New Zealand Continental Shelf Project– a status report of the survey programme

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Abstract

Following ratification of the United Nations Convention on the Law of the Sea (UNCLOS) in 1996, New Zealand is undertaking an extensive programme of marine surveying worth $44 M to delimit an outer legal continental shelf boundary. Delimitation of a legal continental shelf includes the morphological shelf, slope and rise, and thickness of sediments adjacent to the slope, with an underlying principle of natural prolongation from the landmass. Jurisdiction of an outer legal boundary includes potential mineral and hydrocarbon resources.

The New Zealand approach, where a complex geological evolution offers significant opportunity to delimit an outer shelf boundary, has been to accept that geological and geophysical interpretations are equally as important as seafloor morphology. Such a concept has required an innovative survey design that includes both deep-penetration high-fold, and shallow-penetration low-fold seismic reflection, and multi-beam swath bathymetry acquisition. A total of 12,909 line km of deep high-fold, and 7,120 km of shallow low-fold seismic data will have been acquired around the New Zealand margin by mid-2002. Apart from the Atlantic-style continental margin of the Campbell Plateau, much of the New Zealand margin has multiple breaks in slope-morphology and / or variable crust type and thickness. Deep-sea fan systems up to 2 km thick, 1500 km from source, offer opportunities for extension based on sediment thickness. Swath bathymetry surveying (to be completed by March 2002) is being acquired in three areas (Resolution Ridge, Bollons Seamount, and Wishbone Ridge) that have complex, possibly equivocal morphological continuity with New Zealand, but if prolongation can be established, have a significant impact upon the outer shelf boundary.

In four areas of shared extended continental shelf (Lord Howe Rise – Norfolk Ridge, Colville – Lau Ridge, Tonga – Kermadec Ridge, and Macquarie Ridge – Campbell Plateau), New Zealand will enter bilateral negotiation with adjoining states to form agreed boundaries. Australia and New Zealand have agreed to conclude bilateral negotiation by 2003. These surveys will provides new insight into deep-water frontier basins, and ultimately a legal framework for oil exploration beyond the existing 200 M boundary.

Introduction

Since 1996 New Zealand has been undertaking a programme of marine geology and geophysical surveys to delimit an outer legal continental shelf, beyond the 200 nautical mile (M) Exclusive Economic Zone (EEZ) boundary, as allowed under Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS). The UNCLOS convention, coming into force in 1994 after ratification by 60 countries, allows coastal / maritime states to extend jurisdiction of the seabed beyond the 200 M boundary to the outer legal continental shelf. This jurisdiction includes claims to mineral (including hydrocarbons) and living resources on and below the seafloor. For New Zealand, where extensive areas of elevated continental plateau (e.g., eastern Chatham Rise, Challenger Plateau – Lord Howe Rise) lie outside the 200 M boundary (Figure 1), but are clearly part of the New Zealand continental margin, UNCLOS allows a substantial extended legal

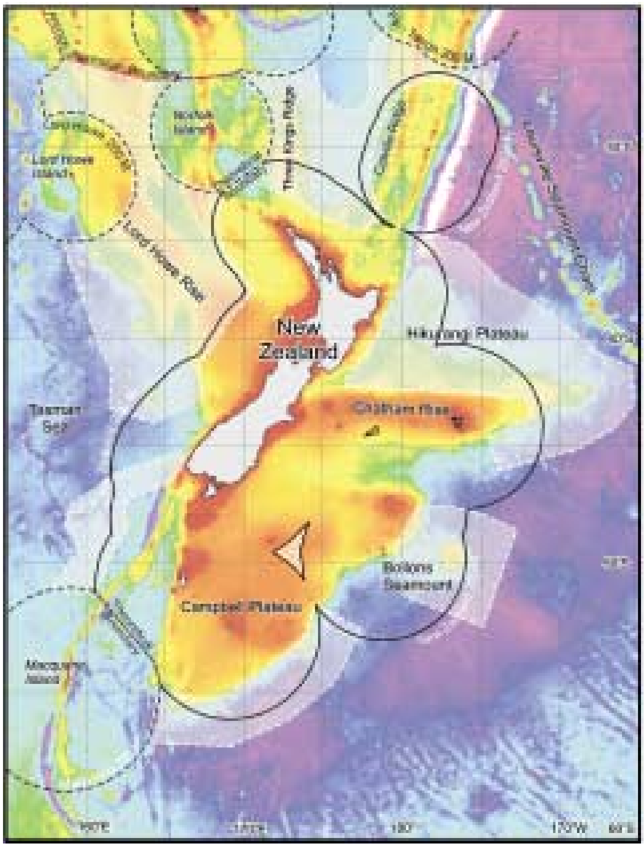

Figure 1. Marine gravity anomaly field for the wider New Zealand region (from Sandwell and Smith 1997) showing areas of elevated seafloor topography, some areas of potential legal continental shelf (shaded), and 200 M Exclusive Economic Zone boundaries of New Zealand and adjacent states.

continental shelf area with significant economic implications for New Zealand and the oil exploration industry. New Zealand is one of a relatively small group of countries that have a legal continental extending beyond its 200 M boundary. Further, UNCLOS boundary definition is the last opportunity that coastal states have to extend jurisdiction over the seabed beyond the 200 M boundary.

Following ratification of UNCLOS by New Zealand in 1996, New Zealand had initially ten years (as prescribed in the convention) to substantiate its outer legal continental shelf and lodge a submission boundary to the UN-appointed *Commission on the Limits of the Continental Shelf (Commission)*. Subsequently, in May 2000, a decision was taken by States Parties to UNCLOS to recognise the date of the adoption by the *Commission* of its Scientific and Technical Guidelines, 13 May 1999, as the commencement of the 10 year period for a making a submission.

Following initial studies in 1995, the New Zealand Government approved in 1998 a budget of $44.4M to acquire and process marine geological and geophysical data (principally bathymetry and seismic reflection data), interpret these data within the context of the UNCLOS delimitation, and formulate a legal boundary for submission to the *Commission.* Land Information New Zealand (LINZ) is the prime government agency for funding, co-ordination of the technical work programme, project administration and contracting of the New Zealand Continental Shelf Project (NZCSP). The Ministry of Foreign Affairs and Trade is providing guidance on international law, and will lead bilateral negotiations, and final legal boundary submission. The National Institute of Water and Atmospheric Research (NIWA) and the Institute of Geological and Nuclear Sciences (GNS) are providing both technical expertise and interpretation of the NZCSP survey data, and are service providers (where appropriate) for survey data acquisition.

Article 76

The Legal Continental Shelf as defined in Article 76 comprises the seabed and subsoil of "the submerged natural prolongation of the land mass of the coastal state" including the "shelf, the slope and the rise", but specifically excludes the deep ocean floor with oceanic ridges. This definition differs substantially from the conventional understanding of the morphological continental shelf between the slope and landmass (Figure 2). An underlying concept is that prolongation must be part of the continental margin. Establishing the outer edge of the continental margin is allowed by either fixed points 60 M from the foot of the continental slope (the so-called Hedberg formula) or fixed points where the thickness of sedimentary rocks is at least 1% of the shortest distance from the foot of the slope (the so-called Irish formula). In the absence of evidence to the contrary the foot of the continental slope (FoS) is determined as the point of maximum change in gradient at its base. The aim of the Irish formula was to ensure that coastal States retained sovereignty over major portions of the continental rise where significant hydrocarbon resources might be expected. In essence this requires a total sediment thickness of >~1 km to benefit a coastal state beyond the 60 M (100 km) allowed with the Hedberg formula. Article 76 allows a coastal state to provide "evidence to the contrary" as the primary criteria in determining the FoS of the outer continental margin (e.g. continental – ocean boundaries or transition zones) lie beyond the FoS. The outer boundaries of the margin are limited, however, by either a distance of 350 M

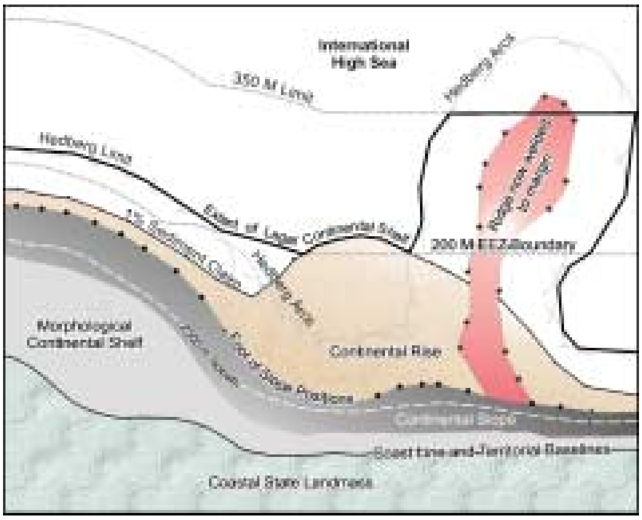

Figure 2. Schematic morphology and geology of a continental margin, including an exotic ridge now welded to it, with interpretations of Hedberg and 1% sediment limits and possible boundary cut-offs defined within Article 76.

from the territorial baselines at the coast or 100 M from the 2500 m isobath, although the 350 M limit does not apply to submarine elevations that are natural components of the margin. In addition, a coastal State can maximise the extent of its continental shelf by invoking combinations of different boundary and limit criteria along different parts of the margin.

Such criteria were initially developed from the prevailing experiences of Atlantic-style passive rift margins during the 1950-1970s. In these regions the application of such criteria is mostly straightforward to define an unambiguous basal continental slope. In contrast, for much of the western Pacific, and especially New Zealand which has been at or near the active Australian – Pacific plate boundary during at least the last 90 Ma, the application of such criteria are inherently more ambiguous where the continental margin can be an amalgam of differing crustal structures. Such margins may be characterised by anomalous terranes and seamounts partially or wholly welded to the margin, and rift basin formation with significant sediment loading. In such cases, the practical aspects of defining the outer margin is difficult - What constitutes natural prolongation? Where is the base of the slope?, Are isolated outlier blocks (with potentially separate closure of the 2500 m isobath) part of the margin? What is a submarine ridge?

New Zealand's approach to boundary delimitation

With such a complex geological evolution of terrane rifting and accretion, New Zealand has significant opportunity to delimit an extended legal continental shelf. Some underlying "principles" of the New Zealand approach have been (i) geological and geophysical interpretations, including evidence to the contrary, are equally as important as seafloor morphology to delimit a legal boundary (Wood, this volume), (ii) most existing data (even that acquired during the 1970s) are considered to be of sufficient quality to make a submission, and (iii) design a survey programme (in areas of insufficient data coverage) that can substantiate a conservative minimum legal boundary, and also support arguments for a more expansive legal boundary. The latter has required, at times, an innovative survey design. For example, deep-crustal high-fold multi-channel seismic reflection (MCS) data have been be acquired along rifted margins, rather than conventional echo-sounding profiles, to test the presence of thinned "transitional" rift blocks beyond morphological FoS positions. Similarly, deep-crustal high-fold MCS lines might have a complex orientation, comprising dog-legs aligned along the crests of ridge spurs radiating from an elevated plateau or rise rather than as a grid of straight lines. In addition, some survey work has been undertaken up to 100 km inside the existing 200 M boundary so as to establish whether "anomalous" terranes are now "welded" to continental New Zealand, thereby establishing the outer edge of the terrane (that might lie outside the 200 M) can be substantiated as the outer boundary of the legal continental shelf.

Survey programme

The survey programme (Figure 3), begun in 1996, initially focussed on the Lord Howe Rise / Norfolk Ridge / Three Kings Ridge regions as a collaborative project with Australia. This collaboration included the sharing of data acquisition in areas of common interest. A review by NIWA and GNS of available data in other areas of potential extended continental shelf surrounding New Zealand (completed in 1998), proposed a further survey work programme that was accepted by the New Zealand Government following national and international peer review. Since 1996, the full survey programme has completed over 300 days of at-sea acquisition, with a further 50-55 at-sea days scheduled for completion by June 2002, which will essentially complete the survey programme.

The four principal components of the survey programme are: (1) multi-beam swath mapping of critical seafloor features to establish morphological continuity with New Zealand, (2) shallow low-fold MCS data to establish FoS positions and test for potential sediment thickness beyond a Hedberg limit, and (3) deep high-fold MCS data to establish FoS positions including those of a possible "transitional" crustal structure seaward of morphological FoS positions, and (4) potential field data to distinguish continental vs. oceanic crust and crustal thickness in conjunction with deep reflection data. In addition, a seafloor-dredging programme has been instigated in critical areas to acquire volcanic and crustal basement rocks to test their geochemical affinity (and hence natural prolongation) with onshore New Zealand using isotopic and radiometric dating techniques. Such a complex survey programme has required a variety of ship capability from chartering of ships of opportunity operating within the New Zealand region to full competitive tendering, contracting and ship mobilisation to New Zealand. By mid-2002, five vessels will have been used for various facets of the programme comprising: *Rig Seismic* and *Geco Resolution* for deep-crustal seismic acquisition, *l'Atalante* and *Melville* for multi-beam surveys, and the New Zealand research vessel *Tangaroa* for shallow seismic acquisition and dredging.

The survey programme has been designed for boundary delimitation without consideration of resource assessment (including hydrocarbons) or scientific research objectives. However, there have been a number of beneficial byproducts including acquisition of line TL-1 (Uruski 2000; Stagpoole et al., 2000) acquired from northern Taranaki Basin along the axis of the New Caledonia Basin (Figure 3) in 1996, deep crustal lines across the Hikurangi Plateau (Davy and Uruski, this volume), seafloor swath mapping, and rock sampling of normally very remote areas of the outer margin. Moreover, research institutes and the petroleum exploration industry have benefited from the project's seismic acquisition programme through access to seismic vessels and lower mobilisation costs.

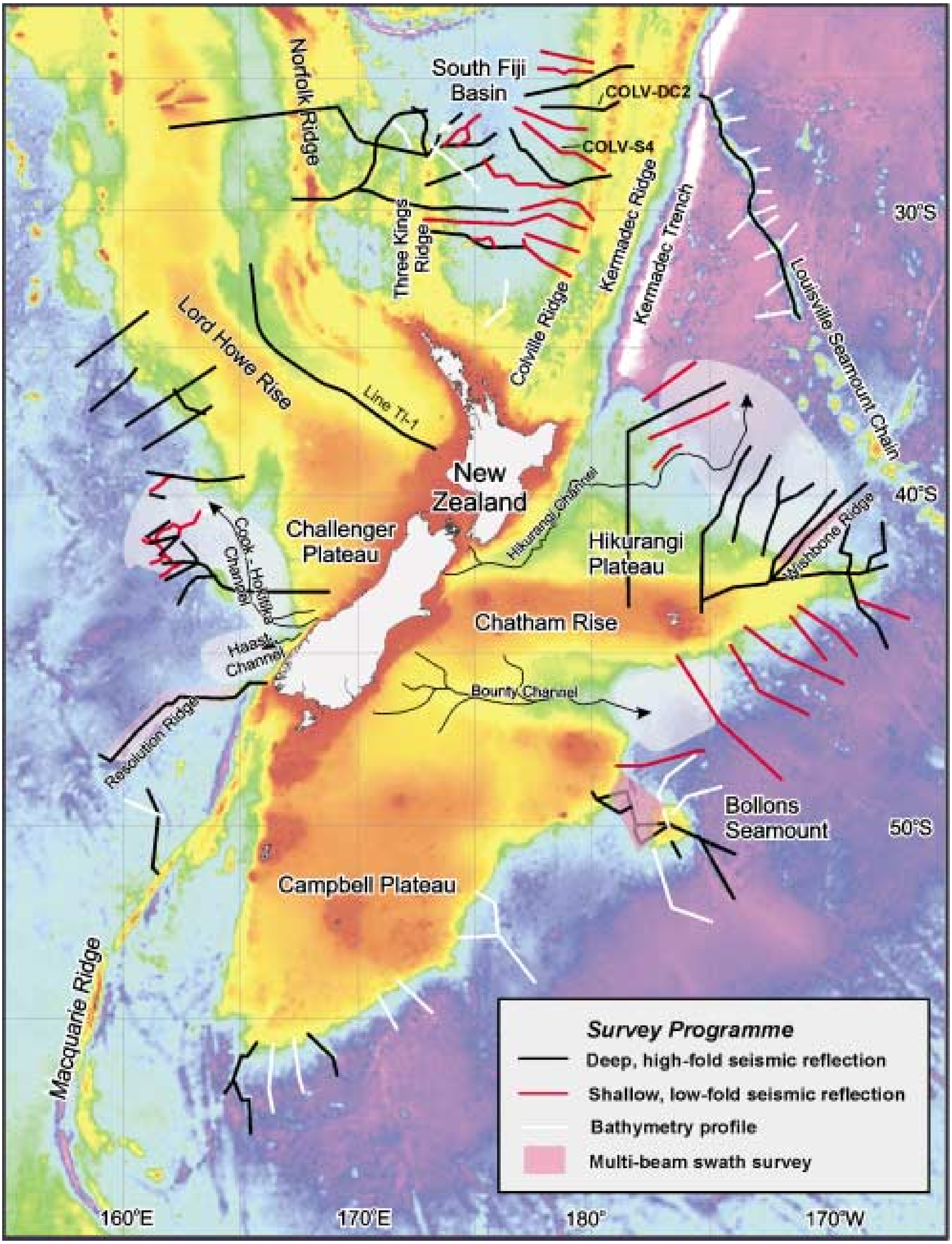

Figure 3. Location and types of data acquisition of the New Zealand Continental Shelf Project survey programme. Marine gravity anomaly field from Sandwell and Smith (1997). Major deep-sea distributary channels systems and associated fan systems (shaded) are shown.

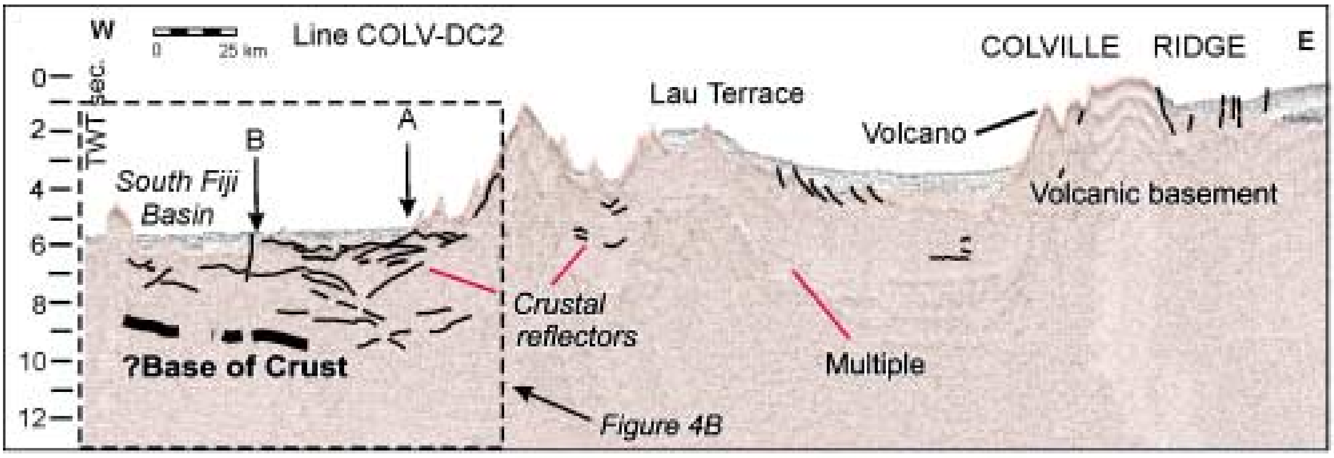

Figure 4a. Representative (shipboard brute-stacked) deep penetration high-fold seismic reflection line (Line COLV-DC2) from western flank of Colville Ridge showing basement topography and sediment cover of the margin slope and rise. Arrows (A) and (B) are the respective positions of the interpreted morphological and geological foot of slopes from which a 60 M arc would define the outer legal continental shelf boundary.

Deep high-fold seismic reflection – FoS and geological prolongation

Deep penetration high-fold seismic reflection data have been acquired around the entire New Zealand margin (Figure 3) using *Rig Seismic* and *Geco Resolution* during September – December 1996 and December 2000 – May 2001, respectively.

A total of 12, 909 line km of deep reflection data, with concurrent acquisition of bathymetry, gravity and magnetic data, have been acquired by this survey programme. Parameters for these data comprise 320-channel, a 4 km-long streamer, and a 3000 cu^3 seismic source resulting in 40 fold coverage; and 480-channel, a 6 km-long streamer and a 8000 cu^3 seismic source resulting in 60 fold coverage, for respectively the *Rig Seismic* and *Geco Resolution* surveys. Typically data were recorded to 16 s. TWT. Outer FoS positions and crustal structure can be mostly interpreted on these records.

Elsewhere around the New Zealand margin, Moho reflectors at the base of true ocean crust are typically identified at 9 s. TWT. A 50 km wide transitional crust between the Lau Terrace and South Fiji Basin could be interpreted as evidence to the contrary to support extension of the continental shelf. As with shallow seismic acquisition, sonobuoy refraction data were recorded to provide better velocity control for both the sedimentary section and basement crust.

Post-acquisition processing of the deep-crustal data (under contract to Robertson Research Australia) will be completed by March 2002. In contrast to normal processing requirements for oil exploration of resolving the sedimentary section well and identifying such features as amplitude anomalies, UNCLOS requirements place considerable emphasis on imaging sub-basement and Moho reflectors. In practice, this has required a fairly standard processing sequence with low signal to noise acceptance and less muting to identify coherent reflectors between 6-11 s. that are often

FoS positions can be equivocal, with a number of possible positions dependent on multiple breaks in slope-morphology and / or variations in crustal structure (Figure 4a). For the case of the Lau Terrace there is convincing evidence of contiguous rifted and faulted block structures, including listric normal faults, between Colville Ridge and Lau Terrace. For deeper parts of the reflection data, coherent reflectors can image rifted fault-blocks with localised syntectonic sediment sequences between 6-8 s., and at 9-11 s. (Figure 4a). Seaward of the Lau Terrace and the morphological FoS position, the base of the crust appears to progressively thin from ~10 s. TWT to 9 s. TWT over some 50 km (Figure 4b).

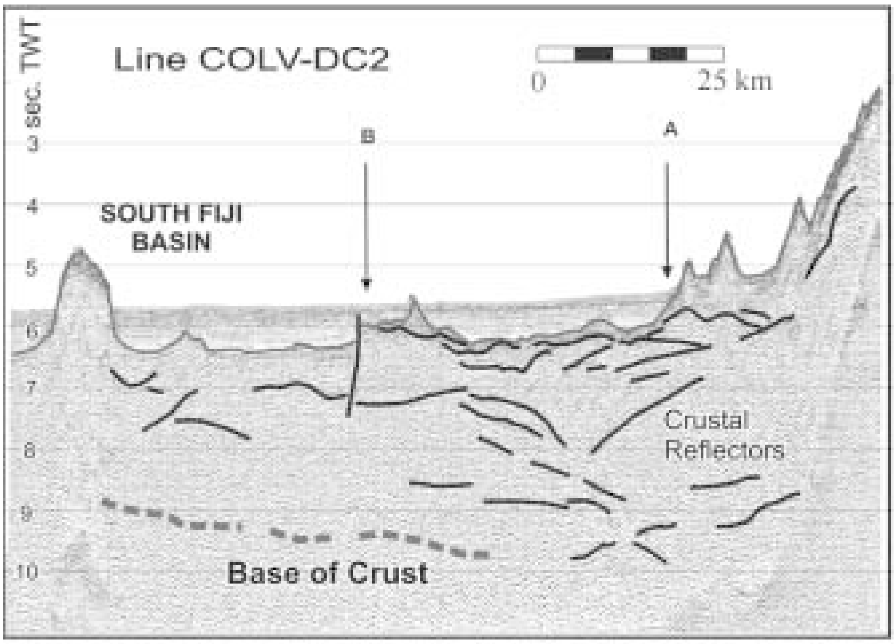

Figure 4b. Segment of processed shipboard brute-stacked data from Line COLV-DC2 showing intra-crust reflectors and the interpreted location of the base of the crust.

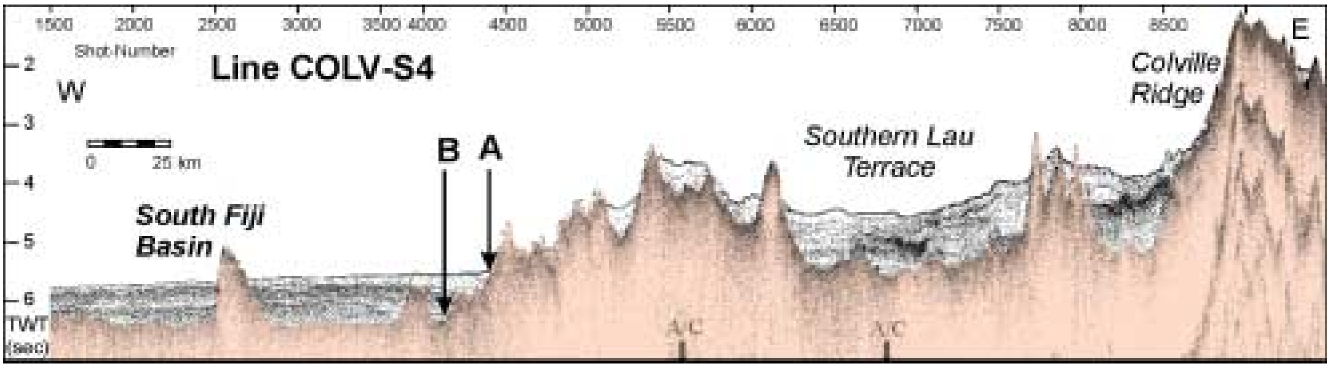

Figure 4c. Representative fully processed and migrated shallow low-fold seismic reflection line (Line COLV-S4) from western flank of Colville Ridge showing basement topography and sediment cover of the margin slope and rise. Arrows (A) and (B) are the respective positions of the interpreted morphological and geological foot of slopes from which a 60 M arc would define the outer legal continental shelf boundary.

obscured by deep-water seafloor multiples. The processing sequence also includes FK, Radon or predictive multiple attenuation, velocity analysis at 2 km spacing, and pre-stack time (or depth) migration for critical line segments.

Shallow low-fold seismic reflection – FoS and sediment boundaries

Shallow low-fold seismic reflection data, together with marine gravity and magnetic data, will have been acquired around the entire New Zealand margin (Figure 3) during a three-survey programme using *Tangaroa* – two of the surveys were completed in September – October 1999 and May – June 2000, whilst the last is scheduled for May – June 2002. A total of ~7120 line km of shallow reflection data and 1853 line km of bathymetry data will be acquired during this component of the survey programme. Parameters for the reflection data generally comprise 48-channel, ≤500 m long streamer and a ≤210 cu^3. GI gun seismic source. These data are processed to achieve 3-fold coverage. Typically these data image the uppermost 1.5-2.5 s. of the sedimentary section, providing a robust dataset for interpreting outer FoS positions, and defining almost universally the sedimentary sequence overlying acoustic basement (Figure 5a).

Easily identifiable FoS positions occur along the southern Campbell Plateau margin, a simple Atlantic-style continental margin formed by seafloor spreading along the Pacific – Antarctic Ridge since about 80 Ma. Elsewhere, FoS positions can be more equivocal, with a number of possible positions selected on the same profile due to multiple breaks in slope-morphology and / or variable crust type and thickness. The western flank of Colville Ridge (Figure 4c) shows an extended, 45-km wide, mid-slope terrace (the southern extension of the Lau Terrace) that progressively deepens from 2500 m to 4120 m water-depth. A morphological FoS position can be identified at the seaward edge of this terrace (Figure 4c, Arrow A), but is it the position of maximum change in gradient at the foot of the slope?. Similarly, a geological FoS position (Figure 4c, Arrow B), invoking evidence to the contrary, can be identified a further 13 km seaward of the morphological FoS position. It is uncertain whether this geological FoS position, that generates a more expansive Hedberg arc and an additional 2890 km^2 of extended continental shelf, would be accepted by the C*ommission*?

Possible 1% sediment boundaries beyond the 60 M Hedberg boundary include regions associated with major distributary submarine channels forming conduits for transport of New Zealand terrigeneous sediment to deep-sea depositional fan systems (Figure 3). These fan systems, often modified by vigorous bottom-current flows into elongate fan-drifts, can be upward of 2 km thick ~1500 km from their source. These fan systems occur at the western edge of the Lord Howe Rise and Fiordland margin, the outer edge of the Hikurangi Plateau, and possibly the outer Bounty Trough (Figure 3) and are sourced from the Cook – Hokitika, Haast, Hikurangi, and Bounty channels, respectively. Sediment thickness in most other regions is generally insufficient to extend beyond a Hedberg boundary (Figure 4). Velocities used to determine the thickness of the sedimentary sequence may have a significant impact on whether such boundaries extend beyond the Hedberg limit. Stacking velocities derived from data collected with a short streamer have limited capability for determining true sediment velocities. As a result, sonobuoys have been routinely deployed to record *P*-wave velocities on long-offset refraction records.

Seafloor "swath" bathymetry mapping – morphological prolongation

Multi-beam swath bathymetry acquisition has been proposed for three areas; Resolution Ridge system, Bollons Seamount, and Wishbone Ridge (Figure 5). All three areas are characterised by complex, possibly equivocal morphological continuity with the New Zealand margin. However, if prolongation can be established, then they may have a very significant impact on the outer shelf boundary. For example, if a successful argument for natural prolongation from the Bounty Plateau to Bollons Seamount can be established, then the outer continental shelf boundary would be potentially expanded by a minimum of ~45,000 km^2.

The first of these areas, the Resolution Ridge system was mapped, with the acquisition of ~36,000 km^2 of multi-beam data, in February 2000 from Resolution Ridge proper southwestward to 48°15'S. At the landward end of the system, Resolution Ridge is underthrust and morphologically continuous with the Fiordland margin, although the active Pacific-Australian plate boundary traverses the zone of connection. Further seaward, the ridge system comprises a series of connected en echelon ridge segments dissected by faults and high-standing volcanoes. Within this central segment of the system (Figure 5) individual ridge segments may be as narrow as 3 km, but nevertheless they form a continuous ridge complex that rises 500-1000 m above the surrounding ocean floor at a depth of 4500 m. A large conical volcano rises to 2800 m water-depth. Further to the southwestward, ridge segments have a basement fabric orientated northwest-southeast dissected by fracture zones orientated northeast-southwest. The Bollons Seamount and Wishbone Ridge areas are scheduled to be swath-mapped by the *Melville* during a transit leg back from the Southern Ocean in March 2002.

Coastal states adjacent to New Zealand have also undertaken extensive multi-beam mapping programmes. Australia has swath-mapped parts of the southern Tasmanian Rise (southwest Tasman Sea) and eastern flanks of the Macquarie Ridge during December 1999 – February 2000. In addition, Australia and France mapped during November 1999 (the FAUST-2 project) some 190,000 km^2 of the seafloor northwest of New Zealand, including the northern extent of Three Kings Ridge and parts of the Norfolk Ridge and adjacent Norfolk Basin.

Following the near completion of the survey programme in mid-2002, the continental shelf project will enter a phase of data interpretation and synthesis (of both existing and new UNCLOS survey data) to substantiate the New Zealand submission for an extended legal continental shelf (Sheppard and Pickering, 2000). Much of this interpretative phase of the project is based on GIS analysis, including possibly the final submission to the *Commission*. This analysis to formulate the extended continental shelf boundary will be completed on a regional basis, with the Lord Howe Rise area the first scheduled for completion by the end of 2002. Other regions will be completed between 2003 and 2006. Although the States Parties to UNCLOS (including New Zealand) have now until to 2009 to submit a claim, the present project schedule continues toward submission in 2006.

Bilateral negotiation with adjoining states

The extension of the New Zealand continental shelf will require bilateral negotiation with adjoining coastal states to form agreed boundaries in some areas. Four regions share extended continental shelf with New Zealand: Lord Howe Rise – Norfolk Ridge (Australia, France), Macquarie Ridge – southern Campbell Plateau (Australia), Colville-Lau Ridge (Fiji), and Tonga-Kermadec Ridge (Tonga) (Figure 1). Negotiations of agreed boundaries between adjoining coastal states can be completed prior to either state submitting a legal boundary definition to the *Commission* or after a joint submission of an outer legal shelf boundary. Australia ratified the convention in 1994, and Fiji and Tonga in 1996, initially requiring respective legal boundary submissions to the *Commission* in 2004 and 2006. Following the decision to extend the deadline for submissions, all four states involved are now required to make submissions to the *Commission* by May 2009. Under a joint New Zealand/Australian Prime Ministerial Agreement in 1999 the New Zealand/Australian negotiations for overlapping continental shelf areas are supposed to be concluded by 2003. Australia has already completed bilateral negotiations with France for a common boundary crossing the northernmost Lord Howe Rise – New Caledonia Basin – Norfolk Ridge system (Figure 1). Similarly, Australia has completed negotiations for boundaries within the Timor and Arafura Seas (northern Australia) producing an arrangement that includes different boundary positions for mineral, hydrocarbon, and pelagic fisheries resources.

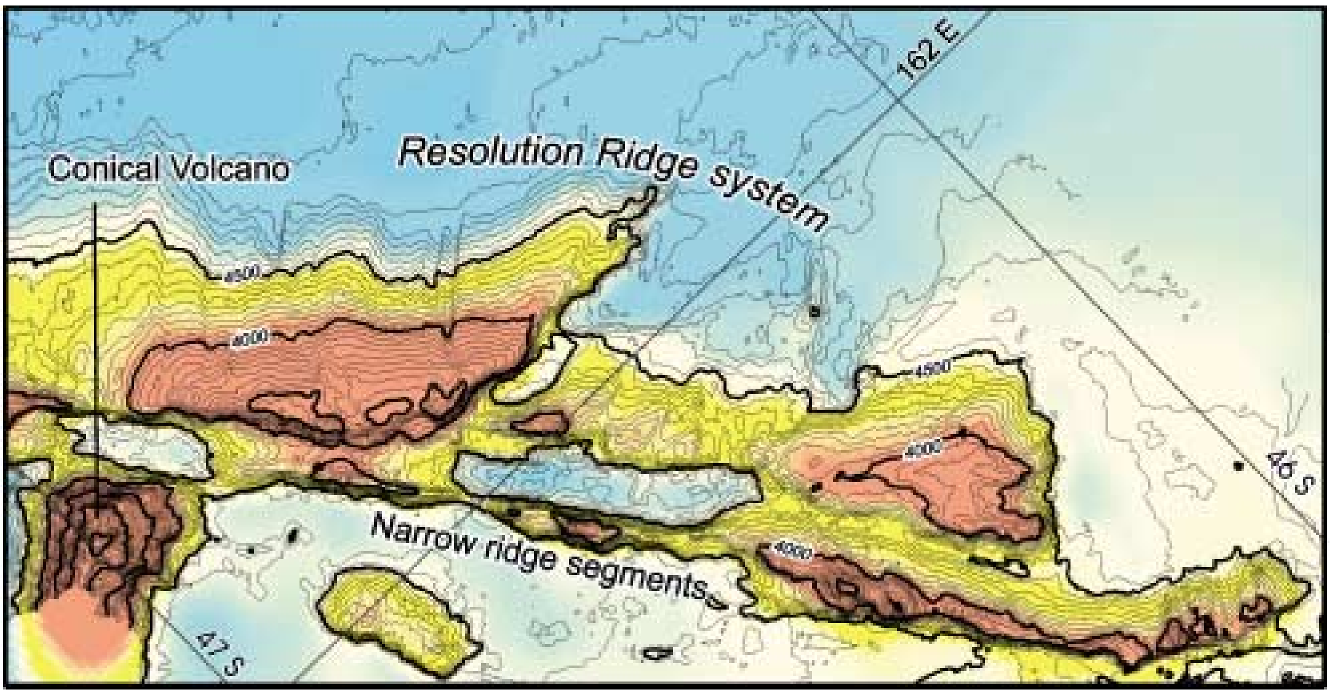

Figure 5. Swath bathymetry (acquired using an EM-12D multi-beam system) contoured at 50 m isobath interval for the central sector of the Resolution Ridge system.

Legal continental shelf and hydrocarbon exploration

The extension of a New Zealand legal continental shelf, beyond the existing 200 M boundary, will potentially accrue significant benefits to New Zealand. These potential benefits, combined with UNCLOS offering a last opportunity from which to extend jurisdiction to the seafloor and sub-seafloor resources, has prompted an extensive survey programme by New Zealand to delimit its outer legal continental shelf boundary. For the oil exploration industry this programme will provide both new insights into frontier offshore basins (both in deeper water and more distant from onshore New Zealand), and ultimately a legal framework for exploration beyond the existing 200 M boundary. Within longer term, areas beyond the 200 M boundary, such as the easternmost Chatham Rise (Davy and Uruski, this volume) and the Lord Howe Rise – New Caledonia Basin (Wilcox et al., 1980; Stagpoole et al., 2000; Uruski, 2000) offer prospective regions for oil exploration.

References

Continental Shelf Limits: The Scientific and Legal Interface, 2000, Edited by P.J. Cook and C. M. Carleton, Oxford University Press, 363 pp.

Davy, B., Uruski, C., 2002. Results of the 2001 deep seismic survey of the Chatham Rise and Hikurangi Plateau and implications for petroleum exploration. New Zealand Petroleum Exploration Conference Proceedings, Ministry of Commerce, Wellington, this volume.

Sandwell, D.T., Smith, W.H.F., 1997. Marine gravity anomaly from Geosat and ERS1 satellite altimetry, Journal of Geophysical Research 102, 10,039-10,054.

Scientific and Technical Guidelines of the Commission on the Limits of the Continental Shelf, 13 May 1999, New York.

Sheppard, J., Pickering, R., 2000. New Zealand's Continental Shelf Project. New Zealand Petroleum Exploration Conference Proceedings, Ministry of Commerce, Wellington.

Stagpoole, V., Herzer, R., Funnell, R., Uruski, C. 2000. Deepwater, frontier basins of northwestern New Zealand – Burial history and hydrocarbon maturation. New Zealand Petroleum Exploration Conference Proceedings, Ministry of Commerce, Wellington.

The Law of the Sea, Definition of the Continental Shelf, 1993, New York, Division of Ocean Affairs and the Law of the Sea, Publication No. E93. V 16, United Nations.

The United Nations Convention on the Law of the Sea, 1997, New York, Publication No. E97. V10, United Nations.

Uruski, C. 2000. Petroleum potential of New Zealand's deep-water basins. New Zealand Petroleum Exploration Conference Proceedings, Ministry of Commerce, Wellington.

Wilcox , J.B. Symonds, P.A., Hinz, K., Bennett, D., 1980. Lord Howe Rise, Tasman Sea – preliminary geophysical results and petroleum prospects. BMR Journal of Australian Geology and Geophysics 5: 225-236.

Wood, R., 2002. Finding the continental shelf – integration of geology and geophysics. New Zealand Petroleum Exploration Conference Proceedings, Ministry of Commerce, Wellington, this volume.

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