

Table of Contents

Chapter 1	INTRODUCTION	1
	<i>Introduction to Geological Challenges in Radioactive Waste Isolation: Third Worldwide Review P.A. Witherspoon and G.S. Bodvarsson</i>	
1.1.	Introduction	1
1.2.	Some Highlights from the <i>Third Worldwide Review</i>	1
1.3.	Conclusions	12
Chapter 2	ARGENTINA	15
	<i>Deep Geological Disposal Research in Argentina Carlos A. Ninci, Arturo M. Bevilacqua, Luis A. Jolivet, Elvira R. Maset, Raul E. Ferreyra, Alicia R. Vullien, Oscar Elena, Luis E. López, Alejandro L. Maloberti, Humberto O. Nievas Nancy C. Reyes, and Juan J. Zarco</i>	
2.1.	Introduction	15
2.2.	Geological Investigations	16
2.3.	Social Communication	21
2.4.	Conclusion: Geological Research without Social Communication	23
Chapter 3	ARMENIA	27
	<i>Some Geological Aspects of Underground Disposal of Radioactive Waste in the Republic of Armenia R.T. Jrabashyan and Yu. G. Ghukasyan</i>	
3.1.	Introduction	27
3.2.	General Characteristics of Radioactive Wastes	28
3.3.	Statement of Problem and Approaches to Its Solution	29
3.4.	Methods of Selecting Appropriate Areas and Potential Sites	29
3.5.	Geodynamic Conditions and the Main Characteristics of Tectonics in the Region	30
3.6.	Mapping of Areas with Appropriate Conditions and Selection of Potential Sites	31
3.7.	Stages in the Process of Selecting Sites and Directions for Future Research	35
3.8.	Conclusions and Recommendations	37
Chapter 4	BELARUS	39
	<i>Geological Problems in Radioactive Waste Isolation for Belarus Anatoly V. Kudelsky</i>	
4.1.	Introduction	39
4.2.	Low-Level and Conventional Radioactive Waste	40
4.3.	HLW and Medium-Level Radioactive Waste	44
4.4.	Intermediate Radioactive Waste	46
Chapter 5	BELGIUM	47
	<i>The Belgium RD&D Program on Long-Lived and High-Level Waste Disposal: Status and Trends B. Neerdael and G. Vokaert</i>	
5.1.	The Belgian Framework	47
5.2.	The Reference Concept in Performance-Assessment Studies	48
5.3.	The Belgian Program for Geological Disposal	50
5.4.	Trends Regarding the Future of the Program	53

Chapter 6	BULGARIA	55
Current Status of the Site Selection for Radioactive Waste Disposal in Bulgaria		
<i>Dimcho Evstatiev and Dimitar Kzhukharov</i>		
6.1.	Introduction	55
6.2.	Sources of Radioactive Waste	56
6.3.	LILW Repository Site Selection	57
6.4.	HLW Repository Site Selection	61
6.5.	Geological Settings of the Novi Han Storage Facility Site	63
6.6.	Conclusion	64
Chapter 7	CANADA	67
Long-Term Management of Nuclear Fuel Waste in Canada:		
Technical Developments in the Concept for a Deep Geologic Repository		
<i>S.B. Russell, P.J. Gierszewski, M.R. Jensen, and T.F. Kempe</i>		
7.1.	Canadian Nuclear Fuel Waste Management—Historical Review	67
7.2.	Policy and Regulatory Framework	70
7.3.	Status of Technology for a Deep Geologic Repository of Used Fuel	71
7.4.	International Activities	74
7.5.	Concluding Remarks	75
Chapter 8	CHINA	77
Preliminary Site Characterization at Beishan, Northwest China—		
A Potential Site for China's High-Level Radioactive Waste Repository		
<i>Ju Wang, Weiming Xue, Hualing Zheng, and Rui Su</i>		
8.1.	Introduction	77
8.2.	Belshian Region (Gansu Province, North West China)—	
The Potential Area for China's Geologic Repository	78	
8.3.	Site Characterization at Jiujing Section, Beishan Area	80
8.4.	Conclusions	84
Chapter 9	CROATIA	85
Site Selection and Characterization for a Low- and Intermediate-Level		
Radioactive Waste Repository in the Republic of Croatia		
<i>Antun Schaller</i>		
9.1.	Introduction	85
9.2.	Final Stage of LILW Repository Site Selection	85
9.3.	Results of Site-Characterization Activities Performed	86
9.4.	Basic Geo-Ecological Characteristics of the Trgovska gora Site	88
9.5.	LILW Disposal Facility	88
9.6.	Project Activities To Be Undertaken	93
9.7.	Conclusions	94
Chapter 10	CZECH REPUBLIC	97
Progress Towards a Deep Geological Repository in the Czech Republic		
<i>Frantisek Woller and Lumir Nachmilner</i>		
10.1.	Introduction	97
10.2.	Legal Foundation for Waste Management	97
10.3.	Radioactive Waste Management Concept	98
10.4.	Reference Design for the Deep Geological Repository	98
10.5.	Progress in Site Selection	99
10.6.	Supporting Activities: Programs and Projects	101
10.7.	Conclusions	104

Chapter 11 FINLAND	105
Decision-in-Principle on Final Disposal of Spent Fuel in Finland	
<i>Juhani Väistö</i>	
11.1. Introduction	105
11.2. Disposal Concept	106
11.3. Site-Selection Process	107
11.4. Environmental Impact Assessment	108
11.5. Decision-in-Principle	113
11.6. The Future	114
Chapter 12 FRANCE	117
Status of Research on Geological Disposal	
for High-Level Radioactive Waste in France	
<i>Patrick Lebon, Bernard Mouroux, and Gerald Ouzounian</i>	
12.1. Legal Process of Research	117
12.2. Execution of Research Program on Meuse/Haute-Marne Site by 2006	119
12.3. Progress in Granitic-Site Research Program	125
Chapter 13 GERMANY	129
Nuclear Waste Disposal in Germany: Background, Status, and Future Research	
<i>Manfred Wallner and Volkmar Bräuer</i>	
13.1. Introduction	130
13.2. History of German Nuclear Waste Policy	130
13.3. Institutional Framework	130
13.4. Legislative Framework	131
13.5. National Repository Projects	131
13.6. New Developments in the German Waste Management Policy	133
Chapter 14 HUNGARY	137
Geological Disposal as the Preferred Option in the	
Hungarian Radioactive Waste Management Program	
<i>P. Ormai, F. Frigyesi, Z. Balla, L. Kovács, and G. Hámossy</i>	
14.1. Introduction	137
14.2. Siting of an LILW Repository	138
14.3. HLW Management	146
Chapter 15 INDIA	153
Evaluation of a Plutonic Granite Rock Mass for a Geological Repository in India	
<i>R.K. Mathur, P.K. Nayyan, V. Armugam, A. Acharya, R.K. Bajpai, and K. Balu</i>	
15.1. Introduction	153
15.2. Geology of Western Rajasthan	153
15.3. Geology of Jalore Granite	154
15.4. Investigations	154
15.5. Conclusions	162
Chapter 16 ITALY	163
Radioactive Waste Management in Italy:	
A Site for a Low-Level Radioactive Waste Repository	
and High-Level Radioactive Waste Long-Term Storage	
<i>Piero Risoluti</i>	
16.1. Introduction	163
16.2. The LLW Repository	164

Table of Contents

16.3. The HLW Long-Term Storage System	164
16.4. Site Investigation	165
16.5. Conclusion	166
Chapter 17 JAPAN	167
The Japanese High-Level Radioactive Waste Disposal Program <i>Sumio Masuda and Tomio Kwata</i>	
17.1. Introduction	167
17.2. The Japanese Disposal Concept: Making the Safety Case	168
17.3. Achievement in Research and Development	169
17.4. Building Confidence in Geological Disposal	175
17.5. New Framework for the Program	177
17.6. Concluding Remarks	179
Chapter 18 KOREA	183
Radioactive Waste Disposal of LILW and HLW in Korea <i>C.L. Kim, J.W. Park, E.Y. Lee, M.J. Song, T.S. Hahn and K.W. Han, C.H. Kang, D.S. Bae, P.S. Hahn, H.S. Pak</i>	
18.1. LILW Disposal	184
18.2. HLW Disposal	190
Chapter 19 LITHUANIA	195
Lithuania's Approach to Disposal of Radioactive Waste and Spent Nuclear Fuel <i>Povilas Poskas</i>	
19.1. Introduction	195
19.2. Low- and Intermediate-Level Waste	195
19.3. Spent Nuclear Fuel and Long-Lived Waste	197
Chapter 20 NETHERLANDS	199
Retrievable Disposal of Radioactive Waste in The Netherlands <i>Bob P. Hageman and Leo van de Voete</i>	
20.1. Introduction	199
20.2. Long-Term Surface Storage	200
20.3. Retrievable Disposal in a Rock-Salt Formation	200
20.4. Retrievable Disposal in a Clay Deposit	201
20.5. Other Options to Reduce Risks	201
20.6. Societal Aspects	201
20.7. Cost Aspects	201
20.8. International Cooperation	202
20.9. Conclusions and Recommendations	202
Chapter 21 POLAND	205
The Polish Concept of Radioactive Waste Disposal <i>Janusz Janeczek and Janusz Włodarski</i>	
21.1. Introduction	205
21.2. Site Selection for a Deep Geological Repository	205
21.3. Concluding Remarks	208

Chapter 22 ROMANIA	209
Long-Term Safety Assessment for Repositories in Rock Salt in Romania	
Margarit Pavelescu	
22.1. Introduction	209
22.2. Modeling	210
22.3. Input Data	213
22.4. Results	213
22.5. Summary and Conclusions	217
Chapter 23 RUSSIA	219
Disposal of Radioactive Waste in Deep Geological Formations in Russia:	
Results and Prospects	
Valeryi A. Lebedev, Victor D. Akhunov, Victor V. Lopatin, Evgeni N. Kamnev, and Andrey I. Rybalchev	
23.1. Introduction	219
23.2. Development of Research on the Disposal of Radioactive Waste in Russia	219
23.3. Criteria for Safe Disposal of Radioactive Waste	220
23.4. Existing Geological Storage Projects for Liquid Radioactive Waste	221
23.5. Repositories for Solid and Solidified Radioactive Waste in Geological Formations	223
23.6. Conclusions	224
Chapter 24 SLOVAK REPUBLIC	225
Status of the Deep Geological Disposal Program in the Slovak Republic	
Igor Matejovic, Jan Timulak, Milos Kovacik, and Jozef Hok	
24.1. Introduction	225
24.2. Project Status	226
24.3. International Cooperation	234
24.4. Future Activities	234
Chapter 25 SLOVENIA	237
Present Status, Objectives, and Preliminary Geological Suitability Assessment for LILW Disposal in Slovenia	
Peter Tomse, Irena Mele, and Nadja Zeleznik	
25.1. Introduction	237
25.2. Site-Selection Process	238
25.3. Inclusion of Radioactive Waste Disposal into the National Physical Plan	239
25.4. Preliminary Geological-Suitability Assessment for LILW Disposal	239
25.5. Repository Conceptual Design and Preliminary Performance Assessment	243
25.6. Conclusion	243
Chapter 26 SOUTH AFRICA	245
Current Status of a Potential Future Geological Disposal Facility in South Africa	
P.J. Bredell and E. Raubenheimer	
26.1. Introduction	245
26.2. History of Vaalputs and Subsequent Investigations for Geological Disposal	245
26.3. Possible Future Scenarios	246

Chapter 27 SPAIN	247
Geological Disposal of High-Level Radioactive Wastes in Spain	
<i>Julio Astudillo</i>	
27.1. Introduction	247
27.2. Activities and Aims of ENRESA in Geological Disposal	247
27.3. Site-Selection Plan	248
27.4. Repository Design	248
27.5. Repository Technology Components	250
27.6. Geological Barrier	254
27.7. Natural Analogues	256
27.8. Biosphere and Climatic Change Evolution	256
27.9. Repository Performance Assessment	258
Chapter 28 SWEDEN	259
The Swedish Program for Spent-Fuel Management	
<i>Berit Lundqvist</i>	
28.1. Background	259
28.2. Funding	260
28.3. The Deep Repository	260
28.4. Canister Design and Fabrication	265
28.5. Encapsulation Technology	266
28.6. Research	267
28.7. Safety Analyses	267
28.8. Conclusions	268
Chapter 29 SWITZERLAND	269
Swiss Geological Studies to Support Implementation of Repository Project:	
Status 2001 and Outlook	
<i>I. McKinley, P. Zuidema, S. Vomvoris, and P. Marschall</i>	
29.1. Background	269
29.2. Characteristics and Evolution of the Swiss Nuclear Waste Disposal Program	269
29.3. Site-Characterization Studies to Support Project Entsorgungsnachweis	272
29.4. Geological Studies at Grimsel and Mont Terri	273
29.5. The Swiss Program in an International Context	274
29.6. Conclusions	274
Chapter 30 TAIWAN	277
Current Status of Radioactive Waste Administration in Taiwan	
<i>Wuu-Kune Cheng and Ruey-Yau Wu</i>	
30.1. Introduction	277
30.2. Radioactive Waste Management Policy and Organizational Structure	277
30.3. Development of Radioactive-Waste-Related Regulations	278
30.4. LLW Management	279
30.5. LLW Final Disposal	280
30.6. Spent-Fuel Management Program	281
30.7. Conclusion	282
Chapter 31 UKRAINE	283
Deep Geological Disposal of Radioactive Waste in Ukraine	
<i>Dimitriy Krushchov and Leonid Tabachny</i>	
31.1. Introduction	283

31.2. Present State of the Problem	283
31.3. Results of Regional Studies	286
31.4. Future R&D and Strategic Priorities	288
31.5. Conclusion	289
Chapter 32 UNITED KINGDOM	291
The Long-Term Management of the United Kingdom's Radioactive Wastes:	
Current Status	
<i>Alan J. Hooper</i>	
32.1. Introduction	291
32.2. Background	291
32.3. Lessons from the RCF Decision	293
32.4. Nirex Responses to "Lessons Learned"	294
32.5. Government Consultation	295
32.6. Conclusions / Summary	296
Chapter 33 UNITED STATES	299
The Yucca Mountain Site Characterization Project for the United States	
<i>J. Russell Dyer and Michael D. Voegele</i>	
33.1. Introduction	299
33.2. Regulatory Requirements	299
33.3. Sources of Materials Considered for Disposal	300
33.4. Site Characterization Data and Analyses	301
33.5. The Viability Assessment	302
33.6. Repository Design	302
33.7. Natural Barriers	304
33.8. Engineered Barriers	304
33.9. Processes Important to Performance of a Repository at Yucca Mountain	306
33.10.Uncertainties in Data and Models	310
33.11.Performance Confirmation and Monitoring	311
33.12.Conclusions	312
Chapter 34 WIPP	313
An Update on the Geological Disposal of Radioactive Waste	
at the Waste Isolation Pilot Plant in Southeastern New Mexico, U.S.A.	
<i>R.L. Patterson and R.A. Nelson</i>	
34.1. Introduction	313
34.2. The WIPP Land Withdrawal Act	314
34.3. Certification by the EPA	314
34.4. The Resource Conservation and Recovery Act	315
34.5. Waste Characterization at Generator Sites	316
34.6. Buildup of WIPP's Transportation System Capacity	316
34.7. Waste Volumes and Characteristics	317
34.8. Repository Mining	317
34.9. Future Returns of the Investment in WIPP	318
34.10.Conclusions	318
Chapter 35 INTERNATIONAL REPOSITORIES	319
International Repositories: An Essential Complement to National Facilities	
<i>Charles McCombie, Neil Chapman, Marcis Kurzeme, and Ralph Stoll</i>	
35.1. Introduction	319

Table of Contents

35.2. Responding to the Needs of Countries with Limited Resources or Limited Requirements	320
35.3. Contributing to Global Nuclear Security	320
35.4. International Repositories and National Programs	321
35.5. Options for International Solutions	321
35.6. Storage or Disposal?	322
35.7. Options for an International Repository	322
35.8. Getting Waste to an International Repository	325
35.9. The Way Ahead for International Repositories	325
Chapter 36 DEEPGEOLOGIC REPOSITORIES FOR NUCLEAR WEAPONS	327
The Contribution of Deep Geologic Repositories to Nuclear Nonproliferation	
<i>David Pentz and Ralph Stoll</i>	
36.1. Introduction	327
36.2. Dismantling Nuclear Weapons Is a Serious Global Security Challenge	327
36.3. The Solution Is Permanent Disposition of the Nuclear Materials in Deep Geological Repositories	327
36.4. Commercial Spent Fuel Also Must Be Safeguarded	327
36.5. National Geological Repositories Have Non-proliferation Benefits	328
36.6. International Repositories Can Increase Global Security Yet Further	328
36.7. Conclusion	328
Chapter 37 INTERNATIONAL COOPERATION	331
International Cooperation in Nuclear Waste Management	
<i>Alex R. Burkart</i>	
37.1. Ensuring the Safety of Spent Fuel and Radioactive Waste	331
37.2. Some Important Considerations in Transferring Spent Fuel and Nuclear Waste between States	332
Appendix A List of <i>Third Worldwide Review Workshop</i> Attendees	335