## GEOL 4720-5720 Ore Deposits

## Fall 2018

**Department of Geology and Geophysics, University of Wyoming**

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| **Class:** MWF 1:10-2:00 PM, ESB 1038 | **Lab:** W 4:10-6:00 pm, GE 209 |

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| **Instructor**: Simone Runyon | **Office phone**: (307)-314-9262 |
| **Office**: ESB 3010 | **Email:** srunyon@uwyo.edu |
| **Office hours:** M,W 2:00-3:00, Th11:00-12:00 | |

The most reliable way to contact me is through email.

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| **Teaching Assistant**: Nathaniel Applegate **Office hours**: *TBD* |

### Course description

This course is an introduction to ore deposit types and processes. Ore deposits are complex geochemical systems that are influenced by tectonic setting, host rock, temperature, pressure, and preservation among many other variables. Ore deposits are the source of materials used for just about everything in our day to day lives, from the aggregate for concrete to indium for solar panels and dysprosium magnets for hybrid vehicles. Ore-forming systems are fascinating, producing some of the most spectacular mineral samples available. Due to the impacts that ore deposits have on our daily lives, it is essential that we understand and help educate the public about these systems.

**Course materials:** No assigned textbook. Exam questions will draw upon lecture notes, lab assignments, problem sets, and readings from references listed in this syllabus.

**Credit hours**: 4

**Prerequisites**: “C” grade or above in GEOL 2020 Petrology.

### Course objectives and outcomes

Broadly, there are two types of objectives for this course: learning the terminology of ore deposits and understanding ore deposits as process-based, geochemical systems.

**Outcomes include**:

1) Familiarity with ore-forming processes: be familiar with specific examples of each deposit type and be familiar with host rocks, common ore minerals, and alteration types

2) Familiarity with basic economic geology terminology

3) Understand the general characteristics that make a deposit economically viable

4) Familiarity with debates about ore deposit formation

5) Understand the role of economic geology and natural resources in a societal context.

**Fundamental scientific skills** required to complete the above objectives include:

1) Three-dimensional (to four-dimensional) thinking

2) Making and utilizing graphs and graphical representation of data

3) Applying knowledge of ore deposits to solve problems in real-world scenarios

4) Critical thinking to evaluate multiple lines of evidence for problem solving

5) Effective scientific communication through oral, written, and graphical means.

### Grading

**Geol. 4720 Geol. 5720**

Midterm Exam 100 100

Final Exam 100 100

Problem sets 90 90

Presentations (5720 only) 0 50

Lab 110 160

Total 400 500

Final letter grades will be assigned from the total numerical score:

**Geol. 4720 Geol. 5720**

A (100-90%) 360-400 points 450-500 points

B (89-80%) 320-359 points 400-449 points

C (79-70%) 280-319 points 350-399 points

D (69-60%) 240-279 points 300-349 points

F (≤ 59%) ≤ 239 points ≤ 299 points

**Exams**: There will be two exams. The midterm exam will cover the first half of the course material and the final exam will be cumulative.

**Problem Sets**: Students will have 3 problem sets totaling 90 points.

**Presentations**: Students enrolled in 5720 will create and present a ~12-15 minute talk about an ore deposit of their choice, worth 50 points. A rubric will be provided.

**Laboratory Assignments**: There will be 5 lab assignments based on samples available during lab time. Each lab will have some questions that only students enrolled in 5720 will be required to answer, and will be marked as such.

**Extra Credit**: Students enrolled in 4720 may create presentations in the style of those required for 5720. These presentations will be worth up to 20 points of extra credit.

**Grading Curve**: There will not be a grading curve.

### Attendance policy

Please contact the instructor before any known, UW authorized absences. Make-up work will only be offered in case of illness when accompanied with appropriate documentation (documentation from physician) or UW authorized absences. University sponsored absences are cleared through the Office of Student Life. Should a lecture be missed, it is the responsibility of the student to establish the content and make the necessary notes- the instructor will not provide students with replacement lectures.

**Labs and problem sets:** Lab assignments must be completed during scheduled lab times. Make-up work must be scheduled with the instructor and must occur within one week of the missed lab. If assignments are late *without* a UW authorized absence, lab assignments and problem sets may be turned in up to 5 days after their original due date: a 10% grade deduction will be imposed for every day the assignment is late.

**Exams:** Make-up exams will only be offered in the case of illness with proper documentation from your physician or for UW approved absences. Make-up exams must be scheduled with your instructor and must occur within one week of the missed exam. No one will be allowed to take an exam early.

**Extended Absence:** In case of an accident or anything that prevents you from attending class for an extended period, contact the Office of Student Life (307)766-3296, dos@uwyo.edu to facilitate arranging make-up work.

### Conduct

The College of Arts and Sciences has guidelines for attendance, classroom etiquette, phone and email protocol, office hours, etc. For more information, visit: http://www.uwyo.edu/as/\_files/current/students%20and%20teachers%20working%20together.pdf#students and teachers working together.

### Academic Honesty

Each student is expected to abide by the academic dishonesty policy UW Regulation 2-114. See (http://www.uwyo.edu/regs-policies/\_files/docs/section-2-regulations-july-2018/uw\_reg\_2-114\_format\_effective\_7-1-18.pdf) for details. Ignorance of these policies is not an acceptable defense against any charge of academic dishonesty. Plagiarism and cheating are not tolerated, and there is a university procedure to judge such cases.

### Diversity Statement

The University of Wyoming values an educational environment that is diverse, equitable, and inclusive. The diversity that students and faculty bring to class, including age, country of origin, culture, disability, economic class, ethnicity, gender identity, immigration status, linguistic, political affiliation, race, religion, sexual orientation, veteran status, worldview, and other social and cultural diversity is valued, respected, and considered a resource for learning.

### Disability Statement

If you have a physical, learning, sensory, or psychological disability and require accommodations, please let your instructor know as soon as possible. You will need to register with, and provide documentation of your disability to University Disability Support Services (UDSS) in SEO, room 330 Knight Hall, TTY: 766-3073, (307)766-6189, [udss@uwyo.edu](mailto:udss@uwyo.edu). Visit their website for more information: www.uwyo.edu/udss.

### Mandatory Reporter

The instructor of this course is a Mandatory Reporter, meaning that the instructor must report all Title IX related concerns to the Title IX Coordinator or their supervisor.

### Changes to the Syllabus

The information within this syllabus are subject to change as a result of the breadth of material discussed. Therefore, the schedule will be flexible. Any substantive modifications will be announced in advance in class and/or posted on Wyocourses.

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| Tentative Lecture schedule | | **Reading** |
| Aug 29 | Intro: mineral economics |  |
| **Aug 31** | **Rocky Mountain Field Trip – no class** |  |
| **Sept 3** | **Labor Day – no class** |  |
| Sept 5 | How to build an ore deposit |  |
| Sept 7 | Intro to 5 types: Variation in ore deposits |  |
| Sept 10 | Intro to magmatic: review igneous petrology | Arndt et al. (2005)\* Cawthorn et al. (2005)\* |
| Sept 12 | Mag: Ni-Cu, PGE |
| Sep 14 | Mag: Fe-Ti-V oxide, anorthositic complexes |
| Sep 17 | Mag: Gemstone, rare-metal pegmatite | London and Kontak (2012) |
| Sep 19 | Mag: Diamonds | Gurney et al. (2005)\* |
| Sep 21 | Mag: REE carbonatite | Jones et al. (2013) |
| **Sept 24** | **SEG Conference – no class** |  |
| Sept 26 | Review: Magmatic deposits |  |
| Sept 28 | Hydro alteration. Terms, styles, and textures |  |
| Oct 1 | Hydrothermal alteration: variables, textures |  |
| Oct 3 | Porphyry I: classification, porphyry W-Sn-Mo | Seedorff et al. (2005)\*  Sillitoe (2010) |
| Oct 5 | Porphyry II: porphyry Cu (±Au ± Mo) |
| Oct 8 | Skarn + replacement deposits | Meinert et al. (2005)\* |
| Oct 10 | Supergene alteration |  |
| Oct 12 | Alkaline Au |  |
| Oct 15 | Review: magmatic hydrothermal deposits |  |
| **Oct 17** | **Exam I** |  |
| Oct 19 | Terrestrial hydrothermal systems |  |
| Oct 22 | IOCG systems | Groves et al. (2010) |
| Oct 24 | Carlin type deposits | Cline et al. (2005)\* |
| Oct 26 | Epithermal deposits | Simmons et al. (2005)\* |
| Oct 29 | Metamorphic deposits: metamorphic gold | Groves et al. (2003) |
| Oct 31 | Marine-hydrothermal: VMS / VHMS deposits | Huston (2010) |
| Nov 2 | Marine and terrestrial hydr. deposits review |  |
| Nov 5 | Intro: Basin-related (sediment-hosted) systems. |  |
| Nov 7 | Sediment-hosted Cu | Hitzman et al. (2005)\* |
| Nov 9 | Clastic-dominated Pb-Zn | Leach et al. (2005)\* |
| Nov 12 | MVT | Leach et al. (2001) |
| Nov 14 | Broken-Hill type Mn-rich deposits |  |
| Nov 16 | Review: Basin-Related deposits |  |
| Nov 19 | Intro: weathering and sedimentary deposits |  |
| Nov 21 | Chemical sediments: BIF, Mn, phosphorites |  |
| **Nov 23** | **No class – Thanksgiving break** |  |
| Nov 26 | Mechanical sediments: placers and laterite |  |
| Nov 28 | Energy: oil, coal, and uranium | Cuney (2009, 2010) |
| Nov 30 | Industrial |  |
| Dec 3 | Ore deposits through time | Barley and Groves (1992),  Cawood and Hawkesworth (2015) |
| Dec 5 | Student presentations |
| Dec 7 | Student presentations |
| Dec 10 | Review for final |  |
| **Final exam**: Friday, December 14th, 1:15-3:15 pm | | |

\*In Economic Geology 100th anniversary volume, on reserve in Geology Library

### Tentative Lab Schedule

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| **Hand out** | **Due** | **Subject** | **4720 pts.** | **5720 pts.** |
| Sept. 5 | Sept. 26 | Lab 1: Magmatic Ores | 20 | 30 |
| Sept. 26 | Oct. 3 | Lab 2: Hydrothermal alteration | 20 | 30 |
| Oct. 3 | Oct. 31 | Lab 3: Porphyry and Epithermal deposits | 20 | 30 |
| Oct. 31 | Nov. 14 | Lab 4: Sediment-hosted and Basin-related | 25 | 35 |
| Nov. 14 | Dec. 5 | Lab 5: Low Temperature Deposits | 25 | 35 |

### Problem set schedule

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| **Prob. #** | **Hand out** | **Due** | **Topic** | **Pts.** |
| (1) | Sept. 12 | Sept. 19 | Distribution Coefficients | 20 |
| (2) | Sept. 19 | Oct. 5 | Oxygen buffers & Sulfur speciation | 20 |
| (3) | Oct. 5 | Nov. 16 | Exploration problem | 50 |

Full readings citations:

Arndt, N.T., Lesher, C.M., and Zcamanske, G.K., 2005, Mantle-derived magmas and magmatic Ni-Cu-(PGE) deposits: Economic Geology, v. 100, p. 5-24.

Barley, M.E., and Groves, D.I., 1992, Supercontinent cycles and the distribution of metal deposits through time: Geology, v. 20, p. 291-294.

Cawood, P.A., and Hawkesworth, C.J., 2015, Temporal relations between mineral deposits and global tectonic cycles: Geological Society Special Publication, v. 393, p. 9-21.

Cawthorn, R.G., Barnes, S.J., Ballhaus, C., and Malitch, K.N., 2005, Platinum group element, chromium, and vanadium deposits in mafic and utramafic rocks: Economic Geology, v. 100, p. 215-249.

Cline, J.S., Hofstra, A.J., Muntean, J.L., Tosdal, RM., and Hickey, K.A., 2005, Carlin-type gold deposits in Nevada: Critical geologic characteristics and viable models: Economic Geology, v. 100, p. 451-484.

Cuney, M., 2009, The extreme diversity of uranium deposits: Mineralium Deposita, v. 44, p. 3-9.

Cuney, M., 2010, Evolution of uranium fractionation processes through time: Driving the secular variation of uranium deposit types: Economic Geology, v. 105, p. 553-569.

Groves, D.I., Goldfarb, R.J., Robert, F., and Hart, C.J.R., 2003, Gold deposits in metamorphic belts: Overview of current understanding, outstanding problems, future research, and exploration significance: Economic Geology, v. 98, p. 1-29.

Groves, D. I., Bierlein, F. P., Meinert, L. D. & Hitzman, M. W. 2010. Iron oxide copper–gold (IOCG) deposits through Earth history: implications for origin, lithospheric setting, and distinction from other epigenetic iron oxide deposits. Economic Geology, 105, 641– 654.

Gurney, J. J., Helmstaedt, H. H., Le Roux, A. P., Nowicki, T. E., Richardson, S. H. & Westerland, K. J. 2005. Diamonds: crustal distribution and formation processes in time and space and an integrated deposit model: Economic Geology, v. 100, 143– 178.

Hitzman, M., Kirkham, R., Broughton, D., Thorson, J., and Selley, D., 2005, The sediment-hosted stratiform copper ore system: Economic Geology, v. 100, p. 609-642.

Huston, D.L., Pehrsson, S., Eglington, B.M., and Zaw, K., 2010, The geology and metallogeny of volcanic-hosted massive sulfide deposits: Variations through geologic time and with tectonic setting: Economic Geology, v. 105, p. 571-591.

Jones, A.P., Genge, M., and Carmody, L., 2013, Carbonate melts and carbonatites: Reviews in Mineralogy and Geochemistry, v. 75, p. 289-322.

Leach, D.L., Bradley, D., Lewchuk, M.T., Symons, D.T.A., de Marsily, G., and Brannon, J., 2001, Mississippi Valley-type lead-zinc deposits through geological time: implications from recent age-dating research: Mineralium Deposita, v. 36, p. 711-740.

Leach, D.L., Sangster, D.F., Kelley, K.D., Large, R.R., Garven, G., Allen, C.R., Gutzmer, J., and Walters, S., 2005, Sediment-hosted lead-zinc deposits: A global perspective: Economic Geology, v.100, p. 561-607.

London, D., and Kontak, D.J., 2012, Granitic pegmatites: scientific wonders and economic bonanzas: Elements, v. 8, p. 257-261.

Maier, W.D., and Groves, D.I., 2011, Temporal and spatial controls on the formation of magmatic PGE and Ni-Cu deposits: Mineralium Deposita, v. 46, p. 841-857. Doi:10.1007/s00126-011-0339-6.

Meinert, L.D., Dipple, G.M., and Nicolescu, S., 2005, World skarn deposits: Economic Geology, v 100, p. 299-336.

Seedorff, E., Dilles, J.H., Proffett, J.M., Einaudi, M.T., Zurcher, L., Stavast, W.J.A., Johnson, D.A., and Barton, M.D., 2005, Porphyry deposits: Characteristics and origin of hypogene features, Economic Geology, v. 100, p. 251-298.

Sillitoe, R.H., 2010, Porphyry copper systems: Economic Geology, v. 105, p. 3-41.

Simmons, S.F., White, N.C., and John, D.A., 2005, Geological characteristics of epithermal precious and base metal deposits: Economic Geology, v. 100, p. 485-522.