STRUCTURE OF THE SUNDA TRENCH LOWER SLOPE OFF SUMATRA FROM MULTICHANNEL SEISMIC REFLECTION DATA*

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Abstract. Multichannel seismic reflection profiles across the Sunda Trench slope off central Sumatra reveal details of subduction zone structure. Normal faults formed on the outer ridge of the trench offset deep strata and the oceanic crust, but die out upsection under the trench sediments. At the base of the inner trench slope, shallow reflectors are tilted seaward, while deeper reflectors dip landward parallel to the underlying oceanic crustal reflector. Intermediate depth reflectors can be traced landward through a seaward-dipping monocline. We interpret this fold as the shallow expression of a landward-dipping thrust fault at depth. Landward of this flexure, relatively undeformed strata have been stripped off the oceanic plate, uplifted 700 meters, and accreted to the base of the slope. The oceanic crust is not involved in the deformation at the toe of the slope, and it can be observed dipping landward about 25 km under the toe of the accretionary prism.

The middle portion of the trench slope is underlain by deformed accreted strata. Shallow reflectors define anticlinal structures, but coherent deep reflectors are lacking. Reflectors 45 to 55 km landward of the base of the slope dip 4°-5° landward beneath a steep slope, suggesting structural imbrication.

A significant sediment apron is absent from the trench slope. Instead, slope basins are developed in 375-1500 m water depths, with an especially large one at about 1500 m water depth that is filled with more than 1.1 seconds of relatively undeformed sediments. The seaward flank of the basin has recently been uplifted, as indicated by shallow landward-dipping reflectors. Earlier periods of uplift also appear to have coincided with sedimentation in this basin, as indicated by numerous angular unconformities in the basin strata.

1. Introduction

It has been proposed that sediments are stripped off the descending oceanic plate and accreted to the base of the inner trench slope in active arc systems where a thick sedimentary cover is being swept into the subduction zone (e.g., Silver, 1969; Seely et al., 1974). Accretion in this type of trench has been inferred primarily from marine seismic reflection surveys, but interpretation of the complex structure of trench slopes is very difficult without migrated multichannel seismic reflection data, and the details of this accretion process remain obscure. Although Deep Sea Drilling has corroborated the accretionary model in the Shikoku (J. C. Moore and Karig, 1976) and northern Middle America Trenches (J. C. Moore et al., 1979), drilling results have cast doubts as to the applicability of the model to the Japan Trench (DSDP Staff, 1978) and the Middle America Trench off Guatemala (von Huene et al., in press). Seismic reflection profiles across the Oregon-Washington margin (Silver, 1972; Carson et al., 1973), the northern Sunda Trench (Curray and D. G. Moore, 1974), the

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Shikoku Trench (J. C. Moore and Karig, 1976), the Aleutian Trench (Seely, 1977; von Huene, 1979), the Middle America Trench (Seely, 1979; Seely et al., 1974), and the Makran Trench (White and Klitgord, 1976) suggest that trench and/or lower plate sediments are first folded into anticlines at the base of the lower trench slope and may be subsequently incorporated into the subduction complex along thrust faults. Profiles across the Java portion of the Sunda Trench (Beck and Lehner, 1974) suggest that very little folding occurs in that area, with most of the deformation presumably occurring by thrusting.

A ridge and trough morphology occurs on trench slopes, with slope sediments accumulating in the troughs. Single-channel analog seismic reflection profiles show that the slope basin sediments are tilted landward (Curray and D. G. Moore, 1974; G. F. Moore and Karig, 1976; White and Klitgord, 1976), but the high vertical exaggeration and shallow penetration of analog profiles have hampered interpretations of slope basin stratigraphy and structure.

The forearc region of the Sunda Arc (Figure 1) has often been cited as one of the classic examples of an accretionary margin (see, for example, W. Hamilton, 1977, 1979; Dickinson and Seely, 1979). The region has a sediment-filled forearc basin, an emergent outer-arc ridge (trench slope break), and a thick sediment section on the underthrusting Indian plate (McDonald, 1977; Karig et al., 1979). As part of the International Decade of Ocean Exploration/Studies of East Asian Tectonics and Resources (IDOE/SEATAR) program (CCOP-IOC, 1974), we conducted a multidisciplinary marine study of the central Sumatra portion of the Sunda Arc in cooperation with the Indonesian National Institute of Geology and Mining. During March 1977, we collected 830 km of multichannel seismic reflection data across the inner trench slope west of central Sumatra on the R/V Thomas Washington of the Scripps Institution of Oceanography (Figure 1). The multichannel seismic lines were oriented approximately perpendicular to the strike of the trench slope and were run from the trench across the lower trench slope to the outer-arc ridge in order to delineate the structure of the lower slope and to locate a small area for later detailed study using analog seismic reflection and bathymetric methods. A seismic refraction program was also carried out on the inner trench slope. Much of our shallow structural interpretation was made on the basis of the localized detailed survey and has been presented by Karig et al. (in press). The multichannel seismic data presented here confirm and extend the inferences drawn from those single-channel data. The seismic refraction data, interpreted by Kieckhefer et al. (1980), have also been employed in the interpretation of our multichannel seismic profiles.

2. Data Acquisition and Processing

An array of three Bolt airguns (300, 120, and 40 cubic inches or 4.92, 1.97, and 0.66 liters), operated at 1800–2000 psi, and fired simultaneously at 15-second