MONTANA
TECHNOLOGICAL UNIVERSITY

Ore Deposits

COURSE LEVEL OBJECTIVES
• **CO1** - List characteristics of each main ore deposits **(remember)** • **CO2** - Sketch each ore deposit model **(apply)** • **CO3** - Analyze a deformed ore deposit to distinguish between the initial model and secondary deformation **(analyze)** • **CO4** - Assess the economic potential of a deposit early in the exploration process **(evaluate)**

COURSE FINAL PROJECT
Formal Proposal – Professional Report (simplified SEC/JORC/NI-43101 format) of a given ore deposit: recognize the type, the model, its geological setting, how deformation affects it, compare the resources to existing deposits and assess its economic potential (including ore grade and tonnage, what infrastructures are needed, permitting, investment VS return, identify processing pathways).

MODULE 1 OBJECTIVES
• **MO1** - List characteristics of magmatic Cu-Ni and magmatic PGE deposits **(remember)** • **MO2** - Sketch a model of each magmatic Cu-Ni-PGE group **(apply)** • **MO3** - Analyze a deformed magmatic Cu-Ni-PGE deposit to distinguish b/w model and deformation **(analyze)** • **MO4 -** Investigate magmatic Cu-Ni-PGE deposits in production **(analyze)**

MODULE 1 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Lecture (ppt?) of the 2 groups of magmatic Cu-Ni-PGE deposits • Reading of USGS' report • Exercise / interactive activity • Video of the Noril'sk deposit, Russia (lightboard) • Google Earth exploration of Duluth, Minnesota • Video of Stillwater deposit • Interactive map of the Bushveld deposit, SA • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A	• Quiz – multiple choice or T/F **(MO1)** • Sketch free-hand drawing **(MO2)** • Memos with figures **(MO3 and MO4)**

MODULE 2 OBJECTIVES
• **MO1** - List characteristics of carbonatite REE-Nb-Ta deposits **(remember)** • **MO2** - Sketch a model of a carbonatite REE-Nb-Ta deposit **(apply)** • **MO3 -** Analyze a deformed carbonatite REE-Nb-Ta deposit to distinguish b/w model and deformation **(analyze)** • **MO4** - Investigate carbonatite REE-Nb-Ta deposits in production **(analyze)**

MODULE 2 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture carbonate-rich melts geochemistry (Incl. video snippets) • Reading of Berndt, J. and Klemme, S., 2022. Origin of carbonatites—liquid immiscibility caught in the act. Nature Communications, 13(1), p.2892. • Exercise / interactive activity on Oldonyo Lengai volcano, Tanzania (the only active carbonatite and its place in plate tectonics) • Video of Mountain Pass deposit, California • Interactive map of the Palabora Complex near Phalaborwa, RSA • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe a typical Carbonatite REE-Nb-Ta deposit (multiple choice answers, self-graded) **(MO 1)** • Sketch a Carbonatite REE-Nb-Ta deposit (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed Carbonatite REE-Nb-Ta deposit and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring a Carbonatite REE-Nb-Ta deposit into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 3 OBJECTIVES
• **MO1** - List characteristics of the 3 types of pegmatite deposits: mafic/ultramafic, syenite, and granitic **(remember)** • **MO2** - Sketch a model of each pegmatite deposit group **(apply)** • **MO3** - Analyze a deformed pegmatite deposit to distinguish b/w model and deformation **(analyze)** • **MO4** - Investigate pegmatite deposits in production **(analyze)**

MODULE 3 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on the three groups of pegmatites and their mineralogies (Incl. video snippets) • Reading of the "mafic-ultramafic Hamn intrusion, Northern Norway" article and questionnaire? • Google Earth exploration of Pegmatite Peak (syenite), Bearpaw Mts, Montana • Exercise / interactive activity on "LCT" vs "NYF" (granitic) pegmatites • Video of Black Hills pegmatite deposits, South Dakota • Interactive map of the Lithium pegmatites of the Carolina Tin-Spodumene Belt • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe the 3 types of pegmatite deposits (multiple choice answers, self-graded) **(MO 1)** • Sketch a Pegmatite Li-Be deposit (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed pegmatite deposit and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring a pegmatite deposit into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 4 OBJECTIVES
• **MO1** - List characteristics of the five classes of porphyries based on the dominant element: Au, Cu, Mo, Sn, W **(remember)** • **MO2** - Sketch a model of a porphyry deposit **(apply)** • **MO3** - Analyze a deformed porphyry deposit to distinguish b/w model and deformation **(analyze)** • **MO4** - Investigate porphyry deposits in production **(analyze)**

MODULE 4 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on the three groups of pegmatites and their mineralogies (Incl. video snippets) • Reading of the "mafic-ultramafic Hamn intrusion, Northern Norway" article and questionnaire. • Google Earth exploration of Pegmatite Peak (syenite), Bearpaw Mts, Montana • Exercise / interactive activity on "LCT" vs "NYF" (granitic) pegmatites • Video of Black Hills pegmatite deposits, South Dakota • Interactive map of the Lithium pegmatites of the Carolina Tin-Spodumene Belt • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe the basic characteristics of porphyry deposits formation and the particularities that make them enriched in a specific element (Au, Cu, Mo, Sn, W), as well as their usual alteration envelops (multiple choice answers, self-graded) **(MO 1)** • Sketch a porphyry deposit (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed porphyry deposit and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring a porphyry deposit into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 5 OBJECTIVES
• **MO1** - List characteristics of the two types of skarns (prograde, retrograde) and of Carbonate Replacement Deposits **(remember)** • **MO2** - Sketch a model of each skarn and CRDs **(apply)** • **MO3** - Analyze a deformed skarn and CRD system to distinguish b/w model and deformation **(analyze)** • **MO4** - Investigate skarns and CRDs in production **(analyze)**

MODULE 5 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on skarns and CRDs incl. their mineralogies and relationship (Incl. video snippets) • Reading of the "Biro et al, 2024. Recsk Porphyry-Mineralized Complex, Hungary" article and questionnaire? • Google Earth exploration of Hecla Pb-Ag-Zn skarn, MT • Exercise / interactive activity (match) on elements VS their deposit (skarn vs CRDs) • Video of Elkorn, MT, Au-Bi deposit • Interactive map of the Calvert Mine W skarn • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe skarns (prograde, retrograde) and carbonate replacement deposits and their relationship (multiple choice answers, self-graded) **(MO 1)** • Sketch a prograde skarn, a retrograde skarn, and a CRD (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed skarn/CRD system and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring a skarn deposit and a CRD into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 6 OBJECTIVES
• **MO1** - List characteristics of the two types of epithermal gold deposits: High sulfidation (HS) and low sulfidation (LS) **(remember)** • **MO2 -** Sketch a model of each skarn and CRDs **(apply)** • **MO3 -** Analyze a deformed epithermal gold deposit to distinguish b/w model and deformation **(analyze)** • **MO4 -** Investigate epithermal gold deposits in production **(analyze)**

MODULE 6 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on Hs and LS epithermal gold deposits (Incl. video snippets) • Reading of the USGS' "Descriptive models for epithermal gold-silver deposits" article and questionnaire? • Google Earth exploration of Yanacocha, Peru (HS) • Exercise / interactive activity (match) on alterations around epithermal Au deposits • Video of Ore Deposits Hub 019: Magmatic–hydrothermal systems and the formation of epithermal deposits – Jeffrey Hedenquist (1 hour) • Interactive maps of the Summitville, CO (HS) and McLaughlin, CA (LS) • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe the two types of epithermal gold deposits (High sulfidation, low sulfidation) (multiple choice answers, self-graded) **(MO 1)** • Sketch a model of a high sulfidation and of a low sulfidation epithermal gold deposit (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed epithermal gold deposit and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring epithermal gold deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 7 OBJECTIVES
• **MO1** - List characteristics of orogenic gold deposits **(remember)** • **MO2** - Sketch a model of an orogenic gold deposit **(apply)** • **MO3** - Analyze a deformed orogenic gold deposit to distinguish b/w model and deformation **(analyze)** • **MO4** - Investigate orogenic gold deposits in production **(analyze)**

MODULE 7 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on orogenic gold deposits and their tectonic environment (Incl. video snippets) • Reading of "Nassi et al, 2022, Formation of orogenic gold deposits" article and questionnaire. • Google Earth exploration of Yilgarn craton, Australia • Exercise / interactive activity (match) on Faults and veins (tectonic context for precipitation of orogenic gold). • Video of Homestake Mine, SD • Interactive maps of the Timmons-Val d'Or greenstone belt, CA • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe orogenic gold deposits (multiple choice answers, self-graded) **(MO 1)** • Sketch a model of an orogenic gold deposit (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed orogenic gold deposit and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring an orogenic gold deposit into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 8 OBJECTIVES
• **MO1** - List characteristics of Carlin gold deposits **(remember)** • **MO2** - Sketch a model of a Carlin gold deposit **(apply)** • **MO3** - Analyze a deformed Carlin gold deposit to distinguish b/w model and deformation **(analyze)** • **MO4** - Investigate Carlin gold deposits in production **(analyze)**

MODULE 8 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on orogenic gold deposits and their tectonic environment (Incl. video snippets) • Reading of "Muntean, J.L., 2018. Diversity in Carlin-Style Gold Deposits. Society of Economic Geologists." article and questionnaire. • Google Earth exploration of the Carlin Trend, Nevada • Exercise / interactive activity (match) on the tectonic environment of Carlin type gold deposits. • Video of geohug "François Robert Carlin gold deposits of Nevada" • Interactive maps of the Yunnan–Guizhou–Guangxi “golden triangle”, South China • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe Carlin gold deposits (multiple choice answers, self-graded) **(MO 1)** • Sketch a model of a Carlin gold deposit (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed Carlin gold deposit and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring Carlin gold deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 9 OBJECTIVES
• **MO1** - List characteristics of VMS deposits **(remember)** • **MO2** - Sketch a model of a VMS deposit **(apply)** • **MO3** - Analyze a deformed VMS deposit to distinguish b/w model and deformation **(analyze)** • **MO4** - Investigate VMS deposits in production **(analyze)**

MODULE 9 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on VMS deposits (Incl. video snippets) • Reading of USGS report "Morgan, L.A., 2012. Geophysical characteristics of volcanogenic massive sulfide deposits." article and questionnaire. • Google Earth exploration of the Kidd Creek, CA • Exercise / interactive activity (match) on the mineral zonation of VMS deposits. • Video of Our Metallic Earth "Volcanogenic massive sulphide (VMS) deposits" • Interactive maps of the Bousquet-La Ronde deposit, Qc • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe VMS deposits (multiple choice answers, self-graded) **(MO 1)** • Sketch a model of a VMS deposit (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed VMS deposit and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring VMS deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 10 OBJECTIVES
• **MO1** - List characteristics of MVT deposits **(remember)** • **MO2** - Sketch a model of a MVT deposit **(apply)** • **MO3** - Analyze a deformed MVT deposit to distinguish b/w model and deformation **(analyze)** • **MO4** - Investigate MVT deposits in production **(analyze)**

MODULE 10 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on MVT deposits (Incl. video snippets) • Reading of USGS report "Leach et al., 2010. A deposit model for Mississippi Valley-type lead-zinc ores." article and questionnaire. • Google Earth exploration of the Kidd Creek, CA • Exercise / interactive activity (match) on the mineral zonation of VMS deposits. • Video of Overview of MVT deposits in the world. • Interactive maps of Pine Point, NWT, CA • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe MVT deposits (multiple choice answers, self-graded) **(MO 1)** • Sketch a model of a MVT deposit (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed MVT deposit and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring MVT deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 11 OBJECTIVES
• **MO1** - List characteristics of SEDEX deposits **(remember)** • **MO2** - Sketch a model of a SEDEX deposit **(apply)** • **MO3** - Analyze a deformed SEDEX deposit to distinguish b/w model and deformation **(analyze)** • **MO4** - Investigate SEDEX deposits in production **(analyze)**

MODULE 11 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on SEDEX deposits (Incl. video snippets) • Reading of USGS report "Emsbo et al, 2016. Sedimentary exhalative (sedex) zinc-lead-silver deposit model" article and questionnaire. • Google Earth exploration of the Red Dog, AK • Exercise / interactive activity (match) on the depositional environment of SEDEX (tectonics, sedimentary, seawater chemistry) • Video of SEDEX vs VMS • Interactive maps of the Sullivan Mine, BC • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe SEDEX deposits (multiple choice answers, self-graded) **(MO 1)** • Sketch a model of a SEDEX deposit (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed SEDEX deposit and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring SEDEX deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 12 OBJECTIVES
• **MO1** - List characteristics of Red bed copper deposits **(remember)** • **MO2** - Sketch a model of a Red bed copper deposit **(apply)** • **MO3** - Analyze a deformed Red bed copper deposit to distinguish b/w model and deformation **(analyze)** • **MO4** - Investigate Red bed copper deposits in production **(analyze)**

MODULE 12 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on Red bed copper deposits (Incl. video snippets) • Reading of Government of Canada Publications "Kirkham, R.V., 1995. Volcanic redbed copper." article and questionnaire. • Google Earth exploration of the Michigan redbed copper deposits and their tectonic environment • Exercise / interactive activity (match) on the depositional environment of redbed copper deposits (tectonics, sedimentary, sea water chemistry) • Video on Kupferschiefer deposits in Poland • Interactive maps of the Lisbon Valley, UT • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe Red bed copper deposits (multiple choice answers, self-graded) **(MO 1)** • Sketch a model of a Red bed copper deposit (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed Red bed copper deposit and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring Red bed copper deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 13 OBJECTIVES
• **MO1** - List characteristics of the two main types of uranium deposits (primary vs secondary) **(remember)** • **MO2** - Sketch models of the main uranium deposit **(apply)** • **MO3** - Analyze a deformed Uranium deposit to distinguish b/w model and deformation **(analyze)** • **MO4** - Investigate Uranium deposits in production **(analyze)**

MODULE 13 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on uranium deposits (Incl. video snippets) • Reading of New Mexico Bureau of Geology and Mineral Resources webpages By: Dana S. Ulmer-Scholle and Virginia T. McLemore "Uranium — What is It?", "Uranium — Where Is It Found?", "Uranium Resources in New Mexico", "Uranium — How Is It Mined?" and "Uranium Legacy Issues In New Mexico". • Google Earth exploration of the Athabasca basin, CA, uranium deposits • Exercise / interactive activity (match) on the depositional environment of uranium deposits (primary vs secondary) and their geochemistry • Video from geohug "Mark Travis Styles of Uranium Mineralization: Current Market & Exploration" • Interactive maps of the uranium deposits in North America • Lecture (lightboard) of deformation examples • Presentation of memos to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe the two main types of uranium deposits (multiple choice answers, self-graded) **(MO 1)** • Sketch different models of a primary and secondary uranium deposits (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Recognize a deformed Uranium deposit and analyze the structural geology that affects the model. **(MO 3)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring Uranium deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 4)**

MODULE 14 OBJECTIVES
• **MO1** - List characteristics of BIF deposits **(remember)** • **MO2** - Sketch models of BIF deposit **(apply)** • **MO3** - Investigate BIF deposits in production **(analyze)** • **MO4** - List characteristics of the 3 types of FeMn oxide deposits (BIF-related, sea-level change related, sea floor nodules) **(remember)** • **MO5** - Sketch models of FeMn oxide deposit **(apply)** • **MO6** - Investigate FeMn oxide deposits in production **(analyze)**

MODULE 14 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on uranium deposits (Incl. video snippets) • Reading of Australian Earth Science Education • "Banded Iron Formations". • Google Earth exploration of the Michigan BIF deposits • Exercise / interactive activity (match) on the depositional environment of BIF deposits and their geochemistry • Video from Earth Science Classroom "Banded Iron Formations (BIFs)" • Interactive maps of the iron districts of Lake Superior, CA • Presentation of memos to instructor and Q&A • Discussion on environmental impacts • Interactive lecture on FeMn oxide deposits (Incl. video snippets) • OVERVIEW Reading of USGS reports on "Ferromanganese-oxide deposits". • Exercise / interactive activity (match) on the three types of FeMn oxides deposits • Video of GeologyHub "The Geologic Oddity in the Deep Ocean; Millions of Valuable Manganese Nodules"	• Quiz: Describe BIF deposits (multiple choice answers, self-graded) **(MO 1)** • Sketch a BIF deposit (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring BIF deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 3)** • Quiz: Describe the 3 types of FeMn oxide deposits (BIF-related, sea-level change related, sea floor nodules) (multiple choice answers, self-graded) **(MO 4)** • Sketch different models of FeMn oxide deposits (by hand, on white

• Interactive map of Paleoproterozoic Mn is in the Kalahari region of South Africa • Presentation of memo to instructor and Q&A • Discussion on environmental impacts	paper, scan and send to instructor) **(MO 5)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring FeMn oxide deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 6)**

MODULE 15 OBJECTIVES
• **MO1** - List characteristics of the 3 types of Ni-Co laterites deposits (Clay silicate, Mg hydrous silicate, Fe oxide) **(remember)** • **MO2** - Sketch models of Ni-Co laterites deposit **(apply)** • **MO3** - Investigate Ni-Co laterites deposits in production **(analyze)** • **MO4** - List characteristics of Li- and REE-rich clay deposits **(remember)** • **MO5** - Sketch models of Li- and REE-rich clay deposit **(apply)** • **MO6** - Investigate Li- and REE-rich clay deposits in production **(analyze)** • **MO7** - List characteristics of Li-brines deposits **(remember)** • **MO8** - Sketch models of Li-brines deposit **(apply)** • **MO9** - Investigate Li-brines deposits in production **(analyze)**

MODULE 15 ACTIVITIES and ASSESSMENTS	
ACTIVITIES	**ASSESSMENTS**
• Interactive lecture on Ni-Co laterites deposits (Incl. video snippets) • OVERVIEW Reading of "Domènech, C. and Villanova-de-Benavent, C., 2023. Geochemistry and Mineralogy of Ni-Co Laterite Deposits". • Google Earth exploration of SE Asia Ni-Co laterites • Exercise / interactive activity (match) on the soil profile of Ni-Co laterites • Video of African Ni-Co laterite deposits • Interactive maps of Central America Ni-Co laterite deposits • Presentation of memo to instructor and Q&A • Discussion on environmental impacts • Interactive lecture on Liand REE-rich clay deposits (Incl. video snippets) • Reading of Benson et al, 2017. "Lithium enrichment in intracontinental rhyolite magmas	• Quiz: Describe the 3 types of Ni-Co laterites deposits (Clay silicate, Mg hydrous silicate, Fe oxide)(multiple choice answers, self-graded) **(MO 1)** • Sketch different models of Ni-Co laterites deposits (by hand, on white paper, scan and send to instructor) **(MO 2)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring Ni-Co laterites deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 3)**

leads to Li deposits in caldera basins". • Google Earth exploration of Liand REE-rich clay deposits in South China • Exercise / interactive activity (match) on the geochemistry of Liand REE-rich clay deposits • Presentation of memo to instructor and Q&A • Discussion on environmental impacts • Interactive lecture on Li-brines deposits (Incl. video snippets) • Reading of Nevada Bureau of Mines and Geology publication: "Lithium in Nevada-origins, extent, role in the energy transition, and implications for economic development and national security." • Google Earth exploration of the Nevada Li-brines deposits • Exercise / interactive activity (match) on the groundwater circulation and brine accumulation • Interactive map on Chilean Li-brines deposits • Presentation of memo to instructor and Q&A • Discussion on environmental impacts	• Quiz: Describe Li- and REE-rich clay deposits (multiple choice answers, self-graded) **(MO 4)** • Sketch a Li- and REE-rich clay deposit (by hand, on white paper, scan and send to instructor) **(MO 5)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring Li- and REE-rich clay deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 6)** • Quiz: Describe Li-brines deposits (multiple choice answers, self-graded) **(MO 7)** • Sketch a Li-brines deposit (by hand, on white paper, scan and send to instructor) **(MO 8)** • Memo (1 page w/ figures): Evaluate what economic characteristics are required to bring Li-brines deposits into production by analyzing grades and tonnages of minor and majors case studies, as well as the investment/return that was involved. **(MO 9)**