

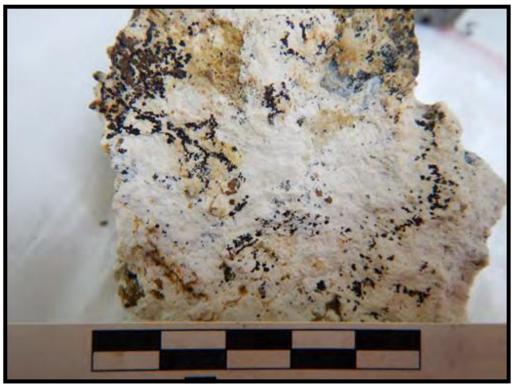
DR018Av



DR018Avii



DR018Bii



DR018C

All samples A are distinct fragments coming from a single breccia.
**DR18Ai:** 15x15x15 cm jointed block of hard, fresh, medium light grey (N6) vesicular feldspar-phyric (10%) basalt. Rare pyroxene phenocrysts too. Relatively large sparse (5%) vesicles (up to 1.5 cm) compared to other samples in dredge, some vesicles filled with calcite.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR18Aii:** 10x10x7cm block of vesicular feldspar phyric basalt similar to above but smaller (1-2 mm) vesicles.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR18Aiii:** 50x60x70 cm block of greyish brown (5 YR 3/2) poorly sorted, polymict basalt breccia. Clasts are varitextured basalts. Brown matrix may be due to higher glass (altered) proportions. Grey fresh clasts separated as i, ii, iv, v, vi, vii. Hard white limestone crusts up to 5 mm on parts of boulder.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR18Aiv:** 10x10x5 cm block of light olive grey (5 Y 6/1) feldspar-phyric basalt with flow foliated groundmass. Sllightly paler than other basalts of the dredge.
*Subsamples at IUEM Brest, GNS Wellington*

**DR18Av:** 20x20x10 cm block of dense, medium grey (N5) vesicular plagioclase- and pyroxene-phyric basalt. Some vesicles lined with clay minerals.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR18Avi:** 10x10x5 cm block of dense, light olive grey (5 Y 6/1) microvesicular basalt. Some clay alteration around edge but mainly fresh (vesicles 30%)
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR18Avii:** 15x10x10 cm block of basalt with prominent (up to 5 mm, 20%) plagioclase phenocrysts and 10% vesicles.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR18Bi:** one 20x50x60 cm boulder in dredge. Bulk sample of polysorted polymict volcanic breccia. More altered to light brown 5YR 5/6 colour than Aiii, but still with some less altered clasts most clasts 1-15mm size
*Subsamples at GNS Wellington, SGNC Nouméa*

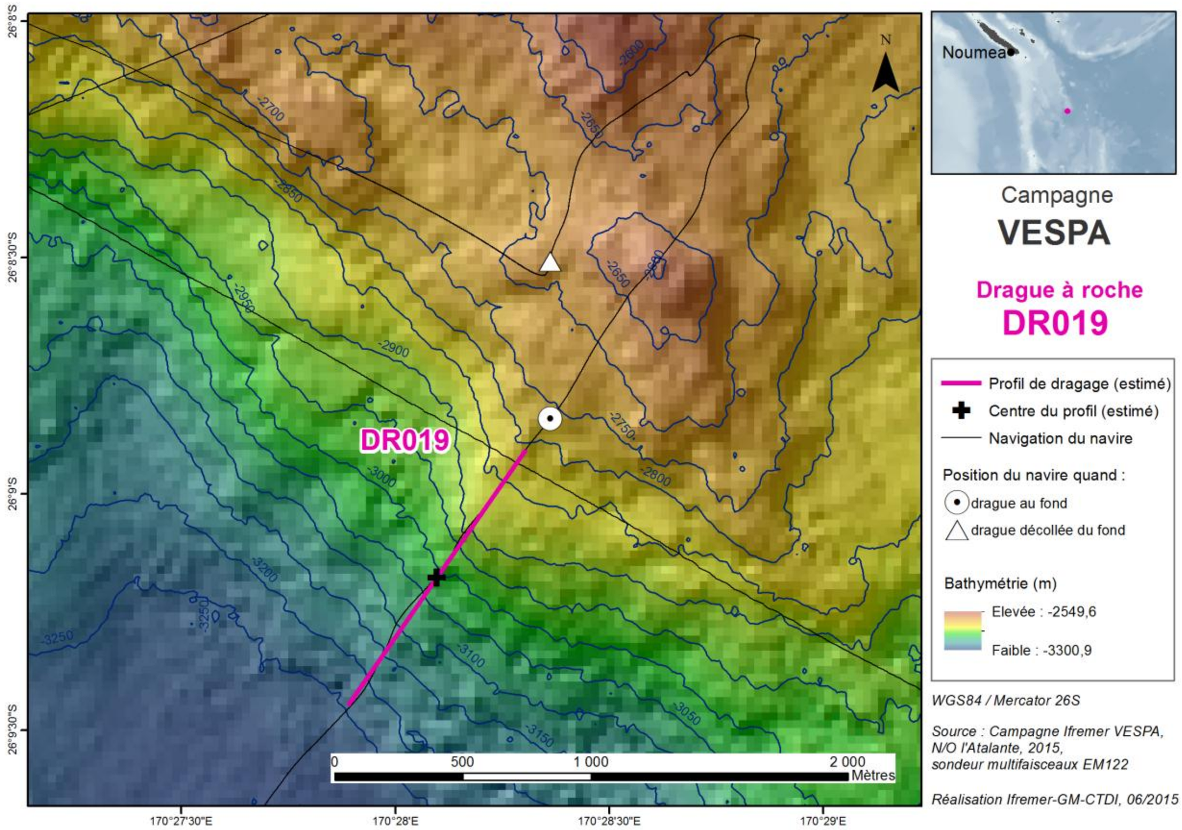
**DR18Bii:** 10x10x10 cm clast in breccia. Medium light grey (N6) pyroxene-plagioclase phyric basalt, vesicular. More pyroxene than any clast sampled from DR18A breccia and the highest amount of olivine of DR18 .
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR18C**: 20x20x20 cm piece of basalt breccia identical to Bi but partially coated and cracks infilled by moderately indurated white (N9) chalky limestone. Sampled for limestone not basalt.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR18D**: Seafloor sediment pipe sample. *Subsamples at GNS Wellington*

# *DR19*

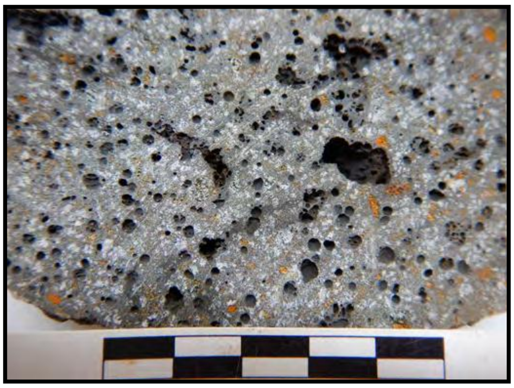
**Target:** Loyalty Ridge area. Cook Fracture Zone scarp near long. 170.5°E.



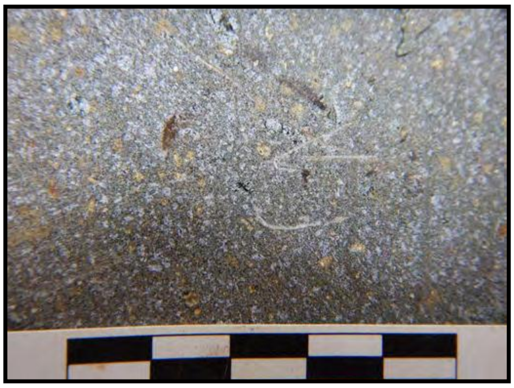

| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 06/06/2015 | 01:16:00 | -26,169922 | 170,4534409 | MISE A L'EAU | Mise à l'eau DR_019, 1750m de la cible |
| 06/06/2015 | 01:26:00 | -26,167012 | 170,4567612 | DEBUT DE FILAGE | Début de filage DR_019, 1343 m de la cible |
| 06/06/2015 | 02:25:00 | -26,147340 | 170,4727192 | AU FOND | 3600m filés, 1400m de la cible |
| 06/06/2015 | 02:36:05 | -26,143357 | 170,4755005 | CROCHE | Croche 6.8T, 3798m filés, 1898m de cible |
| 06/06/2015 | 02:38:00 | -26,142813 | 170,4759147 | DEBUT VIRAGE | 3798 m filés, 1989 m de la cible |
| 06/06/2015 | 02:43:00 | -26,141252 | 170,4773789 | CROCHE | Croche 10T. 3725 m filés, 2187 m de la cible |
| 06/06/2015 | 02:49:00 | -26,139017 | 170,4787456 | CROCHE | Croche 11T. 3617 m filés, 2469 m de la cible |
| 06/06/2015 | 02:55:00 | -26,136949 | 170,4799647 | CROCHE | Croche 11T. 3500 m filés, 2778 m de la cible |
| 06/06/2015 | 02:57:00 | -26,136312 | 170,4804269 | CROCHE | Croche 17T. 3495 m filés, 2811 m de la cible |
| 06/06/2015 | 02:58:00 | -26,13602 | 170,4803702 | CROCHE | Croche 12T. 3485 m filés, 2837 m de la cible |
| 06/06/2015 | 02:59:00 | -26,135651 | 170,4803441 | CROCHE | Croche 11T. 3466 m filés, 2876 m de la cible |
| 06/06/2015 | 03:00:00 | -26,135246 | 170,4804393 | CROCHE | Croche 10T. 3442 m filés, 2924 m de la cible |
| 06/06/2015 | 03:04:30 | -26,134207 | 170,4807446 | CROCHE | Croche 12T. 3375 m filés, 3030 m de la cible |
| 06/06/2015 | 03:06:00 | -26,134048 | 170,4808562 | CROCHE | Croche 15T. 3346 m filés, 3054 m de la cible |
| 06/06/2015 | 03:48:00 | -26,141794 | 170,4727043 | DRAGUE DECOLLEE | 2877 m filés, 1878 m de la cible |
| 06/06/2015 | 04:57:51 | -26,132143 | 170,43807 | A BORD | DR_019 à bord |

**Approx. weight:** 150 kg
**Main rock types:** Altered volcanic breccia with large blocky clasts of basalt.
**Other rock types:** Moderately hard coloured siltstones, chalky limestone
**Dredging notes:**

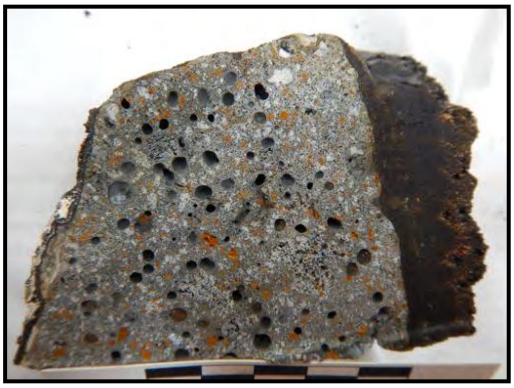
DR019



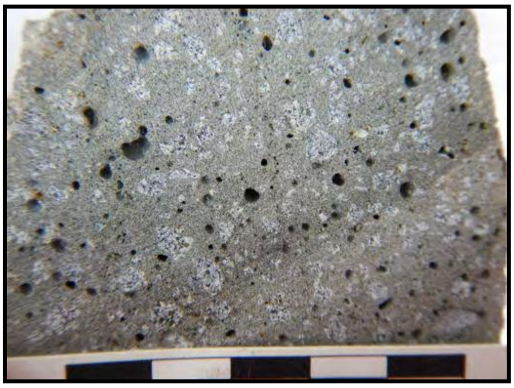
DR019A



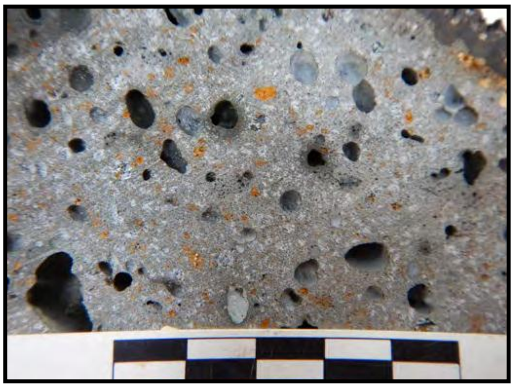
DR019B



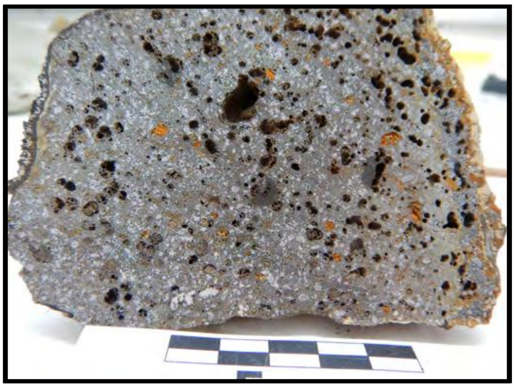
DR019C



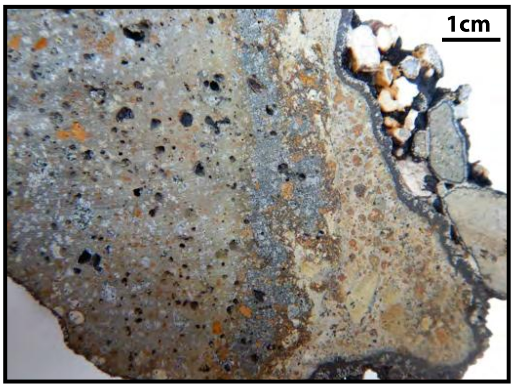
DR019D



DR019E



DR019F



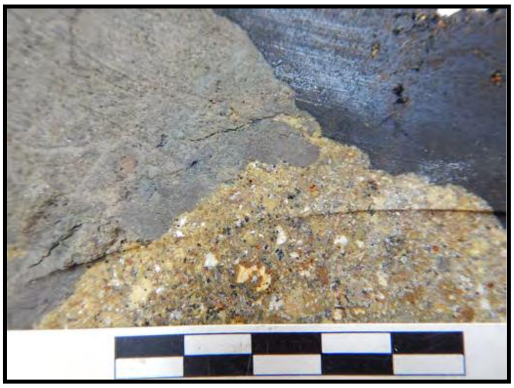

DR019G

DR019I

DR019Ji

DR019Jii

DR019Jiii



DR019Jiv

DR019K

**DR19A:** 20x10x10 cm clast in DR19H breccia of medium dark grey (N4) vesicular porphyritic basalt. Phenocrysts up to 2 mm in size of plagioclase (15%), olivine (<1%), pyroxene (<<1%). Olivine altered to orange clay mineral. 15% vesicles up to 10 mm in size. Clasts are coated on one side by Mn crust.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR19B:** 40x20x20 cm angular blocky clast in DR19H breccia. Brownish black (5 YR 2/1) non vesicular porphyritic basalt (25% plagioclase, <1% olivine, <<1% pyroxene). Some scattered yellow clay alteration of plagioclase. There are some xenoliths of aphyric basalt with irregular (magma mingling) margins. Olivine altered to orange clay mineral.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR19C:** Separate, rounded 15x10x10 cm cobble in dredge (not in main breccia boulder). Medium dark grey (N4) vesicular (10%) porphyritic (olivine and plagioclase 10%)

basalt. Phenocrysts up to 2 mm in size. Some sediment infiltration into vesicles. Some vesicles filled with yellow-green clay. Olivine altered.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR19D:** 20x10x1cm block of medium light grey (N6) slightly vesicular plagioclase (10%) phyric basalt. Trace only of olivine phenocrysts.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR19E:** Separate, rounded 15x10x10 cm cobble in dredge (not in main DR19H breccia boulder). Medium dark grey (N4) vesicular and porphyritic (plagioclase 10%, olivine 12%) basalt. Olivine altered to orange clay mineral. Some clay infiltration/precipitation in vesicles. Similar to DR19C.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR19F:** Separate, subrounded 20x15x10 cm cobble in dredge (not in main DR19H breccia boulder) of dark grey (N3) vesicular (plagioclase 10%, olivine 2%, pyroxene <<1%) phyric basalt. Olivine altered (glassy rind on one convex edge of basalt against orange hyaloclastite. Possible pillow lava.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR19G:** Subrounded 20x15x10 cm separate cobble of dark yellowish brown (10 YR 4/2)basalt otherwise similar to DR19F including ?glass edge.
*Subsamples at IUEM Brest, SGNC Nouméa*

**DR19H:** 40x40x30 cm boulder in dredge of light brown (5 YR 5/6) moderately sorted basaltic volcanic breccia. Much former glass hyaloclastite altered to red clay. Most clasts ( 5-15mm) except for outsize fresh basalt clasts. DR19A-B have been sampled from this boulder.
*Subsamples at GNS Wellington, SGNC Nouméa*

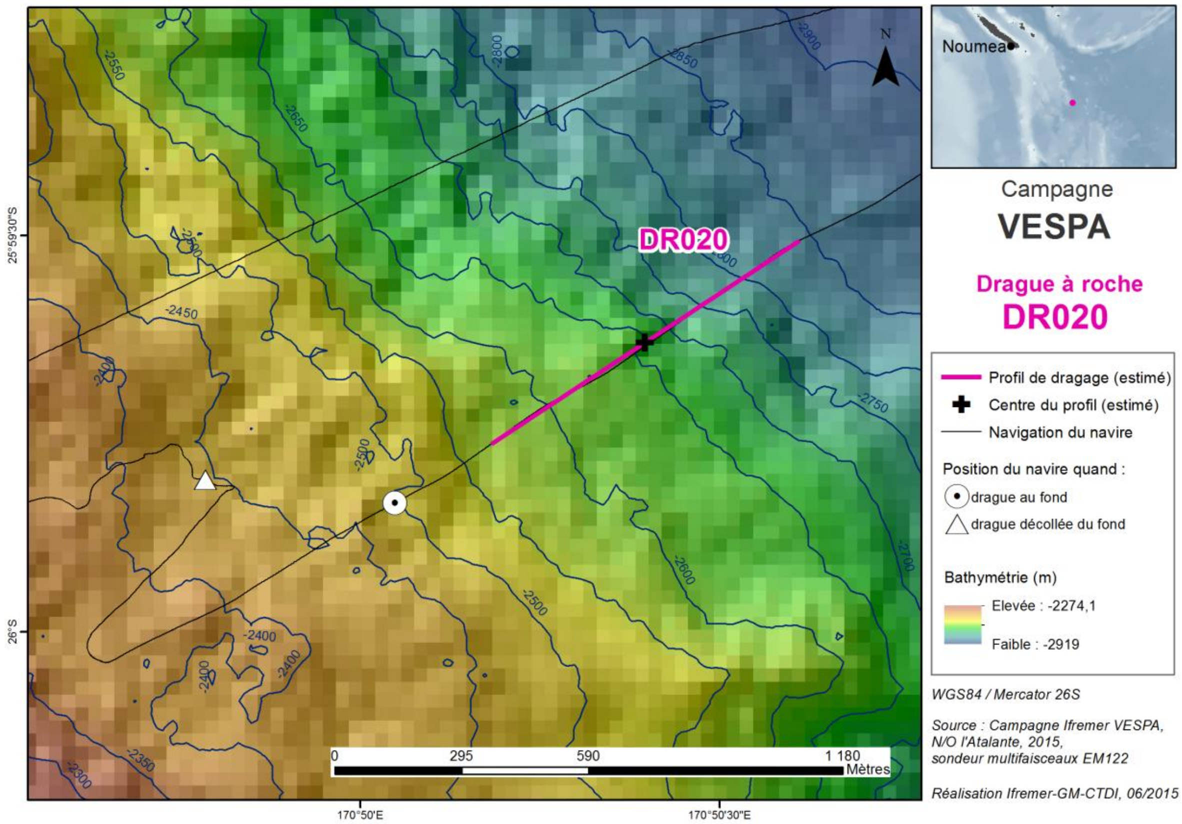
**DR19I:** One 15x10x10 cm piece of of Mn-cemented pebbles with shark's tooth on exterior.
*Sample at SGNC Nouméa*

**DR19J:** Four separate 10x15x10 cm pieces of soft, greyish green (5G 5/2) sandstone and mudstone. Non-calcareous. **Jii:** pale yellowish green (10 GY 7/2) mudstone possibly radiolarian bearing. **Jiii:** separate piece of mudstone, possiblly radiolarian bearing and calcareous. **Jiv:** brownish grey (5YR4/1) mudstone at contact between volcanic breccia and Mn rind.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR19K**: Broken piece of main DR19H boulder. Probable cavity fill in breccia of pinkish grey (5 YR 8/1) soft chalky limestone.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

# *DR20*

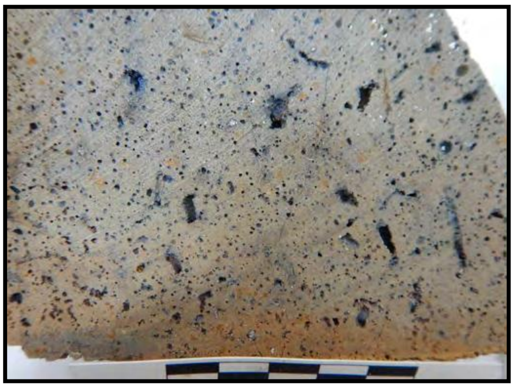
**Target:** Loyalty Ridge area. South tip of  Loyalty Ridge at 170.8°E.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 06/06/2015 | 08:37:00 | -25,986508 | 170,845794 | MISE A L'EAU | Mise à l'eau DR_020, 504m de la cible |
| 06/06/2015 | 08:54:00 | -25,988684 | 170,8490493 | DEBUT DE FILAGE | Début de filage DR_020, 642m de la cible |
| 06/06/2015 | 09:36:00 | -25,997291 | 170,8341469 | AU FOND | Drague au fond, 2860m filé, 1150m de la cible |
| 06/06/2015 | 09:48:00 | -25,999413 | 170,830248 | CROCHE | Croche 5.4T, 3060m filés 1607m de la cible |
| 06/06/2015 | 09:50:00 | -25,999703 | 170,8295955 | CROCHE | Croche 5.8T, 3060m filés 1614m de la cible |
| 06/06/2015 | 09:51:00 | -25,999828 | 170,8292859 | CROCHE | Croche 6.3T, 3060m filés 1685m de la cible |
| 06/06/2015 | 09:53:00 | -26,000082 | 170,828713 | CROCHE | Croche 8.4T, 3063m filés 1768m de la cible |
| 06/06/2015 | 09:54:00 | -26,000200 | 170,82844 | CROCHE | Croche 6.2T, 3063m filés 1694m de la cible |
| 06/06/2015 | 10:21:00 | -25,997412 | 170,8298669 | CROCHE | Croche 15T, 2907m filés 1490m de la cible |
| 06/06/2015 | 10:22:00 | -25,997302 | 170,8299713 | CROCHE | Croche 8.2T, 2892m filés 1485m de la cible |
| 06/06/2015 | 10:27:00 | -25,997008 | 170,8303447 | CROCHE | Croche 8.2T, 2892m filés 1485m de la cible |
| 06/06/2015 | 10:32:00 | -25,996803 | 170,829752 | DEBUT VIRAGE | 2640m filés, 1483m de la cible |
| 06/06/2015 | 10:32:00 | -25,996803 | 170,829752 | DRAGUE DECOLLEE | Drague décollée, 2640m filé, 1483m de la cible |
| 06/06/2015 | 11:30:02 | -25,996491 | 170,8149871 | A BORD | DR_020 à bord |

**Approx. weight:** 3 kg
**Main rock types:** Very altered basalt
**Other rock types:**
**Dredging notes:** Dredge must have barely plucked Mn rinds and not much underlying rock.


DR020



DR020A

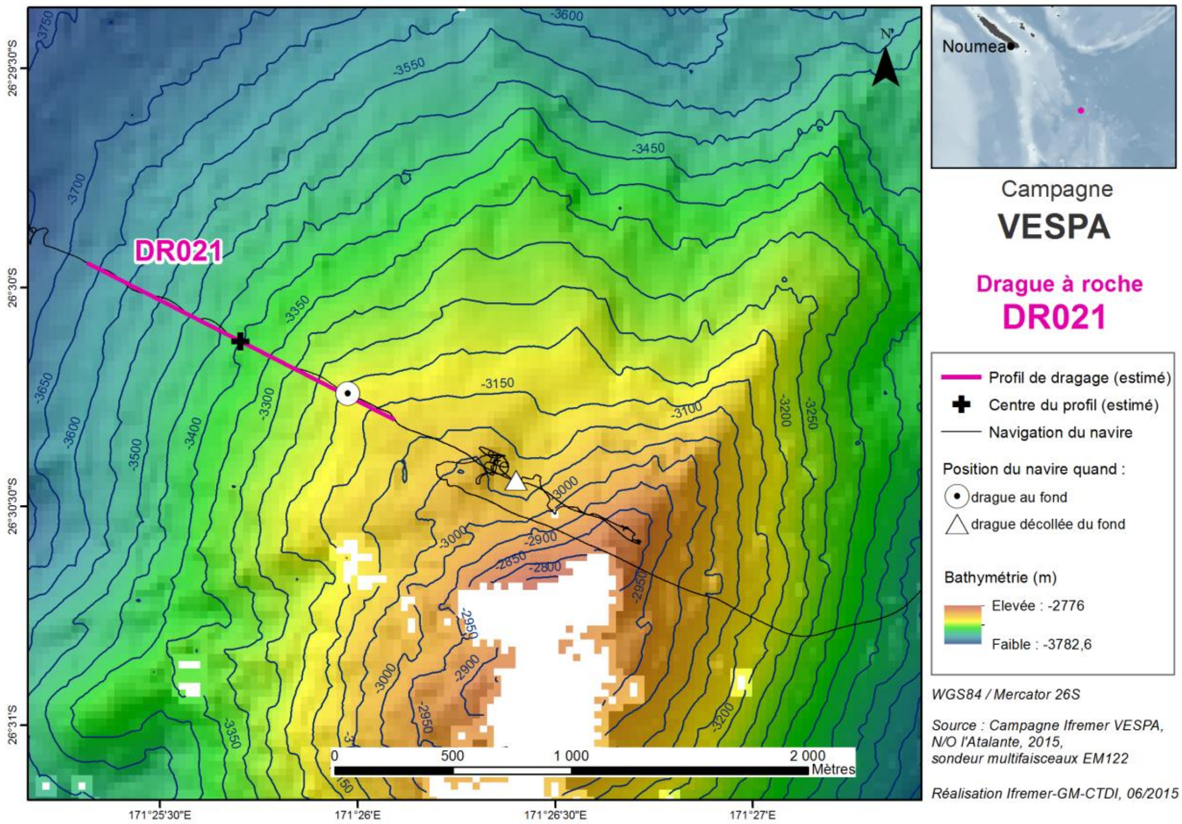

DR020B rock clast in sediment pipe

**DR20A:** One 15x10x10cm block of light brown vesicular, very highly altered olivine basalt . This was the only attached substrate rock to a large slab of 5 cm thick Mn crust. Lava is highly penetrated by Mn. Glassy groundmass is mainly altered to red clay. Grey patches adjacent to vesicles are probably reduced altered basakt, not less altered basalt.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR20B:** Five pieces 7x7x7 cm typical Mn crust.
*Subsample at IFREMER Brest*

# *DR21*

**Target:** South Fiji Basin area. Western seamount in South Fiji Basin North of Cook Fracture Zone



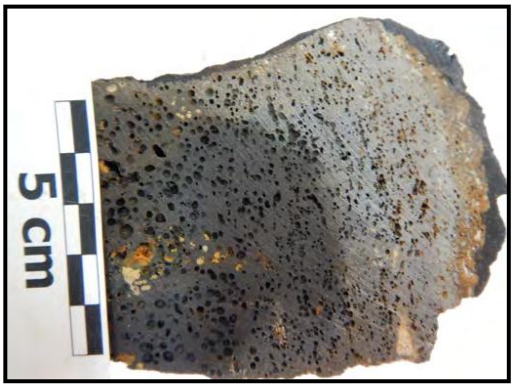

| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 06/06/2015 | 18:30:47 | -26,483049 | 171,5099825 | MISE A L'EAU | |
| 06/06/2015 | 19:02:03 | -26,471793 | 171,4937778 | INCIDENT | Arrêt du dragage. Le bateau va trop vite. |
| 06/06/2015 | 20:40:01 | -26,491987 | 171,4044414 | MISE A L'EAU | DR_021_O-E |
| 06/06/2015 | 20:55:34 | -26,494383 | 171,41118 | DEBUT DE FILAGE | DR_021_O-E, 1070m de la cible |
| 06/06/2015 | 22:19:00 | -26,504038 | 171,4329133 | AU FOND | Drague au fond DR_021, 3960m filés, 1357m de la cible |
| 06/06/2015 | 22:34:00 | -26,506894 | 171,4387867 | CROCHE | Croche 7.3T, 4196m filés, 2009m de la cible |
| 06/06/2015 | 22:38:27 | -26,507475 | 171,4405686 | DEBUT VIRAGE | 4194m filés, 2158m de la cible |
| 06/06/2015 | 22:40:18 | -26,507759 | 171,4412429 | CROCHE | Croche 11T, 4170m filés, 2235m de la cible |
| 06/06/2015 | 22:48:33 | -26,509114 | 171,4440858 | CROCHE | Croche 8T, 4068m filés, 2540m de la cible |
| 06/06/2015 | 22:50:03 | -26,509471 | 171,4445638 | CROCHE | Croche 10,1T, 4038m filés, 2640m de la cible |
| 06/06/2015 | 22:57:03 | -26,509615 | 171,4450035 | CROCHE | Croche 10.2T, 3874m filés, 2657m de la cible |
| 06/06/2015 | 23:02:28 | -26,509144 | 171,4447208 | CROCHE | Croche 10.7T, 3742m filés, 2615m de la cible |
| 06/06/2015 | 23:09:29 | -26,509127 | 171,4445646 | CROCHE | Croche 10.2T, 3520m filés, 2607m de la cible |
| 06/06/2015 | 23:34:17 | -26,507260 | 171,4404842 | CROCHE | Croche 16T, 3267m filés, 2127m de la cible |
| 06/06/2015 | 23:37:17 | -26,507336 | 171,4400197 | DRAGUE DECOLLEE | Drague décollée 3090m filés, 2092m de la cible |
| 07/06/2015 | 00:45:00 | -26,506818 | 171,4366539 | A BORD | DR_021 à bord |

**Approx. weight:** 70 kg in ~10 pieces

**Main rock types:** Vesicular, pillowed aphyric basalts as big boulders and smaller pieces
**Extra types:** White cemented volcanic monomict breccia

DR021

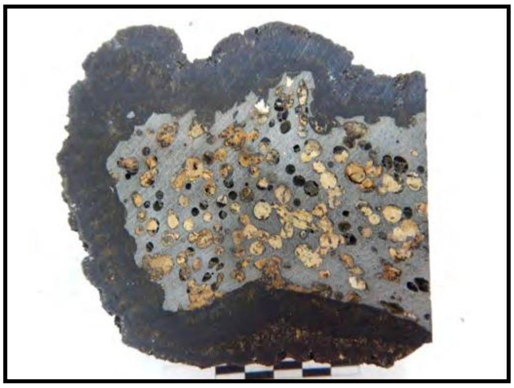

DR021A




DR021A


DR021Bi


DR021Bii



DR021Biii


DR021C

DR021D


DR021D

DR021E

DR021F

**DR21A:** One 70x50x40 cm boulder of medium dark grey (N4) aphyric pillow basalt. Dimensions of basalt without Mn are only 30x20x20 cm i.e. it has a thick Mn crust. One face has a convex, rounded outline. Altered rind of devitrified and some possibly fresh glass. 30-40% round amygdules 2.3 mm in size (up to 1 cm) mostly filled with white non-carbonate material (clay or other sediment?).
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR21Bi:** Three separate pieces 16x10x15cm, 16x18x10cm and 10x7x3cm of medium dark grey (N4) highly vesicular aphyric basalt similar to A but fewer vesicles/amygdules. 1mm-1cm Mn rind.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR21Bii:** 10x7x5 cm piece of medium dark grey (N4) aphyric vesicular basalt. Less vesicular (20%) compared to A and Bi. Very few orange crystals (altered olivine) Mn rind up to 2cm.
*Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR21Biii:** Two pieces, 9x10x4cm and 14x7x5cm of medium dark grey (N4) basalt aphyric(?) amygdaloidal basalt. Thick Mn crust (up to 3 cm).
*Subsample at SGNC Nouméa*

**DR21C:** 18x12x10 cm block of greyish red (5 R4/2) basalt. Possible pillow lava (altered rind seen). Highly vesicular (30%). Vesicles are round and up to 3 mm in size. Half are filled with material as above. Visibly redder than others.
*Subsamples at IUEM Brest, SGNC Nouméa*

**DR21D:** 20x10x15 cm block of medium grey (N5) vesicular aphyric vesicular basalt. Vesicles are larger but with fewer amygdule infillings than other samples. Thin Mn crust
*Subsamples at IUEM Brest, SGNC Nouméa*

**DR21E:** One rounded 15x10x7 cm lump of pumice.
*Sample at SGNC Nouméa*

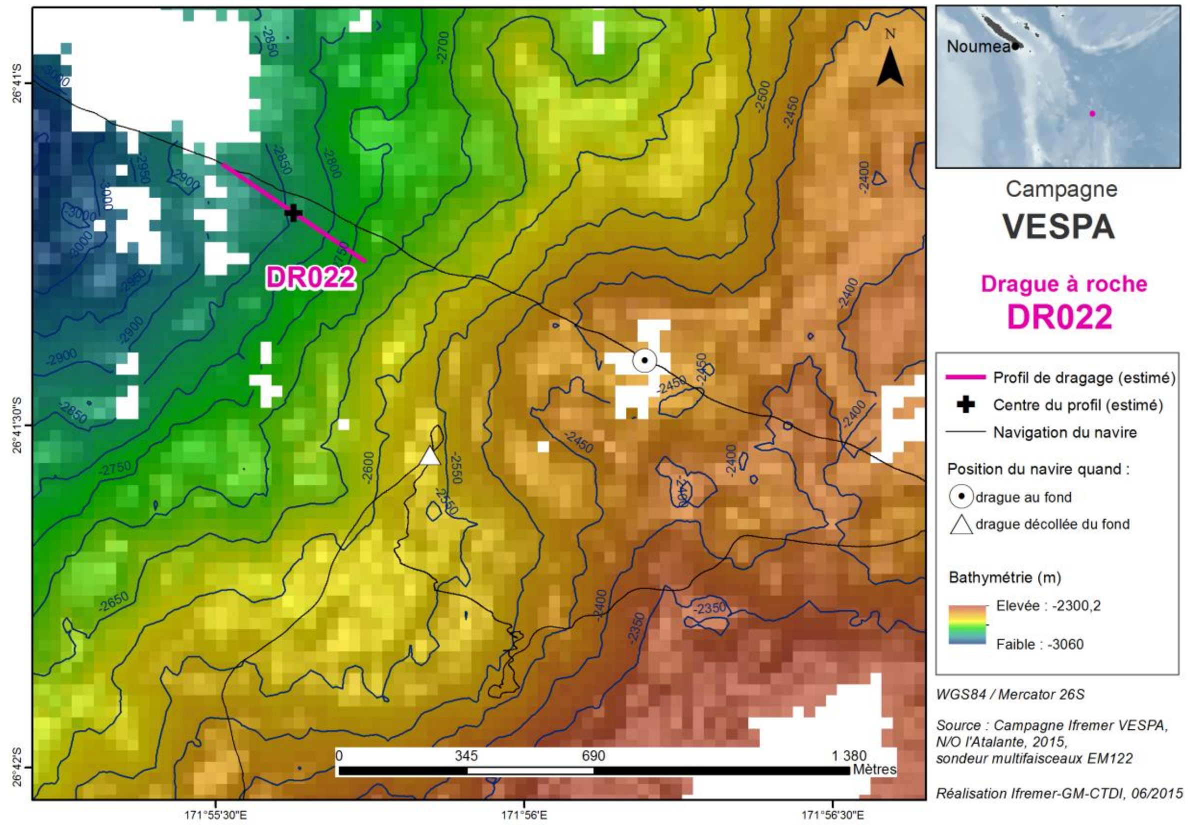
**DR21F:** Mn crust.
*Subsamples at IFREMER Brest, SGNC Nouméa*

**DR21G:** 20x15x10 cm piece of volcanic breccia. Cemented with white non-calcareous material. Moderately sorted hyaloclastite breccia mantled and penetrated by Mn rind. Fresh glass in many clastic fragments which are mainly 1-2 cm size.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR21H:** Seafloor sediment pipe sample.
*Subsample at GNS Wellington*

# *DR22*

**Target:** South Fiji Basin area. Large seamount on west side of inferred South Fiji Basin spreading
axis.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 07/06/2015 | 06:53:25 | -26,679971 | 171,9126238 | MISE A L'EAU | Mise à l'eau DR_022 |
| 07/06/2015 | 07:05:06 | -26,681205 | 171,9153827 | DEBUT DE FILAGE | Début filage DR_022, 1248m de la cible |
| 07/06/2015 | 07:55:00 | -26,690080 | 171,9366002 | AU FOND | Drague au fond, 3220m filés, 1096m de la cible |
| 07/06/2015 | 08:05:00 | -26,691679 | 171,9405738 | CROCHE | Croche de 7T, 3400m filés, 1543m de la cible |
| 07/06/2015 | 08:09:03 | -26,692416 | 171,9427607 | DEBUT VIRAGE | 3399m filés, 1790m de la cible |
| 07/06/2015 | 08:11:00 | -26,692835 | 171,9437479 | CROCHE | Croche 9T, 3373m filés, 1908m de la cible |
| 07/06/2015 | 08:13:00 | -26,693156 | 171,9444015 | CROCHE | Croche 16T, 3362m filés, 1958m de la cible |
| 07/06/2015 | 10:15:11 | -26,692581 | 171,930748 | CROCHE | Croche 19T, 2836m filés, 810m de la cible |
| 07/06/2015 | 10:17:10 | -26,692185 | 171,9308665 | CROCHE | Croche 15T, 2796m filés, 635m de la cible |
| 07/06/2015 | 10:20:29 | -26,691684 | 171,93103 | CROCHE | Croche 12,5T, 2700m filés, 767m de la cible |
| 07/06/2015 | 10:24:08 | -26,692381 | 171,9307886 | DRAGUE DECOLLEE | Drague décollée, 2540m filés, 817m de la cible |
| 07/06/2015 | 11:11:58 | -26,712455 | 171,9263999 | A BORD | DR_022 à bord |

**Weight:** 45 kg
**Main rock types:** Pillow basalt with fresh glass rinds
**Other rock types:** Soft carbonate infill
**Dredging notes:**


DR022

DR022A


DR022A (fresh black glass)


DR022B

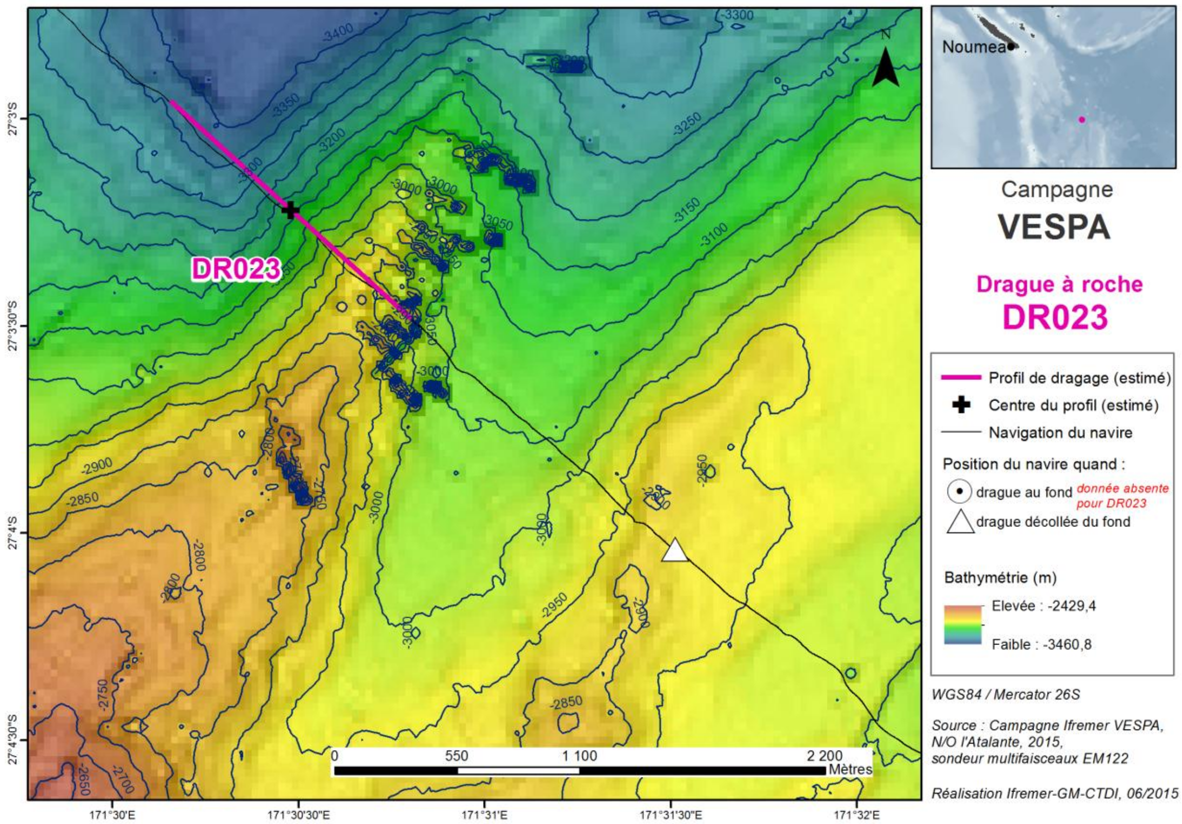
**DR22A:** One 40x35x30 cm piece of medium grey (N5) pillow basalt with fresh glassy rinds. Classical radial cooling/contraction fracture structure. Sparsely olivine-phyric (altered)(1%), small vesicles (7%). Glassy margin under Mn crust (some glass well preserved).
*Sample at IUEM Brest, GNS Wellington, SGNC Nouméa*

**DR22B:** One piece (size not recorded) of pillow basalt with carbonate (fizzes in acid) infill. Soft cream carbonate with microfossils fill fissure within basalt. Some conspicuous microfossils (forams) followed by Mn crust.
*Sample at GNS Wellington*

**DR22C:** Seafloor sediment pipe sample. Soft orange-brown mud.
*Sample at GNS Wellington*

# *DR23*

**Target:** Three Kings Ridge area. Fault scarp in a terrace well west of the main Three Kings
Ridge

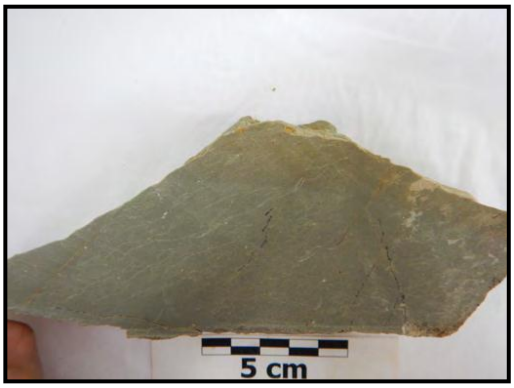



| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 07/06/2015 | 15:27:00 | -27,040387 | 171,4917448 | MISE A L'EAU | Mise à l'eau DR_023. 1776 m de la cible |
| 07/06/2015 | 15:40:30 | -27,044322 | 171,4959124 | DEBUT DE FILAGE | Début filage DR_023, 1310m de la cible |
| 07/06/2015 | 16:47:11 | -27,062482 | 171,5188637 | CROCHE | Croche 7.2T, 4064m filés, 1700m de la cible |
| 07/06/2015 | 16:49:00 | -27,062855 | 171,5194126 | DEBUT VIRAGE | 4064m filés, 1796m de la cible |
| 07/06/2015 | 17:06:42 | -27,066406 | 171,5239957 | CROCHE | Croche 12T, 3780m filés, 2352m de la cible |
| 07/06/2015 | 17:09:12 | -27,066849 | 171,524546 | CROCHE | Croche 9.2T, 3610m de filés, 2463m de la cible |
| 07/06/2015 | 17:11:00 | -27,067327 | 171,5251997 | DRAGUE DECOLLEE | 3530m filés, 1480m de la cible |
| 07/06/2015 | 18:24:00 | -27,080797 | 171,5484342 | A BORD | DR_023 à bord |

**Approx. weight:** 250 kg
**Major rock types:** Siltstone
**Minor rock types:** Cataclastic siltstone, foram ooze
**Dredging notes:** Dredge was 60% full of angular decimetre-sized pieces. No boulders. Based on abundance of closely-jointed and cataclastic rock, a fault zone was dredged.

DR023


DR023A



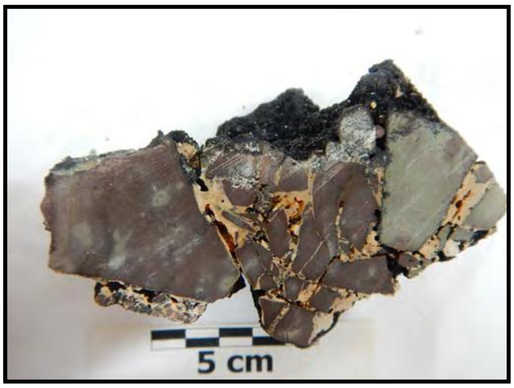

DR023B


DR023C


DR023D


DR023E


DR023F




DR023G

**DR23A:** Hundreds of decimetre-size angular joint blocks total of hard, light olive grey (5 Y 5/2) mottled and weakly bedded sandy siltstone. Non-calcareous. Some trace fossils, intensely bioturbated, abundant microfossils.
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR23B:** Hundreds of decimetre-size angular joint blocks total of hard, pale olive (10 Y 6/2) uniform, homogeneous coarse siltstone. Non-calcareous. Scattered very fine sand grains. Abundant microfossils - radiolarians?
*Subsamples at GNS Wellington, SGNC Nouméa*

**DR23C:** Hundreds of decimetre-size angular joint blocks total of hard, yellowish grey (5 Y 7/2) uniform, homogeneous siltstone. MnO2 dendrites on fractures and inside the rock. Intensely bioturbated. Abundant microfossils.
Subsamples at GNS Wellington, SGNC Nouméa

**DR23D:** Decimetre-size joint blocks, probably <5% of total dredge. Hard, yellowish grey (5 Y 7/2) slightly calcareous silitstone. Otherwise similar to DR23C. Has microfossils.
Subsamples at GNS Wellington, SGNC Nouméa

**DR23E:** Decimetre-size joint blocks, probably <5% of total dredge. Hard, greyish red purple 5 RP 4/2 siltstone, otherwise similar to DR23C.
Subsamples at GNS Wellington, SGNC Nouméa

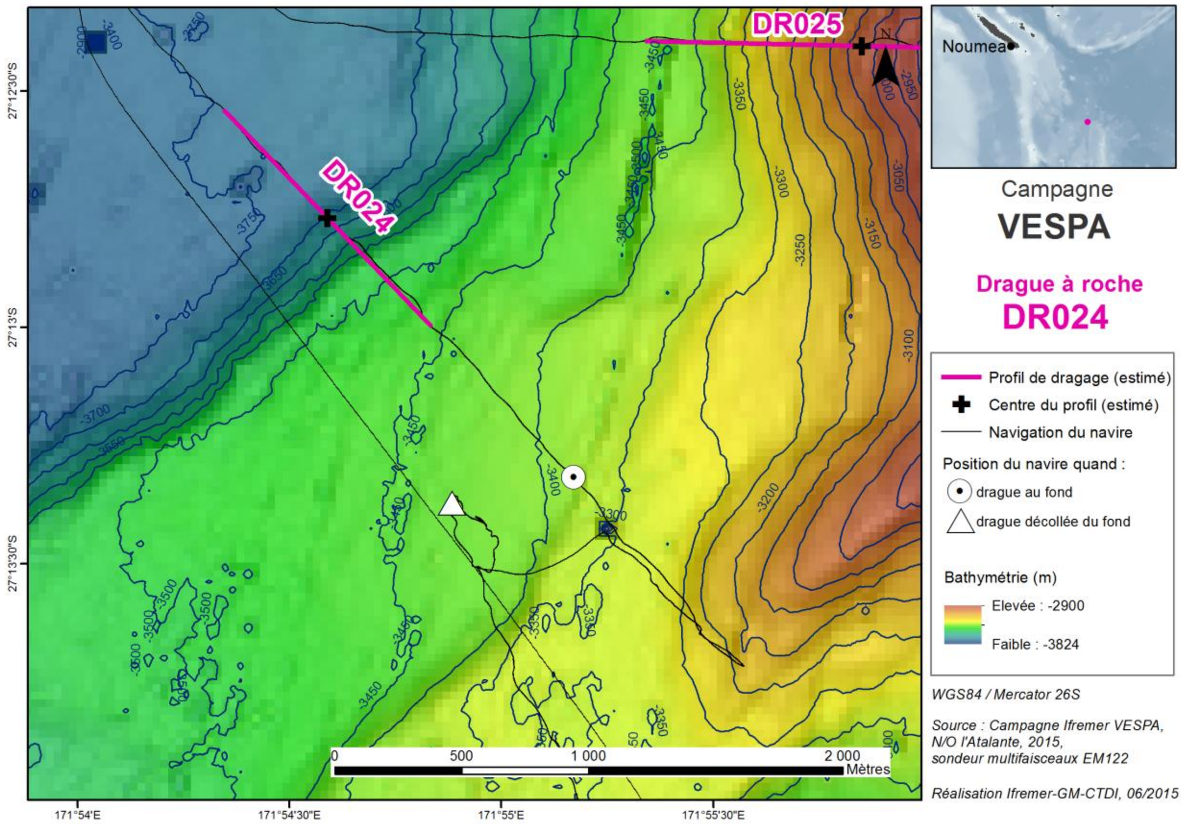
**DR23F:** Three 30cm slabs of hard, cemented monomict cataclastic siltstone breccia. Cement colour is pale yellowish orange 10 YR 8/6. Non-calcareous, could be siliceous, phosphatic or ?barite. Angular clasts of siltstone are mm-cm size. Includes band of brittely pulled-apart pale grey carbonate lithology (marble, limestone or, more likely, a calcite vein).
Subsamples at GNS Wellington, SGNC Nouméa

**DR23G:** One 10x10x7cm piece of polymict red and green siltstone breccia (clasts similar to C and E). Non-calcareous micritic cement like F. Microfossils are present in clasts and in micritic cement.
Subsamples at GNS Wellington, SGNC Nouméa

**DR23H:** Seafloor sediment pipe sample.
Subsample at GNS Wellington

# *DR24*

**Target:** Three Kings Ridge area. Eastern scarp of the northern Cagou Trough, lower part.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 07/06/2015 | 21:57:09 | -27,200007 | 171,8963971 | MISE A L'EAU | Mise à l'eau DR_024, 1853m de la cible |
| 07/06/2015 | 22:06:07 | -27,202923 | 171,8992651 | DEBUT DE FILAGE | Début de filage DR_023, 1474m de la cible |
| 07/06/2015 | 23:12:13 | -27,221938 | 171,9195051 | AU FOND | Drague au fond, 4360m filés, 1461m de la cible |
| 07/06/2015 | 23:28:08 | -27,226639 | 171,9241041 | CROCHE | Croche 8,3T, 4399m filés, 2139m de la cible |
| 07/06/2015 | 23:30:15 | -27,227157 | 171,9243374 | DEBUT VIRAGE | 4390m filés, 2198m de la cible |
| 07/06/2015 | 23:34:00 | -27,228066 | 171,9255473 | CROCHE | Croche 15,8T, 4328m filés, 2356m de la cible |
| 08/06/2015 | 00:09:24 | -27,223878 | 171,9207716 | CROCHE | Croche, 3995m filés, 1672m de la cible |
| 08/06/2015 | 00:15:05 | -27,225113 | 171,9185516 | CROCHE | Crochée 10.5T, 3814m filés, 1663m de la cible |
| 08/06/2015 | 00:31:08 | -27,22356 | 171,9149239 | CROCHE | Dérochée, 3672m filés, 1330m de la cible |
| 08/06/2015 | 00:34:23 | -27,222873 | 171,9147231 | DRAGUE DECOLLEE | Drague décollée, 3580m filés, 1252m de la cible |
| 08/06/2015 | 01:53:00 | -27,228865 | 171,917132 | A BORD | DR_024 à bord |

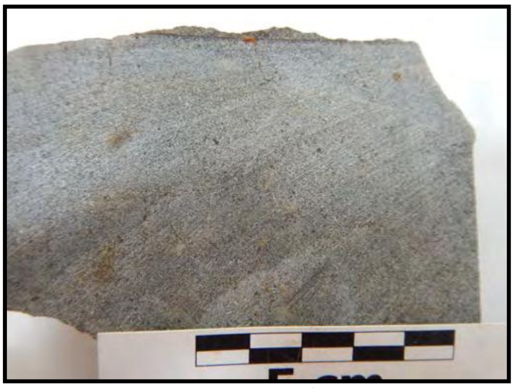
**Approx. weight:** 350 kg. Dredge 50% full
**Major rock types:** Pillow basaltic andesite with fresh glass rinds
**Minor rock types:** Cumulate gabbro, silty mudstone
**Dredging notes:**


DR024

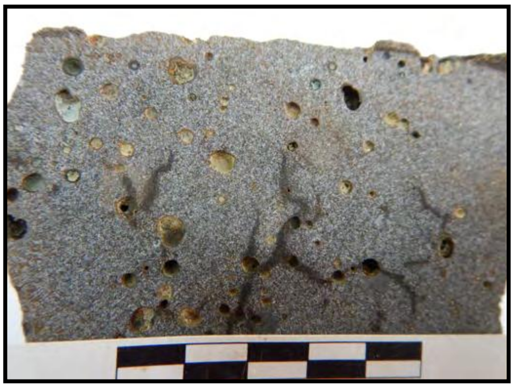

DR024Ai

DR024Ai


DR024Aii



DR024Bi



DR024C


DR024D

DR024E

**DR24Ai:** Four pieces 25x15x11 cm, 10x10x5 cm, 13x9x6 cm, 10x7x5 cm retained of hard, dense, light grey (N6) to greyish black (N2) olivine + plagioclase porphyritic basalt. Largest piece is wedge shaped, jointed and with a convex face, it probably represents part of a pillow. Fresh black glassy rinds up to 1.3 cm thick. Plagioclase <5% up to 5 mm in size, olivine (red, altered) 3% up to 1 mm. Circumferential crack under rind is filled with white, non- calcareous micritic material.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR24Aii:** Four pieces 26x12x11 cm, rest 9x7x7 cm or smaller retained of rock type similar to DR24Ai but less fresh: a greyish orange (10 YR 7/4) colour.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR24Bi:** Three pieces 24x14x12 cm, 15x15x10 cm and 10x10x3 cm retained of hard, medium grey (N5) fine grained (c. 0.3mm) aphyric non-vesicular basalt. No glassy rind. Consists of c. 35% plagioclase and 65% pyroxene.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR24Bii:** Four pieces, one 20x10x10 cm, rest 15x10x2 cm retained of medium grey (N5) fine grained, nonvesicular basalt similar to DR24Bi but with phenocrysts up to 1 mm in size and contains (altered) olivine. Consists of 5% olivine, 20% plagioclase and 75% pyroxene.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

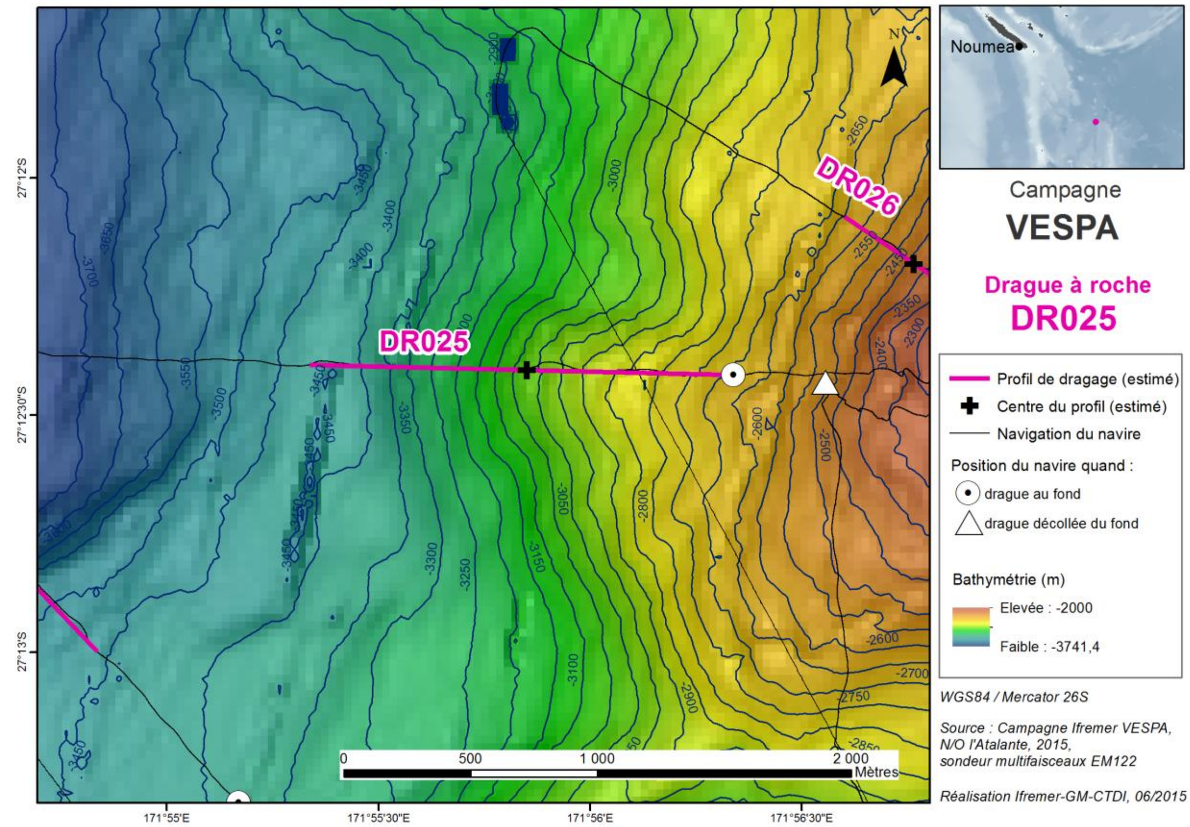
**DR24C:** Four 10x10x5 cm pieces retained of medium grey (N5) fine grained vesicular basalt. 5% vesicles, 40% plagioclase, 55% pyroxene, trace olivine. 0.3mm grain size, olivines up to 1mm. Vesicles filled with whitish yellow material.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR24D:** Dozens of pieces, typical size 10x10x3 cm. Medium dark grey (N4) fine to coarse grained inequigranular cumulate gabbro. Cumulate pyroxene is 5 mm in size (partly altered to hornblende?). Intercumulus material is a fine grained olivine, pyroxene, plagioclase gabbro. Olivine 1 mm, <7%.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR24E:** One 10x5x4cm piece of greyish orange (10 YR 5/4) silty mudstone. Bored, some tubes have Mn infiltration.
Subsamples at GNS Wellington, SGNC Nouméa

# *DR25*

**Target:** Three Kings Ridge area. Eastern scarp of the northern Cagou Trough, middle part.

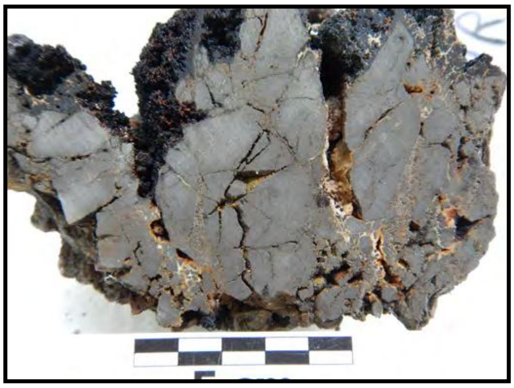



| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 08/06/2015 | 02:58:00 | -27,202520 | 171,9039248 | MISE A L'EAU | Mise à l'eau DR_025, 1963m de la cible |
| 08/06/2015 | 03:20:00 | -27,206314 | 171,9144867 | DEBUT DE FILAGE | Début de filage DR_025 |
| 08/06/2015 | 04:14:18 | -27,206905 | 171,9389844 | AU FOND | Drague au fond |
| 08/06/2015 | 04:14:29 | -27,206905 | 171,9389844 | CROCHE | Croche 7.5T, 3852m filés, 1475m de cible |
| 08/06/2015 | 04:22:01 | -27,206932 | 171,9419707 | DEBUT VIRAGE | 3852m filés, 3274m de la cible |
| 08/06/2015 | 05:01:00 | -27,208404 | 171,9479722 | CROCHE | 18T, 2864m filés, 2352m de cible |
| 08/06/2015 | 05:47:00 | -27,207177 | 171,9426027 | DRAGUE DECOLLEE | Drague décollée, 2729m filés, 1819m de la cible |
| 08/06/2015 | 06:53:00 | -27,228177 | 171,9477932 | A BORD | DR_025 à bord |

**Approx. weight:** 600 kg
**Main rock types:** Basalt
**Other rock types:** Andesite
**Dredging notes:**

DR025

DR025Ai



DR025Aii


DR025B

DR025Ci

DR025Cii

DR025D

DR025E

DR025F

DR025G

**DR25Ai:** Three pieces, c. 30x10x10 cm, retained of hard, dense, medium light grey (N5) aphyric basalt. Some oxidation alteration along cracks. Chilled margin along one piece.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR25Aii:** Similar to Ai with 'bread crust' brecciated surfaces.
Subsamples at GNS Wellington, SGNC Nouméa

**DR25B:** Three pieces 30x20x20 cm retained of hard, medium light grey (N6) slightly porphyritic basalt. Phenocrysts of olivine (<0.1 mm), plagioclase (<0.1 mm) and pyroxene (<0.5 mm). Olivine altered.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR25Ci:** Two pieces, 15x10x10cm retained of hard, light grey (N6), medium grained (0.5 mm) equigranular basalt. Olivine, pyroxene and plagioclase.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR25Cii:** 15x10x10 cm piece retained of basalt similar to Ci but with porphyritic feldspars, up to 1 mm in size.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR25D:** Three pieces 15x15x15cm retained of light brownish grey (5 YR 6/1) highly plagioclase porphyritic andesite or basaltic andesite. Minor pyroxene phenocrysts too. Total phenocrysts 15%, up to 2 mm in size.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR25E:** Two pieces 10x10x10 cm retained, of medium dark grey (N4) basalt with relatively large (1 mm) sized phenocrysts that are >50% of rock, mainly of plagioclase but also some olivine (altered) and pyroxene.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR25F:** Two pieces up to 30x10x10 cm retained of brecciated porphyritic basalt similar to DR25B.
Subsamples at GNS Wellington, SGNC Nouméa

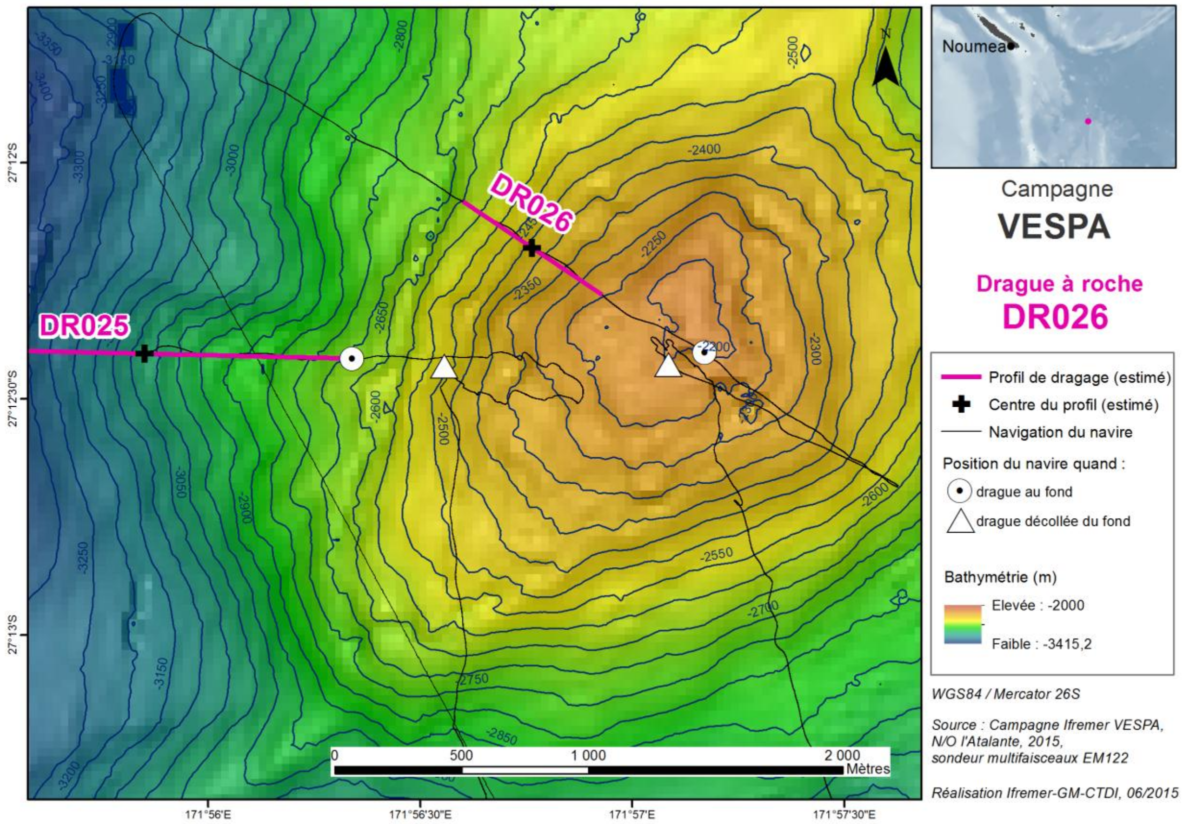
**DR25G:** One 10x5x5 cm rounded lump of pumice, very light grey (N7). Highly vesicular. Has fiamme.

Sample at SGNC Nouméa

**DR25H:** sea floor sediment pipe sample
Subsample at GNS Wellington

# *DR26*

**Target:** Three Kings Ridge area. Eastern scarp of the northern Cagou Trough, upper part. Edge of a volcanic feature dredged. Not a guyot.

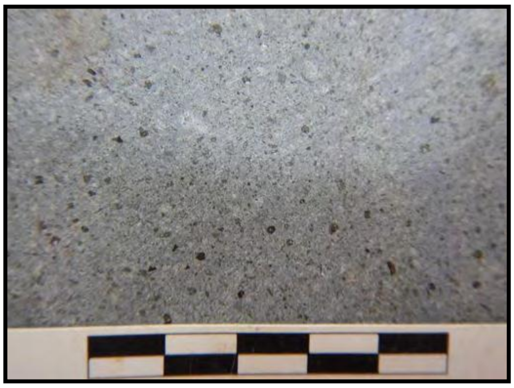



| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 08/06/2015 | 08:07:00 | -27,195017 | 171,9315729 | MISE A L'EAU | Mise à l'eau DR_026 |
| 08/06/2015 | 08:19:00 | -27,197805 | 171,9368576 | DEBUT DE FILAGE | Début de filage DR_026, 822m de la cible |
| 08/06/2015 | 09:00:25 | -27,206689 | 171,952843 | AU FOND | Drague au fond, 2900m filés, 1015m de la cible |
| 08/06/2015 | 09:07:08 | -27,208045 | 171,9548204 | DEBUT VIRAGE | 3100m filés, 1274m de la cible |
| 08/06/2015 | 09:11:05 | -27,208947 | 171,9562268 | CROCHE | Croche 7.5T, 3063m filés, 1438m de la cible |
| 08/06/2015 | 09:15:18 | -27,209702 | 171,9575564 | CROCHE | Croche 9T, 2988m filés, 1585m de la cible |
| 08/06/2015 | 09:19:35 | -27,210452 | 171,9586627 | CROCHE | Croche 9.3T, 2883m filés, 1724m de la cible |
| 08/06/2015 | 09:21:02 | -27,21062 | 171,9590834 | CROCHE | Croche 11.1T, 2844m filés, 1776m de la cible |
| 08/06/2015 | 09:32:05 | -27,210679 | 171,9590221 | CROCHE | Croche de 5 min, 2540m filés, 1733m de la cible |
| 08/06/2015 | 09:54:32 | -27,207121 | 171,9514228 | CROCHE | Croche de 20min, 2264m filés, 933m de la cible |
| 08/06/2015 | 09:54:35 | -27,207121 | 171,9514228 | DRAGUE DECOLLEE | Drague décollé, 2230m filés, 890m de la cible |
| 08/06/2015 | 10:50:34 | -27,210284 | 171,9532624 | A BORD | DR_026 à bord |

**Approx. weight:** 700 kg
**Main rock types:** Biotite andesite
**Other rock types:** Hydrothermally altered granite
**Dredging notes:**

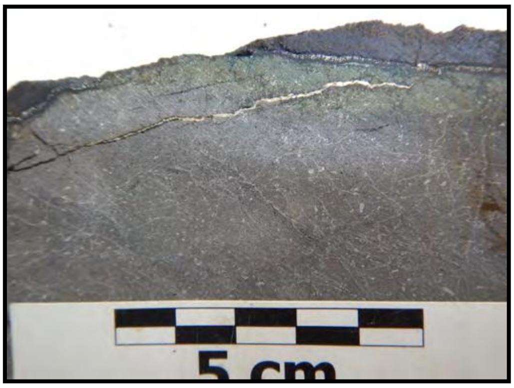
**DR026**

**DR026Ai**



**DR026Aii**

**DR026Aiii**



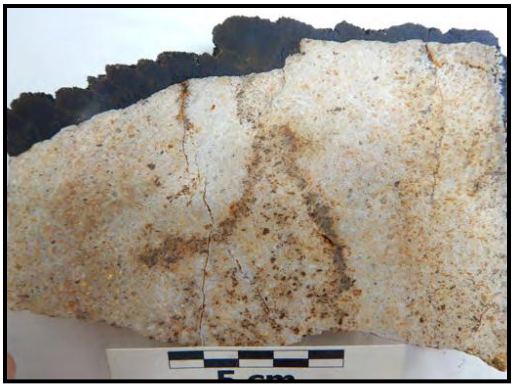

**DR026B**

**DR026C**

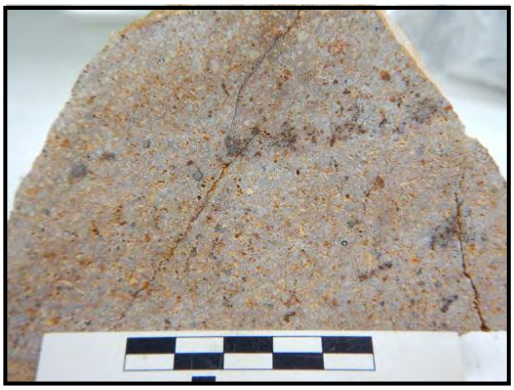
**DR026D**

**DR026E**

DR026Fi

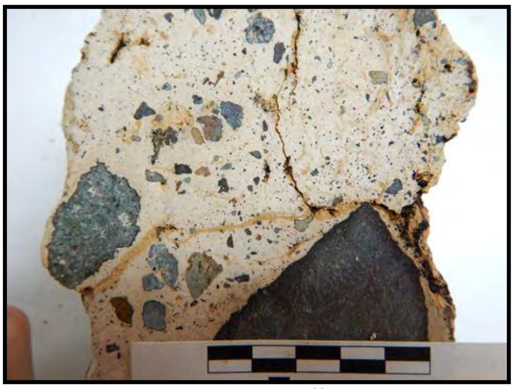


DR026Fii



DR026Fiii

DR026Gi



DR026Gii

**DR26Ai:** one large boulder in dredge, 80x50x50 cm. Hard, medium light grey (N5) biotite porphyritic trachyandesite. 1 mm-sized fresh biotite phenocrysts and feldspar phenocrysts (possibly K-feldspar). Local, wispy mingling textures involve darker, finer grained material of similar composition.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR26Aii:** One 50x40x40 cm piece retained of hard, medium light grey (N5) trachyandesite. Similar to Ai but homogeneous (no mingling) and <1% amphibole phenocrysts as mm-long needles.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR26Aiii:** One 40x30x30 cm piece retained of trachyandesite. Similar to Ai but more weathered. Biotites still fresh, though.
Subsamples at GNS Wellington, SGNC Nouméa

**DR26Aiv:** 40x30x30 cm piece retained of trachyandesite. Similar to Aii but with more (c. 5%) acicular amphibole phenocrysts. Mn crust 1-2 mm thick.
Subsamples at GNS Wellington, SGNC Nouméa

**DR26B:** 30x20x20 cm piece retained of hard, light brownish grey (5 YR 6/1) weathered aphyric basalt. Possible chilled margins and a 1 cm Mn crust. Numerous fractures with non-calcareous micritic infilling.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR26C:** 5x5x5 cm piece retained (one of few in dredge) of hard, dusky yellow (5 Y 6/4) altered volcanic/tuffisite breccia with an igneous matrix. Angular lithic fragments up to 1cm in size.
Subsamples at GNS Wellington, SGNC Nouméa

**DR26D:** 10x5x5 cm piece retained (one of few in dredge) of hard, greenish grey (5 G 6/1) coarse grained (>1mm) andesitic lava, mostly weathered. 1-2mm size feldspars. Unidentifiable mafic minerals >1mm.
Subsamples at SGNC Nouméa

**DR26E:** 30x20x20 cm piece retained (one of few in dredge) of hard, bicolored greyish blue (5 PB 5/2) and light brownish grey (5 YR 6/1) volcanic breccia/tuffisite. Feldspars and amphiboles identified.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR26Fi:** 15x10x10 cm piece (only one in dredge) of hard, pale yellowish brown (10 YR 6/2) mottled with light brown (5 YR 6/4) equigranular to subporphyritic, medium grained biotite granite. Rusty stains indiocate hydrothermal alteration. Mode c. 55% quartz, 35% feldspar, 5% dark mica. Overall grain size 1 mm, up to 2 mm for feldspars.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR26Fii:** 20x15x10 cm separate piece (only one in dredge) of hard, very pale orange (10 YR 8/2) to pale brown (5 Y 5/2) hydrothermally altered medium grained granite similar to Fi. Slightly more micaceous than Fi (8%) and Mn-crusted.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR26Fiii:** 20x15x10 cm separate piece (only one in dredge) of granite similar to Fi.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

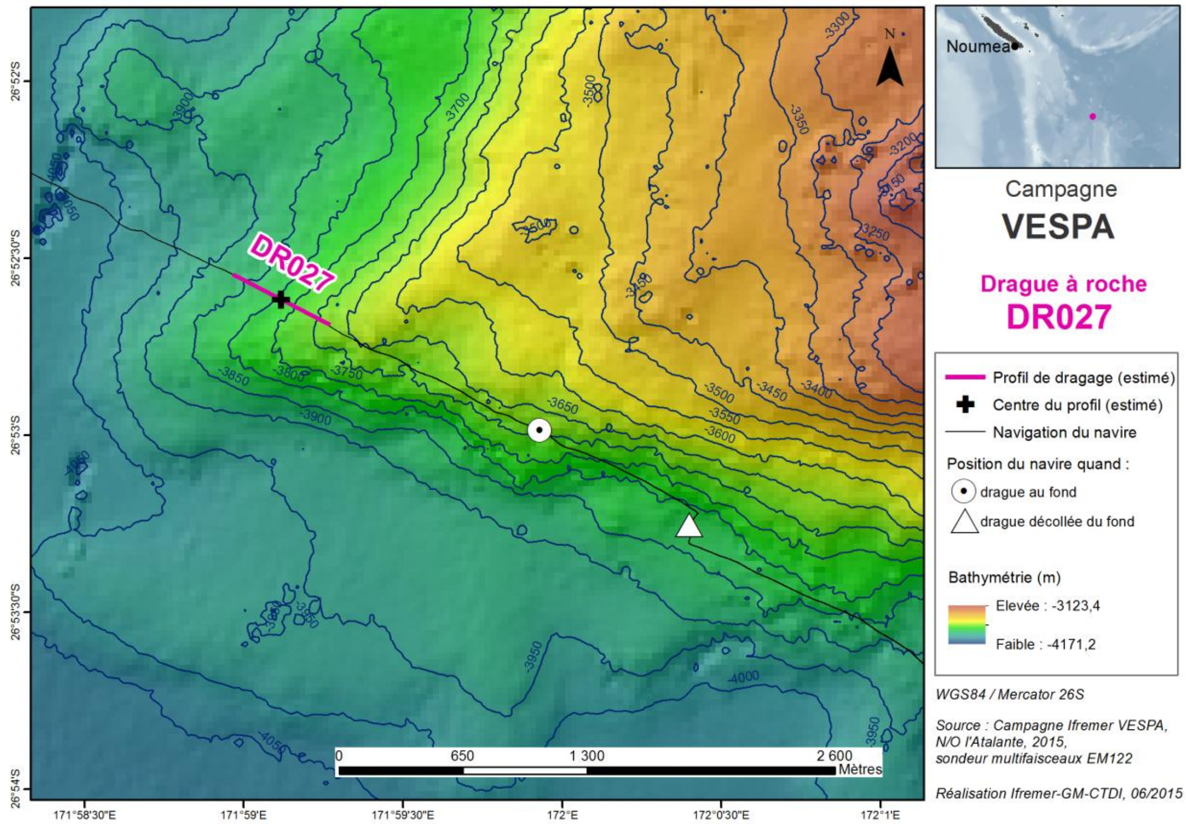
**DR26Gi:** One 20x15x10 cm piece of hard, clast-supported, poorly sorted (2-60 mm) epiclastic polymict volcanic breccia. Clasts are medium grey (N5) and similar to DR26A and B. Matrix is pale yellowish orange (10 YR 8/6) and calcareous.
Subsamples at SGNC Nouméa

**DR26Gii:** Separate 20x5x5 cm piece of breccia similar to DR26Gi. Clast size 1-100mm.
Subsample at SGNC Nouméa

**DR26H:** sea floor sediment pipe sample
Subsample at GNS Wellington

# *DR027*

**Target:** South Fiji Basin area. East side of inferred South Fiji Basin spreading axis, where it intersects the Cook Fracture Zone.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 08/06/2015 | 23:52:39 | -26,869792 | 171,9699115 | MISE A L'EAU | Mise à l'eau DR_027 |
| 08/06/2015 | 23:56:44 | -26,870604 | 171,9714867 | DEBUT DE FILAGE | Début de filage DR_027 |
| 09/06/2015 | 01:06:00 | -26,883102 | 171,9988245 | AU FOND | Drague au fond, 4300 m filés, 2124 m de la cible |
| 09/06/2015 | 01:15:00 | -26,884616 | 172,0023063 | CROCHE | Croche à 7.6T, 4399 m filés, 2535m de la cible |
| 09/06/2015 | 01:20:00 | -26,885528 | 172,0043837 | DEBUT VIRAGE | Début de virage DR_027. 2769m de la cible, 4399 m filés |
| 09/06/2015 | 01:24:00 | -26,886291 | 172,0058883 | CROCHE | Croche à 12.5T environ, 4340 m filés, 2934m de cible |
| 09/06/2015 | 01:26:00 | -26,886561 | 172,00639 | CROCHE | Croche à 9.5T. 4310 m filés, 2982m de la cible |
| 09/06/2015 | 01:35:00 | -26,887570 | 172,0066503 | DRAGUE DECOLLEE | Drague décollée DR_027, 4000 m filés |
| 09/06/2015 | 03:04:00 | -26,903750 | 172,0360203 | A BORD | DR_027 à bord |

**Approx. weight:** 40 kg in small pieces
**Main rock types:** Sparsely olivine-phyric basalt. Very altered but with thin glassy rinds.
**Other rock types:** No other rocks
**Dredging notes:**

DR027

DR027A

DR027A, with fresh glass

DR027B, without fresh glass

**DR27A:** Two pieces 10x10x7cm and 10x7x5cm retained of hard, moderately fresh sparsely olivine-phyric basalt. Fresh glass at rim (except for outermost 1mm = orange palagonite), greyish orange (10 YR 7/4) core-stone is the least fresh. Glass occurs along convex faces strongly suggestive of pillow basalts. Mn rind up to 1.5cm and Mn infiltration along cracks.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

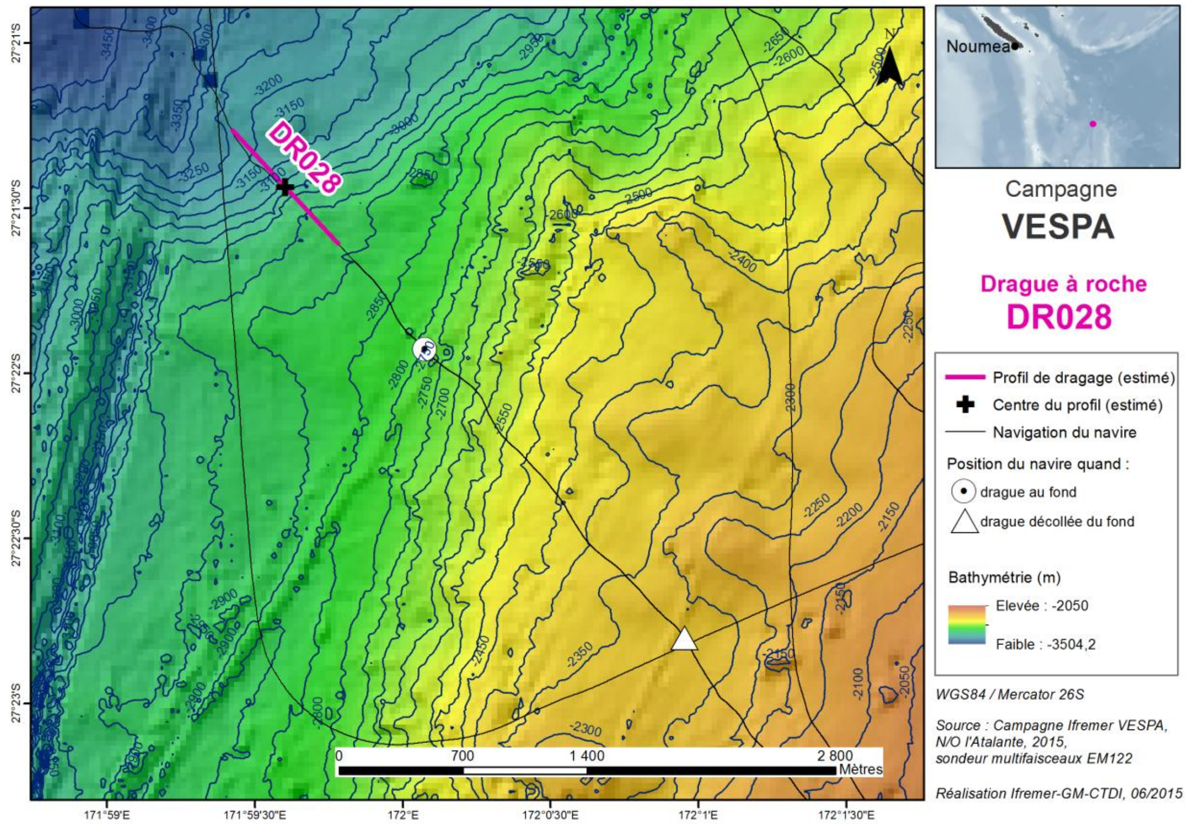
**DR27B:** Similar size pieces and lithology to A except no glass rims preserved. Olive grey 5 Y 4/6.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR27C:** Similar size pieces and lithology to A except this category is the elast fresh: gfreyish orange 10 YR 7/4.
Subsample at SGNC Nouméa

**DR27D:** sea floor sediment pipe sample
Subsample at GNS Wellington

# *DR028*

**Target:** Three Kings Ridge area. E scarp Cagou Trough, middle part.



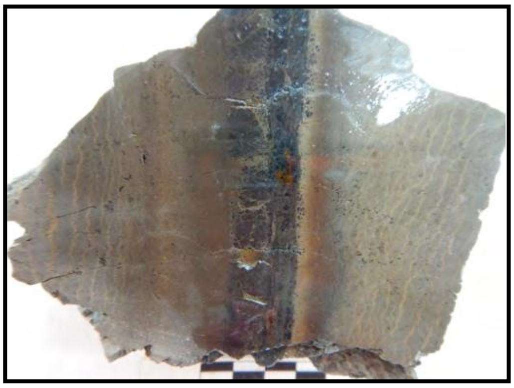

| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 09/06/2015 | 06:10:02 | -27,349247 | 171,9828354 | MISE A L'EAU | Mise à l'eau DR_028 |
| 09/06/2015 | 06:24:48 | -27,350667 | 171,988247 | DEBUT DE FILAGE | Début de filage DR_028,665m de la cible |
| 09/06/2015 | 07:16:00 | -27,365448 | 172,0012468 | AU FOND | Drague au fond, 3450m filés, 1476m de la cible |
| 09/06/2015 | 07:28:52 | -27,369397 | 172,0052878 | CROCHE | 7T, 3650m filés, 2000m de cible |
| 09/06/2015 | 07:30:00 | -27,369664 | 172,0054761 | DEBUT VIRAGE | 3650m filés, 2084m de la cible |
| 09/06/2015 | 07:34:40 | -27,370750 | 172,0066973 | CROCHE | 8T, 3650m filés, 2222m de la cible |
| 09/06/2015 | 07:36:11 | -27,371247 | 172,007194 | CROCHE | 12.5T, 3580m filés, 2352m de la cible |
| 09/06/2015 | 08:06:34 | -27,380016 | 172,0158742 | DRAGUE DECOLLEE | Drague décollée 2438m filés, 1947m de la cible |
| 09/06/2015 | 08:57:53 | -27,395084 | 172,0284925 | A BORD | DR_028 à bord |

**Weight:** 250 kg in small pieces
**Main rock types:** Chilled fragmented glassy basalt-andesite.
**Other rock types:** Devitrified ashy hyaloclastite.
**Dredging notes:**

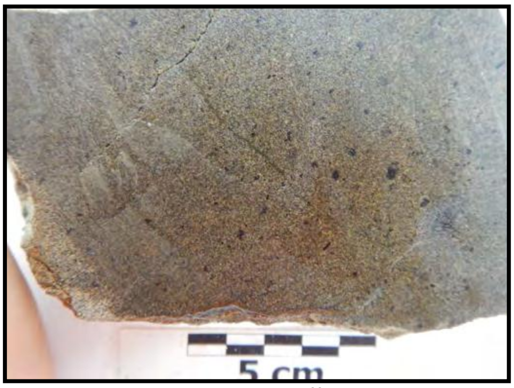
DR028

DR028A

DR028A



DR028A



DR028Bii

DR028C

DR028D


DR028E

**DR28Ai:** 25x15x15 cm piece retained of hard, dark grey (N3) glassy ?andesite with elongate, quench-textured plagioclase microphenocrysts (7%). Dusky yellow green (5GY5/2) celadonite clay (30%, formerly glass) within the rock.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR28Aii:** 10x10x5 cm block retained. Same as Ai but more glass (40%) and less plag (5%). Dark grey (N3). Without celadonite.
Subsamples at IUEM Brest, SGNC Nouméa

**DR28Aiii:** 20x15x10 cm block retained. Dark grey (N3) andesite with 5% plagioclase, 40% glass. Upper part weatered to light olive gray. Crack sfilled with phosphate (?).
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR28Aiv:** 12x12x10 cm piece of banded glassy andesite (10% glass). Glassy part dark gray (N3) to medium light grey where slightly more weathered (flow foliation?).
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR28Av:** 20x15x8 cm piece retained. Typical of most of the dredge in that these pieces are slightly less fresh, a brownish grey (5 YR 4/1) to brownish black (5 YR 2/1) colour.
Subsamples at IUEM Brest, SGNC Nouméa

**DR28Avi:** 28x20x15 cm piece retained. Separate piece, similar to Ai and Aiii.
Subsamples at IUEM Brest, SGNC Nouméa

**DR28Bi:** 30x20x10 cm piece of hard, greenish grey (5 GY 6/1) fine grained basalt. 10% phenocrysts of black pyroxene up to 2mm in size, also plagioclase. Alteration along cracks.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR28Bii:** 30x25x10 cm piece retained of petrographically similar lava to Bi but more altered.
Subsamples at IUEM Brest, SGNC Nouméa

**DR28C:** 10x10x5 cm piece of hard, olive black (5 Y 2/1) olivine porphyritic basalt. 15% phenocrysts.
Subsamples at GNS Wellington, SGNC Nouméa

**DR28D:** 10x10x8 cm piece of hard, moderate yellow-brown (10 YR 5/4) monomict sedimentary breccia-conglomerate. Moderately well sorted, matrix supported. Clasts are basaltic, subrounded to subangular, 1-6mm.
Subsamples at GNS Wellington, SGNC Nouméa

**DR28Ei:** 25x20x10 cm piece retained of hard, light grey (N7) aphyric, very fine grained basalt. Possibly a finer-grained equivalent of Bi.
Subsamples at SGNC Nouméa

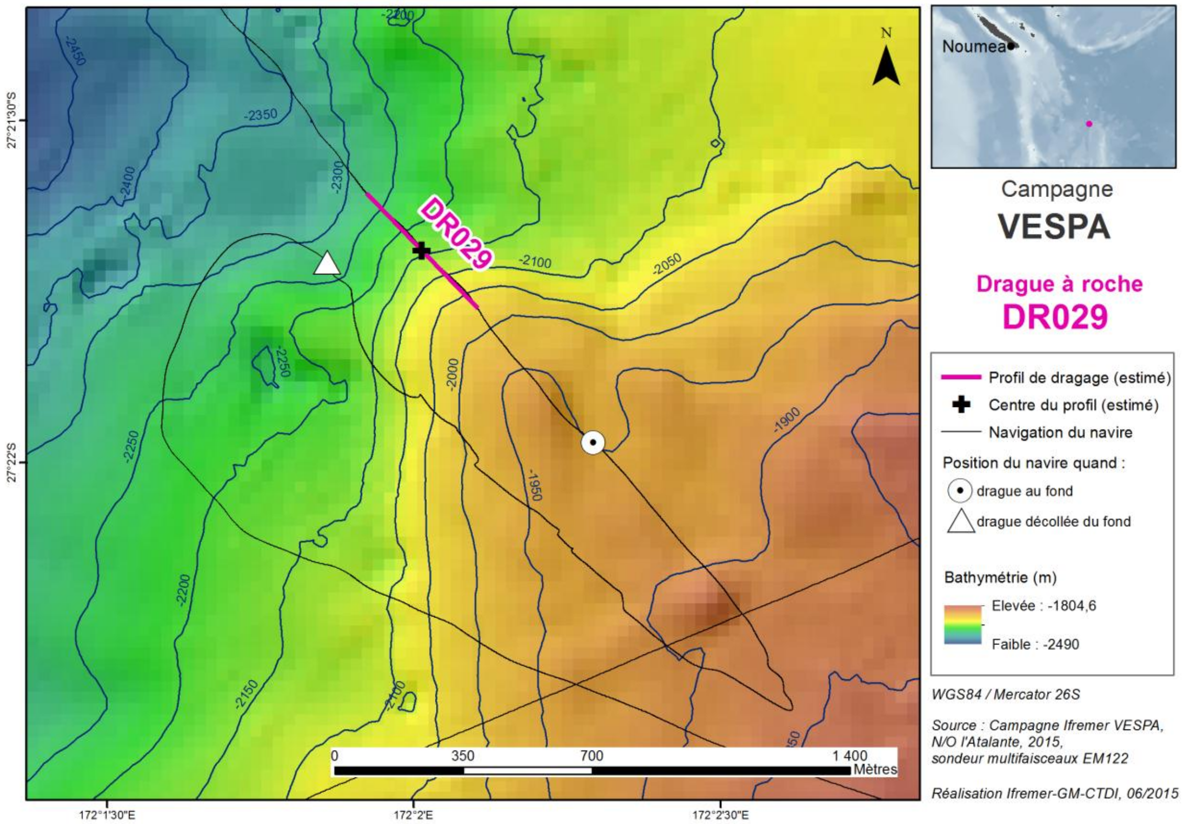
**DR28Eii:** 15x10x6 cm, another piece of lava similar to Ei.
Subsamples at GNS Wellington, SGNC Nouméa

**DR28Eii:** 12x10x10 cm piece as Ci but flow banded like some DR28A samples away from their glassy parts. So probably a coarser, less glassy, more interior part of 'A' samples.
Subsamples at SGNC Nouméa

**DR28F:** sea floor sediment pipe sample
Subsamples at GNS Wellington

# *DR029*

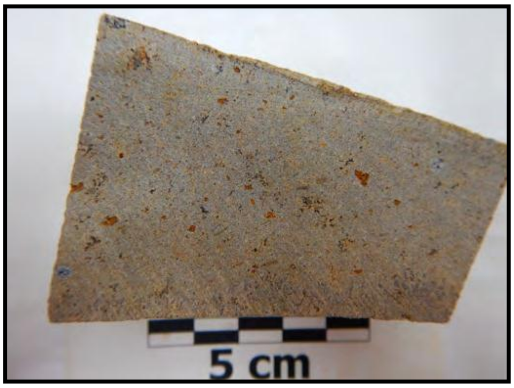
**Target:** Three Kings Ridge area. E scarp Cagou Trough, upper part.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 09/06/2015 | 10:14:25 | -27,352087 | 172,0246169 | MISE A L'EAU | Mise à l'eau DR_029 |
| 09/06/2015 | 10:23:42 | -27,354871 | 172,0272194 | DEBUT DE FILAGE | Début filage DR_029, 805m de la cible |
| 09/06/2015 | 11:01:00 | -27,366174 | 172,038217 | AU FOND | Drague au fond, 2440 m filés, 889 m de la cible |
| 09/06/2015 | 11:10:21 | -27,369108 | 172,0411346 | CROCHE | Croche à 5T, 2650m filés, 1307m de cible |
| 09/06/2015 | 11:14:00 | -27,370134 | 172,0420818 | DEBUT VIRAGE | 2650 m filés, 1481 m de la cible |
| 09/06/2015 | 11:17:00 | -27,371049 | 172,0427683 | CROCHE | Croche à 16T. 2604 m filés, 1589 m de la cible |
| 09/06/2015 | 11:23:00 | -27,372322 | 172,0434477 | CROCHE | Croche à 18T. 2500 m filés, 1737 m de la cible |
| 09/06/2015 | 12:43:00 | -27,361794 | 172,0309779 | DRAGUE DECOLLEE | Drague décollée 2090 m filés, 226 m de la cible |
| 09/06/2015 | 13:36:00 | -27,371299 | 172,0355976 | A BORD | DR_029 à bord |

**Approx. weight:** 40 kg
**Main rock types:** Trachytic/phonolitic lavas, highly altered
**Other rock types:** Bioclastic limestone adhering to lavas and forming matrix to volcaniclastic conglomerate.
**Dredging notes:**

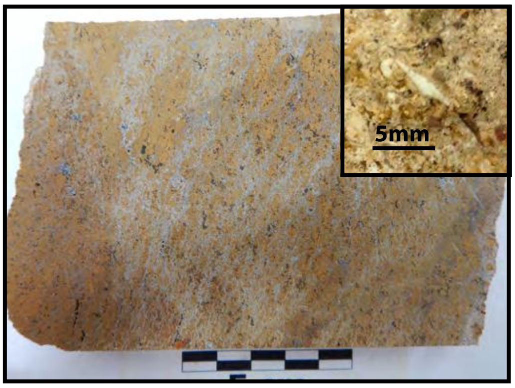
DR029



DR029A


DR029B


DR029C



DR029D


DR029E


DR029F


DR029G

**DR29A:** Several flat 30x30x5 cm slabs of hard, light olive grey (5 Y 6/1) porphyritic ?trachyte with a feldspathic groundmass. Mafic phenocrysts (5-10%) all altered: needle shaped amphiboles are not fresh. Red clay-altered minerals could beolivine (as usual) or maybe pyroxene. There are texturally indisticnt amygdules, xenocrysts or phenocrysts of a clear, glassy mineral (non calcareous, can be scratched with steel); possibly a zeolite. The rock 'rings' like a phonolite when struck. Platy jointing also suggests an intermediate silicic lava. 1 cm Mn crust on one platy piece.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR29B:** Two 7x7x5cm pieces in dredge of hard, greyish orange (10 YR 7/4) porphyritic andesite or dacite. 15% phenocrysts of altered hornblende or biotite and fresh feldspar. Some red alteration veins criss-cross the rock.
Subsamples at GNS Wellington, SGNC Nouméa

**DR29C:** Two 15x15x10cm pieces in dredge of volcanic conglomerate with fossiliferous limestone matrix. Most of sample consist of 12x7x7cm subrounded clast of hard, vesicular, light brown (5 YR 8/4) basalt or andesite. 5% altered mafic phenocrysts (pyroxene?); no feldspar phenocrysts. 30% vesicles are partly filled with zeolite. Sample also has large quantity of attached hard, very pale orange (10 YR 8/2) cemented, bioclastic limestone. This is matrix to a subrounded poorly sorted conglomerate whose clasts are lavas simialr to the main piece and up to 3cm in size. There are a few tiny fresh hornblendes and small fresh lava clasts in the conglomerate. Echinoderm fragments, forams and brachiopod fragments noted.
Subsamples at GNS Wellington, SGNC Nouméa

**DR29D:** One 15x10x10cm piece and one 10x7x5cm piece in dredge of two rock types: (1) hard, dark yellowish orange (10 YR 6/6) flow-foliated, non vesicular lava, somewhat similar to DR29A in that it has altered mafics and scattered water-clear crystals. Rock is penetrated by manganese. (2) Bioclastic limestone as described for DR29C. On oyer surface, Asterocyclina (Late Eocene) was provisionally identified.
Subsamples at GNS Wellington, SGNC Nouméa

**DR29E:** One 15x15x15cm piece in dredge of hard, very weathered and altered light brown (5 YR 5/6) ?andesite. Mafic phenocrysts are 5% of rock (?olivine and/or pyroxene) and are replaced by red clay. Highly vesicular (20%) and zeolite amygdaloidal. Thick Mn rind.
Subsamples at SGNC Nouméa

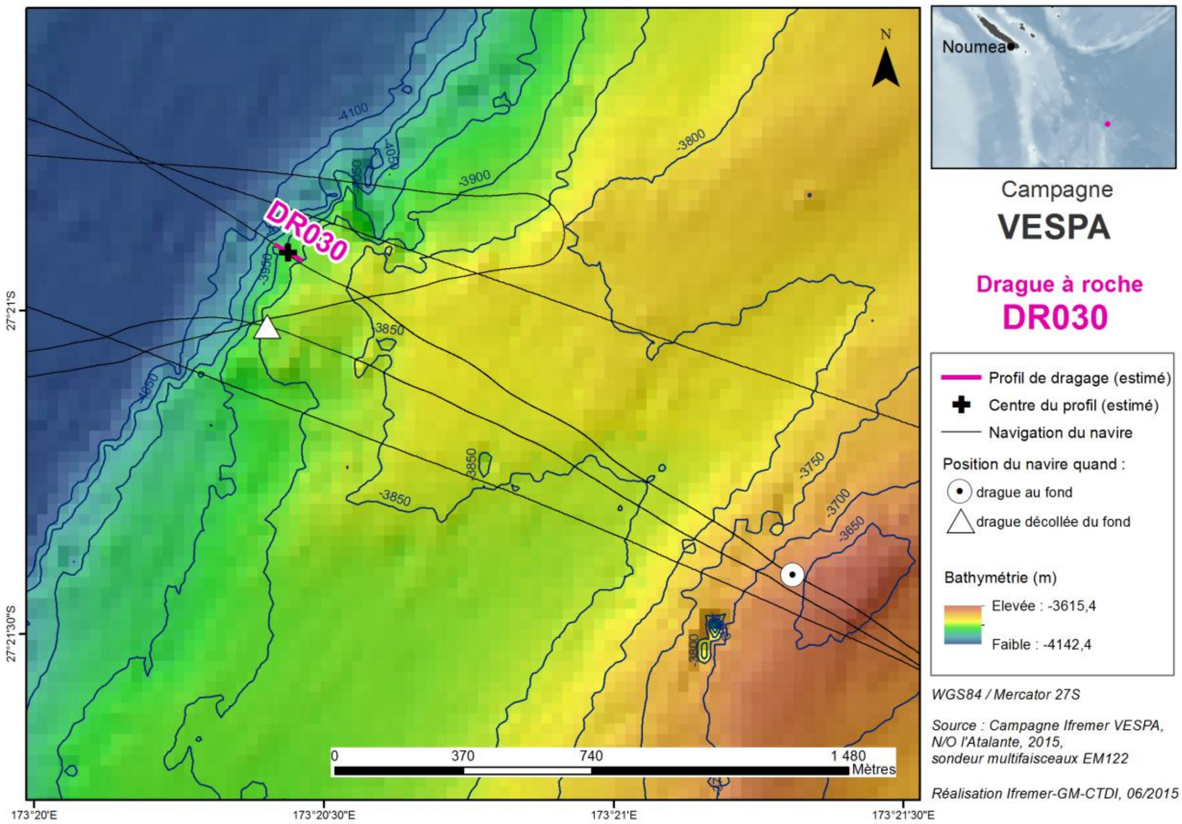
**DR29F:** Two 5cm pieces plus a piece of DR29E. 3cm thick Mn crust pieces. 5cm Mn crust attached to DR29E.
Subsamples at IFREMER Brest, SGNC Nouméa

**DR29G:** 4x3x2cm pumice lump.
Sample at SGNC Nouméa

**DR29H:** sea floor sediment pipe sample
Subsample at GNS Wellington

# *DR030*

**Target:** Three Kings Ridge area. Normal fault scarp footwall at southeast termination of Cook Fracture Zone. The samples probably are from the west edge of the Fantail Terrace which is an ocean crust part of Three Kings Ridge block.

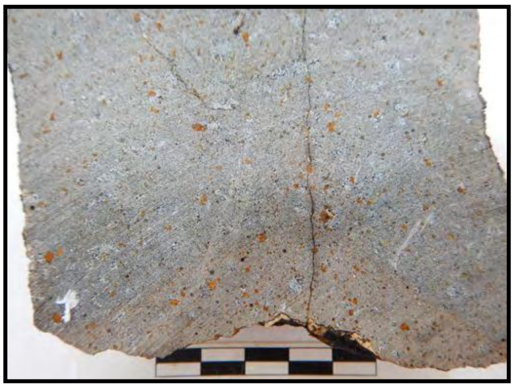



| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 09/06/2015 | 23:49:00 | -27,339085 | 173,323891 | MISE A L'EAU | Mise à l'eau DR_030 |
| 09/06/2015 | 23:56:45 | -27,340797 | 173,3267703 | DEBUT DE FILAGE | Début de filage DR_030 |
| 10/06/2015 | 01:10:00 | -27,356797 | 173,3551512 | AU FOND | 4350 m filés, 1926m de la cible |
| 10/06/2015 | 01:16:00 | -27,358005 | 173,3575163 | CROCHE | Croche à 7.6T, 4635 m filés 2195m de la cible |
| 10/06/2015 | 01:22:00 | -27,359163 | 173,359066 | CROCHE | Croche 16T. 4635 m filés. 2361m de cible |
| 10/06/2015 | 01:25:00 | -27,359539 | 173,3597378 | CROCHE | Croche à 18T. 4618 m filés, 2430m de la cible |
| 10/06/2015 | 02:21:00 | -27,350402 | 173,3400342 | DRAGUE DECOLLEE | Drague décollée 4000 m filés, 300 m de la cible |
| 10/06/2015 | 03:48:00 | -27,350512 | 173,3389159 | A BORD | DR_030 à bord |

**Weight:** 100 kg as c. 30 dm-size slabs, thinly Mn crusted
**Main rock types:** Fresh plag-ol porphyritic basalts, some with fresh glass rinds
**Other rock types:**
**Dredging notes:**

DR030

DR030Ai



DR030Aii

DR030Bi

DR030Ci

DR030Cii

**DR30A:** Four-five 20x20x10 cm separate pieces in dredge of hard fresh medium grey (N5) basalt. Sparsely olivine and plagioclase-phyric with 1 cm glassy rind (<10% phenocrysts). Olivine altered to red clay. May have missed clinopyroxene crystals (not prominent, if present).

**Ai:** best sample with glassy rind (to GNS, Brest);
**Aii:** second best;
**Aiii:** vesicular with freshest plagioclase (for pXRF)
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR30B:** Six-seven 20x20x10 cm separate pieces in dredge of basalt. Hard fresh medium grey (N5) porphyritic basalt with 10% plagioclase and 1cm glassy rind. May have missed camouflaged pyroxene crystals.
**Bi:** best sample with glassy rind;
**Bii:** 2nd best
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

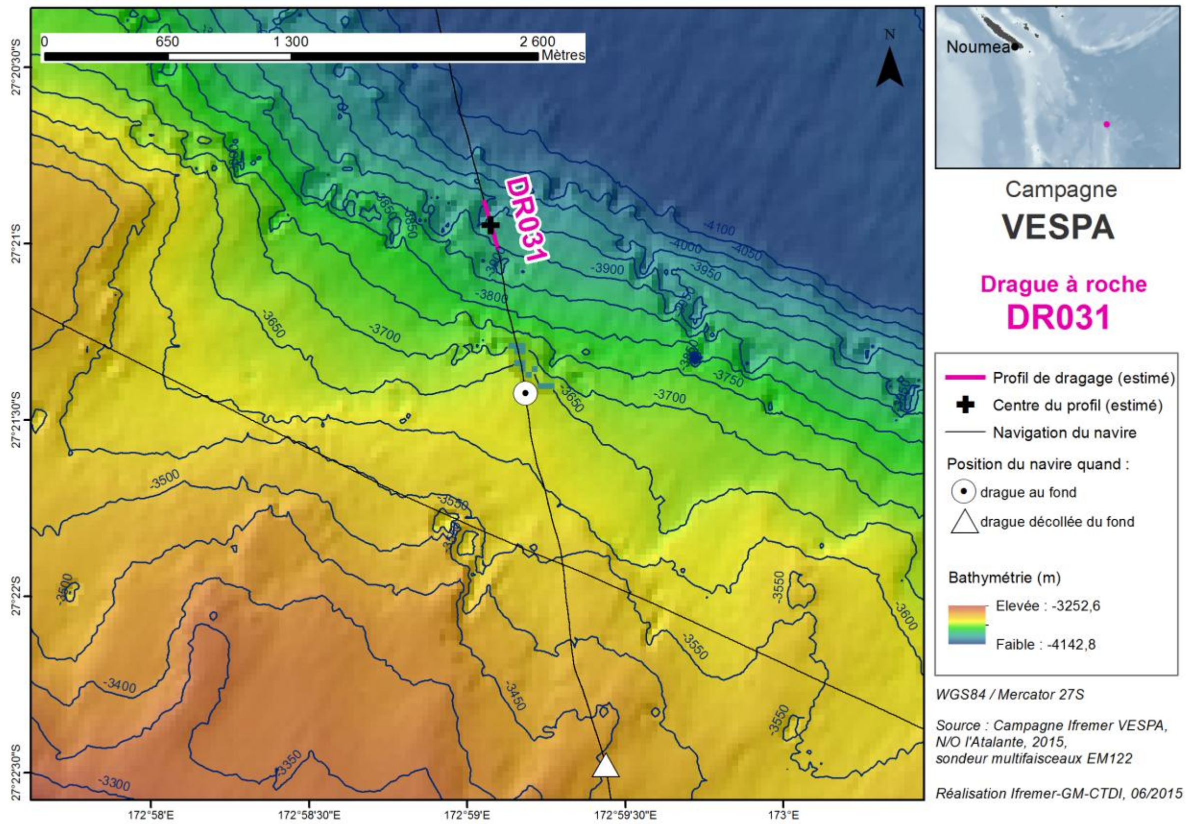
**DR30C:** About twenty 20x20x10 cm pieces (most of dredge) of hard, fresh, medium dark grey (N4) basalt. Essentially aphyric with c. 5% vesicles. 1cm glass rind. Some interior alteration fronts.
**Ci:** best sample
**Cii:** 2nd best
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR30D:** Chiselled out small flakes of hard, pinkish grey 95 YR 8/1) silicified, dolomitised or phosphatised limestone. Occurs as thin (1 mm) skin on pillow rinds and as infill within glass rinds, especially on DR30C. Catalogued separately as DR30D.
Subsamples at GNS Wellington

No sediment in pipe.

# *DR031*

**Target:** Three Kings Ridge area. Cook Fracture Zone scarp towards eastern end, near 173.0°E.

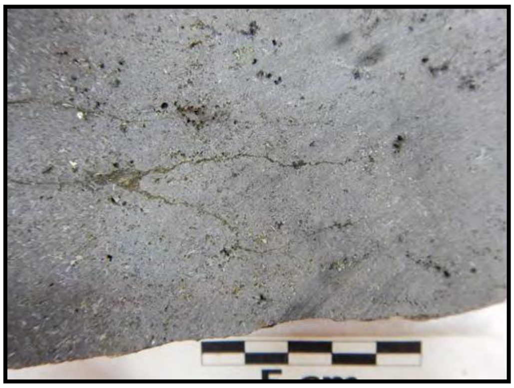



| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 10/06/2015 | 06:16:38 | -27,328247 | 172,9790064 | MISE A L'EAU | Mise à l'eau DR_031 |
| 10/06/2015 | 06:29:39 | -27,332731 | 172,9803751 | DEBUT DE FILAGE | Début filage DR_031, 1100m de la cible |
| 10/06/2015 | 07:33:49 | -27,357064 | 172,9864052 | AU FOND | 4540m filés, 1587m de la cible |
| 10/06/2015 | 07:44:31 | -27,361281 | 172,9873337 | CROCHE | Croche 8T, 4626m filés, 2093m de la cible |
| 10/06/2015 | 07:54:00 | -27,364994 | 172,9883521 | DEBUT VIRAGE | 4625m filés |
| 10/06/2015 | 07:54:03 | -27,364994 | 172,9883522 | CROCHE | Croche 9.7T, 4626m filés, 2576m de la cible |
| 10/06/2015 | 08:00:00 | -27,367412 | 172,9886545 | CROCHE | Croche 9.3T, 4533m filés, 2576m de la cible |
| 10/06/2015 | 08:19:45 | -27,374611 | 172,9906322 | DRAGUE DECOLLEE | Drague décollée 3600m filés |
| 10/06/2015 | 09:34:00 | -27,394283 | 173,011076 | A BORD | Drague à bord |

**Approx. weight:** 50 kg
**Main rock types:** Very fresh hard basalt
**Other rock types:** Soft, muddy calcareous ashy pumiceous volcaniclastic rocks
**Dredging notes:**

DR031

DR031Ai



DR031Aii


DR031Bi


DR031Bii


DR031C

**DR31Ai:** 20x15x15cm piece retained of hard, fresh, medium grey (N5) slightly plagioclase porphyritic basalt. Glassy rims, coated with white clay. About 20% plagioclase phenocrysts up to 1mm in size. Almost doleritic in texture. Thin (<0.5mm) Mn coating.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR31Aii:** 15x10x10cm piece retained of hard fresh dark medium grey (N4) dolerite. About 20% of sample is 0.5mm long needles of plagioclase. Doleritic texture present. Thin (<0.5mm) Mn coating
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR31Bi:** a few dozen 15x10x10cm pieces of softish yellowish grey (5 Y 7/2) calcareous mudstone. Bored.
Subsamples at GNS Wellington, SGNC Nouméa

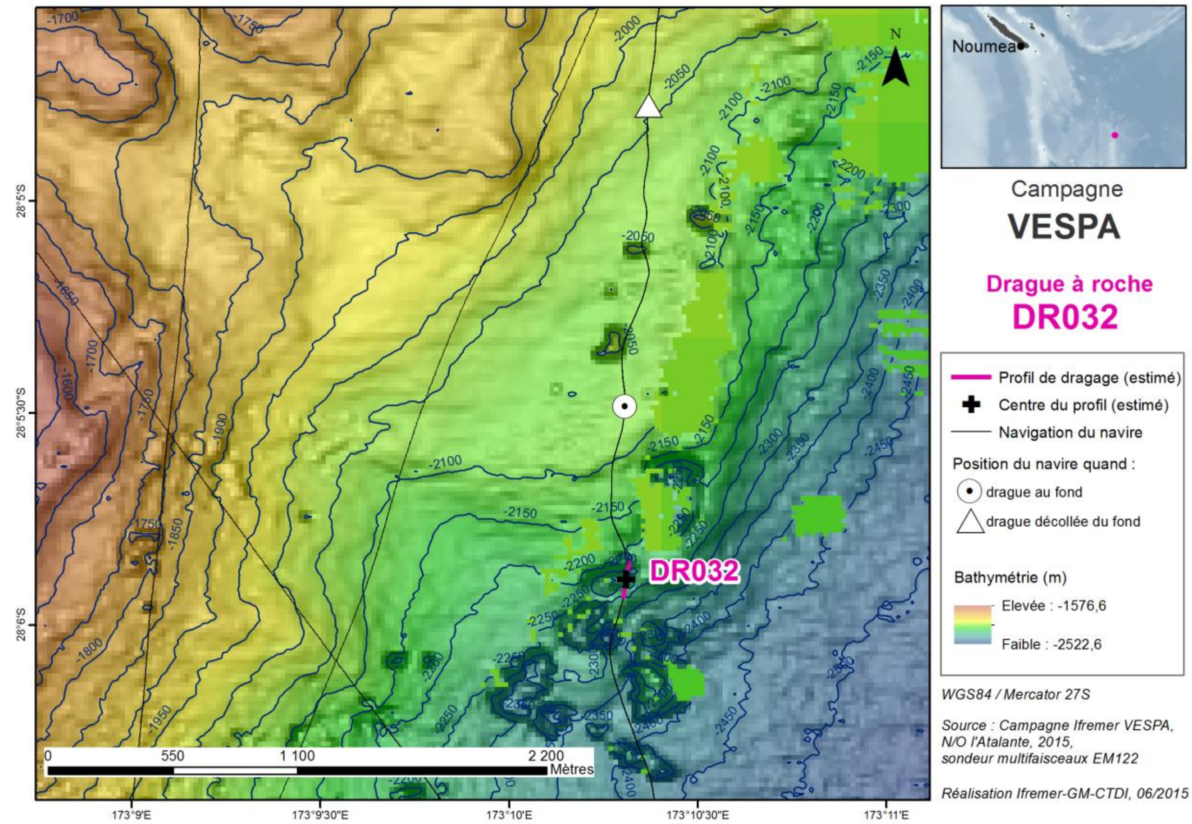
**DR31Bii:** a few dozen 15x10x10cm pieces of softish dusky yellow (5 Y 6/4) calcareous mudstone. Bored and penetrated by manganese oxides
Subsamples at GNS Wellington, SGNC Nouméa

**DR31C:** one 7x7x7 cm rounded pinkish grey (5 YR 8/1) lump of soft, pure, homogeneous calcareous mudstone. Described from memory.
Subsamples at SGNC Nouméa

**DR31D:** Sea floor sediment pipe sample
Subsamples at GNS Wellington

# *DR032*

**Target:** Three Kings Ridge area. East side of long guyot, in relatively deep water northern Three Kings Ridge.



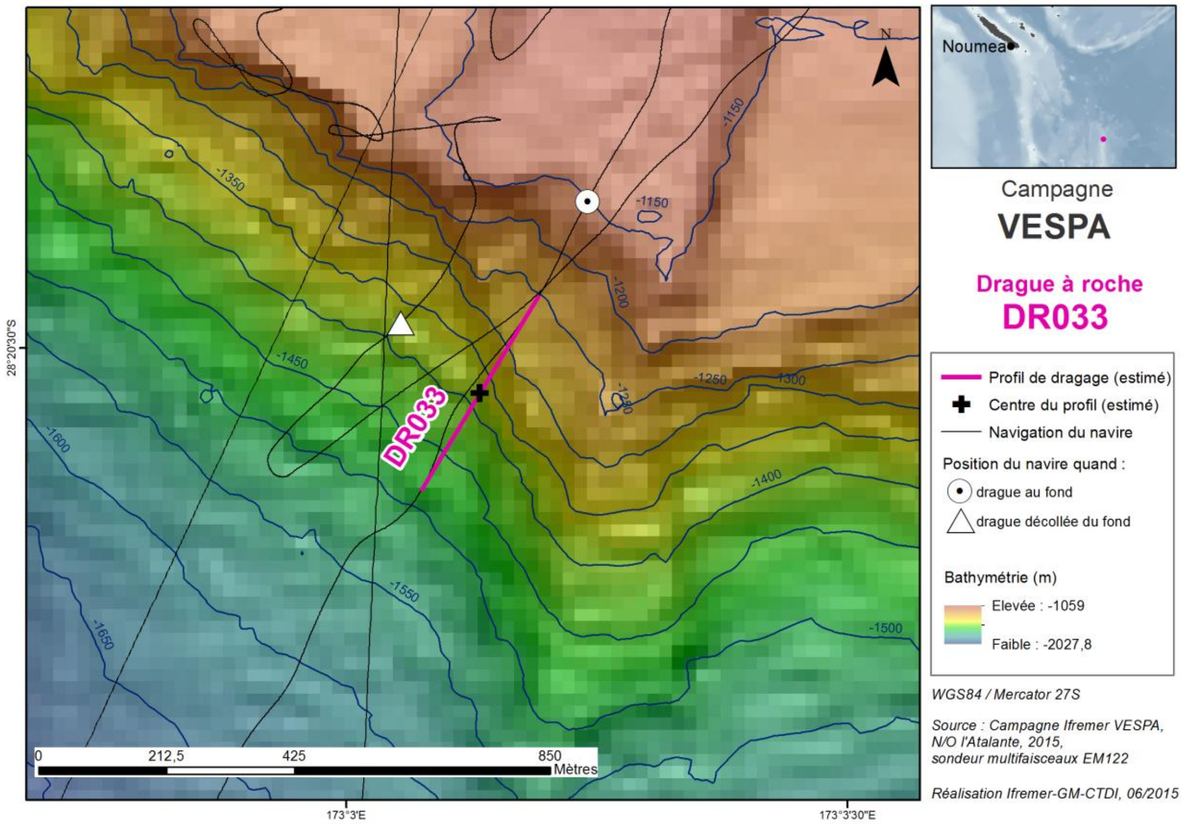

| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 10/06/2015 | 20:23:00 | -28,110242 | 173,1725926 | MISE A L'EAU | Mise à l'eau DR_032 |
| 10/06/2015 | 20:28:08 | -28,107270 | 173,1731362 | DEBUT DE FILAGE | Début de filage DR_032, 240m de la cible |
| 10/06/2015 | 21:04:38 | -28,091398 | 173,1717836 | AU FOND | 2430m filés, 1166m de la cible |
| 10/06/2015 | 21:13:24 | -28,087805 | 173,1722555 | CROCHE | Croche 5.4T, 2614m filés, 1572m de cible |
| 10/06/2015 | 21:15:29 | -28,087145 | 173,1725657 | CROCHE | Croche 5.2T, 2614m filés, 1661m de cible |
| 10/06/2015 | 21:16:19 | -28,086732 | 173,1727015 | CROCHE | Croche 7.8T, 2614m filés, 1724m de cible |
| 10/06/2015 | 21:17:01 | -28,086508 | 173,172765 | DEBUT VIRAGE | 2614m filés, 1731m de la cible |
| 10/06/2015 | 21:34:24 | -28,079570 | 173,1728363 | DRAGUE DECOLLEE | 2060m filés, 2407m de la cible |
| 10/06/2015 | 22:19:15 | -28,06026 | 173,1769538 | A BORD | DR_032 à bord |

**Weight:** 0 kg
**Main rock types:** Empty dredge
**Other rock types:**
**Dredging notes:**

**DR32A:** Sea floor sediment pipe sample
Subsample at GNS Wellington

# *DR033*

**Target:** Three Kings Ridge area. South side of long guyot at relatively shallow water depth, northern Three Kings Ridge.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 11/06/2015 | 00:23:00 | -28,352763 | 173,0445588 | MISE A L'EAU | Mise à l'eau DR_033 |
| 11/06/2015 | 00:31:00 | -28,349907 | 173,0471657 | DEBUT DE FILAGE | Début de filage DR_033. 730 m de la cible |
| 11/06/2015 | 01:01:08 | -28,339502 | 173,0540148 | AU FOND | Drague au fond, 1586m filés, 600m de la cible |
| 11/06/2015 | 01:12:00 | -28,335801 | 173,0562331 | CROCHE | Croche à 6T. 1798 m filés, 1069 m de la cible |
| 11/06/2015 | 01:17:00 | -28,334485 | 173,057011 | CROCHE | Croche à 15T. 1750 m filés, 1200 m de la cible |
| 11/06/2015 | 01:35:00 | -28,336045 | 173,052844 | CROCHE | Croche à 20T. 1400 m filés, 900 m de la cible |
| 11/06/2015 | 01:57:00 | -28,336303 | 173,0498754 | CROCHE | Croche 15T, 1232m filés, 860m de cible |
| 11/06/2015 | 01:57:02 | -28,336303 | 173,0498754 | CROCHE | Croche  10T, 1232m filés, 860m de cible |
| 11/06/2015 | 03:38:00 | -28,341301 | 173,0509074 | DRAGUE DECOLLEE | 1300 m filés, 300 m de la cible. |
| 11/06/2015 | 04:14:00 | -28,339079 | 173,0550412 | A BORD | DR_033 à bord |

**Approx. weight:** 100 kg
**Main rock types:**  Hard, fresh andesite and basalt
**Other rock types:** Limestone attached to outside of andesite.
**Dredging notes:** Dredge stuck for more than an hour, chain bag damaged

DR033

DR033Ai

DR033Aii

DR033B

DR033Ci


DR033Cii

**DR33Ai:** One 60x30x30 cm tapering boulder, that rang like a bell. Extremely hard, compact and tough medium light grey (N6) nonvesicular very weakly olivine-porphyritic basaltic andesite. Feldspathic groundmass. Fresh interior.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR33Aii:** One 25x25x7cm separate boulder but identical to DR33Ai.
Subsample at SGNC Nouméa

**DR33B:** One 15x15x10 cm block of hard, medium grey (N5) basalt. Slightly more olivine porphyritic than DR33A (but still <5% phenocrysts). Olivine is replaced by green waxy mineral as are irregular ?former glass patches in groundmass.

Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

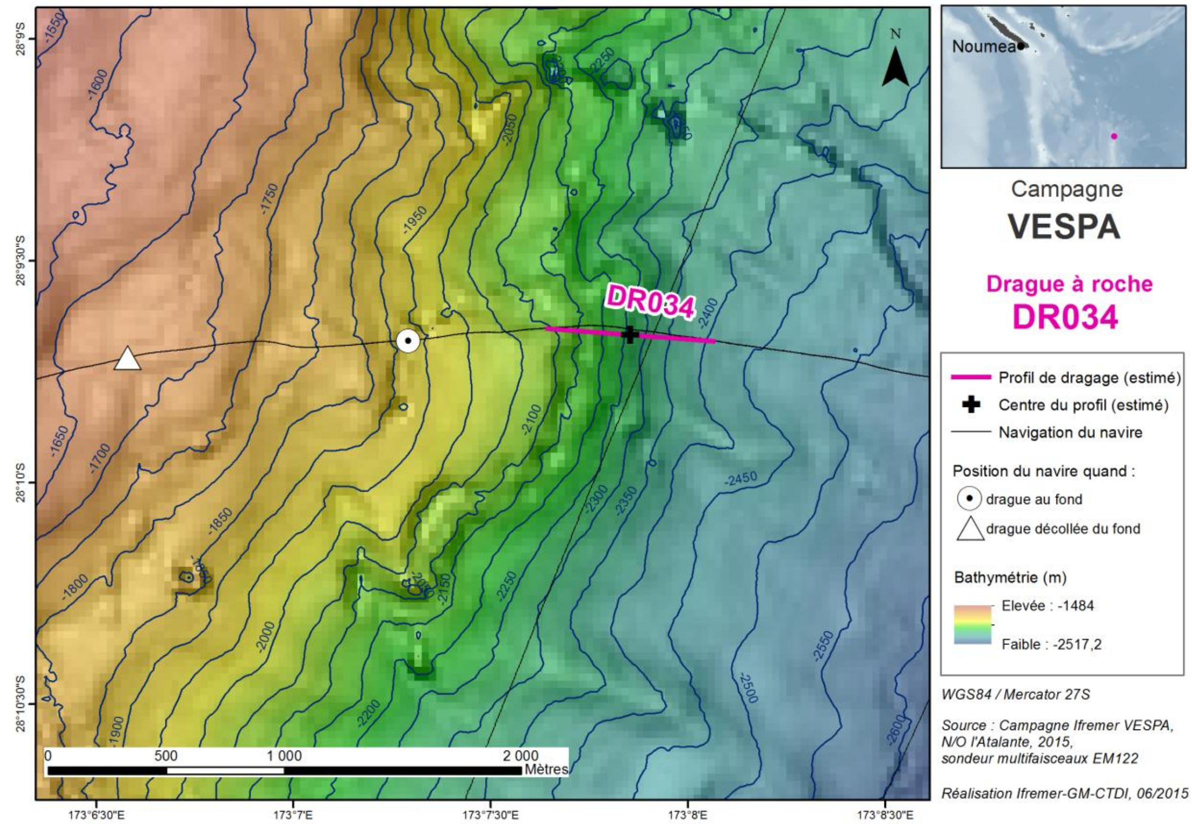
**DR33Ci:** Two sculpted 15x15x10 cm pieces of hard, light olive grey (5 Y 5/2), olivine-plagioclase- and pyroxene-microporphyritic andesite or basalt. Phenocrysts <0.5mm 5%. Different lava to A and B and consistently more altered. No fresh parts.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR33Cii:** Hard limestone attached to outside of DR33Ci but catalogued separately. Fizzes in acid. Bored by worms. Contains forams, echinoderm fragments and solitary corals.
Subsample at GNS Wellington

**DR33D:** Sea floor sediment pipe sample
Subsample at GNS Wellington

# *DR034*

**Target:** Three Kings Ridge area. East side of long guyot in relatively deep water, northern Three Kings Ridge. A retry close to the empty DR32.



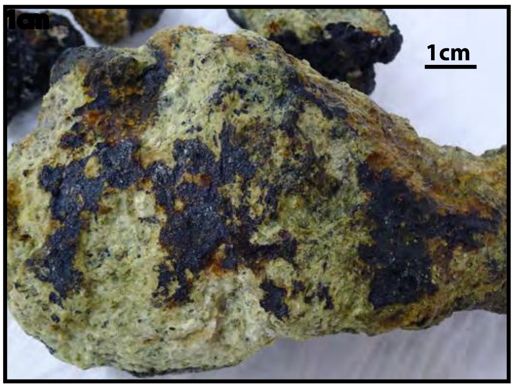

| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 11/06/2015 | 05:45:00 | -28,162755 | 173,1439271 | MISE A L'EAU | Mise à l'eau DR_034 |
| 11/06/2015 | 05:55:37 | -28,161763 | 173,1377622 | DEBUT DE FILAGE | Début de filage DR_034 |
| 11/06/2015 | 06:30:00 | -28,161328 | 173,1215234 | AU FOND | 2440m filés, 1100m de la cible |
| 11/06/2015 | 06:40:00 | -28,161579 | 173,1171685 | CROCHE | Croche 8T. 2600m filés, 1540m de la cible |
| 11/06/2015 | 06:40:28 | -28,161571 | 173,1169652 | DEBUT VIRAGE | 2600m filés, 1540m de la cible |
| 11/06/2015 | 06:41:00 | -28,161562 | 173,1167657 | CROCHE | Croche 10.5T. 2595m filés, 1600m de la cible |
| 11/06/2015 | 06:41:03 | -28,161562 | 173,1167657 | CROCHE | Croche 13T. 2582m filés, 1620m de la cible |
| 11/06/2015 | 06:57:02 | -28,161974 | 173,1096737 | DRAGUE DECOLLEE | 2021m filés, 2222m de la cible |
| 11/06/2015 | 07:44:02 | -28,168026 | 173,0880947 | A BORD | DR_034 à bord |

**Weight:** 70 kg in large cobbles, some embedded in clay
**Main rock types:** Pumice conglomerate
**Other rock types:** Clay
**Dredging notes:**

DR034


DR034A


DR034A




DR034A

DR034B

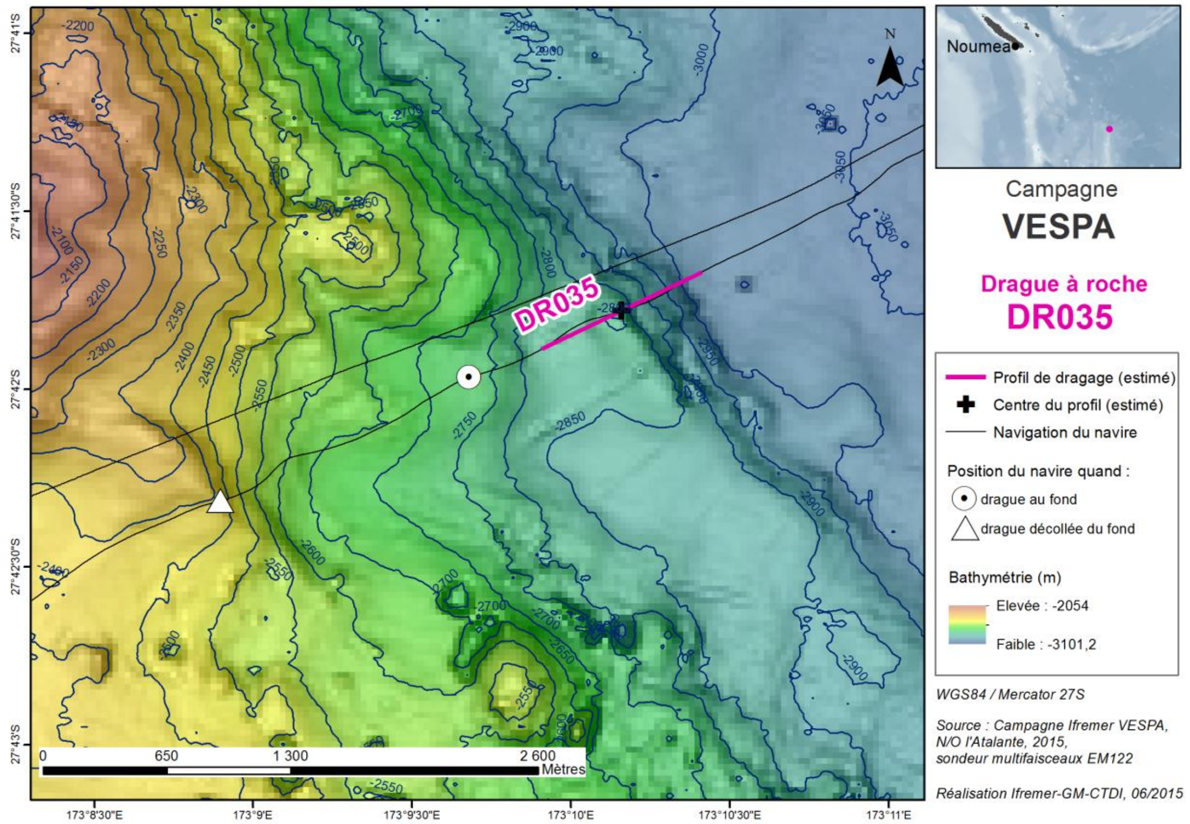
**DR34A:** About 100 pieces of 10-20 cm and a few 40 cm boulders of red, green, cream and black very weakly consolidated conglomerate. Contains clasts of reasonably fresh rhyolitic pumice (i.e. not flattened or turning to jellystone with diagenesis). Cemented by black Mn oxide which thoroughly penetrates the pumice and hardens the rock. Various veining or diagenetic structures & textures (not described). A ‘cleaner’ 5-10cm thick Mn crust was present on outer surface of some rocks. Reference samples kept. No local rock. Subsamples at IFREMER Brest, GNS Wellington, SGNC Nouméa

**DR34B:** One 50x50x10 cm slab of very pale orange (10 YR 8/2) unconsolidated sticky plastic clay. Some Mn pebbles (from sample A) were embedded in a platy chunk of the clay. Subsamples at GNS Wellington, SGNC Nouméa

**DR34C:** Sea floor sediment pipe sample. Subsamples at GNS Wellington

# *DR035*

**Target:** Three Kings Ridge area. Small northeast-facing scarp low on east side of northern Three Kings Ridge.



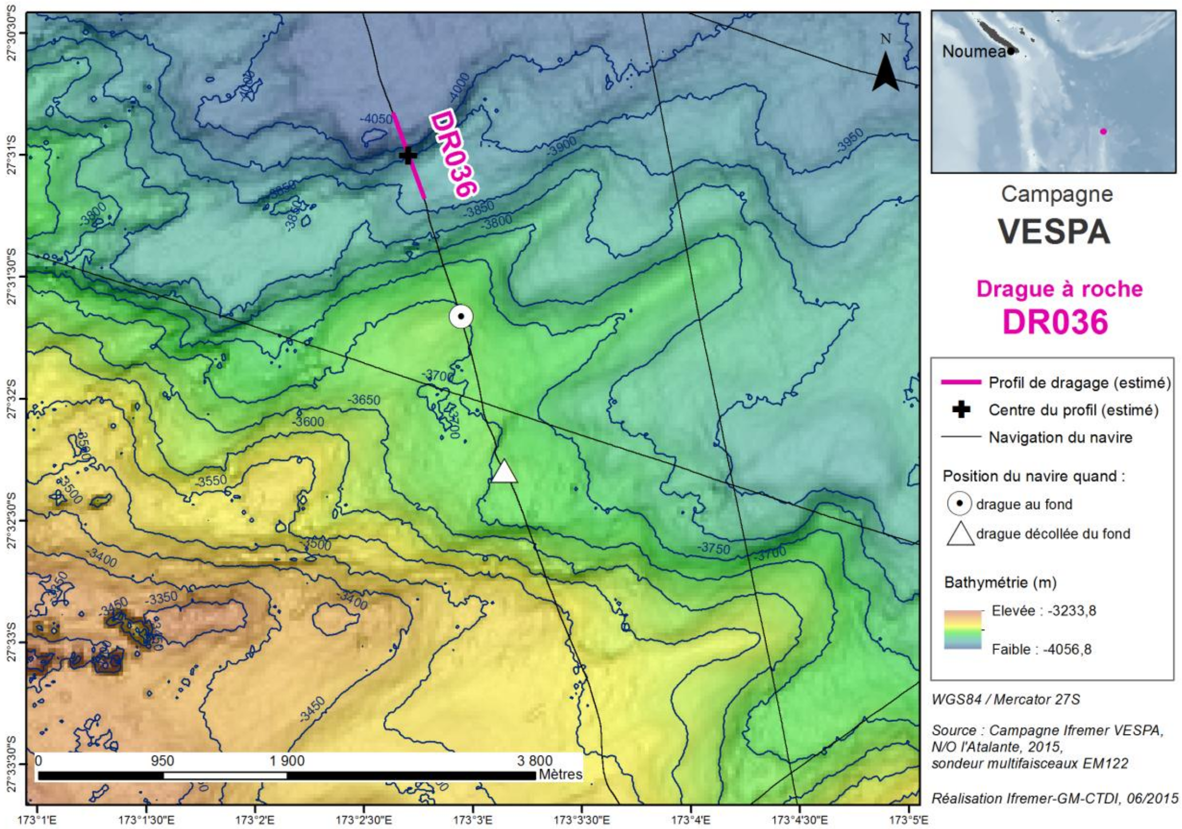

| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 11/06/2015 | 11:17:00 | -27,688077 | 173,1863339 | MISE A L'EAU | Mise à l'eau DR_035 |
| 11/06/2015 | 11:25:00 | -27,689603 | 173,1834196 | DEBUT DE FILAGE | Début de filage DR_035, 1198 m de la cible |
| 11/06/2015 | 12:19:00 | -27,699427 | 173,1613285 | AU FOND | 3324 m filés, 1246 m de la cible |
| 11/06/2015 | 12:29:00 | -27,701564 | 173,1572002 | CROCHE | Croche à 6,3T. 3523 m filés, 1722 m de la cible |
| 11/06/2015 | 12:36:00 | -27,702707 | 173,1542316 | DEBUT VIRAGE | 2521 m filés, 2037 m de la cible |
| 11/06/2015 | 12:39:00 | -27,702992 | 173,1529631 | CROCHE | Croche à 9T, 3490 m filés, 2553 m de la cible |
| 11/06/2015 | 12:43:00 | -27,703661 | 173,1512503 | CROCHE | Croche à 7,2T, 3435 filés, 2578m de la cible |
| 11/06/2015 | 12:50:00 | -27,705231 | 173,1482836 | DRAGUE DECOLLEE | 3270 m filés, 2692 m de la cible |
| 11/06/2015 | 14:05:00 | -27,725670 | 173,1173653 | A BORD | DR_035 à bord |

**Weight:** 0 kg
**Main rock types:**
**Other rock types:**
**Dredging notes:** Dredge empty

**DR35A:** Sea floor sediment pipe sample. Also containing three 1cm-size pieces of pumice Subsample at GNS Wellington

# *DR036*

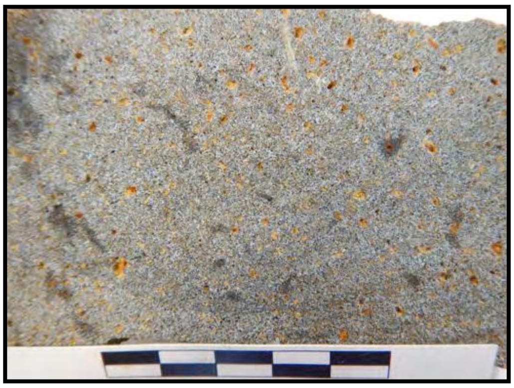
**Target:** Three Kings Ridge area. Bottom of canyon south of Cook Fracture Zone near long. 173.5°E.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 11/06/2015 | 17:55:26 | -27,499526 | 173,0394401 | MISE A L'EAU | Mise à l'eau DR_036 |
| 11/06/2015 | 18:09:00 | -27,503876 | 173,0401637 | DEBUT DE FILAGE | Debut de filage DR_036, 1240m de la cible |
| 11/06/2015 | 19:11:00 | -27,527681 | 173,0490882 | AU FOND | 4450 m de files, 1500m de la cible |
| 11/06/2015 | 19:31:00 | -27,535878 | 173,051527 | CROCHE | Croche 10.2T, 4645m de filés, 2408m de la cible |
| 11/06/2015 | 19:33:00 | -27,536488 | 173,0517568 | CROCHE | Croche 16.3T, 4645m de filés, 2500m de la cible |
| 11/06/2015 | 19:37:00 | -27,537382 | 173,0518438 | DEBUT VIRAGE | 4645m de filés, 2500m de la cible |
| 11/06/2015 | 19:38:00 | -27,53779 | 173,0520937 | CROCHE | Croche 12T, 4630m de filés, 2704m de la cible |
| 11/06/2015 | 19:39:00 | -27,538251 | 173,0523943 | DRAGUE DECOLLEE | 4490m de filés, 3037m de la cible (incertitude) |
| 11/06/2015 | 21:14:47 | -27,559135 | 173,073982 | A BORD | DR_036 à bord |

**Weight:** 100 kg
**Main rock types:** Fresh, columnar jointed aphyric basalt
**Other rock types:** Very soft, pumice-derived calcareous mudstone
**Dredging notes:**

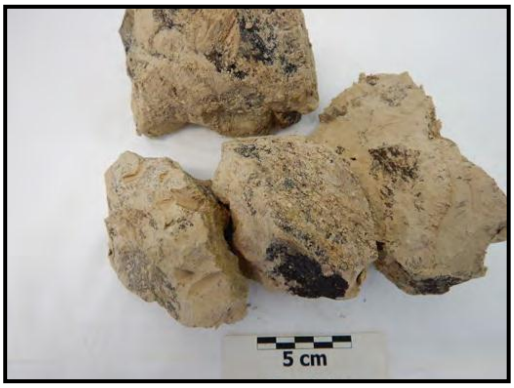

DR036


DR036A


DR036B


DR036C

DR036D



DR036E

**DR36A:** One 50x40x40 cm piece (largest boulder in dredge). Very hard tough equigranular aphyric basalt with columnar jointing. Slight pale brown weathering rind on outer 2 cm. Corestone extremely hard and tough but glassy groundmass is thoroughly altered to orange palagonite.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR36B:** Several 40x15x15 cm broken jointed columns of fine-grained basalt. More holocrystalline than A. Glassy rind with fresh glass – the only such piece in the dredge. Weakly vesicular.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR36C:** Similar to B but no glass rind. Less vesicular part retained, more vesicular part discarded.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

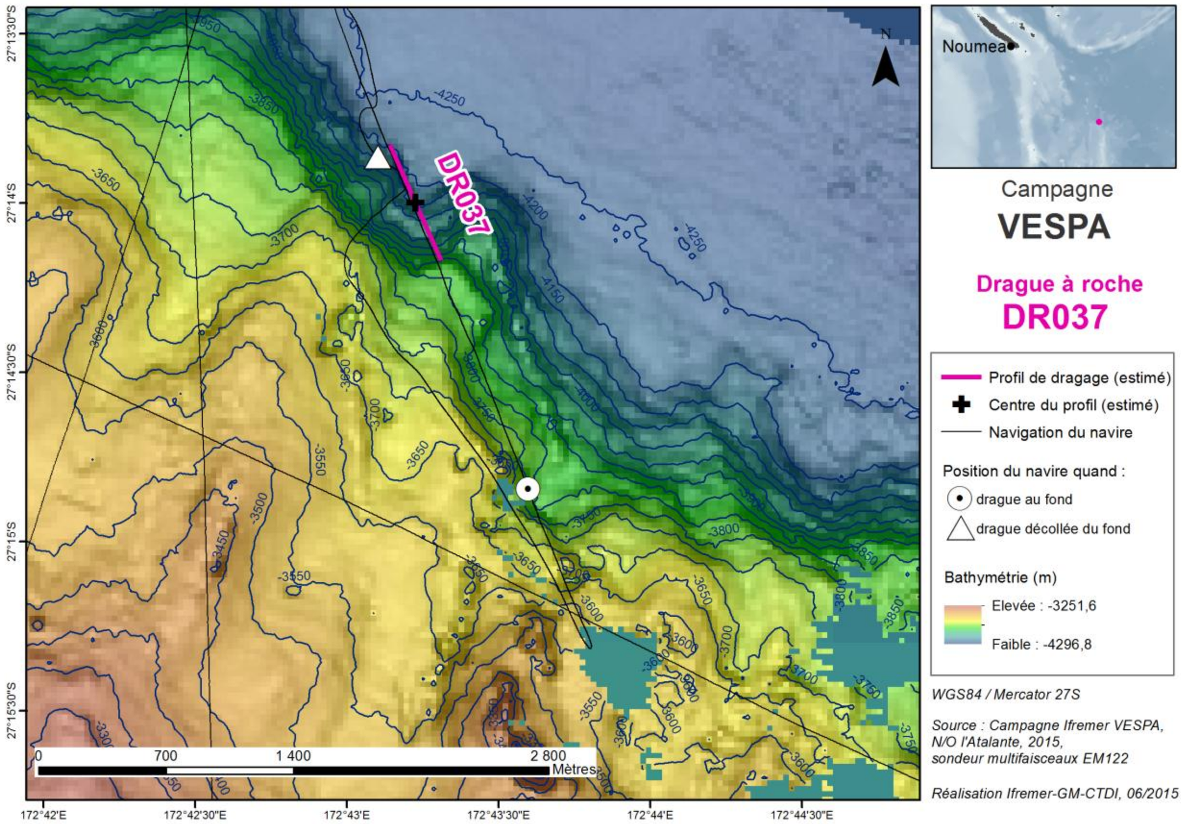
**DR36D:** One 25x10x10 cm jointed column of uncut basalt
Subsample at SGNC Nouméa

**DR36E:** A few dozen dm-size slabs/pieces of soft calcareous mudstone. Probably mainly composed of pumice and ash but with a moderate carbonate content (forams).
Subsample at GNS Wellington, SGNC Nouméa

**DR36F:** Sea floor sediment pipe sample
Subsample at GNS Wellington

# *DR037*

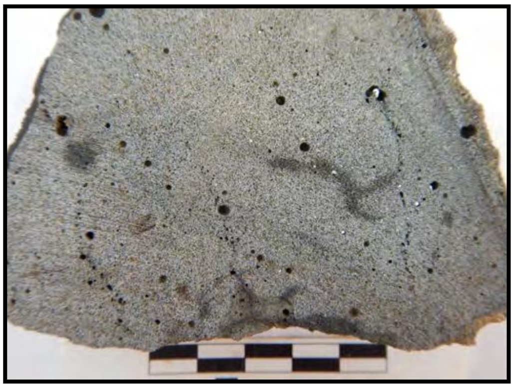
**Target:** Three Kings Ridge area. Cook Fracture Zone scarp near 172.7°E, c. 10 km southeast of Faust-2 dredge




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 12/06/2015 | 01:35:00 | -27,213373 | 172,7125453 | MISE A L'EAU | Mise à l'eau DR_037, 2241m de la cible |
| 12/06/2015 | 01:57:00 | -27,221507 | 172,7149395 | DEBUT DE FILAGE | Début filage DR_037,1200m de la cible |
| 12/06/2015 | 03:06:00 | -27,247398 | 172,7266171 | AU FOND | 4752 m filés, 1789m de la cible |
| 12/06/2015 | 03:12:00 | -27,249813 | 172,7276843 | CROCHE | Croche 10T. 4800m filés, 2113m de la cible |
| 12/06/2015 | 03:16:00 | -27,251303 | 172,728358 | DEBUT VIRAGE | 4800m filés, 2222m de la cible |
| 12/06/2015 | 03:20:00 | -27,252746 | 172,7290028 | CROCHE | Croche 13.1T, 4744 m filés, 2459m de la cible |
| 12/06/2015 | 03:26:00 | -27,254901 | 172,7300383 | CROCHE | Croche 1.7T, 4685 m filés, 2704m de la cible |
| 12/06/2015 | 04:50:11 | -27,231074 | 172,7183873 | DRAGUE DECOLLEE | 4070m filés. 3333m de la cible. |
| 12/06/2015 | 06:19:00 | -27,189316 | 172,7047985 | A BORD | DR_037 à bord |

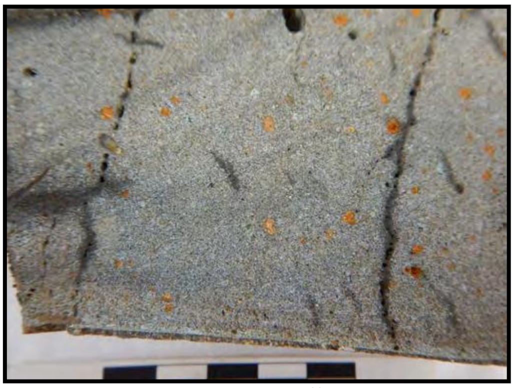
**Weight:** 150 kg
**Main rock types:** Fresh, columnar jointed aphyric basalt
**Other rock types:** Volcanic breccia
**Dredging notes:**

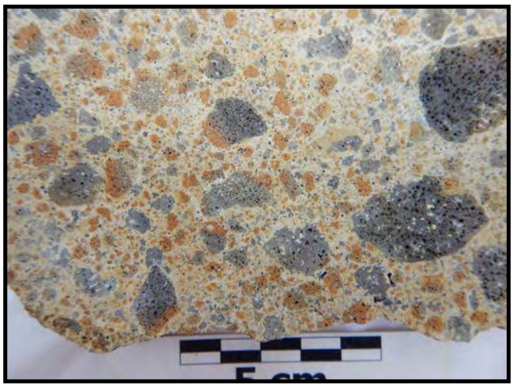

DR037


DR037Ai


DR037Aii


DR037Bi


DR037Bii


DR037C


DR037D

**DR37Ai:** Half a dozen 50x10 cm pieces (retained sample is a small 20x10x10 cm columnar joint column). Hard medium dark grey (N4) aphyric sparsely vesicular basalt.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR37Aii:** Similar pieces to A but more vesicular and olive grey colour (5 Y 4/1) which reflects slight alteration of glassy groundmass
Subsamples at IUEM Brest, SGNC Nouméa

**DR37Bi:** Most of dredge. c. 40 cm boulders and many smaller joint blocks of hard, medium dark grey sparsely (<5%) olivine- pyroxene-porphyritic basalt. Olivine altered to red clay but groundmass is fresh
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR37Bii:** Similar to Bi but slightly vesicular and more altered
Subsample at SGNC Nouméa

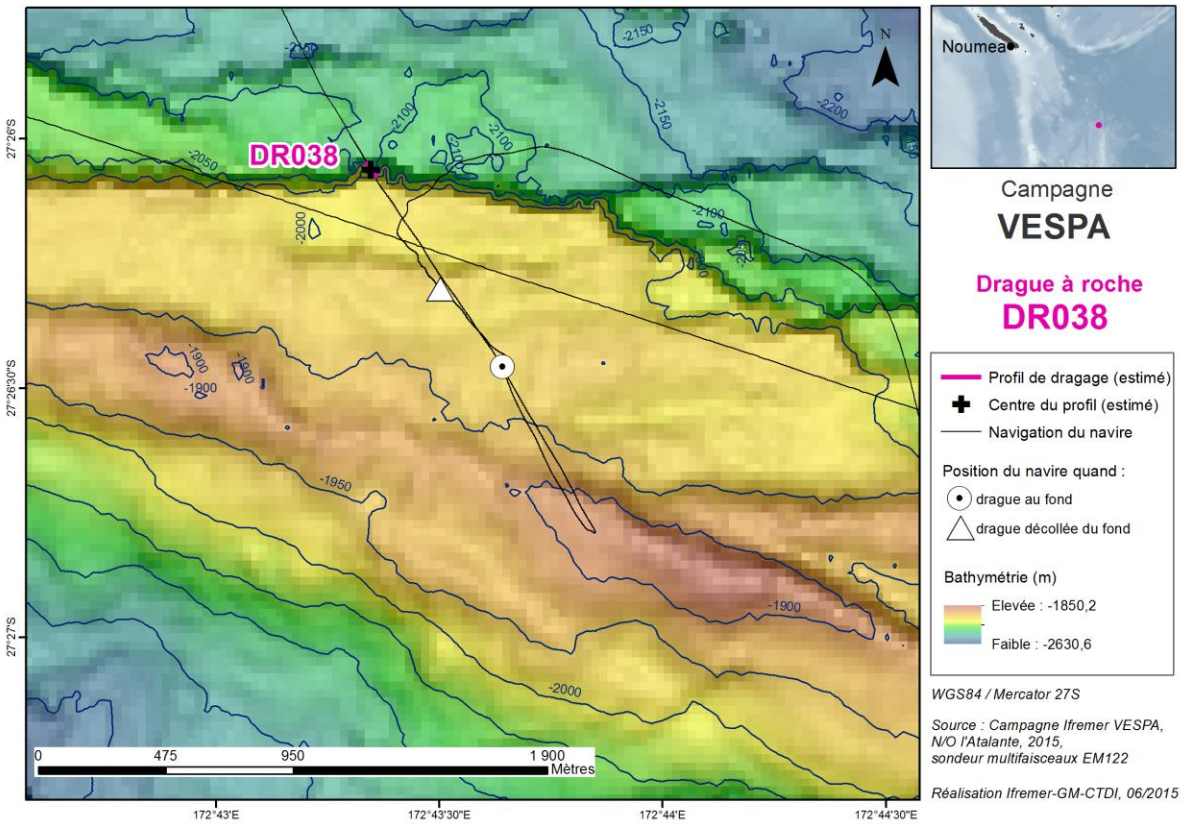
**DR37C:** one 50x30x20 cm angular boulder and a few additional pieces. Hard, moderate brown 5YR4/4 monomict volcanic breccia, probbaly a pillow breccia. Much orange coloration due to altered glass. Glass is attached to aphyric, vesicular lava clasts similar to A. Maximum clast size 2 cm, moderately to poorly sorted (down to sand size) sub-angular clasts; Cream coloured micritic atrix does not fizz. No fresh glass.
Subsamples at GNS Wellington, SGNC Nouméa

**DR37D:** One 20x20x10 cm piece of hard brownish (5 YR 4/1) monomict volcanic breccia. Poorly sorted angular clasts of olivine basalt like DR37B. Clasts are not weathered. Breccia has a carbonate matrix/cement (confirmed by fizzing in HCl). No forams seen; there is much volcanic sand in there. Some breccia clasts fit together like a jigsaw, suggesting little transport since fragmentation.
Subsamples at GNS Wellington, SGNC Nouméa

**DR37E:** Sea floor sediment pipe sample. The ooze this time was a distinctive moderate brown (5 YR 4/4) chocolate-caramel colour instead of the usual greyish orange (10 YR 7/4). DR37E had a very high clay content and relatively low foram content.
Subsample at GNS Wellington

# *DR038*

**Target:** Three Kings Ridge area. East-west normal fault scarp (one of many) high on the Three Kings Ridge, south of the Cook fracture Zone near long. 172.7°E.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 12/06/2015 | 07:58:19 | -27,423415 | 172,7145518 | MISE A L'EAU | Mise à l'eau DR_038, 1461m de la cible |
| 12/06/2015 | 08:16:12 | -27,428538 | 172,7188548 | DEBUT DE FILAGE | Début filage DR_038, 700m de la cible |
| 12/06/2015 | 08:51:00 | -27,440949 | 172,7273493 | AU FOND | 2350m filés, 910m de la cible. |
| 12/06/2015 | 08:57:00 | -27,443095 | 172,7287228 | CROCHE | Croche à 4T, 2459m filés, 1140m de la cible |
| 12/06/2015 | 09:00:00 | -27,444120 | 172,7294023 | CROCHE | Croche 9T, 2459m filés, 1259m de cible |
| 12/06/2015 | 09:01:00 | -27,444455 | 172,7296193 | DEBUT VIRAGE | 2459m filés, 1330m de la cible |
| 12/06/2015 | 09:40:00 | -27,43869 | 172,7254477 | CROCHE | Croche , 1980m filés, 650m de cible |
| 12/06/2015 | 09:42:19 | -27,438358 | 172,7250433 | DRAGUE DECOLLEE | 1970m filés, 625m de la cible |
| 12/06/2015 | 10:30:00 | -27,434083 | 172,7258852 | A BORD | DR_038 à bord |

**Weight:** 1 kg
**Main rock types:** Very altered hyaloclastite breccia with limestone matrix
**Other rock types:**
**Dredging notes:**


DR038

DR038A

DR038B

DR038C

**DR38A:** 15x15x5 cm piece of hard moderate brown (5YR 8/4) extremely altered and Mn crusted and penetrated and hyaloclastite breccia. No holocrystalline clasts. Nothing fresh in the sample. Interclast brown noncalcareous micritic cement (also as veins cutting sample) and white calcareous cement
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

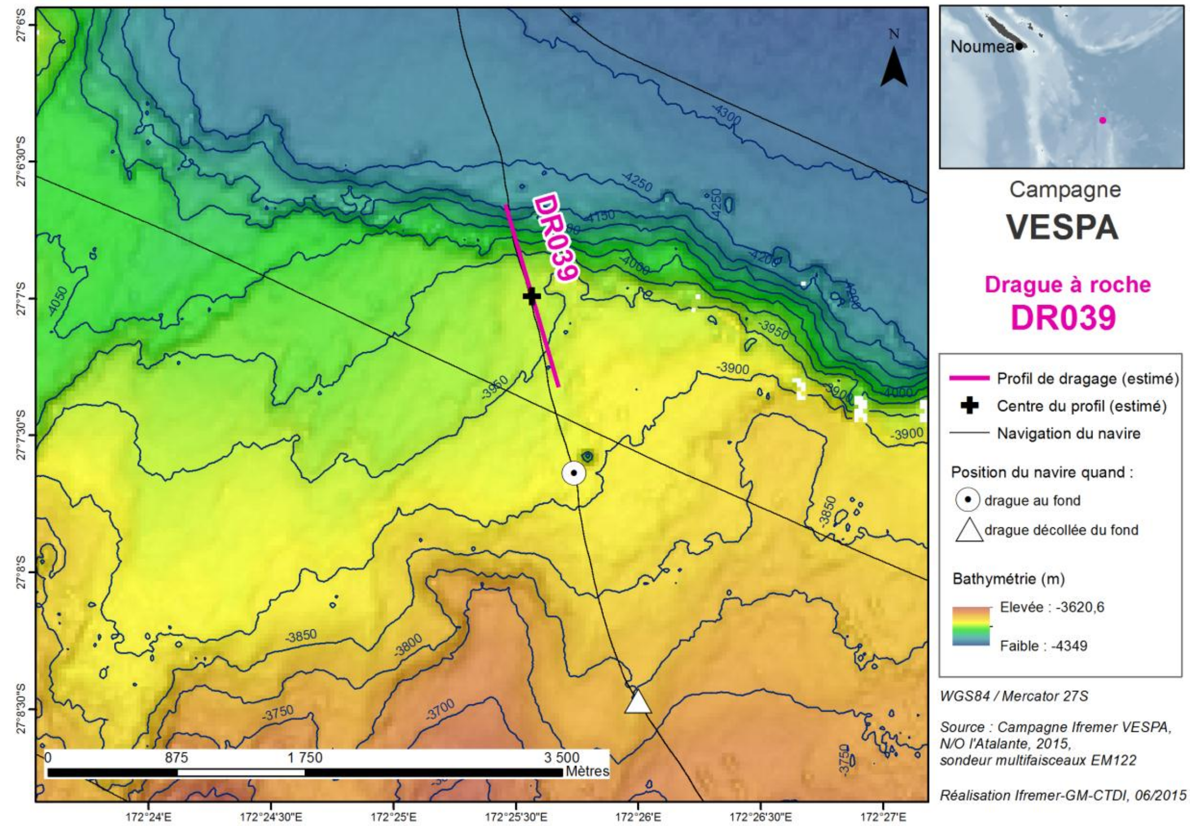
**DR38B:** 15x5x5 cm piece of Mn crust with thin skin of attached altered hyaloclastite breccia like DR38A. Mainly Mn crust.
Subsample at SGNC Nouméa

**DR38C:** three pieces 15-5 cm Mn crust up to 3 cm thick
Subsample at SGNC Nouméa

**DR38D:** Sea floor sediment pipe sample
Subsample at GNS Wellington

# *DR039*

**Target:** Three Kings Ridge area. Scarp on Cook Fracture Zone near 172.4°E




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 12/06/2015 | 16:26:00 | -27,092714 | 172,4171082 | MISE A L'EAU | Mise à l'eau DR_039, 2098m de la cible |
| 12/06/2015 | 16:40:00 | -27,099503 | 172,4211115 | DEBUT DE FILAGE | Début de filage DR_039, 1275 m de la cible |
| 12/06/2015 | 17:49:15 | -27,127287 | 172,4289803 | AU FOND | 1889m de la cible, 4700m filés |
| 12/06/2015 | 18:00:02 | -27,131852 | 172,429836 | DEBUT VIRAGE | Croche 8T, 4800 m filés, 2408m de la cible |
| 12/06/2015 | 18:03:30 | -27,133317 | 172,4302293 | CROCHE | Croche 12T. 4786m de filés, 2519m de la cible |
| 12/06/2015 | 18:07:27 | -27,135102 | 172,4306817 | CROCHE | Croche 10T. 4750m de filés, 2685m de la cible |
| 12/06/2015 | 18:08:02 | -27,135338 | 172,4307532 | CROCHE | Croche 13T. 4730m de filés, 2778m de la cible |
| 12/06/2015 | 18:12:02 | -27,13708 | 172,4313198 | CROCHE | Croche 12T. 4730m de filés, 2963m de la cible |
| 12/06/2015 | 18:20:40 | -27,141150 | 172,4333158 | DRAGUE DECOLLEE | 4397m filés, 3519m de la cible |
| 12/06/2015 | 19:47:02 | -27,167046 | 172,4483611 | A BORD | DR_039 à bord |

**Weight:** 50 kg as 10-20 cm jointed blocks
**Main rock types** Basalt
**Other rock types:** Fresh, columnar jointed aphyric basalt
**Dredging notes:**


DR039

DR039A


DR039B


DR039C


DR039D


DR039E


DR039F

DR039G

**DR39A:** Six 20x10x10 cm pieces of hard, fresh, medium grey (N5) aphyric basalt with fresh glass rind.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR39B:** Six 20x10x10cm pieces of hard, fresh, medium grey (N5) sparsely olivine-phyric basalt. Fresh olivine?
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR39C:** Five 10-20 cm pieces of brownish black (5 YR 2/1) dolerite. Plagioclase laths to 2 mm in length. Dark interstitial matrix not resolvable into minerals Slightly more altered than DR39A and B.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR39D:** A dozen 10-20 cm pieces of brownish grey (5 YR 4/1) hard vesicular basalt. Vesicles partly filled with clay. Mn crusts up to 5 mm thick.
Subsamples at SGNC Nouméa

**DR39E:** One 15x10x5 cm piece of hard yellowish grey (5 Y 8/1) basaltic hyaloclastite breccia. Glass altered to a yellow green waxy mineral not to the typical orange colour. No sediment infill.
Subsamples at SGNC Nouméa

**DR39F:** Two 15x10x10 cm pieces (one kept) of basalt breccia with brown, micritic, non-calcareous cement/matrix.
Subsamples at GNS Wellington, SGNC Nouméa

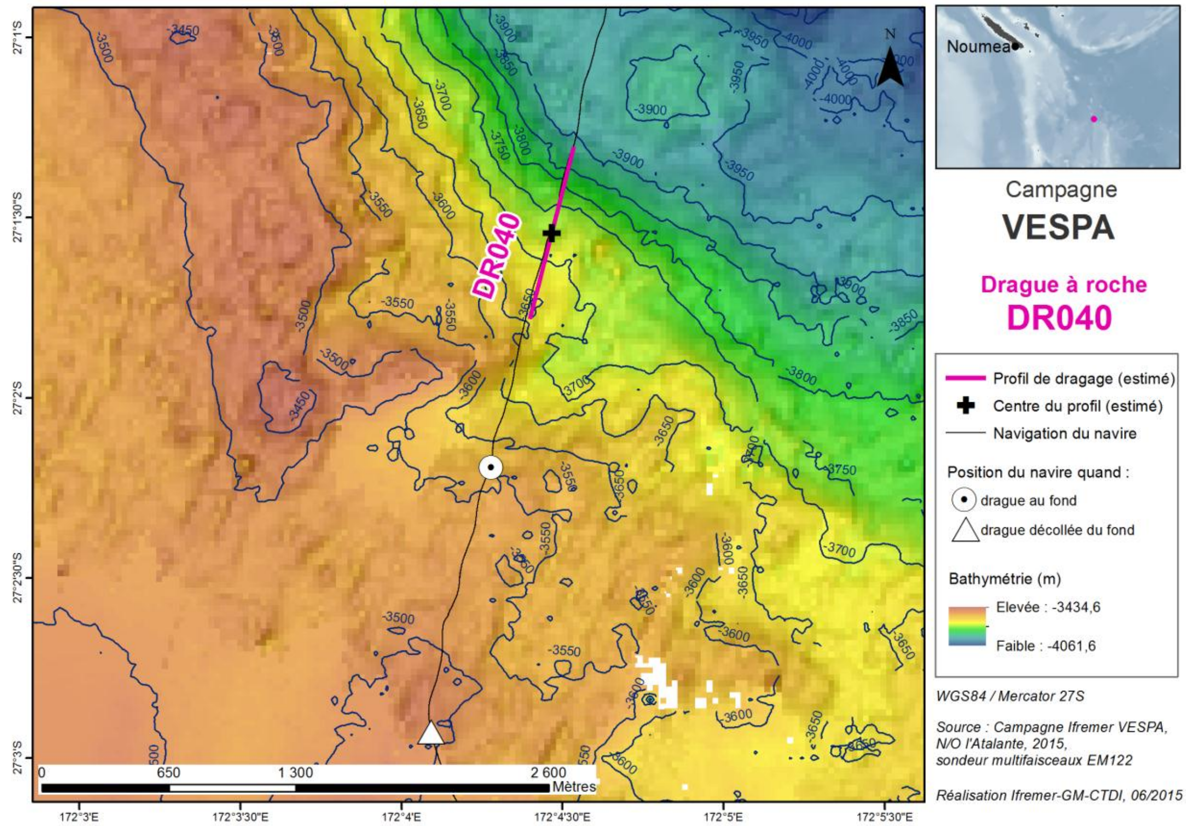
**DR39G:** A dozen 10-20 cm pieces in dredge (one kept) of soft yellowish grey (5 Y 7/2) non-calcareous mudstone. Probably composed of compacted recent pumice tephra.
Subsamples at SGNC Nouméa

**DR39H:** rounded pumice lump. Mn stained
Sample at SGNC Nouméa

**DR39I:** Sea floor sediment pipe sample
Subsample at GNS Wellington

# DR040

**Target:** Three Kings Ridge area. Cook Fracture Zone scarp near 172.1°E.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 12/06/2015 | 21:59:39 | -27,008904 | 172,0788254 | MISE A L'EAU | Mise à l'eau DR_040, 1430m de la cible |
| 12/06/2015 | 22:06:38 | -27,011800 | 172,0781805 | DEBUT DE FILAGE | Début de filage DR_040, 1102m de la cible |
| 12/06/2015 | 23:13:16 | -27,036546 | 172,0713082 | AU FOND | 4306m filés, 1746m de la cible |
| 12/06/2015 | 23:18:00 | -27,038095 | 172,0706617 | CROCHE | Croche à 7T, 4399m filés, 1875m de la cible |
| 12/06/2015 | 23:24:00 | -27,040481 | 172,069997 | DEBUT VIRAGE | 4400m filés, 2152m de la cible |
| 12/06/2015 | 23:33:00 | -27,043511 | 172,0689943 | CROCHE | Croche à 10.4T, 4313m filés, 2520m de la cible |
| 12/06/2015 | 23:42:10 | -27,048785 | 172,0682166 | DRAGUE DECOLLEE | Drague décollée, 4090m filés, 2960m de la cible |
| 13/06/2015 | 01:05:00 | -27,076867 | 172,0835199 | A BORD | DR_040 à bord |

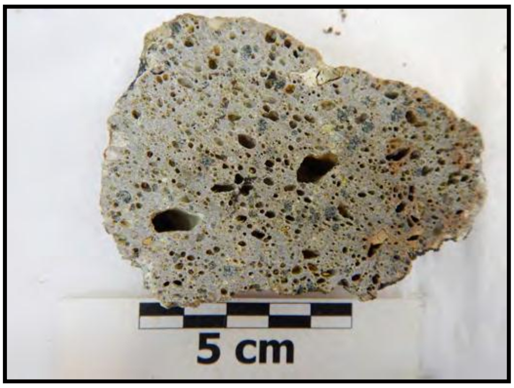
**Weight:** 250 kg, as 10-20 cm jointed blocks
**Main rock types:** Hyaloclastic breccia, siltstone-mudstone
**Other rock types:** Aphyric and porphyritic basalts as clasts in breccia
**Dredging notes:**


DR040

DR040Ai

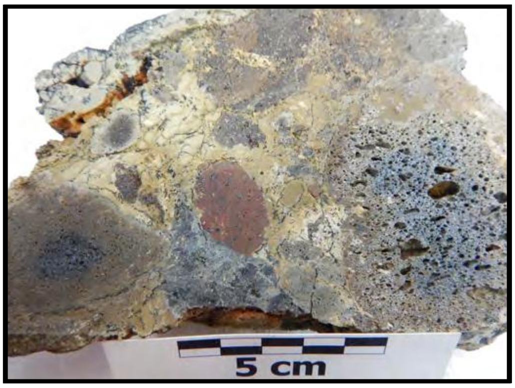

DR040Aii


DR040Bii



DR040C

DR040Di



DR040Dii

DR040F

**DR40Ai:** Breccia clast of 20x8x8 cm medium grey (N5) very sparsely porphyritic basalt with fresh glass rind. A few 1 mm olivine and up to 1-2 m pyroxene phenocrysts Mostly unweathered. Very thin (<0.5mm) Mn crust.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR40Aii:** Breccia clast of 4x5x5 cm medium grey (N5) mostly aphyric vesicular basalt. Similar to DR40Ai but more vesicular.
Subsamples at IUEM Brest, GNS Wellington

**DR40Bi:** 8x5x5 cm columnar jointed breccia clast with outer 1 cm (weathered) part light olive gray (5Y 6/1) colour. Inner part is medium grey (N5). Rock is highly porphyritic basaltic lava. Very speculatively and optimistically a picritic ankaramite (it has 5-10%, 3 mm size pyroxene phenocrysts and 10% 1 mm size olivine phenocrysts). All crystals are mostly fresh.
Subsamples at IUEM Brest, GNS Wellington

**DR40Bii:** 8x4x4 cm medium grey (N5) porphyritic basalt with c. 5% 2mm plagioclase phenocrysts and <1% <1 mm pyroxenes. Fresh.
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR40Biii:** 15x10x10 cm porphyritic ankaramite clast in breccia. Medium grey N5 similar to DR40Bi but smaller (<1mm) pyroxene and olivine phenocrysts
Subsamples at IUEM Brest, GNS Wellington, SGNC Nouméa

**DR40C:** 8x5x5 cm weathered vesicular pyroxene-phyric basalt. Light olive gray (5 Y 7/2) highly weathered scoriaceous basalt. Numerous (10%) 1 cm vesicles. 2 mm pyroxene phenocrysts.
Subsamples at GNS Wellington, SGNC Nouméa

**DR40Di:** One 7x5x5 cm piece of pebbly sandstone. Hard light olive grey (5 Y 6/1) sub-angular pebbly sandstone. Polymict. So variable colour and texture clasts but mostly very fine grained aphyric volcanics. Separate clastic grains of olivine, pyroxene and amphibole? Latter mineral is not present in the other lavas in the dredge.
Subsamples at GNS Wellington, SGNC Nouméa

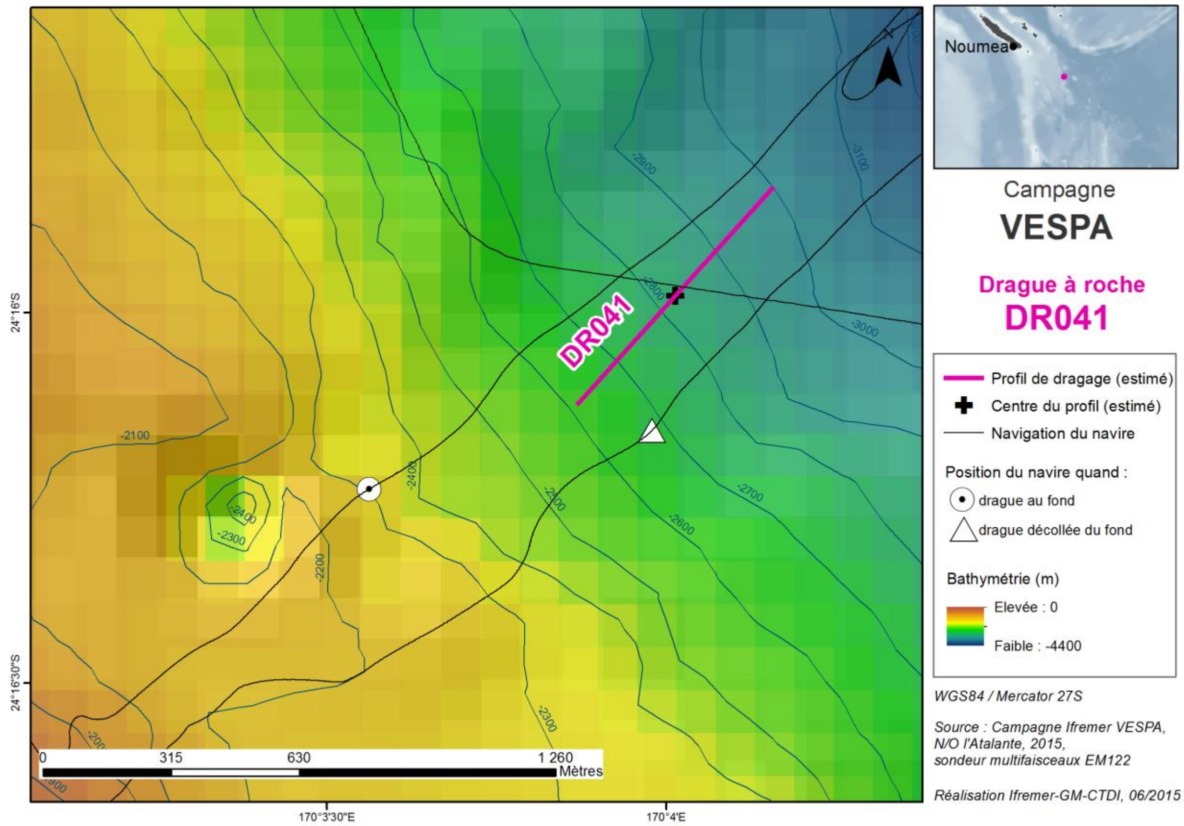
**DR40Dii:** Several15x10x15 cm pieces of hard, light olive grey (5 Y 6/1) polymict volcanic breccia. Contains fresh vesicular and porphyritic lavas like A and B but these have distinctive weathering rinds. Altered hyaloclastite matrix.
Subsamples at GNS Wellington, SGNC Nouméa

**DR40E:** Sea floor sediment pipe sample. >95% mud (i.e. <75 µm)
Subsamples at GNS Wellington

**DR40F:** One piece of 15x10x15cm pale olive grey (5 Y 5/2) massive siltstone (sandy parts) and mudstone (smooth to touch). Vague outlines of ?breccia mudstone clasts in places. No bioturbation. Calcareous (fizzes). No fossils visible.
Subsamples at GNS Wellington, SGNC Nouméa

## *DR041*

**Target:** Loyalty Ridge area. Straight part of east side Loyalty Ridge above South Fiji Basin abyssal plain, near lat. 24.3°S.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 13/06/2015 | 21:15:00 | -24,254669 | 170,0788602 | MISE A L'EAU | Mise à l'eau DR_041 |
| 13/06/2015 | 21:21:00 | -24,256766 | 170,0770752 | DEBUT DE FILAGE | Début filage DR_041 |
| 13/06/2015 | 22:13:20 | -24,270629 | 170,0593789 | AU FOND | 330m filés, 1039m de la cible |
| 13/06/2015 | 22:23:42 | -24,273519 | 170,0562942 | DEBUT VIRAGE | 3450m filés, 1505m de la cible |
| 13/06/2015 | 22:25:01 | -24,273904 | 170,0558103 | CROCHE | Croche à 9.3T, 3442m filés, 1544m de cible |
| 13/06/2015 | 23:09:00 | -24,275312 | 170,0559369 | CROCHE | Croche 22:41 décrochée, 2959m filés, 1643m de cible |
| 13/06/2015 | 23:17:32 | -24,274192 | 170,0601764 | CROCHE | Croche à 15T, 2624m filés, 1255m de cible |
| 13/06/2015 | 23:33:16 | -24,26945 | 170,0661381 | CROCHE | Croche 23:19 décrochée, 2512m filés, 550m de cible |
| 13/06/2015 | 23:33:51 | -24,269320 | 170,0663125 | DRAGUE DECOLLEE | 2512m filés, 550m de la cible |
| 14/06/2015 | 00:30:18 | -24,262519 | 170,0844429 | A BORD | DR_041 à bord |

**Weight:** 80 kg, as 10-20 cm jointed blocks
**Main rock types:** Ol-cpx phyric lavas
**Other rock types:** White limestone, volcanic breccia
**Dredging notes:**


DR041


DR041Ai

DR041Aii

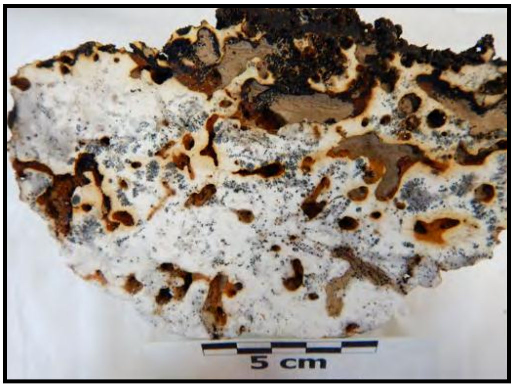

DR041Aiii


DR041B


DR041C

DR041Di


DR041Dii




DR041Ei


DR041Eii


DR041G

**DR41Ai:** 30x15x10 cm joint block of very light grey (N7) porphyritic and vesicular (10%) olivine- and pyroxene-phyric basalt. 1-2 mm olivine phenocrysts, >20% 1 mm sized pyroxenes. Glassy rim (weathered to palagonite) on one side. c. 1 cm Mn crust.
Subsamples to IUEM Brest, GNS Wellington, SGNC Nouméa

**DR41Aii:** 50x20x30 cm medium grey (N5) olivine-phyric basalt. Similar to Ai but fresher, less vesicular, and with smaller pyroxene phenocrysts (c. 0.5 mm, 20%)
Subsamples to IUEM Brest, GNS Wellington, SGNC Nouméa

**DR41Aiii:** 15x10x10 cm medium light grey (N6) highly vesicular (~20% >1mm vesicles), olivine porphyritic basalt. About half the vesicles have been secondary filled with yellowish gray cryptocrystalline material.
Subsamples to IUEM Brest, GNS Wellington, SGNC Nouméa

**DR41B:** 35x20x20 cm piece of moderate brown (5YR 4/4) and light brown (5YR5/6) volcaniclastic breccia. Fragments of weathered basaltic clasts; probably similar to sample DR41A. Non-calcareous white matrix. c. 1 cm thick Mn crust.
Subsamples to GNS Wellington, SGNC Nouméa

**DR41C:** 8x5x10 cm piece of black Mn crust, 3cm thick.
Subsamples to IFREMER Brest

**DR41Di:** Four 10x5x1 cm pieces retained of volcaniclastic breccia. Varicolored but averages a moderate greenish yellow (10 Y 7/4) colour. Polymict, angular to sub-angular clasts of green, brown and grey basalt lithologies. Creamy white/grey micritic or hyaloclastic matrix is not calcareous. No fossils.
Subsamples to GNS Wellington, SGNC Nouméa

**DR41Dii:** Three 15x5x5 cm pieces of light olive brown (5 Y 5/6) volcaniclastic sandstone-conglomerate. Mn crust. Has carbonate content (fizzes). Pockets and thin layers adhering to clasts with conspicuous microfossils.
Subsamples to GNS Wellington, SGNC Nouméa

**DR41Ei:** Two 10x5x5 cm pieces of cemented, white foram limestone. Riddled with borings (worms?). Holes are infilled with soft grey/brown mud/ooze. Sample has an Mn crust.
Subsamples to GNS Wellington, SGNC Nouméa

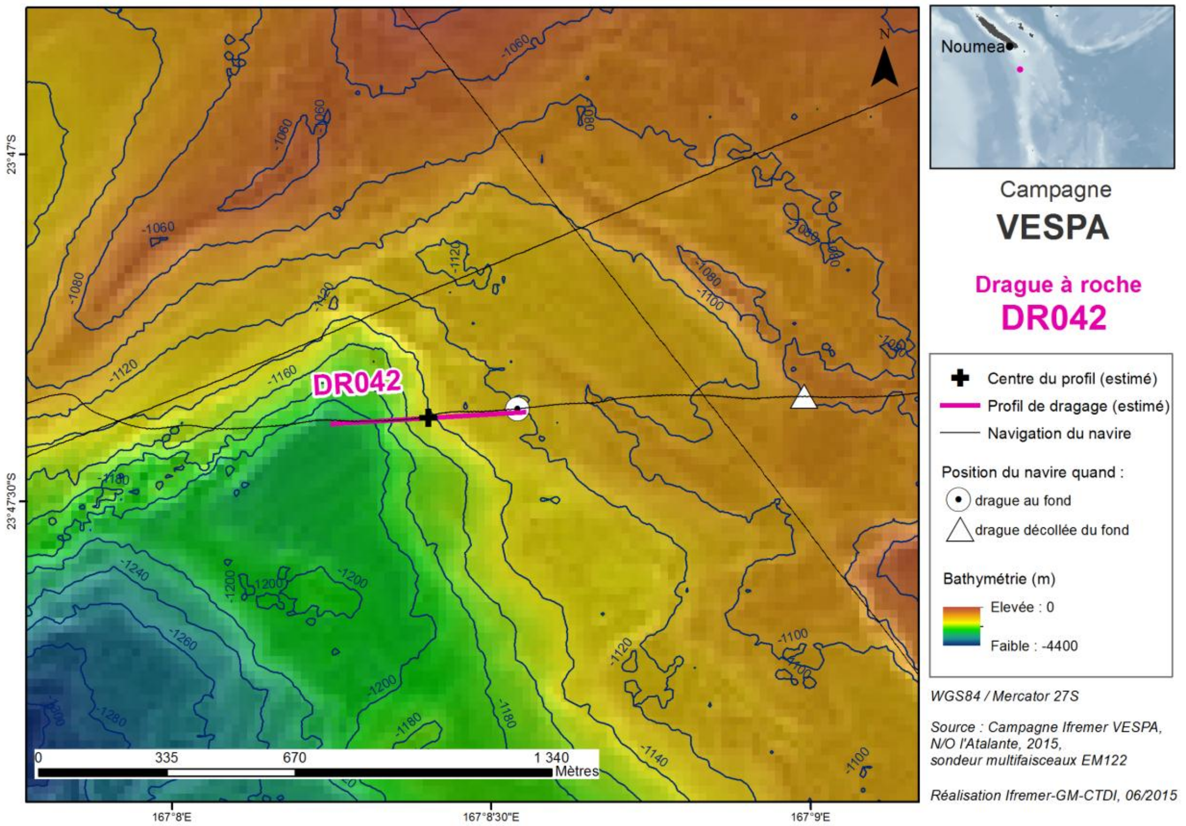
**DR41Eii:** Three 15x5x5 cm pieces of limestone . As above but seemingly more stratified with two Mn crusts.
Subsamples to GNS Wellington, SGNC Nouméa

**DR41F:** Sea floor sediment pipe sample. Muddy.
Subsample to GNS Wellington

**DR41G:** 15x10x10 cm piece of poorly sorted conglomerate. Contains 1-10 cm rounded clasts of lava like DR41A. Rounded pebbles cemented together by Mn crusts. In fact, some of the DR41A lavas may have been clasts in a D41G rock (prior to being broken up by the dredge).
Subsample to SGNC Nouméa

# *DR042*

**Target:** Norfolk Ridge area. Seabed exposure of TECTA seismic horizon on steep, sediment-free slope.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 15/06/2015 | 05:30:16 | -23,789326 | 167,1286721 | MISE A L'EAU | Mise à l'eau DR_042 |
| 15/06/2015 | 05:42:23 | -23,789903 | 167,1330998 | DEBUT DE FILAGE | Début de filage Dr_042 |
| 15/06/2015 | 06:03:01 | -23,789448 | 167,1423541 | AU FOND | 1317m filés. 400m de la cible |
| 15/06/2015 | 06:12:36 | -23,789122 | 167,1468647 | DEBUT VIRAGE | 1500m filés. 800m de la cible |
| 15/06/2015 | 06:16:25 | -23,789185 | 167,1486283 | CROCHE | Croche 8T, 1420m filés, 1050m de la cible |
| 15/06/2015 | 06:17:19 | -23,789162 | 167,1491093 | CROCHE | Croche 16T, 1400m filés, 1170m de la cible. |
| 15/06/2015 | 06:18:37 | -23,789147 | 167,1496056 | CROCHE | Croche 14.5T, 1400m filés, 1170m de la cible |
| 15/06/2015 | 06:19:01 | -23,789141 | 167,1498364 | DRAGUE DECOLLEE | 1400m filés, 1200m de la cible. |
| 15/06/2015 | 06:56:38 | -23,788152 | 167,163514 | A BORD | DR_042 à bord |

**Weight:** 30 kg
**Main rock types:** Soft mudstone
**Other rock types:** Hard siltstone, hard limestone, piece of hardground
**Dredging notes:**

DR042


DR042A


DR042B

DR042Ci


DR042Ci


DR042Cii


DR042D

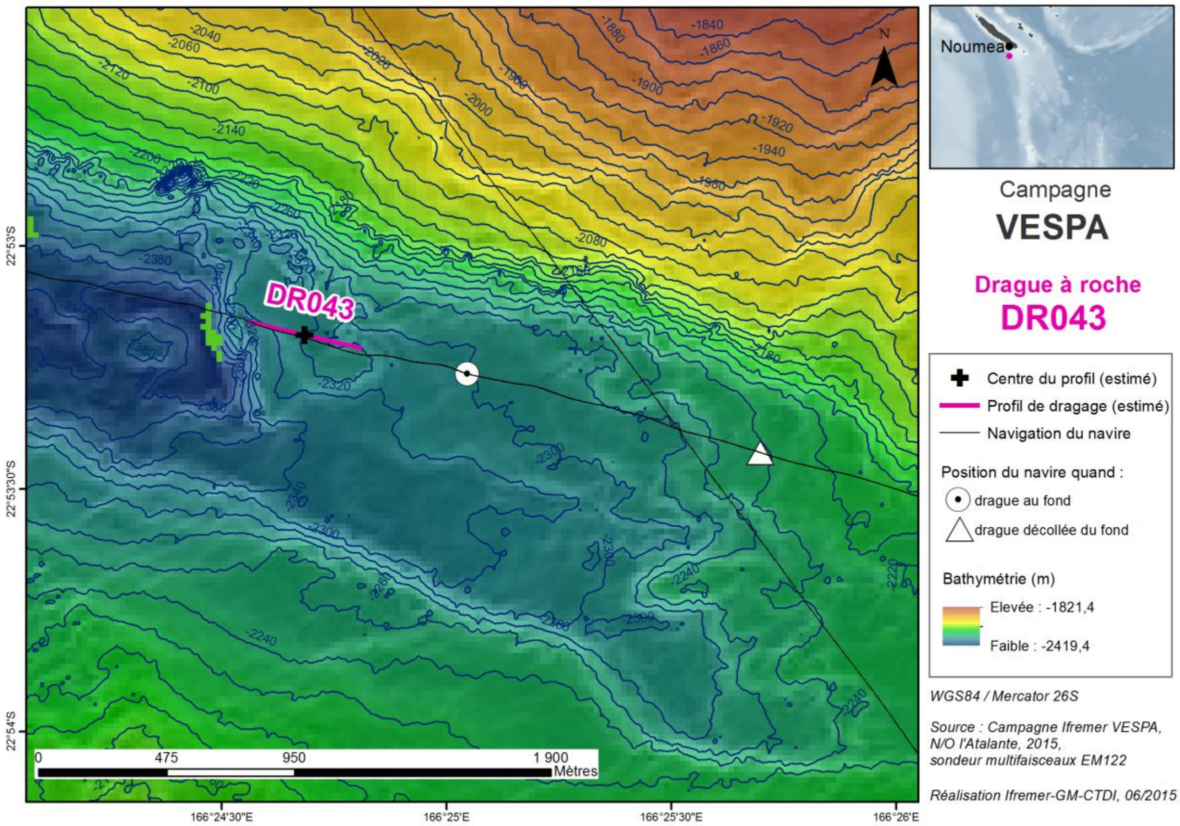
DR042E

**DR42A:** One 50x20x10 cm rounded elongate slab in dredge of indurated dusky yellow (5 Y 6/4) graded siltstone. Contains a 2 cm bed of very fine sandstone. Some trace fossils (fileld burrows). Shaped like a concretion, and fizzes very weakly in HCl. Sandstone appears mafic volcanic lithic, no quartz visible. Grading indicates a specific facing direction. No body fossils seen but there are a few scattered forams in the finer part. Modern coral 'stubs' on one face.
Subsamples to IUEM Brest, GNS Wellington, SGNC Nouméa

**DR42B:** One 25x10x10 cm piece in dredge of cemented and heavily bioturbated moderate brown (5 YR 4/4) laminated silicified limestone (a hardground). Some 5-10 mm irregular 'pockets' of hard, very pale orange (10 YR 8/2) limestone (fizzes) with visible forams. The limestone may occupy void spaces or borings in hardground. 4 cm Mn rind on one side of sample; coral stubs on the other side.
Subsamples to GNS Wellington, SGNC Nouméa
**DR42Ci:** One 30x30x30 cm piece in dredge of hard, slightly friable pinkish grey (5 YR 8/1) well sorted (winnowed?) coarse grained angular bioclastic calcarenite. No bedding. Bored with open (unfilled) burrows, one set 1 cm diameter, another set 2 mm diameter. Scattered oversize (3-6 mm) clasts of moderate red (5 R 4/6) basaltic lithics through the limestone. Fossil content dominated by echinoderm fragments and some bryozoans. Overall, suggestive of high energy environment.
Subsamples to GNS Wellington, SGNC Nouméa
**DR42Cii:** One 7x7x5 cm piece in dredge. Separate piece of bioclastic calcarenite limestone somewhat similar to DR42Ci but overall slightly harder, less friable and fine-medium grained. Still well sorted with reddish volcanic lithics. Contains unfilled 2 mm diameter borings.
Subsamples to GNS Wellington, SGNC Nouméa
**DR42D:** About 2/3 of the dredge consists of many dm-sized pieces of soft, light olive grey (5 Y 5/2) homogeneous calcareous mudstone. Conspicuous microfossils.
Sample to GNS Wellington, SGNC Nouméa
**DR42E:** One 7x7x3 cm piece of Mn crust.
Sample to IFREMER Brest
**DR42F:** Sea floor sediment pipe sample.
Sample to GNS Wellington

# *DR043*

**Target:** Norfolk Ridge area. Seabed exposure of TECTA seismic horizon in erosional canyon identified on VESPA seismic line, early in the cruise.




| Date | Heure | Latitude | Longitude | Nom Action | Observation |
|---|---|---|---|---|---|
| 15/06/2015 | 20:02:02 | -22,883807 | 166,3984392 | MISE A L'EAU | Mise à l'eau DR_043 |
| 15/06/2015 | 20:09:11 | -22,884350 | 166,4016416 | DEBUT DE FILAGE | Début filage DR_043, 605m de la cible. |
| 15/06/2015 | 20:48:01 | -22,887716 | 166,4174444 | AU FOND | Drague au fond |
| 15/06/2015 | 20:58:15 | -22,888703 | 166,4218758 | CROCHE | Croche 4.6T, 2700m filés, 1540m de cible |
| 15/06/2015 | 20:59:00 | -22,888769 | 166,4222743 | CROCHE | Croche 6.3T, 2700m filés, 1576m de cible |
| 15/06/2015 | 21:00:00 | -22,888843 | 166,4226521 | DEBUT VIRAGE | Début virage |
| 15/06/2015 | 21:10:18 | -22,890419 | 166,4283078 | DRAGUE DECOLLEE | Heure incertaine |
| 15/06/2015 | 22:08:11 | -22,913477 | 166,4608 | A BORD | DR_043 à bord |

**Weight:** 1 kg
**Main rock types:** Andesite
**Other rock types:** Tiny pieces of limestone in pipe
**Dredging notes:** Dredge hit bottom slightly late


DR043


DR043Ai


DR043Aii


DR043B


DR043C

**DR43Ai:** Irregular 15x101x10cm jointed angular block of hard, fresh, brownish black (5 YR 2/1) aphyric andesite or basalt. Fine grained randomly oriented plagioclase laths in groundmass along with ?black hornblende (or could be pyroxene). Despite random crystal orientation there is a platy ?flow foliation spaced 2-3 mm apart within the rock. No Mn crust
Subsamples to IUEM Brest, GNS Wellington, SGNC Nouméa

**DR43Aii:** Separate, jointed 15x10x10cm piece of andesite. Identical to DR43Ai and plausibly plucked from the same rock platform.
Subsamples to GNS Wellington, SGNC Nouméa

**DR43B:** Four 5-15 mm rock chips in pipe of hard, greyish orange pink (5 YR 7/2) mediummgrained calcarenite. Calcareous (fizzes). A few volcanic lithic grains. Penetrated by Mn. Slight risk that they are residual from an earlier dredge if pipe was not thoroughly emptied.
Sample to GNS Wellington

**DR43C:** Four 5-10 mm soft balls in pipe. Soft and pliable light olive grey (5 Y 6/1) mud/mudstone. Calcareous. Somewhat resemble DR42D; slight risk that they are residual from an earlier dredge if pipe was not thoroughly emptied.
Sample to GNS Wellington

**DR43D:** Sea floor sediment pipe sample..
Subsample to GNS Wellington

# VIII) ANNEXE 2 :Calibration of the depth of the rock dredge during an experiment in deep water

*Martin Patriat and Clément Roussel*

During dredge operations the exact depth of the rock dredge is not known, from its launching to its arrival on the bottom. It can only be estimated from the length of unwound cable.

For the VESPA scientific cruise we wanted to master the depth of the dredge landing to have the most accurate possible idea of the path of the dredge on the bottom. So we instrumented a rock dredge and we deployed it in several implementation configurations to determine the relationship between the cable length and the dredge depth.

The experiment lasted seven hours, from 05: 30 to 12:30 Wednesday, June 3 (UTC) (4:30 p.m. to 11:30 p.m. local time)

## *Experiment principle*

The purpose of this experiment was to measure the depth of the rock dredge according to the cable length. This was done using instruments attached to the rock dredge during the experiment.

The relationship between cable length and dredge depth depends on the dip angle of the whole device and the deviation from the linearity of the path of the cable in the water, deviation which depends in particular on the drag of the cable, the cable weight, the weight of the rock dredge, its lifting, and the relative velocity of the whole device with respect to the water mass  (Figure 1).

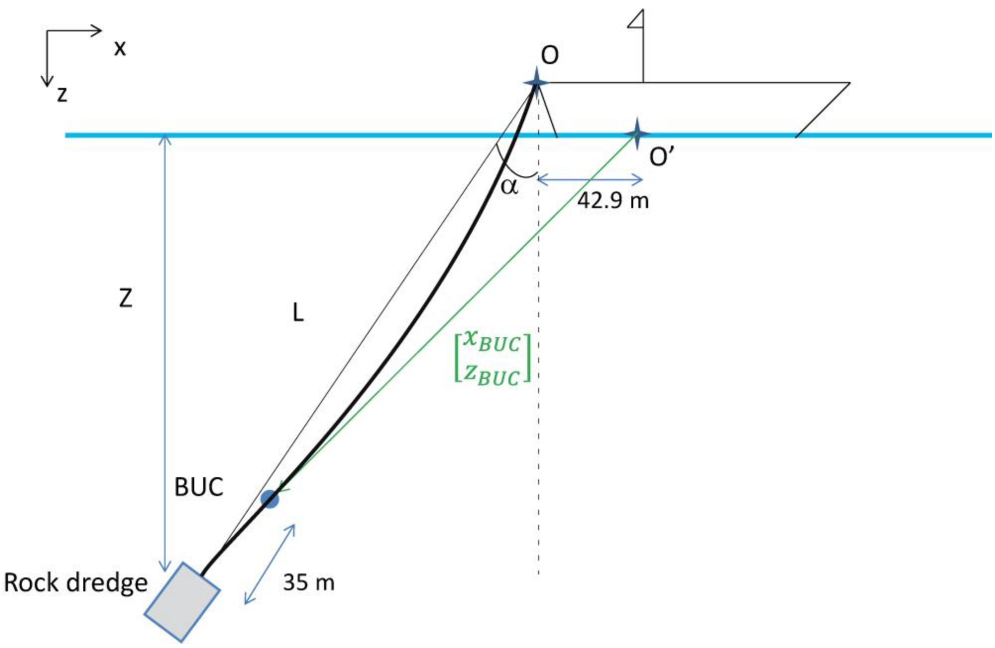



Figure 1: Schema of the cable path from the back of the boat to the dredge.

The idea of this experiment was to have an empirical knowledge of the relationship between cable length and depth of the dredge, from a simple and realistic setting compared to the usual dredging conditions.

In these experiments we simply set tools measuring the position and depth of the dredge and asked the bridge to keep the boat on a fixed GPS route at the speed (GPS) of 1.5 knots.

To minimize the risk of currents skewing the experiment, the first test, at constant unwinding speed (see below), was followed by a second similar test (same settings, including speed), along the same profile, but with the boat progressing in the reverse direction.

### *Instruments*

The rock dredge and its rig were those used throughout the VESPA voyage. Just for the duration of the experiment, an Ultra Short Base transmitter (BUC) and a depth and inclination recorder were fixed on the dredge.

The BUC (Figure 27) was attached to the cable 35 m above the rock dredge. Reception of its acoustic signal by the hull mounted transponders allowed pinpointing of the BUC relative to the boat reference frame as a function of time (measured by ship's clock).

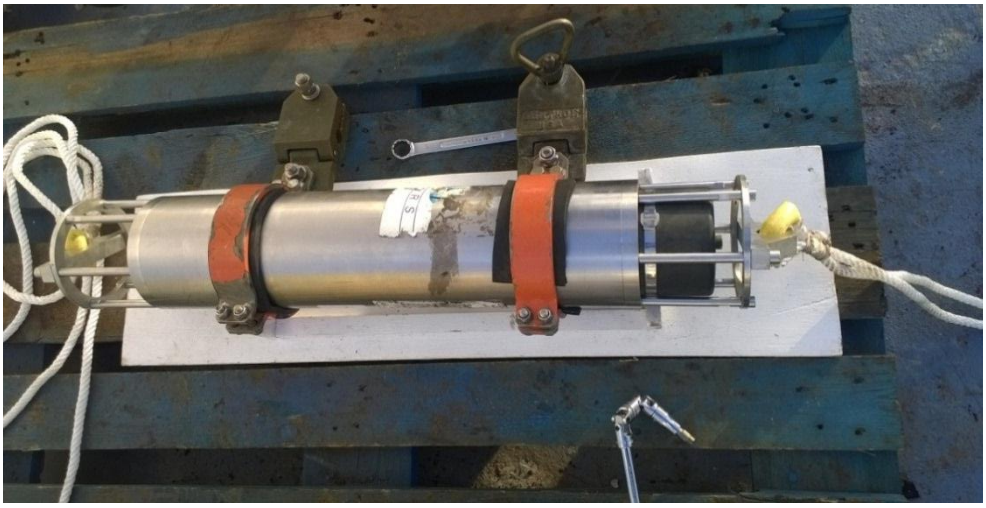


Figure 27: BUC before being attached to the cable. Note (top of the photo), the two jaws in dark color, which clamp the BUC to the cable.

To measure the depth we used a depth gauge / inclinometer loaned by INSU, attached directly to the dredge in a cage welded on the handle of the dredge (

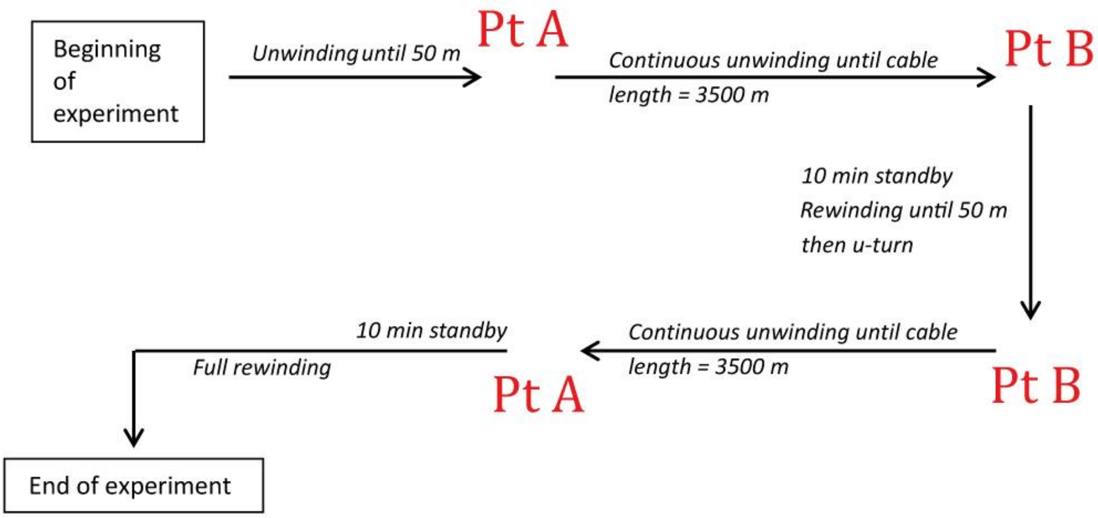
Figure 3: ) . It allowed a continuous measure of the depth and inclination as a function of time synchronized with the ship clock.

Figure 3: Cage welded to the handle of the dredge, and in which the inclinometer / gauge was fixed

### *Continuous unwinding calibration (CFC_1 and CFC_2)*

For continuous unwinding calibration, we continuously unwound the cable, at constant speed, as in a true dredging operation, until the maximum length (3500 m). Then we waited 10 minutes before rewinding the whole cable.

We asked that the unwinding speeds be identical to those applied during the actual dredging. In practice 50m of cable was unwound at low speed (according to the recommendations accompanying the use of the deep sea cable) then the cable was unwound at maximum speed (~ 1 m / s) up to the final length of 3500 m (the sea bottom was over 4000 m but we wanted absolutely to avoid bottoming the dredge because of the fragility of the instruments).

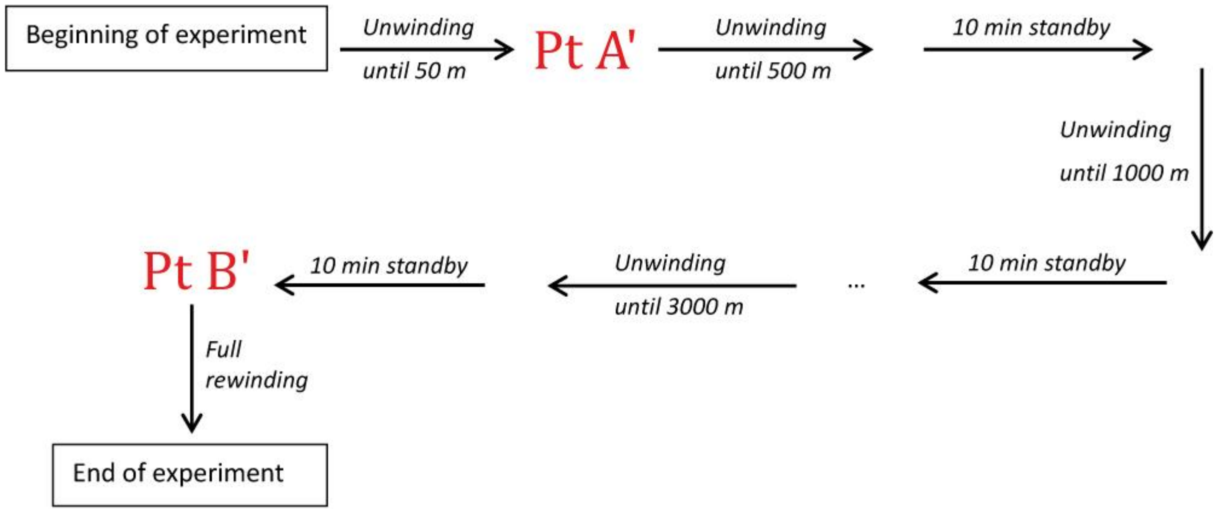



The first test (CFC_1) was carried out on a straight route with constant speed (1.5 knots). It was followed, as explained above, and to assess the potential effect of currents, by a second test (CFC_2) exactly the same but in the reverse direction.

### *Calibration with unwinding stops (CAF)*

When dredging, it is common to stop unwinding while the dredge has not yet landed on the sea bottom, especially while approaching the dredge site along a steep slope. To know the depth of the dredge relative to the cable length in such a situation it seemed important to test if the depth of the dredge was different during unwinding at 1m / s and during no unwinding . So we performed the same test as above but punctuated with a number of unwinding stops (CAF).

For calibration with unwinding stops, we thus asked that the cable unwinding be stopped for 10 minutes every 500 m, with up to 3000 m of cable length deployed (in the previous test, we already tested the 3500 m cable length).




### *Results*

Three sensors recorded data continuously throughout the calibration procedure:

- The depth gauge, attached to the dredge, directly measured the Z depth of the dredge.

- The BUC, attached to the cable at 35 m from the rock dredge, measured its position denoted $\begin{bmatrix} x_{BUC} \\ z_{BUC} \end{bmatrix}$ in the (O',x,z) reference. The reference point O' is located 42.9 m before the stern (Figure 1).

- The cable length sensor simply measured cable length as a function of time. Zero was established while fixing the BUC on cable, when the BUC was on deck. Measured cable length thus corresponds to the distance between the back of the ship and the BUC. To know L, the length of cable between the stern and the dredge, we therefore added 35 m to the measured length.

These three sets of measurements were recorded as a function of time and synchronized with the ship clock. They were therefore correlated with the time frame.

To be comparable, the measures must be brought into a common spatial reference, we chose to be (O, x, z). With O the back of the ship, x the horizontal coordinate and z the vertical coordinate (depth).

We thus did the following translations:

$$\begin{bmatrix} x_{BUC} \\ z_{BUC} \end{bmatrix} \rightarrow \begin{bmatrix} x_{BUC} + 42.9 - 35\sin(\alpha) \\ z_{BUC} + 35\cos(\alpha) \end{bmatrix}$$

$$L \rightarrow L + 35$$

Assuming that O, O' are both at sea level.

For the purposes of this report, the cable length corresponds to the length of the cable unwound since the launching of the rock dredge, and therefore to the cable length between the stern and the dredge itself, while the depth corresponds to the depth of the dredge itself.

Data were processed with Matlab. The first step was to interpolate the BUC and cable length data on the same time base as the depth gauge. We also cut data in three time windows corresponding to the three tests, in order:

1) CFC_1, the continuous unwinding calibration (one way) from 5:30 to 7:35

2) CAF, the calibration with unwinding stops, from 7:45 to 10:10

3) CFC_2, the continuous unwinding calibration (return), from 10:20 to 12:30

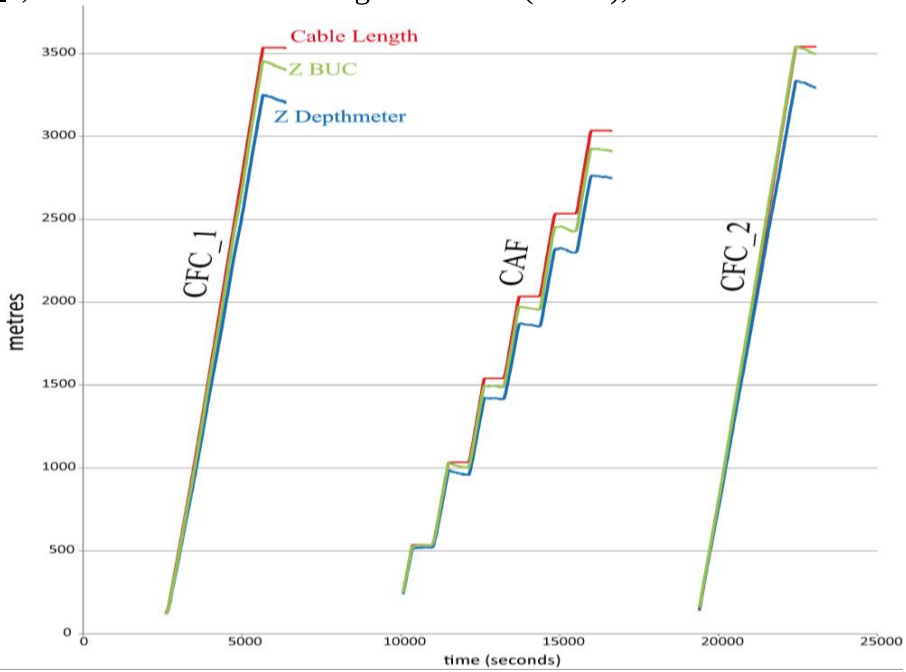



Figure 4: Different parameters versus time. The depth deducted from the BUC (Z BUC), the depth measured by the gauge (Z Depthmeter) and the cable length, are represented for the total duration of the experiment.

Very quickly during the data analysis it appeared that **the inclinometer / gauge had produced erroneous data**. The depth indicated by this tool was at times very (too) close to the cable length, as if the cable was hanging vertically, and the difference between the two increased only very little with the cable length. And this error worsened with time, the depth even exceeding the cable length at the end of the experiment! For the data analysis we therefore only considered the depths derived from the use of the BUC. A calibration of the inclinometer / gauge by the INSU staff few weeks after the cruise confirmed that the tool was faulty.

Therefore, we based our analysis of the relationship between cable length and depth of the dredge only on depth data from the BUC.

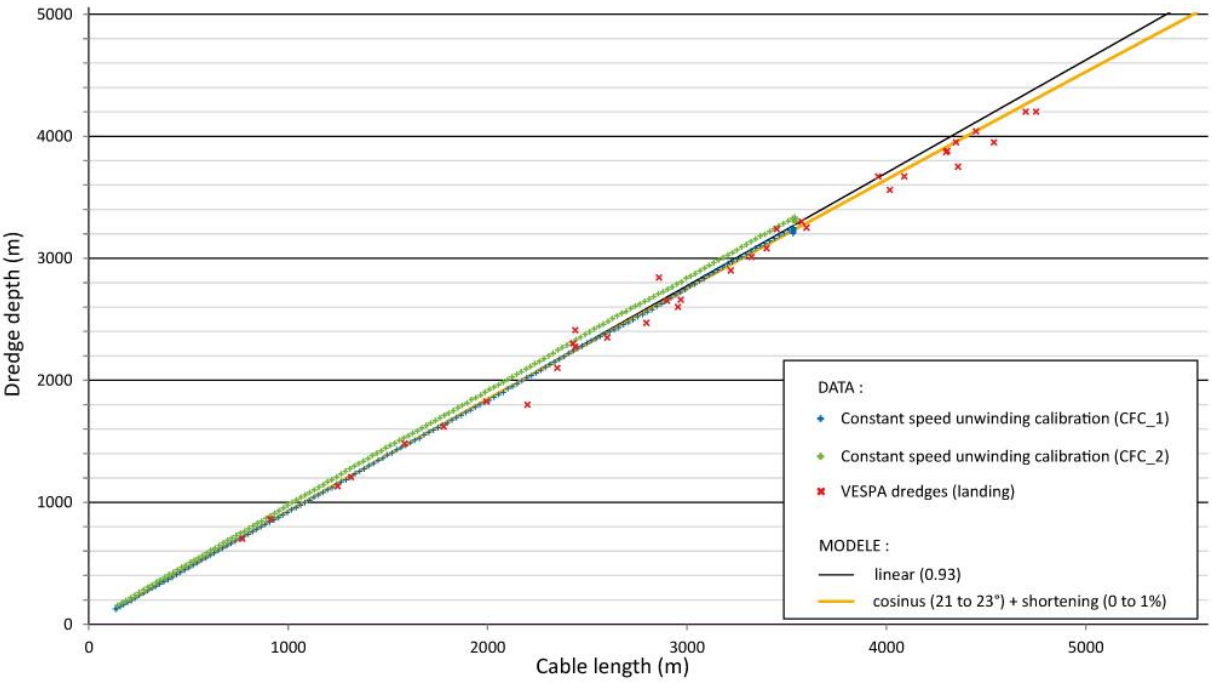



Figure 5: All data and models, Depth = f (cable length)

The analysis of the relationship between depth of the dredge and cable length (Figure5) shows that the relationship is very close to proportionality, with, as a first approximation,

(1) $Z = 0.93 * L$ (with Z = dredge depth and L = cable length)

The geometric description of the device (figure 1) still leads us to propose a relationship related to the cosine of the apparent angle between the device and the vertical, while applying a shortening coefficient reflecting the fact that the cable is not straight but slightly curved (catenary effect due to the dragging of the cable).

(2) $Z = L * k * \cos(\alpha)$ (with k = shortening coefficient and $\alpha$ = apparent dip of the whole device)

The catenary effect, and therefore k, must increase with the length of cable, as well as the angle $\alpha$.

We propose that the shortening increases linearly with the cable length. It is zero at the beginning (k = 1) and reaches 1% at 4000m (k = 0.99). Similarly the dip (□) increases from 21° at 100 m until 23° at 4000 m

(3) $Z = L * (99+( (4000-L)/4000)) * \cos(21+(2/3900*(L-100))$

## *Conclusions*

The analysis of the data, coming both from the experiments and also from the actual VESPA dredge operations, show that despite the attempt to reproduce exactly the same dredging process, significant variations in the dredge depth appear for the same cable length. Unfortunately, and as confirmed by the differences between the two experiments conducted in opposite direction, the variations are due primarily to the effects of currents. These appear significant.

We nevertheless propose a very simple formula linking depth and cable length in the case of dredging procedures performed with the parameters used during Vespa as well as during the experiment (constant speed 1.5 knots, constant unwinding speed 1 m / s):

**Depth = cable length * (99 + ((4000 - cable length) / 4000)) / 100 * cos (21 + (2 / 3900 * (cable length - 100))**

For cable lengths of up to 4000 m, the following simplified formula applies:

**Depth = cable length * 0.93**

Using this simple formula does not allow a finer positional precision better than c. 100 m, or worse in the case of strong currents.

If cable unwinding is interrupted, the dredge lifts slightly up, its depth decreasing b c. 20 m or , or even up to 40 m.

To know with more precision the depth of the dredge the feasibility of equipping the dredge with an inclinometer / gauge during the actual dredging should be considered. The obstacle to this, of course, is the relative fragility of the instrument compared with the violence of accelerations when the dredge is working on the seafloor.

# IX) ANNEXE 3 :Observation des mammifères marins et mitigation associée durant des opérations de tirs sismiques et hors tir de la campagne scientifique VESPA (L'Atalante, 23 Mai-16 Juin 2015).

GOUVERNEMENT
NOUVELLE-CALÉDONIE

# RAPPORT FINAL

Campagne Scientifique VESPA :

Volcanic Evolution of South Pacific Arcs

*Observation des mammifères marins et mitigation associée durant des opérations de tirs sismiques et hors tir de la campagne scientifique VESPA (L'Atalante, 23 Mai-16 Juin 2015).*

**Réalisé pour**

**le Gouvernement et les Affaires Maritimes de Nouvelle-Calédonie.**


**Réalisé par**

**Laura Ceyrac**

**Consultante et observateur mammifères marins**


L'Atalante
Navire océanographique
Genavir
GNS SCIENCE TE PŪ AO
Ifremer

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## 1. INTRODUCTION

Le projet VESPA (Volcanic Evolution of the South PAcific) a pour but de récolter des prélèvements géologiques et d'acquérir des données acoustiques afin de comprendre un évènement tectonique régional majeur qui a affecté la zone de Tasman au cours du Cénozoique. La campagne VESPA se propose de tester des hypothèses précises concernant l'âge, la migration et la polarité des arcs volcaniques et bassins arrière-arcs associés situés entre la Nouvelle-Calédonie et la Nouvelle-Zélande.

Or dans le cadre des campagnes océanographiques impliquant l'utilisation de sismique marine susceptibles de générer un impact sonore sur les mammifères marins, l'Ifremer applique un protocole d'analyse préliminaire, suivi d'une obligation de précautions opératoires applicables lors des travaux en mer. Lors de la campagne VESPA, les sources sismiques utilisées étant de puissance modérée « sismique rapide numérique SISRAP », il a été montré après analyse spécifique, qu'il n'était pas nécessaire, dans ce contexte, de prendre des mesures particulières de protection des mammifères marins.

Cependant, la Direction des Affaires Maritimes de Nouvelle-Calédonie DAM, dans son approche de mise en place du plan de gestion du parc marin pour le compte du gouvernement de Nouvelle-Calédonie souhaite tendre vers un niveau de précaution équivalent à celui applicable en Nouvelle-Zélande. De ce fait, un protocole de mitigation adapté, normalement réservé par l'Ifremer aux sources sismiques de très forte puissance, a été appliqué lors de la campagne VESPA à bord du N/O *L'Atalante* dans les eaux sous juridiction de la Nouvelle Calédonie et en dehors.

## 2. OBSERVATEURS MAMMIFERES MARINS EMBARQUES

Durant toute la durée de la campagne de géosciences VESPA, deux observateurs mammifères marins qualifiés et indépendants ont embarqués à bord du N/O *L'Atalante* de l'Ifremer et ont visé à la bonne conduite du protocole de mitigation lors des phases de tirs sismique, ainsi qu'au protocole d'observation en dehors des tirs.

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**Thomas Auger**

Coordonnateur des observations dans le parc naturel de la mer de Corail – Service de la pêche et de l’environnement - Direction des Affaires Maritimes – Nouvelle Calédonie. Expérience en tant qu’observateur et contrôleur des pêches (Lybie, Terres Australes et Antarctiques Françaises TAAF), observateur mammifères marins et mégafaune marine (Nouvelle Calédonie).

## 3. CAMPAGNE VESPA ET DESCRIPTION DES SOURCES SONORES

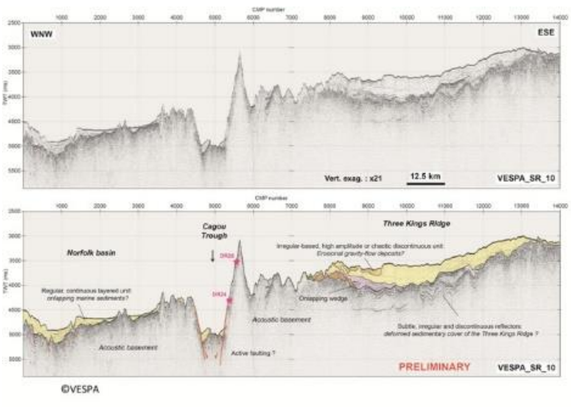
Lors de la campagne VESPA, et dans le but de tester des hypothèses précises concernant l’âge, la migration et la polarité des arcs volcaniques situés entre la Nouvelle-Calédonie et la Nouvelle-Zélande, des dragages sur les rides de Norfolk et des Loyautés/Trois Rois, trois principaux outils ont été utilisés :

Un sondeur multifaisceaux, outil acoustique fournissant une cartographie bathymétrique haute-résolution. Un magnétomètre, enregistrant le champ d’induction magnétique terrestre et océanique. Ainsi que deux types de sismique réflexion, dont une sismique de surface (sondeur de sédiment CHIRP) utilisant une source de 3,5kHz et une sismique rapide (SISRAP) qui utilise une source de 55 Hz permettant la création de profils en deux dimensions de la structure profonde des sédiments et des roches du plancher océanique.

Compte tenu du fait que seules les opérations de sismique semblent, à ce jour, avoir un impact sur les cétacés, seules ces dernières seront détaillées ci-dessous.

- Sismique rapide numérique sisrap

Cette technique implique deux canons à air situés sur les côtés du navire, dont le signal est réceptionné à son retour par des géophones positionnées à l’arrière du navire, le long d’une flûte de 600m de long. L’enregistrement par les géophones, du temps de retour des ondes acoustique émises par les canons et réfléchies sur les discontinuités des roches profondes, permet la création de profils en deux dimensions.




Profil sismique SISRAP traité (en haut) et son interprétation provisoire (en bas).

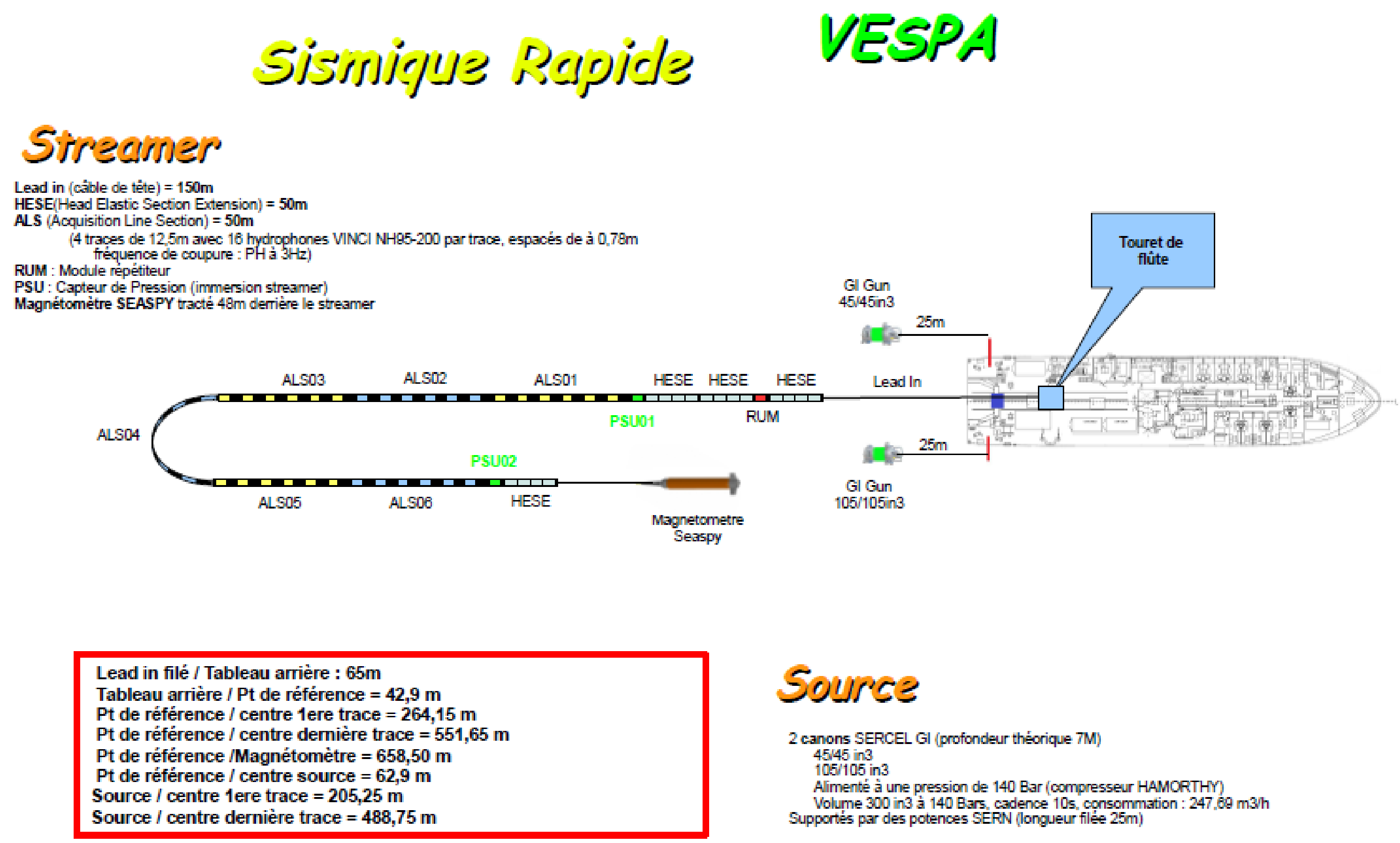
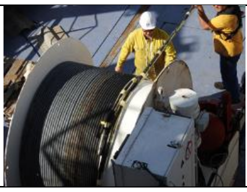
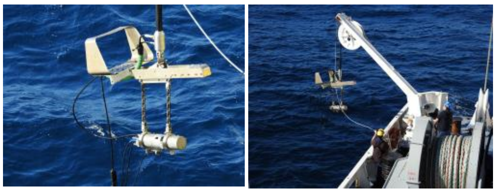



**FIGURE 1: SCHEMA TECHNIQUE DISPOSITIF SISMIQUE RAPIDE SISRAP**

Le dispositif SISRAP présent à bord comprend :

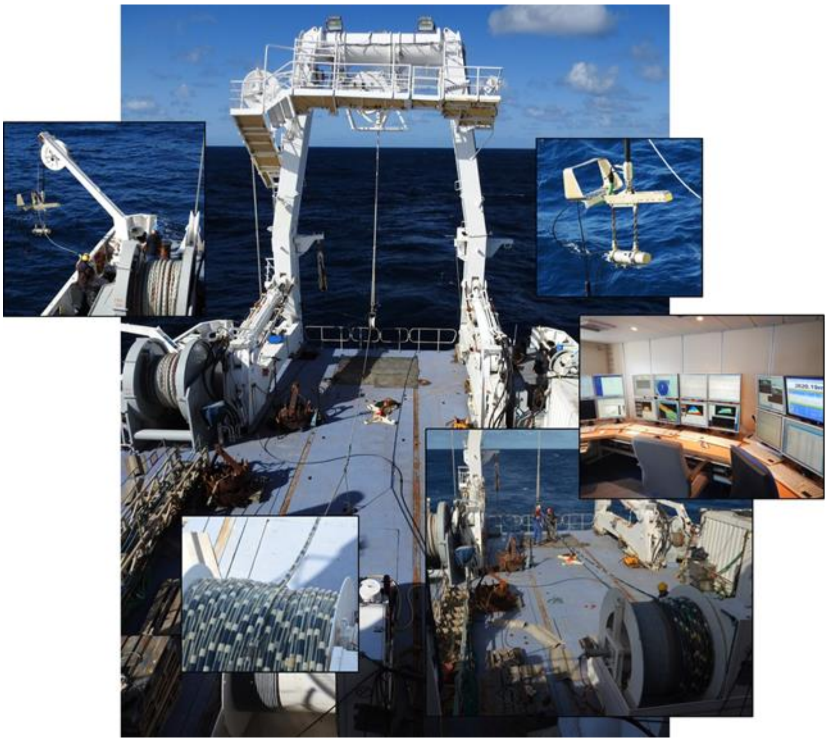
| | |
|---|---|
|  | La flûte sismique |
| | L'électronique d'acquisition |
|  | Deux capteurs d'immersion (capteurs de pression en tête et en queue du tronçon actif, datation précise des tirs). |
|  | Les outils de contrôle qualité/ traitement à bord (déport des écrans de mise en œuvre et du contrôle qualité du PC scientifique, positionnement DGPS, gyrocompas, sonde). |

| | |
|---|---|
|  | Le dispositif source, canon. |

Profil acoustique de chaque canon :

- ✓ Gamme de fréquence allant de 5 à 100Hz.
- ✓ Cadence de tir de 10 secondes.
- ✓ 6,24 bars au niveau crête.
- ✓ Volume totale de la source : 300 cubic inch.
- ✓ Pression max crête : 6,25 bar à 1m ; niveau maximum de pression pic de 235,9 dB re 1µPa.
- ✓ SEL (Sound Exposure Level) pour un tir à 1m est de 214 dB re 1.µPa².s à 1m.

Mise en place (à gauche) du dispositif de sismique rapide. Dispositif en cours d'utilisation et visualisation des bulles d'air remontant en surface après explosion acoustique (à droite).



## 4. OBJECTIFS

Lors de la campagne océanique VESPA, le rôle des observateurs mammifères marins (MMO) présents à bord du navire lors d'opérations de prospection sismique marine, est de détecter, suivre et alerter de la présence de mammifères marins sur la zone d'opération. Ils veillent également à ce que les opérations sismique se fassent en accord avec les protocoles de mitigation établis par l'Ifremer visant à minimiser les risques de perturbations et de blessures des mammifères marins.

## 4.1. METHODE D'OBSERVATION

Lors des acquisitions sismiques en période diurne, au moins un des observateurs se tient à son poste d'observation pour s'assurer de l'absence de mammifères marins dans la zone d'exclusion. La *zone d'exclusion* définit le périmètre autour des sources sismiques dans lequel aucun mammifère marin ne doit être présent. Au-delà de cette zone, le risque de lésions physiologiques pour ces espèces est négligeable. Le rayon d'exclusion pour toute la durée de la campagne VESPA est fixé à 500 mètres, soit un facteur de 10, compte tenu des résultats de l'analyse d'impact sonore de cette campagne (rèf. Ifremer AS-2014-100).

Afin de garantir une observation rigoureuse, les observateurs se sont relayés toutes les 2 heures. Au-delà, la vigilance diminue et la détection n'est plus considérer comme fiable.

Les observateurs étaient postés sur deux points d'observation du navire selon les conditions climatiques. Lorsque les conditions étaient favorables, ils se tenaient sur le pont avant (le pont arrière du navire n'étant que peu accessible) et lorsqu'elles étaient défavorables (vent fort, pluie..) ils observaient depuis la passerelle de pilotage à l'intérieur. Lorsque les opérations nécessitaient la présence des deux observateurs simultanément, chacun d'eux couvrait une zone d'observation de 180°, si elles n'en nécessitaient qu'un, il couvrait la totalité de la zone, soit 360°. Chaque période d'observation, hors phases sismiques ou durant les phases sismiques, se déroulait par un scan de la zone à l'œil nu, et par une observation à l'aide d'une paire de jumelles 7x50 munie d'un réticule, permettant l'estimation de la distance si nécessaire.

La détection des cétacés étant extrêmement dépendante des conditions climatiques, l'effort maximum a été réalisé lors des conditions de mer sur l'échelle de Douglas allant de 0 à 2, puis diminuant à 3 et s'arrêtant au-delà de 4.

### 4.1.1. EFFORT D'OBSERVATION

- **PLANNING DES OBSERVATIONS**

Durant les phases de *pré-watch* et de *ramp-up*, les deux observateurs réalisaient les observations ensemble. Durant les acquisitions sismiques et hors phases de *pré-watch* et de *ramp-up*, les observateurs se sont relayés toutes les 2 heures du lever du jour au coucher du soleil, tant que les conditions d'observation le permettaient. Durant les opérations hors tirs sismiques, soit les périodes de transits (route), les deux observateurs se relayaient toutes les deux heures, en effectuant des pauses selon la fatigue de chacun. Durant les périodes de stationnement du navire (dragage et arrêt), les observateurs ont effectué ensemble une heure d'observation au début et à la fin de la période stationnaire ainsi qu'un tour d'horizon d'un quart d'heure toutes les heures par un seul observateur. Cependant, les phases d'arrêt étant parfois très courtes (une ou deux heures), le protocole n'a pas toujours pu être appliqué. Les heures d'observation pré- et post- arrêt n'ont pu être que partiellement réalisées ou fusionnées avec l'heure d'observation (route) précédente ou suivante à l'arrêt du navire.

De plus, selon les conditions d'observations et météo (conditions difficiles ou conditions idéales) et la fatigue, lorsque le protocole prévoyait la présence de deux observateurs en surveillance, parfois seul l'un d'eux a réalisé les observations.

- TEMPS TOTAL PASSE EN OBSERVATION

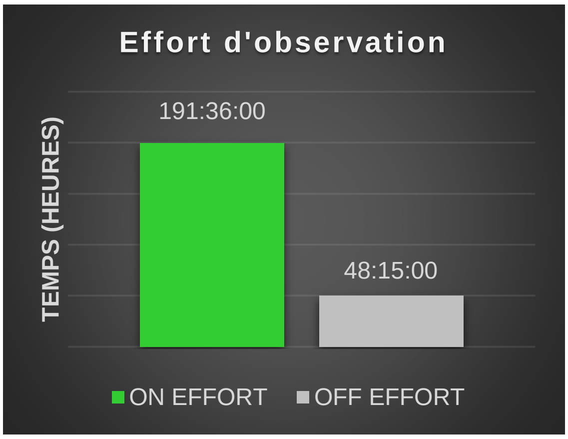



FIGURE 2 EFFORT D'OBSERVATION

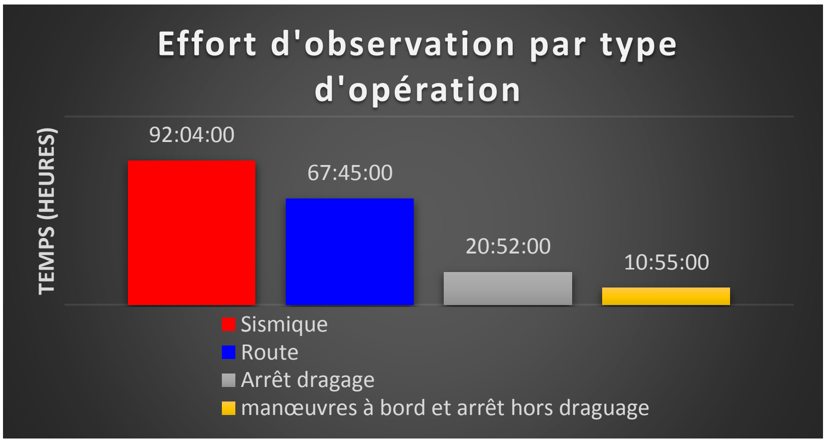



FIGURE 3 EFFORT D'OBSERVATION PAR TYPE D'OPERATION

#### 4.1.2. DETAILS DU PROTOCOLE DE MITIGATION PENDANT LES ACQUISITIONS SISMIQUES

Le protocole de mitigation établi par l'Ifremer se décompose en plusieurs étapes lors des opérations sismiques (Ifremer AS-2015-117).

1. Phase de *pre-watch* ou recherche pré-tir : observations visuelles avant le début du *ramp-up.* Les 2 observateurs effectuent une surveillance visuelle de la zone d'exclusion pour s'assurer qu'aucun mammifère marin n'est présent dans cette zone avant le début de tirs à pleine puissance. La durée du *pre-watch* est de 30 minutes.

2. Phase de *ramp-up* ou *soft-start* : démarrage progressif et graduel des canons à air, en commençant par le canon de puissance la plus faible, jusqu'à obtenir la puissance opérationnelle maximale. Le but est de permettre aux mammifères marins qui n'ont pas été détectés pendant le *pre-watch* ou qui viennent d'arriver dans le périmètre, de fuir la zone d'exclusion. La surveillance se fait également avec les 2 observateurs en simultané. La durée du *ramp-up* est de 20 minutes.

3. L'acquisition sismique ou tirs à pleine puissance. La surveillance visuelle est réalisée en continu par un observateur tant que les conditions d'observations (météo et visibilité) le permettent.

4. Interruption des tirs due à la présence de mammifères marins dans la zone d'exclusion. Lorsqu'un mammifère marin est détecté dans la zone d'exclusion, un arrêt immédiat des canons est demandé par le(s) observateur(s). Toute discussion se fait après arrêt.

5. Diminution et interruption des tirs de plus de 15 minutes : Si l'intensité des tirs des émissions a été diminuée ou si les tirs ont été arrêtés, par exemple lors d'une giration ou pour des raisons techniques, pour une durée supérieure à 15 minutes, alors la procédure de *ramp-up* doit être appliquée à nouveau pour revenir au niveau d'émission opérationnel, sous réserve qu'aucun mammifère marin n'ait été détecté dans la zone d'exclusion au cours de cette phase de diminution ou d'arrêt. En cas de détection pendant ces dernières minutes, les procédures de *pre-watch* et de *ramp-up* doivent être appliquées avant le retour aux acquisitions sismiques à pleine puissance.

6. Début de profil : Les débuts de profils sismiques doivent être effectués de jour et lorsque la visibilité est suffisante pour que les observateurs puissent effectuer correctement les phases de *pre-watch* et de *ramp-up* dans la zone d'exclusion.

7. Délai de reprise :

   - ✓ Cas 1 : un animal est observé pendant le *pre-watch*. Après avoir confirmé la sortie de l'animal, un nouveau *pre-watch* de 30 minutes doit être effectué.
   - ✓ Cas 2 : un animal est observé pendant le *ramp-up*. Les tirs sont arrêtés immédiatement. Après avoir confirmé la sortie de l'animal, un nouveau *pre-watch* de 30 minutes doit être effectué suivi d'un *ramp-up* d'au moins 20 minutes, avant la reprise des tirs.
   - ✓ Cas 3 : un animal est observé pendant les tirs à pleine puissance. Les tirs sont arrêtés immédiatement. Après avoir confirmé la sortie de l'animal, un *pre-watch* de 30 minutes doit être effectué suivi d'un *ramp-up* d'au moins 20 minutes, avant la reprise des tirs à pleine puissance.

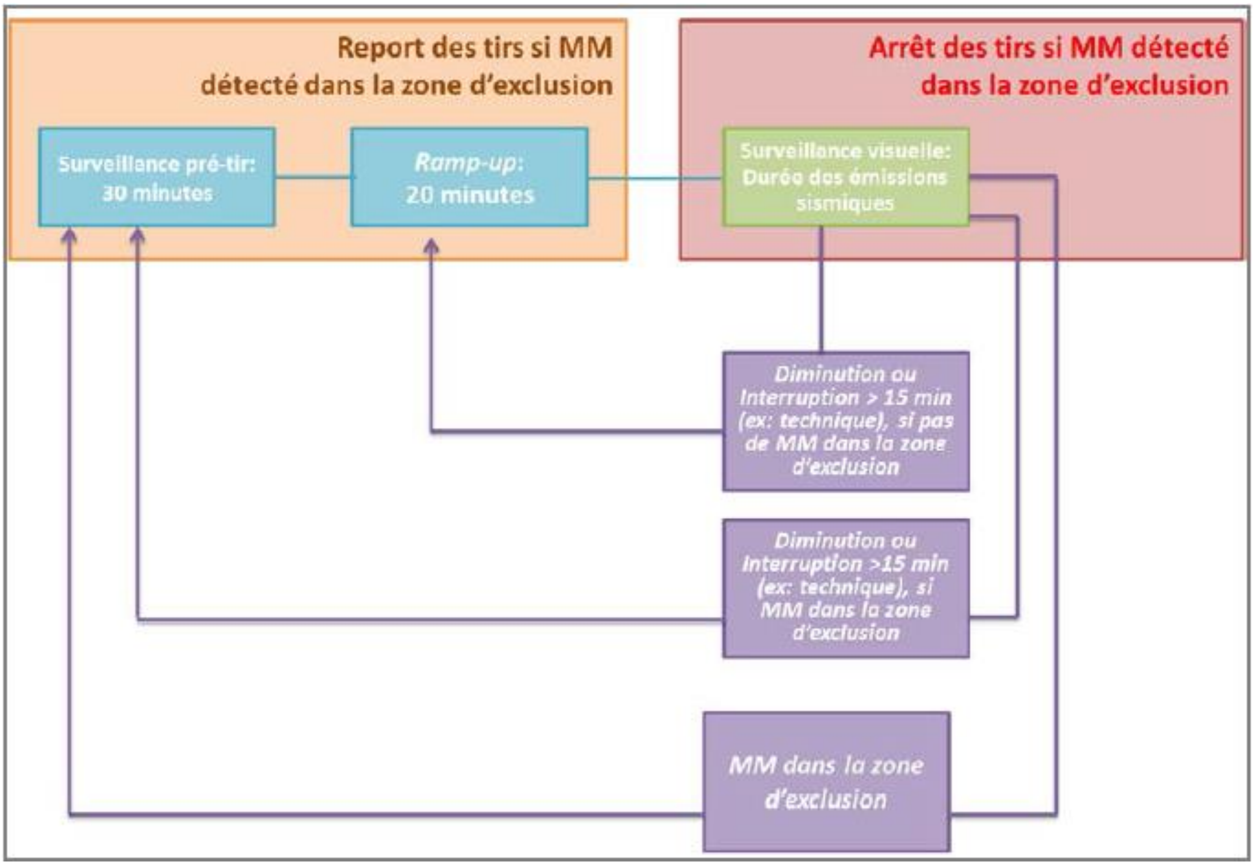



**FIGURE 4 SYNTHESE DU PROTOCOLE DE MITIGATION**

### 4.1.3. DETAILS DU PROTOCOLE HORS TIR

Durant les transits (Ifremer AS-2015-117), les deux observateurs effectuent un scan à l'avant du navire couvrant 180° (90° de chaque côté + 20° vers le côté opposé, créant ainsi une zone de recouvrement de 40° à l'avant du navire permettant d'assurer une couverture maximale de la ligne de suivi et de couvrir les angles morts opposés). L'effort des observateurs ne doit pas excéder 12 heures par jour durant les phases de transit, par tranches de 2 heures continues à 2 observateurs, entrecoupées de 2 fois ½ heure de pause en relais. Compte tenu du fait que les phases de transit n'ont pas excédé quelques heures, en prenant en compte les conditions météorologiques, les heures de repas et le fait que les observateurs se relayaient afin qu'aucun d'eux n'observe plus de deux heures d'affilées, ils n'ont pas toujours pu respecter le planning d'observation établit.

Durant les stationnements du navire (dragages) les deux observateurs effectuent un scan à 360° sur le point le plus haut du navire durant une heure au début et la fin de la période stationnaire du navire + un tour d'horizon d'un quart d'heure toutes les heures par un seul observateur. L'effort est de 2 heures d'observations communes durant la période de stationnement ainsi qu'un tour d'horizon d'un quart d'heure toutes les heures. Cependant, une certaine flexibilité a dû être apportée au protocole selon les événements (cf.§3 Effort d'observation-Planning des observations).

## 5. RESULTATS ET DISCUSSION

### 5.1. Trajet du navire campagne VESPA

Durant la campagne VESPA, le navire a suivi un plan de navigation prévu à l'avance selon les phases de prospections sismiques et les phases de dragages, mais il a évolué en fonction des premières données géologiques recueillis, des conditions environnementales et d'imprévu (retour sur Nouméa le 1er et le 2 Juin 2015 pour le rapatriement d'un membre d'équipage).

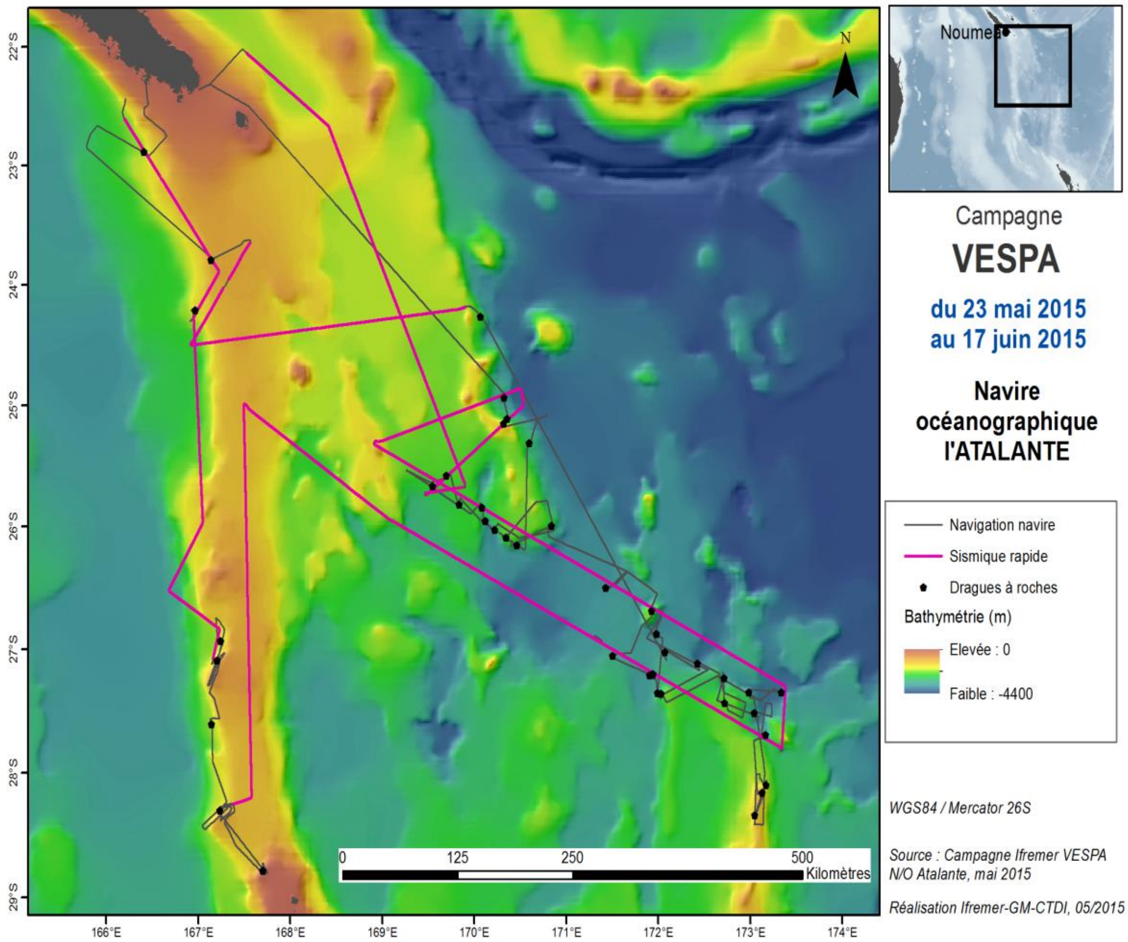



**FIGURE 5 CARTE NAVIGATION, SISMIQUE ET DRAGAGE CAMPAGNE VESPA**

Les opérations de tirs sismiques à puissance maximale diurnes et nocturnes ont été effectuées sur plusieurs périodes, n'excédant pas 3 jours en continu et entrecoupées de phases de transits et/ou de dragage.

**TABLEAU 1 OPERATIONS DE SISMIQUES EFFECTUEES**

| Date | Durée (h) | Latitude début | Longitude début | Latitude fin | Longitude fin |
|---|---|---|---|---|---|
| **23/05-24/05** | 15:06:00 | 22°32 | 166°10 | 24°15 | 166°57 |
| **24/05-25/05** | 11:45:00 | 24°13 | 166°56 | 27°40 | 167°9 |
| **27/05-29/05** | 46:00:00 | 28°15 | 167°22 | 26°55 | 171°19 |
| **29/05-01/06** | 72:40:00 | 26°53 | 171°19 | 22°20 | 167°16 |
| **14/06-15/06** | 24:13:00 | 24°10 | 169°57 | 23°37 | 167°32 |

Les opérations de tirs sismiques à pleine puissance ayant été réalisées de jour comme de nuit, la proportion des opérations sismiques diurnes où les MMO ont pu effectuer des observations correspondent à environ un tiers des opérations sismiques effectuées durant la campagne.

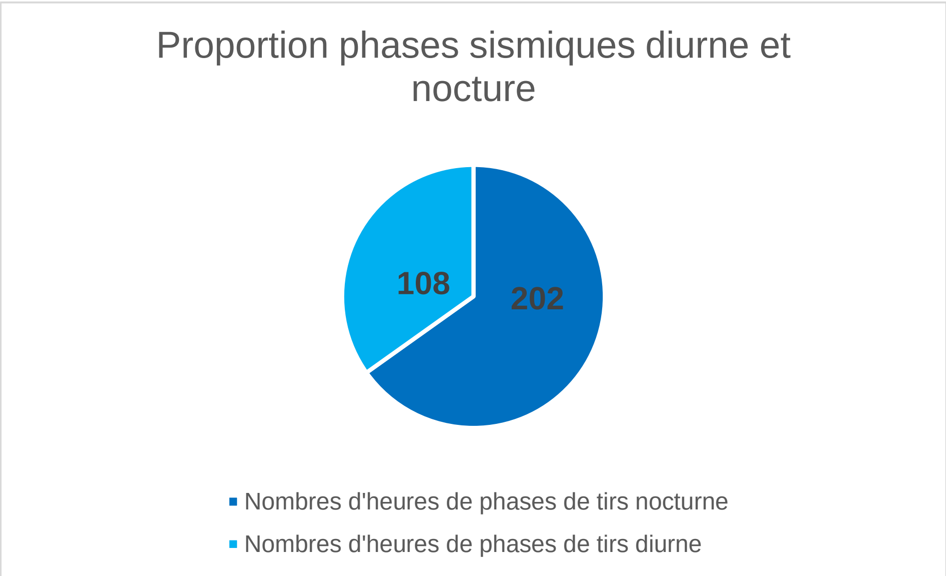



**FIGURE 6 PROPORTION DES OPERATIONS DE TIRS SISMIQUE DURANT LA CAMPAGNE VESPA**

### 5.2. Mitigation des mammiferes marins – Arret des tirs sismiques

Lors de la campagne VESPA, sur l’ensemble des phases d’opérations sismiques diurnes, seul deux arrêts des tirs ont été incombés à la présence de cétacés dans la zone d’exclusion (gris sombre). Ces interruptions ont été qualifiées « d’incident », afin de les différencier des observations en dehors de la zone de mitigation durant les tirs (blanc) et en dehors des phases de sismiques (gris clair).

| Date | Lat | Long | Source sismique et état | Autres équipements | Obs | Position de l'animal/source | Arrêt des tirs | Comportement / navire | Nb | Composition groupe | Comportement groupe | Activité | Espèce | Niveau confiance (0-5) | Description | BF | T°air/eau (°c) | Pluie | Visibilité (0-25) | Vitesse vent (nœuds) | Direction vent (°) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26/05 | 28°20 | 167°18 | hors tirs | sonar | LC | 800m | non | inchangé | 3 | 3A | Souffle, nage lente puis plongée | route | Rorqual | 4 | taille>10m, dos sombre, dorsale, souffles taille moyenne | 2 | 20,1/22 | non | 25 | 6 | 138 |
| 26/05 | 27°10 | 167°33 | opérationnel | sonar | TA | 800m | non | inchangé | 6 | 6 A dont 1 mâle | Souffle discret/ se tient éloigné du navire | route | Orque | 5 | noir, 1 individu avec une très grande nageoire dorsale | 1-2 | 20,2/22,0 | non | 25 | 6 | 284 |
| 28/05 | 25°22 | 168°60 | opérationnel | sonar | TA | >1km | non | inchangé | 6 | 5A/1J | Groupé, route opposée au navire puis s'éloigne | route | Rorqual à bosse | 5 | souffles courts et arrondis. Dorsale triangulaire et trapue | 3 | 20,6/22,6 | non | 25 | 10 | 157 |
| 28/05 | 25°25 | 168°12 | opérationnel | sonar | TA | >2km | non | inchangé | 8 | 8A | Reste éloignés du navire, sans changement de trajectoire | route | Rorqual à bosse | 5 | 2 groupes distants de 200m (2 + 6). Souffles courts et arrondis. Saut | 3 | 20,6/22,6 | non | 25 | 10 | 162 |
| 29/05 | 26°54 | 171°18 | opérationnel | sonar | TA | 300m | oui | souffle puis plongée | 1 | - | - | autre | Cachalot | 3 | bosses marquées sur pédoncule caudale, dorsale triangulaire | 3 | 19,5/23,1 | non | 25 | 12 | 136 |
| 30/05 | 26°40 | 171°58 | opérationnel | sonar | LC | 700m | non | 2 souffles successifs | 1 | - | - | arrêté | Rorqual commun | 3 | souffles puissants de 3 à 4m de haut, en colonne | 3 | 20,5/22,6 | non | 25 | 14 | 144 |
| 31/05 | 24°53 | 170°23 | opérationnel | sonar | LC et TA | 800m | non | inchangé | 30 | 30A | Nage à bonne vitesse, même direction, groupe compact | route | Delphinidés | 5 | massif, cape sombre grise unis, dorsale falciforme. | 1 | 21,0/23,4 | non | 25 | 5 | 28 |
| 01/06 | 23°25 | 168°47 | opérationnel | sonar | LC | 600m | non | déviation cap du navire pour évitement | 10 | 10A | 3 petits groupes distants, pas de plongée précipitée | route | Cachalot | 5 | souffle oblique à gauche, dorsale triangulaire, "tronc d'arbre" | 1 | 22,2/23,7 | non | 25 | 3 | 324 |
| 01/06 | 23°08 | 168°38 | opérationnel | sonar | TA | 2km | non | souffles 10 minutes puis a disparu | 1 | - | - | route | Cachalot | 3 | souffle oblique et dorsale triangulaire | 1 | 22,6/25,1 | non | 25 | 3 | 20 |
| 05/04 | 25°46 | 169°48 | hors tirs | sonar | TA et LC | 700m | - | inchangé | 4 | 4A | Beaucoup de respirations, allure réduite, direction nord | route | Cachalot | 5 | souffles obliques à gauche, dorsale triangulaire | 2-3 | 20,7/22,2 | non | 25 | 9 | 224 |
| 06/06 | 26°05 | 170°20 | hors tirs | drague | LC et TA | 1km | - | inchangé | 1 | - | - | arrêté | Rorqual commun | 3 | 2 à 3 souffles en colonne et droit, hauteur>3m, toutes les 20-25 secondes | 2-3 | 20,6/22,9 | non | 25 | 9 | 142 |
| 14/06 | 24°13 | 169°38 | opérationnel | sonar | LC | 1,5km | non | inchangé | 6 | 6A/J? | Contournement du navire et reste à distance | route | Cachalot | 3 | souffles inclinés vers l'avant | 4 | 21,1/22,6 | non | 25 | 16 | 118 |
| 14/06 | 24°13 | 169°33 | opérationnel | sonar | TA et LC | 1km | non | inchangé | 30 | - | Vitesse rapide, longue plongée | route/ chasse? | Dauphins de Fraser | 4 | Nombreux mouvements dans l'eau, éclaboussures | 4 | 21,1/22,7 | non | 25 | 15 | 109 |
| 15/06 | 24°03 | 167°14 | opérationnel | sonar | LC et TA | 2km | non | inchangé | 1 | - | - | autre | Rorqual | 3 | souffle haut, en colonne, toutes les 20-30 secondes | 3 | 21,5/22,9 | non | 25 | 15 | 108 |
| 15/06 | 24°00 | 167°17 | opérationnel | sonar | TA et LC | 200m | oui | surface rapide avant de sonder | 1 | - | - | autre | Rorqual | 3 | souffle en colonne environ 4m, dorsale falciforme et assez grande | 3 | 21,5/22,8 | non | 25 | 11 | 107 |
| 15/06 | 23°52 | 167°23 | opérationnel | sonar | TA | 1,5km | non | pas de changement de comportement | 1 | - | - | route | Rorqual | 3 | souffle bien visible, haut en colonne, toutes les 20-30 secondes | 4 | 21,6/23,3 | non | 25 | 16 | 111 |

**TABLEAU 2 BILAN DES OBSERVATIONS CETACES ET DONNEES ENVIRONNEMENTALES DURANT LES TIRS ET HORS TI**

### 5.3. Observations des mammiferes marins durant les phases de tirs sismiques

Treize observations de cétacés se sont produites durant les phases de sismique sur seize au total. La grande majorité d'entre elles, onze sur treize, ont montré la présence de cétacés en dehors de la zone d'exclusion, ne nécessitant pas d'interruption des émissions sismiques. Au cours de ces observations, plusieurs espèces ont été rencontrées, parmi elle, un groupe d'Orque, *Orcinus orcas*, deux groupes de Rorqual à bosse, *Megaptera novaeangliae*, deux groupes et un individu seul de Cachalot, *Physeter macrocephalus*, un groupe de Dauphins de Fraser, *Lagenodelphis hosei* ainsi qu'un groupe de Delphinidés et trois Rorquals non identifiés.

La première observation ayant nécessité une interruption des tirs sismiques, a eu lieu le 29/05 à 6h30, impliquant la présence d'un individu, identifié comme un Cachalot, à environ 300m du navire. Les observateurs ont prévenu dans les secondes qui suivirent le lieutenant de quart, demandant immédiatement l'arrêt des tirs. Entre le moment de l'observation et l'arrêt des tirs, il s'est écoulé moins de deux minutes. L'animal n'a été observé que durant quelques secondes avant qu'il n'effectue une plongée, sans être revu par la suite.

La seconde observation ayant entraîné un arrêt des émissions sismiques, a eu lieu le 15/06 à 10h30, impliquant un seul individu, identifié comme un rorqual. A la demande des observateurs, les tirs ont été arrêtés immédiatement. L'animal a fait rapidement surface avant de sonder. Les observateurs ont continué leurs observations durant 15 minutes et l'animal a été revu 5 minutes plus tard en dehors de la zone d'exclusion, à environ 800m du navire, nageant dans la direction opposée à celle du navire. L'animal étant en dehors de la zone d'exclusion et les conditions de mer ayant atteint un niveau de 3 Douglas et s'intensifiant fortement, l'application du protocole, par une phase de *pré-watch* de 30min et d'une phase de *ramp-up* de 20min, aurait rendu la reprise des tirs impossible car les conditions de mer auraient été trop mauvaises pour que les observateurs puissent reprendre leur observations. Après concertation avec le commandant, les chefs de missions et les observateurs, il a été décidé d'effectuer directement la phase de *ramp-up* de 20min. Cet écart au protocole initial n'a été engagé qu'en ayant la certitude que l'animal été hors de portée des tirs. Cela ne remet pas en cause le protocole initial qui doit être appliqué prioritairement.

**CACHALOT 01/06/2015 CREDIT M.PATRIAT**

**CACHALOT 01/06/2015 CREDIT M.PATRIAT**

**DELPHINIDES 31/05/2015 CREDIT T.AUGER**

**DAUPHINS DE FRASER 14/06/2015 CREDIT L.CEYRAC**

### 5.4. OBSERVATIONS DES MAMMIFERES MARINS EN DEHORS DES PHASES DE TIRS SISMIQUES

En dehors des phases de tirs sismiques, trois observations de cétacés ont eu lieu. Deux durant les phases de transits et une durant une phase de dragage. Un groupe identifié comme appartenant au genre des rorquals à bosse, *Megaptera novaeangliae* et un autre au genre des Cachalots, *Physeter macrocephalus*, ont été observés pendant que le navire faisait route. Enfin, un individu, identifié comme un Rorqual commun, *Balaenoptera physalus* a été observé durant de longues minutes lors d’une phase d’arrêt (dragage).

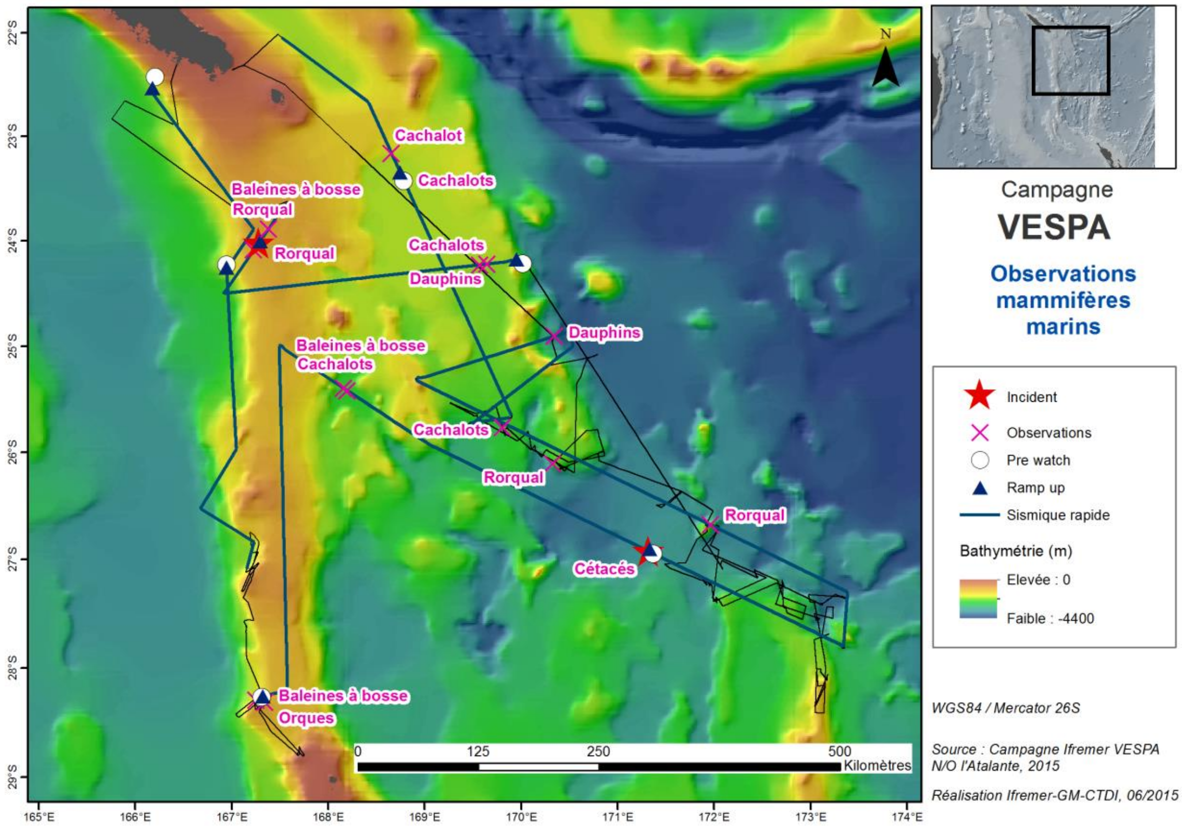



**FIGURE 7 CARTE BILAN OBSERVATIONS MAMMIFERES MARINS CAMPAGNE VESPA 2015**

Durant la campagne, la majorité des observations de cétacés ont eu lieu lorsque la bathymétrie était élevée (profondeur relativement faible : 2000m). De plus, la majorité des observations été incombées à la présence de grand cétacés, tels que les cachalots et les rorquals (rorquals à bosse, rorquals commun et rorquals non identifiés). La présence des cachalots sur des zones de profondeurs de 1500 à 3000m est cohérente avec la littérature compte tenu de leur régime alimentaire composé de céphalopodes vivant dans des zones de grandes profondeurs (Gaskin 1973 ; Jacquet *et al*. 1996 ; Nemoto *et al*. 1988). La campagne ayant eu lieu durant les mois de Mai et Juin, la présence de rorquals à bosse est aussi cohérente avec une arrivée vers leurs zones de reproduction (Nouvelle Calédonie) après une migration au départ du continent Antarctique où ils résident plusieurs mois sur leurs aires d'alimentation (Dawbin 1966 ; Garrigue *et al.* 2000). La présence d'un groupe d'orque vers des latitudes de 29°S est également cohérente avec leur aire de répartition dans l'ouest du Pacifique sud même si une telle observation reste rare (Garrigue and Greaves, 2001).

## 6. RETOURS SUR EXPERIENCES

- Conditions de travail des observateurs à bord.

Les conditions de travail des MMO à bord lors de la campagne ont été satisfaisantes. Un dialogue constructif avec les chefs de missions, le commandant et les membres d'équipage s'est instauré permettant une application efficace des protocoles.

- Analyse de l'utilité du travail effectué par les observateurs lors de la mission.

La présence de MMO à bord était indispensable à la protection des cétacés durant la campagne, compte tenu de la détection de mammifères marins dans la zone d'exclusion à deux reprises et ayant entraîné l'arrêt des tirs afin de minimiser la gêne des cétacés. Mesures de protections, qui, sans la présence de MMO à bord, n'aurait pu avoir lieu et cela malgré le fait que la prospection sismique mise en place soit de type légère. La zone de mitigation de 500mètres établit par l'Ifremer a permis une marge de sécurité complémentaire compte tenu de l'absence de PAM (Opérateur en acoustique passive) à bord.

- Recommandations pour des observations futures

Aucune difficulté particulière n'a été rencontrée lors de la campagne, grâce à une bonne coopération et une bonne compréhension des protocoles par les chefs de missions et les membres d'équipage. Cela a permis une bonne efficacité lors des incidents (animaux observés dans la zone d'exclusion durant les phases de tirs) durant les phases de tirs sismiques. Seul deux incidents ont eu lieu et les tirs ont été stoppés immédiatement après l'observation.

Concernant le protocole de mitigation durant les phases de tirs sismiques, il est efficace et peut être appliqué aisément. Cependant, lorsque les conditions de mer sont proches de l'impossibilité d'observation (4 sur l'échelle de Beaufort) et qu'un animal est observé dans la zone d'exclusion, il peut être difficile par la suite de reprendre le protocole de tirs (*pré-watch et ramp-up*) pour la reprise de la prospection sismique.

Il est parfois complexe à l'œil d'estimer les conditions de mer sur l'échelle de Douglas (hauteur de vagues). Les MMO ne pouvaient se baser objectivement que sur la vitesse du vent, qui varie fortement d'un moment à l'autre pour estimer l'état de mer et décider de reprendre ou non le protocole de reprise de tir après un incident, ce qui pouvait être problématique au bon déroulement de la mission géophysique. De ce fait, il serait intéressant de préciser dans le futur protocole, une échelle d'observation objective combinant l'échelle de Beaufort (vent) et l'échelle de Douglas (état de la mer) avec des descriptifs, permettant ou non la reprise des observations des MMO. Cela éviterait un flou dans la prise de décision lorsque ce genre d'événement se produit. « A partir d'une hauteur de vague de x mètres, d'une vitesse de vent de x nœuds, du type de vague (crêtes présentent plus de 5 secondes), l'observation n'est plus fiable et la reprise des tirs n'est plus possible ». Il serait dont très utile que les MMO puissent faire référence à cette échelle de valeur afin de justifier objectivement la non reprise des tirs si les conditions d'observations ne le permettent plus. Le dialogue était possible lors de la campagne VESPA avec les chefs de missions et les membres d'équipage mais cela pourrait ne pas être toujours le cas.

**TABLEAU 3 ECHELLE D'OBSERVATION**

| Beaufort | Vitesse vent (nœuds) | Description | Conditions de mer | Douglas | Description | Hauteurs de vagues (m) |
|---|---|---|---|---|---|---|
| 0 | 0 | Calme plat | Mer comme un miroir | 0 | Plate | 0 |
| 1 | 1-3 | Très légère brise | Ondulations mais sans crête d'écume | 1 | Calme | 0 à 0.10 |
| 2 | 4-6 | Légère brise | Petites ondelettes ; les crêtes ne se cassent pas | 2 | Belle | 0.10 à 0.50 |
| 3 | 7-10 | Petite brise | Grandes ondelettes ; crêtes d'écume dispersées | 3 | Peu agitée | 0.50 à 1.25 |
| 4 | 11-16 | Jolie brise | Petites vagues ; écume assez fréquentes | 4 | Agitée | 1.25 à 2.50 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | 17-21 | Bonne brise | Vagues modérées ; nombreuses crêtes d'écume | | | |
| 6 | 22-27 | Vent frais | Grosses vagues se formant, crêtes à mousse blanches et pulvérisation | | | |
| 7 | 28-33 | Grand frais | La mer grossit et la mousse est soufflée en trainée dans le sens du vent | 5 | Forte | 2.50 à 4 |
| 8 | 34-40 | Coup de vent | Vagues modérément hautes ; crêtes brisées et tourbillon d'embruns | | | |
| 9 | 41-47 | Fort coup de vent | Hautes vagues ; mousse dense dans le vent ; crêtes de vagues roulent ; vaporisation peuvent affecter la visibilité | 6 | Très fort | 4 à 6 |
| 10 | 48-55 | Tempête | Très forte vagues avec longue barre de crêtes ; surface de la mer blanche ; visibilité affectée | 7 | Grosse | 6 à 9 |
| 11 | 56-63 | Violente tempête | Vagues de hauteurs exceptionnelles ; mer recouverte de mousse ; visibilité réduite | 8 | Très grosse | 9 à 14 |
| 12 | 64+ | Ouragan | Air remplit de mousse et d'embruns ; mer blanche et jet d'embruns ; visibilité très sérieusement réduite | 9 | Enorme | 14 et + |

Durant les phases de transit, lorsque les conditions de mer sont favorables, le protocole peut être appliqué. Cependant, lorsque les conditions sont plus difficiles, une flexibilité des relais peut être envisagée dans ces cas-là.

Durant les phases de stationnement (dragage dans notre cas), il a parfois été complexe d'appliquer tel quel le protocole (cf.§ 4.1.3 Détails du protocole hors tirs). La majorité du temps, les phases de dragage durait entre 2 et 3 heures, rendant les observations d'une heure  en début et en fin de période d'arrêt difficile à appliquer. De ce fait, ces heures de pré-observation et post-observation ont souvent été combinées avec l'heure d'approche sur zone et l'heure de départ de la zone (en transit à faible vitesse).

## 7. CONCLUSIONS

Les données d'observations des cétacés obtenues seront exploitables en termes de distribution ou d'analyse de la présence/absence ou dans le cas de présence seule. Compte tenu de la difficulté à obtenir ce type de données à des fins scientifiques, il a donc était très utile de référencer les cétacés observés en dehors des phases de sismiques.

De plus, les protocoles sont adaptés à ce type de campagne de prospection géophysique tout en maintenant une certaine flexibilité. Enfin, il semble également important que les MMO puissent se référer à des valeurs objectives (échelle d'observation) dans le cas de situations floues ou délicates (reprises des tirs lorsque les conditions de mer sont à la limite de la fiabilité d'observation).

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