Geological Map of the Marginal Seas of Eastern Papua New Guinea and the Solomon Islands

2024

Scale 1:1 000 000

0 50 100 150 200 250 300 km

0 50 100 150 mi.

Plate Carrée - D WGS 1984

The background is the 15 arc-second resolution GEBCO 2019 global terrain model with multidirectional hillshading.

Brandl, P.A.[1], Emberley, J.[1], Kritschell, A.[1], Hannington, M.D.[1,2], Stewart, M.S.[1,3], Petersen, S.[1], the Marine Mineral Resources Group at GEOMAR and Metal Oceans at the University of Ottawa

[1] GEOMAR Helmholtz Centre for Ocean Research Kiel, 24148 Kiel, Germany
[2] Department of Earth and Environmental Sciences, University of Ottawa, Ontario, K1N 6N5, Canada
[3] Department of Earth and Environmental Sciences, Mount Royal University, Alberta, T3E 6K6, Canada

Map production by J. Emberley, A. Kritschell, P.A. Brandl, and M.S. Stewart (Version 1.0)

Suggested Citation: Geological Map of the Marginal Seas of Eastern Papua New Guinea and the Solomon Islands at 1:1,000,000 as a Digital Supplement to Brandl, P.A., Hannington, M.D., Kritschell, A., Petersen, S., Baxter, A.T., Stewart, M.S., Galley, C., Emberley, J., and Sander, S.G. (2024). A New Geological Map of the Marginal Basins of Eastern Papua New Guinea: Implications for Crustal Accretion and Mineral Endowment at Arc-Continent Collisions. Lithosphere 2024(4), lithosphere_2024_145. doi: 10.2113/2024/lithosphere_2024_145.

ABSTRACT

The marginal seas of Eastern Papua New Guinea and the Solomon Islands include several active and remnant arc and backarc systems that formed in response to complex plate tectonic adjustments following subduction initiation in the Eocene. Although there has been extensive exploration for offshore petroleum resources, and more than 54 research cruises have investigated or transited the region since 1993, a comprehensive regional geological map, including the deep marine areas, has not been available at a scale that permits quantitative analysis of the basin history. This is the first map that depicts interpreted assemblage- and formation-level lithostratigraphic units in one sheet correlated across the marginal seas and adjacent land masses. The mapped assemblages and large-scale formations are derived from a compilation of land-based geological maps, marine geophysical data (hydroacoustics, magnetics, and gravity) integrated with the results of sampling, ocean drilling, seismic surveys, and seabed observations. More than 400,000 km² of the map area covered by ship-based multibeam and other geophysical data were inspected to define the offshore geological units. In areas with limited data, the units were extrapolated from well-documented formations in adjacent regions with more complete information, including on land. This approach follows closely the techniques used for remote predictive mapping in other regions of the Earth where geological information is sparse. Unit boundaries were constrained by ship-based multibeam data reprocessed at 30-m to 150-m resolution (Figure S1 and Table S1) and integrated with the Global Multi-Resolution Topography (GMRT v. 3.6). Lithotectonic assemblages were assigned on the basis of plate structure, crustal type and thickness, age, composition, and sedimentary cover and further refined by bathymetric and geophysical data from the literature and cruise reports listed in the data sources. These interpretations are summarized in a Lithotectonic Assemblage Map (Figure S2). Relative ages are from published data, crosscutting structural relationships, shared fabrics (e.g., spreading fabric), and sediment cover. These are summarized in a Lithostratigraphic Correlation Diagram (Figure S3). Formation-level maps were compiled at 1:200,000 to 1:500,000 for interpretation of specific geological features and correlation of units. The final compilation is generalized and presented here at 1:1 M.

LABEL	UNIT NAME AND DESCRIPTION
	CARBONATE PLATFORM
Cp	**Carbonate platform** Carbonate rocks (reef complexes) built on active and extinct volcanoes and exposed basement
	CONTINENTAL CRUST AND OROGENIC BELTS
Orfb	**Folded basement rocks** Undivided folded and metamorphosed basement rocks
Orme	**High-grade metamorphic rocks** High-grade metamorphic rocks exhumed by orogenic processes
Oro	**Ophiolite** Obducted fragment of oceanic crust
Orfs	**Pre- or syn-collisional sedimentary succession** Undivided folded sediments or low-grade metamorphic sedimentary rocks
Ors	**Post-collisional sedimentary succession** Sediments of intra-orogenic and/or foreland basins (e.g., molasse)
Orv	**Syn-collisional volcano** Volcanic edifice built on older metamorphosed basement rocks
Ori	**Intrusive complex** Syn- to post-collisional plutonic rocks (may include exposed older intrusions)
	OTHER CONTINENTAL FORMATIONS
Ccb	**Continental crustal block** Coherent block of undivided continental crust
Cex	**Extended continental crust** Isolated block of extended continental crust
	UNDIVIDED SHELF FORMATIONS
Ush	**Undivided sedimentary succession** Sediments (>500 m) belonging to the continental shelf
	RIFTED MARGINS
Mfv	**Rift volcano** Volcanic complex related to rifting of arc crust
Mfs	**Rift sedimentary succession** Sediments (>500 m) within a rift basin
Mfc	**Undivided rifted margin crust** Rifted margin crust distinguishable from adjacent formations but not further divided
Mfb	**Undivided crustal block** Coherent, isolated block of rifted crust distinguishable from adjacent formations but not further divided
	ACTIVE ARC
Upper uAv1	**Arc-front volcano** Volcanic edifice at the arc front (typically active)
uAv2	**Inner-arc volcano** Volcanic edifice behind the arc front (may be active or inactive)
uAs	**Intra-arc sedimentary succession** Sediments (>500 m) belonging to an intra-arc succession or eroded from an adjacent arc
uAc	**Upper arc crust** Undivided crust belonging to an active arc, including volcaniclastic material, flows, and dikes
Lower lAc	**Lower arc crust** Earliest exposed extrusive and intrusive rocks of an active arc (may include arc basement)
UAc	**Undivided arc crust** Crust associated with an active arc that cannot be correlated with upper or lower units
	RELICT ARC
Upper uRas	**Upper relict-arc sedimentary succession** Sediments (>500 m) belonging to a relict intra-arc succession overlying upper relict-arc crust
uRac	**Upper relict-arc crust** Crust belonging to the latest episode of relict-arc construction (comprises volcaniclastic rocks and flows associated with the latest arc magmatism)
Middle mRas	**Middle relict-arc sediment** Sediments (>500 m) belonging to a relict intra-arc succession overlying middle relict-arc crust
mRac	**Middle relict-arc crust** Crust belonging to an intermediate stage of arc construction (comprises volcaniclastic rocks and flows associated with arc magmatism)
Lower lRac	**Lower relict-arc crust** Earliest exposed extrusive and intrusive rocks in a relict arc, commonly obscured by volcaniclastic cover
URac	**Undivided relict-arc crust** Crust associated with a relict arc that cannot be correlated with upper, middle, or lower units

LABEL	UNIT NAME AND DESCRIPTION
	ARC-BACKARC TRANSITION
uTr	**Ridge at the arc-backarc transition** Volcanic or tectonic ridge in a zone of arc rifting (may be a product of rift volcanism or block faulting)
ITc	**Lower transitional arc-backarc crust** Crust immediately surrounding volcanic or tectonic ridges in a zone of arc rifting
	BACKARC VOLCANOES
Bav1	**Conical volcano** Cone-shaped edifice composed of lava flows and volcaniclastic material erupted onto backarc crust (>1 km diameter; width/height ≥5)
Bav2	**Shield volcano** Mound-shaped edifice composed of lava flows extruded onto backarc crust (>1 km diameter; width/height >5)
Bav3	**Dome volcano** Steep-sided edifice composed of lava flows extruded onto backarc crust or an axial volcanic ridge (>1 km diameter; length/width ~1)
Bav4	**Fissure volcano** Elongate volcanic edifice composed mostly of lava flows extruded onto backarc crust; commonly with a central dike (>1 km length; length:width >3)
BavF	**Volcanic field** A broad area of lava flows and volcaniclastic material surrounding a number of closely-spaced volcanoes
	BACKARC RIFTS AND SPREADING CENTERS
Upper uBar	**Axial backarc volcanic ridge** Volcanic ridge marking the active spreading center; commonly with discrete volcanic edifices (cones and domes), dike complexes, or calderas
uBac	**Axial backarc crust** Backarc crust in the inner rift valley of an active spreading center
Middle mBar	**Proximal volcanic or tectonic ridge** Elongate volcanic edifice or coalesced ridges on the rift flank or backarc crust adjacent to an active spreading center
mBaf	**Rift flank** Backarc crust on the flank of an active spreading center, including volcanic ridges, volcaniclastic material, and flows (may include products of off-axis volcanism)
mBac	**Proximal backarc crust** Undivided backarc crust adjacent to the rift flank or to the active spreading center where a rift flank is absent
Lower lBar	**Distal volcanic or tectonic ridge** Elongate volcanic edifice or ridges on distal backarc crust, commonly obscured by volcaniclastic cover
lBac	**Distal backarc crust** Undivided backarc crust beyond the outer rift flank of an active spreading center (may include products of intraplate volcanism)
	RELICT BACKARC
Upper uRr	**Relict backarc ridge** Elongate volcanic edifice or coalesced ridges outside an identifiable area of active spreading (may be a product of intraplate volcanism or rifting of backarc crust)
uRbc1	**Upper relict backarc crust** Undivided backarc crust outside an identifiable area of active spreading
uRbc2	**Tectonized relict backarc crust** Intensely deformed backarc crust outside an identifiable area of active spreading
Lower lRbc	**Lower relict backarc crust** Earliest extrusive and intrusive rocks outside an identifiable area of active spreading
	ACTIVE FOREARC
Fas	**Forearc sedimentary succession** Sediments (>500 m) in the forearc basin of an active subduction zone
Fac1	**Forearc crust** Undivided crust of the forearc; including sediment of the forearc slope
Fac2	**Forearc crustal block** Uplifted block of active forearc crust (commonly tectonized)
	RELICT FOREARC
Rfs1	**Relict-forearc sedimentary succession** Sediments (>500 m) in a basin of a relict forearc
Rfc2	**Tectonized relict-forearc sedimentary succession** Sediments (>500 m) in a basin of a relict forearc strongly disturbed by tectonic processes
Rfc1	**Relict forearc crust** Undivided crust of a relict forearc; including sediment of the forearc slope
Rfc-2	**Relict forearc crustal block** Uplifted block of relict forearc crust (commonly tectonized)

LABEL	UNIT NAME AND DESCRIPTION
	TRENCH
Trac	**Accretionary complex** Sediments (>500 m) of the trench and accretionary wedge, obducted crust, and/or volcanic features of the subducting plate
Trar	**Accretionary complex ridge** Tectonized crust belonging to the accretionary complex
Trbc	**Backarc crust in the trench** Deformed backarc crust on the trench outer slope
Troc	**Oceanic crust in the trench** Deformed oceanic crust on the trench outer slope
Trop	**Oceanic plateau crust in the trench** Deformed oceanic plateau crust on the trench outer slope
Truc	**Undivided crust in the trench** Deformed undivided crust on the trench outer slope
	OCEANIC CRUST AND SPREADING CENTERS
Onvz	**Axial volcanic zone** Volcanic zone marking the active spreading center; commonly with discrete volcanic edifices (volcanic cones and domes), dike complexes, or calderas
Onvi	**Inner rift-valley floor** Oceanic crust in the axial or median rift valley bounded by active, inward dipping faults
Onar	**Proximal oceanic volcanic ridge** Elongate volcanic edifice or coalesced ridges adjacent to an active spreading center (younger than magnetic chron 2A)
Onac	**Proximal oceanic crust** Oceanic crust adjacent to an active spreading center (younger than magnetic chron 2A)
Ooar	**Distal oceanic volcanic ridge** Elongate volcanic edifice or coalesced ridges within an identifiable region of seafloor spreading (older than magnetic chron 2A)
Ooac	**Distal oceanic crust** Oceanic crust within an identifiable region of seafloor spreading (older than magnetic chron 2A)
Obmc	**Ocean basin margin crust** Mixed crust at the margin of an ocean basin, adjacent to and/or including rifted continental, arc-related, or oceanic-plateau crust
Obss	**Ocean basin sedimentary succession** Sediments (>500 m) on oceanic crust
Oc	**Undivided oceanic crust** Mz – Mesozoic; Pg – Paleogene
	OCEANIC VOLCANOES
Ov1	**Conical volcano** Cone-shaped edifice composed mostly of lava flows extruded onto oceanic crust (>1 km diameter; width/height ≥5)
Ov2	**Shield volcano** Mound-shaped edifice composed of lava extruded onto oceanic crust (>1 km diameter; width:height >5)
Ov3	**Dome volcano** Steep-sided edifice composed of lava extruded onto oceanic crust; commonly flat-topped (>1 km diameter; length:width ~1)
Ovf	**Volcanic field** Flows encompassing one or more volcanoes
	OTHER OCEANIC FORMATIONS
Upper uOi	**Intraplate seamount** Volcanic or tectonic edifice of undetermined origin on oceanic crust
Our	**Undivided oceanic ridge** Elongate volcanic or tectonic edifice of undetermined origin on oceanic crust
uOp	**Oceanic plateau edifice** Flat-topped volcanic edifice built on oceanic plateau crust
Lower lOp	**Oceanic plateau** Oceanic plateau crust and rise
	DEFORMATION ZONES
Dxf	**Leaky transform** Deformed crust and lava flows associated with a leaky transform fault
Dz2	**Deformation zone** High-strain zone occurring along crustal-scale faults lacking obvious volcanism
	OTHER UNDIVIDED CRUST
Ur	**Unassigned ridge** Elongate volcanic or tectonic feature of undetermined origin
Uc	**Unassigned crust** Crust that is distinguishable from adjacent formations but cannot be assigned to a particular origin
Ux	**Unassigned extended crust** Extended crust that is distinguishable from adjacent formations but cannot be assigned to a particular origin
Uss	**Unassigned sedimentary succession** Sediments in a basin of uncertain origin

SYMBOLS

- Caldera rim
- Lineament
- Active subduction
- Major fault zone
- Thrust fault
- Inactive subduction

ABBREVIATIONS

ETZ	Extensional Transform Zone
MSC	Manus Spreading Center
SER	Southern Rifts
SR	Southern Rift
WMSC	Willaumez Spreading Center
WSC	Woodlark Spreading Center

MAP SOURCES

Baldwin, S.L., Fitzgerald, P.G. and Webb, L.E. (2012), Annual Review of Earth and Planetary Sciences, 40, 495-520.
Bulois, C., Pubellier, M., Chamot-Rooke, N., and Deleclusse, M. (2018), Tectonics, 37, 3–29.
Cowley, S., Manna, P., Coffin, M.F. and Shipley, T.H. (2004), Tectonophysics, 389, 267– 307.
Davies, H.L. (1969), Bureau of Mineral Resources, Geology and Geophysics, 1959133.
Davies, H.L. (2012), Episodes 35, 87–102.
Fitton, J. G., Mahoney, J. J., Wallace, P. J. and Saunders, A. D. (2004), Geological Society, London, Special Publications, 229, 1.
Guina, C., Muller, D., Royer, J., and Symonds, P (1999), Journal of Geophysical Research, Vol. 104, No. B6, 12,927-12,939.
Goodliffe, A.M., Taylor, B., and Martinez, F (1999), Proceedings of the Ocean Drilling Program, Initial Reports Volume, 180, Taylor, B., Huchon, P, Klaus, A., et al.
Holm, R.J. and Richards S.W. (2013), Journal of Earth Sciences, 60, 605–619.
Holm, R. J., Rosenbaum, G. and Richards, S.W. (2016), Earth-Science Reviews, 156, 66-81.
Keith, A., Crook, W. and Taylor, B. (1994) Marine Geophysical Researches, 16, 65-89.
Martinez, F. and Taylor, B. (1996), Marine Geophysical Researches, 18, 203- 224.
Petterson, M.G., Babbs, T., Neal, C.R., Mahoney, J.J., Saunders, A.D., Duncan, R.A., Tolia, D., Magu, R., Qopoto, C., Mahoa, H. and Natogga, D. (1999), Tectonophysics, 301, 35–60.
Seton, M., Mortimer, N., Williams, S., Quilty, P., Gans, P., Meffre, S., Micklethwaite, S., Zahirovic, S., Moore, J., and Matthews, K.J. (2016), Gondwana Research 39, 77–95. doi:10.1016/j.gr.2016.06.011
Taylor, B. (2006), Earth and Planetary Science Letters, 241, 372–380.
Trail, D.S. (1961), Bureau of Mineral Resources, Geology and Geophysics, 1961/111.
Webb, L. E., Baldwin, S.L. and P. G. Fitzgerald (2014), Geochemistry Geophysics Geosystems, 15, 4024–4046.
Weatherall, P., Marks, K.M., Jakobsson, M., Schmitt, T., Tani, S., Arndt, J.E., Rovere, M., Chayes, D., Ferrini, V., and Wigley, R. (2015), Earth and Space Science, 2, 331-345.
Zirakparvar, N.A., Baldwin, S.L. and Vervoort, J.D. (2013), Gondwana Research, Volume 23, Issue 3, 931-943.

SELECTED REFERENCES

ACKNOWLEDGEMENTS

This map is a product of the Marine Mineral Resources Group at GEOMAR Helmholtz Centre for Ocean Research Kiel and the Metal Earth Project funded by the Canada First Research Excellence Fund (CFREF). The Helmholtz Association, the Natural Sciences and Engineering Research Council of Canada (NSERC), and CFREF are acknowledged for the support of this work through research grants and project funding to the authors. Particular thanks are owed to the members of the Research Division Dynamics of the Ocean Floor at GEOMAR and members of the Metal Earth project who critically reviewed the map and accompanying figures. This is Metal Earth contribution MERC-ME-2024-30.

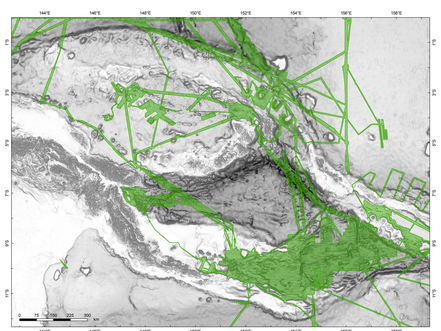

Figure S1. Overview of areas where multibeam and other geophysical data are available and were used in the creation of the map. Selected multibeam datasets that were reprocessed with 30-m to 150-m grid spacing for the purpose of geological interpretation are listed in Table S1. Background is the slope shaded GEBCO 2019 grid.

Table S1. Multibeam data used for reprocessing and geological interpretation. Cruise numbers, year, and expedition are indicated. Data sets were obtained from publicly available national repositories, cruise reports, and chief scientists of the respective expeditions. Data sets were reprocessed as indicated. All other bathymetry used in the preparation of the map are already part of the GMRT global compilation.

EW0201, 2002, 50 m	MR10-07, 2010, 150 m
FS2009, 2009, 25 m	MR12-03, 2012, 150 m
KA01-11/2, 2001, 150 m	MR12-15/1, 2012, 150 m
KM0625, 2006, 50 m	SO94, 1994, 30 m
MANAUTE, 2000, 50 m	SO133, 1998, 30 m
MR99-K06, 1999, 150 m	SO166, 2002, 30 m
MR02-K02, 2002, 150 m	SO203, 2009, 35-40 m
MR04-08/2, 2004, 150 m	SO216, 2011, 30 m
MR06-01, 2006, 150 m	SO252, 2016, 50 m
MR09-01/3, 2009, 150 m	YK06-13/1, 2006, 150 m
MR09-04, 2009, 150 m	

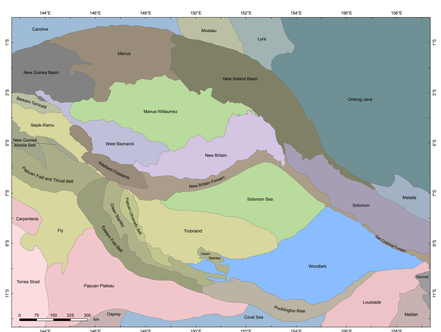

Figure S2. Lithotectonic Assemblage Map of the marginal seas of Eastern Papua New Guinea and the Solomon Islands. The map shows the distribution of 35 different assemblages defined by inspection of marine geophysical data (hydroacoustics, magnetics, and gravity) integrated with the results of structural mapping, sampling, ocean drilling, seismic surveys, and seabed observations. Colors assigned to the assemblages are for illustration purposes only, approximating those in the Lithostratigraphic Correlation Diagram (Figure S3). See accompanying text for assemblage descriptions.

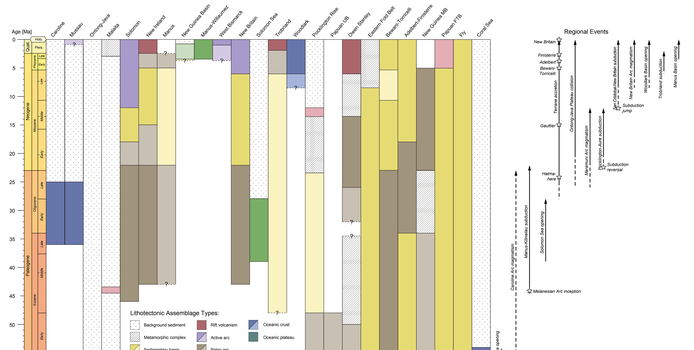

Figure S3. Regional Lithostratigraphic Correlation Diagram of the marginal seas of Eastern Papua New Guinea and the Solomon Islands showing the inferred age correlations of tectonic events and lithostratigraphic units, emphasizing volcanic and sedimentary episodes. The plot summarizes the general stratigraphy within each of the assemblages depicted in S2, with reference to published ages of volcanic units, depositional ages of sedimentary units, and relative ages of assemblages. See accompanying text for descriptions of regional events. Papuan UB: Papuan Ultramafic Belt, New Guinea MB: New Guinea Mobile Belt, Papuan FTB: Papuan Fold and Thrust Belt.