CHAPTER 3

Seismic Stratigraphic Interpretation

An interpretation of seismic profiles to accomplish the geologic objective needs an application of seismic stratigraphic concept. Distinctively, seismic sequence and seismic facies are two informative seismic significances that can be directly extracted from seismic profiles. Relative sealevel change analysis, on the other hand, can only be comparatively studied from existing relevant geological information, *i.e.* sequence correlation, core sample dated data, lithological logs and regional and local relative sealevel curves. The overall steps of the study can be used to reconstruct the possible past geological models of the study area.

In this chapter, the interpretation of high resolution seismic profiles concentrates on the depositional environments and evolution of Quaternary sedimentary sequences. Seismic signatures of different bedrock types will not be discussed here since the previous works of the Gulf of Thailand Project have largely concentrated on an identification of different bedrock types to determine primary source rocks of heavy minerals and gemstones, and bedrock identification is not the objectives of this study. However, seismic signatures will be briefly explained when inferred types of bedrock appear on the selected profiles as complimentary figures.

A total number of 40 seismic profiles were selected for regional interpretation and 18 selected drillhole sections were incorporated with the seismic sections crossing them. The selected seismic profiles from fixed survey lines have a relative quality-range from less fair to good. Drill logs were coordinately used to obtain more accurate sequence stratigraphy, thickness of the sequences, lithology, depositional environments, as discussed in Chapter 4. Locations of the selected seismic sections and drillholes used in this study are shown in Figure 3.1. The results of the study on seismic stratigraphy will be described in the following sections.

3.1 Seismic Sequence Determination

Conceptually, seismic sequences are used to interpret depositional and erosional history in relation to high and low sealevel stands in the past. For seismic sequence analysis, the determination of the seismic sequences is principally based on the classification of seismic sections into concordance reflection packages which are separated by surface of discontinuity defined by systematic reflection termination. The seismic sequences determined on seismic profiles are representative of depositional sequences which their top and base are bounded by unconformities and correlative conformities.

In this study, an effort has been made to define boundaries of the Quaternary sequences. The interpretation of seismic sequences is simply based on an identification of the major boundaries between sequences on the profiles. Nevertheless, ambient noise, seabed multiple and low energy of acoustic source to penetrate at great depths cause sometimes inaccurate sequence

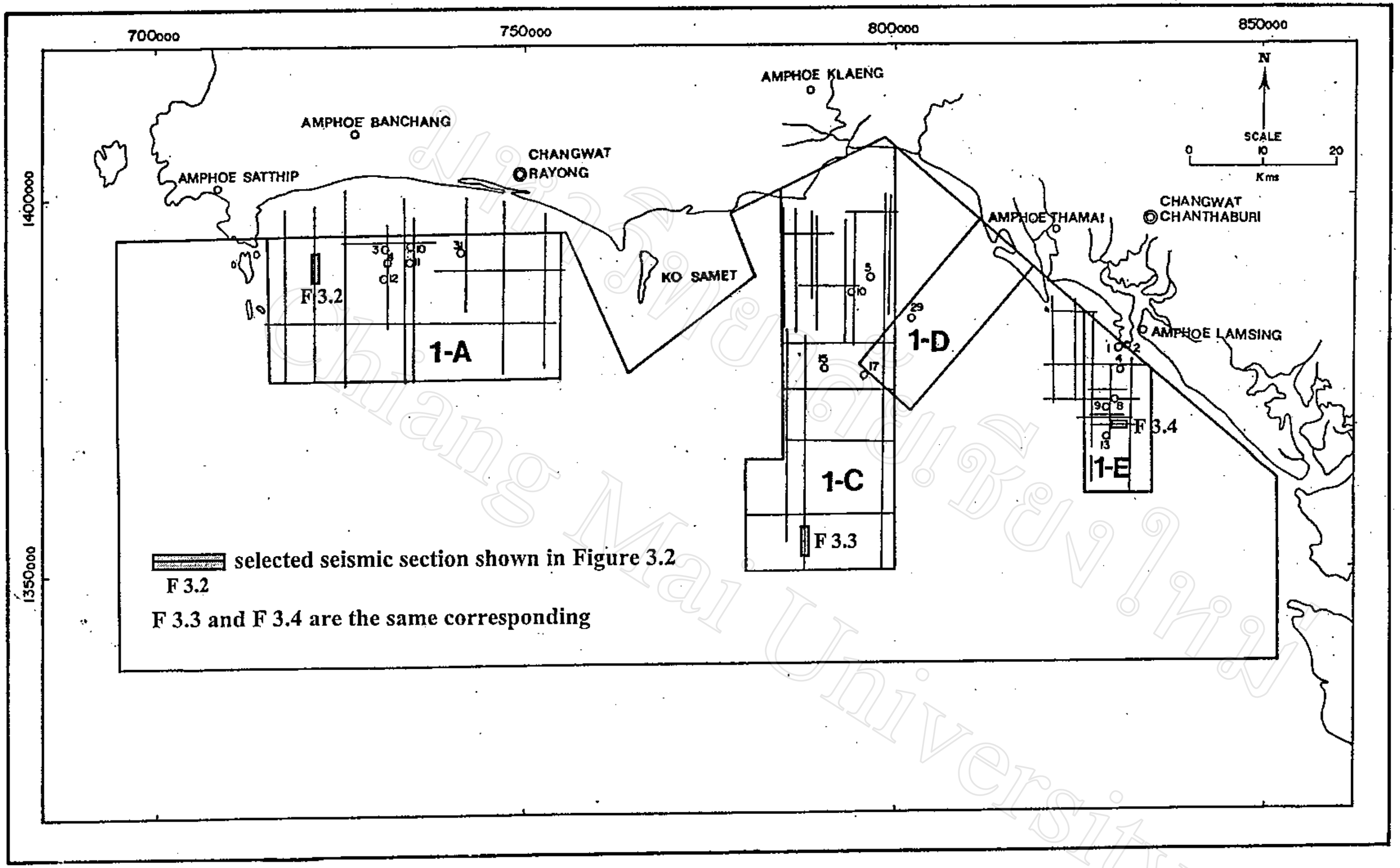


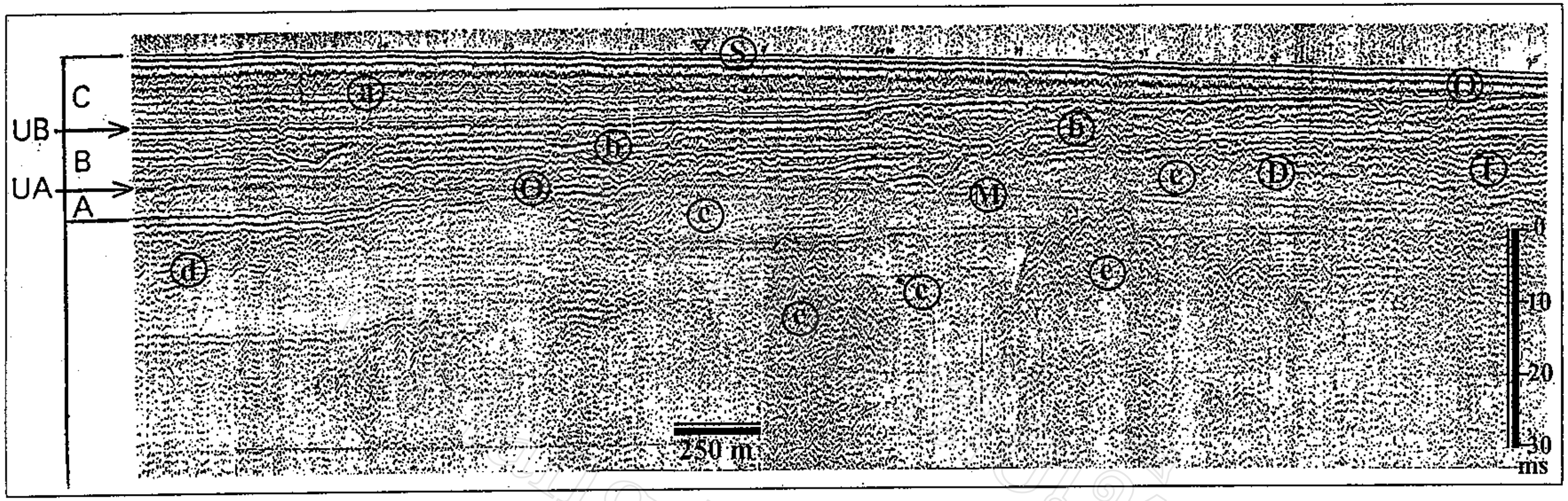
Figure 3.1 Map showing locations of selected seismic profiles showing sequence determination and locations of drillholes for the study of lithology, environments of deposition and lithofacies.

determination. Clear sequence determination was obtained locally from moderately fair to good quality seismic profiles. The upper boundaries of these sequences determined on the profiles are unconformities (erosional truncation) and correlative conformities; they, in general, exhibit relatively strong to moderate reflections.

Dividing the seismic sequences into broadband over the study area is the prime aim of the seismic sequence analysis. Such broadband sedimentary sequences with a wide range of sedimentary environments were determined and classified. In this study, the boundaries of the Quaternary sequences are principally based on seismic interpretation. In some locations, the divisions of the Quaternary sequences are correlated with some known sedimentary sequences from drill logs obtained during 1994-1997.

The results of sequence determination are shown in highlighted profiles in Figures 3.2, 3.3 and 3.4 and the locations of those profiles are shown in Figure 3.1. The study can explain only a regional examination over the study area which is the part of coastal zone and inner shelf of the Gulf of Thailand. The depositional sequences in the Quaternary period are divided into 3 major sequences as follows.

Sequence A : Sequence A is the lowermost sequence of Quaternary sediments. It is considered to be the oldest Quaternary sequence in the study area and this region, as it is immediately overlying an initial depositional surface, *i.e.* weathered bedrock, regolith and old piedmont fan. Thickness of the sequence A varies from place to place, ranging from naught to over 50 m. The lower boundary of the sequence A is rarely observed; except where

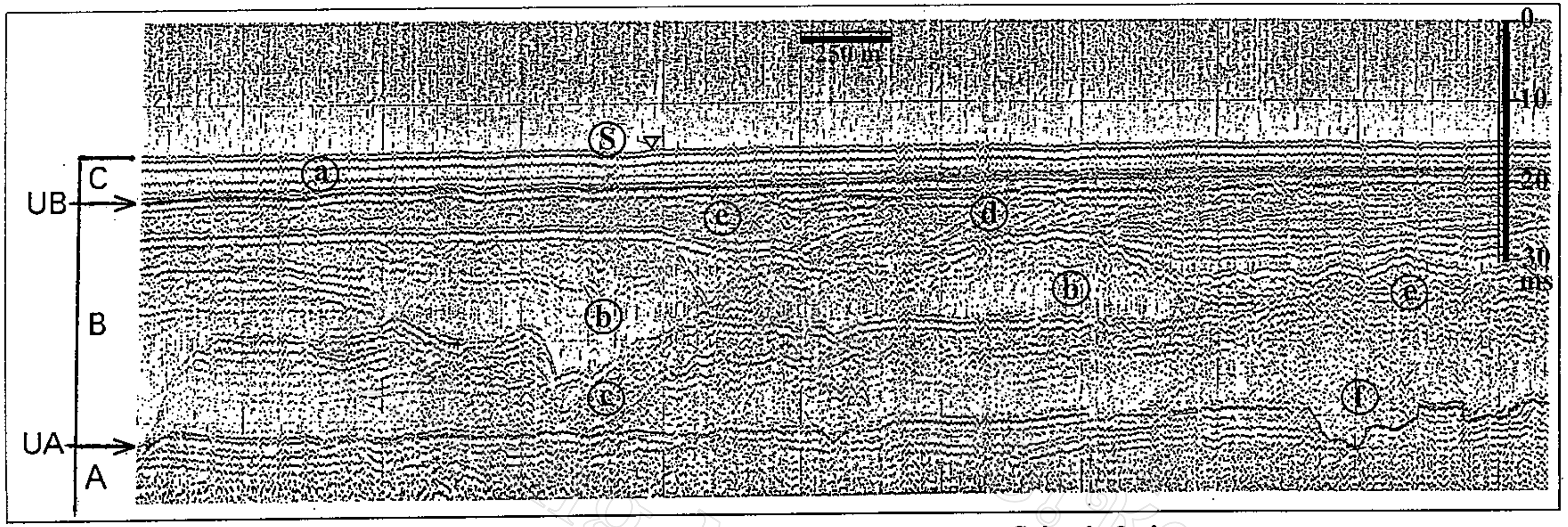


Symboles
A is the lowermost sequence A
B is the middle sequence B
C is the uppermost sequence C
UA is the unconformity on the upper surface of the lowermost sequence A
UB is the unconformity on the upper surface of the middle sequence B

O is coastal onlapping feature
D is downlapping feature
M is seabed multiple
ms is millisecond

Seismic patterns
a: parallel
b: subparallel
c: chaotic (weathered bedrock)
d: more or less chaotic with subparallel pattern (inferred regolith)
e: overlapping hyperboles (inferred fresh granite)
f: obliquely divergent pattern

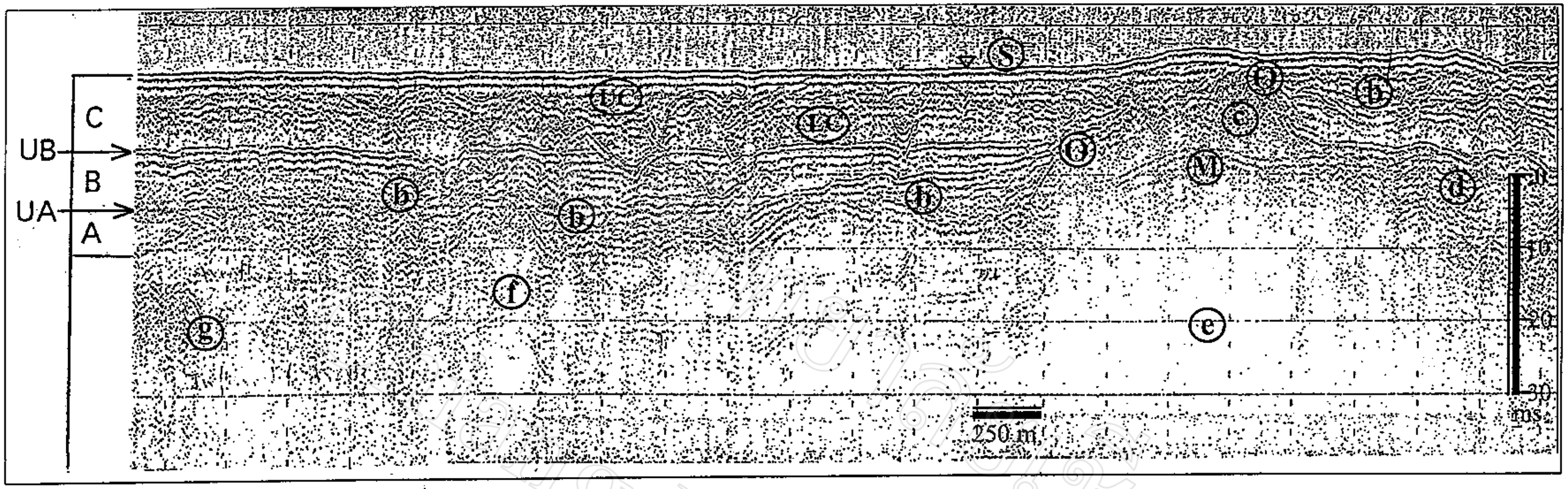
Figure 3.2 Typical seismic section near the bedrock topographic high of inferred weathered granite bedrock in the northern part of the sub-area 1-A (near the coast) showing sequences onlapping the weathered bedrock and 3 seismic sequences determined by unconformities UA and UB



Symboles
A is the lowermost sequence A
B is the middle sequence B
C is the uppermost sequence C
UA is the unconformity on the upper surface of the lowermost sequence A
UB is the unconformity on the upper surface of the middle sequence B
S is the seabed
ms is millisecond

Seismic facies
a: parallel
b: semitransparent
c: more or less chaotic pattern;
d: obliquely dipping fills
e: subparallel
f: chaotic pattern with some speckled seismic signatures

Figure 3.3 Typical seismic section in the southernmost part of the sub-area 1-C showing 3 major seismic sequences of the Quaternary sediments determined by 2 major unconformities UA and UB, and various seismic patterns.



Symboles
A is the lowermost sequence A
B is the middle sequence B
C is the uppermost sequence C
UA is the unconformity on the upper surface of the lowermost sequence A
UB is the unconformity on the upper surface of the middle sequence B

LC is the lower subsequence LC
UC is the uppermost subsequence UC
S is the seabed
M is the seabed multiple
O is onlapping termination

Seismic facies
a: parallel
b: subparallel
c: chaotic pattern
d: more or less chaotic with subparallel pattern
e: acoustically transparent
f: acoustically semitransparent
g: overlapping hyperboles

Figure 3.4 Typical seismic section near bedrock in the middle part of the sub-area 1-E (E-W section) showing the sediments filled in topographic lows of bedrock interpreted as remnant of the sequences A with clearly identified sequences B and C, and unconformities A (UA) and B (UB) in the area.

topographic highs of bedrocks, it shows relatively moderate to strong reflections (Figure 3.2). It exhibits an onlapping structure in relation to underlain geological units.

Sequence B : Sequence B is defined as the middle sequence of Quaternary sediments in the study area. In general, this sequence is extensively observed on the profiles over the area. It shows several internal seismic configurations in the sequence. Its lower boundary is simply recognized as an infilled depression on erosional upper surface of the sequence A with relatively strong reflections. This sequence generally laps out landward with onlapping near the coast. However, the onlapping structures are sometimes obscured by chaotic reflections, strong side-reflections from adjacent bedrock surface and seabed multiples. On the upper boundary, it distinctively exhibits disconformity, as a prominent flat surface of correlative conformity. Nevertheless, it locally shows some erosional surfaces by deep incision with infilled deposits. On its upper surface, it is characterized by relatively moderate to strong reflections from place to place. Its thickness varies from naught to over 30 m. It becomes thicker seaward and thinner shoreward. It has a few relative conformable inner-reflectors with fainted reflections and was partly eroded as incised channels on the upper surface of the sequence.

Sequence C : Sequence C is the uppermost sequence recently deposited in the area. Its thickness ranges from 1 m to over 25 m. Stratigraphically, the sequence C can be sub-divided into 2 subsequences including the lower subsequence (LC) and the uppermost subsequence (UC).

The lower subsequence LC is locally found and generally overlying the sequence B. The lower boundary of the subsequence exhibits relatively moderate to strong reflections. Close to the shoreline, its lower boundary laps out shoreward as onlapping the regolith (weathered bedrock) and old piedmont fans at the coast (Figure 3.2). It exhibits disconformity on the upper boundary, as a prominent flat surface with little erosion. The erosional surfaces are characterized by cut and filled channels on the top of the sequence with relatively moderate to weak reflections. It is similar to the upper boundary of the sequence B but less continuity of surface boundary. In contrast, the surface boundary between the subsequence LC and the sequence B shows relatively moderate to strong reflections with extensive continuity. Thickness ranges from naught to approximately 15 m. The upper boundary exhibits weak to moderate reflections with fairly high continuity.

The uppermost subsequence UC is the superficial sequence interpreted as a recent marine mud unit overlying the subsequence LC as a sediment blanket like sheet or drape over the subsequence LC. The lower boundary of the subsequence UC laps out shoreward by onlapping the underlying subsequence LC or regolith (weathered bedrock) or the old piedmont fans at the coast or near islands. Locally, the top surface (seafloor) shows a mound pattern, interpreted as sand or mud bank deposits built up by submarine current. They appear within a distance of about 5-15 km from the coast in the west of sub-area 1-A. Drilling results proved that it is a mud bank. The thickness varies from 1 m to over 10 m.

In addition, all sequence and subsequence terminations by onlapping can be sometimes observed when close to the shoreline or topographic highs of bedrocks. The sequences are definitely superimposed on different type of pre-existing geological units at the coast. Most of the sequences become thicker seaward, but the uppermost sequence UC locally thins seaward and eastward.

3.2 Seismic Facies Recognition

A seismic reflection pattern is an appearance of reflectors that make up seismic facies termed by Mitchum *et al.,* (1977a). The terms were adapted for Quaternary deposits on the continental shelf by Berryhill (1986). An analysis of seismic facies is intimately related to an identification of the seismic patterns or seismic signatures. The technique of seismic facies analysis is a powerful tool to decipher depositional environments and related lithofacies. Each seismic sequence, in general, is composed of several sedimentary units of various sedimentary facies which can be indirectly interpreted from seismic facies appearing on the profiles.

This section discusses various seismic facies recognized in the study area. Depositional environments of each facies, related energy of transportation and deposition, and expected lithofacies are also interpreted. The environments, lithology and thicknesses of sedimentary sequences obtained from drill logs can assist in the interpretation of the seismic sections to be more precise.

The main criteria employed for the interpretation are amplitude, reflection continuity and reflection configuration. The amplitude of reflectors depends on acoustic impedance contrast across the interface which generates the reflection. The continuity can be used as an indicator of the depositional environment of the sedimentary facies. The reflection configuration is an indication of the internal geometry of the seismic facies which are indirectly related to depositional setting and lithofacies. Their external geometry and relationships are also considered for obtaining geological relations among those physical appearances. Seismic facies recognition applied in this study follows the works of Evans *et al.* (1995), Ringis (1986 and 1994), Mitchum *et al.* (1977), Sangree and Widmier (1977), and Brown and Fisher (1979). The depositional environments and sedimentary features and processes are extracted from the works of Sangree and Widmier (1977), Reineck and Singh (1973), Evans *et al.* (1995), Davis (1987), Roy (1989) and Ringis (1986 and 1994).

The numbers of seismic profiles from sub-areas 1-A, 1-C and 1-E have been selected for seismic facies interpretation (Figure 3.1). However, only 9 seismic sections are representatively highlighted (Figures 3.5, 3.6a-3.14a). The results of interpretation are illustrated in Figures 3.6b-3.14b. Correlation between seismic interpretation and drilling results is illustrated in Appendix C. The seismic patterns observed in each sequences in relation to their depositional and environmental settings are somewhat similar in sub-areas 1-A, 1-C and 1-E, as following described.

In general, the sequence A mainly consists of some acoustically semitransparent and a few chaotic patterns with relatively weak to moderate reflections seaward (Figures 3.6a, 3.7a and 3.8a). In the central part of the sub-areas, the internal seismic patterns laterally changes to chaotic and

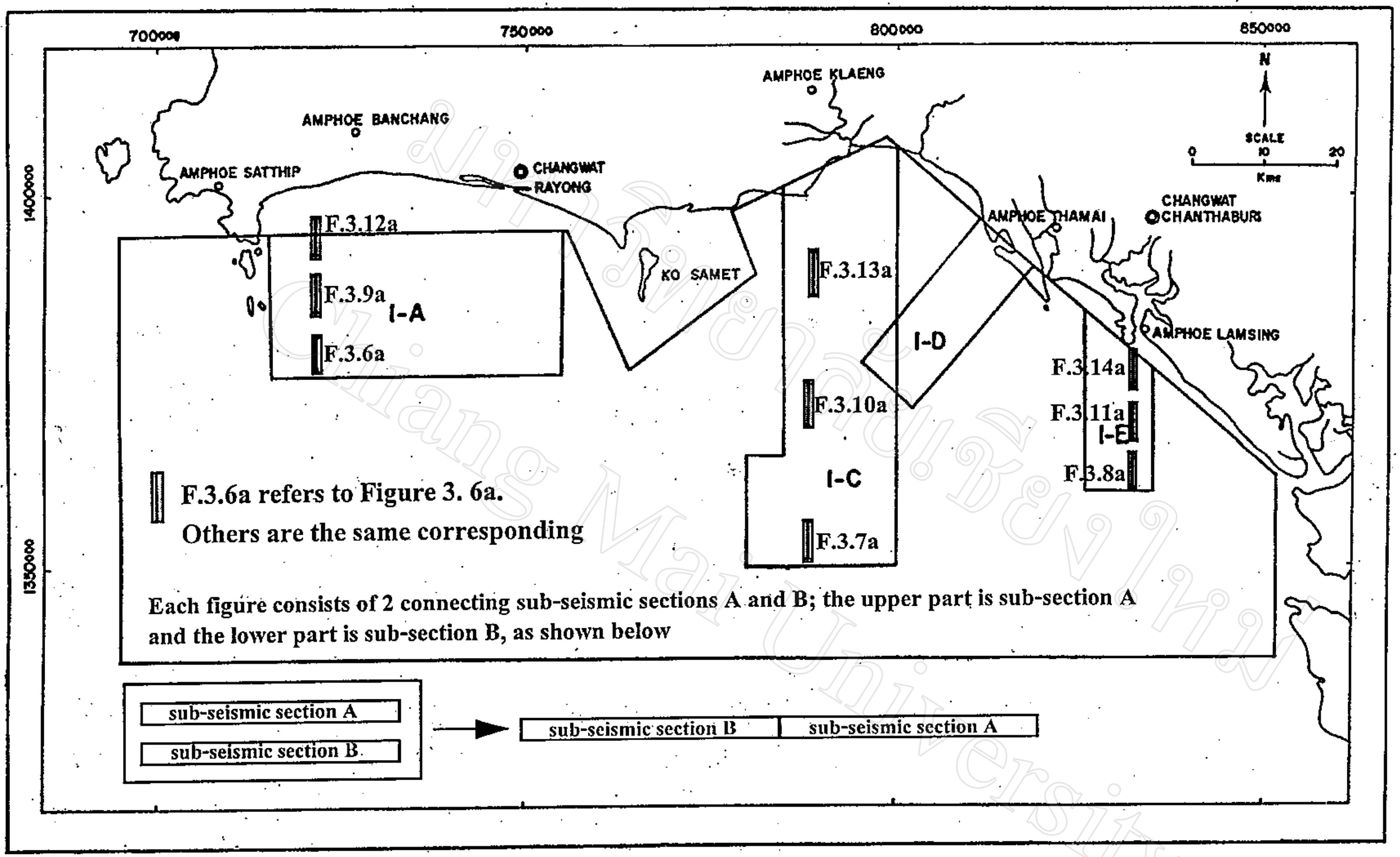


Figure 3.5 Map showing locations of highlighted seismic sections for discussion

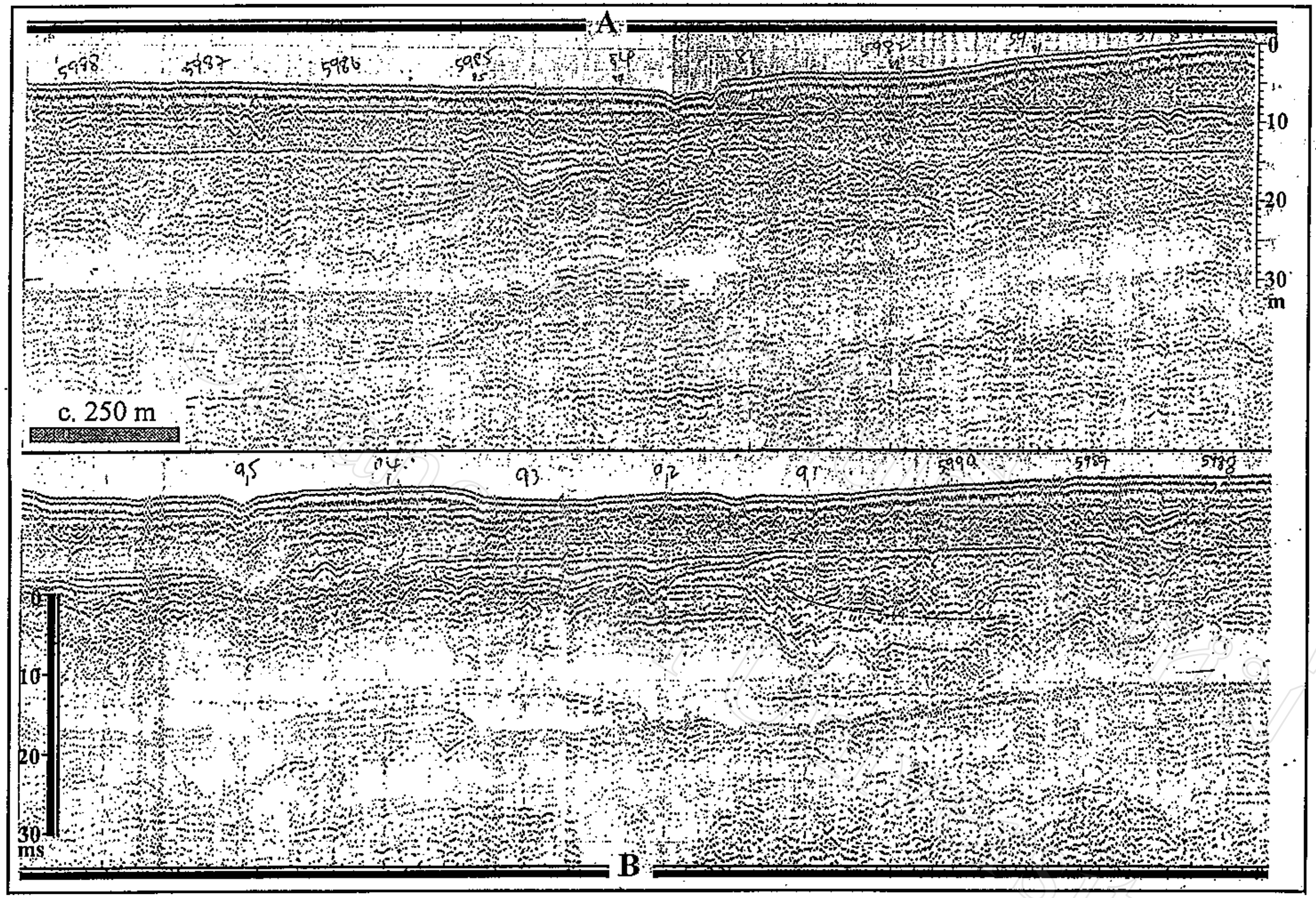
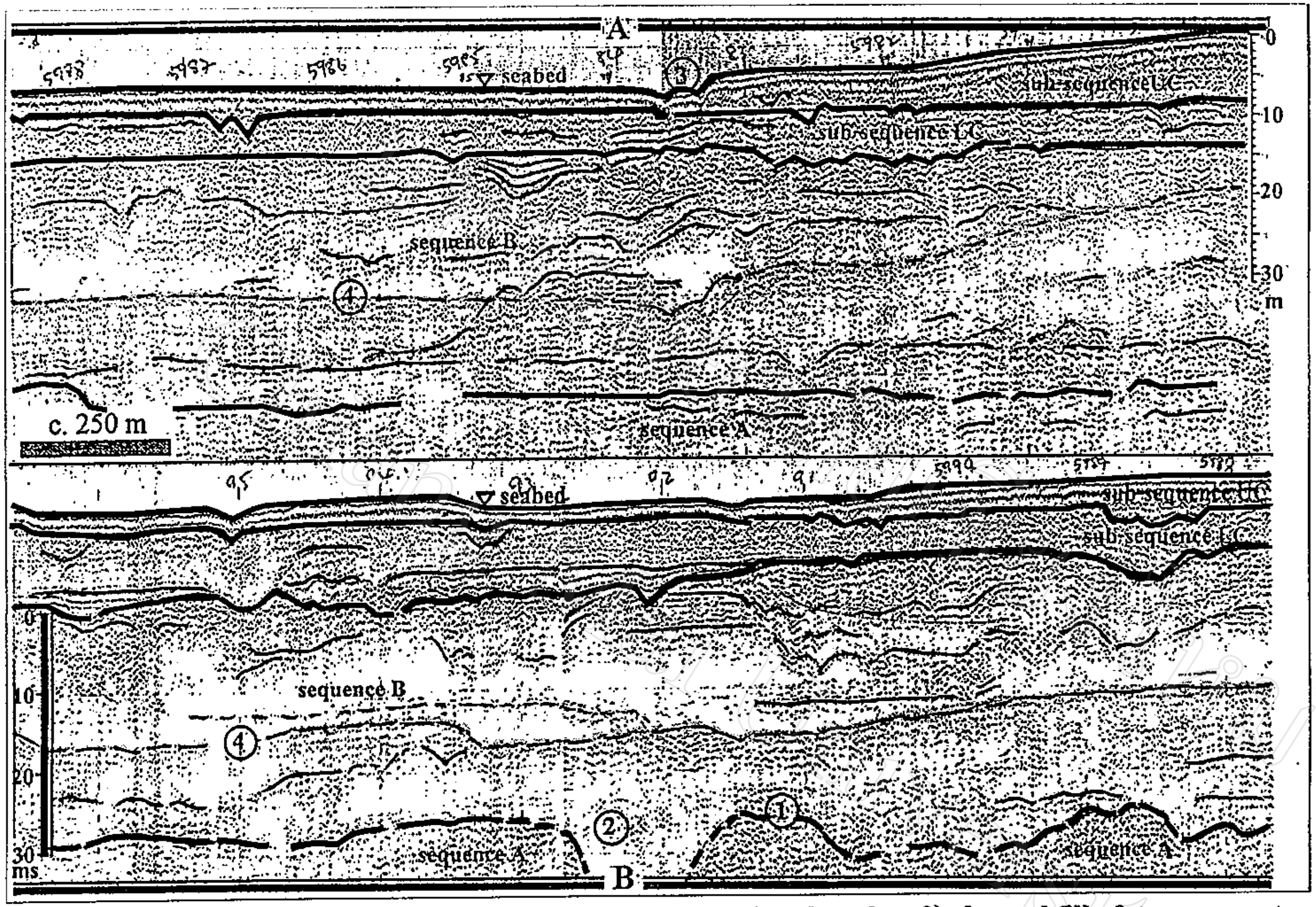


Figure 3.6a Uninterpreted seismic section in the southern part of the sub-area 1-A and interpreted seismic section shown in Figure 3.6b



1) discontinuous reflector associated with sub-aerial erosional surface 2) channel fill of transparent reflectors, inferred mud fill 3) channel on the seabed 4) seabed multiple reflection

Figure 3.6b Interpreted seismic section from original section in Figure 3.6a

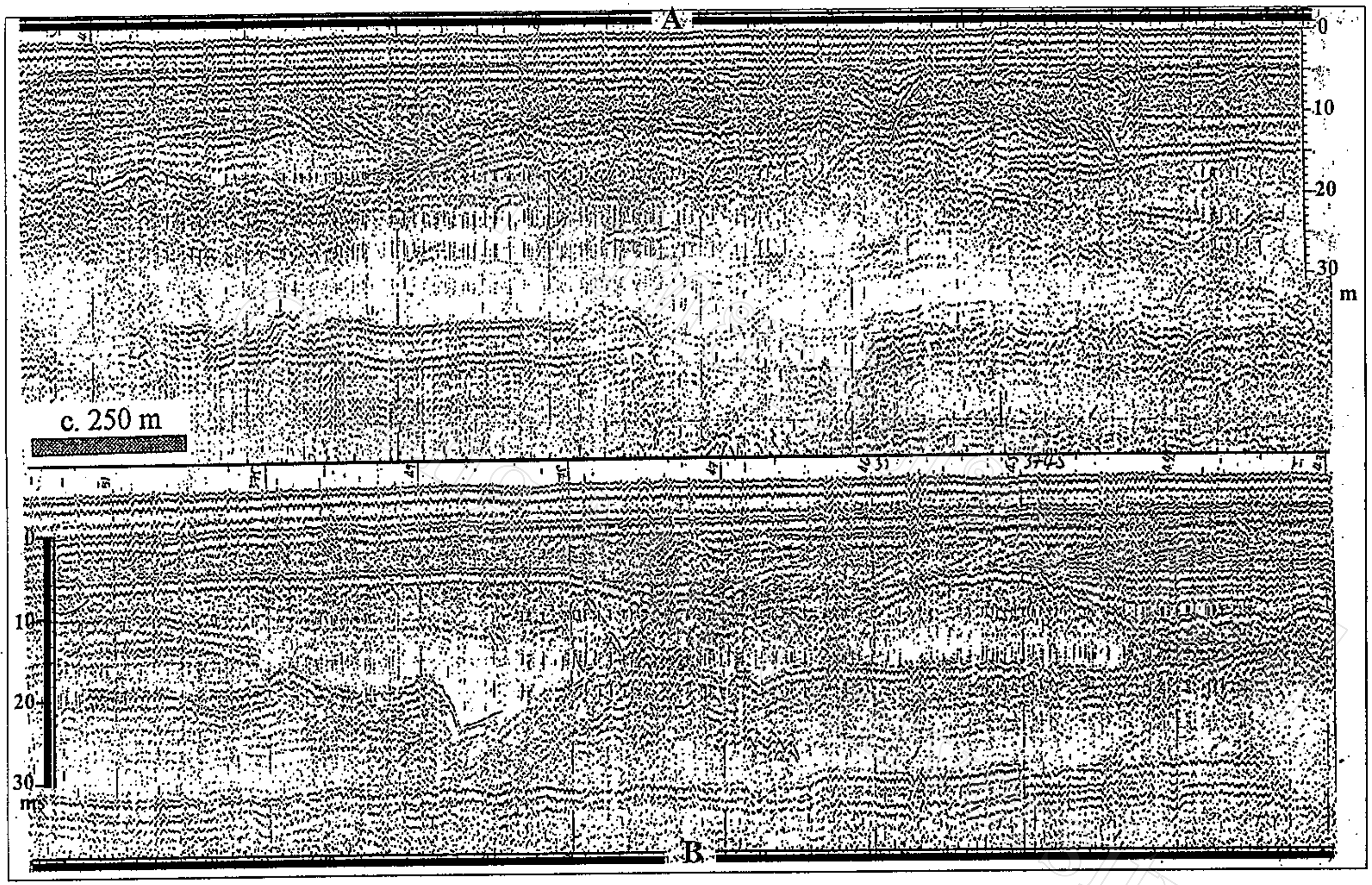
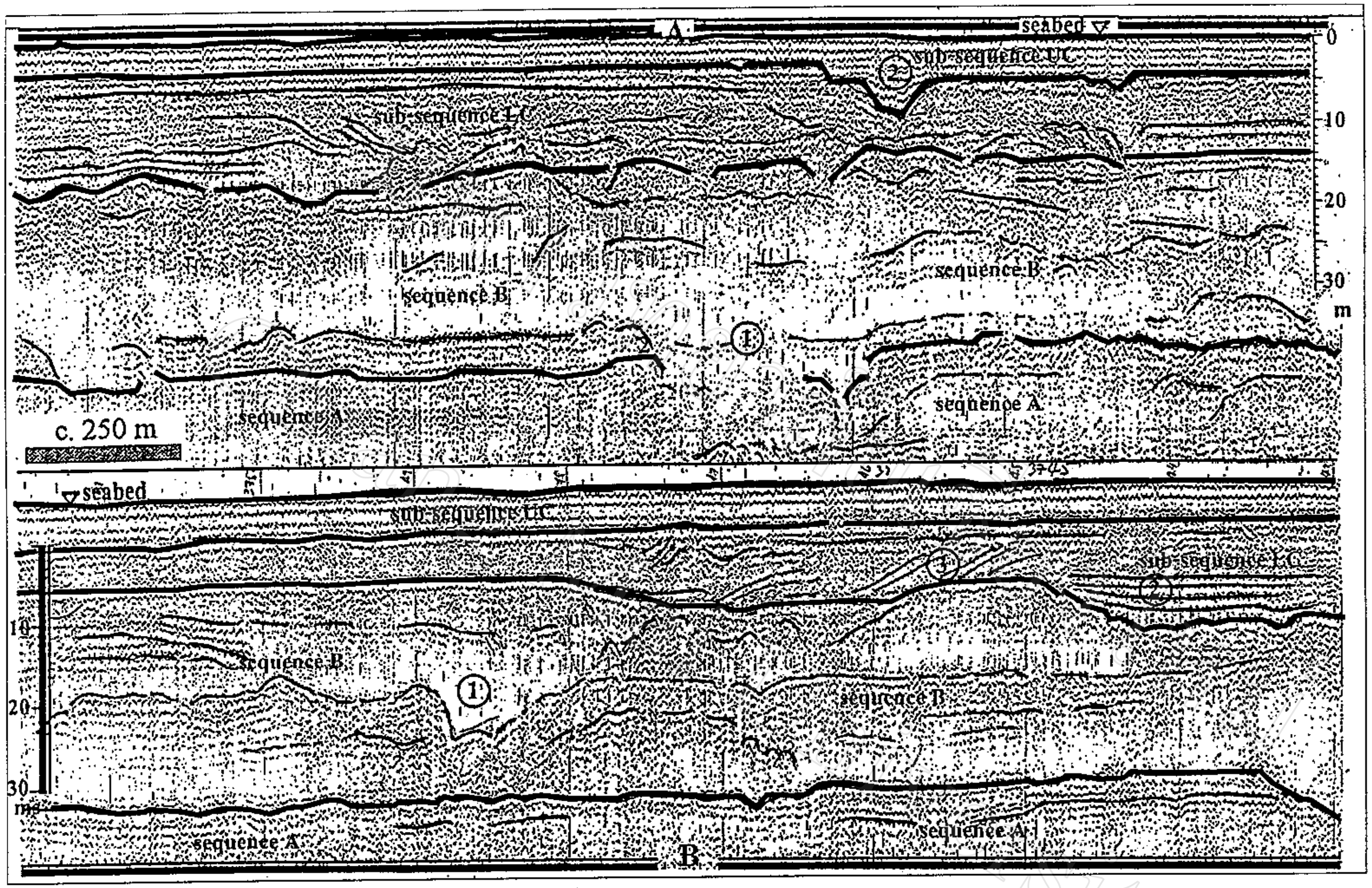


Figure 3.7a Uninterpreted seismic section in the southern part of the sub-area 1-C and interpreted seismic section shown in Figure 3.7b



1) channel fill of transparent reflectors, inferred mud fills 2) channel fill of subparallel reflectors inferred muddy sediments 3) oblique clinoform reflectors, inferred sandy sediments

Figure 3.7b Interpreted seismic section from original section in Figure 3.7a

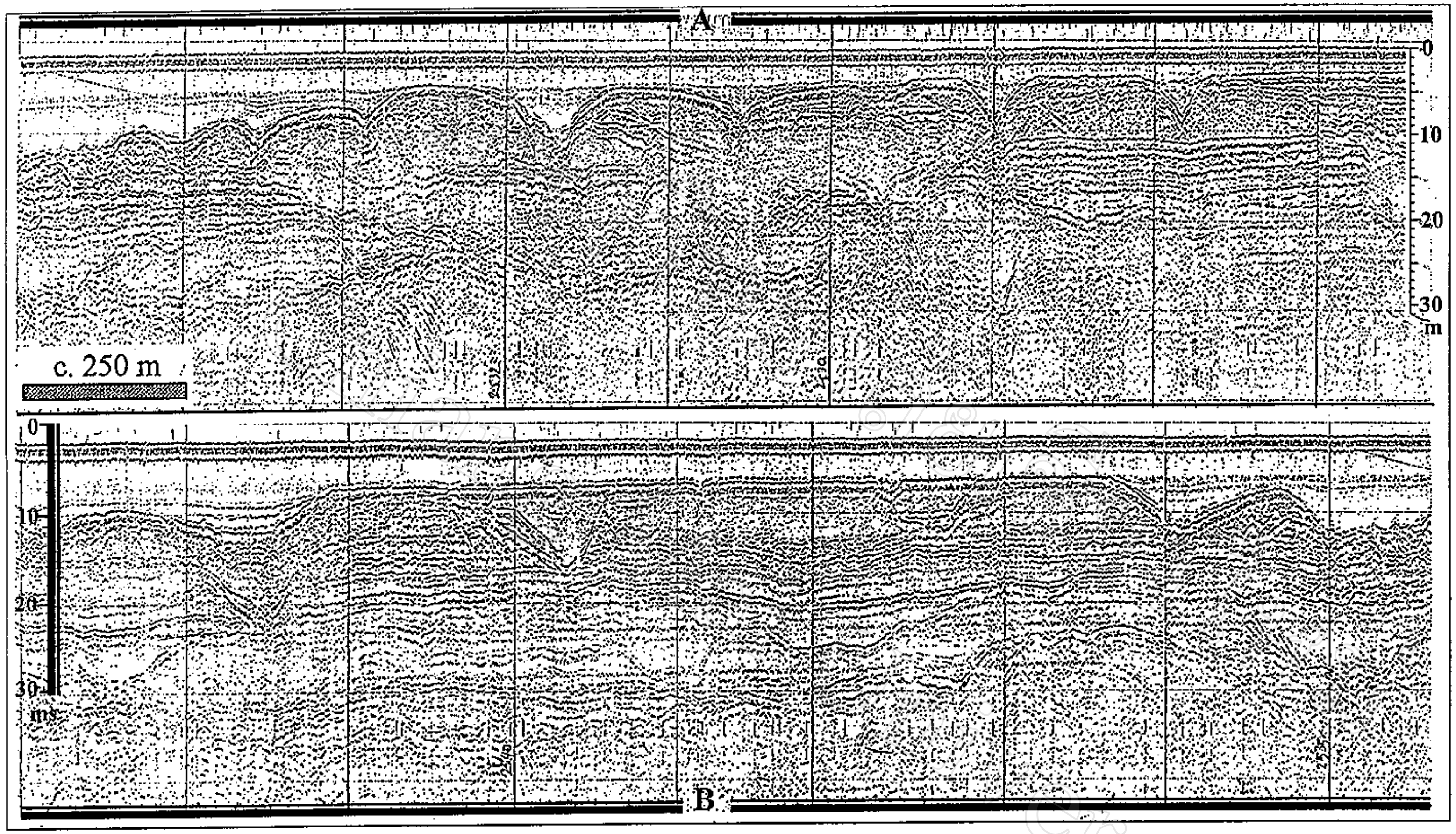
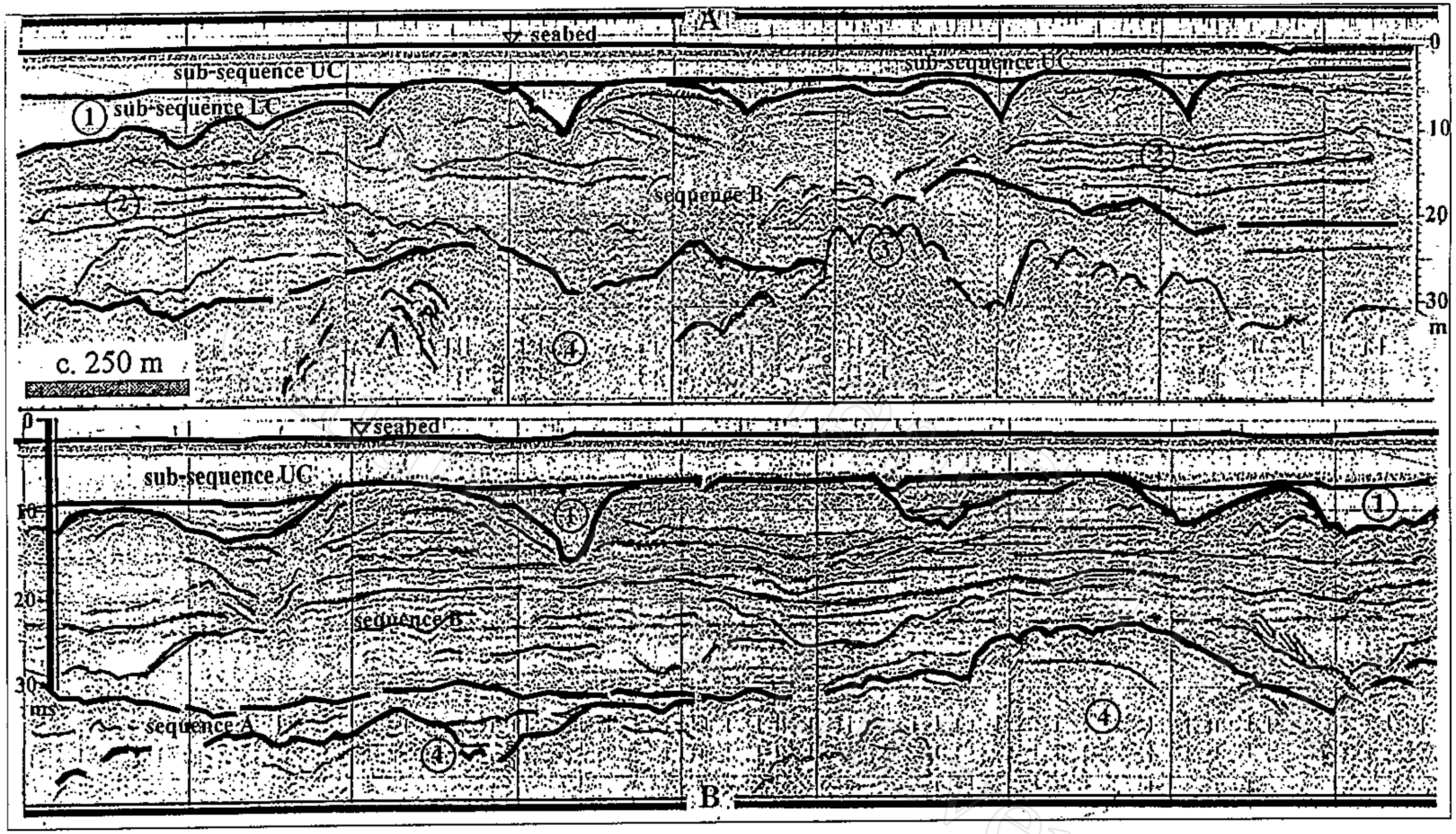


Figure 3.8a Uninterpreted seismic section in the southern part of the sub-area 1-E and interpreted seismic section shown in Figure 3.8b



1) channel fill of transparent reflectors, inferred mud 2) subparallel reflectors, muddy sediments
3) hyperbolic pattern, inferred granite bedrock 4) chaotic reflectors, weathered bedrock

Figure 3.8b Interpreted seismic section from original section in Figure 3.8a

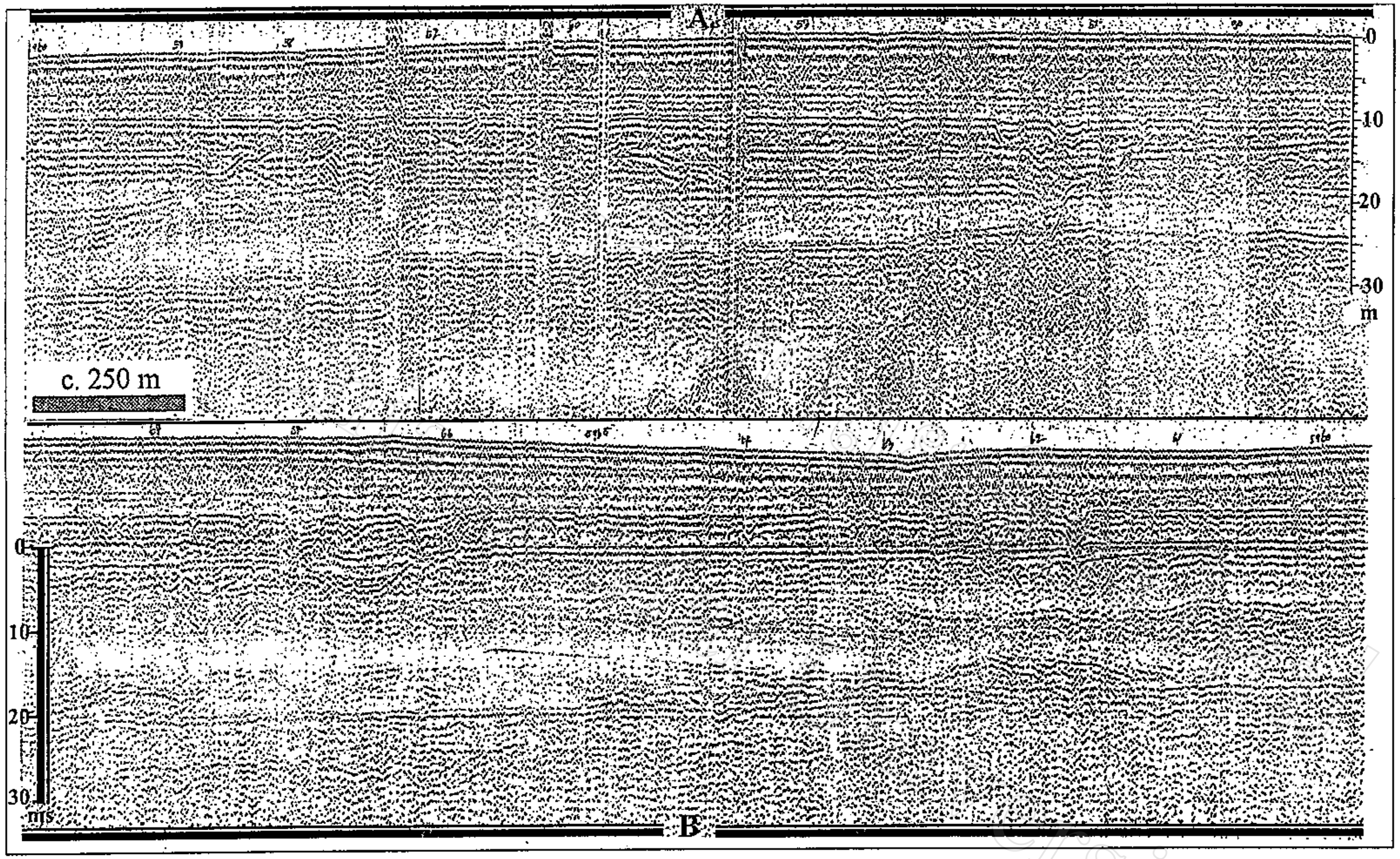
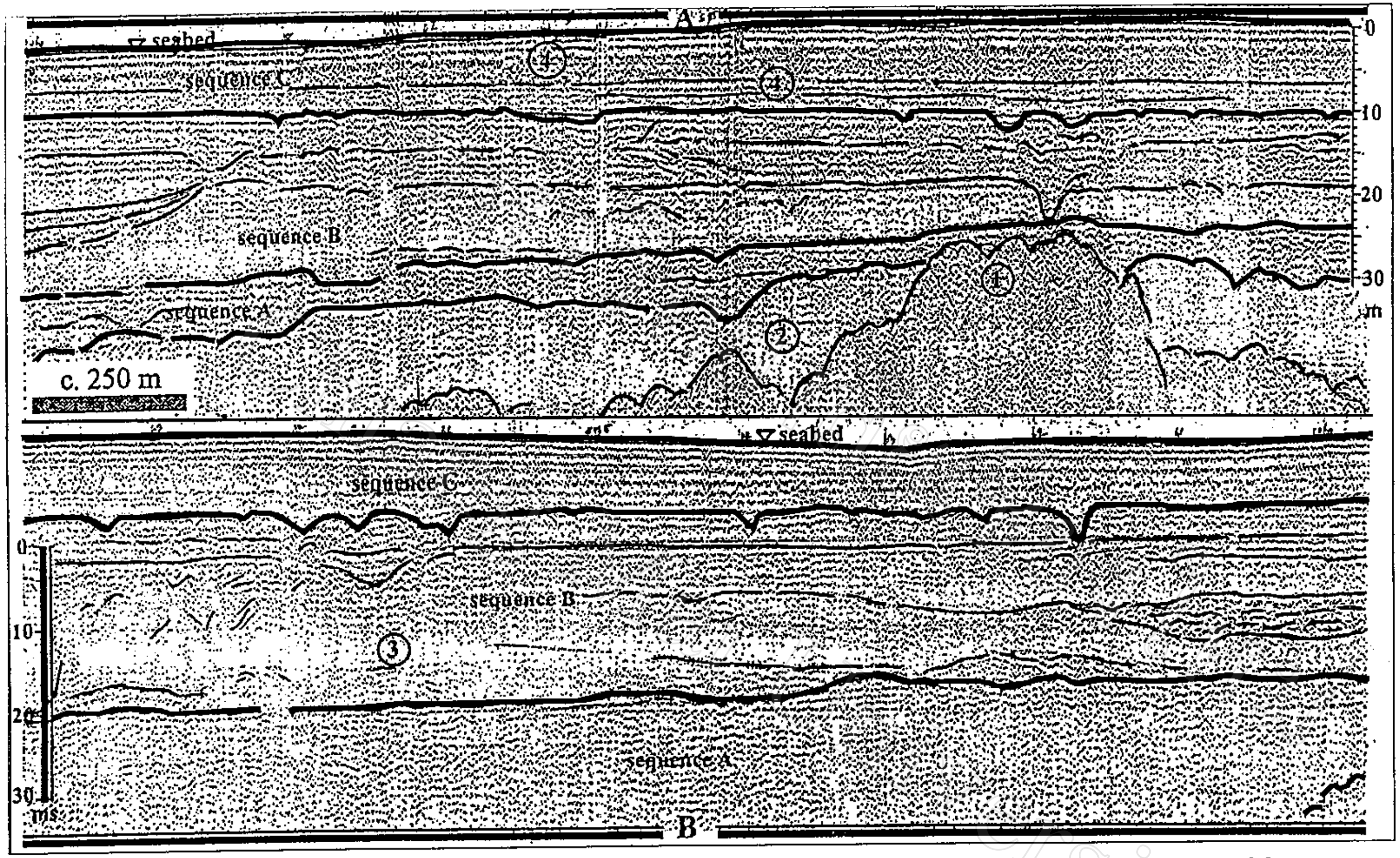


Figure 3.9a **Uninterpreted seismic section in the middle part of the sub-area 1-A and interpreted seismic section shown in Figure 3.9b**



1) hyperbolic patterns, inferred granite bedrock 2) chaotic reflectors, weathered bedrock or regolith
3) transparent reflectors, inferred clayey or muddy sediments 4) parallel reflectors, muddy sediments

Figure 3.9b Interpreted seismic section from original section in Figure 3.9a

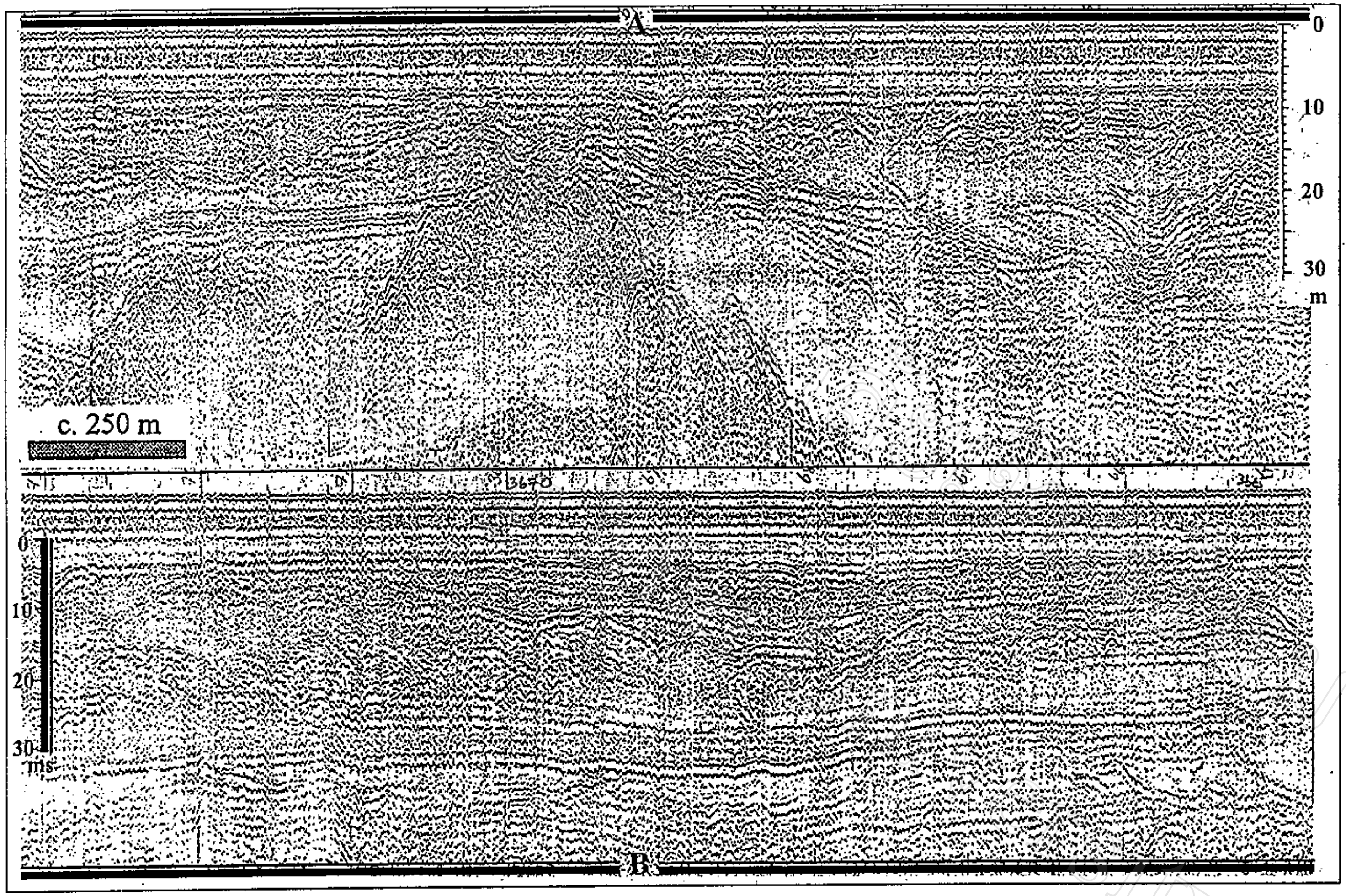
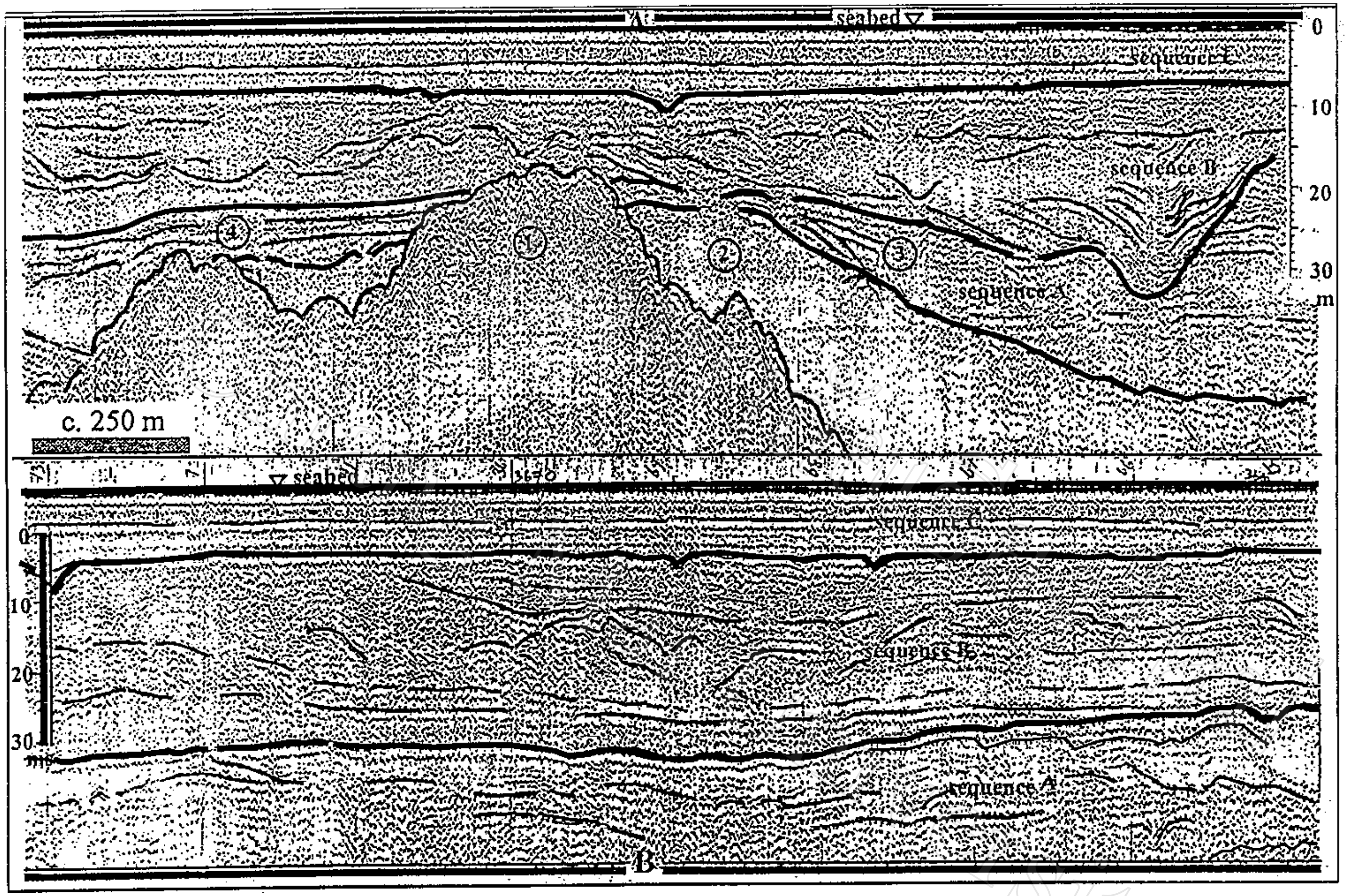


Figure 3.10a Uninterpreted seismic section in the middle part of the sub-area 1-C and interpreted seismic section shown in Figure 3.10b



1) hyperbolic patterns, inferred bedrock 2)semitransparent and chaotic reflectors, weathered bedrock 3) oblique clinoform reflectors, sandy sediments 4) high amplitude, subparallel, continuous reflector, muddy or clayey sediments

Figure 3.10b Interpreted seismic section from original section in Figure 3.10a

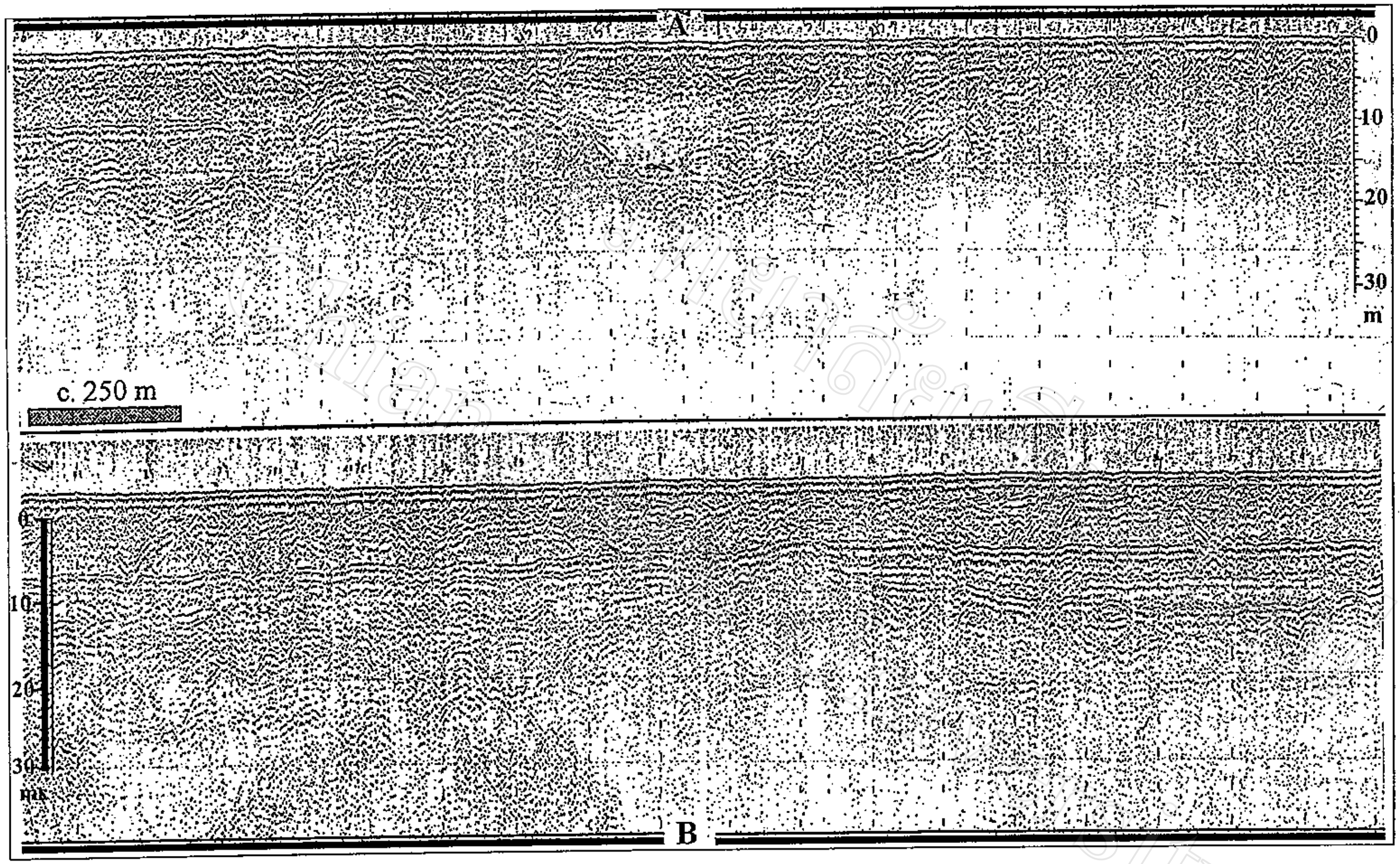
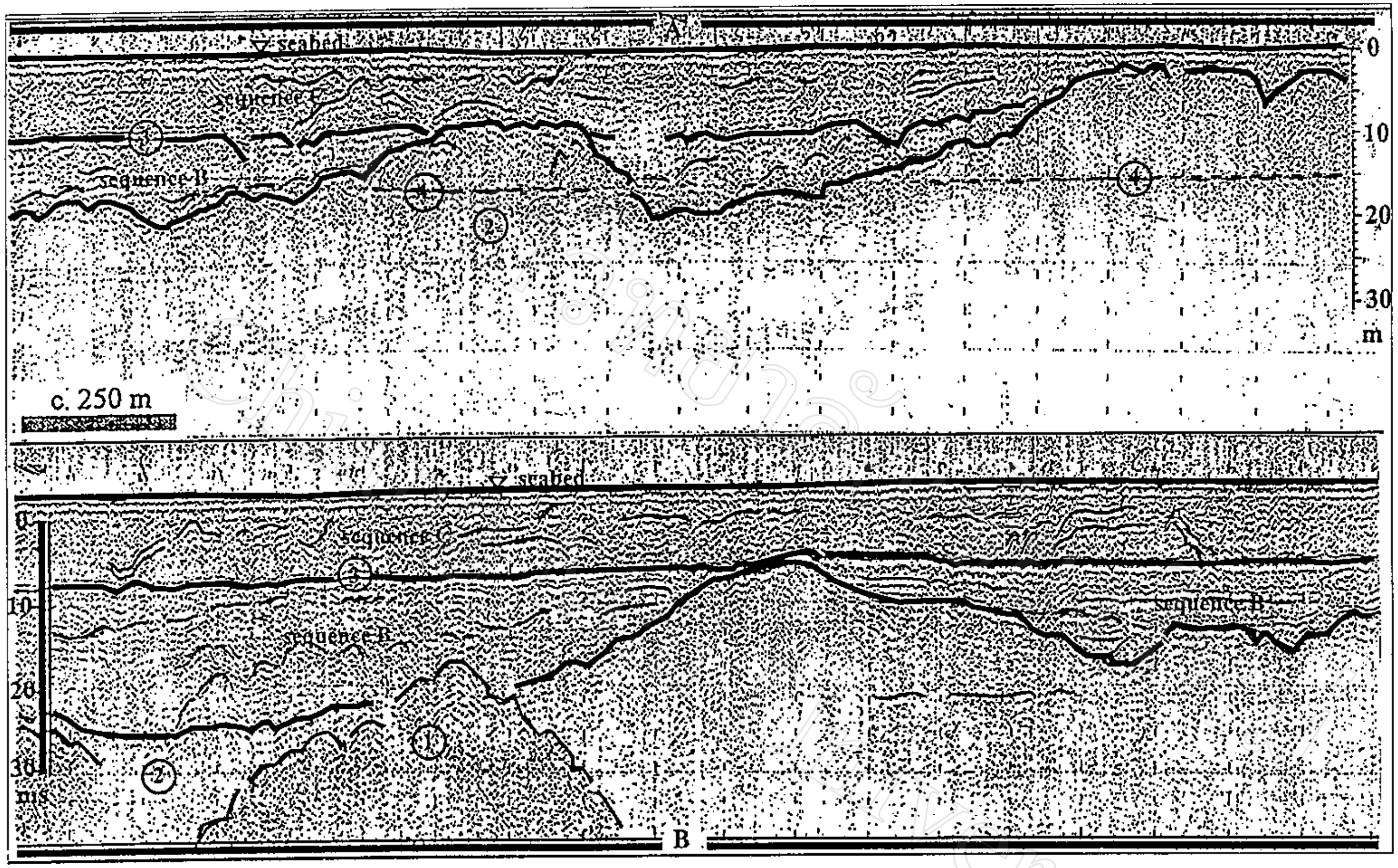


Figure 3.11a Uninterpreted seismic section in the middle part of the sub-area 1-E and interpreted seismic section shown in Figure 3.11b



1) hyperbolic patterns, inferred bedrock 2) transparent andchaotic reflectors, weathered bedrock 3) ravinement surface, interpreted as marine trangression surface 4) seabed multiple reflection

Figure 3.11b   Interpreted seismic section from original section in Figure 3.11a

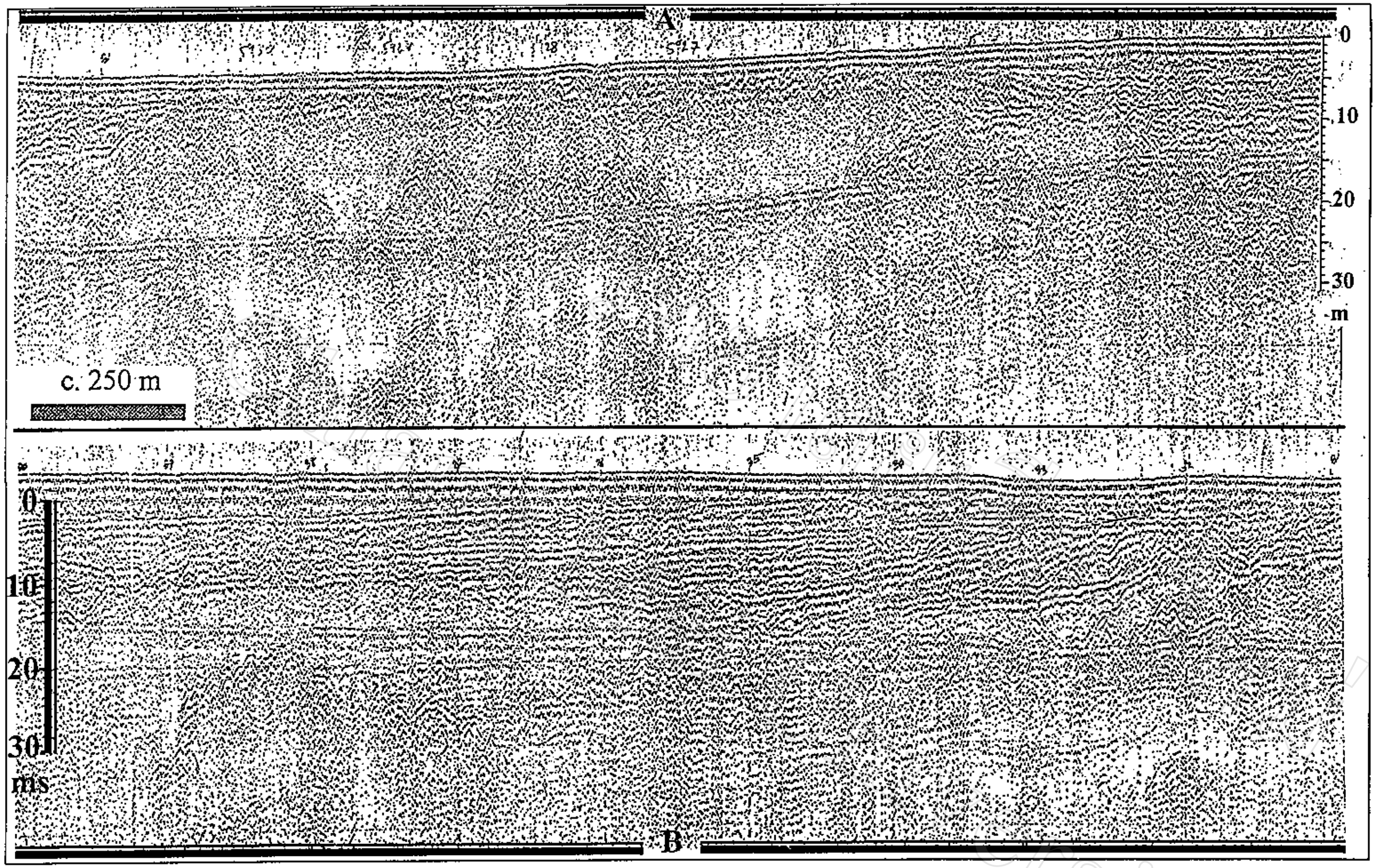
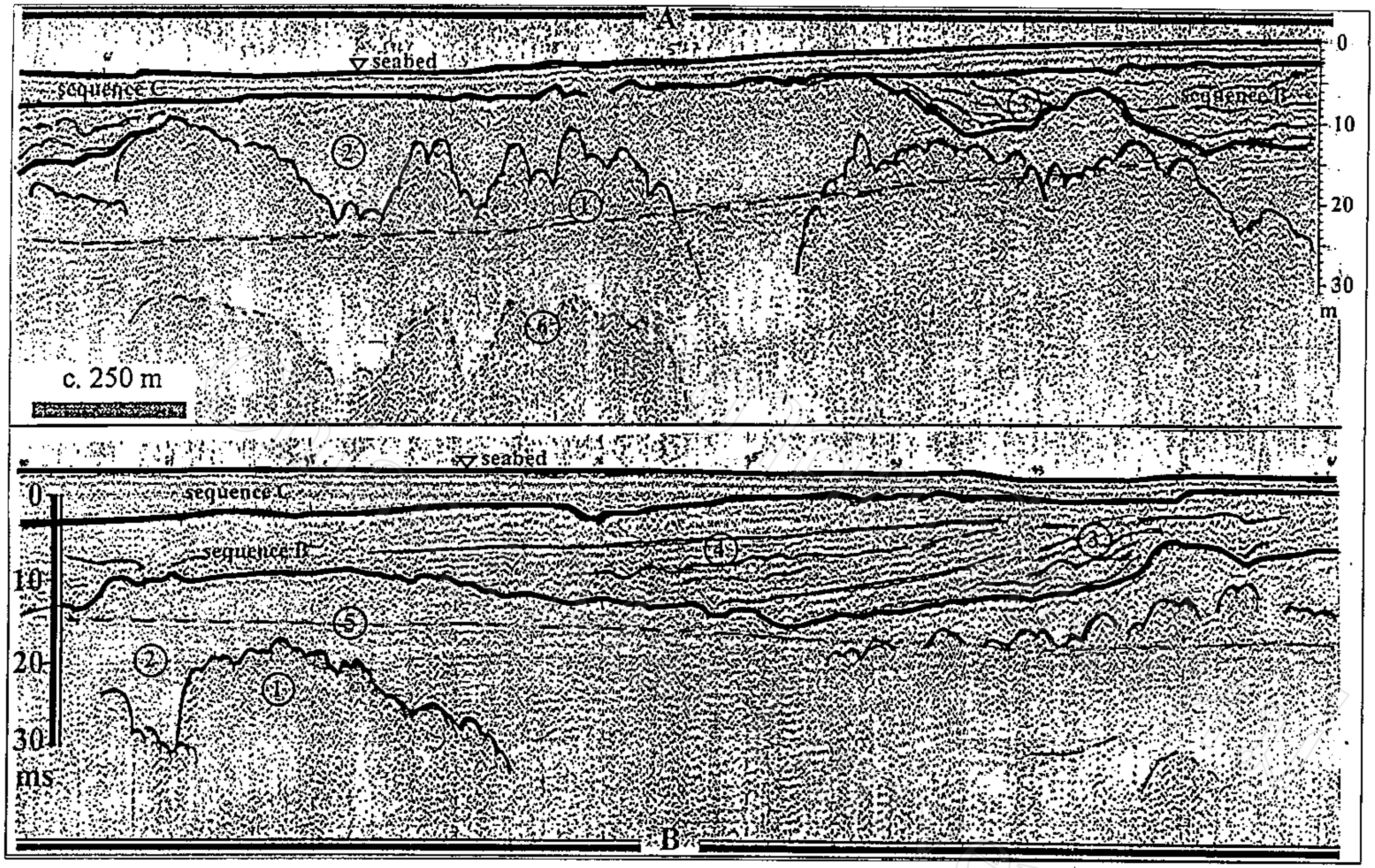


Figure 3.12a Uninterpreted seismic section in the northern part of the sub-area 1-A and interpreted seismic section shown in Figure 3.12b



1) hyperbolic pattern, inferred bedrock 2) chaotic reflectors, weathered bedrock 3) channel fill of oblique clinoform reflectors, sandy sediments 4) continuous reflectors, oblique divergent pattern, muddy (or sandy ?) sediments 5) seabed multiple reflection 6) bedrock multiple reflection

Figure 3.12b Interpreted seismic section from original section in Figure 3.12a

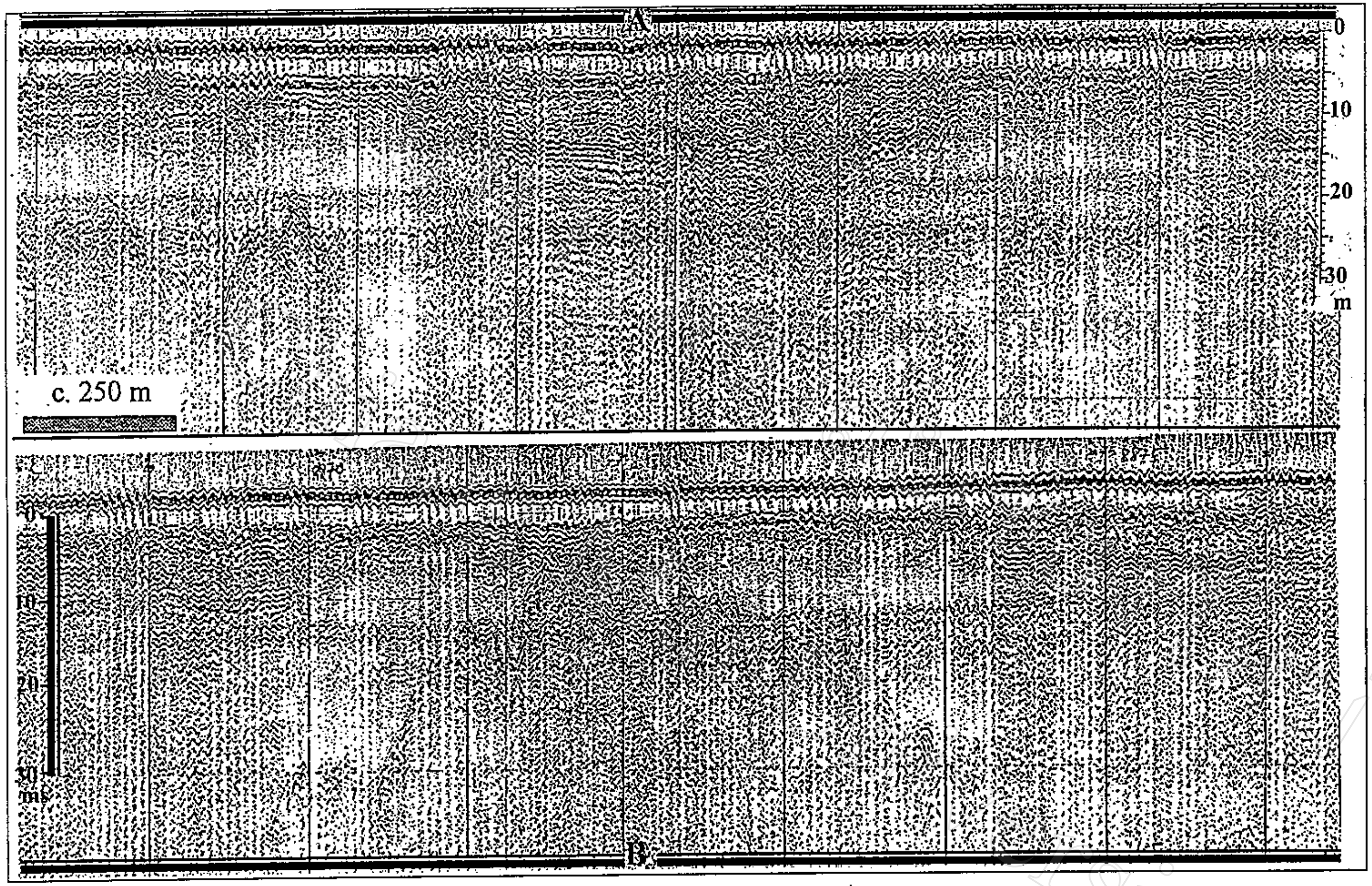
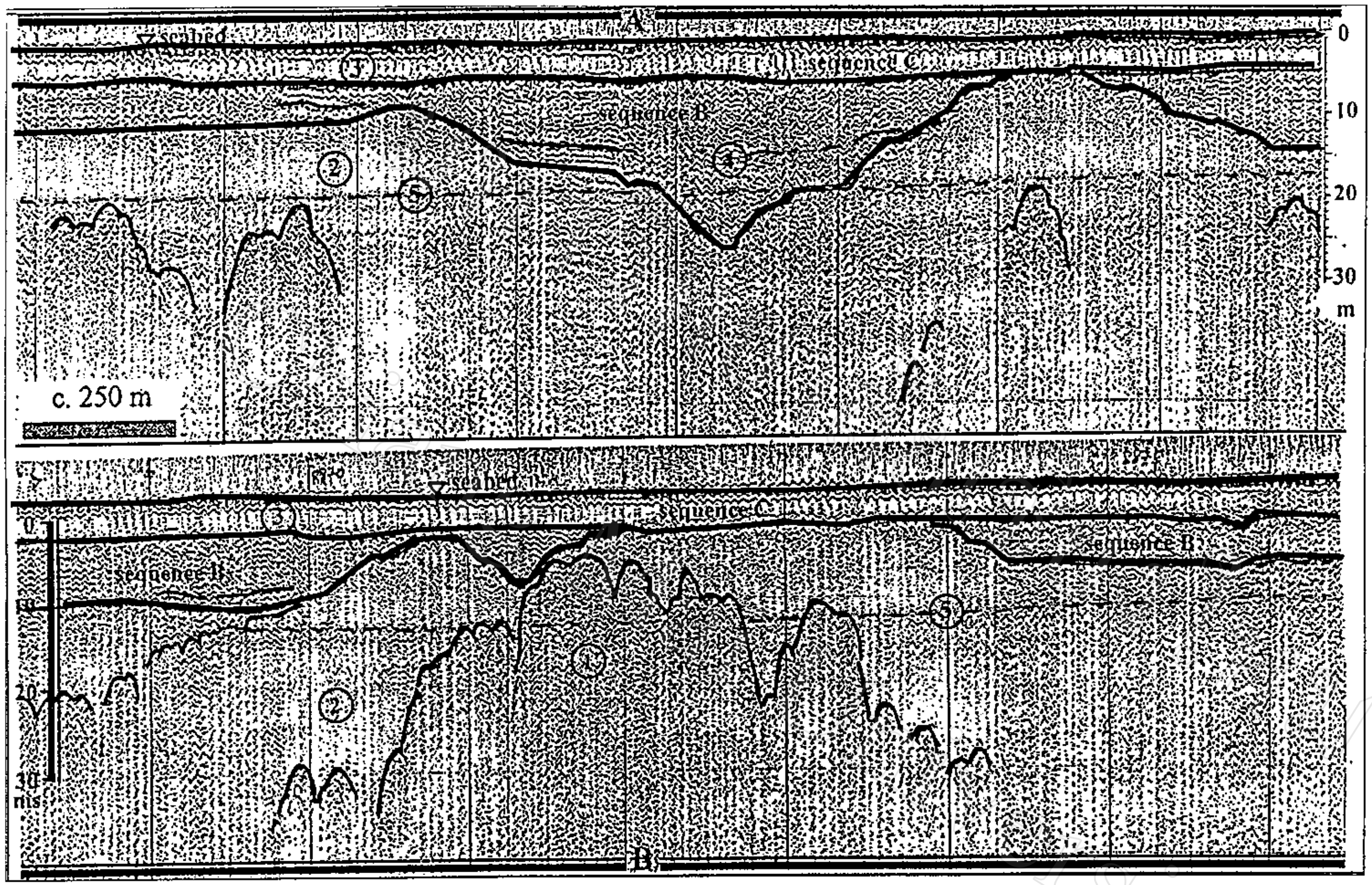


Figure 3.13a **Uninterpreted seismic section in the northern part of the sub-area 1-C and interpreted seismic section shown in Figure 3.13b**



1) hyperbolic pattern, inferred bedrock 2) chaotic and semitransparent reflectors, weathered bedrock 3) reflection free (transparent), muddy sediments 4) channel fill of subparallel reflectors, muddy sediments 5) seabed multiple reflection

Figure 3.13b Interpreted seismic section from original section in Figure 3.13a

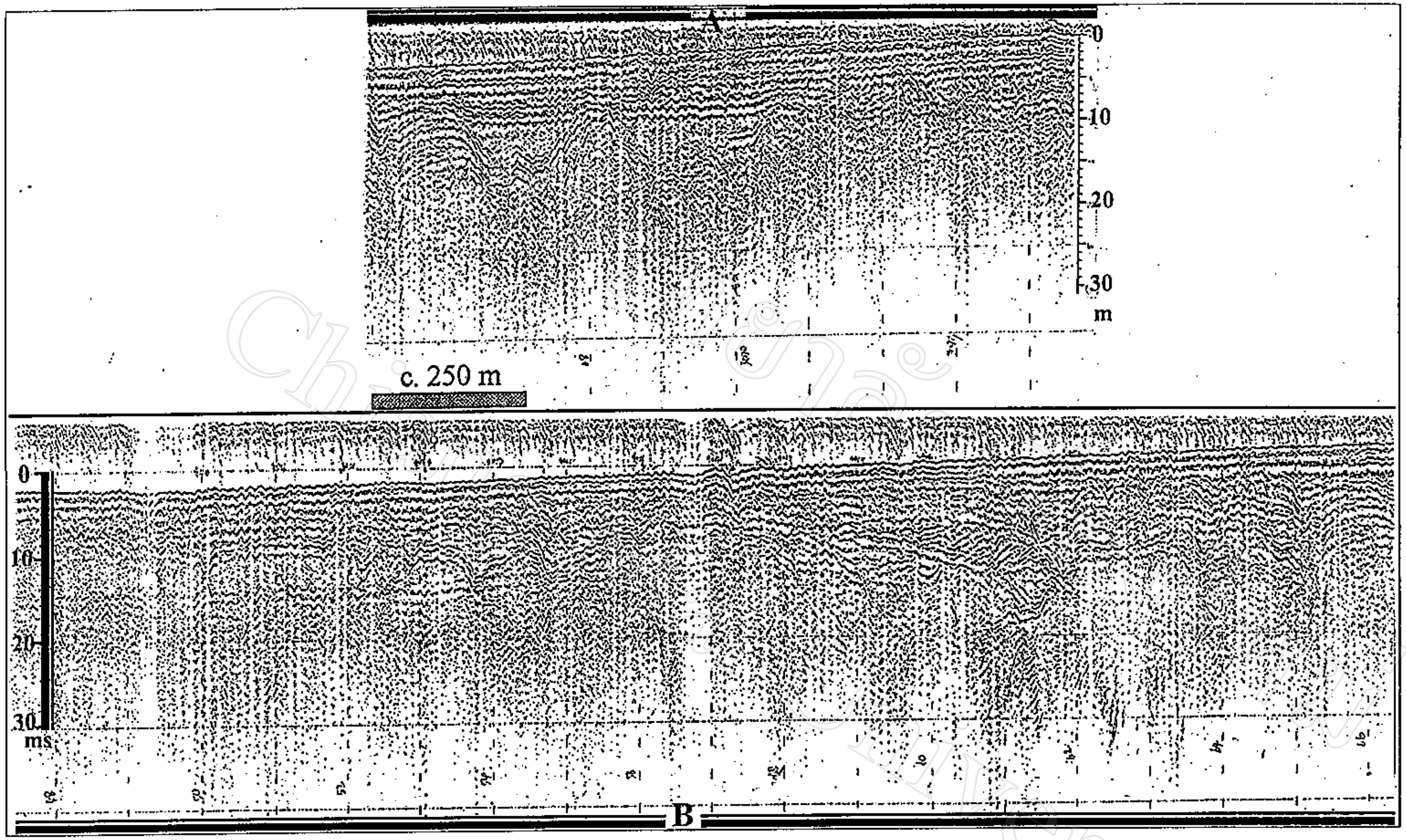
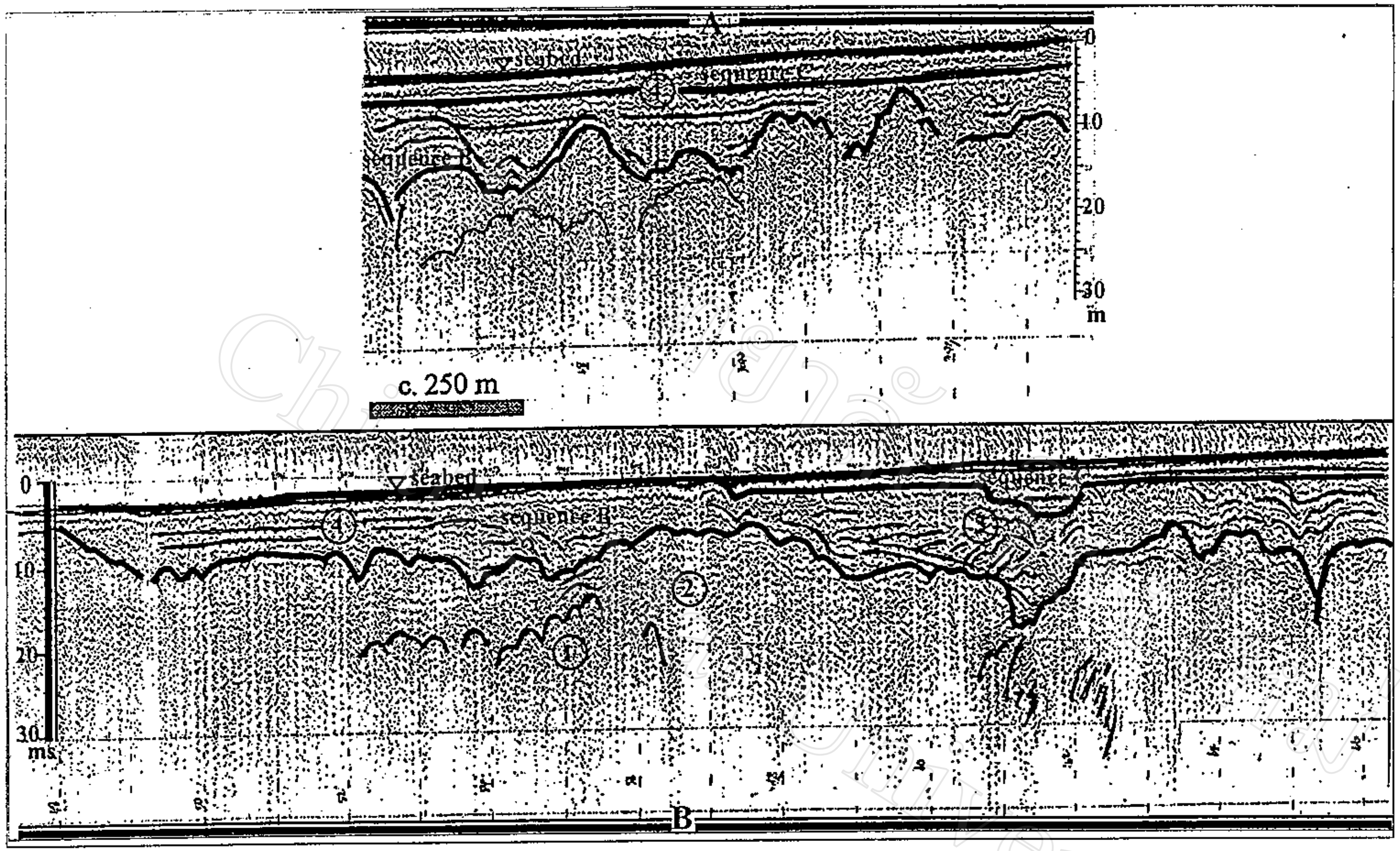


Figure 3.14a Uninterpreted seismic section in the northern part of the sub-area 1-C and interpreted seismic section shown in Figure 3.14b



1) hyperbolic reflectors, inferred bedrock 2) chaotic reflectors, weathered bedrock
3) oblique clinoform, sandy sediments 4) high amplitude, parallel, continuous reflectors, muddy sediments

Figure 3.14b Interpreted seismic section from original section in Figure 3.14a

subparallel pattern with relatively weak to moderate reflections, and there is no distinctive channel fill developed (Figures 3.9a, 3.10a). When close to the shore, the sequence A is most likely dominated by subparallel patterns, relatively moderate reflections at lower part of the sequence. However, the top of the sequence A exhibits parallel patterns with relatively strong reflections, as sediment fills in depression. The parallel and subparallel patterns often suggest uniform deposition and vertical variation in lithology under tranquil condition, usually as sheet or sheet drapes and infill depression (Ringis, 1986 and 1994; Evans *et al.*, 1995) (Appendix C; Figures C5, C8 and C10) and they are mostly inferred to mud, clay and sandy clay (Appendix C; Figures C8 and C16, see also corresponding tables). In Figures 3.8a, 3.9a and 3.10a, the sequence A overlies regolith or weathered bedrock that displays chaotic and acoustically semitransparent patterns on the top of its body. The chaotic pattern usually suggests disordered arrangement and discontinuous reflections (Ringis, 1986 and 1994). The sequence A exhibits chaotic pattern as illustrated in Appendix C (Figures C3, C7 and C15). The chaotic and subparallel patterns may sometimes be associated with small hyperbolic reflectors (speckles) with irregular amplitude at the bases of erosional surface or depression (Appendix C; Figures C3, C7 and C15). This pattern likely implies the presence of gravels and pebbles at erosional bases, *i.e.* stream bed deposit as channel lags, piedmont fans, colluvium, eluvium and talus slope deposits (Ringis, 1979a, 1986 and 1994; Evans *et al.*, 1995). The acoustically transparent and semitransparent seismic facies in unconsolidated sediment usually reflect homogenous lithological units or slightly incoming of different sediment types (sand and clay) deposited in low energy environments (Ringis, 1986 and 1994; Evans *et al.*, 1995) (Appendix C; Figures C10 and C12_13). An overlapping hyperbolic pattern of bedrock body is inferred to fresh granitic rock types (Offshore Mineral Exploration in the Gulf of Thailand Project, 1988 b, 1989a and 1989b; Lallier, 1988; Ringis, 1979a, 1979b and 1986) (Figure 3.10a). Granite bedrocks which produced overlapping hyperbolic pattern are illustrated in Appendix C (Figures C8 and C9, see also corresponding tables).

In the sequence B, a predominant reflection pattern observed on the profiles seaward is a complexity of channel cut and fill feature (Figures 3.6a, 3.7a, and 3.8a). This feature suggested that the sequence at those locations was influenced by sealevel fluctuations which resulted in the development of cut and filled channels. The seismic examples show the likely rapid lateral and vertical lithological variations in the sequence, especially within the lower part of the sequence.

The lower part of the sequence mostly exhibits acoustically transparent (reflection free) and semitransparent patterns with some weak to moderate subparallel reflections (Appendix C; Figures C5, C11, C12_13 and C17). The upper part of the sequence mostly exhibits chaotic and subparallel fills in channels (Figures 3.6a, 3.7a, and 3.8a) (Appendix C; Figures C5, C9, C10, C15 and C16). Those patterns still appear in the middle part of the study area (Figures 3.9a, 3.10a, and 3.11a). In most channel fills within the sequence B, the bottoms of channels mainly exhibit acoustically transparent and immediately overlain by subparallel pattern with relatively strong reflections on the top of channels (Appendix C; Figure C11). The channel fill pattern locally displays speckled seismic signature; this suggests that the deposits are likely to be sandy and pebbly rather muddy lithology (Ringis, 1986 and 1994; Evans *et al.*, 1995) (Appendix C; Figures C5, C10 and C14). Several channel deposits within the sequence B produced chaotic pattern (Appendix C; Figures C5, C9, C16 and C17).

When approaching to the shore, the upper part of sequence is gradually dominated by subparallel, parallel and obliquely dipping fills (prograded oblique fills) in depression on the upper surface of the sequence A (Figures 3.12a, 3.13a, and 3.14a) (Appendix C; Figures C1-C3, C7, C8 and C12_13). Obliquely dipping fills in channels suggest the deposit of sandy sediment as cross bedding, point bar of braided stream (Ringis, 1994) (Appendix C; Figures C7, C11 and C12_13). In Figure 3.8a, the sequence laps out on weathered bedrock, regolith and sometimes on the sequence A.

In the sequence C, seismic facies observed in the lower subsequence (LC) are acoustically semitransparent with some fainted internal reflections seaward (Figures 3.6a, 3.7a and 3.8a) (Appendix C; Figure C10). It exhibits parallel and subparallel patterns with relatively moderate to weak reflections in the middle of the study area (Figures 3.9a-3.11a) (Appendix C; Figure C6, see the bottom of the sequence C) and gradually becomes parallel patterns with relatively strong reflections as approaching to the shore (Appendix C; Figures C3, C6-C7 and C12_13, see the bottom of the sequence C). Some minor channel fills show speckled seismic signature. In channels on the upper surface of the LC, acoustically opaque (or acoustically blanking) zone is sometimes observed and it always obscures the deeper part of seismic sections

(Figure 3.15). This characteristic suggests the presence of zone of gas escaping from peaty sediment deposits in estuarine or lacustrine environment (Ringis, 1986 and 1994; Lallier, 1988; Evans *et al.*, 1995). The LC onlaps weathered bedrock and old piedmont fans near the coast or at place of bedrock topographic highs.

The UC can be obviously distinguished from the LC in the study area by prominent flat surface generally exhibiting relatively weak to moderate reflections (Appendix C, Figure C10). This surface may be equivalent to a ravinement surface. The ravinement surface is a mark of a time transgressive unconformity which the retreat path left by migrating shoreface (Suter *et al.*, 1987; Foyle and Oertel, 1992). The UC distinctively reveals parallel patterns with relatively weak to moderate reflections seaward (Appendix C; Figure C10, see the top of the sequence C) and strong reflection shoreward with moderate continuity (Appendix C; Figure C12_13, see the top of the sequence C). Locally, broad rise mounds with fainted parallel internal reflection are observed on the top of the UC, particularly in the westernmost of the sub-area 1-A, with a thickness of more than 10 m. This pattern suggests deposition of loosely homogeneous material such as muds. The display of internal parallel reflection in the UC likely represents to subtle change in density of sediments rather than lithological change (Evans *et al.*, 1995).

In unconsolidated sediments, sandy sediment usually produce chaotic low amplitude reflections with some discontinuous, often inclined reflectors due to scattered acoustic energy of lost continuity reflectors (Ringis, 1986; Evans *et al.*, 1995) (Appendix C; Figures C3, C5, C7, C10 and C14-C16, see

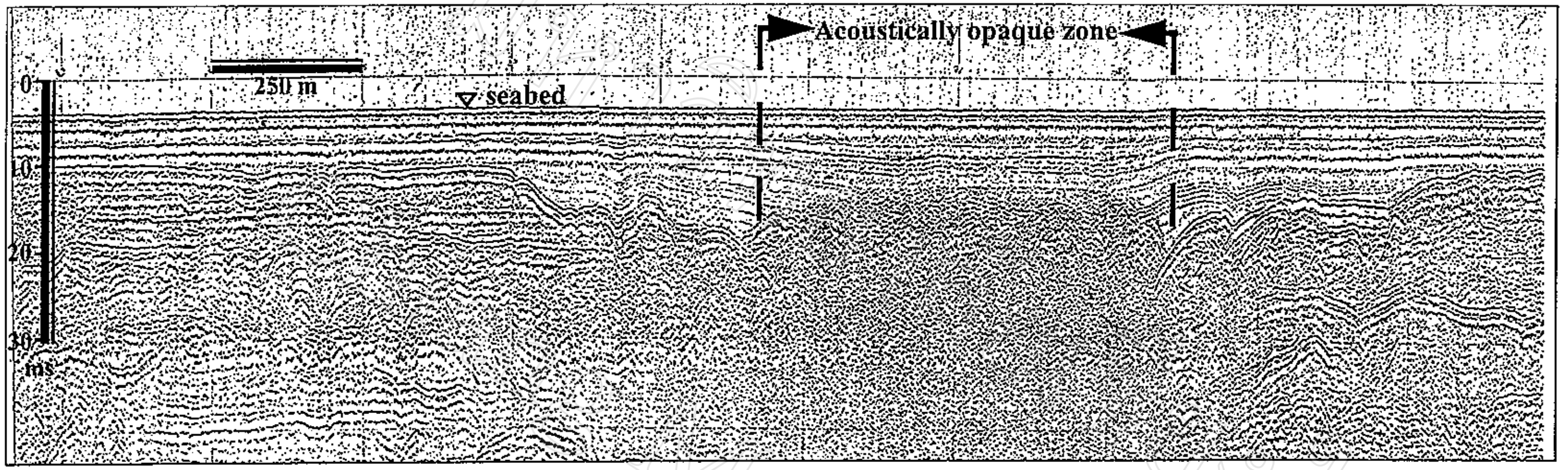


Figure 3.15 **Seismic section showing acoustically opaque zone representing zone of gas escaping from organic matter decay in the deposits under estuarine environment.**

also corresponding tables). But in this study sandy deposits in many drillholes produced subparallel pattern with relatively weak to moderate reflections and sometimes low continuity (Appendix C; Figures C3, C5, C6, C11 and C15, see also corresponding tables).

Based on regional observation on the profiles, it seems that the bedrock topography is gradually high to the east of the study area (in sub-areas 1-C and 1-E). At topographic highs of bedrocks, the lowermost sequence A may sometimes disappear or rarely be observed. This may suggest that the depositional and erosional processes were controlled by topographic relief. The sequence A might be previously deposited on the topographic highs of bedrocks until the last interglacial high sealevel. Then, during marine regression (in last glacial stadial, as discussed in section 3.3), sediments of the sequence A on topographic highs of bedrocks were eroded and developed to be sediment source supply for later deposition period of the sequence B. Or otherwise, the sequence A which cannot be observed on the seismic profiles might be reworked and left as a thin residual on the weathered bedrock. In Figures 3.11a and 3.12a, both show bedrock topographic highs in nearshore zone where the sequence A disappears. In general, the sequences A and B, and LC often terminate as onlapping deposits on weathered bedrock and regolith when close to the shore or at topographic highs of bedrocks.

3.3 Relative Sealevel Change History

The studies of the relative sealevel changes during the Quaternary period in the study area are mainly complied from the previous works in other areas and in this region. Without dating data, the correlation of unconformities identified on the seismic profile is therefore directly related to the major lowstands on the Quaternary sealevel curves. But the minor fluctuations may lead to confusions because it may produce local unconformities within the sedimentary sequences.

According to Evans *et al.* (1995), the eustatic sealevel curves for the past 160,000 years show a number of cycles of variable amplitude with minor fluctuations superimposed onto the major cycles. The maximum heights of the highstands are well defined, but the depths of the lowstands are less certain. Published eustatic sealevel curves from three authors are comparatively assembled as shown in Figure 3.16b. Although there were some contradictions in the timing and magnitude of those events, the dominant trends are mostly concordant. These models nearly agree with the sealevel curve model proposed by Thom and Roy (1985), as shown in Figure 3.17a. This sealevel curve may likely be used for the southeast Asian region, since the data are from southeast Australia and it is very similar to the curve proposed by Bone *et al.*, 1992 (Figure 3.16b).

During the Quaternary period, the significant sealevel changes are well documented, particularly in the middle Pleistocene lowstand (oxygen isotope stage 6), middle Pleistocene highstand (stage 5e), late Pleistocene lowstand (stage 2) and Holocene highstand (stage 1) (Figure 3.16b). Those events are worldwide recognized. Such distinctive events have been documented in many regions. Evans *et al.* (1995) indicated that transgression only reached a highstand level comparable to the present one about 125,000

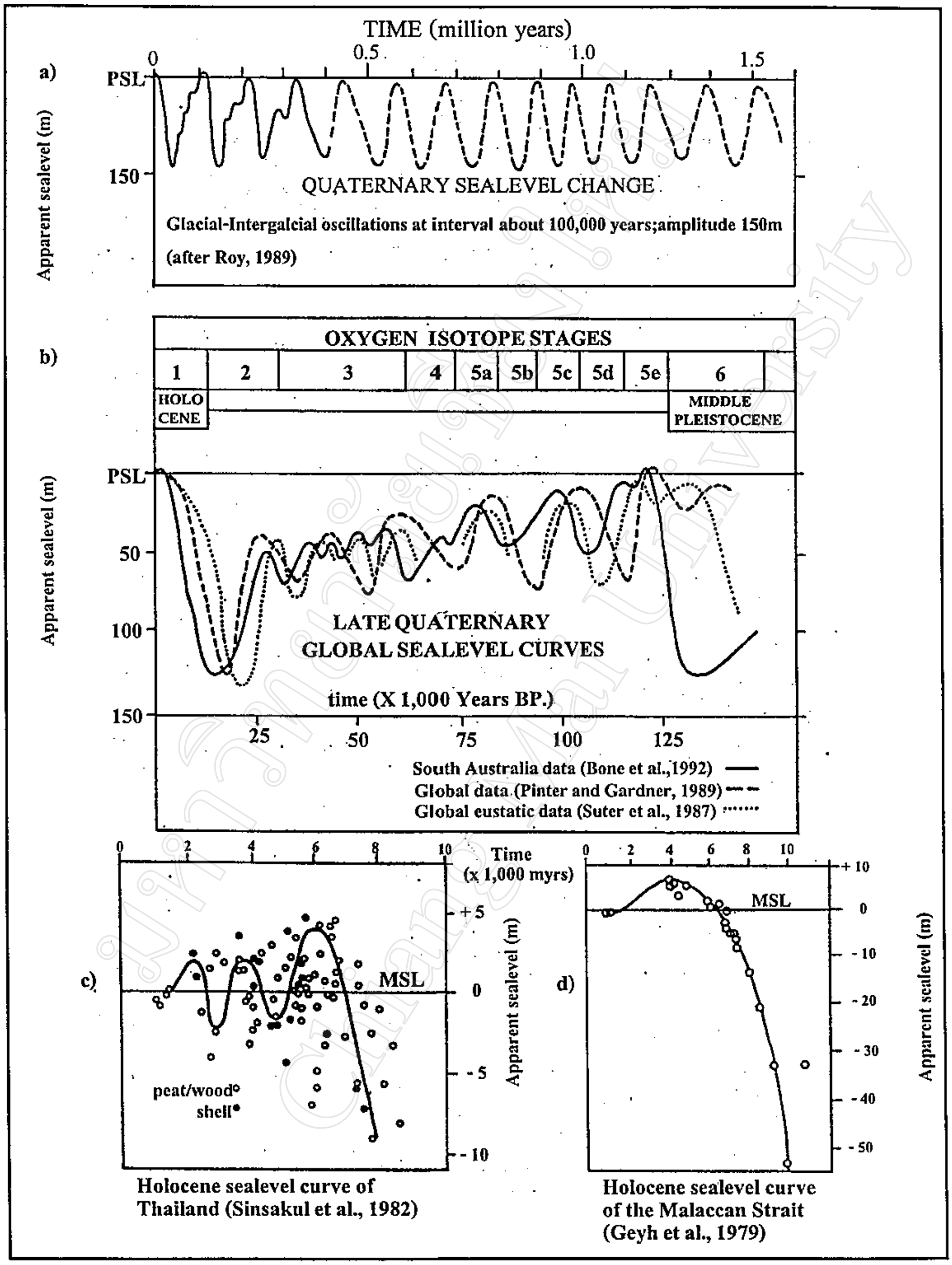
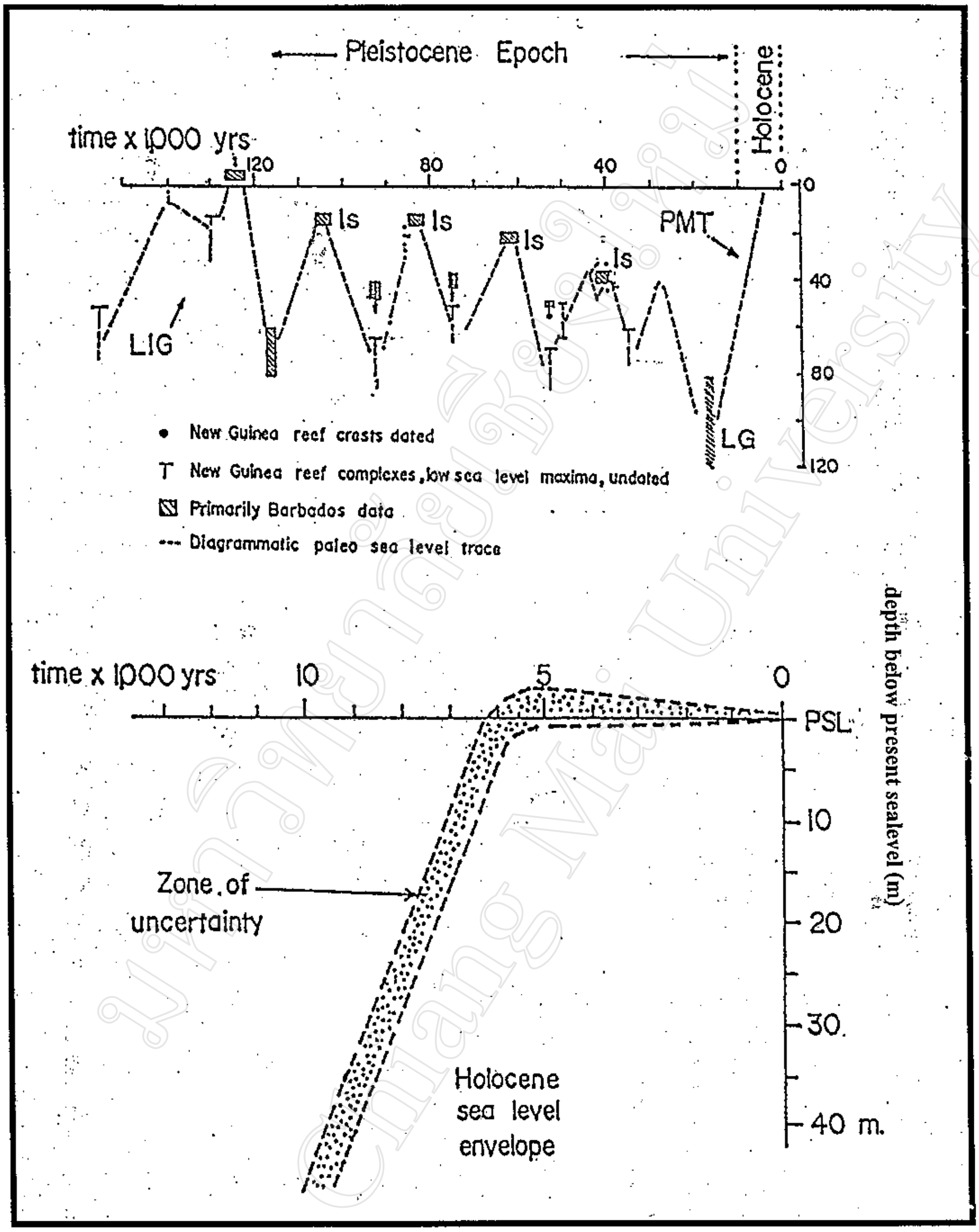


Figure 3.16 Eustatic sealevel curve models (a) Quaternary sealevel oscillations at intervals of about 100,000 years, (b) Late Quaternary global sealevel curves, (c) Holocene sealevel curves of the Malaccan strait, (d) Holocene sealevel curve of Thailand.



(a) The late Pleistocene showing the last interglacial high sealevel stand (LIG; 120,000 yrs BP.), the last glacial maximum (LG; 17,000 yrs BP.) and a number of interstadials (IS). (b)The Postglacial marine transgression (PMT); (after Roy, 1989).

Figure 3.17 Glacio-eustatic sealevel curves for the late Quaternary period.

years BP. (before present) during the oxygen isotope stage 5e (Figure 3.16). This event is most likely equivalent to the last interglacial (LIG) for Southeast Asia, during 120,000-140,000 years ago (Thom and Roy, 1985; Roy, 1989). Numerous minor transgressions between 125,000 and 25,000 years BP. attained heights ranging from -10 m to -50 m relative to the present sealevel (Evans *et al.*, 1995; Thom and Roy, 1985 and Roy, 1989).

Two major transgressions and two major regressions can be noted from this study. Evidences of two major unconformities, defined as unconformities "A" and "B" can be observed widespread on the upper boundaries of the sequences A and B respectively (Figures 3.2, 3.3 and 3.4).

Evans *et al.* (1995) suggested that the most easily identifiable unconformity on seismic profile across most continental shelves is associated with the late Weichselian (late Pleistocene) lowstand some 18,000 to 25,000 years BP. when sealevel fell to a global average of about -120 m to -130 m below the present sealevel (Figure 3.16), whereas Thom and Roy (1985) and Roy (1989) suggested that in southeast Asia sealevel of the late Pleistocene stadial is about -120 m below the present sealevel at some 17,000 years BP. (Figure 3.17). However, both studies are concordant. In addition, Evans *et al.* (1995) suggested that the reflector representing this unconformity should be firstly picked up when interpreting of shallow seismic profiles for Quaternary sediments underlying the continental shelves. This unconformity is referred to the unconformity "B" in this study.

Roy (1989) suggested that the Post marine transgression (PMT) caused dramatic environmental change in recent geological time. In less than

10,000 year ago, the Gulf of Thailand changed from a terrestrial to marine environment affecting various regional changes, *i.e.* geology, biology, climate *etc.* Models of the Holocene were also presented by Tjia (1986), Sinsakul *et al.* (1985); (Figure 3.16c), and Geyh, *et al.* (1979); (Figure 3.16d).

3.4 Drilling Results

A total of 270 holes were drilled in Area 1 at water depths ranging from 2.2 to 21.9 m. Of these, 180 holes were drilled in sub-areas 1-A, 1-C, 1-D, and 1-E by the counterflush circulation drilling system, in the fiscal years 1994 and 1995 (Table 1.2). A total of 60 holes were drilled in sub-area 1-A in 1996 by using the direct flush circulation drilling system. In 1997, rotary core sampling was employed in sub-area 1-E to collect more representative samples and a total of 30 holes were drilled. The positions and numbers of all drillholes are indicated in Tables in Appendix B.

Some 4,500 m of sediment were recovered. A total of 1,666 bulk-samples from the counter flush and direct flush systems, and 30 core samples were analyzed, but without detailed palynological analyses and any dating.

The detailed stratigraphy of selected seismic profiles incorporated drilling results are shown in Appendix C. Most drillholes show reasonably good agreement with the interpreted seismic sequences (Appendix C; Figures C1-C2, C4-C8, C10, C12_13 and C14-C15).