Accuracy analysis of the CTBTO nuclear test detection scale and Improvement

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1. Introduction

CTBTO (Comprehensive nuclear Test Ban Treaty Organization) is charge of nuclear test monitoring for nuclear non-proliferation. CTBTO has 170 seismic stations in operation in 76 countries in order to detect the artificial earthquake that was caused by an underground nuclear test. Korea use formula that is based on the equations that are used by the IMS (International Monitoring System) of CTBTO for analysis of explosive scale, and reflect the nature of the terrain, such as rock. But the expression for calculating the exact scale explosive is still un-established state.

And generally CTBTO doesn't care about artificial explosive that is being received low-yield in accordance with the criteria of nuclear detection. [1] But, at the time that North Korea conduct a nuclear test, it should not be overlooked that the scale of the earthquake detection criteria below. Because DPRK is trying to conceal their nuclear development capability, there are possibility of low-yield nuclear test or possibility of install a buffer to hide actual explosive scale. A typical example can be referred to events that occurred in 2010. Between 13 and 23 May 2010, four atmospheric radionuclide surveillance stations, in South Korea, Japan, and the Russian Federation, detected xenon and xenon daughter radionuclides in concentrations up to 10 and 0.1 mBq/m^3 respectively. These radionuclide observations were consistent with a DPRK low-yield nuclear test on May 2010, even though no seismic signals from such a test have been detected (fig.1) [2]. But there were a few times of low-yield (magnitude 1.39~1.93) occurred around DPRK nuclear test site at that time (Table 1) [3].

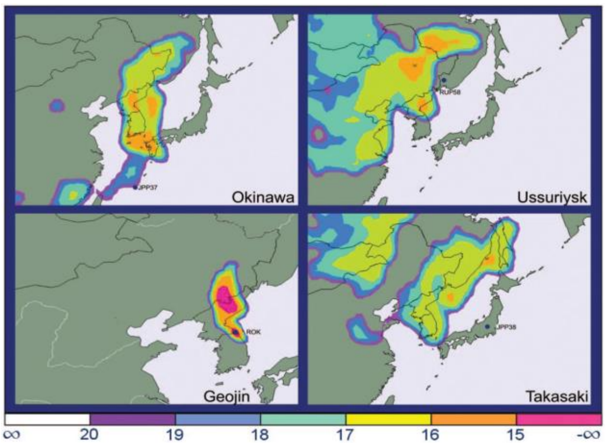

Fig. 1. Differential Fields of Regard as calculated by Web Grape based on the first detections at the four stations indicated

Table 1: Results for DPRK explosions on five days in 2010.

Period	Time	Magnitude
14-16 Apr	15 Apr 04:03:47.20	1.93
14-16 Apr	15 Apr 04:04:28.00	1.80
14-16 Apr	15 Apr 10:46:04.60	1.44
14-16 Apr	16 Apr 11:19:53.45	1.15
10-11 May	10 May 01:53:45.40	1.51
10-11 May	10 May 08:10:31.35	1.49
10-11 May	11 May 03:52:59.00	1.39
10-11 May	11 May 07:08:53.10	1.68

In the following section, I took analysis about low-yield artificial explosion that have been occurred in Korea peninsula in accordance with the monitoring criteria of IMS in CTBTO. In a final section, I proposed a way in which an assessment that is related to low-yield explosion for monitoring nuclear test by analyzing correlation between the scale of the artificial explosion and the actual amount of explosion.

2. Methods and Results

2.1 Methods

I used data that is about the amount of TNT which uses mining in the Gang-won province (Han-la cement) to analyze the correlation between the amount of the actual explosion and earthquake magnitude [4]. In the case of seismic events, I received the data from KIGAM (Korea Institute of Geoscience and Mineral Resources) where is charge of NDC (National Data Center) in CTBTO [5].

By using these data, I analyzed blasting detection rate, the position error, and correlation between the scale of the artificial explosion and the actual amount of explosion. And then I applied to the artificial earthquake that occurred in DPRK that is related with low-yield nuclear test on Apr/May in 2010

2.2 Nuclear test monitoring explosion yield calculation

As I explained in the first section, Korean peninsula has been used the formula that is based on IMS of CTBTO (1) or KIGAM's own formula (2) in related to explosion yield,.

$$Mb = \log(yield) + 4.0 \quad \text{-------------- (1)}$$

$$Mb = 0.84\text{x}\log(yield) + 4.28 \quad \text{------------ (2)}$$

In addition, it can be estimated underground nuclear test and seismic scale through analysis of the different types of formula (Murpy [7] etc.). For example, if seismic scale shown in Table 1. substitute each formula, the explosive scale can be found as follows (Table 2.).

Table 2: Results for TNT yield (kg) about event that is shown Table 1

Magnitude	CTBTO	KIGAM	Murpy
1.15	1413	883	2097
1.39	2455	1534	3643
1.44	2754	1721	4088
1.49	3090	1931	4587
1.51	3236	2022	4803
1.68	4786	2990	7104
1.8	6310	3942	9365
1.93	8511	5318	12633

2.3 Current status of low-yield artificial explosion

In order to more accurately evaluate about the correlation between the explosive yield and earthquake, I analyzed of information of Blasting conducted for three years (2011-2013) in the mines located in Gangneung, Gangwon Province through site verification.

And based on the data obtained from KIGAM was posted in the map about artificial earthquake occurred on the Korea peninsula from 2011~2013 (fig. 2).

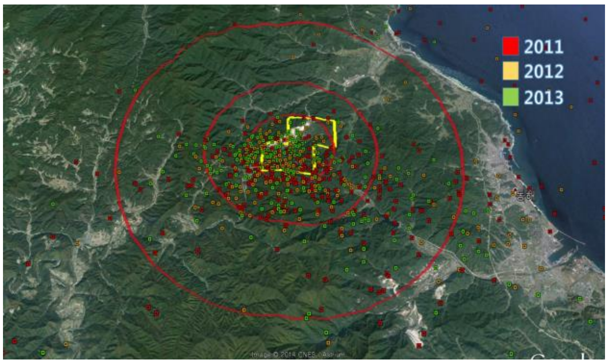

Fig. 2. Mining blasting status (2011~2013)

There were a total 966 times of mining activity during last 3years (2011~2013). Among these activity, KIGAM received 593 times (61.4%) of seismic signal. (373 events (38.6%) were missed.)

If we consider the mining blasting time (regularly 11:30 to 12:30) with considering earthquake detection time, it can be determined a valid seismic signal. And the signal can be increased to a total of 821 times (85%) as the overall detection rate. But it's too difficult to estimate as a valid seismic data which occurred more than 20km far away from epicenter.

Before analyzing about correlation between TNT usage and yield, I calculated the relationship between the TNT (Trinitrotoluene, Unit of energy : 1.0 x $10^6 kcal/ton$) as the estimate standard the nuclear explosive yield and 'New Mite Plus (Unit of energy : 1.1 x $10^6 kcal/ton$)' as using mining explosion.

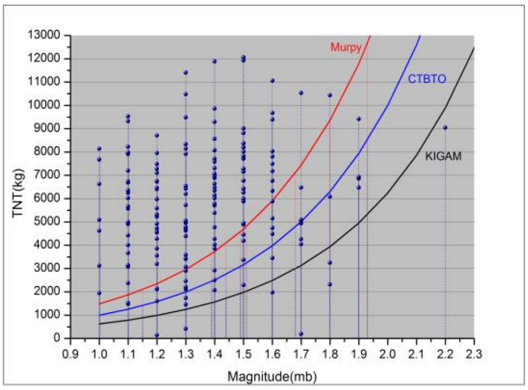

Fig. 3. Actual usage TNT and detected magnitude

In the Fig. 3, blue spheres are actual usage of TNT status and there are many gap even same magnitude.

In the case of magnitude 1.1~1.6, 3~9tons of TNT were used for explosion. Also, increasingly large-scale (mb>1.6) earthquake was close to the size of the CTBTO formula (mb=log(yield)+4.0), and the accuracy of Murpy scale expression (0.84 x log(yield)+4.28) was increased in less than 1.6.

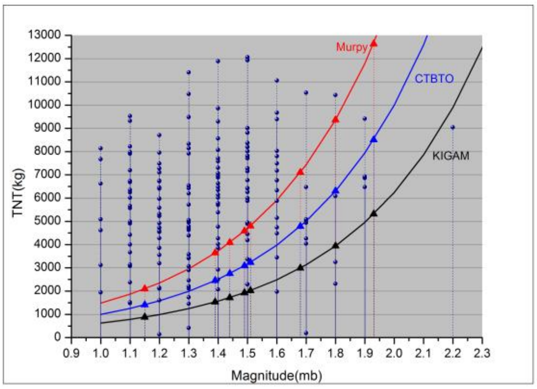

Fig. 4. Compare with event that is in the table 1

In the Fig. 4, triangle icon stands for magnitude that were described in the Table 1. It shows similar trends that CTBTO and Murpy formulas in low-yield explosion. But it requires more data in order to analyze statistically the reliability.

3. Conclusions

Correlation between underground nuclear tests and earthquake magnitude can be estimated by several types of analysis, mainly based on the underground nuclear test data in the United States and Russia. Through this study, artificial scale explosion caused by low yield was confirmed that it can be analyzed in the scale threshold of the nuclear type, too. Of course, there are the structural limitations that can only obtain a nuclear weapons-related technology to the DPRK through our ability. However we should not just wait and see the

North's nuclear capability as an excuse. Nuclear tests have been conducted to determine whether artificial earthquake is higher than 1kt or not by CTBTO. However, we can't be conclude there is no seismic signals that is related to nuclear development. (uranium mining, HE explosive test, nuclear test etc.) among low-yield earthquake that occurred in the North. Therefore it required continuous monitoring and evaluation about the small earthquakes that occur within 10km around facilities. Based on these data, it should be operational by establishing a proactive information system concerning precision weapons.

REFERENCES

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[2] Lars-Erik De Geer(2012), Radionuclide Evidence for Low-Yield Nuclear Testing in North Korea in April/May 2010.

[3] Paul G. Richards(2012), Seismological Constraints on Proposed Low-Yield Nuclear Testing in Particular Regions and Time Periods in the Past, with Comments on "Radionuclide Evidence for Low-Yield Nuclear Testing in North Korea in April/May 2010" by Lars-Erik De Geer.

[4] Log blasting operations, Daerim & Joongang resource development, 2010~2013.

[5] Status of artificial explosion in Korea peninsula, KIGAM, 2006~2013.

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[7] Mb = 0.81 x log(yield)+3.92