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Global tectonic significance of the Solomon Islands and Ontong Java Plateau convergent zone

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Abstract

Oceanic plateaus, areas of anomalously thick oceanic crust, cover about 3% of the Earth's seafloor and are thought to mark the surface location of mantle plume "heads". Hotspot tracks represent continuing magmatism associated with the remaining plume conduit or "tail". It is presently controversial whether voluminous and mafic oceanic plateau lithosphere is eventually accreted at subduction zones, and, therefore: (1) influences the eventual composition of continental crust and; (2) is responsible for significantly higher rates of continental growth than growth only by accretion of island arcs. The Ontong Java Plateau (OJP) of the southwestern Pacific Ocean is the largest and thickest oceanic plateau on Earth and the largest plateau currently converging on an island arc (Solomon Islands). For this reason, this convergent zone is a key area for understanding the fate of large and thick plateaus on reaching subduction zones.

This volume consists of a series of four papers that summarize the results of joint US–Japan marine geophysical studies in 1995 and 1998 of the Solomon Islands–Ontong Java Plateau convergent zone. Marine geophysical data include single and multi-channel seismic reflection, ocean-bottom seismometer (OBS) refraction, gravity, magnetic, sidescan sonar, and earthquake studies. Objectives of this introductory paper include: (1) review of the significance of oceanic plateaus as potential contributors to continental crust; (2) review of the current theories on the fate of oceanic plateaus at subduction zones; (3) establish the present-day and Neogene tectonic setting of the Solomon Islands–Ontong Java Plateau convergent zone; (4) discuss the controversial sequence and timing of tectonic events surrounding Ontong Java Plateau–Solomon arc convergence; (5) present a series of tectonic reconstructions for the period 20 Ma (early Miocene) to the present-day in support of our proposed timing of major tectonic events affecting the Ontong Java Plateau–Solomon Islands convergent zone; and (6) compare the structural and deformational pattern observed in the Solomon Islands to ancient oceanic plateaus preserved in Precambrian and Phanerozoic orogenic belts. Our main conclusion of this study is that 80% of the crustal thickness of the Ontong Java Plateau is subducted beneath the Solomon island arc; only the uppermost basaltic and sedimentary part of the crust (~ 7 km) is preserved on the overriding plate by subduction–accretion processes. This observation is consistent with the observed imbricate structural style of plateaus and seamount chains preserved in both Precambrian and Phanerozoic orogenic belts.

Keywords: Global tectonic; Solomon Islands; Ontong Java Plateau

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1. Introduction

1.1. Significance of the Ontong Java Plateau–Solomon Islands convergent zone

The Ontong Java Plateau of the southwestern Pacific Ocean is the largest and thickest oceanic plateau on Earth and largest oceanic plateau currently interacting with an active subduction zone (Fig. 1). For this reason, this region is a key area to collect observational data that can place geologic constraints on: (1) the fate of oceanic plateaus on reaching subduction zones; (2) the modification of plateaus by magmatic and tectonic subduction processes; and (3) the potential of plateaus to contribute significantly to the growth of continents.

Several different tectonic scenarios have been proposed for the fate of oceanic plateaus subduction zones (e.g., Saunders et al., 1996; Petterson et al., 1999; Kerr et al., 2000).

(1) Oceanic plateaus are entirely subducted and leave no vestige on the overriding plate and, therefore, have no effect on continental growth. Complete subduction of oceanic plateaus contrasts to the proposal by Schubert and Sandwell (1989) that oceanic plateaus contribute significantly to the growth of continents. Schubert and Sandwell (1989) calculate that the accretion of oceanic plateaus formed over the past 200 Ma would increase the total volume of continental crust by about 5%.

(2) The uppermost plateau and its overlying sedimentary cover is detached, obducted, and preserved on top of the island arc as thrust-bounded "tectonic flakes" kilometers in thickness (Oxburgh, 1972; Hoffman and Ranalli, 1988; Petterson et al., 1999) or multiple "oceanic peels" tens to hundreds of meters in thickness (Kimura and Ludden, 1995). A compilation of crustal structures of previously studied oceanic plateaus, typical oceanic crust, and typical continental crust is shown in Fig. 2. Although the crustal thickness of known plateaus varies from 8 to 35 km, a distinguishing characteristic of all oceanic plateaus is their dense "lower crustal body" with a velocity of 7.0–7.6 km/s. Most workers agree that the lower crustal body represents a dense crustal root of garnet-granulite or eclogite subject to either tectonic or gravity-driven delamination from its less-dense, mainly basaltic upper crust (Farnetani et al., 1996; Kerr et al., 1997).

One possibility to make significant oceanic plateau contributions to the growth of continents is to structurally "delaminate" and subduct the more mafic lower crustal body and accrete the more felsic upper crust to island arcs. Predictions of possible levels of detachment of a subducting oceanic plateau vary among different researchers and are compared to the observed crustal thickness of oceanic plateaus in Fig. 2.

(3) The entire crust and upper mantle of the oceanic plateau may be accreted to the overriding plate of subduction zones and produce continental growth rates much faster than those produced by the accretion of island arcs alone. This scenario would support the proposal by Nur and Ben-Avraham (1982), Schubert and Sandwell (1989), Abbott (1996), and Albarede (1996) that plateaus are major contributors to to the growth of continents. Plateau accretion to continents could occur by two structural modes: thrust-related obduction of plateau material onto crust as proposed in western Colombia (Kerr et al., 1997) and in the Solomon Islands (Petterson et al., 1999), or by underplating of the oceanic plateau beneath the forearc area as proposed for the ancient Siletz oceanic plateau terrane beneath the Cascadia forearc of Oregon (Trehu et al., 1994).

1.2. How oceanic plateaus may contribute to continental growth

1.2.1. Compositional effects

Distinguishing the fate of plateaus at subduction zones is an important step in understanding the role (if any) of oceanic plateaus in continental growth. There are two basic ideas for the growth of continental crust. The longstanding "andesite model" (McLennan and Taylor, 1982) proposes that arcs produce crust of bulk andesitic composition in accord with the observed andesitic bulk composition of continental crust (Christensen and Mooney, 1995). However, petrologic (Kay and Kay, 1988) and geophysical observations (Suyehiro et al., 1996; Holbrook et al., 1999) of intra-oceanic island arcs indicates that their bulk composition is closer to basalt than to andesite, thus posing a problem for continued acceptance of the "andesite model" of continental growth.

A more recent "subduction modification" model for the formation of new continental crust postulates

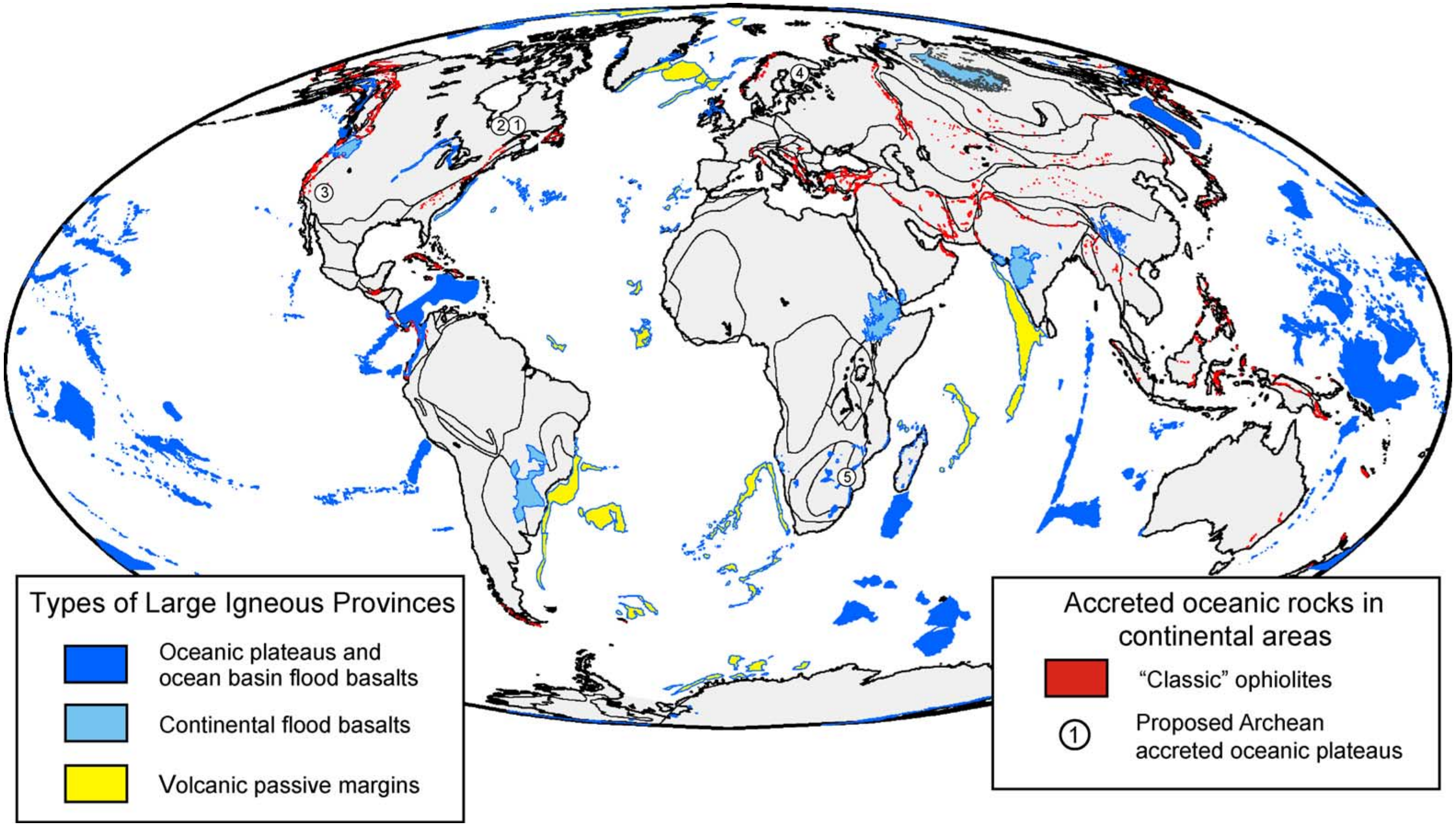
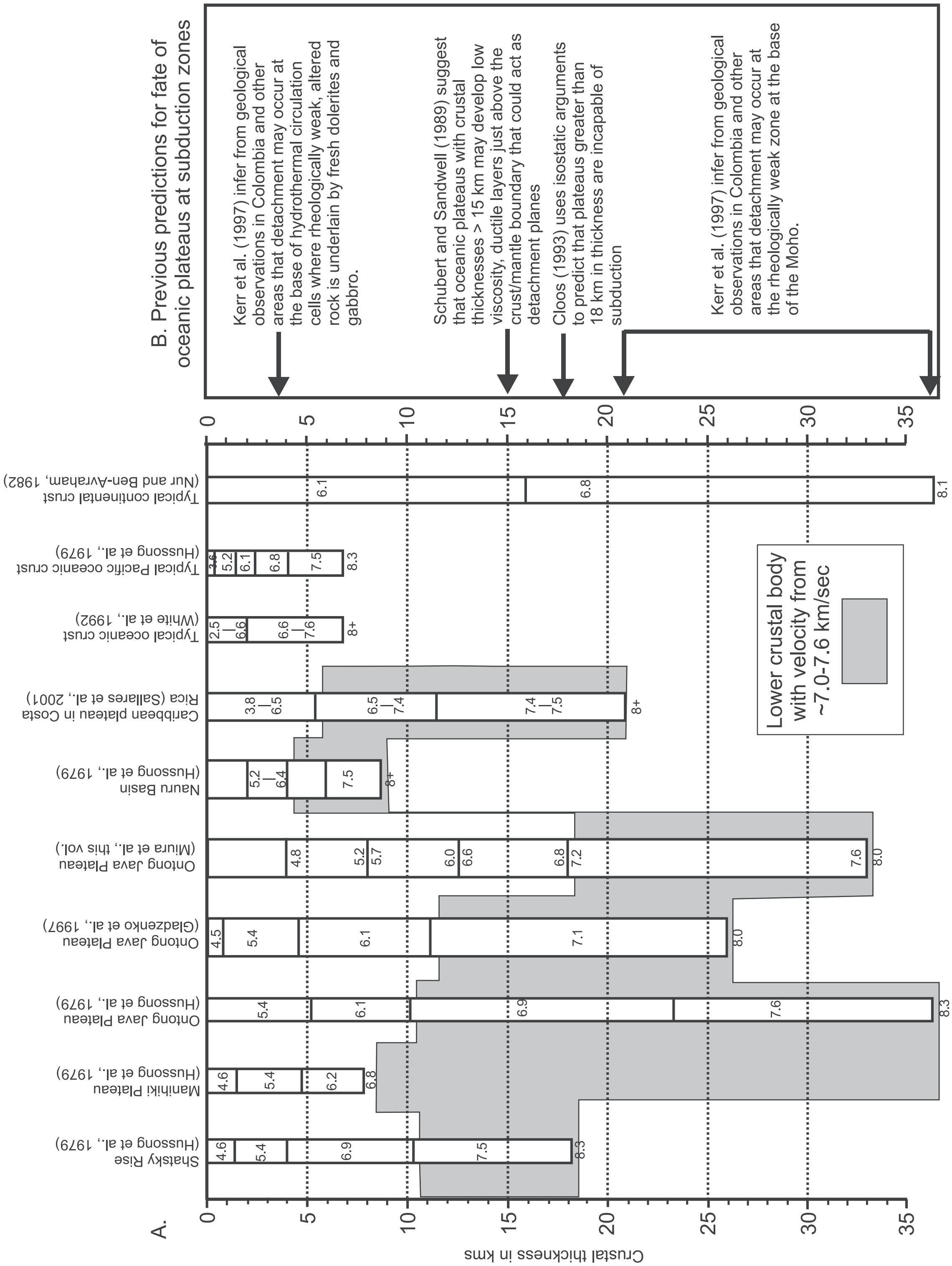


Fig. 1. Global distribution of Phanerozoic large igneous provinces, or "LIP's", subdivided into their three main categories (map modified from Coffin and Eldholm, 2001). Also shown are accreted oceanic rocks in ancient orogenic belts, or "classic ophiolites", as compiled by Exxon Tectonic Map of the World (1985) and Coffin and Eldholm (2001). Numbered areas 1–5 within Precambrian cratons are selected localities of proposed Archean oceanic plateaus taken from the literature and summarized on Table 1. The Solomon Islands–Ontong Java convergence zone in the southwest Pacific (boxed area) is the only known example of active accretion of a plateau to an island arc and therefore provides insights into the possible accretion mechanisms of widespread "classic ophiolites" as well as proposed examples of accreted oceanic plateaus of Archean age.


A.
B. Previous predictions for fate of oceanic plateaus at subduction zones
Kerr et al. (1997) infer from geological observations in Colombia and other areas that detachment may occur at the base of hydrothermal circulation cells where rheologically weak, altered rock is underlain by fresh dolerites and gabbro.
Schubert and Sandwell (1989) suggest that oceanic plateaus with crustal thicknesses > 15 km may develop low viscosity, ductile layers just above the crust/mantle boundary that could act as detachment planes
Cloos (1993) uses isostatic arguments to predict that plateaus greater than 18 km in thickness are incapable of subduction
Kerr et al. (1997) infer from geological observations in Colombia and other areas that detachment may occur at the rheologically weak zone at the base of the Moho.
Shatsky Rise (Hussong et al., 1979)
Manihiki Plateau (Hussong et al., 1979)
Ontong Java Plateau (Hussong et al., 1979)
Ontong Java Plateau (Gladzenko et al., 1997)
Ontong Java Plateau (Miura et al., this vol.)
Nauru Basin (Hussong et al., 1979)
Caribbean plateau in Costa Rica (Sallares et al., 2001)
Typical oceanic crust (White et al., 1992)
Typical Pacific oceanic crust (Hussong et al., 1979)
Typical continental crust (Nur and Ben-Avraham, 1982)
Lower crustal body with velocity from ~7.0-7.6 km/sec
Crustal thickness in kms
0 5 10 15 20 25 30 35

that the crust is first extracted from the mantle within ocean basins, either at island arcs or at LIPs forming above mantle plumes (Abbott and Mooney, 1995). This new continental crust is then tectonically accreted to the edges of pre-existing continents by emplacement along active subduction zones. Thus, the majority of newly accreted continental crustal blocks are rapidly exposed to subduction zone magmatism, which chemically modifies the newly emplaced mafic crust into something more akin to "typical" andesitic continental crust (White et al., 1998; Sallares et al., 2001).

1.2.2. Crustal growth rates

Schubert and Sandwell (1989) calculate that accretion of all oceanic plateaus to the continents on a time scale of 100 my would result in significantly higher rates of continental growth (3.7 km^3/year) than the continental growth rates based only on accretion of island arcs (1.1 km^3/year—Reymer and Schubert, 1986).

1.3. A brief review of oceanic plateaus on the Earth's crust

Oceanic plateaus, like the Ontong Java Plateau of the southwestern Pacific Ocean, form one of three main categories of mafic large igneous provinces, or "LIPs" (Coffin and Eldholm, 1994) (Fig. 1). The other two categories of LIPs include continental flood basalts and volcanic passive margins. All three categories of LIPs represent large-scale transient magmatism rooted deep in the Earth's mantle and therefore not controlled by lithospheric processes predicted by plate tectonic theory.

Although no major LIPs are forming today, either in the oceans or continents, at least 25 large flood-basalt provinces have formed since 250 Ma (i.e., roughly one every 10 m.y). For this reason, LIPs are a common and widespread feature of the Earth's seafloor (Coffin and Eldholm, 1994) (Fig. 1).

Oceanic plateaus form in deep-ocean basins as broad, more or less flat-topped features lying 2000 m or more above the surrounding seafloor. The six largest oceanic plateaus in order of decreasing volume are the Ontong Java Plateau, the Kerguelen Plateau of the Indian Ocean, the Caribbean plateau, the Chagos Laccadive Ridge of the Indian Ocean, the Ninetyeighteast ridge of the Indian Ocean, and the Mid-Pacific Mountains of the Pacific Ocean (Coffin and Eldholm, 1994; Tatsumi et al., 1998) (Fig. 1). These six plateaus constitute 54% of the total anomalous crustal volume of all oceanic plateaus (Schubert and Sandwell, 1989) (Fig. 2). A few plateaus like the Kerguelen plateau in the Indian Ocean have had sufficient magma flux to build above sea level, although many like the Ontong Java Plateau appear to remain submerged well below sea level throughout their development (Neal et al., 1997).

Oceanic-basin flood basalts such as the Nauru and Caribbean plateaus grow by extensive submarine lava flows and sills that form at abyssal oceanic depths (Fig. 1). Oceanic-basin flood basalts lie above, and post-date normal oceanic crustal basement. Marine geophysical studies of the Caribbean plateau document both existing rough oceanic basement of late Jurassic–early Cretaceous age and overlying plateau basalts of late Cretaceous age (Mauffret and Leroy, 1997; Driscoll and Diebold, 1999). Oceanic-basin flood basalts vary in thickness, morphology, and may or may not be related to the proximal construction of an oceanic plateau (Fig. 2).

The third and final category of LIPs shown in Fig. 1 are volcanic passive (continental) margins formed during the breakup and separation of continents. The majority of passive continental margins worldwide are now considered "volcanic", with the best-studied examples in the North and South Atlantic (Fig. 1). Formation of volcanic passive margins produces a rapid succession of mafic flows over large areas. Unlike submerged oceanic plateaus, the mafic flows of volcanic passive margins are commonly erupted in subaerial settings.

Fig. 2. (A) Crustal velocity structure for a selection of some of the world's largest and best studied oceanic plateaus compared to typical oceanic crust, Pacific oceanic crust, and continental crust. Gray area indicates velocities inferred to represent a dense lower crustal body characteristic of oceanic plateaus. (B) Selected previous predictions compiled from the literature for the fate of oceanic plateaus at subduction zones. Of all the plateaus shown in A, only the Ontong Java and Caribbean plateaus are currently undergoing subduction and are therefore key areas to observe how plateau crust responds to subduction.

1.4. Crustal structure and fate of oceanic plateaus at subduction zones

Incorporation of a LIP into continental crust would require either that the LIP either formed on a continent or its margins, or that the LIP was transferred from an oceanic to a continental setting by subduction zone tectonic process (Coffin and Eldholm, 2001). Of the three types of LIPs shown on the global map in Fig. 1, continental flood basalts form on continents and are, therefore, the most likely type of LIP to be preserved intact within continental settings. Volcanic passive margins would tend to be preserved following rifting, but deformed and eroded by subsequent oceanic closures and continent–continent collisions. Oceanic plateaus, because of their widespread distribution on the seafloor (Fig. 1) and continental-like crustal thicknesses (Fig. 2), might be expected to behave more like continents upon reaching subduction zones and, therefore, accrete, rather than subduct (Nur and Ben-Avraham, 1982).

There appears to be a growing consensus among field-based Precambrian geologists and geochemists that some, if not all Archean greenstone belts, represent ancient oceanic plateaus that have been transferred by subduction or collision processes onto continental crust (Desrochers et al., 1993; Skulski and Percival, 1996; Condie, 1997; Polat and Kerrich, 2000, 2001). In Fig. 1 and Table 1, we summarize the characteristics of six well-studied examples of accreted oceanic plateaus in Archean greenstone belts now incorporated into the cratonic cores of Canada, the Baltic, and Africa.

Although Condie (1997) argues that oceanic plateaus are rare in the Phanerozoic rock record, the number of proposed Phanerozoic plateaus is growing; Kerr et al. (2000) compiles five examples based on various geochemical and crustal criteria for ‘‘LIP reading’’ or recognition in the ancient record. We compile the age and structural characteristics of 13 examples in Table 2B.

Based on this compilation of previous studies, we propose that the structural style of both Precambrian and Phanerozoic plateaus is similar: that is, distinct fault slivers of various lithologies of the upper crust and sedimentary cover of the plateau deformed by imbricate thrust faults (Desrochers et al., 1993; Lowe, 1994; Kimura and Ludden, 1995; Kerr et al., 2000; Struik et al., 2001). Unfortunately, low to high metamorphic grades, superposition of younger tectonic events, erosional effects, and overall structural complexity makes inferences about the obduction process difficult. Moreover, Hoffman and Ranalli (1988) and Abbott (1996) emphasize that tectonic boundary conditions, including spreading rate and heat flow, for the formation and obduction of Archean plateaus were probably quite different from those tectonic boundary conditions governing the formation and obduction of Phanerozoic plateaus.

1.5. ‘‘LIP reading’’ in Cenozoic intraplate settings

Oceanic plateaus originate as massive outpourings of basalt that mark the surface location of mantle plume ‘‘heads’’, whereas hotspot tracks represent continuing magmatism associated with the remaining plume conduit or ‘‘tail’’ (Richards et al., 1989; Duncan and Richards, 1991) (Fig. 3A). Unfortunately, head–tail relations are not always straightforward due to their partial subduction, overprinting by adjacent head–tail pairs, and relative movement of the underlying mantle plumes as illustrated schematically in Fig. 3B.

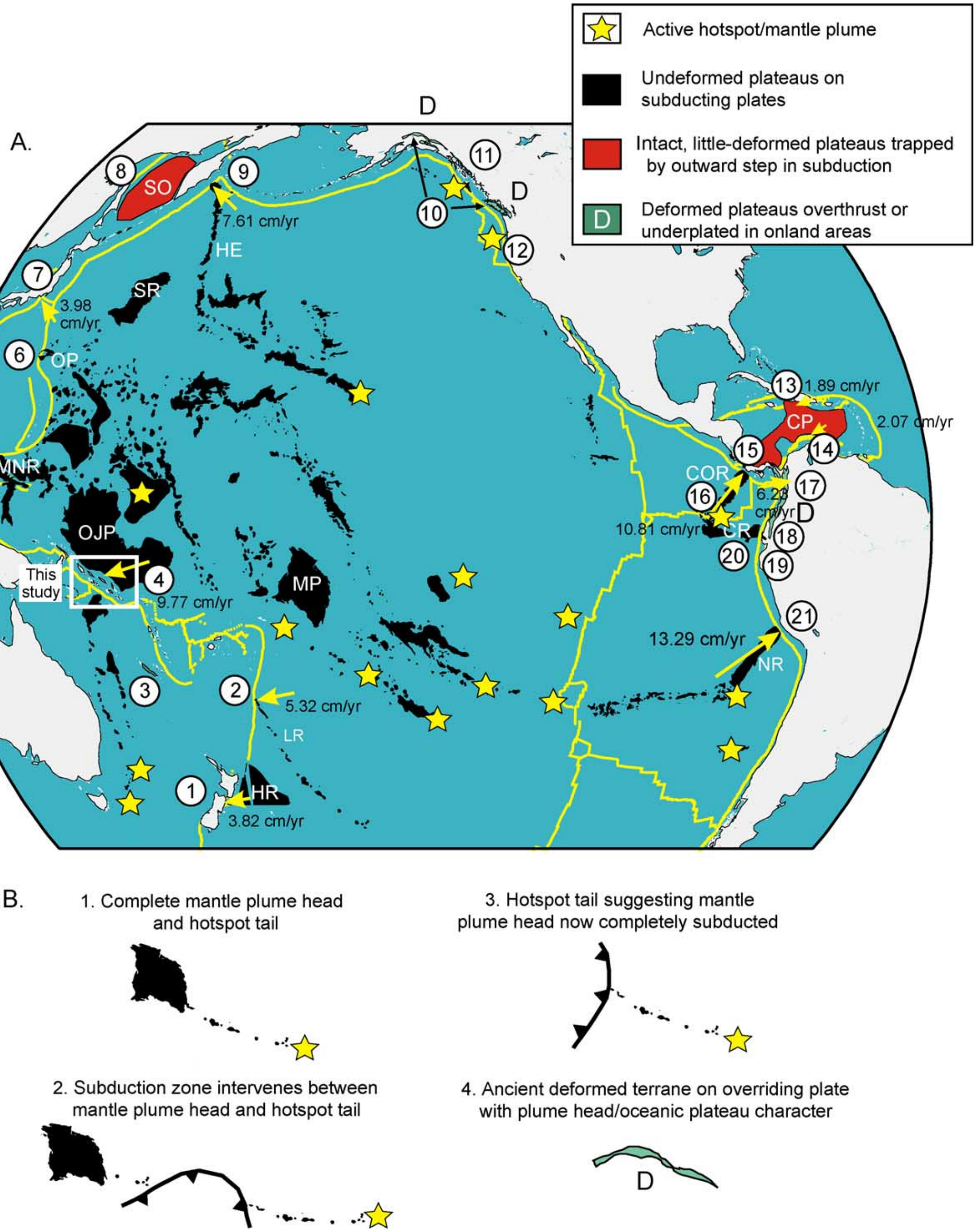
1.6. Three tectonic settings of circum-Pacific oceanic plateaus

1.6.1. Intraplate settings

Circum-Pacific oceanic plateaus can be places into three tectonic settings as indicated in the inset of Fig. 2A. The first category is undeformed plateaus formed by mantle plume processes in intraplate areas including the Pacific and Caribbean plates. The main tectonic process that would have affected this category of plateaus is cooling and thermal subsidence of the oceanic plateau and surrounding oceanic lithosphere and possible flexural or ‘‘sagduction’’ effects imposed by the load of the plateau on the surrounding thinner crust. Undeformed plateaus located in intraoceanic settings would include the Ontong Java, Hikurangi (Mortimer and Parkinson, 1996; Manihiki, and Shatksy (Sager et al., 1999) plateaus along with associated hotspot tracks like the Hawaii-Emperor seamount chain (Duncan and Richards, 1991) (Fig. 2A). These plateaus are undeformed except at their distal, subducting edges or ends.

Table 1
Proposed oceanic plateaus accreted during Precambrian collision events involving continental crust

Site number	Craton/ greenstone belt	Name/ composition of inferred plateau	Thickness of inferred plateau	Age of deformation (Ma)	Name of colliding block	Thickness and crustal level preserved	Structural style of collided block	Reference
1	Archean Superior Province, Canada (Schreiber greenstone belt),	Unnamed tholeiitic basalt komatiite sequence	Not given	2680–2695	Unnamed magmatic arc and subduction accretion complex	High-grade metamorphic terrane	Thrust-imbricated tectonic malange	Desrochers et al. (1993), Polat and Kerrich (1999, 2000, 2001)
2	Archean Superior Province, Canada (Vizier greenstone belt)	Unnamed basalt, andesite, and komatiite sequence	Not given	2718–2693	Not given	Mid-amphibolite grade	Five imbricated thrust slices with distinct internal stratigraphy	Skulski and Percival (1996)
3	Archean, SW Laurentia, western Arizona	Iron King Volcanics, Big Bug Group: submarine basalt, chert, andesite, felsic volcanics	Nor given	1650	Not given	Not given	Not given	Frey et al. (2001)
4	Archean, NW, Baltic Shield, Russia (Kostomuska greenstone belt)	Pillowed to massive tholeiites and komatiites, ash flows, tuffs	Unknown	2813–2843	Shelf-type sedimentary rocks	Not given	Plateau sequence overthrust along mylonitic fault surface	Puchtel et al. (1998)
5	Archean Zimbabwe craton, Zimbabse, Africa (Belingwe greenstone belt)	Mafic, ultramafic and felsic volcanic rocks, pyroclastic rocks, sedimentary rocks	6.5 km	2700–2900	Passive margin type sedimentary rocks	Low metamorphic grade	Plateau sequence imbricated in thrust sheets	Kusky and Kidd (1992)



Active hotspot/mantle plume
Undeformed plateaus on subducting plates
Intact, little-deformed plateaus trapped by outward step in subduction
Deformed plateaus overthrust or underplated in onland areas
A.
D
SO
HE
SR
OP
MNR
OJP
MP
This study
HR
LR
CP
COR
CR
NR
7.61 cm/yr
3.98 cm/yr
9.77 cm/yr
5.32 cm/yr
3.82 cm/yr
1.89 cm/yr
2.07 cm/yr
6.28 cm/yr
10.81 cm/yr
13.29 cm/yr
B.
1. Complete mantle plume head and hotspot tail
2. Subduction zone intervenes between mantle plume head and hotspot tail
3. Hotspot tail suggesting mantle plume head now completely subducted
4. Ancient deformed terrane on overriding plate with plume head/oceanic plateau character

In Fig. 3A and Table 2A, we have compiled 11 examples of oceanic plateau and hotspot tracks presently subducting at circum-Pacific or circum-Caribbean plate boundaries. Of these 11 examples, only one, the Ontong Java Plateau, is being actively accreting to the overriding arc system. The other 10 examples listed in Table 2A appear to be subducting without any significant frontal arc accretion of the uppermost crust.

1.6.2. Trapped settings

The second category of plateaus are those that are largely intact but now trapped in an intercontinental or continental margin setting by an outward step in subduction. These trapped plateaus may reflect more deformation at their edges because of their confined setting. For example, Bogdanov and Dobretsov (2002) have proposed that the Sea of Okhotsk along the edge of the northeastern Pacific Ocean formed as an oceanic plateau in Cretaceous time and was trapped against the Eurasian margin by an early Cenozoic, outward step of subduction to the Kamchatka Peninsula as recognized from tomographic studies (Gorbatov et al., 2000). Similarly, the Caribbean plateau which formed in the eastern Pacific, was inserted between the Americas in Cenozoic time and now forms the core of the strike–slip- and subduction-bound Caribbean plate (Mann, 1999). In the circum-Caribbean, plate-edge deformation is responsible for exposure of plateau sections over a wide region and provides some of the deepest, natural exposures of plateau lithologies (Sinton et al., 1998; Kerr et al., 1997, 1998, 2000; Lapierre et al., 1999, 2000; Lewis et al., 1999; Reynaud et al., 1999; Revillon et al., 2000a,b; Hauff et al., 2000). These natural, deeper level exposures include the only Phanerozoic examples of komatiites on the island of Gorgona in western Colombia (Kerr et al., 1996; Franco and Abbott, 1999; Revillon et al., 2000a,b).

1.6.3. Orogenic belts

A final category of plateaus are those that have been accreted during Phanerozoic collision events involving island arcs and continental margins. In Fig. 2A and Table 2B, we have compiled 13 proposed examples of oceanic plateau crust now incorporated into typically highly deformed and metamorphosed, circum-Pacific and Caribbean orogenic belts. The structural style of these plateaus is complex with the dominance of fault slivers separated by various combinations of low-angle thrust faults, high-angle reverse faults, and strike–slip faults (Richards et al., 1991; Kimura et al., 1994; Struik et al., 2001) (Table 2A). In a few cases, like the Ontong Java Plateau (Phinney et al., 1999) and the trapped setting of the Caribbean plate edges (Kerr et al., 1997), the obducted plateau material can be linked directly to an adjacent plateau on the incoming plate. However, in most cases, the obducted, orogenic plateau fragment cannot be related to a nearby modern plateau probably because all surrounding crust of normal thickness has been subducted or removed by strike–slip faulting (van der Hilst and Mann, 1994).

2. Tectonic setting of the Ontong Java Plateau–Solomon island arc convergent zone

2.1. Regional setting

The Ontong Java Plateau covers about 1,900,000 km^2 of the southwestern Pacific Ocean, or an area about the size of the conterminous United States (Fig. 4). The southwestern margin of the plateau is subducting at the

Fig. 3. (A) Map of Pacific and Caribbean LIP's compared to modern plate boundaries (yellow lines), active hotspots/mantle plumes (yellow stars), and rates of the Pacific and Caribbean plate relative to surrounding plates from global plate motion model of DeMets et al. (1994). Oceanic plateaus are subdivided into three tectonic settings as shown in the key to the upper right. Box denotes Solomon Islands–Ontong Java Plateau study area for papers in this volume. Key to abbreviations for larger LIP's and hotspot tracks: HE = Hawaii–Emperor seamount chain; SR = Shatsky Rise; SO = Sea of Okhotsk; OP = Ogasawara Plateau; MNR = Marcus Necker Ridge; OJP = Ontong Java Plateau; MP = Manihiki Plateau; HR = Hikurangi Plateau; NR = Nazca Ridge; CR = Carnegie Ridge; COR = Cocos Ridge; CP = Caribbean Plateau. Numbered LIP's 1–21 are keyed to Table 2A (oceanic plateau or hotspot tracks presently subducting at Pacific and Caribbean plate boundaries) and Table 2B (proposed oceanic plateaus accreted during Phanerozoic collision events involving island arcs or continental orogenic belts). (B) Schematic diagram summarizing four possible relationships between hotspot or mantle plume heads and hotspot tracks or "tails" in intraplate (1), subduction (2, 3) and in ancient orogenic belts (4). See text for discussion.

Table 2A
Oceanic plateau or hotspot tracks presently subducting at circum-Pacific subduction boundaries

Site number in Fig. 3	Plate boundary	Name of plateau or hotspot track	Thickness of plateau	Age of deformation	Thickness and crustal level preserved	Structural style of plateau	Crustal type of opposed block	References
1	Pacific–Australia	Hikurangi	10–15 km	Miocene to recent	Not present on upper plate	Not present on upper plate	Islands are built on continental crust	Davy and Wood (1994), Mortimer and Parkinson (1996)
2	Pacific–Tonga arc (Australia)	Louisville Ridge	Not known	Plio-Pleistocene	Not present on upper plate	Not present on upper plate	Intraoceanic island arc	Ballance et al. (1989)
4	Pacific–Solomon arc (Australia)	Ontong Java	33 km	Late Miocene to recent	Basalt and overlying pelagic limestone	Imbricate thrust slices < 10 km thick	Intraoceanic island arc	Miura et al. (2004) Phinney et al. (2004)
5	Pacific–Philippine	Marcus–Necker Ridge	Not known	Neogene	Not present on upper plate?	Not present on upper plate?	Intraoceanic island arc	Hsui and Youngquist (1985)
6	Pacific–Philippine	Ogasawara Plateau	Not known	Neogene	Not present on upper plate	Not present on upper plate	Intraoceanic island arc	Hsui and Youngquist (1985)
9	Pacific–North America	Hawaii–Emperor seamount chain	Not known	Neogene	Not present on upper plate	Not present on upper plate	Island arc built on continental crust	Marsaglia et al. (1999)
13	Caribbean–North America	Caribbean (Hispaniola)	10–20 km	Late Miocene to recent	Not present on upper plate	Gently folded and thrusted	Intraoceanic island arc	Mann et al. (1991), Mauffret and Leroy (1997), Sinton et al. (1998)
14	Caribbean–South America	Caribbean (Dutch Antilles)	10–20 km	Late Cretaceous (~ 84 Ma)	Mafic extrusive and mitrusive magmas	Gently folded	Intraoceanic island arc	White et al. (1998)
16	Caribbean–Cocos	Cocos Ridge	15 km	Late Miocene to recent	Not present on upper plate	Largely undeformed	Intraoceanic island arc built on oceanic plateau	Kolarsky et al. (1995), Sallares et al. (2001)
20	Nazca–South America	Carnegie Ridge	?	15–1 Ma	Not present on upper plate	Largely undeformed	Arc built on accreted oceanic or oceanic plateau material	Gutscher et al. (1999), Spikings et al. (2001)
21	Nazca–South America	Nazca Ridge	18 ± 3 km	Neogene	Not present on upper plate	Largely undeformed	Arc built on oceanic or oceanic plateau material	Hagen and Moberly (1994), Woods and Okal (1994)

Table 2B
Proposed oceanic plateaus accreted during Phanerozoic collision events involving island arcs or continental orogenic belts

Site number in Fig. 3	Plate boundary	Plateau/terrane	Lithologies	Age of deformation	Thickness of preserved plateau section	Structural style of plateau	Crustal type of overthrust block	References
3	Pacific–Australia	New Caledonia	Mafic volcanic rocks, dolente, gabbro, abyssal sedimental rocks	Late Eocene	?	Nappe sheet	Intraoceanic island arc	Cluzel et al. (1997)
4	Pacific–Australia	Malaita accretionary prism, Solomon Islands	Mafic volcanic rocks, pelagic carbonate rocks	Late Miocene to Recent	7–10 km	Prism with imbricate thrusts	Intraoceanic island arc	Phinney et al. (2004) Rahardiawan et al. (2004)
7	Pacific–Eurasia	Sorachi Belt, Hokkaido, Japan	Basaltic lava, tuff, pelagic limestone, chert	Early Cretaceous	< 2 km	Imbricate thrust faults	Intraoceanic island arc	Kimura et al. (1994)
8	Pacific–Eurasia–North America	Sea of Okhotsk, Russia	Not known	Latest Jurassic–Earliest Cretaceous	~ 25 km	Apparent normal faults	Not overthrust	Bogdanov and Dobretsov (2002)
10	Pacific–North America	Wrangellia, Canada and USA	Basalt and pelagic clastic and carbonate rocks	Cretaceous	3–6 km	Largely undeformed	Carboniferous–Permian andesitic arc	Richards et al. (1991), Lassiter et al. (1995)
11	Pacific–North America	Cache Creek terrane, Canada	Mafic lavas, pelagic limestone, shale, sandstone	Mid-Permian	?	Imbricate thrust faults; strike–slip faults	Middle Jurassic Stikine terrane	Struik et al. (2001), Tardy et al. (2001)
12	Pacific–North America	Siletz terrane, Oregon	Not known	Eocene (~ 50 Ma)	25–35 km	Gently folded; preserved as forearc basement	Not known	Trehu et al. (1994)
13	Caribbean–North America	Hispaniola, Caribbean	Metavolcanic and cumulate rocks	Late Cretaceous (110–85 Ma)	?	High angle faults between major units	Intraoceanic island arc built on oceanic plateau	Kerr et al. (1996), Lapierre et al. (1999)
14	Caribbean–South America	Dutch Antilles, Caribbean	Mafic extrusive and intrusive rocks	Late Cretaceous (~ 84 Ma)	10–20 km	Largely undeformed	Intraoceanic arc built on oceanic plateau	Kerr et al. (1996) White et al. (1998)
15	Caribbean–Cocos	Costa Rica, Caribbean	Mafic extrusive and intrusive rocks, chert	Late Cretaceous (~ 90Ma)	40 km	Largely undeformed	Intraoceanic arc built on oceanic plateau	Sinton et al. (1998), Kerr et al. (1996), Sallares et al. (2001)
17	Nazca–South America	Western Colombian terranes	Basalt, dolerite, picrite	Late Cretaceous	?	High-angle thrust faults	Intraoceanic arc built on oceanic plateau	Kerr et al. (1996, 1997)
18	Nazca–South America	Piñon Formation, Ecuador	Basalt and dolerite	Cretaceous (123 Ma)	?	High-angle faults	Intraoceanic arc built on oceanic plateau	Reynaud et al. (1999)
19	Nazca–South America	Raspas Complex, Ecuador	Mafic and ultramafic rocks	Latest Jurassic–Early Cretaceous	?	High-angle faults	Intraoceanic arc built on oceanic plateau	Bosch et al. (1999)

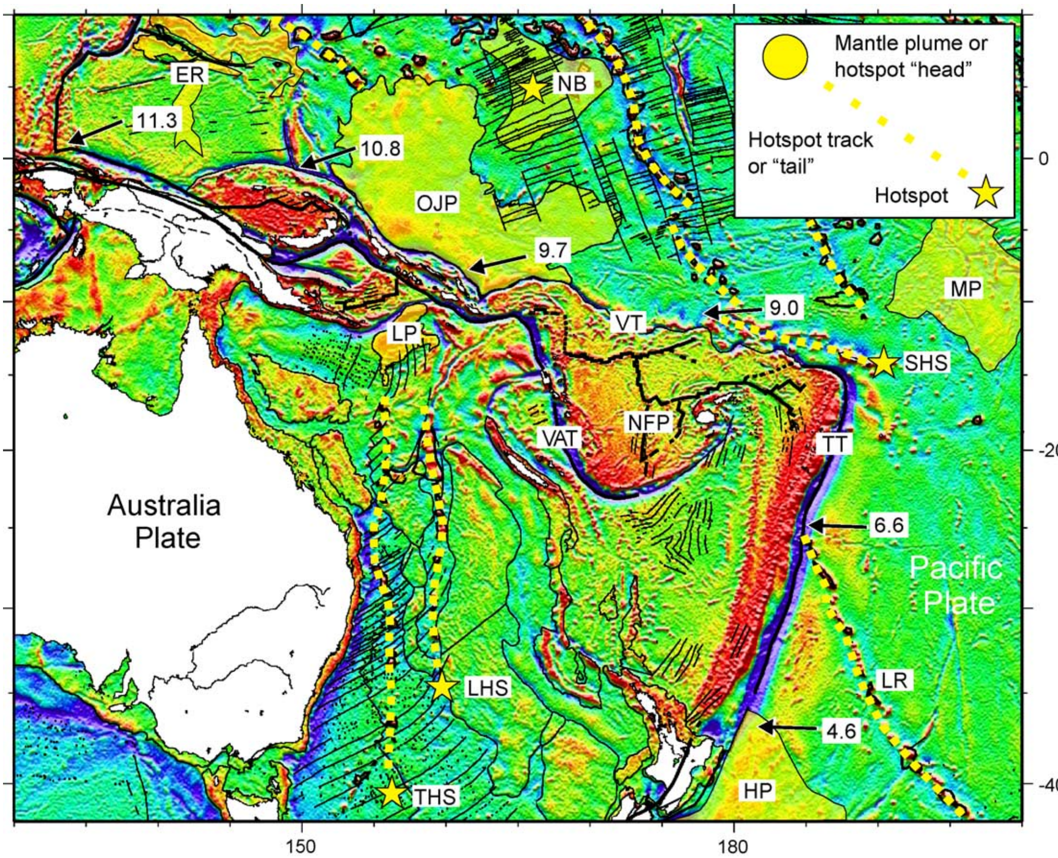


Fig. 4. Free-air gravity anomalies of the Ontong Java Plateau–Solomon Islands convergent zone derived from Geosat and ERS-1 altimetry data (Sandwell and Smith, 1997). Arrows indicate direction and rate of Pacific plate relative to adjacent plates from DeMets et al. (1994). Large yellow areas are known or inferred oceanic plateaus compiled by Coffin and Eldholm (1994); dashed yellow lines represent hotspot tracks or "tails". Key to abbreviations: NB = Nauru basin; ER = Eauripik Rise; LP = Louisiade Plateau; OJP = Ontong Java Plateau; VAT = Vanuatu trench; VT = Vitiaz trench; NFP = North Fiji Plateau; MP = Manihiki Plateau; SHS = Samoa hotspot; TT = Tonga trench; LR = Louisville ridge; HP = Hikurangi Plateau; THS = Tasminid hotspot; LHS = Lord Howe hotspot. Note the general difficulty in correlating individual hotspot tracks to oceanic plateaus because of intervening subduction zones.

North Solomon–Kilinailau trench, the southeastern margin of the plateau is translating in a left-lateral sense along the Cape Johnson trench and the northern and northeastern margins of the plateau merge gradationally with normal oceanic crust of late Jurassic and early Cretaceous age (Gladzenko et al., 1997).

Because the Pacific plate is rotating in CCW direction relative to the Australia plate about a pole located southeast of New Zealand, rates of plate convergence range from slower more orthogonal rates near New Zealand to faster, more oblique rates in the Solomon Islands (DeMets et al., 1994) (Fig. 4). The intervening area between the Australia and Pacific plates includes several microplates detached by back-arc spreading or convergence and moving independently from the two larger plates. Microplates within the Pacific–Australia plate boundary zone of interaction include the Tonga (Bevis et al., 1995), North Fiji (Auzende et al., 1995); Solomon Sea, North Bismarck, South Bismarck, and Woodlark (Tregoning et al., 1998a).

2.2. Connecting mantle plume heads and tails in the southwest Pacific

Known or inferred large plateaus or mantle "heads" in this region are mainly located on the

Pacific plate and include the Ontong Java, Eurapik, Manihiki, and Hikurangi plateaus (Duncan and Richards, 1991; Coffin and Eldholm, 1994, 2001) (Fig. 4, Table 2A). Oceanic basin flood basalts include the Nauru basin. The Tasminid and Lord Howe hotspot tracks trend and age directly towards the Louisiade plateau and suggest that the Louisiade plateau may have formed above a late Cretaceous plume in an oceanic area of the Australian plate (Gaina et al., 1999) (Fig. 4).

The complete disappearance of the Louisville ridge or hotspot track at the Tonga trench suggests either the complete subduction of the corresponding oceanic plateau head (as in the case of the Hawaii Emperor seamount chain of the northwestern Pacific Ocean—Fig. 3) or the localized subduction of the intervening part of the ridge as shown schematically in Fig. 3B. Phinney et al. (1999) proposed the latter scenario with the Louisville hotspot chain representing the mantle "tail" formed as a result of continued movement of a hotspot following the generation of the late Cretaceous Ontong Java Plateau mantle plume "head". The tectonic reconstructions of Phinney et al. (1999) for the Ontong Java Plateau illustrate the challenge of relating individual LIPs to hotspots.

3. Timing of major events in the Ontong Java–Solomon island arc convergent zone

3.1. Contrasting tectonic models

3.1.1. Introduction

The Solomon Islands arc has been the focus of seismic, geologic, and marine geophysical studies over the past three decades since it was first proposed by Karig and Mammerickx (1972) and Kroenke (1972) that the Solomon arc was the best example of an island arc polarity reversal on Earth. As shown schematically in Fig. 5, "arc polarity reversal" is defined as a process in which subduction below an island arc ceases, the arc is accreted to the formerly consuming plate (here, the Pacific plate) and subduction reverses direction to consume the formerly overriding plate (the Australian plate) (Musgrave, 1990; Petterson et al., 1999).

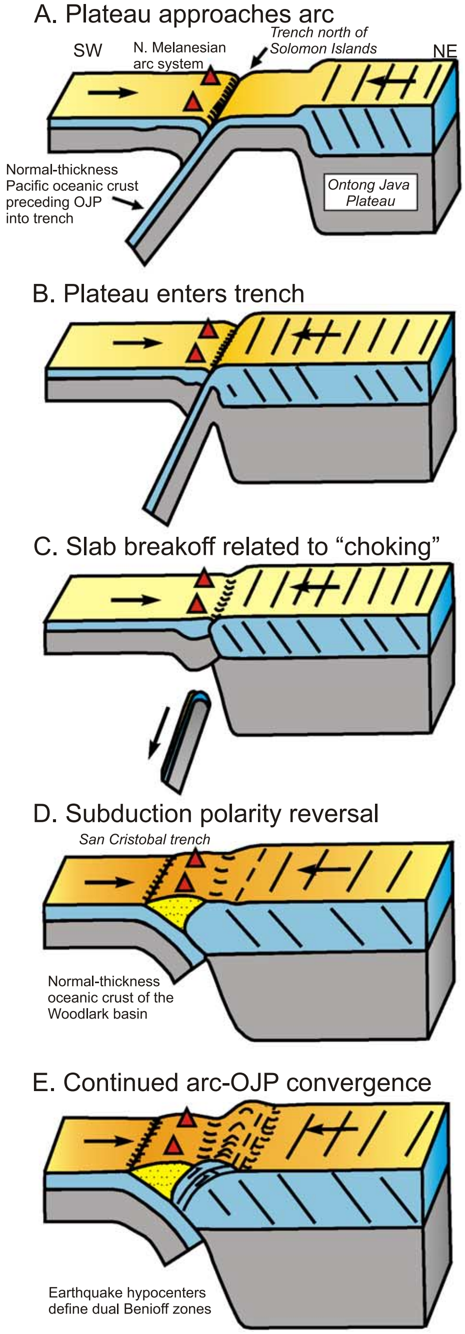
Over the years, all previous workers agree that polarity reversal has occurred mostly because of the presence of dual, inwardly dipping Benioff zones correlated to the Pacific and Australia plates beneath the Solomon Islands (Cooper and Taylor, 1985; Miura et al., 2004). However, the timing of the arc polarity reversal and the timing of tectonic events leading up to the present-day pattern of opposed Benioff zones is an important topic on which no clear consensus has emerged. In this section and in Fig. 5, we briefly review some of the contrasting interpretations of timing of events.

3.1.2. Discrete soft and hard docking events

Kroenke et al. (1986), Kroenke (1989), Yan and Kroenke (1993), and Petterson et al. (1995, 1999) propose that the subduction of the Ontong Java Plateau initiated the formation of the Malaita anticlinorium or folded zone north of the Solomon Islands at 22 Ma (Middle Miocene) because the Ontong Java Plateau was too thick to to be subducted at the North Solomon trench (Fig. 5A,B). The proposed initial arrival of the Ontong Java Plateau at the trench at 22 Ma (Early Miocene) was termed a "soft docking event" with no obvious record of associated deformation in the Solomon arc. The manifestation of this soft docking event was proposed to be reflected in a hiatus in Miocene arc volcanism (~ 20–15 Ma) and by quantitative plate reconstructions by Yan and Kroenke (1993) that juxtapose the Ontong Java Plateau and the Solomons arc in early Miocene time. Their proposed early Miocene soft docking stage was sufficient to initiate polarity reversal in the period of ~ 12–6 Ma (Fig. 5D). The subsequent "hard docking" stage of Ontong Java Plateau–Solomon arc convergence is proposed by these workers to have occurred much later at ~ 4–2 Ma, a time consistent with widespread and discernible deformational and uplift events in the Malaita anticlinorium (Resig et al., 1986; Petterson et al., 1995, 1999) (Fig. 5E). These workers assumed that the North Solomon trench became inactive at the time of this convergent event and Pacific–Australia motion was entirely accommodated by subduction of the Australia plate at the San Cristobal trench (Fig. 5E).

3.1.3. Paleomagnetic constraints

Musgrave (1990) used paleomagnetic data from uplifted rocks exposed in the Solomon Islands previously correlated by Hughes and Turner (1977) and



Stage	Yan and Kroenke (1993) Petterson et al. (1999)	This paper Phinney et al. (this volume) Cowley et al. (this volume)
A. Plateau approaches arc	**Eocene:** Initiation of SW-directed subduction of the Pacific Plate and formation of the Vitiaz - or “Stage 1” - arc (equivalent to the Northern Melanesian arc).	**Eocene:** Initiation of SW-directed subduction of the Pacific Plate and formation of the Vitiaz - or “Stage 1” - arc (equivalent to the Northern Melanesian arc).
B. Plateau enters trench	**~25-20 Ma:** OJP enters the trench during this phase of “soft docking”. Phase 1 volcanic activity ceases possibly due to steepening of the SW-dipping slab.	**~25-20 Ma**: Normal subduction at extensional, intra-oceanic-type arc system. NE-facing subduction zone marked by present-day KKK fault zone. Central Solomon intra-arc basin opening and filling with arc-derived sediments.
C. Slab breakoff related to “choking”	**~20-15 Ma:** Continued hiatus of Phase I arc-volcanic rocks. Inferred slab breakoff beneath the arc.	**~20-15 Ma**: Normal subduction at extensional, intra-oceanic-type arc system. NE-facing subduction zone marked by present-day KKK fault zone. Central Solomon intra-arc basin opening and filling with arc-derived sediments.
D. Subduction polarity reversal	**~12-6 Ma:** NE subduction initiates along San Cristobal trench. South Solomons (Phase 2) arc volcanism initiates at 6 Ma.	**~12-6 Ma**: Normal subduction at extensional, intra-oceanic-type arc system. NE-facing subduction zone marked by present-day KKK fault zone. Central Solomon intra-arc basin opening and filling with arc-derived sediments.
E. Continued arc-OJP convergence	**~4-2 Ma:** “Hard docking” of OJP leads to 30% shortening in Malaita area, formation of the Malaita anticlinorim, and its eventual emergence above sealevel. Subduction is inferred to occur in a NE direction along the San Cristobal trench. Little or subduction is inferred along the North Solomon trench.	**~5-0 Ma**: Arrival of 33-km-thick OJP at trench marked by KKK fault zone. Subduction-accretion of upper 20% of OJP forms NE-vergent Malaita accretionary prism and North Solomon trench; lower 80% of plateau continues to subduct. Subduction initiation occurs at San Cristobal trench and oblique-slip motion along KKK fault zone.

Fig. 5. Schematic illustration modified from Petterson et al. (1999) showing the major tectonic events of the subduction polarity reversal in the Solomon Islands. Interpretations for the timing of these events by Yan and Kroenke (1993) and Petterson et al. (1999) are compared to those presented in this volume. See text for discussion.

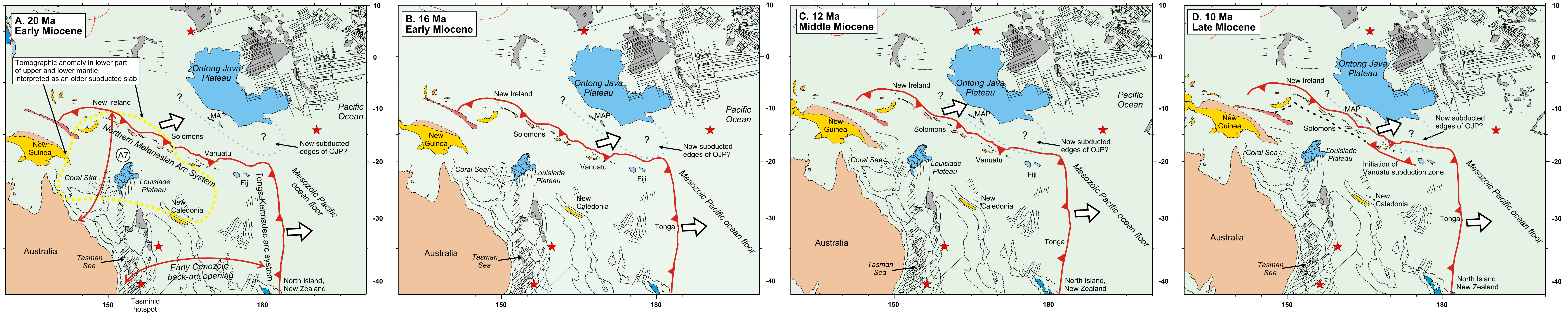


Fig. 6. (A – F) Computer-based tectonic reconstructions of the Ontong Java Plateau and Solomon island arc convergence zone from 20 Ma to the present. The Ontong Java and Louisiade Plateaus are shown in light blue; plate boundaries are shown in red, hotspots correspond to red stars; and large white arrows show general direction of Australia plate motion. (A) 20 Ma, early Miocene. (B) 16 Ma, early Miocene. (C) 12 Ma, middle Miocene. (D) 10 Ma, late Miocene. (E) 8 Ma, late Miocene. (F) 6 Ma, Late Miocene. (G) 4 Ma, early Pliocene. (H) 2 Ma, late Pliocene. (I) 0 Ma and present-day mantle slabs (from Hall and Spakman, 2002). See text for discussion.

Fig. 6 (*continued*).

Hughes (2004) to infer that these rocks were never part of the incoming Ontong Java Plateau but instead originated as a lithologically similar but tectonically discrete forearc basin sequence attached to the Solomon arc. Improved correlations of the basement and sedimentary stratigraphy of the Malaita prism and the incoming Ontong Java Plateau by Tejada et al. (1996, 2002), Petterson et al. (1995, 1999), Phinney et al. (1999; 2004), and Rahardiawan et al. (2004) leave little doubt that the Malaita prism is the offscraped equivalent of the upper crust of the plateau.

3.1.4. Single tectonic event model

In Phinney et al. (2004) and Cowley et al. (2004), we use marine geophysical data and onland geologic data to constrain an alternative scenario for arc polarity reversal that is summarized in Fig. 5. This tectonic scenario proposes that the Ontong Java Plateau converged on the Solomon arc only in the last 5 Ma and that the "Malaita anticlinorium" (Kroenke, 1972), or "Malaita accretionary prism" in our revised terminology, formed entirely since that time of contact (Fig. 5E).

Prior arrival of the plateau around 5 Ma (latest Miocene), the tectonic setting of the Solomon was much different than it is at present. First, the Solomon arc was a longlived extensional, intra-oceanic arc system with the Central Solomon intra-arc basin bounded by normal faults (Bruns et al., 1986; Cowley et al., 2004). Second, subduction occurred along the KKK fault zone until the arrival of the Ontong Java Plateau about 5 Ma (Phinney et al., 2004; Rahardiawan et al., 2004). "Choking" of this subduction zone caused the subduction zone to step seaward to form the present-day North Solomon trench as observed along other Cenozoic subduction zones consuming anomalously thick plateau or seamount crust (Trehu et al., 1994; Franco and Abbott, 1999; Mazzotti et al., 2002). And, finally, subduction continues along the North Solomon trench with about 20% of the uppermost 33-km-thick plateau being transferred by subduction accretion to the overriding Malaita accretionary prism and the lower 80% of the plateau subducting beneath the arc (Phinney et al., 2004; Rahardiawan et al., 2004). Therefore, Pacific–Australia convergence is partitioned between both subduction zones as indicated by GPS-based geodetic studies (Tregoning et al., 1998b).

3.2. Plate reconstructions in this paper

3.2.1. Introduction

In order to support our interpretation of convergence starting in the Solomon Islands ~ 5 Ma, we present a series of eight computer-based reconstructions made using PLATES interactive software. Reconstructions are shown at 2–4 Ma increments based on hierarchical closure of larger and smaller plate pairs, including Pacific–Antarctica (Cande and Kent, 1995), Australia–Antarctica (Royer et al., 1997); opening of the Woodlark basin (Lee and Lawver, 1995; Taylor et al., 1995); and opening of the North Fiji basin (Malahoff et al., 1982; Auzende et al., 1988, 1995).

3.2.2. 20 Ma (Early Miocene)

A single, semi-continuous arc system existed in the southwest Pacific Ocean in Cenozoic time (Fig. 6A). The northern arm of the arc system is called the Northern Melanesian arc system and includes the present-day areas of New Ireland, Solomon Islands, and Fiji. The eastern arm is called the Tonga–Kermadec arc system that included the present-day areas of Tonga and the North Island of New Zealand (Auzende et al., 1988, 1995). Back-arc basin openings, large-scale rotations, and strike–slip faulting transverse to the trend of the arc has disrupted the geometry of this once-continuous volcanic chain over the past 20 Ma (Gill et al., 1984).

The dotted area marked A7 in Fig. 6A outlines tomographic anomalies in the upper and lower mantle (500–700 km) associated with older periods of subduction from Hall and Spakman (2002). Hall and Spakman (2002) interpret the A7 anomaly to be the result of south and southwest-directed subduction of the Pacific plate beneath the Northern Melanesian–Tonga–Kermadec arc in the period between 45 and 25 Ma.

A fundamental difference in these reconstructions with those by Audley-Charles (1991) and Yan and Kroenke (1993) is related to the geographic origin of this arc system relative to the Australian continent. Following previous tectonic and paleogeographic interpretations by Crook and Belbin (1978), Gaina et al. (1999), Hall (2002), and Hall and Spakman (2002), we propose the Northern Melanesian–Tonga–Kermadec arc was rifted away from the Australian continental margin by backarc spreading related to southward and westward early Cenozoic subduction of the Pacific plate. Vigorous back-arc opening in the early Tertiary is likely related to a strong subduction rollback component produced by consumption of relatively old Mesozoic oceanic crust beneath the intraoceanic arc systems (Gaina et al., 1999).

In contrast to this view, Audley-Charles (1991) and Yan and Kroenke (1993) propose that the same arc system originates in an intra-oceanic setting by southward subduction far north of Australia. This interpretation is not consistent with the location or southward dip of tomographic anomaly A7 (Hall and Spakman, 2002) (Fig. 6A).

The original extent of the Ontong Java Plateau prior to its initial subduction at the Northern Melanesian arc is shown speculatively in Fig. 6A. It is possible that the Ontong Java Plateau tapered in thickness towards its edges as observed today along its northern and eastern margins (Gladzenko et al., 1997). It is also likely a hotspot "tail" of the plateau projected to the southeast and corresponds to the present-day Louisville hotspot track now being subducted at the Tonga trench (Phinney et al., 1999) (Fig. 4). We infer that the presence of a now-subducted southeastward extension of the Ontong Java Plateau will disrupt the Vanuatu segment of the north-facing Northern Melanesian arc system. In our plate reconstructions, the present-day islands of the Malaita accretionary prisms are attached to the incoming Ontong Java Plateau because of their close lithologic and age similarities (Neal et al., 1997; Phinney et al., 1999, 2004; Tejada et al., 1996, 2002). Because of the oblique entry of the Ontong Java Plateau into the subduction zone of the Northern Melanesian arc system, deformation along the length of arc is highly diachronous with earlier Miocene collisonal effects in the eastern segment of Fiji and Vanuatu followed by Plio-Pleistocene deformational effects in the Solomons region (Fig. 6A).

3.2.3. 16 Ma (Early Miocene)

During this period, the Ontong Java Plateau and the Solomon arc continue to converge in a southwesterly direction (Fig. 6B). The plateau is approximately 500 km from the trench. Intra-arc rifting and igneous intrusion culiminates in the older, western block of the Vanuatu arc (Carney and Macfarlane, 1982).

3.2.4. 12 Ma (Middle Miocene)

The Ontong Java Plateau and the Solomon arc continue to converge in a southwesterly direction (Fig. 6C). At this time, the plateau is approximately 300 km from the trench. Studies by Cowley et al. (2004) show that the Central Solomon intra-arc basin is forming as an elongate, normal-fault-bounded depression without any evidence for convergent deformation. Studies by Phinney et al. (1999) show evidence for normal faulting at 15 Ma as the Ontong Java Plateau bends during its approach to the Northern Melanesian subduction zone.

3.2.5. 10 Ma (Late Miocene)

About 10–8 Ma, the eastern segment of the Northern Melanesian arc system begins to collide along the Vitiaz trench with the now-subducted southeastern extension of the Ontong Java Plateau (Auzende et al., 1988, 1995; Pelletier and Auzende, 1996) (Fig. 6D). The result of this convergent event was a reversal of subduction polarity and NE–SW opening of the North Fiji basin by clockwise rotation of the Vanuatu arc between about 8 and 3 Ma (Auzende et al., 1995). Volcanism and a general absence of sedimentary rocks between 11 and 8 Ma occur on the older, western block of Vanuatu (Carney and Macfarlane, 1982). A period of folding, uplift, and erosion called the "Colo orogeny" begins in the Fiji Islands about 10 Ma (Rodda and Kroenke, 1984; Hamburger and Isacks, 1987). We propose that the Miocene Colo orogeny is an ancient analog for the Ontong Java Plateau-related convergent deformation that has affected the Solomons segment of the Northern Melanesian arc system in Plio-Pleistocene time.

3.2.6. 8 Ma (Late Miocene)

During this time, clockwise rotation of the Vanuatu arc about a pivot point on a thick area of the Ontong Java Plateau crust near the Solomon Islands (Gladzenko et al., 1997) leads to lengthening of the left-lateral Fiji transform fault connecting the Tonga and Vanuatu trenches (Fig. 6E). Volcanism begins in the younger, eastern block of Vanuatu between 7 and 4 Ma that is presumably the manifestation of northeast-dipping subduction of the Australia plate (Carney and Macfarlane, 1982).

3.2.7. 6 Ma (Late Miocene)

Clockwise rotation of the Vanuatu arc about a pivot point on the Ontong Java Plateau near the Solomon Islands led to lengthening of the left-lateral Fiji transform fault connecting the Tonga and Vanuatu trenches (Hamburger and Isacks, 1988) (Fig. 6F). Paleomagnetic studies by Malahoff et al. (1982) show that the Fiji Islands (Vitu Levu) rotate 90° CCW in Late Miocene time consistent with a broad zone of right-lateral shearing along the Fiji transform. Rifting of the younger, eastern part of Vanuatu occurs at about 5 Ma (Carney and Macfarlane, 1982). According to Petterson et al. (1995, 1999) “Phase 2” volcanism in the Solomon Islands associated with northeastward subduction at the San Cristobal trench initiates at 6 Ma. Magnetostratigraphic work by Musgrave (1990) places an age of 5.8 Ma for the transition from open-ocean pelagic carbonate rocks in the Malaita prism to more terrigenous and higher-energy clastic sedimentary rocks. Workers like Hughes and Turner (1977) propose this facies transition as evidence for proximity between the incoming Ontong Java Plateau and the Solomon arc.

3.2.8. 4 Ma (Early Pliocene)

We propose this period for arrival of the Ontong Java Plateau arrival at the paleo-trench of the Solomon Islands (present-day KKK fault zone) because this period is characterized by: (1) the major phase of folding and uplift in the southeastern part of the Malaita accretionary prism (Phinney et al., 2004); (2) compressional-type inversion of normal faults in the Central Solomon intra-arc basin (Cowley et al. 2004) and (3) pelagic sedimentary rocks of the Malaita accretionary prism were rapidly uplifted from a 2-km water depth beginning in Pliocene time based on foraminiferal biostratigraphic and paleobathymetric data (Resig et al., 1986) (Fig. 6G). The North Fiji basin starts to open in an EW direction from 3 to 0 Ma (Auzende et al., 1995). The Lau basin rifts at 5.5 Ma and begins oceanic spreading about 3.5 Ma as the Tonga arc experiences rapid rollback (Bevis et al., 1995).

3.2.9. 2 Ma (Late Pliocene)

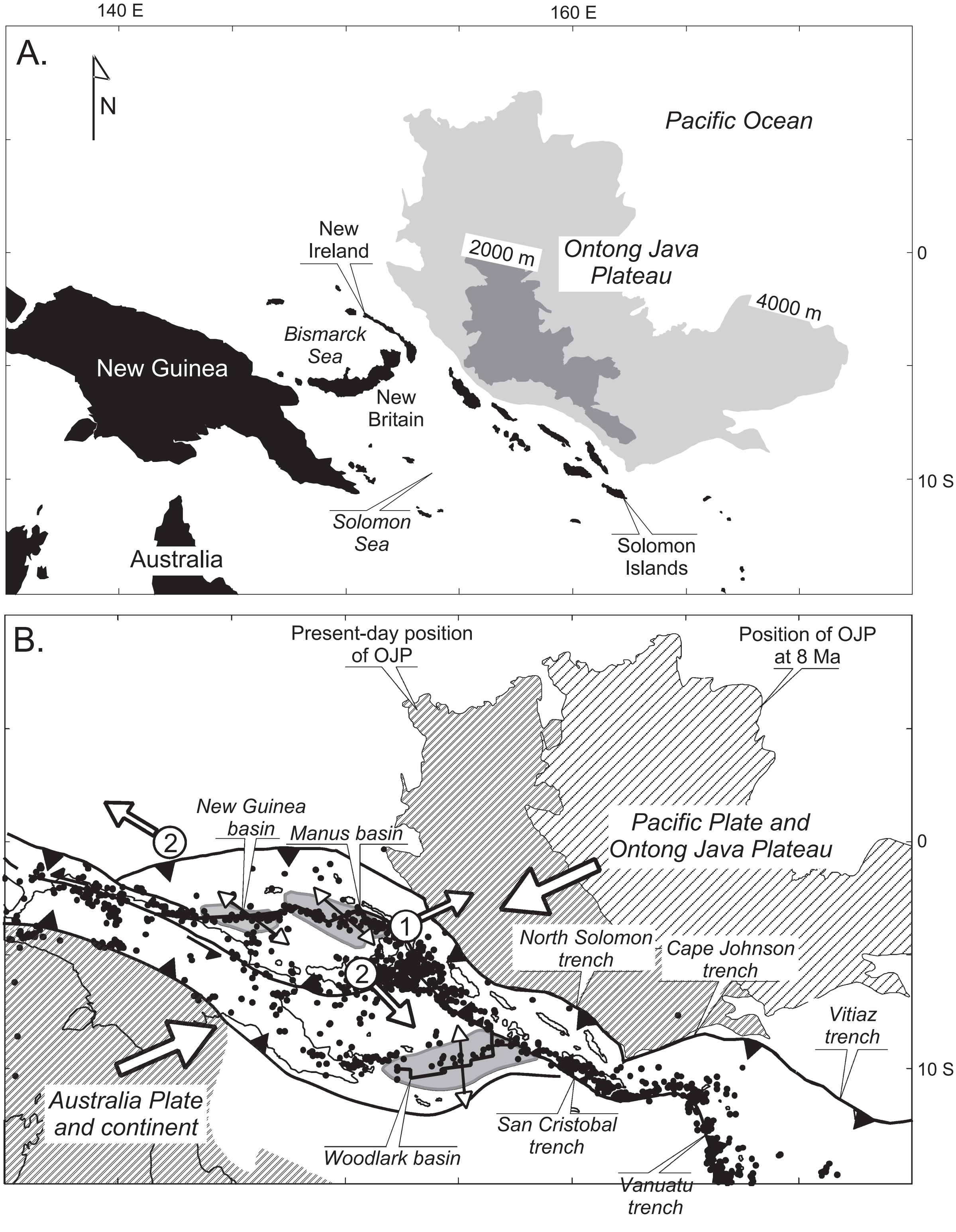
By this time, the southeastern part of the Malaita accretionary prism has formed and subduction has stepped out from the KKK fault zone and is occurring at the North Solomon trench (Fig. 6H). Because of the oblique direction of subduction of the plateau, younger deformation occurs more to the west in both the Malaita accretionary prism (Phinney et al., 2004; Rahardiawan et al., 2004) and the Central Solomon intra-arc basin (Cowley et al., 2004). Phinney et al. (2004) present evidence that the southeastern area of the Malaita accretionary prism is no longer actively shortening because flat-lying Pliocene carbonate rocks caps the underlying folds in plateau material.

3.2.10. 0 Ma (present-day)

Present-day boundaries represent the culmination of the 20 Ma tectonic history outlined above. One possible explanation for the complex migration of the arc system is the role of “pivot points” provided by both the Ontong Java Plateau entering the subduction zone in the north and the Hikurangi Plateau entering the subduction zone in the south in Miocene time (Mortimer and Parkinson, 1996). The inset shows schematically the effects of the large-scale clockwise rotations of the Vanuatu and Tonga arcs separated by the diffuse Fiji left-lateral transform (Hamburger and Isacks, 1988). The dotted areas marked A1, A2, and A3 in Fig. 6I are tomographic anomalies in the upper mantle from Hall and Spakman (2002). These tomographic anomalies correspond well to the downdip extensions of Benioff zones mapped from earthquake hypocenters (Hamburger and Isacks, 1987; Pelletier et al., 1998; Okal and Kirby, 1998).

3.3. Regional tectonic model to explain present-day arc activity and plate interactions

Mann (1997) proposed that the Neogene convergent history of the New Guinea–Bismarck Sea–Solomon Sea–Ontong Java Plateau region of the southwest Pacific Ocean can be viewed in terms of large-scale regional convergence between the ~50-km-thick Australia plate and the ~33-km-thick Ontong Java Plateau (Fig. 7). The global plate motion model shown in Fig. 4 along with GPS observations from the Solomon Islands (Tregoning et al., 1998b)


140 E
160 E
A.
N
Pacific Ocean
New Ireland
2000 m
Ontong Java Plateau
0
4000 m
Bismarck Sea
New Guinea
New Britain
10 S
Solomon Sea
Solomon Islands
Australia
B.
Present-day position of OJP
Position of OJP at 8 Ma
New Guinea basin
Manus basin
2
Pacific Plate and Ontong Java Plateau
0
1
2
North Solomon trench
Cape Johnson trench
Vitiaz trench
10 S
Australia Plate and continent
San Cristobal trench
Woodlark basin
Vanuatu trench

indicates about 10 cm/year of oblique east–northeastward convergence between the Australia and Pacific plates. The Ontong Java Plateau behaves as a continent upon entering the subduction zone at the Pacific–Australia plate boundary, because the plateau crustal thickness is roughly four times that of normal oceanic crust and is similar to that of many continental areas (Miura et al., 2004) (Fig. 2).

The tectonic model of Mann (1997) helps to explain the relationship between present-day trends of waning or extinct arcs and extremely active arcs migrating at almost right angles to the less active arcs. A northwest- to west–northwest-trending, largely extinct segment of the Northern Melanesian arc system in New Ireland and the Solomon Islands formed during an extended Cenozoic period of Australia–Pacific convergence in the direction marked by the arrow 1 in Fig. 7B (Auzende et al., 1988, 1995), whereas a much more seismically and volcanically active, east- to northeast-trending arc system in New Britain (Cooper and Taylor, 1989; Tregoning et al., 1998a) is proposed to have undergone Plio-Pleistocene "escape tectonics" in the direction marked by arrow 2 because of its progressive constriction between the converging Ontong Java Plateau and the Australia plate.

Shallow subduction of Australian continental crust beneath the New Guinea arc (Audley-Charles, 1991; Cooper and Taylor, 1987; Abers and McCaffrey, 1988) and subduction and accretion of the Ontong Java oceanic plateau crust in the New Ireland–Solomon region (Bruns et al., 1989; Stracke and Hegner, 1998) led to waning late Miocene–Pleistocene volcanic activity in those arc systems that advance relatively slowly in the convergence direction marked by arrow 1 in Fig. 7B. Southeastward escape of the intervening block (South Bismarck microplate) behind the seismically and volcanically active New Britain arc is drawn at a rapid rate to the southeast by self-sustaining subduction of Oligocene-age oceanic crust in the Solomon Sea (Cooper and Taylor, 1989; Taylor et al., 1994). The Manus and New Guinea basins of the Bismarck Sea east of the island of New Guinea developed as oceanic-floored pull-aparts along a left-lateral strike–slip fault subparallel to the north- and northwest-trending arc of New Ireland (Taylor et al., 1994).

In this model, these basins formed as a response to the splitting of the plate as it reoriented in a southeastwardly direction marked by arrow 2 in the direction of subductable oceanic crust of the Solomon Sea basin. The formation of the Pliocene to recent Woodlark spreading system (Taylor et al., 1995) to the south may be related to the rifting of the Solomon Sea plate as its dense ocean floor undergoes simultaneous slab pull in two directions at subduction zones beneath New Britain and the Solomon Islands. Wortel and Cloetingh (1981) have proposed a similar style of breakup of the oceanic Farallon plate along the Cocos–Nazca spreading center. Plate breakup is inferred as the result of tensional forces produced by simultaneous slab pull at the differently oriented Central and South America subduction zones.

4. Geographic and geologic setting of the Ontong Java Plateau–Solomon Islands convergent zone

4.1. Areas of arc and oceanic plateau crust

The Solomon Islands group is a 800-km-long linear, double chain of islands composed of arc crust of the Northern Melanesian arc system now juxta-

Fig. 7. (A) Geography of the Solomon Islands–Ontong Java Plateau convergence area. The Solomon Islands, New Britain, and New Ireland constitute the Cretaceous–Cenozoic northern Melanesian island arc system. The Ontong Java Plateau is an Early Cretaceous submarine oceanic plateau with a continental-like, 35-km-thick crust. (B) Tectonic setting of the Solomon Islands showing convergence of the Ontong Java Plateau (OJP) and Pacific plate on the northern Melanesian arc system and the Australian plate and continent. Oblique convergence at a rate of about 10 cm/year in a WSW–ENE direction between the OJP and Australian continent over the past 4 my (DeMets et al., 1994) may have reoriented arc systems and convergent margins previously moving in a direction indicated by "1" into the direction marked by "2". This radical change in microplate motions towards the oceanic "free face" to the southeast may have activated extension in the New Guinea, Manus, and Woodlark basins. Note 300-km-long indentation of the North Solomon trench at the Cape Johnson trench whose strike matches the overall Pacific–Australia west–southwestward convergence direction between the Ontong Java Plateau and the Solomon intra-oceanic island arc. Black dots are 1185 earthquake epicenters from the International Seismological Centre (ISC) database with depths from 0 to 20 km and magnitudes >4.5.

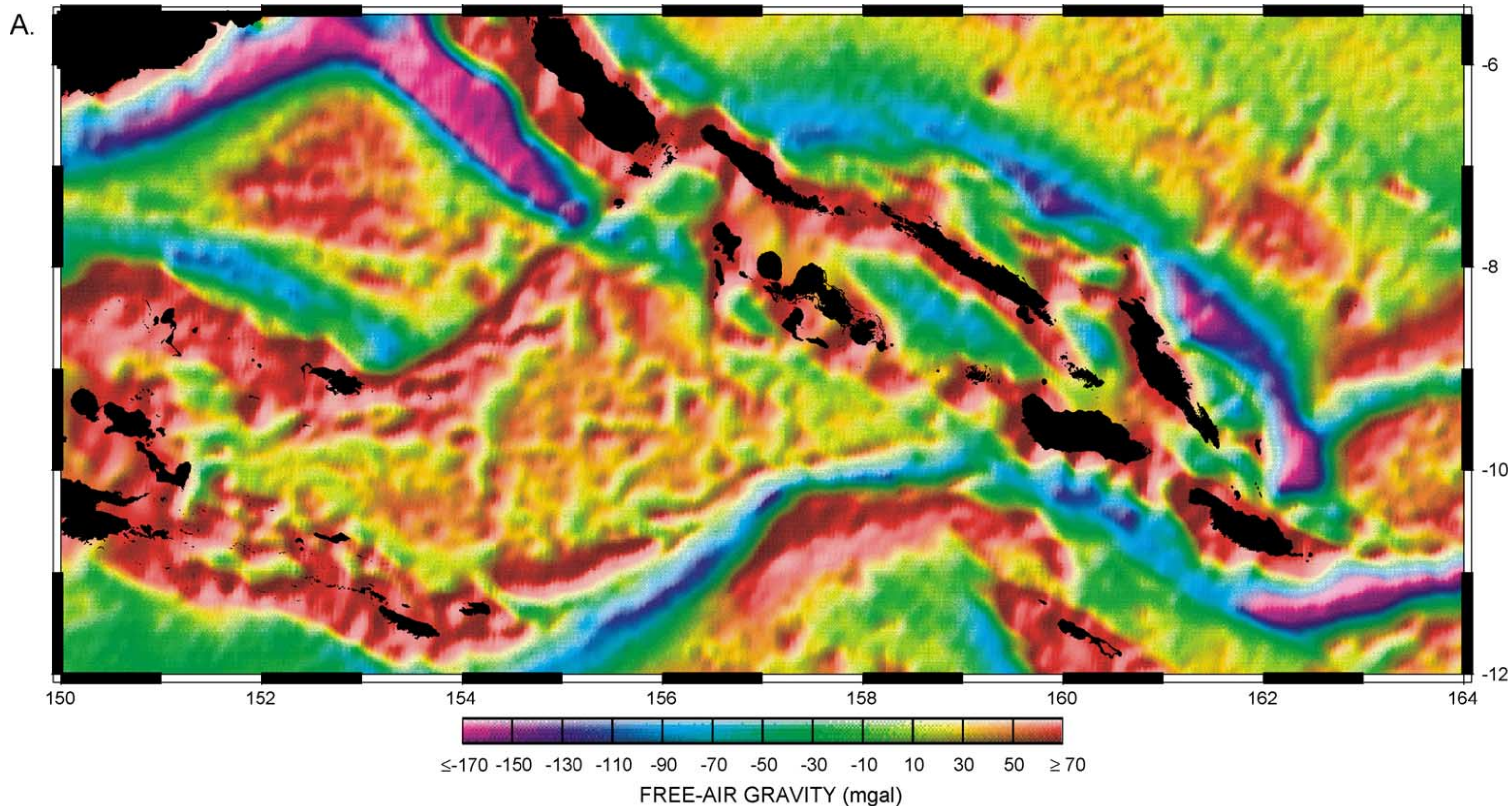


Fig. 8. (A) Free-air gravity anomalies of the Solomon Islands from Sandwell and Smith (1997). Land areas are shown in black and data are illuminated from an azimuth of 128°. (B) Tectonic interpretation of the area shown in (A). Land is dark gray; late Neogene oceanic crust of the Woodlark basin is light gray; areas of thick crust of the Ontong Java and Louisiade Plateaus are shown with horizontally ruled pattern; heavy lines with barbs represent subduction boundaries; double lines indicate active spreading ridges; circles (yellow in the web version) represent Plio-Pleistocene volcanic centers; triangles (red in the web version) represent volcanic centers with historic activity; large black arrow gives direction and rate of convergence of the Pacific plate relative to the Australia plate from DeMets et al. (1994). Earthquakes with magnitudes >4.5 are shown as black dots and were compiled by the International Seismological Centre (ISC) for the period 1963–1999. Key to geographic abbreviations: PNG = Papua Peninsula (Papua New Guinea); NB = New Britain; B = Bougainville (PNG); C = Choiseul, Solomon Islands (SI); SH = Shortland Islands (SI); NG = New Georgia Island Group (SI); RI = Russell Islands (SI); SI = Santa Isabel (SI); M = Malaita (SI); FI = Florida Islands (SI); G = Guadalcanal (SI); MA = Makira (SI—note that this island was formerly known as "San Cristobal"). Key to abbreviations of tectonic features: TT = Trobriand trench; NBT = New Britain trench; KT = Kilinailau trench; WSR = Woodlark spreading center; SR = Simbo ridge; GR = Ghizo ridge; MAP = Malaita accretionary prism; KKKF = Kia–Kaipito–Korigole fault zone; SCT = San Cristobal trench; NST = North Solomon trench; CJT = Cape Johnson trench. Bars marked A, B, C, and D indicate transect areas of earthquakes plotted as sections A, B, C, and D in Fig. 9. Two dashed lines through the northern and southern Solomon island arc represent gravity lineaments seen in A and may correspond to transverse faults.

B.

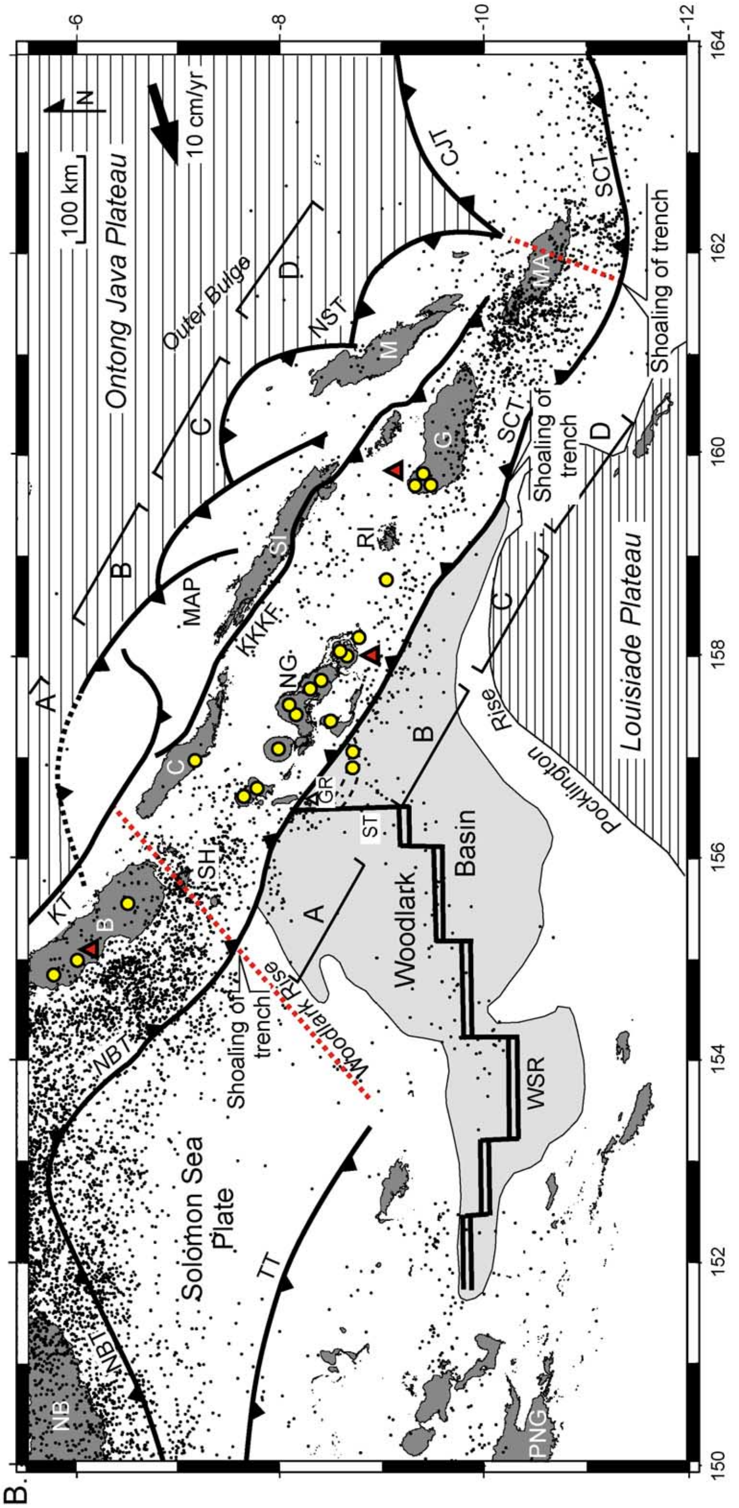


Fig. 8 (continued).

posed against oceanic plateau material accreted during late Neogene contact with the Cretaceous Ontong Java Plateau (Hughes and Turner, 1977; Kroenke et al., 1986; Mann et al., 1996a) (Fig. 8A,B). The area of accreted and folded Ontong Java crust, the Malaita accretionary prism of Mann et al. (1996a), Phinney et al. (1999) and Phinney et al. (2004), is exposed in the D-shaped area bounded by the North Solomon trench and the KKK fault zone. This fault has been mapped on Santa Isabel as high-angle reverse or strike–slip fault (Petterson et al., 1995, 1999) and extends as a southeast-dipping and active thrust between Malaita and Guadalcanal (Fig. 8B).

4.2. Erosional levels of rocks in the Solomon Islands

Island outcrops of arc and accreted rocks of the Ontong Java Plateau constitute topographic uplifts ranging from about 200 m to over 2 km with associated gravity highs >50 mgal (Fig. 8A). High topography to the west in the New Georgia group (1768 m) and Bougainville (2743 m) is related to the construction of large, Pliocene to recent stratovolcanoes while high topography on Guadalcanal (2447 m), Makira (1250 m), and Malaita (1251 m) is related to the shortening, uplift and erosion of the deeper, crustal levels of the Northern Melanesian arc and Malaita accretionary prism. The deeper level of erosion and greater crustal seismicity of the Guadalcanal–Makira–Malaita area may reflect the position of these islands in the convergent zone between the Ontong Java oceanic plateau on the Pacific plate and continental and oceanic plateau or continental crust of the Louisiade Plateau on the Australia plate (Fig. 7).

4.3. Central Solomon intra-arc basin

A submarine and synclinal intra-arc basin (Central Solomon basin) lies between the twin island chains of the Solomon Islands and is filled by up to 2 km of Oligocene to recent sedimentary rocks. Bruns et al. (1986) and Cowley et al. (2004) have shown that the Oligocene–middle Miocene history of this intra-arc basin was controlled by normal faulting roughly parallel to the double chain of islands. These normal faults were reactivated during late Miocene–early Pliocene time by shortening probably related to the entry of the Ontong Java Plateau into the North Solomon trench and the formation of the Malaita accretionary prism (Cowley et al., 2004). Wells (1989) and Auzende et al. (1994) have proposed a strike–slip-related subsidence mechanism for the intra-arc basin based on the opening of a rectangular pull-apart basin between left-lateral strike–slip faults roughly parallel to both sides of the double chain of islands. However, we prefer the simple synclinal model of basin formation as proposed by Bruns et al. (1986) and Cowley et al. (2004) because strike–slip features and strike–slip-generated earthquakes are confined to a linear zone along the KKK fault zone and are otherwise not widespread in the Solomon Islands.

The Central Solomon intra-arc basin is similar to other synclinal-type arcs caught in a vice-like manner between converging continental or high-standing plateaus or hotspot tracks (Fig. 2A). For example, the synclinal nature of the Costa Rican forearc reflects shortening of the arc system between the Caribbean oceanic plateau and the incoming Cocos Ridge (Kolarsky et al., 1995) and the synclinal nature of the Banda arc in near Timor reflects shortening of this arc between the Sunda continent and the subducting Australian continental plate (Snyder et al., 1996).

4.4. Areas of Quaternary uplift and subsidence

To a first approximation, one may assume that emerged islands in the Solomons chain area uplifting and offshore areas are subsiding (Fig. 8B). Previous studies of numerous uplifted Quaternary reefs found throughout the Solomon Islands confirm that most of the islands have been uplifting in Quaternary time (Stoddart, 1969; Ramsey, 1982; Taylor and Tajima, 1987; Ridgway, 1987). The Florida Island group and most of Santa Isabel and Choiseul appear to be subsiding based on drowned river valleys and coastlines and their location adjacent to the Central Solomons intra-arc basin, a major zone of late Quaternary synclinal downwarping and sedimentation (Bruns et al., 1986; Cowley et al., 2004) (Fig. 8B). The most spectacular area of the late Quaternary uplift is in the outer forearc area of the New Georgia island group and reflects shallow subduction of a seamount feature on the incoming, extinct Woodlark spreading center (Hughes et al., 1986; Mann et al., 1998).

4.5. Morphology of the North Solomon and San Cristobal trenches

4.5.1. North Solomon trench

This trench marks a southwest-dipping subduction zone separating the Malaita accretionary prism from the Ontong Java Plateau (Fig. 8B). The North Solomon trench ranges in depth from 6000 m at its deepest point north of Makira to a depth of 3500 m north of Santa Isabel (Fig. 8B). Associated gravity lows in these trenches range from − 170 to − 80 mgal (Fig. 8A). The Kilinailau trench extends to the northwest of the North Solomon trench and juxtaposes the Ontong Java Plateau with arc rocks in Bougainville with little or no intervening accreted material similar to that found in the Malaita accretionary prism (Bruns et al., 1989) (Fig. 8B).

4.5.2. New Britain–San Cristobal trench

This trench marks a northeast-dipping subduction zone separating the Solomon–Bougainville section of the Northern Melanesian arc system from the Australia and Solomon Sea plates (Fig. 8B). The New Britain–San Cristobal trench can be divided into four main segments based on water depth. The well-defined New Britain trench northeast of the Woodlark Rise ranges from 6000 to 8000 m in depth and is associated with a gravity lows >170 mgal. The New Britain trench shallows abruptly from a depth of ~ 6000 m to the northwest of the Woodlark Rise to a depth of ~ 5000 m to the southeast of the rise where the trench becomes known as the San Cristobal trench. Young oceanic crust of the Woodlark basin is subducted beneath the Solomon arc at the San Cristobal trench from the Woodlark Rise to the Pocklington Rise near Guadalcanal (Fig. 8B).

In most places the San Cristobal "trench" is a not a well-developed physiographic trench because of limited flexure of the subducting Woodlark oceanic crust (Taylor and Tajima, 1987; Cowley et al., 2004). The depth to the base of the steep trench slope composed of arc-related rocks averages about 3500 m and the small trench formed by limited flexure of the subducting Woodlark oceanic crust at the base of the slope is commonly devoid of sediment. Near the trenchward projection of the Pocklington Rise, the third segment of the San Cristobal trench exhibits an average water depth of 4000–5000 m and juxtaposes older oceanic plateau or continental crust of the Louisiade Plateau with the arc. The fourth and final segment of the San Cristobal trench is defined by a deepening to a depth of 7500 m. The point this deepening occurs coincides with a gravity lineament crossing Makira at the Warihito River and connecting to the cusp where the North Solomon and Cape Johnson trenches join (Fig. 8B). The lack of a prominent physiographic trench, the shoaling of the trench area and the less frequent earthquakes along the San Cristobal trench all coincide with the entry of young and buoyant oceanic crust of the Woodlark basin into the trench or the entry to older oceanic plateau or continental crust of the Louisiade Plateau into the trench (Cooper and Taylor, 1985, 1987; Shinohara et al., 2003).

4.6. Tranverse arc lineaments seen on gravity data

Two lineaments in the regional gravity field cross the Solomon arc (Fig. 8B). The lineaments connect the northwestern and southeastern edges of the Woodlark basin oceanic crust, the points of abrupt shoaling of the San Cristobal trench, and the northwestern and southeastern edges of the D-shaped Malaita accretionary prism.

The correspondence of these lineaments to the distal edges of late Neogene oceanic crust of the Woodlark basin and to the distal edges of the D-shaped Malaita accretionary prism indicates that the young oceanic crust of the Woodlark basin may serve as either a passive "backstop" or an active "indentor" for the formation of the Malaita accretionary prism within the broad zone of convergence between the Ontong Java Plateau and the Australia continent (Phinney et al., 2004) (Fig. 8B).

Ripper (1982), Weissel et al. (1982), Cooper and Taylor (1987) and Taylor et al. (1995) present earthquake evidence for dominantly right-lateral motion along the seaward extension of the northeastern lineament into the Solomon Sea plate along the Woodlark Rise (Fig. 8B). Such differential motion within the Solomon Sea plate may result from impeded and shallower subduction of the younger late Neogene Woodlark basin oceanic crust in comparison to the steeper subduction of the Oligocene Solomon Sea crust to the northwest (Weissel et al., 1982).

4.7. Outer bulges on subducting plates

A broad, continuous outer bulge of the Ontong Java Plateau (Stewart arch) marked by gravity values up to 70 mgal is formed by its flexure beneath the North Solomon trench (Fig. 8A). Seismic reflection studies show that flexing continues to the present-day because faults penetrated the seafloor and the late Neogene pelagic cover of the plateau (Phinney et al., 1999). A more discontinuous outer bulge with values up to 70 mgal affects the more heterogeneous and thinly sedimented crustal types subducted at the San Cristobal and New Britain trenches.

4.8. Morphology of late Neogene oceanic basins within the Ontong Java Plateau–Solomon Islands convergent zone

4.8.1. Bismarck sea

The Manus and New Guinea basins of the Bismarck Sea east of New Guinea range in water depth from 1.8 to 2.7 km and developed over the past 3.5 my along a left-lateral strike–slip fault subparallel to the north and northwest-trending, extinct arc in New Ireland (Taylor et al., 1994; Martinez and Taylor, 1996). These authors have documented short spreading ridges within the pull-apart basins that are forming normal oceanic crust at full spreading rates of 100 mm/year.

4.8.2. Woodlark basin

To the south, the V-shaped, 3- to 5-km-deep Woodlark basin formed by westward propagation of the Woodlark spreading ridge between continental crust of the Woodlark and Pocklington rises (Taylor and Exon, 1987; Taylor et al., 1995) (Fig. 8B). Active spreading is occurring along 3.5–4.0-km-deep short ridge segments characterized by 6–7-km-wide axial valleys clearly visible on the regional gravity map shown in Fig. 8A.

The Ghizo ridge, the short spreading segment adjacent to the San Cristobal trench and Solomon island arc, became extinct about 500 ka when motion between the Australia and Solomon Sea plate shifted eastwards to be accommodated by right-lateral transpressional motion on the Simbo Ridge (Crook and Taylor, 1994) (Fig. 8B). This shift in the plate boundary transferred the small triangular area of Woodlark oceanic crust north of the Ghizo ridge from the Solomon Sea plate to the Australia plate. The active Woodlark spreading center and the Ghizo ridge are associated with numerous near- and off-axis seamounts (Crook and Taylor, 1994; Taylor et al., 1995).

5. Geophysical evidence for subducted slabs beneath the Solomon Islands

5.1. Cross-arc transects using earthquake hypocenters

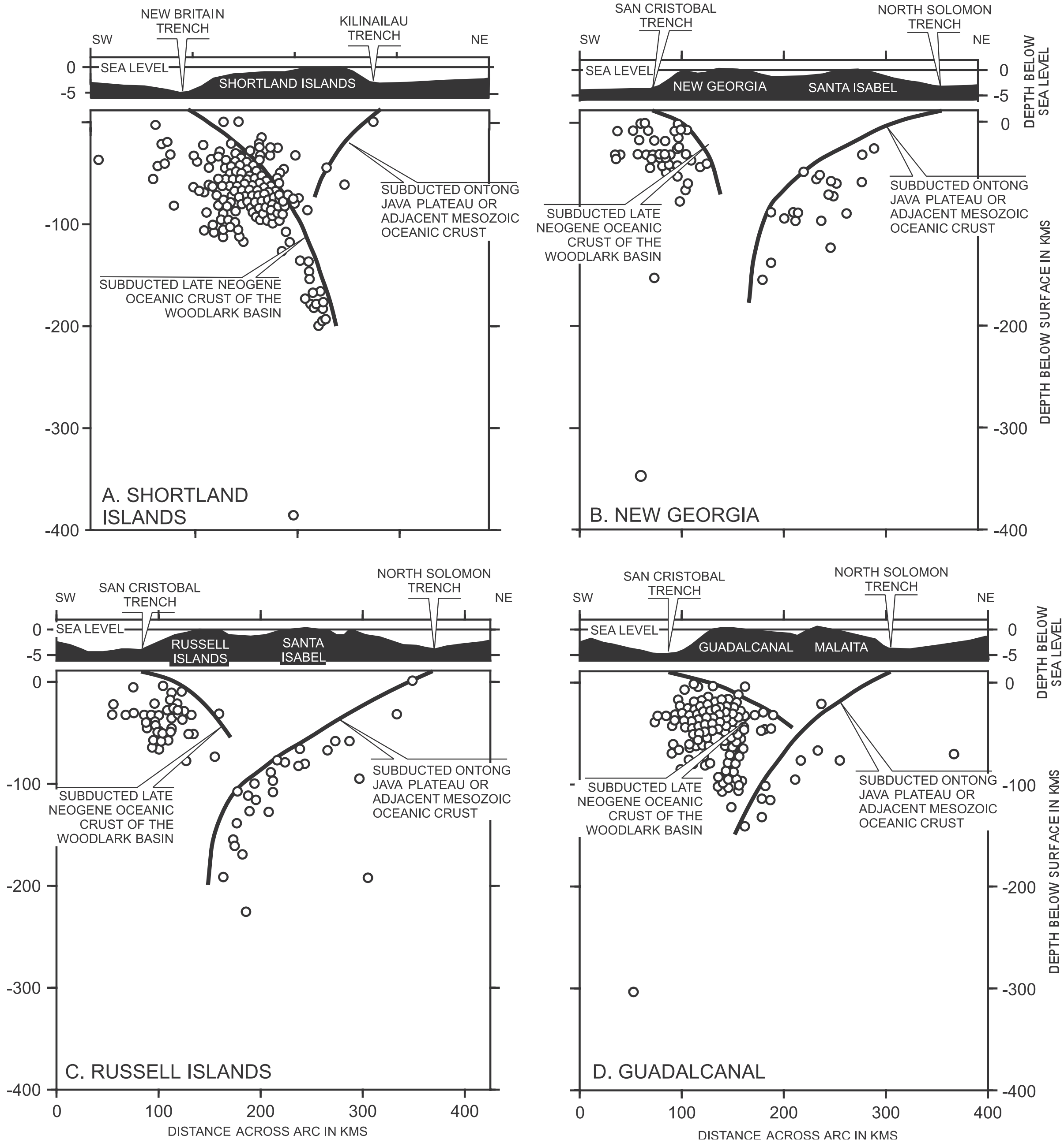
Fig. 9 summarizes seismic evidence for the presence of subducted slabs along four earthquake hypocenter transects through the Solomon Islands at the Shortland Islands, the New Georgia Island group, the Russell Islands and Guadalcanal (Fig. 8B). The hypocenter data shown in Fig. 9 were compiled from the earthquake catalogue of the International Seismological Centre for the period 1963–1999 and projected onto the center lines of the four 150-km-wide transect areas shown in Fig. 8B.

Two slabs of opposing dip and extending to the San Cristobal and North Solomon trenches are present on all transects in Fig. 9. The 200- to 300-km-long, southwest-dipping slab that projects to the North Solomon trench corresponds to subducted oceanic

Fig. 9. Profiles of ISC earthquake hypocenters from the period 1963–1999 beneath bathymetric profiles of the northern Melanesian arc system. Earthquake hypocenters are projected onto the four 150-km-wide transect areas shown in Fig. 8B. The vertical exaggeration is greater for the bathymetric profile in the upper panel than for the hypocenters in the lower panel in order to accentuate crustal tectonic features. Solid lines within hypocenters are the inferred top of the downgoing plate. (A) Bougainville transect. Subducted slabs of Eocene-age oceanic crust of the Solomon Sea plate and Cretaceous-age Ontong Java oceanic plateau or its adjacent Mesozoic oceanic crust are present at depth but do not appear to be in contact. (B) New Georgia transect. Subducted slabs of late Neogene (4.5–0 Ma) oceanic crust of the Woodlark basin and Ontong Java Plateau and/or its adjacent Mesozoic oceanic crust are present at depth but do not appear to be in contact. (C) Russell Islands transect. Subducted slabs of late Neogene (4.5–0 Ma) oceanic crust of the Woodlark basin and Ontong Java Plateau and/or its adjacent Mesozoic oceanic crust are present at depth but do not appear to be in contact. (D) Guadalcanal transect. Subducted slabs of late Neogene oceanic crust of the Woodlark basin and Ontong Java Plateau and/or its adjacent Mesozoic oceanic crust are present at depth and may be in contact.

plateau material of the Ontong Java Plateau or Mesozoic oceanic crust that formed adjacent to the Ontong Java Plateau (Gladzenko et al., 1997). The 75- to 100-km-long, northeast-dipping slab that projects to the San Cristobal trench corresponds to subducted late Neogene oceanic crust of the Woodlark basin or subducted Oligocene oceanic crust of the Solomon Sea (Taylor et al., 1995). The southwestward-dipping slab at the North Solomon trench is less seismogenic than the northeastward-dipping slab.

Previous workers like Weissel et al. (1982), Cooper and Taylor (1985), Taylor and Exon (1987) and



Cooper and Taylor (1988) have noted that the subducted slab of Woodlark basin crust beneath the New Georgia Islands is not well defined. They have related the slab's poor definition to the buckling or underthrusting of its warm lithosphere and/or the rapid thermal equilibration of its young ($\leq$3 Ma) lithosphere in the surrounding mantle material.

However, the earthquake data we have compiled for the New Georgia area in Fig. 9C shows that the subducted slab of Woodlark oceanic crust containing the subducted spreading center is well defined and extends to a depth of 75 km at an average dip of 45°. Its shorter length relative to the subducted Ontong Java Plateau to the north probably reflects the recent onset of subduction over the past several million years in response to subduction polarity reversal as shown schematically in Fig. 5.

The average 45° dip of the young, $\leq$3 Ma Woodlark oceanic crust over the length of the San Cristobal trench is similar to the average dip of Cretaceous oceanic and oceanic plateau crust along the North Solomon trench. Despite the existence of two subducted slabs beneath much of the Solomons and Bougainville, historically active arc volcanism is restricted to only three localities plotted in Fig. 8B. In the Solomon Islands, this volcanism may be related to the melting of the Ontong Java Plateau or its adjacent oceanic crust that has been subducted to a depth >100 km.

6. Geologic basement provinces of the Solomon Islands

6.1. Pacific province (Malaita accretionary prism)

Coleman and Hackman (1974) and Hughes and Turner (1977) subdivided the geology of the Solomon Islands into two fault-bounded geologic provinces that have been accepted by most subsequent workers (e.g., Coulson and Vedder, 1986) (Fig. 10). The islands of Ulawa, Malaita, and the northeastern flank of Santa Isabel form part of the "Pacific province" composed of oceanic plateau rocks that have been transferred from adjacent Ontong Java Plateau (Hughes and Turner, 1977; Kroenke et al., 1986). The Pacific province is equivalent to the "Malaita anticlinorium" of Kroenke et al. (1986) and the "Malaita accretionary prism" of Mann et al. (1996a) and Phinney et al. (2004).

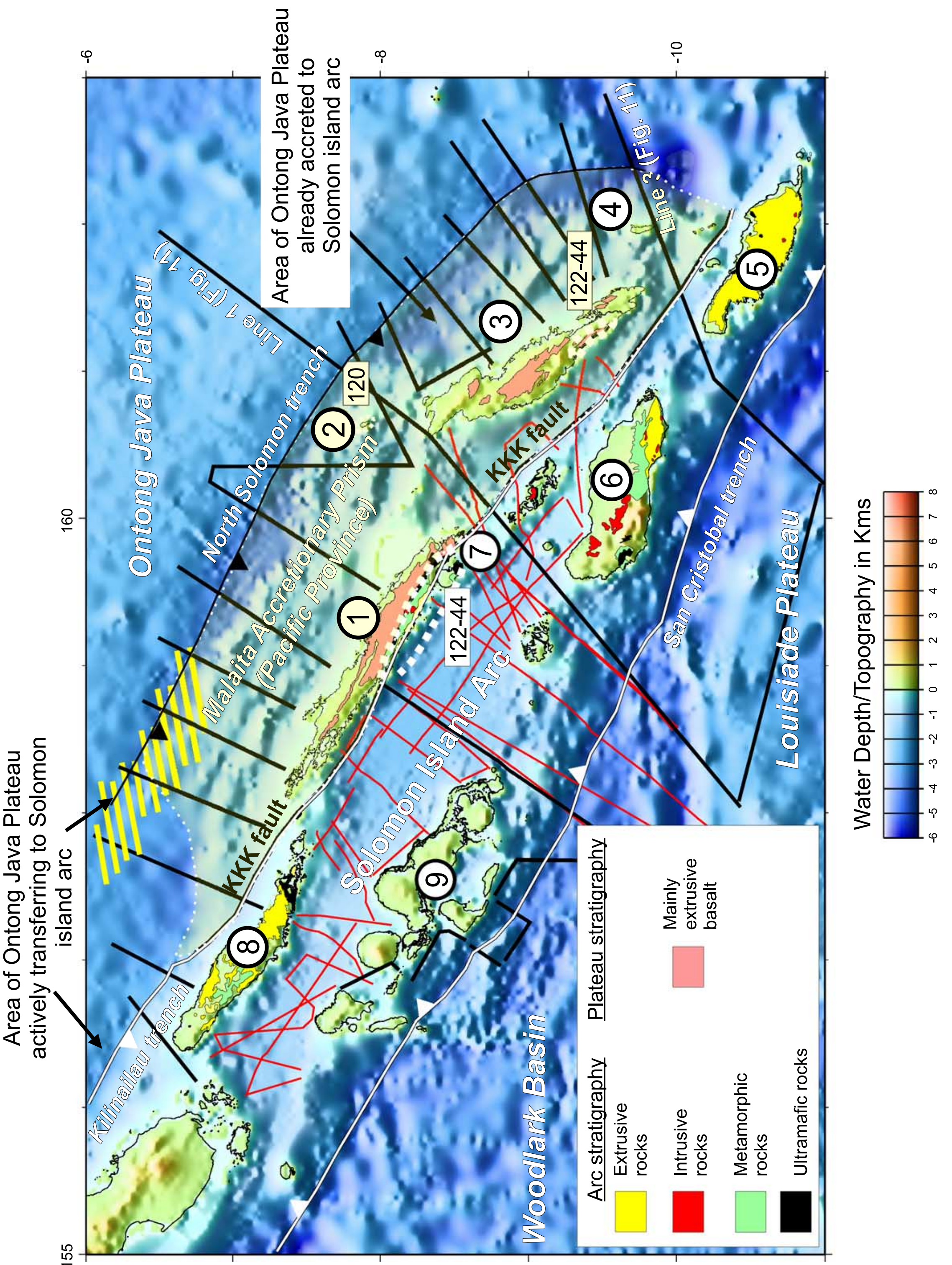
The basement rocks of the Malaita accretionary prism consist of a 0.5–3.5-km-thick outcrop section on Malaita of unmetamorphosed tholeiitic basalts that occur as pillowed and massive flows of Cretaceous age (Tejada et al., 1996; Petterson et al., 1995, 1999; Tejada et al., 1996, 2002; Hughes 2004) (Fig. 10). Radiometric dating by Tejada et al. (1996, 2002) on Malaita, Santa Isabel and Makira indicate two age provinces within the onland plateau rocks: 121–125 and 90 Ma, which correspond precisely to Ontong Java Plateau basaltic basement ages determined by the Ocean Drilling Project on the Ontong Java Plateau (Neal et al., 1997).

The overlying sedimentary rocks studied in outcrop by Van Deventer and Postuma (1973), Hughes and Turner (1977), and Petterson et al. (1995, 1999) include thick sequences of pelagic carbonate rocks that range in age from late Cretaceous to Holocene. The entire pre-Quaternary succession is folded along northwest- to west-trending fold axes. Folds generally verge to the northeast consistent with subduction–accretion of the incoming Ontong Java Plateau.

6.2. Volcanic province (Solomon island arc)

The volcanic province of the Solomon Islands is a Miocene–Pleistocene volcanic arc that includes the

Fig. 10. Limits of the "Pacific province" consisting of Ontong Plateau-derived material (called the Malaita accretionary prism in this volume), Solomon island arc, and bounding trenches. Boundaries are plotted on a bathymetric map derived from the satellite gravity data shown in Fig. 8A. Black ship tracks represent MCS data collected in 1995 during EW95-11 and discussed in this paper, in Miura et al. (2004), Cowley et al. (2004), and Phinney et al. (2004). Red lines represent MCS data collected in 1982 during the Tripartite study (U.S. Geological Survey cruise LEE82—cf. Bruns et al., 1986). Yellow lines represent SCS and sidescan data collected in 1998 by the University of Tokyo on the RV *Hakuho Maru* and discussed in this paper and by Rahardiawan et al. (2004). Cretaceous and Paleogene oceanic plateau and island arc "basement" outcrops are compiled from Coulson and Vedder (1986); colors correspond to Cretaceous and early Cenozoic rock types shown in the inset key. Radiometric dates on onland basement outcrops are in millions of years and are compiled from Tejada et al. (1996, 2002). Key to numbered areas mentioned in text: 1 = Santa Isabel; 2 = offshore Malaita accretionary prism; 3 = Malaita; 4 = Ulawa; 5 = Makira (also called San Cristobal); 6 = Guadalcanal; 7 = Florida Islands; 8 = Choiseul; 9 = New Georgia Island Group.



Area of Ontong Java Plateau already accreted to Solomon island arc
Area of Ontong Java Plateau actively transferring to Solomon island arc
Ontong Java Plateau
Line 1 (Fig. 11)
Line 2 (Fig. 11)
North Solomon trench
Malaita Accretionary Prism (Pacific Province)
KKK fault
KKK fault
Solomon Island Arc
Kilinailau trench
San Cristobal trench
Woodlark Basin
Louisiade Plateau
120
122-44
122-44
1
2
3
4
5
6
7
8
9
155
160
-6
-8
-10
Arc stratigraphy
Extrusive rocks
Intrusive rocks
Metamorphic rocks
Ultramafic rocks
Plateau stratigraphy
Mainly extrusive basalt
Water Depth/Topography in Kms
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7
8

areas of New Georgia and Shortland Islands, parts of Choiseul, the Russell Islands, northwest Guadalcanal, and Savo Island (Figs. 8B and 10). In this paper and volume, we refer to the volcanic province as simply the "Solomon arc". Most workers assume that the arc is southwest-facing and formed by melting of shallowly subducted crust of the Woodlark basin. However, melting of the steeper-dipping and deeper southwestward-subducted slab associated with the Pacific plate and Ontong Java Plateau is equally as plausible given that the Pacific slab extends into the assumed 110-km depth range for slab melting (Fig. 9).

This arc is marked by an alignment of submarine and emergent of Plio-Pleistocene volcanic centers characterized by subalkaline basalt and andesite (Hackman, 1979) (Fig. 8B). A closely associated intra-arc basin (Central Solomon intra-arc basin of Bruns et al., 1986, and Cowley et al., 2004) contains up to 5 km of Cenozoic sedimentary rocks. This basin formed as an extensional intra-oceanic arc and has been modified by collisonal tectonics between the Solomon island arc and the Ontong Java Plateau.

7. Marine geophysical data distribution and coincident reflection–refraction transect across Ontong Java Plateau–Solomon Island arc convergent zone

7.1. Marine geophysical data from the Solomon Islands region

7.1.1. Previous marine geophysical surveys

In 1982, an extensive marine seismic reflection/refraction, gravity, and magnetics survey of the Solomon Islands was completed by the U.S. Geological Survey and agencies in Australia, New Zealand, and other nations in the southwest Pacific ("Tripartite" survey). This survey, whose main intention was to investigate potential, oil, gas, and mineral resources, established the offshore tectonic and geophysical framework and integrated all previous geologic and industry data from the area including the results of sparker surveys (Kroenke, 1972) and a 1972 Western Geophysical multi-channel-seismic (MCS) reflection survey (Bruns et al., 1986; Kroenke et al., 1986; Kroenke, 1989). A key MCS line from this survey is line 37–13 that is roughly parallel to the cross-arc MCS–OBS line 1 we collected in 1995 (Fig. 10).

7.1.2. 1995 RV Maurice Ewing cruise

Researchers from the University of Texas at Austin's Institute for Geophysics (UTIG), University of Tokyo's Ocean Research Institute (ORI), and Chiba University collected over 2000 km of 2-D marine MCS data and a 550 km long ocean-bottom seismometer (OBS) profile across the Solomon Islands and Ontong Java Plateau (Mann et al., 1996a,b) (Fig. 11).

Streamer length for most lines was 3000 m with a receiver group spacing of 25 m. The 20-element gun array (8510 in.^{3} total displacement) was fired every 20 s or minus a random time interval in an attempt to attenuate any coherent previous shot noise during stack. A processing flow of velocity analysis, weighted stack, and constant-velocity fk-migration was applied to the lines including Line 1 shown in Fig. 11. Seven OBSs were deployed at about a 27-km interval along Line 1 (Fig. 11). The processing and interpretation of the OBS is described in detail by Miura et al. (2004).

7.1.3. 1998 RV Hakuho Maru cruise

Researchers from ORI, UTIG, and Scripps Institute for Oceanography collected 16 sidescan sonar and 24-channel seismic reflection lines over the northwestern part of the North Solomon trench in an attempt to better resolve the neotectonic, northwestward propagation of the trench in this area (Rahardiawan et al., 2004) (Fig. 10).

7.2. Overview of main results from Ewing MCS-OBS line 1

7.2.1. Summary of reflection results

Both reflection and refraction results for Line 1 are summarized and compared at similar scales in Fig. 11. Both data sets illustrate the five distinct tectonic components of the Ontong Java Plateau–Solomon Island arc convergent zone: (1) Ontong Java Plateau (OJP); (2) Malaita accretionary prism (MAP); (3) Solomon island arc; (4) oceanic crust of the Woodlark basin; and (5) Louisiade plateau.

In the following sections, we point out some of the key structural and stratigraphic features of reflection

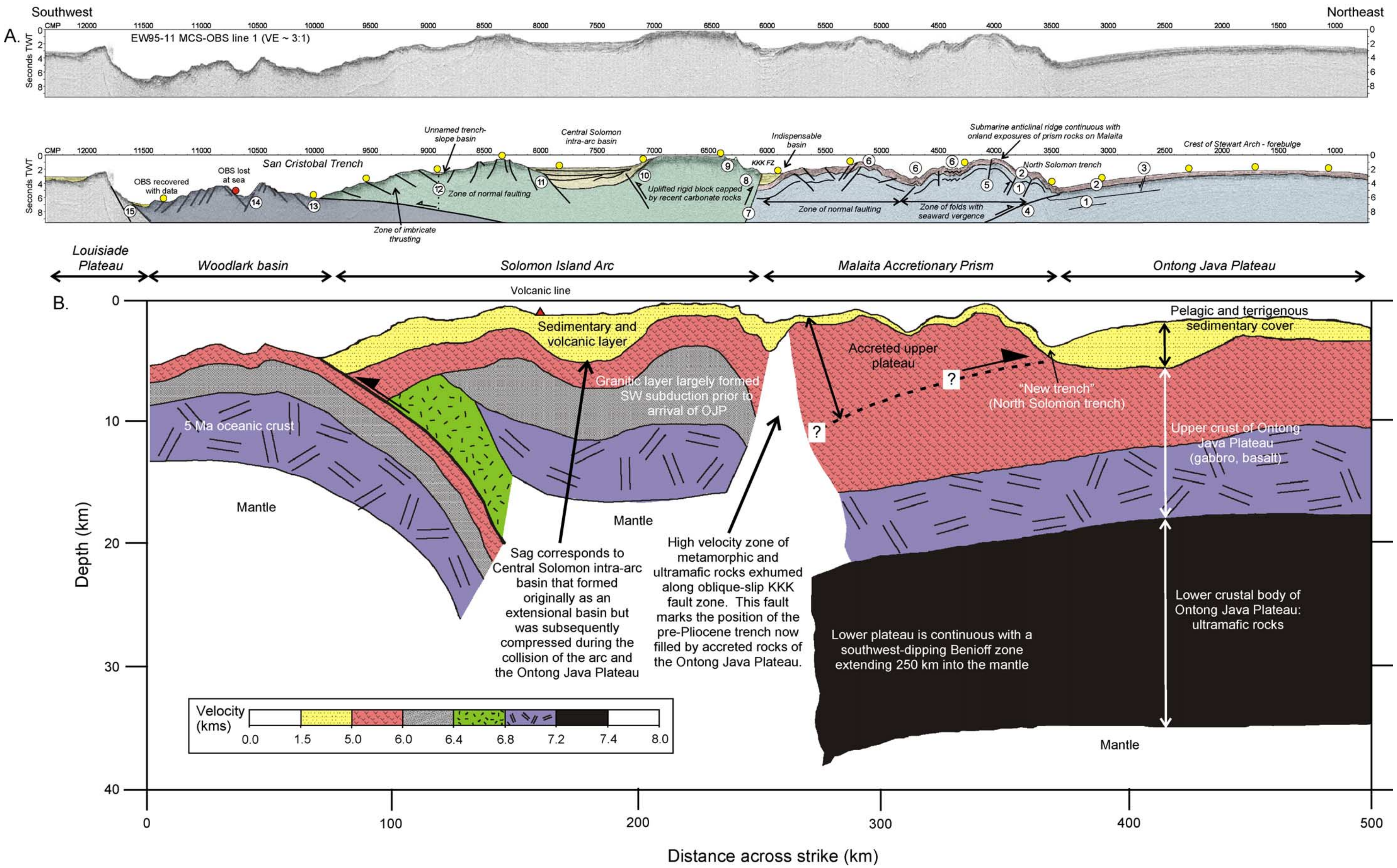


Fig. 11. Interpretation of EW95-11 MCS line 1 illustrating the major geologic provinces of the Solomon Islands shown in map view in Fig. 10. Numbers correspond to features discussed in the text.

line 1 and compare these surficial features to the results of the OBS-based refraction study. We refer the reader to more detailed descriptions in this volume or in other related papers: Ontong Java Plateau (Phinney et al., 1999); Malaita accretionary prism (Phinney et al., 2004); Central Solomon intra-arc basin and adjacent blocks (Cowley et al., 2004) and all areas (Miura et al., 2004). The numbered features below are keyed to the numbers indicated on the section in Fig. 11A.

7.3. Reflection results for Ewing MCS-OBS line 1 (numbers keyed to features shown in Fig. 11A)

7.3.1. Ontong Java Plateau

(1) OJ1 and 2 units. Based on its seismic character and correlation to distant wells, Phinney et al. (1999) interpret seismic unit OJ1 as the the upper basaltic crust of the Cretaceous OJP. These same rocks crop out on islands in the MAP (Petterson et al., 1995, 1999) Deep reflectors within OJ1 probably correspond to either sediment–basalt or basalt–basalt interfaces or alternatively pegleg multiples. Unit OJ2, inferred to be Cretaceous deep-water mudstone and possibly carbonate, unconformably overlies unit OJ1. Unit OJ2 is also thought to crop out in the MAP.

(2) Upper pelagic section. Seismic unit OJ3 is Cenomanian to Recent pelagic limestone capping units OJ1 and OJ2. This unit is also correlated to rocks exposed in the MAP.

(3) Normal faults related to plateau bending. A series of normal faults are seen on the incoming OJP and are related to plate bending as the plateau enters the North Solomon trench (Phinney et al., 1999).

7.3.2. Malaita accretionary prism

(1) Deep reflectors. Similar deep reflectors of unit OJ1 are observed landward of the North Solomon trench in the MAP, lending support to the idea that the MAP was derived by offscraping the upper crust of the OJP.

(2) Upper pelagic section. Similar deep reflectors of unit OJ3 are seen in the MAP, lending support to the idea that the MAP was derived by offscraping the upper crust of the OJP (Petterson et al., 1995, 1999).

(3) North Solomon trench and decollement. The detachment is not well imaged on Line 1 or adjacent lines (Mann et al., 1996a), but the detachment is shown in Fig. 11A to project downdip and separate undisturbed deeper reflectors in OJ1 and folded rocks of the overlying MAP (Phinney et al., 2004). Folding and faulting of young trench deposits demonstrates that convergence is active (Tregoning et al., 1998a; Rahardiawan et al., 2004).

(4) Normal faults within the MAP. These faults affect large anticlines and probably reflect localized crestal extension. An inboad zone of normal faulting appears to have collapsed an earlier-accreted anticline of the MAP. The outboard zone of MAP-related folding appears less affected by normal faults.

(5) Seaward-verging folds of the MAP. All folds in this outer area of the MAP verge seaward and support the present of a single arcward-dipping detachment at the base of the MAP. We see no evidence for landward vergence of folding as mapped in local areas of Malaita by Petterson et al. (1999).

7.3.3. Solomon island arc

(6) KKK fault zone and Indispensable basin. The KKK fault marks the surface trace of the pre-Pliocene trench, now filled at depth by accreted rocks of the OJP (Miura et al., 2004). At shallow depths the fault is an apparent reverse fault which controls the subsidence of the adjacent Indispensable basin on its footwall (Bruns et al., 1986; Cowley et al., 2004). Because the active decollement has jumped seaward to the North Solomon trench, the KKK fault zone now functions as a "backstop fault" against which rocks of the MAP are accreted.

(7) Small accretionary prism. This prism is active and reflects ongoing underthrusting of MAP rocks beneath the Solomon island arc.

(8) Carbonate banks and reefs. This crystalline block of the Solomon island arc is a large structural pop-up block between two high-angle reverse faults. The block has remained close to sea level and mantled by recent carbonate banks and "keep-up" coral reefs.

(9) Inverted normal faults and unconformities. This area was the former normal-faulted margin of the Central Solomon intra-arc basin. Convergence of the OJP in early Pliocene time reactivated or "inverted" these normal faults and produced localized folding that youngs along the length of the trough to the northwest (Cowley et al., 2004).

(10) Normal fault margins of intra-arc basin. This normal fault margin of the Central Solomon intra-arc

basin has maintained its normal character probably because it is farther removed from the OJP convergent area. The late Neogene submerged volcanic line of the Solomon arc occurs in this area (Cowley et al., 2004).

(11) Transition area between zones of normal faults and imbricate thrust faults related to underthrusting at the San Cristobal trench. A small, unnamed slope basin marks this transition area.

(12) San Cristobal trench. This < 5-Ma-old trench is devoid of young sediment and as a result it is characterized by large subduction-related thrust earthquakes including "doublets" probably generated by sequential breakages of hard-rock contacts and asperities along the decollement (Schwartz et al., 1989).

7.3.4. Woodlark basin and Louisiade Plateau

(13) Rift structure in oceanic crust? Mann et al. (1996a) used the symmetrical rift morphology of this feature to infer an abandoned spreading center in 5 Ma old oceanic crust of the Woodlark basin. A. Goodliffe (pers. comm., 1998) notes that there is no magnetic anomaly constraints on the existence of an abandoned ridge in this area.

(14) Rifted margin between the Louisiade Plateau and the Woodlark basin. This rift margin formed about 5 Ma (Taylor et al., 1995).

7.4. Reflection results for Ewing MCS-OBS line 1

7.4.1. Ontong Java Plateau

Refraction data show that the OJP entering the North Solomon trench is 33 km thick and therefore at least four times thicker than normal oceanic crust (Fig. 2) (Miura et al., 2004). The upper crust of the OJP is about 10 km while its lower crust, or "lower crustal body" with a velocity greater than 7 km/s, is about 22 km. This dense crustal root is continuous with a southwest-dipping Benioff zone extending 250 km into the mantle beneath the Solomon Islands (Fig. 9).

7.4.2. Malaita accretionary prism

The velocities of the MAP match that of the upper OJP and further support the idea that the two areas share a common origin (Miura et al., 2004).

7.4.3. Solomon island arc

A layer beneath the arc with a P-wave velocity of 6.0–6.2 km/s is similar in velocity to a layer beneath the Izu–Bonin arc that Suyehiro et al. (1996) attribute to granitic rocks formed by arc-related intrusions. It is likely that this activity records southwest-dipping subduction the Solomon arc prior to the arrival of the OJP as shown in Fig. 6. The prominent, synclinal sag in the arc corresponds to the Central Solomon intra-arc basin. This basin formed originally as an extensional basin in the early Cenozoic but was subsequently compressed during the convergence of the arc and the OJP (Cowley et al., 2004). A high-velocity zone near the KKK fault zone is thought to represent metamorphic and ultramafic rocks exhumed along the oblique-slip KKK fault zone.

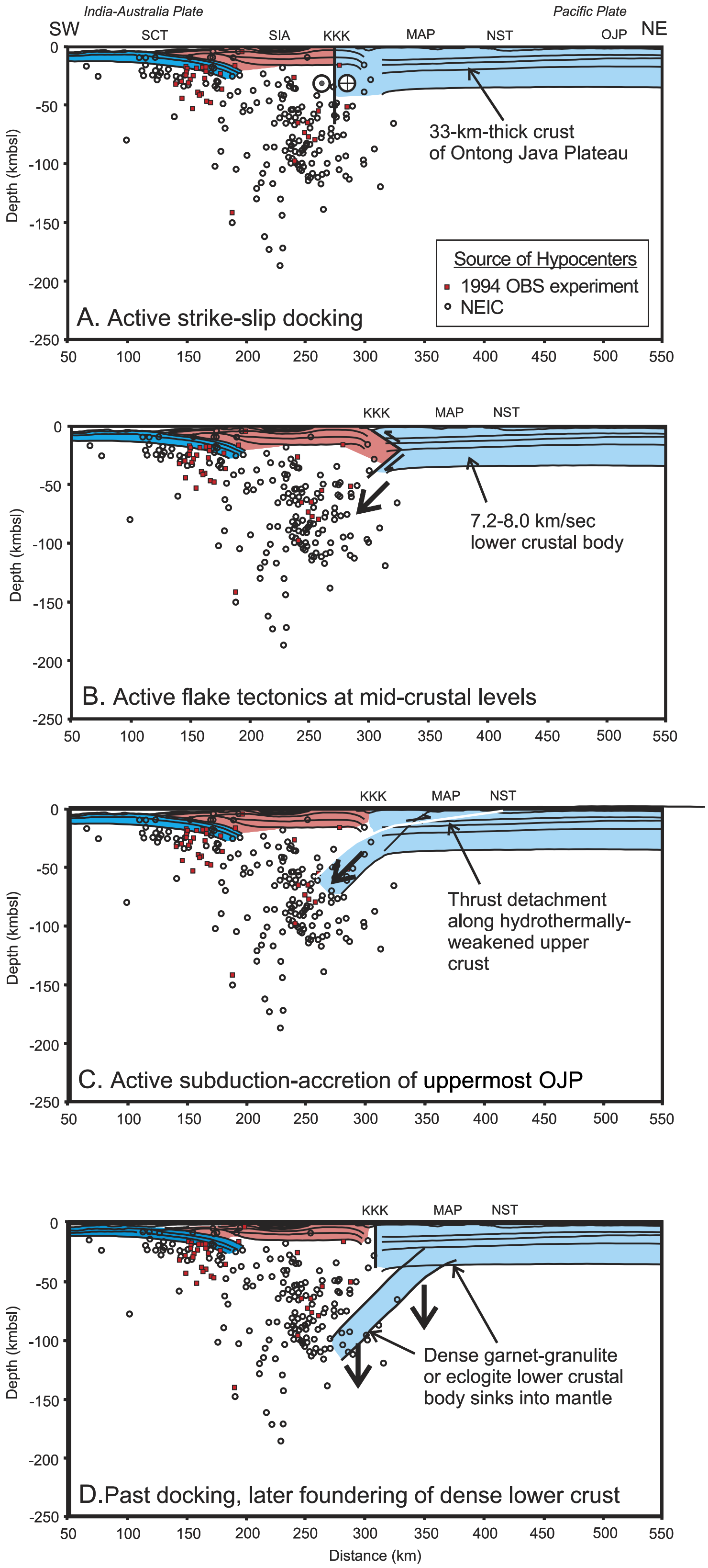
7.4.4. Oceanic crust of Woodlark basin

This 5 Ma old crust is 8 km thick and thicker than normal oceanic crust. Oblique subduction of this thicker-than-average oceanic crust can explain the topographic uplift of the southern part of the Solomon Islands, particularly Guadalcanal (Taylor and Tajima, 1987) (Fig. 8B).

7.4.5. Louisiade Plateau

No refraction results were attempted across this feature.

Fig. 12. Four possible models for the current interactions between the Ontong Java Plateau and the Solomon island arc compared to the known velocity structure and best located earthquake hypocenters of the convergence zone (line of section of hypocenters is taken parallel to transect 1 shown on the map in Fig. 10 and in cross section in Fig. 11. (A) Strike–slip docking (Ryan and Coleman, 1992). The OJP is juxtaposed by strike–slip faults along the KKK fault zone and North Solomon trench. Cessation of strike–slip motion "docks" or emplaces the plateau against the margin. (B) Active "flake tectonics" (Oxburgh, 1972). Arc rocks of the Solomon Islands act as a wedge into the incoming Ontong Java Plateau. The upper part of the plateau is overthrust southwestwards onto the arc (thrust faults dip northeast). (C) Active subduction–accretion (Phinney et al., 2004; Rahardiawan et al., 2004). The upper 20% of the plateau basalts and overlying pelagic sedimentary rocks are accreted to the front of the arc. Thrust faults dip southwest. (D) Ancient collision and foundering of the dense lower crust, or lower crustal body (cf. Fig. 3) (Kerr et al., 1997). High-density garnet granulite (or even eclogite) in the lower crustal body may founder at the subduction zone and lead to progressive subduction–erosion even after the cessation of active plate convergence.


India-Australia Plate
Pacific Plate
SW
NE
SCT
SIA
KKK
MAP
NST
OJP
Depth (kmbsl)
33-km-thick crust
of Ontong Java Plateau
Source of Hypocenters
1994 OBS experiment
NEIC
A. Active strike-slip docking
7.2-8.0 km/sec
lower crustal body
B. Active flake tectonics at mid-crustal levels
Thrust detachment
along hydrothermally-
weakened upper
crust
C. Active subduction-accretion of uppermost OJP
Dense garnet-granulite
or eclogite lower crustal
body sinks into mantle
D.Past docking, later foundering of dense lower crust
Distance (km)

8. Discussion

8.1. Fate of the Ontong Java Plateau at the Solomon subduction zone

Fig. 12A–D summarizes four possible fates of the Ontong Java Plateau at the Solomon subduction zone. These scenarios have been discussed in general terms by Saunders et al. (1996) and by Petterson et al. (1995, 1999) for the Solomon Islands using onland geologic data from the Malaita accretionary prism. We briefly summarize the main observations presented in this paper and the volume as a whole to distinguish the most realistic model. We superimpose the predicted structures on the known crustal structure of the convergent zone and best-located hypocenters from Miura et al. (2004).

8.1.1. Active strike–slip docking

Plateau-arc docking could occur in this mode by cessation of motion along a sub-vertical strike–slip fault (Fig. 12A). With the exception of the KKK fault, a sinistral oblique–slip reverse fault, we find no evidence in the geophysical data set shown in Fig. 10 for regional-scale strike–slip faults in either the MAP (Phinney et al., 2004) or the Central Solomon intra-arc basin (Cowley et al., 2004). This finding contradicts previous proposals for regional-scale, sinistral strike–slip faults by Wells (1989), Ryan and Coleman (1992), and Auzende et al. (1994).

8.1.2. Active flake tectonics at mid-crustal levels

Oxburgh (1972) proposed the idea that, when two plates collide, it is possible for large, sheet-like masses or material (“flakes”) to be sheared from the top of one plate and driven over the other for distances of more than 100 km. One block acts as a triangular wedge that splits the other block into a thin upper flake that overrides it and a thick lower slab that dips beneath it. This process, which has recently become known as “tectonic wedging” (Unruh et al., 1991), has been documented from mainly onland reflection profiles across the mountain fronts of fold–thrust belts (Vann et al., 1986). Hoffman and Ranalli (1988) note that flaking may have been more common in the Precambrian than the Phanerozoic because Precambrian oceanic crust was thicker and more prone to delamination during subduction.

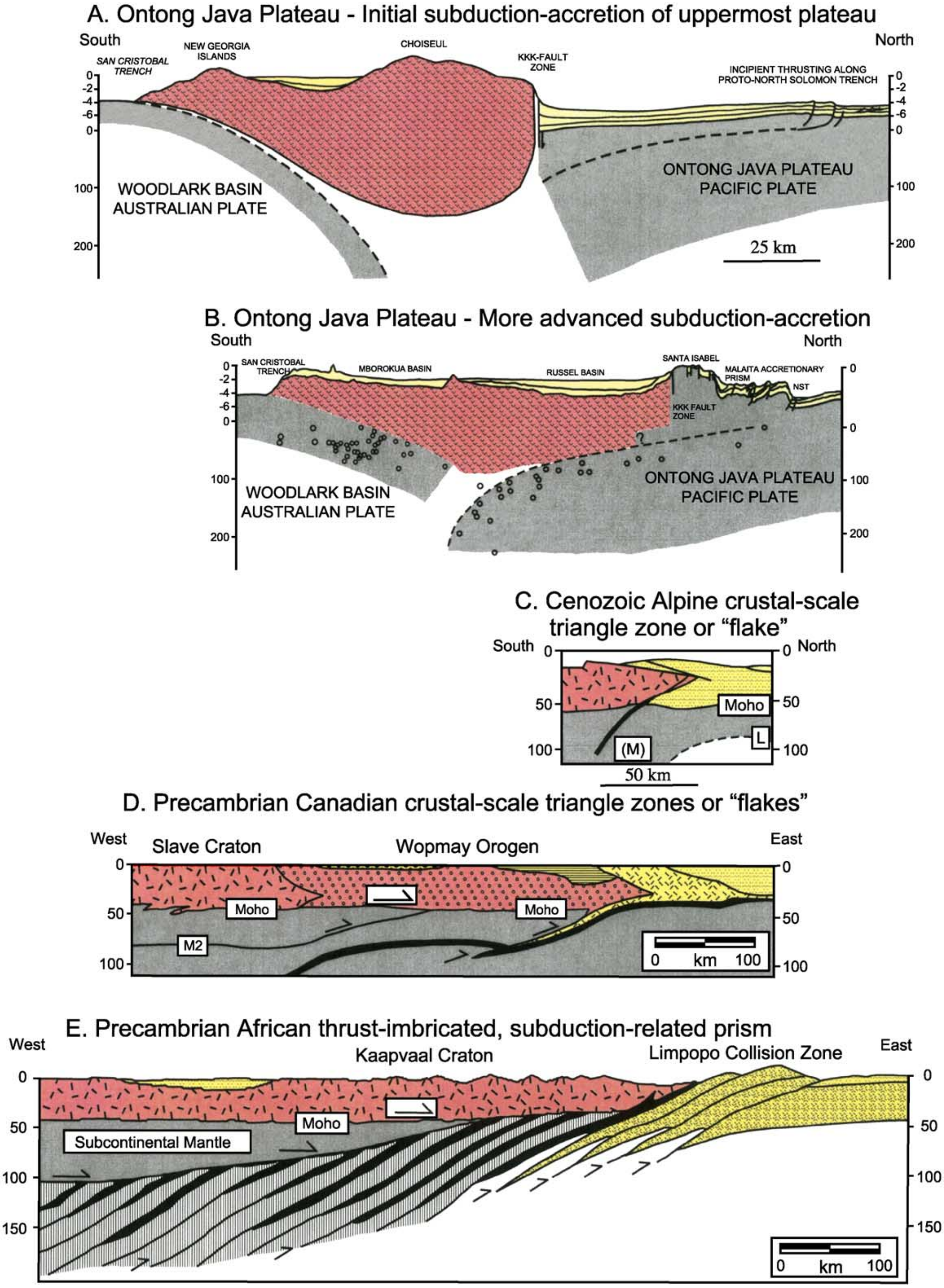
Unruh et al. (1991) point out examples of tectonic wedging in the forearc setting of the Great Valley of California and the Barbados area of the Lesser Antilles. In both forearc and fold–thrust belt settings, wedging appears to always be associated with thrusting towards a thick continental or heavily sedimented block. A diagnostic characteristic of wedging are unfaulted monoclines dipping towards the foreland.

The remarkable consistency of seaward-verging folds in the MAP (Phinney et al., 2004; Rahardiawan et al., 2004) and on Malaita and Santa Isabel (Petterson et al., 1999) does not support active, arcward-verging flake tectonics in the manner described by Oxburgh (1972) and Unruh et al. (1991) (Fig. 12). Moreover, almost all lines crossing the North Solomon trench show a southwestward-dipping thrust, rather than an unfaulted monocline expected for thrust wedging.

8.1.3. Active subduction–accretion of the uppermost crust of the OJP

Our reflection lines across the MAP support the idea of frontal subduction–accretion of the uppermost crust of the OJP (Phinney et al., 2004; Rahardiawan et al., 2004). Our seismic lines unfortunately only resolve the arcward-dipping detachment on two lines, 26 and 28, from the western part of the MAP (Fig. 13A). The structural style of the prism consists of

Fig. 13. Comparison of pattern of deformation observed in Ontong Java Plateau–Solomon arc convergent zone with examples of Phanerozoic and Precambrian patterns of deformation in collision zones. Key to lithospheric compositions: red = upper crustal, mainly igneous rocks; yellow = upper crustal, mainly sedimentary rocks; gray and black = upper mantle, mainly ultramafic rocks. (A) Ontong Java Plateau—initial subduction–accretion of uppermost plateau in western Malaita accretionary prism (modified from Rahardiawan et al., 2004). Open dots represent ISC hypocenters (M>4.0). (B) Ontong Java Plateau—more advanced subduction–accretion in eastern Malaita accretionary prism. (C) Cenozoic Alpine crustal-scale triangle zone or “flake” (modified from Oxburgh, 1972); L = base of lithosphere; M = subducted Moho. (D) Precambrian Canadian crustal-scale triangle zones or “flakes” (modified from Cook et al., 1998); M2 = base of Slave Province mantle. (E) Precambrian African thrust-imbricated, subduction-related prism (modified from Helmstaedt and Schulze, 1986). See text for discussion.


A. Ontong Java Plateau - Initial subduction-accretion of uppermost plateau
South
North
SAN CRISTOBAL TRENCH
NEW GEORGIA ISLANDS
CHOISEUL
KKK-FAULT ZONE
INCIPIENT THRUSTING ALONG PROTO-NORTH SOLOMON TRENCH
WOODLARK BASIN
AUSTRALIAN PLATE
ONTONG JAVA PLATEAU
PACIFIC PLATE
25 km
B. Ontong Java Plateau - More advanced subduction-accretion
South
North
SAN CRISTOBAL TRENCH
MBOROKUA BASIN
RUSSEL BASIN
SANTA ISABEL
MALAITA ACCRETIONARY PRISM
NST
KKK FAULT ZONE
WOODLARK BASIN
AUSTRALIAN PLATE
ONTONG JAVA PLATEAU
PACIFIC PLATE
C. Cenozoic Alpine crustal-scale triangle zone or "flake"
South
North
Moho
(M)
L
50 km
D. Precambrian Canadian crustal-scale triangle zones or "flakes"
West
East
Slave Craton
Wopmay Orogen
Moho
Moho
M2
0 km 100
E. Precambrian African thrust-imbricated, subduction-related prism
West
East
Kaapvaal Craton
Limpopo Collision Zone
Moho
Subcontinental Mantle
0 km 100

thrust offsets and related fault propagation folds that progressively decrease to the west in the younger part of the prism (Rahardiawan et al., 2004). This fault possibly imaged on our two western lines because it is the propagating nortwestward in this area and has not been subject to overprinting by continued convergence as in areas more to the east (Fig. 13B).

The youngest area of accretion shows active accretion of about 1 km of sedimentary rocks and 6 km of the upper crystalline part of the plateau (Phinney et al., 2004; Fig. 13). The lower 80% of the plateau crust beneath the MAP thrust decollement appears unfaulted and unfolded and is continuous with a southwestward-dipping subducted slab of presumably denser plateau material (lower crustal body) (Miura et al., 2004) (Fig. 9).

8.1.4. Past docking, later foundering of dense oceanic crust

Saunders et al. (1996) propose that high-density garnet granulite or even eclogite exists in the lower crustal bodies of large plateaus, like the Ontong Java, and is subject to foundering under its own weight into the mantle (Fig. 12D). This foundering would be prompted by mineral phase transitions and could occur long after docking and the cessation of active subduction.

Foundering of the lower crustal body in the Solomon subduction is certainly possible given the 250 km length of slab subducted along the KKK fault and North Solomon trench and the existence of the accreted upper part of the plateau as the MAP (Fig. 9). However, recent deformation of North Solomon trench sediments (Phinney et al., 2004; Rahardiawan et al., 2004) and GPS results (Tregoning et al., 1998a) indicate continued plateau-arc convergence is the likely tectonic driver for delamination rather than gravity acting alone upon the dense, lower crustal body.

8.2. Oceanic plateaus and arcs as potential building blocks of continental crust

8.2.1. Ontong Java Plateau

To our knowledge (Table 2A), the Ontong Java Plateau–Solomon island arc convergent zone is the only known example on Earth of active accretion of a plateau at subduction zone. The Ontong Java Plateau is also now established as the largest and thickest (33 km) on Earth (Miura et al., 2004).

Our observations from this study indicate that oceanic plateaus are not significant contributors to the crustal growth of arcs, and therefore, to continental growth (Fig. 13A,B). In contrast, Cloos (1993) used isostatic arguments to predict that oceanic plateaus greater than 18 km in crustal thickness (or about half the thickness of the Ontong Java Plateau) are incapable of subduction and would result in complete accretion to continents (Fig. 2). The almost complete subduction of the Ontong Java Plateau shown by our studies indicates that the feature is considerably less buoyant than estimated by Cloos (1993). Improved buoyancy estimates would require a more detailed knowledge of lithospheric densities of the plateau.

The shallow depth of detachment of the Ontong Java Plateau supports the prediction by Kerr et al. (1997) that the depth of detachment of plateaus may occur at the base of hydrothermal circulation cells, where rheologically weak, altered rock is underlain by fresh dolerites and gabbro (Fig. 13A). Weakening could also be related to the formation of numerous, normal faults formed during flexure of the plateau as it enters the trench (Phinney et al., 1999) (Fig. 11). Our observations do not support deeper predicted depths of detachment near the Moho (Schubert and Sandwell, 1989; Kerr et al., 1997) (Fig. 2).

8.2.2. Arcs

In Fig. 14, we compare the crustal structure of the Solomon arc with the Aleutian (Holbrook et al., 1999) and Izu–Bonin (Suyehiro et al., 1996) arcs that were studied by other groups using similar wide-angle experiments. The morphology and crustal structure of the Solomon arc contrasts strongly with the other two arcs because the Solomon arc is being compressed in a vice-like manner between the incoming Ontong Java Plateau and thickened crust of the Woodlark basin and Louisiade Plateau (Figs. 7 and 8B). Major differences in the crustal structure of the Solomon arc in comparison to the Aleutians and Izu–Bonin arcs are: (1) the presence of the Central Solomon intra-arc basin, an Oligocene–Miocene extensional basin compressed in Pliocene–recent time (Cowley et al., 2004) and; and (2) the larger accretionary prism, related to offscraping of Ontong Java Platea (Fig. 14).

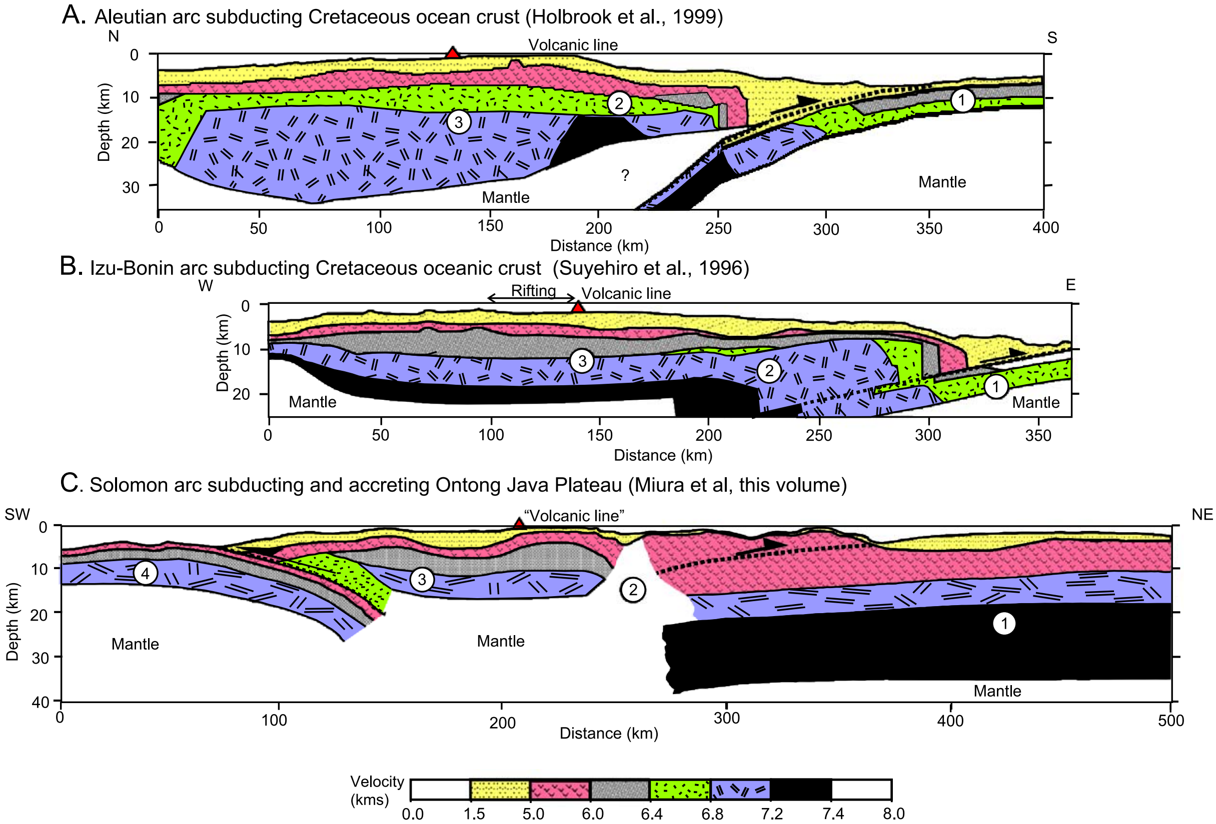


Fig. 14. Comparison of the crustal structure of the Japanese arc (Suyehiro et al., 1996), the Aleutian arc (Holbrook et al., 1999) and the Ontong Java Plateau (Miura et al., 2004). (A) Key to numbered features for Aleutian arc: 1 = incoming Pacific oceanic plate; 2 = sialic upper arc crust; 3 = mafic, lower arc crust. See text for discussion and explanation of numbered features on the sections. (B) Key to numbered features for Izu–Bonin arc: 1 = incoming Philippine oceanic plate; 2 = tonalitic arc crust; 3 = base of upper arc. (C) Key to numbered features for the Ontong Java–Solomon arc convergent zone: 1 = 33-km-thick crust of the Ontong Java Plateau; 2 = data gap along the KKK fault zone (suture between plateau and arc); 3 = tonalitic lower crust of the Solomon arc; 4 = young oceanic crust of the Woodlark basin.

Miura et al. (2004) note that both the Solomon and Izu–Bonin arc share a similar middle crustal unit with Vp = 6.0–6.4 km/s and making up about one quarter of the arc's volume. Suyehiro et al. (1996), Taira (1998, 2001), and Aoike (1999) have documented the obduction of the Izu–Bonin arc (including the tonalite belt) during the collision of the arc with southern Japan about 15 Ma. The infer is that the obducted, central part of the arc with tonalitic composition has a hotter, thicker, and more intermediate crust that is more prone to obduction upon collision. By analogy, it could be argued that the tonalitic part of the Solomon arc might also be prone to obduction and preservation upon convergence.

In contrast to the Solomon and Izu–Bonin arc, the Aleutian arc exhibits a more mafic crustal composition that lacks the inferred tonalitic layer observed in the other two arcs (Holbrook et al., 1999) (Fig. 14). The contrast in the Aleutians structure suggests the potential for a large amount of variability in the crustal structure of arcs that may relate to many different parameters such as subduction rate, age and thickness of subducting lithosphere, presence of back-arc extension, and obliquity of subduction. Holbrook et al. (1999) conclude that—if arcs form a significant source for continental crust—the bulk properties of mafic arc like the Aleutians must be modified during or after accretion to margins. For example, modification might involve the delamination of mafic to ultramafic residuum is required to transform arc crust into mature continental crust.

Our study offers few insights onto the fate of the Solomon arc or its preservation potential following its convergence with the Ontong Java Plateau. The most profound effect of the Ontong Java Plateau convergence on the Solomon arc is the large-scale folding of the arc crust (i.e., modification of the intra-arc basin structure into a large syncline).

8.3. Comparison of active accretion of the Ontong Java Plateau to ancient examples

Because the Ontong Java Plateau convergence offers the only known modern example of oceanic plateau accretion at a subduction zone, it is instructive to compare its structure to some of the better studied examples of ancient plateau accretion (Fig. 13). As previously discussed, we see no evidence for "flaking" or "tectonic wedging" observed in the Cenozoic Alpine collision (Oxburgh, 1972) (Fig. 13C), in forearc settings (Unruh et al., 1991), and in Precambrian lithosphere of northwestern Canada (Cook et al., 1998) (Fig. 13D).

Instead, the dominant structure style we observe in the Malaita accretionary prism is thrust-imbrication as a result of subduction accretion (Phinney et al., 2004; Rahardiawan et al., 2004) (Fig. 13A,B). Based on our compilation of previous studies (Table 2A), we propose that the structural style of many Precambrian and Phanerozoic obducted plateaus is similar to what we describe from the Solomon Islands: that is, distinct fault slivers of various lithologies of the upper crust and sedimentary cover of the plateau deformed by imbricate thrust faults (Desrochers et al., 1993; Kimura and Ludden, 1995; Kerr et al., 2000; Struik et al., 2001; Polat and Kerrich, 2001). These imbricated slices generally are basaltic and represent only the uppermost part of the plateau as have been documented by onland studies in the Solomon Islands (Petterson et al., 1995, 1999). The lower part of the plateau is presumably completely subducted into the mantle as we observe in the Solomon Islands.

In Fig. 13E, we show an interpretation of a thrust-imbricated accretionary prism of the Precambrian Limpopo belt by Helmstaedt and Schulze (1986) that is broadly similar to the imbricated structure we see in the Malaita accretionary prism. The African greenstone belts including the Limpopo and other greenstone belts worldwide are now thought to represent the offscraped remnants of Precambrian oceanic plateaus (Kusky and Kidd, 1992; Kusky, 1998). The imbricated and underplated Precambrian plateau shown in Fig. 13E is also similar to the pattern of deformation observed for the Siletz terrane underplated along the Oregon margin in Eocene time (Trehu et al., 1994). In conclusion, the structural and style of the active example of plateau accretion in the Solomon Islands supports the view that only the upper crust of ancient oceanic plateaus is preserved in the form of thrust-imbricated, accretionary wedges.

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References

Abbott, D., 1996. Plumes and hotspots as sources of greenstone belts. Lithos 37, 113–127.

Abbott, D., Mooney, W., 1995. The structural and geochemical evolution of the continental crust: support for the oceanic plateau model of continental growth. Reviews of Geophysics, 231–242 (Supplement, July).

Abers, G., McCaffrey, R., 1988. Active deformation in the New Guinea fold-and-thrust belt: seismological evidence for strike–slip faulting and basement-involved thrusting. Journal of Geophysical Research 93, 13332–13354.

Albarede, F., 1996. The growth of continental crust. Tectonophysics 296, 1–14.

Aoike, K., 1999. Tectonic evolution of the Izu collision zone. Research Report of the Kanagawa Prefectural Museum of Natural History 9, 113–151 (in Japanese).

Audley-Charles, M., 1991. Tectonics of the New Guinea area. Annual Review of Earth and Planetary Sciences 19, 17–41.

Auzende, J., Lafoy, Y., Marsset, B., 1988. Recent geodynamic evolution of the north Fiji basin (southwest Pacific). Geology 16, 925–929.

Auzende, J.-M., Collot, J.-Y., Lafoy, Y., Gracia, E., Geli, L., Ondreas, H., Eissne, J.-P., Larue, M.B., Olisukulu, C., Tolia, D., Biliki, N., 1994. Evidence for sinistral strike–slip deformation in the Solomon island arc. Geo-Marine Letters 14, 232–237.

Auzende, J., Pelletier, B., Eissen, J., 1995. The North Fiji basin: geology, structure, and geodynamic evolution. In: Taylor, B. (Ed.), Back-arc Basins: Tectonics and Magmatism. Plenum, New York, pp. 139–175.

Ballance, P., Scholl, D., Vallier, T., Stevenson, A., Ryan, H., Herzer, R., 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.

Bevis, M., Taylor, F., Schutz, B., Recy, J., Isacks, B., Helu, S., Singh, R., Kendrick, E., Stowell, J., Taylor, B., Calmant, S., 1995. Geodetic observations of very rapid convergence and back-arc extension at the Tonga arc. Nature 374, 249–251.

Bogdanov, N., Dobretsov, N., 2002. The Okhotsk volcanic oceanic plateau. Geologiya i Geofizika (Russian Geology and Geophysics) 43, 87–99.

Bosch, D., Gabriele, P., Lapierre, H., Malfere, J., Jaillard, E., 1999. Geodynamic significance of the Raspas metamorphic complex (SW Ecuador): geochemical and isotopic constraints. Tectonophysics 345, 83–102.

Bruns, T., Cooper, A., Vedder, J., 1986. Seismic stratigraphy and structure of sedimentary basins in the Solomon Islands region. In: Vedder, J., Pound, K., Boundy, S. (Eds.), Geology and Offshore Resources of the Pacific Island Arcs-Central and Western Solomon Islands. Circum-Pacific Council for Energy and Mineral Resources, vol. 4. Earth Science Series, Houston, TX, pp. 177–214.

Bruns, T., Vedder, J., Culotta, R., 1989. Structure and tectonics along the Kilinailau trench, Bougainville–Buka region, Papua New Guinea. In: Vedder, J., Bruns, T. (Eds.), Geology and Offshore Resources of the Pacific Island Arcs–Solomon Islands and Bougainville, Papua New Guinea Regions. Circum-Pacific Council for Energy and Mineral Resources, vol. 12. Earth Science Series, Houston, TX, pp. 93–123.

Cande, S., Kent, D., 1995. Revised calibration of the geomagnetic polarity timescale for the Late Cretaceous and Cenozoic. Journal of Geophysical Research 100, 6093–6095.

Carney, J.N., Macfarlane, A., 1982. Geological evidence bearing on the Miocene to recent structural evolution of the New Hebrides arc. Tectonophysics 87, 147–175.

Christensen, N., Mooney, W., 1995. Seismic velocity structure and composition of the continental crust: a global view. Journal of Geophysical Research 100, 9761–9788.

Cloos, M., 1993. Lithospheric buoyancy and collisional orogenesis: subduction of oceanic plateaus, continental margins, island arcs, spreading ridges, and seamounts. Geological Society of America Bulletin 105, 715–737.

Cluzel, D., Picard, C., Aitchinson, J., Laporte, C., Meffre, S., Parat, F., 1997. The Poya terrane (formerly Formation des Basaltes) of New Caledonia, southwest Pacific: a Campanian-upper Paleocene oceanic plateau obducted during the upper Eocene. Comptes Rendus de l'Académie des Sciences. Série 2. Sciences de la Terre et des Planètes 324, 433–451.

Coffin, M., Eldholm, O., 1994. Large igneous provinces: crustal structure, dimensions, and external consequences. Reviews of Geophysics 32, 1–36.

Coffin, M., Eldholm, O., 2001. Large igneous provinces: progenitors of some ophiolites? In: Ernst, R., Buchan, K. (Eds.), Mantle Plumes: Their Identification Through Time. Special Paper-Geological Society of America, vol. 352, pp. 59–70.

Coleman, P., Hackman, B., 1974. Solomon Islands. Mesozoic–Cenozoic Orogenic Belts: Data for Orogenic Studies. Special Publication-Geological Society of London, vol. 4, pp. 453–461.

Condie, K., 1997. Contrasting sources for upper and lower continental crust: the greenstone connection. Journal of Geology 105, 729–736.

Cook, F., van der Velden, A., Hall, K., Roberts, B., 1998. Tectonic delamination and subcrustal imbrication of the Precambrian lithosphere in northwestern Canada mapped by LITHOPROBE. Geology 26, 839–842.

Cooper, P.A., Taylor, B., 1985. Polarity reversal in the Solomon Islands arc. Nature 314, 428–430.

Cooper, P., Taylor, B., 1987. Seismotectonics of New Guinea: a model for arc reversal following arc–continent collision. Tectonics 6, 53–67.

Cooper, P., Taylor, B., 1988. Seismotectonics of New Guinea: a model for arc reversal following arc-continent collission. Tectonics 6, 53–67.

Cooper, P., Taylor, B., 1989. Seismicity and focal mechanisms at the New Britain trench related to deformation of the lithosphere. Tectonophysics 164, 25–40.

Coulson, F., Vedder, J., 1986. Geology of the central and western Solomon Islands. In: Vedder, J., Pound, K., Boundy, S. (Eds.), Geology and Offshore Resources of the Pacific Island Arcs-Central and Western Solomon Islands. Circum-Pacific Council for Energy and Mineral Resources, vol. 4. Earth Science Series, Houston, TX, pp. 59–87.

Cowley, S., Mann, P., Coffin, M.F., Shipley, T.H., 2002. Oligocene to recent tectonic history of the Central Solomon intra-arc basin as determined from marine seismic reflection data and compilation of onland geology. Tectonophysics 389, 267–307.

Crook, K., Belbin, L., 1978. The southwest Pacific area during the last 90 million years. Journal of the Geological Society of Australia 25, 23–40.

Crook, K., Taylor, B., 1994. Structure and Quaternary tectonic history of the Woodlark triple junction region, Solomon Islands. Marine Geophysical Researches 16, 65–89.

Davy, B., Wood, R., 1994. Gravity and magnetic modelling of the Hikurangi Plateau. Marine Geology 118, 139–151.

DeMets, C., Gordon, R., Argus, D., Stein, S., 1994. Effect of recent revisions to the geomagnetic reversal time scale on estimates of current plate motions. Geophysical Research Letters 21, 2191–2194.

Desrochers, J., Hubert, C., Ludden, J., Pilote, P., 1993. Accretion of Archean oceanic plateau fragments in the Abitibi greenstone belt, Canada. Geology 21, 451–454.

Driscoll, N., Diebold, J., 1999. Tectonic and stratigraphic development of the eastern Caribbean: new constraints from multichannel seismic data. In: Mann, P. (Ed.), Caribbean Basins. Sedimentary Basins of the World, vol. 4. Elsevier, Amsterdam, pp. 591–626. K. Hsu, series editor.

Duncan, R., Richards, M., 1991. Hotspots, mantle plumes, flood basalts, and true polar wander. Reviews of Geophysics 29, 31–50.

Exxon Tectonic Map of the World, 1985. World Mapping Project, Exxon Production Research Company, Houston, TX.

Farnetani, C., Richards, M., Ghiorso, M., 1996. Petrological models of magma evolution and deep crustal structure beneath hotspots and flood basalt provinces. Earth and Planetary Science Letters 143, 81–94.

Franco, H., Abbott, D., 1999. Gravity signatures of terrane accretion. Lithos 46, 5–15.

Frey, B., Condie, K., Kerrich, R., 2001. The Iron King volcanics: a remnant of an oceanic plateau accreted to southwestern Laurasia 1.7 Ga. Abstracts with Programs-Geological Society of America, Rocky Mountain Section 33, 24.

Gaina, C., Mueller, D., Royer, J., Symonds, P., 1999. Evolution of the Louisiade triple junction. Journal of Geophysical Research 104, 12927–12939.

Gill, J.B., Stork, A.L., Whelan, P.M., 1984. Volcanism accompanying back-arc basin development in the southwest Pacific. Tectonophysics 102, 207–224.

Gladzenko, T., Coffin, M., Eldholm, O., 1997. Crustal structure of the Ontong Java Plateau: modeling of new gravity and existing seismic data. Journal of Geophysical Research 102, 22711–22729.

Gorbatov, A., Widiyantoro, S., Fukao, Y., Gordeev, E., 2000. Signature of remnant slabs in the North Pacific from P-wave tomography. Geophysical Journal International 142, 27–36.

Gutscher, M., Olivet, J., Aslanian, D., Eissen, J., Maury, R., 1999. The "lost Inca plateau": cause of flat subduction beneath Peru? Earth and Planetary Science Letters 171, 335–341.

Hackman, B.D., 1979. Geology of the Honiara area. Bulletin—Solomon Islands Geological Survey 3. 46 pp.

Hagen, R., Moberly, R., 1994. Tectonic effects of a subducting aseismic ridge: the subduction of the Nazca ridge at the Peru trench. Marine Geophysical Researches 16, 145–161.

Hall, R., 2002. Cenozoic geological and plate tectonic evolution of SE Asia and the SW Pacific: computer-based reconstructions, model, and animations. Journal of Southeast Asian Sciences 20, 353–434.

Hall, R., Spakman, W., 2002. Subducted slabs beneath the eastern Indonesia–Tonga region: insights from tomography. Earth and Planetary Science Letters 201, 321–336.

Hamburger, M., Isacks, B., 1987. Deep earthquakes in the southwest Pacific: a tectonic interpretation. Journal of Geophysical Research 92, 13841–13854.

Hamburger, M., Isacks, B., 1988. Diffuse backarc deformation in the southwestern Pacific. Nature 332, 599–604.

Hauff, F., Hoernle, K., Tilton, G., Graham, D., Kerr, A., 2000. Large volume recycling of oceanic lithosphere over short time scales: geochemical constraints from the Caribbean Large Igneous Province. Earth and Planetary Science Letters 174, 247–263.

Helmstaedt, H., Schulze, D., 1986. Southern African kimberlites and their mantle sample: implication for Archean tectonics and lithosphere evolution. In: Ross, J. (Ed.), Kimberlites and Related Rocks. Special Publication-Geological Society of Australia, vol. 14, pp. 358–368.

Hoffman, P., Ranalli, G., 1988. Archean oceanic flake tectonics. Geophysical Research Letters 15, 1077–1080.

Holbrook, S., Lizarralde, D., McGeary, S., Bangs, N., Diebold, J., 1999. Structure and composition of the Aleutian island arc and implications for continental growth. Geology 27, 31–34.

Hsui, A., Youngquist, S., 1985. A dynamic model of the curvature of the Mariana trench. Nature 318, 455–457.

Hughes, G.W., 2004. Accretion of the Ontong Java plateau to the Solomon arc: a historical perspective. Tectonophysics 389, 127–136.

Hughes, G., Turner, C., 1977. Upraised Pacific Ocean floor, southern Malaita. Geological Society of America Bulletin 88, 412–424.

Hughes, G., Varol, O., Dunkley, P., 1986. Pleistocene uplift of Tetepare Island, Solomon Group, as implied by foraminiferal and calcarous nannofossil evidence. Bulletin-Royal Society of New Zealand 24, 397–408.

Karig, D., Mammerickx, J., 1972. Tectonic framework of the New Hebrides island arc. Marine Geology 12, 187–205.

Kay, R., Kay, S., 1988. Crustal recycling and the Aleutian arc. Geochimica et Cosmochimica Acta 52, 1351–1359.

Kerr, A., Mariner, G., Arndt, N., Tarney, J., Nivia, A., Saunders, A., Duncan, R., 1996. The petrogenesis of Gorgona komatiites, picrites, and basalts: new field, petrographic, and geochemical constraints. Lithos 37, 245–260.

Kerr, A., Tarney, J., Marriner, G., Nivia, A., Saunders, A., 1997. The Caribbean–Colombian Cretaceous igneous province: the internal anatomy of an oceanic plateau. In: Mahoney, J., Coffin, M. (Eds.), Large Igneous Provinces: Continental, Oceanic, and Planetary Flood Volcanism. American Geophysical Union, Washington, DC, pp. 123–144.

Kerr, A., Tarney, J., Nivia, A., Marriner, G., Saunders, A., 1998. The internal structure of oceanic plateaus: inferences from obducted Cretaceous terranes in western Colombia and the Caribbean. Tectonophysics 292, 173–188.

Kerr, A., White, R., Saunders, A., 2000. LIP reading: recognizing oceanic plateaux in the geological record. Journal of Petrology 41, 1041–1056.

Kimura, G., Ludden, J., 1995. Peeling oceanic crust in subduction zones. Geology 23, 217–220.

Kimura, G., Sakakibara, M., Okamura, M., 1994. Plumes in central Panthalassa: deductions from accreted oceanic fragments in Japan. Tectonics 13, 905–916.

Kolarsky, R., Mann, P., Montero, W., 1995. Island arc response to shallow subduction of the Cocos Ridge, Costa Rica. In: Mann, P. (Ed.), Geologic and Tectonic Development of the Caribbean Plate Boundary in Southern Central America. Special Paper-Geological Society of America, vol. 295, pp. 235–262.

Kroenke, L., 1972. Geology of the Ontong Java Plateau. Unpublished PhD dissertation. University of Hawaii. 119 pp.

Kroenke, L., 1989. Intepretation of multi-channel seismic reflection profile northeast of the Solomon Islands from the southern flank of the Ontong Java Plateau across the Malaita anticlinorium to the Solomon island arc. In: Vedder, J., Bruns, T. (Eds.), Geology and Offshore Resources of the Pacific Island Arcs–Solomon Islands and Bougainville, Papua New Guinea regions. Circum-Pacific Council for Energy and Mineral Resources, vol. 12. Earth Science Series, Houston, TX, pp. 145–148.

Kroenke, L., Resig, J., Cooper, P., 1986. Tectonics of the southeastern Solomon Islands: formation of the Malaita anticlinorium. In: Vedder, J., Pound, K., Boundy, S. (Eds.), Geology and Offshore Resources of the Pacific Island Arcs-Central and Western Solomon Islands. Circum-Pacific Council for Energy and Mineral Resources, vol. 4. Earth Science Series, Houston, TX, pp. 109–116.

Kusky, T., 1998. Tectonic setting and terrane accretion of the Archean Zimbabwe craton. Geology 26, 163–166.

Kusky, T., Kidd, W., 1992. Remnants of an Archean oceanic plateau, Belingwe greenstone belt, Zimbabwe. Geology 20, 43–46.

Lapierre, H., Dupuis, V., Mercier de Lepinay, B., Bosch, D., Monie, P., Tardy, M., Maury, R., Hernandez, J., Polve, M., Yeghicheyan, D., Cotten, J., 1999. Late Jurassic oceanic crust and upper Cretaceous Caribbean plateau picritic basalts exposed in the Duarte igneous complex, Hispaniola. Journal of Geology 107, 193–207.

Lapierre, H., Bosch, D., Dupuis, V., Polve, M., Maury, R., Hernandez, J., Monie, P., Yeghicheyan, D., Jaillard, E., Tardy, M., Mercier de Lepinay, B., Mamberti, M., Desmet, A., Keller, F., Senebier, F., 2000. Multiple plume events in the genesis of the peri-Caribbean Cretaceous oceanic plateau province. Journal of Geophysical Research 105, 8403–8421.

Lassiter, J., DePaolo, D., Mahoney, J., 1995. Geochemistry of the Wrangellia flood basalt province: implications for the role of continental and oceanic lithosphere in flood basalt genesis. Journal of Petrology 36, 983–1009.

Lee, T., Lawver, L., 1995. Cenozoic plate reconstruction of southeast Asia. Tectonophysics 251, 85–138.

Lewis, J., Hames, W., Draper, G., Lapierre, H., Dupuis, V., Mercier de Lepinay, B., Bosch, D., Monie, P., Tardy, M., Maury, R., Hernandez, J., Polve, M., Yeghicheyan, D., Cotten, J., 1999. Late Jurassic oceanic crust and upper Cretaceous Caribbean plateau picritic basalts exposed in the Duarte igneous complex, Hispaniola: discussion and reply. Journal of Geology 107, 497–512.

Lowe, D., 1994. Accretionary history of the Archean Barberton greenstone belt (3.55–3.22 Ga), southern Africa. Geology 22, 1099–1102.

Malahoff, A., Hammond, S.R., Naughton, J.J., Keeling, D.L., Richmond, R.L., 1982. Geophysical evidence for post-Miocene rotation of the island of Viti Levu, Fiji, and its relationship to the tectonic development of the North Fiji basin. Earth and Planetary Science Letters 57, 398–414.

Mann, P., 1997. Model for the formation of large, transtensional basins in zones of tectonic escape. Geology 25, 211–214.

Mann, P., 1999. Caribbean sedimentary basins: classification and tectonic setting from Jurassic to present. In: Mann, P. (Ed.), Caribbean Basins, Sedimentary Basins of the World (series editor: K. Hsu). Elsevier, Amsterdam, pp. 3–31.

Mann, P., Draper, G., Lewis, J., 1991. An overview of the geologic and tectonic development of Hispaniola. In: Mann, P., Draper, G., Lewis, J. (Eds.), Geologic and Tectonic Development of the North America–Caribbean Plate Boundary in Hispaniola. Special Paper-Geological Society of America, vol. 262, pp. 1–28.

Mann, P., Coffin, M., Shipley, T., Cowley, S., Phinney, E., Teagan, A., Suyehiro, K., Takahashi, N., Araki, E., Shinohara, M., Miura, S., and Tivuru, L., 1996a. US–Japan marine geophysical study of the Solomon Islands arc–Ontong Java Plateau convergent zone, southwest Pacific Ocean, EW95-11 cruise report. Institute for Geophysics, University of Texas at Austin. Unpublished technical report.

Mann, P., Coffin, M., Shipley, T., Cowley, S., Phinney, E., Teagan, A., Suyehiro, K., Takahashi, N., Araki, E., Shinohara, M., Miura, S., Tivuru, L., 1996b. Researchers investigate fate of oceanic plateaus at subduction zones. EOS Transactions American Geophysical Union 77, 282–283.

Mann, P., Taylor, F., Lagoe, M., Quarles, A., Burr, G., 1998. Accelerating late Quaternary uplift of the New Georgia Island Group (Solomon island arc) in response to subduction of the recently active Woodlark spreading center and Coleman seamount. Tectonophysics 295, 259–306.

Marsaglia, K., Mann, P., Hyatt, R., Olson, H., 1999. Evaluating the influence of aseismic ridge subduction and accretion (?) on detrital modes of forearc sandstone: an example from the Kronotsky Peninsula in the Kamchatka forearc. Lithos 46, 17–42.

Martinez, F., Taylor, B., 1996. Backarc spreading, rifting, and microplate rotation between transform faults in the Manus basin. Marine Geophysical Researches 18, 203–244.

Mauffret, A., Leroy, S., 1997. Seismic stratigraphy and structure of the Caribbean igneous province. Tectonophysics 283, 61–104.

Mazzotti, S., Lallemant, S., Henry, P., Le Pichon, X., Tokuyama, H., Takahashi, N., 2002. Intraplate shortening and underthrusting of a large basement ridge in the eastern Nankai subduction zone. Marine Geology 187, 63–88.

McLennan, S., Taylor, S., 1982. Geochemical constraints on the growth of the continental crust. Journal of Geology 90, 347–361.

Miura, S., Suyehiro, K., Shinohara, M., Takahashi, N., Araki, E., Taira, A., 2002. Seismological structure and implications of collission between the Ontong Java Plateau and Solomon Island

Arc from ocean bottom seismometer-airgun data. Tectonophysics 389, 127–136.
Mortimer, N., Parkinson, D., 1996. Hikurangi Plateau: a Cretaceous large igneous province in the southwest Pacific Ocean. Journal of Geophysical Research 101, 687–696.
Musgrave, R., 1990. Paleomagnetism and tectonics of Malaita, Solomon Islands. Tectonics 9, 735–759.
Neal, C., Mahoney, J., Kroenke, L., Duncan, R., Petterson, M., 1997. The Ontong Java Plateau. In: Mahoney, J., Coffin, M. (Eds.), Large Igneous Provinces: Continental, Oceanic, and Planetary Flood Volcanism. Geophysical Monograph, vol. 100. American Geophysical Union, Washington, DC, pp. 183–216.
Nur, A., Ben-Avraham, Z., 1982. Oceanic plateaus, the fragmentation of continents, and mountain building. Journal of Geophysical Research 87, 3644–3661.
Okal, E., Kirby, S., 1998. Deep earthquakes beneath the Fiji basin, SW Pacific: Earth's most intense deep seismicity in stagnant slabs. Physics of the Earth and Planetary Interiors 109, 25–63.
Oxburgh, R., 1972. Flake tectonics and continental collision. Nature 239, 202–204.
Pelletier, B., Auzende, J.-M., 1996. Geometry and structure of the Vitiaz trench lineament (SW Pacific). Marine Geophysical Researches 18, 305–335.
Pelletier, B., Calmant, S., Pillet, R., 1998. Current tectonics of the Tonga–New Hebrides region. Earth and Planetary Science Letters 164, 263–276.
Petterson, M., Neal, C., Mahoney, J., Kroenke, L., Saunders, A., Babbs, T., Duncan, R., McGrail, B., 1995. Structure and deformation of north and central Malaita, Solomon Islands: tectonic implications for the Ontong Java Plateau–Solomon arc collision and for the fate of oceanic plateaus. Tectonophysics 283, 1–33.
Petterson, M., Babbs, T., Neal, C., Mahoney, J., Saunders, A., Duncan, R., Tolia, D., Magu, R., Qopoto, C., Mahoa, H., Natogga, D., 1999. Geological-tectonic framework of Solomon Islands, SW Pacific: crustal accretion and growth within an intra-oceanic setting. Tectonophysics 301, 35–60.
Phinney, E., Mann, P., Coffin, M., Shipley, T., 1999. Sequence stratigraphy, structure, and tectonics of the southwestern Ontong Java Plateau adjacent to the North Solomon trench and Solomon Islands arc. Journal of Geophysical Research 104, 20449–20466.
Phinney, E.J., Mann, P., Coffin, M.F., Shipley, T.H., 2004. Sequence stratigraphy, structural style, and age of deformation of the Malaita accretionary prism (Solomon arc-Ontong Java Plateau convergent zone). Tecnotophysics 389, 221–246.
Polat, A., Kerrich, R., 1999. Formation of an Archean tectonic melange in the Schreiber–Hemlo greenstone belt, Superior Province, Canada: implications for Archean subduction–accretion process. Tectonics 18, 733–755.
Polat, A., Kerrich, R., 2000. Archean greenstone belt magmatism and the continental growth-mantle evolution connection: constraints from Th–U–Nb–LREE systematics of the 2.7 Ga Wawa subprovince, Superior Province, Canada. Earth and Planetary Science Letters 175, 41–54.
Polat, A., Kerrich, R., 2001. Geodynamic processes, continental growth, and mantle evolution recorded in late Archean greenstone belts of the southern Superior Province, Canada. Precambrian Research 112, 5–25.
Puchtel, I., Hofmann, A., Mezger, K., Jochum, K., Shchipansky, A., Samsonov, A., 1998. Oceanic plateau model for continental crustal growth in the Archean: a case study from the Kostomuksha greenstone belt, NW Baltic shield. Earth and Planetary Science Letters 155, 57–74.
Rahardiawan, R., Taira, A., Mann, P., 2004. Incipient subduction of the Ontong Java Plateau at the North Solomon trench. Tectonophysics 389, 247–266.
Ramsey, W., 1982. Crustal strain phenomena in the Solomon Islands: constraints from field evidence and relationship to the India–Pacific plate boundary. Tectonophysics 87, 109–126.
Resig, J.M., Kroenke, L.W., Cooper, P.A., 1986. Elevation of the Pacific Province, Solomon Islands, at the Pacific and Indo-Australian plate boundary. Circum-Pacific Council for Energy and Mineral Resources. Earth Science Series, vol. 4, pp. 261–266.
Revillon, S., Arndt, N., Chauvel, C., Hallot, E., 2000a. Geochemical study of ultramafic volcanic and plutonic rocks from Gorgona Island, Colombia: the plumbing system of an oceanic plateau. Journal of Petrology 41, 1127–1153.
Revillon, S., Hallot, E., Arndt, N., Chauvel, C., Duncan, R., 2000b. A complex history for the Caribbean Plateau: petrology, geochemistry, and geochronlogy of the Beata Ridge, south Hispaniola. Journal of Geology 108, 641–661.
Reymer, A., Schubert, G., 1986. Rapid growth of some segments of continental crust. Geology 14, 299–302.
Reynaud, C., Jaillard, E., Lapierre, H., Mamberti, M., Mascles, G., 1999. Oceanic plateau and island arcs of southwestern Ecuador: their place in the geodynamic evolution of northwestern South America. Tectonophysics 307, 235–254.
Richards, M., Duncan, R., Courtillot, V., 1989. Flood basalts and hotspot tracks: plume heads and tails. Science 246, 103–107.
Richards, M., Jones, D., Duncan, R., DePaolo, D., 1991. A mantle plume initiation model for the Wrangellia flood basalt other oceanic plateaus. Science 254, 263–267.
Ridgway, J., 1987. Neogene displacements in the Solomon island arc. Tectonophysics 133, 81–93.
Ripper, I.D., 1982. Seismicity of the Indo-Australian/Solomon Sea plate boundary in the Southeast Papua Region. Tectonophysics 87, 335–369.
Rodda, P., Kroenke, L.W., 1984. Fiji: a fragmented arc. In: Kroenke, L.W. (Ed.), Cenozoic Tectonic Development of the Southwest Pacific, U.N. ESCAP CCOP/SOPAC. Technical Bulletin, vol. 6, pp. 87–109.
Royer, J.-Y., Gordon, R., DeMets, C., Vogt, P., 1997. New limits on the motion between India and Australia since chron 5 (11 Ma) and implications for lithospheric deformation in the equatorial Indian Ocean. Geophysical Journal International 129, 41–74.
Ryan, H., Coleman, P., 1992. Composite transform-convergent plate boundaries: description and discussion. Marine and Petroleum Geology 9, 89–98.
Sager, W., Kim, J., Klaus, A., Nakanishi, M., Khankishieva, L., 1999. Bathymetry of Shatsky Rise, northwest Pacific Ocean: implications for ocean plateau development at a triple junction. Journal of Geophysical Research 104, 7557–7576.
Sallares, V., Danobeitia, J., Flueh, E., 2001. Lithospheric structure

of the Costa Rica Isthmus: effects of subduction zone magmatism on an oceanic plateau. Journal of Geophysical Research 106, 621–642.

Sandwell, D., Smith W., 1997. Marine gravity anomaly from GEOSAT and ERS-1 satellite altimetry. Journal of Geophysical Research 102, 10039–10054.

Saunders, A., Tarney, J., Kerr, A., Kent, R., 1996. The formation and fate of large oceanic, igneous provinces. Lithos 37, 81–95.

Schubert, G., Sandwell, D., 1989. Crustal volumes of the continents and of oceanic and continental submarine plateaus. Earth and Planetary Science Letters 92, 234–246.

Schwartz, S., Lay, T., Ruff, L., 1989. Source processes of the great 1971 Solomon Islands doublet. Physics of the Earth and Planetary Interiors 56, 294–310.

Shinohara, M., Suyehiro, K., Murayama, T., 2003. Microearthquake seismicity in relation to double convergence around the Solomon Islands by ocean-bottom seismometer observation. Geophysical Journal International 153, 691–698.

Sinton, C., Duncan, R., Storey, M., Lewis, J., Estrada, J., 1998. An oceanic flood basalt province within the Caribbean plate. Earth and Planetary Science Letters 155, 221–235.

Skulski, T., Percival, J., 1996. Allochthonous 2.78 Ga oceanic plateau slivers in a 2.72 Ga continental arc sequence: Vizien greenstone belt, northeastern Superior Province, Canada. Lithos 37, 163–179.

Snyder, D., Prasetyo, H., Blundell, D., Pigram, C., Barber, A., Richardson, A., Tjokosaproetro, S., 1996. A dual, doubly-vergent orogen in the Banda Arc continent–arc collision zone as observed on deep seismic reflection profiles. Tectonics 15, 34–53.

Spikings, R., Winkler, W., Seward, D., Handler, R., 2001. Along-strike variations in the thermal and tectonic response of the continental Ecuadorian Andes to the collision with heterogeneous oceanic crust. Earth and Planetary Science Letters 186, 57–73.

Stoddart, D., 1969. Geomorphology of the Solomon Islands coral reefs. Transactions of the Royal Society of London, Part B 255, 355–382.

Stracke, A., Hegner, E., 1998. Rifting-related volcanism in an oceanic post-collisional setting: the Tabar–Lihir–Tanga–Feni (TLTF) island chain, Papua New Guinea. Lithos 45, 545–560.

Struik, L., Schiarizza, P., Orchard, M., Cordey, F., Sano, H., MacIntyre, D., Lapierre, H., Tardy, M., 2001. Imbricate architecture of the upper Paleozoic to Jurassic Cache Creek terrane, central British Columbia. Canadian Journal of Earth Sciences 38, 495–514.

Suyehiro, K., Takahashi, N., Ariie, Y., Yokoi, Y., Hino, R., Shinohara, M., Kanazawa, T., Hirata, N., Tokuyama, H., Taira, A., 1996. Continental crust, crustal underplating, and low-Q upper mantle beneath an oceanic island arc. Science 272, 390–392.

Taira, A., 1998. Nature and growth rate of the northern Izu–Bonin (Ogasawara) arc crust and their implications for continental crust formation. The Island Arc 7, 395–407.

Taira, A., 2001. Tectonic evolution of the Japanese island arc system. Annual Review of Earth and Planetary Sciences 29, 109–134.

Tardy, M., Lapierre, H., Struik, L., Bosch, D., Bruet, P., 2001. The influence of mantle plume in the genesis of the Cache Creek oceanic igneous rocks: implications for the geodynamic evolution of the inner accreted terranes of the Canadian Cordillera. Canadian Journal of Earth Sciences 38, 515–534.

Tatsumi, Y., Shinjoe, H., Ishizuka, H., Sager, W., Klaus, A., 1998. Geochemical evidence for a mid-Cretaceous superplume. Geology 26, 151–154.

Taylor, B., Exon, N., 1987. An investigation of ridge subduction in the Woodlark–Solomons region: introduction and overview. In: Taylor, B. (Ed.), Geology and Offshore Resources of the Pacific Island Arcs–Solomon Islands and Bougainville, Papua New Guinea regions. Circum-Pacific Council for Energy and Mineral Resources, vol. 7. Earth Science Series, Houston, TX, pp. 1–24.

Taylor, F., Tajima, F., 1987. Seismic activity and late Cenozoic vertical movements in the region of Guadalcanal and San Cristobal, Solomon Islands. EOS Transactions American Geophysical Union 68, 1500.

Taylor, B., Crook, K., Sinton, J., 1994. Extensional transform zones and oblique spreading centers. Journal of Geophysical Research 99, 19707–19718.

Taylor, B., Goodliffe, A., Martinez, F., Hey, R., 1995. Continental rifting and initial sea-floor spreading in the Woodlark basin. Nature 374, 534–537.

Tejada, M., Mahoney, J., Duncan, R., Hawkins, M., 1996. Age and geochemistry of the basement and alkalic rocks of Malaita and Santa Isabel, Solomon Islands, southern margin of Ontong Java Plateau. Journal of Petrology 37, 361–394.

Tejada, M., Mahoney, J., Neal, C., Duncan, R., Petterson, M., 2002. Basement geochemistry and geochronology of central Malaita, Solomon Islands, with implications for the origin and evolution of the Ontong Java Plateau. Journal of Petrology 43, 449–484.

Tregoning, P., Tan, F., Gilliland, J., McQueen, H., Lambeck, K., 1998a. Present-day crustal motion in the Solomon Islands from GPS observations. Geophysical Research Letters 25, 3627–3630.

Tregoning, P., Lambeck, K., Stolz, A., Morgan, P., McClusky, S., van der Beek, P., McQueen, H., Jackson, R., Little, R., Laing, A., Murphy, B., 1998b. Estimation of current plate motions in Papua New Guinea from Global Positioning System observations. Journal of Geophysical Research 103, 12181–12203.

Trehu, A., Asudeh, I., Brocher, T., Luetgert, J., Mooney, W., Nabelek, J., Nakamura, Y., 1994. Crustal architecture of the Cascadia forearc. Science 265, 237–243.

Unruh, J., Ramirez, V., Phipps, S., Moores, E., 1991. Tectonic wedging beneath forearc basins: ancient and modern examples from California and the Lesser Antilles. GSA Today 1, 187–190.

van der Hilst, R., Mann, P., 1994. Tectonic implications of tomographic images of subducted lithosphere beneath northwestern South America. Geology 22, 451–454.

Van Deventer, J., Postuma, J., 1973. Early Cenomanian to Pliocene deep-marine sediments from North Malaita, Solomon Islands. Journal of the Geological Society of Australia 20, 145–150.

Vann, I., Graham, R., Hayward, A., 1986. The structure of mountain fronts. Journal of Structural Geology 8, 215–227.

Weissel, J., Taylor, B., Karner, G., 1982. The opening of the Woodlark basin, subduction of the Woodlark spreading system, and the evolution of northern Melanesia since mid-Pliocene time. Tectonophysics 87, 253–277.

Wells, R., 1989. The oceanic basalt basement of the Solomon Islands arc and its relationship to the Ontong Java Plateau—Insights from Cenozoic plate motion modes. In: Vedder, J., Bruns, T. (Eds.), Geology and Offshore Resources of the Pacific Island Arcs–Solomon Islands and Bougainville, Papua New Guinea regions. Circum-Pacific Council for Energy and Mineral Resources, vol. 12. Earth Science Series, Houston, TX, pp. 7–22.

White, R., Tarney, J., Kerr, A., Saunders, A., Kempton, P., Pringle, M., Klaver, G., 1998. Modification of an oceanic plateau, Aruba, Dutch Caribbean: implications for the generation of continental crust. Lithos 46, 43–68.

Woods, M., Okal, E., 1994. The structure of the Nazca ridge and Sal y Gomez seamount chain from the dispersion of Rayleigh waves. Geophysical Journal International 117, 205–222.

Wortel, R., Cloetingh, S., 1981. On the origin of the Cocos–Nazca spreading center. Geology 9, 425–430.

Yan, C., Kroenke, L., 1993. A plate tectonic reconstruction of the SW Pacific, 0–100 Ma. In: Berger, T., Kroenke, L., Mayer, L., et al. (Eds.), Proceedings of the Ocean Drilling Program. Scientific Results, vol. 130, pp. 697–709.