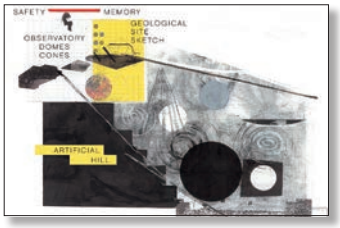
Radioactive Waste Management
2015

Radioactive Waste Management and Constructing Memory for Future Generations

Proceedings of the International Conference and Debate 15–17 September 2014 Verdun, France





OECD
BETTER POLICIES FOR BETTER LIVES

NEA
NUCLEAR ENERGY AGENCY

Radioactive Waste Management and Constructing Memory for Future Generations

Proceedings of the International Conference and Debate
15-17 September 2014, Verdun, France

© OECD 2015
NEA No. 7259

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of 34 democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission takes part in the work of the OECD.

OECD Publishing disseminates widely the results of the Organisation's statistics gathering and research on economic, social and environmental issues, as well as the conventions, guidelines and standards agreed by its members.

This work is published on the responsibility of the Secretary-General of the OECD. The opinions expressed and arguments employed herein do not necessarily reflect the official views of the Organisation or of the governments of its member countries.

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 31 countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information.

The NEA Data Bank provides nuclear data and computer program services for participating countries. In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Corrigenda to OECD publications may be found online at: *www.oecd.org/publishing/corrigenda*.

© OECD 2015

You can copy, download or print OECD content for your own use, and you can include excerpts from OECD publications, databases and multimedia products in your own documents, presentations, blogs, websites and teaching materials, provided that suitable acknowledgment of the OECD as source and copyright owner is given. All requests for public or commercial use and translation rights should be submitted to *rights@oecd.org*. Requests for permission to photocopy portions of this material for public or commercial use shall be addressed directly to the Copyright Clearance Center (CCC) at *info@copyright.com* or the Centre français d'exploitation du droit de copie (CFC) *contact@cfcopies.com*.

Foreword

Many member countries of the Nuclear Energy Agency (NEA) have been engaging in the development of deep geological disposal projects for the long-term, final management of radioactive waste and spent fuel. Disposal facilities will be implemented and operated over several decades, but once they are closed, they will need to remain safe for millennia. Geological repositories are designed to be intrinsically safe and final, as safety should not depend on human presence and/or intervention. However, the intention is not to renounce, at any time, the obligation of maintaining records, knowledge and memory (RK&M) of the repository and the waste it contains. Enabling future members of society to make informed decisions is part of responsible, ethically sound and sustainable radioactive waste management. This attitude is also in line with a prudent approach to safety.

Preparing for future RK&M preservation is best addressed while waste management plans are being designed and implemented, and while funding is available. In 2011, the NEA Radioactive Waste Management Committee (RWMC) launched its initiative on the Preservation of RK&M across Generations to foster international reflection and progress towards this goal and meet increasing demands by waste management specialists and other interested parties for viable and shared strategies. The RK&M initiative is now in its second phase, which is to last until 2017. Current members include radioactive waste management organisations, regulators, nuclear research institutes and national archives from Belgium, Canada, the Czech Republic, Finland, France, Germany, Hungary, Japan, Spain, Sweden, Switzerland, the United Kingdom and the United States. The International Atomic Energy Agency (IAEA) takes part as an observer and the initiative is supported by the European Commission (EC). Other organisations and specialists contribute on an ad hoc basis, for instance by completing targeted questionnaires and by participating in meetings and workshops.

The reflections and activities of the RK&M initiative have included an ever-widening group of interested parties. Phase I of the initiative culminated on 15-17 September 2014 with the organisation of "Constructing Memory: An International Conference and Debate on the Preservation of Records, Knowledge and Memory of Radioactive Waste across Generations". The conference took place at the Centre Mondial de la Paix, des Libertés et des Droits de l'Homme in the city of Verdun, France, and is documented in these proceedings.

It was attended by approximately 200 participants, representing 17 countries and 3 international organisations (the NEA, IAEA and EC). Among the participants were specialists from both nuclear and non-nuclear organisations, academics, local community representatives, interested citizens and artists, who took part in the conference by means of invited presentations, panel sessions, round-table discussions and poster sessions.

These proceedings include *i)* an introduction outlining the RK&M initiative; *ii)* a synthesis of the conference providing an overview of the talks that were delivered, of the art work that was exhibited and of the group discussions that took place; *iii)* lessons and conclusions for the RK&M initiative, and *iv)* extended abstracts provided by panellists, artists and poster presenters. The presentations that supported the talks delivered at the conference are available at: www.oecd-nea.org/rwm/rkm/constructingmemory/.

Acknowledgements

"Constructing Memory – An International Conference and Debate on the Preservation of Records, Knowledge and Memory (RK&M) of Radioactive Waste across Generations" was organised by the NEA, with the support of the French National Agency for Radioactive Waste Management (Andra).

The programme committee was led by Claudio Pescatore (RK&M co-ordinator) and included the following RK&M initiative members: Anne Claudel, National Cooperative for the Disposal of Radioactive Waste (Nagra), Switzerland; Jean-Noël Dumont, French National Agency for Radioactive Waste Management (Andra), France; Stephan Hotzel, Gesellschaft fuer Anlagen- und Reaktorsicherheit (GRS) mbH, Germany; Sofie Tunbrant, Swedish Nuclear Fuel and Waste Management Company (SKB), Sweden and Simon Wisbey, Nuclear Decommissioning Authority (NDA), United Kingdom.

Jantine Schröder (Belgian Nuclear Research Centre, SCK•CEN), a member of the RK&M initiative, provided the draft synthesis included in these proceedings. Radu Botez and Marine Formentini (NEA) participated in the organisation of the conference and finalisation of these proceedings.

Special thanks are due to the Andra team which made extensive efforts in supporting the organisation of the conference: Patrick Charton, Catherine Cobat, Jean-Noël Dumont, Bernard Faucher, Pauline Fournier, Corinne Le Veo, Valérie Renauld and Mathieu Saint-Louis.

The organisers would also like to express their gratitude to the Centre Mondial de la Paix, des Libertés et des Droits de l'Homme and its President, Gérard Longuet, for providing the venue of the conference.

The conference owes its success to the active involvement of all participants.

Table of contents

Part I. Preservation of Records Knowledge and Memory (RK&M) 7

Introduction to the NEA RK&M initiative 9

Synthesis of the Constructing Memory Conference 15

Conclusions from the Constructing Memory Conference 31

Part II. Extended abstracts 33

Conference opening 35

Knowledge for the future – Time eats information 37

Short term: Period until repository closure 41

Preparing for the future today: The findings of the NEA RK&M initiative for the short term 43

The Nuclear Decommissioning Authority (United Kingdom) Nuclear Archive: The importance of stakeholder engagement 49

What's the story? Using art, stories and cultural heritage to preserve knowledge and memory 53

Memory provisions for the Manche Surface Repository 57

Medium term: Period of continued oversight 63

The concept of oversight, its connection to memory keeping and its relevance for the medium term: The findings of the RK&M initiative 65

Heritage messages of a post-nuclear nature 71

The Great Hedge of India 75

Archival and museum curatorship challenges for RK&M preservation 79

Day 2 closing lecture: Anthropocene's archive? 81

Long term: Period with no oversight 83

Long-term preservation and the concept of oversight 85

Could the landscape preserve traces of a deep underground nuclear waste repository over the very long term? 89

Defining a communication system for the long term 93

Archaeology and the future: Managing nuclear waste as a living heritage 97

Conference closure 103

Comments on the Constructing Memory Conference 105

Part III. Contributions from artists, and posters 107

Artists 109

Cumbrian Alchemy (2012-2014) 111

Gérard Larguier 117

Constructing memory through artistic practices 125

A temporary index 133

Posters 137

Constructing Memory: Competence Maintenance, Education and Training Working Group on the Implementation of Geological Disposal of the Radioactive Waste Technology Platform 139

United States regulations for institutional controls at high-level waste repositories 143

Record keeping for the disposal of very low-level concrete waste at the Tokai-Mura site 145

Nuclear knowledge management in radioactive waste management programmes 149

List of annexes

1. List of abbreviations and acronyms 153

2. Final Programme of the Constructing Memory Conference and Debate 155

3. Biographies of speakers 161

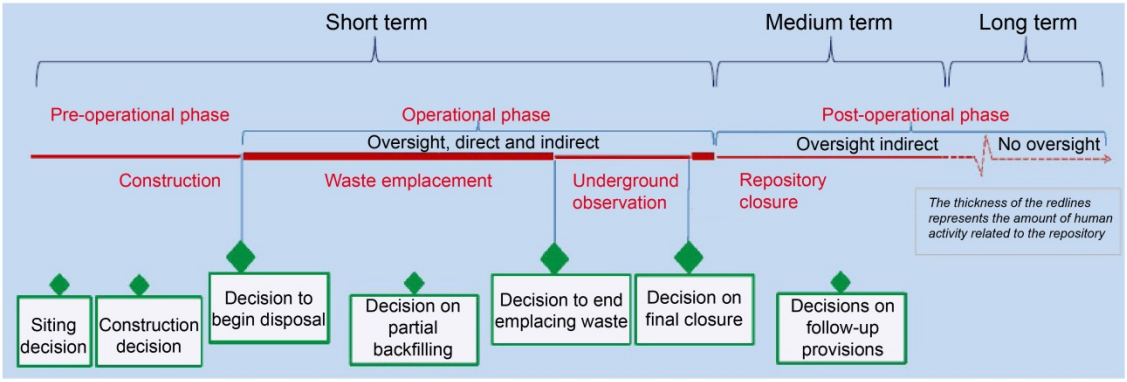
4. List of participants 169

Part I. Preservation of Records Knowledge and Memory (RK&M)

Introduction to the NEA RK&M initiative

The Nuclear Energy Agency's (NEA) initiative on the Preservation of Records Knowledge Memory (RK&M) across Generations, launched in 2011, has adopted a multidisciplinary and comprehensive approach to the study of the preservation of records, knowledge and memory of a repository in the short, medium and long term. These three time scales represent the three oversight regimes as indicated in Figure 1: *i)* short term – the period where oversight can be direct and indirect (i.e. up to repository closure); *ii)* medium term – the period of indirect oversight (up to 1 000 years); and *iii)* long term – the period of no oversight (beyond the medium term) (see also NEA, 2014a). Current practices are being assessed and compared internationally, and harmonisation among participating countries and organisations is encouraged.

Figure 1: Repository life phases and oversight regimes



Note: The thickness of the red lines represents the amount of human activity related to the repository.

The initiative is addressing this complex topic from a variety of perspectives. The RK&M members have drawn insights from disciplines other than radioactive waste management, such as archaeology, cultural heritage studies, and archival science. Specialists from these fields have participated in RK&M's two workshops and eight regular meetings. Within this approach, "Constructing Memory: An International Conference and Debate" brought together a diverse audience to discuss ideas developed during Phase I of the initiative and to receive input in preparation for Phase II.

Thus far, strategic themes and topics examined within the NEA RK&M initiative have included, for example, archives, markers, regulation, memory loss, the relation between RK&M and monitoring, the connection between RK&M and safety and international mechanisms. Larger studies and/or short briefs have been written on these topics. A glossary defining important concepts and terms has been created to foster consistency when discussing long-term RK&M preservation and transfer (NEA, 2014a). A dedicated bibliography presenting publications in this area has also been developed. Both the glossary and the bibliography are updated on a regular basis.

In April 2014, the 47th NEA Radioactive Waste Management Committee (RWMC) agreed to extend the RK&M initiative for another three years, until April 2017. On the same occasion, the RWMC adopted a collective statement on "Foundations and Guiding Principles for the Preservation of Records, Knowledge and Memory across Generations" (NEA, 2014b).

The collective statement underlines that enabling future members of society to make informed decisions is part of responsible, ethically sound and sustainable radioactive waste management. This attitude is also in line with a prudent approach regarding safety. The statement emphasises that preparing for future RK&M preservation is best addressed while waste management plans are being designed and implemented, and funding is available.

More information and documentation, including topical studies, strategic briefs, foundation documents, progress reports, proceedings of previous workshops and summary records of meetings can be found on the RK&M web page: www.oecd-nea.org/rwm/rkm/.

Findings from Phase I

The main overarching finding is that:

> *There is no single mechanism or technique that would achieve, alone, the preservation of RK&M over centuries and millennia. Rather, an RK&M preservation method is needed whose components offer a variety of RK&M transmission mechanisms that are integrated with one another or that complement one another with a view to maximising information accessibility, understandability and survivability over the timescales considered. This is referred to as a systemic approach.*

A systemic approach for reaching out to future generations in the medium term would be based on a dual-track strategy – providing mechanisms for both mediated and non-mediated transmission of information – whereby the transmission mechanisms are designed to be complementary, to reinforce information content and to act as indexes for each other.

In addition, the following five main conclusions can be drawn at the end of Phase I:

> *The context has changed greatly since the 1980s, when RK&M preservation was thought to serve the sole function of deterring intrusion into a repository. Today, the goal is to preserve information to be used by future generations while maintaining technical and societal oversight of the repository for as long as practicable.*

Oversight, understood as a general term for "watchful care" and referring to society "keeping an eye" on the technical system of the disposal facility and on the actual implementation of plans and decisions, may take many forms. This concept, which has been promoted by the International Commission on Radiological Protection (ICRP), could be implemented through regulatory supervision in the form of monitoring of pathways, through active memory keeping by preserving archival information and/or through society maintaining memories about the facility through lore and local history. While it would not mean ceasing oversight, the potential loss of oversight needs to be anticipated and planned. Provisions for the preservation of RK&M could facilitate recovery of oversight (see section on "the concept of oversight, its connection to memory keeping and its relevance for the medium term – findings of the RK&M initiative" on page 65).

> *There are a number of mechanisms for international co-operation that can foster RK&M preservation. They constitute a potential resource for waste management organisations and governments.*

The 2011 collective statement of the RWMC on RK&M preservation (NEA, 2011) called for the systematic identification of mechanisms for RK&M transfer. In the course of the initiative, a wide array of international mechanisms for RK&M preservation has been identified and will be further examined in Phase II of the initiative.

The period of time of a few centuries that will follow repository closure – defined in the RK&M glossary as the medium term – is rarely specifically addressed in the literature. Yet, this is an important period for RK&M preservation and for preparing the future.

The medium term refers to the period of indirect oversight activities that would follow repository closure. The envisaged timescale is in the order of a few hundred years. During Phase I of the initiative, an extensive literature review was conducted. The review indicated that the period conceived as the "medium term" by the RK&M initiative has often not been addressed as such, most of the literature dealing either with the current period or with an indefinite "long term".

The regulatory aspects of long-term RK&M preservation are much in need of formulation and systematisation. Transfer of responsibilities is an important area. Much information is lost typically during changes in responsibilities.

During Phase I, the RK&M initiative reviewed national instruments (legislation, regulation, guidelines) governing the preservation of RK&M, which showed that long-term RK&M preservation is not covered adequately at the moment, nor is the question of transfer of responsibilities after closure. In order for oversight to continue after closure, other institutions and stakeholders than those who formulated relevant regulation and operated the facility will need to become involved.

Terminology is important when discussing long-term issues.

Discussions regarding RK&M preservation have underlined that it is important to use a consistent and well-elaborated vocabulary, particularly as commonly used concepts may change meaning when used with regard to the long term. For this reason, the RK&M initiative has developed a glossary of terms (NEA, 2014a).

Phase II work priorities

During Phase I, the initiative identified and examined areas important for the preservation of RK&M. These were introduced to the public at the international conference "Constructing Memory". Input from the participants on these specific areas was sought during dedicated group discussions.

The lessons learnt from the conference were reviewed during the 8th RK&M meeting in January 2015.

The members of the initiative decided to prioritise the selected topics that are presented below.

Archives

The RK&M initiative will learn more about participating organisations' experiences with and expectations in relation to archives in their countries, especially national archives. RK&M members will provide an overview of current relations with archives. These overviews will be used to develop an understanding of how national archives can contribute to RK&M preservation. As archives traditionally work in a historical perspective, there is a possible need for dedicated nuclear archives that take safety aspects into account. In addition, the RK&M initiative is building up a working relationship with representatives of national archives in order to examine preservation and accessibility issues with these specialists.

Key information file

Related to the question of archives, the RK&M initiative has originated and is developing the concept of a key information file (KIF). The KIF corresponds to the top level within a three-tiered information system, consisting of the following levels:

- A basic level consisting of documents sent to the archives as a result of legal and regulatory requirements. Typically, public bodies have to send all the documentation in their internal archives to the national archive. This documentation goes beyond safety case documents.
- A second level at which a selection would take place that aims at extracting the documents that are related to the post-closure safety. These documents would be identified as such and also kept in the national archives and elsewhere.
- A top, third level which would consist of a summary of the previous documentation in a format and language accessible to a public of non-specialists. The summary (KIF) would contain information not necessarily limited to safety, but referring also to the history of decision making concerning the repository.

The RK&M initiative will develop a table of contents for the KIF. Existing national examples of similar documents, such as Andra's synthesis document based on documents related to its *Centre de la Manche* disposal facility will serve as useful references. In a following step, the table of contents will be tested among participating organisations.

Markers

The RK&M initiative 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" (NEA, 2014a). A marker is a good example for a non-mediated mode of information transmission under the dual-track strategy as it aims to reach an audience in the medium and long term without intermediaries.

In December 2013, the initiative published a "Literature Survey on Markers and Memory Preservation for Deep Geological Repositories" (NEA, 2013).

Phase II will study the issue of markers by discussing national case studies as well as by discussing emerging concepts such as surface traces that could be left behind on relevant sites to indicate past activity.

Underlining the concept of a systemic approach, markers could, for instance, point to the KIF outlined above. Also, they are strongly linked to the question of cultural heritage as they may persist if deemed culturally important and if they are becoming a part of society, which can also be a result of certain functions that markers may have.

International mechanisms

The RK&M initiative reviewed international mechanisms from different fields beginning in Phase I, for instance cultural heritage (e.g. the United Nations Educational, Scientific and Cultural Organization – UNESCO), that could be used as a means of collaborating and/or adapting the particularities of the field of radioactive waste management to support the preservation of RK&M. In preparing Phase II, the RK&M has subdivided international mechanisms into two different classes, for the purpose of studying them better with a view to establishing a systemic approach to RK&M preservation. These two classes are as follows:

- An international governmental mechanism (IGM) consists of entities and activities that are based on mutual agreements between a number of national governments.

- An international non-governmental mechanism (INGM) consists of entities and activities that bring together non-governmental, private or commercial organisations.

An additional categorisation of international mechanisms will be undertaken in Phase II.

Transfer of responsibilities

The question of transferring responsibilities is important: *i)* in order to demonstrate the willingness to continue maintaining oversight of the facility; and *ii)* because it is typically when responsibilities are handed over to another institutional body that much information is lost. Regulation and legislation tend not to address this issue. The RK&M initiative will make use of the presence of regulators and implementers among its participants to develop a discussion document on this issue. To further explore the question, the RK&M initiative will receive input from the NEA Regulators' Forum.

The RK&M initiative has issued two studies that are related to the question of transfer of responsibilities. "Monitoring of Geological Disposal Facilities – Technical and Societal Aspects" (NEA, 2014d), which includes a contribution by the Forum on Stakeholder Confidence (FSC), discusses the role of local communities in maintaining the memory of a facility and provides an overview of issues related to technical monitoring. The study on "Loss of Information, Records, Knowledge and Memory – Key Factors in the History of Conventional Waste Disposal" (NEA, 2014c) concludes in part that records and information are often lost when responsibilities change.

Way forward

Through its activity over the past four years, the RK&M initiative has identified, examined and provided recommendations on the core components of any future national strategy for the preservation of RK&M. During the coming three years, it will analyse the interaction of these components to identify and provide suggestions for fostering synergies. This will provide waste management organisations and other interested parties with the resources necessary to address the issue of RK&M preservation adequately in their future activities.

References

NEA (2011), "Preservation of Records, Knowledge and Memory across Generations: An International Project of the NEA/RWMC", OECD, Paris, www.oecd-nea.org/rwm/rkm/documents/rkm-collective-statement-2011-en.pdf.

NEA (2013), "Literature Survey on Markers and Memory Preservation for Deep Geological Repositories", OECD, Paris, www.oecd-nea.org/rwm/docs/2013/rwm-r2013-5.pdf.

NEA (2014a), "Glossary of Terms: Preservation of Records, Knowledge and Memory (RK&M) across Generations", OECD, Paris, www.oecd-nea.org/rwm/docs/2011/rwm2011-14-rev4.pdf.

NEA (2014b), "Foundations and Guiding Principles for the Preservation of Records, Knowledge and Memory across Generations: A Focus on the Post-closure Phase of Geological Repositories", OECD, Paris, www.oecd-nea.org/rwm/rkm/documents/flyer-A4-rkm-collective-statement-en-2014.pdf.

NEA (2014c), "Loss of Information, Records, Knowledge and Memory – Key Factors in the History of Conventional Waste Disposal", OECD, Paris, www.oecd-nea.org/rwm/docs/2014/rwm-r2014-3.pdf.

NEA (2014d), "Monitoring of Geological Disposal Facilities – Technical and Societal Aspects", OECD, Paris, www.oecd-nea.org/rwm/docs/2014/rwm-r2014-3.pdf.

Synthesis of the Constructing Memory Conference

Conference opening

Opening remarks to the conference were delivered by Thierry Dujardin, NEA Acting Deputy Director-General, Gérard Longuet, French Senator, former Minister and President of the *Centre Mondial de la Paix, des Libertés et des Droits de l'Homme*, and François-Michel Gonnot, President of Andra. These speakers highlighted that giving future generations the ability to make informed decisions about their heritage is a fundamental aspect of sustainable development. They expressed the opinion that the NEA RK&M initiative is helping break new ground in this regard, going beyond the technical aspects of nuclear technology development, encouraging a holistic approach and highlighting radioactive waste management as a humanistic and intergenerational endeavour.

Constructing memory in the digital era – experience, expectations and insights from the field of preservation of cultural heritage (Marinos Ioannides)

Prof. Marinos Ioannides from the Cyprus University of Technology highlighted the importance Mankind attaches to cultural heritage in all its various forms, but also the vulnerability of cultural heritage to deterioration and destruction. The centre of the talk was on research initiatives that aim to tackle this vulnerability by making cultural content available in digital forms through the support of information and communication technology (ICT). Prof. Ioannides mentioned existing international initiatives for the electronic documentation and preservation of cultural heritage (such as the EU Digital Library Europeana and the UNESCO Memory of the World Library) and showcased the development of various digitalisation tools and accessibility features (such as digital 3D reconstruction of artefacts and monuments and the inclusion of metadata in digitally preserved books).

Knowledge for the future – time eats information (Klaus Kornwachs)

Prof. Klaus Kornwachs of the University of Ulm gave the second opening lecture. He emphasised that for long-term RK&M preservation, one needs to think not only about technologies but, even more, about institutions that could preserve RK&M such as universities, academies or libraries. Support by international institutions like the OECD or the United Nations would also facilitate RK&M preservation. The reason one cannot rely on technological means alone is that information needs to be revisited in order to remain understandable and usable over time. In addition, it is important to indicate why information should be preserved; in the cases of chemical waste and the location of land mines, for instance, the reason for preserving information arises from their dangerous nature. We should not lead future generations into dilemmatic situations in which they cannot act in a responsible way anymore. RK&M preservation initiatives were thus presented as a way to meet our duty and help foster responsible behaviour over time.

Preservation of records, knowledge and memory (RK&M) across generations: An NEA initiative under the aegis of its Radioactive Waste Management Committee (Claudio Pescatore, RK&M Co-ordinator)

To close the opening session of the conference and give a vision of the succeeding sessions, Claudio Pescatore, the RK&M Co-ordinator gave an introduction and overview of the RK&M initiative, its main findings and the role of this conference within its scope of

work. Namely, to present and test the RK&M findings, to enlarge the circle of potential contributors beyond radioactive waste management specialists, and to lay the foundations for Phase II of the programme of work. Section III of these proceedings provides a detailed introduction and overview of the initiative.

He explained that, in order to be effective in RK&M preservation, it is important to have in mind reference time scales, hence the organisation of this conference around three time periods characterised, respectively, by the active presence of technical specialists and regulators (short term: direct oversight), by surveillance by institutions that would include civil society and representing the taking of collective responsibility for memory preservation (medium term: indirect oversight), and a third period characterised by loss of societal memory keeping (long term: no oversight). He declared that "We do not inherit the earth from our ancestors; we borrow it from our descendants" and explained that the main driving factor to memory preservation is to give future generations the means to make their own informed decisions regarding their radioactive waste legacy.

Contributions from artists

Cécile Massart – Constructing memory through artistic practices: Laboratories

Throughout her artistic work, which deploys a variety of visual media (video, photography, paint, and installations) Cécile Massart aims to raise awareness about radioactive waste disposal sites and to study their life within their surroundings for future generations. She proposes "laboratories" to be located within the perimeter of the disposal site, which would fulfil the function of markers and living research platforms at the same time. Through such laboratories each generation would try "to visualise" the radioactive waste sites, thus creating an international community of guardians, weaving a link from one generation to the next. The idea is to bring together people with a variety of backgrounds (musicians, archaeologists, writers, economists, artists, farmers, poets, among others) who would reflect about the transmission of memory from an ethical, economic or artistic perspective. These laboratories would work towards studying all the non-technical resources that could preserve the functions of this site in its landscape. It is thus Cécile Massart's belief that artistic proposals carried out along with waste management agencies, local community projects, new media types and networks, changing institutions and connections with databases can provide a cultural anchor for future generations. Examples of Massart's own artistic proposals for disposal sites can be found in *Cover*, a book published in 2009.

Gérard Larguier

Since 1998, the French painter Gérard Larguier has taken up the theme of memory in his works *Chronique du XXème siècle*, *Autodafés et Palimpsestes* and his series *A saute-souvenance*. Recently, he also completed an exhibition to increase the awareness of school children of the First World War, entitled *Un regard neuf sur un siècle de mémoire*. His compositions, which consist of collages with torn and burnt paper, express the complexity of society and its contradictions. For Larguier, memories occur in bursts and are reconstituted according to the vision of the moment and objective chance, which is what determines the judgements that one makes. His work reflects the idea that memory is fluctuating and fleeting, and ultimately concerned with giving meaning to life.

Robert Williams and Bryan McGovern Wilson: Cumbrian Alchemy

The *Cumbrian Alchemy* project explores issues emerging from an enquiry into convergent relationships among nuclear and other energy industries, archaeological monuments, oral traditions and landscapes of the North Lancashire and Cumbrian region in the north-west of England, a region characterised by richness in all these areas. Topically, it focuses on ideas of "places of power", issues and discourse associated with hazardous industrial sites, long-term nuclear repositories, matters of "deep-time" with respect to the recording and remembering of these repositories, language preservation and stewardship of the

land. The work includes photographs, drawings, sculptures, material assemblages and film, and forms an interconnected network of possible readings and meanings to promote further insight, speculation, discourse and debate on RK&M.

Jon Thomson and Alison Craighead: A temporary index

With *Temporary Index*, Jon Thomson and Alison Craighead wish to create a series of decorative, real-time numeric counters expressing radioactive decay. Each display will countdown in seconds, showing the time remaining before the given item of waste or a particular site is considered to be safe for humans. As a first step, data projections have been displayed in art galleries. The next step will be to establish a network of these counters online, in what could be described as a "virtual physiography". Once the building of a network of counters in virtual spaces has begun, the information will be attached to places such as Google Earth and as this network of counters evolves it can also be displayed in galleries and museums. Ultimately, Thomson and Craighead will also look at possibilities of building semi-permanent physical counters in the places they refer to, with a view to making them self (solar) powered. However, they focus on developing these artworks in a way that concentrates on the present and not on their own physical persistence into a far-flung future. The underlying idea is that in making information more transparent, more visible and more widely known in societies now, we can have a greater chance that information will be transmitted into the future via our collective institutional memory. Cultural institutions have proven to be reasonable stores of pan-generational memory in this regard.

Session 1 – Short term: Period until repository closure

Preparing for the future today – the findings of the NEA RK&M initiative concerning the short term (Jantine Schröder)

RK&M initiative members define the short term as the period of time that ends with repository closure, thus including both the pre-operational and the operational phases of the repository and the possibility of both direct and indirect oversight. Jantine Schröder introduced the session on this time period by highlighting that RK&M loss takes place rapidly if it is not acted upon in a conscious, participatory, diverse and ongoing manner that starts today. RK&M preservation in the short term was explained as being concurrently about supporting ongoing implementation activities and preparing for the future. Against this background, project studies on RK&M loss, on present regulation in the field (or the lack thereof), and on existing international mechanisms (also outside the field of radioactive waste management) that could foster RK&M preservation were presented. Additionally, insights were drawn from the way the US Department of Energy Office of Legacy Management currently organises its long-term stewardship activities.

The UK national archive initiative and the role of its different stakeholders (Simon Wisbey in lieu of Simon Tucker)

This presentation sketched how the United Kingdom's Nuclear Decommissioning Authority (NDA) deals with its obligation of identification, storage, preservation, sharing and destruction of records related to the memory of the UK civilian nuclear industry. Based on the experience of the ongoing establishment of a National Nuclear Archive, the speaker reflected on who the main actors are and how they could contribute; to what extent their work should be co-ordinated; whether there are guidelines; whether "stories" are being generated out of these archives for the benefits of all readerships; and whether there are issues of secrecy. It was highlighted that to successfully maintain the interest and the knowledge, it will be necessary to go beyond the technical and legislative areas and reach out to the wider society, for instance to the fields of education and culture.

Using art, stories and cultural heritage to preserve knowledge and memory (Hans Codée)

In the Netherlands, the Central Organisation for Radioactive Waste (COVRA) is in charge of storing radioactive waste over a period of at least 100 years. After this period, deep geological disposal is planned. In order to make the waste management concept more visible and understandable, an art concept has been developed and implemented at HABOG (*Hoogradioactief Afval Behandeling- en Opslag Gebouw* – high-level radioactive treatment and storage building), which is COVRA's waste storage facility. Externally, the facility will be repainted in different and fading colours over the decades as a reminder of the radioactive decay of its contents. Collaboration with Dutch museums has also been established to use HABOG's space as storage for museum collections that are not currently on display. With the recent, planned extension of the facility, the art concept has been refined further, for instance by making use of the periodical incidence of natural light on the facility and by creating a watching ritual around it. Thus, Hans Codée outlined how the implementation of artistic and cultural mechanisms can add value to something (waste) that by definition has no value, and in the process keep memory alive.

RK&M preservation for a recently closed repository: The study of Andra's Centre de la Manche (Florence Espiet)

The French La Manche repository site received its last radioactive waste package in 1994. In 2003, the official surveillance phase of the closed repository started under the supervision of Andra (the national industrial operator), the French Nuclear Safety Authority (ASN) and society (e.g. the local municipalities). Florence Espiet explained that information on the existence of the repository, its content, how it was operated and how it works needs to be preserved. It also is planned to review the information periodically for a minimum of 300 years. She described the creation of two documents on memory (a detailed and a summary one), both on permanent paper, and the preservation of the land registration. The latter constitutes "passive" provisions for preserving memory. In addition, a number of "active" provisions are and will be put in place: guided visits, exhibitions, partnerships with organisations dealing with memory preservation, and the creation of a think tank. The latter consists of local citizens and politicians, retired employees from Andra and artists that meet several times a year and reflect on memory preservation from the perspective of, for instance, local history, education, arts and rituals. Finally, two types of markers will be used to preserve the repository's memory: *i)* three herbaria cataloguing the plants growing on the site of the repository, including a very short description of the repository, will be stored at different sites in France; *ii)* a stele indicating the main characteristics of the repository, potentially linked to an art work, will be erected at the repository.

Group discussions on the short term

Discussion Group 1: Policy and regulation

- (Moderator: Jean-Paul Minon – Secretary: Sylvie Voinis)

Participants agreed that RK&M policy and regulation, as well as funding mechanisms, need to be put in place at the beginning of the disposal planning and accompany its developments. Updates will be needed as disposal projects evolve and new information is generated. Guidelines should address the general context, provide advice on creating summaries for non-professionals and decision makers, and foster the development of multiple ways to keep memory, balancing diversity of means and redundancy. Redundancy can be understood as preserving multiple copies of records in separate locations and different formats, such as hard copy or digital documents, to ensure information is not lost in case one of the copies be damaged or disappears. Participants were of the opinion that the two-way relationship between the local community and the operator should also be addressed through regulations. It was also suggested that each country should develop its own RK&M preservation organisation. Overall, the opinion

was that geological disposal is the responsibility of society at large, and that RK&M policy and regulation are a democratic obligation (response to a societal demand) and have a role in safety (complementing the "built-in" safety of the repository system).

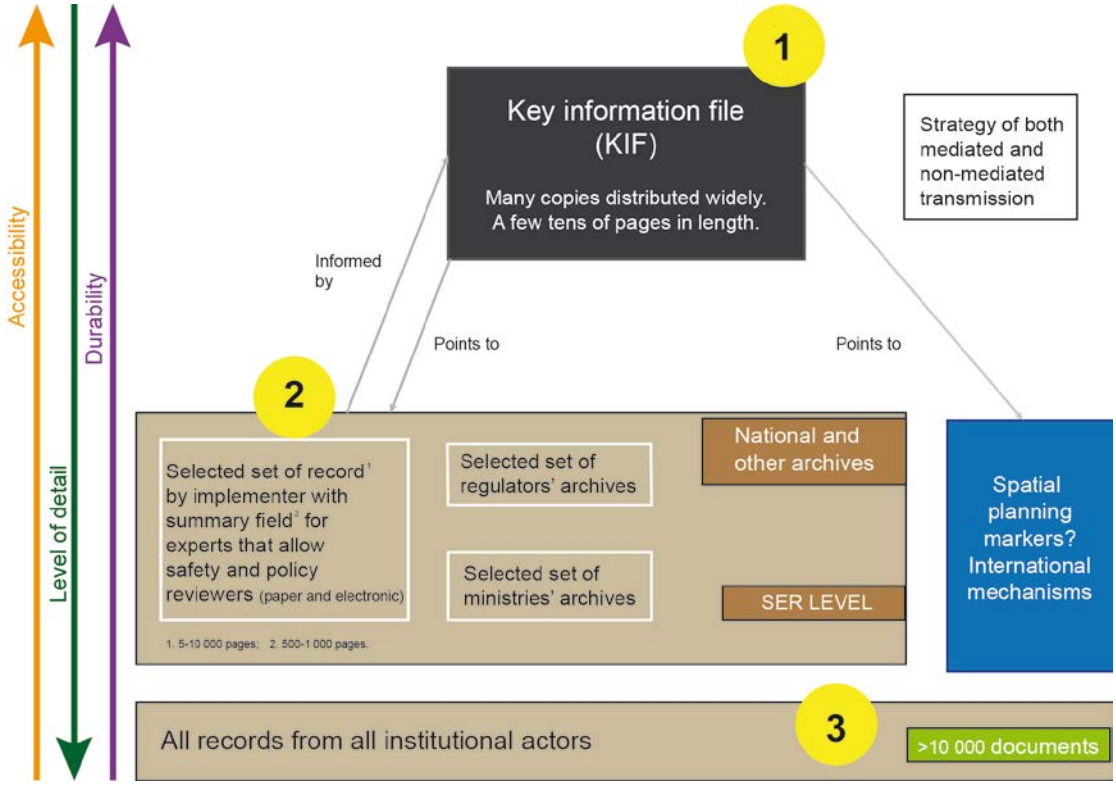
Discussion Group 2: Key information file

- (Moderator: Claudio Pescatore – Secretary: Anne Claudel)

As a basis for discussion, the RK&M initiative's systematisation of repository information in three levels was presented. With reference to Figure 2, the top level (level 1) consists of the key information file (KIF), level 2 is the set of essential records (SER), and level 3 consists of all records as they are typically transferred to the archives.

The group insisted on the principle of maintaining accessibility to as much information as possible and for as long as practicable. The reasons for this included reducing the probability of inadvertent intrusion as well as facilitating retrievability. The majority of participants were of the view that no discarding of documents should take place, even though it was acknowledged that large collections of records are difficult to access and understand. Care should be taken to structure the collections in a meaningful way and to include appropriate retrieval tools to facilitate access and interpretation. The three-level systematisation is a good step in that direction.

Figure 2: Systematisation of repository information in three levels



There was consensus on the need for synthesis documents or document collections, in the sense of KIFs/SERs, compiled to fulfil the needs of various audiences. It was suggested that the general public will not need the same set of information as specialists, such as the operator of the facility, and the needs of each audience should be respected. Ideally, the KIF should be reviewed and updated regularly. These synthesising files should act as indexes or pointers to more detailed information resources. As KIFs can be duplicated and kept in a large number of locations, they are more likely to survive over

long periods of time than larger collections, which become more vulnerable over the years. However, all levels of detail are important for proper interpretation.

It was pointed out that in many countries records are eventually delivered to the National Archives, which have their own selection criteria and recommendations regarding the structure of records collections (classification schemes). National Archives traditionally cater for the needs of historians. In order to ensure the accessibility and the comprehensibility of collections of technical records, there is a need for collaboration between the National Archives and agencies involved in radioactive waste management. The RK&M initiative could act as a discussion platform for archivists and other specialists interested in this subject.

Discussion Group 3: Avoiding loss of critical records/opportunities of the digital world

- (Moderator: Kevin McMahon – Secretary: Alexander Carter)

The discussion group began with a review of the major factors for the loss of records as identified (NEA, 2014a) in the RK&M initiative:

- natural events and disasters (e.g. floods);
- lack of resources (e.g. inadequate preservation, management, indexing);
- regulatory inadequacies (e.g. agencies only hold what they are required to, often focusing more on data than on knowledge or memory);
- neglect or unlawful activities (e.g. deliberate suppression of flood or contamination records to preserve property prices);
- societal discontinuities (e.g. war, epidemic, mass migration).

The group reached a general agreement that, inevitably, "time eats information" (NEA, 2014a) and that knowledge transfer between generations constitutes a difficult problem; it is important to ensure that future generations understand why such information needs to be conserved and that they also retain sufficient interest in its preservation.

The group moved on to discuss how the loss of essential records could be mitigated. Some proposals were:

- use of multiple storage locations to provide redundancy;
- use of national archives;
- application of robust and well thought out regulations.

There was a discussion about how much information should be preserved, with some persons suggesting that all information should be preserved ("how do we know what will be required in the future, especially if unexpected technical problems arise?") and others suggesting that we should be selective ("by keeping everything, we will end up not finding anything"). In this regard, international standards or guidelines that would be common to all were judged beneficial.

If large amounts of information are stored, the group felt that there need to be some criteria to identify critical/essential records. These should be developed by considering what is likely to be important to future generations and what story we need to tell them to understand what present generations have done. The RK&M idea of three levels of information with a common key information file was widely supported.

The group discussed the nature of the waste being disposed of, some participants voicing their concerns that, in time, some components of the disposal system may become valuable resources (e.g. lead, copper, iron, or even the radioactive materials themselves). Bearing in mind that the materials may not remain waste, some participants wondered whether they should not continue to be stored on the surface.

If such materials do become valuable in the future, information and records must be available to help future generations realise how hazardous future retrieval may be. It was also noted that this may not always work in a benevolent fashion (with reference to, for instance, the present-day theft of copper cables). Others were of the opinion that RK&M should be kept not for the waste but for human health. The idea was also expressed that a deliberate loss of all records may actually be beneficial. However, there are two significant counter-arguments against this approach: firstly, to prevent accidental intrusion while exploring natural resources, and, secondly, to prevent non-factual information about the facility entering folklore and attracting future archaeologists or explorers.

There was a brief discussion about the role that digital archives may play in the future although many people felt that paper was a "tried and tested" medium (lasting at least 300 years) which should be supplemented, rather than replaced. Digital archives, however, do have several advantages, such as easy dissemination of large volumes of information to multiple locations quickly and efficiently; improved searchability; and the chance to store links between pieces of information via metadata. It was noted that for large volumes of information (reference was made to the Yucca mountain nuclear waste repository licensing with around two million documents), digitalisation may offer the only practical solution, although it was also pointed out that previous digitalisation efforts (such as the Domesday book) had been less successful than hoped. Again, it was felt that a multi-level approach would be best, with the most important information being stored in multiple ways, including paper.

Session 2 – Medium term: Period of continued oversight

The concept of oversight, its connection to memory keeping and its relevance for the medium term – the findings of the RK&M initiative (Stephan Hotzel)

The medium term was introduced as the period of indirect oversight after repository closure, with timescales in the order of a few hundred years. While the importance of intrinsic control or "passive" safety features in the post-closure phase of a geological repository has been recognised and stressed before, the role of oversight, by providing the capability to reduce or avoid some exposures, has come to the fore only recently. Oversight for the time being generally refers to "watchful care" and society "keeping an eye" on the technical system and the actual implementation of plans and decisions. In some regulatory frameworks oversight is indirectly required, for instance when mandating the creation of a land exclusion zone. In other frameworks, oversight is directly required, as illustrated, for instance, by the long-term stewardship concept of the US Environmental Protection Agency. Although sheer memory of the presence of the facility cannot be enough to constitute oversight, oversight and RK&M preservation do go hand in hand. For example, monitoring after repository closure fosters RK&M preservation, and vice versa. The presenter focused on terminology, potential oversight measures, and on roles and responsibilities of different stakeholders.

Heritage messages of post-nuclear natures (Anna Storm)

Anna Storm, a scholar examining post-industrial landscapes, explained how abandoned industrial sites often carry a multitude of meanings, from pride to fear, from technological beauty to danger. After some time nature takes over these sites, either due to a conscious human strategy or as spontaneous overgrowth. Like scars, they ambiguously combine a variety of physical and mental properties. There is a thin line between "healing" and "concealing"; the presenter asked, for instance, how future generations will perceive a closed nuclear waste repository covered by forests. More generally, she encouraged reflection with regard to the potential heritage messages of post-nuclear sites, and proposed the mirroring of human nature interactions to articulate, over time, the message that "something happened here".

Researching the great hedge of India: RK&M lessons on what to do and what to avoid for memory preservation (Roy Moxham)

The "Great Hedge of India", a 3 700 kilometre-long hedge installed by the British customs to safeguard the colonial salt tax system and avoid salt smuggling totally faded from both memory and records (e.g. maps) in less than a century. Roy Moxham found traces of the hedge in a book footnote and searched it for several years until he found its meagre remains. The speaker wrote a book about this quest. He said that this story reveals how things disappear when they are no longer useful and, especially, when they are linked to parts of history that are not deemed particularly positive (the hedge was a means of colonial power).

Archival and museum curatorship challenges for RK&M preservation (Christophe Jacobs)

Heritage institutions, such as national archives, libraries, museums and monuments, face numerous challenges to their durability: political and geopolitical hazards (such as armed conflicts), natural hazards (such as floods), economic and social hazards (such as censorship and book burning) and everyday hazards (such as small-scale fires). For those running heritage institutions it is difficult to anticipate and adapt to these threats. However, a number of successful strategies to meet them and develop resilience have been formulated at the international (e.g. 1954 Hague Convention protecting heritage in times of war), national (e.g. guidelines to protect heritage sites from natural disasters) and local levels. Local communities and associations of heritage professionals appear to be of particular importance for contributing to the resilience and survival of these institutions.

Group discussions on the medium term

Discussion Group 4: International mechanisms

- (Moderator: Georg Lindgren – Secretary: Erik Setzman)

To start the discussion, the RK&M initiative's definition of an international mechanism (IM) that supports RK&M preservation was mentioned: "a mechanism for RK&M preservation that has an international influence, scope or support and is based on international co-operation" (NEA, 2014b). It can be governmental (intergovernmental mechanism – IGM), which implies mutual agreements between national governments or non-governmental (international non-governmental mechanism – INGM).

In the discussion group the aims and drivers for IMs were discussed and it was observed that such mechanisms can improve chances of success of RK&M preservation, for instance, because they add redundancy. Furthermore, the openness and transparency that may come with such a mechanism can be a good basis for stakeholder dialogue. International comparisons that could be undertaken within the framework of IMs can also serve as a quality assurance for national strategies. Finally, it was observed that an IM may be a way to foster international standardisation.

The view was expressed that standardisation, with a harmonisation of symbols and markers all over the world, is favourable. However, the countries implementing radioactive waste facilities first should not automatically be the ones to set the standard; co-operation among both more and less advanced programmes was argued for. It was also noted that difficulties have been experienced with standardisation efforts in general among national programmes (e.g. waste categorisation). However, its necessity was agreed upon, especially in light of the timeframes involved in radioactive waste management. It was found that the aim should be to standardise some minimum content (data and metadata), thus also supporting the idea of a KIF, but not the concrete ways national programmes should go about RK&M preservation. Standardisation of messages does not have to mean standardisation of practices. It should be more about procedural standardisation, and national specificities should be taken into account. As for siting,

models cannot simply be copied across borders. In this regard, the fact that representatives from the continents of South America, Africa, and, to a large extent, Asia were absent at the conference was mentioned, recognising that these, nevertheless, make up a large share of the world's population. It was thus recommended to include these countries, including those without nuclear programmes, in future meetings addressing RK&M preservation issues. "Respect" and "sharing" were put forward as key terms.

Discussion Group 5: Archives

- (Moderator: Christophe Jacobs – Secretary: Arne Berckmans)

In order to set the scene for the diverse participants of the discussion group, a few concepts were defined based on the glossary of the RK&M initiative:

- Archives are defined as a "collection of records that have been selected for permanent preservation due to their continuing administrative, informational, legal and historical value as evidence of the work of the creating organisation or programme".
- The medium term refers to "the period of time of indirect oversight activities that would follow repository closure". This implies that the waste is no longer readily accessible. "Indirect oversight after closure" includes monitoring of radioactive release pathways under a variety of institutional arrangements. Land use controls will exercise further oversight of the repository at all times and are part of the protective measures that can be enforced.

It was mentioned that archiving in the short term will need to take into consideration the fact that at a later stage (medium term) the focus will change from operation activities to post-closure (monitoring) activities. As such, a new subset of knowledge and information will be needed. It was suggested that these knowledge subsets can be, at least, partly anticipated by constructing "what if" scenarios and supplying appropriate answers ("how to" topics) to questions springing from such scenarios. Moreover, it was felt that significant care should be taken on supplying sufficient context to all the technical data, in order to enable future generations to understand why things were built and why monitoring was and/or is done ("why" topics).

It was advised that apart from archives on acid free paper or other "permanent" carriers, all knowledge stored on digital carriers should be migrated to more recent software products on a regular interval (for example, every five years).

It was mentioned and acknowledged that history shows that to assure a transfer of knowledge about a given topic or issue, it is imperative that the knowledge is absorbed and embedded in the day to day life of a variety of stakeholders. This might not be relevant for the medium term, when indirect oversight is implemented by a given agency, but should the assigned agency fail for whatever reason (war, economic disruption, etc.), a redundant mechanism should be able to take over in the sense that local stakeholders, for example, will try to assure oversight, which is why they need to have knowledge about and of the disposal site.

Therefore, in order to assure accessibility of archives in the medium term, knowledge should not only be stored in national archives or with interested parties such as the regulator or the entity responsible for the site oversight. Certain subsets of knowledge, such as basic knowledge of the disposal site, the area where no excavation activities, drilling, groundwater pumping etc. are allowed, need to be disseminated to other relevant parties, discussion participants said. It is, thus, not a question of duplicating the same knowledge at different places, but to extract sets from the archives tailored to different stakeholders in society.

Discussion Group 6: Transfer of responsibilities/cultural provisions

- (Moderator: Johan Swahn – Secretary: Simone Brander)

All participants agreed that transfer of responsibilities would take place. Although it is important to discuss the issue of responsibility transfer now, the opinion was also expressed that future generations should have the possibility to make their own decisions, and that it would be arrogant to presume that all questions can be answered today. Participants from the local communities highlighted that it is important to have regulations in place before the start of a project, in order to know how future RK&M transfer would take place.

In order to avoid that safety responsibilities would pass to the local level after the implementer ceases to exist, it was suggested that responsibilities would be transferred to the state after repository closure. The *polluter pays principle* was called upon: a fund should be established by the waste producers, to be transferred along with responsibilities. It was also acknowledged, however, that in the long run it is difficult to secure money in a fund according to the polluter pays principle.

It was mentioned that the envisioned responsible institutions should already be involved today, to avoid the loss of information.

Regulation for responsibility transfer was supported, but only in a general manner. Clear principles should be defined as part of the licence application, but specific guidelines should follow in the process of the project. Some expressed the importance of public participation in developing regulations for the transfer of RK&M responsibilities. International standards, for instance by the IAEA on record keeping, were deemed helpful in this regard, but regulation should fit the national level, for instance related to land use. Keeping in mind the volatility of national boundaries, the importance of the international level was also mentioned specifically for safeguards. Oversight, on the other hand, was perceived as more of a local issue.

Overall, it was said that risk management needs to be organised in such a way that an international mechanism can take over if a state fails at the national level. The local, national and international levels were thus all mentioned, but for different responsibilities, and there was some discussion on what regulation should specifically cover.

The International Commission on Radiological Protection (ICRP) guidelines of continuing forms of oversight for as long as practical was also discussed. Although all participants seemed to agree with the principle, there was no clarity about what it meant exactly and what compliance would consist of. A comparison was made with the dike maintenance system in the Netherlands. It was pointed out, however, that, for this case, the threat is clear and visible (danger of flooding), while for the case of geological repositories it is more complex. “You have to see the problems to know that you have to prepare” and “why would you believe in information when you do not see the problem?” it was said. The current situation in Syria was brought up and the group tried to imagine how to deal with geological repository oversight in such a situation. The relevance of international mechanisms came to the fore in this regard.

Day 2. Closing lecture by Peter van Wyck

Prof. Peter van Wyck’s lecture drew from Crutzen and Stoermer’s concept of the Anthropocene and argued for its theoretical, practical, and rhetorical value with regard to the broad set of concerns that brought participants to Verdun. As an ontological claim, the Anthropocene offers a conceptual challenge to any meaningful distinction between “human” and “natural” history: the human and natural are globally merged like never before (referring to issues such as global warming, biodiversity, space debris, etc.). The Anthropocene is a new fundamental concept and a philosophical event. It marks, for

instance, the time when we ask for consideration of time scales beyond anthropometric dimensions. Within the geological, social, and human sciences, one of the questions of the Anthropocene circles around when it would have started. There are various competing ideas about this. Some date it back to the acquisition of fire, others to the Industrial Revolution, and others to the great acceleration of science and technology in the mid-20th century. Nuclear energy has also been suggested as a signature. Overall, Prof. van Wyck suggested that the Anthropocene, as a kind of cultural meme, offers a moment in which cultural awareness around questions relating to nuclear energy may be broadened and enhanced.

Session 3 – Long term: Period with no oversight

Preservation of records, knowledge and memory in the long term – the findings of the RK&M initiative (Anne Claudel)

In line with the RK&M initiative's glossary (NEA, 2014b), the "long term" was introduced as the period of time after repository closure with no repository oversight, extending over hundreds of thousands of years. Anne Claudel focused on the RK&M initiative findings regarding markers. She explained that, although they have often been presented as the main method to preserve memory and deter human intrusion, the RK&M literature survey on markers shows that there are no straightforward, conclusive answers to the objectives, messages and methods of marking. Even if they remain physically intact and traceable over time, future neglect or misunderstanding of their meaning cannot be ruled out. It was thus announced that the potential role of markers for RK&M preservation should be studied within a systemic approach to RK&M preservation. For instance, RK&M will investigate further the interaction of markers with other methods and tools, and the potential of internationally standardised markers.

Could the landscape preserve traces of a deep underground nuclear waste repository over a very long time? A study of the French case (Dominique Harmand)

Prof. Dominique Harmand presented a study conducted on behalf of Andra that focused on the archaeology of abandoned underground mines in order to illustrate how ancient human activities have left traces in the landscape. Old mines often have left some traces at surface such as slag heaps and parts of shafts over relatively long timescales, up to thousands of years. Geological disposal projects are equally likely to leave traces in the landscape over time. In the case of the French Cigéo project (*Centre industriel de stockage géologique*), research into the past and future geological evolution of the area shows that traces of heads of shafts and inclined tunnels, and filled excavations will likely still exist at surface in the distant future. However, as these traces could be confused with other human and natural traces of all ages, steps need to be taken to ensure that they are correctly interpreted. A suggested approach to facilitate the correct interpretation in the future consists in marking the site, and especially its long-lasting traces, with long-lived anthropological elements, such as small engraved ceramic pieces. These could be placed around the repository's surface buildings, but also in drill holes that would be a few metres deep. As a result of the natural erosion of the site, they would progressively reach the surface of the area in the long term.

Semiotics and the long term: Research avenues and current results (Eleni Mitropoulou)

Prof. Eleni Mitropoulou presented an ongoing study, undertaken on behalf of Andra, on long-term communication. The speaker highlighted that it is not so much the marking that needs to be sustainable, but above all what the marking communicates. She highlighted the importance of sustainable human action to produce memory and, thus, the need to reconcile the passive character of geological disposal and the active character of memory keeping. Focusing on semiotics, the interaction between the short, medium and long term was pointed out, highlighting the need to create a relay system.

A multidimensional message was proposed, for the purposes of information ("storage site here"), interpellation (to warn, prevent or alert) and integration (with regard to the surrounding environment). This corresponds to the systemic approach of the RK&M initiative, which is based on a variety of RK&M transmission mechanisms that are integrated with and/or complement one another.

Archaeology and the long-term future: Managing nuclear waste as a living heritage (Cornelius Holtorf and Anders Högberg)

Archaeology, the study of the remains of the ancient past, may be relevant to the long-term preservation of RK&M, because it works to recover information, knowledge and meaning that have been lost. As a discipline, archaeology studies how the past is understood in the present, potentially drawing lessons that could guide future action concerning the preservation of RK&M across time by indicating how future societies could make sense of the past. Case studies, such as an examination of European megalithic tombs, show that the understanding of the past varies across time. It was emphasised that archaeological interpretation always reflects contemporary perceptions of past and future, which are socially and culturally embedded and highly mutable over time. What is more, archaeology is a fairly recent discipline and there is no certainty that it will exist in the long term, to help recover and reconstruct lost RK&M. As a result, it cannot be assumed that information, knowledge and meaning of the past can be transmitted reliably in the long term. Based on this understanding Profs. Cornelius Holtorf and Anders Högberg made a case for trying to keep knowledge alive over time, continuously engaging each present. They used the notion of "living heritage", which refers to striving for continuity in the short and medium terms as a way to reach the long term, keeping in mind that reinterpretation and knowledge development over time is a given. As a result, they suggest to "think about the long term but act for the short and medium terms".

Group discussions on the long term[1]

Discussion Group 2: Markers and beyond

- (Moderator: Cornelius Holtorf – Secretary: Stephan Hotzel)

Discussion participants identified two poles with regard to marking: on one side, extreme marking to provide as much information as possible, as accessible as possible, for as long as possible. On the other side, no marking of the repository site in order to avoid stirring curiosity. One will have to find a convincing position somewhere on, or in between, these poles depending on the peculiar situation of the deep geological repository under consideration (i.e. in each country).

International standardisation (possibly with the help of e.g. the United Nations Educational, Scientific and Cultural Organization [UNESCO]) of, at least, some types of markers was considered a good idea as it could ease comprehension and create a link between sites, which was judged highly relevant over time (global recognition). However, risks were also pointed out; if the selected common marker is not understood, this is a common failure across sites.

It was agreed that the work on markers should not focus only on the long term; in light of oversight, they have importance for the medium term, too. Overall, participants saw markers functioning as pointers to where to look for more information. A "marking strategy" is thus needed, rather than just markers. Markers should be complemented by,

1. The discussion summaries include additional remarks made by F. Boissier (Andra, France) during the plenary session synthesising the group the discussions on the long term.

at least, a minimum key to interpret them, like the Rosetta Stone method, since language is likely to change.

The idea of time capsules, a cache of records or goods, intended to outlast long time spans before being opened, was also discussed. These could be included in repositories.

"Authentic marking" could increase credibility of the markers it was said, i.e. to develop natural (unintentional) traces of the disposal activity like landscape "scars" or "surface (and possibly sub-surface) traces" into markers.

Discussion Group 3: Facilitating knowledge reconstruction

- (Moderator: Thomas Kaiserfeld – Secretary: Evaristo Bonano)

The purpose of this discussion group was to examine ideas and thoughts about how to reconstruct knowledge over the long term, defined as the period without oversight.

A key thought, consistent with other discussions groups for both the short and medium term, was the need for redundancy. It was not clear who shall secure the available knowledge and facilitate the reconstruction of knowledge that may have been lost or misplaced: Should it be groups that have a personal interest (or passion) in preserving the knowledge or should it be groups – such as a formal institutions or organisations – that are either paid or required by law or regulation to preserve existing knowledge and reconstruct lost or misplaced knowledge?

There was agreement among the discussants that synergies should be developed and implemented with similar efforts to preserve knowledge. For example, it was mentioned that advantages should be taken for developing systems to preserve knowledge for nuclear waste jointly with similar efforts about chemical or conventional waste, and that links should be established between the NEA's RK&M effort and similar efforts in other international organisations.

It was suggested that a "reflective approach", rather than the direct or technical approach, could be considered, deciding what knowledge should be preserved and how it should be preserved by examining what the value associated with preserving the information or knowledge is and who would be interested in this information in the future. Should it be a "human" value in the interest of protecting human health and safety, or should it be the potential future economic value of the waste and/or of other materials buried with the waste?

It was also discussed that maintaining massive amounts of records could, perhaps, be of less importance than preserving key messages or specific pieces of knowledge, due to the uncertainty of how sophisticated future generations would be. It was mentioned that attempting to decide at the present time how to organise and preserve knowledge for generations more than tens of thousands of years in the future was a rather utopian undertaking. Instead, an evolutionary approach to maintaining the information that would allow adapting the methods and techniques for knowledge preservation to be consistent with generations at specific intervals in time might be a better approach, helping to address the uncertainty associated with the level of sophistication of future generations. One important aspect of this "adaptive approach" should be educating younger generations about radioactivity and nuclear waste matters.

Discussion Groups 4 and 6: Cultural heritage

- (Moderators: Peter van Wyck and Hans Codée – Secretaries: Jantine Schröder and Sofie Tunbrant)

Cultural heritage was explained as referring to the legacy of a group or society that is maintained in the present and bestowed for the benefit of future generations. It includes tangible heritage (such as buildings, monuments, man-made landscapes, books, works of art and artefacts), intangible culture (such as folklore, traditions, knowledge), and

components from the natural world (such as culturally significant landscapes, geologies, and biodiversity) (NEA, 2014b). The aim of the discussion groups was to reflect on developing this concept further for RK&M preservation in the context of geological disposal over the long term.

Cultural heritage mechanisms

Reference was made to the "Old Weather" project where members of the public are asked to help scientists recover worldwide weather observations since the mid-19th century by transcribing hand-written weather log-books into digital records. It was noticed that preserving and making use of records requires an "understandable" topic, something part of popular of public knowledge. For RK&M mechanisms to work, it is necessary to know what is being recorded and marked. Measuring radiation should become as common as measuring the weather, it was argued, and since Fukushima Daiichi, it has indeed become much more common, at least in Japan.

However, it was also pointed out that the proliferation of measurements could lead to confusion, for instance about knowing the difference between detecting a waste site or simply natural radiation. In this context, the importance of redundancy and a systemic approach was raised again, for instance by adding markers to waste sites that reveal the "man-made" essence. Other proposals were to elaborate the site of the repository into a place which would encourage to seek additional information than that on the repository, for instance by moving the National Archives there, or, if appropriate, to make it a place of valuable nature and biodiversity worth visiting and informing oneself about. Whatever it will become, local interest was judged indispensable to preserve the site and its associated RK&M in a good condition.

One group also thought that preservation of memory through rituals might work, as they relate time, format and content to something that touches and engages a wider public. But rituals are not created by themselves, it was added; some kind of organisation has to start and make the event interesting, enjoyable and beneficial to a wide public, in order for it to survive on its own merits.

In both discussion groups, the establishment of a network at the international level between the sites was judged desirable, but the concrete modalities to do so remain unclear.

Can and should a deep repository become cultural heritage?

One group was positive about the connection between radioactive waste repositories and cultural heritage, and saw it as a means to shift the discourse from burdening future generations to creating something of interest.

The other group was more critical. For one, it was mentioned that the "invisibility" of waste is a challenging issue, which makes it difficult to turn it into cultural heritage (a comparison with ancient drawings was made, arguing that we can relate to those as we recognise people, animals, and other elements). On the other hand, it was pointed out that in some parts of the world, France for example, acknowledging industrial heritage has become increasingly common. It was questioned whether we should perhaps stop using the word *waste* in order for geological disposal sites (GDs) to become part of cultural heritage.

More fundamentally, this group asked whether we even want GDs to become part of cultural heritage. Cultural heritage is about keeping something "alive", raising the question whether this does not contradict the idea of final, "passive" disposal, and the main aim to prevent human intrusion. It should be examined whether markers could be considered as invitations for intrusion.

As a response, it was suggested that things that have received dedicated collective attention over a substantial period of time will, in any case, leave traces that will be interpreted one way or the other.

The question then is whether we should try to let these traces be as trivial or as eye-catching as possible? In response to this question it was asked what the true aim for RK&M preservation is. If the answer is safety, the risk of inadvertent intrusion was judged to be minimal by some participants, the reasoning being that if people can dig that deep, they are very likely to be also able to measure radioactivity (for instance, before we start mining activities today, we also do a survey which would detect anomalies). In sum, the key question asked was whether there is a consensus about keeping oversight for as long as possible. The answer was yes, but there was no view about how this might be achieved. In this regard, contradictory regulation was also pointed out; that is, on one hand, requiring site remediation to restore the initial state of the area, while on the other hand asking, e.g. to mark it.

Discussion Group 5: Systemic approach

- (Moderator: Simon Wisbey – Secretary: Joaquín Farias Seifert)

The RK&M initiative supports a systemic approach to RK&M preservation. A definition of this concept is included in the initiative's glossary: "An RK&M preservation method whose components offer a variety of RK&M transmission mechanisms that are integrated with one another or that complement one another with a view to maximising information accessibility, understandability and survivability over the timescale considered" (NEA, 2014b).

Firstly, group participants discussed the question of what a systemic approach should include. It was said that it should provide a message to future society. The examples of ancient messages may help in its design (materials, symbols, and messages). The existence of archives, although necessary, is not sufficient to ensure the preservation of RK&M. An active role for local society may provide a tool for maintaining interest in the site. Educational use of archives is also a possibility. Other land uses complementing its use as a radioactive waste repository were also suggested, for instance hazardous and toxic wastes disposal and mining debris. It was also suggested that, close to the waste, in the repository galleries, markers with information on the content of disposal elements may help in case of a severe intrusion. And the necessity to preserve metadata concerning the buried wastes to properly understand the information preserved was also pointed out.

Secondly, the question of how can it be implemented was discussed. The international level was considered essential. International organisations should help to implement elements of the systemic approach, and to maintain a network of archives, as a key tool for the identification of their location.

It was also mentioned that, since the repository should be considered eternal, society might consider it as a monument as a whole. The visible part, at the surface, needs to be pinpointed preferably using the same system of markers as other repositories in other countries. Establishing and maintaining cross references among them should be useful to identify any particular repository. It was proposed that to design this system of markers, archaeologists might be consulted, for markers to be properly recognised considering their usefulness both at international and intercultural levels, now and in the future.

Lastly, areas needing attention were discussed. Any unique documentation system is highly vulnerable with respect to technological changes (needed for the interpretation), it was noted here. The risk of rapid obsolescence would make the reconstruction of information, if possible at all, very costly. The fact that metadata is time sensitive was also mentioned, and attention should be placed on creating a system of metadata transfer not relying on the present context. Finally, participants said that ethical issues should also be considered when elaborating a systemic approach. It is clear that future generations will live with the consequences of our present activities, therefore we are expected to do the best we can to reduce the transmitted risks. It means that while we

should not hand over full responsibility, we should also enable them to make their decisions in an informed manner.

Session Chair's report and further reflection on group discussions on the long term (Fabrice Boissier)

Fabrice Boissier reported on the discussions that were held on the long-term period, which is characterised by the lack of societal oversight. He stressed that the medium term should last as long as possible, including millennia. And if a period without oversight begins at one point, ideally, the aim should be that oversight could start again. In this view, a "medium term" type of situation could once again exist after an interval of "long-term" regime. The RK&M chart of oversight periods may need to be updated to reflect this possibility.

He reiterated that keeping memory alive is key. To achieve this, emphasis should be placed on preventing the lack of, or the decreasing of, memory keeping, through the systemic approach suggested by the RK&M initiative and through a strong cultural heritage implemented and reinforced in a consistent way, at the national and/or international level. Placing additional emphasis on favouring the regeneration of awareness and facilitating knowledge reconstruction can help increase the longevity of the medium-term and reduce the duration of the long-term, no oversight period.

Conference closure

Summary of conference rapporteur's report (Erik Van Hove)

Prof. Erik Van Hove observed that a number of presentations show that significant progress has been made over the past years, at the technical level (for instance related to record keeping methods) as well as in the domain of corporate responsibility and ethics. With regard to the latter, he referred to the acknowledgement of the need for a new conception (beyond a system of prohibitions) and longer periods of oversight; the fact that within the international co-operation network of the NEA no agency can be found that acts against or despite society's will to manage waste safely and for long periods of time; and the efforts to involve local stakeholders.

Prof. Van Hove expressed the opinion that we should not have the ambition to dictate a distant future of thousands of years ahead. We should consider ourselves to be engaged in a relay run where we have the responsibility to pass the "RK&M baton" in the best possible condition to our successors. To do so, according to Prof. Van Hove, we need to go beyond scientific information and professional practices, which are very context specific and subject to evolution, and go towards the experiences of daily life, which have a universal meaning over time and space. Means to embed disposal projects into daily local life could be, for instance, to add cultural, recreational, educational or ecological value to repository sites, and to involve local communities in the implementation and oversight processes which include the setting up of agencies, activities and related documentation.

References

NEA (2014a), "Loss of Information, Records, Knowledge and Memory in the Area of Conventional Waste Disposal", OECD, Paris, www.oecd-nea.org/rwm/docs/2014/rwm-r2014-3.pdf.

NEA (2014b), "Glossary of Terms: Preservation of Records, Knowledge and Memory (RK&M) across Generations", OECD, Paris, www.oecd-nea.org/rwm/docs/2011/rwm2011-14-rev4.pdf.

Old Weather (2015), Old Weather Project (web page), www.oldweather.org/ (accessed 19 March 2015).

Conclusions from the Constructing Memory Conference

"Constructing Memory: An International Conference and Debate on the Preservation of Records, Knowledge and Memory of Radioactive Waste across Generations" was met with a great deal of enthusiasm by participants. The wealth of new topics, the presence of both specialists and of interested stakeholders, and the structure of the conference that allowed both scholarly presentations and group discussions, were particularly appreciated. Academics found that it laid the basis for new academic research. One participant expressed his appreciation in this way: "It gave me food for thought not only on the issue of nuclear waste information but also on other preservation issues".

Overall, the conference upheld the findings of the RK&M initiative's Phase I and its main work directions. Namely, it confirmed the RK&M overarching findings that:

> *There is no single mechanism or technique that would achieve, alone, the preservation of RK&M over centuries and millennia.*
>
> *An RK&M preservation method is needed whose components offer a variety of RK&M transmission mechanisms that are integrated with one another or that complement one another with a view to maximising information accessibility, understandability and survivability over the timescales considered.*

The RK&M initiative is thus well advised to continue working on a systemic approach for RK&M preservation and to map its various components and highlight their internal synergies.

At a higher level, the RK&M also found confirmation that:

> *There should be no intention to forgo, at any time, records, knowledge and memory (RK&M) of the repository and of the waste it contains. Enabling future members of society to make informed decisions is part of responsible, ethically sound and sustainable radioactive waste management.*

During the conference's long-term session, its rapporteur, Fabrice Boissier (Andra), emphasised the idea that the medium term should last as long as possible and that there should be provisions to help society go back to an indirect oversight regime (like it will be in the medium term), in case oversight was lost at one time (long-term period).

In this sense, the RK&M initiative is on the right track in terms of raising the issue of the transfer of responsibilities for both RK&M preservation and for repository oversight. The need for further attention to the area of knowledge reconstruction was also noted.

The RK&M initiative's work in the area of creating a key information file (KIF), with a table of contents that is standardised internationally, was supported as was the work in the area of international mechanisms in general. Participants agreed that these mechanisms can improve not only RK&M preservation but also favour transparency.

The role of national and local archives was highlighted, and new information was provided on the practical challenges to their continued existence. Local stakeholders, it was underlined, can contribute to their durability and resilience.

Examples were given of markers in association with art to address short-term memory needs, but also of small discovery markers that surface erosion could expose to suggest, thousands of years from now, that "something happened here".

Surface traces of large projects are liable to survive for centuries and millennia, and they could acquire or be given cultural significance, which would extend memory in relation to the place. Examples were also given of how added cultural value could help preserve memory in the short term and prepare for the medium term. However, one example also showed that memory is easily lost if there is no willingness to remember.

Overall, there is worldwide interest in the topic of RK&M preservation across generations. It is an issue that cuts across many other fields in addition to radioactive waste management. Twenty-five per cent of the participants in the conference came from local communities where a waste repository is planned, and from associations that want to preserve local heritage. Progress in the RK&M initiative could federate all these interests and generate mutual learning. A future conference along the lines of "constructing memory" could be a good occasion to mark the state of the art in a few years from now.

Part II. Extended abstracts

Conference opening

The conference opening was held on the first day of a three-day event, at which time the NEA RK&M initiative was presented to the audience and presentations were made to provide food for thought for the following two days. The focus on the cross-disciplinary essence of the conference and initiative was highlighted at this time. Cultural heritage, history, archaeology and archiving all held an important place throughout the sessions and discussions. This section includes the presentation given by Professor Emeritus Klaus Kornwachs, which outlines the impact of technology, organisations, context and responsibility on transmitting information to future generations.

Knowledge for the future – Time eats information

Klaus Kornwachs
Office for Culture and Technology
Germany

Long-term technologies

The need to pass knowledge on to future generations is not unique to radioactive waste management. Think, for instance, of chemical waste, space debris, the location of land mines, or the genetic code of manipulated organisms, etc. (Kornwachs and Berndes, 1999). In all these cases we have to handle the impacts and effects of technologies over the long term. The time frame of these effects surmounts the lifetime of one generation and more. In order to enable future generations to handle this precarious legacy we need to hand on suitable information. However, this is not enough; we have to facilitate the understanding of the very meaning of this information, too (Kornwachs, 2008; Sebeok, 1984, 1990). This can be referred to as a "wicked problem", since the legacy of the nuclear age is distributed all over the world and huge amounts of wastes have been accumulated. There is not yet any solution available which could reduce the half-life of nuclear waste on a large industrial scale (Acatech, 2014).

Time eats information

Information is constantly decaying, e.g. due to copy processes and the limited lifetime of information carriers such as paper, chemical, electronic and nano-storage technologies. For time frames greater than 1 000 years none of the present technologies seems to be long lasting enough or effective by itself. It can be shown that no presently known information and communication technology (ICT) can preserve written or electronically stored information over 4 000 years, say (Kornwachs and Berndes, 1999). The preservation effort would have to include the reception, deciphering, and the semantically correct understanding. The decay of information entails the decay of knowledge. This leads to a decrease of possibilities to act. However, we and future generations need this knowledge (including the basics of physics and relevant technology) in order to be able to take action in the future. This task is still unresolved, both for nuclear waste management and for other issues (Jensen, 1993; NEA, 1995; Kornwachs and Berndes, 1996; Hotzel et al., 2014).

Stable organisations

One can only try to pass knowledge on to future generations via institutions. However, an organisational solution via institutions will not be effective, unless we know what kind of knowledge will be important in the future. Thus, selection processes need to be managed. To do so in an effective way, there are three preconditions:

- We have to transfer not only the scientific and technological information, but we also have to ensure that it might be understood in an adequate way.
- We have to collect the information about nuclear waste sites with the help of stable institutions, which are responsible for the appropriate availability of the data.

- The option "bury it and forget it" does not seem to be a reasonable one. All sites should be kept in a reversible mode. If new scientific or technologic findings will become available, one should have the possibility to manage the waste problem under new points of view. Hence, any information handed on should include the reversibility of the relevant technology.

Information is not yet knowledge

To gain knowledge, it is necessary to understand information as a message in a given context; hence context information (language, culture, technology) must be passed on, too.[1] This is not a technical problem of databases. It remains the question how we can organise public education in technology. Information can be transformed into knowledge, when it has been understood (reception, reading, interpretation etc.). This transformation process needs time. Hence, the availability of information is a necessary but not sufficient condition to gain knowledge. Written papers, databases, web pages, and even books, are not enough, because we do need certain pre-knowledge to understand them. Additionally, we need practice and implicit knowledge to understand the information about the nuclear waste legacy. All this must be kept vivid and well trained (Acatech, 2011). This task cannot be substituted by an automated technology but by already existing institutions like universities, academies or libraries with political support by international organisations like the OECD or the United Nations.

The possibility to act in a responsible way

Finally, we need to clarify the ethical foundation of any obligation to future individuals, whom we would force to deal with our technological heritage. We have also to hand on the strong conviction that the dissemination of information about the nuclear waste for each subsequent generation is essential in order to enable knowledge (Ott, 2014; Kornwachs, 2010). There is a simple ethical reason for that: We should not lead future generations into dilemmatic situations in which they cannot act in a responsible way anymore. The least we can do is to keep them informed effectively (Human Interference Task, 1984). The next generation will have the same task, and so on and so on. This can be considered as a kind of induction. Nevertheless, this will be only a necessary condition for them to keep the possibilities open to act in a responsible way today and in far future years.[2] But it is a way to propagate responsibility.

References

Acatech (2011), *Den Ausstieg aus der Kernkraft sicher gestalten: Warum Deutschland kerntechnische Kompetenz für Rückbau, Reaktorsicherheit, Endlagerung und Strahlenschutz braucht,* acatech POSITION, Springer, Berlin, Heidelberg, www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Publikationen/Stellungnahmen/acatech_POSITION_Ausstieg_WEB.pdf.

Acatech (2014), *Partitionierung und Transmutation nuklearer Abfälle – Chancen und Risiken in Forschung und Anwendung*, acatech POSITION, H. Utz Verlag, Munich.

1. The definition of knowledge is often confused with the term of information. Here, information is defined as something what can be understood. Knowledge is the result of understanding information and of integrating it into already existing knowledge. See Kornwachs (2010).
2. The principle according to which this requirement has been formulated, is: "Act always in a way such that the conditions for the possibility of responsible actions are preserved for all concerned". See also Kornwachs (2000).

Berndes, S. and K. Kornwachs (1996), "Transferring knowledge about high level waste repository: An ethical consideration", in *High Level Radioactive Waste Management*, Proceedings of the 7th Annual International Conference, Las Vegas, 29 March to 3 May.

Hotzel, S. et al (2014), "When dealing with long term, care as to how terms are used: Reflections from the NEA RK&M Project Glossary – 14437", paper at WM2014 Conference, Phoenix, 2-6 March, 2014.

Human Interference Task Force (1984), *Reducing the Likelihood of Future Human Activities that could affect Geologic High-level Waste Repositories*, Technical Report BMI/ONWI-537, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus.

Jensen, M. (1993), *Conservation and Retrieval of Information – Elements of a Strategy to Inform Future Societies about Nuclear Waste Repositories*: *Final Report of the Nordic Nuclear Safety Research Projekt Kan*, 1.3 Nordiske Seminar, og Arbejdsrapporter 1993:596, Nordic Council of Ministers, Copenhagen.

Kornwachs, K. and S. Berndes (1999), "Wissen für die Zukunft: Abschlußbericht an das Zentrum für Technik und Gesellschaft" (Knowledge for the future: Final report for the Center of Technology and Society), in *Berichte der Fakultät für Mathematik, Naturwissenschaften und Informatik der Brandenburgischen Technischen Universität Cottbus*, 3 Bände, PT-03/1999, Cottbus.

Kornwachs, K. (2000), *Das Prinzip der Bedingungserhaltung: Eine ethische Studie*, Lit, Münster, London.

Kornwachs, K. (2008), "Tradierung von Wissen setzt Haltbarkeit von Information voraus", in A. Groh (ed.), *Was ist Zeit? – Beleuchtungen eines alltäglichen Phänomens*, Weidler, Berlin, pp. 69-86.

Kornwachs, K. (2010), "Logische Strukturen technischen Wissens", in K. Kornwachs (ed.), *Technologisches Wissen – Entstehung, Methoden, Strukturen, Acatech diskutiert,* Springer, Heidelberg, pp. 137-157.

Kornwachs, K. (2010), "Zeit zerstört Information. Kann man Tradierprozesse optimieren?" in *Zeitschrift für Semiotik*, ZfS 32 , Heft 1-2, pp.153-173.

NEA (1995), *Future Human Actions of Disposal Sites: Safety Assessment of Radioactive Waste Repositories*, OECD, Paris.

Ott, K. (2014), "Handeln auf Probe für die Ewigkeit? Die Einlagerung hochradiaoaktiver Reststoffe als eine Generationsaufgabe", in N. Karafyllis (ed.), *Das Leben führen? Lebensführung zwischen Technikphilosophie und Lebensphilosophie – Festschrift für Günter Ropohl zum 75. Geburtstag*, Edition Sigma, Berlin, pp. 259-276.

Sebeok, T.A. (1984), *Communication Measures to Bridge Ten Millenia*, Technical Report, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus.

Sebeok, T.A. (1990), "Die Büchse der Pandora und ihre Sicherung – Ein Relaissystem in der Obhut einer Atompriesterschaft", in Posner R. (ed.), *Warnungen an die ferne Zukunft – Atommüll als Kommunikationsproblem*, Raben-Verlag, Munich, pp. 141-168.

Short term: Period until repository closure

Chair: Jean-Paul Minon
Belgian Agency for Radioactive Waste and
Enriched Fissile Materials (NIRAS/ONDRAF)
Belgium

Preparing for the future today: The findings of the NEA RK&M initiative for the short term

(This period covers several decades and likely more than 100 years. The actual duration will vary across national programmes)

Jantine Schröder
Belgian Nuclear Research Centre (SCK•CEN)
Belgium
On behalf of the NEA RK&M initiative

Introduction

The NEA initiative on Records, Knowledge and Memory (RK&M) across Generations is an initiative that expresses, supports and aims to answer to an evolution in long-term radioactive waste management (RWM) thinking over the past decades. In the earlier days, the vision seems to have been that waste management ends with the closure of disposal sites. Oversight after closure was not an issue that was studied, (tacitly) assuming safe oblivion of geological repositories, or that archives, markers and other similar tools would suffice, e.g. to avoid human intrusion and/or to understand the nature of the underground facility. Today, it is recognised that oversight[1] should take place for as long as practicable. The new vision includes the preservation of information to be used by future generations (see Council of the European Union, 2011; ICRP, 2013; NEA, 2014a).

In this paper we want to highlight that such a vision shift with regard to the future requires an accompanying shift with regard to present thinking and practices. To this aim, we will outline some of the studies undertaken within the RK&M initiative that substantiate this finding that the future starts today, and offer suggestions to support its concretisation.

RK&M loss

The point of departure of the RK&M project is that if we do not make efforts to substantiate and transfer information and knowledge, it will, without doubt, get (partly) lost, forgotten, or become inadequate for future sense and decision making. Several case studies, e.g. from the field of conventional waste disposal, demonstrate this finding, as well as the fact that RK&M reconstruction is challenging from a practical, economic and safety point of view. Dedicated studies and presentations carried out within the framework of the RK&M initiative (NEA, 2012: 19-21, 25; NEA, 2014d) reveal moreover that human factors (notably the lack of human, financial and regulatory resources) and not so much technical factors (e.g. material decay) are determinant for RK&M loss, explaining either the lack of information or its (intended or unintended) neglect. In summary, RK&M

1. Oversight is a general term for "watchful care" and refers to society "keeping an eye" on the technical system and the actual implementation of plans and decisions (NEA, 2014a: 6).

loss was found to be a very fast process (decades) that notably has to do with a general lack of awareness of the importance of RK&M preservation issues and the dedicated effort it requires.

Short term – The time until repository closure

Although RK&M preservation may seem to be an issue that is located in the future, RK&M initiative members underline the importance of the short term, of awareness and action in the present. For our topic of RWM RK&M, the short term is defined as the period of time that ends with repository closure. It thus includes both the pre-operational and the operational phases of the repository life cycle. Timescales are in the order of 100 years (NEA, 2014b). The "short term" is differentiated from the "very short term", which is defined as a period of time consistent with staff stability, foreseeable cycles of organisational change and regulatory expectations of periodic safety reviews (timescales of 10 to 20 years) (NEA, 2014b: 7). Our definition of the short term thus reveals that, firstly, this period is in fact not that "short", and secondly, it represents a dynamic phase, in which various actions take place, various actors play a role, important decisions are taken (e.g. how the repository is designed and finally constructed), and enormous amounts of information (explicit and implicit, physical and tacit, structured and non-structured, theoretical and practical, etc.) are produced.

Short-term RK&M preservation is thus concerned both with supporting ongoing activities (the focus of the Radioactive Waste Repository Metadata Management [RepMet] initiative)[1] as with preparing the future (the focus of the RK&M initiative) (NEA, 2014a).[2] It is not only about creating information in an ad hoc manner, but also about proactively working on preserving it and sustaining its accessibility, comprehensibility and relevance. In this sense, the notion of the "long now" was found relevant. It was brought to the RK&M initiative in exchange with the Long Now Foundation, which critically addresses our societies' current short-term thinking, and aims to symbolically embody this philosophy by means of a real clock designed to run for ten thousand years – thus creating engagement in each present (NEA, 2013: 79-80).

Regulation

Cognisance of the importance of short-term awareness and action for RK&M preservation is, to a certain degree, already reflected in present guidance, for instance on record keeping and archiving (International Atomic Energy Agency [IAEA, 2006]; US Nuclear Waste Technical Review Board [NWTRB, 2013]). However, an ongoing study of the RK&M initiative dedicated to compiling a regulatory catalogue has revealed that existing RWM RK&M regulation may lack precision, and seems to struggle with providing guidance beyond archiving records in the immediate context of licensing requirements. Many regulations tend to not recognise explicitly that some records are produced not only to demonstrate compliance but also to inform both current and future generations. Despite silent recognition of the fact that present institutions (such as the implementer and the regulator) will not continue to exist into perpetuity, the issues of the transfer of responsibilities over time are not (adequately) covered either. In summary, a regulatory challenge thus seems to consist in giving guidance on how to connect records with knowledge and memory, and the short term with the medium term (the period currently

1. See the Vision Document of the Radioactive Waste Repository Metadata Management (RepMet) Initiative: www.oecd-nea.org/rwm/docs/2014/rwm2014-2.pdf.

2. We want to highlight the interaction between both, which will be reflected throughout the collaboration between both projects.

conceived as indirect oversight after repository closure (NEA, 2014b). Furthermore, the connection between RK&M and safeguards activities (as regulated by the IAEA and the European Atomic Energy Community [Euratom]) deserves further attention, as it seems to reveal elements of complementarity as well as contradiction (notably related to public versus restricted access to information).

International mechanisms

Awareness of the value and vulnerability of RK&M preservation is reflected by a number of international mechanisms outside radioactive waste management, notably related to the fields of geology and geography (e.g. the Infrastructure for Spatial Information in the European Community [INSPIRE]), environmental protection (e.g. the United Nations Economic Commission for Europe [UNECE] Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters [Aarhus Convention]) and cultural heritage preservation (e.g. the United Nations Educational, Scientific and Cultural Organization [UNESCO] World Heritage Convention). RK&M members share the idea that these mechanisms can constitute a potential resource both theoretically (by means of insights into their functioning) as well as practically (by means of real collaboration) for RK&M preservation in the field of RWM. Several existing governmental, non-governmental and (semi-)commercial mechanisms, varying in scope, membership and resources, are being looked at within the RK&M initiative. Some preliminary insights of this effort are the importance of sustainable funding, the need for redundancy, and the value of a multi-level, multi-stakeholder approach (with specific attention for the local level) (NEA, 2014c: 19). Understanding the pros and cons of international standardisation deserves further attention, as does the interface between RK&M preservation and the long-term role of safeguards mechanisms (Euratom and IAEA).

Insights from US Department of Energy (DOE) Office of Legacy Management (LM)

The main message of the RK&M initiative related to the short term is that RK&M loss takes place rapidly if it is not acted upon in a conscious and ongoing manner that involves various actors and does more than dumping records into archives. This idea has been conceptualised as a "systemic approach" towards RK&M preservation, which refers to an RK&M system deploying a variety of practical means and redundant functions, where various elements are linked to each other, act as indexes to each other, and complement and reinforce each other (NEA, 2014b: 7). Insights on what a systemic approach could look like in practice and what we can do to substantiate such an approach today, were and are being drawn from interaction with the US Department of Energy (DOE) Office of Legacy Management (LM) and the "long-term stewardship" activities it is conducting today for World War II and the Cold War legacy sites across the United States. At all sites, records-related activities are combined with stakeholder support activities. For some sites these activities are complemented with routine inspections and monitoring and maintenance activities. This substantiates the finding of the initiative that records, knowledge and memory components should function as a "team", and that information and warnings must be regularly proved valid to be believed, understood and sustained. What also stands out is the combination of methods used by LM to enable the previously mentioned functions, ranging from archiving records (centrally and locally), running visitors' centres, annual site management activities, to conditional re-use of sites (e.g. turning sites into ecological projects, sports fields, solar energy production systems, or grazing/hay production fields). A thread throughout all activities is the close co-ordination and co-operation with a variety of stakeholders, in which the local level plays a key part, which indeed reveals the importance of clarifying roles and responsibilities and preparing for their transfer (NEA, 2013: 63).

The preparation of a "key information file"

In line with the practical findings of LM and the fact that enormous amounts of information are produced during the short term, a difficult aspect of RK&M preservation is that the knowledge base that is preserved needs to be in a form that is digestible by future actors, for instance those that may be charged with future land-use decision making. Unstructured, scattered, tacit knowledge will not support this need, nor will archives filled with data, implementer decision-reports and regulatory decisions. The synthesised structuring of information is an area that requires further work, not only by the RK&M group, but also by other constituencies and stakeholders. RK&M members aim to open the way by means of outlining a "key information file" to inform decision makers of the future, especially at the local level. Such a file would be widely distributed and provide both a technical and contextual overview of the project in a concise form. It would contain a discussion of the risks inherent in the site, from what chemical and radiological waste components, located at what depth and within what boundaries, and how they may spread over time, as well as a summarised history of decision making concerning the repository. This simplified description can then point to other mechanisms, for instance archives with more detailed information that can be used if experts are brought in to advise decision making.

Preliminary conclusions

In line with the vision that long-term RWM involves the continuation of technical and societal oversight as long as practicable, we should acknowledge the fact that RK&M loss takes place rapidly if it is not acted upon in a conscious and ongoing manner that involves various actors and does more than dumping records into archives. The success of RK&M preservation cannot be judged today by whether they will last for one or ten thousand years. Instead, it lies in establishing and maintaining awareness of the need and responsibility for RK&M preservation in the minds of regulators, operators, stakeholders and, especially in the longer term, the local and regional authorities and general public (NEA, 2013: 108). Therefore, we should not only think about future activities, but act upon the idea that the long term starts today, and that RK&M preservation needs to be prepared for in the present, while the interest-level is high and funding is available (NEA, 2014c: 17). Throughout the initiative in general and this paper in particular, RK&M members aim to give both encouragement and support for this task.

References

Council of the European Union (2011), "Council Directive 2011/70/EURATOM of 19 July 2011 'Establishing a Community Framework for the Responsible and Safe Management of Spent Fuel and Radioactive Waste'", in *Official Journal of the European Union*, 2 August 2011, L 199/48.

IAEA (2006), *Data Requirements and Maintenance of Records for Spent Fuel Management: A Review*, IAEA-TECDOC-1519, IAEA, Vienna.

ICRP (2013), "Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste", ICRP Publication 122, Annals of the ICRP, 42(3), International Commission on Radiological Protection.

NEA (2012), "The Preservation of Records, Knowledge and Memory (RK&M) across Generations: Scoping the Issue: Proceedings of the first RK&M Workshop, Issy-les-Moulineaux, France, 11-13 October 2011", OECD, Paris, www.oecd-nea.org/rwm/docs/2012/rwm_r_2012_6.pdf.

NEA (2013), "The Preservation of Records, Knowledge and Memory (RK&M) across Generations: Improving Our Understanding – Proceedings of the second RK&M

Workshop, 12-13 September 2012, Issy-les-Moulineaux, France", OECD, Paris, www.oecd-nea.org/rwm/reports/2013/rwm-r2013-3.pdf.

NEA (2014a), "Foundations and Guiding Principles for the Preservation of Records, Knowledge and Memory across Generations: A Focus on the Post-closure Phase of Geological Repositories", OECD, Paris, www.oecd-nea.org/rwm/rkm/documents/flyer-A4-rkm-collective-statement-en-2014.pdf.

NEA (2014b), "Glossary of Terms: Preservation of Records, Knowledge and Memory (RK&M) across Generations", definitions as of 3 March 2014, OECD, Paris, www.oecd-nea.org /rwm/docs/2011/rwm2011-14-rev4.pdf.

NEA (2014c), "Expert Group on Preservation of Records, Knowledge and Memory across Generations: Articles about Strategic Aspects of the Preservation of Records, Knowledge & Memory (RK&M) across Generations", OECD, Paris, www.oecd-nea.org/ rwm/docs/2014/rwm-rkm2014-5.pdf.

NEA (2014d), "Preservation of Records, Knowledge and Memory across Generations (RK&M): Loss of Information, Records, Knowledge and Memory – Key Factors in the History of Conventional Waste Disposal", OECD, Paris, www.oecd-nea.org/rwm/docs /2014/rwm-r2014-3.pdf.

US NWTRB (2013), *Review of US Department of Energy Activities to Preserve Records Created by the Yucca Mountain Repository: A Report to Congress and the Secretary of Energy*, US Nuclear Waste Technical Review Board, Washington.

The Nuclear Decommissioning Authority (United Kingdom) Nuclear Archive: The importance of stakeholder engagement

Simon Tucker
Nuclear Decommissioning Authority (NDA) Archives Limited
United Kingdom

Over 70 years' worth of information from the UK civil nuclear industry will be brought together at a new archive to be established in the far north of Scotland. The Nuclear Decommissioning Authority's (NDA) Information Governance team has been working on the project for the last nine years and, it is hoped, the facility will be operational in late 2016.

A vast number of records, plans, photographs, drawings and other important information and data, some dating back to the Second World War, are currently stored in various locations around the country, some at individual NDA sites which are in the process of being cleaned up and decommissioned, and others managed by specialists contractors, see below. Very few of these collections, however, are operated to the standards required by the NDA. The NDA's sites currently hold material in varying kinds of storage, some of it in buildings scheduled for demolition, while some is also stored in off-site locations. Sellafield, the NDA's largest site, is estimated to hold more than 50% of all the records in numerous separate stores, while in excess of 80 000 boxes are held in commercial storage facilities.

The NDA is legally accountable for managing this work and has been developing a solution to preserve the information and ensure it remains secure and accessible for the future, in line with legislation on maintaining public records. The facility will be operated as a "place of deposit" on behalf of The National Archives in Kew, London. The decision to proceed with the project, initially launched in 2005, follows a careful re-evaluation of the options and costs in the climate of ongoing economic constraint.

Once the decision was reached to find a single UK home for all the relevant material, the NDA focused on its four priority regions, where ageing nuclear sites have long been a dominant influence in the local economy and where, therefore, site closures will have greatest local impact. Caithness, with 2 000 people working in decommissioning, was selected as the region mostly likely to benefit, as the effective closure of its major employer, Dounreay, is set to become a reality circa 2025.

The new facility will be located near Wick Airport, not far from the Dounreay site, and will be built to all of the relevant archive standards in the UK today, with the aim of developing a base for training archivists and offering apprenticeships, linking up with the University of the Highlands and Islands, and North Highland College. Much of the information will eventually be digitised and made available for electronic research. Ultimately the Archive will also be responsible for the cross-estate Information Management Policies and Procedures on behalf of the NDA and recognised as a centre of excellence in this regard.

With a total project cost in excess of GBP 20 million, the site is being developed in partnership with The Highland Council, which currently owns the land, and will at the same time provide a permanent home for existing North Highland Archive which has

outgrown its current location in Wick Library. The archive is a popular attraction for visitors and tourists seeking information about their and others' Scottish heritage.

Around 20 full-time jobs will be created, while the construction phase is likely to generate dozens of temporary posts and should lead to opportunities for local contractors. The Archive will also house an enormous number of specialist records including microfiche and moving images, currently stored on all sorts of media across the Estate. This too will present one of the biggest challenges to the staff, one of standardisation and interpretation of best practice for managing these and other types of record.

The NDA is in the process of appointing both a Design and Build Contractor and a Commercial Partner to operate the facility once completed. The National Nuclear Archive project represents a major workstream in the overarching Information Governance Programme (IGP). This programme is being developed in order to meet a number of obligations and opportunities as defined in the Information Governance Strategy.

It was clear from the start that the Stakeholder Engagement plan for this project should not be underestimated. Six groups of stakeholders were identified and a plan to engage with each was (and continues to be) developed as part of the IGP:

- **UK government** – The decision makers have to approve the projects and their funding (sometimes at ministerial level).
- **Regulators, non-governmental organisations (NGOs) and Suitably Qualified and Experienced Person (SQEP) Authorities** – This is a key community in terms of setting the rules and offering advice. Includes, but not limited to: the National Archive, National Archives of Scotland, Office for Nuclear Regulation, Environment Agency (and their regional equivalents), British Library and the Digital Preservation Coalition.
- **Commercial organisations** – The supply chain who will build the facility and deliver the operational services.
- **Nuclear industry** – Considered the prioritised "customers" of the facility. Includes tier 2 and 3 suppliers.
- **Local communities** – Most of NDA's sites are located in areas where the nuclear industry has had, and continues to have, a significant impact on the local community. A decision was quickly taken to seek to co-locate the archive with a local Authority's archive to benefit both organisations in terms of engagement and funding. Accordingly, NDA's Archive will be co-located with the North Highland Archive – a collection of more than 400-year-old clan records. This community also includes local business groups, schools/colleges/universities.
- **The public** – NDA will be operating their Archive with "Place of Deposit" status which will allow them to manage UK government-owned records in accordance with the relevant legislation (Public Records Act and Public Records Scotland Act). This means the archive will be publicly accessible and able to be used by the local and wider communities.

In summary

Do not underestimate the importance of effective stakeholder engagement.

- Programming stakeholder communication and events is critical to ensure consistency and frequency of message. Senior stakeholders like to be communicated with regularly. Do not neglect them!
- Engage with and involve the local community at every opportunity. An advisory panel is a good way to do this.

- Stakeholder engagement is an ongoing process. It does not stop so long as the Archive remains open for business.
- Contractual incentivisation is a good way to get what you want. Service level agreements and scheduled business plans will help to plan this.
- Always consider the staff as critical stakeholders. If they feel valued they are more likely to represent your business as you would expect them to.

What's the story?

Using art, stories and cultural heritage to preserve knowledge and memory

Hans Codée and Ewoud Verhoef
Central Organisation for Radioactive Waste (COVRA N.V.)
The Netherlands

"Once upon a time, a long, long time ago, there were a people that used electricity as a source of energy. In the first years they generated the electricity by burning coal and, later, used oil and gas. In the middle of what was called the twentieth century, they also started to use nuclear fission to produce electricity. Burning carbon products generated, of course, carbon dioxide as a waste, which could not be kept under control. The nuclear fission process generated waste."

This could be the start of a story told more than thousands of years from now. A story told by people living in a way difficult to imagine today. But as we know about the past, it seems unlikely that future generations will be ignorant of the past. Story-telling is an ancient and powerful craft to pass on information to the future. Today, we still enjoy the Iliad and the Odyssey, telling us about the events that took place around 1 200 BC: that is some 3 000 years ago. These poems from Homer are believed to be the oldest literature of the Western world and were written around 800 BC. Between 1200 BC and 800 BC the information was kept alive because the stories were told over and over again. Storytelling is a way to preserve knowledge and memory and when a written base exists then the content can, to some extent, be controlled over time. The oldest written texts are found in Egypt and Mesopotamia. The oldest book is believed to be the Chinese "Diamond Sutra" dating from AD 868.

Even older than the stories and written texts are the pictures that give information to others and pass it on to next generations. The oldest drawings in the world can be found in southern France; drawings of animals, dated by C-14 method, are 30 000 to 32 000 years old. As pictures do not require any knowledge of words and language, the drawings can have a meaning far into the future. At the same time, pictures leave more freedom for interpretation and hence deviation from the original "knowledge". When paintings and sculptures telling a story are also meant to be a thing of beauty, there is a reason to keep them forever. The importance and power of religion, as well as of emperors and institutional governors, is told and passed on to future generations through art. Historical events such as battles, coronations, floods as well as the beauty of

landscapes, flowers and animals are preserved in art paintings and sculptures forming our cultural heritage.

Art, stories, and cultural heritage are long-term tools to preserve knowledge and memory.

The story of time

What is the story with radioactive waste? Radioactivity decays with time, and time will ultimately make radioactivity harmless. In radioactive waste management there is awareness of the importance of time. Managing the waste covers periods longer than a hundred thousand years, entailing that information has to be passed on to many generations to come.

In our daily life, "forever" is generally translated into the period of a human life or three generations, but in radioactive waste management such a period is short term. The awareness of the need to consider timeframes covering many, many generations, or even the period in which homo sapiens exist, should be present in all aspects of environmental management, but is dominantly found in radioactive waste management. Obviously, the reason is that "forever" has no numerical value as compared to the half-life of uranium-235 of 704 million years. Preservation of records, knowledge and memory is seen as an important aspect of radioactive waste management. The tools such as art, stories, and cultural heritage could help us tell the story of management of radioactive waste.

Management of radioactive waste at COVRA in the Netherlands

In the Netherlands, the Central Organisation for Radioactive Waste (COVRA) will store all kinds and categories of waste in buildings for a period of at least hundreds of years. This is done at a central location in the south-western part of the country. After the foreseen period of long-term storage, all remaining waste will be brought into one deep geological repository in salt or clay, scheduled to start from 2130. How to preserve knowledge and memory during the period of long-term storage and communicate the tasks to be executed to at least three generations in the future?

A story of art

The idea of using art to tell the story of radioactive decay was born during the construction of the high-level waste treatment and storage building (HABOG). Discussions with a local artist, William Verstraeten, resulted in a provocative, and as it turned out, brilliant idea. He launched the idea to integrate the building in an art concept. In 2003, he created "Metamorphosis 2003-2103". The inclusion of art in the activities of COVRA shows pride in the work performed. At the same time, art creates opportunities for communication.

The building itself is now a piece of art; it is a statement by itself. The building is an orange object. The colour orange was chosen to represent the metamorphosis of something dangerous (red) into a safe situation (green). To tell a story about the activities inside the facility, on the outside wall three formulas are painted in green. The "Einstein formula", written in the well-known form as $E = mc^2$ as well as $m = E/c^2$ and "Planck's formula", $E = h\upsilon$; metamorphosis from mass to energy.

The decrease in heat production of the high-level waste will be shown on the outside of the building. Every 20 years the building needs to be repainted. This will be done in a colour that is slightly lighter than the last one. After around a hundred years, the colour will be white instead of orange; a fading colour creating a story to explain radioactive decay. Inside the building there are many more relations between the art concept and aspects of waste management. Both are mixed and related, and cannot be separated

anymore. The strictly rational scientific world and the emotional world of art have to become one. With "Metamorphosis 2003-2103" COVRA offered to the local community the largest work of art in the region together with the storage facility for radioactive waste. It is not questionable that the art work will be preserved "for ever".

Figure 3: HABOG changing from orange in 2003 to white in 2103



A story of cultural heritage

How can we explain the long-term aspect of radioactive waste management in a way that people can relate to? The answer is surprisingly simple: show people that we have a very long history of preserving things, things that are often far more difficult to store than immobilised waste. Ask people how long we should preserve our cultural heritage such as the paintings of Rembrandt or Van Gogh. The answer is generally: "forever". The link between the long-term preservation of art and the management of radioactive waste helps people to visualise and trust the concept of long-term management. Interestingly, a real connection with the cultural heritage could be created. Museums in the region where COVRA is situated, have endured shortage of storage capacity for the artefacts that are not exhibited. This represents generally some 90% of their collections. While looking for suitable storage space, the museums and COVRA found each other. The conditioned COVRA storage buildings for low and intermediate level waste have enough unused space to store the museum's artefacts. This space is available as a result of the robust construction of the storage building and this space cannot be used for the radioactive waste itself. The climate conditions are favourable because there are only gradual temperature changes and air humidity is under 60%. In 2009, the storage space has been offered for free to the museums by means of a contract for a hundred years. Such a long-term contract is unique, even for museums. The National Museum of the Netherlands (the Rijksmuseum) for instance, where works by Rembrandt can be seen, only has a 40-year contract with a storage depot.

A story of the future

Telling stories to future generations in view of passing on knowledge and memory is a demanding craft. To make the story last, it has to be a thing of beauty and it needs vivid descriptions that appeal to emotions. Boring, complex, or difficult to understand metaphors, can turn an imaginative journey into a lifeless plot. Emotions are subconscious and they will leave a trace long after the words have been forgotten. Art and cultural heritage give such stories and provide compelling metaphors for radioactive waste.

Now that the storage capacity for both depleted uranium and high-level waste has to be extended, art will be included again. The storage facility for depleted uranium will become a sundial, whereas the extension of HABOG will create a special event only twice a year. The sun will perform a visual play with the building in the same tradition as in Stonehenge or as in the pyramid of Quetzalcoatl in Mexico. To communicate these new plans, a short movie with time animation has been produced.

The combination of art, stories, cultural heritage and the management of radioactive waste may result in long-term preservation of knowledge and memory.

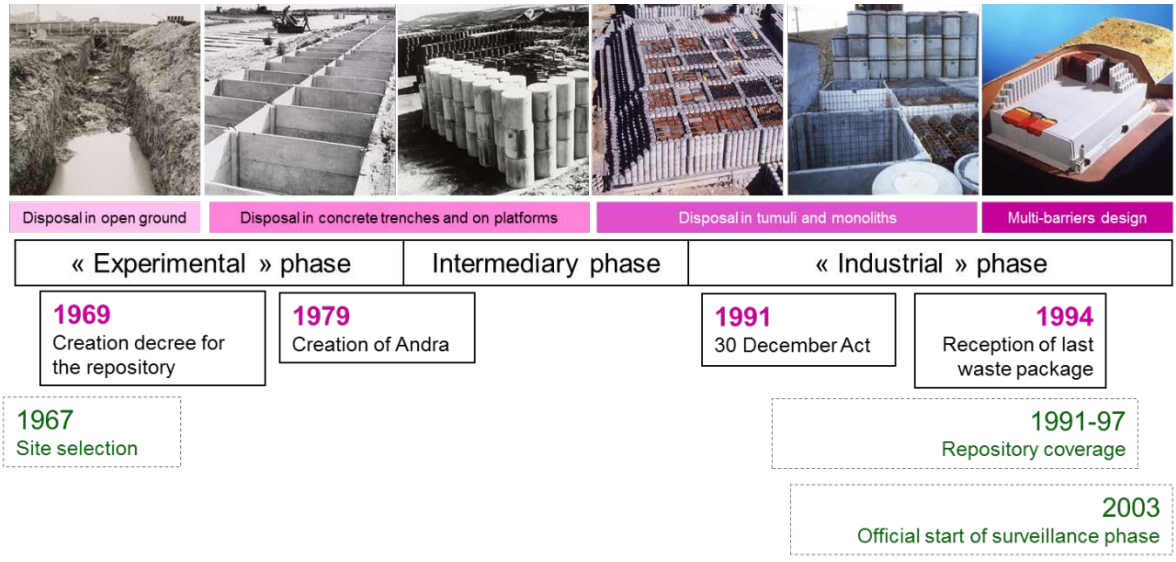
Memory provisions for the Manche Surface Repository

Jean-Noël Dumont and Florence Espiet
French national Radioactive Waste Management Agency (Andra)
France

Introduction

The Manche Surface Repository (CSM), the first radioactive waste repository operated in France, was created in 1969, and received its last waste package in 1994. The closure operations lasted from 1991 to 1997. It entered officially in the surveillance phase in 2003. The surveillance phase will last at least 300 years. The main milestones of the life of CSM are presented in Figure 4.

Figure 4: Main milestones regarding the Manche Surface Repository



The memory provisions of the Manche Surface Repository

As required by the safety authority, memory regarding the repository must be preserved for at least three centuries, corresponding to the oversight period. This requirement relates to the existence of the repository and its content. A complementary objective is to provide knowledge in order to: *i)* understand how the repository was implemented and what is happening on the site; *ii)* correct possible unwanted events; or *iii)* transform the site if desired. A set of provisions has been defined by Andra to allow this. They consist in: *i)* "passive" provisions; and *ii)* "active" provisions.

Passive provisions

Passive provisions comprise three archives provisions: *i)* the "detailed record", set of more than 10 000 documents, enriched with a complementary set every 5 years (surveillance data); *ii)* the "summary record", one single volume describing in widely understandable terms the repository, its history, its inventory; *iii)* public utility easements, reported in documents restricting future uses of the site. The detailed record is copied in two sets; one is kept at Andra, the second is transferred to the French National Archives. To allow durability of the physical support, all documents have been duplicated on permanent paper, according to international standards.

The summary record is written for decision makers and for the public. When stabilised, it will be widely distributed, maybe by thousands of copies: one copy per decision maker (mayor, notary, etc.), one per audience (non-governmental organisation NGO, etc.) and one per organisation or state agency. The diffusion of the public utility easements will be instituted by a ministerial decree.

Why "permanent paper"?

Until the middle of the 19th century, paper was made out of rag. At the beginning of the industrial revolution, its composition was modified by the massive use of wood pulp and rosin during the sizing stage. Those components produced an acid that generated the self-destruction of paper within a few decades.

Therefore, international standards have been adopted for a long-lasting paper, called "permanent paper" (International Organization for Standardization [ISO] 9706 and 11108).

"Permanent paper" allows a long durability, demonstrated over more than three centuries, thanks to its composition: no mechanical wood pulp, no recycled paper, no composite material and no wood pulp mix in the manufacturing process; minimum alkali reserve of 2% in calcium carbonate; presence of lignin providing a high oxidation resistance.

Permanent paper allows easy and intuitive access to the documents, and by-passes the impossibility to demonstrate that digital archives will be legible for at least 300 years.

Active provisions

Active provisions consist in communication activities, vis-à-vis two types of audiences: *i)* institutional partners, such as the French Safety Authority (Autorité de sûreté nucléaire [ASN]), the Local Information and Oversight Committee (Commission locale d'information [CLI]); *ii)* the public in general.

Regarding the public, in order to promote the transmission of living memory, Andra:

- Proposes guided visits all year long.
- Organises exhibitions and events related to memory preservation and transmission.
- Develops partnerships with associations and scientific societies whose missions deal with memory.
- Has established a think tank on memory, composed of local representatives, local residents, former workers from Andra and from the nuclear industry, and artists. Meetings are held several times per year. Work areas include, for example, memory through art, long-term markers, a project of "ultra-summary record", analysis and critical follow-up of work being performed by Andra at the Manche repository, etc.

Another type of active provisions is the periodic review of the set of memory provisions, which will be performed on a ten-year basis, by Andra experts and by national and international experts. The first review was conducted in 2012; it focused on

the detailed record. Two internal assessments were performed in January 2012, followed by the first international assessment in September of the same year. This was prepared by: *i)* an internal critical review in 2009, based on comments from the safety authority (ASN) and its technical support organisation (*Institut de radioprotection et de sûreté nucléaire* [IRSN]) when they reviewed the 2009 Safety Report; and *ii)* a critical review of the summary record in 2011-2012 performed by the CLI.

In the future, appraisals will be organised regularly. This monitoring process, which will be associated to the decennial revisions of the safety case, will aim at periodically testing and upgrading the so-called "passive memory" provisions of the CSM. This could build a kind of local ritual contributing to memory preservation. This process could be subject to validation reviews, outside of the decennial framework.

Constituting the detailed record of the Manche Surface Repository

First phase of implementation of the solution: "Historical reconstruction"

At the beginning of the operation phase of CSM, in the very first years, part of the waste was received without inventory. Knowledge on the waste content had thus to be built a posteriori. This was done through an investigation work and through modelling. Historical data were collected with operators of activities producing the waste, in the various nuclear workshops. Then, radioactive spectra of possible waste were inferred for each of these activities. Finally, waste inventory was reconstructed, residual uncertainties being covered by safety margins.

Second phase: Selection/incorporation

The second phase of implementation of the solution dealt with identification of needs, through a risk approach, consistent with long-term safety analysis. This was followed by the selection of relevant information and knowledge necessary for addressing the needs, which was performed with the help of retired staff from Andra. Then collected information was hierarchised, according to a tree structure. Work was conducted to enhance legibility of information: a glossary was created, acronyms explained, a short abstract was written for each archive box. All the selected documents were printed on permanent paper.

Around 20 000 hours were spent in preparing the first set of the detailed record.

The international appraisal of the detailed record

As mentioned above, in 2012, Andra organised an international appraisal of the detailed record. The appraisal process was prepared by internal exercises in January 2012 with former CSM workers and new Andra employees. It was based on a role-playing game simulating "future memory needs". The scenarios placed the participants in a somewhat far future, in 2262, and they had access to records (the detailed record) related to the CSM site. Information available on the origin and nature of CSM varied according to the scenarios. Participants were asked to imagine that they were facing a green hill (the closed repository), and have to answer a set of questions. These questions were elaborated on the basis of the plausible evolution scenarios defined when the first set of detailed record had been constituted (1995-2000).

The questions had been established in connection with the safety assessment scenarios. They dealt with general understanding of the site and knowledge on the components of the repository, environmental pollution issues and intervention modalities above or inside the site.

The experts had access to a "numerical image" of the detailed record archives (more than 60 metres of archive boxes, several thousands of plans).

Experts had a few guiding tools to get through these thousands of pdf documents:

- The summary record, which in 2262 would have been distributed on a large scale (local, national and international).
- All the guides and search lists elaborated when constituting the successive complementary sets of the detailed record (2004, 2005 and 2010).

Lessons learnt

During the appraisal, the summary record revealed its key role for getting into CSM history as well as into the detailed record, as it is self-supporting and understandable by all public. This appraisal highlighted the importance and quality of the work performed over more than 15 years on memory preservation, which was quite a surprise for some of the participants, and the relevancy of such simulation exercise.

However, some difficulties were also encountered, and issues were raised, for example:

- The detailed record proved difficult to access (structure and volume of documents); it was found that the summary record was the tool most often used for understanding the CSM and getting access into the set of documents.
- New needs were brought to light, for example the need for: *i)* upgrading the environment evolution scenarios, namely on the toxic chemicals aspect and for a better visualisation of the radioactive decay by steps of ten years; *ii)* adding societal documents and iconographic inputs.
- This type of exercise was considered very fruitful for upgrading the memory provisions.

Areas for improvement

- Access to the detailed record: updating and merging the various search methodologies is recommended. This work should be based on the simple and instinctive logic of the summary record. This should lead to simplification and a better access to relevant information, providing in a single document the tools for guiding the search, according to various simple and instinctive logics: chronology, geography, context, etc. Concomitantly, work has to be performed to develop a new classification of the archives. First level documents will be emphasised.
- New documents: work will also be continued on checking the completeness of the archives, possibly leading to introducing records from external sources, and on assessing the relevance of the present selection of records. This will be performed, not only, in the framework of plausible events but also by considering the evolution of environmental protection issues, of societal expectations, or by anticipating events not considered during the initial safety assessment (where no existing archive is available). Work will also be devoted to introducing historical knowledge on the disposal process context.
- Ease of access for all types of audience access to the information provided in the detailed record should be made easier, by adding pictures for example. To help solving understanding difficulties of non-experts, providing knowledge frameworks on specific subjects with a high scientific content (e.g. plutonium) is also envisioned.
- For future appraisals, experts from other realms (ethnologists, sociologists, archivists, etc.) could join the panel.

Current actions and projects

Based on the experience gained from the past, Andra continues its efforts related to memory preservation for the CSM. The main current actions are:

- Improvement of the detailed record: searching methodology, new structure, incorporation of new documents (societal context, press articles, etc.).
- Upgrading of the summary record.
- Periodical appraisals of the memory provisions.
- Perpetuation of the think tank on memory.
- Creation of three herbaria presenting plants growing at the repository. It will include a very short description of the repository ("ultra-summary record"), thus being the first marker of the repository. One of them will be kept at the repository; the others will be kept by scientific institutions together with historical herbaria.

Reference

Boissier, F., P. Charton and G. Martin (2011), "The Long-Term Memory-Preservation Project of the French National Radioactive Waste Management Agency (Andra)", Andra, Châtenay-Malabry, www.andra.fr/international/download/andra-international-en/document/andra---long-term-memory-program.pdf.

Medium term: Period of continued oversight

Chair: Michael Sailer
Institute for Applied Ecology (Öko Institute e.V)
Germany

The concept of oversight, its connection to memory keeping and its relevance for the medium term: The findings of the RK&M initiative

(This period will likely last several centuries after repository closure, extending to perhaps 1 000 years)

Stephan Hotzel
Gesellschaft für Anlagen- und Reaktorsicherheit (GRS)
Germany
On behalf of the NEA RK&M initiative

Oversight as a key concept

Oversight is the new reference concept promoted by the NEA and the International Commission on Radiological Protection (ICRP) for reconciling geological disposal with fundamental principles of radiological protection (NEA and ICRP, 2013). The ICRP states in publication ICRP-122 (ICRP, 2013) how the system of radiological protection – as it was laid down in ICRP-103 (ICRP, 2007) – can be applied to very long periods of time, such as those that are involved in the geological disposal of radioactive waste. It identifies oversight as a crucial factor in this respect.

In the course of Phase I of the RK&M initiative, it was recognised that oversight is a key concept not only because it provides a basis for the applicability of the radiological protection system. It is also a key concept for the preservation of records, knowledge and memory (RK&M) across generations, since the "level" of oversight (see below) has an impact on the availability and applicability of RK&M preservation strategies.

The term "oversight", as used in this context, can be described in the following way:

> Oversight is a general term for "watchful care" and refers to society "keeping an eye" on the technical system and the actual implementation of plans and decisions. […] Oversight is always by people and has a different, partly broader focus than control. Oversight includes regulatory supervision (such as control and inspection), institutional control (e.g. monitoring), preservation of societal records (such as archiving) and societal memory keeping of the presence of the facility. Oversight is complemented with the "built-in controls" carried out by the technical system itself. (NEA, 2014a)

Oversight, repository life phases and reference time scales

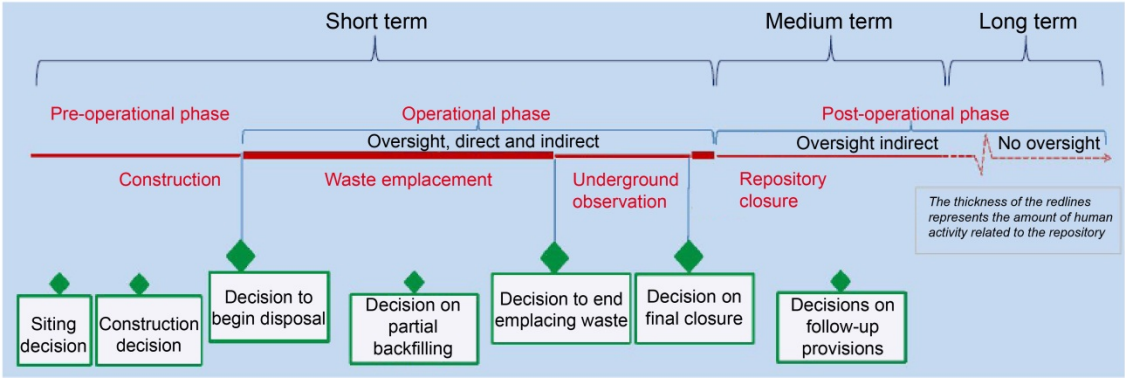
Three "levels" or categories of oversight are distinguished in ICRP-122 (ICRP, 2013) during the repository lifetime: direct oversight, indirect oversight and no oversight, respectively (see also figure):

- Direct oversight refers to oversight of the repository when the waste is accessible. Thus, direct oversight implies the availability of measures comparable to the control functions at other licensed nuclear facilities that handle similar radioactive materials.

- Indirect oversight refers to oversight of the repository when the waste is no longer readily accessible. This will take place when sections of the repository or the whole of the repository are sealed. Any measurement of the state of the technical system is then by remote or indirect means. Indirect oversight after closure may include monitoring of release pathways under a variety of institutional arrangements.
- "No oversight" will be discussed below.

Figure 5, adapted from Figure 1 in ICRP-122 (ICRP, 2013), shows the connection between the repository life phases, the oversight conditions and the RK&M reference timescales.

Figure 5: Repository life phases and examples of associated decisions



In the upper part of Figure 5, in red, the life phases of the repository (pre-operational, operational and post-operational phases) are indicated. They correspond to construction or operational activities with respect to the repository, indicated equally in red in the lower part of the figure. In between those two lines the level of oversight is indicated in black: direct oversight, when the waste is accessible, and indirect oversight, when the waste is not readily accessible anymore, so principally after the closure of the geological repository. Be it direct or indirect, oversight means that society is "keeping an eye" on the technical system and on plans and decision regarding this technical system. Since the post-operational phase extends over the whole time of concern in the safety regulations, i.e. over hundreds of thousands of years in the case of high-level waste, it would be unreasonable to assume that this oversight can be upheld over this virtually endless timespan. Therefore, it must be assumed that there will be a period in the post-closure phase with "no oversight". Along these repository life phases and oversight conditions, the RK&M initiative reference timescales are defined, as indicated in the top line of Figure 5:

- The "short term" refers to the period of time that ends with repository closure. This period includes both the pre-operational and the operational phases of the repository. Timescales are in the order of 100 years.
- The "medium term" refers to the period of time of indirect oversight activities that would follow repository closure. Timescales are in the order of a few hundred years, though it is not possible to foresee the point at which oversight might terminate.
- The "long term" refers to the period of time with no repository oversight. This period extends over the time of concern in the safety regulations, typically over hundreds of thousands of years in the case of high-level waste.

It should be emphasised that there is no intention to relinquish oversight. This view is shared by the NEA Radioactive Waste Management Committee (NEA, 2014a) and it is suggested also by the ICRP (2013). With regard to RK&M preservation this means that removal of oversight is not to be planned for, but planning must be made for potential loss of oversight. This notion can be further developed into a call for a dual-track RK&M preservation strategy, namely, planning now both for a condition where there will be continued oversight and one where oversight is lost. Ideally, with reference to Figure 5, through planning for RK&M preservation, efforts should be pursued to ensure that society is as long as possible in a medium-term oversight situation.

Oversight and control in the short, medium and long term

"Control" can be defined as "the function of directing, ruling, regulating, restraining or limiting" (NEA, 2014a); by and large it means checking something and taking corrective actions, which is not too far from the meaning of "oversight". However, oversight and control are not the same:

- In the short term, direct oversight is effectively the same as regulatory control – like in other nuclear facilities. Sometimes, therefore, this type of oversight is called "regulatory oversight".
- In the long term, when there is no oversight any longer, there can be no control by humans or institutions anymore – or else there would be oversight (and according to the RK&M initiative definition we would be considering the medium term and not the long term). However, control – in the sense of checking and taking corrective action – can be carried out by inanimate objects, too. The ICRP uses the term "built-in control", which is intrinsic control carried out by the system components: by the canister, by the buffer, by the host rock, etc.[1] This intrinsic control – unlike oversight – will still be in place in the long term, and radiological protection in the long term must inevitably rely entirely on these.
- In the medium term, there is oversight and intrinsic control in parallel. They are complementing each other and both of them are important (ICRP, 2013). While the importance of intrinsic control or "passive safety features" in the post-closure phase of a geological repository has been recognised and stressed before (International Atomic Energy Agency (IAEA), 2011), the role of oversight, by providing "the capability to reduce or avoid some exposures", has come to the fore only recently (ICRP, 2013). So the new concept of oversight has its largest impact for the medium-term timescale. The medium term can be regarded as the era of oversight, and it is intended to last as long as practicable.

Measures of oversight in the medium term

Monitoring of release pathways and the environment, but also monitoring of administrative provisions and their implementation, are widely discussed oversight measures for the medium term. Due to a wealth of stakeholder inputs monitoring is both popular and conceptualised to quite some extent. This is reflected in the large interest in the International Repository Monitoring Conference in 2013 in Luxembourg (MoDeRn and European Commission, 2013) and a number of studies and reports published recently (e.g. NEA, 2014b). Some of the monitoring projects developed primarily for the short term

1. These features are often called "passive safety", where "passive" means "no human action needed" to have safety.

may continue in an adapted form in the medium term, e.g. barrier system monitoring (if the necessary remote technology is available), host formation monitoring, environmental monitoring and safeguards monitoring. Additionally in the medium term, monitoring of non-technical parameters may come into focus, such as monitoring of institutional/ administrative provisions or monitoring of the implementation of measures and agreements. All these activities are part of oversight as they mean to keep an eye, either on the technical system itself, or on effects of the technical system, which allow drawing conclusions about the state of the technical system, or on the actual implementation of plans and decisions. Monitoring, e.g. of water or air quality, may well be required for reasons beyond radiological protection, too. In any case, as a form of collecting, interpreting and managing data, monitoring also serves the purpose of RK&M preservation.

Other oversight measures in the medium term may include:

- Land use controls: These may be not only prohibitions but also positive administrative specifications about how land should be used, e.g. for a museum or as a recreation area. In this sense, land use controls could serve the purpose of oversight in a multiple, systemic way.
- Preservation of records: In the medium term, this means managing archives, which may be both conventional national archives and dedicated repository archives.
- Societal memory keeping of the presence of the facility: This includes local memorialisation, e.g. due to unique technical features of the surface facilities (NEA, 2007), but also national memorialisation using, e.g. cultural mechanisms.
- Periodic review of arrangements and measures, regular inspections, etc.
- Regular reporting under international conventions, such as the IAEA Joint Convention (IAEA, 1997), the Council Directive (Council of the European Union, 2011) or for Safeguards (IAEA, 1970; IAEA, 1972; EURATOM, 2010).

Some actual examples of oversight provisions currently in place and carried out in connection with radioactive waste or legacy sites in their post-closure phases exist (e.g. Centre de la Manche (see section on "Memory provisions for the Manche Surface Repository" on page 57), DOE Legacy Management sites (Shafer, 2013). However, not yet in the ICRP-122 regime of geological disposal of high-level waste.

Oversight and memory keeping

One of the apparently open issues in the concept of oversight is the question: Does oversight end when "all memory is lost" or earlier when "watchful care", in any meaningful sense, has ended?

While it would be simple to define it the first way, e.g. "the 'time of no oversight' is the period when memory of the presence of the disposal facility is lost", this would be contradictory to the notion that "Inadvertent human intrusion […] is not a relevant scenario during the period of direct or indirect oversight" (ICRP, 2013), because – given this ICRP statement – sheer memory of the presence of the facility cannot be enough to constitute oversight. Therefore:

- Oversight is an active concept. It is an activity. Oversight is lost when all forms of preserving it have been relinquished.
- Oversight and memory are not the same. But the two work hand in hand, reinforcing each other.
- Memory is a pre-condition for oversight to exist.

- Memory preservation is one basic provision of oversight.
- Exercising oversight, e.g. by monitoring, is an effective way to preserve memory and to some extent even knowledge of the facility.

Responsibilities for oversight in the medium term

"Maintaining indirect oversight and memory of the facility should become a societal responsibility" (ICRP, 2013), i.e. society at large should become responsible for oversight in the medium term. However, the actual provisions and roles should be clearly assigned. They can be organised and fulfilled under a variety of institutional arrangements, involving e.g. national and local regulators, environmental bodies, advisory bodies, local committees (these may include non-institutional players) and international bodies (on the basis of international conventions).

In the RK&M initiative it was recognised that roles and responsibilities should be assigned in the regulation. Namely, studying examples of loss of RK&M in the field of hazardous waste management from the past, it was found that prevalent causes for RK&M loss were lack of human action, among others in terms of weak regulatory enforcement (NEA, 2014c). For example, if a transfer of responsibilities is foreseen at the operational/post-operational phase transition, this transfer needs to be planned well in advance. However, current regulatory frameworks concern themselves primarily with the short term. Even though oversight is sometimes indirectly required to last at least a number of centuries, the medium term and the transition period are hardly covered. An early reflection and development of regulatory requirements for oversight in the medium term would be useful for avoiding loss of RK&M at transition periods.

Summary

- "Oversight" means "watchful care" of the repository.
- The "level" of oversight has a number of implications both for application of the radiological protection system and for RK&M preservation.
- "Oversight" is a recently developed concept; work is ongoing.
- The medium term is the era of indirect oversight after repository closure. There is no intention to relinquish oversight.
- Preservation of RK&M in the medium term is the baseline for oversight. A well-planned oversight regime and supporting RK&M preservation provisions will extend the medium term and postpone the time when oversight may be lost.
- Oversight and memory keeping reinforce each other.
- Examples of oversight in the medium term in other domains than geological disposal of high-level waste already exist, and can serve as models.
- An early reflection and development of regulatory requirements for oversight in the medium term would be useful for reducing the risk of RK&M loss, particularly at transition periods.

References

Council of the European Union (2011), "Council Directive 2011/70/EURATOM of 19 July 2011 'Establishing a Community Framework for the Responsible and Safe Management of Spent Fuel and Radioactive Waste'", *Official Journal of the European Union*, 2.8.2011, L 199/48.

EURATOM (2010), "Consolidated Version of the Treaty Establishing the European Atomic Energy Community", *Official Journal of the European Union*, 30.3.2010, C 84/1.

IAEA (1970), "Treaty on the Non-Proliferation of Nuclear Weapons", INFCIRC/140, IAEA, Vienna.

IAEA (1972), "The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons", INFCIRC/153(Corrected), IAEA, Vienna.

IAEA (1997), "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management", INFCIRC/546, IAEA, Vienna.

IAEA (2011), "Disposal of Radioactive Waste", *IAEA Safety Standards*, Specific Safety Requirements No. SSR-5, IAEA, Vienna, www-pub.iaea.org/MTCD/publications /PDF/Pub1449_web.pdf.

ICRP (2007), "The 2007 Recommendations of the International Commission on Radiological Protection", International Commission on Radiological Protection Publication 103, Annals of the ICRP 37 (2-4).

ICRP (2013), "Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste", International Commission on Radiological Protection Publication 122, Annals of the ICRP 42(3).

MoDeRn and EC (2013), "Monitoring in Geological Disposal of Radioactive Waste: Objectives, Strategies, Technologies and Public Involvement", International Conference and Workshop, Luxembourg, 19–21 March, 2013, MoDeRn EURATOM Project and the European Commission, www.modern-fp7.eu/monitoring-gdrw-2013/home (accessed 31 Oct. 2014).

NEA (2007), *Fostering a Durable Relationship Between a Waste Management Facility and its Host Community: Adding Value Through Design and Process*, OECD, Paris, www.oecd-nea.org/ rwm/reports/2007/nea6176-fostering.pdf.

NEA (2013), *Radiological Protection and Geological Disposal. The Guiding Principles and Recommendations of the International Commission on Radiological Protection (ICRP)*, OECD, Paris, www.oecd-nea.org/rwm/igsc/docs/icrp-flyer-2013.pdf.

NEA (2014a), "Glossary of Terms: Preservation of Records, Knowledge and Memory (RK&M) across Generations", OECD, Paris www.oecd-nea.org/rwm/docs/2011/rwm2011-14-rev4.pdf.

NEA (2014b), "Preservation of Records, Knowledge and Memory across Generations (RK&M): Monitoring of Geological Disposal Facilities – Technical and Societal Aspects", NEA/RWM/R(2014)2, OECD, Paris, www.oecd-nea.org/rwm/docs/2014/rwm-r2014-2.pdf.

NEA (2014c), "Key Factors of Loss of Records, Knowledge and Memory", in *Expert Group on Preservation of Records, Knowledge and Memory across Generations: Articles about Strategic Aspects of the Preservation of Records, Knowledge and Memory (RK&M) across Generations*, NEA/RWM/RKM(2014)5, OECD, Paris, www.oecd-nea.org/rwm/docs/2014/rwm-rkm 2014-5.pdf.

Shafer, D.S. (2013), "Inviting People in as Opposed to Keeping Them Out: An Alternative Strategy for Knowledge and Memory Preservation", in *RK&M Workshop Proceedings 12-13 September 2012*, NEA/RWM/R(2013)3, OECD, Paris, p. 63, www.oecd.org/official documents/publicdisplaydocumentpdf/?cote=NEA/RWM/R(2013)3&docLanguage=En.

Heritage messages of a post-nuclear nature

Anna Storm
Stockholm University
Sweden

My research is focused on post-industrial sites in general, or post-industrial landscapes, for example, related to mining (like in Malmberget in northern Sweden), iron- and steel industry (like in Duisburg in the Ruhr district in Germany), and nuclear power (like at the Ignalina nuclear power plant (NPP) in Lithuania).

I have analysed the history, heritage and contemporary situation of these post-industrial landscapes. However, heritage is such a messy and difficult concept to work with, and my areas of interest are often not considered as heritage in the first place. Lately, I have begun using the metaphor of a "scar" – and tried to articulate a category which I term "post-industrial landscape scars" (Storm, 2014).

I propose that the metaphor of a scar might be useful to better understand and manage these post-industrial sites, including NPP and radioactive waste. Briefly, I suggest three subcategories: reused, ruined, and undefined post-industrial landscape scars. I will not go into details, but I guess they are intuitively rather easy to understand. The NPPs I have been working on mainly belong to the undefined category.

What is a scar then, and how can it be used metaphorically? A bodily scar is a reminder, pain of the past, the trace of a wound, ugly, spontaneously understood as something negative. But it can also carry positive or more ambiguous connotations (Caesarean section operation, Mensur scars, for the veteran and the fiction hero, body ornamentation through so-called scarification) – these scars tell a story about courage and even resilience. Therefore, the scar is ambiguous and significant, but always telling that something important has taken place, reminding about important pasts. Furthermore, this metaphor implies a process, from wound over a scab to form a scar. However, this process of healing is not linear or automatic, that is, not deterministic, but instead it could be cyclic, and demand active work and wounds can reopen.

In this conference the notions of memory and heritage are crucial, and the scar metaphor is closely related to heritage. Heritage is usually understood as something positive, but I believe that heritage is not only positive, and a scar is not only something negative, instead both of them are basically areas of intensified cultural negotiation (Giblin, 2013).

The scar metaphor challenges contemporary understandings of heritage in two ways especially. Firstly, in the heritage debate there has been a movement from the physical to the mental and by using the scar metaphor I want to bring the material world back into the centre of heritage understandings. The scar denotes something that is both physical and mental, that is, the material world is not only equivalent to a "tool" or "facilitator" for memory (Smith, 2006) but integrated experience.

Secondly, the scar contests the notion of layered stories (palimpsest, the recycling practice of Antiquities), since I think this idea misses the interconnectedness between

the different stories and meanings. Instead, the scar metaphor suggests heritage to be organic and interconnected, skin layers merged together into a new dense scar tissue.

On this basis, the idea I want to bring into our discussions concerns industrial nature, or rather post-industrial nature, and its expressions as specifically post-nuclear natures and its relation to the scar metaphor. But to begin with, what is post-industrial nature? I have found two main characteristics.

The first characteristic is that industrial nature is a strategy of controlled overgrowing – providing recreational areas as well as making possible biodiversity-rich habitats (for example, ruderal species). The concept of urban-industrial nature emerged among botanists in Berlin in the 1970s. Today, ecologists even talk about nature of a fourth kind (from an ecological point of view) – after the pristine, the agricultural, and the horticultural nature (Kowarik, 2005). This nature of a fourth kind emphasises a capacity for process, and can even be understood as the most natural kind of nature, even represent a new wilderness.

The second characteristic is that industrial nature is a photographic genre of "nature taking back", expressed in activities like urban exploration, concepts like industrial cool, and the fact that these sites are used as contemporary stages, in countless films among other examples. This genre has, however, also been criticised as "ruin porn", without any people in the pictures, hiding social justice and so on.

The post-industrial nature relates to the scar metaphor in that there is a thin line between, on the one hand, the positive effects of the strategies of creating forests and parks in former industrial sites, and the visual appreciation of these places, and, on the other hand, the negative effects, mainly in terms of hiding real problems of a bad economy, contamination, social problems, etc. Therefore, post-industrial nature can be understood both as contributing to the healing of a wound into a scar, and as concealing hurting pasts behind a fancy surface.

If we now move to the specific post-*nuclear* natures, that is new and experimental to me. I tentatively see two main types so far, based on NPPs and not on waste storage facilities.

The first is marked by the ideal of returning the site to the original state – that is, prior to the NPP, examples are found in Yankee Rowe NPP in the United States and Barsebäck NPP in Sweden. The Yankee Rowe has been dismantled and the site has been turned into a green lawn, while in Barsebäck, the plant is still there and there are competing future visions about what will happen at the site. The local politicians' vision for Barsebäck is to turn it into a seaside resort. "To clean and make green". Take away every trace, seen as responsible behaviour – but what about memory and heritage in this process?

The second type of post-nuclear nature I have identified so far is marked by the idea of setting areas aside and letting wildlife return, pictures from the exclusion zone around Chernobyl, where there is also a dedicated nature reserve in the Belarusian part, highlight the unique pristine nature. To what extent the animals and plants are affected by radiation is certainly debatable. It emphasises a flourishing wildlife – but what about memory and heritage? Both in terms of biological and chemical heritage and in terms of the human experiences connected to this place.

So, what to do with the idea of post-nuclear natures? What are the heritage possibilities? Firstly, it has to acknowledge that the post-nuclear nature can mirror human nature interactions. Secondly, to consider ways of letting the post-nuclear nature bring a message to future generations: telling "Here" as its basic message (Bandolin and Sörlin, 2007). Translated into my understanding of the landscape scars, the message would be: "Here is a scar in the landscape, telling that something important has happened".

I believe that nature will most probably overtake any remains (whether they are deliberately given shape or unintended leftovers) and this is something we must count on.

So, if the strategy of communicating with the future is to leave messages then we must try to let nature be a force that contributes to making visible, not primarily hiding or concealing what has happened. And this can be considered for different time frames; decades, centuries or millennia – while more short-lived constructions (like recreational areas, or exhibition centres) connected to the profoundly changed landscape (like piling of rock) can articulate experiences and knowledge to new generations.

I conclude that heritage, here understood in terms of landscape scars, includes both material and mental legacies that are ambiguous and do not heal automatically. So, I suggest that we should firstly, articulate the *scar*, with all its ambiguities, saying: something important happened "here". And secondly, in this work of articulation, make use of *post-nuclear natures* – perhaps through landscape formations as a basis. And finally, always bear in mind, the thin line between *healing* and *concealing* in this process.

References

Bandolin, G. and S. Sörlin (2007), *Laddade landskap – värdering och gestaltning av teknologiskt sublima platser*, R-07-14, Swedish Nuclear Fuel and Waste Management Company, Stockholm.

Giblin, J. D. (2013), "Post-conflict heritage: symbolic healing and cultural renewal", *International Journal of Heritage Studies*, 1-19.

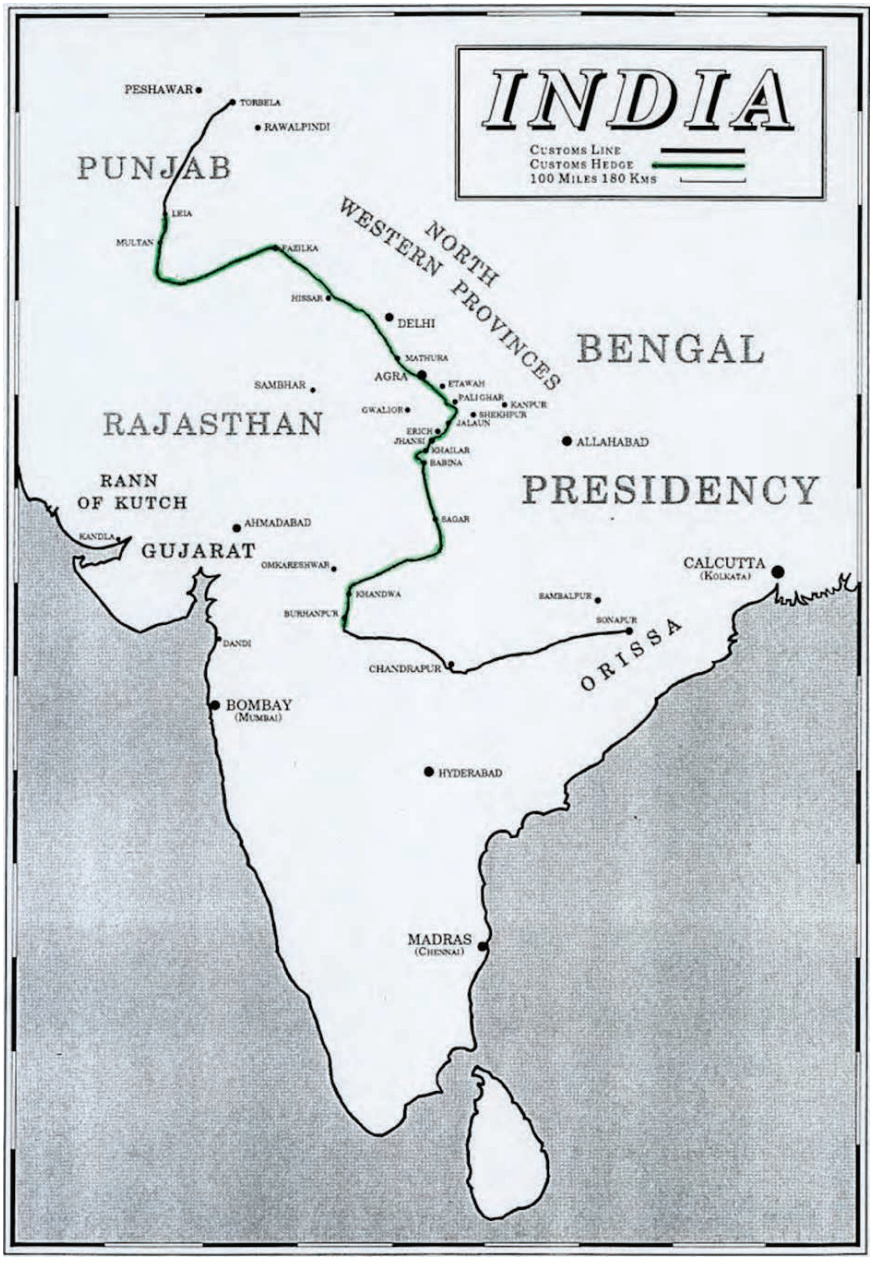
Kowarik, I. (2005), "Wild urban woodlands: Towards a conceptual framework" in Kowarik, I. and S. Körner (eds.), *Wild Urban Woodlands: New Perspectives for Urban Forestry*, Springer-Verlag Berlin Heidelberg, New York.

Smith, L. (2006), *Uses of heritage*, Routledge, New York.

Storm, A. (2014) *Post-Industrial Landscape Scars*, Palgrave Macmillan, New York.

The Great Hedge of India

Roy Moxham
www.roymoxham.com
United Kingdom



In 1995, I purchased a copy of *Rambles and Recollections of an Indian Official* by Sir William Sleeman (Sleeman, 1844) in a second-hand bookshop. This book was first published in 1844, but the copy that I bought was from an edition of 1893 that had been edited by Vincent Arthur Smith, an officer in the India Civil Service. It had numerous explanatory footnotes. Sleeman's text had a brief reference to a customs post at Horal in central India. This was a surprise to me as I had not known that there were any inland customs barriers in British India. Fortunately, Smith had added a footnote with a quotation from a book by Sir John and Richard Strachey, *The Finances and Public Works of India, 1869-1881* (John and Strachey, 1882):

> To secure the levy of a duty on salt [….] there grew up gradually a monstrous system, to which it would be almost impossible to find a parallel in any tolerably civilised country. A Customs Line was established which stretched across the whole of India, which in 1869 extended from the Indus to the Mahanadi in Madras, a distance of 2 300 miles [3 700 km]; and it was guarded by nearly 12 000 men [….] It would have stretched from London to Constantinople [….] It consisted principally on an immense impenetrable Hedge of thorny trees and bushes.

The Stracheys' book cited a report by the Commissioner for Inland Customs for 1869-1870.

To my surprise, when I checked the two standard histories of India published by the Oxford and Cambridge University presses, there was no mention of this barrier, nor in other histories that I consulted. I managed, however, to locate the printed report for 1869-1870, and for several other years, in the collections transferred to the British Library from the old India Office. (It seems that there are no copies in India.)

The Inland Customs Line was established in 1823 to enforce a very high tax on salt levied in the eastern third of British India, an area of 500 000 square miles (1 295 000 sq km) in which there is very little natural salt. It was designed to prevent smuggling from the rest of India, where many places have salt. There was also a small tax on sugar coming in the reverse direction. Originally it was merely a line of customs posts guarding roads and rivers. Eventually the portion that ran from the River Indus almost to the eastern ocean was made into a thorn Hedge. Ideally this was 12 feet (3.7 m) high and 14 feet (4.3 m) thick at the base. Much of the Hedge was planted on an embankment. There were also cuttings to take it through hills. In 1879 the salt tax was equalised across India and the Customs Line abandoned. The reports described the gradual consolidation of the Hedge, its realignments as the British acquired more territory, and its routes. There was a small map too.

As it happened, I was scheduled to visit India in 1996 to visit friends in a small village that was situated close to the line of the old Hedge. I thought that I could get them to show me its remnants. The village would have been about 20 miles (32 km) inside the area enclosed by the Hedge. Its inhabitants would have been starved of cheap salt and been forced to pay a salt tax equivalent to about two month's income.

To my astonishment no one had heard of the Hedge. I questioned the older inhabitants without success. Moreover, when I hired a vehicle to explore nearby areas on which the Hedge would have stood there was no sign of any remnants. This was not so surprising as everywhere was cultivated. However, no one in those places had any knowledge or memories of the great Hedge. Since many of those I interviewed were much older than me, and my own grandfather had told me of things he had seen in years prior to the abandonment of the Hedge, a Hedge which would have scarred the landscape for some years afterwards, I was mystified.

Back in Britain, I searched for more accurate maps so as to fix the exact location of the Hedge. Such maps proved elusive until I found a set of maps of Agra District in the Royal Geographical Society. On these, one inch to the mile maps, dated 1879, there was a line of trees clearly labelled as the customs line. I went back to India in 1997 and tramped

the fields of Agra. Flood irrigation had levelled the landscape and nothing remained. Hereditary landowners and farmers knew nothing of the Hedge.

Returning to Britain, I looked at various maps (mostly low-scale) that I found in British libraries, I began to realise that the Hedge, which had often been the boundary between Princely States and British India, was now a road. The government had used the land acquired for the Hedge for road-building, and thus obliterated any remains.

When I returned to India in 1998, I started to look at places where for some reason the modern road did not follow the old state boundary. Using a Global Positioning System (GPS) I walked the old boundaries in these areas, but without success. However, by chance in one of these places, I met an old monk who knew of what he called "the old line". He showed me a line of widely spaced tamarind trees that ran across the fields. They ran very close to where I had calculated the Hedge would have run and I had read that tamarind trees had been planted to give shade to patrolling customs officers. There was no sign, however, of any of the barrier's thorn trees. Nevertheless, I was fairly confident that I had found some sign of the customs line.

I had a small-scale map that showed the customs line as running between the rivers Yamuna and Chambal, close to where they meet. This, I reasoned, might be a good place to look. I went to a nearby town and met an old man who knew of what he called the "Parmait Lain", although he had no idea of what its function was. This description, which alluded to the customs permit that was needed to cross the line, I had come across in an old map lettered in Hindi and Urdu. However, he told me, the very road we were standing on was built on top of it some years ago.

Nevertheless, I decided to walk along the bank of the River Chambal to where I had calculated that the line diverged from the new road and crossed the river. At this spot there was a small village called Pali Ghar. There I found a retired college principal, Mr Chauvanji, who assured me that I was indeed in the right place. He took me to the edge of the village where, on top of a substantial embankment, a line of thorn trees wended its way north. We walked along the embankment until, after a few hundred yards (metres), it came to a deep cutting that took the line through some crumbling hills. Beyond the hills, it once again ran along an embankment before coming to a halt as it merged with a new road. I was confident that I had found a surviving stretch of the great Hedge. Mr Chauvanji reinforced my confidence by telling me of how, when he was a child, old men had reminisced. They had told of the high price of salt, of smugglers, and of how customs officers had shouted messages from mouth to mouth along the line for many miles.

My GPS reading at Pali Ghar was 26° 32.2' N, 79° 09.2' E. If this reading is put into Google Earth, the embankment of the Hedge is clearly visible – but only if you already know it is there.

I published my finding in *The Great Hedge of India* (Moxham, 2001). It received wide publicity both in the press and on air. I fully expected people to come forward to tell me that they knew all about the Hedge and had written about it years before, but no. Indeed many thought the book was a hoax. It may be that the huge amount of coverage given to Gandhi's famous campaign against the later small tax on salt had obscured any memory of the earlier much larger tax and its Hedge. I appealed for anyone who knew of a photograph to contact me, but nothing happened.

The one interesting communication I received was from Richard Hingley, a Roman archaeologist, who cited a passage about the Hedge from Essays (Pelham, 1911). Haverfield likened the Hedge to barriers built across Germany by the Romans in the second century. Interestingly, the wooden stakes of one of these barriers were found near Gunzenhausen in 1894. Haverfield, who had excellent connections in India, also tried to find a photograph of the Indian Hedge but failed.

In 2013, I went to Pakistan hoping to see if anything remained of that part of the Hedge which is now situated in that country. I looked at some of the western section, coming from the Indus, but the landscape had been levelled for flood irrigation and there was nothing to be seen. No one I spoke to knew of the Hedge. The eastern portion, which ran to the border with modern India, was controlled by the Taliban. I did not visit.

Why the Hedge disappeared from memory is rather difficult to fathom. The emphasis on Gandhi's campaign was probably one factor, as was the obliteration of remnants by roads. There would appear to be no copies of the detailed colonial annual reports in either India or Pakistan, and the copies in the British Library are poorly catalogued and have yet to be digitalised, all of which would make research by scholars difficult. The peasants, who would have been most affected by the high tax and the obstruction of the barrier, were mostly illiterate and would have left no written record. Nevertheless, it is surprising that more folk-memory has not survived.

References

John, S. and Lt. Gen. R. Strachey (1882), *The Finances and Public Works of India From 1869-1881*, Kegan Paul, Trench, & Co, London.

Moxham, R. (2001), *The Great Hedge of India*, Constable, London.

Pelham, H.F. (1911), *Essays*, Clarendon Press, London.

Sleeman, Sir W.H. (1844), *Rambles and Recollections of an Indian Official*, J. Hatchard and Son, London.

Archival and museum curatorship challenges for RK&M preservation

Christophe Jacobs
Limonade & Co
France

Memory is supported by various types of records: archives, equipment, monuments, buildings, etc. In addition to its own efforts to preserve and transmit memory, the operator will rely on institutions specialised in heritage and memory transmission: national archives, museums, libraries, etc. These institutions are facing two major issues: their own durability, and the durability of the pieces in their collections. From an international survey on institutions, which favourable factors for sustainability of this transmission may be identified? (For example, how can users' communities play a role in RK&M preservation? Which lessons may be learnt?)

Abstract

The main purpose of this study is to investigate how heritage institutions are handling their duty to transmit their collections, buildings, etc. on a long-term basis. It is often said that they are here to ensure a transmission of the heritage for eternity (which means very the long term). Of course, there are plenty of examples in history where libraries were burnt, museums looted, monuments destroyed and archives' buildings collapsed due to a hurricane or an earthquake, decades or centuries ago, but even very recently.

So, this study had to begin with a worldwide "state of the art" on institutional curators' durability throughout history. It has to be complemented by a study of what is done today in these institutions to ensure their sustainability and the durability of the heritage transmission on a very long-term basis. We firstly had to define the scope of our investigation and select archives, libraries, museums and monuments, but also include institutions which are more and more in charge of transmitting intangible heritage. This state of the art is based on a bibliographical research on heritage losses that where documented, consisting of published scientific articles, studies or books. Then, the study had to focus on trying to understand what kind of risks these institutional curators are facing, why some of them could survive after a disaster, and why others could not.

The first thing to keep in mind is that an institution dedicated to the curation of a memory or a heritage has its own lifecycle. There are several phases and each of them has its own vulnerability. For instance, the first one is the establishment of the institution itself, then a phase of institutionalisation, the "age" of conservation and then the transmission. Often, conservation and transmission take place in parallel. There is an implicit memorial link or thread between generations. When a society decides to create an institution dedicated to the curation of part of the community's heritage, there is a moral contract between this community and the people who are responsible for this mission. More precisely, this means that the society recognises itself through this institution and leaves the heritage, itself, as a message to future generations.

A number of hazards have been identified to define more precisely which disasters hit heritage institutions most often. Among the cases identified in the bibliography, most of the disasters are due to political and geopolitical hazards (armed conflicts, acts

committed in times of war, political regime changes, etc.). Then come the natural hazards (floods, hurricanes, the natural degradation of heritage materials themselves, etc.) and the economic and social hazards (censorship and book burnings, theft, societal or demographic changes), and finally the "everyday hazards" (small scale floods or fires). The "patrimonialisation" (or creation of heritage) also represents a risk for the newly protected institutions (such as the United Nations Educational, Scientific and Cultural Organization (UNESCO) world heritage nomination) but is not perceived as such.

Of course, people developed many strategies during centuries to protect those heritage pieces and improve their security, at different levels. Society answered through organisational or legal arrangements, at a national scale as well as at the international one. This means, for instance, the adoption of international conventions protecting heritage from armed conflicts (1954 Hague Convention), or guidelines to safeguard world heritage sites from natural disasters, etc. Heritage professionals have not been outdone, they are providing technical and scientific solutions, finding new ways to avoid disasters or, at least, irretrievable losses or damages. Those solutions are more or less efficient according to the level of damage or the kind of hazard they have to face. We have not excluded from our scope individual initiatives that allowed rescuing some heritage pieces from destruction, even if those stories are not well documented.

We have also identified some "survival factors" for institutions that have faced damages and survived with limited losses. Heritage institutions that are able to adapt themselves despite societal changes continue to have value in the eyes of their contemporaries. Continuing to keep this memory is highly valued by the community. The most difficult task for professionals running these institutions is to identify and anticipate these insidious societal changes, which require that their institution undergo an important adaptation effort. We are investigating the notion of "tutors of resilience" as we have found out that communities played a role in the survival of some institutions, and, for instance, heritage professionalised organisations. Another hypothesis to continue this investigation is to define if the "institutional age" is just a step to transmit heritage on the very long term or not. Communities could have a greater role to play in this long-term conservation.

One of the last works that needs to be done is to complete the study using information and experiences provided by the current heritage institutions. Through an international survey, we will try to find out which measures people are taking nowadays to ensure the long-term transmission of these heritages. It will also be a good occasion to find out if heritage professionals are aware of some undergoing societal challenges that could impact their institution and how they will try to manage or anticipate their consequences.

Day 2 closing lecture: Anthropocene's archive?

Peter van Wyck
Concordia University
Canada

My lecture will draw from Paul Crutzen and Eugene Stoermer's concept of the Anthropocene – proposed in 2000 as a designation for the present geological moment. In just less than 15 years, the term itself has spawned a veritable growth industry in the hard sciences, the social sciences, humanities, and increasingly, the fine arts. Although the term has yet to be "officially" adopted, it has installed itself as a theoretical touchstone in a broad swath of academic domains.

From literary theory to cultural anthropology, biology to evolutionary psychology, the Anthropocene, as concept – as condition, or sentence – is seeping into the cultural imaginary with strange legitimacy. And it is – or should be – I will argue, of considerable theoretical, practical, and rhetorical interest within the broad set of concerns that brought participants to Verdun for the Constructing Memory conference. Specifically, within the geological, social, and human sciences the question of the Anthropocene circles in part around issues of what the relevant human signature is that marks the intersection of humans as agents within biospherical systems – that is, where and when does the Anthropocene's archive begins. There are various competing ideas about all of this, from early human settlements and the acquisition of fire, to the Industrial Revolution, to the great acceleration of the mid-20th century.

To this we might add other potential signatures including techno stratigraphic features (terrestrial and orbiting), nuclear testing, accidents, and of course the lingering problem of historical, present, and future nuclear wastes. Figuring "neither purely 'natural' nor purely 'human' history" (Chakrabarty, 2012: 10), but rather the collapse of the two, the Anthropocene asks of us – demands, perhaps – to seriously and comprehensively come to consider timescales outside of an anthropocentric register. I want to suggest that the Anthropocene, as a kind of evolving cultural and scientific meme, offers us a "moment" in which cultural awareness around questions of the nuclear and its peculiar temporalities may be broadened and enhanced.

Reference

Chakrabarty, D. (2012), "Postcolonial Studies and the Challenge of Climate Change", *New Literary History,* 43:1, pp. 1-18.

Long term: Period with no oversight

Chair: Saida Laârouchi Engström
Swedish Nuclear Fuel and Waste Management Company
Sweden

Long-term preservation and the concept of oversight

(The start of this period is very speculative.
It may begin at perhaps 1 000 years from closure)

Anne Claudel
National Cooperative for the Disposal of Radioactive Waste (Nagra)
Switzerland
On behalf of the NEA RK&M initiative

According to the definition of the Records Knowledge and Memory (RK&M) initiative, "long-term" refers to "the period of time with no repository oversight. This period extends over the time of concern in the safety regulations, typically over hundreds of thousands of years in the case of high-level waste" (NEA, 2014a). "Oversight", in turn, "is a general term for 'watchful care' and refers to society 'keeping an eye' on the technical system and the actual implementation of plans and decisions" (NEA, 2014a). Oversight is always exercised by people and includes regulatory supervision (such as control and inspection), institutional control (e.g. monitoring), preservation of societal records (such as archiving) and societal memory keeping of the presence of the facility (ICRP, 2013). After closure, and as more time goes by, oversight and preserving RK&M should become a societal endeavour.

The lack of oversight, as defined above, is therefore equivalent to the lack of memory keeping and awareness of the facility. This implies that, in order to allow any transmission of information, RK&M preservation mechanisms still in place at the time of loss of oversight must have the potential to generate awareness of the facility, thus initiating a new period of oversight. Although the facility is designed to be safe by itself, this "regeneration of awareness" is desirable, because oversight will reduce the probability of inadvertent intrusion and favour taking informed decisions about the facility.

In the course of Phase I of the RK&M initiative, it was recognised that there was no single best means of RK&M preservation over all time scales: a combination of mediated and non-mediated transmission methods should be preferred ("dual-track strategy") within a systemic approach in which the various elements complement and reference to one another. This would provide redundancy and therefore maximise the survivability of a recognisable and comprehensible message.

Phase I of the RK&M initiative has led to the conclusion that markers or other marking strategies, taken individually and in isolation, may not be fully effective. They could, however, play an important role in a systemic approach to RK&M preservation.

Markers and marking strategies

Throughout Phase I of the initiative, a number of RK&M preservation methods frequently mentioned in the literature were discussed during meetings and workshops to gain input from members and other specialists, whereby considerable attention was given to the

general topic of "marking a site". This concept was first established in the United States and has, for many years, been a recurring topic in the discussions surrounding geological disposal. It has been presented as the main non-mediated method for preserving memory and deterring human intrusion.

As other important concepts, the term has been included in the RK&M Glossary, whereby 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. Any marker is conceived to be immobile (i.e. in permanent association with a site), robust, in order to maximise survivability on its own, and [able] to provide messages that are likely to be understandable across generations" (NEA, 2014a).

Furthermore, the topic was looked into specifically when compiling the RK&M Regulatory Catalogue. At present, no country other than the United States and Switzerland legally requires the use of markers. However, discussions have shown that issues such as whether markers should be used at all, when to start preparing for them, and when to construct them will require further evaluation and development of the corresponding regulatory guidance. This was found to be potentially beneficial, both for the repository planning process and the dialogue with local communities.

Finally, two dedicated studies – a literature review and reflections on the role of traditional tsunami warning stones in Japan – were sponsored by the initiative and are briefly presented below.

A survey of existing marking concepts

The original *Literature Survey on Markers and Memory Preservation for Deep Geological Repositories* (NEA, 2013), commissioned by the Swiss Federal Office of Energy in 2008, was translated and edited by the RK&M group. It reviews some 150 publications, with a large number of titles published between in the 1990s and 2000s. The study aimed at compiling existing information and conveying both the complexity of the topic and the variety of interdisciplinary issues that remain to be addressed. The remarks below reflect some findings of the literature survey as well as discussions held in the framework of the RK&M initiative.

A wealth of ideas, technologies and materials has been proposed for marking a repository, both on surface and sub-surface (e.g. berms, magnets, radar reflectors, small ceramic tokens, tracers, acoustic signals, marking of disposal shafts and waste containers, or biological marking). With regard to materials, adaptation to the natural environment and/or the use of non-recyclable and non-reusable materials has been suggested. In line with historical markers in other fields, such as archaeological artefacts, large surface markers in the form of monuments have received a lot of attention. In addition to deliberately placed markers, residual surface features such as retaining walls built to preserve visual amenity, altered water courses or access routes for road and rail were noted to leave marks or "scars" in the landscape, thus hinting at previous activity. It has been suggested that geological disposal sites mark themselves by means of their content and/or artificial barrier materials, implying the possibility of a message based on radioactivity or on other physical properties of the disposal components, e.g. gravitational magnetism. The concept of cultural marking, for instance through choosing a meaningful name for the site, has also been mentioned. Finally, additional methods, not yet discussed in this particular context, have been found to be worthy of further investigation. This is the case for "time capsules", ranging from a simple box to a full room holding a range of artefacts and due to be opened or accessed at a future date. These three-dimensional "information repositories" have the potential to preserve meaningful content with some degree of complexity over long periods of time.

However, in spite of the variety of proposals discussed, no straightforward, conclusive answers – and therefore no clear recommendations – have emerged as to the objectives,

the messages and the methods to be used. Arguments against the implementation of markers are just as numerous, and plausible, as arguments in favour of them, for instance: even if individual markers remain intact and traceable over time, they can be moved or destroyed. Cultural and aesthetic interpretations or even deliberate falsification can alter the meaning of the messages they bear. They may also attract intruders rather than deter them.

A case study on an existing marking method was considered necessary in order to assess the role and effectiveness of markers in more detail.

Tsunami stones: A model for repository markers?

Hundreds of so-called "tsunami stones" can be found on the north-eastern shore of Japan. Emplaced at different times in history to commemorate past tsunamis, they carry different messages, e.g. a warning against building houses close to the sea. The case study *Markers – Reflections on Intergenerational Warnings in the Form of Japanese Tsunami Stones* (NEA, 2014) was aimed at assessing how effective stone markers could be in preserving information in order to warn populations and urge them to take appropriate actions to protect themselves.

The potential longevity of this type of marker has clearly been demonstrated, as tsunami stones have been shown to last up to 1 000 years with, in some cases, old stones being regularly replaced by new ones. It has also been shown that their historical and cultural significance may accrue over time, although the evolution of language may make it more difficult to understand the messages of commemoration and warning they convey.

However, the effectiveness of the tsunami stones as warning devices can be questioned: in many cases, the messages they bear were not heeded. Reasons for this include a lack of awareness or understanding, but also, more importantly, reliance on other, more modern warning systems, deferring responsibility to the authorities, and pursuit of short-term economic interests. Memory may be kept alive – the actual warning function, however, seems more likely to survive in relatively small rural communities that have closer links to their past, an oral history tradition and more limited access to, or confidence in, the latest technologies.

Markers and beyond

As for other means of RK&M preservation, the effectiveness of markers on the long term, i.e. in the absence of oversight, depends on the care exercised during periods of oversight. Even if stone markers are conceived for non-mediated information preservation and transmission, society undoubtedly has an important role to play in the longevity of comprehensible messages. Indeed, in earlier periods, markers may be part of a strategy fostering the existence of cultural links between the waste repository and the siting communities. They can be included in mediated, memory-regenerative processes, restricted land use functions, rituals, and/or conceived as mediated objects themselves.

If the goal is to ensure that awareness and knowledge of the repository are periodically regained, the marking strategy must be geared towards purposefully leaving traces – possibly with some traces being designed to be immediately visible, while others would only be rediscovered in the future. This could be achieved by a network of redundant markers – a marking system – placed strategically and designed to arouse curiosity and the desire to learn more. To design individual markers, the methods compiled during Phase I (briefly outlined above) should be further evaluated.

Regarding the content and level of detail of the message conveyed by the marking system, the case study on tsunami stones has shown that factual information is transferred more easily than warnings and memory more easily than knowledge.

However, the sole awareness of past events and impacts is not enough to ensure the kind of oversight that supports safety. It is knowledge that saves lives: the marking strategy should therefore be aimed at reinitiating awareness and oversight at a level that would foster learning and understanding. This could be done by stimulating the willingness to understand the sense and purpose of the markers, but also by pointing to other sources of information that may be available elsewhere. With this in mind, the potential use of "time capsules" within a marking system should be further assessed.

Conclusions

An important conclusion reached during the course of Phase I of the RK&M initiative is that there is no single best means of RK&M preservation over all time scales: a combination of mediated and non-mediated transmission methods should be preferred (dual-track strategy) within a systemic approach in which the various elements complement and reference to one another. This would provide redundancy and therefore maximise the survivability of a recognisable and comprehensible message.

Visible markers placed near or above a waste disposal site have been the most studied form of marking so far. Taking into account the results presented before, the effectiveness of markers taken by themselves and in isolation may be questioned. However, markers could play an important role in a systemic approach to RK&M preservation. At this stage, their specific function – in relation with the defined time scales – remains to be outlined in more detail, as do potential interactions with other RK&M preservation and transmission methods. Whether some degree of international standardisation would be beneficial when designing markers also needs to be evaluated.

References

ICRP (2013), "Radiological Protection in Geological Disposal of Long-lived Solid Radioactive Waste", ICRP Publication 122, Annals of the ICRP 42(3), International Commission on Radiological Protection.

NEA (2013), "Literature Survey on Markers and Memory Preservation for Deep Geological Repositories", OECD, Paris, www.oecd-nea.org/rwm/docs/2013/rwm-r2013-5.pdf.

NEA (2014a), "Glossary of Terms: Preservation of Records, Knowledge and Memory (RK&M) across Generations: Draft", definitions as of 3 March 2014, NEA/RWM(2011)14/REV4, OECD, Paris, www.oecd-nea.org/rwm/docs/2011/rwm2011-14-rev4.pdf.

NEA (2014b), "Preservation of Records, Knowledge and Memory across Generations (RK&M): Markers – Reflections on Intergenerational Warnings in the Form of Japanese Tsunami Stones", OECD, Paris, www.oecd-nea.org/rwm/docs/2014/rwm-r2014-4.pdf.

Could the landscape preserve traces of a deep underground nuclear waste repository over the very long term?

What we can learn from the archaeology of ancient mines

Dominique HARMAND
(Université de Lorraine)
and
Jacques BRULHET
French Radioactive Waste Management Agency (Andra)
France

A study conducted by the French Radioactive Waste Management Agency (Andra) outlines which traces of the *Centre industriel de stockage géologique* (Cigéo) project installations will be left over the very long term at surface on the Bure limestone plateau (north-east of France) despite natural erosion, and analyses the possibility that these traces could be detected and well interpreted in the far future.

The basis for this research lies on an archaeological and geomorphological approach.

The assessment of possible traces is performed for different time frames. It is conducted with a temporal perspective which extends in the future until the next tens and hundreds of thousands of years, taking into account the possible site evolution scenarios defined by Andra, including global climate change due to human activities.

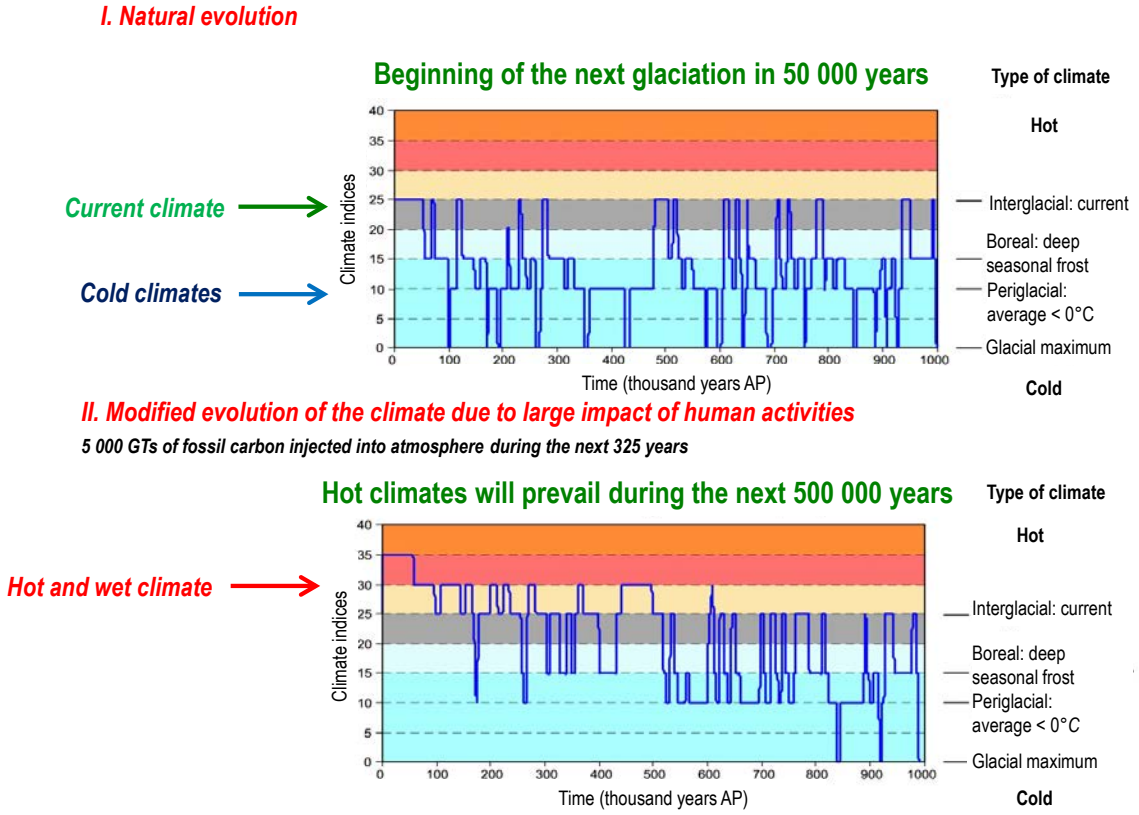
During a future millennium time scale, the most superficial traces will gradually disappear, and all traces will be combined with other human traces of all ages. The aim of this study is to point out the probable duration of many traces, especially those that are most commonly associated with the existence of a deep underground installation. This is illustrated by archaeological examples, such as the traces of old mines. Some are cited: the silver mines of the Laurion, in Greece (2 500 to 3 500 years old), the copper mines of Khirbat-en-Nahas, in the Jordanian desert (3 000 years old), as well as the Great Orme site (4 000 years old) located in a temperate country (Llandudno, Wales, United Kingdom), and Neolithic flint mining complexes which may be up to 10 000 years old.

Such traces differ significantly from those that the Cigéo project will leave, but they give concrete examples about traces' duration and illustrate the possibility that future archaeologists and geomorphologists could detect Cigéo's traces using present time knowledge and methods.

Over a larger time frame, erosion will gradually remove traces of Cigéo; many of them will disappear completely. However, even for a distant future, traces of the heads of shafts and inclined tunnels, and filled excavations will still exist at surface.

But, without some detailed observations, such traces could be mistaken for natural features that could look similar. Their current natural analogues correspond to the filled karstic depressions, pits and wells, commonly developed at present time on the Bure plateau; and these natural structures will develop all around the Cigéo site. In this way, the traces of Cigéo could be easily mistaken for geomorphological structures of little interest and they would not be noticed nor studied by future archaeologists.

Figure 6: The 2 scenarios taking into account future climate change (bioclim)



Source: Projet mémoire – Archéologie du paysage, Agence nationale pour la gestion des déchets radioactifs, DRD/MG/11-0195 (25 novembre 2011).

Figure 7: The Neolithic flint mining complex of Brandon, east of England, 4 000 to 5 000 years old

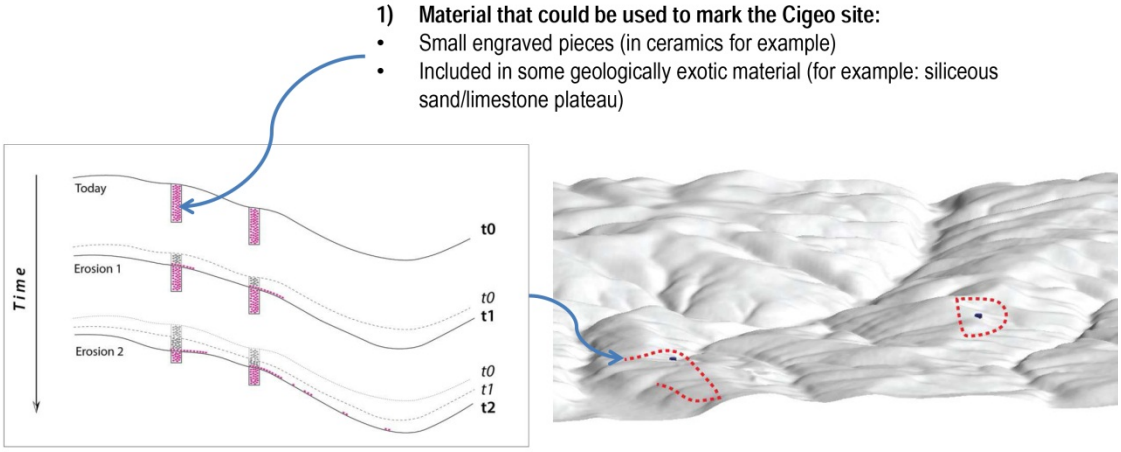


Sources: Copyright Ron Strutt and licensed for reuse under this Creative Commons Licence.

To allow the detection and the interpretation of these traces in a far future it is essential to tag them. The proposed solution is to mark the Cigéo site. The concept, in progress, is to dispose a lot of small long-lived anthropological pieces (made of ceramic for example) to indicate the human origin of the structures and to enable a correct interpretation. Such small pieces could be mixed with exotic material filling drill holes and/or trenches disposed around the main Cigéo installations.

This concept could create detectable soil anomalies and allow the surface distribution of pieces over a long time period, despite natural erosion of the site.

Figure 8: Marking the site and the long-lived traces



2) The marks design
The material could be included in a few metre-long drilled holes. This concept allows pieces to be distributed at the surface over a long time period despite the natural erosion of the site.

3) Spatial distribution of the marks in the landscape
Markers could be distributed around the main Cigeo surface facilities.

Sources: Dominique Harmand and Jacques Brulhet (left); Jacques Brulhet (right).

Defining a communication system for the long term

Eleni Mitropoulou
Centre de recherches sémiotiques (CeReS), Université de Limoges
France

One year ago, the *Centre de recherches sémiotiques* (CeReS – Semiotics Research Centre) at Limoges University launched a research project within the scope of Andra's Memory project. As research at the CeReS focuses on semiotics, linguistics and information and communication technologies, these disciplinary fields also provided the framework for our work on radioactive waste repositories and long-term memory. Communicating with the general public about waste repositories is an integral part of the construction of a memory. However, the lack of historical experience in communication, especially when dealing with "marking", has been highlighted. Accordingly, in close collaboration with our contacts at Andra – who gave us their requirements and expectations in terms of results – we established the relevant objectives and studies for this undertaking. We presented our method at the Constructing Memory international conference and gave an update on our fields of investigation.

The initial purpose of the research project

The starting point was to identify the methodological and theoretical requirements for undertaking a semiological study on how to "guarantee" long-term communication on radioactive waste disposal.

We then introduced the premise that it was not marking (consisting in a language, image, symbol or code, etc.) that needed to be made sustainable but rather *the process for communicating on it*. So the initial hypothesis on the "long-term" communication process (with "long" defined in terms of the Records, Knowledge and Memory project) assumes the need for a "communication system" approach i.e. a coherent and significant set comprising elements that interdepend on each other according to differences and similarities. The communication system is a system of relations, which entails the notions of stratification and sub-system in particular.

The work undertaken

Two types of related assignments were launched, at different stages:

Bibliographical research (at the start of and throughout the project)

This work confers scientific legitimacy to the research project by inventorying everything that has been produced on long-term communication in general, and, when it exists, on radioactive waste storage in particular. This inventory helped identify a lack of bibliographical references on the subject. As a result, the preparation of an *appropriately*

comprehensive [1] reference source on the thematic of the Memory project was methodologically indispensable (see the initial purpose above) for establishing a bibliographical classification (by type, theme and chronology).[2] The classification also revealed that, to this day, no seminal study in the field of long-term communication exists, only introductory work (Human Interference Task Force; Sebeok), thereby further confirming the findings reported by Buser (i.e. that there is a lack of in-depth studies on long-term communication). More importantly, the classified reference source helped establish the "profile" of the study to come. This profile is the guiding thread for conceiving long-term memory through communication devices that are to be adopted or avoided.

This "guiding thread" was followed by **two studies**, on **durability/longevity** (of media and language) and on **exposure** (in terms of accessibility, sharing and exploitation) that resulted in the following steps:

- creating a methodological "profile" for semiological studies on the Memory project (with objectives unrelated sociology, behavioural psychology or cognitive science);
- promoting the written form as the best guarantee for reliable transmission;
- transmitting it according to a "principle of tradition";
- drafting semiotic specifications for the long-term marking communication system;
- managing the repository as a site that "enunciates" and "communicates", neither term being metaphorical in the context of a semiotic study;
- creating a dedicated communication system for the collective memory of radioactive waste.

The durability/longevity study highlighted that it is not a linguistic structure, languages, images (e.g. pictograms) or the materials used for a specific medium that guarantee the longevity of an informational message, but rather the fact that a series of elements form a meaningful whole that is transmitted using the principle of tradition.

Still, the Exposure study revealed that, in addition to not guaranteeing the longevity of an informational message, languages, media etc. also do not guarantee its integration/being taken on board. It is the repository itself, and in its role as such, that becomes "discourse" by way of a contract of communication.

The notion of discourse brings a fundamentally semiotic dimension to the objectives of Andra's Memory project, as the repository itself has to enunciate and therefore has to live; and to do so it needs to be associated with mankind.

A semiotic study of sound perception, connected to this project through work on robust sounds, also includes this fundamental dimension.

The findings pointed towards the use of a *multidimensional* message for radioactive waste repositories, for the purposes of information ("storage site here"), calling out (warning, preventing or alerting people), and integration (with regard to the surrounding environment), which entails a series of conditions:

- In order to be multidimensional, the message should be in accordance with a definition *of the conditions of its transmissibility*.

1. This includes domestic and international publications about social science (the field of the CeReS study), classified by selective research areas using keywords.
2. By a team of archivists/librarians from the Joint Documentation Department at Limoges University.

- This transmissibility cannot be established independently of human integration of the repository.
- Human integration of the repository, which is a reflexive acquisition, cannot be defined in the long term independently of the human integration of the repository in the short and medium terms, for the purpose of a long-term memory.

Nevertheless, like memory, the integration of the repository in the long term is not the sum of short- and medium-term integrations; neither is the long-term communication system the sum of the communication systems designed for short- and medium-term storage. It is therefore necessary – and this is a field that is currently being explored – to define the communication system *per se* and the integration of long-term storage *per se*, both in terms of the short and medium terms and independently of them.

This approach needs to be considered from a semiotic perspective.

With reference to the above conditions, it is important to highlight that one main method of ensuring longevity in terms of integration is not to isolate the repository from people, but rather the opposite. Even if the communication system requires sustainable media it mainly requires sustainable human actions to produce its memory. Consequently, the *prohibition* of human actions (in the short and medium terms) on the site of the repository needs to be "counterbalanced" by an *authorisation* for the respective communication systems in order to encourage long-term integration of the marking. These communication systems have to integrate the value system linked to radioactive waste, i.e. the value attributed to waste by people – in both the short and the medium terms, as the study of the question of long-term communication cannot be treated independently of the issues of short- and medium-term systems (their contexts and organisation) to establish a long-term communication protocol, i.e. one that is beyond context and temporality. The protocol has to be acontextual and achronic as it needs to meet requirements for all contexts and all timeframes. Lastly, the protocol needs to assimilate the repository within its environment by associating in the same significant whole the marking, the site's design and human actions.

Current objectives

This hypothesis is currently being examined in the form of a protocol of transmissibility with the aim of:

- thinking more deeply about the link between "media" and "tradition";
- making proposals for a communication system based on a "model relay";
- defining a protocol of transmissibility based on three storage stages/three memory stages;
- in order to develop links between communication systems, transmissibility and memory construction.
- our methodology is based on:
  - Notes/directions for use[1] covering a bibliographical selection (with one research axis on the performance of communication systems using linguistic structures/languages/media, another on public perception). The notes all contain four sections:

1. Prepared by final year and doctoral students on our Semiotics, Linguistics, Information and Communication Sciences courses.

  - references of the publications or articles;
  - field (e.g. linguistics);
  - summary;
  - relevance of the article for the Memory project.
- Two ad hoc studies included in the protocol of transmissibility:
  - A questionnaire on the perceived risk of nuclear power (to test the mind-set of a given population regarding radioactive waste).
  - Discourse strategies in communication on nuclear risk using precise expressions designed to guarantee medium-term understanding of the communication in question.

The next step is towards a monitoring system *for communication*.

References

Human Interference Task Force (1984), *Reducing the Likelihood of Future Human Activities that could affect Geologic High-level Waste Repositories*, Technical Report BMI/ONWI-537, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus.

Sebeok, T. (1984), *Communication Measures to Bridge Ten Millennia*, Technical Report BMI/ONWI-532, commissioned by the Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, www.osti.gov/scitech/servlets/purl/6705990/.

Archaeology and the future: Managing nuclear waste as a living heritage

Cornelius Holtorf and Anders Högberg
Linnaeus University
Sweden

Archaeology is the study of the past and its remains in the present. It is relevant to the long-term preservation of records, knowledge and memory, e.g. regarding final repositories of nuclear waste, in two ways. Firstly, future archaeology may promise the recovery of lost information, knowledge and meaning of remains of the past. Secondly, present-day archaeology can offer lessons about how future societies will make sense of remains of the past.

Archaeology is always situated in a larger social and cultural context and the information, knowledge and meaning it generates is necessarily of its own present. Archaeological knowledge reflects contemporary perceptions of past and future; these perceptions change over time. Indeed, we cannot assume that in the future there will be any archaeology at all. We think, therefore, that future societies will want, and need, to make their own decisions about sites associated with nuclear waste, based on their own perceptions of past and future. To facilitate this process in the long term we need to engage each present, keeping safe options open.

In this text we elaborate on these issues from our perspective as archaeologists (see also Holtorf and Högberg, 2013; 2014a; 2014b; and forthcoming).

Has information, knowledge and meaning of the past been transmitted to the present?

Previous applications of archaeology to questions about the preservation of records, knowledge and memory have often attempted to draw lessons from what has been successfully preserved to the present day. For example, the Pyramids of Giza or the stone circle of Stonehenge are often mentioned as surviving monuments from the past containing ancient information and meaning for us to decode today (e.g. Kaplan and Adams, 1986).

From our perspective, however, we would be more cautious regarding the possibility of maintaining or recovering information, knowledge and meaning over long timespans. The example of European megalithic tombs shows how people's interpretations of their meanings and significance has changed drastically over the circa 5 000 years of their existence (Holtorf, 2000-2008). Indeed, many were completely destroyed. What was preserved or recovered was, at best, the assumption that these monuments stemmed from a distant past beyond human memory and that people may have been buried in them. But these assumptions hardly constitute the kind of maintenance or recovery of relatively complex information, knowledge and meaning that is relevant in the present context of nuclear waste repositories. The lesson to be learnt from this example is that information, knowledge and meaning are created in every present. Historical

development, including the history of interpretations, is not predictable and full of changes.

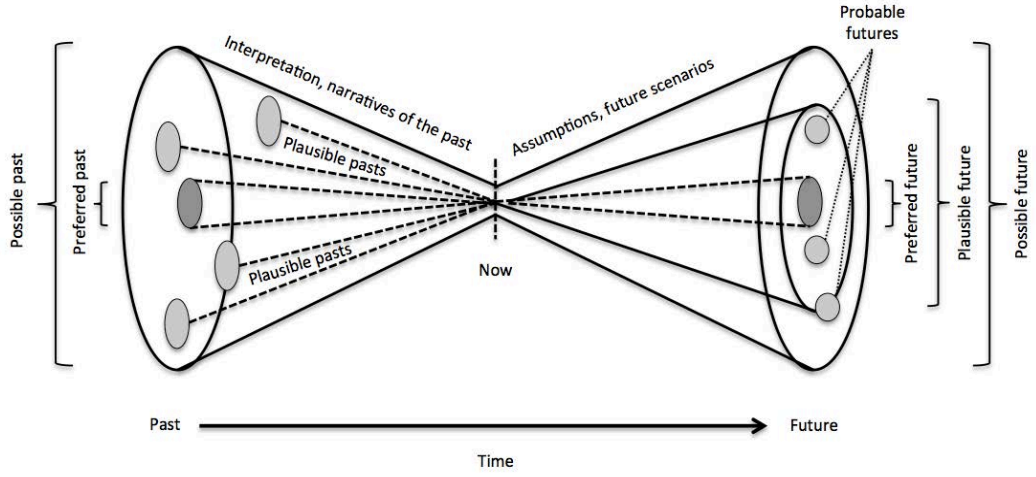
Like most scholarly disciplines, archaeology, as an academic discipline, is only about 150 years old, with roots maybe twice as old. In the long perspective it appears that archaeology does not look at its study objects such as megalithic tombs from a position that transcends history but it is instead itself part of history. Archaeology, like other academic disciplines of the present, is to be understood as situated in a larger social and cultural context. It is a particular way of creating information, knowledge and meaning of selected study objects in the present (Thomas, 2004). We cannot assume that current archaeological ways of making sense of the past will persist, nor that academic archaeology in the long-term future will even exist. Nor will most of the scientific disciplines as we know them today.

But archaeology can nevertheless offer valuable insights about the way in which future societies will make sense of remains of the past.

How will future societies make sense of remains of the past?

Archaeology is an important tool for understanding human and cultural development in time. The information, knowledge and meaning it generates is necessarily of its own present, reflecting that present's perceptions of both the past and the future. These perceptions are based on interpretations and narratives of the past and assumptions about the future. In Figure 9, we hypothesise on some of the processes involved when this takes place.

Figure 9: Schematic illustration of how interpretations of the past are transformed through the needle's eye of *Now* into assumptions of the future



Source: Anders Högberg, inspired by http://adventurefuture.wordpress.com.

Crucially, this is a "rolling now" constantly moving along the axis of time as the future becomes present and the present becomes past.

The way humans make sense of pasts and futures in the present is important for how we understand ourselves and our present time. We assume that this applies to all humans, past, present and future. Arguably, the ability to understand the present as a consequence of history and the way we plan for the future separates us from other species. Indeed, to think about time in complex abstract terms is unique to humans (Donald, 1991).

Society exists in the present, in its *Now*. Assumptions about different futures create different perceptions of the future in the present. The *preferred future* is what different stakeholders would like to happen and therefore varying among individuals and communities. The *probable futures* are what will likely happen. Since the probable futures are not one but many futures, it is likely that several stakeholders can agree on them. *Plausible* and *possible futures* are what could happen respectively of what might happen. These are not specific futures but rather theoretical possibilities deriving from certain detectable trends and movements in the present.

In analogy with the future, various interpretations about the past create different perceptions of the past in the present. Within the wide and almost infinite spectra of things which have taken place in the long-term history of *possible pasts*, a selection is made of *plausible pasts* and a *preferred past*.

The point to be made here is that these pasts all have to be processed in our present, the *Now* in Figure 9. As sand in a sandglass has to flow from one container into another through a narrow passage, time is constantly flowing through an ever changing present. And by passing through that narrow passage, the needle´s eye comprising our present, the past is transformed into various assumptions about the future, i.e. future scenarios.

When we move the needle's eye of the *Now* along the timeline in Figure 9 back into the past or forward into the future, the shape of the figure will always stay the same. Every past and future present has specific limits and possibilities on how people understand their specific *Now* in relation to their interpretations of the past and their assumptions about the future.

We argue, therefore, that it is by understanding changing perceptions of past and future and indeed change over time more generally that archaeology allows us to make better decisions concerning the sustainable preservation of information, knowledge and meaning in a long-term perspective.

Implications for long-term preservation of records, knowledge and memory

Based on the previous argument we suggest that future societies will want, and need, to make their own decisions about sites associated with nuclear waste. They will, after all, have their own perceptions of past and future resulting in their own preferences in the *Now*.

To facilitate this process in the long term we need to engage continuously each present, keeping many options open provided they are safe. Consequently, we should not think too much about acting for the long-term, beyond keeping options open for future societies to make their own decisions and recognising that historical development is never predictable and full of unexpected changes. We can therefore say that a wise strategy is to think about the long-term but act for the short and medium terms. The best chance to have an impact on the long-term, is to keep knowledge alive in the short and medium terms (see also Holtorf and Högberg, forthcoming). Markers to inform future generations (such as the Waste Isolation Pilot Plant) are not wrong, but we must not put too much hope in them. We agree with NEA's integrated strategy of concurrent marking strategies that are directed at various short-term, medium-term and long-term futures.

Particularly important are forms of communication that will create contributions to contemporary life to keep knowledge about the sites alive (Pescatore and Mays, 2007). By that we mean to create appropriately themed forms of living heritage, i.e. traditions related to a particular theme that draw on the past and are constantly reinterpreted for the future. They can take many different forms, from specific designs (for example of markers) to skilful craft and from regular rituals (religious, seasonal, academic?) to continuing story-telling, all linked to the topic of nuclear waste and geological repositories. Over time, these specific contributions to contemporary life, like other heritage, will be reinterpreted, changed, supplemented and perhaps replaced in future

Nows. This type of communication is not limited to convey what we know and how we want somebody in the future to understand the sites or act upon them. Instead, we embrace fully that all futures will want, and need, to shape their own *Now* and thus make sense, and use, of final repositories of nuclear waste in their own way (Holtorf and Högberg, 2014a, 2014b).

In this approach, reinterpretation and indeed change of information, knowledge and meaning over time is not a problem to be eliminated as far as possible, but a basic condition of human development over time which we need to understand and take on board. We have to allow for future *Nows* to create their own knowledge to act upon. This way of looking at communication with the future does not focus on the fact that information and knowledge may be lost but builds instead on our knowledge of future human beings as creative and innovative creatures able to generate information, knowledge and meaning that we today cannot even imagine.

Conclusions

Archaeology is about the present and reflects present perceptions of the past and the future. Indeed archaeology as such is part of history; it emerged some 150 years ago and will not exist for all future. It is thus utopian to assume that in the long-term future there will be archaeologists able to recover lost information, knowledge and meaning from the clues we leave for them. Information, knowledge and meaning of the past cannot be transmitted reliably in the long term.

Even if the half-life of nuclear waste is long, we suggest here to focus mostly on the short and medium terms. Extending our previous argument about nuclear waste as cultural heritage of the future (Holtorf and Högberg, 2014a), we argue that the best way to communicate with the future is to create appropriately themed forms of living heritage in relevant communities.

It is unwise to try and pre-empt the future. We need to recognise that future societies will make their own decisions and that they will have their own views not only of the past but also of the future.

Acknowledgement

We would like to thank Claudio Pescatore and the organisers of the conference for a very interesting event in Verdun, bringing together a unique group of people from different backgrounds. The final version of this text has benefitted a lot from what we have learnt in Verdun. The project from which this paper derives is in parts funded by the Swedish Nuclear Fuel and Waste Management Company (SKB).

References

Donald, M. (1991), *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition*, Harvard University Press, Cambridge.

Holtorf, C. (2000-2008), *Monumental Past: The Life-histories of Megalithic Monuments in Mecklenburg-Vorpommern (Germany)*, Electronic monograph, University of Toronto, Centre for Instructional Technology Development, http://hdl.handle.net/1807/245.

Holtorf, C. and A. Högberg (2013), "Heritage Futures and the future of heritage", in Bergerbrant, S. and S. Sabatini (eds), Counterpoint: Essays in Archaeology and Heritage Studies in Honour of Professor Kristian Kristiansen, BAR Int. Ser. 2508, Archaeopress, Oxford, pp. 739-746.

Holtorf, C. and A. Högberg (2014a), "Nuclear Waste as Cultural Heritage of the Future", WM2014 Conference Proceedings, www.xcdsystem.com/wmsym/member/2014_proceedings.cfm.

Holtorf, C. and A. Högberg (2014b), "Communicating with future generations: What are the benefits of preserving for future generations? Nuclear power and beyond", *European Journal of Post-Classical Archaeologies*, 4, pp. 315-330.

Holtorf, C. and A. Högberg (forthcoming), "Zukunftbilder in erhaltungsstrategien" in Holmann, M. and A. Schüller-Zwierlein (eds), *Diachrone Zugänglichkeit als Prozess: Kulturelle Überlieferung in systematischer Sicht*, de Gruyter, Berlin and Boston, pp. 197-214.

Kaplan, M.F. and M. Adams (1986), "Using the past to protect the future: Marking nuclear waste disposal sites", *Archaeology*, Vol. 39, No. 5, pp. 107-112.

NEA (2007), *Fostering a Durable Relationship Between a Waste Management Facility and its Host Community: Adding Value Through Design and Process*, OECD, Paris, www.oecd-nea.org/rwm/reports/2007/nea6176-fostering.pdf.

Thomas, J. (2004), *Archaeology and Modernity*, Routledge, London and New York.

Conference closure

Comments on the Constructing Memory Conference

Erik Van Hove
University of Antwerp
Belgium

A number of presentations at the conference have shown that a lot of progress has been made over the past years:

At the technical level:

- record keeping over longer periods is feasible;
- information decay is a real problem but can be managed once one is aware of it;
- markers can be effective and sufficiently durable.

In the domain of corporate responsibility and ethics:

- The need for longer periods of oversight is accepted. But "oversight" of another kind than a system of prohibitions.
- Within the international co-operation network of the NEA, no agencies can be found that renege on their responsibility to manage waste safely and for long periods.
- Some efforts have been made to involve local stakeholders.

These achievements are the fruit of sustained committee work, research papers written, meetings held, site visits organised, using all the tools at the disposal of organisations that are sufficiently funded to ensure a good functioning. Results at the operational level were presented in several waste disposal sites already in operation. The story was told of Central Organisation for Radioactive Waste's (COVRA) RK&M Provisions to cover the storage of radioactive waste at HABOG for the next 100 years or more. This showed how a storage facility that did not start out to become a valued landmark accepted in the region could become so by providing additional services to the art community and some paint. Andra's *Centre de La Manche* has done remarkable work in setting up a robust archival information system.

How far can we get within the present organisational framework and is that sufficient to fulfil the mission? Will our improved capacity to preserve information also lead to more certainty that the message will be understood, let alone, acted upon? Will our willingness to provide a positive oversight over longer periods facilitate the inevitable transfer of responsibility to future generations? Of course, we should not have the ambition to dictate a distant future of thousands of years ahead. We should consider ourselves to be engaged in a relay run where we have the responsibility to bring the "baton" of information and repositories in the best possible condition to our successors.

We believe that in order to make further progress we need to go beyond the institutional, professional world and cross into the human world of daily local life. Messages of more than 5 000 years old on cuneiform tablets that give us recipes for a stew or register complaints of a weary father about his lazy son are immediately clear to

us. Ovid's love poems or the Shakespeare sonnets need no lengthy explanation. Try that with a chemistry treatise a few hundred years old. In contrast with the experiences of daily life that have a universal meaning over time and space, scientific information and professional practices are very context specific. Science is constructed from a great number of building blocks, its power lies in the ability to work incrementally and is therefore of necessity fragmented. Organisations and firms also work this way: problem solving is incremental, the work can be distributed over many, each in its proper slot, without the need for everyone to understand the whole. When this kind of information gets decontextualised it becomes very quickly unintelligible. At the conference, several warnings were issued that local anchoring is needed not only for future intelligence but even for a site to be preserved. We were told the amazing story of the inland customs fence (taking the form of a hedge) in India that disappeared without a trace in just a few years.

How can we reach out and "embed" our projects into daily local life? Here are a few suggestions:

- Add value to a repository in such a way that it becomes something to be proud of or has a local use. This can be at the cultural level (art sponsorship seems to be a favoured one) or recreational or educational, and even ecological. Sports facilities would be nice, but so would be a cemetery. HABOG has even the ambition to become a pilgrimage site. The Forum on Stakeholder Confidence report entitled "Fostering a Durable Relationship between a Waste Management Facility and its Host Community" (NEA, 2007) could help.
- Oversight with insight. Have local residency requirements for agency personnel and locate repository offices and staff within the local community.
- Have non-professional locals involved in document preparation to avoid specialist jargon and actively pursue the language of daily life.

For those agencies that have involved local stakeholders, the experience has been positive. The objections raised have not materialised. In Belgium, the partnerships flourish and are able to sustain the effort. They are rejuvenating spontaneously. Nor have they been co-opted by the agency: they firmly and critically represent the local community.

Reference

NEA (2007), *Fostering a Durable Relationship Between a Waste Management Facility and its Host Community: Adding Value Through Design and Process*, OECD, Paris, www.oecd-nea.org/rwm/reports/2007/nea6176-fostering.pdf.

Part III. Contributions from artists, and posters

Artists

The RK&M initiative and its Constructing Memory conference have highlighted the need to integrate visual tools and culture to ensure the passing of important messages from generation to generation. In this framework, artists and artistic projects revolving around the theme of memory presented their work with physical exhibitions during the three-day event.

Cumbrian Alchemy (2012-2014)

Robert Williams and Bryan McGovern Wilson
Cumbrian Alchemy project
United Kingdom

The *Cumbrian Alchemy* project explores issues emerging from an enquiry into convergent relationships among the nuclear and other energy industries, archaeological monuments and oral traditions of the North Lancashire and Cumbrian region in the north-west of England. Topically, it focuses on ideas of "places of power", issues and discourse associated with hazardous industrial sites, long-term nuclear repositories, matters of "deep-time" with respect to the recording and remembering of these repositories, language preservation and stewardship of the land. The project was supported by Arts Council England and the University of Cumbria.

As part of the fieldwork, sites were visited at the nuclear facilities at Heysham 1&2 reactors, historical site of Sellafield and the associated training facility for vitrification of nuclear waste. Historical and heritage sites were explored at Heysham in North Lancashire, as well as a variety of prehistoric archaeological sites in the region including the monuments of Long Meg and her Daughters, the cursus at King Arthur's Round Table near Penrith, and the stone circle at Castlerigg. The fieldwork stage led to the making of new work, notably three large-scale Diasec photographs, the series of drawings included in the exhibition at The Rheged Centre (February-April 2014) and Centre Mondial de la Paix at Verdun (September 2014), and a collaborative sculpture in which a collection of stones sourced from folkloric sites in Cumbria, were sent to New York to be cast in uranium glass. These were then returned to Cumbria with their radioactive doubles as part of the sculpture *Ghost Stones* (Figure 10). The film *Gryss-hryggr* focuses on narrated elements of the *Volsünga Saga* found on the Heysham Hogback Stone monument. Material associated with Britain's Energy Coast, the archaeology and folklore of the region was collected to form documentation of place and context, with bibliographic references and associative material presented within two plan-chests that act as archival repositories.

The illustrated book, designed by the artist James Brook, brings together material invoked and generated by the project. Essays by eminent professionals form a parallel enquiry, mirroring the themes for the artwork with particular reference to records knowledge and memory (RK&M) issues. Essayists include the archaeologist Dr David Barrowclough from the University of Cambridge, a leading expert on the prehistory of Lancashire and Cumbria who considers the concept of deep-time in Cumbria and the future archaeology of long-term nuclear storage. Nuclear specialist Dr Paul Abraitis investigates the natural history of radiation in the context of the region, while journalist Alan Cleaver provides insights into the folklore of Cumbria in his discussion of semi-mythical animal and supernatural stewards of the land. The introduction is by renowned American artist Mark Dion.

Figure 10: Sculpture Ghost Stones



© Robert Williams, Bryan McGovern and Sam Knight.

Wilson made the trans-Atlantic journey in early 2011. By this time Wilson and Williams had completed research that informed the dialogic and interdisciplinary project. Not least of which was in the identification of three principle areas of interest that emerged from the investigation of the region in consideration of RK&M themes as a contribution to the discourse. The first aspect being the "energy coast" of Cumbria and North Lancashire, which encompasses the historically significant nuclear power, renewable energy production and mineral extraction industries. That these were then considered in relation to what the artists had begun to conceptualise as other "places of power" in Cumbria, was significant in their exploration of the extant archaeological monuments in the region, referencing millennia of human occupation since the last glaciation. The monuments informing this second strand ranged from the Mesolithic and Neolithic periods, later western Megalithic cultures, Brythonic Celt, to the Roman occupation signalled by the presence of Hadrian's Wall, and the region's mediaeval Norse heritage. The third aspect of their interest was to consider how ideas of these places of power, of "deep-time", "mythic-time" form a sense of continuity with the land that might find expression within the narratives, stories, place names and folklore of the region in an exploration of ideas that form part of current proposals and strategies for RK&M. The extent of the field area encompassed territory within the nexus of old Lancashire, Westmorland and Cumberland. In the centre and across to the coast on the west and the Pennine Hills to the east lies the ancient kingdom of Cumbria, a place of dramatic scenery, lakes and mountains, huge geological formations and great valleys carved by glaciers nearly a mile thick during the last Ice Age.

The region is important culturally in informing the rise of Romanticism, particularly with reference to Edmund Burke's idea of *The Sublime* (1756), which focused not only on creating the dichotomy between beauty and the sublime, but also with reference to emotional and physiological responses to landscape as part of a dynamic for interpretation. However, less well-known and yet as equally important is Harriet Martineau. A reformer and early pioneer of women's rights, racial equality and political science, she is considered to be the first woman sociologist. Of significance for our project, she was the author of *The Complete Guide to the English Lakes* (1855), in which she advocates a structured and aestheticised approach to the land in order to seek out

sublime elements. This represents a development of Thomas West's earlier guide book on Lakeland (1780) which led to the setting up of viewing stations linked to historical, aesthetic and antiquarian qualities which were invoked according to the theory of the significance of "place" and "context", in order to fully appreciate the sublime experience.[1] Martineau was interested in this holistic approach to the concept of place, her guidebook invoked folkloric elements, oral histories, along with antiquarian, geographical and topographical information to draw in all the aspects of a particular location in order to read landscape and to make meaning.

Central to the *Cumbrian Alchemy* project are the energy industries, perhaps most directly referenced in the form of the nuclear installations on the coast. To the west is Sellafield, now no longer a producer but a reprocessing site. Sellafield began life as Calder Hall, the world's first atomic power station and the first British facility built to provide enriched plutonium for use in Britain's nuclear arsenal during the Cold War. Significantly, the site of production for the British nuclear submarine fleet is at Barrow-in-Furness in the south-west of the county. After Calder Hall, the nuclear facility known as Windscale was developed. It was here on 10 October 1957 that the world saw its first civil nuclear disaster. The air-cooled reactor in unit 1 malfunctioned and burnt for three days, creating a disaster of severity level 5 on the International Nuclear Event 7 point scale. While most of the nucleotide releases had short half-life decay cycles, there was still significant contamination of the site, the surrounding region and in the Irish Sea. Memory of this event and its consequences remain topical in the region. Consequently, the issue of long-term geologic storage of nuclear waste under Cumbria is a significant social, political and cultural matter within the region. The plan for a geologic repository was narrowly defeated at a local level during the lifetime of the project. The no vote surprised both local and national governments alike. It is the urban communities that oppose these underground storage facilities. The inhabitants of the West Coast and the communities surrounding Sellafield are emphatically pro-storage, representing long-term economic stability, employment and security in a very deprived part of the country.

It seemed important within the framework of our enquiry, to put aside particular ethical, moral or political positions. To treat the existence of these industries and the concomitant issues that they give rise to as phenomenon to be addressed and investigated. The artists became interested in the current discourse about the preservation of knowledge and the deep-time marking of nuclear repositories, in view of the wealth of archaeological material in close proximity to the Cumbrian sites.

Less than a mile north of the Heysham nuclear facility lies the Barrows, a site of human occupation for more than 10 000 years (see Salisbury and Sheppard, 1994; and ARS, 2009). Here are found a series of stone coffins cut into the bedrock of the premonitory that once held the bodies of Christianised Vikings at a site of one of the earliest churches established in Britain in the 8th or 9th century. Nearby in the mediaeval church of St. Peter built around 1340 on earlier Saxon foundations, is preserved the famous Viking Hogback Stone. Hogback sculptures are found in a narrow corridor on the west side of the country – a single stone found on Merseyside marks the southernmost extent, while there is a group at Govan which forms the most northerly range. The vast concentration of all known hogbacks lies within Cumbria. However, this Lancashire example is the best preserved of them all. The stone carries within its carvings two stories from the Norse *Völsunga Saga*, an epic tale concerning the heroes Sigmund and his son, Sigurd. They are stories of epic battles, voracious wolves, magical transformations,

1. At viewing stations such as Claife, overlooking Windermere, special viewing windows were constructed and glazed with coloured glass to act as framing devices in order to provide the "correct" and most beautiful views. The Lake District has been a tourist destination since the late 17th century.

and the famous story of dragon slaying when Sigurd defeats the monster Fafnír. The narration in the film, *Gryss-Hryggr* was provided by the late Mr John Disney, senior guide at St. Peter's church. This was his personal account of the ancient tale, delivered in his own idiom as part of an oral tradition that goes back more than a thousand years. As a Yorkshire man, Mr Disney's dialect owed its cadence and rhythms to the Norse speech that it developed from. Short of hearing this story in Old Icelandic, this is as authentic as it gets and is a way to link the deep past to the contemporary world.

Figure 11: Sellafield Drawer



© Robert Williams, Bryan McGovern and Sam Knight

One strategy considered in the project emerged from an encounter with the work of Thomas Seboek, a Hungarian born folklorist and semiotician. He is noted particularly for the development of the theory of Zoosemiotics, in relation to theories of mind in terms of animal communication, intelligence and language use (also see Williams R., 2013). It was his interest in languages that led to his appointment by the US Nuclear Regulatory Commission to consider ways to mark nuclear sites for future generations, in many ways a precursor to the discourse and the concerns of the Constructing Memory conference. This work led to his noted 1984 paper *Communication Measures to Bridge 10 Millennia* (Sebeok, 1984). He proposed what he called a "folkloric relay system" to use narrative and oral traditions, as well as a sequence of signs to create an "Atomic Priesthood". Wilson took this as a lead in his development of the *Alchemical Host* that chimes directly with his persona as the Atomic Priest within *Cumbrian Alchemy*. Here the Atomic Priest's vestments are drawn from the cult originator's clothes as they reference Robert Oppenheimer, father of the atomic bomb. Wilson and Williams decided that the Atomic Priest would make a pilgrimage to the archaeological monuments of the region, a sort of magical, alchemic tourist testing Seboek's novel and controversial ideas in relation to his proposals for RK&M.

Figure 12: Atomic Priest at Castlerigg



© Robert Williams, Bryan McGovern and Sam Knight

The third thematic aspect of the exploration in considering how power – natural, human, or supernatural – might be identified with *place,* speculated on how the communication of this might warn, beguile or control, in view of maintaining knowledge of dangerous or significant sites while transcending time on the scale of a human lifespan. Folkloric stories and oral traditions informed the research and guided this aspect of the enquiry. On the upper Eden valley lies Wild Boar Fell, where Sir Richard Musgrave killed the last wild boar of England. A tusk of this beast, formerly buried with Sir Richard's body, is now preserved as a relic in the Parish Church of Kirby Stephen. At the western extent is a precipitous premonitory, Humphrey Head. This is the very spot where the last wolf of Cumbria was killed. The significance of these animals is also preserved within Norse place names in Cumbria – the Boar or Grisle, gives its name to many locations in the county that have the *gris* prefix, like Grizedale or Grisland. Similarly, the wolf is very much represented in place names, the word *Ulpha*, of which here are many in the county, means "hill of the wolves", and gives its name to places like Ulverston and Ullswater and Ullscarf. These two animals became important within the project as evidence of the preservation of meaning in relation to place and land over lengthy periods of time. These powerful and potent animals were imagined as elemental stewards of the land, they might have been so in the past, and remain so in terms of their continued existence in an eternal mythic space.

The overall strategy for the project was to create a work that forms a complex and related set of correspondences between the three strands of the enquiry, to invoke our research and speculation about RK&M, and to act out themes in relation to the different elements of the enquiry. These elements join together, but not necessarily in neat or even logical ways. One may see the dynamic of the project as behaving like thought itself, one aspect referencing and triggering another, to form an interconnected network of possible readings and meanings to promote further insight, speculation, discourse and debate.

Robert Williams, a British artist, holds a personal chair as Professor of Fine Art at the University of Cumbria. His interdisciplinary practice draws from subjects as diverse as archaeology, taxonomy, alchemy and anthropology. Recent practice includes collaborative projects with his 16-year-old son, Jack Aylward-Williams, the American artist Mark Dion, German cultural sociologist Dr Hilmar Schäfer and the British conceptual writers, practitioners and publishers Information as Material.

Bryan McGovern Wilson is a multidisciplinary artist whose work addresses themes of time, the body, and ritual. Wilson looks to craft traditions as methodology, archaic symbolism and field research as strategy to inform his works. Wilson is the recipient of the 2014 Irwin Borowsky Prize in Glass Arts. He currently lives and works in New York City.

Wilson and Williams have worked together over several years on projects such as *Opus Magnum: Theatrum Chemicum Britannicum* for the Mildred's Lane Project in Pennsylvania, and *An Ordinall of Alchimy* with Mark Dion for Cabinet Magazine in Brooklyn, New York. *Cumbrian Alchemy* is their first UK-based project together.

References

ARS (2009), *North West Rapid Coastal Zone Assessment (NWRCZA)*, Archaeological Research Services Ltd Report 2009/53, ARS Ltd, Gateshead.

Burke, E. (1998), *A Philosophical Enquiry into the Sublime and Beautiful*, Penguin Classics, London (original work published 1756).

Martineau, H. (1855), *A Complete Guide to the English Lakes*, Garnett, Windermere/Whittaker, London.

Sebeok, T.A. (1984), *Communication Measures to Bridge Ten Millennia*, BMI/ONWI-532, prepared by Research Center for Language and Semiotic Studies, Indiana University, for Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus.

West, T. (1780), *A Guide to the Lakes in Cumberland, Westmorland and Lancashire,* Pennington, Kendal (original work published 1777).

Williams R. (2013), "Wilder Talents (Even): Uncanny Talking Animals", in *I, Sparkie: Andrew Dodds*. Nick Thurston (ed.), Information as Material, York.

Salisbury, C.R. and D. Sheppard (1994), "The Mesolithic Occupation of Heysham Head, Lancashire", *Transactions of Lancashire and Cheshire Antiquarian Society*, No. 87, pp. 141-149.

Gérard Larguier

Artist
France

Since 1994, the French National Agency for Radioactive Waste Management (Andra) has been pursuing a study of collective memory, based on its experience with the Manche disposal facility. In 2010 – in response to the project *Centre industriel de stockage géologique* (Cigéo), its concomitant need to preserve collective memory of the site for at least 500 years, and public demand – Andra launched an initiative to ensure that future generations do not forget about the existence of radioactive waste disposal facilities. Pursuing its investigations in this area, Andra has led theoretical enquiries that consider art as a possible vehicle of collective memory.

Memory is often found between parentheses that do not overload the spirit but enclose it in rules that facilitate forgetting... which is a vanity of the present moment. The past must always have the role of providing future ferment. And then the transfer occurs that can open up to history.

Born in 1938, **Gérard Larguier** began working in 1956 with the renowned poster artist Paul Colin of Nancy before going on to study at the Beaux-Arts in Paris and Académie Julian. He has worked at his studio in the Bateau Lavoir in Paris since 1979 as well as Bonnet's former presbytery in the Meuse since 1973. Using both materials and relief, he has exhibited his artwork at leading institutions around the world. Since 1998, he has taken up the theme of memory in his works *"Chronique du XXème siècle"*, *"Autodafés et palimpsestes"* and his series *"A saute-souvenances"*. He has also tackled the evolution of artwork over the centuries in a series of fifty works entitled *"Les chefs-d'oeuvre revisités"*.

In 2008, Gérard Larguier completed a fresco commissioned by Andra on the local heritage and environment of the Bure Laboratory. In 2010, the municipality of Soulaines d'Huys commissioned a fresco of the history of the town from the sixteenth century to the present using the archives of residents and the municipality.

His compositions, which consist of collage, torn and burnt paper, express the complexity of society and its contradictions. For him, memories occur in bursts that must be reconstituted according to the vision of the moment and objective chance, which is what determines the judgements that one makes.

Gérard Larguier considers himself an eyewitness of his era in the service of society rather than being served by society. For this reason, he has recently finished a series of eight paintings on the First World War with funding from Andra. He has just completed a yearlong residency with National Education in France on the topic to increase the awareness of 8- to 13-year-old school children on the war, which resulted in an exhibition at the Meuse Departmental Council entitled "*Un regard neuf sur un siècle de mémoire*", which was on display until 30 September 2014.

Figure 13: Les twins

280 X 190 collage and acrylic on canvas

"Somewhere, it states 'If you want the truth, ask your enemies'. In general, however, they lie to make it easier to believe their own lies! This is when the cry chokes on a reality that is too obvious and chaos roams in search of any sort of explanation. But what explanation is there but hatred, which challenges the irrational."



Autodafés series

Figure 14: Autodafés/La grande peur du loup

100 X 100 Collage and acrylic on canvas

"In the labyrinth of emotions that are felt heavily or lightly, jostling unspoken words and questions without real responses, each person ultimately invents a path that has no conclusion. No truth merits becoming exemplary. So is it not better to burn in an act of bad faith that eliminates only errors of vision than to seek in alternative thinking the future traces of the failure of executioners? That is the enigma ... and the great fear of the wolf."



Figure 15: Autodafés d'un magazine/L'attaque

100 X 100 Collage and acrylic on canvas



A saute-souvenances series

Figure 16: A saute-souvenances N°10

100 x 81 collage and acrylic on canvas

"Memory is thus fluctuating and fleeting. It selects images at a moment of chance or opportunity. Then it offers its chain of events to give meaning to life and integrate it in the imperfection of existence, the greatness of doubt, the incompleteness of dreams, the emotion of finding oneself curious. It then becomes a quest to live in a marvellous loss of time in which reflection can be achieved."

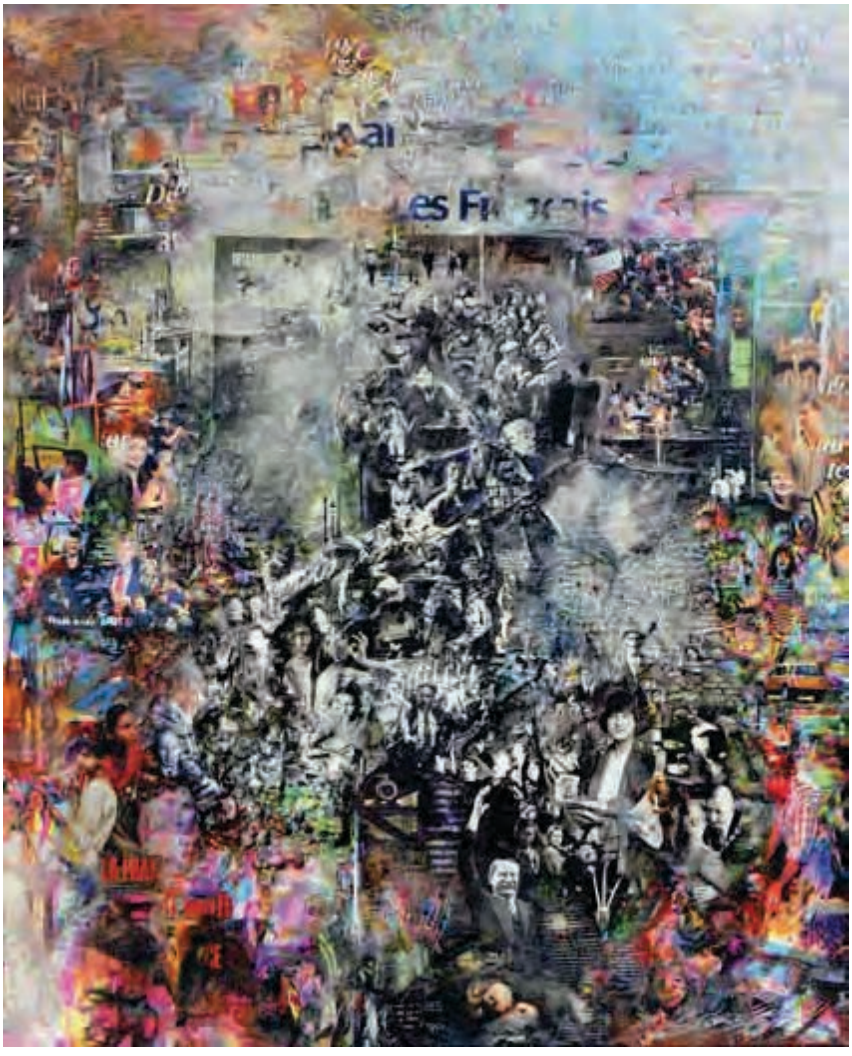


Figure 17: A saute-souvenances N°11

100 x 81 collage and acrylic on canvas

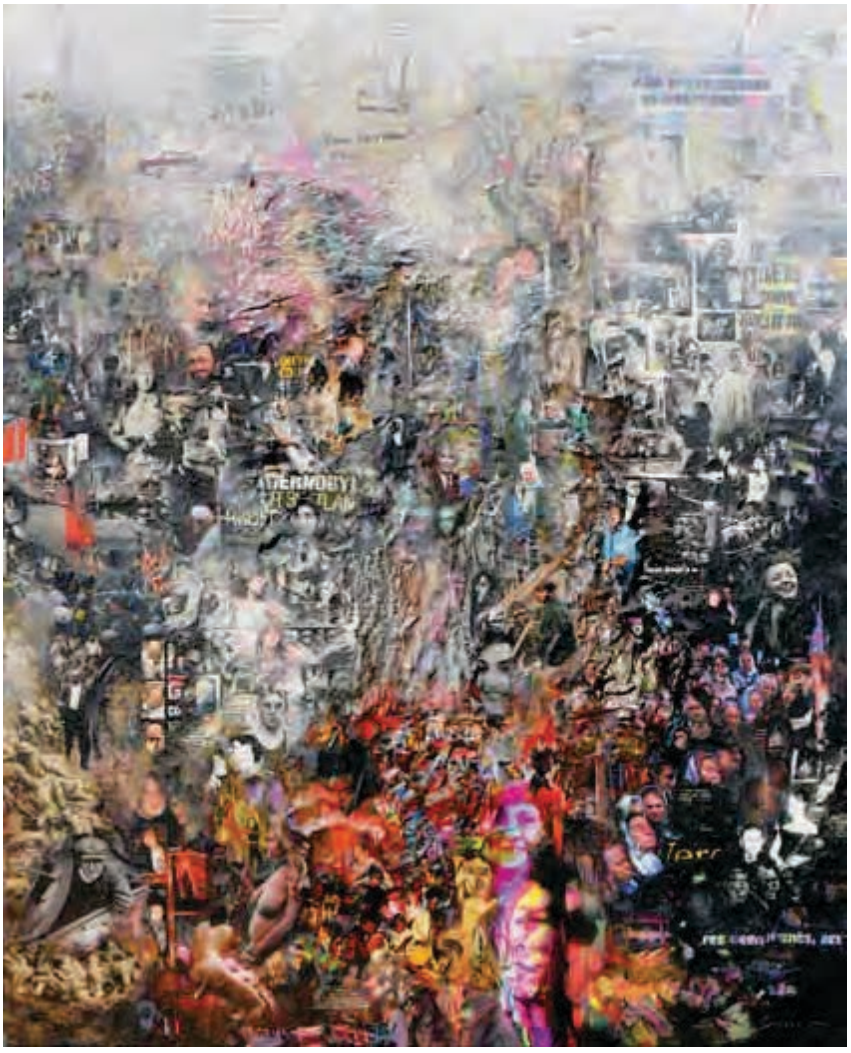
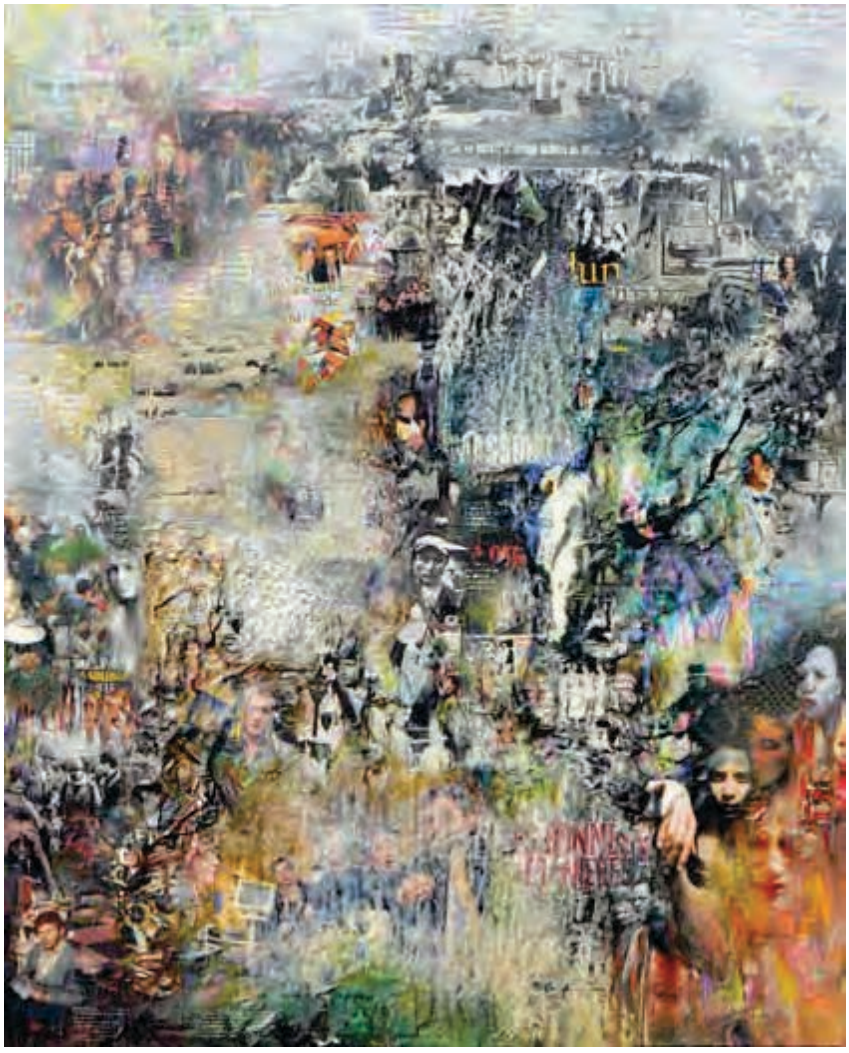


Figure 18: A saute-souvenances N°12

100 x 81 collage and acrylic on canvas



www.gerard-larguier.com

Photos by Patrick A. Martin and Alain Durey

Constructing memory through artistic practices

Cécile Massart
Artist/Researcher
Belgium

Cécile Massart is a visual artist who lives and works in Brussels, Belgium. Her teaching career includes Academy of Ixelles, École Supérieure des Arts Plastiques et Visuels in Mons, and École Nationale Supérieure des Arts Visuels La Cambre in Brussels. Cécile Massart has presented her extensive artistic research at numerous international conferences. Her works are featured in private and public collections.

Since 1994, Cécile Massart has been investigating international sites for radioactive waste storage, exploring how this 21st century archaeological stratum is being inscribed in the landscape. Researching radioactive waste sites around the world for over 20 years, her main focus has become their identification in the landscape. Her ideas are communicated through her visual research and writings that aim to raise the awareness of radioactive disposal sites and to study their life within their surroundings for future generations.

Her drawings, films, books and exhibitions investigate a new kind of architecture of the sites that become research platforms. Her first graphic research, edited under the title *Un site archivé pour Alpha, Bêta, Gamma,* helps in revealing their true nature. Her photographs, silkscreen prints, installations and pictures testify to the need to preserve the memory and knowledge of such sites across generations ensuring the safety of the living world.

With this objective in mind, to build a memory, she has developed an architectural vocabulary functioning as warning sculptures to identify the nuclear repositories in the landscape: markers or archi-sculptures. In the following sections, Cécile Massart describes her work in her own words. For more details on her work, see www.cecilemassart.com.

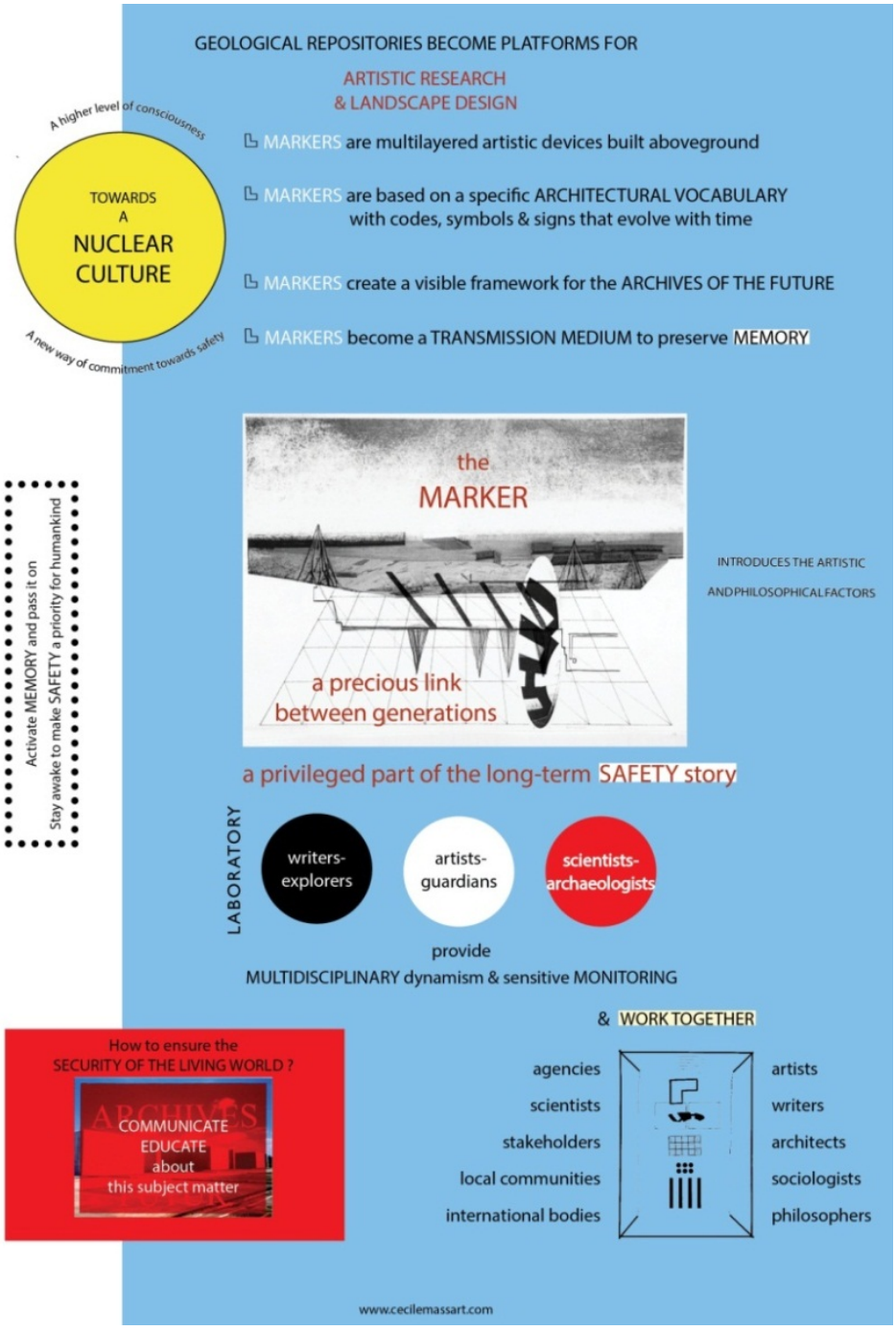
Marking monuments

The memory of any civilisation generally results in the emergence of monuments. Here the monuments contain highly radioactive waste. They symbolise our civilisation where nuclear energy with its constraints can be dangerous and unpredictable. A new culture must come to decrypt these places in the landscape. Invisible and buried in the ground, I called them *monuments* because humans will project in them their dreams, their fears and their curiosity over millennia. Sacred places hold the human at a distance. The danger that characterises radioactive waste initiates a backlash that hinders the memory process.

New ways of communicating and working culture essential for the transmission of knowledge are appearing. This should be an integral part of the industrial choices that are considered for long-term storage as our current political and economic vision is far from adequate. Knowing which technology is used and its inseparability with the material define a certain image of monuments. Ensuring their follow-up, each generation

will try to visualise them. Thanks to their strong cultural references they may also include various migration groups. Communities across the world will share their knowledge on this subject matter. In order to achieve this, a special place should be considered for people aware considered as part of this new community of guards. The laboratory, working closely with its local management agency, will relay the work which has not been planned upfront. Nevertheless, the image of this archaeology of the future should be contemplated at the surface.

Figure 19: Geological repositories become platforms for artistic research and landscape design



Source: Design by Anne Marquet.

Conveying something that is beyond us but depends on our choices

The idea was born to bring together those who reflect on an ethical, economic or artistic basis: musicians, archaeologists, writers, economists, artists, farmers, poets, etc. For a hundred years – the time needed to fill the site – a laboratory allows the residents to conduct research on the transmission of memory. The laboratory is a first marker.

I believe that artistic proposals along with management agencies, new media types and networks, changing institutions and connections with databases, provide a cultural anchor for future generations. The artist translates, invents, echoes the thoughts and anxieties of humans and weaves a link from one generation to the next. If we want this connection to stay alive, we must work on the development of architectural, musical, poetic, and choreographic markers that are rooted in cultural and community projects. The laboratories offer this great opportunity to the people living near the sites.

Moreover, companies investing in renewable energy should contribute to the financial support of these unusual residences. It is, perhaps, in this way that art will live on and will facilitate the transmission of knowledge of this type of challenge to various social groups that reinvent the marking for the preservation of the living world.

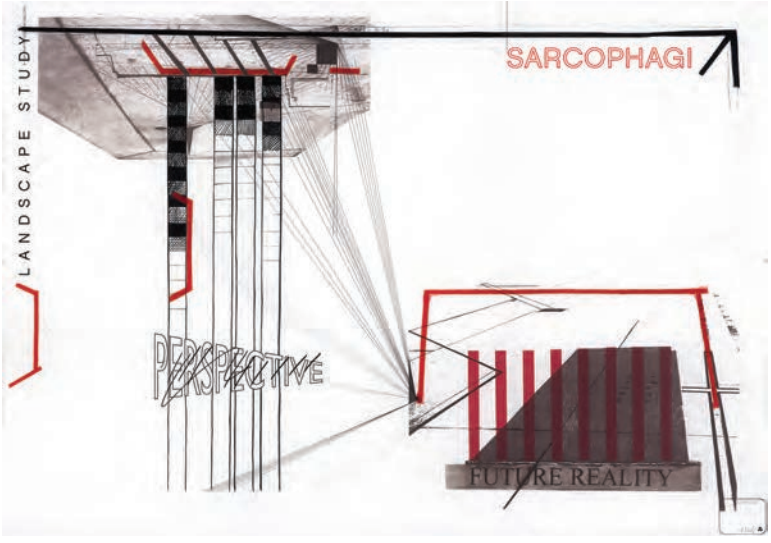
The laboratories

The radioactive waste sites require a multidisciplinary research to work on nuclear issues in the world of tomorrow. Places called "laboratories", more accurately designed as conceptual proposals, are located within the perimeter of the storage site. Through experimentations, new ideas come to light for the safety of the living world.

The drawings presented here relate to archaeological sites and other specific places that I visited and photographed. They are made on sheets from the edition of *Cover*, a book published in 2009, and reflect the maintained connection with past civilisations.

Figure 20: Sarcophagi

Limited edition (20 numbered and signed copies), 2013

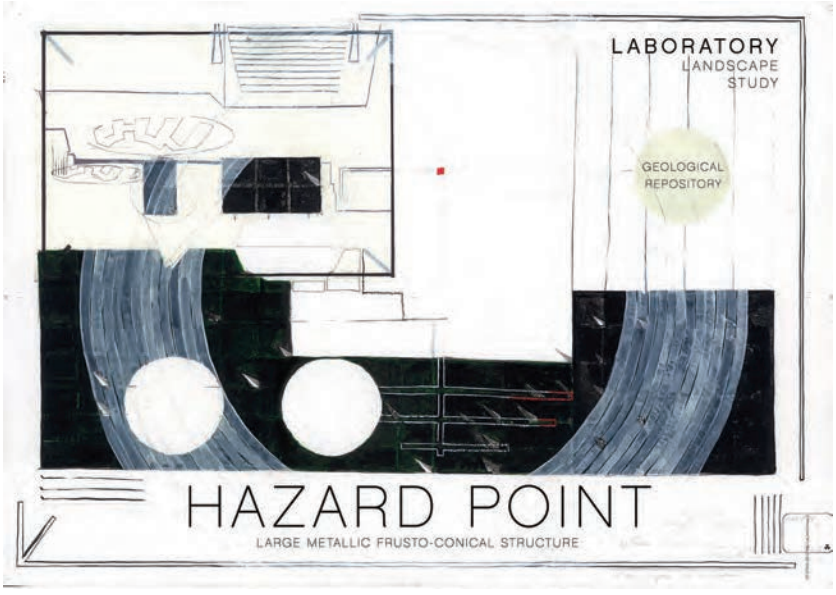


The perspective related to geological storage for millennia remains blurred. Humans cannot conceive as far away in time.

The sarcophagus, referring to the frame, the preservation for eternity of beings or valuable properties, is the envelope for the archive of our nuclearised era: this is a

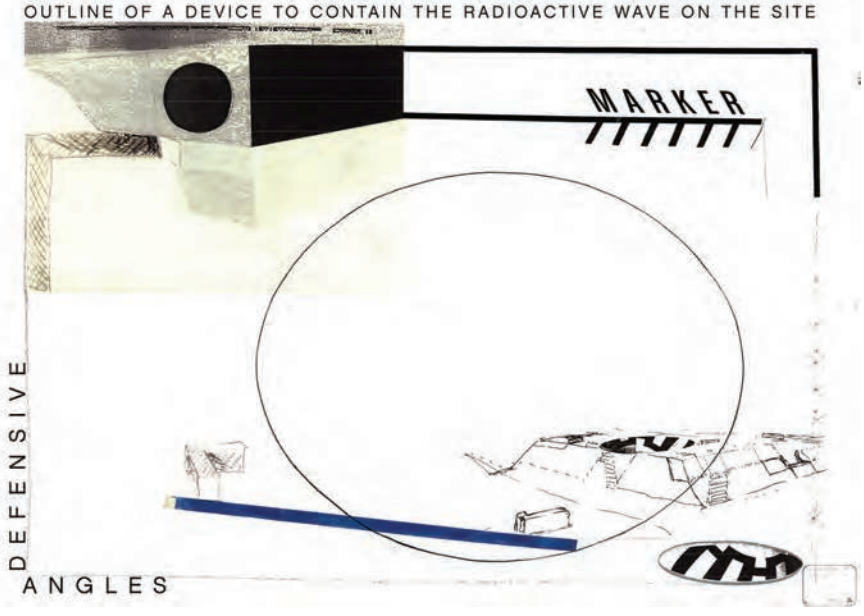
monument whose design in geological strata shows extensive scientific studies. The exercise within the laboratory will be to seek to predict and to study all the non-technical resources which will preserve the living world and the function of this place in the landscape.

Figure 21: Hazard point



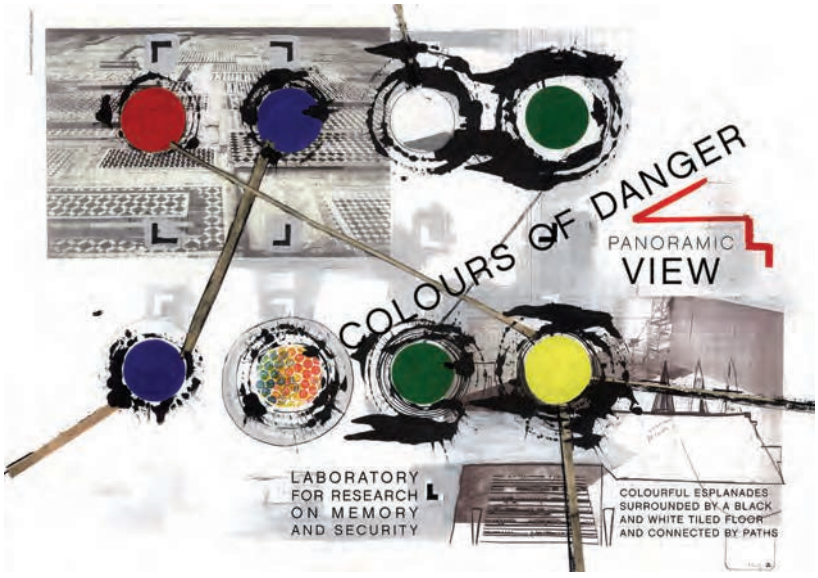
During the filling of the underground galleries around the well, a bearing metal construction grabs sets of cylindrical volumes. It is frusto-conical shaped and houses workshops for researchers. In the future, they will work on the transmission of danger which will put on a new archetypal iconography, whose instruments will offer a new reading. As from today, our concerns should include these issues.

Figure 22: Defensive angles



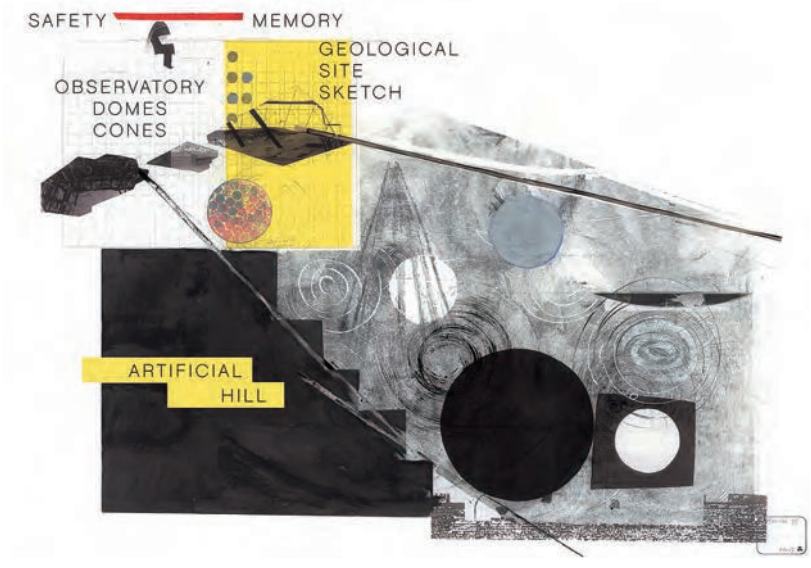
Defending a territory has been considered by humans for a long time. Securing the storage towards the outside world is technical and rigorous: one must indicate the danger existing inside. Devices often have an angular shape. However the laboratory, being an integral part of it, studies specific markers to protect the living world, creating a circle of humanistic knowledge. A circular composition consisting of trees makes it visible from a distance. Over time, the circle can grow and regenerate thus perpetuating the marking.

Figure 23: Colours of danger



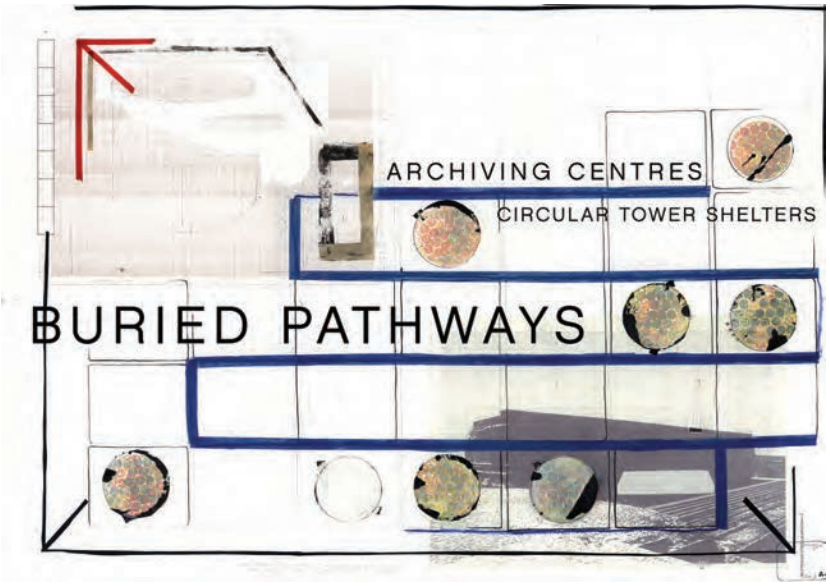
On the surface of the site, a point of view allows to discover eight colourful circles. Concrete or glazed earthen esplanades reveal the intersections of underground galleries housing the waste. Pathways link them. At the location of one of the circles, a laboratory surmounted by a colourful glass dome is erected, symbolising waste degradation over time. This memorial welcomes researchers who study the image or the most appropriate marker to echo and reflect what is moving in the shadow, giving it a visibility in the landscape.

Figure 24: Artificial hill



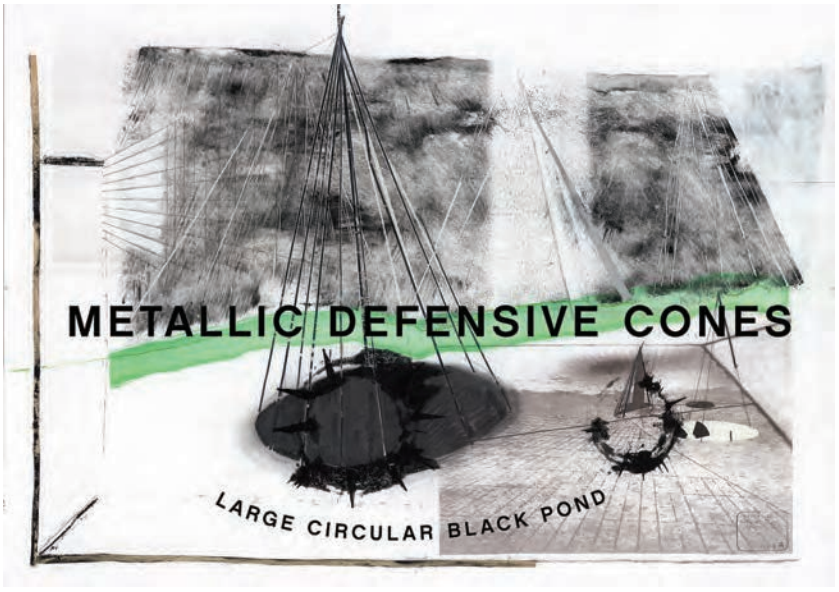
An artificial hill is built. A tunnel and several pathways lead to laboratories. These are cone-shaped structures located beside a metal structured pyramid open to the landscape. Cylindrical markers surrounded by concentric paths evoke waves on the grass cover. In these laboratories, composers, videographers, engineers and dancers take turns to co-ordinate their discoveries.

Figure 25: Buried pathways



A network of blue paths crosses the surface of the site. They are located just above the underground tunnels. Humans walk there, becoming aware of the extent of the site being built under their feet. Along these paths several cylindrical buildings are erected for the storage and the presentation of information, and for research; these are especially designed to receive questions from the public.

Figure 26: Metallic defensive cones



These are large areas, like spots in the landscape that will need to be secured. Cones with rods drawn to a point simulate spaces that will become dangerous in a very distant time. Metal captures the sunlight and the moon. Nearby, in his laboratory, the human, in front of this show, will make every effort using science and one's imagination to open a new era.

A temporary index

Jon Thomson and Alison Craighead
United Kingdom

Background

The ongoing management of low, intermediate and high-level nuclear waste is an unresolved issue for humanity, not least because the timeframes in question when dealing with the hazards of radioactive wastes, range from as little as a few tens of years to more than 100 000 years. It is from this starting point that we are beginning the development of an ambitious multifaceted artwork aiming to help us consider our relationship with deep-time and our nuclear legacy. The expressed aim of *Temporary Index* is to raise general awareness about these long-term management issues, and in doing so, to embed this knowledge into our collective cultural memory so as to transmit useful information about our nuclear waste into the future.

Proposal

We wish to create a series of decorative, real-time numeric counters based on the probabilistic decay (including decay of daughter products) of existing nuclear waste that we identify from the earliest weapons' development programmes in the United States right through to contemporary wastes being produced by nuclear energy production today across the world. Each display will countdown in seconds, showing the time remaining before the given item of waste (or a particular site) is considered safe to humans. A hypothetical example of one counter could be a bottle of sludge containing plutonium discovered in 2004 during an attempted clean-up of the Hanford nuclear site in Washington State, United States. Another example might be the geological storage facility for vitrified nuclear waste at Horonobe in Japan, should it be established in the future. Accident sites, such as Chernobyl or Fukushima Daiichi could also be tagged with counters, as could low-level waste (LLW) repositories such as the one at Drigg near Sellafield in the United Kingdom. Whatever the items identified **and this will be a complex process requiring collaboration with experts in the field**, it is important that a wide range of short- and long-term counters are established to represent diverse timescales resulting in a rich constellation of data.

Next steps

Each decorative counter will exist in a number of different forms. Initially we have been using data projections in art galleries as places to test the decorative visual abstraction of information we are proposing, which is to mirror each countdown so they appear like totems – one pictured here is based on the half-life of Actinium; the photo was taken during the set-up of a group exhibition curated by Dr Ele Carpenter at Oyoyo gallery in Sapporo during the summer of 2014.

Figure 27: A concept drawing of a physical counter on the beach at Drigg near Sellafield



Figure 28: A counter based on the half-life of Actinium
(Photo taken during set-up of a group exhibition in Sapporo, 2014)



The next stage will be to establish a network of these counters online, in what could be described as our "virtual physiography". Once we have begun building a network of counters in virtual spaces, we will attach the information to places like Google Earth etc. and as this network of counters evolves we will then be able to manifest them in more concrete ways in galleries. It is at this point, that information contained in these collected art works will begin the long process of becoming embedded into the collective cultural memory of institutions like art museums. Ultimately we will also look at possibilities of building semi-permanent physical counters in the places they refer to with a view to making them self (solar) powered.

Conclusions

These representations of time in *Temporary Index* far outstrip the human life cycle right now, and provide us with a glimpse into the vast time scales that define the universe in which we live in. They also represent a future limit of humanity's temporal sphere of influence: at the moment it is difficult to think of much else we have made lasting longer than our nuclear waste. So this is why we have decided to focus on developing these collected artworks in a way that focuses on the present and not on their own physical persistence into a far-flung future. It is in making *information* more transparent, more visible and more widely known in societies now that we can have a greater chance of it being transmitted into the future by our collective institutional memory -in this case cultural institutions that have proven to be reasonable stores of pan-generational memory to date.

Biography

Jon Thomson (born in 1969) and **Alison Craighead** (born in 1971) live and work in London and Kingussie. They make artworks and installations for galleries and site-specific locations including the worldwide Web. Much of their recent work looks at how global digital communications networks are changing the way we all understand the world around us. They live and work in London and Kingussie in the highlands of Scotland. Recent exhibitions include; Haus Lange, Krefeld; Tate Britain; Dundee Contemporary Arts; Brighton Photo-biennial 2012; Haus der Kunst, Munich; BFI Southbank, London; Berkeley Art Museum, California; Artists Space, New York and Tang Contemporary, Beijing. Jon is Reader in Fine Art at The Slade School of Fine Art, University College London, while Alison is Reader in contemporary art and visual culture at University of Westminster and lectures in fine art at Goldsmiths University, London.

Posters

A call for posters (relating to the themes of the conference – radioactive waste management, cultural heritage, history, archaeology and archiving) was sent during the summer preceding the conference. Guidelines and a template were provided. After revision by the Conference Programme Committee, the selected posters were displayed and each author was invited to participate in the conference and provide explanations about their poster to interested participants. This section consists of the extended abstracts submitted for each poster.

Constructing Memory: Competence Maintenance, Education and Training Working Group on the Implementation of Geological Disposal of the Radioactive Waste Technology Platform

Marjatta Palmu
Posiva Oy
Finland
and the CMET Working Group members

Introduction to IGD-TP's overall vision and link to competence maintenance

The Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP) community, with over 115 participants in 2014, according to its Vision 2025 (IGD-TP, 2009) aims to proceed to obtaining licences to construct and to safely operate deep geological repositories for spent fuel, high-level waste, and other long-lived radioactive waste in their respective countries. The commitment to Vision 2025 includes developing joint means to facilitate access to expertise and technology, and maintain competences in the field of geological disposal in Europe.

Working Group on Competence Maintenance, Education and Training

In 2012, IGD-TP launched a Working Group on Competence Maintenance, Education and Training (CMET), as one of its permanent joint activities for addressing its commitment to maintain competences (Palmu et al., 2013a). In 2013, this permanent organisational working group convened for its first meeting and started working with the support of the IGD-TP Secretariat (i.e. Euratom FP7 project SecIGD2).

The CMET Working Group's main objectives currently are:

- Reviewing the present state of the art of strategies and activities for CMET related to the implementation of Vision 2025, the Strategic Research Agenda (SRA) (IGD-TP, 2011). Furthermore, the group wishes to promote awareness about the existing approaches and ongoing activities. At the core is the requirement to identify what the specific CMET needs are for implementing the SRA and the IGD-TP's first Deployment Plan until 2016.
- Developing both the quality assurance of training programmes aimed at new and experienced professionals in the field of geological disposal; and confidence in the learning outcomes (LOs) of individuals. These approaches require the development of the related quality assurance procedures and criteria: i.e. in practice a voluntary accreditation scheme for training (and education) in the sector. The work that is ongoing includes a feasibility study for an accreditation scheme for informal learning, which can also be applied within the formal educational framework and become complementary to the existing education and training (E&T) accreditation solutions. The basis for this scheme is derived from the European Credit system for Vocational Education and Training approach (ECVET).

- Further identification of the existing and relevant content of training. I.e. a type of "curriculum or curricula" for professionals in geological disposal is needed for addressing the competence needs for the different stages of repository development. This requires pooling joint training efforts or alternatively engaging educators and trainers to address the E&T needs derived from IGD-TP's research, development and demonstration (RD&D) work and to support it further. The identification of the prevailing state of curricula already developed and existing for geological disposal are the starting points of the CMET work towards this objective. Mapping them in relation to the generic stages of repository development identified in the SRA 2011 is needed.

And finally, the CMET group by co-operating on the work towards these objectives and by accomplishing them:

- Contributes to ensuring indirectly both the sustainability of providers and the necessary infrastructures/facilities for CMET, and new personnel and their development in the future. A voluntary pooling of resources for the required development and implementation is foreseen to strengthen the sustainability of expertise supply in various forms.

A tool for knowledge transfer over the different repository development stages: ECVET

The work on competence maintenance within this IGD-TP's working group is first of all focusing on benefiting from and promoting the ECVET approach's application in geological disposal and in future competence building of the community (Palmu et al., 2013b). ECVET approach identifies the LOs that need to be mastered by professionals to carry out their work – starting from the early stages of a waste management programme to running the nuclear waste facilities safely and efficiently.

LOs are defined in terms of knowledge, skills and competence (KSC) in ECVET ("attitude" is the corresponding term used by the International Atomic Energy Agency). In their different job functions or tasks the professionals carrying out their work need to master these KSCs at specified European Qualification Framework qualification levels (European Qualification Framework (Palmu et al., 2013b) or International Standard Classification for Education (UNESCO, 2011) according to the job's requirements. The ECVET approach is useful for higher education and continuous professional development, too, not just for vocational education and training, when the different qualification levels are taken into practice. The acknowledgement of the LOs is also independent of any means for acquiring them. In geological disposal the individual who is learning exploits many different means and learning paths. All these LOs can be demonstrated and acknowledged on an equal basis when the required qualification level is reached.

The systematic process of identifying and documenting the KSC needed by the geological disposal community job holders serves as one approach to the community's memory keeping over long timeframes, which is characteristic for the development of a repository. The importance of using all available approaches to prevent the loss of competence, now that our community is faced with the imminent retirement of the professionals who have worked on geological disposal since the beginning, should not be undervalued.

Closing remarks or the beginning?

The CMET strategy and action plan under preparation is based on the identification of existing European initiatives and recommendations in geological disposal. The document is now in its editing stage by this voluntary group with members from 13 European countries. The document addresses all of the CMET group's objectives, not only the

feasibility of the voluntary accreditation scheme based on ECVET. The working group remains open for all interested stakeholders to participate on a voluntary basis to its work.

The research leading to these results has received funding from the European Union's European Atomic Energy Community's (Euratom) Seventh Framework Programme (2007-2013) under agreement n°323260 SecIGD2.

Selected references (IGD-TP publications available on www.igdtp.eu)

IGD-TP (2009), *Implementing Geological Disposal of Radioactive Waste Technology Platform: Vision Report*, EUR 24160 EN, Publications Office of the European Union, Luxembourg.

IGD-TP (2011), *Implementing Geological Disposal of Radioactive Waste Technology Platform: Strategic Research Agenda 2011* (SRA 2011), Publications Office of the European Union, Luxembourg.

Palmu P.M. et al. (2013a), "Towards a European CMET Strategy: The CMET Working Group Actions within IGD-TP", Euradwaste '13 Conference Paper for 8th EC Conference on the Management of Radioactive Waste Community Policy and Research on Disposal, held in Vilnius, Lithuania, 14-16 October 2013, http://cordis.europa.eu/fp7/euratom-fission/euradwaste-2013_en.html.

Palmu P.M. et al. (2013b), "The CMET Working Group Actions within IGD-TP: Feasibility of Voluntary Accreditation in Geological Disposal Using ECVET Approach", Conference paper and presentation held at NESTet 2013 Conference, 17-21 November 2013, Madrid, Spain, www.euronuclear.org/events/nestet/nestet2013/transactions.htm.

UNESCO (2012), *International Standard Classification of Education*, UNESCO Institute for Statistics, Paris, www.uis.unesco.org/Education/Pages/international-standard-classification-of-education.aspx.

United States regulations for institutional controls at high-level waste repositories

Josephine Piccone, Ph.D.
US Nuclear Regulatory Commission
United States

The United States regulations for disposal of spent nuclear fuel and high-level radioactive waste are found at Title 10 of the Code of Federal Regulations (10 CFR) Parts 60 and 63, which cover deep geologic disposal at a generic site and at Yucca Mountain, Nevada, respectively. As an independent regulator, the US Nuclear Regulatory Commission (NRC) is responsible for licensing and oversight of a high-level waste repository in the United States.

The licensing approach for disposal has discreet decisions, made by the NRC, that include approval of construction authorisation, approval to receive and possess high-level radioactive waste, and approval for permanent closure. For construction authorisation approval, the applicant must provide a description of the programme to be used to maintain the records. The NRC will have an active oversight role during the construction and operation period, which can be on the order of 100 years for the facility before permanent closure.

The oversight activities are part of the active institutional controls, and serve as a means of conveying knowledge for that initial period, given that this will likely involve multiple generations of workers for both the implementer and the regulator. Additionally, the NRC provides requirements for the physical protection of stored spent nuclear fuel and high-level radioactive waste at 10 CFR § 73.51. For permanent closure approval, the applicant must provide a detailed description of the measures to be employed-such as land use controls, construction of monuments, and preservation of records. The NRC's regulations at 10 CFR § 63.51, "Licence amendment for permanent closure", require the applicant to provide, among other things:

- A description of the programme for post-permanent closure monitoring of the geologic repository.
- A detailed description of the measures to be employed-such as land use controls, construction of monuments, and preservation of records-to regulate or prevent activities that could impair the long-term isolation of emplaced waste within the geologic repository and to assure that relevant information will be preserved for the use of future generations. As a minimum, these measures must include:
- Identification of the site and geologic repository operations area by monuments that have been designed, fabricated, and emplaced to be as permanent as is practicable.
- Placement of records in the archives and land record systems of local, state, and federal government agencies, and archives elsewhere in the world, that would be likely to be consulted by potential human intruders-such records to identify the location of the geologic repository operations area, including the underground

facility, boreholes, shafts and ramps, and the boundaries of the site, and the nature and hazard of the waste.

- A programme for continued oversight, to prevent any activity at the site that poses an unreasonable risk of breaching the geologic repository's engineered barriers; or increasing the exposure of individual members of the public to radiation beyond allowable limits.

The NRC's regulatory role in any licensing action is to apply the applicable regulations and guidance, and to review applications for proposed actions to determine if compliance with regulations has been achieved. The burden of proof is on the applicant or licensee to show that the proposed action is safe, to demonstrate that regulations are met, and to ensure continued compliance with the regulations. In conducting its reviews, the NRC evaluates whether an applicant or licensee has demonstrated that its proposed approach is adequate to meet the codified requirements. As such, the NRC does not select sites or designs, or participate with licensees or applicants in selecting proposed sites or designs.

Record keeping for the disposal of very low-level concrete waste at the Tokai-Mura site

Tomoyuki Tsuji
Japan Atomic Energy Agency
Japan

Outline of the disposal of VLL concrete wastes

The Japan Atomic Energy Agency (JAEA), who conducted the dismantling project of Japan Power Demonstration Reactor (JPDR) completed in March 1996, has been performing the safe demonstration test of near-surface disposal of very low-level (VLL) concrete waste at its Tokai-Mura site. Approximately 1 700 tons of VLL concrete wastes arising from the JPDR dismantling were placed in a simple disposal facility from November 1995 until March 1996, its dimensions were 45 m x 16 m and 3.5 m in depth without any engineered barrier, and covered with soil of 2.5 m thickness (Abe, 1996).

Figure 29: The disposal facility before emplacement



Figure 30: Emplacement



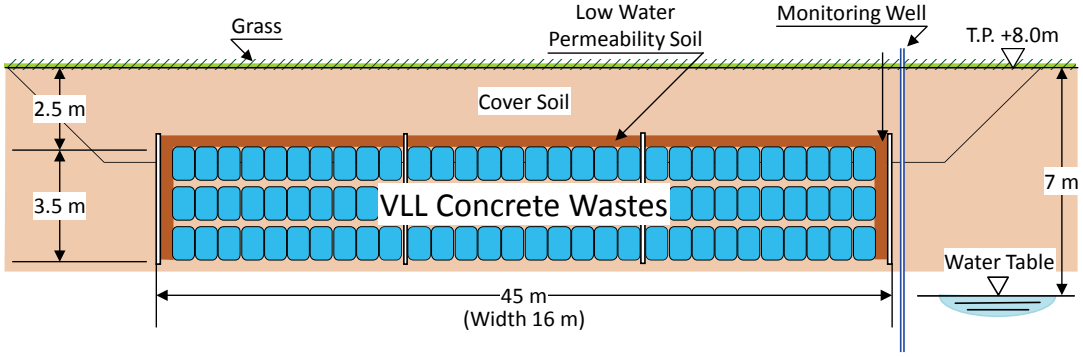
Figure 31: Compaction



Figure 32: Overview of the disposal facility



Figure 33: Cross section view of the disposal facility



Records for the disposal

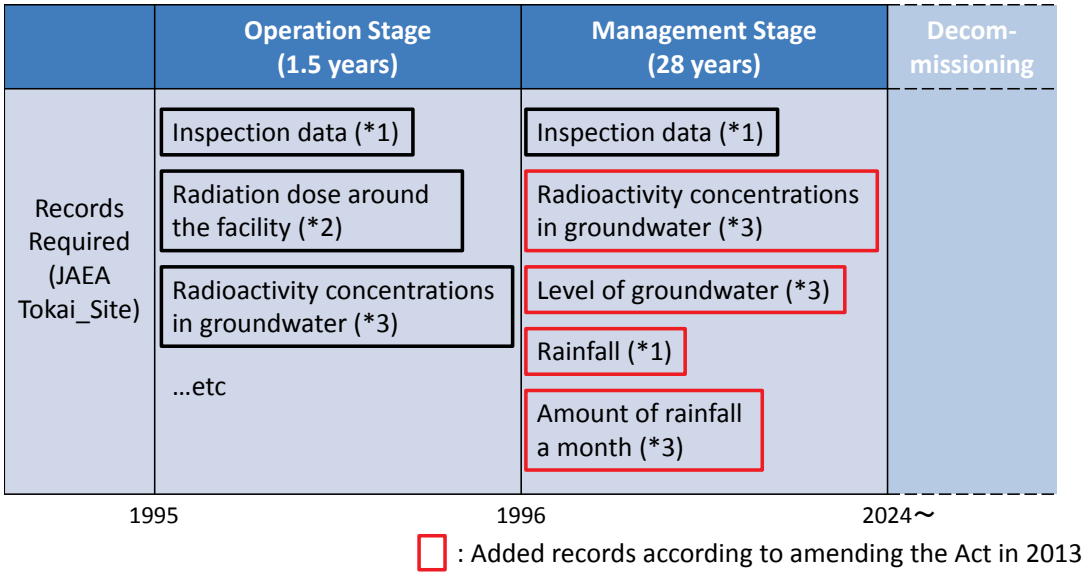
The safe demonstration test of near-surface disposal of VLL concrete waste consists of an operation stage (1995-1996) and a management stage (1996-2024). During the operation stage, the radiation dose around the disposal facility was measured, and groundwater and soil were analysed for radioactivity concentrations. After entering the management stage, radiation monitoring was continued for an additional three years. Inspections for potential outflows, cracks and soil-cover subsidence are conducted once a week.

Regarding VLL concrete waste, it has been required to record its radioactivity concentrations and preserve the record until the end of institutional control period in accordance with the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors. JAEA has been required to preserve these records until the end of the institutional control period.

Added record according to Amending the Act

It is planned to preserve the radiation monitoring data during the operation stage and until the end of institutional control period. Inspection data are preserved in accordance with the act. When amending the act in 2013, the requirements to implement the periodic safety review were added. For this purpose, it has been required to record in the management stage the following measures: a level of groundwater, radioactivity concentrations in groundwater, rainfall and total amount of rainfall a month.

Figure 34: Records required to be preserved



*1. Preserve for one year; *2. Preserve for ten years; *3. Preserve until end of institutional control period.

Conclusions

These records will have been preserved for a year (inspection and rainfall) or until the end of institutional control period (level of groundwater, radioactivity concentrations in groundwater, and total amount of rainfall a month) and checked by safety inspection.

Reference

Abe, M. et al. (1996), "Safety demonstration test for the disposal of very low level concrete waste", *Journal of Decommissioning*, No.15, p.50 (in Japanese).

Nuclear knowledge management in radioactive waste management programmes

Claudia L. Vetere, Pablo R. Gomiz, Myriam Lavalle, Elvira Masset
National Atomic Energy Commission Argentina (CNEA)
Argentina

Nuclear activities began in Argentina in 1950 with the creation of the Argentine Atomic Energy Commission (CNEA). Since its creation, the CNEA and the Argentine nuclear sector have been covering the whole spectrum of the peaceful uses of Nuclear Energy.

Originally, the management of the radioactive wastes and spent fuels generated by nuclear activities was a CNEA responsibility, then formally appointed by a national law in 1997. Finally, and as a consequence to the Radioactive Waste Management Regimen, the National Programme for Radioactive Waste Management (NPRWM) was created depending on CNEA to fulfil the institutional functions and responsibilities to guarantee the safe management of radioactive waste.

In late 2007, the Nuclear Knowledge Management (NKM) group, understanding the need to preserve knowledge related with radioactive waste, formulated the CONRRaD Project with the aim of developing and implementing a sustainable knowledge management system.

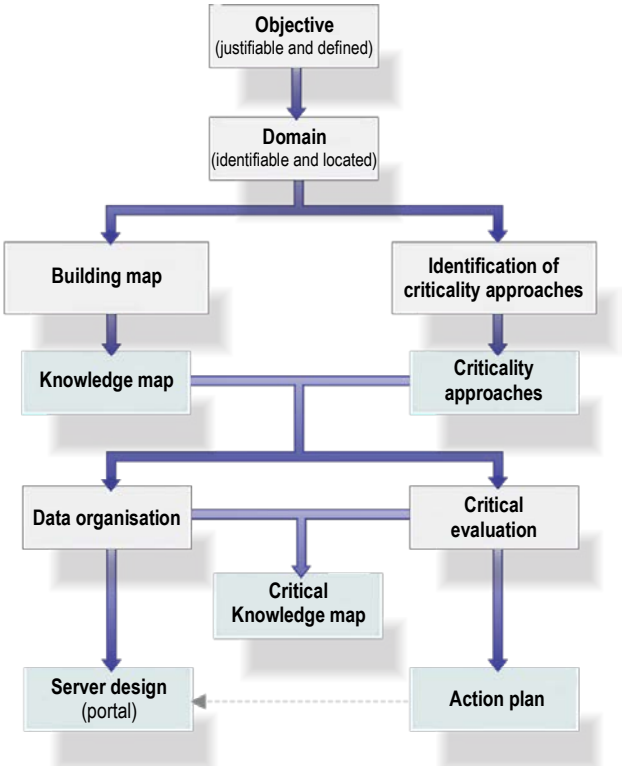
The CONRRaD Project was highly focused on minimising the loss of radioactive waste management knowledge related to processes and facilities as a consequence of staff ageing and retiring, promoting transfer and preservation so as to ensure that future generations interpret and improve the management of waste, protecting the environment and people's health.

Therefore, during the execution of the CONRRaD Project, the following activities were performed applying NKM tools and methodologies:

- A Knowledge Loss Risk Assessment of the Radioactive Waste Management staff was conducted. Then the attrition factor of every member was obtained. As a result, an attrition factor ranking was elaborated and used in the formulation of the Knowledge retention plan.
- The Radioactive Knowledge map was developed; this activity consists of structuring and categorising the knowledge domain, identifying the taxonomies, the processes, the concepts and other entities.
- The CONRRaD portal was designed, developed and implemented based on the Open software which integrates knowledge tools, data, systems and Knowledge database. Working as a repository of critical knowledge, the portal has a search engine with document indexation, a collaborative Wiki, a forum to capture virtual discussions, tools to follow up projects and resources to surf on the whole available knowledge domain.

Figure 35 shows the process that has been applied in the development and implementation (D&I) of the CONRRaD Project. This methodology was previously applied to the Nuclear Power Plant NKM project that allowed testing the method.

Figure 35: CONRRaD Project



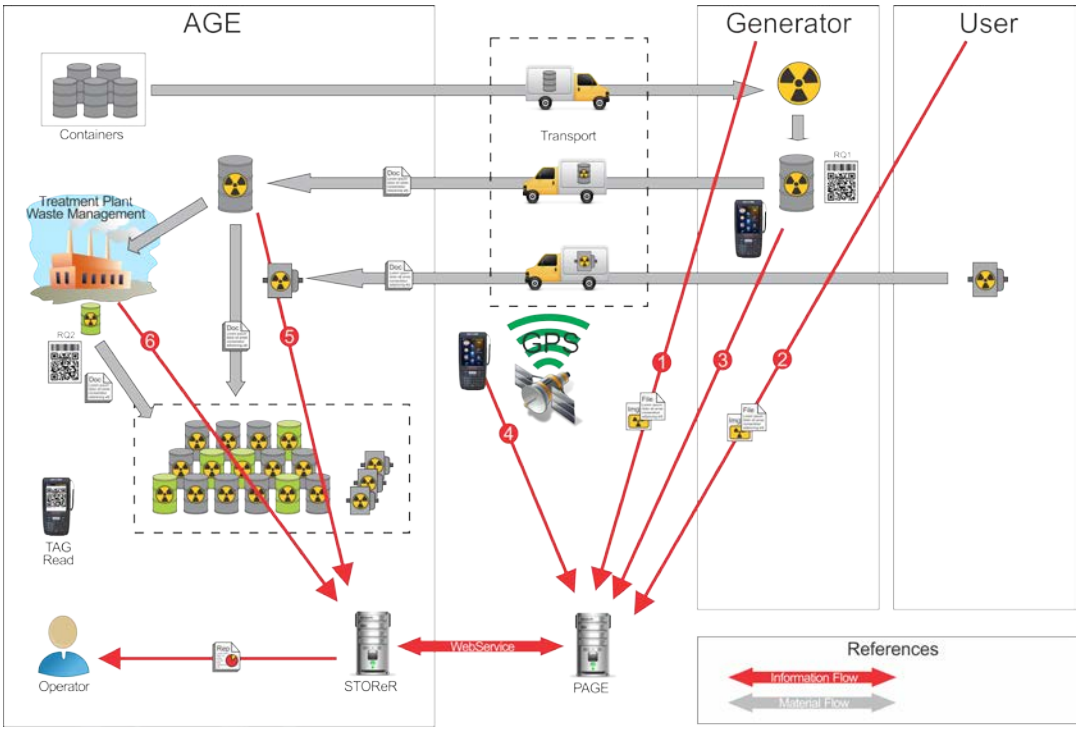
Since 1969 the National Atomic Energy Commission (CNEA) has been operating a waste management area called *Área de Gestión Ezeiza* (AGE) in Buenos Aires' Province, which, among its facilities, has laboratories for waste characterisation, and facilities for radioactive wastes treatment, conditioning, packaging, storing and disposal of low-level radioactive wastes.

Among its duties, the NPRWM has the responsibility of maintaining a documented record system to preserve the knowledge that is available and relates to the mentioned facilities. The STOReR system has been designed with the aim of ensuring traceability through all the steps of radioactive waste management from generation to storage or disposal. Apart from upgrading an application in use since 2001, the new software includes improvements in the inventory calculations according to the current regulations.

Basically, the system consists of two applications. One application called PAGE is on the Net and it is available for the producers. These producers are the facilities that generate radioactive waste as a consequence of their normal operation. PAGE enables the producers to access all the services provided by AGE more easily. Not only are producers the users of PAGE, but there are also authorised owners of radioactive sources and devices because AGE provides transitory or permanent storage of these elements.

The other application called STOReR is the main one which provides the capabilities needed to support the whole system, such as the databases storage and management. STOReR is for the exclusive use of AGE workers who are grouped and entitled to specific permissions according to their operational duties and these have access to the system via an internal network. The STOReR system is a tool for knowledge management applied to process and is expected to be used in other facilities such as nuclear power plants. Figure 36 shows a simplified scheme of the whole system, including users, applications, drivers and radioactive waste elements, to facilitate the understanding of its global operation.

Figure 36: STOReR system



1. Request of containers.
2. Request of waste management services.
3. Inspection services.
4. Vehicle tracking during journey.
5. Radioactive waste access to the *Área de Gestión Ezeiza* (AGE).
6. Waste management records, inventory.

The following long time strategies have to be adopted to assure the sustainable NKM program applied to waste management:

- The continuous monitoring of IT hardware and software infrastructures to minimise the risk of knowledge loss due to the fact that IT technologies may become obsolete.
- Motivation of young people in R&D on Radioactive Waste management.
- The continuous up-to-date teaching and training methods and technologies to facilitate young generations knowledge transfer.
- The continuous administration and maintenance of the CONRRaD portal.
- The continuous up-to-date NKM process.
- The continuous up-to-date waste management process.
- The permanent alignment of the CONRRaD strategy with the Strategic Plan of Nuclear Waste Management.

The successful implementation of the whole NKM program will provide traceability and preservation in such a way that people can trust in the authenticity and veracity of the information to use it with confidence.

Annex 1. List of abbreviations and acronyms

Aarhus Convention	UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters
Andra	Agence nationale pour la gestion des déchets radioactifs (French National Agency for Radioactive Waste Management)
ASN	Autorité de sûreté nucléaire (French Nuclear Safety Authority)
CeReS	Centre de recherches sémiotiques
Cigéo	Centre industriel de stockage géologique
CLI	Commission locale d'information (Information and Oversight Committee)
COVRA	Central Organisation for Radioactive Waste
CSM	Centre de stockage de la Manche (Manche surface repository)
DOE	US Department of Energy
EC	European Commission
GD	Geological disposal site
GPS	Global Positioning System
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit
HABOG	Hoogradioactief Afval Behandeling- en Opslag Gebouw (High-level radioactive treatment and storage building)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ICT	Information and communication technology
IGM	Intergovernmental mechanism
IM	International mechanism
INGM	International non-governmental mechanism
INSPIRE	Infrastructure for Spatial Information in the European Community

IRSN	Institut de radioprotection et de sûreté nucléaire (French Institute for Radiological Protection and Nuclear Safety)
ISO	International Organization for Standardization
KIF	Key information file
LM	Legacy management
Nagra	National Cooperative for the Disposal of Radioactive Waste (Switzerland)
NDA	Nuclear Decommissioning Authority
NEA	Nuclear Energy Agency
NGO	Non-governmental organisation
NPP	Nuclear power plant
NWTRB	US Nuclear Waste Technical Review Board
OECD	Organisation for Economic Co-operation and Development
Öko Institute e.V	Institute for Applied Ecology (Germany)
RepMet	Radioactive Waste Repository Metadata Management
RK&M	Records, knowledge and memory
RWM	Radioactive waste management
RWMC	NEA Radioactive Waste Management Committee
SCK•CEN	Centre d'Étude de l'énergie Nucléaire (Belgian Nuclear Research Centre)
SER	Set of essential records
SKB	Svensk Kärnbränslehantering Aktiebolag (Swedish Nuclear Fuel and Waste Management Company)
UNECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organization

Annex 2. Final Programme of the Constructing Memory Conference and Debate

Organised by the NEA
With the support of Andra (French National Agency for Radioactive Waste Management)

Verdun, France
15-17 September 2014
www.constructing-memory2014.org

Monday, 15 September

Conference opening

16:40-16:45	Introduction – master of ceremonies
16:45-16:55	**Welcome address on behalf of the NEA** *Thierry Dujardin, Acting Deputy Director-General and Deputy-Director for Science and Development, NEA*
16:55-17:05	**Welcome address on behalf of the Centre Mondial de la Paix** *Gérard Longuet, President, Centre Mondial de la Paix*
17:05-17:15	**Welcome address on behalf of Andra** *François-Michel Gonnot, President, Andra*
17:15-17:40	**Opening lecture, "Constructing memory in the digital era – experience, expectations and insights from the field of preservation of cultural heritage"** *Prof. Marinos Ioannides, Cyprus University of Technology*
17:40-18:15	Coffee break
18:15-18:40	**Opening lecture, "Knowledge for the future – time eats information"** *Emeritus Prof. Klaus Kornwachs, University of Ulm, Germany*
18:40-19:00	**Preservation of records, knowledge and memory (RK&M) across generations – an NEA initiative** *Claudio Pescatore, Co-ordinator, RK&M Initiative, NEA*
19:30-20:00	**Presentations by artists on their work** *Cécile Massart, Gérard Larguier, Cumbrian Alchemy, UNESCO Centre of Troyes*
20:00-22:00	Reception, Gardens of the Centre Mondial de la Paix

Tuesday, 16 September

08:50-09:00	Introduction to day 2 – Master of ceremonies

Session 1 – Short term
Period until repository closure

(This period covers several decades and likely more than 100 years. The actual duration will vary across national programmes.)

Chair: *Jean-Paul Minon (ONDRAF/NIRAS, Belgium)*

09:00-09:05	**Introduction** *Session chair*
09:05-09:25	**Preparing for the future. The findings of the RK&M project concerning the short term** *Jantine Schröder, RK&M, SCK•CEN, Belgium*
09:25-09:45	**The UK National Nuclear Archive initiative and the role of its different stakeholders** *Simon Tucker, NDA, United Kingdom*
09:45-10:05	**COVRA's RK&M provisions to cover the storage of radioactive waste at HABOG for the next 100 years or more** *Hans Codée, COVRA, Netherlands*
10:05-10:25	**RK&M preservation for a recently closed repository: The study case of Andra's Centre de La Manche** *Florence Espiet-Subert, Andra, France*
10:25-10:45	**Questions from audience and panel discussion** *The panel includes session speakers and Prof. M. Ioannides. The session chair moderates the discussion.*
10:45-11:15	Coffee break

Session 2 – Medium term
Period of continued oversight

(This period will likely last several centuries after repository closure, extending to perhaps 1 000 years.)

Chair: *Michael Sailer (Öko-Institut, Germany)*

11:15-11:20	**Introduction** Session chair
11:20-11:40	**The concept of oversight, its connection to memory keeping and its relevance for the medium term – the RK&M project findings** *Stephan Hotzel, RK&M, GRS, Germany*
11:40-12:00	**Heritage messages of post-nuclear natures** *Anna Storm, Stockholm University, Sweden*
12:00-12:20	**Researching the Great Hedge of India: RK&M lessons on what to do and what to avoid for memory preservation** *Roy Moxham, Author of "The Great Hedge of India", United Kingdom*

Tuesday, 16 September *(Cont'd)*

12:20-12:40	**Archival and museum curatorship challenges for RK&M preservation** *Christophe Jacobs, Limonade & Co, France*
12:40-13:00	**Questions from audience and panel discussion** The panel includes session speakers and Emeritus Prof. K. Kornwachs. The session chair moderates the discussion
13:00-14:45	Lunch break (Centre Mondial de la Paix) Transfer to group discussion rooms

Session 3a – Short and medium term

Group discussions

14:45-14:50	**Introduction** *Group moderators*
14:50-16:15	**Group discussions**
16:15-16:45	Coffee break and transfer to Plenary room

Session 3b – Short and medium term

Plenary discussion

Chair: *József Fekete (PURAM, Hungary)*

16:45-16:50	**Introduction** *Session chair*
16:50-17:20	**Oral reports from group moderators**
17:20-17:45	**Plenary discussion moderated by session chair**
17:45-18:10	**Day 2 closing lecture** *Prof. Peter van Wyck, Concordia University, Canada*
	Optional visit of the Centre Mondial de la Paix
19:45-20:00	Bus transfer from the Centre Mondial de la Paix to the dinner venue
20:00-22:00	Conference dinner, Château des Monthairons

Wednesday, 17 September

08:25-08:30	Introduction to day 2 – master of ceremonies

Session 4 – Long term

Period with no oversight

(The start of this period is very speculative. It may begin at perhaps 1 000 years from closure.)

Chair: *Saida Laârouchi Engström (SKB, Sweden)*

08:30-08:35	**Introduction** Session chair
08:35-08:50	**RK&M project findings regarding the long term** *Anne Claudel, NAGRA, Switzerland*
08:50-09:05	**Could the landscape preserve traces of a deep underground nuclear waste repository over a very long time? A study of the French case** *Prof. Dominique Harmand, University of Lorraine, France*
09:05-09:20	**Semiotics and the long term: Research avenues and current results** *Prof. Eléni Mitropoulou, University of Limoges, France*
09:20-09:40	**Archaeology of the future** *Profs. Cornelius Holtorf and Anders Högberg, Linnaeus University, Sweden*
09:40-10:00	**Questions from audience and panel discussion**
10:00-10:10	Transfer to discussion rooms

Session 5a– Long term

Group discussions

10:10-10:15	**Introduction** Group moderators
10:15-11:00	Group discussions
11:00-11:30	Coffee break and transfer to Plenary room

Session 5b – Long term

Plenary discussion

Chair: Fabrice Boissier (Andra, France)

11:30-12:00	**Report on group discussions followed by plenary discussion** Session chair

Wednesday, 17 September (*Cont'd*)

Conference closure

12:00-12:20	**Conference rapporteur's report** Emeritus Prof. Erik Van Hove, University of Antwerp, Belgium
12:20-12:30	**Closing remarks** Claudio Pescatore, RK&M co-ordinator, NEA
12:30-13:30	Lunch break (Centre Mondial de la Paix)
	Optional visits World War I Battlefields City of Verdun Bure Underground Research Laboratory (organised by Andra)

Thursday, 18 September

All day: Optional visits, Bure URL

Annex 3. Biographies of speakers



Thierry Dujardin

Thierry Dujardin was the NEA's Acting Deputy Director-General and Deputy-Director for Science and Development at the time of the conference. In this domain, the NEA activities range from the development and dissemination of sound scientific and technical knowledge to the provision of authoritative, reliable information to governments on nuclear technologies, economics, strategies and resources. Dr Dujardin was also responsible for the Technical Secretariat services that the NEA provides to the Generation IV International Forum (GIF). He holds a PhD in Chemical Engineering from the Swiss Federal Institute of Technology in Lausanne.



Gérard Longuet

Graduate of the Institut d'Etudes Politiques de Paris in 1966, he earned a graduate degree (DES) in political science in 1968. In 1973, Gérard Longuet graduated from the École Nationale d'Administration (promotion Rabelais).

In 1978, Gérard Longuet was elected Senator for the first constituency of the Meuse. Member of the Meuse General Council for the canton of Seuil-d'Argonne from 1979 to 1992, he became Vice-President from 1982 to 1986. He was also Municipal Councillor of Bar-le-Duc in 1983. Gérard Longuet was elected a Member of the European Parliament (MEP) in 1984 and remained an MEP until 1986.

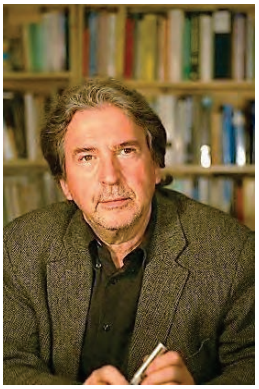
In 1986, Gérard Longuet was appointed Secretary of State and Deputy Minister in charge of Posts and Telecommunications. In 1988, he once more became Senator for the Meuse. In 1992, Gérard Longuet became President of the Regional Council of Lorraine, a position he held until 2004. In 1993, he was also appointed Minister of Industry, Posts and Telecommunications and Foreign Trade

From 2009 to 2011, Gérard Longuet was the elected president of the Union for a Popular Movement Group (UMP) in the Senate. He was appointed Minister of Defence and Veterans Affairs from 2011 to 2012. In the Senate elections in 2011, he was re-elected Senator of the Meuse in the first round. He is President of the Centre Mondial de la Paix. Since January 2013, Gérard Longuet has been serving as Vice President of the UMP.



François-Michel Gonnot

Lawyer and honorary parliamentarian, François-Michel Gonnot has been Vice-President of the Energy Study Group of the French National Assembly and President of the Energy and Development Club. He has also acted as rapporteur on the gas and electricity markets law. He was the President of the Economic Affairs Commission of the National Assembly from 1994 until 1997. Since May 2005, he has been the president of the French National Agency for Radioactive Waste Management (Andra). He is also Honorary President of the Avenir Transports association.



Emeritus Professor Klaus Kornwachs

Prof. Klaus Kornwachs is Honorary Professor of Philosophy at Ulm University, and was Chair for Philosophy of Technology at Brandenburg Technical University of Cottbus from 1992 to 2011. Since 2013, he has been serving as Honorary Professor of the Tongji University of Shanghai. He also runs the Office for Culture and Technology. His main fields of research include: philosophy of pure and applied sciences; general system theory; technology assessment; theoretical philosophy; ethics; science, technology and society.



Claudio Pescatore

Claudio Pescatore was the Principal Administrator in charge of decommissioning and radioactive waste management at the Nuclear Energy Agency at the time of the conference. He has managed the international project on reversibility and retrievability and currently manages the international initiative on preservation of records, knowledge and memory across generations. Dr Pescatore holds a PhD in nuclear engineering. He has been a tenured staff scientist and group leader at Brookhaven National Laboratory and adjunct professor of marine environmental sciences at the State University of New York at Stony Brook.



Christian Namy

Elected for the first time as Departmental Councillor of the canton of Pierrefitte-sur-Aire (Meuse) on 17 March 1985, he was re-elected in 1992, 1998, 2004 and 2011. Since 1 April 2004, he has been President of the Meuse General Council, after having been its Vice-President from 1986. He was elected Senator of the Meuse in September 2011. He is a member of the Foreign Affairs, Defence and Armed Forces Committee of the French Senate, and of the Parliamentary Office of Scientific and Technological Choices (OPECST).



Jean-Paul Minon

Jean-Paul Minon is the General Manager of the Organisme national des déchets radioactifs et des matières fissiles enrichies (ONDRAF). He is also a member of the Board of Belgoprocess; a member and past Chairman of the International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM); the Vice-Chairman of the Permanent Waste Group of the French Nuclear Safety Authorities; the Chair of the NEA Radioactive Waste Management Committee; and a member of the European Nuclear Safety Regulators Group (ENSREG).



Jantine Schröder

Jantine Schröder is a researcher. Since 2008, she has worked at the Belgian Nuclear Research Centre on the Programme of Integration of Social Aspects into Nuclear Research. Between 2011 and 2014, she worked with the research team Society and Environment at the University of Antwerp, which co-ordinated InSOTEC – a European project on socio-technical challenges related to geological disposal of radioactive waste. She holds a master in philosophy with additional degrees in international relations and conflict prevention, and sustainable development and human ecology.



Simon Tucker

Simon Tucker is Head of Information Governance and Chief Information Officer at the Nuclear Decommissioning Authority (NDA) in the United Kingdom. Simon's role is currently focused on developing the strategic role of the NDA in implementing an Information Governance Programme (IGP) to optimise business value from the NDA knowledge and information assets in a compliant and secure manner. Simon presented the UK's latest plans for the short-term management of records and knowledge with specific regard to how an active knowledge management programme needs to be embedded into business now to ensure that as much of the legacy is captured prior to nuclear licensed site closures and repository operations commencement.



Hans Codée

Hans Codée has more than 35 years of experience in the field of radioactive waste and spent fuel management. In 1985, he joined the national waste management organisation, COVRA N.V. Here, he became deputy director in 1988 and was responsible for the construction of the COVRA facilities at Vlissingen-Oost. In 1995 he became its Managing Director. His specialisation in all aspects of RWM added an international perspective in 1996 when he became Chairman of the Board of the Cassiopee Consortium until 2005. In 2014, he stepped down as Managing Director of COVRA and is now part-time advisor to the organisation.



Florence Espiet-Subert

Florence Espiet joined Andra in 2013 as Director of the Manche Disposal Facility (CSM), the first repository for low and intermediate level radioactive waste in France, which operated from 1969 to 1994. It has been under official surveillance ("surveillance phase") since 2003. She graduated as a geologist in 1995 and she has worked for 17 years in the field of disposal and "valorisation" of conventional waste for SITA (SUEZ Environnement). Initially specialised in the design of degasing networks, she then operated several facilities in metropolitan and overseas France, in the Yonne department in 2003-2004, Manche department in 2004-2009, and Guadeloupe, from design to operation, in 2009-2012.



Michael Sailer

Michael Sailer is a chemical engineer (Dipl.-Ing.) from the Technische Universität Darmstadt (1982). Since 1980, his key focus has been on providing consultancy and expert advice on nuclear energy, most notably on the safety of nuclear power plants and other nuclear installations, the storage of nuclear waste, and the final disposal of radioactive waste. He has been working with Öko-Institut e.V. (Institute for Applied Ecology) since 1980, and has been exercising the function of CEO since 2009. Öko-Institut e.V. is an independent scientific research institute. Mr Sailer has held several positions within several advisory bodies to the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).



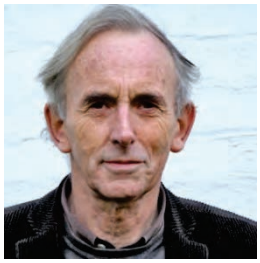
Stephan Hotzel

Stephan Hotzel is a technical expert at GRS, a Technical Safety Organisation in the field of nuclear safety and radiological protection. Based in Cologne (Germany), he has seven years of experience in safety assessments for radioactive waste disposal facilities and in regulatory issues of deep geological disposal. He holds a physics degree from Hamburg University and a PhD from Heidelberg University. For the last three years, he has been engaged in the international initiative on the Preservation of Records, Knowledge and Memory across Generations of the Nuclear Energy Agency.



Anna Storm

Anna Storm is a researcher at the Department of Human Geography at Stockholm University, Sweden. Her research focuses on post-industrial landscapes, the iron and steel industry, mining, company towns, nuclear power, the history of science, technology and the environment, and the politics of urban and industrial nature. Her postdoctoral project dealt with heritage processes at the Ignalina and Barsebäck nuclear power plants and was carried out at the Centre for Baltic and East European Studies at Södertörn University. In the course of 2014, her monograph "Post-Industrial Landscape Scars" was published by Palgrave Macmillan.



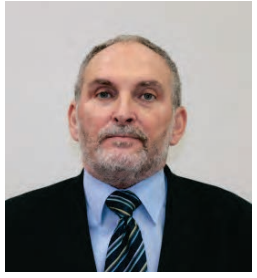
Roy Moxham

Roy Moxham is the author of *The Great Hedge of India* (2001), *Tea – Addiction Exploitation and Empire* (2003) revised and updated as *A Brief History of Tea* (2009), *Outlaw – India's Bandit Queen and Me* (2010), and is currently writing a history of the European invasions of India between 1498 and 1757. A conservator (restaurateur), he was until retirement in charge of conservation and preservation at the University of London's Senate House Library and he was teaching in the University's Institute of English Studies on their MA in "The History of the Book". For further details see http://roymoxham.com.



Christophe Jacobs

Christophe Jacobs is the Co-founder and Manager of Limonade & Co, a company founded in 2012, which provides consultancy and technical assistance in the field of records and knowledge preservation and transmission. He graduated in archives science in 2005. While pursuing research ("A policy for archives in France, 1852-1945?"), he provides consultancy and training for public and private institutions, in various cultural and organisational contexts. His fields of expertise include: electronic edition, digital humanities, document engineering, records management, archiving. Since September 2012, he has been serving as research and training assistant in archives science at the University of Angers.



József Fekete

József holds degrees in Computer and Economic Sciences and is a Chartered Accountant. Earlier, he worked for PricewaterhouseCoopers leading a number of information-related projects. He is the Chief Information Officer of the Public Limited Company for Radioactive Waste Management (PURAM) in Hungary and is responsible for formulating PURAM's Information and Communication Strategy, including computer systems designed for the long-term preservation of radioactive waste related data. József is co-ordinating a partnership between PURAM and the University of Pécs on the subjects of long-term data preservation technologies, software formats for preservation of vector graphic data (AutoCad, PDF/A), database metadata structures in accordance with international standards and complying with EU directives for interoperability.



Professor Peter van Wyck

Peter C. van Wyck is Professor of Communication and Media Studies at Concordia University in Montréal. He is an interdisciplinary scholar and writer, with an abiding interest in the theoretical and practical relations between culture, nature, environment, landscape, memory and waste. His most recent book, "The Highway of the Atom" (McGill-Queens University Press) – winner of the 2011 Gertrude J. Robinson book award from the Canadian Communication Association – is a theoretical and archival investigation concerning the material and cultural history of uranium production in the North of Canada. He is now working on several new projects concerning nuclear repositories, atomic media and the Anthropocene, apology, justice and the future.



Saida Laârouchi Engström

Saida L. Engström has a background in chemistry engineering. She started her career in the Swedish Nuclear Inspectorate as a safety inspector of nuclear installations in Sweden. After 11 years, she joined the Swedish Nuclear Fuel and Waste Management Company (SKB), first as a leader for feasibility studies in view to select a site for a final repository for spent fuel in Sweden. Under the site investigation project, Saida was in charge of the environmental assessment studies and licensing. Saida has been, and still is, in charge of the dialogue between SKB and all the stakeholders in the Swedish society. Currently, she is Vice President Strategy and Programme at SKB.



Anne Claudel

Born and educated in France, Dr Anne Claudel holds a PhD in information and communication science from the University of Paris X, as well as a degree in art history and archaeology. She worked for several years on the project of a Swiss Database for Cultural Heritage, aiming at co-ordinating museum inventories at the federal level. She later joined Memoriav, the Swiss Association for the Preservation of Audiovisual Heritage. She has been employed by Nagra, the Swiss National Cooperative for the Disposal of Radioactive Waste, since 1998 and is currently Head of the Information Management Section. In this position, she has the overall responsibility for documentation and archiving strategies and activities. She also monitors developments in the preservation of RK&M over generations and has been actively involved in the RK&M project since 2010.



Professor Dominique Harmand

Dominique Harmand is Professor of Geography at the University of Lorraine in Nancy. His research relates to geomorphology, including changes in river systems, captures, alluvial terraces and datings, karst, as well as links between geomorphology and archaeology. His domain of study relates in particular to the east of the Paris Basin and its paleozoic borders in France, Germany, Luxembourg and Belgium.



Professor Eléni Mitropoulou

Eleni Mitropoulou teaches semiotics at the University of Limoges (Research Center Semiotics). Qualified in linguistics, information science and communication, she is editor of the journal *Proceedings Semiotics*. The discourse of the media (audiovisual, script-visual, visual) has been her research subject since 1997. "From a semiotic approach to interactivity" (2007), her work offers a critique of mediated communication specific to digital processes. This review develops a semiotic of the medium of communication (2012) based, in particular, on multi-media publishing, SMS language, design in media, sports and science online, net art, communication of interactive organisations, hardware interfaces and tech news.



Professor Cornelius Holtorf

Cornelius Holtorf is currently Professor of Archaeology at Linnaeus University in Kalmar, Sweden. After studies in Germany and the United Kingdom, he received his PhD in archaeology from the University of Wales in 1998. He has published books and numerous papers investigating the role of the past, archaeology and cultural heritage in past, contemporary and future societies. He is also associate editor of the journals Heritage and Society and the Journal of Contemporary Archaeology. Currently, Prof. Holtorf works, together with his colleague Prof. Högberg, on a project about long-term communication concerning the final repository of nuclear waste in Sweden, partly funded by the Swedish Nuclear Fuel and Waste Management Company.



Professor Anders Högberg

Anders Högberg is an Associate Professor in Archaeology at Linnaeus University in Kalmar, Sweden. He has numerous publications within the field of archaeology and heritage studies, and has carried out research on issues on historical and future consciousness, or how the past is given meaning in the present and how this may affect the future. He is an invited research fellow at the Stellenbosch Institute for Advanced Study (STIAS) Wallenberg Research Centre of Stellenbosch University where he works on a project about human cognitive evolution.



Fabrice Boissier

Fabrice Boissier holds a postgraduate degree in mathematics and in economics from the prestigious French Ecole Normale Supérieure in Paris, and is a graduate engineer from the Paris School of Mines. At the time of the conference, Fabrice Boissier was Director of the Risk Management Division in Andra, the French National Agency for Radioactive Waste Management. In this position, he was mainly responsible for the safety of Andra's waste repositories, existing or in project. In his position, Fabrice Boissier was, more specifically, in charge of the preparation of the safety case for the licence application of the Cigéo project, the French geological disposal. Throughout his career, Fabrice Boissier has always been highly involved in issues concerning the environment, safety, mining activity and energy.



Emeritus Professor Erik Van Hove

Erik Van Hove is Emeritus Professor of the University of Antwerp, where he has taught social science research methodology, statistics and computer processing for over 25 years. His research has been in health and welfare planning and collective decision making. His research led to the establishment of non-profit agencies that continue fighting against urban poverty. Since 1994, he advised the agency responsible for nuclear waste disposal (ONDRAF/NIRAS) on the safe disposal of low-level waste with the full approval of the local communities involved: the "partnership" approach.

Annex 4. List of participants

Name	First name	Organisation	Country
KUNZE	Martin	Memory of Mankind	Austria
BERCKMANS	Arne	The Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS)	Belgium
BOYAZIS	Jean-Paul	The Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS)	Belgium
CEULEMANS	Hugo	Mols Overleg Nucleair Afval vzw (MONA)	Belgium
DRAULANS	Hugo	STudie- en Overleg Radioactief Afval Dessel (STORA)	Belgium
DRIES	Fons	STudie- en Overleg Radioactief Afval Dessel (STORA)	Belgium
LAUWEN	Geert	STudie- en Overleg Radioactief Afval Dessel (STORA)	Belgium
MASSART	Cécile	Artiste	Belgium
MELIS	Willy	STudie- en Overleg Radioactief Afval Dessel (STORA)	Belgium
MINON	Jean-Paul	The Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS)	Belgium
SANNEN	Herman	STudie- en Overleg Radioactief Afval Dessel (STORA)	Belgium
SCHRÖEDER	Jantine	Studiecentrum voor Kernenergie - Centre d'Etude de l'Energie Nucléaire (SCK•CEN)	Belgium
VAN HOVE	Erik	University of Antwerp	Belgium
VERSTAPPEN	Kathy	STudie- en Overleg Radioactief Afval Dessel (STORA)	Belgium
WILLEMS	Viviane	STudie- en Overleg Radioactief Afval Dessel (STORA)	Belgium
HOLLINGTON	Kathleen	Natural Resources Canada (NRCan)	Canada
THELEN	John	Canadian Nuclear Safety Commission (CNSC)	Canada
VAN WYCK	Peter	Concordia University	Canada
IOANNIDES	Marinos	Cyprus University of Technology	Cyprus
KUCERKA	Miroslav	Radioactive Waste Repository Authority (RAWRA)	Czech Republic
MIKSOVA	Jitka	Research Centre Rez (CVREZ)	Czech Republic
NACHMILNER	Lumir	Research Centre Rez (CVREZ)	Czech Republic
PALMU	Marjatta	Posiva Oy	Finland
ALESSANDRINI	Marie-Claude	Membre du groupe de réflexion mémoire	France
APARICIO	Luis	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
ARTISSON	Alain	Conseil Général de la Meuse	France
BARON	Yves	Commission locale d'information (CLI) du Centre de Stockage de la Manche	France
BIENVENU	Hervé	Agence nationale pour la gestion des déchets radioactifs (Andra)	France

Name	First name	Organisation	Country
BOISSIER	Fabrice	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
BRIXY	Richard	Groupe de réflexion sur la mémoire du Centre de stockage de la Manche	France
BRULHET	Jacques	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
CARTEGNIE	Frédéric	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
CHANDES	Gérard	Centre de Recherches Sémiotiques, Université de Limoges	France
CHARTON	Patrick	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
CLERC	Gwenaelle	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
COBAT	Catherine	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
COLLET	Christian	Groupe Mémoire Aube	France
CORRIER	Roland	Comité Local d'Information et de Suivi (CLIS) du Laboratoire souterrain de recherche sur la gestion des déchets radioactifs de Bure	France
COUDRY	Jean	Comité Local d'Information et de Suivi (CLIS) du Laboratoire souterrain de recherche sur la gestion des déchets radioactifs de Bure	France
COUTURIER	Cécile	Groupe Rouge Vif	France
DE HOYOS	Amélie	L'Institut de Radioprotection et de Sûreté Nucléaire (IRSN)	France
DEMANDRE	Jean Luc	Connaissance de la Meuse	France
DENAUW	Patrick	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
DERE	Nelly	Centre pour l'UNESCO Louis François	France
DIWO	Gérard	Archives départementales de la Meuse	France
DRESSAYRE	Catherine	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
DUMEZ	Roger	(précédemment) Conseil Général de la Meuse	France
DUMONT	Jean-Noël	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
ESPIET-SUBERT	Florence	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
FONTAINE	Tiphanie	Groupe Mémoire Bure	France
FOOS	Jacques	Commission locale d'information (CLI) du Centre de Stockage de la Manche	France
FOURNIER	Pauline	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
FRANCOIS	Henri	Municipalité de Saudron	France
GARD	Louis-Marie	Préfecture de la Meuse	France

Name	First name	Organisation	Country
GERARD	Gilles	Commission locale d'information (CLI) du Centre de Stockage de l'Aube	France
GERMAIN	Marie-Pierre	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
GIROST	Michel	Centre pour l'UNESCO Louis François	France
GOMEZ	Franck	Groupe Mémoire Aube	France
GONNOT	François-Michel	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
GRIFFAULT	Lise	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
HAMELIN	Jacques	Commission locale d'information (CLI) du Centre de Stockage de la Manche	France
HARMAND	Dominique	LOTERR, Université Nancy 2	France
HURAUT	Martine	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
JACOBS	Christophe	Limonade & Co	France
JAQUET	Benoît	Comité Local d'Information et de Suivi (CLIS) du Laboratoire souterrain de recherche sur la gestion des déchets radioactifs de Bure	France
JURAIN	Pierrette	Groupe Mémoire Aube	France
LAGRANGE	Marie-Hélène	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
LARGUIER	Michèle	Artiste	France
LARGUIER	Gérard	Artiste	France
LE VEO	Corinne	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
LEMAITRE-XAVIER	Elsa	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
LEMEE	Mireille	Centre pour l'UNESCO Louis François	France
LEVERD	Pascal	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
LOISY	Sophie	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
LONGUET	Gérard	Centre Mondial de la Paix	France
MALINGREAU	Jean-Marie	Comité Local d'Information et de Suivi (CLIS) du Laboratoire souterrain de recherche sur la gestion des déchets radioactifs de Bure	France
MARIE	Michel	Comité Local d'Information et de Suivi (CLIS) du Laboratoire souterrain de recherche sur la gestion des déchets radioactifs de Bure	France
MAYS	Claire	Symlog	France
MER	Dominique	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
MITROPOULOU	Eleni	Centre de Recherches Sémiotiques (CeReS), Université de Limoges	France

Name	First name	Organisation	Country
MUZERELLE	Sophie	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
NAMY	Christian	Conseil Général de la Meuse	France
NAUDIN	Patrick	Préfecture de la Meuse	France
OGE	Frédéric	Pôle de Recherche pour l'Organisation et la Diffusion de l'Information Géographique (PRODIG) du Centre national de la recherche scientifique (CNRS)	France
PEUREU VALANT	Claire	Comité Local d'Information et de Suivi (CLIS) du Laboratoire souterrain de recherche sur la gestion des déchets radioactifs de Bure	France
QUENET	Annabelle	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
RAMPONT	Michel	Connaissance de la Meuse	France
RENARD	Jean-François	Conférence de citoyens Cigéo	France
RENAULD	Valérie	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
ROBERT-DEHAULT	Elisabeth	Sauvegarde du Patrimoine Métallurgique 52	France
ROCHE	Michel	Commission locale d'information (CLI) du Centre de Stockage de l'Aube	France
ROGER	Emilie	Commissariat à l'énergie atomique et aux énergies alternatives (CEA)	France
ROULET	Claudie	Centre pour l'UNESCO Louis François	France
SAINT-LOUIS	Mathieu	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
SALDANA-PIERRE	Carolina	Centre pour l'UNESCO Louis François	France
SALLAH-FADE	Michel	Agence nationale pour la gestion des déchets radioactifs (ANDRA)	France
SAUVAGE	Marité	Conférence de citoyens Cigéo	France
SOLENTE	Nicolas	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
TAILLEBOIS	Christian	Électricité de France (EDF)	France
TELLENE	Claude	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
THERIN	Yves	Comité Local d'Information et de Suivi (CLIS) du Laboratoire souterrain de recherche sur la gestion des déchets radioactifs de Bure	France
TORRES	Patrice	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
VOINIS	Sylvie	Agence nationale pour la gestion des déchets radioactifs (Andra)	France
BEUTH	Thomas	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS)	Germany
HOTZEL	Stephan	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS)	Germany
KORNWACHS	Klaus	Brandenburg University of Technology	Germany
LEOPOLD	Karsten	Bundesamt für Strahlenschutz (BfS)	Germany

Name	First name	Organisation	Country
NOSECK	Ulrich	Gesellschaft für Anlagen- und Reaktorsicherheit (GRS)	Germany
SAILER	Michael	Öko-Institut e.V.	Germany
SCHMIDT	Gerhard	Öko-Institut e.V.	Germany
SPIETH-ACHTNICH	Angelika	Öko-Institut e.V.	Germany
FEKETE	József	Public Limited Company for Radioactive Waste Management (PURAM)	Hungary
KRACHUN	Szilárd	Public Limited Company for Radioactive Waste Management (PURAM)	Hungary
MORHAUSER	Tamás	Public Limited Company for Radioactive Waste Management (PURAM)	Hungary
NAGY	Zoltan	Public Limited Company for Radioactive Waste Management (PURAM)	Hungary
NAKAMURA	Takashi	Japan NUS Co	Japan
TAKESHI	Sugiyama	Japan NUS Co	Japan
TOMOYUKI	Tsuji	Japan Atomic Energy Agency (JAEA)	Japan
CODEE	Hans	Centrale Organisatie Voor Radioactief Afval (COVRA)	Netherlands
VAN HENSBERGEN	Saskia	Ministry of Economic Affairs of the Netherlands	Netherlands
JELEV	Adrian	Nuclearelectronica	Romania
FARIAS	Joaquín	Empresa Nacional de Residuos Radiactivos (Enresa)	Spain
ÅHR	Frida	Miljörörelsens kärnavfallssekretariat, Milkas	Sweden
ANVEGÅRD	Christine	The Swedish NGO Office for Nuclear Waste Review (MKG)	Sweden
BERGMAN	Anders	Municipality of Östhammar	Sweden
FRIES MARKIEWICZ	Johanna	Swedish National Archives (Riksarkivet)	Sweden
FROEJD	Ingmar	Swedish National Archives (Riksarkivet)	Sweden
HÖGBERG	Anders	Linnaeus University	Sweden
HOLTORF	Cornelius	Linnaeus University	Sweden
KAISERFELD	Thomas	Lund University	Sweden
KINCH	Anna	Municipality of Oskarshamn	Sweden
LAÂROUCHI ENGSTRÖM	Saïda	Svensk Kärnbränslehantering AB (SKB)	Sweden
LIF PIKAS	Katarina	Uppsala Regional Council	Sweden
LINDGREN	Georg	Swedish Radiation Safety Authority	Sweden
PALM	Jonas	Swedish National Archives (Riksarkivet)	Sweden
PERSSON	Rolf	Municipality of Oskarshamn	Sweden
SANRELL	Sanna	Miljörörelsens kärnavfallssekretariat (Milkas)	Sweden
SETZMAN	Erik	Svensk Kärnbränslehantering AB (SKB)	Sweden
STORM	Anna	Stockholm University	Sweden
SWAHN	Johan	The Swedish NGO Office for Nuclear Waste Review (MKG)	Sweden
TUNBRANT	Sofie	Svensk Kärnbränslehantering AB (SKB)	Sweden

Name	First name	Organisation	Country
YNGVE TORNQVIST	Johanna	Municipality of Östhammar	Sweden
BÄTTIG	Michèle	Regionalkonferenz Nördlich Lägern	Switzerland
BRANDER	Simone	Swiss Federal Office of Energy (SFOE)	Switzerland
CLAUDEL	Anne	Nationale Genossenschaft für die Lagerung radioaktiver Abfälle (NAGRA)	Switzerland
FRITSCHI	Markus	Nationale Genossenschaft für die Lagerung radioaktiver Abfälle (NAGRA)	Switzerland
KUHN	Peter	Platform Wellenberg	Switzerland
MÜELLER	Markus	Regionalkonferenz Südranden	Switzerland
CARPENTER	Ele	Nuclear Culture curatorial research project	United Kingdom
CARTER	Alexander	Nuclear Decommissioning Authority (NDA)	United Kingdom
MILSTON	Peter	Cumbrian Alchemy	United Kingdom
MOXHAM	Roy	Author of “The Great Hedge of India”	United Kingdom
WILLIAMS	Robert	Cumbrian Alchemy	United Kingdom
WISBEY	Simon	Nuclear Decommissioning Authority	United Kingdom
APPEL	Gordon	Sandia National Laboratories	United States
BONANO	Evaristo	Sandia National Laboratories	United States
HADDAL	Risa	Sandia National Laboratories	United States
MCDANIEL	Michael	Sandia National Laboratories	United States
McMAHON	Kevin	Sandia National Laboratories	United States
PICCONE	Josephine	US Nuclear Regulatory Commission (NRC)	United States
VAN LUIK	Abraham	US Department of Energy (DOE)	United States
BOTEZ	Radu	Nuclear Energy Agency (NEA)	International organisation
DUJARDIN	Thierry	Nuclear Energy Agency (NEA)	International organisation
FORMENTINI	Marine	Nuclear Energy Agency (NEA)	International organisation
ORMAI	Peter	International Atomic Energy Agency (IAEA)	International organisation
PESCATORE	Claudio	Nuclear Energy Agency (NEA)	International organisation
ZEIN	Ali	European Commission (EC), DG Energy	International organisation

NEA PUBLICATIONS AND INFORMATION

The full **catalogue of publications** is available online at www.oecd-nea.org/pub.

In addition to basic information on the Agency and its work programme, the **NEA website** offers free downloads of hundreds of technical and policy-oriented reports.

An **NEA monthly electronic bulletin** is distributed free of charge to subscribers, providing updates of new results, events and publications. Sign up at www.oecd-nea.org/bulletin/.

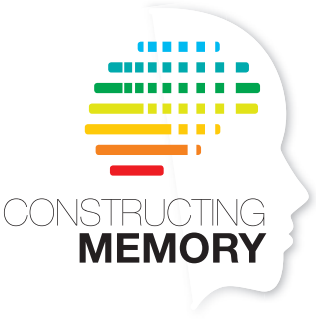
Visit us on **Facebook** at www.facebook.com/OECDNuclearEnergyAgency or follow us on **Twitter @**OECD_NEA.

OECD/NEA PUBLISHING, 2 rue André-Pascal, 75775 PARIS CEDEX 16

Radioactive Waste Management and Constructing Memory for Future Generations

The Preservation of Records, Knowledge and Memory (RK&M) across Generations initiative was launched by the Nuclear Energy Agency in 2011 to foster international reflection and progress towards this goal and to meet increasing demands by waste management specialists and other interested parties for viable and shared strategies. The RK&M initiative is now in its second phase, which is to last until 2017. Phase I culminated on 15-17 September 2014 with the organisation of an international conference and debate on "Constructing Memory" held in Verdun, France.

The conference was attended by approximately 200 participants from 17 countries and 3 international organisations. Participants included specialists from the radioactive waste management area and beyond, academics in the fields of archaeology, communications, cultural heritage, geography and history, as well as artists, archivists and representatives from local heritage societies and from communities that could host a radioactive waste repository.



Nuclear Energy Agency (NEA)
12, boulevard des Îles
92130 Issy-les-Moulineaux, France
Tel.: +33 (0)1 45 24 10 15
nea@oecd-nea.org www.oecd-nea.org

NEA No. 7259