V22F MCC: 3008 Tuesday 1340h

Crustal and Mantle Processes in Ophiolites and Ocean Crust Generation IV *(joint with GP, T)*

Presiding: **J H Bedard,** Geological Survey of Canada**; Y Niu,** University of Houston

V22F-01 1340h INVITED

How Variable Slow-Spread Ocean Crust?

Henry J.B. Dick[1] (508-289-2590; hdick@whoi.edu); Peter Kelemen[1] (508-548-1400; pkelemen@whoi.edu); Eiichi Kikawa[2]; Michael J. Cheadle[3]; Peter J. Michael[4] (pjm@utulsa.edu); Jon Snow[5]; Hans Schouten[1] (508-548-1400; hschouten@whoi.edu); Jian Lin[1] (508-548-1400; jlin@whoi.edu); Greg Hirth[1] (508-548-1400; jhirth@whoi.edu); . Leg 209 Scientific Party[6]

[1]Dept. of Geology & Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, United States

[2]Japan Marine Science and Technology Center, Natsushima-cho, Yokosuka 2-15, Japan

[3]Department of Geology, University of Wyoming, Laramie, WY 82070, United States

[4]University of Tulsa, 600 S College Ave., Tulsa, OK 74104, United States

[5]Max-Planck Institut für Chemie, Abt. Geochemie, Postfach 3060, Mainz D-55020, Germany

[6]Ocean Drilling Program, 1000 Discovery Drive, College Station, TX 77845, United States

Field studies at slow and ultra-slow spreading ocean ridges reveal a diversity of crustal architecture. At the extreme, ultra-slow spreading ridges consist of linked magmatic and amagmatic accretionary segments. The latter replace transform faults and en-echelon magmatic segments to accommodate ridge obliquity. They are sparsely volcanic and expose large areas of peridotite on the sea floor. Gabbros are largely absent in dredges and dikes uncommon. At magmatic accretionary segments, sheeted dikes and pillow lavas, and gabbros are exposed in abundance, including primitive layered gabbros, and the crustal section appears to fit the Penrose ophiolite model. At slow spreading ridges, by contrast, en-echelon magmatic segments linked to non-transform discontinuities and transforms accommodate ridge obliquity. Diabase, gabbro and peridotite are dredged largely from transform walls and locally at non-transform offsets. Lithologic relationships inferred from dives and dredges suggest a non-Penrose stratigraphy. However, mapping at the Atlantis Bank oceanic core complex suggests that this may be due to sampling fault faces that localize late serpentine diapirism and intrusions of mostly highly differentiated gabbro. There, detachment faulting rooted at the dike-gabbro transition has dismembered Penrose type oceanic crust exposing a 400 km2 gabbro massif less than 5 km thick, that tapers out at variable distances towards the fracture zone. Large mantle outcrops, however, are exposed along rift valley walls away from transforms in the 15°20'N region of the MAR. ODP Leg 209 drilling at 8 widely spaced sites found more abundant gabbro than expected from the dredging. Here, a non-Penrose stratigraphy consists of numerous gabbro plugs intruded at varying depth in a mantle section beneath the ridge axis. These, in turn, are locally cross-intruded by dikes and covered by a veneer of pillow basalts. Most gabbros are highly evolved, suggesting more primitive gabbros are abundant at depth. The abundance of dredged peridotite likely reflects strain localization in the roof zone where peridotites are intruded by gabbros, commonly exposing deformed intrusion breccias and net vein complexes in massive metamorphosed peridotites, rather than the main gabbro body. With this exception, oceanic crust at slow spreading ridge magmatic accretionary segments likely largely conforms to a Penrose model, while that at amagmatic accretionary segments, spreading discontinuities, and transforms have an attenuated stratigraphy, often quite different than the Penrose model of massive pillow basalt, sheeted dikes, isotropic and layered gabbro overlying a massive peridotite tectonite.

V22F-02 1355h INVITED

A Polygenetic Origin for some Oceanic Lithosphere: Evidence from Forearc, Continental Margin and Ophiolite Mantle Sequences

Julian A Pearce[1] (44-2920-875124; PearceJA@cardiff.ac.uk)

Ian J Parkinson[2] (44-1908-659780; i.j.parkinson@open.ac.uk)

[1]School of Earth, Ocean and Planetary Sciences, Cardiff University, Cardiff CF10 3YE, United Kingdom

[2]Dept. of Earth Sciences, The Open University, Milton Keynes MK7 6AA, United Kingdom

It is a common assumption that ophiolites and oceanic lithosphere attain their structures and compositions through partial melting of mantle in a single tectonic setting and with a simple petrogenetic relationship between all the units. There is, however, growing evidence that some oceanic lithosphere and ophiolite complexes contain a record of a polygenetic history of formation. This may be apparent in crustal units (complex lava stratigraphies or cross-cutting dykes and gabbros) but the best evidence is recorded in the chrome spinel compositions of residual mantle. Among the most effective plots is that of oxygen fugacity, calculated from accurately-determined ferric iron concentrations, against Cr-number. In the ocean basins, forearc peridotites from the Izu-Bonin Mariana, Tonga and South Sandwich systems may be of two types. In the first, both peridotites and dunites have similar oxygen fugacities and a small range in Cr-number. We interpret these as mongenetic. In the second, the peridotites have low oxygen fugacities and moderate Cr-number and trend towards dunites with high oxygen fugacities and high Cr-number. We interpret these as representing mid-ocean ridge mantle lithosphere, which existed prior to a subduction event and was subsequently invaded by subduction-related melts. The time-gap between the ridge and subduction events may be millions of years or, in the case of subduction initiation, represent a continuum. At passive continental margins, such as the Galicia margin, the origin may again be monogenetic or polygenetic. In the latter case, the mantle peridotites may exhibit a trend from low Cr-number to moderate Cr-number and decreasing oxygen fugacity. We interpret these as representing orogenic peridotite uplifted during an amagmatic extensional event and invaded by MORB magma during subsequent spreading. As with forearc peridotites, the time gap between these two events may be large or there be a continuum. A surprising number of ophiolites exhibit this polygenetic character, especially those which may be linked to subduction initiation (such as the northern Semail ophiolite, Pindos, Zambales) or to ocean opening (e.g. Western Mediterranean ophiolites, Othris, Lizard). And even in essentially monogenetic ophiolites, such as the Troodos Massif, there are subtle variations that may be related to ridge jumps or other local processes. These observations raise questions over the extent to which oceanic lithosphere really is the product of 100% extension or whether it may sometimes contain relics of a more complex history.

V22F-03 1410h

Magmatic Cycles at Spreading Centers: Geochemical Study of a Continuous Extrusive Section in the Oman Ophiolite

Florence Einaudi[1] ((33) 4 67 14 93 09; einaudi@dstu.univ-montp2.fr)

Marguerite Godard[2] ((33) 4 67 14 39 37; margot@dstu.univ-montp2.fr)

Philippe A Pezard[1,2] ((33) 4 67 14 93 10; pezard@dstu.univ-montp2.fr)

Jean-Jacques Cocheme[3] ((33) 4 91 28 85 19; jean-jacques.cocheme@univ.u-3mrs.fr)

Tim Brewer[4] ((44) 0116 2523611; tsb5@leicester.ac.uk)

[1]Laboratoire de Geophysique et d'Hydrodynamique en Forage,, ISTEEM, cc056, Universite de Montpellier II, Montpellier 34095, France

[2]Laboratoire de Tectonophysique, ISTEEM, Universite de Montpellier II,, Montpellier 34095, France

[3]Laboratoire de Petrologie Magmatique, Universite d'Aix Marseille, Faculte des Sciences de St Jerome, Marseille 13397, France

[4]Department of Geology, University of Leicester, University Rd.,, Leicester LE1 7RH, United Kingdom

The continuous volcanic stratigraphy of the basaltic crust at mid-ocean ridges is of primary importance to understand magma transport and accretion processes at different spreading rates. In order to provide detailed constraints on the construction of the upper oceanic crust, and on possible temporal variations in the ridge activity, we sampled at high-frequency a continuous volcanic transect (300 m-thick) in the Oman ophiolite along Wadi Shaffan. The Wadi Shaffan section is composed of MORB-type lavas (V1-Geotimes volcanism). It consists mainly of pillow lavas interbedded with abundant massive flows in the lower part of the section, the latter getting more scattered in the upper part of the section. Trace element ratios (e.g. Zr/Nb and La/Yb) allow to distinguish two main sequences with two different parental magmas. This suggest that the Wadi Shaffan transect was built through two main petrological and geochemical sequences of volcanic activity. Within each sequence, variations in trace element abundances (TiO2 ,Zr, REE) involve differentiation processes prior to emplacement. In the lower sequence, the less differentiated lavas form the upper part of the cycle. Magma mixing is proposed to explain this reversed geochemical evolution through time. The upper sequence consists of multiple events of magma emplacement. Variations in trace element abundance suggest four magmatic cycles. Each magmatic cycle is characterized by primitive lavas evolving to more differentiated lavas with time. The upper sequence lavas appear to be in equilibrium with clinopyroxene sampled in the Mantle-Crust Transition Zone (MTZ) sills, for the most primitive lavas, and with clinopyroxene sampled in the lower gabbros. We propose a model in which the upper sequence lavas were directly derived from the MTZ and lower gabbro and then transported to the surface without interaction with higher crustal levels.

V22F-04 1425h

Heterogeneous melting of intermediate/fast spreading backarc peridotites, Parece-Vela Rift, Marianas backarc

Jonathan E Snow[1] (01149 6131 305 202; jesnow@mpch-mainz.mpg.de)

Yasuhiko Ohara[2] (ohara@jodc.go.jp)

Eric Hellebrand[1] (ehelle@mpch-mainz.mpg.de)

Kyoko Okino[3] (okino@ori.u-tokyo.ac.jp)

Teruaka Ishii[3] (ishii@ori.u-tokyo.ac.jp)

[1]Max-Planck-Institut für Chemie, Postfach 3060, Mainz 55020, Germany

[2]Hydrographic and Oceanographic Department of Japan, 5-3-1 Tsukiji, Chuo-ku, Tokyo 104-0045, Japan

[3]Ocean Research Institute, University of Tokyo, Tokyo 164-8369, Japan

The Marianas backarc region is unique in being the only one in which peridotites are extensively exposed. It is also paradoxically one of the fastest-spreading mantle peridotite localities on the ocean floor, second only to Hess Deep. The dredging cruise Kairei KR03-01 in January 2003 added considerably to the sample set available for study from this region. The samples range from fertile lherzolite to harzburgite and dunite. The level of alteration was quite high: Since the Parece Vela Rift (PVR) failed, these samples have been exposed on the sea floor a minimum of 10 million years. The oldest section of the rift sampled was a megamullion structure in chaotic terrain west of the PVR, on crust that is about 25 million years old. Peridotites from a single dredge haul (dredge 3) on this megamullion structure range from residual to highly melt impregnated, with spinel TiO2 contents from 0.01 to 0.9 wt.%. The degree of melting is moderate to high, judging from Cr# (Cr/(Cr+Al)) between 0.4 and 0.5 in residual (i.e. low TiO2) samples. This is in keeping with an estimated full spreading rate of 8cm/yr during the time the PVR was spreading E-W. In the Parece Vela Rift proper, the new dredging was about evenly divided between fertile compositions (dredges 7, 9 and 15) and more depleted ones (dredges 6, 10, and 12). The dredges without significant TiO2 enrichment are quite homogeneous. In the PVR, the long fracture zones would be expected to have some effect on the melting of the peridotites, but they apparently do not. Fertile dredges 7 and 9 are relatively close to the northern Godzilla Mullion bounding fracture zone, but depleted dredge 12 is on an outside corner (where it should be fertile) and depleted dredge 10 is no farther from the fracture zone than fertile dredge 7. We thus cannot yet draw firm conclusions about the relationship between fracture zone proximity and melting in this region. The intermediate to fast spreading rate (7-8 cm/yr) seems to have resulted in a preponderance of the sites having about 15-17% melting, and is in line with data from Hess Deep (10cm/yr, Cr# .55, F=18%). In contrast to Hess Deep, many of the samples are quite fertile (Cr# 15), thus either the degree of melting or the efficiency of melt extraction was not as great as at the East Pacific Rise during the formation of the Hess Deep mantle section. This may be due generally to the many fracture zones in the region even if individual dredge hauls fail to show a clear transform fault effect.

V

V22F-05 1440h

Isotopic Equilibrium in Mature Oceanic Lithosphere: Insights From Sm-Nd Isotopes on the Corsica (France) Ophiolites

Elisabetta Rampone[1] (0039-010-3538315; betta@dipteris.unige.it)

Albrecht W. Hofmann[2]

Ingrid Raczek[2]

Anna Romairone[1]

[1]Dipartimento per lo Studio del Territorio e delle sue Risorse, Univ. Genova, C.so Europa 26, Genova 16132, Italy

[2]Max-Planck-Institut fuer Chemie, Postfach 3060, Mainz 55020, Germany

In mature oceanic lithosphere, formed at mid-ocean ridges, residual mantle peridotites and associated magmatic crust are, in principle, linked by a cogenetic relationship, because the times of asthenospheric mantle melting and magmatic crust production are assumed to be roughly coheval. This implies that oceanic peridotites and associated magmatic rocks should have similar isotopic compositions. Few isotope studies have been devoted to test this assumption. At mid-ocean ridges, similar Nd isotopic compositions in basalts and abyssal peridotites have been found by Snow et al. (1994), thus indicating that oceanic peridotites are indeed residues of MORB melting. By contrast, Salters and Dick (2002) have documented Nd isotope differences between abyssal peridotites and associated basalts, with peridotites showing higher ^{143}Nd/^{144}Nd values, and they concluded that an enriched pyroxenitic source component is required to explain the low end of the ^{143}Nd/^{144}Nd variation of the basalts. Here we present Sm/Nd isotope data on ophiolitic mantle peridotites and intruded gabbroic rocks from Mt.Maggiore (Corsica, France), interpreted as lithosphere remnants of the Jurassic Ligurian Tethys ocean. The peridotites are residual after low-degree (<10%) fractional melting. In places, spinel peridotites grade to plagioclase-rich impregnated peridotites. Clinopyroxene separates from both spinel- and plagioclase- peridotites display high ^{147}Sm/^{144}Nd (0.49-0.59) and ^{143}Nd/^{144}Nd (0.513367-0.513551) ratios, consistent with their depleted signature. The associated gabbros have Nd isotopic compositions typical of MORB (^{143}Nd/^{144}Nd = 0.51312-0.51314). Sm/Nd data on plag, whole rock and cpx from an olivine gabbro define an internal isochron with an age of 162 $\pm$ 10 Ma, and an initial epsilon Nd value (9.0) indicating a MORB-type source. In the Sm-Nd isochron diagram, the peridotite data also conform to the above linear array, their initial (160 Ma) epsilon Nd values varying in the range 7.6-8.9. Sm/Nd isotopic compositions of the peridotites are therefore consistent with a Jurassic age of melting and melt impregnation, and point to isotopic compositional similarities between depleted peridotites and associated magmatic rocks. In a regional geodynamic context, Sm/Nd isotope data for the Mt.Maggiore gabbro-peridotite association represent the first record of the attainment of a mature oceanic stage of the Ligurian Tethys ocean. Also, the data presented provide striking evidence of the existence of isotopic equilibrium between melts and their mantle residue. References Snow et al. (1994), Nature 371, 57-60. Salters and Dick (2002), Nature 418,68-72.

V22F-06 1455h

Trace Elements in Clinopyroxenes of Peridotites From Mariana Forearc Seamounts (ODP Leg 195, Site 1200A, and ODP Leg 125, Sites 779A and 784A): Evidence for Polybaric, High-Degree, Fractional Mantle Melting

Piera Spadea[1] (39 0432 558760; spadea@uniud.it)

Alberto Zanetti[2] (zanetti@crystal.unipv.it)

Massimo D'Antonio[3] (masdanto@unina.it)

Riccardo Vannucci[4] (vannucci@crystal.unipv.it)

[1]Dipartimento di Georisorse e Territorio, Universita' di Udine, Via Cotonificio 114, Udine I-33100, Italy

[2]CNR-Istituto di Geoscienze e Georisorse, Via Ferrata 1, Pavia I-27100, Italy

[3]Dipartimento di Scienze della Terra, Universita' Federico II, Largo S. Marcellino 10, Napoli I-80138, Italy

[4]Dipartimento di Scienze della Terra, Universita' di Pavia, Via Ferrata 1, Pavia I-27100, Italy

The clinopyroxenes from peridotite clasts drilled during Ocean Drilling Program Leg 195 and Leg 125 in Mariana forearc serpentinite mud volcanoes are depleted to extremely depleted in FeO, $Al_(2)O_(3)$, $Na_(2)O$, and enriched in MgO and CaO with respect to those from abyssal peridotites far from intra-oceanic subduction areas. Consistently, they contain very low amounts of incompatible trace elements. Although strongly LREE depleted, trace element signatures of Leg 195 clinopyroxenes show a significant variability. Cpx from Site 1200A 6R-2, 66 cm and 17G1, 106 cm harzburgites, have REE patterns ($Nd_(N)/Yb_(N)$0.03; $Sm_(N)/Ho_(N)$=0.26-0.30;$Yb_(N)$=2.0-2.7) consistent with 15% of melt removal from the Depleted MORB Mantle source via fractional melting under spinel-facies conditions. Cpx from Site 1200A 6R-1, 93-96 and 10R-1, 90 cm harzburgites have REE patterns characterised by a stronger MREE/HREE fractionation ($Sm_(N)/Ho_(N)$=0.08-0.14) which can be explained by a polybaric fractional melting process, started in the garnet peridotite stability field (minimum 3-4%) and proceeded (>10%) during the ascent through the spinel peridotite stability field. Cpx from Site 1200A 16R-2, 12 cm and 1W-1, 56 cm harzburgites occur as euhedral to anhedral small grains enclosed in coarse orthopyroxene and are have extremely low REE content (maximum at $Lu_(N)$=0.6-1.2 C1; $Ho_(N)/Yb_(N)$=0.16-0.18), and strong HREE fractionation. According to petrographic evidence, they formed by sub-solidus exolution from a pristine Ca-rich orthopyroxene stable at high temperature during decreasing temperature. Clinopyroxenes from Leg 125 harzburgites are also strongly depleted in incompatible trace elements. Cpx from Site 779A 26R-2, 98 cm and 779A 26R-2, 20 cm cores show extremely fractionated patterns in the MREE-HREE region, and can be modelled by 6-8% garnet-facies peridotite fractional melting followed by $\sim$12% spinel peridotite fractional melting. As a whole, the MREE-HREE distributions are consistent with those reported by Parkinson and Pearce (1998) for clinopyroxenes from Site 779A 14R-2, 40 cm harzburgite core. Differently, clinopyroxenes from Site 784A 45R-CC, 10 cm and 784A 45R-1, 108 cm harzburgites show less fractionated patterns ($Nd_(N)/Yb_(N)$ up to 0.25), very low HREE content ($Yb_(N)$=0.9-1.2) and sometimes relatively large LREE content ($Ce_(N)$ up to 0.13 in 784A 45R-CC, 10 cm cpx). The overall REE distributions are not consistent with large degrees of fractional melting under spinel-facies conditions (up to 20% as deduced by HREE) and suggest some melt entrapment after the melting event. In summary, the REE composition of Leg 195 and Leg 125 clinopyroxenes indicates that: 1) the melting process for most peridotites started under garnet-facies conditions and continued during the upwelling of the asthenosphere at shallow, spinel-facies, levels; 2) the effects of melt migration or entrapping are apparent only in a couple of samples; 3) the late stages of the lithospheric evolution comprise sub-solidus re-equilibration, with clinopyroxene exsolution from primary high-Ca orthopyroxene. Reference: Parkinson, I.J.and Pearce, J.A., J. Petrol., 39, 1577-1618 (1998).

V22F-07 1510h

High H_2O in MORB From Gakkel Ridge

Peter J Michael[1] (918-631-3017; pjm@utulsa.edu); Andrew K Matzen[1] (918-631-2517; andrew-matzen@utulsa.edu); Charles H Langmuir[2] (617-384-9948; langmuir@eps.harvard.edu); Steven L Goldstein[3] (845-365-8787; steveg@ldeo.columbia.edu); Gad Soffer[3] (845-365-8906; gsoffer@ldeo.columbia.edu); Paul Schmieder[1,3] (schmied@ldeo.cilumbia.edu); David W Graham[4] (541-737-4140; dgraham@coas.oregonstate.edu)

[1]The University of Tulsa, 600 S. College Ave., Tulsa, OK 74104, United States

[2]Harvard University, 20 Oxford St, Cambridge, MA 02138, United States

[3]Lamont-Doherty Earth Observatory of Columbia Univ., Rt. 9W, Palisades, NY 10964, United States

[4]Oregon State University, COAS, Corvallis, OR 97331

Enriched and depleted mid-ocean ridge basalts (MORB) from western Gakkel Ridge (GR) in the Arctic Ocean have distinctive trace element and volatile characteristics compared to MORB globally. They are enriched in H_2O and large ion lithophile (LIL) relative to rare earth elements (REE), so have high H_2O/Ce and Ba/La. To a lesser degree, they are enriched in REE relative to HFS (e.g., high La/Nb). The order of enrichment is H_2O >Ba>Rb>K>La and is similar to the subduction zone signature displayed by some back-arc basin basalts. There has been about 200 km of shortening in this region as Greenland converged with the Arctic Basin during the Cenozoic (Brozena et al, 2003) but true subduction is less likely. The enrichment pattern also has some similarity with continental lithosphere, which may be present in the source region since continental rifting was relatively recent in this region. Continental involvement was suggested for Knipovich R. (Schilling et al., 1999). The geographic extent of the distinctive enrichment should help constrain its origin, since an anomaly associated with Greenland convergence should be localized to western GR. H_2O/Ce and Ba/La both diminish toward the eastern GR, where basalts resemble Pacific MORB.However, H_2O/Ce remains high toward the North Atlantic along Knipovich, Mohns, Kolbeinsey and Reykjanes Ridges, suggesting a much larger region, perhaps related to a larger and more ancient subduction event. The extent of the high Ba/La in the northernmost Atlantic is not clear from current data. Isotopic data from Gakkel ridge MORB should provide additional constraints on the nature of the high- H_2O component on GR. When MORB are considered globally, there are no consistent associations between H_2O/Ce and other trace element and isotopic characteristics. Some MORB with high Ba/Nb and high ^{87}Sr/^{86}Sr relative to ^{206}Pb/^{204}Pb have high H_2O (SEIR) whereas others (southern MAR) have distinctive low H_2O (Dixon et al; 2002; Michael and Kamenetsky, 2002). This might reflect very different high-Ba components, or it could reflect different behavior of H_2O within the high Ba component compared to the normal peridotite. Brozena et al. (2003) Geology Dixon et al., (2002) Nature 420, 385-389 Schilling et al., (1999) JGR 104, 10543-10569

V22F-08 1525h

Strontium and Oxygen Isotopic Profiles Through a Complete Sequence of Oceanic Crust Exposed on Macquarie Island

Damon AH Teagle[1] (+44-23-8059-2723; dat@soc.soton.ac.uk)

Rosalind M Coggon[1] (+44-23-8059-2723; rmc01@soc.soton.ac.uk)

Jeffrey C Alt[2] (734-764-8380; jalt@umich.edu)

Garry J Davidson[3] (61-3-6226-2815; Garry.Davidson@utas.edu.au)

[1]Southampton Oceanography Centre, University of Southampton, Southampton SO14-3ZH, United Kingdom

[2]Department of Geological Sciences, University of Michigan, Ann Arbor, MI 48109, United States

[3]School of Earth Sciences, University of Tasmania, Hobart, Tas 7001, Australia

Macquarie Island, approximately 1000 km south of New Zealand, is a thin sliver of ocean crust exposed by recent transpression along the Pacific - Australian plate boundary. The crust formed $\sim$11 Ma-ago most probably on a short spreading segment of a slow spreading mid-ocean ridge. Uplift and erosion on Macquarie Island has exposed unique sections through the ocean crust and an opportunity to describe and sample regions of the ocean basement that have yet to be sampled in situ despite 30 years of scientific ocean drilling. Here we present the first strontium and oxygen isotope profiles for a complete ocean basement stratigraphy from a single location. Although there are local complications, the isotope profiles yield general trends of decreasing seawater Sr and increasing temperatures of alteration with depth. $^{87}Sr/^{86}Sr$ ratios of the uppermost lavas are highly elevated ($\sim$0.703-0.704) compared to the primary ratios determined from fresh glass ($^{87}Sr/^{86}Sr$ $\sim$0.70255-0.70275) due to reaction with seawater. These lavas yield heavy oxygen isotopic compositions (δ^{18}O $\sim$8-10 $^o/_{oo}$) indicative of low temperature exchange with seawater. Relatively radiogenic $^{87}Sr/^{86}Sr$ of prehnites and chlorite bearing samples with elevated δ^{18}O indicate that there may be a lower temperature overprint of some samples. Dikes from deeper in the crust yield a more restricted range of $^{87}Sr/^{86}Sr$ ($\sim$0.703-0.7035). Oxygen isotopic compositions of these samples bracket the primary mantle value and show a trend of decreasing δ^{18}O with depth representing greater extents of exchange at higher temperatures. Sr isotope ratios of gabbros, dikes and layered gabbros from the lower Macquarie crust are slightly elevated from primary igneous values ($^{87}Sr/^{86}Sr$ $\sim$0.7025-0.703) indicating that there is minor penetration of seawater-derived strontium to the lowermost regions of the crust. These samples consistently yield relatively light oxygen isotopic compositions (δ^{18}O $\sim$3-6 $^o/_{oo}$) requiring significant exchange with hydrothermal fluids at high temperatures. Two peridotite samples from near the crust-mantle boundary have near seawater $^{87}Sr/^{86}Sr$ ratios ($\sim$0.7085-0.7088) but visible late stage carbonate may be responsible for these highly elevated values. Heavy oxygen isotope ratios for some peridotites may indicate serpentinization at low temperatures although this occurred with little exchange of seawater strontium. The Macquarie Island section reveals similar trends in strontium and oxygen isotopic compositions with depth to those from the uppermost crust drilled into in situ ocean crust (ODP Holes 504B and 896A) although the rocks are less altered than samples from the major suprasubduction zone ophiolites (Troodos and Oman).