

Shallow Seismics of Recent Sediments Deposited in the Miaoli-Hsinchu Offshore Area, Taiwan

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ABSTRACT

Uniboom seismic data acquired in the Miaoli-Hsinchu offshore area were analyzed in terms of seismic sequence and seismic facies. A gas chimney and an anticlinal structure were discovered in Sequence I of the shallow marine area off Miaoli. This gas chimney is probably the first one ever discovered offshore Taiwan. Transgressive basal sands of Sequence I were then deposited on the unconformity which separates Sequences I & II. Slope front fill facies and slump facies of Sequence III dominate the recent sediments off Tunghsiao and Paishatun. A visible broad deltaic lobe facies was deposited in the Houlung and Chuwei offshore areas. The apex of the lobe does not directly face the estuaries of the Houlung Hsi or the Chungkang Hsi Rivers indicating the deposition of the lobe was affected by the topography of the sea floor and the longshore currents. Paleostorm sand bars and lagoonal seismic facies are recognized in the Chiting and Hsiangshan offshore areas.

Uniboom seismic stratigraphy proved useful in the research subjects of Quaternary paleoenvironmental evolution, sea level change, shallow structure, gas chimney and the stability of the sea floor in the Taiwan area.

(Key words: Uniboom, Gas chimney, Seismic facies, Deltaic lobe, Sand bars)

1. INTRODUCTION

High resolution seismic reflection profiling systems of shallow penetration, such as the Uniboom system, are commonly used by research geoscientists and by the offshore industry (Bouma *et al.*, 1983; Canals *et al.*, 1988; Harris *et al.*, 1993; Sieck and Self, 1977; among others). The high resolution data produced by the Uniboom systems allow for more detailed interpretations of geological phenomena in a shallow sedimentary column, which provides valuable information on paleoenvironments, sea floor stability and even on shallow exploration.

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On the Taiwan Side-Looking Airborne Radar Mosaic Image published by the Industrial Technology Research Institute (1981), it is easy to recognize the Chuhuangkeng anticline exposed at land surface near Miaoli City. Actually this is the oldest natural gas field found in Taiwan and is currently being operated by the Chinese Petroleum Corporation (CPC). Since the Chuhuangkeng anticline is not far from the coast, the tectonic compression mechanism of this anticline has probably influenced the offshore area of Miaoli-Hsinchu. The question, then, arises as to whether the mechanism could have formed another anticlinal structure in the shallow marine area. Because large seismic vessels of oil industries cannot approach the shallow marine area, the CPC does not have any good seismic sections in this shallow marine area. This affords an ideal opportunity to utilize Uniboom seismic data to study whether the tectonic force formed another anticline. If another anticline was indeed formed, this anticline should be similar to the Chuhuangkeng anticline in terms of hydrocarbon source maturation. Then suspicion is aroused as to whether or not, in such case, a gas chimney may be found around the expected anticline.

Soil conservation has become a serious problem in Taiwan in recent years with the rivers of a steep stream gradient transporting a large quantity of soils into the ocean. It will be interesting to know how these soils are distributed or what the sedimentary patterns of these soils are in the study area.

2. HIGH RESOLUTION MARINE SEISMICS

Uniboom seismic reflection is one kind of high resolution marine seismic survey. The Uniboom Transducer is an electromechanical sound producing device consisting of an electrical coil magnetically coupled to a plate. Energy contained in the electrical storage capacitors is discharged into the coil, thereby causing induction currents in the plate which produce an outward force.

The resultant acoustic pressure pulse has a broad spectrum rich in medium to high frequencies (400 to 14,000 kHz) for reasonable penetration (30 to 60 meters) with excellent resolution (15 to 30 cm) in water depths of over 300 meters (EG&G, 1991).

This study pertains to the research of the Uniboom seismics conducted in the Miaoli-Hsinchu offshore area (Figure 1). The seismic profiles obtained are of good quality with structural and sedimentary features obvious on some profiles. Seismic stratigraphic analytical methods have been applied to these seismic sections. In the following text, the authors illustrate some representative sections obtained in the southern, middle, and northern parts of the study area; then their stratigraphic meanings and applications are discussed.

3. SOUTHERN PART

With the seismic sequence analysis (Van Wagoner *et al.*, 1983; Vail *et al.*, 1977) method being used, the seismic section obtained in the Tunghsiao-Paishatun offshore area was divided into three sequences (Figure 2) for the present study. Then, a detailed seismic facies analysis was applied to each of these sequences.

3.1 Sequence I (Gas Chimney)

Two seismic features seem very interesting in Sequence I (Figure 3): the tight anticline and the appearance of a gas chimney. It is clear that the compression force onshore still influences the study area because of the clear presence of an anticline on the seismic section

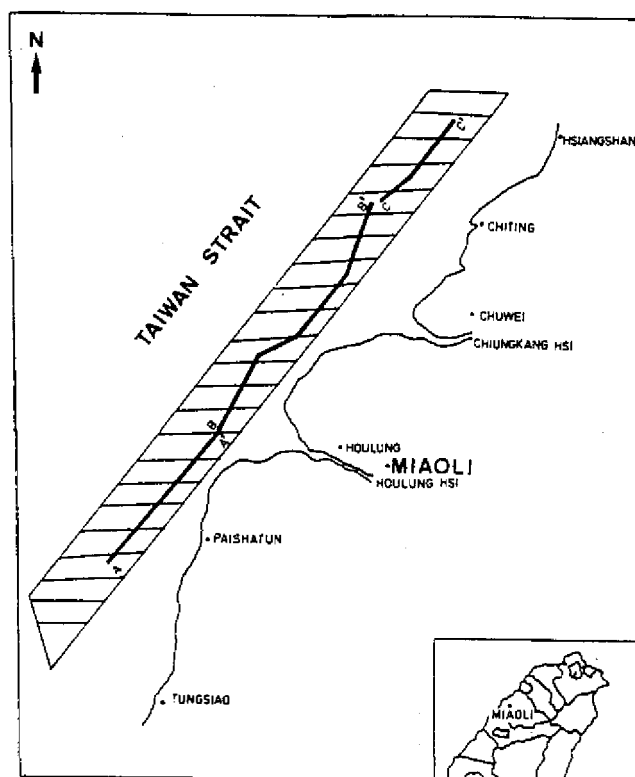


Fig. 1. Map showing the location of the study area. AA', BB' and CC' are seismic lines illustrated in the text.

(Figure 3). The tight anticline found in the shallow marine area seems valuable due to the following reasons. The CPC has shot many seismic lines in the deep water of the Hsinchu-Miaoli offshore area, but satisfactory seismic data are not available in the shallow marine area. Most structures on the seismic sections shot in the deep offshore area are normal faults, and only a few are very gentle folds (Chow *et al.*, 1991; Fuh, 1992; Sun, 1982). Another reason that this anticline deserves attention is that this one along with the one in Chuhuankeng have similar properties in terms of reservoir, source rock, and maturation. However, a more careful examination of the anticline finds that the continuity of reflectors is abruptly interrupted by a chaotic zone in the middle.

This interruption suggests a gas chimney or the presence of a fault zone. Many gas seepages have been found in the vicinity of the Chuhuankeng gas field and other structures onshore Taiwan (CPC, 1971). But until now, no gas seepages on seismic sections shot in offshore Taiwan have ever been discovered. In contrast, there have been many reports of gas seepages on seismic sections, which are called gas chimneys, in other offshore areas of the world (Bouma *et al.*, 1983; Kingston, 1987). The reason that a gas chimney had not been found in the offshore Taiwan area is probably that no high resolution shallow marine seismics, such as the Uniboom study, have been conducted. The facts that deterioration of data quality, low velocity and pull down of seismic signals around the above mentioned chaotic zone (Figure 3) coincide with the definition of the gas chimney as described in the SEG

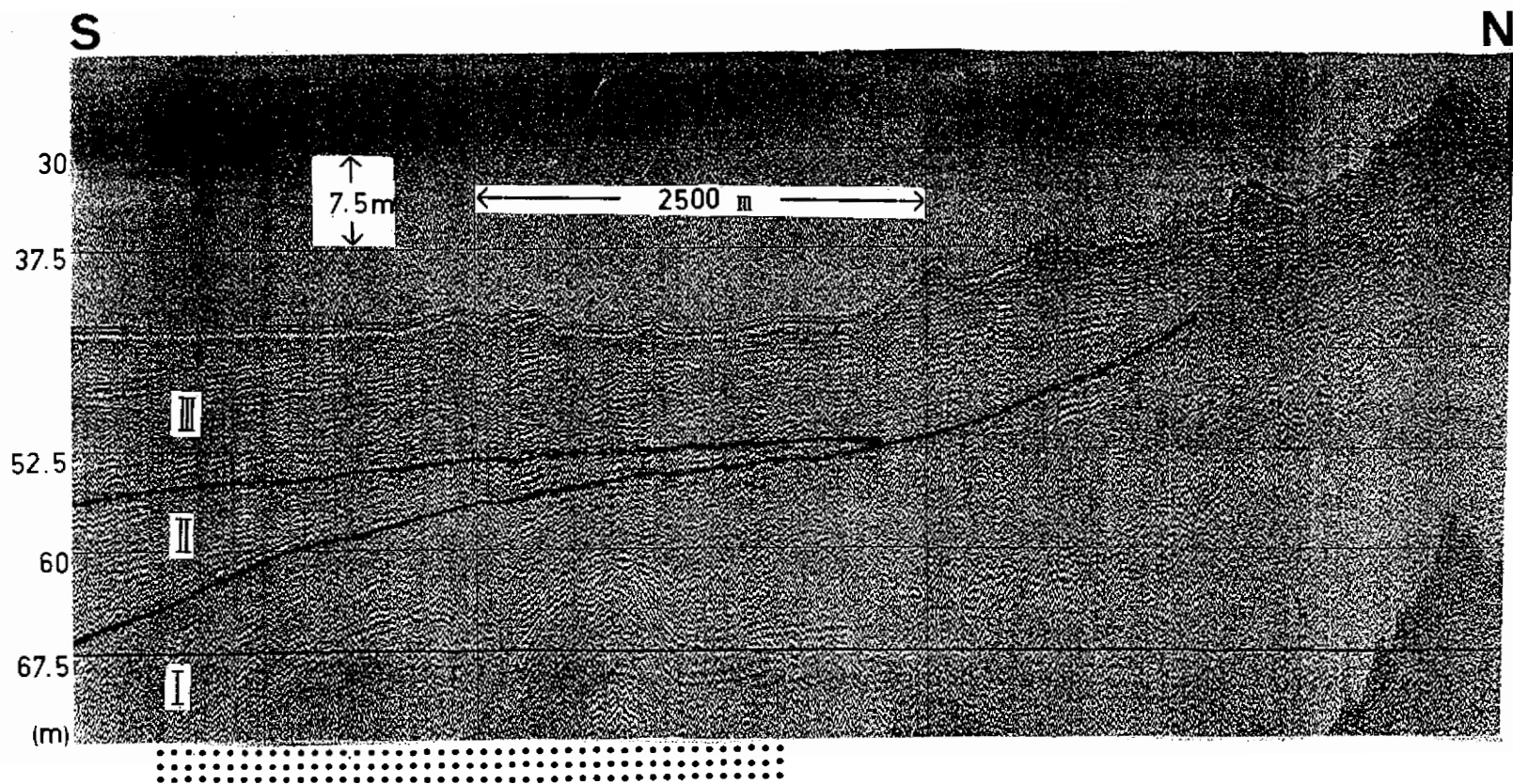


Fig. 2. A representative Uniboom seismic section of line AA' shot in the southern part of the study area. Seismic sequence analysis was employed to divide the section into three sequences.

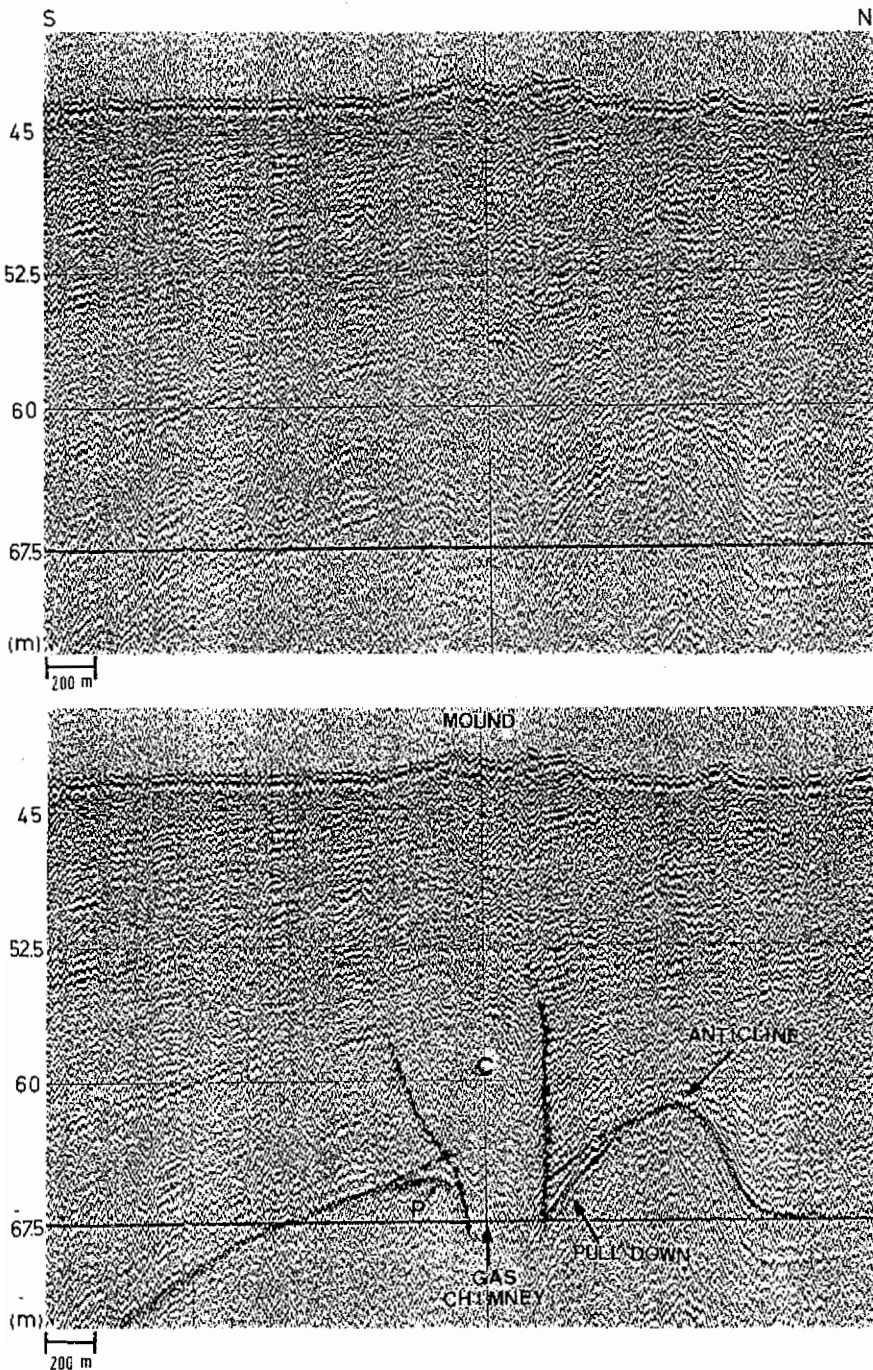


Fig. 3. Uninterpreted(A) and interpreted(B) seismic sections showing an anticline. Phenomena of seismic data deterioration, low velocity and pull down of seismic signals(P) around the chaotic zone(C) coincide with the definition of a gas chimney. The mound on the sea floor above the chaotic zone gives further evidence for the derivation of a gas chimney. The seismic section corresponds to the dotted part on the left of Figure 2.

Encyclopedic Dictionary of Exploration Geophysics (Sheriff, 1973). The chaotic zone feature is also much like many gas chimneys found in other areas (Bouma *et al.*, 1983; Kingston, 1987). Further evidence to support this derivation is that the sea floor above the gas chimney has a mound with a central depression (Figure 3). This mound may have been formed when the natural gas migrated up from the fault fractures of a gas anticlinal trap and stirred the overlying sediments through the migration path. Sieck and Self (1977) also discovered similar mounds above gas seepages in offshore Texas. The existence of this gas chimney also suggests that there are hydrocarbons in the anticlinal trap, and it provides invaluable information which will help minimize any hazards when marine engineering activities, like drilling operations, are designed for the study area.

3.2 Sequence II (Transgressive Basal Sand)

The interpretive cross-section of the seismic section of Figure 2 is shown in Figure 4. The uplift movement of this area could have occurred during the folding. This area was then elevated above sea level to form an unconformity by erosion. After the unconformity developed, there may have been a transgression in this area as indicated by the onlapping of the sedimentary strata (Figures 2&4). Vail *et al.* (1977) suggest transgressive basal sand could have been deposited on the unconformity when high energy deposition took place in this kind of paleocoastal area. Therefore, it is reasonable to assume that transgressive basal sand has possibly been deposited on this unconformity.

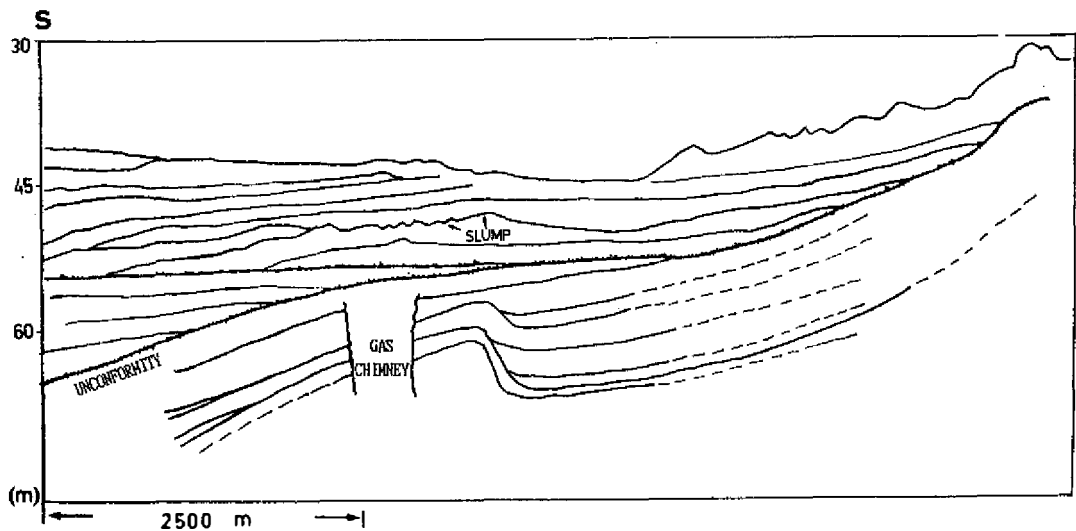


Fig. 4. The interpretive cross-section of Figure 2.

3.3 Sequence III (Slope Front Fill)

The seismic facies of Sequence III are totally different from those of Sequence I or II (Figures 2&4). The seismic facies of slope front fill and slumps can be recognized in Sequence III. The slope front fill facies, which was inferred by Sangree and Widmier (1977) as a common deeper-water shelf seismic facies, characteristically show parallel to subparallel reflections sloping southward, with updip onlap and downdip downlap. The deeper-water

shelf means the water is deeper than that in the coastal shelf. The present water depth of the location of the seismic line seems to agree well with the seismic facies inference. According to Vail *et al.*, (1977), for the lithological interpretation of the slope front fill facies, the following possible derivation can be made. The sediments of this facies are dominated by deeper shelf marine finer-grain silts and clays associated with local sands that are carried or even slumped downslope from the nearby highland. The existing slumps (Figures 2&4) suggest the sea floor is too unstable for pipeline construction. The chaotic reflections of the slumped features indicate the poor sorting character of the sediments in the local area.

4. MIDDLE PART (Broad Deltaic Lobe)

The river systems are generally short and steep in Taiwan. How are the clastic eroded materials deposited when these rivers enter the ocean? The Houlung Hsi and The Chungkang Hsi are the two rivers situated in this study area (Figure 1). A long seismic section of good quality running across the offshore area of these was selected and displayed here. A broad, low relief deltaic lobe is clearly observed on this section (Figure 5). This is a lobe sixteen-kilometers wide but only five-meters thick. According to Sangree and Widmier (1977), this kind of gentle mound may be interpreted as reflecting a complex of delta lobes formed on a subsiding shelf. This reveals that the sea floor where this seismic line runs is now subsiding. The seismic line is located between the offshore areas of the towns of Chiting and Houlung. The deltaic lobe apex usually lies just outside the estuary, but this seismic section shows that the apex of this lobe does not directly face the estuaries of the Chungkang Hsi or Houlung Hsi Rivers. In fact, the apex of the lobe actually lies between the estuaries of these two rivers. Besides, the two deltaic lobes of these two rivers have been blended together. The shifting of the apexes and blending of the lobes were probably due to the confining topography of the sea floor and the modification of longshore currents.

5. NORTHERN PART (Drowned Bar and Lagoon)

There is a typical seismic section representing the seismic facies feature in the offshore area between the towns of Chiting and Hsiangshan in Hsinchu County (Figure 6). The seismic section shows two sand bars with high angle seaward-dipping cross stratification and low-angle, landward-dipping or nearly horizontal stratification (Figure 6). Some sedimentologists have found this kind of sand bar is usually deposited after storms, and many of this kind of sand bar likely preserved during net progradation (McCubbin, 1982; Hayes and Boothroyd, 1969). Therefore, it seems reasonable to deduce that this particular sand bars in this study area were probably deposited after storms during typhoon seasons. The seismic reflections of strata layers in these sand bars are clearly visible. However, the reflection characteristics change to chaotic or nonreflective landward side next to the sand bars (Figure 7). The seismic facies with chaotic or nonreflective characteristics probably indicate a lagoon paleoenvironment adjacent to the sand bars because the abundant muds in the lagoon do not result in any acoustic contrast for the seismic signal generation.

6. CONCLUSIONS

- (1) Because of the use of shallow seismics, an anticlinal structure whose reservoir maturation conditions are similar to those of the Chuhuangkeng anticline on land has possibly been discovered in the Miaoli offshore area. In addition, a gas chimney has been found on the discovered anticline.

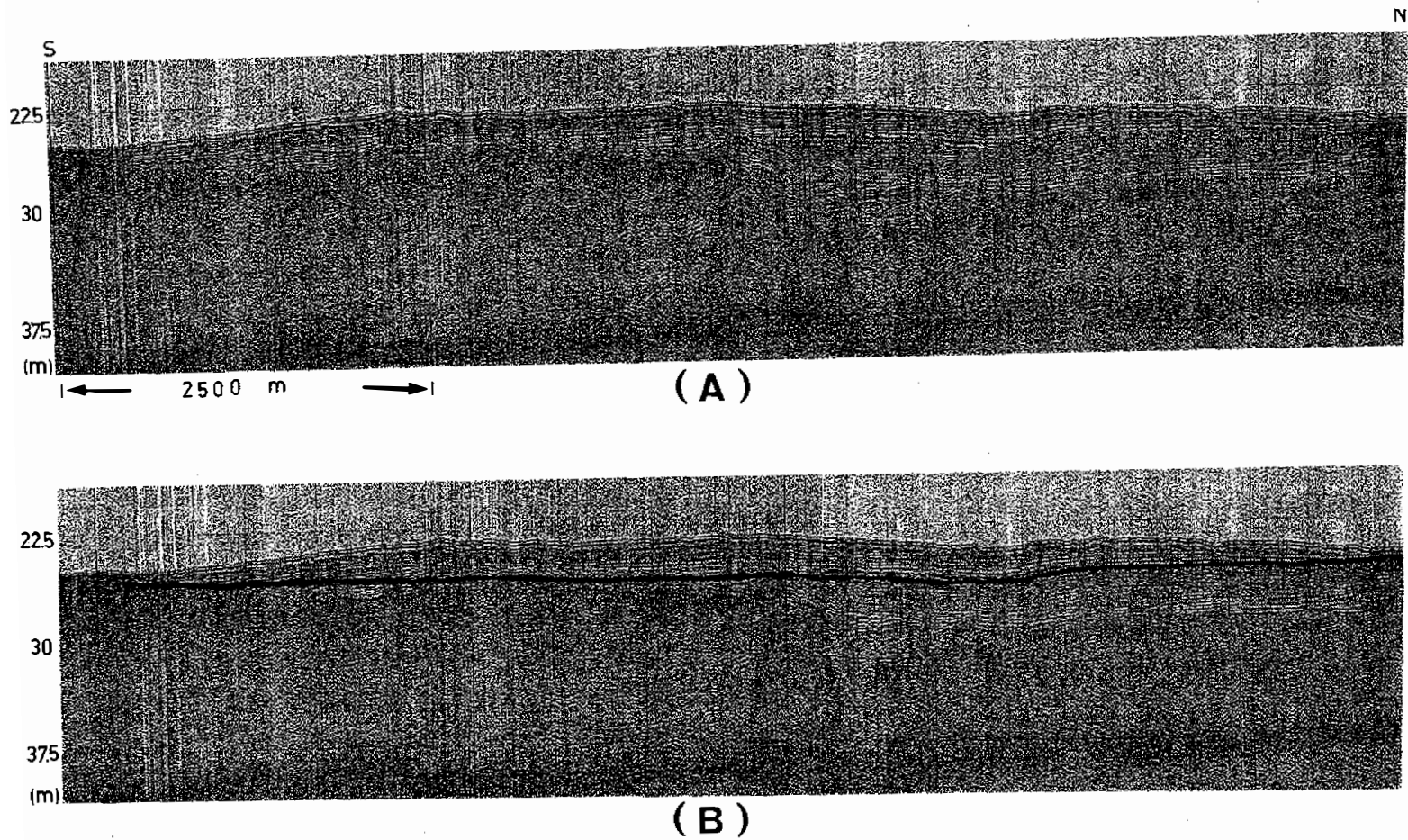


Fig. 5. Uninterpreted(A) and interpreted(B) seismic sections BB'. A broad, low relief delta lobe is discernible from this section.

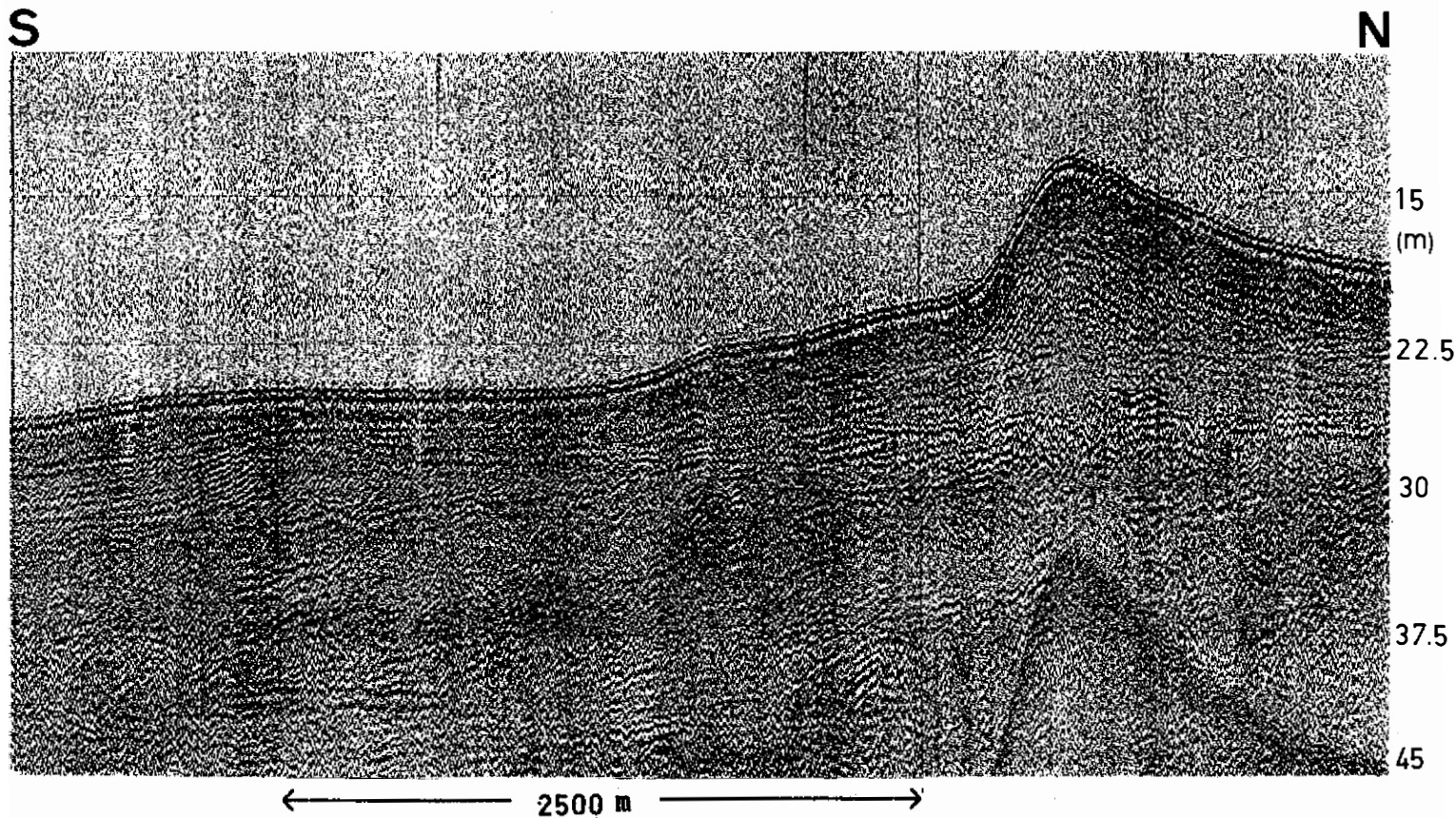


Fig. 6. The southern portion of section CC' showing two sand bars seismic facies with high angle, seaward-dipping cross stratification and low angle, landward-dipping or nearly horizontal stratification. These sand bars may have been deposited after storms during typhoon seasons.

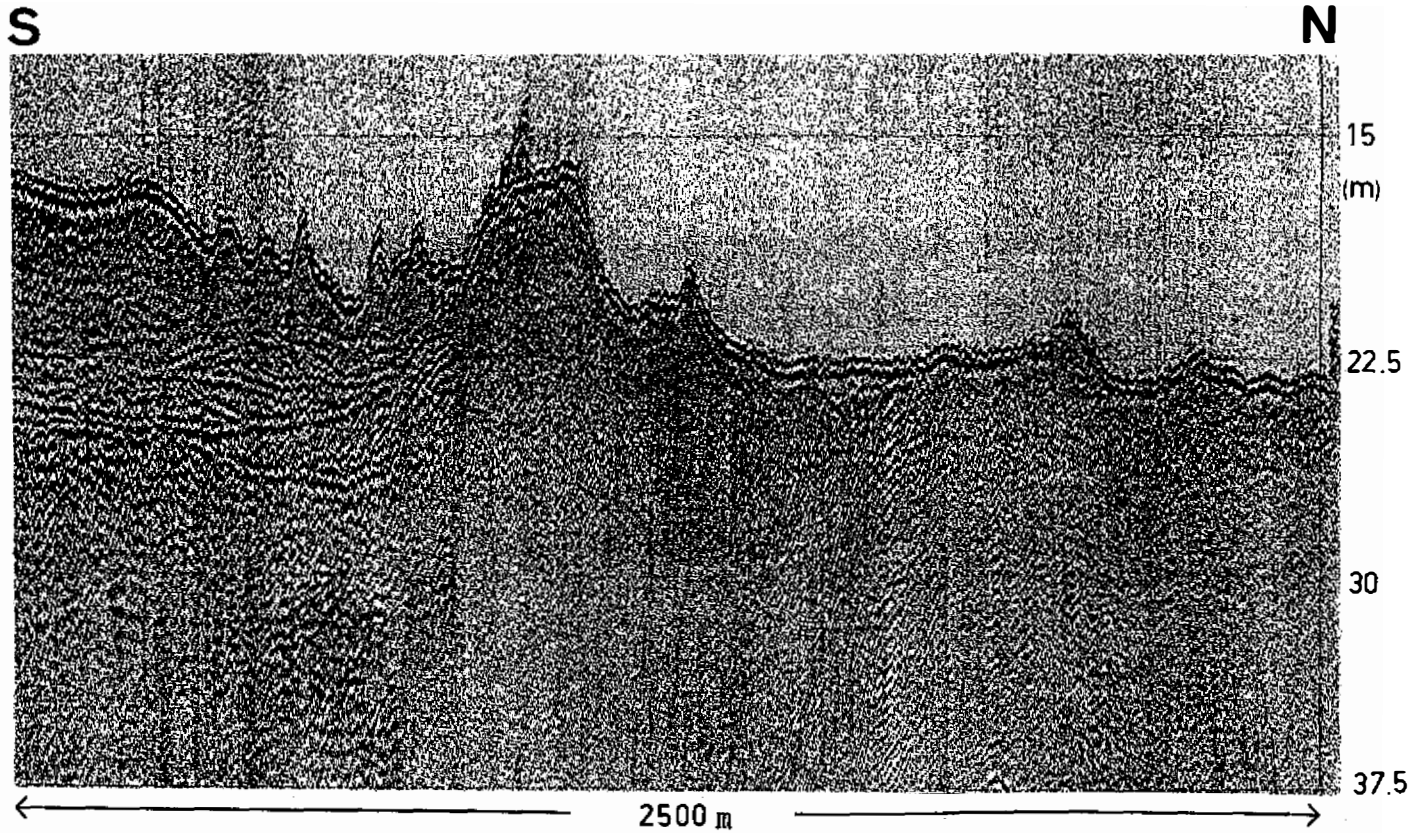


Fig. 7. The northern portion of seismic section CC' showing seismic facies with chaotic or nonreflective characteristics, indicating lagoon environments.

- (2) The phenomena of this gas chimney coincide very well with the definition of the gas chimney as described by the SEG, i.e., (a) abrupt deterioration of data (b) low velocity, and (c) pull down effects of seismic signals. This seismic gas chimney is possibly the first one ever discovered in offshore Taiwan.
- (3) The seismic facies of Quarternary sediments about five kilometers off the coastal line of the Tunghsiao-Paishatun area is a slope front fill and slumps facies, which reflects the unstable sea floor environments of a deeper-water shelf.
- (4) The unconformity formed after the Quarternary orogenic event can be recognized between Sequences I & II. Transgressive basal sands were possibly deposited on the unconformity.
- (5) A manifest deltaic lobe seismic facies can be identified in the offshore area of Houlung-Chuweí. It is worth noting that the apex of this deltaic lobe does not directly face the estuaries of the Houlung Hsi or Chungkang Hsi Rivers. This reveals that the lobe deposition was influenced by the confining seafloor topography and the longshore currents.
- (6) Seismic facies of the sand bars and lagoon can be distinguished off Chiting-Hsiangshan in Hsinshu County. The drowned sand bars may have been deposited during typhoon seasons.
- (7) The high resolution Uniboom seismic stratigraphy has proved useful in the research subjects of Quaternary paleoenvironmental evolution, sea level change, the presence of a gas the presence of chimney, and the stability of the sea floor in the Taiwan Strait.

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