Tectonic controls on facies transitions in an oblique collision: The western Solomon Sea, Papua New Guinea

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ABSTRACT

The western Solomon Sea is the site of a closing ocean basin and an incipient arc-continent collision between the Bismarck arc and the Australian continental margin in Papua New Guinea. Migrated seismic reflection profiles and HAWAII MR1 sidescan sonar data indicate that sedimentation within the Solomon Sea basin is controlled by topographic gradients generated by flexure of the Solomon Sea plate. Turbidites delivered to the basin by the submarine Markham Canyon extend farther eastward down the axis of the deeper New Britain Trench (north side of the Solomon Sea) than they do in the shallower Trobriand Trough (south side of the Solomon Sea). The stratigraphic record of the foredeep, in the zone of arc continent collision, is controlled by the steep topography of the Australian continental margin. A long (1.5–3 m.y.) period of deep marine turbidite deposition is followed by a short (50–100 k.y.) period of shallow-marine deposition and a long (0.5–1 m.y.) period of fluvial deposition. Comparisons between the foredeep record of Taiwan and the Papua New Guinea collision indicate that the steep topography of the Australian continental margin exerts significant control over the evolution of the foredeep, and the Taiwan foredeep is more controlled by the dynamic link between the flexural properties of the lithosphere and the orogenic load.

INTRODUCTION

The evolution of a foreland basin from deep-marine deposition into fluvial deposition has been documented in many ancient mountain belts. The flysch to molasse transition observed in the European Alps (Allen et al., 1991) is an example of this evolution, and analogous transitions have been observed in Taiwan (Covey, 1986), the Himalayas, the Appalachians (Graham et al., 1975), and the Apennines (Ricci-Lucci, 1986). The tectonic history of many ancient mountain belts has been unraveled by careful analysis of foreland basin deposits. For example, analysis of the flysch sequences in the Alpine front ranges has provided a wealth of information about the paleogeography and geodynamic history of the Alps (Caron et al., 1989).

Some observations suggest that foreland basins eventually reach a steady state in which the accommodation space in the basin remains relatively constant despite continued overthrusting of the orogen (Covey, 1986), but the role of inherited basement topography on the stratigraphic evolution of a foredeep is not well understood. It is well known that an oblique collision will generate a time-transgressive facies progression (e.g., Crook, 1989; Silver et al., 1991), but the links between tectonics and facies progression rates are not well known. In order to understand the relationships between tectonic and depositional processes in collisional orogens, we must study modern orogens where the tectonic processes are still active. Furthermore, it is important to study a variety of modern settings, because each modern case reveals something different about the relationships between tectonics and depositional processes. The active collision between the Bismarck Arc and the Australian continental margin in Papua New Guinea (Fig. 1) provides an excellent setting to study the links between tectonics and depositional processes in a collisional orogen. Furthermore, the obliquity of the collision provides an approximate time-space equivalency (Suppe, 1981), allowing us to infer the tectonics and related depositional processes for most of the history of the collision. In this study, we show how the flexural deformation of a closing ocean basin controls the stratigraphic evolution of a precollisional turbidite basin. Tectonic and depositional processes in the Papua New Guinea collision are also contrasted with those of the active arc-continent collision in Taiwan to show how geodynamically similar settings can lead to greatly different stratigraphic records.

TECTONIC SETTING

The modern Bismarck volcanic arc formed when subduction of the Solomon Sea plate beneath the South Bismarck plate initiated, probably during late Miocene time (Musgrave, 1990). The Bismarck forearc contains the relict Finisterre arc, a Paleogene–earliest Neogene volcanic arc that was part of the larger Outer Melanesian Arc. The Outer Melanesian Arc was built above the West Melanesian Trench in response to Pacific plate subduction beneath the Australian plate (Robinson, 1974). Finisterre Arc volcanism ceased in early Miocene time, probably when the Ontong Java Plateau collided with the West Melanesian Trench and induced regional plate reorganization (Musgrave, 1990).

The continental margin against which the Bismarck arc is colliding is a mountainous, tectonically active amalgamation of previously accreted terranes (Fig. 1). The tectonic history of eastern Papua New Guinea since middle Miocene time has been dominated by the docking of a large composite terrane, the east Papua composite terrane of Pigram and Davies (1987), with the Australian craton. Recent shallow seismicity in the New Guinea Highlands and the Papuan Peninsula is evidence for active tectonism in the Papua New Guinea continental margin (Abers and Roecker, 1991). Present elevations in the New Guinea Highlands and Owen Stanley Mountains are in excess of 4 km.

The collision between the Bismarck forearc and the Australian continental margin is estimated to have initiated about 3.0–3.7 Ma in the vicinity of Madang (Abbott et al., 1994b). This age is based on dating the sandstone provenance shift from continental-orogenic sources to an arc volcanic source, interpreted to represent the uplift of the relict Finisterre arc in response to collision (Abbott et al., 1994a). The collision has propagated to the southeast through time, and the modern collision tip is located in the western Solomon Sea (Fig. 1). East of the modern collision tip, the Solomon Sea plate is subducting be-

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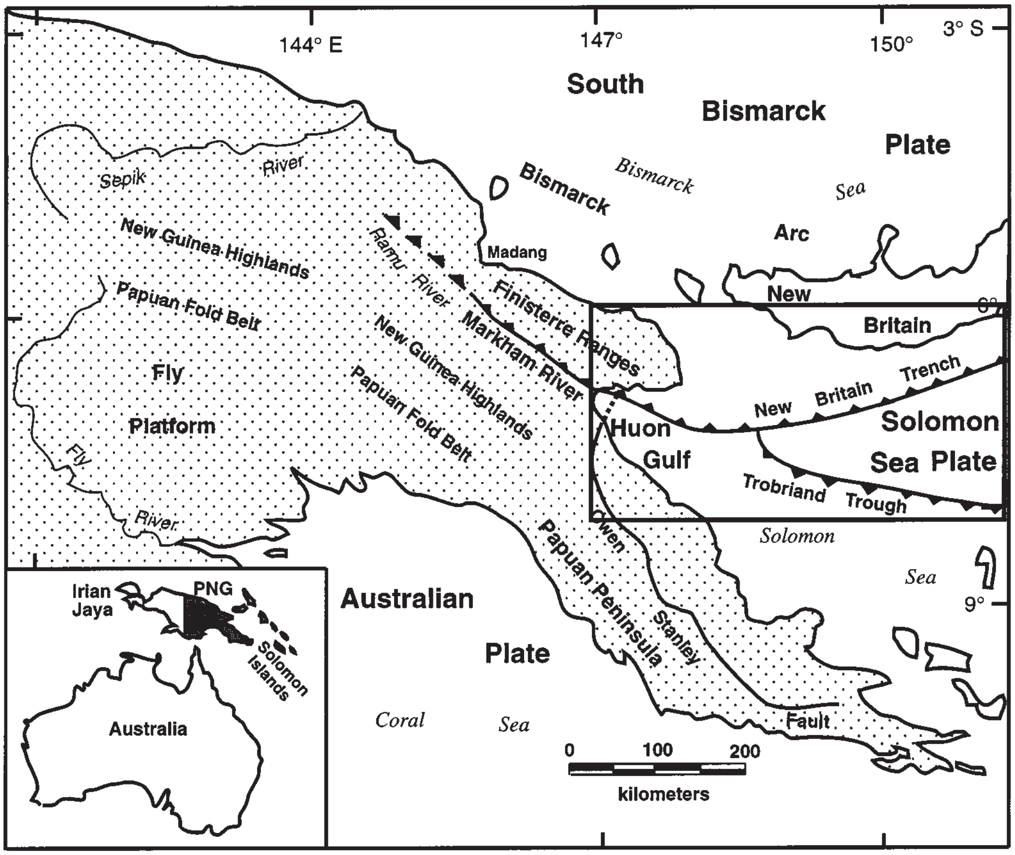

Figure 1. Tectonic map of Papua New Guinea. Inset map shows study location. Rectangle shows locations of Figures 2 and 3, A and B. The modern collision tip is at the juncture of the Trobriand Trough and the New Britain Trench.

neath the New Britain Trench at about 90 km/m.y. (Johnson, 1979; Taylor, 1979; Schouten and Benes, 1994). Slow convergence (~6 km/m.y.) between the Solomon Sea plate and the Australian continental margin is accommodated along the Trobriand Trough (Kirchoff-Stein, 1992). The modern collision tip is defined to be the location where the frontal thrust of the Trobriand Trough enters the New Britain Trench, long 148°30′E (Fig. 3B). This intersection marks the initial point where the Bismarck forearc overthrusts the Australian continental slope. The Finisterre Ranges (Fig. 1), rising more than 4 km, have formed as a result of this collision. The Finisterre Mountains are producing so much sediment that the streams issuing from the range have created large alluvial fans that prograde into the Markham Valley, pushing the Markham River to the far southern part of the valley (Loffler, 1977). This progradation has caused the development of marshlands at the mouths of the major highlands tributaries, in which much of the sediment load of the highlands rivers is deposited. The Markham Valley is therefore filled mostly by sediments shed from the rising Finisterre Ranges. Deposition in modern coastal areas is characterized by coral reef development along the Morobe coastline and by clastic deposition associated with the mouth of the Markham River near Lae (von der Borch, 1972). Details of the shallow water and subaerial deposits in the ancient record were described in Crook (1989), Liu and Crook (1991), and Silver et al. (1991). The foredeep that has formed in response to this collision between the Bismarck forearc and the Australian continental margin occupies the subaerial Markham Valley (Abers and McCaffrey, 1994) and extends offshore into the Huon Gulf.

Central to developing our understanding of tectonodepositional processes in the western Solomon Sea is the concept of time-space equivalency (Suppe, 1981). Suppe (1981) defined this term to refer to a steady-state collision (Taiwan, in his interpretation) in which the structure observed 90 km spatially along the collision zone is equivalent to going back in time 1 Ma, where the rate of propagation of the collision is 90 km/m.y. The Papua New Guinea collision is oblique because the Australian continental margin is oriented northwest-southeast, and the Bismarck arc is oriented approximately east-west. The southeastward rate of collision propagation was assessed by Silver et al. (1991) and Abbott et al. (1994b).

On the basis of purely kinematic considerations, Silver et al. (1991) determined the rate of collision propagation to be 120–180 km/my. They presented a sedimentologically derived estimate of 212 km/m.y., and Abbott et al. (1994b) presented sedimentologically derived estimates of 108–151 km/m.y. These results are based on the assumption of steady-state collision and simple geometry; the wide range of results is probably due to departures from these assumptions (Liu and Crook, 1991; Silver et al., 1991; Kirchoff-Stein, 1992). Nevertheless, these rates provide valuable constraints on the rate of collision progression and associated progression of collision-related facies (Crook, 1989; Silver et al., 1991). Because of the obliquity of the collision, the temporal evolution of the arc-continent collision translates to an equivalent spatial evolution; that is, moving about 150 km southeast along the modern Bismarck forearc is equivalent to moving about 1 m.y. back in time in the evolution of the collision.

PHYSIOGRAPHY

The western Solomon Sea (Fig. 2) consists of a central basin (the Solomon Sea basin) bounded on the north by the New Britain Trench and on the south by the Trobriand Trough. South of the Trobriand Trough is the Trobriand platform, a broad shallow shelf that narrows to the northwest to become the Morobe shelf. Between the Trobriand Trough and the Morobe shelf lies the Deboin spur, an isolated submarine ridge. The Huon Ridge is a submarine ridge that projects to the east from the Huon Peninsula and is bounded on the north by a deep basin, the Finsch deep,

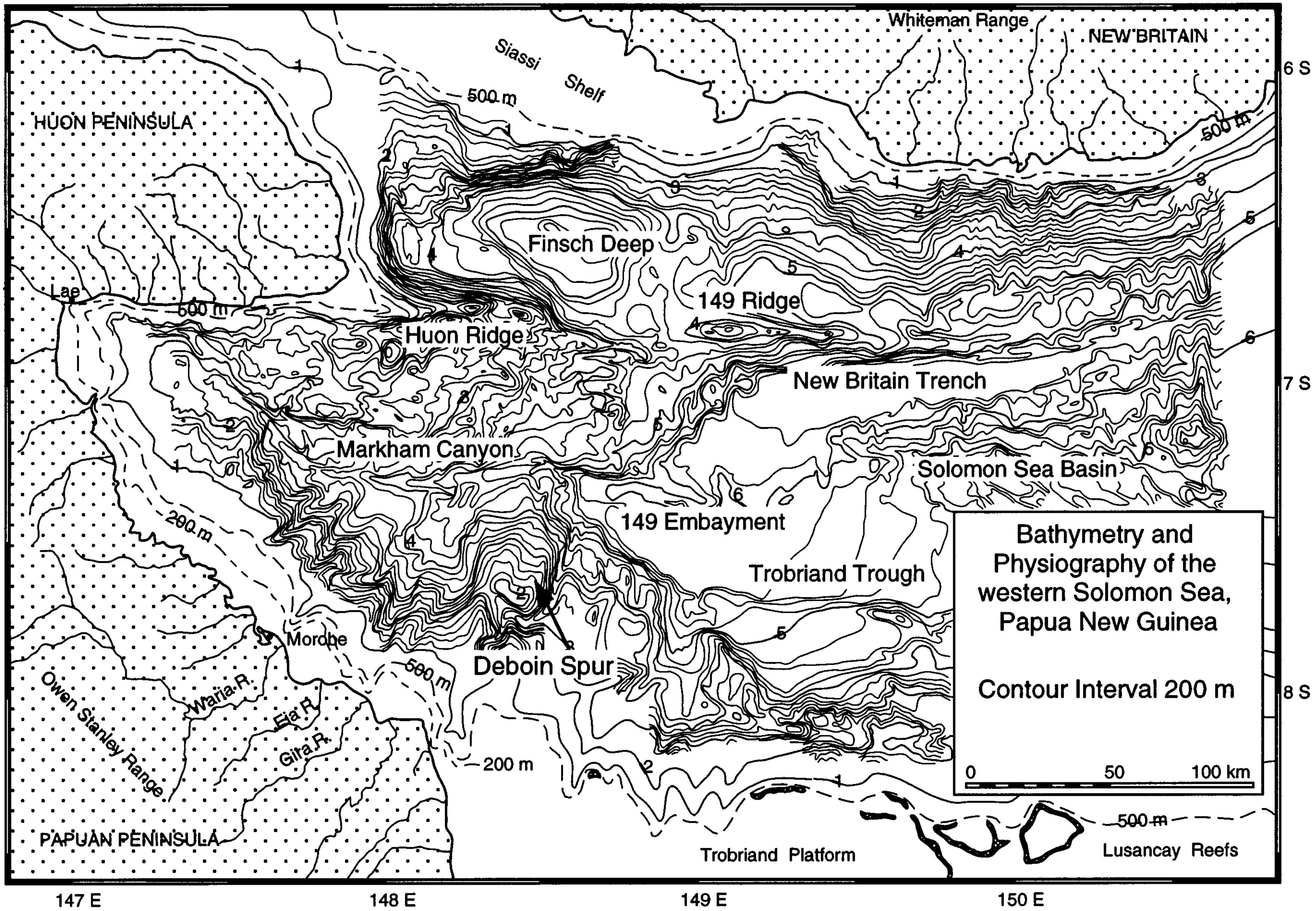

Figure 2. Physiography and bathymetry of the western Solomon Sea, based on bathymetric data from the HAWAII MR-1 swath-mapping system. Map was created by G. Whitmore (published with permission). Contour interval is 200 m.

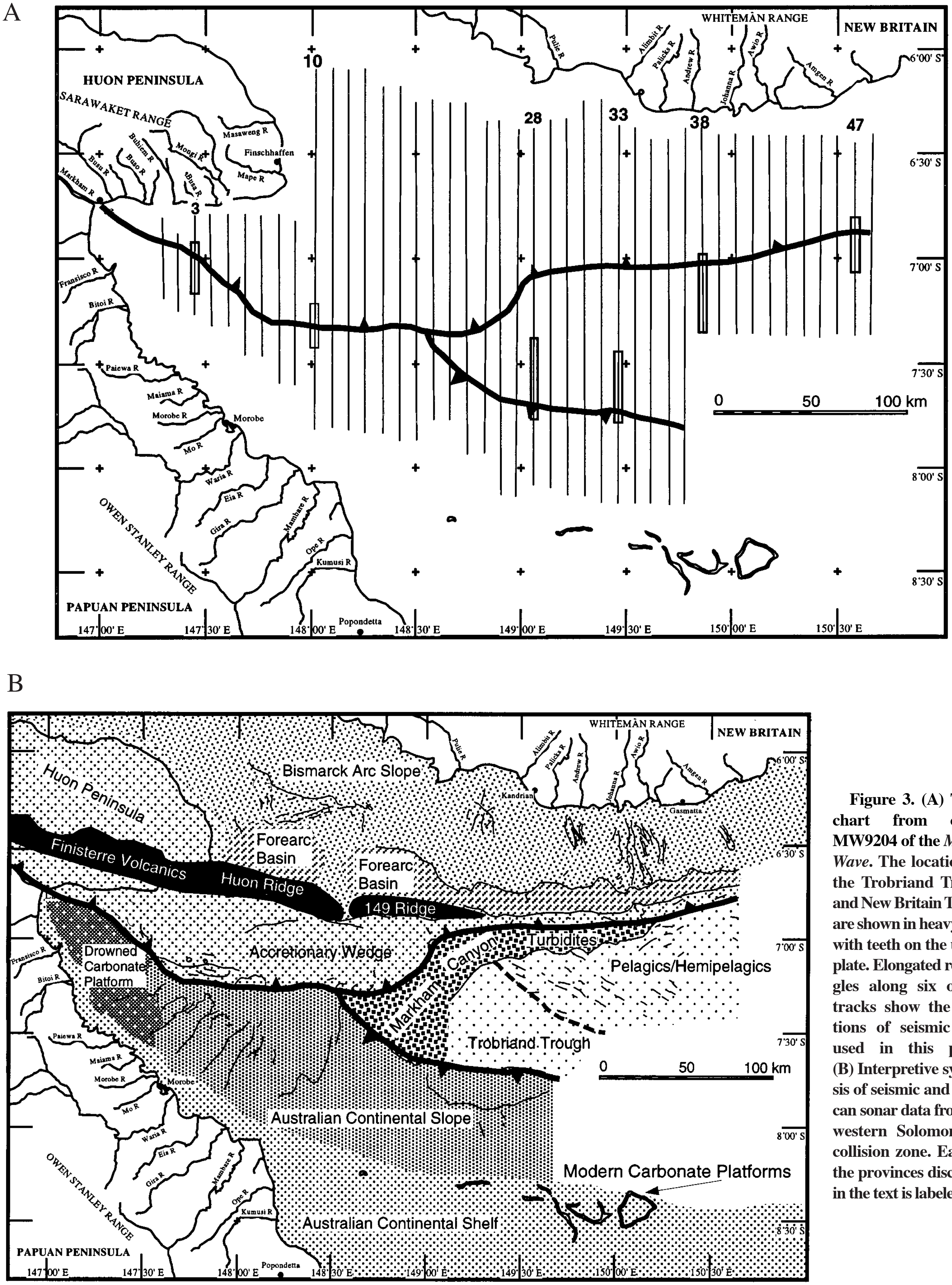

Figure 3. (A) Track chart from cruise MW9204 of the *Moana Wave*. The locations of the Trobriand Trough and New Britain Trench are shown in heavy lines with teeth on the upper plate. Elongated rectangles along six of the tracks show the locations of seismic lines used in this paper. (B) Interpretive synthesis of seismic and sidescan sonar data from the western Solomon Sea collision zone. Each of the provinces discussed in the text is labeled.

and on the south by the Markham Canyon. There is a broad shallow shelf north of the Finsch deep, the Siassi shelf, but virtually no shelf exists to the east along the coast of New Britain. Southeast of the Huon Ridge is a broad deep basin, the 149° Embayment, where the Trobriand Trough intersects the New Britain Trench. The bathymetric expression of the Huon Ridge vanishes just north of the 149° Embayment, but another submarine ridge, the 149° Ridge is present to the northeast of the 149° Embayment and east of the Huon Ridge.

The Morobe shelf is a broad, flat platform sloping at about 3° to the north. The modern continental shelf is extremely narrow, less than 11 km, and slopes to the north at about 1.5° (von der Borch, 1972) (Fig. 2). The Morobe shelf is overlain by a drowned carbonate platform in the western Huon Gulf (Galewsky et al., 1996) (Fig. 3B). The carbonate platform occupies about 900 km^2; depths are as great as 2500 m. Active carbonate deposition along the Morobe coast was documented by von der Borch (1972).

West of the modern collision tip, the Australian continental slope occupies that part of the Australian continental margin downslope from the continental shelf and upslope of the deformation front of the colliding Bismarck forearc. The continental slope is about 100 km wide, slopes to the northeast at about 6°, and strikes northwest-southeast. It is incised by several canyons, including the Waria, Gira, Eia, and Binandere canyons draining the Papuan Peninsula (Davies et al., 1987), and the Markham Canyon, which drains the Markham Valley to the west (Krause et al., 1970; Davies et al., 1987). East of the modern collision tip, the base of the continental slope is marked by the frontal thrust of the Trobriand Trough (Fig. 3B). The lowermost toe of the slope abutting the Trobriand Trough consists of several thrust sheets, suggesting formation by a relatively small amount of total convergence.

The New Britain Trench has little or no accretionary wedge east of 149°E (Fig. 3B). To the west of this line, the accretionary wedge increases rapidly in width. Little or no change in the width of the wedge is noted across the collision point, even though the thrusts bordering the Trobriand Trough are overthrust at this point by the New Britain north-dipping subduction system (for discussions of this geometry, see Galewsky, 1996). It is not clear from existing seismic data whether the thrusts accreted to the Trobriand platform are detached and reaccreted to the New Britain accretionary wedge west of the collision point. A broader discussion of this topic can be found in Abbott et al. (1994b).

DATA

Data for this study were collected during cruise MW9204 of the *Moana Wave* in March and April 1992 (Fig. 3A); we focus on analysis of HAWAII MR1 sidescan sonar and bathymetry, and six channel seismic reflection data. Seismic data were processed using ProMAX software. Processing steps included preliminary quality control, deconvolution, a simple normal move out (NMO) correction, stacking, and FK-migration. Because of the short offsets involved with the six channel system, there was no velocity control; we therefore used a simple velocity structure for the entire data set: 1500 m/s at the sea floor linearly increasing to 3000 m/s five seconds below the sea floor. Seismic interpretations were carried out using Landmark software, and the results were visualized using GMT software.

TECTONICS AND DEPOSITIONAL PROCESSES IN THE SOLOMON SEA COLLISION ZONE

East of 148°40′E, the principal tectonic control on sediment distribution in the Solomon Sea basin is the flexural deformation of the Solomon Sea plate in response to the encroaching Bismarck arc. The Solomon Sea plate dips to the north beneath the New Britain Trench, to the southwest at the Trobriand Trough, and plunges to the west beneath the modern collision tip (Fig. 4). Seismic reflection data indicate that three main sedimentary units occupy the Solomon Sea basin and overlie the oceanic crust (Fig. 8). These units include a discontinuous lower pelagic-hemipelagic deposit, an intermediate set of turbidites (the Trobriand Trough deposits), and an uppermost turbidite sequence called the Markham Canyon turbidites (see Fig. 8). The stratigraphically lowest unit is a 0.25–0.5 s thick hemipelagic-pelagic unit that drapes oceanic basement (Fig. 5). Seismic data show that this unit is of low amplitude and moderate continuity and is locally acoustically transparent. In the southern Trobriand Trough, 2 s of trench fill onlaps oceanic basement and isolated packages of hemipelagic-pelagic deposits (Figs. 6–8). Overall, reflections from the Trobriand Trough fill are continuous and of relatively high amplitude, suggesting that they represent turbidites. In addition, geometric indicators of channel and levee systems within the Trobriand Trough deposits support the turbidite interpretation.

West of about 150°, New Britain Trench fill onlaps the hemipelagic-pelagic deposits and oceanic basement of the eastern New Britain Trench (Fig. 7). In the southern Solomon Sea basin, high-amplitude, parallel reflections of New Britain Trench fill onlap the northward-thinning turbidites of the Trobriand Trough (Fig. 8, A and B). New Britain Trench turbidites are delivered to the Solomon Sea basin via the Markham Canyon, which longitudinally transports sediment derived from the uplifting Finisterre Ranges to the west. The spatial distribution of Markham Canyon turbidites in the Solomon Sea basin is controlled by gradients generated by

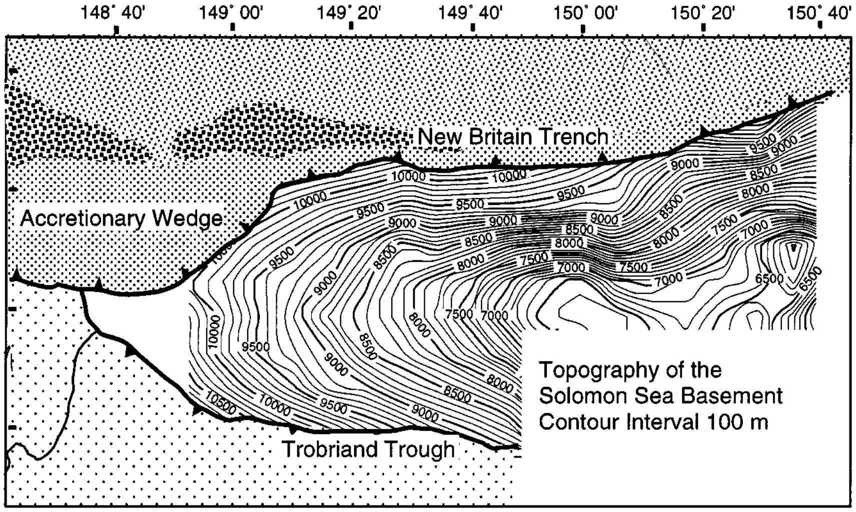

Figure 4. Topography of the Solomon Sea plate from seismic profiles. The contours are structure contours of the Solomon Sea plate where it is bounded by the New Britain Trench and Trobriand Trough. The antiformal shape of the plate is due to flexural loading of both the New Britain forearc and the Trobriand platform.

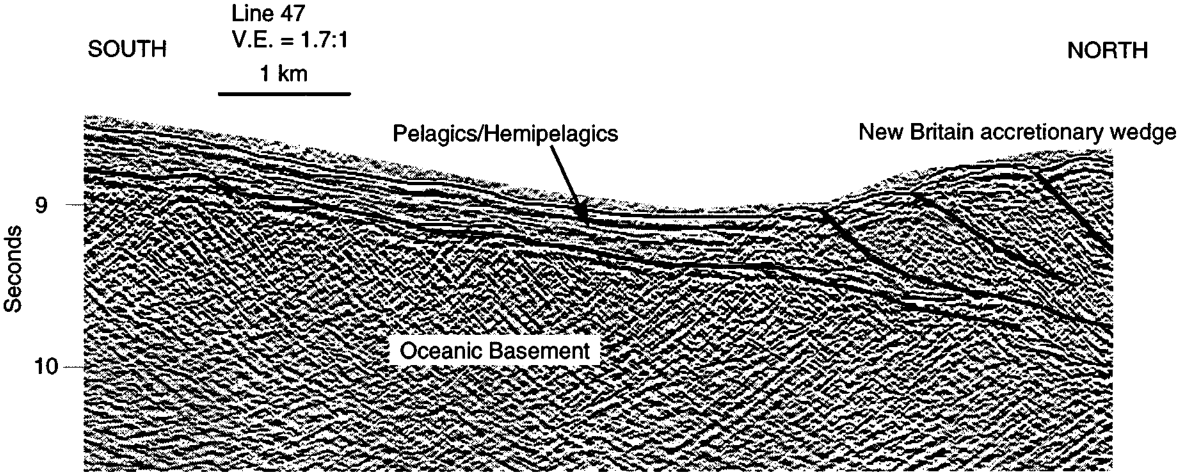

Figure 5. Seismic profile 47 from the eastern New Britain Trench. No turbidites are resolved on this section; it is used as a clear example of pelagic and hemipelagic sediments overlying oceanic basement. Vertical scale is seconds of two-way travel time.

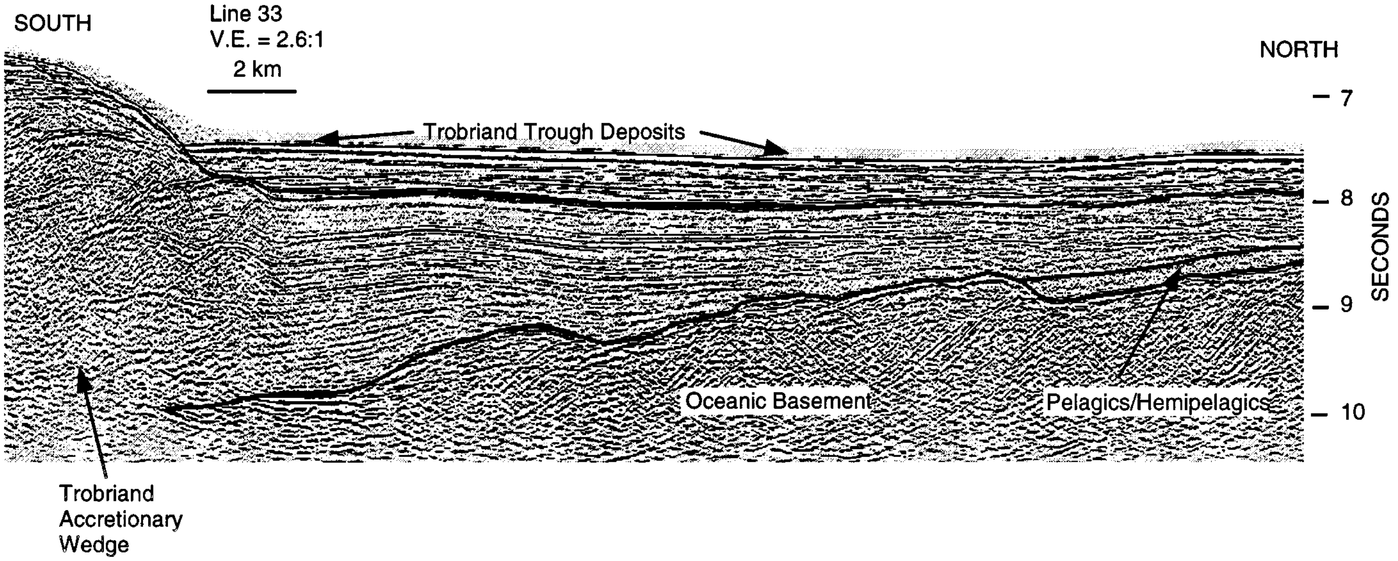

Figure 6. Seismic profile 33 from the Trobriand Trough. The Trobriand Trough deposits overlie pockets of pelagic and hemipelagic sediments and oceanic basement. The heavy horizontal line is a probable sequence boundary, but both sequences are within the broadly defined Trobriand Trough deposits. Vertical scale is in seconds of two-way travel time.

the flexurally deforming Solomon Sea plate (Fig. 9).

Subduction of the Solomon Sea plate beneath the Bismarck arc has produced the deep New Britain Trench, with depths of almost 7 km below sea level; the Trobriand Trough is a bathymetric high relative to the New Britain Trench and the modern collision tip. Markham Canyon turbidites extend farther eastward in the New Britain Trench than they do in the Trobriand Trough (Fig. 3B). Turbidites travel a downhill path into the New Britain Trench, from about 5.8 km water depth at the modern collision tip to about 6.6 km water depth in the New Britain Trench. Conversely, turbidites must travel a slightly uphill path into the Trobriand Trough, from 5.8 km at the modern collision tip to about 5.5 km in the Trobriand Trough.

The result of this pattern is a complex unconformity where Markham Canyon turbidites onlap the deposits of the Trobriand Trough and the pelagic-hemipelagic deposits of the eastern New Britain Trench. The unconformity is expected to be youngest in the east and oldest in the west. Because turbidite transport is influenced by topography, the propagation rate of this unconformity is likely to be higher in the eastern New Britain Trench than in the southern Trobriand Trough. The unconformity may be due to either erosion by the turbidites, to nondeposition prior to turbidite deposition, or both.

We can quantify the cross-basin difference in turbidite propagation rate by applying estimates of collision propagation to the observed facies distribution in the Solomon Sea basin. If we assume that collision propagation rates (about 110–210 km/m.y.) can be used as a proxy for the rate of turbidite propagation in the New Britain Trench, we estimate that at around 0.8–1.5 Ma, the most distal Markham Canyon turbidites were located at what is now the modern collision tip. During the past 0.8–1.5 m.y., the collision continued to propagate to the southeast and the most distal Markham Canyon turbidites prograded about 150 km, to their modern position (at line

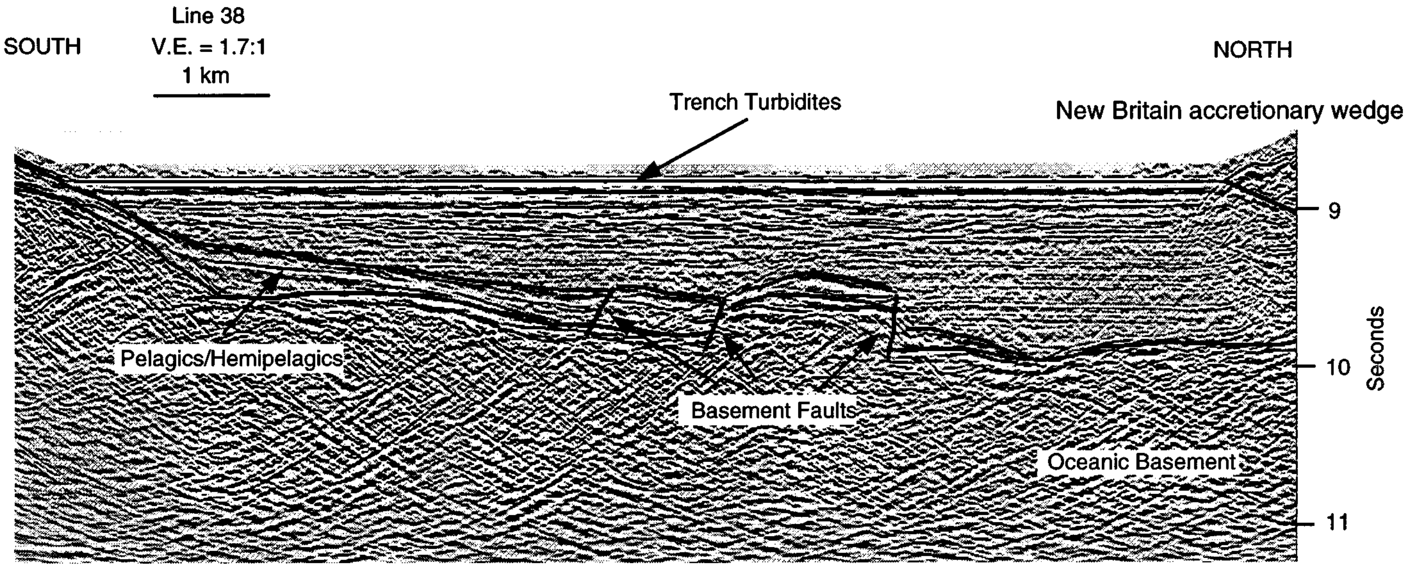

Figure 7. Seismic profile 38 from the New Britain Trench showing Markham Canyon turbidites onlapping pelagic and hemipelagic deposits within the New Britain Trench. New Britain accretionary wedge is just visible on the right edge of the section. Vertical scale is in seconds of two-way travel time.

42). Assuming that the same amount of time was required for turbidites to prograde from what is now the collision tip to the easternmost occurrence of Markham Canyon turbidites in the Trobriand Trough, we estimate that the rate of turbidite progradation in the Trobriand Trough was about 45–90 km/m.y. These simple calculations indicate that facies propagation rates in the Trobriand Trough are less than half of the rates in the New Britain Trench.

East of 148°40′ (Fig. 3B), the Bismarck arc overthrusts the Australian continental slope, and the main tectonic control on sedimentation in the syncollision zone is the geometry of the intersection between the toe of the Bismarck forearc and the Australian continental slope. This intersection controls the geometry of the Markham Canyon, which traverses about 200 km between the mouth of the Markham River near Lae to the 149° Embayment in the Solomon Sea basin and encompasses both shallow- and deep-marine deposition. Figure 10 shows a longitudinal profile of the Markham Canyon. The canyon drops steeply (about 3°) from the mouth of the Markham River to about –2200 m, where the slope shallows to less than 1° at the drowned continental shelf. Shallow-marine deposition near the mouth of the Markham River was documented by von der Borch (1972).

Seismic reflection profiles from the drowned continental shelf (Fig. 11) show turbidites onlapping acoustic basement at around –2200 m, indicating deep-marine deposition. The canyon drops again into the forearc–continental slope collision, where the gradient of the canyon is about 1.3°. Seismic reflection data (Fig. 12) show that Markham Canyon turbidites onlap deposits associated with the canyons of the Papuan Peninsula. Truncation of reflectors against the Markham Canyon wall indicates erosion of levee deposits, presumably by flow of turbidites down the Markham Canyon. At about –5000 m, the gradient of the canyon increases to nearly 3° where the canyon drops into the 149° Embayment in the Solomon Sea basin. The stratigraphy on seismic lines 3 and 10 (Figs. 11 and 12) differs from that of the seismic data shown in the Solomon Sea Basin (Figs. 6, 7, and 8) because the latter stratigraphy is in part subducted and otherwise deformed as the plate enters the collision zone.

The approximate time-space equivalence of the collision allows us to translate the spatial pattern of deposition into a corresponding temporal evolution. We present three stages in the precollisional evolution of the Solomon Sea basin (1–3 in Fig. 13) and three stages in the postcollisional evolution (4–6 in Fig. 13). Stage 1 depicts the east-central Solomon Sea, with no New Britain Trench turbidites and relatively thick Trobriand Trough deposits. Stage 2 shows New Britain Trench turbidites nearly filling the trench as the collision point is being approached in the west central part of the Solomon Sea. The third stage is close to the collision point where New Britain Trench turbidites overlap the Trobriand Trough deposits, due to the much greater rate of deposition of the former. The initial stage of the arc-continent collision (4 in Fig. 13) was the contact between the Bismarck forearc and the Australian continental slope. The load of the encroaching orogen deflected the Australian continental shelf, drowning the previously active carbonate platform on the continental shelf, while turbidite deposition along the Markham Canyon continued (4 in Fig. 13). As the Bismarck forearc continued to move up the steep Australian continental shelf, the water depth continued to shallow, and shallow-water clastic deposition began (4 in Fig. 13). Finally, the forearc moved far enough up the continental shelf that it was raised above sea level and subaerial deposition commenced (6 in Fig. 13).

We can estimate the length of time the basin will favor deep-marine, shallow-marine, and subaerial (fluvial) deposition by applying the estimates of collision propagation to the spatial observations of facies distribution. In the modern setting, deep-marine deposition is active for approximately 300 km along strike. Assuming collision propagation rates of 108–212 km/m.y. (Silver et al., 1991; Abbott et al., 1994b), the foredeep at any point along strike would be expected to exist in deep-marine conditions for about 1.5–3 m.y. Shallow-marine deposition is observed for about 10 km along the strike of the orogen (von der Borch, 1972), indicating that the basin would be expected to exist in shallow-marine conditions for about 50–100 k.y. Fluvial deposits in the Markham Valley occur over about 100 km strike length, suggesting about 0.5–1 m.y. of fluvial deposition in the foredeep.

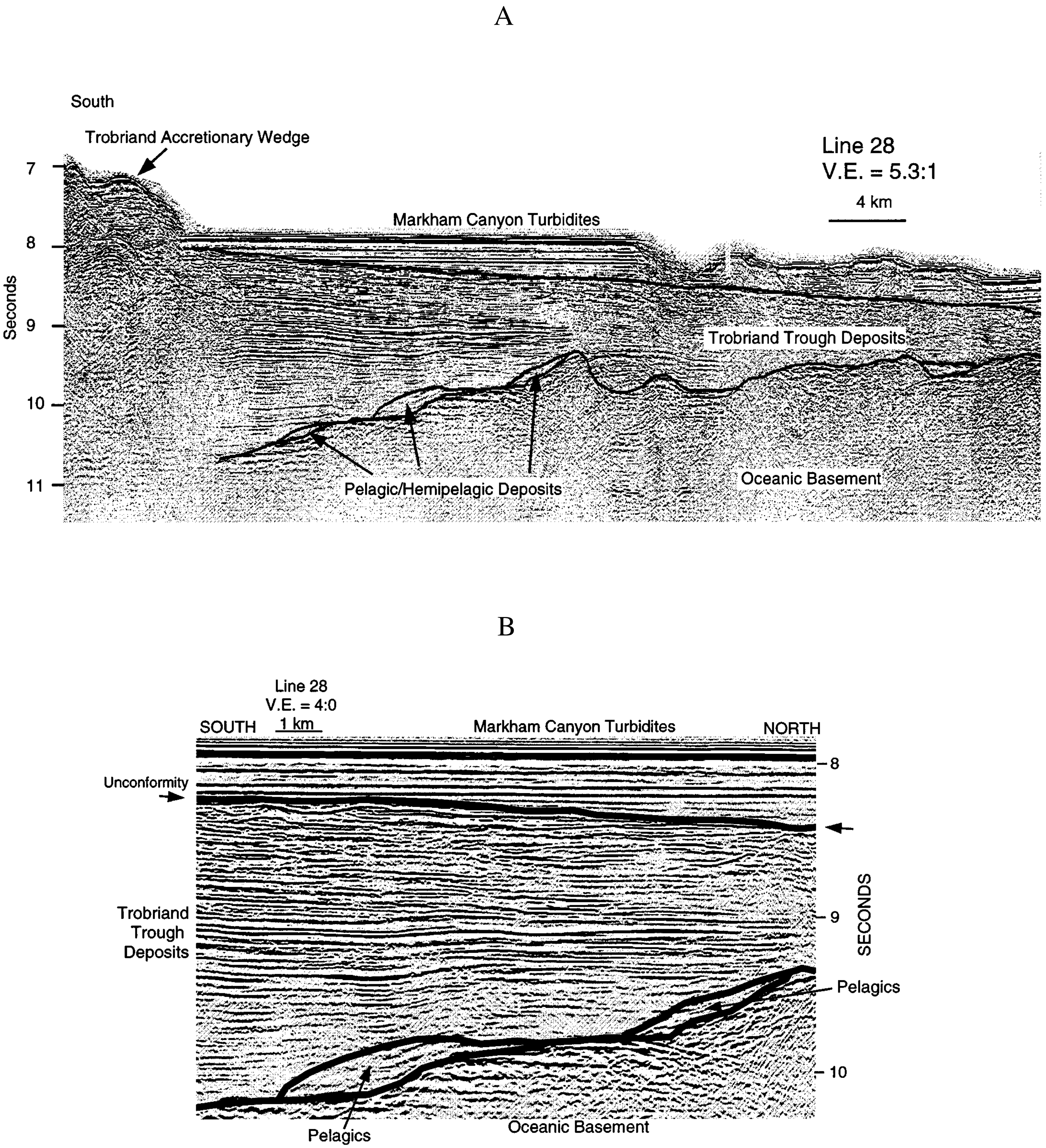

Figure 8. (A) Seismic profile 28 showing the Markham Canyon turbidites onlapping Trobriand Trough deposits. Small pockets of pelagic and hemipelagic sediments are noted, and the Trobriand accretionary wedge occurs on the left side of the section. Vertical scale is in seconds of two-way travel time. (B) Detail of line 28 showing the unconformity between the Markham Canyon turbidites and Trobriand Trough turbidites. The latter overlie small pockets of pelagic sediments and oceanic basement. Vertical scale is in seconds of two-way travel time.

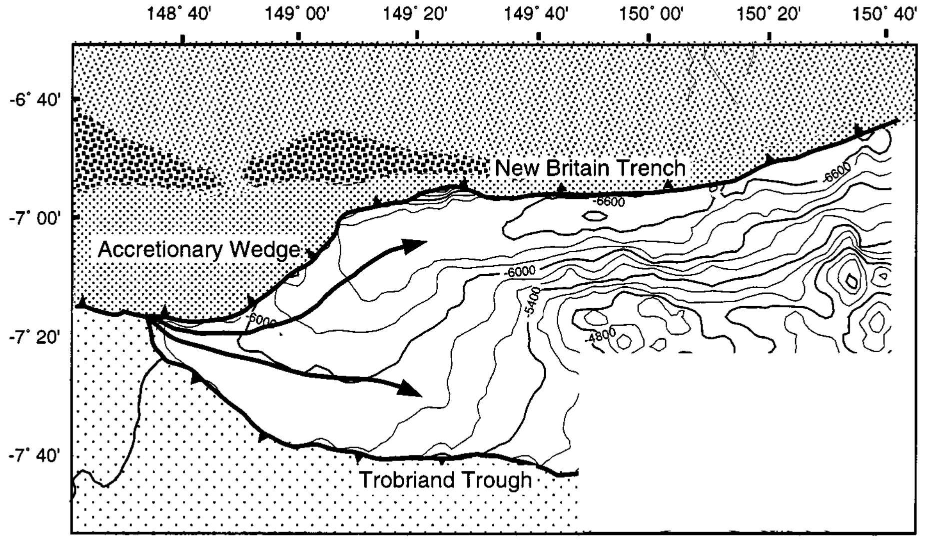

Figure 9. Bathymetry of the Solomon Sea basin. Arrows indicate turbidite dispersal paths from the Markham Canyon into the basin.

COMPARISON WITH THE TAIWAN COLLISION ZONE

The active arc-continent collision in Taiwan (left inset map in Figure 14) is another modern setting in which to study depositional responses to collision. The collision between the Luzon arc and the Chinese continental margin began during the early Pliocene (Suppe, 1980; Dorsey, 1988) and has propagated to the south at about 95 km/m.y. (Suppe, 1981). The maximum elevations in Taiwan are about 4 km. The continental shelf west of Taiwan is about 200 km wide; slopes are less than 1°. The continental slope is about 200 km wide, and slopes are approximately 1°. Covey (1986) studied the tectonodepositional processes in the western Taiwan foredeep and proposed a model for the evolution of the foredeep through the deep-marine to subaerial deposition transition (Fig. 14, left side). In this model, the early growth of the orogen and associated foredeep subsidence occurred while the orogen was still submarine and while little detritus was being shed from the orogen. Thus subsidence initially outpaced sedimentation, and deep-water deposition predominated (Fig. 14, Taiwan–1).

As the orogen migrated farther onto the continental margin, it eventually reached a maximum steady-state size, limited by erosion. Once the orogen reached a steady-state size, the tectonic load remained constant, but the erosion rates in the orogen continued to rise, reaching a maximum as the sedimentation rate began to outpace the subsidence rate and the basin began to fill with sediment (Fig. 14, Taiwan–2). Thick (2000 m) sequences of shallow-marine deposits indicate that after the basin filled close to sea level, subsidence and sedimentation rates balanced, probably allowed by longitudinal transport of sediment out of the basin. The steady-state sedimentary sequence in the western Taiwan foredeep consists of prograding shallow-marine, deltaic, and fluvial deposits that have persisted throughout late Pliocene and Pleistocene time (Fig. 14, Taiwan–3).

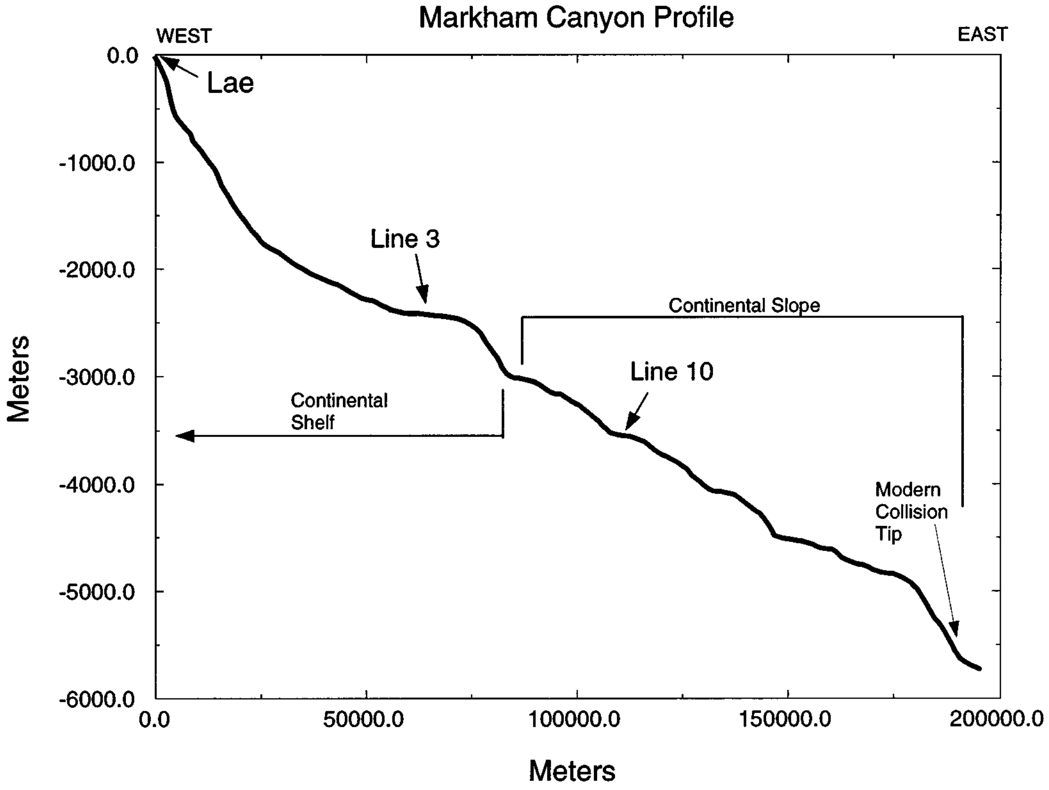

Figure 10. Markham Canyon longitudinal profile, derived from the HAWAII MR1 and 3.5 kHz bathymetry. The significance of the changes in gradient along the canyon is discussed in the text. Note the lack of a classic equilibrium profile for this canyon.

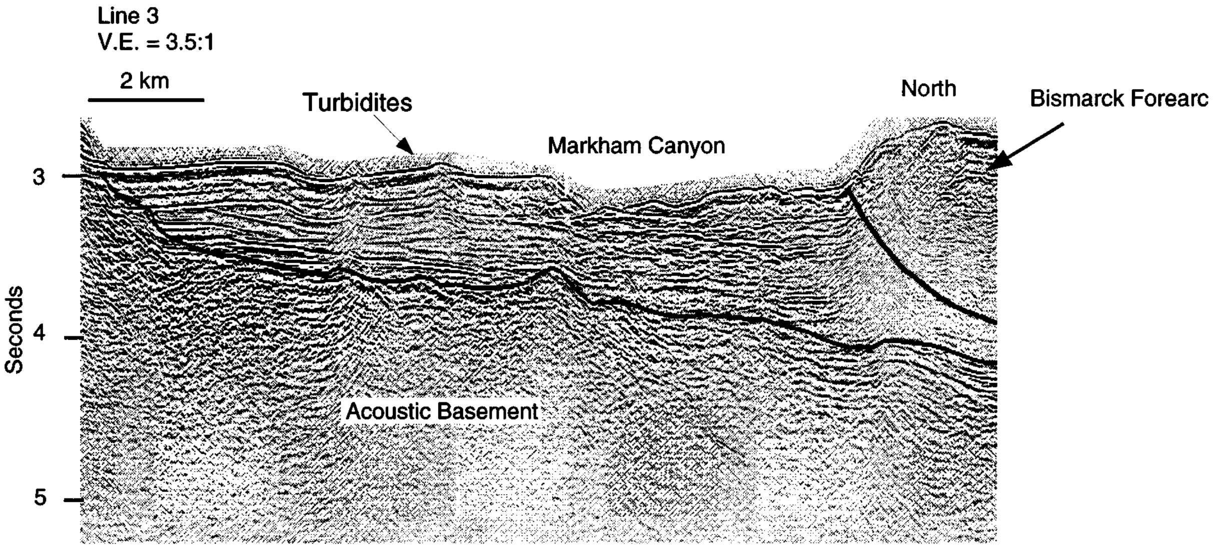

Figure 11. Seismic profile 3 from the western Huon Gulf showing the distribution of Markham Canyon turbidites. Part of the accretionary wedge of the Bismarck forearc is shown on the far right. The drowned carbonate platform shown in Figure 3B is to the left of this section (see Galewsky et al., 1996, for details). Vertical scale is in seconds of two-way travel time.

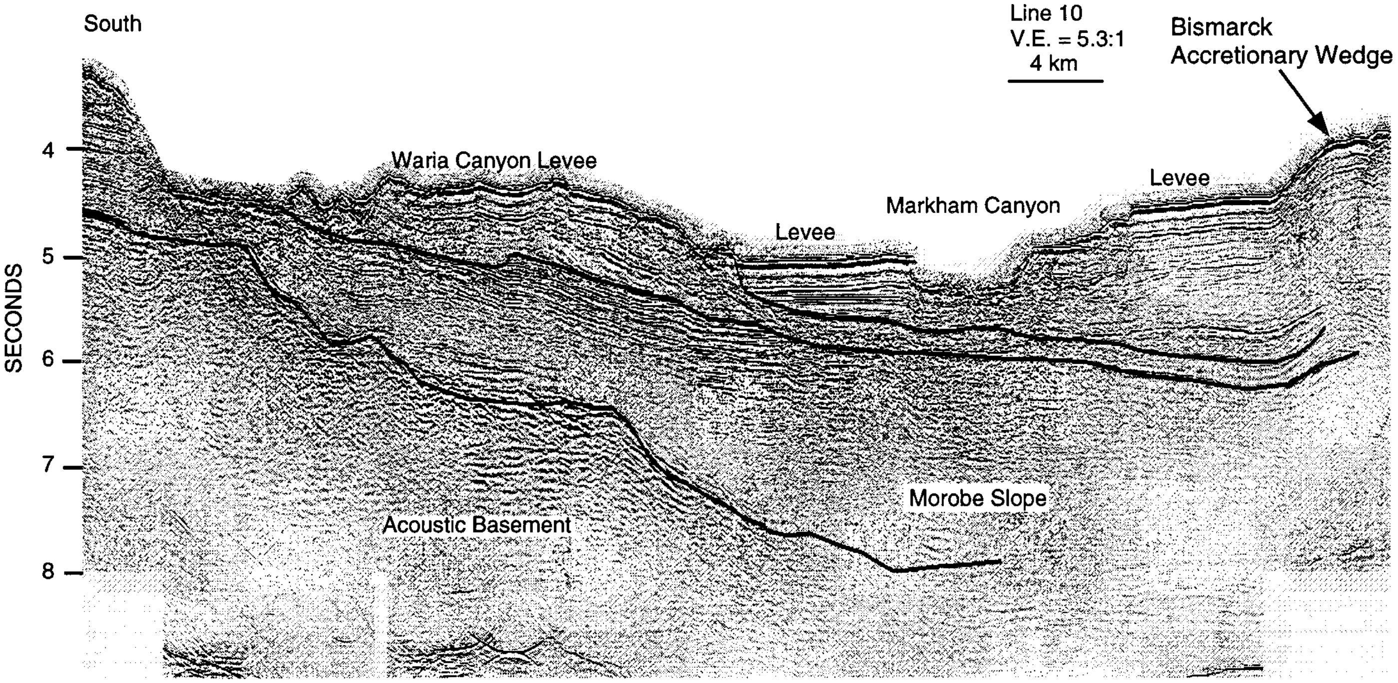

Figure 12. Seismic profile 10 showing the relationships between the Markham Canyon turbidites and deposits from the Waria canyon. These deposits overlie thick strata from the Morobe slope and shelf. Acoustic basement here is the surface of an accreted terrane. Vertical scale is in seconds of two-way travel time.

The foredeep associated with the Luzon-China collision exhibits a markedly different deep-water–subaerial deposit transition from the Bismarck-Australia collision. The western Taiwan foredeep is an excellent example of a classical foredeep in which accommodation space and sediment supply are directly linked to the growth of the orogen. The Chinese passive margin is wide (200 km) and flat (slopes less than 1°), which is conducive to the development of long-lived (millions of years) facies distribution observed in the foredeep, because continuing convergence between the orogen and the foreland will not significantly alter the basin geometry. In contrast, the basement topography of the Finisterre foredeep

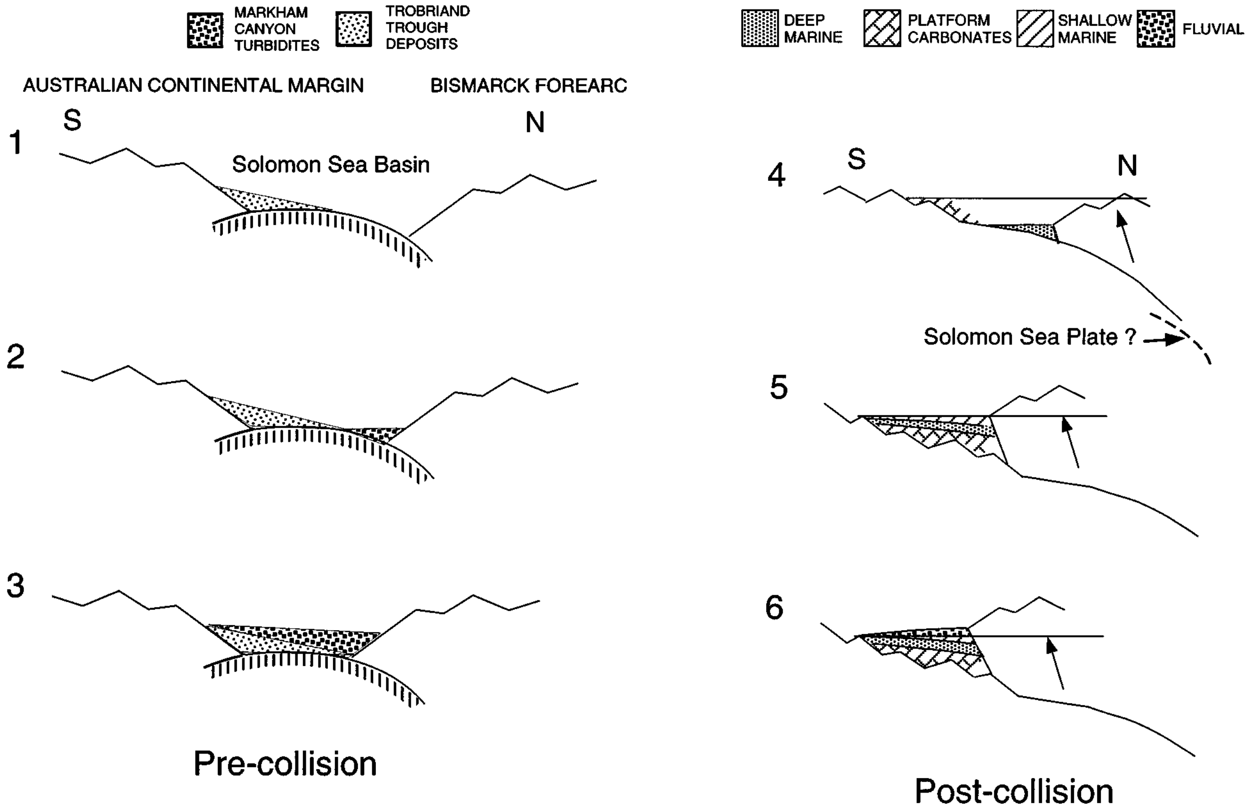

Figure 13. Stratigraphic evolution of the Finisterre foredeep. Precollisional setting shown in 1–3, postcollisional in 4–6. Locations of 1–3 are the east-central, central, and west-central parts of the Solomon Sea plate. Locations 4–6 coincide with lines 2–4 in Figure 14 (right side). The Solomon Sea plate that underlies the basin in 1–3 has been overridden by section 4; the dashed line shows its approximate position. The strata that accumulated in the Solomon Sea basin in sections 1–3 either accreted to the bounding New Britain accretionary wedge or were overridden by the New Britain forearc. We expect that the upper part of the section was accreted, but that part of the sediment was likely overridden.

plays a very active role in the evolution of the basin, and facies changes can be quite rapid. The continental shelf is narrow, about 6 km wide, and has slopes of 3°. Therefore, as the Bismarck forearc moves up the continental slope and onto the former shelf areas, the foredeep will shallow quite rapidly and the basin will exist in shallow-marine conditions very briefly before the entire basin becomes subaerial. This scenario is in marked contrast to the shallow-marine conditions observed in Taiwan, which have persisted for time scales of millions of years. Furthermore, the steep topography of the New Guinea Highlands provides a barrier to the development of the foreland prograding facies observed in Taiwan.

The Luzon-China collision and the Bismarck-Australia collision are similar in many ways; the age of the collision, convergence rates, maximum elevation of the orogen, and the development of a flexurally controlled basin are similar in both collision zones. An essential difference between the Luzon-China collision and the Bismarck-Australia collision lies in the nature of the continental margin in each case. The margin against which the Luzon arc is colliding is a true passive margin; the margin against which the Bismarck arc is colliding is a conglomeration of recently accreted terranes. The high topographic relief of the Australian continental margin has exerted significant control over the evolution of the Finisterre foredeep, including sediment flux and dispersal patterns, and has prevented a steady-state evolution.

DISCUSSION AND CONCLUSIONS

The Solomon Sea represents a rapidly changing sedimentary system, the changes of which are governed by the collision of the New Britain arc with the Australian continental margin. The high rate of eastward propagation of the initial point of collision is a key factor that influences the rate of change of sedimentary facies within the basin. High rates of plate convergence of the northern part of the Solomon Sea plate beneath the New Britain arc contrast with very slow convergence of the southern part of the plate, beneath the Trobriand platform. The difference in convergence rates translates to great differences in the rates of plate flexure beneath these margins, producing a deep, underfilled trench in the north and a shallower, filled trench in the south. Topographic gradients generated by these differences in rates of flexure of the Solomon Sea plate exert significant control over the turbidite dispersal pattern in the western Solomon Sea.

A complex unconformity is created by these differences in rates of plate flexure and the corresponding differences in bathymetry that is expected to be youngest in the east. Turbidites delivered to the Trobriand Trough and to the New Britain Trench bury earlier pelagic and hemipelagic deposits of the deep Solomon Sea basin. In the 149° Embayment, Markham Valley turbidites are directed northeastward by the bathymetry of the basin and enter the New Britain Trench. These turbidites overlap those of the

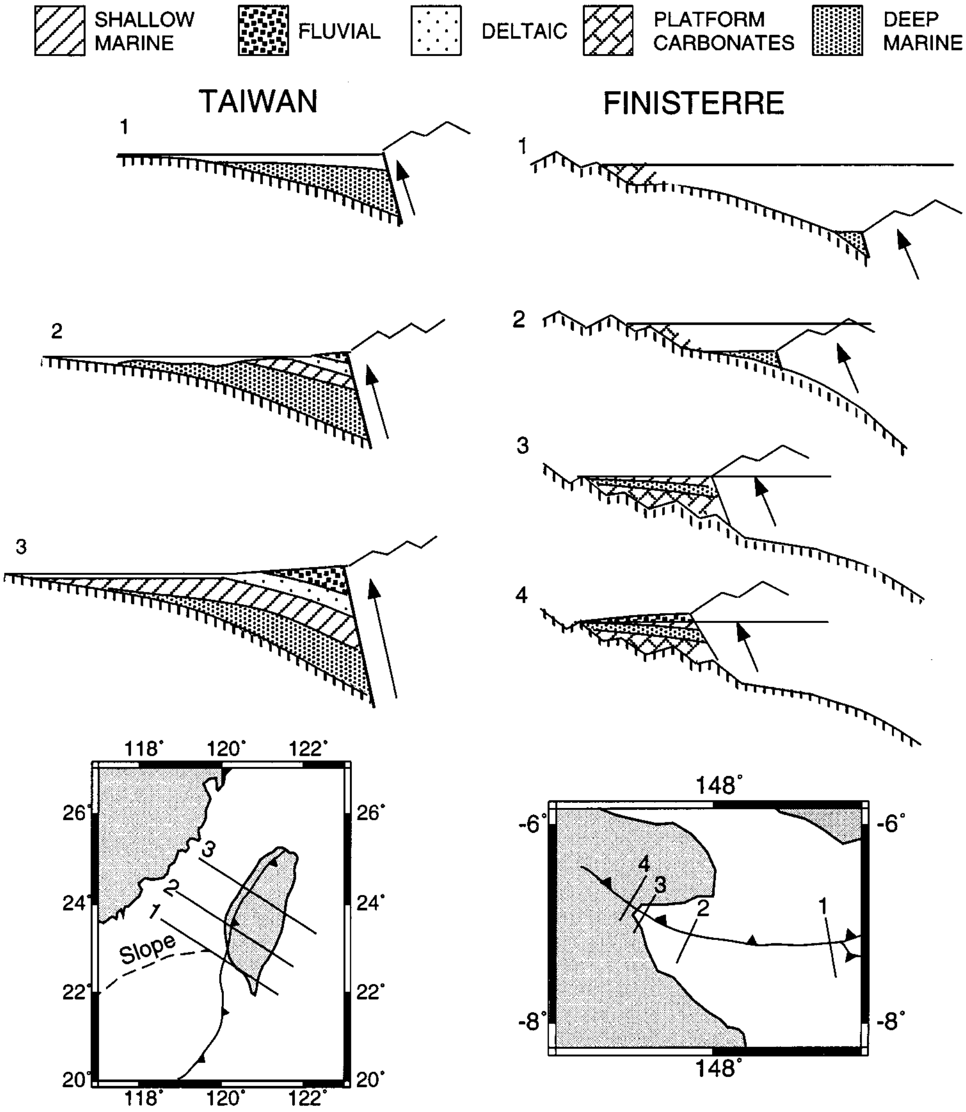

Figure 14. Stratigraphic evolution of the western Taiwan foredeep (left side), from Covey (1986), compared to the stratigraphic evolution of the Finisterre foredeep (right side). Small insets maps show the locations of these profiles with respect to Taiwan (left) and Papua New Guinea (right).

Trobriand Trough, and facies migration rates are probably twice as high in the New Britain Trench as in the Trobriand Trough. Where present in the same sections (Fig. 8, A and B) three major facies groups form the following stratigraphic sequence from lower to higher: pelagic-hemipelagic sediment, becoming discontinuous southward; Trobriand Trough turbidites; and New Britain Trench turbidites. Each facies continues to be deposited today, but the sequence reflects the geometry of the basin and rates of deposition. The pelagics are deposited very slowly (<10 m/m.y.), the Trobriand Trough turbidites are deposited at intermediate rates (<100 m/m.y.), and the New Britain Trench turbidites are deposited most rapidly (<1000 m/m.y.). It is not possible to define these rates much more precisely because of the lack of information on the age of the Solomon Sea plate or the details of the age distribution of the sediments. However, considering the Solomon Sea to be mid-Tertiary in age (20–40 Ma) and the Trobriand Trough to record a relatively small amount of convergence, the above rate limits are reasonable.

The transition from deep-water deposition to shallow-water and subaerial deposition is dependent on basement topography. The foredeep associated with the Finisterre Ranges shifts from a long period (1.5–3 m.y.) of deep marine deposition, into a rapid (~100 k.y.) transition from shallow-marine deposition to fluvial deposition. This is in sharp contrast to the western Taiwan foredeep, where shallow-water conditions have persisted for millions of years. These differences in facies transition periods can account for some of the differences in generalized stratigraphy shown in Figure 14.

Given a relatively steady-state collision system in Taiwan and Papua New Guinea, the two collisions will develop very differently because of the reasons discussed above. Further complicating the picture is the fact that the Solomon Sea collision does not appear to be steady state. Variation in terrane foreland basin geometry along strike is one example of a lack of steady state. Both along the Markham fault system in the Huon Gulf and onshore in the Markham valley, major variations in lower plate sediment distributions are evident (Silver et al., 1991; Liu and Crook, 1991; Abbott et al., 1994a, 1994b). In addition, the geometry of the northern margin of the Australian plate is highly irregular, and the spurs and reentrants of this margin produce major variations in the accretionary development of the Finisterre Range front.

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