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Case Study on Liquidation of Nuclear Test Site: Former Soviet Union Nuclear Test Site(Semipalatinsk)

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1. Introduction

On 20 April 2018, the Workers' Party of North Korea adopted the decision that it would cease its nuclear test and launch test of ICBMs, and for the transparent way to ensure its cease of nuclear test, it would destroy its nuclear test site. According to this decision, the North Korea invited media press to show the destroy process of nuclear test site (Punggye-ri) on 24 May 2018.

North Korea destroyed its nuclear test site using explosives to blast 3 portals (North, South, West portals), each tunnels, observation and support facilities. Because we could have only visual observation of blast of the entrances of portals through media, we could not be sure that these process were effective from the point of CVID (Complete, Verifiable, Irreversible, dismantlement) perspective[1].

So the purpose of this article is to study other case of dismantlement of nuclear test site, especially former Soviet Union nuclear test site(Semipalatinsk) in Kazakhstan and propose applicable and verifiable methods to ensure denuclearization of the North Korea in the future.

2. Former Soviet Union Nuclear Test Site(Semipalatinsk)

2-1 General Information of Nuclear Test Site

The decision to create the Semipalatinsk Nuclear Test Site was adopted by the Central Committee of the Communist Party of the Soviet Union and the Council of Ministers of the Soviet Union. Nuclear weapons test at the Semipalatinsk Test Site, conducted from 29 August 1949 to 19 October 1989.[2]

Underground nuclear tests, the first of which was performed on 11 October 1961 and the last, on 19 October 1989, were performed predominantly at three operational areas of the test site:

- the Degelen Area, the total area of which within Degelen Mountain stood at 33 ,100ha, was used for underground explosions in tunnels (horizontal mines);
- the Balapan Area, with a total area of about 100,000 ha, was used for underground explosions in boreholes;
- the Sary-Uzen (Murzhik) Area - this was an ancillary area for underground explosions in boreholes.

By 1991, 181 tunnels had been made at Degelen Mountain, with a cross-section measuring from 9 to 25 square meters and from 300 and more meters long. Nuclear tests were performed in 163 mines. In the period from 1961 to 1989, 213 nuclear tests were performed in tunnels within Degelen Mountain (295 underground nuclear blasts).

2-2 Dismantlement of Nuclear Test Site

On 24 September 1993, according to the joint Protocol of Intent between the governments of the USA and Kazakhstan, a group of specialists from these two countries was assembled to perform a preliminary study of the harm caused to the Kazakh population and economy by the nuclear tests at the former Semipalatinsk Test Site. A group of specialists from the USA, headed by the former head of the Nevada test site, arrived in Kurchatov, on 9 November 1993.

On 11-14 November 1993, a group of experts from the USA paid a visit to conduct a preliminary assessment of the impact of the Soviet nuclear weapons test program at the Semipalatinsk Test Site on the environment and public health. These results were to evaluate the radiological situation within the former Semipalatinsk Nuclear Test Site in the interests of Kazakhstan, Russia and the United States.

On 13 December 1993, Kazakhstan and the United States signed an agreement on the destruction of shaft-located intercontinental ballistic missile launch installations, eradication of the consequences of accidents and prevention of nuclear weapons proliferation.

On 3 October 1995, an agreement was signed between the US Department of Defense (US DOD) and the Kazakh Ministry of Science and New Technologies on the destruction of nuclear infrastructure.

Tunnels at Degelen Mountain at the former Semipalatinsk Nuclear Test Site were characterized in 1995- 1996.

The research obtained the following main data, characterizing each tunnel:

- number (conventional name) of tunnel;
- entrance coordinates (a marker, installed 20 m from the entrance), specifying the latitude, longitude and altitude above sea level, measured using Magellan GPS;

- geometric dimensions of the entrance (height and width in metres);
- the year when nuclear tests were performed and the force of the nuclear blast (in TNT equivalent) in the given tunnel;
- the condition of the tunnel entrance;
- survey depth of the tunnel in metres from the tunnel entrance;
- the presence of structures near the entrance, that have an impact on the work on tunnel closure;
- the presence of support fixtures near the entrance, outside the entrance and in the cut trench;
- water flow (Umin);
- maximum equivalent dose of y-radiation, recorded near the entrance or in the tunnel (J..IR/hr);
- maximum flux density of ~-particles, recorded near the entrance or in the tunnel (particles/(min x cm2));
- maximum specific activity ofcaesium-137 in soil or smear samples, taken in the given tunnel (Bq/kg);
- maximum specific activity ofamericium-241 in soil or smear samples, taken in the given tunnel (Bq/kg);
- maximum specific activity of caesium-137 in water samples, taken in the given tunnel (Bq/L);
- presence and maximum specific activity of tritium in water samples, taken in the given tunnel (Bq/L).

Closure methods were developed for each tunnel, allowing for individual features, including either one of the methods detailed below or, as a rule, a combination thereof.

The closure method of separate tunnel entrances was amended after agreement with the DTRA representative, as stipulated under contract.

Table 1 presents certain features for the application and implementation of approved methods. In addition, two tunnels, that were dug for experiments (l60-B and 160-C) were sealed using blasts of 100 tonnes of explosives in the blast chambers of these tunnels. Each stage in liquidation of the tunnel entrance concluded with backfilling of the trench or crater that formed after the blasting work and levelling to reinstate the natural relief.

Table 1. Certain features of tunnel closure methods

No.	Liquidation method	Conditions of use	Main types of work performed
1	Experimental closure	The ability to install a drilling rig at the tunnel entrance with minimum costs, the availability of a crown over the entrance	Preparation of the entrance section, drilling of 2-10 horizontal boreholes with a diameter of 102 mm and up to 30 m long and triggering of borehole explosive charges
2	Pressure charges (collapsing the entrance to the tunnel with pressure charges)	Unstable rock in the tunnel, the lack of or undermined support, radioactive contamination and the slope relief do not allow drilling work to proceed.	Triggering of explosive pressure charges with the filling of natural cavities over the entrance
3	Drilling of blast holes from within (drilling-and blasting method with the drilling of blast holes from inside the tunnel and the collapsing of the tunnel crown and side walls on the set line with a blast)	Stable rock in the tunnel, a satisfactory condition of supports, no radioactive contamination, a thick layer of covering rock or an inability to perform drilling from the surface	Preparation of the tunnel section, drilling of blast holes in the tunnel cover and walls and triggering of blast hole explosive charges
4	Drilling from the surface (drilling and blasting with the drilling of boreholes from the surface and the collapsing of the tunnel crown at the set length)	Unstable rock in the tunnel, the lack of or undermined support, a significant amount of repair and recovery work in the tunnel, radioactive contamination and the slope relief allow drilling work to proceed.	Preparation of the surface section, drilling blast holes or boreholes with a 102 rum diameter over the tunnel cover, including into the entrance crown and triggering borehole charges
5	Installation of concrete plugs (creation of a cast-in place concrete (reinforced concrete) plug on the set length of the tunnel)	Radioactive contamination in the tunnel, the presence of metal supports or pipes of large diameter, the presence of pre-installed concrete barriers, the inability to drill from the surface and a considerable thickness of the covering rock and high costs in preparation of the blast hole drilling inside the tunnel	Preparation of the tunnel section and erection of the concrete plug
6	Combined: surface charges and concrete plug	Radioactive contamination of the tunnel, the presence of metal supports, high costs in preparation of the blast hole drilling inside the tunnel, many flaws in the cover and a considerable flow of water	Drilling blast holes and boreholes from the surface, including into the entrance crown, triggering borehole explosive charges and erecting the concrete plug
7	Combined: drilling from inside and the concrete plug	A lack of radioactive contamination in the tunnel, presence of metal supports of concrete lining of walls and cover, the inability to drill from the surface or a considerable thickness of covering rock, and a high flow of water	Preparation of the tunnel section, drilling of blast holes in the tunnel cover and walls, triggering of blast hole explosive charges and erection of the concrete plug
8	Performance of experiment 100 tonnes of explosives	Performance of experiment	Triggering 100 tonnes of explosive in the tunnel blast chamber

4. Conclusion

As listed in Table 1., many methods have been applied to close the Semipalatinsk Test Site. These methods and the combination of these could be applied to Punggye-ri Test Site in the future in a part of denuclearization process. Especially, methods applied to the Degelen

Area are great example that could be applied to the North Korea.

Using explosives to blast the entrances of tunnels is one of the methods to dismantle nuclear test site, but it is not enough to ensure complete and verifiable dismantlement.

In the case of Semipalatinsk Test Site, 3 countries (Kazakhstan, U.S. and Russia) have been cooperated very closely from the start of closure process. It also good example of the future work for the denuclearization of North Korea.

REFERENCES

[1] WSJ, "Nuclear Test Ban Group Skeptical of North Korea's Denuclearization Efforts", 2018

[2] Scientific, Technical and Engineering Work to Ensure the Safety of the Former Semipalatinsk Test Site, Vol.1 2017