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# Deformation and sedimentation along a developing terrane suture: Eastern Sunda forearc, Indonesia

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## ABSTRACT

**The collision of the eastern Sunda arc with northwest Australia has resulted in the development of a suture between the Sumba ridge and Sawu-Timor terranes along a zone of intraforearc convergence. The developing suture varies from the low-angle Sawu thrust, with attendant mud diapirs in the Sumba basin, to high-angle reverse faults near a basement high of the underthrust Sumba ridge terrane. Bottom currents, associated with the flow of Pacific Ocean deep water into the Indian Ocean, have eroded the terranes and subsequently deposited the detritus in an assemblage of contourites along the suture. This study reveals the high structural variability of a terrane suture and the oceanographic influence on the deposition of overlap assemblages.**

## INTRODUCTION

Critical to terrane analyses are the structural development of terrane sutures and stratigraphic evolution of sedimentary overlap assemblages (Coney et al., 1980). Equally important is the need to delineate paleoceanographic phenomena from tectonic relations in understanding tectonostratigraphic sequences. This study integrates marine geophysical data, piston cores, and geologic field investigations to examine the dynamic processes of terrane amalgamation. The terranes are juxtaposed along a zone of backthrusting of the accretionary wedge in the eastern Sunda forearc of Indonesia (Silver and Reed, in prep.).

## REGIONAL TECTONIC SETTING

The late Neogene collision of the eastern Sunda arc and northwest Australia has resulted in the development of a large accretionary wedge and differential uplift of the forearc region (Fig. 1) (Hamilton, 1979). The outer forearc basin has been uplifted along the Sumba ridge, which, in turn, is partially overthrust by the accretionary wedge along the south-dipping Sawu thrust (Fig. 1B) (Silver et al., 1983). Hence, the thrust can be viewed as a nascent suture between terranes of the forearc basin (Sumba ridge) and the accretionary wedge in a modern collision setting (Fig. 1C).

## SUSPECT TERRANES

This study recognizes two suspect terranes: (1) the Sumba ridge terrane and (2) the Sawu-Timor terrane (Fig. 1). These informal names serve to emphasize the geologic differences between the terranes; however, this study is concerned primarily with structural and stratigraphic relations along the intervening suture formed by the Sawu thrust.

### Sumba Ridge Terrane

Several workers have considered Sumba Island as a microcontinent within a region of arc-continent collision (Audley-Charles, 1975; Hamilton, 1979), and more recently as an accreted terrane (Nur and Ben-Avraham, 1982; Howell et al., 1983). The island exposes rifted blocks of mildly deformed turbidites, marls, and slates of pre-Tertiary age. These strata are intruded by calc-alkalic dikes and plutons of early Paleocene age (Fig. 1D) (Burollet and Sallé, 1982). Nonmarine strata of Paleogene age rest unconformably on the pre-Tertiary units and are, in turn, overlain unconformably by lower Miocene carbonate reefs in west Sumba and middle to upper Miocene volcaniclastic turbidites and pelagic chalks in the east (Fig. 1D) (Burollet and Sallé, 1982; von der Borch et al., 1983). Offshore reflection data reveal that the Neogene strata comprise early sequences of the forearc basin that lap onto the ridge and thus reveal its stable position within the forearc since the early Miocene initiation of the arc-trench system (Figs. 2 and 3) (Reed, 1985).

### Sawu-Timor Terrane

In contrast to the Sumba ridge, the nearby island of Sawu exposes thrust-deformed strata of the accretionary wedge (Rosidi et al., 1979; Hamilton, 1979). This part of the wedge consists of blocks of Triassic through Tertiary quartzose turbidites, deep-water limestones, ribbon radiolarites, and pelagic limestones that are interspersed with zones of highly sheared scaly clay (Fig. 1D) (Reed, 1985). The deformed strata compose a late Neogene accretionary complex that is unconformably overlain by markedly less deformed upper Miocene and Pliocene marls and chalks. The marl sequence is somewhat younger than similar rocks on the Sumba ridge (Crostella, 1977) and extends into the forearc basin, where it is deformed along the Sawu thrust.

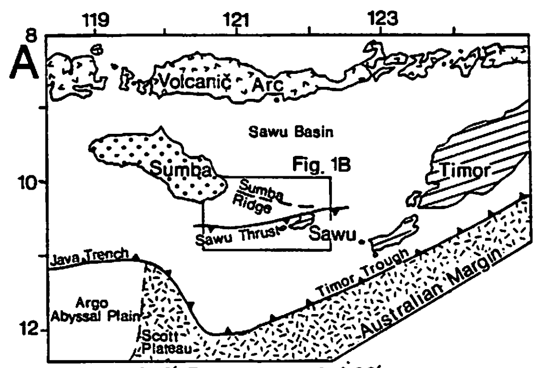
## SAWU THRUST—DEVELOPING TERRANE SUTURE

From west to east, the Sawu-Timor terrane has been thrust to progressively higher levels on the Sumba ridge terrane (Fig. 1). The oblique intersection of the terranes along the developing suture has resulted in a culmination of the Sawu-Timor terrane (accretionary wedge) at Sawu Island. To the west of the island, a trough has been formed by the deflection of the southern margin of the Sumba ridge terrane beneath the load of the Sawu-Timor terrane (Figs. 2A and 3A). This trough, hereafter referred to as the Sumba basin, is filled with more than 1 km of strata that have been intruded by mud diapirs along the Sawu thrust. A 5-km-wide ridge of deformed Sumba basin strata has been accreted to the arcward side of the Sawu-Timor terrane. The ridge has a relief of 0.5 km and extends for at least 50 km along the developing suture zone.

In the Sumba basin, thrust-related deformation does not involve the pre-Tertiary basement of Sumba ridge terrane (Fig. 3A) and is confined to a 1-km-thick mound of contourite sediments (Reed, 1985). The numerous mud diapirs along the thrust front suggest high pore-fluid pressures in the basin strata that have been deformed above a low-angle, possibly blind, decollement (Fig. 2A). Such elevated fluid pressures were attributed to similar structures to the east of Barbados by Westbrook and Smith (1983). Southeast of Sumba Island, the thrust divides into numerous splay faults that are located within a wide zone of deformation and diapirism. Deformation along the irregular thrust front appears to be occurring in many regions (Fig. 3A). However, within a few kilometres of the active segments diapirs are less extensive, and shallow strata of the Sumba basin lap onto the thrust front (Fig. 2A). Another major thrust is located about 15 to 20 km to the south, although it appears to be inactive.

To the east, the oblique intersection of the two terranes has truncated the Sumba basin, thus eliminating the depocenter for the contourite deposit. Deformation extends into the Sumba ridge terrane, where the suture is composed of high-angle reverse faults in the pre-Tertiary basement and passive drape folds in the overlying Neogene strata (Fig. 3B). The high-angle structures may also be formed in part by diapirs that originated in the pre-Tertiary basement in front of the Sawu thrust. Swift bottom currents have eroded the folded Neogene strata, removing stratigraphic evidence for the timing of late Neogene and Quaternary deformation. A few kilometres to the south of the high-angle basement faults, the Neogene strata are disrupted across a wide zone that extends westward into the low-angle Sawu thrust.

The high-angle faults may flatten at depth and merge with a low-angle decollement surface. Wiltschko and Eastman (1983) attributed similar steep frontal ramps to deflections in the principal stress trajectories at the intersection of a thrust sheet and warps in the underthrust basement. Regardless of the fault geometry at depth, horizontal shortening is distributed along several of the reverse faults and appears to be less than that observed farther west in the Sumba basin. This decrease in convergence is



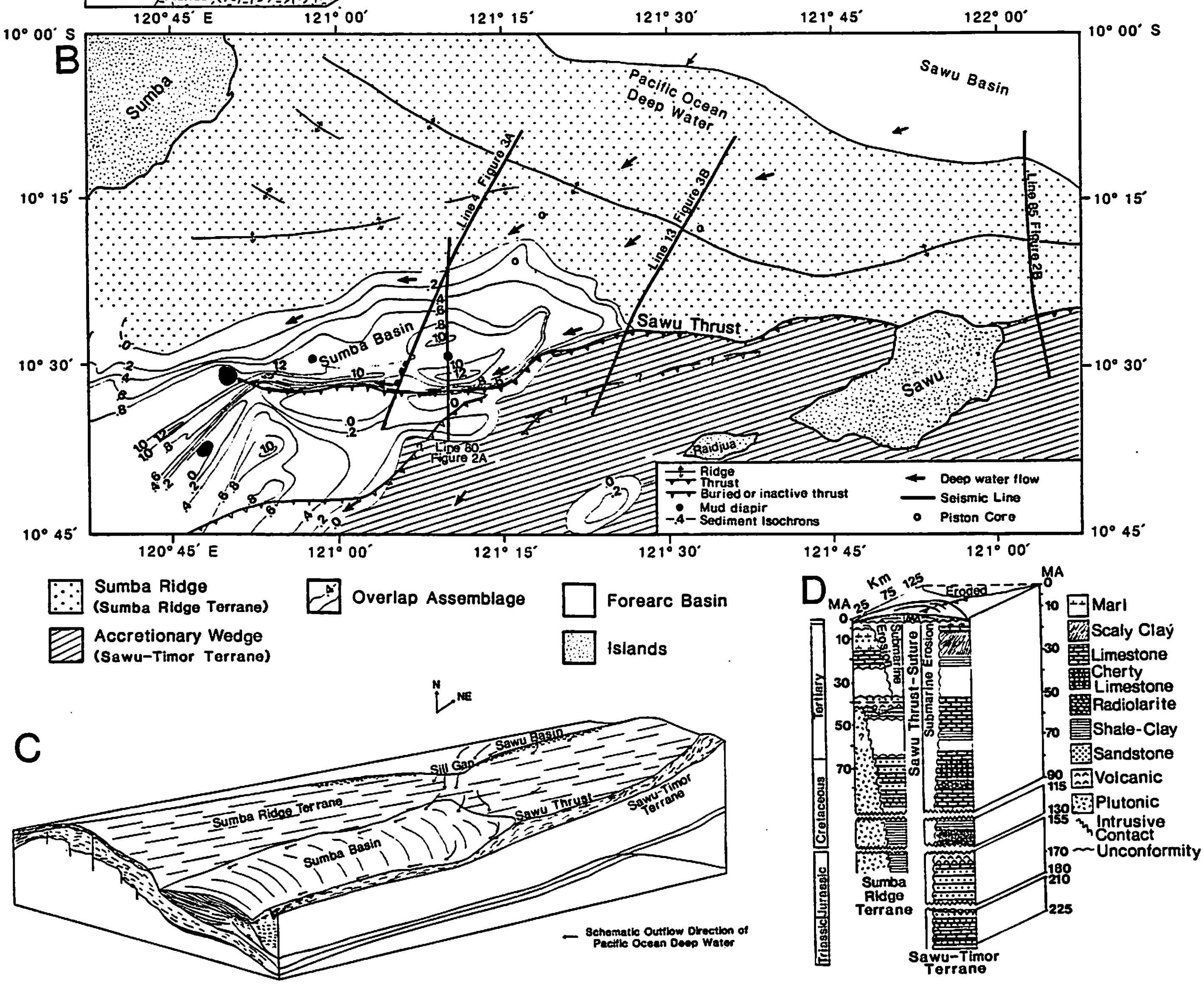




**Figure 1. A: General location of developing terrane suture (Sawu thrust) in eastern Sunda arc-trench system. B: Tectonic map of Sumba ridge and Sawu-Timor terranes. Contours of isochrons of two-way travel time are shown for overlap assemblage in Sumba basin. Arrows indicate general flow of deep currents responsible for deposition of overlap assemblage (Wyrtki, 1961). C: Physiographic diagram of terranes and flow of bottom currents along developing terrane suture (Sawu thrust). D: Comparative stratigraphic diagrams of Sumba ridge and Sawu-Timor terranes, and overlap assemblage.**

probably compensated by shortening and vertical uplift within the accretionary wedge and thus may be partly responsible for the culmination of the wedge at Sawu Island. In contrast to the style of deformation in the Sumba basin, the faulting of the pre-Tertiary basement and folding of Neogene strata suggest elevated stress concentrations, possibly facilitated by decreased pore-fluid pressures along the frontal ramps. Surprisingly, the reactivation of inherited faults in the basement is not observed along the front of the thrust system.

To the east of Sawu Island, the pre-Tertiary basement and a thin sequence of strata of the Sumba ridge terrane can be traced for at least 10 km beneath a wedge of deformed strata along the margin of the Sawu-Timor terrane (Fig. 2B). The contact between the terranes consists of an active, low-angle decollement located in the upper few hundred metres of Neogene turbidites of the forearc basin. North of the thrust front, the turbidites are offset by numerous normal faults above a flexure in the forearc basement along the uplifted Sumba ridge.

## SEDIMENTARY OVERLAP ASSEMBLAGE OF THE SUMBA BASIN

The timing of terrane amalgamation can be established from overlap assemblages in successor basins and provenance linking of adjacent terranes (Jones et al., 1983). Although overlap assemblages are commonly perceived as post-orogenic sheet deposits, the progressive tectonism of terrane amalgamation produces evolving structural geometries that result in complicated depositional systems.

The uplifted amalgamation of the Sumba ridge and Sawu-Timor terranes forms a barrier to the flow of Pacific Ocean deep water into the Indian Ocean (Wyrtki, 1961; Reed et al., in prep.). The flow of these deep currents is focused along the suture between the Sumba ridge and Sawu-Timor terranes. The accelerated bottom currents have removed as much as 1 km of Neogene chalks from the Sumba ridge terrane and subsequently redeposited the detritus in an extensive (25 × 75 km) drift deposit along the terrane suture (Fig. 1C). Consequently, the sediment drift forms an overlap assemblage of contourites that laps onto mid-Miocene to Pliocene strata of the Sumba ridge terrane and, in some regions, onto the deformed ridge along the margin of the Sawu-Timor terrane. To the east, the amalgamated terranes are elevated above the Sumba basin, and vigorous bottom currents have eroded both terranes and prevent the deposition of the sediment drift along the developing suture (Figs. 2B and 3B). Thus, although the sediment drift is more than 1 km thick in the Sumba basin, it is bounded by wide areas of extensive erosion. Because of this variable occurrence of erosion and sedimentation, the age assigned to the unconformity at the base of the drift deposit, and hence the amalgamation event, will vary according to geographic location.

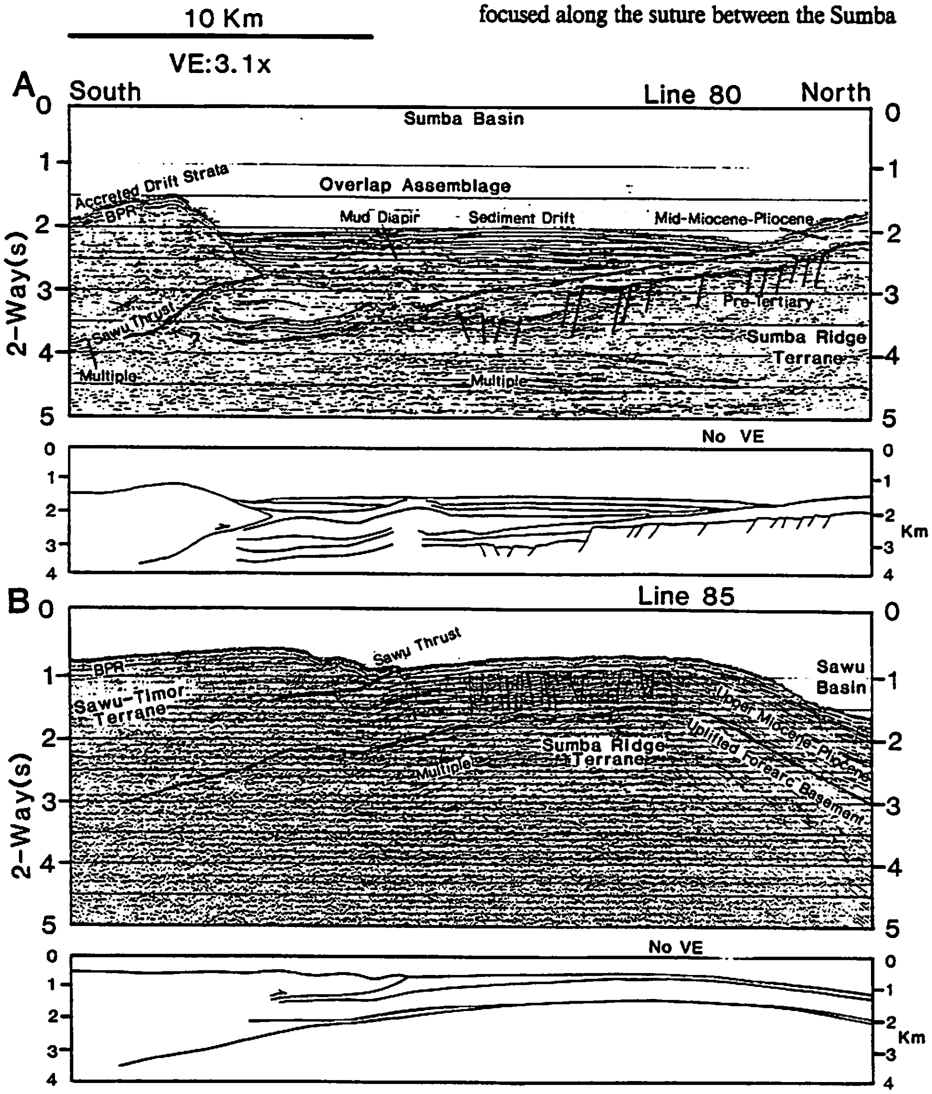



**Figure 2. A: F-K migrated time section (line 80, Fig. 1B) of developing terrane suture (Sawu thrust). BPR = strong bubble pulse reflection of sea floor. Generalized line drawing at no vertical exaggeration is converted to depth below seismic section. B: Unmigrated time section (line 85, Fig. 1B) of developing terrane suture near crest of Sumba ridge terrane to east of Sawu Island. VE = vertical exaggeration.**

## RELATIONSHIP TO STUDIES OF ANCIENT TERRANES

Intraforearc convergence along the Sawu thrust has produced diverse structures along a zone of terrane amalgamation (Fig. 4). The oblique trends of the Sumba ridge and Sawu-Timor terranes, position of the developing suture relative to basement morphology, and distribution and thickness of sediment drift (overlap assemblage) all affect the structural variability of the terrane suture. This variability might be misinterpreted to represent unrelated tectonic events if observed in scattered outcrops of an orogenic belt. Bottom currents along the developing suture have eroded both terranes and redeposited the detritus as a thick assemblage of contourites along the developing suture. Such overlap assemblages are strongly influenced by oceanographic phenomena that can obscure tectonic relations. The overlap assemblage is not laterally continuous, and the chronological variation at its base illustrates the need for extensive dating to resolve the timing of terrane amalgamation. Therefore, although terrane analysis provides a valuable technique for investigating orogenic belts, caution must be exercised in extrapolating geologic and geophysical data to resolve the structure of terrane sutures and the sedimentary dynamics of overlap assemblages.

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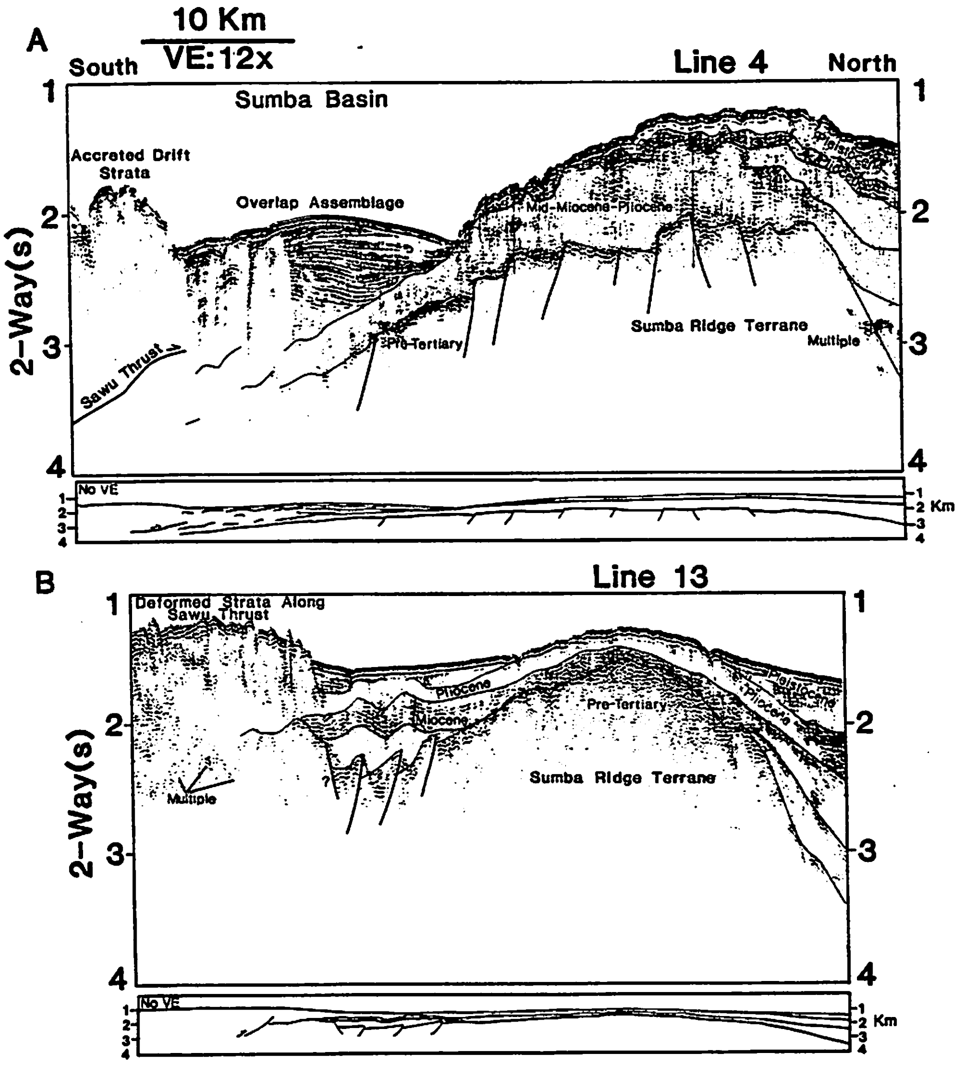


**Figure 3. A: Analog 80 in.$^3$ watergun profile (line 4, Fig. 1B) showing numerous mud diapirs along Sawu thrust. B: Analog watergun profile (line 13, Fig. 1B) showing reverse faults and extent of submarine erosion along Sumba ridge terrane. VE = vertical exaggeration.**

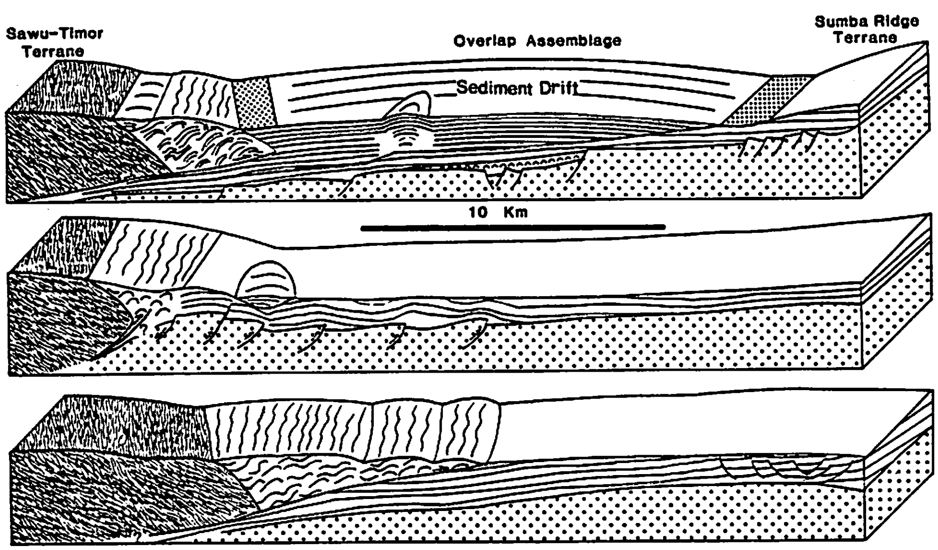


**Figure 4. Interpretation of spatial variation in structural and stratigraphic relations at three sites along developing terrane suture and contourite overlap assemblage. Block diagrams are arranged from west (top) to east (bottom).**

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