PRELIMINARY SITE INVESTIGATION FOR LL AND IL RADWASTE DISPOSAL FOR QINSHAN NPP

HUANG Yawen CHEN Zhangru et al.

China Institute for Radiation Protection

ABSTRACT

With the purpose of selecting a disposal site for the low- and intermediate-level radwastes arising from Qinshan NPP, site investigations were carried out in several districts of Zhejiang Province. Investigation objectives included the circumstances of geology, hydrogeology, environmental ecology, and social economy. On the basis of collected data, five possible sites were recommended for policy-making reference and further investigation.

1. Introduction

Qinshan NPP is the first one which is designed and constructed on domestic efforts. It is necessary to build a disposal site for the low- and intermediate-level radioactive wastes to be produced in the plant. Upon review and evaluation, it was concluded that the disposal site should be located in Zhejiang Province. Therefore, a site review group has been formed to perform a preliminary survey of the possible sites. Some references and data have been collected.

2. The Criteria of Siting

2. 1 Geological stabilization

The site must be kept away from the area with serious detrimental geological conditions to waste disposal, such as faults, folds, earthquake, active volcano, collapse, erosion, subsidence, landslide, the highly-concentrated ground stress, and the earth surface rising or subsiding fast. In addition, it must be kept away from the tsunami and surge zones.

2. 2 Geological formation and lithology

The geological formation of the disposal site and its adjacent area shall be as simple as possible, and the evolution of geological environment can be predicted to a certain extent. The geological barrier can effectively prevent the transfer of radionuclides. The wall rock has enough stretch range.

2. 3 Hydrology and hydrogeology

The site must be kept away from the water resources protection area, the area where the groundwater can be intruded into, and the area that can be overwhelmed by floods. The hydrogeology features of the site must be beneficial to waste isolation, which include porosity, permeability, chemical composition of groundwater, acidity and basicity, oxidation and reduction, supply and discharge and dynamics of groundwater; and the hydrogeological insulation of the site shall not be damaged because of the excavation of the disposal cave.

2. 4 Engineering geology

The mountain body has good integrity without trenches and gullies, and there is no landslide and collapse topography. The rock body is of uniform integrity, there is no soft stratum in the stratified rock, the karst is not developing, there is no water-bearing structure, and the faults and folds are not developing. The silt and ooze strata, too high hill stress, and active hill areas shall be avoided.

2. 5 Social economy

The site must be kept away from densely-populated areas, the mines valuable for exploitation, the scenic spots, and the natural protective zones. It must be kept far away from the airport, the military testing fields, and the production or storage areas of the inflammable and explosive materials. Water and electricity shall be available without much difficulty.

3. The Main Steps and Methods

3. 1 Regional investigation

According to the siting criteria and the information available, 17 possible sites were finalized for future reconnaissance as a result of the preliminary site investigation.

3. 2 Preliminary site investigation

A comprehensive investigation team was formed with experts in the fields of waste management, geology, hydrogeology, engineering, and environment protection to perform field reconnaissance and collect information on geology, hydrogeology, mine exploitation, environment ecology, and social and economic development. The investigation resulted in priliminary evaluation on the 17 sites and recommendation of several favourable sites for further detailed investigation and analysis.

4. The Features of the Recommended Sites in Preliminary Site Investigation

4. 1 Qinshan area

This area, 8 km away from the Qinshan NPP, is located in the south-east of Haiyan County, Zhejiang Province. It is about 90 km from Shanghai and 78 km from Hangzhou. Qinshan and Fangjia Mountains are linked together, forming an area of about 10^6 m^2. The whole mountain area is within the development zone of Qinshan NPP. The population density is 745/km^2. The highest altitude of the mountain is 185. 8 m. It is surrounded by water on the north, east, and south sides, and stretches into Hangzhou Bay. In the west, there is a plain area for agriculture development. The first phase of Qinshan NPP Project is located on the north side of the rear of the mountain. Now, there is an arterial highway directly to Shanghai and Hangzhou. The nearest railway is 26 km from Qinshan and a wharf has been planned for the plant.

This area belongs to Middle China subtropic humid climate zone in the East Asian monsoon climate area. The average temperature is 16. 2℃, the maximum temperature, 37. 4℃, and the minimum temperature, minus 5. 3℃. The relative humidity is normally over 80% and the highest, 98%. The annual rainfall is 1175. 6 mm, 167 days, the longest continuous rainfall is 10 days, and the maximum precipitation in one day is 65. 5 mm.

The geological formation of this area belongs to Yangzi fault-block area. The west Zhejiang

belongs to earth syncline in Paleozoic Era. Because of Indochina and Yanshan movement, the earth crust suffered from strong pressing, the earth syncline returned to folds, thus the mountain formed. The Paleozoic Era formation laid the basis of this area. By the time of late Jurassic Period, a large scale of volcanic eruption and magma intrusion occured. The volcanic rock layers built up the covering strata of this area. The layers which can be directly observed in the surface are mainly the second lithology section of late Jurassic Period (J_3^2), volcanic rubble rocks; the upper cover layers are eluvium in Holocene Series (Q_4) and Upper Pleistocene Series (Q_3). There are some faults through the horseshoe valley near Shuang Long Gang, but they belong to secondary small structures and they are all filled and cemented.

There are not any active faults which may result in earthquake over 5 on the Richter scale within 8 km area around Qinshan NPP. The active faults, which may cause large relative displacement, are not found in the surface or near the surface. The earthquake activity in this area is so weak that the earthquake relative to motive fracture can not happen.

There are mainly two types of groundwater in Qinshan area: (1) the perch groundwater of upper layers, which is normally distributed at contact zone between eluvium of slope section and bedrock. It is characterized by constant changes of water level and small water quantity, which is controlled by atmospheric precipitation; and (2) the fracture water of bedrock with the dense and hard lithology. There is not much fracture water at upper weathering fracture zone or local structure fracture zone. The groundwater is difficult to remain in the deep complete rockbody. It belongs to groundwater micro-aquifer. The surface runoff and the groundwater all flow to seabeach area.

The north, east, and south sides of Qinshan area are surrounded by Hangzhou Bay. There is a plain area in the west of Qinshan and the rivers are interwoven to facilitate water communication. The river adjacent to the NPP is the Changshan River, 8 km from the Plant, and it is the main recharge water source of the Plant. The tidal current in the Hangzhou Bay runs strongly, and the tide range is large. Ganpu tide section, 9 km upstream from the Plant, is the largest tidal range (8.93 m), and the annually-averaged tidal range is 5.47 m. The water in Hangzhou Bay is of low salinity—10 ~ 22‰. The groundwater quality of the seabeach is the same as that of the sea water.

4.2 Daishan lead-zinc mine

The Daishan Lead-Zinc Mine is located in Siping Town in the northeast of Qushan Island, Daishan County, Zhejiang Province. The mine faces the water with hills behind. The east of the island is East Sea, the west is the mouth of the Qiantang River, the south is Daiquyang, and the north is Huangzeyang. It is 120 km from Qinshan. The area is about 50 km^2 and it has a population of 60,000. The communication to the outside is mainly sea-route. There are wharfs for passengers and oil transportation with a capacity of 1 kt and roads through this island. In the west, 2 km from the mine area, there is a 400 households village with a population of about 1,600, and a small ridge, between the village and the mine area.

The annual precipitation is 899.5 mm; the annual evaporation is 1476.6 mm; the annual relative humidity is 70%. The annual average temperature is 16.2℃. Typhoon totalled up to 120 times from 1954 to 1981, mostly from July to September. The strong typhoon accounted for 17.5%.

The geologic formation belongs to metamorphic rock of AnDchc lithology section of Chencai

group. The bedrock is well insulated, and separated from sea water. There are two intermediate pits in the mining area, 1,500 m long, and the cross section is 2.2×2.5 m in general with maximum one 4×5 m. The stoped-out area is about 160,000 m^3. The rock in the pit is plagioclase hornblende, marble, biotile plagioclase gneiss, hornblende plagioclase, hypergene, granulite, etc. The rock is of good integrity and stability in the mining districts. Though there are no supporting facilities in the stoped-out area, collapse, roof fall, and landslide never occured. The first intermediate pit is about 50 m above sea level and the second, about 5 m above the sea level.

The fracture water is not developing, so it is dry in the pits.

There is no natural water source or stream in the open air within 1 km in the mining area. The area totals 12,359 m^2. There is a 300 t wharf in the mine area. The mine was closed in 1976. The island is an area of weak earthquake with scattering frequency.

4.3 No. 771 mine area

The No. 771 Mine is situated at the south-westen end of the south-easten Jinqu basin edge and above the erosion basis. The elevation of Baixi pit mouth is 178 m. The rock of Baixi pit belongs to massive flowline tuff in Moshi mountain groups of Upper Jurassic System, and it is integral and stable.

A group of small-angled and west-eastward overthrust faults are made up of Jiangshan-Shaoxing fault zone in the northern mine area and it is overthrusted on the Moshi mountain group of Upper Jurassic System, therefore, this group is slightly destructed.

The No. 771 Mine is an area of weak earthquake with scattering frequency. In this area, the annual average temperature is 17.3℃, and the annual rainfall is 1717.6 mm. The rainfall is mainly from April to October. There are 153.8 rainy days each year. 5 floods occured from 1950 to 1980. The landform is relief and deeply dissected to facilitate drainage and prevent floods. The Shengtang River flows through the west side of Baixi pit and its maximum flowrate is 22.44 m^3 per second.

Fracture in Baixi pit's rhyolite is not developing, effective waterproof strata exists. Based on observation that water-bearing faults in No. 20 pit are not developing, the rock has become steady and the compressive strength ranges from 456 to 1,250 kg/cm^2, the bending strength, from 136 to 470 kg/cm^2.

The No. 2 fault, which controls the Baixi pit groundwater flow, is composed of clay, kaolin mixed with sandy clay, and debris. As can be seen in No. 20 pit, this fault itself contains no water and has good performance of water-isolation.

The area around the Baixi pit has a sparse population, only about 202 inhabitants living within 2 km range. Clearly, the environmental isloation is really fine.

In Baixi pit, the cross section of the main tunnel is 2.2×2.5 m and the length, 500 m and mining fields of branch tunnels are small and irregular, so there is only a limited space available for waste disposal, it is required to excavate new disposal tunnel and gallery.

4.4 Longzhu mountain lead-zinc mine area in Linhai County

Longzhu Mountain Pb-Zn Mine area is 60 km from Sanmen Jiantiao Port and 250 km from Hangzhou. There is a 1,000 t civil wharf at the Jiantiao Port, communication is rather

convenient there. There are only ten households about 50 inhabitants living in this area and it is relatively isolated from the outside world.

This area is within the subtropical oceanic climate circle, the annual average temperature is 17℃, annual precipitation is 1,700 mm, plum rains often fall in spring, the annual evaporation is 1,020 mm, and the annual maximum precipitation, 2242. 8 mm.

The geologic formation is grey volcanic tuff which belongs to Moshi Mountain group of Upper Jurassic System. The rock is dense and hard, generally silicified.

The mountain slope of the mine area is steep and the water drains fast. A stream runs through the area. The mine body is above the erosion datum plane. There is no obvious runoff area in the pit, the fracture water has little impact on the water in ore deposit.

The stope is divided into four levels, the total stoped-out area is 220,000 m^3. The No. 1 middle pit is 247 to 250 m above the sea level, the stoped-out area is about 28,000 m^3. The No. 2 middle pit is 215 m above the sea level, the stoped-out area is about 56,000 m^3. The No. 3 middle pit is 182 to 198 m above the sea level, the stoped-out area is 84,000 m^3. The No. 4 middle pit is 130 to 169 mm above the sea level, the stoped-out area is 53,000 m^3. The rock in each section is of good integrity and stability. There is no supporting facility in the stope, roof fall and collapse never occured. The cross-section of the pit is 2×2.5 m $\sim$ 3×3 m.

The earthquake intensity in this area is less than 7 on the Richter scale. It is a stable area as a whole.

4. 5 Gaoyubajiaotang

The Gaoyubajiaotang is located in the northwest of Anji County, Zhejiang Province, and its western neighbor is Guangde County, Anhui Province. It is 40 km from Anji County, 120 km from Hangzhou, 220 km from Shanghai, and 200 km from Qinshan. Gaoyubajiaotang is an extension of Xuan-Lang-Guang mound. The rear of the mound is round and plain, and appears as stripped structure. It is a sparsely-populated area.

The Gaoyu area belongs to north subtropic monsoon climate zone, and it is warm and moist there. The annual temperature is 15. 6℃, the relative humidity is 80%, the annual precipitation is 1,290 mm, and the maximum precipitation is 1766. 6 mm. The rainfall occurs mainly from April to June. The evaporation is 800 mm. The rainstorms appear 37 times during one year, when the rainfall in one day is equal to or more than 50 to 100 mm and the maximum is 100 to 200 mm. The rainstorms mainly appear in September. The typhoon totals 0. 8 time in one year, mainly from August to October.

This area belongs to Tai Lake hydrographic net. In the northeast 10 km away from the Bajiaotang area, there is a Tianzigang Reservoir with a capacity of 18,000,000 m^3.

The groundwater belongs to porous fracture water of weathering red bed. The aquiferous formation is weathering rock of the Qifang Village group of Cretaceous System and the main component is clay with poor permeability, which leads to an extreme shortage of water. The water capacity in the civil wells is 12 to 13 tones per day. The groundwater dynamics is in an unstable state. The groundwater level is 10 m subsurface. The groundwater is only recharged by rainwater and flows steadily to surrounding ditches, i. e. local recharge and local discharge. The surface water is the drinking water source for the inhabitants.

The surficial stratum in this area belongs to Guangde group of Upper Jurassic System and Qifang Village group of Lower Cretaceous System.

The bed rock is argillaceous sandstone.

This area is located along the central line of the fourth small belt of the east-west tectonic system, which belongs to later Yanshan movement. Faults and fractures might be developed parallel to the edge of the basin. They are small in scale and the rock is subject to least destruction.

This area is of weak earthquake with scattering frequency. The main plant in this area is oil-tea camellia. It is rich in bentonite resources there. The average population is about 230/km^2 inhabitants per square km.

5. Preliminary Assessment of the Recommended Sites

According to the above-mentioned characteristics of the different sites, it is regarded that Qinshan as cave disposal site for Qinshan NPP low- and intermediate-level radwastes has such advantages as stable formation, simple hydrogeology conditions, good isolation properties, and convenient transportation. There are few township enterprises within 5 km of Qinshan NPP, and there is no large enterprise within 20 km. However, the Qinshan area is part of Hangjiahu plain of Shanghai economic development zone, a developed area in agriculture, fishery, and light textile industries. The essential factors unfavourable to the siting determination are: the long-term development project in this area, the distribution of the environmental radiation dose of the Qinshan long-term nuclear power project, the development of north-south lake tourism area 12 km from the plant.

As to Daishan Lead-Zinc Mine, the bedrocks have good water isolation. Observed from the pit, the fractures are not developing, and the tunnels are dry. There is a 400 households village nearby, separated by a small hill. The mining area faces the water with hills behind, and is well isolated with human activities. The abandaned mine has certain spacial capacity, and there is potentiality to expand the capacity of the mountain body. Although the mining area is closed now, there are some houses and technical workers there. There is a wharf in the mining area, it is 120 km from Qinshan by sea route, the sea transportation is very convenient. But the sea area of the Qushan island where the mining area is located is a main part of the Zhoushan fishing ground, the public psychology and social opinion will possibly cause unfavourable conditions relating to development of such a disposal site.

The Baixi pit of No. 771 Mine will be decommissioned soon, the equipment remain complete and there are enough technical workers. The mountain body is under good integral and stable conditions. But the existing excavation space is small and irregular, the abandoned pit can hardly be used as a whole. The main disposal space needs to excavate. The communication in the mining area is convenient, though it is a bit too far from Qinshan.

The Longzhu Mountain Lead-Zinc Mine area is located in remote mountains of Linhai County. There are very few inhabitants there, and the separation is good. The bedrock of this mine belongs to volcanic tuff. The rock is integral and stable, the fractures of the bedrock is poor, and the pit is dry. The tunnels are long and the excavation space is large, the availability in space is high. But the reconstruction is complicated. The mining area is about 360 km from

Qinshan highway, and the communication wants land- and water-coordinated transportation.

The Gaoyubajiaotang area is 200 km from Qinshan. The communication is convenient. The population density is relatively low. As a state-owned barren area, it is easy to make a requisition of land. The surface water in this area is well drained out, and the ground water is 12 m below the surface. But the bedrock is gritrock, the separation property of the strata is poor, the demolitions are required for the shallow strata disposal. This area is part of the edge area of Hangjiahu plain, and there is potentiality for further exploitation.

The above sites all have the prerequisites to dispose of the low- and intermediate-level radwastes. However, the assessment of the site characteristics shall take a lot of practical field survey so as to gain more specific and detailed data and go deep into the analyses.