

Recent Progress in Active Fault Studies in Korea

- Major Results from the Joint Research between KEPRI and CRIEPI -

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1. Introduction

Recently the Fukuoka-ken seiho-oki earthquake (2005. 3. 20. M_w 6.6, M_{JMA} 7.0) has affected the southeastern part of the Korean Peninsula with the level of MMI III-IV(KMA, 2005). This earthquake disclosed not only the fact that even a low seismicity area could bring forth a large magnitude of earthquake but also the importance of aseismic countermeasures including seismic design. Even though little earthquake damage has occurred throughout the 20th century in Korea, historical earthquake reveals that earthquakes incurred significant damage. In December 1996, the earthquake with magnitude 4.5 struck the Youngwol, spreading impact on the whole Korean peninsula. In June 1997, Gyeongju earthquake with magnitude of 4.3 stunned many people because its epicenter was found to lie in the Yangsan fault.

Over 40% of total electricity generation in Korea depend on 19 units of NPP in operation. The design earthquake for NPP and many structures can be determined based on the earthquake catalogues. Unfortunately, historical records in the earthquake catalog contain various uncertainties such as epicenter, magnitude and so on. Alternatively the design earthquake can be better estimated through geological survey. For this purpose, two phases of joint researches on active faults in Korea were conducted between KEPRI (Korea Electric Power Reseache Institute) and CRIEPI (Central Research Institute of Electric Power Industry) from 2001 to 2005.

The latest finding of new Quaternary faults along the Yangsan and Ulsan fault zones and the occurrence of intermittent earthquakes near the fault raised the safety issue of the NPPs near the fault zone and heightened researches by the experts in the related fields. Yangsan fault with NNE - SSW strike is a very large and long lineament about 200km in the southeastern part of Korea. There have been arguments on whether Yangsan fault is active or not since the 1980s. Also many geologists and seismologists discuss whether Yangsan fault can be a seismic source and will affect the safety of NPPs. Most of the Quaternary fault planes which cut alluvial fan or fluival deposits are vertical or very steep and sense of fault are stirke-slip.

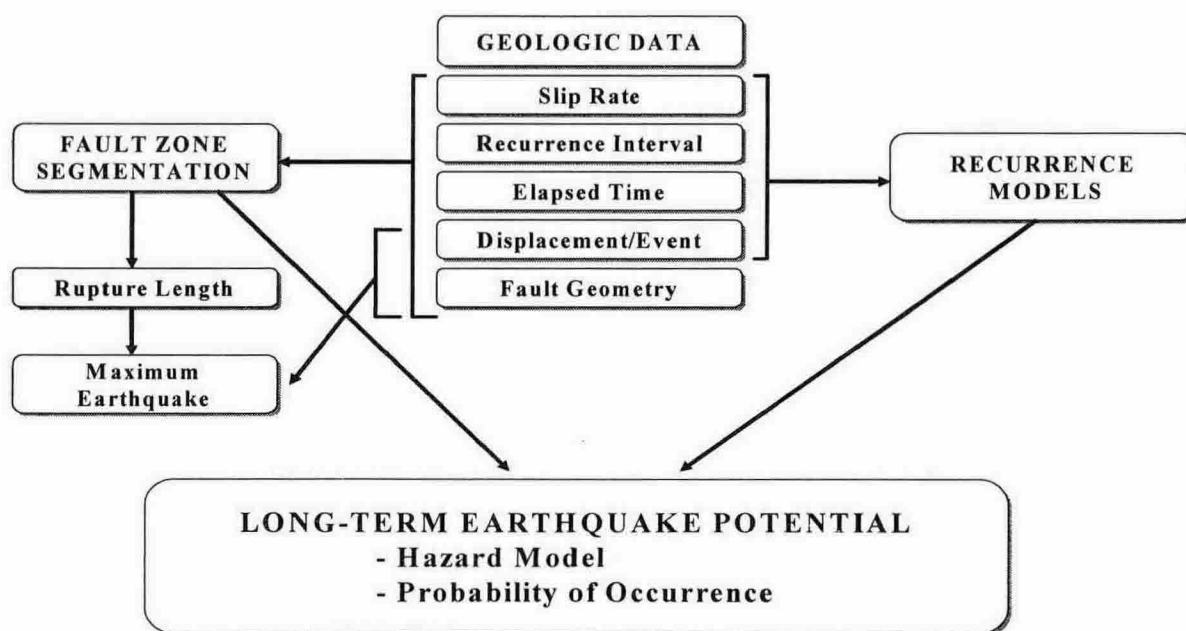


Figure 1. Relationship between geologic data and aspects of seismic hazard evaluation
(Schwartz and Coppersmith, 1986)

The Ulsan fault with NNW-SSE strike is a very wide and long lineament about 50km from Ulsan to Gyeongju city in Korea. According to previous studies the Ulsan fault was not considered only as a long lineament since no displacement was found along the lineament. Recently several Quaternary faults were reported in the eastern part of lineament. At present there are some reports of the Quaternary faults near the Ulsan fault but there is no direct evidence that the Ulsan fault is a seismic fault.

The previous studies have only focused on the age dating of the fault with the specific outcrops without quantitative paleoseismic evaluation. Recently, joint research project has just been carrying out 1) to interpret aerial photographs and lineament, 2) to excavate trenches on the lineament, 3) to elucidate tectonic evolution by fault movement and marine terrace uplift, 4) to develop domestic active faults criteria and 5) finally to assess long term seismic hazard (Figure 1).

2. The 1st phase of joint research

The title of the 1st phase of joint research carried out from August 2001 to July 2003 was "Recognition of the Quaternary Faults through Aerial Photographs Interpretation and Evaluation of Maximum Earthquake Potential from the Faults". The objectives of joint research are 1) to interpret the aerial photographs of the southeastern part of Korea which include the area of new nuclear power plant sites, Yangsan fault system and Ulsan fault system for recognition of Quaternary faults, 2) to determine the age of the Quaternary deposit (marine and fluvial deposits) by checking Tephra layer and trenches, and 3) to evaluate the potential earthquakes from Quaternary faults. To accomplish the objectives, joint research team

have visited each other to investigate geology and faults, and exchange all the related information.

According to specialized fields of each institutes, detailed work scopes have been divided as follows.

Task 1. KEPRI scope

- Field mapping for the Quaternary sediments in Korea
- Geological mapping for the Quaternary fault in Korea
- Trench survey and analysis for the Quaternary faults in Korea
- Detailed geological mapping around the New nuclear power plant sites
- Detailed fault mapping around the main fault system
- Dating of the fault gouge, parent rocks and Quaternary sediments

Task 2. CRIEPI scope

- Aerial photographs interpretation (Yangsan and Ulsan fault system, coastal area)
- Classification of the active faults according to the degree of certainty
- Segmentation of the Yangsan and Ulsan fault systems
- Transfer of the techniques for interpretation of aerial photographs
- Transfer of the techniques for interpretation of geological structures on trench wall
- Training KEPRI-KEPCO researchers for evaluation of earthquake potential from faults

Task 3. JOINT scope

- KEPRI researchers' participation in trench survey and analysis for active fault in Japan
- Classification of the active fault according to the degree of certainty
- Estimation of recurrence interval of Quaternary faults in Korea
- Estimation of maximum earthquake potential from active faults

3. The 2nd phase of joint research

The title of the 1st phase of joint research carried out from May 2003 to May 2005 was "The Evaluation of Slip Rate and Segmentation of the Ulsan Fault System". Based on the result of the first phase of Joint researches, the second phase of joint research has concentrated on Neotectonic fault activity assessment through segmentation of major Faults and Quaternary fault behavior model interpretation. The objectives of the 2nd joint research are 1) to interpret the aerial photographs along Ulsan Fault system in detail, 2) to excavate trenches on the lineament, 3) to determine the fault slip rate by interpretation and age dating of C-14, OSL, and Tephra layer, 4) to segment the Ulsan fault based on lineament rank and slip rate, and 5) to estimate earthquake magnitude from the Ulsan fault. For the purpose of accomplishing the objectives, joint research team will visit each other to investigate geology and faults, and exchange all the related information(Figure 2).

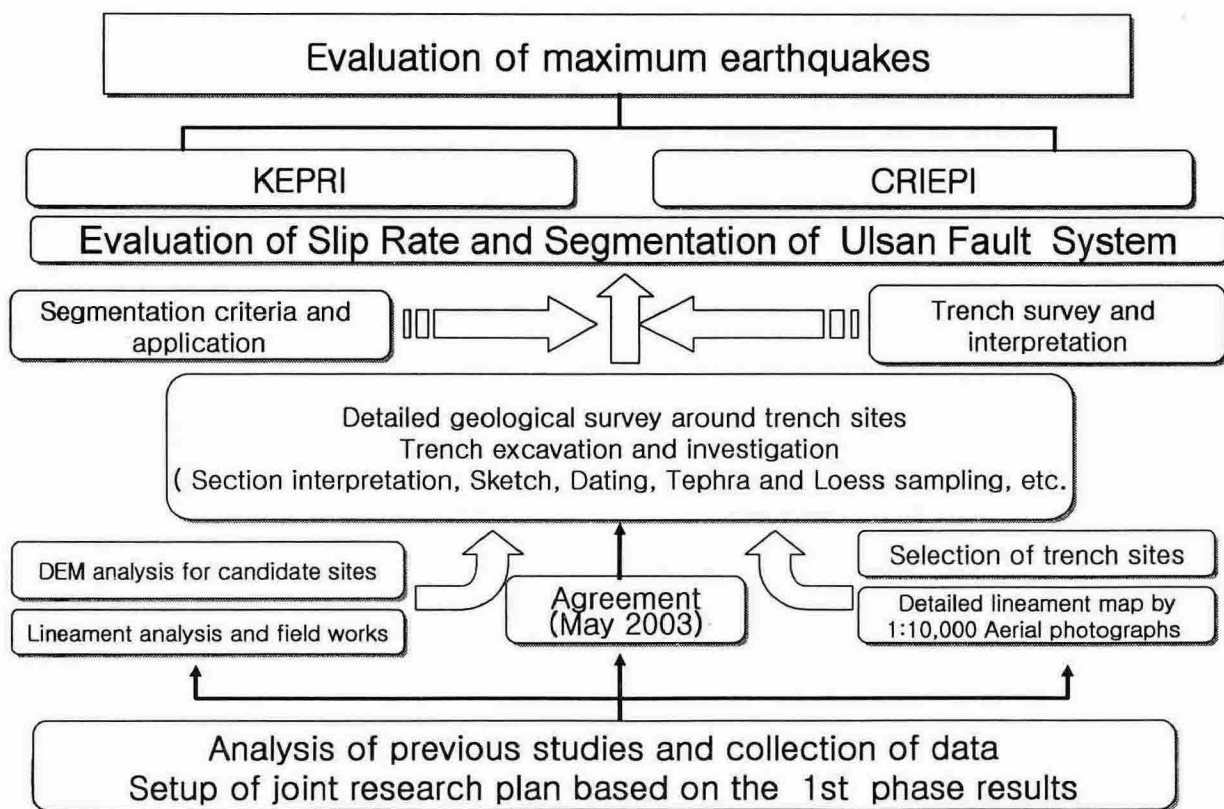


Figure 2. Flow chart of the 2nd phase of joint research between KEPRI and CRIEPI

Detailed work flow is shown in Figure 2 and described as follows(Figure 2).

Task 1. KEPRI scopey

- Detailed field mapping for Quaternary sediments along the Ulsan fault system
- Detailed geological mapping for Quaternary faults along the Ulsan fault system
- Detailed trench survey and analysis for lineaments along the Ulsan fault system
- Analysis of DEM data and 3-D topographic modeling along the Ulsan fault system
- Additional dating for Quaternary fault and sediments

Task 2. CRIEPI scope

- Detailed Aerial photographs interpretation(1:10,000 scale)
(Rank A and B lineament extracted from first phase research results)
- Classification of the active faults according to fault parameters
(slip rate and displacement etc.)
- Segmentation of the Ulsan fault systems
- Transfer of the techniques to select the trench sites from lineament through interpretation of aerial photographs
- Transfer of the techniques for interpretation of geological sequences by describing the minor structures on the cross section of trenches

Task 3. JOINT scope

- KEPRI researchers' participation in trench survey and analysis for fault in Japan
- Detailed Aerial photographs interpretation (1:10,000)
- Borehole logging and interpretation of subsurface structures
- Classification of the active fault according to fault parameters
- Estimation of recurrence interval and slip rate of Quaternary faults along the Ulsan fault system by trenches in Korea
- Segmentation of the Ulsan fault
- Analysis of already known faults and geology data

4. Major results from the joint researches on active faults in Korea

The 4 years of Joint Researches between CRIEPI and KEPRI from 2001 to 2005 were very helpful for transferring techniques, exchanging information and have produced precious results in active fault studies in Korea. Also, the joint researches have promoted and strengthened mutual understanding and technical cooperation each others.

Major results from two phases of joint research are summarized as follows.

- Lineament maps along the Yangsan and Ulsan fault system and coastal area in southeastern part of Korean Peninsula (1:5,000, 1:25,000, 1:50,000 scale)
- Marine terrace distribution map along the coastal line (1:5,000 scale)
- Age data for determination of fluvial and marine terrace and the fault activity
- Tephra identification for age determination of marine terraces and introduction of tephrochronology concept for the first time (AT tephra : 25ka , Aso 4 tephra : 84-88ka, Ata tephra : 100-110ka)(Figure 3)

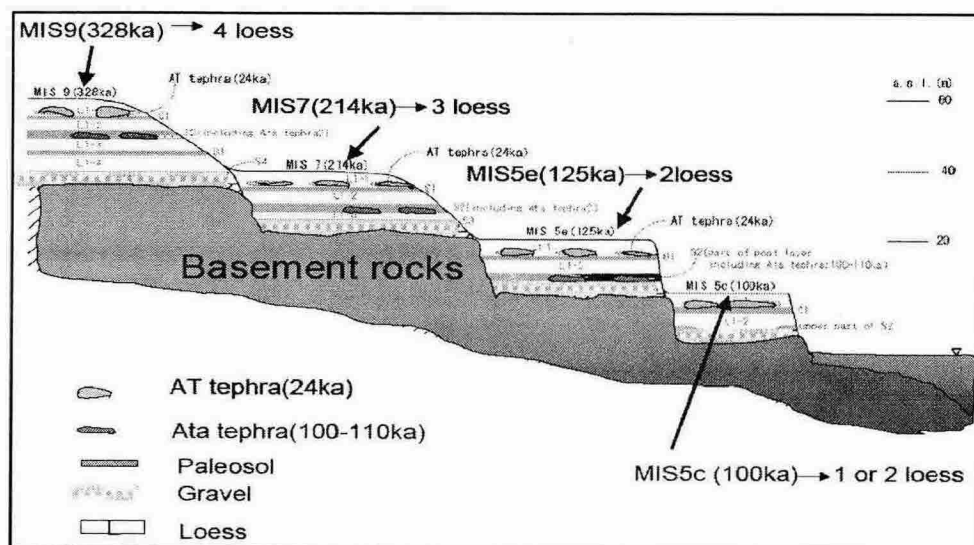


Figure 3. Schematic diagram for marine terrace shows the age of sediments along the line in the southeastern part of Korean Peninsula.

- Loess analysis for age determination of marine and fluvial terrace(Malbangri, Yonghanri, Eupcheonri)(Figure 3)
- 6 trench excavations and interpretation of fault movements along the Ulsan fault system
- Field investigations for active faults and Quaternary deposits
- More than 15 times along the Yangsan and Ulsan fault and around New Nuclear Power Plant sites in Korea
- 5 times in Japan (Danna, Nojima, Ito-Shizu line, Atera, and Neodani faults in central Honshu, volcanic and Quaternary deposits in Kyushu, Tsunami deposit at Tateyama)
- More than 15 times for presentation of papers in GSK, EESK, KOQUA, GSJ, IGC, etc.

Some of these results such as age data of marine and fluvial terraces will contribute in setting up the active fault criteria. The lineament map and terrace distribution map will be very helpful for making active fault map in Korea. The assessment of fault activities along Ulsan fault will support reasonable seismic design value and reduce the uncertainty of seismic safety for NPPs. Next joint research will be performed timely if site suitability problems were issued by regulatory body in near future.

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