

NUCLEAR ENERGY AGENCY

Radioactive Waste Management Committee**Preservation of Records, Knowledge and Memory across Generations (RK&M)****Markers - Reflections on Intergenerational Warnings in the Form of Japanese Tsunami Stones**

Nations with nuclear power programmes are, or intend to, become engaged in planning to dispose of their higher-level and/or longer-lived radioactive waste in deep geologic repositories. If they remain undisturbed, geologic repositories can isolate these materials from the biosphere for extremely long times. To ensure that future generations are aware of these repositories, one element of the communication strategy could be the use of long-lasting markers and/or monuments placed in the vicinity of closed repositories. In order to develop an understanding of the potential effectiveness of markers - on their own - as a medium to convey information and warnings to future generations, this paper examines the role of Japanese stone markers in informing current generations for protecting themselves against the potential devastation of tsunamis.

For more publications related to the Preservation of Records, Knowledge and Memory (RK&M) across Generations, please see <http://www.oecd-nea.org/rwm/rkm/>.

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OECD NUCLEAR ENERGY AGENCY

**PRESERVATION OF RECORDS, KNOWLEDGE AND MEMORY (RK&M)
ACROSS GENERATIONS**

**MARKERS - REFLECTIONS ON INTERGENERATIONAL WARNINGS
IN THE FORM OF JAPANESE TSUNAMI STONES**

MAY 2014

Foreword

As states with nuclear power programmes are, or intend to become, engaged in planning the disposal of their high-level and/or long-lived radioactive waste in deep geological repositories, means to ensure that future generations will be aware of these repositories and not disturb them are being studied. Preservation of Records, Knowledge and Memory (RK&M) across Generations, launched in March 2010, is the relevant initiative under the NEA Radioactive Waste Management Committee in this area. Its several years of work and findings are documented online at www.oecd-nea.org/rwm/rkm. A strategy of communicating important information to future generations must be based on several complementary means and approaches. Markers placed in the vicinity of closed repositories represent one potential component of this strategy.

The RK&M initiative's glossary defines a marker as "a long-lasting object that indicates an area of influence, power or danger. It is placed strategically at or near the site for immediate recognition or for discovery at a later time." Markers are meant to reach future generations in the medium (a few hundred years) to long term (hundred thousand of years) and are conceived to be immobile (that is, in permanent association with a site), robust (in order to maximize survivability on its own) and provide messages that are likely to be understandable across generations. A marking system can range from a simple stone to a contrived and monumental multi-component system.

The RK&M initiative has held dedicated discussions on the issue of markers during project meetings and workshops. It has also published a "Literature Survey on Markers and Memory Preservation for Deep Geological Repositories" (NEA/RWM/R(2013)5", available online.

The present report seeks to develop the understanding of the potential effectiveness of markers drawing from the study of the role that stone markers played in Japan during the Tōhoku tsunami event of 2011. There are hundreds such markers placed at various epochs on Japan's north-eastern coast to warn future generations about the dangers of tsunamis.

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Introduction

Nations with nuclear power programmes are, or intend to, become engaged in planning to dispose of their higher-level and/or longer-lived radioactive waste in deep geologic repositories. If they remain undisturbed, geologic repositories can isolate these materials from the biosphere for extremely long times. To ensure that future generations are aware of these repositories, a means to draw attention to latter's presence could be the use of long-lasting markers¹ and/or monuments placed in the vicinity of closed repositories.²

In order to develop an understanding of the potential effectiveness of markers - on their own - as a medium to convey information and warnings to future generations, this paper examines the role of Japanese stone markers in informing current generations in order for them to take appropriate actions to protect themselves against the potential devastation of tsunamis. These markers, or “tsunami stones”, found primarily on the country's north-eastern shore, were brought to international attention by the 2011 Tōhoku earthquake and tsunami. They commemorate past tsunamis and carry different messages about the same, for instance about how to protect oneself by not building houses close to the sea. Media reports indicate that, in some cases, the local population acted upon the warnings, whereas in other cases, they were unaware of, or ignored, them.

Japanese stone markers are fairly unique as markers for warning across generations about a devastating phenomenon. There are hundreds of them, built at different times in Japanese history. While centuries-old stone markers do exist in Japan, most of them were installed after the 1896 Meiji Sanriku and 1933 Showa Sanriku tsunamis. According to the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT), which, after the 2011 events, has created a list with information about the geographical location and messages of the stone markers, 317 stone markers were erected since 1896 and 125 (40%) disappeared with the devastation of the 2011 tsunami.³

According to records, Japan is, on average, hit by a tsunami every three years.⁴ Tsunamis causing fatalities take place, on average, every 23 years, while the deadliest tsunamis have occurred, on average, every 60 years. The 2011 tsunami has been compared in strength to the tsunami that took place in 896 AD (Yoshida, 2012), making it a thousand-year event.⁵

The OECD NEA project on the Preservation of Records, Knowledge and Memory (RK&M) across Generations is particularly interested in the question of the effectiveness of markers. As a result, this paper also asks whether and in what regard the tsunami stones provide lessons and may constitute a model for repository markers in the sense of the RK&M project.

Effectiveness of the stone markers in warning population of danger

This examination of Japanese stone markers was spurred by a number of press articles (Fackler, 2011; Holguín-Veras, 2012; Alabaster, 2011; Nagai 2011) that were published after the Tōhoku

¹ According to the RK&M project glossary, a marker is defined as “a long-lasting object that indicates an area of influence, power or danger. It is placed strategically at or near the site for immediate recognition or for discovery at a later time.” See also the chapter on Markers in OECD-NEA (2014: 22).

² For a literature survey on markers for geological repositories, see Buser (2013).

³ See <http://www.thr.mlit.go.jp/bumon/b00045/road/sekijijouhou/archive/map-ichiran/ichiran.pdf> (in Japanese) for detailed information about the stones markers. See <http://www.thr.mlit.go.jp/road/sekijijouhou/archive/top.pdf> (in Japanese) for a map of the stone markers' geographical locations.

⁴ These calculations are based on data from the National Geophysical Data Center / World Data Service (NGDC/WDS): Global Historical Tsunami Database. National Geophysical Data Center, NOAA, available at http://www.ngdc.noaa.gov/hazard/tsu_db.shtml (accessed 22 April 2014).

⁵ According to the Japanese building code for the Fukushima area, informed by tsunami height from the past 100 years, the maximal wave height was estimated to be 5.7 metres. The nuclear power plant was built on a terrace at 10 metres above sea level, and a dike of 6.5 metres protected components of the nuclear power plant at sea. The tsunami wave was 14-15 metres high.

earthquake and tsunami⁶. The article focuses on stone markers in the village of Aneyoshi and in the village of Murohama. Japanese scholarly work has also been consulted.⁷

Heeded warnings: Murohama and Aneyoshi villages

Sediments in Murohama suggest that a tsunami, historically referred to as the Jogan earthquake and tsunami, hit the village in the year 869 AD. According to the local population, the tsunami stone in the village was erected following the Jogan event in which residents of Murohama, who fled to the top of a hill close-by, were killed by waves coming from both directions and colliding at the hill. The stone marker warns future generations of this trap. The local population is not only aware of the message but also heeds its advice. When the 2011 Tōhoku earthquake and tsunami hit Murohama, most of the population sought refuge on high ground farther away and was saved, although at least one person was reported dead.

In Aneyoshi, a tsunami stone reads: ‘High dwellings ensure the peace and happiness of our descendants. Remember the calamity of the great tsunami. Do not build any homes below this point.’ Here, the markers proved effective as people built their houses above the safe line and remained unharmed when the 2011 tsunami hit the coast. Sources disagree about the age of the stone: One source indicates that it was built centuries ago (Alabaster, 2011) while a second claims it was erected after the 1933 tsunami (Fackler, 2011). None of the villagers seems aware of the age or origins of the marker, which is one of very few carrying information about where to build dwellings.⁸

Both Murohama and Aneyoshi are small villages with only a dozen households (Fackler, 2011). In 2011 in Murohama, the tsunami warning tower collapsed as a result of the earthquake, leaving the population with no functioning modern tsunami warning systems (Holguín-Veras, 2012).

The press accounts highlight size of communities and education as two factors that played an important role in keeping memory alive and maintaining awareness of the stone markers in these villages. A relatively low population may enhance the effectiveness of memory preservation through an oral history tradition⁹. According to the reports, awareness of the stone markers and their messages was also raised by studying them in school. The stone markers thus contributed to the general awareness of tsunamis and encouraged more practical education about how to act in the case of a tsunami.

In addition the following observations, also intended to flag potential avenues for further inquiry, could be made:

- It is possible that the population in rural, remote areas has continuity and stronger ties to the past and the land than the population in urban spaces, with families living in the same village for generations and passing down knowledge to younger members.
- As far as education is concerned, it is worthwhile to question whether the curriculum in a larger city would not be shaped by different considerations. For instance, focusing on other, modern warning systems than tsunami stones. In the case in which villagers fell prey to the waves, the elder residents, aware of the danger, expressed remorse that they had not taught

⁶ Two media reports were independently reviewed and verified by Hiroyuki Umeki and Hideki Sakuma of the Japan Atomic Energy Agency,

⁷ See, for instance, Shuto et al (2011: 993-1018).

⁸ In addition to the tsunami stones, some places, in Aneyoshi and Murohama, have names that implicitly carry a message for the population. One place, for instance, is called “Octopus Grounds”, suggesting a location where sea life was probably washed up, or ‘Valley of Survivors’, indicating a safe area.

⁹ The interplay of oral history and markers appears to be one of mutual reinforcement: Awareness of the markers is passed on from generation to generation through oral history, and the presence of markers keeps oral history alive. This process, which highlights the complementarity of inter-generational communication strategies, is of particular importance with regard to the preservation of memory across generations.

their younger peers survival basics, thus suggesting that traditional knowledge was not taught sufficiently.

- It may also be difficult for present generations to understand some of the messages of the past given the evolution of the Japanese language¹⁰.

Neglected warnings

Murohama and Aneyoshi are the only two known villages that heeded the stone markers' warnings. While a few more may exist, the majority of villages was unaware or ignored the messages, with fatal consequences. For instance, after the earthquake people in Kesennuma, a village close to Aneyoshi, returned to their houses in the low-lying areas, although messages on stone markers warned: "If earthquake comes, beware of tsunami" and "choose life over your possessions and valuables" (Macan-Markar, 2013).

This was not the only time that messages were ignored. One account (Fackler, 2011) suggests that this was rather the rule in post-1945 Japan, when the population started building their homes closer to the shore, in areas marked by the stone markers as being at risk. Coastal towns grew rapidly against the backdrop of economic prosperity, and it appeared more advantageous for fishermen to live close to their boats. Many villages were built closer to the shore after sea walls were erected in the 1960s. One explanation for neglecting the warnings might thus have been the conviction that modern technology would protect the village. In the case of Murohama, one report suggests (Holguín-Veras, 2012), that the people were mindful of the warnings from the past despite a modern warning system, which, however, did not work at the time of the tsunami as it had been damaged by the earthquake.

A second account (Alabaster, 2011) suggests that people simply were too "busy" with their lives and jobs to pay attention to the stone markers, also quoting a professor in disaster planning from Tōhoku University, who argues that it takes "three generations for people to forget". Indeed, it only took three generations from the devastating tsunami of 1933.¹¹

However, Japan is well known for its preparedness exercises and tsunamis are events that are present in the memory of the people¹². The cases of neglected warnings illustrate that memory – in the sense of awareness of past events and impacts - is not enough for safety in the case of recurring but still unpredictable events of variable devastating force. Memory should be complemented by an active safety culture all along the timeline, based on an attitude of learning and humility. In the present case, past generations fulfilled their ethical responsibility of providing memory to future generations, but the latter mostly failed to protect themselves because of their own insufficiently protective actions, for instance by not enough studying historical records.

Japanese stone markers as a model for repository markers

Nature of phenomena

A tsunami is a recurrent event, which, depending on its magnitude, may cause damage visible for several decades. The recurrent nature of the event ensures that the population is constantly reminded of the risks of tsunamis and can assess information and warnings about the event, such as those carried by the stone markers, on a regular basis.

¹⁰ Hiroomi Aoki, OECD-NEA, in personal communication.

¹¹ According to data from the US National Geophysical Data Center Global Historical Tsunami Database, 425 tsunamis reached the shores of Japan since 684 AD. In other words, a tsunami hits Japan on average every three years. Tsunamis that caused fatalities in Japan – 56 in 1330 years – occur, on average, once every 23 years. If one is only to take into consideration the 'deadliest' tsunamis in Japanese history, the average of occurrence is one every 60 years.

¹² Tsunami is a Japanese word (meaning wave –nami- in the harbor –tsu-). All tsunami, including the 869 Jogan tsunami, have been given names.

Repositories are built at a depth to shield the waste from surface phenomena such as floods. They are designed to be safe on their own for indefinite periods of time and not to have sudden surges in activity. They are therefore immensely more static than tsunamis and unlikely to raise interest among the host population, especially not on a regular basis.

A degree of unpredictability enters into the picture if the repository is inadvertently intruded upon. However, neither the resulting damage to the repository, nor the consequences of the same would be visible in the event – a significant difference with regard to tsunamis and the visible devastation they bring.

Finally, tsunamis impact long coastlines and large areas of land. This is not the foreseeable case for a repository.

Longevity

The stone markers mentioned in the examined accounts extend over a time span of up to a thousand years, covering the short-term¹³, the medium-term¹⁴, and the early part of the long-term¹⁵ as defined in the RK&M project glossary.

The lesson to be drawn with regard to longevity is that, in the Japanese example, of the “short term” stone markers, 40% have survived a little longer than a century. An undefined, but likely much smaller, proportion of previously built stone markers has survived for up to a thousand years. The Japanese case is therefore instructive as it indicates that the concept of (fairly) long-lasting markers is feasible.

These and other historical examples of megalithic objects and monuments (for instance, Stonehenge, Megalithic Temples of Malta, Pyramids) suggest that large stone markers and monuments may stand the test of time from a few hundred to a few thousand years.¹⁶ Although tsunamis have removed some of them, large stone markers are hard to move through natural forces, and there must be a strong will to move or destroy them if man gives himself that task. It must be presumed, however, that they have a finite life, whose timespan is difficult to define and would depend on the local circumstances. For the repository, some national legislation requires that marking be permanent.¹⁷ This is an ambitious goal that, however, can hardly be fulfilled by a single stone marker or by a few. On the other hand, markers could be replaced with new ones. In Japan, for instance, new tsunami stones were erected after the various tsunamis, and it is known, by experience, that new monuments are at times erected in the place of older one. In this context, however, it appears pertinent to ask whether the building of a repository at one point in time would constitute a sufficient reason to renew its markers many generations thereafter without the manifestation of visible impacts.

Historical and cultural significance

Experience and research suggests that any monument that survives long enough will accrue an historical and cultural significance independent of its original function. It appears that the stone markers in Japan had accrued such historical significance, but the interest of the public in the information and warnings they carried was not strong, as are things from the past that no longer carry an immediate use. This suggests that although the historical and cultural significance may accrue over

¹³ According to the RK&M project glossary, short term refers to a timescale of “a hundred years”.

¹⁴ According to the RK&M project glossary, medium term refers to a timescale of “a few hundred years”.

¹⁵ According to the RK&M project glossary, long term refers to a timescale of hundred thousand of years”.

¹⁶ See, for instance, the Megalithic Temples of Malta, believed to be more than 4500 years old (UNESCO, n.d.)

¹⁷ For instance, the Swiss Nuclear Energy Act of 21 March 2003, Art. 40 § 7., reads: The Federal Council stipulates that the repository be permanently marked.”

time, the original function may no longer be appreciated. In fact, additional functions and significance may emerge over time, sometimes leading to new uses and interpretations (Holtorf, 2000-8).

Just as happened in the past, after important tsunamis, new stone markers were erected commemorating the 2011 Tōhoku earthquake and tsunami. 500 such new markers pass on the lessons from this recent event to future generations.¹⁸ The initiative of creating and installing these modern stones was led by the Japanese guild of stone masons and not by the authorities. This highlights, on the one side, the potential role of civil society organisations in developing and maintaining markers and, on the other side, the absence of interest by the authorities in this type of warning and commemoration.

Messages

The messages of the Japanese stone markers can be qualified as informative or admonitory, and belong generally to one of the following categories:

- Commemoration-information: *“On 15 June 1896, big Tsunami reached here. Over 600 people were killed and over 500 houses were damaged in this area.”*
- Warning-prediction: *“If earthquake comes, beware of tsunami.”*
- Warning-advice: *“Run to the highest place. Do not run only to far place because you will be caught up by Tsunami.” or “High dwellings ensure the peace and happiness of our descendants. Remember the calamity of the great tsunami. Do not build any homes below this point.”*

Stone markers for a repository could be of the commemorative and information kind, of the type “a repository was built here in the year ...”, “the repository lies at a depth of ...” etc. Stone markers for a repository could also be of the warning-advice kind, of the type “please do not dig in these areas at a depth of more than..., you may expose yourself and others to dangerous radioactivity.” Perhaps more can be done with stone markers. For instance they could carry a message on where it would be likely to find additional information.¹⁹

The messages on the Japanese stone markers do not display graphical features of devastation or other scaring features. In the past, work on markers for a repository dedicated attention to monuments and graphical descriptions that would scare people from accessing the site or living on it (Buser, 2013). If a graphical – scary – description was and is not used on markers in the case of a recurring phenomenon such as a tsunami, could it be envisaged for events that are uncertain and unlikely to occur, such as for a negative impact from a deep repository on the living environment?

The Japan Tsunami Trace database, developed by the Japan Nuclear Energy Safety Organization (JNES) and Tōhoku University, is an interesting example of how present generations can make use of the information provided by past ones, in this case through the stone markers. Launched in 2007, the objective of the database was to collect and analyse historical materials and documents of tsunamis in Japan (Iwabuchi, 2010) and to use them to inform safety evaluations of nuclear power plants. As part of this work, field survey teams made use of information written on the stone markers to identify the location of the impact of past tsunamis and collect more detailed tsunami data. Similarly, repository markers may carry information that future specialists may want to collect in a database.

¹⁸ For an example, see the Zenyuseki Memorial Stone of the Tsunami Project at <http://www.tsunami-kioku.jp>.

¹⁹ Information about the repository will be preserved through a variety of means. See, for instance, the envisaged WIPP summary, to be sent to several archival organisations but also to be addressed in educational texts (DoE, 2008).

Conclusions

The existence of markers for recurrent, destructive events may help save lives, as in the case of the villages of Murohama and Aneyoshi. However, in most other cases, the markers did not help protect the population from the March 2011 tsunami.

The villages of Murohama and Aneyoshi have shown interest in passing on the messages through oral history and in school education. However, it is worth asking whether these villages would have heeded the messages of the stone markers if the rest of society had given them other forms of assurance against tsunamis besides their own vigilance, for instance, if they had a tsunami wall or a functioning modern tsunami warning systems.

This historical example illustrates that, over the course of several generations, markers informing and warning about disasters are of limited effectiveness for local protection. Despite the historical record and the widespread awareness of the danger that has materialised on a recurrent basis, the local population has, by and large, taken risks with or without the presence of markers. Reliance on new technologies, deferring responsibility to the authorities, and pursuit of short-term economic interests are three potential reasons for this behaviour. On the other hand, the March 2011 tsunami was a thousand-year event; it is questionable whether the population can be asked to live in the constant fear of and preparation for such a rare event, in Japan and in similarly latently dangerous areas around the world²⁰.

The Japanese tsunami stones provide a rare example of warning markers and allow a number of considerations to be made for markers in the context of repository projects:

- The longevity of stone markers in Japan - up to one thousand years - illustrates the possibility of survival of markers over similar timescales, especially in regions that are not subject to devastations from natural catastrophes. Stone markers and monuments of similar age and older exist in other parts of the world.
- Visible markers contribute to keeping memory alive. They may, however, become objects of historical and cultural value with no real influence on present day continued vigilance. Their warning function is more likely to survive in relatively small communities that have continuity to the land and honour their past.
- Memory does not guarantee safety. The current international position that a geological repository should be safe by itself is confirmed by this study.
- Memory may save lives under special circumstances and it should be fostered.
- More than memory, knowledge saves lives. Markers may be part of a larger strategy to foster learning and understanding and therefore knowledge. For instance, markers placed strategically near the repository site so that they are discovered in the course of time could arouse curiosity and desire to learn more.

²⁰ For instance, people live near the Saint Andreas fault in California or elsewhere on calderas that may explode at one point.

Sources

- Alabaster, J. (2011), “Tsunami-Hit Towns Forgot Warnings from Ancestors”, *Associated Press*, 6 April, accessed 28 January, 2014, http://www.huffingtonpost.com/2011/04/06/japan-tsunami-warnings-fr_n_845818.html.
- Buser, M. (2013) “Literature Survey on Markers and Memory Preservation for Deep Geological Repositories”, OECD-NEA, Paris, <http://www.oecd-neo.org/rwm/docs/2013/rwm-r2013-5.pdf>.
- DoE (2008) “How Will Future Generations Be Warned?”, Carlsbad: Department of Energy, Carlsbad Field Office, The Waste Isolation Pilot Plant, <http://www.wipp.energy.gov/fctshts/warned.pdf>.
- Fackler, M. (2011) “Tsunami Warning, Written in Stone”, *New York Times*, 20 April, accessed 28 January, http://www.nytimes.com/2011/04/21/world/asia/21stones.html?pagewanted=all&_r=0.
- Holguín-Veras, J.(2012) “Japan’s 1000-year-old-warning”, *Los Angeles Times*, 11 March, accessed 28 January, 2014, <http://articles.latimes.com/2012/mar/11/opinion/la-oe-holguin-veras-tsunami-20120311>.
- Holtorf, Cornelius (2000-8) *Monumental Past: The Life-histories of Megalithic Monuments in Mecklenburg-Vorpommern (Germany)*, Electronic monograph, University of Toronto: Centre for Instructional Technology Development, accessed 18 April 2014, <http://hdl.handle.net/1807/245>.
- Iwabuchi, Y. (2010) “Development of Tsunami Trace Database with Reliability Evaluation on JAPAN Coasts”, Presentation at the 1st Kashiwazaki International Symposium on Seismic Safety of Nuclear Installations, 26 November 2010, http://www.jnes.go.jp/seismic-symposium10/presentationdata/3_sessionB/B-10.pdf.
- Kozak, J. and Cermak, V. (2010) *The Illustrated History of Natural Disasters*, Springer Verlag, Heidelberg.
- Macan-Makar, M. (2013) “Stories Sprout like Warnings in Japan’s Tsunami Wasteland”, *Inter Press Service*, 19 March, accessed 22 April 2014, <http://www.ipsnews.net/2013/03/stories-sprout-like-warnings-in-japans-tsunami-wasteland/>
- Megalithic Portal (2013) “The new tsunami memorial tablets”, accessed 12 February, 2014, <http://www.megalithic.co.uk/article.php?sid=34249>.
- Nagai, M. (2011) “The Forgetting Stone”, *Foreign Policy*, July 27, accessed 18 April 2014, http://www.foreignpolicy.com/articles/2011/07/27/the_forgetting_stone
- OECD-NEA (2014) “Articles about strategic aspects of the preservation of Records, Knowledge & Memory (RK&M) across Generations’, <http://www.oecd-neo.org/rwm/docs/2014/rwm-rkm2014-5.pdf>
- Shuto, N., Suppasri, A., Imamura, F., Koshimura, S., Mas, E., Yalciner, A. H. (2011) “Lessons Learned from the 2011 Great East Japan Tsunami: Performance of Tsunami Countermeasures, Coastal Buildings, and Tsunami Evacuation in Japan”, *Pure and Applied Geophysics*, No 170, pp. 993-1018.
- Yoshida, R. (2012) ‘869 Tōhoku tsunami parallels stun’, *The Japan Times*, 11 March, accessed 21 February, 2014, <http://www.japantimes.co.jp/news/2012/03/11/news/869-Tōhoku-tsunami-parallel-stun/#.UwdoXPldWck>