

出國報告（出國類別：其他）

赴美國參加 2013 國際高放射性廢棄物 管理研討會

服務機關：核能研究所

姓名職稱：蕭憲明 助理研究員

派赴國家：美國

出國期間：102 年 4 月 27 日~102 年 5 月 4 日

報告日期：102 年 6 月 4 日

摘 要

於 102 年 4 月 27 日至 102 年 5 月 4 日共計 8 天公差赴美國，參加 2013 年國際高放射性廢棄物管理研討會 (International High-Level Radioactive Waste Management Conference)，該研討會內容關注在高放射性廢棄物(主要為用過核子燃料)之再處理、貯存、運送及處置等處理議題，公差人藉由參加主題討論及各單元之技術報告研討，蒐集有關用過核子燃料在規劃、模擬、運送及暫貯等研究及技術資料，並與參加會議中之其他核能先進國家如法國、美國、韓國、及日本等專家學者進行討論與交流，蒐集之相關資料望可提供本所在未來推動設置高、低放處置場及用過核子燃料貯存之參考。

關鍵字：用過核子燃料、高放射性廢棄物、再處理、處置

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一、目的

此次公差主要目的是參加 2013 國際高放射性廢棄物管理研討會(International High-Level Radioactive Waste Management Conference)，蒐集高放射性廢棄物之再處理(reprocessing)、處置(disposal)、貯存(storage)、運送(transportation)等資料，希望提供未來國內用過核子燃料之處理、處置規劃與高放處置場設置之相關資料。

二、過程

(一)行程及工作摘要

本次公差期間為民國 102 年 4 月 27 日至 5 月 4 日共計 8 天，主要參加 2013 國際高放射性廢棄物管理研討會，收集會議發表之論文資訊並選擇參加與國內議題相關之各技術討論會，獲取各國之經驗並與之交流與學習。此次之公差行程如下表 1 所示。

表 1 出差行程表

時間	地點	活動項目	活動內容	參加人員
04 月 27 日~ 04 月 28 日	桃園 → Albuquerque	旅程	桃園國際機場搭機赴美國 Albuquerque(經由香港、洛杉磯轉機)	全員(蕭憲明先生一人)
04 月 29 日~ 05 月 02 日	美國 Albuquerque	參加 2013 國際高放射性廢棄物管理研討會	報到、開幕式、主題討論、Technical Sessions	全員
05 月 03~04 日	Albuquerque →桃園	回程	美國 Albuquerque 搭機返回桃園國際機場(經由洛杉磯、香港轉機)	全員

(二)會議議程及研討會內容

該會議主要著重在以下幾個議題，投稿之技術報告共 153 篇：

Track 1 : Total Repository System (Generic and Site-Specific) (16 篇)

Track 2 : Natural Systems for Disposal (Generic and Site-Specific) (26 篇)

Track 3 : Engineered Systems for Disposal (29 篇)

Track 4 : Biosphere (6 篇)

Track 5 : Regulatory Topics (5 篇)

Track 6 : Institutional Topics (With Emphasis on Lessons Learned) (12 篇)

Track 7 : Storage of Used Nuclear Fuel and High Level Waste(39 篇)

Track 8 : Advanced Fuel Cycles: Impacts on Waste Management(18 篇)

Track 9 : High-Level Radioactive Waste Transportation(2 篇)

全體與會人員參加的主題討論(Plenary discussion)有五個主題：

Plenary- I: Perspectives on the Backend of the Fuel Cycle

Plenary-II: How Did We Actually Get Into This Mess?

Plenary-III: China's Nuclear Energy Program

Plenary-IV: Fast Reactors as a Means of Closing the Fuel Cycle

Plenary-V: Consent-Based Nuclear Facility Siting

專題討論(panel discussion)有四個主題：

Panel Discussion-I: Waste From Recycling

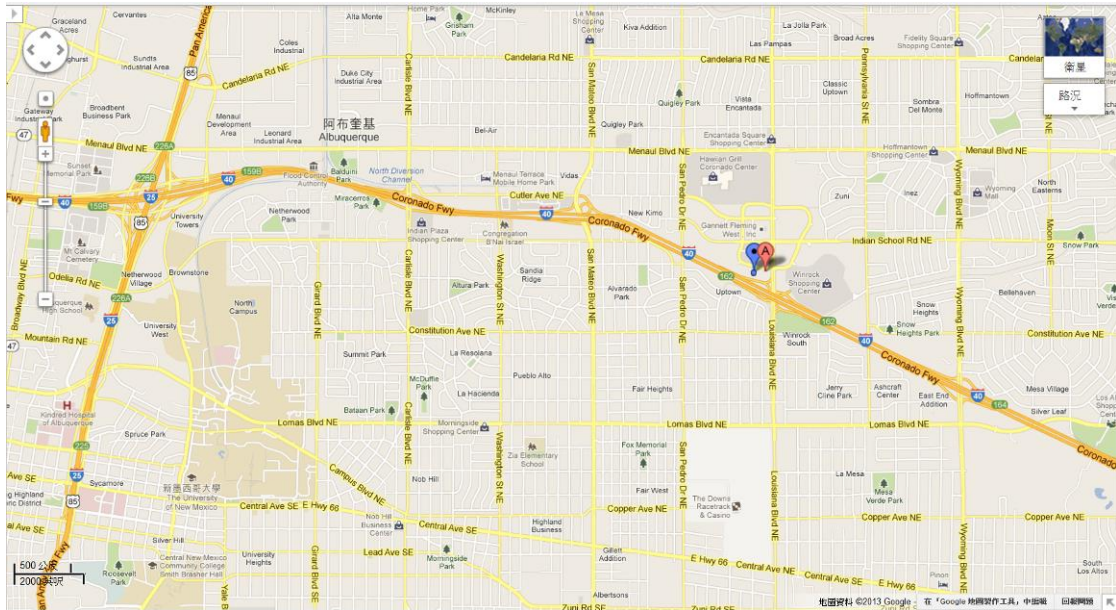
Panel Discussion-II: Discussion of Activities in China

Panel-III: Fast Reactors as a Means of Closing the Fuel Cycle

Panel Discussion-IV: Large-Volume Wastes from Accident Cleanups

舉辦地點在新墨西哥州 Albuquerque(阿布奎基)的 Marriott 飯店，其相關位置如圖 1 所示，而圖 2 為該飯店舉行此次會議所用之房間，因為場次不多，僅使用該飯店一樓之各會議室，相關位置如圖所示。





圖(1) 會議場址與其地理位置概況

GRAND BALLROOM

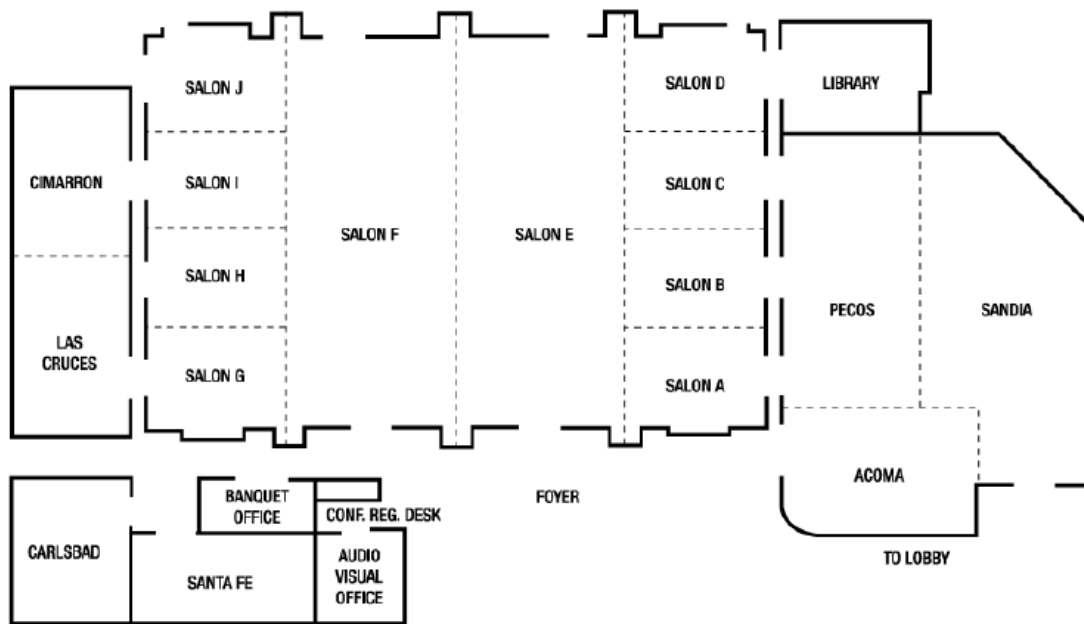


圖 2 會議場地分佈

會議議程如下：

第一天-報到 SUNDAY, APRIL 28, 2013 12:00 PM - 5:00 PM

領取大會手冊(包含投稿會議之論文全文光碟)等資料，工作人員解說會議之舉辦方式、時間及參加該注意之事項。

第二天-MONDAY, APRIL 29, 2013

時間：8:00 AM–8:25 AM

主題：Welcome and Opening Remarks

地點：Grand Salon F

主席：Kevin McMahon (*SNL*), Barry Butterfield (*HDR Engineering*)

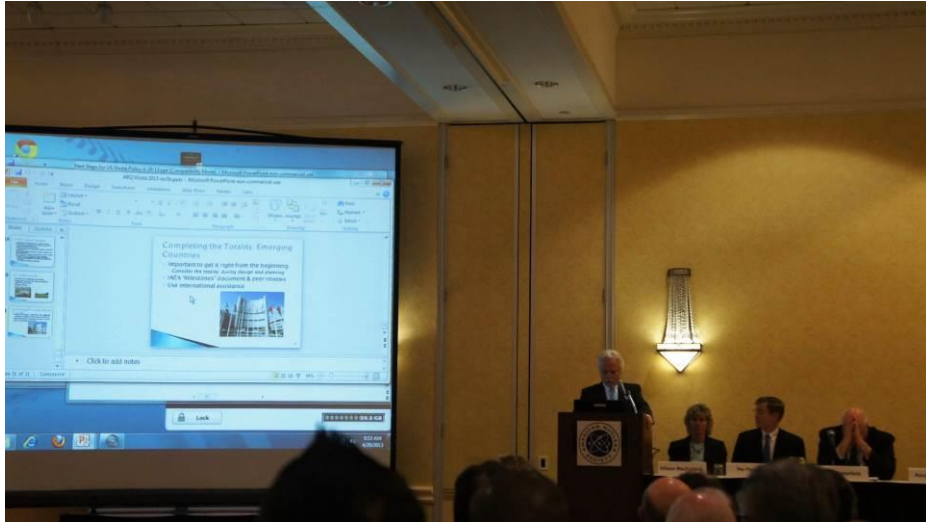


圖 3 會議主席 Dr. McMahon 主持開幕式

時間：8:25 AM–10:00 AM

主題：Plenary- I: Perspectives on the Backend of the Fuel Cycle

飯店地點：Grand Salon F

主席：Kevin McMahon (*SNL*), Barry Butterfield (*HDR Engineering*)

主講者：Nuclear Waste Policy- Dr. Allison Macfarlane(*NRC*), Blue Ribbon
Commission- Dr. Per Peterson (*Univ of California*)

內容：Dr. Allison Macfarlane 來自 NRC(如下圖 4 所示)，簡略介紹美國現在 fuel cycle 的情形，及 NRC 之職責與目前政策方向；另一主講者 Dr. Per Peterson(如下圖 5 所示)為 Blue Ribbon Commission 成員之一，除了說明 fuel cycle 的技術問題及 Blue Ribbon 決議事項外，也分享當時 Blue Ribbon 成員對於調查 Yucca Mountain 時的趣事及經驗，可惜某些幽默公差人無法理解。



圖 4 Dr. Allison Macfarlane 簡報



圖 5 Dr. Per Peterson 簡報

時間：10:10 AM–11:20 AM

主題：Plenary II, How Did We Actually Get Into This Mess?

飯店地點：Grand Salon F

主席：Kevin A. McMahon (*SNL*)

主講者：A. David Rossin (*Rossin & Assoc*), Michael Voegle (*Consultant*), Paul Dickman (*ANL*)

內容：Nuclear power hit its “cliff” on April 7, 1977. President Jimmy Carter in office less than 100 days, announced an Executive Order to “indefinitely defer reprocessing of spent nuclear fuel.” He said that his policy was designed to protect the world from nuclear weapons proliferation. He also said that the U.S. would lead by example and that nuclear power could go ahead just fine. President Carter was dead wrong on all counts. The U.S. lost its leadership and it derailed our program on nuclear waste disposal. He had asked no leaders in

weapons or energy programs for input. He listened to academics and activists. The nuclear industry was caught totally by surprise. This was nuclear technology: the poster child for Environmental Impact Statements and public participation in decision-making! And how does it still impact us all?

Mr. David Rossin 講述美國停止 reprocessing 的緣由，由總統 Carter 宣布停止 reprocessing 以防止核武擴散，但此一決定主講者認為使美國喪失了在此方面的領先地位，且讓廢棄物處置的計畫脫軌，主講者批評 Carter 總統只依照學術界及激進份子的建言做成決定，並沒有詢問核武或核能相關計畫的 leaders，David 也展示許多較早年代的文件；Michael Voegle 則討論 Yucca Mountain 終止的前因後果。

時間：11:20 AM–1:00 PM

主題：Panel Discussion—I: Waste From Recycling

地點：Grand Salon F

主席：Paul Murray (AREVA)

主講者及文章：

1. (6907) Utilization of Used Nuclear Fuel in a Potential Future U.S. Fuel Cycle Scenario, Andrew Worrall (*ORNL*)

(1)美國至今共生產 68,000 MTHM(metric tons of heavy metal)的用過核子燃料(used nuclear fuel, UNF)，即使沒有新增機組，用過核子燃料每年還是以 2,000 MTHM 的速度增加，假設再處理(reprocessing)的處理技術容量，及未來有多少核燃料需要進行再處理，可以估算出有多少鈾可以被取出並貯存供未來使用。

(2)預估快中子反應器(fast reactor)在 2050 年後才可商業運轉，在這之前發電廠都是使用輕水反應器(light-water reactor)；美國預計 2030 年才開始執行 reprocessing，估計 2025 年之前產生的用過核子燃料可以直接進入處置場，2025 年之後產生的用過核子燃料足夠提供 2050 年後開始商轉的快中子反應器。

2. (6927) Evaluating Feasibility of Reactor Grade Mixed Oxide Fuel Use in U.S. Reactors: Application of EPRI's Decision Analysis Framework, Andrew A. Dykes, David H. Johnson (*ABSG Consulting, Inc.*), Andrew G. Sowder, Albert J. Machiels (*EPRI*)

3. (6989) An Expert, Top-Level Risk Assessment for Deployment of Future Fuel Cycles, Steven Krahn (*Vanderbilt Univ*), John Vienna (*PNNL*), Allen Croff (*Vanderbilt Univ*), Albert Machiels, Andrew Sowder (*EPRI*)

(1)論文針對燃料循環評估(fuel cycle assessment)許多評估項目中，選出風險評估(risk assessment)進行研究，在技術風險(technical risks)、法規風險(regulatory risks)及計畫風險(programmatic risks)等細項上進行評估。

(2)核燃料循環的技術風險評估，應將時間分成三段：近程(10 年)、中程

(10-40 年)及長程(40 年以上)，將時間與技術做整體評估；另外針對法規及計畫方面的風險評估也提出多點考量因素。



圖 6 Steven Krahn 進行簡報

4. (7012) Assessment of Used Nuclear Fuel Inventory Relative to Disposition Options, John C. Wagner, Joshua L. Peterson, Donald E. Mueller, Jess C. Gehin, Andrew Worrall (*ORNL*), Temitope Taiwo, Mark Nutt, Mark A. Williamson, (*ANL*), Michael Todosow (*BNL*), Roald Wigeland (*INL*), William G. Halsey (*LLNL*), Ronald P. Omberg (*PNNL*), Peter N. Swift (*SNL*), Joe Carter (*SRNL*)

(1)評估美國現已存有的用過核子燃料種類(至 2011 為止共有 70150 MTHM, metric tons of heavy metal)，做為燃料再循環的策略、研究、發展與展示 (research, development and demonstration, RD&D)等決定之參考。

(2)可將美國現有之用過核子燃料(來自商用電廠、國防及研究計畫)分成三種：處置(disposal)、研究(research)及回收再利用(recycle/recovery)，其中大部分用過核子燃料都應該歸類為處置，而在研究及回收再利用上應有 RD&D 及國家安全方面需求才可保留使用，主要數量及比例如下表 2 所示；用過核子燃料種類繁多且分散，每年以 2000MTHM 速度增加，電廠之主要貯存方式為現地之乾式及濕式貯存，下圖 7 為美國 BWR 及 PWR 電廠貯存之用過核子燃料數量分佈，顯示仍以濕式貯存的方式居多。

表 2 美國用過核子燃料分類及數量統計(單位：MTHM)

UNF Type	Total	Disposal	Research	Recycle/ Recovery
Commercial	67,600	65,954	1,646	0
DOE owned	2,500	2,500	0	0
HEU	50	0	0	50
Total	70,150	68,454	1,646	50
Percent of total		97.58	2.35	0.07

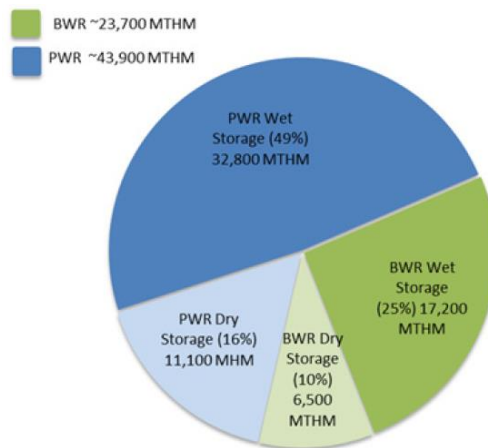


圖 7 美國至 2011 為止 BWR 及 PWR 電廠貯存的用過核子燃料數量
 時間：2:00 PM–3:40 PM
 主題：Technical Sessions

1. Track 4, Session 1: Biosphere

Organizer: Andrew Sowder

主席：Nava Garisto (*SENES Consultants*)

飯店地點：Grand Salon G/H

主講者及文章：

- (1) (6990) Model Development for Transport of Radionuclides via Heterogeneous Geological Media, Bret Patrick Van den Akker, Joonhong Ahn (*Univ of California, Berkeley*)
- (2) (6707) Algebraic Calculation of ERB Dilution, Capture, Retardation, Decay, and Dose, Paul E. Mariner (*SNL*)
- (3) (6867) Potential Impacts of Irrigation Recycling on the Repository Performance, E. A. Kalinina, B. W. Arnold (*SNL*)
- (4) (6873) Short-Term Period Simulation of Atmospheric Dispersion on Braka NPP Site Area, Jong Kuk Lee (*KAIST*), Jae Chul Kim (*Kangwon National Univ*), Kun Jae Lee (*KAIST*)

2. Track 2, Session 1: Natural Systems for Disposal (Generic and Site-Specific)

Organizers: Jude McMurry (*CNWRA*), Stratis Vomvoris (*NAGRA*)

主席：Erik Kremer (*NWMO*)

飯店地點：Grand Salon A/B

主講者及文章：

- (1) (6835) A Characterization Study of Fault Zone Hydrology Kenzi Karasaki (*LBNL*), Celia T. Onisha (*USGS*), Kenzo Kiho (*CRIEPI*), Junichi Goto (*NWMO*)

- (2) (6915) Historic Testing Relevant to Disposal of Heat-Generating Waste in Salt, Kristopher Kuhlman (*SNL*)
- (3) (6839) Sensitivity Analysis on Impact of Continental Glaciation on Radionuclide Transport Shaoping Chu, Scott L. Painter (*LANL*)
- (4) (6931) Assessment of Alternative Host-Rock Distribution in the U.S. Using GIS, Frank V. Perry, Patrick F. Dobson (*LBNL*), Richard E. Kelley (*LANL*)

3.Track 7, Session 1: Storage of Used Nuclear Fuel and High Level Waste

Organizers: Brady Hanson (*PNNL*), Vincenzo Rondinella (*EC-JRC-ITU*)

主席：Ken Sorenson (*SNL*)

飯店地點：Carlsbad

主講者及文章：

- (1) (6713) Concept Plan for a High Burn-Up Fuel Storage and Transportation Confirmatory Data Project, Marcus Nichol, Rodney McCullum (*NEI*), John Kessler, Keith Waldrop (*EPRI*), Tom Brookmire (*Dominion*), Paul Murray (*AREVA Federal Services*), Steve Nesbit (*Duke Energy*)
- (2) (6827) Spent Fuel Storage in Dual Purpose Casks Beyond the Original Design Basis, Holger Volzke, Dietmar Wolff (*BAM Federal Inst for Materials Research and Testing*)
- (3) (6830) Potential Stress on Cladding Imposed by the Matrix Swelling from Alpha Decay in High Burnup Spent Nuclear Fuel, Tae Ahn (*NRC*), V. Rondinella, T. Wiss (*European Commission, Institute for Transuranium Elements*)
- (4) (6832) Extended Dry Storage and Transportation: Model for Evaluating of Vacuum Drying Adequacy, T. Ahn (*NRC*), Jung, P. K. Shukla, E. L. Tipton, (*CNWRA*)

4.Track 7, Session 2: Storage of Used Nuclear Fuel and High Level Waste

Organizers: Brady Hanson (*PNNL*), Vincenzo Rondinella (*EC-JRC-ITU*)

主席：Keith Waldrop (*EPRI*)

飯店地點：Cimarron

主講者及文章：

- (1) (6868) Logistics Case Study for Shipping Used Nuclear Fuel from Shutdown Reactor Sites, E. A. Kalinina (*SNL*), I. K. Busch (*ORNL*), P. E. McConnell (*SNL*), S. J. Maheras (*PNNL*)
 - (a) 計算從除役的電廠運送用過核子燃料所需之費用，主要影響因子有：貯存時間(campaign duration)、何種燃料優先運送(fuel selection approach)、運送護箱大小(consist size)、貯存場地地點(location of storage site)等因素；貯存時間考慮 1、2、3、4、5、6、8 年；運送的燃料選

擇有三種考慮：CALVIN 規則(選擇貯存較久的燃料)、連續的(sequential approach)及平行的(parallel approach)；表 3 為美國各除役後電廠貯存之用過核子燃料種類及數量。

表 3 美國各除役後電廠貯存之用過核子燃料種類及數量

Site	Fuel Type	Number of Assemblies in Storage	Type of Storage Canister	Canister Capacity	Number of Canisters	Type of Transportation Overpack
Big Rock Point	BWR	441	W150	64	8	TS-125
Haddam Neck	PWR	1019	MPC-26	26	40	NAC-STC
Maine Yankee	PWR	1434	UMS-24	24	60	NAC-UMS
Yankee Rowe	PWR	533	MPC-36	36	15	NAC-STC
Rancho Seco	PWR	493	24PT	24	21	MP187
Trojan	PWR	780	MPC-24E/EF	24	34	HI-STAR 100
Humboldt Bay	BWR	390	MPC-80	80	5	HI-STAR 100
La Crosse	BWR	333	MPC-LACBWR	68	5	NAC-STC
Zion 1 and 2	PWR	2226	TSC-37	37	61	NAC-MAGNATRAN

NOTE: These data are from (Leduc, 2012)

(b)運送所需全部費用(total cost)包括資本成本(capital cost)及運轉成本(operational cost)，其關係如下圖 8 所示，影響資本成本最大的因素為貯存時間，其次為燃料選擇與護箱大小，全部費用的影響因素與資本成本相似，但貯存場地同時也會變成是重要的影響原因。

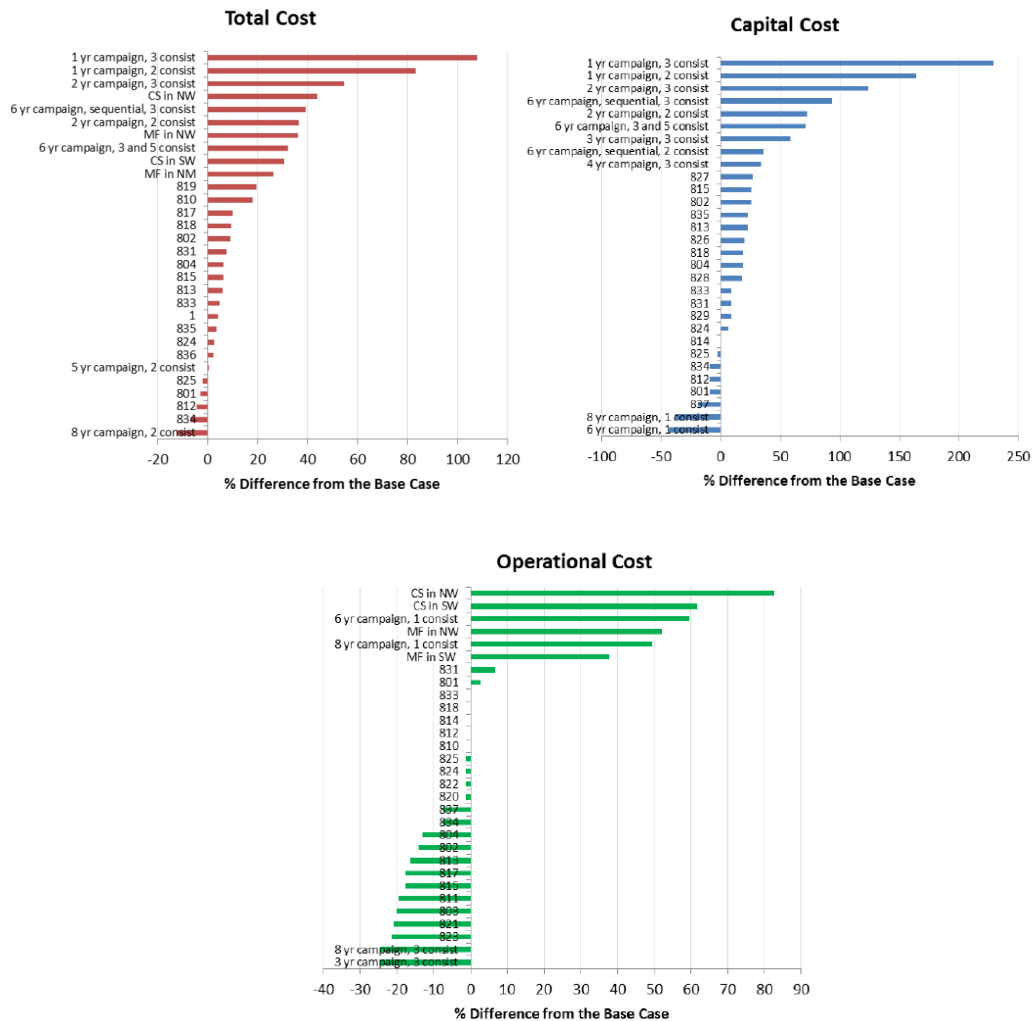


圖 8 全部費用、資本成本及運轉成本受各種參數之影響及關係

(2) (6981) Used Fuel Management System Architecture and Interface Analyses, W. Mark Nutt (ANL), Robert Howard, Ingrid Busch (ORNL), Joe Carter, Phillip Rodwell, Alexcia Delley (SRNL), Elena Kalinina, Ernest Hardin (SNL), Thomas Cotton (Complex Systems)

(a)用過核子燃料管理最重要的考量，是用過燃料組件包裝後，於處置時需要與不同地質媒介相容，因此某些用過核子燃料可能需要再包裝，表 4 為燃料組件(fuel assembly)貯存容量受不同媒介(media)或處置場設計概念之影響。

表 4 燃料組件(fuel assembly)貯存容量受不同媒介(media)或處置場設計概念之影響

Media/Design Concept	Waste Package Size	Discussion
Deep borehole	1 PWR/ 2 BWR	Limited by diameter of deep borehole (could be 2 PWR/4 BWR if fuel is consolidated)
Clay/shale: enclosed	4 PWR/ 9 BWR	100°C Limit, 50-year-cooled fuel
Crystalline: enclosed	4 PWR/ 9 BWR	100°C Limit, 100-year-cooled fuel
Salt: enclosed	12 PWR/ 24 BWR	200°C Limit, 50-year-cooled fuel
Clay/shale: open	21 PWR/ 44 BWR	100°C Limit, 50-year-cooled fuel

(3) (6985) A Modular Design Concept for a Used Nuclear Fuel Repackaging Facility, R. L. Howard, D. R. Giuliano, T. L. Lessard (ORNL), J. T. Carter, P. O. Rodwell (SRNL)

(a)處置大組件的用過核子燃料罐(典型貯存容器如圖 9 所示)時，需先將其進行重新包裝以符合處置場之接收要求，本篇利用模組化(modularity)評估影響該廢棄物重新包裝系統的因子，例如重新包裝設施應該獨立設置或與貯存設施(consolidated storage facility, CSF)或處置場相鄰。本篇重新包裝廠是依據每年 1500 MTU 的生產量來做計算，主要設施有 Carrier Receipt Bay、Waste Handling Building、Carrier Release Bay 及 Air Locks 等，如圖 10 所示；該篇論文中列有局部放大的規劃圖面可供參考，圖 11 為處置燃料罐(disposal canister)在封蓋及乾燥的設計概念佈置。

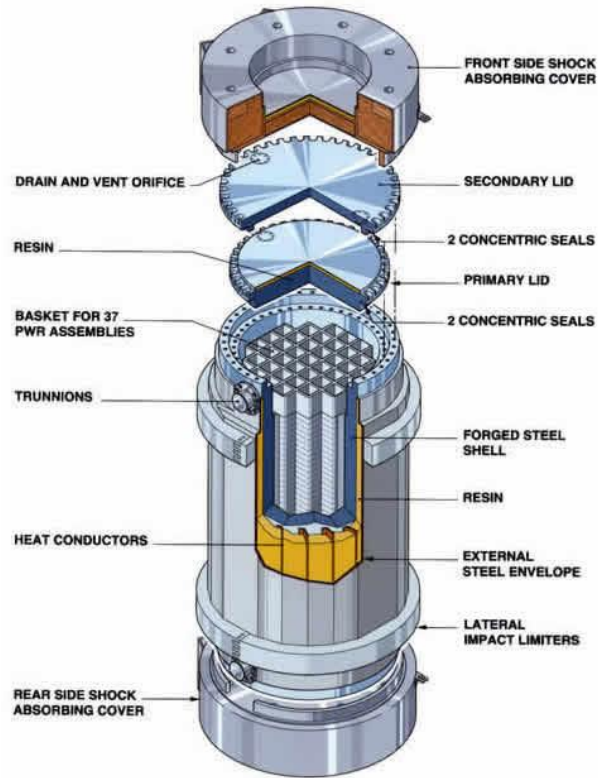


圖 9 典型的貯存容器(資料來源：

http://world-nuclear.org/info/Nuclear-Fuel-Cycle/Nuclear-Wastes/Appendices/Radioactive-Waste-Management-Appendix-2--Storage-and-Disposal-Options/#.Uaf2-9jhf_A)

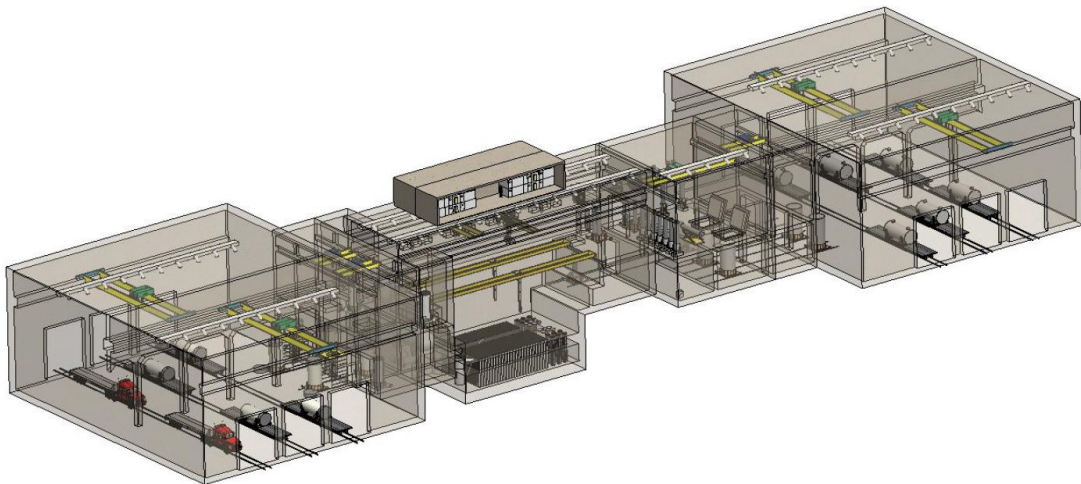


圖 10 重新包裝廠之全景(從左到右分別為 Carrier Receipt Bay、air locks、Waste Handling Building 及 Carrier Release Bay.)

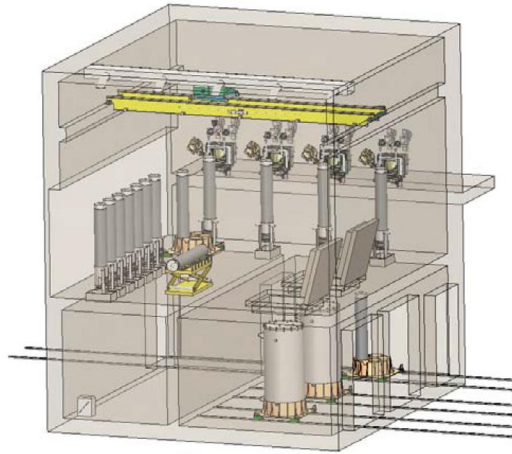


Fig. 7. View of disposal canister closure and drying/inerting area.

圖 11 處置燃料罐的封蓋及乾燥

5.Track 3, Session 1: Engineered Systems for Disposal

Organizers: Frank Garisto (*NWMO*), Asdul Chowdhury (*CNWRA*), David Pickett (*CNWRA*)

主席：Frank Garisto (*NWMO*)

飯店地點：Grand Salon C/D

主講者及文章：

- (1) (6934) The Grimsel Test Site—Going into the Fourth Decade of Applied RD&D, S. Vomvoris, I. Blechschmidt, I. Gaus, J. Rueedi, A. Martin, T. Spillmann (*NAGRA*)
- (2) (6878) Used Fuel Container Retrieval from a Deep Geological Repository in Sedimentary Rock, J. E. Villagran, D. Marinceu (*NWMO*)
- (3) (6923) Operational Efficiency Through Regulatory Change at WIPP, Russ Patterson (*DOE*), Thomas Klein (*URS-Professional Solutions*)

6.Track 5, Session 1: Regulatory Topics

Organizers: Daniel Bullen (*DNFSB*), Barry Butterfield (*HDR Eng*)

主席：Daniel Bullen (*DNFSB*)

飯店地點：Grand Salon I/J

主講者及文章：

- (1) (7020) The Logic and Benefits of a Regional Approach to HLW, SNF, and TRU Waste Disposal in New Mexico, Christopher M. Timm (*PECOS Management Services, Inc.*)
- (2) (6872) Recent Technical Issues Raised by the State of Nevada to be Addressed Should the Yucca Mountain License Application Process be

Restarted, Michael Voegele, Darrell Lacy (*NWRPO*)

時間：3:50 PM–5:30 PM

主題：Technical Sessions

1.Track 5, Session 2: Regulatory Topics

Organizers: Daniel Bullen (*DNFSB*), Barry Butterfield (*HDR Eng*)

主席：Barry Butterfield (*HDR Eng*)

飯店地點：Pecos

主講者及文章：

- (1) (7246) The IAEA World Advisory Safety Standard for Radioactive Waste Disposal: A Critique of a “Generic Standard”, Abraham Van Luik (*DOE*)
- (2) (6901) Initial Review of a License Application for a Spent Nuclear Fuel Repository in Sweden, Björn Dverstorp, Bo Strömberg (*Swedish Radiation Safety Authority (SSM)*)
- (3) (6890) The Finnish Regulatory Experience in the Construction of ONKALO, Jussi Heinonen, Kai Hämäläinen, Risto Paltmaa (*STUK*)

2.Track 2, Session 2: Natural Systems for Disposal (Generic and Site-Specific)

Organizers: Jude McMurry (*CNWRRA*), Stratis Vomvoris (*NAGRA*)

主席：Irina Gaus (*NAGRA*)

飯店地點：Las Cruces

主講者及文章：

- (1) (6836) Iodide Uptake onto Clay Minerals and the Relationship to Fixed Charge, Andrew Miller, Jessica Kruichak, Melissa Mills, Hernesto Tellez, Yifeng Wang (*SNL*)
- (2) (6837) Relationship Between Water Flux and Hydraulic Gradient for Clay Formations, Hui-Hai Liu, Jens Birkholzer (*LBNL*)
- (3) (6850) Modeling Swelling and Swelling Pressure in Expansive Clays, G. Ofoegbu, B. Dasgupta, C. Manepally, H. Basağaoğlu (*CNWRRA*), R. Fedors (*NRC*)
- (4) (6974) Pore Characteristics and Their Evolution in Clays Using Small Angle Neutron Scattering, M. Ding, M. Hartl, H. Xu, R. P. Hjelm (*LANL*), A. Miller, Y. Wang (*SNL*)

3.Track 7, Session 3: Storage of Used Nuclear Fuel and High Level Waste

Organizers: Brady Hanson (*PNNL*), Vincenzo Rondinella (*EC-JRC-ITU*)

主席：Vincenzo Rondinella (*EU-JRC-ITU*)

飯店地點：Acoma

主講者及文章：

- (1) (6871) Assessing Material Degradation Effects on Long Term Storage Structural Analyses, Nicholas A. Klymyshyn, Harold E. Adkins, Jr., Brady D. Hanson (*PNNL*)
- (2) (6908) Consequences of Used Nuclear Fuel Failure on Criticality Safety, William J. Marshall, J. C. Wagner (*ORNL*)
- (3) (6913) Optimizing Back-End Flexibility with the CARE Concept CARE, M. J. Apted (*Intera, Inc.*), I. G. McKinley (*McKinley Consulting*)
- (4) (6920) Corrosion of Canister Materials for Extended Storage of Used Fuel, Benjamin Hauch, Brandon Semerau, Soham Banerjee, Kumar Sridharan (*Univ of Wisconsin, Madison*)

4.Track 3, Session 2: Engineered Systems for Disposal

Organizers: Frank Garisto (*NWMO*), Asdul Chowdhury (*CNWRA*), David Pickett (*CNWRA*)

主席：George Danko (*Univ of Nevada-Reno*)

飯店地點：Carlsbad

主講者及文章：

- (1) (6976) A Demonstration of the Disposal Systems Evaluation Framework (DSEF), Harris R. Greenberg, James A. Blink, Mark Sutton, Montu Sharma (*LLNL*)

(a)由 Lawrence Livermore 國家實驗室發展此套評估軟體：Disposal Systems Evaluation Framework (DSEF)，用來發展處置設計之概念，針對廢料種類(waste forms)、地質環境(geologic environments)、處置場設計概念(repository design concepts)及處置場運作模式(repository operating modes)等做評估分析。

(b)此系統為一知識管理系統，目前為止可以提供 300 筆的熱分析結果、查詢材料特性及處置場的花費等資訊；此一系統是以 Microsoft Office Excel 2010 為基礎撰寫而成，圖 12 為作者提供的幾個在處置場概念設計時需考量的因素。

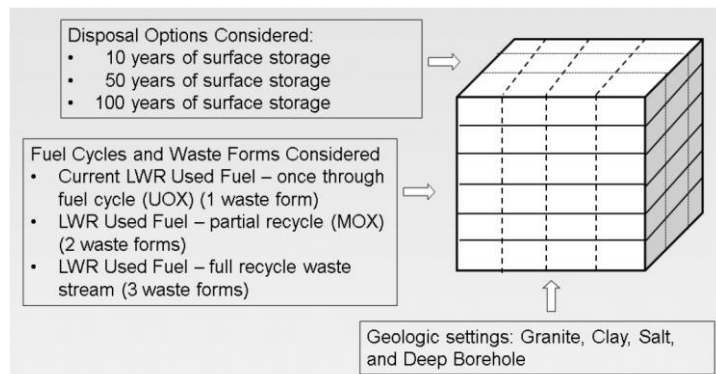


圖 12 處置場概念設計需考量之因素

(2) (6806) FIRST-Nuclides: European Project on Radionuclide Release from Spent Fuel, Bernhard Kienzler, Ernesto González-Robles, Volker Metz (KIT), Alba Valls, Lara Duro (*Amphos 21*)

- (a) FIRST-Nuclides(Fast/Instant Release of Safety Relevant Radionuclides from Spent Nuclear Fuel)為歐洲數國的合作計畫，目的是評估輕水式反應器(light water reactors, LWR)的用過核子燃料(spent nuclear fuel, SNF)在地下處置場中，發生燃料罐破損其核種快速釋放到環境中的現象；最重要的安全評估因素為各核種(包括碘、氯、碳及銻等現仍未知)快速釋放比率(instant release fraction, IRF)，該些核種會形成陰離子而不容易保留在處置場的障壁層中。
- (b)下圖 13 為 leaching 測試的部分照片，該篇選用的用過核子燃料來自燃料丸、去掉護套之燃料丸、碎片及粉末等，來測試核種溶解釋放速率。



Cladded SNF pellet (KIT)



Fragment preparation (KIT)



Leaching of fragments and cladding (Studsvik)

圖 13 用過核子燃料樣品及 leaching 測試

(3) (6859) The Manufacturing of a Disposal Canister Using a Cold Spray Coating of Copper, Minsoo Lee, Heui Joo Choi, Jong Youl Lee, Jong Won Choi (KAERI)

- (a)處置用燃料罐內層是鑄鐵材質，主要提供機械強度，外層為銅，做為抗腐蝕用，韓國 KAERI 發展出利用 CSC(cold spray coating)技術

將銅顆粒噴灑約 10mm 厚度到鑄鐵上製造出處置用燃料罐，測試其強度、含氧量、空隙率及機械張力，結果顯示 CSC 銅較一般銅具高機械張力，但在拉伸方面強度較差，其 CSC 技術圖示如圖 14。

(b)在各種環境下測試其耐腐蝕強度，結果顯示短期間內 CSC 銅較一般銅容易受腐蝕，而長期間之實驗則在地下模擬環境中測試，其腐蝕速率與一般銅相當，約為 $1.0 \mu\text{m}/\text{year}$ ；銅燃料罐的製作則以實物的 1/10、利用此 CSC 法製造完成，在鑄鐵外層約有 10mm 厚度的銅層包覆，經過實驗，證實此 CSC 方法可以非常方便的製造出鐵-銅雙層燃料罐，其完成品如圖 15 所示。

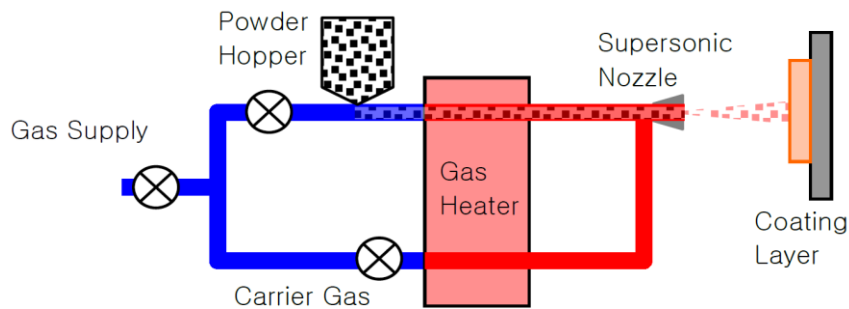


圖 14 CSC(cold spray coating)技術之圖示



圖 15 利用 CSC 法製造鐵-銅雙層燃料罐

(4) (6863) Design Code Application and Preliminary Structural Evaluation of a Used Fuel Container, Chris Boyle (NWMO)

(a)NWMO(Nuclear Waste Management Organization)正在研發可盛裝 CANDU 燃料的用過燃料罐(used fuel container)，其概念設計如圖 16，並做該結構之分析。

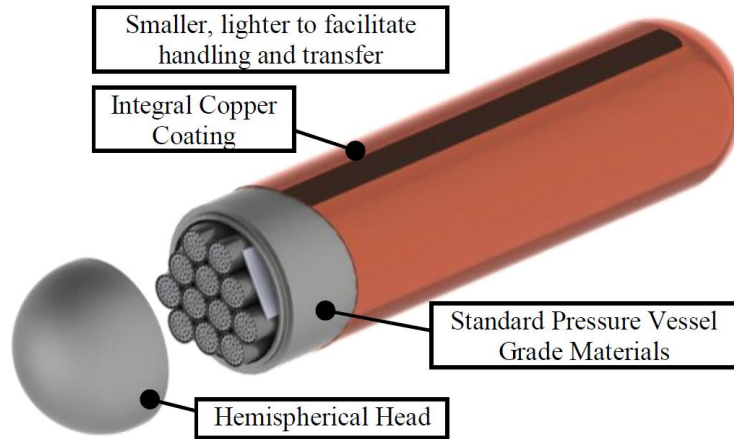


圖 16 用過燃料罐概念設計圖

5.Track 9, Session 1: High-Level Radioactive Waste Transportation

Organizer: Ruth Weiner (SNL)

討論小組成員：John Cook (NRC), Douglas Ammerman (SNL), Ruth Weiner (SNL), Carlos Lopez (SNL), Victor Figueroa (SNL)

飯店地點：Grand Salon C/D

主講者及文章：

(1) Spent Fuel Transportation on Risk Assessment–Panel

The U. S. Nuclear Regulatory Commission (NRC) is responsible for promulgating regulations for the packaging of spent fuel (and other large quantities of radioactive material) for transport that provide for public health and safety during transport). In 1977 the NRC published NUREG-0170, an assessment of the adequacy of those regulations to provide the assurance of safety. In that assessment, the measure of safety was risk of radiation doses to the public under routine and accident transport conditions, and the risk was found to be acceptable. The panel will present the results of the most recent investigation into the safety of spent nuclear fuel transportation. This investigation shows the risk from the radiation emitted from the casks to be a small fraction of that from naturally occurring background radiation and the risk from accidental release of radioactive material to be several orders of magnitude less. The calculated dose due to the external radiation from the cask under routine transport conditions is similar to that found in earlier studies. The improved analysis tools and techniques, improved data availability, and reduction in the number of conservative assumptions has made the estimate of accident risk from the release of radioactive material in this study approximately five orders of magnitude less than was estimated in NUREG-0170. The results

demonstrate that the regulations of the NRC continue to provide adequate protection of public health and safety during the transportation of spent nuclear fuel.

6.Track 8, Session 1: Advanced Fuel Cycles: Impacts on Waste Management

Organizers: Joonhong Ahn (*Univ of California, Berkeley*), Jongwon Choi
(*KAERI*)

主席：Joonhong Ahn (*Univ of California, Berkeley*)

飯店地點：Grand Salon A/B

主講者及文章：

- (1) (6858) Modeling the Environmental Health and Safety Risks of the Present U.S. Nuclear Fuel Cycle, Bethany Smith, Kevin Brown, Steven Krahn, James H. Clarke (*Vanderbilt Univ*), Albert Machiels, Andrew Sowder (*EPRI*)
- (2) (6892) Developing Operational Safety Performance Measures for Nuclear Chemical Facilities, Lyndsey Fyffe (*Vanderbilt Univ*), James A. Hutton (*DOE*), James H. Clarke, Steven Krahn (*Vanderbilt Univ*)
- (3) (6964) Transient Analysis of Nuclear Technologies—Input for Decision Making, J. Hart, A. I. van Heek, F. Roelofs, A. Wakker (*NRG*)
- (4) (7005) Energy Return on Energy Investment for an LWR Fuel Cycle, Harris R. Greenberg, Clara Smith, James A. Blink (*LLNL*), Massimiliano Fratoni (*Penn State*), William G. Halsey, A. J. Simon, Mark Sutton (*LLNL*)

時間：7:00 PM–9:00 PM

Opening Reception

與會者互相認識並討論核能相關之議題，與 Dr. Wang、Dr. Lee 及 Dr. Yang 討論美國核能政策之改變、美國國家實驗室之工作內容及制度等議題，並與其他與會者交換名片。



圖 17 晚宴會場，左起為李傳斌博士(成功大學)、Dr. Wang (Oak Ridge National Lab.)、Dr. Yan Yong (Oak Ridge National Lab.)及公差人

第三天- TUESDAY, APRIL 30, 2013

時間：8:00 AM–9:00 AM, APRIL 30

主題：Plenary—III: China's Nuclear Energy Program

Organizer: Mick Apted (*Intera, Inc*)

主席：Kevin A. McMahon (*SNL*)

飯店地點：Grand Salon F

主講者：Dr. Ju Wang (*BRIUG*)

內容：由中國中核集團核工業北京地質研究院的副院長王駒博士說明中國現行核能政策及高放處置場規劃情形。據資料(紀立民，國際高放射性廢棄物處置概況研究，2009)，中國從 1999 年起在甘肅北山進行初步場址特性調查研究，並鑽設六口探查深孔，初步規劃為研發選址、地下實驗、設計建造三個階段，預估在 21 世紀中期可以完成深層地質處置場興建。下圖 18 王駒博士展示中國可以作為處置母岩的花崗岩體地點，分別為阿齊山、雅滿蘇及天湖(參考資料：何建国、高阳、黄贤芳、李建中、高洪雷，西北地区高放废物处置库备选区预选初步结果，2010)。



圖 18 王駒博士展示中國做為處置母岩的花崗岩體可能地點

時間：9:00 AM–10:15 AM, APRIL 30

主題：Panel Discussion–II: Discussion of Activities in China

Organizer: Mick Apted (*Intera, Inc.*)

主席：Mick Apted (*Intera, Inc.*)

飯店地點：Grand Salon F

主講者及文章：

1. (6882) Site-Specific FEP Analysis for the Beishan Area, China, W. Zhou, M. Stenhouse, M. J. Apted (*Intera, Inc.*), W. M. Chen, J. Wang (*BRIUG*)

(1)中國甘肅省的北山地區為中國高放處置場的場址之一，利用瑞典及美國的 FEP(feature, event and processes)分析方法評估此場址的效能，圖 19 為 Xinchang 的花崗岩鳥瞰圖，BS06 及 BS18 為鑽探井，黃色框內為處置場的場址地點，最近的村莊用 Jijing 標示，該地點有淺層的井水取用，而地下水流向則是往北流動。

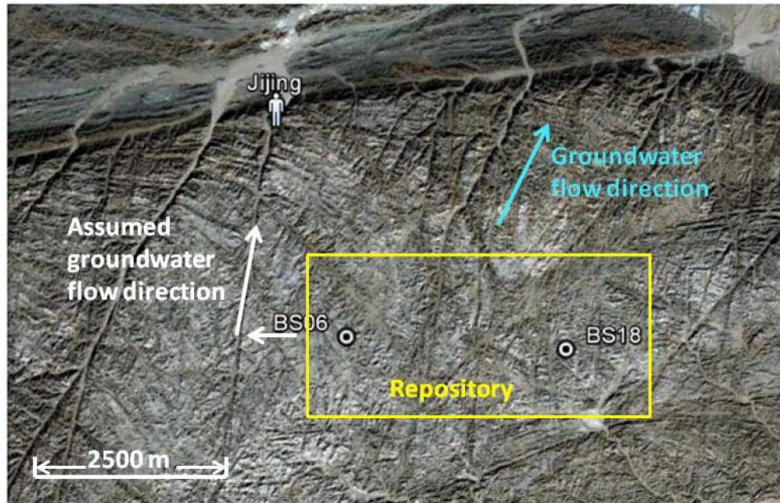


圖 19 Xinchang 的花岡岩鳥瞰圖

2. (6883) Performance Assessment of the Candidate Site for HLW Repository in Beishan, China, W. Zhou, M. J. Apted (*Intera, Inc.*), W. M. Chen, J. Wang (*BRIUG*)

(1)該文章針對中國北山高放候選場址描述其效能評估模式(performance assessment modeling)，該評估模式是依據 FEP 分析之結果，模擬軟體使用 GoldSim[®] 2003；The repository concept is a KBS-3 multi-barrier variant, having shaft-tunnel access, with vitrified HLW glass encapsulated in a carbon-steel overpack surrounded by a bentonite buffer located in saturated zones within granite；圖 20 為核種遷移路徑示意圖；圖 21 為公差人與周瑋博士(Wei Zhou, INTERA Incorporated)合照留念，並請教關於台灣處置場設置之問題。

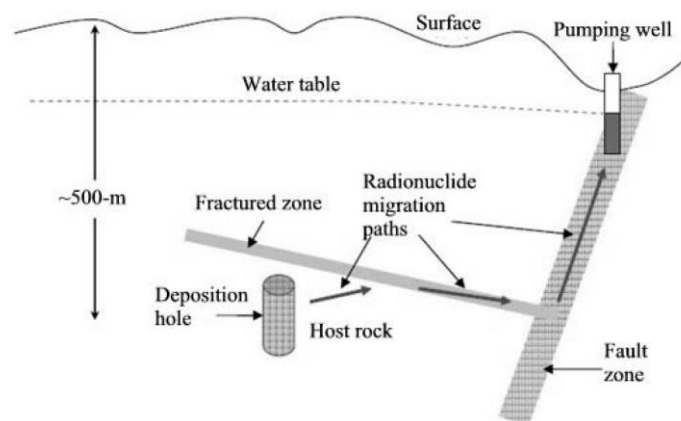


圖 20 中國北山高放處置場之核種遷移路徑示意圖



圖 21 公差人與周瑋博士(INTERA Incorporated)合照

3. (6980) Geological Disposal Program for High Level Radioactive Waste in China: Update 2012, Ju Wang, Zihua Zong, Rui Su, Weimin Chen (*BRIUG*)

- (1)提供中國最新的高放廢棄物地質處置計畫消息，中國政府預計在 2020 年達到核電廠輸出容量為 40GW，其中有 18GW 正在興建中，所以在 2050 年估計共有 82,630 噸的用過核子燃料產生，中國目前對於用過核子燃料政策是先經再處理(reprocessing)，再經過驗證(verification)後用地質處置，而處置的概念是 shaft-tunnel model，設置在花崗岩的飽和區域中，而用來做最終處置的是玻璃化的高放射性廢料。
- (2)將地質處置計畫分成三階段：實驗室研究及高放處置場篩選(2006-2020)；地下現地(in situ)實驗(2021-2040)；處置場興建(2041-2050)，最重要的一個目標是建立地下實驗室，詳細說明如下表 5。下圖 22 及 23 分別為中國北山位置示意圖及中國高放處置場在花崗岩之概念示意圖。

表 5 中國高放處置場之長期規劃

Table 1 The 3-step Long Term Plan for Geological Disposal of HLW in China

Steps	Period	Milestones
Step 1: Laboratory Studies and Site Selection for HLW Repository	2006—2020	Repository sites should be preliminary selected, site characterization preliminary completed, a site for an underground research laboratory (URL) confirmed, the construction of an URL completed, technical capabilities in major areas preliminary established through laboratory studies.
Step 2: Underground In Situ Tests	2021—2040	Site characterization should be completed, the repository site confirmed, most in situ tests in the URL completed, technical capability for construction of repository established, detailed design for repository completed.
Step 3: Repository Construction	2041—the middle of 21st Century	The repository construction is completed around 2050, the demonstration for HLW disposal is conducted, while vitrified HLW is accepted and disposed in the repository.

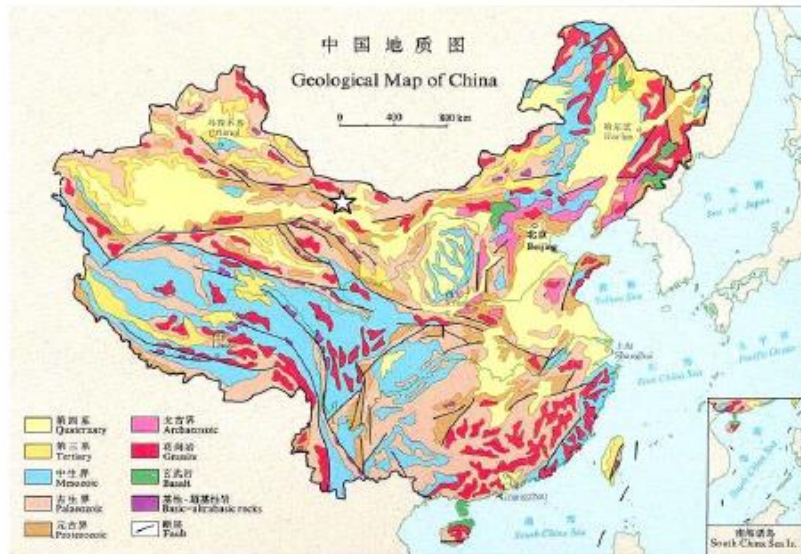


圖 22 中國北山位置示意圖(以☆標示)

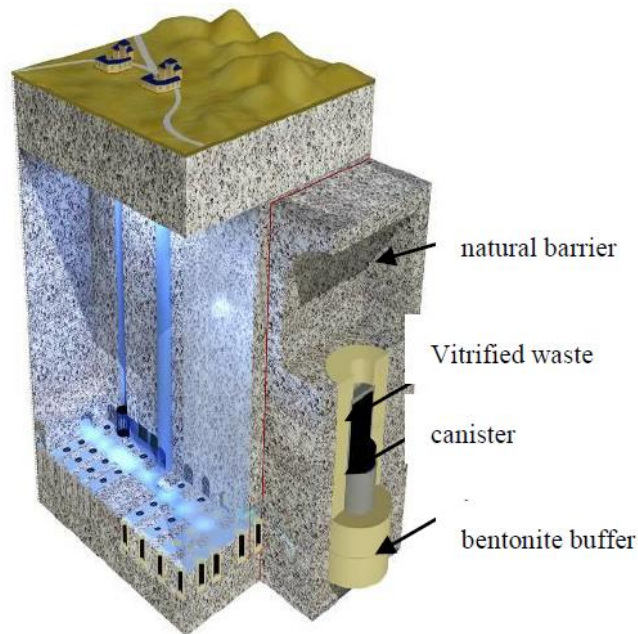


圖 23 中國高放處置場在花岡岩之概念示意

時間：10:30 AM–12:10 PM, APRIL 30

主題：Technical Sessions

1.Track 1, Session 1: Total Repository System (Generic and Site-Specific)

Organizers: Peter Swift (SNL), Matt Kozak (Intera, Inc.), George Danko (Univ. of Nevada, Reno)

主席：Peter Swift (SNL), O. Pensado (CNWRA)

飯店地點：Grand Salon A/B

主講者及文章：

(1) (6852) Building Confidence for the Korean Repository Performance

Assessment Model, Olufemi Osidele, Osvaldo Pensado (*CNWRA*),

Youn-Myoung Lee, Jongtae Jeong (*KAERI*)

(2) (6875) Verification of Calculational Cases in Performance Assessment for KBS-3 Repository, Osvaldo Pensado, Sitakanta Mohanty, Patrick LaPlante (*CNWRA*)

(3) (6876) Fourth Case Study: Analysis of Disruptive Scenarios, F. Garisto (*NWMO*), J. Avis (*Geofirma Engineering Ltd*), M. Gobien, C. Medri, E. Kremer (*NWMO*)

2.Track 2, Session 3: Natural Systems for Disposal (Generic and Site-Specific)

Organizers: Jude McMurry (*CNWRA*), Stratis Vomvoris (*NAGRA*)

主席：John Walton (*UTEP*)

飯店地點：Grand Salon C/D

主講者及文章：

(1) (6864) Modeling of Induced Damage and Plastic Deformation in Granite, Liang Chen, Chunping Wang (*BRIUG*), Jianfeng Liu (*Sichuan Univ*), Xiyong Wang, Ju Wang (*BRIUG*), Jianfu Shao (*Univ of Lille*)

(2) (6877) Integrated-Tool Development for Evaluation of Radionuclide Transport in the Far-Field of High-Level Radioactive Waste Repositories, Teklu Hadgu, Yifeng Wang (*SNL*)

3.Track 7, Session 4: Storage of Used Nuclear Fuel and High Level Waste

Organizers: Brady Hanson (*PNNL*), Vincenzo Rondinella (*EC-JRC-ITU*)

主席：Robert Einziger (*NRC*)

飯店地點：Grand Salon I/J

主講者及文章：

(1) (6925) Criticality Safety for Plutonium-Filled Canister in a Repository, Elsa Lemaître-Xavier, Joonhong Ahn (*Univ of California, Berkeley*)

(2) (6962) Observation and Mechanism of Hydride in Zircaloy-4 Re-Orientation Induced by High Pressure at High Temperatures, Y. Yan, A. Blackwell, L. Plummer, B. Radhakrishnan, S. Gorti, K. Clarno (*ORNL*)

4.Track 3, Session 3: Engineered Systems for Disposal

Organizers: Frank Garisto (*NWMO*), Asdul Chowdhury (*CNWRA*), David Pickett (*CNWRA*)

主席：William Halsey (*LLNL*)

飯店地點：Grand Salon G/H

主講者及文章：

(1) (6887) Using Copper Coatings for Corrosion Protection of a Used Fuel

Container During Geological Storage, Peter G. Keech (*NWMO*)

- (2) (6893) Alteration of Clinoptilolite into High-Silica Analcime Within a Bentonite Barrier System Under Used Nuclear Fuel Repository Conditions, M. C. Cheshire, F. A. Caporuscio (*LANL*), C. Jové-Colon (*SNL*), M. K. McCarney (*Univ of Wyoming*)
- (3) (6894) Metallic Alloy Waste Forms—A First Principles Approach to Corrosion, C. D. Taylor, X-Y. Liu (*LANL*), O. Olatunji-Ojo, D. P. Moore, D. G. Kolman (*LANL*), E. Kim, K. R. Czerwinski (*UNLV*)
- (4) (6994) Thermodynamic Model Development of Engineered Barrier System Materials: Cement Leaching and Clay Hydration, Carlos F. Jové Colón, Harry K. Moffat (*SNL*)

5.Track 7, Session 5: Storage of Used Nuclear Fuel and High Level Waste

Organizers: Brady Hanson (*PNNL*), Vincenzo Rondinella (*EC-JRC-ITU*)

主席：Brady Hanson (*PNNL*)

飯店地點：Carlsbad

主講者及文章：

- (1) (6984) Integrating Data and Analysis Capabilities for Cask-Specific Safety Evaluations, J. M. Scaglione, R. A. Lefebvre, G. Radulescu, H. J. Smith, D. Ilas, Koo Robb, J.C. Wagner (*ORNL*), H. E. Adkins, T. E. Michener (*PNNL*), D. Vinson (*SRNL*)
- (2) (6881) Effect of Ground Materials on Dose Rates at Dry Storage for Spent Fuel, Gilyong Cha, Kyoungyong Noh, Yisoo Kim (*Radiation Core Technologies*), Taeman Kim, Chang Yeal Baeg (*Korea Radioactive Waste Management Corporation*), Soonyoung Kim (*Radiation Core Technologies*)
- (3) (6986) Considerations for an Integrated Storage, Transportation, and Disposal Canister, J. M. Scaglione, A.G. Caswell, J. B. Clarity, G. Radulescu (*ORNL*)

時間：12:10 AM–1:30 PM, APRIL 30

主題：Conference Luncheon

飯店地點：Grand Salon E

主講者及文章：John Heaton (*presently serving the mayor of Carlsbad, New Mexico as the volunteer energy coordinator*), The Fuel Cycle Solution-Southeast New Mexico Nuclear Corridor

時間：1:30 PM–3:10, APRIL 30PM

主題：Technical Sessions

1.Track 1, Session 2: Total Repository System (Generic and Site-Specific)

Organizers: Peter Swift (*SNL*), Matt Kozak (*Intera, Inc.*), George Danko (*Univ. of Nevada, Reno*)

主席：Matt Kozak (*Intera, Inc.*), E. Kremer (*NWMO*)

飯店地點：Cimarron

主講者及文章：

- (1) (6880) Reference Case for Generic Disposal of HLW and SNF in Salt, Palmer Vaughn, S. David Sevougian, Ernest L. Hardin, Paul Mariner, Michael B. Gross (*SNL*)
- (2) (6905) New Transport Modeling Approach for the Groundwater Pathway in PA Models, Bruce A. Robinson, Shaoping Chu (*LANL*)
- (3) (6935) Development of Complex Scenarios for a Safety Case Development, Jongtae Jeong, Jung-Woo Kim, Youn-Myoung Lee, Dong-Keun Cho, Chul-Hyung Kang (*KAERI*)
- (4) (6954) Performance Assessment Model Development Methodology for a Bedded Salt Repository, S. David Sevougian, Geoff A. Freeze, Michael B. Gross, Ernest L. Hardin, Joon Lee, Christi D. Leigh, Robert J. MacKinnon, Paul Mariner, Palmer Vaughn (*SNL*)

2.Track 2, Session 4: Natural Systems for Disposal (Generic and Site-Specific)

Organizers: Jude McMurry (*CNWRA*), Stratis Vomvoris (*NAGRA*)

主席：Scott Painter (*LANL*)

飯店地點：Las Cruces

主講者及文章：

- (1) (6906) Experimental Evaluation of Actinide Transport in a Fractured Granodiorite, Timothy M. Dittrich, Paul W. Reimus (*LANL*)
- (2) (6928) Thermal-Hydrologic Modeling of a Deep Borehole Disposal System, Bill W. Arnold, Teklu Hadgu (*SNL*)
- (3) (6941) Mesoscale Modeling of Brine Processes in a Single Salt Crystal, Qinjun Kang, Bruce Robinson (*LANL*), Li Chen (*LANL/Xi'an Jiaotong Univ*)
- (4) (6932) A Thermodynamic Model for Na-Mg-B(OH)₃-HCO₃-CO₃-Cl- SO₄, System to High Ionic Strengths, Yongliang Xiong (*SNL*)

3.Track 7, Session 6: Storage of Used Nuclear Fuel and High Level Waste

Organizers: Brady Hanson (*PNNL*), Vincenzo Rondinella (*EC-JRC-ITU*)

主席：Jim Tulenko, (*Univ of Florida*)

飯店地點：Grand Salon A/B

主講者及文章：

- (1) (6993) Development of Closure Bolt Analysis Rules for Division 3 Containments, Z. H. Han, V. N. Shah, Y. Y. Liu (*ANL*)

- (2) (6995) Used Nuclear Fuel Storage and Transportation Data Gap
Prioritization, Christine T. Stockman (*SNL*), Brady D. Hanson (*PNNL*),
Abdelhalim A. Alsaed (*Enviro Nuclear Services*)
- (3) (6996) Aging Management for Extended Storage and Transportation of
Used Fuel, Y. Y. Liu, O. K. Chopra, D. Ma, D. Diercks (*ANL*)
- (4) (7006) Radiological Implications of Extended Storage of Spent Nuclear
Fuel, Ethan Bates, Charles Forsberg (*MIT*)

4.Track 3, Session 4: Engineered Systems for Disposal

Organizers: Frank Garisto (*NWMO*), Asdul Chowdhury (*CNWRA*), David
Pickett (*CNWRA*)

主席：Emory Collins (*ORNL*)

飯店地點：Santa Fe

主講者及文章：

- (1) (6947) Repository Criticality Analysis for Damaged Fuels: Geometry Effect
in the Modeling of Uranium and Plutonium Deposition in Geological
Formations, Xudong Liu, Joonhong Ahn (*Univ of California, Berkeley*),
Fumio Hirano (*JAEA*)
- (2) (6960) Anoxic Corrosion of Steel and Lead in Na-Cl±Mg Dominated Brines,
Gregory T. Roselle (*SNL*)
- (3) (6987) Integrating Used Fuel Degradation Models into Generic
Performance Assessment, David C. Sassani, Carlos F. Jové Colón, Philippe
F. Weck (*SNL*)

5.Track 6, Session 1: Institutional Topics (With Emphasis on Lessons Learned)

Organizers: Charles McCombie (*MCM Consulting*)

主席：Dan Bullen (*DNFSB*), Charles McCombie (*MCM Consulting*)

飯店地點：Pecos

主講者及文章：

- (1) (6936) National Programmes and Implementation of EU Nuclear Waste
Directive, Gunnar Buckau [*European Commission (JRC-ITU)*]
- (2) (7000) Overview of the United States Department of Energy's Used Fuel
Disposition Research and Development Campaign, Peter N. Swift (*SNL*),
Jens T. Birkholzer (*LBNL*), William J. Boyle, Timothy C. Gunter, Ned B.
Larson (*DOE*), Robert J. MacKinnon, Kevin A. McMahon (*SNL*), W. Mark
Nutt (*ANL*), Ken B. Sorenson (*SNL*)
- (3) (6703) Integrating Fuel Cycles with the Repository: What Fuel Cycle
Facilities and What Institutional Structures?, Charles Forsberg (*MIT*)
- (4) (6869) A Blueprint for the New Used Fuel Management Organization, Steve
Nesbit (*Duke Energy*), Lake Barrett (*L. Barrett Consulting*), Rod McCullum

(NEI), Dan Stout (TVA)

6.Track 8, Session 2: Advanced Fuel Cycles: Impacts on Waste Management

Organizers: Joonhong Ahn (*Univ of California, Berkeley*), Jongwon Choi
(KAERI)

主席：Max Fraton (Penn State Univ)

飯店地點：Acoma

主講者及文章：

- (1) (6843) The Concentration and Distribution of Beryllium in Hanford High-Level Waste, Jacob G. Reynolds (*Washington River Protection Solutions, LLC*)
- (2) (6856) Partitioning and Durable Waste Forms for Highly Radiotoxic Isotopes, Bruce E. Kirstein, Sue B. Clark (*NWTRB*)

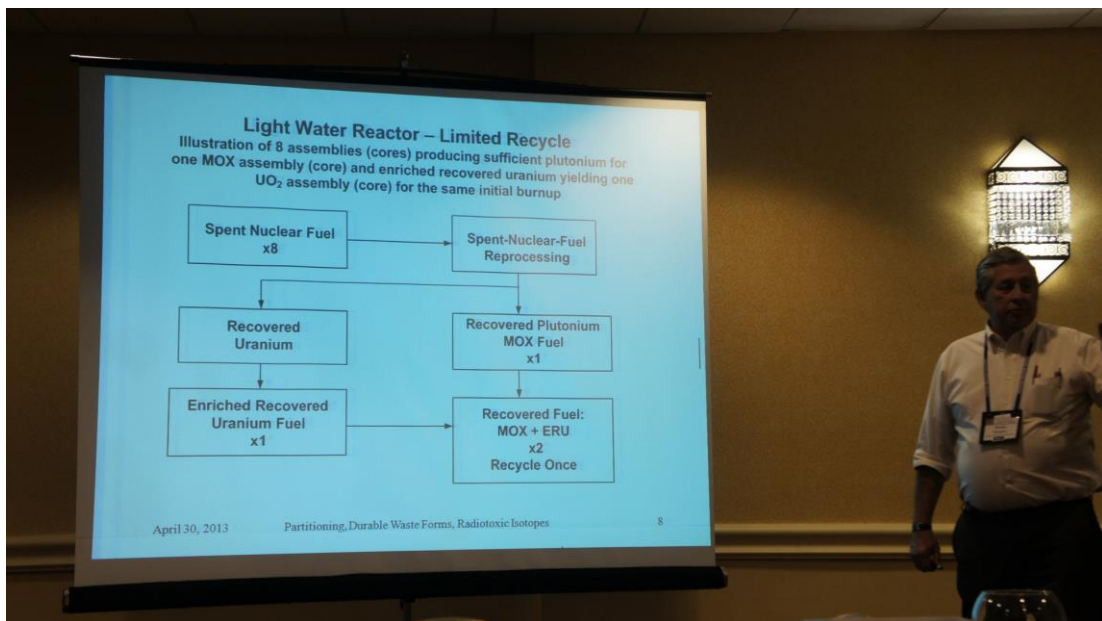


圖 24 簡報用過核子燃料再處理過程

- (3) (6870) Evaluation of High-Level Melter Feed at Hanford, Jeremy Belsher, Amy Ramsey, William Ramsey (*Washington River Protection Solutions, LLC*)
- (4) (6924) Inorganic Metal Fluorite Materials as Novel Adsorbents for Gaseous Radioiodine Capture, Yifeng Wang, Andy Miller (*SNL*)

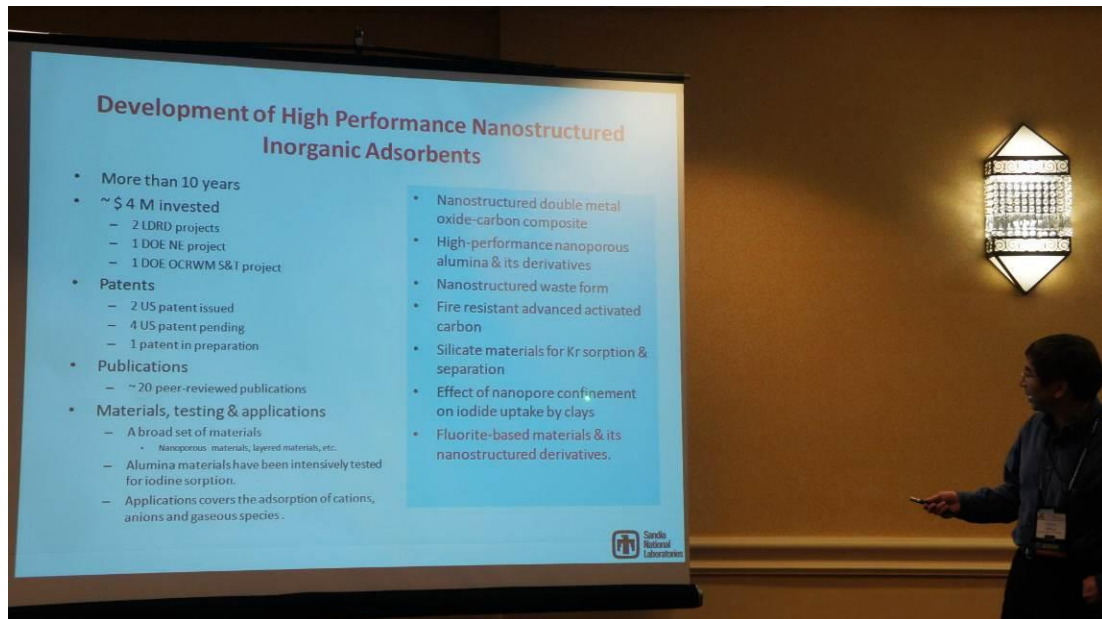


圖 25 高效率奈米結構之無機吸附劑(無全文資料)

時間：3:30 PM–5:10 PM, APRIL 30

主題：Technical Sessions

1.Track 1, Session 3: Total Repository System (Generic and Site-Specific)

Organizers: Peter Swift (*SNL*), Matt Kozak (*Intera, Inc.*), George Danko (*Univ. of Nevada, Reno*)

主席：D. Sevougian (*SNL*), G. Freeze (*SNL*)

飯店地點：Grand Salon C/D

主講者及文章：

- (1) (6977) Leveraging Existing Process Modeling Capability in Geosphere Performance Assessments, Dylan R. Harp, Scott L. Painter (*LANL*)
- (2) (7004) Repository Performance Insights from Simplified Generic Safety Assessment Models, Geoff Freeze, Peter Swift, Palmer Vaughn (*SNL*)
- (3) (7040) Fourth Case Study: Postclosure Safety Assessment of a Used Fuel Repository in Crystalline Rock, E. P. Kremer, N. G. Hunt (*NWMO*), J. D. Avis (*Geofirma Engineering ILtd*), T. Chshyolkova (*AECL*), F. Garisto, P. Gierszewski, M. Gobien (*NWMO*), C. I. Kitson (*AECL*), C. L. D. Medri (*NWMO*), T. W. Melnyk, L. C. Wojciechowski (*AECL*)

2.Track 2, Session 5: Natural Systems for Disposal (Generic and Site-Specific)

Organizers: Jude McMurry (*CNWRA*), Stratis Vomvoris (*NAGRA*)

主席：Budhi Sagar (*Consultant*)

飯店地點：Carlsbad

主講者及文章：

- (1) (6943) Modeling of Fate and Transport of Water in a Salt-Based Repository, Philip Stauffer, Dylan Harp, Bruce Robinson (*LANL*)
- (2) (6948) Modeling of Coupled Thermo-Hydro-Mechanical Processes at Mont Terri Heater Experiments in Opalinus Clay Using TOUGH-FLAC, Jonny Rutqvist, Fei Chen, Jens Birkholzer, Hui-Hai Liu (*LBL*), Benoit Garitte, Tim Vietor (*NAGRA*)
- (3) (6949) Hydrological and Hydrochemical Studies in KAERI Underground Research Tunnel, Korea, Yong-Kwon Koh, Jang-Soon Kwon, Geon-Young Kim, Jong-Won Choi (*KAERI*)
 - (a) 介紹韓國的地下研究坑道 KURT(KAERI Underground Research Tunnel, KURT)及此地下坑道周圍所做之地層等相關研究。

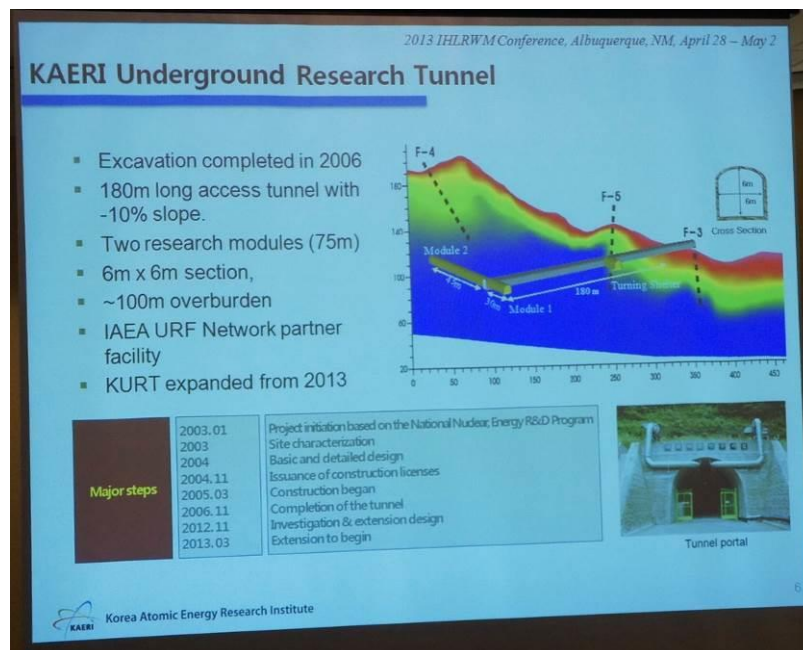


圖 26 韓國 KURT 處置場之介紹

3.Track 7, Session 7: Storage of Used Nuclear Fuel and High Level Waste

Organizers: Brady Hanson (*PNNL*), Vincenzo Rondinella (*EC-JRC-ITU*)

主席：John Scaglione (*ORNL*)

飯店地點：Grand Salon I/J

主講者及文章：

- (1) (7013) Phase Field Simulations of Hydride Reorientation in Zircalloys, B. Radhakrishnan, S. B. Gorti, K. Clarno, Y. Yan (*ORNL*)
- (2) (7016) Impact of Atmospherically Deposited Salts on the Localized Corrosion Performance of Materials Used for the Interim Storage of Used Nuclear Fuel, David G. Enos, Charles R. Bryan (*SNL*)
- (3) (7032) Low Temperature Creep of Used Nuclear Fuel During Long Term

Dry Storage, Carl E. Beyer (*PNNL*), James S. Tulenko, Yong Yang, Gerhard E. Fuchs (*Univ of Florida*), James Stubbin (*Univ of Illinois*), Jacob Eapen, Korukonda Murty (*NCSU*)

- (4) (7037) Simulation of Hyride Reorientation in Zr-Based Claddings During Dry Storage, Veena Tikare (*SNL*)

4.Track 3, Session 5: Engineered Systems for Disposal

Organizers: Frank Garisto (*NWMO*), Asdul Chowdhury (*CNWRA*), David Pickett (*CNWRA*)

主席：Charles Forberg (*MIT*)

飯店地點：Cimarron

主講者及文章：

- (1) (6955) Electrochemical Modeling and Experimental Study of Used Fuel Matrix Degradation, James L. Jerden, Jr., Kurt E. Frey, Terry A. Cruse, William L. Ebert (*ANL*)
- (2) (6991) Spectroscopic Detection of Hydrogen Peroxide Generated by Alpha Radiolysis in Solution, Frances N. Smith, Sergey I. Sinkov, Chuck Z. Soderquist, Richard S. Wittman, Alexander R. Geanes, Bruce K. McNamara, Edgar C. Buck (*PNNL*)
- (3) (6926) Spent Nuclear Fuel and its Corrosion Products: A Quantum-Mechanical Modeling Investigation, Philippe F. Weck (*SNL*), Eunja Kim (*UNLV*), Carlos Jové-Colón, David C. Sassani (*SNL*)
- (4) (6997) Formation of Studite during the Oxidative Dissolution of Doped UO_2 by Hydrogen Peroxide: Effect of Dopant Chemistry, Edgar Buck, Andrew Casella, Rick Wittman, Lanee Snow, Bruce McNamara, Frannie Smith (*PNNL*)

5.Track 8, Session 3: Advanced Fuel Cycles: Impacts on Waste Management

Organizers: Joonhong Ahn (*Univ of California, Berkeley*), Jongwon Choi (*KAERI*)

主席：Jim Blink (*LLNL*)

飯店地點：Grand Salon G/H

主講者及文章：

- (1) (6942) Influence of Advanced Fuel Cycles on Uncertainty in the Performance of Geologic Disposal Systems, Rob P. Rechard (*SNL*), Mark Sutton, James A. Blink, Harris R Greenberg, M. Sharma (*LLNL*), Bruce A. Robinson (*LANL*), Mark Nutt (*ANL*)
- (2) (7010) Secondary Waste Estimate for Recycling Based on AREVA Operating Experience, Genevieve Foare, Florian Meze (*AREVA*), Don

McGee, Paul Murray, Sven Bader (*AREVA Federal Services*)

第四天-WEDNESDAY, MAY 1, 2013

時間：8:00 AM–10:15 AM

主題：Plenary—IV and Panel—III: Fast Reactors as a Means of Closing the Fuel Cycle

Organizer: Paul Dickman (*ANL*)

飯店地點：Grand Salon F

主席：Kevin A. McMahon (*SNL*), Paul Dickman (*ANL*)

主講者：John Kelly (*US Dept of Energy*), Dr. Mark Peters (*ANL*), Neile Miller (*NNSA*)—invited, Won-Seok Park (*KAERI*)

時間：10:30 AM–12:10 PM, MAY 1

主題：Technical Sessions

1.Track 1, Session 4: Total Repository System (Generic and Site-Specific)

Organizers: Peter Swift (*SNL*), Matt Kozak (*Intera, Inc.*), George Danko (*Univ. of Nevada, Reno*)

主席：Erik Kremer (*NWMO*), Peter Swift (*SNL*)

飯店地點：Grand Salon A/B

主講者及文章：

(1) (6805) Preliminary Safety Analysis Gorleben: Source Terms for Heat-Producing Wastes, Bernhard Kienzler, Marcus Altmaier, Christiane Bube, Volker Metz (*KIT*)

(2) (6821) Sensitivity Analysis of Probabilistic Dose Results in SKB's License Application, Allan Hedin (*SKB*)

2.Track 2, Session 6: Natural Systems for Disposal (Generic and Site-Specific)

Organizers: Jude McMurry (*CNWRA*), Stratis Vomvoris (*NAGRA*)

主席：Björn Dverstorp (*SSM*), John Walton (*UTEP*)

飯店地點：Cimarron

主講者及文章：

(1) (6956) THM Processes Modeling to Evaluate Salt-Based Repositories in the Long-Term, Laura Blanco Martin, Jonny Rutqvist, James Houseworth, Jens Birkholzer (*LBNL*)

(2) (6944) Development and Verification of a New Particle Tracking Capability for Modeling Radionuclide Transport in Discrete Fracture Networks, Nataliia Makedonska, Scott Painter, Tsung-Lin Hsieh, Quan Bui, Carl Cable (*LANL*)

(3) (6982) Chemical-Mechanical Coupling Related to THMC Modelling of Clay Formations, Liange Zheng, Jonny Rutqvist, Hui-Hai Liu, Jens Birkholzer, Eric Sonnenthal (*LBNL*)

(4) (6988) Thermal-Hydro-Mechanical Modeling of Clay Rock Including Fracture Damage, Daisuke Asahina, Jim Houseworth, Jens Birkholzer (*LBNL*)

3.Track 7, Session 8: Storage of Used Nuclear Fuel and High Level Waste

Organizers: Brady Hanson (*PNNL*), Vincenzo Rondinella (*EC-JRC-ITU*)

主席：Dietmar Wolff (*BAM*)

飯店地點：Grand Salon G/H

主講者及文章：

(1) (7034) Study on the Delayed Hydride Cracking for Used Nuclear Fuel Cladding in Dry Storage, Dallas Burton, Yong Yang (*Univ of Florida*)

(2) (7038) Interim Storage Environment: Considerations for Corrosion Testing of SNF Dry Storage Containers, Charles R. Bryan, David Enos (*SNL*)

(3) (7024) Development of a Comprehensive Health Monitoring System for Dry Storage of Spent Nuclear Fuel, Michael Hurley, Brian Jaques, Vikram Patel (*Boise State Univ*), Jack Ma, Jake Blanchard, Hongyi Mi, Kumar Sridharan (*Univ of Wisconsin*), Sean McDeavitt (*Texas A&M*), Sin Loo, Darryl Butt (*Boise State Univ*)

4.Track 3, Session 6: Engineered Systems for Disposal

Organizers: Frank Garisto (*NWMO*), Asdul Chowdhury (*CNWRA*), David Pickett (*CNWRA*)

主席：Matt Kozak (*Interra, Inc.*)

飯店地點：Grand Salon I/J

主講者及文章：

(1) (6998) Modelling the Interactions of Radiolytic Species with Noble Metal Particles, Alexander Geanes, Frances Smith, Donghai Mei, Edgar Buck (*PNNL*)

(2) (7003) Onset and Stability of Natural Convection in Deep Boreholes, E. A. Bates, E. Baglietto, M. J. Driscoll, J. Buongiorno (*MIT*)

(3) (6909) ADVANTG Shielding Analysis for Closure Operations in an Open-Mode Repository, Aaron M. Bevill, Georgeta Radulescu, John M. Scaglione, Rob L. Howard (*ORNL*)

5.Track 8, Session 4: Advanced Fuel Cycles: Impacts on Waste Management

Organizers: Joonhong Ahn (*Univ of California, Berkeley*), Jongwon Choi (*KAERI*)

主席：Jongwon Choi (*KAERI*)

飯店地點：Grand Salon C/D

主講者及文章：

- (1) (6702) Why We Can't Predict Future Fuel Cycles: Implications for Waste Management and Repository Design, Charles Forsberg (*MIT*)
- (2) (6847) Are Fast Reactors Necessary for Full Actinide Recycle?, E. D. Collins, C. W. Alexander, G.D. Del Cul (*ORNL*), J. P. Renier (*ORNL (Ret.)*)
- (3) (6922) A Practical Path Forward for U.S. Used Nuclear Fuel, Guillermo D Del Cul, Emory D. Collins, Barry B. Spencer, R. T. Jubin (*ORNL*)

時間：1:30 PM–3:10 PM, MAY 1

主題：Technical Sessions

1.Track 1, Session 5: Total Repository System (Generic and Site-Specific)

Organizers: Peter Swift (*SNL*), Matt Kozak (*Intera, Inc.*), George Danko (*Univ. of Nevada, Reno*)

主席：G. Freeze (*SNL*), D. Sevougian (*SNL*)

飯店地點：Cimarron

主講者及文章：

- (1) (6945) Disposal of Heat-Generating Nuclear Waste in Salt—Recent Activities and Future Plans, Bruce A. Robinson (*LANL*), Roger A. Nelson (*DOE*), Douglas J. Weaver (*LANL*)
- (2) (6992) Used Fuel Security—Prioritized Issues, R&D Needs, Best Practices, and Security Risk Analysis for Extended Storage, Felicia A Durán, Gregory D. Wyss (*SNL*), Scott DeMuth (*LANL*), James A. Blink (*LLNL*)

2.Track 2, Session 7: Natural Systems for Disposal (Generic and Site-Specific)

Organizers: Jude McMurry (*CNWRA*), Stratis Vomvoris (*NAGRA*)

主席：Stratis Vomvoris (*NAGRA*)

飯店地點：Grand Salon I/J

主講者及文章：

- (1) (7001) Thermal-Hydrologic-Mechanical Modeling of a Generic Salt High-Level Radioactive Waste Repository, Teklu Hadgu, Mario Martinez, James Bean, Jose G. Arguello, Carlos F. Jové-Colón, Francis Hansen (*SNL*)
- (2) (7021) Morphology of Plutonium Precipitates in the Presence of Goethite at 25 and 80°C, M. Zavarin, P. Zhao, Z. R. Dai, S. A. Carroll, A. B. Kersting (*LLNL*)

3.Track 7, Session 9: Storage of Used Nuclear Fuel and High Level Waste

Organizers: Brady Hanson (*PNNL*), Vincenzo Rondinella (*EC-JRC-ITU*)

主席：Holger Voelzke (*BAM*)

飯店地點：Grand Salon G/H

主講者及文章：

- (1) (6845) Impacts Associated with Early Transfer of Spent Fuel to Dry Storage, Eileen Supko (*Energy Resources International, Inc.*), Keith Waldrop (*EPRI*)
- (2) (6857) Two-Dimensional CFD Simulations of a Square 8x8 Heater Rod Array in an Isothermal Enclosure Filled with Rarified Air, Miles Greiner, Pablo Araya, N. R. Chalasani (*Univ of Nevada, Reno*), Jie Li, Yung Liu (*ANL*)
- (3) (6895) The Effect of Weld Residual Stress on Life Prediction of Used Fuel Storage Canister Material, B. P. Black, R. G. Ballinger, S. E. Ferry (*MIT*), S. Teyseyre (*INL*)
- (4) (6912) Assessment of Available Techniques for the Interim Storage of AGR Fuel, Laura McManniman (*Sellafield Limited*)

4.Track 3, Session 7: Engineered Systems for Disposal

Organizers: Frank Garisto (*NWMO*), Asdul Chowdhury (*CNWRA*), David Pickett (*CNWRA*)

主席：Dan Bullen (*DNFSB*)

飯店地點：Carlsbad

主講者及文章：

- (1) (6846) Modelling Container Failure in a Canadian Deep Geologic Repository, Mark Gobien, Frank Garisto (*NWMO*)
- (2) (6896) Sorption of Neptunium on Graphite under Potential Repository Conditions, C. Keith, M. Kalagorgevich, R. Springs, G. C. S. Cerefice (*UNLV*)
- (3) (6921) Effects of Chemical Solution Conditions on Uranium(VI) Diffusion in Clays, Ruth M. Tinnacher, James A. Davis (*LBNL*)
- (4) (7029) Coupled THMC Ventilation Model Tasks for Integrated, High-Capacity SNF Management, George Danko, Davood Bahrami (*Univ of Nevada, Reno*)

5.Track 6, Session 2: Institutional Topics (With Emphasis on Lessons Learned)

Organizer: Charles McCombie (*MCM Consulting*)

主席：Mick Apted (*Intera, Inc.*), Ray Clark (*EPA*)

飯店地點：Grand Salon D

主講者及文章：

- (1) (6842) The Technical Stability of the Swedish Nuclear Fuel Safety Program, Thomas Kaiserfeld (*Lund Univ*)
- (2) (6897) Planning an Integrated Waste Management Strategy for New Nuclear Nations, Charles McCombie, Neil Chapman, Wolfgang Kickmaier, Ellie Scourse (*MCM Consulting*)
- (3) (6898) Progress with Multinational Disposal Initiatives, Charles McCombie, Neil Chapman (*Arius Association*), Ewoud Verhoef (*COVRA*)
- (4) (6874) Technology Transfer—Identification and Quantification of Potential Benefits, Kjell Westerberg (*SKB International AB*)

6.Track 8, Session 5: Advanced Fuel Cycles: Impacts on Waste Management

Organizers: Joonhong Ahn (*Univ of California, Berkeley*), Jongwon Choi (*KAERI*)

主席：Charles Forsberg (*MIT*)

飯店地點：Las Cruces

主講者及文章：

- (1) (6952) Feasibility Analyses for Electrorefining Waste Disposal in Salt, Joon Lee, Yifeng Wang (*SNL*), Michael Simpson (*INL*), Andy Miller (*SNL*)
- (2) (6958) THM Coupling Analysis of Korea Research Teams for Task B of the International Cooperation Project, DECOVALEX, Changsoo Lee (*KAERI*), Sangki Kwon (*Inha Univ*), Won-Jin Cho, Heui-Joo Choi, Jong-Won Choi (*KAERI*)

時間：3:30 PM–5:10 PM, MAY 1

主題：Technical Sessions

1.Track 1, Session 6: Total Repository System (Generic and Site-Specific)

Organizers: Peter Swift (*SNL*), Matt Kozak (*Intera, Inc*), George Danko (*Univ. of Nevada, Reno*)

主席：O. Pensado (*CNWRA*), M. Kozak (*Intera, Inc.*)

飯店地點：Grand Salon A/B

主講者及文章：

- (1) (6950) Independent Modelling in SSM's Licensing Review, Shulan Xu, Björn Dverstorp, Maria Norden (*Swedish Radiation Safety Authority*)
- (2) (6966) Wireless Data Transmission from Deep Geological Disposal Facilities to the Surface, Thomas J. Schröder, Ecaterina Rosca-Bocancea, Jaap Hart (*NRG*)

2.Track 3, Session 8: Engineered Systems for Disposal

Organizers: Frank Garisto (*NWMO*), Asdul Chowdhury (*CNWRA*), David Pickett (*CNWRA*)

主席：Abe van Luik (*DOE*)

飯店地點：Acoma

主講者及文章：

- (1) (7007) Using the Disposal Systems Evaluation Framework to Evaluate Design Tradeoffs, Harris R. Greenberg, James A. Blink, Montu Sharma (*LLNL*)
- (2) (7022) SNF Disposal Concepts for Small and Large Waste Packages, Ernest Hardin, Teklu Hadgu, Dan Clayton (*SNL*), Rob Howard (*ORNL*), Harris Greenberg, Jim Blink, Montu Sharma, Mark Sutton (*LLNL*), Joe Carter, Mark Dupont, Philip Rodwell (*SRNL*)

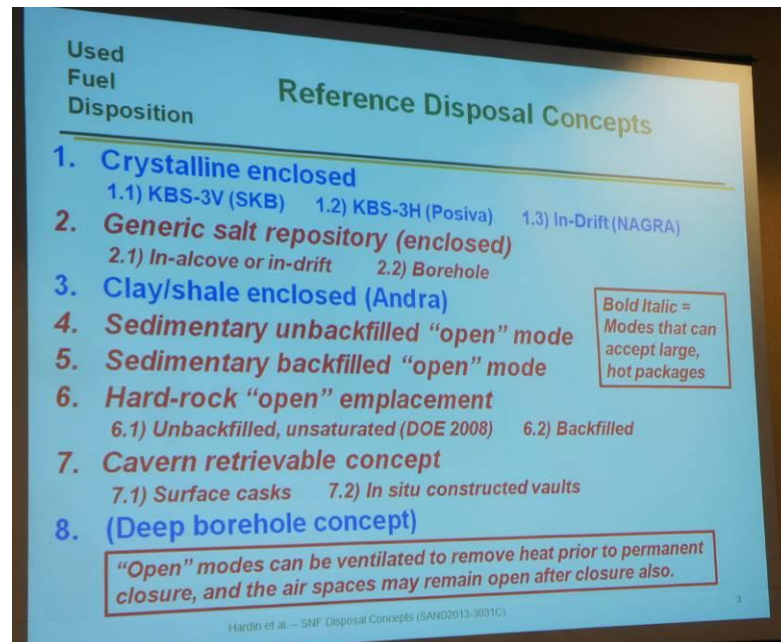


圖 27 用過核子燃料處理之方法

- (3) (6796) Diffusion of Cesium in Compacted Bentonite with Different Column Lengths, Chuan-Pin Lee, Ming-Chee Wu (*National Cheng Kung Univ*), Ching-Yuan Liu (*National Central Univ*), Chun-Hua Pan (*National Cheng Kung Univ*), Tsuey-Lin Tsai, Hwa-Jou Wei, Lee-Chung Men (*Inst of Nuclear Energy Research*)

(a)用過核燃料與其他有害廢棄物最大的差異，就是其「污染源」為許多不同半衰期的放射性核種，在進行深地層處置後，這些放射性核種釋放的衰變熱除了會造成處置設施周圍環境溫度上升，也會造成處置設施近場環境的應力，並影響地下水流、水化學等特性，此因衰變熱造成熱水力化(THMC)耦合行為，使得處置設施的安全評估

更為複雜及困難。因此，目前世界各國在用過核燃料的處置計畫內，均全力發展全面安全評估技術(TSPA)，而針對不特定之虛擬場址進行處置設施封閉後的長期安全評估，將會是我國用過核燃料最終處置相當重要的任務。

- (b)TSPA 功能安全評估中近場環境，包括用過核燃料本體的核種溶解度、滲濾率等，以及核種在緩衝回填材料中的分配係數、擴散係數及遲滯因數，都是非常重要核種遷移參數。理想的回填材料應具備低滲透性、高吸附能力、高化學緩衝性、高導熱性、高抗熱性及在力學上的高穩定性等優點。截至目前已提出較為成熟的工程障壁設計中，緩衝材質的選定以膨潤土與石英砂的混合物(如瑞典與日本所採用者)或膨潤土與粉壓花崗岩的混合物(如加拿大所採用者)為主。
- (c)本論文目的為利用非線性數值模式探討放射性核種銫在膨潤土中的吸附與擴散行為研究是否會受到不同空間尺度的影響，以提供未來處置設施的緩衝回填材料設計，針對其結果分析，可發現在一維擴散行為假設下 ($L/D < 0.4$)，銫並不會受到空間尺度的影響而改變其擴散係數，然而，當擴散尺度 (L/D) 超過 0.4 時，銫擴散係數明顯降低，其結果可證明當空間尺度的改變，將影響核種的擴散係數。(以上資料感謝李傳斌博士指正)



圖 28 成大李傳斌博士介紹銫在不同長度壓密膨潤土之擴散行為

- (4) (6862) Modeling of Cylindrical Casks under Horizontal Drop Test Conditions, Uwe Zencker, Linan Qiao, Eva- Maria Kasperek, Holger Völzke (BAM Federal Inst for Materials Research and Testing)

3.Track 6, Session 3: Institutional Topics (With Emphasis on Lessons Learned)

Organizer: Charles McCombie (*MCM Consulting*)

主席：Ray Clark (*EPA*), Charles McCombie (*MCM Consulting*)

飯店地點：Cimarron

主講者及文章：

- (1) (6841) Cigéo, the French Geological Repository Project, T. Labalette, A. Harman, M. C. Dupuis, G. Ouzounian (*ANDRA*)
- (2) (6844) URLs in European Programs for High Level Waste Disposal— How Used?, Kimitaka Yoshimura (*NUMO*), Irina Gaus (*NAGRA*), Kenichi Kaku (*NUMO*), Stratis Vomvoris (*NAGRA*)
- (3) (6933) Geological Disposal and Site Selection in Switzerland—Accomplishments and Outlook, Thomas Ernst, Efstratios (Stratis) Vomvoris, Anne Claudel (*NAGRA*)
- (4) (6938) The Strategic Role of Underground Rock Laboratories in a Geological Disposal Programme, Wolfgang Kickmaier, Charles McCombie, Ian G. McKinley, Ellie M. Scourse (*MCM Consulting*)

4.Track 7, Session 11: Storage of Used Nuclear Fuel and High Level Waste

Organizers: Brady Hanson (*PNNL*), Vincenzo Rondinella (*EC-JRC-ITU*)

主席：Ken Sorenson (*SNL*)

飯店地點：Grand Salon C/D

主講者及文章：

- (1) (6838) Logistical Simulation of Spent Nuclear Fuel Disposal in a Salt Repository with Low Temperature Limits, E. A. Kalinina, E. L. Hardin (*SNL*)
- (2) (6851) Integrated Modeling of Spent Nuclear Fuel Management Stages, Osvaldo Pensado, Sitakanta Mohanty (*CNWRA*), Keith Compton (*NRC*), E. Lynn Tipton, Razvan Nes, Patrick LaPlante (*CNWRA*)
- (3) (6861) An Auxiliary System to Monitor the Key Environmental Variables in Spent Fuel Pool at the Loss of Power Accident, Chan Hee Park, Jung Min Lee, Arim Lee, Joo Hyun Moon (*Dongguk Univ*), Wook Jae Yoo, Bong Soo Lee (*Konkuk Univ*), Sung Kyu Shin (*Korea Radioactive Waste Management Corp*)
- (4) (6866) Thermal Modeling Studies for Active Storage Modules in the Calvert Cliffs ISFSI, Harold E. Adkins, Jr., James A. Fort, Sarah R. Suffield, Judith M. Cuta, Brian A. Collins (*PNNL*)

第五天- THURSDAY, MAY 2, 2013

時間：8:00 AM–9:15 AM

主題：Panel Discussion—IV: Large-Volume Wastes from Accident Cleanups

Organizer: Charles Forsberg (*MIT*)

主席：Charles Forsberg (*MIT*)

飯店地點：Grand Salon F

主講者及文章：Charles Forsberg (*MIT*), Thomas Cotton (*Complex Systems Group, LLC*), Kaname Miyahara (*JAEA*), John Kessler (*EPRI*)

Waste management systems are designed for process wastes produced at a relatively uniform rate, not the quantities of wastes generated by a major accident. As a consequence waste disposal limits the rate of cleanup after an accident. The panel will address key post-accident waste disposal issues including: Is there a risk-based strategy that is practical and politically viable? How should one classify wastes in a post-accident environment? Are new disposal technologies (such as seabed disposal) required?

時間：9:15 AM–11:00 AM, MAY 2

主題：Plenary—V: Consent-Based Nuclear Facility Siting

Organizer: Hank Jenkins-Smith (*Univ of Oklahoma*)

主席：Barry Butterfield (*HDR Eng*)

飯店地點：Grand Salon F

主講者及文章：

1. (7185) Familiarity as Key to Public Acceptance of Used Nuclear Fuel Facilities, Ann Bisconti (*Bisconti Research, Inc.*)

(1)熟悉度(familiarity)是用過核子燃料場址選定成功的關鍵，該篇文章討論三個部分：經驗(experience)、知曉(awareness)及瞭解(understanding)。



圖 29 介紹用過核子燃料設施對於大眾之接受度與經驗分享

2. (7186) Consent-Based Siting: What We Have Learned, Daniel Metlay (*U.S. Nuclear Waste Technical Review Board*)
3. (7229) Department of Energy Consent-Based Siting Approach, Jeff Williams (*DOE*)
4. (7234) Siting of Radioactive Waste Disposal Facilities—A Synthesis of International Learning, Claudio Pescatore (*OECD/NEA*)

時間：11:10 AM–12:50 PM, MAY 2

主題：Technical Sessions

1. Track 4, Session 2: Biosphere

Organizers: Andrew Sowder (*EPRI*)

主席：Nava Garisto (*SENES Consultants*)

飯店地點：Grand Salon A/B

主講者及文章：

- (1) (6959) Uncertainties in Doses from Agricultural Ecosystems Following Conversion from Wetlands, R. A. Klos (*Aleksandria Sciences Ltd*), Anders Wörman (*KTH*)
- (2) (6709) Continental-Shelf Seabed Disposal: Disposal of Non-Repository Radioactive Wastes for a World of 10 Billion People, Charles Forsberg (*MIT*)

2. Track 2, Session 8: Natural Systems for Disposal (Generic and Site-Specific

Organizers: Jude McMurry (*CNWRA*), Stratis Vomvoris (*NAGRA*)

主席：Stratis Vomvoris (*NAGRA*)

飯店地點：Grand Salon C/D

主講者及文章：

- (1) (6918) Underground Salt Research Laboratory at the Waste Isolation Pilot Plant, F. D. Hansen (*SNL*)
- (2) (6919) An Overview of U.S. Disposal Research Activities Linked to International URLs, Jens Birkholzer, Daisuke Asahina, Fei Chen (*LBNL*), Payton Gardner (*SNL*), James Houseworth (*LBNL*), Carlos Jové-Colón (*SNL*), Annie Kersting (*LLNL*), Prasad Nair (*DOE*), Lianchong Li, Hui-Hai Liu (*LBNL*), Scott Painter, Paul Reimus (*LANL*), Jonny Rutqvist, Carl Steefel (*LBNL*), Mark Tynan (*DOE*), Yifeng Wang (*SNL*), Mavrik Zavarin (*LLNL*)
- (3) (6971) KURT (KAERI Underground Research Tunnel) Activities for HLW Disposal Technology Development in Korea, Jongwon Choi, Kyungsu Kim

(KAERI)

(a)介紹韓國地下研究坑道 KURT 之設置與在地下實驗室中進行的相關實驗，圖 30 介紹韓國地下坑道 KURT 示意圖及外觀等實景，圖 31 則是地下坑道中進行之現地試驗分佈及實際熱測試實驗中照片。

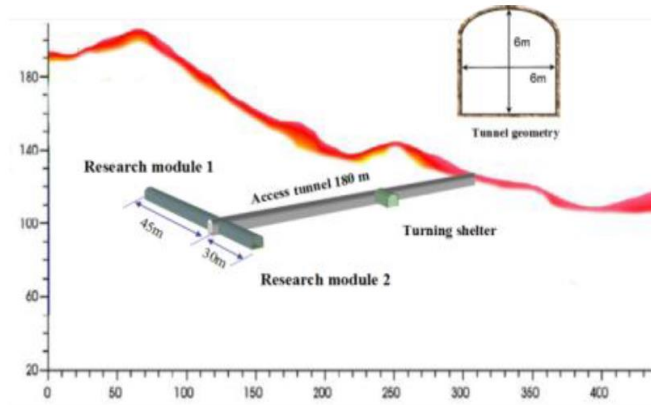
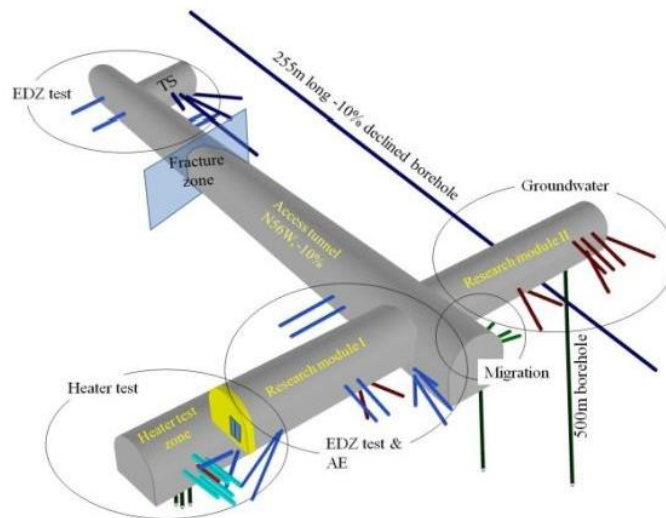


圖 30 韓國地下坑道 KURT 示意圖及外觀等實景



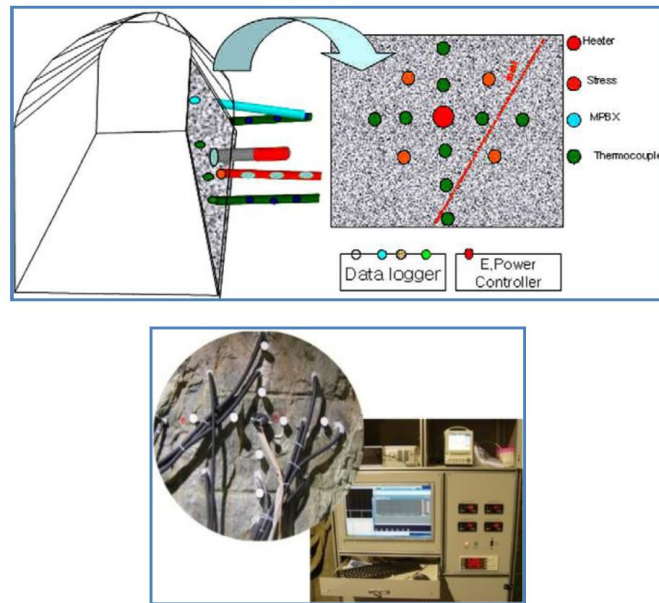


圖 31 地下坑道中進行之現地試驗及熱測試

3. Track 7, Session 12: Storage of Used Nuclear Fuel and High Level Waste

Organizers: Brady Hanson (*PNNL*), Vincenzo Rondinella (*EC-JRC-ITU*)

主席：Robert Einziger (*NRC*)

飯店地點：Carlsbad

主講者及文章：

- (1) (7081) NUHOWS Storage and Transportation of Irradiated Reactor Components and High Level Waste in Large Packages, Glen A. Rae (*Transnuclear*)
- (2) (6979) Production of Simulated High-Burnup Used Fuel Cladding in the HFIR, R. H. Howard, Y. Yan, R. L. Howard, J. L. McDuffee, L. J. Ott (*ORNL*)
- (3) (6983) Test System for Evaluating Spent Nuclear Fuel Bending Stiffness and Vibration Integrity, J-A. Wang, H. Wang, B. B. Bevard, R. L. Howard (*ORNL*), M. E. Flanagan (*NRC*)
- (4) (7018) Microstructure and Macroscopic Alteration Affecting Nuclear Fuel During Extended Storage, Vincenzo V. Rondinella, Thierry Wiss, Dimitrios Papaioannou, Ramil Nasyrow (*EC-JRC-ITU*)

4. Track 8, Session 6: Advanced Fuel Cycles: Impacts on Waste Management

Organizers: Joonhong Ahn (*Univ of California, Berkeley*), Jongwon Choi

(*KAERI*)

主席：Don McGee (*AREVA*)

飯店地點：Grand Salon I/J

主講者及文章：

- (1) (6884) Study of Unfolding Method to Determine Pin-Wise Source Strength Distribution, Yos Panagaman Sitompul, Hee-Sung Shin, Se-Hwan Park, Oh Jong Myeong, Seo Hee, Ho-Dong Kim (*KAERI*)
- (2) (6885) Development of Axial Burnup Measurement System for PWR Spent Fuel Assembly, Hee-Sung Shin, Yos Panagaman Sitompul, Se-Hwan Park, Oh Jong Myeong, Seo Hee, Ho-Dong Kim (*KAERI*)
- (3) (6889) Data Mining to Determine Inventory Characteristics of Used Nuclear Fuel for Potential Future Recycling Campaigns, Josh Peterson (*ORNL*)

5. Track 9, Session 2: High-Level Radioactive Waste Transportation

Organizer: Ruth Weiner (*SNL*)

主席：Ruth Weiner (*SNL*)

飯店地點：Grand Salon G/H

主講者及文章：

- (1) (6973) Effects of Drying and Storage on High-Burnup Cladding Ductility, M. C. Billone, T. A. Burtseva, Y. Y. Liu (*ANL*)
- (2) (6888) Investigating the Performance of Rubber Seals at Low Temperatures, Dietmar Wolff, Matthias Jaunich, Wolfgang Stark (*BAM Federal Inst for Materials Research and Testing*)

三、心得

參加此研討會可蒐集許多高放廢棄物處理之資訊，包含最初的活度模擬及計算、處置之方法概念，到選擇高放處置場之評估方法、瓶頸及與民眾之溝通，都跟我國未來要設置的高放及低放處置場很有相關，值得我們學習，從其分享的經驗中可減少台灣設置處置場的難度。大會除了技術的討論外，亦安排一些企業分享與民眾溝通之經驗，顯示在大部分核能國家都與台灣一樣，在推動處置場設置上面對許多環保團體的質疑與民意代表的施壓，而技術對於大部分先進國家都已不是問題，最重要的都是與當地民眾之溝通。透過參加各論文作者之報告及與會者之討論，有助於對該發表文章的瞭解，加強印象與促進技術之吸收，也可透過討論發現許多改善及加強之處。該研討會主要投稿主題都著重在用過核子燃料及高放射性廢棄物之貯存，以及處置系統之設計及評估上，顯示此些主題的重要性，我國應針對用過核子燃料之貯存及處置系統之評估上加緊腳步，學習他人之經驗並配合我國之國情，才可省時省力達到目的。

放眼亞洲地區，高放處置場設置進行最快的屬中國大陸，已經針對北山及其他地方進行地質調查等研究工作，該國許多研究報告也指出北山地方人煙稀少且地層適合設置地下處置場，應會以該地進行地下實驗室建造及處置場設置；而韓國現也已經建置完成地下研究坑道 KURT，實地進行地下之各種實驗；日本用過核子燃料一部份已經進行再處理，其他的則進行中期貯存，預計 2030 建立完成深層地質處置場；而我國應先整合處置相關之計畫，研擬出可行之地點建置地下實驗坑道，並進行地下實驗驗證各種評估之可靠性，如此才可增加民眾對於場址之接受度與信心。

四、建議事項

- (一)我國各界(包含產、官、學)對於設置高放及低放處置場之意見紛歧，目前進度尚在與民眾溝通階段，確切之設置地點尚須公投決定，更不用說到後面需要規劃的實驗測試及建造，台電公司應儘快將此議題加速進行，否則核一、二廠除役在即，用過核子燃料及低放射性廢棄物也都需要有地方可以安全貯存，盡快建置放射性廢棄物處置場才是解決核廢料污染疑慮的最重要辦法。
- (二)在用過核子燃料再處理議題方面，我國應不用考慮，一來台灣機組不多，產生的用過核子燃料數量少，不足以供應再處理設施需求量，二來建置再處理廠昂貴且技術與經驗皆在法國等其他核能強國上，另外國際間有朝向長效期乾式貯存系統發展之趨勢，美國放棄 Yucca mountain 計畫為其中之一例，可供我國評估用過核子燃料貯存及處理之參考。
- (三)應儘快整合國內處置相關之計畫，研擬出針對我國可行之方法，例如選定合適之地點建置地下坑道及實驗室，並進行各種地下實驗，驗證假設評估之可靠度及可行性，如此才可增加民眾對於處置場址之接受度與信心。