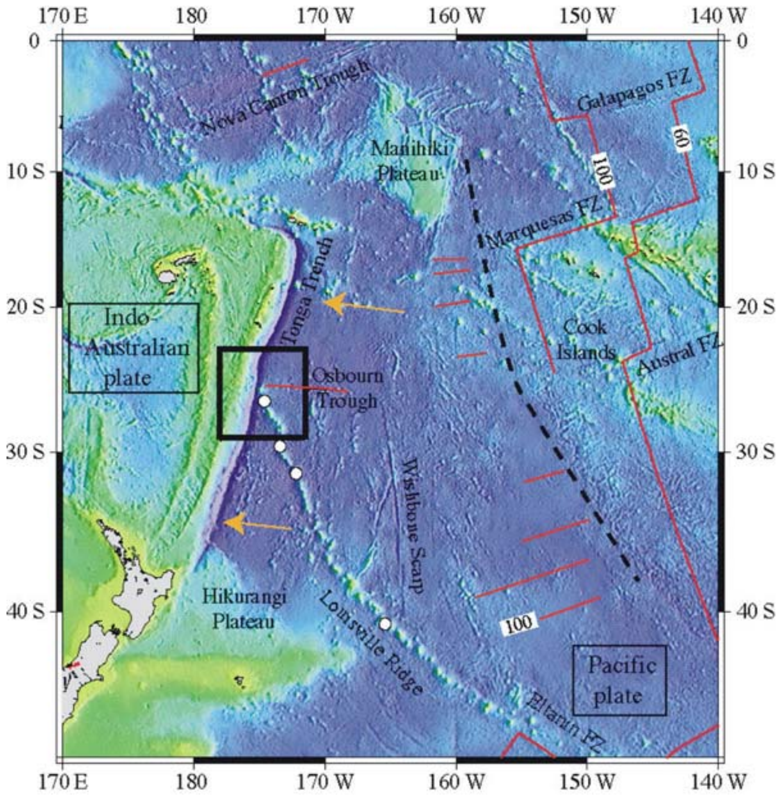
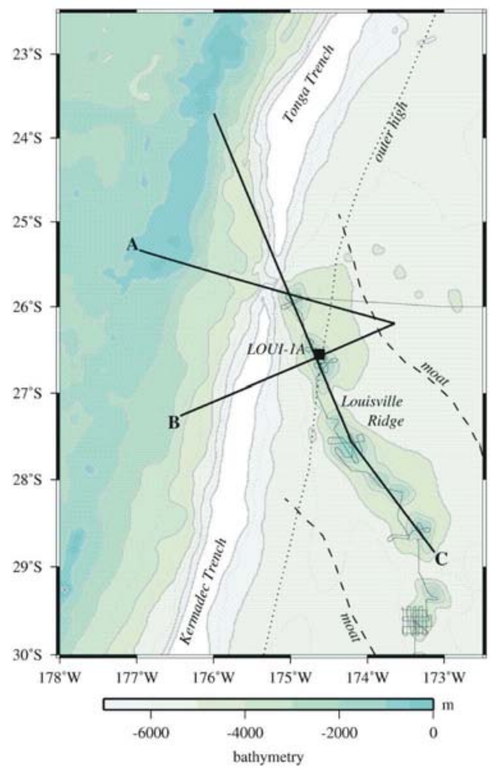
Durham post: vacancy number 3676 **Oxford post: vacancy number 3699**

Apply for either post online via the Durham HR job vacancies web site

Post-Doctoral Researchers in Marine Geophysics
Further Particulars





Contacts:

Dr Christine Peirce
Department of Earth Sciences
Durham University
South Road
Durham
DH1 3LE
UK
Tel: +44 (0)191 334 2315
Email: christine.peirce@durham.ac.uk

Professor Tony Watts
Department of Earth Sciences
University of Oxford
Parks Road
Oxford
OX1 3PR
UK
Tel: +44 (0)186 527 2032
Email: tony@earth.ox.ac.uk

The Hosts

The Departments of Earth Sciences in Durham and Oxford have strong and active commitments to research. In the last Research Assessment Exercise both Departments were highly graded and considered to be amongst the best in the UK for their size. The majority of the marine geophysical research in both hosts is carried out in collaboration with colleagues in either host or in other universities, with industry or with charitable organizations, with substantial programmes funded by UK government, industry, EU sources as well as local councils.

Both hosts have a vibrant undergraduate and postgraduate student community and teach a number of Master in Science, Master of Science and Bachelor of Science degrees, all of which offer a broad-based approach to earth science education. All of these degrees are highly regarded by both employers and prospective students and attract a high quality of intake. Durham also hosts the UK's Nation Ocean-Bottom Seismograph Facility, comprising 50 off 2- and 4-channel seismic platforms and 5 EM receivers.

The Appointments

We are seeking to appoint two Post-Doctoral Research Associates (PDRAs) to join a team working on the recently NERC-funded project "*The Louisville Ridge-Tonga Trench collision: implications for subduction zone dynamics*", under the direction of Dr Christine Peirce in Durham and Professor Tony Watts in Oxford. Both Dr Peirce and Professor Watts have long and well-established careers in marine geophysics-based research and have active research groups making use of seismic and potential field techniques at sea to study a range of processes including continental break-up and rifting, seafloor volcanism and crustal generation and lithospheric plate flexure.

The main objectives of the Louisville project are to better understand a) the crustal and upper mantle structure of subduction zones, b) the influence of seamount subduction on fore-arc structure, subsidence and uplift history, and seismicity, and c) the role of the physical properties of the subducting plate on island arc-trench morphology, back-arc basin extension and down-going slab geometry, integrity and stress state.

Consequently, one of the PDRAs will be directed towards the determination of the crustal and upper mantle structure of the leading edges of the subducting and overriding plates and will be located in Durham, while the other will focus on the analytical and numerical modelling of the collisional system taking into account the thermal and mechanical properties of the lithosphere and will be located in Oxford.

Both posts require the successful completion of an ENG1 Seafarer's medical and a Personal Sea Survival course within 1 month of employment, and a background to at least PhD level in marine geophysical research.

The Louisville Project – summary

Subduction of bathymetric features, such as seamounts, is associated with cessation of arc volcanism and back-arc extension, seismic quiescence, and uplift and deformation of the overriding plate. Modelling studies predict that it is the rate and obliquity of convergence that determines the style and magnitude of deformation. However, these studies do not consider along-strike gravity and topography segmentation of the overriding plate, density variations in the subducting plate, or if deformation is a flexural response to bending of a loaded plate or a plastic response resulting from crustal thickening due to convergence. Here we propose to address these questions by carrying out a multi-disciplinary, international, collaborative project to acquire new geophysical data and to image the crust and uppermost mantle in a subduction zone where a chain of large seamounts is presently colliding with the trench.

The science case which secured the NERC funding for the Louisville project is appended to the back of these Further Particulars as a means of providing further information on the scientific basis of each PDRA.

Responsibilities

The successful candidates will be expected to take part in the sea-going data acquisition programme scheduled during April-June 2011 on the R/V Sonne, and to undertake the processing, analysis and interpretation of the data acquired. They will also be expected to have a flexible attitude and be able to evolve with, and shape their posts and their responsibilities as required. These are challenging roles and we are looking for individuals who will rise to a challenge.

Person Specification

Essential skills, qualifications and experience include:

- qualified to at least PhD level in a relevant discipline by the start date
- have a proven track record of skills and experience in marine geophysical research
- hold, and/or be able to pass, an *ENG1* (or equivalent) *Seafarer's medical certificate**
- hold, and/or be able to pass, a *Personal Sea Survival* (or equivalent) *certificate**
- have a flexible approach to working either in a team or as an individual
- have the ability to work flexible hours to meet deadlines
- have a "can do" attitude to working, the ability to take initiative, problem solve and to work unsupervised
- have proven effective project and time management skills
- have an attention to detail and a thoroughness in checking and testing
- be willing and able to travel globally to rendezvous with research vessels at their ports of call

* This is a mandatory requirement for these posts and, thus, is a condition of employment. If this certificate is not already held it must be passed within one calendar month of the start date.

Desirable skills, qualifications and experience include:

- be able to operate in Microsoft, Linux/Unix or Macintosh platform architectures, including being conversant in programming and scripting
- have a proven publication record in leading journals in the field
- be willing and able to travel to and work at the alternate host for extended periods
- be willing and able to attend courses as required to enhance research skills as necessary depending on background

Staff Training

It is envisaged that the post-holders will take advantage of training opportunities offered by their host university, by a research cruise in 2011, and will also be expected to draw on the extensive sea-going experience within both hosts and develop his/her skills as appropriate. Both universities also offer a wide range of staff development courses which the post-holders will be encouraged to take full advantage of.

Further Information

Informal enquiries may be made to Dr Christine Peirce, Reader in Marine Geophysics at Durham University (email: christine.peirce@durham.ac.uk Tel: +44 (0)191 334 2315) or Professor Tony Watts (email: tony@earth.ox.ac.uk Tel: +44 (0)186 527 2032).

Applicants are also encouraged to browse the web sites of each host department for more general information about on-going research at both hosts.

Selection Process

Candidates will be selected for interview based on their applications and references.

Applications

Applications for these posts must include all of the following:

- your curriculum vitae (CV)
- a letter explaining how you meet the requirements of this post

You should ensure that your CV describes what you have been doing over at least the last 10 years. This may have been employment, education, or you may have taken time away from these activities in order to raise a family, care for a dependent, travel, or for any other reason. Your application will be judged solely on the basis of how your skills and experience match the requirements of the post for which you have applied, and we are happy to consider transferable skills or experience which you may have gained outside the context of paid employment or education.

Applications for either post must be made ***online via the Durham Job Vacancies web site***

https://jobs.dur.ac.uk/default.asp

selecting the post using its reference number from the table to start the application process.

Durham post: vacancy number 3676 **Oxford post: vacancy number 3699**

References

Please give the details of three people who have agreed to provide a reference for you. If you have previously been employed, your referees should be people who have direct experience of your work through working closely with you for a considerable period, and at least one of them should be your formal line manager in your most recent job. It is helpful if you can tell us briefly how each referee knows you (e.g. 'line manager', 'work colleague', 'college tutor'). Your referees should not be related to you.

Your referees will be asked to comment on your suitability for the post and to provide details of the dates of your employment; your attendance during the last 12 months; and of any disciplinary processes which are still considered live. We will assume that we may approach them at any stage unless you tell us otherwise. If you wish us to ask for your permission before approaching a particular referee, or to contact them only under certain circumstances (for example, if you are called to interview) you must state this explicitly alongside the details of the relevant referee(s).

Closing date for applications is **16th April 2010**.

Please quote the relevant reference number on all applications and correspondence, and please use the online application process via Durham University's Human Resources web site for **both** posts.

Interviews will take place around the **26th May 2010**.

Terms & Conditions

The main terms and conditions of employment for either post are as follows (the appointees will receive a full written statement of the Terms and Conditions of Employment from their host university).

- The posts are full time.
- In the first instance, the posts will be for approximately 3 years fixed term from the mutually convenient start date, but preferably 1st march 2011.
- The salary will be in the range £29,852 - £35,646 per annum depending on qualifications and experience.
- The posts are pensionable.

Further information on employment

DURHAM UNIVERSITY

Please refer to Durham University's main web site (http://www.dur.ac.uk/) and Human Resources web site in particular (http://www.dur.ac.uk/hr) for further information related to employment at Durham University.

OXFORD UNIVERSITY

Further information related to employment at University of Oxford is as follows:

Pay and Benefits

If you are appointed at a salary below the top of the range, your salary will automatically be increased each year until you have reached the top point. Increases beyond this point may be available in certain cases. There is also an annual 'cost-of-living' salary review, which normally takes place in summer each year. Pay and benefits for part-time appointments are worked out on a 'pro rata' basis.

For a full-time appointment, the annual holiday entitlement will be 38 days (including five days to be taken on fixed dates at Christmas, and 8 public holidays).

The post is pensionable and the post holders eligible for membership of the Universities Superannuation Scheme (USS), a contributory scheme to which members pay 6.35 per cent of annual salary. Subject to the Statement of Pensions Policy, which will be issued to the successful candidate, the appointee will be deemed to be in membership of the above pension scheme until such time he/she gives notice in writing to exercise the right not to be a member of the scheme. Members of staff are required to retire not later than the 30th of September following their 65th birthday unless they can demonstrate a vested interest as defined in the University's statutes in retirement at 67.

The University has a generous maternity leave scheme and also offers paternity leave to expectant fathers and partners, and adoption leave. It offers subsidised nursery places, a childminding network, a holiday play scheme, and tax and National Insurance savings schemes. For further information see www.admin.ox.ac.uk/eop/child.

How Will the Information Be Used?

Your CV and covering letter will be circulated to the selection panel. They will use this information to assess your suitability for the post against the selection criteria. If appointed, your application will be retained on your confidential staff file. If you are unsuccessful, your application will be retained for six months and then disposed of securely. At all times the information will be held securely in accordance with the terms of the Data Protection Act 1998.

Am I Eligible to Apply to Work for the University?

All appointments are made in accordance with the University of Oxford Equal Opportunities Policy and Code of Practice and applications are welcomed from a wide range of candidates. The University undertakes not to discriminate unlawfully against any applicant on the basis of any information revealed.

The Immigration, Asylum and Nationality Act 2006 makes it a criminal offence for employers to employ someone who is not entitled to work in the UK. We therefore ask applicants to provide proof of their right to work in the UK before employment can commence. Applicants who would need a work visa if appointed are asked to note that under the UK's new points-based migration system they will need to demonstrate that they have sufficient points, and in particular that:

(i) they have sufficient English language skills (evidenced by having passed a test in basic English,
or
coming from a majority English-speaking country, *or* having taken a degree taught in English),

and

(ii) that they have sufficient funds to maintain themselves and any dependants until they receive their first salary payment.

Further information is available at:

http://www.ukba.homeoffice.gov.uk/workingintheuk/tier2/generalarrangements/eligibility/

In accordance with current Home Office regulations you may not be eligible to apply to work for the University if you do not have the right to work in the UK and you are applying for a post in grades 1-5.

Will I be Asked to Provide any Other Information?

Employment with the University is conditional upon satisfying the following requirements:

- proof of identity - in the form of a passport, birth certificate, or other acceptable document;
- proof of address - in the form of a recent utility bill or bank statement;
- proof that you are entitled to work in the UK;
- proof of any qualifications required for this post - in the form of certificates or transcripts.

Please note that you will need to provide original documents and where any documents are not in English a certified translation will be required. ***Do not include these documents with your application***. You will be sent a request for the relevant information at the appropriate point in the selection process.

In addition, if you are selected for this post:

- your medical fitness to undertake the duties of the post will be assessed by the University's Occupational Health Service;
- we will take up references to ensure your suitability for appointment.

Employment with the University is also subject to satisfactory completion of a probationary period.

EQUAL OPPORTUNITIES AT THE UNIVERSITY OF OXFORD

As an Equal Opportunity employer, we positively encourage applications from people of different backgrounds. All our jobs are filled in line with our equal opportunities code of practice, which helps us make sure that men and women, people of different religions or beliefs, ages, racial groups, and those with disabilities are all treated fairly. If you have any questions about equal opportunities at the University of Oxford, please visit our web-site at

http://www.admin.ox.ac.uk/eop.

POLICY STATEMENT

The policy and practice of the University of Oxford require that all staff are afforded equal opportunities within employment. Entry into employment with the University and progression within employment will be determined only by personal merit and the application of criteria which are related to the duties of each particular post and the relevant salary structure. In all cases, ability to perform the job will be the primary consideration. Subject to statutory provisions, no applicant or member of staff will be treated less favourably than another because of his or her gender, marital or civil partnership status, sexual orientation, religion or belief, racial group, age or disability.

WORKING FOR THE UNIVERSITY OF OXFORD

At the University of Oxford, we’re naturally very proud of our outstanding reputation for scholarship and research. But we’re also proud to say that we’re one of the region’s biggest and best established employers, with a real diversity of staff helping to sustain our success - from lab. assistants, cleaners, technicians and secretaries, to IT, finance and administrative professionals.

Join us, and you can expect to find yourself working in a friendly, open-minded atmosphere where your ideas will be welcomed, with an interesting and satisfying job to do, and with plenty of opportunities to learn new skills, or maybe even get some extra qualifications.

Training - we train staff, both in the skills needed for starting the job, and to develop afterwards. If you don't have all the skills listed in an advert (e.g. computer packages), but know that you are a quick learner, it is worth asking if training might be available.

Working hours - departments may be able to be flexible about working patterns to help staff combine work with responsibilities at home. Even if advertisements give full-time hours, this can sometimes be adjusted, and it is always worth asking. For instance, term-time-only working can sometimes be accommodated.

Pensions - all staff are able to join the University's final salary pension scheme, which provides excellent benefits on retirement.

Disability - if you have a disability, we have specialist staff who can help you to start and stay in work.

Childcare - we have three subsidised nurseries for under-fives, subsidised places at some other local nurseries and salary sacrifice and virtual voucher schemes enabling parents to save on tax and/or NI contributions.

Parenting - as well as providing the childcare facilities mentioned above, we have generous maternity and paternity leave schemes to help new parents on our staff.

Cultural and religious needs - we respect the cultural and religious lives of our staff. If you need time away from work, or special facilities, and can give plenty of notice for arrangements to be made, this will always be considered.

Holidays and further benefits - full-time staff receive 38 days holiday and all staff members are allowed free access to the University's first-class sports facilities.

All data supplied by applicants will be used only for the purposes of determining their suitability for the post and will be held in accordance with the principles of the Data Protection Act.

THE LOUISVILLE PROJECT - FULL SCIENCE BRIEFING

BACKGROUND

Subduction zones are dynamically evolving features that mark the sites of plate consumption and the recycling of sediment and magmatic material. They are subject to *both* horizontal and vertical motions and so are of scientific interest, especially as their study results in a better understanding of the driving forces of plate tectonics. Subduction zones are also of societal interest because of their association with explosive volcanism, large-scale slope failures and tsunamigenic earthquakes.

The Tonga island arc–deep-sea trench system is an ideal study site as it is the most linear, fastest converging and most seismically active of any of the world's subduction zones. Moreover, the system has evolved over a long period of geological time (>50 Myr) by successive periods of back-arc spreading, break-up of frontal arc systems, and formation of remnant arcs.

A special feature of this subduction system is that the trench is intersected at ~26ºS by the Louisville Ridge, a 4500 km long chain of seamounts that together with Hawaii and Easter are the three 'classic' hotspot trails in the Pacific Ocean. The Tonga Trench is, therefore, the site of a major collision between a seamount chain on a subducting plate and the fore-arc of an overriding plate. The obliqueness of the collision (~30°) is such that the segment of the subducting plate and fore-arc to the north of the ridge has been affected by the collision while the segment to the south has not. Moreover, the rapidity of the convergence (~80 $mmyr^{-1}$) ensures that the 'signal' from the collision will be strong. Tonga differs, therefore, from other subduction systems such as Sumatra that have a slower convergence rate and a generally less well defined subducting plate morphology.

The rapidity and obliqueness of convergence make the Louisville Ridge–Tonga Trench an ideal locality to determine the mechanical response of the crust and lithosphere to loading and, hence, the integrated strength of the lithosphere. This is important for assessing whether the coupling between the subducting and overriding plates is 'soft' or 'hard' as well as informing parameterization and providing constraints on rheological structure required for numerical modelling of subduction zone processes.

Interestingly, at the Tonga Trench the collision with the Louisville Ridge is also associated with a seismic gap, especially so in shallow seismicity. This makes this, therefore, an ideal locality to also test the 'Kelleher-McCann' hypothesis [*Kelleher & McCann*, 1976] that bathymetric features on the subducting plate may control aspects of arc seismicity. The acquisition of swath bathymetry data, together with the development of new hypocenter determination techniques, has enabled the hypothesis and its significance for the rupture process to tested at a number of subduction zones [e.g. *Robinson et al.*, 2006 – southern Peru; *Bilek et al.*, 2003 – Costa Rica; *Bangs et al.*, 2006 – Nankai Trough]. However, there are no deep crustal/upper mantle seismic studies of these subduction zones and none of them have bathymetric features the size of the Louisville Ridge presently entering the trench.

As part of a partnership with the German funded project **TOTAL** (*To*nga *T*hrust earthquake *A*sperity at *L*ouisville Ridge), we will carry out a deep crustal/upper mantle marine geophysical survey in the region of the collision between the Louisville Ridge with the Tonga Trench. The partnership provides a unique opportunity to play a leading role in the acquisition and reduction of deep seismic data from a major Pacific subduction zone and to develop new models of the mechanical response of the lithosphere to volcanic arc, intra-crustal thrust and slab loads, and the fate and consequences of large bathymetric features on subducting plates.

Wider Justification

This proposal compliments the US Margins programme and its "subduction factory" focus sites at Izu-Bonin, Mariana and Central America as well as German (IFM-GEOMAR) programmes in South America and UK (NERC) programmes in Sumatra. Tonga is an ideal contrast site to Central and South America because it involves older subducting oceanic crust and is not as active volcanically. This proposal builds on more than 3 decades of underway marine geophysical surveys, dredging, and scientific drilling in Melanesia. It is of particular relevance to IODP drilling in 2011 to determine the motion of the Louisville hotspot and the eruptive cycle and geochemical evolution of the Louisville Ridge, and to the SIGHT and NIGHT deep seismic transects of North Island, New Zealand. Finally, this project has relevance to the vulnerable island communities of Melanesia, especially as it impacts on our understanding of the links between earthquake triggering, large-scale slope collapse, uplift and subsidence, and tsunami generation.

The Louisville Ridge–Tonga Trench collision

The Tonga Trench is a simple, essentially linear subduction system, where the Pacific plate is presently underthrusting the Indo-Australian plate (Fig. 1). The subducting plate is of Cretaceous age and is believed to have been generated by the rifting apart of the Manihiki and Hikurangi plateaus and seafloor spreading at the Osbourn Trough [*Downey et al.*, 2007]. These plateaus, together with the Ontong Java plateau, formed one of the world's largest Large Igneous Provinces (LIPs).

The trench is intersected at ~26°S by the Louisville Ridge (Fig. 1) which was generated at a hotspot, presently located near the intersection of the Eltanin Fracture Zone with the East Pacific Rise [*Watts et al.*, 1988]. Seamount ages progressively increase away from the hotspot, such that the oldest (Osbourn ~78 Ma) is presently located on the seaward wall of the Tonga Trench [*Koppers et al.*, 2004].

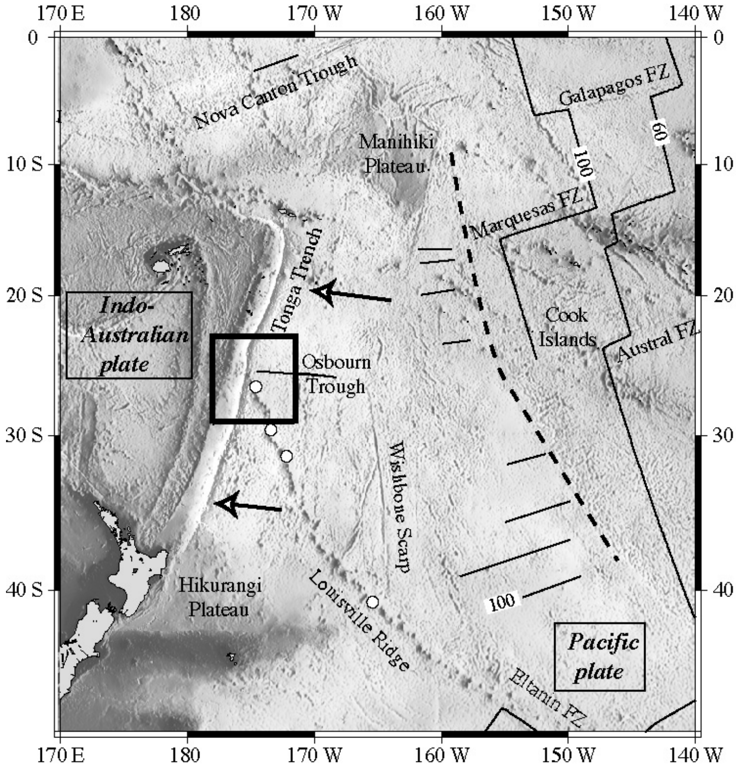


Fig. 1: Bathymetry map of the SW Pacific Ocean based on GEBCO data. Thick black box shows the study area and the white dots show proposed IODP 636 drill sites. Dashed line shows the trace of the Tongareva triple junction that connected the Pacific, Farallon and Phoenix plates during the mid-Cretaceous [*Larson et al.*, 2002]. The E-W trending magnetic lineations to the west [*Cande et al.*, 1989] are part of the former Pacific-Phoenix system while the N-S trending lineations to the east are part of Pacific-Farallon. Arrows show the direction of convergence between the Pacific plate and the Indo-Australian plate based on NUVEL-1.

Subduction of the Louisville Ridge is currently oblique (~30°) and plate reconstructions show that the point of collision has migrated rapidly ~1150 km southwards at up to 180 $mmyr^{-1}$ [*Ballance et al.*, 1989] over the last 5 Myr [*Lallemand et al.*, 1992]. The collision zone is characterised by a shallowing of the trench [*Scholz & Small*, 1997], pervasive normal faulting on the trench seaward wall [*Lonsdale*, 1986], and uplift of the fore-arc [*Clift & MacLeod*, 1999]. Behind the arc, the Lau marginal basin is narrowest and it has been suggested that collision may have triggered back-arc extension [*Lallemand et al.*, 1992].

Bathymetry data show that the once flat-top of Osbourn seamount is being tilted arc-ward as it "rides" the flexural bulge seaward of the trench (Fig. 2). Previous flexure studies suggest the elastic thickness (T_e), a proxy for the long-term strength of the lithosphere, increases from about 27 km beneath the Louisville Ridge [*Lyons et al.*, 2000] to ~30-40 km in the bulge region [*Watts et al.*, 2006] (Fig. 3). The subducting Pacific plate, therefore, appears to be relatively strong in its response to the forces associated with trench loading. However, *Billen* & *Gurnis* [2005] suggests that T_e decreases rapidly by ~15 km between the bulge and trench seaward wall. If this is the case, then it suggests little strength and that viscous, rather than elastic stresses may play a significant role in transferring slab-pull forces to the subducting plate. A fundamental question is, therefore, what are the characteristic structures and rheology of the subducting oceanic plate beneath the ridge and seaward wall of the trench?

It seems likely that trench loading is also deforming the fore-arc. Although fore-arcs are often considered as regions of low cohesion and hence strength, little is known about the Tonga fore-arc. We do know, however, that its collision with the Louisville Ridge correlates with a zone of quiescence in seismicity, dubbed the Louisville 'gap' (Fig. 3). The gap indicates that subducting topographic features may somehow inhibit or even prevent seismicity [*Kelleher & McCann*, 1976]. Indeed, trench shallowing and fore-arc uplift at its intersection with the Louisville Ridge suggests that a large seamount, ahead of Osbourn, is presently being subducted at the Tonga Trench. This supports the view of *Scholz & Small* [1997] that seamounts act as a 'barrier' to seismicity by increasing the recurrence time interval *between* earthquakes.

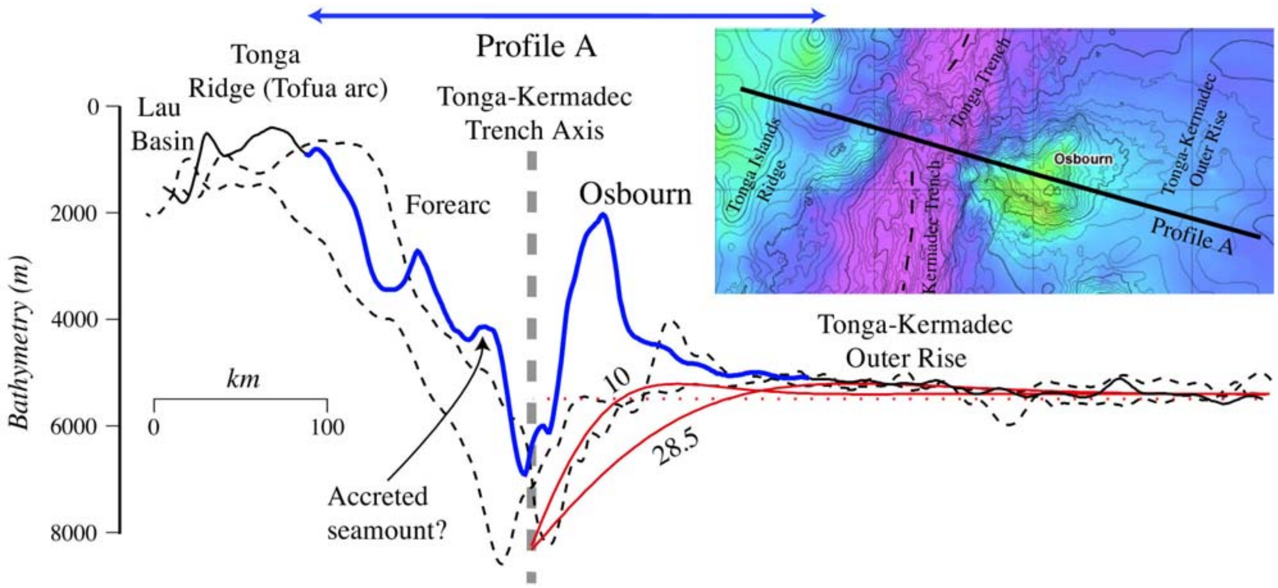


Fig. 2: Bathymetry of the Louisville Ridge–Tonga Trench collision zone. Solid lines show *Profile A* and dashed lines profiles to the north and south. Red lines show calculated profiles based on a semi-infinite (broken) elastic plate model with T_e = 28.5 km, the expected T_e for the plate age. This T_e explains the width of the outer rise, but not the steepness of the seaward trench wall. This region requires a lower T_e of ~10 km. Inset shows a swath bathymetry map of the collision zone (*Koppers pers. comm.*).

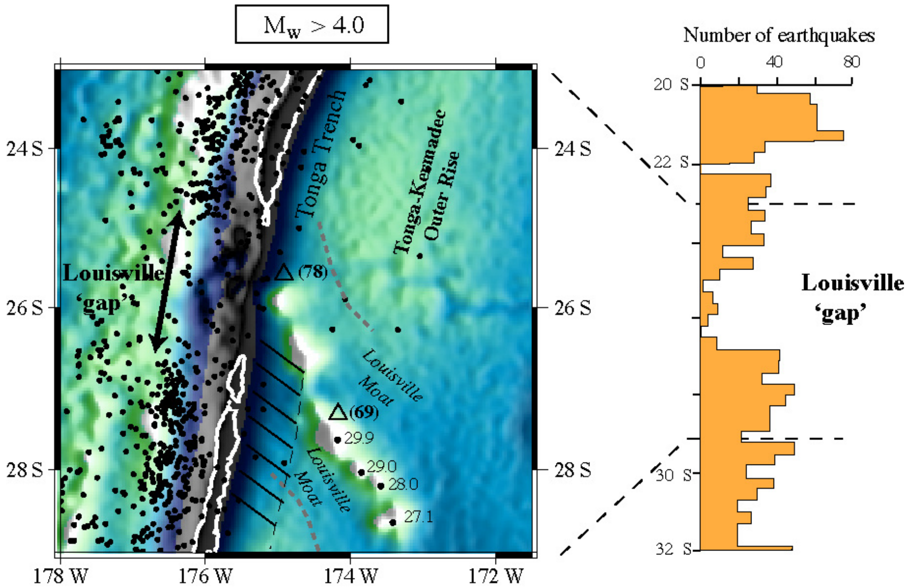


Fig. 3: High-pass free-air gravity anomaly field (light shades high values, dark shades low values) with superimposed earthquakes (black dots) based on a USGS catalogue. Graph shows the distribution of earthquakes along the crest of the Tonga Ridge. Note the gap in seismicity between ~25°S-26.5°S correlates with the intersection of the Louisville Ridge and its flanking moat with the Tonga Trench. Triangles show sample sites with ages in Ma [*Koppers et al.*, 2004] while dots show T_e estimates in km [*Watts et al.*, 2006]. The hatchured region shows the weak zone seaward of the trench identified by *Billen & Gurnis* [2005].

How might this happen? For example, when large seamounts subduct, do they shear off on collision or are they preserved intact to be sheared off after subduction? *Cloos & Shreve* [1996] suggest that this determines whether or not there is a large earthquake. In their model, seamounts may either be truncated aseismically in the low–confining pressure regime of the trench axis and their tops obducted into the accretionary wedge or they are carried into the subduction zone intact and then are sheared off (Fig. 4).

A related issue is the fate of the 'root' that supports a seamount. A seamount that is flexurally supported (e.g. one formed on old seafloor), for example, might be expected to lose some of its support as it enters a subduction zone and, therefore, be carried down by the subducting plate. However, a locally supported seamount (e.g. one formed on young seafloor), might be more buoyant and prone to being obducted.

Probably the best example of a seamount that has been imaged beneath a fore-arc is by *Kodaira et al.* [2000] at the Nankai Trough. These workers used refraction data to image a seamount 13 km thick by 50 km wide at a depth of 10 km beneath the fore-arc. They showed the seamount to be located in the centre of the 1946 Nankaido earthquake rupture zone and that it had acted as a barrier, limiting tsunamigenic brittle rupture to either side.

There is, unfortunately, no refraction data available for the Louisville Ridge–Tonga Trench collision zone and so little is known about the structure of the leading edges of the underthrusting and overriding plates, and the fate and consequences of seamount subduction. Low resolution reflection profiles reveal a prominent reflector beneath the fore-arc which *Ballance et al.* [1989] interpret as the top of a recently subducted Louisville Ridge guyot. Moreover, swath bathymetry data from the upper fore-arc reveals local basement uplifts, and dredging on the lower fore-arc has recovered rocks with an intraplate alkalic affinity [*Lonsdale*, 1986; *Cawood*, 1990; *Wright et al.*, 2000]. Although these observations suggest an intact subducted seamount [*Cawood*, 1990], they do not rule the possibility of truncation [*Lonsdale*, 1986].

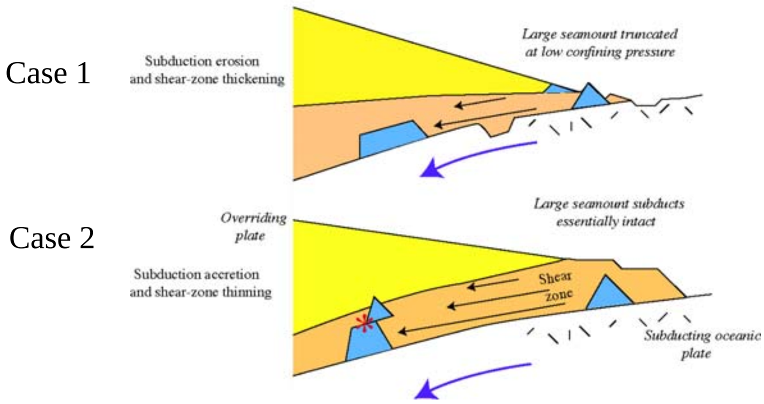


Fig. 4: Schematic diagram illustrating the Cloos-Shreve model that links subducting seamounts with earthquakes (* above). Note that in both cases subduction truncates a subducting seamount. However, in Case 1, the truncation occurs in the low-confining pressure regime of the fore-arc: there is no earthquake and the seamount is obducted. Case 2, in contrast, the seamount is subducted in tact and is then truncated.

HYPOTHESES TO BE TESTED

Our proposed work will test two main hypotheses:

(1) that the mechanical response to the loads associated with convergence involves inelastic behaviour in the leading edge of *both* the underthrusting and overriding plates, and

(2) that bathymetric features on the subducting oceanic plate control aspects of arc seismicity – the 'Kelleher-McCann' hypothesis.

SCIENTIFIC OBJECTIVES

To test the above hypotheses the key scientific objectives (SO) are as follows:

- SO1) Determine the 'background' crustal and uppermost mantle structure of the subducting plate that formed following the rifting apart of the Manihiki-Hikurangi LIP.
- SO2) Determine the crustal and uppermost mantle structure across and along the Louisville Ridge.
- SO3) Determine the physical properties of the leading edges of the subducting and overriding plates.
- SO4) Determine the state of isostasy, ridge-related flexure and moat characteristics at the Louisville Ridge, and the mechanical properties of the subducting and overriding plates.
- SO5) Develop a 3D model of the Louisville Ridge collision zone and seamount subduction.
- SO6) Determine hypocenter depths and rupture mechanisms of earthquakes in the Louisville seismic gap.
- SO7) Determine the seafloor morphology and collision-related deformation in the Tonga fore-arc.
- SO8) Use the resulting crustal models to parameterise and constrain numerical modelling of the thermo-mechanically coupled visco-plastic-elastic response of the lithosphere and the distribution of deformation within the subducting and overriding plates.

METHODOLOGY AND PROGRAMME OF RESEARCH

Our scientific objectives are divided into four work packages (WP) and we will address these using seismic data from profiles of the Tonga Trench-Louisville Ridge collision zone. Profile locations are shown in Fig. 5; *A-C* refer to those to be acquired by this study and *1-4* those acquired as part of **TOTAL**.

WP 1 – Crustal structure of the Louisville Ridge–Tonga Trench collision zone (SO1, 2, 3)

This WP will determine the 'background' crustal and uppermost mantle structure of the leading edges of the underthrusting and overriding plates (*Profiles 1 & 3*). This is essential in order to isolate the effects of the collision. Of particular interest will be to compare the crustal thickness and velocity structure along *Profiles 1 & 3*, since *Profile 3* crosses a segment of the subduction zone where the Louisville Ridge has collided with the trench while *Profile 1* crosses a segment that has not. *Profile 2* will image the change in structure along-strike the fore-arc, between the two segments. In addition *Profile C* will determine whether the subducted seamounts are in tact or instead are decapitated and any compensating root removed. Other objectives of this WP are the structure of the pre-collision Manihiki-Hikurangi LIP and its modification by seafloor spreading at the Osbourn Trough, volcano loading and flexure at the Louisville Ridge (*Profile 4 & part of C*), and bending-induced faulting in the seaward wall of the trench (*Profiles A & B*).

WP 2 – Plate flexure and the rheological properties of the subducting oceanic plate (SO4)

This WP will focus on the long-term thermal and mechanical properties of the subducting oceanic plate. As *Brocher & ten Brink* [1987] have shown at Hawaii, P and S-wave velocities in the region of large loads provide constraints on both T_e and the spatial extent of yielding. The velocity models derived from WP1 in the region of the trench–outer rise will be compared to the predicted strains based on elastic and visco-elastic plate models in order to constrain T_e and, hence, the width of the weak zone of *Billen & Gurnis* [2005]. In addition, the models from WP1 will be used to constrain T_e at the northern end of the Louisville Ridge. Previous studies, based on gravity and bathymetry data, suggest a relatively high T_e (~27 km), yet sample and crustal age data in the vicinity of the Osbourn Trough suggest the ridge loaded relatively young seafloor and, hence, should have a relatively low T_e. This WP will reconcile these different estimates and examine their implications for current hypotheses for the relationship between T_e and load and plate age.

WP3 – Seismicity, structure and morphology of the Louisville Ridge–Tonga Trench collision (SO5, 6)

This WP will focus on the rupture history of selected earthquakes and the possible role that the Louisville Ridge may have played in increasing the seismic coupling and, hence, recurrence time between earthquakes. First, shallow earthquakes for the period 1964-present will be re-located using the *Shoeffel & Das* [1999] method of Joint Hypocenter Determination (JHD). For earthquakes deeper than 50 km, additional depth and core-reflected phases, not reported by agencies, will be read from seismograms. Second, the results from WP1 will be used to constrain the location, size and shape of any seamounts, ahead of Osbourn, that have either been obducted onto the fore-arc or carried down with the subducting plate. Finally, the evidence from swath bathymetry of recent uplift and subsidence, head scars and debris flows in the fore-arc will be compiled and their relationship to the seismicity and seamounts in the fore-arc examined. The resulting models will be used to test the 'Kelleher-McCann' hypothesis.

WP4 – Thermal and mechanical modelling of the Louisville Ridge–Tonga Trench collisional system (SO7, 8)

This WP will use the results from WP1 on crustal and upper mantle structure and from WP2 on the flexural properties of the subducting plate, to parameterise the density and rheological structure of the Louisville Ridge–Tonga Trench collisional system. These parameters will then be used, together with information on rate and orientation of convergence, in a thermally and mechanically coupled, rheologically stratified, visco-elasto-plastic model to compute the response of the underthrusting and overriding plates to island arc, trench and slab loads. Particular emphasis will be given to quantifying the collision of a large seamount with a fore-arc and how this affects the transmission of horizontal stresses through the overriding plate and whether it can trigger back-arc extension, as has been proposed by *Collot et al.* [1985] and *Geist et al.* [1993]. Other questions that will be addressed concern whether the seamount related uplift is a flexural (elastic) response to subduction or whether it is a consequence of crustal thickening (plastic response) resulting solely from collision, and how along-ridge variation in upper and lower plate topography and density affects that response, the latter using the model derived in WP1 for *Profile C.*

Data Acquisition and Analysis

Our scientific objectives will be addressed by an integrated marine geophysical experiment that comprises simultaneous seismic reflection (MCS) and wide-angle (WA) refraction, gravity, magnetic, bathymetry and sub-seabed high resolution imaging of the Louisville Ridge–Tonga Trench collision system (Fig. 5). In outline the acquisition includes:

a) *Profile A* - a 350 km transect across the ridge-trench intersection, designed to determine the across-strike structure of the collision zone between the arc, across the fore-arc and trench, to the outer rise. Whilst also imaging the crust and uppermost mantle structure in the aseismic zone and high-curvature weak zone in the seaward wall of the trench, this profile will also reveal deformation solely related to collision to allow distinction from that induced by seamount interaction with the overriding plate.

b) *Profile B* - a 300 km transect across the Louisville Ridge and moat as they ride the trench outer rise, designed to determine the mode of isostatic compensation beneath the ridge at the northernmost part of the chain, and the effect of collision on the mechanical strength and flexural response of the subduction system.

c) *Profile C* - a 640 km transect along the Louisville Ridge, traversing the proposed IODP drill site LOUI-1A. This transect extends across the Tonga Trench, and is designed to determine the structure of the Louisville Ridge (the pre-subduction crust), any along-ridge variation in crustal structure or underplating, how seamounts interact with the overriding plate upon their subduction, and how along-ridge variation in topography, crust and uppermost mantle structure relate to observed post-collision uplift.

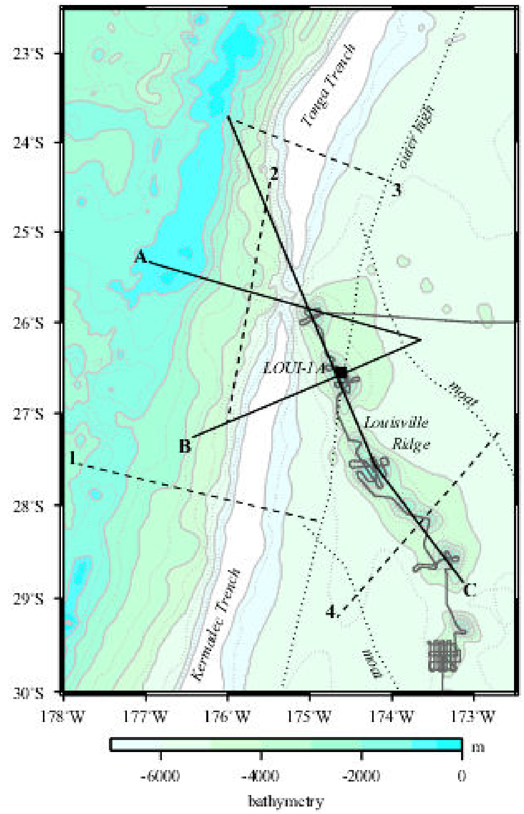


Fig. 5: Acquisition geometry showing the location of *Profiles A-C* (solid black lines) relative to the Louisville Ridge and Tonga-Kermadec Trench. Square – IODP drill site LOUI-1A. Existing R/V Sonne *Profiles 1-4* are shown by dashed lines. Thin grey lines show existing swath bathymetry tracks [*Koppers et al.*, 2004].

We will use the *RV Sonne* via a ship swap agreement. Along each seismic profile ocean-bottom seismographs (OBSs) will be deployed at ~10-15 km intervals, to record airgun shots from an array configured for contemporaneous MCS/WA acquisition. Swath bathymetry data will be acquired throughout to image the seabed expression of faulting and the morphology of seamount flanks along the Louisville Ridge, configuring transits between OBSs and profiles to build up lateral coverage and fill-in gaps in existing coverage [e.g. *Lonsdale*, 1986; *Koppers pers. comm.*]. We will also deploy XBTs along each profile and ground-truth these against a sound velocity dip undertaken in deep water so that the water column can be profiled throughout the work area for WA data modelling purposes.

Brute stacks of the MCS data will be created at sea for quality control and the final sections will be processed and interpreted in-house using Landmark software. The WA data will be modelled using the first-arrival tomography approach [*Zelt & Smith*, 1992] to produce velocity-depth models, which will also underpin migration and depth conversion of the MCS data, and which will be converted to density to constrain thermal and mechanical modelling.

KEY REFERENCES

Ballance, P.F., D.W. Scholl, T.L. Vallier, A.J. Stevenson, H. Ryan, & R.H. Herzer (1989), Subduction of a Late Cretaceous seamount of the Louisville Ridge at the Tonga trench: A model of normal and accelerated tectonic erosion, Tectonics, 8, 953-962.

Bangs, N.L.B., S.P.S. Gulick, & T.H. Shipley (2006), Seamount subduction erosion in the Nakai Trough and its potential impact on the seismogenic zone, Geology, 34, 701-704.

Bilek, S.L., S.Y. Schwartz, & H.R. DeShon (2003), Control of seafloor roughness on earthquake rupture behaviour, Geol. Soc. Amer. Bull., 31, 455-458.

Billen, M.I. & Gurnis, (2005), Constraints on subducting plate strength within the Kermadec trench, J. Geophys. Res., 110 (B5): Art. No. B05407.

Brocher, T. M., and U. S. Ten Brink (1987), Variations in Oceanic Layer 2 elastic velocities near Hawaii and their correlation to lithospheric flexure, J. Geophys. Res., 92, 2647-2661.

Cande, S.C., J.L. LaBrecque, R.L. Larson, W.C. Pitman, Golovchenko, & W.F. Haxby (1989), Magnetic lineations of the world's ocean basins, scale 1:27,400,000, Am. Assoc. Pet. Geol (AAPG map), Tulsa, Oklahoma.

Cawood, P.A. (1990), Provenance mixing in an intraoceanic subduction zone: Tonga Trench-Louisville Ridge collision zone, southwest Pacific, Sedimentary Geology, 67, 35-53.

Clift, P.D., & C.J. MacLeod (1999), Slow rates of subduction erosion estimated from subsidence and tilting of the Tonga fore-arc, Geology, 27, 411-414.

Cloos, M., & R.L. Shreve (1996), Shear-zone thickness and the seismicity of Chilean- and Marianas-type subduction zones, Geology, 24, 107-110.

Collot, J.Y., J. Daniel, & R.V. Burne (1985), Recent tectonics associated with the subduction/collision of the d'Entrecasteaux zone in the central New Hebrides, Tectonophysics, 112, 325-356.

Downey, N.J., J.M. Stock, R.W. Clayton, & S.C. Cande (2007), History of the Cretaceous Osborn spreading center, J. Geophys. Res., 112, doi:10.1029/2006 JB004550.

Geist, E.L., M.A. Fisher, & D.W. Scholl (1993), Large-scale deformation associated with ridge subduction, Geophys. J. Int., 115, 344-366.

Kelleher, J., & W. McCann (1976), Buoyant zones, great earthquakes, and some predictions, J. Geophys. Res., 81, 4885-4896.

Kodaira, S., N. Takahashi, A. Nakanishi, S. Miura, & Y. Kaneda (2000), Subducted seamount imaged in the rupture zone of the 1946 Nankaido earthquake, Science, 289, 104-106.

Koppers, A.A.P., R.A. Duncan, & B. Steinberger (2004), Implications of a nonlinear 40Ar/39Ar age progression along the Louisville seamount trail for models of fixed and moving hot spots, Geochemistry Geophysics Geosystems, 5, do:10.1029/2003GC000671.

Lallemand, S.E., J. Malavielle, & S. Calassou (1992), Effects of oceanic ridge subduction on accretionary wedges: Experimental modeling and marine observations, Tectonics, 11, 1301-1313.

Larson, R.L., R.A. Pockalny, R.F. Viso, E. Erba, L.J. Abrams, B.P. Luyendyk, J.M. Stock, & R.W. Clayton (2002), Mid-Creatceous tectonic evolution of the Tongareva triple junction in the southwestern Pacific Basin, Geology, 30, 67-70.

Lonsdale, P. (1986), A multibeam reconnaissance of the Tonga trench axis and its intersection with the Louisville guyot chain, Mar. Geophys. Res., 8, 295-327.

Lyons, S.N., D.T. Sandwell, & W.H.F. Smith (2000), Three-dimensional estimation of elastic thickness under the Louisville Ridge, J. Geophys. Res., 105, 13,239-213,252.

Scholz, C.H., & C. Small (1997), The effect of seamount subduction on seismic coupling, Geology, 25, 487-490.

Shoeffel, H.-J., and S. Das (1999), Fine details of the Wadati-Benioff zone under Indonesia and its geodynamic implications, J, Geophys. Res., 104, 13,101-113,114.

Wright, D.J., S.H. Bloomer, C.J. MacLeod, B. Taylor, & A.M. Goodliffe (2000), Bathymetry of the Tonga Trench and Fore-arc: a map series, Marine Geophysical Researches, 21, 489-511.

Zelt, C.A & R.B. Smith (1992), Seismic travel-time inversion for 2-D crustal velocity structure, Geophys. J. Int., 108, 16-34.