# Geologic Interpretation of Gorae II 3D Area in Block VI-1, Offshore Korea

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## 1. INTRODUCTION

Gorae II 3D area lies in the southwestern part of Ulleung Basin, 30 km offshore Korean Peninsula (Fig.1). The area covers approximately 255 $km^2$ (total 10,843 L-km). The purpose of the study is to understand the process of sedimentation in relation to structural events affected the Gorae II area. Eight horizons were identified through the seismic stratigraphic interpretation of the Gorae II 3D seismic data volume. Time-structure and isochron maps were constructed to reveal the direction of sediment transport. Since most of the formations in Gorae II area have not been penetrated by drilling, the stratigraphic information near basement was mainly derived from the seismic attribute and isochron maps.

The structural analyses were also performed sequence by sequence to identify the activation time of faults.

## 2. STRATIGRAPHIC INTERPRETATION

### Correlation between Gorae-1 well and Gorae II area

The geologic age of the horizons was quoted from the sequence stratigraphic study of Gorae-1 well done by MicroStrat Inc (1993) which performed a detail high resolution biostratigraphic and depositional environment analysis.

The basement in Gorae II area is becoming shallower toward onshore area. The geologic age of the basement of Gorae II area could not determined because the nearby wells penetrated only up to Mid. Miocene section.

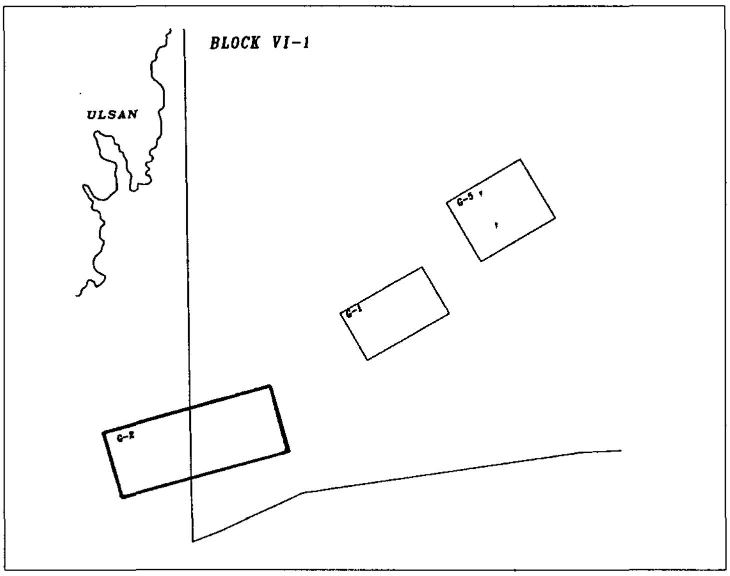


Fig.1 Location map of the study area

The 15.5 Ma and 10.5 Ma sequence boundaries correspond to D and E Horizons in Gorae II area. According to the sequence stratigraphic study by MicroStrat, the TST and HST are separated by a high amplitude continuous reflection. The HST is characterized by discontinuous subparallel reflections which contain significant sandstone. These sequences are typical of those deposited in a delta plain or fluvial environment.

E horizon in Gorae II area exhibit thick lowstand sections. Multiple incised valleys which may have developed over a broad area during the lowstand time are observed in these sequences. It is thought that Late Miocene sections correlated with F sequence are deposited in fluvial to fresh water lacustrine environment with slight marine influx.

Top of the Middle Miocene is dated to 10.2 Ma. Most of the section consists of deltaic and coastal plain with occasional marine influx.

## Stratigraphic Interpretation of Gorae II area

The horizons mapped in Gorae II area are shown in Fig. 2. The correlations between mapped horizons and ages are as follows.

The ages of D, E, F, and G horizons were determined from correlation with Gorae I well. The C horizon and below sections have never been drilled in Block VI-1, however these sequences are thought to have deposited in rift related tectonic regime. Their ages are estimated to be Oligocene or older. The characters of each sequence are as follows.

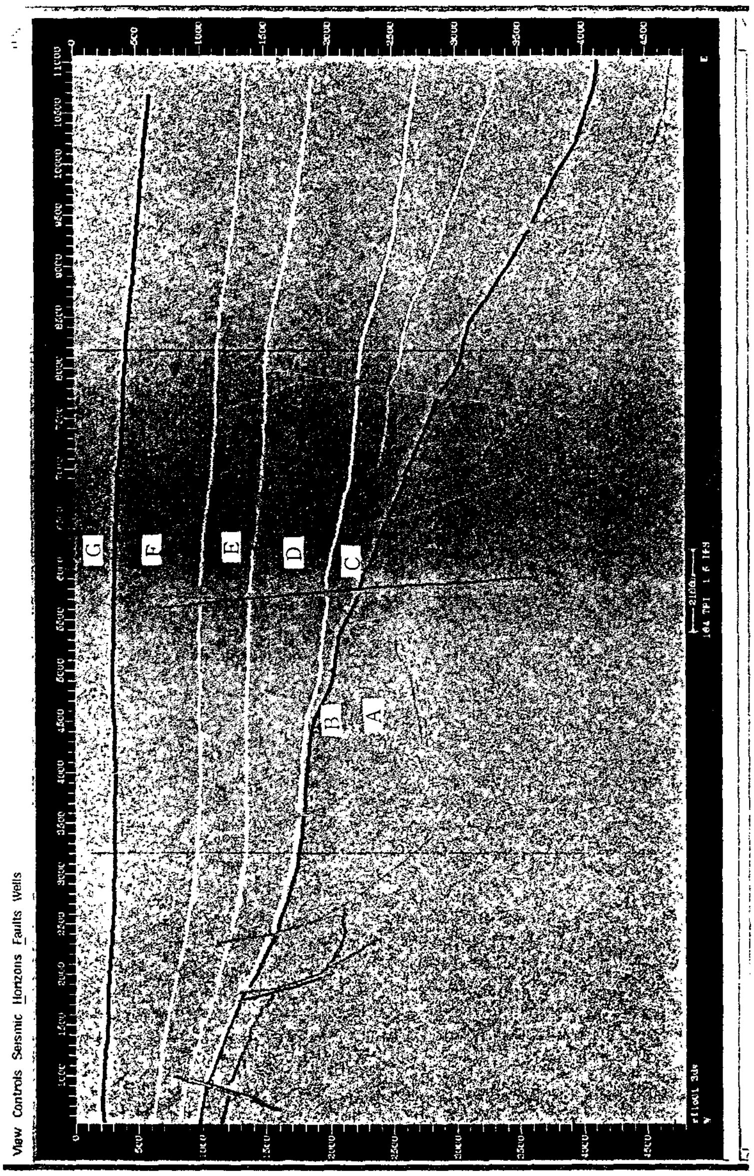


Fig.2 The horizons mapped in the Gorae II 3D area

Table 1. Seismic key horizons observed in the Gorae II 3D area

| *Key Horizons* | *Age* |
|---|---|
| Sequence G | ~6.3 Ma |
| Sequence F | 6.3~10.5 Ma |
| Sequence E | 10.5~15.5 Ma |
| Sequence D | 15.5~17.5 Ma |
| Sequence C | E.Miocene (?) |
| Sequence B | E.Mio~Oligocene (?) |
| Sequence A | E.Mio~Oligocene (?) |
| Basement | Pre-Tertiary (?) |

## Sequence A

This sequence was deposited in a syn-rift tectonic regime. The upper sequence boundaries were eroded severely after the syn-rift deposition as angular unconformity was formed at the boundary between two sequences. The ages of each sequence are unknown because no well penetrated this sequence before. However, in consideration with the regional geology that the Ulleung Basin was mainly formed during Miocene, the age of the sequence is probably Oligocene and older.

The depositional environments of the sequences are probably non-marine to lacustrine because most of the nearby basins around the Ulleung Basin are known to lacustrine basins in origin.

## Sequence B

The age of this unit is also unknown because no well tested this unit. before. The unit is getting more thinner toward the depocenter of the Ulleung Basin. Because of this, the unit is thought to have a relation with the rift tectonics and probably is deposited in a non-marine setting before the major marine transgression comes.

## Sequence C

This unit is rapidly getting thick toward the depocenter of the Ulleung Basin. Numerous channels are observed in the sequence. Channel facies are interbedded with TST sediment which shows onlap termination with the lower sequence. This sequence is composed of several para-sequences which show succession of LST-TST-HST system tracts. The depositional environments probably are thought to coastal to delta plain where relative sea-level fluctuations cause oscillations of the shoreline and the seaward edge of both coastal and delta plains may have temporarily flooded.

The age of this sequence is probably not older than Early Miocene because the opening of Ulleung Basin started to form from Early Miocene until recent. No faults or foldings were active in this sequence except the strike slip faults which were active in the Late Miocene. The basin started to subside after the active rifting phase. These conditions could have been caused by post-rift thermal subsidence. No well ever drilled this sequence before.

## Sequence D

This unit is also getting thick towards the depocenter of the Ulleung Basin. No faults or folds were active at this time. However, the basin seemed to keep on subsiding. There is no thickening or thinning of sequences observed across the thrust fault, and this indicates that compressional tectonics were not active at that time.

## Sequence E

The age of this unit is thought to Middle Miocene. This unit shows similar pattern of sedimentation with D sequence. The compressional tectonics were not active at this time. The stacking pattern of retrogradation is noticed within this sequence. This unit has rarely a fan-shape topography and can be interpreted as a retrograding mouth bar system.

### Sequence F

This section is getting thin on the hanging wall of the thrust fault. This suggests that the compressional tectonics were active during the deposition of this unit. The compressional tectonics are known to occur from 10.5 Ma to 3.0 Ma. Therefore the age of this sequence is thought to mainly Late Miocene.

### Sequence G

This section had experienced no compressional tectonics at the time of deposition. The age of this sequence is thought to range 3.0 Ma to Recent. Correlation with the Gorae-1 well indicates that the sequence was deposited in the marine environment.

## 3. STRUCTURAL INTERPRETATION

The fault map (Fig.3) shows rift faults as well as thrust and wrench faults appeared in Gorae II area. The age of the syn-rift tectonism is unknown because no wells penetrated into the syn-rift section. However, it is generally thought that the syn-rift occurred early Miocene or older.

Major backarc rifting began from the pre-Miocene time in the Ulleung Basin as the Eurasian plate collided with the Pacific and Philippine plate. The resulted subduction of these plates under the Eurasian plate caused major extension to the Eurasian plate. This produced a series of sub-parallel rift basins along the eastern margin of the plate. This extension and basin subsidence phase continued until Middle Miocene during which most of the Ulleung Basin formed.

The Late Miocene collision of the Eurasian plate with the Pacific plate initiated major compressional tectonism which resulted in extensive uplift, thrust and wrenching. The subsidence due to sediment loading and thrust continued to the north and west in front of the thrusts and basin infilling continues until today in this area. The tectonic episode in the region can be divided into 5 stages.

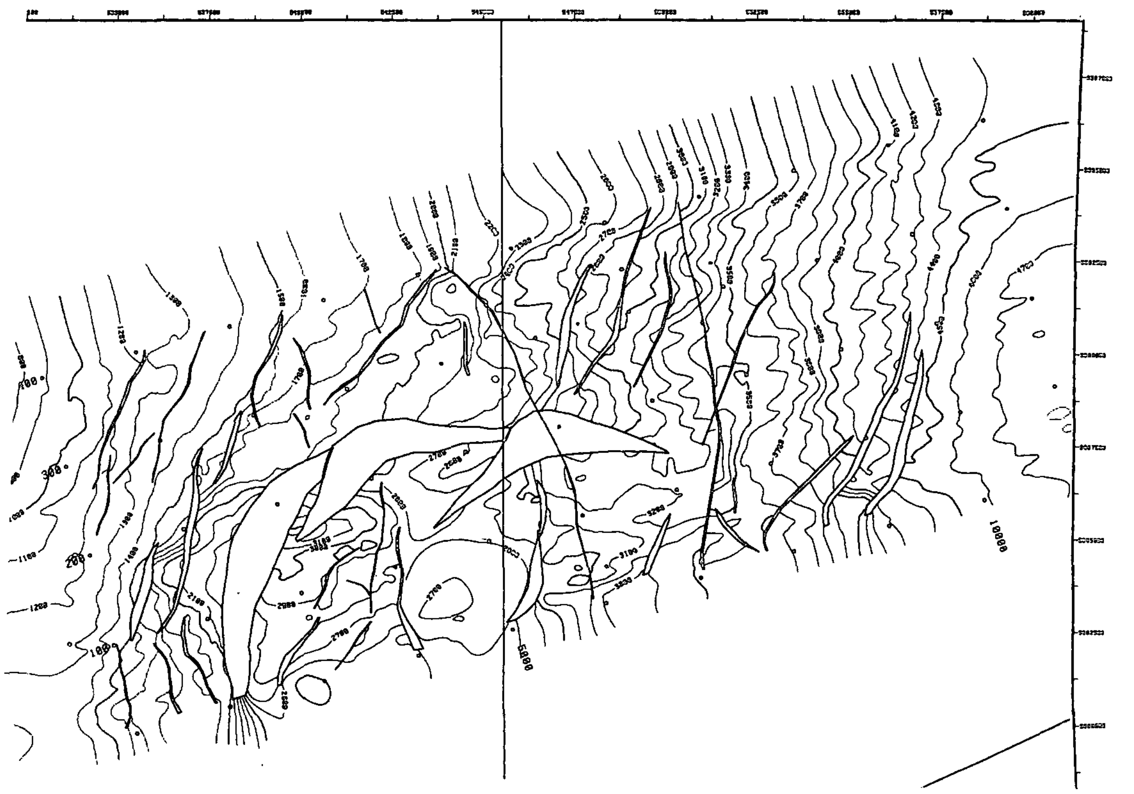

Fig.3 Fault map of the study area

| | | |
|---|---|---|
| Stage 1 | Pre-rift | Cretaceous and older |
| Stage 2 | Syn-rift | Early Mio.~Mid.Oligo. |
| Stage 3 | Post rift subsidence | Early~Middle Miocene |
| Stage 4 | Compression associated with thrusting and wrenching | Late Miocene |
| Stage 5 | Wrenching | Pliocene~Recent |

The time-structural map of the basement shows mainly rifting faults which were activated during the syn-rift tectonism. Also, NW trending strike slip faults are observed in the study area. They were formed during the compressional tectonic stage. The main trend of the rift faults is NE-SW with occasional E-W trending fault.

At this stage, the basin was mainly an extensional half grabens similar to other basins along the eastern margin of the Eurasian plate. After the syn-rifting event, the rift faults are inactive except minor reactivation due to sediment loading. The age of the syn-rift stage is thought to be Paleogene, probably Oligocene according to the tectonic overview of the basin.

The time-structure map of D sequence boundary shows most of the rift faults do not extend into the horizon. Also no other faults or folds are noticed except subsidence. Therefore, after the syn-rift stage, the basin kept on subsiding without any tectonic interruption. The post-rift subsidence stage is probably Early to Middle Miocene time when most of basin was filled.

The following tectonic episode is a period of basin compression as a result of collision between the Eurasian plate and Pacific plate. The initial effects of this compression are expressed as thinning on the hanging wall of the thrust faults. The isochron maps of D shows that the unit doesn't show any thickening or thinning across the thrust faults. The compressional tectonics were not active during the deposition of this unit. Therefore, the activation time of the compressional tectonics is thought to range between 10.5 Ma and 6.3 Ma, mainly of Late Miocene.

The strike slip faults appeared in Gorae II area show NW-SE trend which are perpendicular to the thrust faults. These faults are the tear faults associated with the thrust faults, the active time is the Late Miocene when the compressional tectonics were active.

The sequence above the 6.3 Ma SB shows a concordant facies pattern and indicates little tectonic activity in Gorae II area. In the southern part of Block VI-1, another stage of basin compression began which significantly deformed the 6.3 unconformity by the wrench faulting. This tectonic activity didn't affect Gorae II area.

## Conclusions

It is concluded that the Gorae II area can be divided into 8 stratigraphic sequences including the basement. They are the products of rift activities happened in the area during the opening stage of the East Sea. The extensional tectonics is changed into compressional regimes from Late Miocene time until Recent. They can be grouped into the pre-, syn- and, post- rift sections.

Among the 8 sequences, sequence A, B represent syn-rift sediment. Post-rift sequences are corresponding to C, D, E. The sequence F is deposited during the period of syn-compressional tectonics. The sequence G belongs to the post-compressional tectonics. The dominant control of sequence deposition and geometry in the Ulleung Basin are thought to tectonics and sediment supply rather than eustacy or climate.

## References

이호영, 1994, 동해울릉분지 남동부의 신제3기 유공충 생층서, 미발간 박사학위논문, 서울대 대학원, 328p.

최동림, 오재경, Mikio Satoh, 1994. 동해 울릉분지 남부해역의 신생대 지질

구조 및 지구조 변화, 한국석유지질학회지, 2(2), 59-70

한국동력자원연구소, 1982. 대륙붕 석유탐사자료 평가연구, 342p. (미발간)

한국동력자원연구소, 1987-1994, 돌고래 및 고래 시추공 시료분석보고서; 미발간 용역보고서.

Choi, H.I. and Park, K.S., 1985. Cretaceous/Neogene stratigraphic transition and post-Gyeongsang tectonic evolution along and off the southeast coast, Korea. Journal of Geological Society of Korea, 21(4), 281-296.

Chough, S.K. and Barg, E., 1987, Tectonic history of Ulleung Basin margin, East Sea (Sea of Japan). Geology, 15, 45-48.

Exploitech, 1989, Exploration and Development, Evaluation, Block VI-1, Ulleung Basin; v. 1-6. Geol. Survey Japan, 1992, Stratigraphy and geologic history of the Cenezoic of Japan. 114p.

Ingle, J. C. et al., 1990, Proceedings of the ocean drilling programme, initial reports, v. 128.

Kim, B. K., 1965, The stratigraphic and paleontologic studies on the Tertiary (Miocene) of the Pohang area, Korea ; SNU J. Science & Technology Series, v. 15, p. 32-121.

Mitchum, R.M., Vail,P.L., Sangree, J.B., and Thompson,S. 1976, Stratigraphic interpretation of seismic reflection patterns in depositional sequences ; from AAPG-SEG school on 'Stratigraphic interpretation of seismic Data'.

Micro-Strat, 1993, Integrated seismic sequence stratigraphic analysis of the Gorae-1 well, Block VI-1; 52p.

Minami, A., 1979, Distribution and characteristics of the sedimentary basin offshore San-in to Tsushima Island, Japanese Assoc. Petrol. Technology, v. 44, no. 5, p. 321-328.

Mitchum R, M. Jr. and Vail, P. R., 1977, Seismic stratigraphy and global changes of sea level, part 7: seismic stratigraphic interpretation procedure in seismic stratigraphy - application to hydrocarbon exploration, Charles, E. Payton(Ed); p. 135-143.

Park, K. S., 1990, The seismic stratigraphy, structure and hydrocarbon potential of the Korea Strait; unpublished Ph.D thesis, 431p.

Shell International Petroleum Maatschappij B. V., The Hague, 1993. Ulleung Basin, Japan & South Korea Offshore; Part Ⅰ, Ⅱ.

Vail P.R. and Wornardt W.W. 1990, Well log seismic sequence stratigraphy: an integrated tool for the 90's.