Search for Possible Sites in Korea

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Abstract

This paper is prepared to give brief information on geological conditions for selection of possible candidate sites. Geological conditions in Korea seem to be quite favourable in general. More detailed geotechnical characterization may be required for next step.

1. General Geology of Korea

Throughout the country, mountains are not high, rarely exceeding 1,200 meters, but they are found almost everywhere. The terrain is rugged and steep and only near the west, and southwest coasts are extensive flat alluvial or diluvial plains and more subdued rolling hilly lands.

Korea consists largely of the Precambrian rocks, such as granite gneisses and other metamorphic rocks. The Gyeongsang Supergroup is distributed across a wide area within the Gyeongsang-do province which is one of the area of our concerns.

The Gyeongsang Supergroup is composed of the Sindong and Hwayang groups and the Bulguksa Intrusives. The biotite granite intruded in the Gyeongsang Supergroup is called Bulguksa Granite. Hwayang Group widely distributed throughout the Gyeongsang-do province, consists of conglomerates, sandstone, shale and volcanic rock such as andesite, basalt, rhyolite and tuff, especially in the upper part of the group.

Figure 1 shows the geological map of Korea. The first geological map of Korea, with a scale of 1:1,000,000, was published in 1928. Korea Institute of Geoscience and Mineral Resources (KIGAM) started to publish geological quadrangles with a scale of 1:50,000 from 1961. Figure 2 shows the geological sheets of geological map. Geological map of Korea consists of 350 geological sheets with a scale of 1:50,000.

2. Site Considerations

The requirements for site selection are as follows: 1) The preferable site is located within some degrees from off-axis beam lines. 2) The detector is located about 500 m to 1,000 m deep. Uniform overburden in all direction is desirable. 3) Size of underground research module is 50 m (dia.) $\times$ 280 m (l) in cylindrical shape. 4) One has to consider long term safe operation, economic construction, and research module in good rock mass.

In order to satisfy the overburden of 1 km in depth, preferable site would be mountain area. For flat or easy slope topography, it is necessary to excavate very long tunnel over 1 km because the inclination of tunnel floor is limited. We may need vertical shaft or inclined shaft. It is too costly.

If the site should be located within a 1.0 degree off-axis beam line, there seems no room for the candidate site except Tohamsan area in Gyeongju. It, however, is a part of National Park area, so it may be out of place. This area is geologically

pp. 91–96

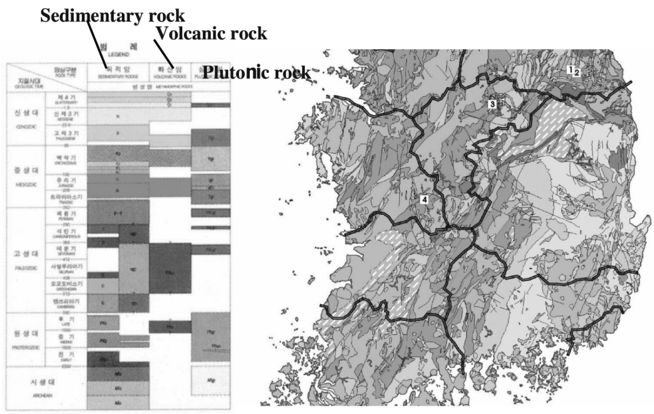

Fig. 1 Geological map of Korea.

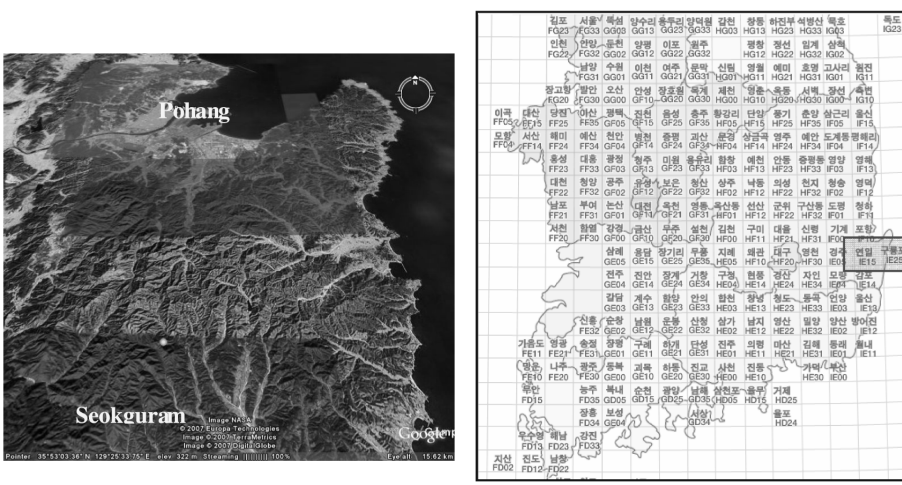

Fig. 2 Candidate site within 1.0 degree off-axis beam line and corresponding geological sheets.

covered by Guryongpo and Yeonil sheets (see Figure 2). 1:50,000 geological maps of these area are not available now. But we may get geological data and some detailed site information because site investigation of some of this area has been performed for high speed rail way construction and roadway construction.

If it is allowed to be located around 2.0 and 2.5 degree off-axis beam lines, there is much room for site selection. Bohyeonsan may be one of the best candidates, which is located about 2.0 degree off axis beam line. The mountain is over 1 km high. National Astronomy Observatory is located on the top of the mountain. Geologically this area is covered by GI GAI sheet. There are some high mountains in this area such as Giryongsan which is 961 m high. GI GAE Sheet is a Southern marginal portion of the Taeback Mountain Range; There are some high mountains; the high peak is 960 m for Giryoungsan; Suseokbong (820 m), etc. The area is underlain by Cretaceous sedimentary, volcanic and plutonic rocks like granite, granodiorite, andesite and rhyolite. These rocks have high strength in general.

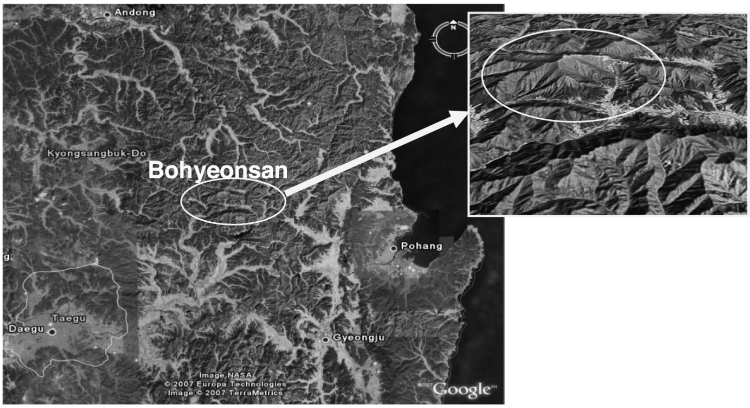

Fig. 3 Bohyeonsan in Yeoncheon.

Gajisan area is located ranging from 1.5 degree to 2.5 degree off axis beam lines. There are several high mountains in this area; Gajisan, the highest peak is about 1.2 km, and Shinbulsan and Cheongwhasan are also over 1 km high. It corresponds to the geological map of EON YANG sheet. The area, in the western part, is underlain by andesite, granite, and other rocks. Palgonsan area in Daegu city may be another candidate. Its high peak is about 1.2 km.

One can find some other high mountains in the area within 2.5 degree off axis beam line such as Bisulsan and Jangansan of which heights are over 1 km. One may consider other sites in Miryang sheet, etc. In MIRYANG geological sheet, There are comparatively high peaks of Togoksan (855 m), Yomsubong (816 m), Muchoksan (700 m), Kumosan (760 m), Hyangrobong (727 m), etc. The geology of the area is composed of Yuchon Group and Bulguksa Intrusive rocks. The Yuchoon group is divided into andesitic rocks (andesite and ruff), and rhyolitic rocks (rhyolite and tuff); Miryang andesite is distributed on a large scale.

If there is a closed mine like Kamioka mine, it would be the best candidate. There are several advantages of utilizing closed mine. One can reduce construction costs considerably, and minimize environmental impacts. Complaints from residents and environmentalist must be decreased. It is easy to get approval and to get support from local government, and also easy to get information on geological conditions. According to a report published in 2004, there were several abandoned mines in Gyeongsangbuk-do province and Jeonra-do province. In MUJU-gun, there are over 25 mines listed in the mine database. Most mines in the area of our concern seem to be on a quite small scale, but one needs to review the possibility of utilization of those mines.

3. Experiences of Construction of Large Underground Rock Caverns in Korea

The detector requires an excavation of a very big underground opening of which size is 50 m in dia. × 280 m in length. It is to be located 1 km deep, which means it is under very high stress condition.

Therefore stability of the cavern would be a critical problem. Critical factors affecting the stability of a cavern are: Stress fields such as orientation, magnitude and stress ratio; Mechanical properties of rock such as strength and elasticity; Structural characteristics such as joint distribution and joint properties; Size and shape of a cavern; Arrangement of cavern and tunnels; Groundwater conditions; Method and quality of excavation. One of the most significant information for

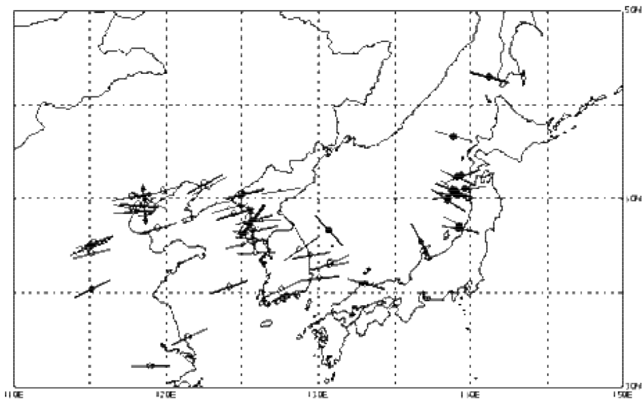

Fig. 4 Orientation of principal in-situ stresses.

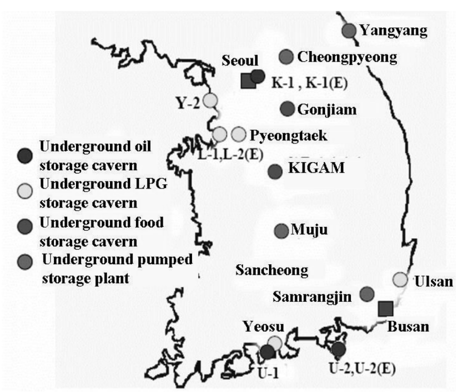

Fig. 5 Various underground rock caverns in Korea.

stability study is an in-situ stress condition. We usually use hydraulic fracturing technique to measure underground in-situ stress field in site investigation stage. The problem is 1 km depth is beyond the measuring range of this technique. There is no other technique to figure out such a deep underground condition before excavation. One of the advantages utilizing closed mines like Kamioka and Homestake is that we have detailed geological information such as stress fields and rock mass characteristics.

Figure 4 shows the orientation of principal stresses measured in Korea, Japan and China. Field measurement in Korea shows that stress ratio at depth up to about 150 m ranges widely from 1 to over 4. Large horizontal stress means that there exist tectonic forces. It implies that we have to be more careful in design of tunnel at shallow depth.

We have experienced to excavate large underground caverns for storage of crude oil, LPG gas, food and several underground pumped storage power plants as shown in Figure 5. Some caverns are located in the area of our concern. The largest cavern for underground pumped storage hydroelectricity is 25 m in width by 50 m in height by 116 m in length. The deepest one is located 350 m below surface.

In order to provide a stable and long term supply of petroleum energy, several

Table 1 Underground rock caverns for oil storage

		U-2	U-1	U-2-1	U-2-2
Cavern Info	Rock type	Granodiorite	Andesite, Tuff	Granodiorite	Granodiorite
	Depth (m)	~ -60	~ -60	~ -60	~ -60
	Size (m)	18×30	18×30	18×30	18×30
	Length (m)	875	1,030	678	450

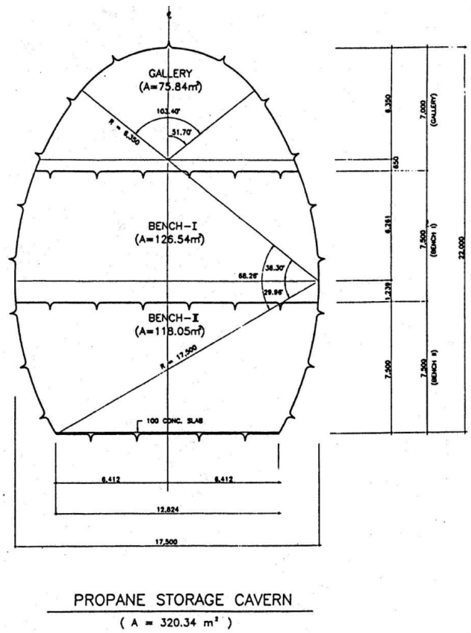

Fig. 6 Layout of LPG storage cavern.

underground crude oil storage facilities have been constructed and in operation. Table 1 shows an example of some caverns for oil storage. The size of cavern is 18 m in width by 30 m in height. The length of a single storage cavern ranges from 450 m to 1,030 m. Several caverns are constructed. The deepest one is located 60 m below surface. Uni-axial compressive strength ranges from 150 to 200 MPa.

The excavation of large cavern profiles for underground oil or gas storage is generally divided into two phases — tunnelling of the top heading and benching of the lower parts of the cavern (Ryu, 1998). Bench is drilled horizontally by the same jumbo drill as was used in the top-heading excavation. The use of explosives to remove rock requires controlled blasting to minimize damage to the remaining rock wall. The normal method that is used in controlled blasting in Korea is smooth blasting, in which the contour charges initiated last in the round.

We had experienced difficulties in excavation of a large scale of cavern in the first stage of construction. Some of the major problems with blasting we encountered are advance rate and overbreak. The initial cut is one of the key factors for the success of tunnel blasting. Control of overbreak in tunnel blasting is another key factor affecting the construction expenses as well as safety. Overbreak causes an increase in the cost of construction by requiring an additional amount of shotcrete.

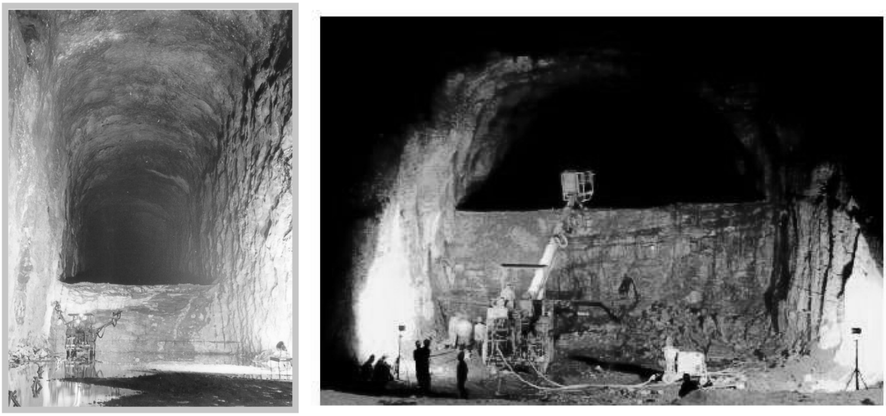

Fig. 7 View of storage cavern.

In addition, blast damage to the final rock face may cause instability and rock fall hazards. For these reasons, controlled blasting is an indispensable routine in tunnel excavation in order to get a smooth face and to reduce damage to the final wall. It is, however, hard to expect the effects of controlled blasting of contour holes when blasting the initial cut and stoping holes fails.

4. Summary and Conclusion

In the area of our concerns, there seems be no closed mines suitable to the purpose. But most mountain area except national park could be candidates. Geological conditions in Korea seem to be quite favourable in general. We do not have much information for deep geological condition and it is hard to get such information due to the great depth. More detailed geotechnical characterization may be obtained during excavation.

From the case studies for construction of underground oil storage cavern or underground pumped storage power plant, it is expected that there would be no big technical problems for construction but that construction costs may be very high. If we have poor geology but no other choice for a new site, then it should be overcome by engineering technology.

References

Ryu, C. H. 1998. Research on the standardization of blasting method. PEDCO 363–439.