

## Earth Sciences

### Program outline

This document outlines the scope of themes that may be included in the Olympiad test. They are grouped by areas and followed by the list of recommended references in English.

### Skill set of the winner of the Olympiad in Earth Sciences

To win the Open Doors Olympiad in Earth Sciences, the participant must have analytical, project and research skills. Those listed below are in line with the focal points of master's programs offered at Russian universities.

#### Analytical activities

*These activities include processing and interpreting geological, geochemical and geophysical information; analysis of regional economic and geographical conditions; the mining and geological conditions of mineral deposits; providing a rationale for technologies for exploiting the georesources of the earth's crust.*

1. **System analysis.** Abilities to analyze information, processes and systems within broad interdisciplinary fields; to set and solve non-standard problems using appropriate analytical, computational and experimental methods, including innovative ones. Therefore, the winner of the Olympiad must:

know	be able to	possess the skill in
<ul style="list-style-type: none"> <li>- the structure of the earth's crust;</li> <li>- modern methods for processing geological, geochemical and geophysical information;</li> <li>- key trends in earth sciences;</li> <li>- the theoretical foundations of technologies for mineral extraction and primary processing</li> </ul>	<ul style="list-style-type: none"> <li>- analyze and assess the economic and geographical conditions of a region;</li> <li>- apply modern computational and experimental methods in providing a rationale for technologies for mineral deposits development</li> </ul>	<ul style="list-style-type: none"> <li>- processing and interpreting geological and geochemical information</li> </ul>

**2. Fundamental knowledge.** Deep knowledge and understanding of chemistry, physics, mathematics, geology and relevant interdisciplinary areas. Therefore, the winner of the Olympiad must:

know	be able to	possess the skill in
<ul style="list-style-type: none"> <li>- the foundations of fundamental natural sciences: chemistry, physics and mathematics;</li> <li>- modern theories of earth sciences, including geography</li> </ul>	<ul style="list-style-type: none"> <li>- apply theoretical knowledge to solve professional problems;</li> <li>- use the foundations of fundamental chemistry, physics and mathematics to describe and build models of objects and processes</li> </ul>	<ul style="list-style-type: none"> <li>- applying an interdisciplinary approach to solving professional problems</li> </ul>

### Project activities

*These activities include launching projects aimed at exploiting subsoil georesources, particularly laying down the principles of sustainable regional development; modeling mineral deposits and mining system elements; providing complete and reliable geological, geochemical and geophysical information for the design and operation of industrial facilities, buildings and structures.*

**1. Analysis and modeling.** Abilities to analyze and build models of objects and processes for exploiting subsoil georesources. Therefore, the winner of the Olympiad must:

know	be able to	possess the skill in
<ul style="list-style-type: none"> <li>- modern methods and techniques for modeling geological and mining facilities and processes;</li> <li>- the theoretical foundations of geoinformatics;</li> <li>- methods for processing and interpreting data on the composition and structure of the earth's crust in studying,</li> </ul>	<ul style="list-style-type: none"> <li>- apply modern methods for processing geodata, including statistical ones;</li> <li>build models of geological and mining facilities</li> </ul>	<ul style="list-style-type: none"> <li>- building models of geological and mining facilities</li> </ul>

modeling and exploiting the resources of the earth's crust		
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**2. Design.** Abilities to develop innovative design solutions, including operational exploration, mining, mineral processing, construction and operation of underground facilities. Therefore, the winner of the Olympiad must:

know	be able to	possess the skill in
<ul style="list-style-type: none"> <li>- modern approaches to designing geological and mining systems;</li> <li>- methods for obtaining geological, geochemical and geophysical information;</li> <li>- basic principles for sustainable regional development</li> </ul>	<ul style="list-style-type: none"> <li>- assess the completeness and reliability of geological, geochemical and geophysical information for the design and operation of industrial facilities, buildings and structures</li> </ul>	<ul style="list-style-type: none"> <li>- developing project elements in operational exploration, mining, processing of minerals, construction and operation of underground facilities</li> </ul>

### Research activities

*These activities are aimed at obtaining and applying new knowledge. They include fundamental and applied scientific research in geology, geochemistry, geography and extraction and processing of minerals.*

**1. Research.** The ability to find data on the object of research, carry out literature search, use databases and other sources of information, simulate objects and processes and analyze the use of the latest technologies. Therefore, the winner of the Olympiad must:

know	be able to	possess the skill in
<ul style="list-style-type: none"> <li>- modern methods for searching for and collecting information about the object of research</li> </ul>	<ul style="list-style-type: none"> <li>- use scientific databases to find information about the research object;</li> <li>- analyze and interpret the results of experimental and theoretical research;</li> </ul>	<ul style="list-style-type: none"> <li>- presenting the results of calculations and forecasts in graphical and analytical forms;</li> <li>- modeling objects and processes;</li> </ul>

**2. Experimenting.** Ability to plan and carry out experimental research, analyze and process results, draw conclusions.

Know	Be able to	Have a skill
<ul style="list-style-type: none"> <li>- modern methods for planning experimental work;</li> <li>- methods for analyzing and interpreting experimental findings;</li> <li>- the methodology for experimental work in geology, geochemistry, geophysics and geotechnology</li> </ul>	<ul style="list-style-type: none"> <li>- plan computational and experimental work;</li> <li>- process experimental results, analyze measurement errors, interpret them and draw up research reports</li> </ul>	<ul style="list-style-type: none"> <li>- choosing and justifying methods and conditions for experimental work</li> </ul>

## Content

### Section 1. GEOLOGY

1. General and regional geology
2. Paleontology and stratigraphy
3. Geotectonics and geodynamics
4. Lithology
5. Mineralogy, crystallography, petrography
6. Geology, prospecting and exploration of oil and gas fields
7. Geology, mineral exploration and
8. Hydrogeology
9. Geoecology

### Section 2. GEOCHEMISTRY

1. The mineral composition of the mantle and its change with depth. The chemical composition of the upper mantle according to the basalt geochemistry of mid-oceanic ridges and oceanic islands
2. Mantle geochemical reservoirs: depleted (DM), enriched (EM1, EM2) and HIMU. The concepts of mantle reservoir origins; the role of metasomatism, crustal and mantle material recycling in mantle heterogeneity
3. Isotope dating methods for rocks and minerals

4. The geochemistry of the earth's crust. The prevalence of elements in the earth's crust, assessment methods. The modern models of the composition of sedimentary shell, upper and lower continental crust and the earth's crust. The mechanisms of crust growth

5. The geochemistry of the magmatic process. Factors affecting the rare-element composition of igneous rocks. Models describing the behavior of trace elements in partial melting and fractional crystallization, mixing and assimilation

6. The geochemistry of the hydrothermal process. The main types of metasomatic processes, associations of elements characteristic of acid and alkaline metasomatism products. The composition, concentration, T- and P- of hydrothermal solutions, forms of migration and main factors of deposition of elements

7. The geochemistry of the sedimentary process. Substance separation during weathering, erosion, transport and sedimentation. The composition of the main types of sedimentary rocks, geochemical systematics of terrigenous rocks. Geochemical and isotopic indicators of terrigenous rock drift areas and their practical use

8. The geochemistry of the atmosphere and the hydrosphere

### Section 3. GEOGRAPHY

1. The main areas of geography: physical geography, economic geography, country studies, cartography

2. The concept of the geographic shell. Geographic shell components: materials, energy. The structure and boundaries of the geographic shell. The aggregate state and composition of the geospheres

3. The areas of continents and oceans. The highest and lowest points on continents. Regularities in the location of continents. Boundaries between continents. Geographic differences between northern and southern continents

4. The composition and structure of the atmosphere. The vertical thickness of the atmosphere, the upper boundary of the geographic shell. Climate formation factors: solar radiation, atmospheric circulation, the underlying surface

5. The volume and structure of the hydrosphere. The World Ocean and its parts. Seas, types of seas: nearly enclosed seas, partly enclosed seas and hypersaline lakes

6. Factors of relief formation. Structural geomorphology

7. Exogenous processes of relief formation. Slopes and slope processes

8. Fluvial processes and landforms

9. Relief-forming activity of groundwaters. The wave-cut platforms formed by rivers, lakes and seas

10. Glacial processes and landforms
11. Aeolian processes and landforms
12. Rates of relief formation processes

#### **Section 4. GEOPHYSICS**

1. Petrophysics. Petrophysical parameters. Petrophysical models
2. Gravity exploration: physical fundamentals, data interpretation and applications
3. Magnetic exploration: physical fundamentals, data interpretation and applications
4. Electrical exploration: physical fundamentals, data interpretation and applications
5. Seismic exploration: physical fundamentals, data interpretation and applications
6. Seismology: physical fundamentals, data interpretation and applications
7. Geothermics: physical fundamentals, data interpretation and applications
8. Geophysical well logging: physical fundamentals, data interpretation and applications
9. Physics of the Earth: the figure of the planet, spheres, rotation, free vibrations, geomagnetic field

#### **Section 5. GEOTECHNOLOGIES (MINING ENGINEERING)**

1. Mineral processing
2. Drilling and well development technology
3. Mining and geology of oil and gas; mine surveying
4. Geomechanics
5. Geotechnology and design basics of mine engineering systems

#### **Recommended literature**

##### **Section 1. GEOLOGY**

1. Golonka J., Krobicki M., Pajak J., Nguyen Van Giang, Zuchiewicz W. Global Plate tectonics and Paleogeography of Southeast Asia / AGH Univ. Sci. Technology. Krakow. 2006. 128 p.
2. Gradstein F.M., Ogg J.G., Smith A.G., and Ogg G.M. The Geologic Time Scale 2012. Vol. 1. Elsevier. 2012. 1144 p.
5. International Stratigraphic Chart. International Union of Geological Sciences. 2004.
6. Scotese C.R. Palaeogeographic Atlas. Paleomap Progress Report 90-0497, Dept. Geology, Univ of Texas at Arlington. Texas. 1997. 45 p.
7. Torsvik T.H., Cocks R.M. Earth history and palaeogeography. Cambridge University Press. Oslo. 2017. 317 p.

11. Superplumes / Eds D.A. Yuen, Sh. Maruyama, B.F.Windley. Springer. 2007. 510 p.
12. Pirajno F. Ore deposits and mantle plumes. Kluwer Acd. Publ. 2000. 556 p.
13. The Andes: active subduction orogeny / Ed. Oncek et al. Dordrecht: Springer. 2008. 610 p.
16. Sedimentary environments and facies. H.G. Reading (Ed.). Blackwells scientific publications. 1978. (Reprinted 1979). 557 p.
17. Selley R.C. Ancient sedimentary environments. Cornell University Press; 2nd edition, 1978. 287 p.
18. Carbonate rocks. George V. Chilingar, Harold J. Bissell, and Rhodes W. Fairbridge (eds.). Elsevier Publishing Company. 1967. Part 1. 471 p.
19. Carbonate rocks. George V. Chilingar, Harold J. Bissell, and Rhodes W. Fairbridge (eds.). Elsevier Publishing Company. 1967. Part 2. 413 p.
20. Kennett J.P. Marine geology. Pearson, 1981. 813 p.
21. Pettijohn F.J. Sedimentary rocks. 3rd ed. Harper and Row, New York, 1975. 628 p.
22. Reineck, H. E., and Singh, I. B., 1980. Depositional Sedimentary Environments, 2nd ed. SpringerVerlag, New York, 549 p.
25. Einsele G. Sedimentary Basins. Evolution, Facies and Sediment Budget // Springer-Verlag, 2002. 550 p.
28. Rock-Forming Minerals, Vol. 3A: Micas 2nd Edition by M. E. Fleet (Author, Editor), R. A. Howie (Editor)
29. W.A.Deer; R.A.Howie; Zussman. An Introduction to Rock-Forming Minerals. London: The Mineralogical Society, 2013.
30. Rock-forming minerals. Non-silicates: sulphates, carbonates, phosphates and halides.. Chang L.L.Y., Howie R.A., Zussman J. he Geological Society, London, 1998, 383
31. Rock-forming minerals. Layered silicates excluding micas and clay minerals38 Deer W.A., Howie R.A., Zussman J.:The Geological Society, London, 2009 , 313
34. Rock-forming minerals in thin section. Pichler H., Schmitt-Riegraf C. Chapman & Hall, London, 1997, 219
35. William D. Nesse. Introduction to Optical Mineralogy Paperback English 2013.
36. A.R. Philpot. Petrography of Igneous & Metamorphic Rocks First Edition, Kindle Edition 2018
37. B. Ronald Frost Carol D. Frost. Essentials of Igneous and Metamorphic Petrology 1st Edition, Kindle Edition 2013



38. Tissot, B., Welte, D. Petroleum Formation and Occurrence, 2nd edition. New York, Springer-Verlag, 1984, 699 p.

39. Sophie Decree, Laurence Robb Ore Deposits: Origin, Exploration, and Exploitation American Geophysical Union 272 Pages 2019

40. John M. Guilbert Charles Frederick Park. The Geology of Ore Deposits by 2007 Hardcover: 985 pages Publisher: Waveland Press, Inc. (February 5, 2007) Language: English

41. John Ridley. Ore Deposit Geology 1st Edition Hardcover: 409 pages Publisher: Cambridge University Press; 2013) Language: English

### **Section 2. GEOCHEMISTRY**

1. White W.M. Geochemistry. First Edition, Wiley-Blackwell, Oxford, UK, 2013. 660 pp.

2. Treatise on geochemistry. Ed. by Turekian K.K. and Holland H.D. Elsevier, 2003, v. 1-9.

3. Parker Andrew FRONTIERS IN GEOCHEMISTRY. CONTRIBUTION OF GEOCHEMISTRY TO THE STUDY OF THE EARTH John Wiley & Sons Limited

4. White William M Geochemistry John Wiley & Sons Limited

5. White William M Isotope Geochemistry | . John Wiley & Sons Limited

6. Tim Jickells D Roy Chester Marine Geochemistry | John Wiley & Sons Limited

7. P. Hender Rare Earth Element Geochemistry, Volume 2, 1st Edition Elsevier Science 1983

### **Section 3. GEOGRAPHY**

1. Geography, Resources and Environment, Vol. 1. SELECTED WRITINGS OF GILBERT F. WHITE. ROBERT W. KATES AND IAN BURTON (eds.) University of Chicago Press, 1986. 486 p.

2. Geography, Resources and Environment, Vol. 2. THEMES FROM THE WORK OF GILBERT F. WHITE. ROBERT W. KATES AND IAN BURTON (eds.) University of Chicago Press, 1986. 392 p

3. Geography. Book 1. Lindsay Frost, Lauren Lewis, Daniel Mace, Viv Pointon, Paul Wraight. Published by Pearson Education Limited, 2016

4. Fundamentals of World Regional Geography, Fourth Edition. Joseph J. Hobbs. Cengage Learning. 2016. ISBN: 978-1-305-57826-5

5. World Regional Geography Atlas, 6th Edition, With Subregions, by Lydia Mihelic Pulsipher and Alex Pulsipher, c. 2014 W.H. Freeman & Co



#### Section 4. GEOPHYSICS

1. Dasgupta S.N., Aminzadeh F. Geophysics for Petroleum Engineers // Elsevier, 2013, 305 p.
2. Dentith M., Mudge S.T. Geophysics for the Mineral Exploration Geoscientist // Cambridge University Press, 2014, 516 p.
3. Liu H. Principles and Applications of Well Logging // Springer, 2017, 372 p.
4. Lowrie W. A Student's Guide to Geophysical Equations // Cambridge University Press, 2011, 296 p.
5. Lowrie W. Geophysics: A Very Short Introduction // Oxford University Press, 2018, 160 p.
6. Milsom J., Eriksen A. Field Geophysics (4th edition) // John Wiley & Sons, 2011, 304 p.
7. Stacey F.D., Davis P.M. Physics of the Earth (4th edition) // Cambridge University Press, 2008, 513 p.
8. Tiab D., Donaldson E.C. Petrophysics: Theory and Practice of Measuring Reservoir Rock and Fluid Transport Properties (4th edition) // Elsevier, 2015, 918 p.

#### Section 5. GEOTECHNOLOGIES (MINING ENGINEERING)

1. Mineral processing handbook, Thirteenth Edition First Printing by TELSMITH, INC. 10910 N. Industrial Dr. P.O. Box 539 Mequon, WI 53092-0539 Phone: (262) 242-6600 Fax: (262) 242-5812 For Repair Parts, Phone: 800-688-6601 Or contact us via our website: [www.telsmith.com](http://www.telsmith.com). Mineral Processing Handbook 11/11 - 1st printing Printed in U.S.A
2. Mineral Processing Technology. FOURTH EDITION, AN INTRODUCTION TO THE PRACTICAL ASPECTS OF ORE TREATMENT AND MINERAL RECOVERY. by B. A. WILLS, BSC, PHD, CENG, MIMM Principal Lecturer Camborne School of Mines, Cornwall, England. PERGAMON PRESS OXFORD • NEW YORK • BEIJING • FRANKFURT SAO PAULO • SYDNEY • TOKYO • TORONTO.
3. Wills' Mineral Processing Technology: An Introduction to the Practical Aspects Item Condition: New. Publisher: Elsevier Science Ltd ISBN 13: 9780080970530.
4. Introduction to Mineral Exploration, 2nd Edition by Charles Moon (Editor), Michael K. G. Whateley (Editor), Anthony M. Evans (Editor). ISBN: 978-1-444-30912-6, March 2009 Wiley-Blackwell. 496 Pages
5. Standard Handbook of Petroleum and Natural Gas Engineering Volume 2 By William C Lyons Eds

6. Applied Drilling Engineering by Adam T. Bourgoyne Jr. Published January 1st 1986 by Society of Petroleum Engineers. ISBN 1555630014 (ISBN13: 9781555630010)
7. Advanced Drilling and Well Technology by Society of Petroleum Engineers (Contributor). Published January 1st 2009 by Society of Petroleum Engineers. ISBN 1555631452 (ISBN13: 9781555631451)
8. Elements of Petroleum Geology by Richard C. Selley. Published September 19th 1997 by Academic Press (first published March 1985). ISBN 0126363706 (ISBN13: 9780126363708)
9. Geological Engineering by Luis Gonzalez de Vallejo (Author), Mercedes Ferrer (Author), Michael de Freitas (Foreword). ISBN-13: 978-0415413527; ISBN-10: 0415413524
10. A Study of Mine Surveying Methods and Their Applications to Mining Engineering by Lewis Emanuel Young. ISBN 978-1-332-20148-8; ISBN (Hardcover) 978-0-265-20491-7
11. A Text-Book of Mining Geology for the Use of Mining Students and Miners by James Park
12. Minerals and Rocks by J. Richard Wilson. Publisher: BookBoon, 2010. ISBN-13: 9788776816476
13. Fundamentals of Rock Mechanics by John Jaeger, Neville G.W. Cook, et al., Publisher: Blackwell Publishers, 2007. DOI: 10.1017/CBO9780511735349
14. Engineering Rock Mechanics - An Introduction to the Principles by John A. Hudson, John P. Harrison. Published May 14th 2014 by Elsevier Science & Technology (first published January 1st 1997). ISBN 0080530966 (ISBN13: 9780080530963)
15. Fundamentals and Applications of Rock Mechanics by Debasis Deb, Abiram Kumar Verma. Published May 2nd 2016 by PHI Learning. ISBN 8120351827 (ISBN13: 9788120351820)
16. Soil mechanics and foundation engineering [Geotechnical engineering] by P.N. MODI. Published March 3rd 2018 by STANDARD BOOK HOUSE SINCE 1960. ASIN B07B7B9NXV
17. Rock Mechanics: For underground mining by Barry H. G. Brady and E. T. Brown. ISBN 978-1-4020-2116-9
18. Introductory Mining Engineering by Howard L. Hartman, Jan M. Mutmansky. Published August 9th 2002 by Wiley (first published July 24th 1987). ISBN 0471348511 (ISBN13: 978047134851)
19. Guidelines for Open Pit Slope Design by John Read, Peter Stacey. Published: 2009-11-09. DOI: 10.1071/9780643101104. ISBN (PDF): 978-0-643-10110-4

20. Underground Mining Methods: Engineering Fundamentals and International Case Studies by William A. Hustrulid (Editor), Richard L. Bullock (Editor). Published June 1st 2001 by Society for Mining Metallurgy & Exploration (first published March 2001). ISBN 0873351932 (ISBN13: 9780873351935)

### Recommended online courses

#### Section 1. GEOLOGY

1. 'Our Earth: Its Climate, History, and Processes'  
<https://www.coursera.org/learn/our-earth>
2. 'Planet Earth...and You!' <https://www.coursera.org/learn/planet-earth>
3. 'Earth Science'  
<https://www.youtube.com/watch?v=ELk00HqFjK4&list=PLNycEeeRg4mU3NDhxQQfOGPJzYWWhbWdkE>
4. 'The Dynamic Earth: A Course for Educators'  
<https://www.coursera.org/learn/earth-amnh>
5. 'Oceanography: a key to better understand our world'  
<https://www.coursera.org/learn/oceanography>
6. 'Extinctions: Past, Present, & Future'  
<https://www.coursera.org/learn/extinctions-past-present-and-future>
7. 'Origins - Formation of the Universe, Solar System, Earth and Life'  
<https://www.coursera.org/learn/origins-universe-solarsystem>
8. 'Emergence of Life' <https://www.coursera.org/learn/emergence-of-life>
9. 'Global Arctic' <https://www.coursera.org/learn/global-arctic>
10. 'Introduction to GIS Mapping' <https://www.coursera.org/learn/introduction-gis-mapping>
11. 'GIS, Mapping, and Spatial Analysis'  
<https://www.coursera.org/specializations/gis-mapping-spatial-analysis>
12. 'Structural Geology'  
[https://www.youtube.com/playlist?list=PLI3yxxPdnJaYZ4Ugxf3Ak\\_r1XbOTRjd-M](https://www.youtube.com/playlist?list=PLI3yxxPdnJaYZ4Ugxf3Ak_r1XbOTRjd-M)
13. 'Earth Explorations'  
<https://www.youtube.com/playlist?list=PL29-1bJ5x6d7TJFfrZS60Cpi4Y34wrB0X>
14. 'Sedimentology'  
<https://www.youtube.com/playlist?list=PLI3yxxPdnJaZvBzxNfG4OovCAOmXD2>

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15. <http://webmineral.com/>

## Section 2. GEOCHEMISTRY

1. 'Earth Science'

<https://www.youtube.com/watch?v=ELk00HqFjK4&list=PLNycEeeRg4mU3NDhxQQfOGPJzYWhbWdkE>

2. 'Mineralogy'

<https://www.youtube.com/playlist?list=PL2Of4YIdodkvERJfIVK4S26liuDzBB22>

3. 'Mineralogy'

[https://www.youtube.com/playlist?list=PLI3yxxPdnJaYFVvw3OWinx\\_Bx\\_iRgwL0u](https://www.youtube.com/playlist?list=PLI3yxxPdnJaYFVvw3OWinx_Bx_iRgwL0u)

4. 'Optical mineralogy'

<https://www.youtube.com/playlist?list=PLI3yxxPdnJaYdUAICstOk2RE1xHDGfIJM>

5. 'Igneous Petrology'

<https://www.youtube.com/playlist?list=PLI3yxxPdnJaYSSN0526DSnLmfkV26dJ82>

6. 'Metamorphic Petrology'

<https://www.youtube.com/playlist?list=PLI3yxxPdnJaZQeK7OA3H5ODD2IVIScDgd>

7. 'Earth Explorations'

<https://www.youtube.com/playlist?list=PL29-1bJ5x6d7TJFfrZS60Cpi4Y34wrB0X>

8. 'Sedimentology'

<https://www.youtube.com/playlist?list=PLI3yxxPdnJaZvBzxNfG4OovCAOmXD2pzs>

9. 'Planet Earth. Chemistry' (Cambridge IGCSE)

[https://www.youtube.com/watch?v=VsxnU3nnHbI&list=PL\\_NyvR04rq4tJaX1Vb9sExZ9Vf1oZg2FC](https://www.youtube.com/watch?v=VsxnU3nnHbI&list=PL_NyvR04rq4tJaX1Vb9sExZ9Vf1oZg2FC)

## Section 3. GEOGRAPHY

1. 'Geography'

<https://www.youtube.com/playlist?list=PL8dPuuaLjXtO85Sl24rSiVQ93q7vcentNF>

2. 'World Geography Course'

<https://www.youtube.com/playlist?list=PLS7x1fGbbJPVF9kQh6GtII31UDvIgyQu8g>

3. 'Geography: Physical Geography Fundamentals'

[https://www.youtube.com/playlist?list=PLDRDP\\_YgUlcYo99O0iPPDEtcg6tg0x13](https://www.youtube.com/playlist?list=PLDRDP_YgUlcYo99O0iPPDEtcg6tg0x13)  
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4. 'Physical Geography'

[https://www.youtube.com/playlist?list=PLPVDr-3uiv3RdEQj3IrJtdoYoNWimen\\_4](https://www.youtube.com/playlist?list=PLPVDr-3uiv3RdEQj3IrJtdoYoNWimen_4)

5. 'Earth Science'

<https://www.youtube.com/watch?v=ELk00HqFjK4&list=PLNycEeeRg4mU3NDhxQQfOGPJzYWhbWdkE>

6. 'Earth Explorations'

<https://www.youtube.com/playlist?list=PL29-1bJ5x6d7TJFfrZS60Cpi4Y34wrB0X>

#### Section 4. GEOPHYSICS

1. 'Basic

Geophysics'

<https://www.youtube.com/playlist?list=PLfk0Dfh13pBPXtgn8BT-dpkfaWMRusJwI>

2. 'Earth Science'

<https://www.youtube.com/watch?v=ELk00HqFjK4&list=PLNycEeeRg4mU3NDhxQQfOGPJzYWhbWdkE>

3. 'Earth Explorations'

<https://www.youtube.com/playlist?list=PL29-1bJ5x6d7TJFfrZS60Cpi4Y34wrB0X>

4. 'Seismic tomography: look inside the Earth'

<https://www.coursera.org/learn/seismic-tomography>

3. 'Seismic Academy'

<https://www.youtube.com/playlist?list=PLFbyYnTZSwbhK0YVgCntgpkyEZOp8l0tG>

6. 'Introduction

to

Petroleum

Engineering'

<https://www.coursera.org/learn/introduction-to-petroleum-engineering>

7. 'The Science of the Solar System' <https://www.coursera.org/learn/solar-system>

#### Section 5. GEOTECHNOLOGIES (MINING ENGINEERING)

1. The Minerals and Mining Business - <https://www.edx.org/course/the-minerals-and-mining-business?index=product&queryID=2bf2b4204d07fa85c40674563b20b5f5&position=2>

2. Minerals and Mining in a Sustainable World - <https://www.edx.org/course/minerals-and-mining-in-a-sustainable-world?index=product&queryID=14a7c15e9e16f0bfd72e9a76783b701b&position=3>

3. Operational Foundations of Mining - <https://www.edx.org/course/operational-foundations-of-mining?index=product&queryID=fd681ceaab3c7828594c09d8652fdd99&position=6>

4. Health, Safety and Wellness in Mining - <https://www.edx.org/course/health-safety-and-wellness-in-mining?index=product&queryID=fd1988bf4c1bc16e9b5286b290e582c2&position=8>

5. The Business of Mining - <https://www.edx.org/course/the-business-of-mining?index=product&queryID=6b4a773ddd40b58e9eed375cb287d7f4&position=9>