Materials and Methods

Outcrop description. Coesite eclogite was discovered in the Tumagabuna Islands (9°29'0"S, 150°27'40"E), located offshore western Fergusson Island, and part of the D'Entrecasteaux Islands. Previous workers had described the mafic eclogites at this locality as xenoliths in granodiorite, Additional field observations were made in January 2008, on new outcrop formed by the damaging effects of a tsunami triggered by a magnitude 8.1 earthquake on April 1, 2007, in the Solomon Islands.

The garnet-bearing quartzo-feldspathic host gneisses are strongly foliated and isoclinally folded. Mafic eclogites appear to have originated as mafic dikes that were metamorphosed in situ at eclogite-facies conditions and now occur as eclogite boudins. The eclogite boudins have retrograde amphibolite rinds that are in turn encapsulated by pegmatite rinds. Pegmatite veins intrude the quartzo-feldspathic host and are locally concordant with the gneissic foliation. Foliation in the mafic eclogites is roughly concordant with that in the host gneiss. Overall, foliations dip south or southwest and have lineations that plunge down-dip. Shear sense is top-to-the-north based on the dragging of foliation into a south-dipping shear zone in the quartzo-feldspathic gneiss.

Raman spectroscopy. Raman analyses were performed on polished thin section (89321c) at the Cornell Center for Materials Research. Spectra were obtained with the Dilor XY 800 Raman system using the 514.532 nm excitation line of an argon-ion laser. Mostly polarized scattered light was collected in the back scattering mode by using the Raman microscope. Excitation energy at the location of the sample was 10 mW, the laser spot size was 5μm. Wavenumber calibration was performed by registering a neon spectrum, thereby confirming the accuracy of the measured frequencies to within 0.2 cm^{-1}. Cryogenically cooled CCD detector covered the spectrum from 165 cm^{-1} to 865 cm^{-1} and the size of the slits corresponded to the spectral resolution of 1.75 cm^{-1}. Frequencies (cm^{-1}) of coesite and quartz Raman bands are given in Table DR1.

Electron probe. Mineral compositions were determined from 27 garnet–pyroxene–phengite triplets on thin section 89321C. Data used for garnet–pyroxene–phengite barometry(Ravna and Terry, 2004), and garnet-pyroxene Fe^{+2}–Mg cation exchange thermometry (Ravna, 2000) were obtained on omphacite encapsulating the coesite relic and adjacent garnet and phengite by wavelength-dispersive X-ray analysis using a fully automated JEOL 733 electron microprobe at Victoria University of Wellington's Analytical facility (http://www.victoria.ac.nz/geo/facilities/analytical/electron-microprobe.html). Operating conditions were 15 kV and 12 nA. Count times were 30 seconds for Si, Ti, Al, Fe, Mn, Mg, Ca, Na, and K. Background count times were 10 seconds. The oxidation state of iron in garnet is assumed to be Fe^{+2}, and Fe^{+3} within pyroxene was estimated by assuming Fe^{3+} = Na–(Al + Cr), with Cr assumed to be zero (i.e., Cr was not analyzed). Garnet standard composition is 39.0% SiO_2, 0.08% TiO_2, 22.1% Al_2O_3, 22.03% FeO (total), 0.39% MnO, 11.53% MgO, 4.20% CaO.

Mineral compositions used for rutile thermometry were obtained using a fully automated Cameca SX-100 electron microprobe at the Rensselaer Polytechnic Institute (http://ees2.geo.rpi.edu/probe). Operating conditions were 15 kV and 20 nA. Rutile is ubiquitous in this coesite-eclogite, occurring as inclusions in garnet, pyroxene, and phengite, and also within a matrix of predominantly garnet, pyroxene and phengite. Analyses used for Zr thermometry were performed on both rutile inclusions and rutile in the matrix. Analytical uncertainty for rutile thermometry is <5°C (2σ) (see Fig. 6 in (Watson et al., 2006). Mineral compositions are given in Tables DR2 and DR3.

Ion Microprobe. *In situ* ion microprobe analyses were conducted on the ims 1270 ion microprobe in the Department of Earth and Space Sciences at the University of California, Los Angeles. Samples were prepared by embedding portions of thin section 89321B within 1 inch-round epoxy mounts. Analytical conditions were 10 kV accelerating voltage, 1 nA primary beam current, and a spot size of ~10 μm. Mass resolution of ~5000 was sufficient to resolve masses of interest in this study. Secondary ion masses analyzed included ^{30}Si, $^{45.5}Zr^{+2}$, ^{57}Fe, and ^{49}Ti. Concentrations were derived relative to SL13 standard zircon with intensities on unknown and standard normalized to $^{45.5}Zr^{+2}$. Zircon grains selected for Ti analyses were the same as those analysed for their U-Pb, trace and REE compositions (Monteleone et al., 2007). Zircons were larger than the primary beam spot size (10 μm), and occur as inclusions in garnet. A combination of secondary ion imaging and the application of a field aperture were used to position the primary beam onto the zircon grain in order to avoid overlap with surrounding phases. Potential contamination from surrounding phases was monitored by measurement of ^{57}Fe and by assessment of $^{45.5}Zr/^{30}Si$. Samples with increased ^{57}Fe intensities and/or decreased $^{45.5}Zr/^{30}Si$ ratios were not used for zircon thermometry. [Ti] and [Zr] used for zircon and rutile thermometry are given in Table DR3.

Supplemental Data

Table DR1: Frequencies (cm^{-1}) of coesite and quartz Raman bands of bimineralic

	Band in Raman spectra (cm^{-1})				
Mineral	**coesite**	**coesite**	**coesite**	**coesite**	**quartz**
Band*	**176-177**	**269-271**	**355-356**	521	464
Analysis #					
2	176	270	354	520	465
4	176	270	354	520	465
6	177	270	354	520	465
12				520	465
14	176	270	356	520	465
16			356	519	463

*from Liu et al., 1997

Table DR2: Mineral Compositions

Mineral	Garnet*	Garnet*	Garnet*	Garnet*	Garnet*	Garnet*
Analysis	2005 ref_1	2005 ref_2	2005 ref_3	2005 ref_4	2008 ref_1	2008 ref_2
SiO_2	39.2 ± 0.19	40.5 ± 0.2	40.4 ± 0.19	39.2 ± 0.19	39.7 ± 0.32	40.2 ± 0.32
TiO_2	0.08 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	0.08 ± 0.00	0.06 ± 0.03	0.13 ± 0.04
Al_2O_3	22.81 ± 0.08	23.1 ± .08	22.98 ± 0.08	22.81 ± 0.08	23.4 ± 0.21	24.2 ± 0.21
FeO	22.72 ± 0.21	22.8 ± 0.21	22.49 ± 0.21	22.72 ± 0.21	23.0 ± 0.50	21.4 ± 0.49
MnO	0.51 ± 0.00	0.52 ± 0.01	0.41 ± 0.00	0.51 ± 0.00	0.40 ± 0.08	0.31 ± 0.08
MgO	11.38 ± 0.04	11.43 ± 0.04	11.36 ± 0.04	11.38 ± 0.04	11.5 ± 0.16	11.1 ± 0.16
CaO	4.61 ± 0.04	4.53 ± 0.04	4.57 ± 0.04	4.61 ± 0.04	4.9 ± 0.15	4.7 ± 0.14
Na_2O					0.01 ± 0.01	0.00 ± 0.00
K_2O					0.00 ± 0.001	0.02 ± 0.02
Total	101.29	102.94	102.21	101.29	102.97	102.08

* garnet reference standard analyses

Mineral	Garnet	Garnet	Garnet	Garnet	Garnet	Garnet	Garnet
Analysis	Core 1.1	Core 1.2	Core 1.3	89321_3	89321_4	3	4
SiO_2	41.24 ± 0.2	40.70 ± 0.20	39.57 ± 0.19	40.0 ± 0.32	38.7 ± 0.31	39.76 ± 0.19	40.65 ± 0.20
TiO_2	0.05 ± 0.00	0.04 ± 0.00	0.09 ± 0.00	0.02 ± 0.03	0.00 ± 0.0	0.02 ± 0.00	0.02 ± 0.00
Al_2O_3	22.26 ± 0.08	22.82 ± 0.08	22.75 ± 0.08	22.89 ± 0.21	22.8 ± 0.21	22.96 ± 0.08	22.56 ± 0.08
FeO	25.96 ± 0.24	26.00 ± 0.24	26.09 ± 0.25	26.07 ± 0.55	25.8 ± 0.54	27.02 ± 0.25	25.93 ± 0.24
MnO	0.36 ± 0.00	0.33 ± 0.00	0.50 ± 0.00	0.30 ± 0.08	0.38 ± 0.01	0.39 ± 0.00	0.42 ± 0.00
MgO	9.12 ± 0.04	9.31 ± 0.04	9.88 ± 0.04	9.84 ± 0.15	10.1 ± 0.15	10.11 ± 0.04	9.93 ± 0.04
CaO	3.48 ± 0.03	3.46 ± 0.03	3.35 ± 0.03	3.04 ± 0.11	2.9 ± 0.11	2.90 ± 0.02	2.93 ± 0.03
Na_2O	0.00 ± 0.00	0.01 ± 0.00		0.06 ± 0.3	0.01 ± 0.01		
K_2O	0.02 ± 0.00	0.01 0.00		0.02 ± 0.02	0.02 ± 0.02		
Total	102.50	102.74	102.23	102.2	100.9	103.21	102.49
Xalm	0.55	0.55	0.54	0.55	0.54	0.55	0.54
Xprp	0.35	0.35	0.36	0.37	0.38	0.37	0.37
Xgrs	0.09	0.09	0.09	0.08	0.08	0.08	0.08
Xsps	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Xjd	-	-	-	-	-	-	-

Mineral	Garnet	Garnet	Garnet	Garnet	Garnet	Garnet	Pyx	Pyx
Analysis #	5	6	9	10	14	15	inc. 1.1	inc 1.2
SiO_2	39.6 ± 0.19	40.0 ± 0.19	40.2 ± 0.19	39.1 ± 0.19	39.6 ± 0.19	39.9 ± 0.19	58.8 ± 0.29	58.0 ± 0.28
TiO_2	0.08 ± 0.00	0.12 ± 0.00	0.12 ± 0.00	0.05 ± 0.00	0.10 ± 0.00	0.00 ± 0.00	0.11 ± 0.00	0.12 ± 0.00
Al_2O_3	22.71 ± 0.08	22.81 ± 0.08	22.68 ± 0.08	22.76 ± 0.08	22.82 ± 0.08	22.87 ± 0.08	13.35 ± 0.05	13.52 ± 0.00
FeO	26.6 ± 0.25	26.3 ± 0.25	26.1 ± 0.24	26.1 ± 0.24	26.3 ± 0.25	26.22 ± 0.25	5.07 ± 0.05	4.82 ± 0.05
MnO	0.53 ± 0.01	0.40 ± 0.00	0.46 ± 0.00	0.54 ± 0.01	0.53 ± 0.01	0.45 ± 0.00	0.1 ± 0.00	0.13 ± 0.00
MgO	9.98 ± 0.04	10.07 ± 0.04	9.69 ± 0.04	10.11 ± 0.04	9.89 ± 0.04	10.13 ± 0.04	6.28 ± 0.02	6.40 ± 0.02
CaO	2.98 ± 0.03	3.27 ± 0.03	3.30 ± 0.03	2.63 ± 0.02	2.99 ± 0.03	2.58 ± 0.02	9.31 ± 0.08	9.32 ± 0.08
Na_2O	0.01 ± 0.00	0.05 ± 0.00	0.00 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	8.6 ± 0.12	8.51 ± 0.11
K_2O			0.05 ± 0.00				0.01 ± 0.00	0.01 ± 0.00
Total	102.49	103.09	102.77	101.30	102.42	102.36	101.59	100.85
Xalm	0.55	0.54	0.54	0.54	0.54	0.55	-	-
Xprp	0.37	0.37	0.36	0.38	0.37	0.38	-	-
Xgrs	0.08	0.09	0.09	0.07	0.08	0.07	-	-
Xsps	0.01	0.01	0.01	0.01	0.01	0.01	-	-
Xjd	-	-	-	-	-	-	0.63	0.62

Mineral	Pyx	Pyx	Pyx	Pyx	Pyx	Pyx
Analysis	inc 1.3	16	1	2	7	8
SiO_2	59.1 ± 0.29	56.2 ± 0.27	57.2 ± 0.28	56.8 ± 0.27	56.1 ± 0.27	55.5 ± 0.27
TiO_2	0.2 ± 0.00	0.22 ± 0.00	0.25 ± 0.00	0.25 ± 0.00	0.24 ± 0.00	0.26 ± 0.00
Al_2O_3	12.99 ± 0.05	13.33 ± 0.05	13.1 ± 0.05	12.94 ± 0.04	13.65 ± 0.05	13.28 ± 0.05
FeO	6.02 ± 0.06	5.58 ± 0.05	5.73 ± 0.05	5.74 ± 0.05	5.69 ± 0.05	5.65 ± 0.05
MnO	0.06 ± 0.00	0.00 ± 0.00	0.14 ± 0.00	0.07 ± 0.00	0.04 ± 0.00	0.09 ± 0.00
MgO	6.89 ± 0.03	6.81 ± 0.03	6.93 ± 0.03	6.62 ± 0.03	6.52 ± 0.03	6.24 ± 0.02
CaO	8.81 ± 0.08	8.92 ± 0.08	8.76 ± 0.08	8.91 ± 0.08	8.64 ± 0.07	8.72 ± 0.08
Na_2O	8.9 ± 0.12	8.75 ± 0.12	9.03 ± 0.12	8.95 ± 0.12	9.32 ± 0.13	8.98 ± 0.12
K_2O	0.03 ± 0.00	0.01 ± 0.00	0.03 ± 0.0	0.02 ± 0.00	0.02 ± 0.00	0.01 ± 0.00
Total	102.99	99.81	101.14	100.28	100.16	98.71

Mineral					
	Phg.	Phg.	Phg.	Phg.	Phg.

Analysis	1	2	3	5	6
SiO_2	50.0 ± 0.24	50.4 ± 0.24	51.6 ± 0.25	51.2 ± 0.25	50.2 ± 0.24
TiO_2	0.79 ± 0.00	0.89 ± 0.01	0.79 ± 0.00	0.58 ± 0.00	0.56 ± 0.00
Al_2O_3	26.08 ± 0.09	25.64 ± 0.09	25.38 ± 0.09	26.28 ± 0.09	26.47 ± 0.09
FeO	1.94 ± 0.02	2.19 ± 0.02	2.00 ± 0.00	1.56 ± 0.01	2.1 ± 0.02
MnO	0.00 ± 0.00	0.03 ± 0.00	0.05 ± 0.00	0.19 ± 0.00	0.03 ± 0.00
MgO	4.37 ± 0.02	4.26 ± 0.02	4.34 ± 0.02	4.52 ± 0.02	4.51 ± 0.02
CaO	0.03 ± 0.00	0.01 ± 0.00	0.06 ± 0.00	0.02 ± 0.00	0.05 + 0.00
Na_2O	0.70 ± 0.01	0.73 ± 0.01	0.64 ± 0.01	1.02 ± 0.01	1.14 ± 0.02
K_2O	9.91 ± 0.15	9.52 ± 0.15	9.51 ± 0.15	9.23 ± 0.14	8.84 ± 0.14
Total	93.92	93.81	94.65	95.11	94.19

Note: Fe^{3+} within pyroxene was estimated by assuming Fe^{3+} = Na–(Al + Cr), with Cr assumed to be zero (i.e., Cr was not analyzed).

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Table DR3: Rutile and Zircon Thermometry

Phase	Analysis	Ti (ppm)	Zr (ppm)	T(°C)	T (°C)
Rt	1 (i)		240.8	709	
Rt	2 (i)		239.3	708	
Rt	2_2 (i)		204.8	695	
Rt	3_1 (m)		303.1	729	
Rt	3_3 (m)		271.2	719	
Rt	3_2 (m)		285.0	723	
Rt	4_1 (m)		250.1	712	
Rt	4_2 (m)		281.2	722	
Rt	4_3 (m)		290.4	725	
Rt	5_1 (*_		234.4	706	
Rt	7_1 (i)		230.0	705	
Rt	8_1 (i)		216.3	700	
Rt	9_1 (i)		235.5	707	
Rt	10_1 (m)		219.1	701	
Rt	10_2 (m)		227.6	704	
Rt	10_3 (m)		231.0	705	
Rt	11_1 (m)		277.3	721	
Rt	11_2 (m)		239.7	708	
Rt	12_1 (m)		275.2	720	
Rt	12_2 (m)		353.0	743	
Rt	12_3 (m)		298.4	727	
Rt	13_1 (i)		242.4	709	
Rt	14_1 (*)		244.2	710	
Rt	15_1 (*)		226.5	704	
Rt	16_1 (*)		245.3	710	
Rt	17_1 (m)		320.8	734	
Zr	3.2 (i)	3.9			665
Zr	3.3(i)	3.6			660
Zr	3.4 (i)	3.7			660
Zr	4.1 (i)	3.2			650
Zr	4.2 (i)	4.5			675

Note: (i) indicates grain is inclusion in garnet. (m) indicates grain is not an inclusion in garnet (matrix). (*) indicates location of grain not known due to loss of photo file data. Rutile grain size for inclusion grains is approximately 30 – 80 microns. Matrix rutile is approximately 200 – 400 microns. Zircon inclusions are ~20 – 30 microns.

Monteleone, B.D., Baldwin, S.L., Webb, L.E., Fitzgerald, P.G., Grove, M., and Schmitt, A., 2007, Late Miocene to Pliocene eclogite facies metamorphism, D'Entrecasteaux Islands,SE Papua New Guinea: Journal of Metamorphic Geology, v. 25, p. 245-265.

Ravna, E.K., 2000, The garnet-clinopyroxene Fe+2-Mg geothermometer: an updated calibration: Journal of Metamorphic Geology, v. 18, p. 211-219.

Ravna, E.K., and Terry, M.P., 2004, Geothermometry of UHP and HP eclogites and schists- and evaluation of equilibria among garnet- clinopyroxene-kyanite-phengite-coesite/quartz: Journal of Metamorphic Geology, v. 22, p. 579-592.

Watson, E.B., Wark, D.A., and Thomas, J.B., 2006, Crystallization thermometers for zircon and rutile: Contributions to Mineralogy and Petrology, v. 151, p. 413-433.