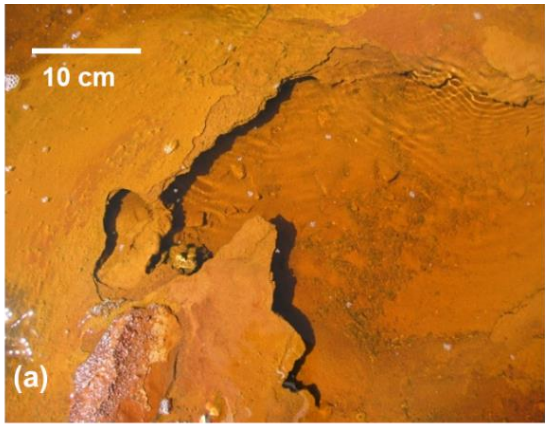
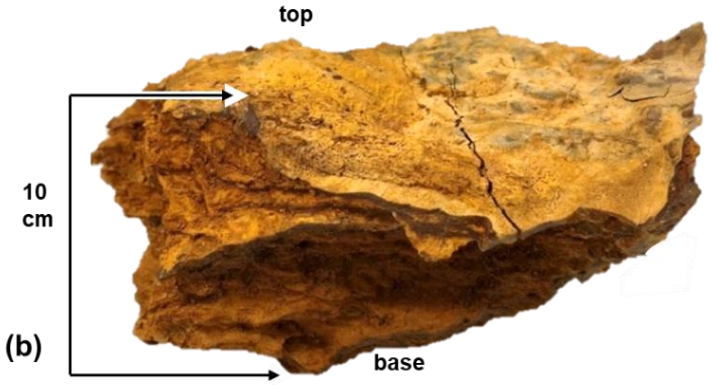
THE UNIVERSITY OF NEW SOUTH WALES

**FACULTY OF SCIENCE**

**SCHOOL OF BIOLOGICAL, EARTH and ENVIRONMENTAL SCIENCES**




## GEOS3281

# Applied Geochemistry

### On-campus and on-line

## Course Manual

## Term 2, 2022

**Prof David Cohen, course convener**

# SCHOOL OF BIOLOGICAL, EARTH and ENVIRONMENTAL SCIENCES

## GEOS3281

# Applied Geochemistry

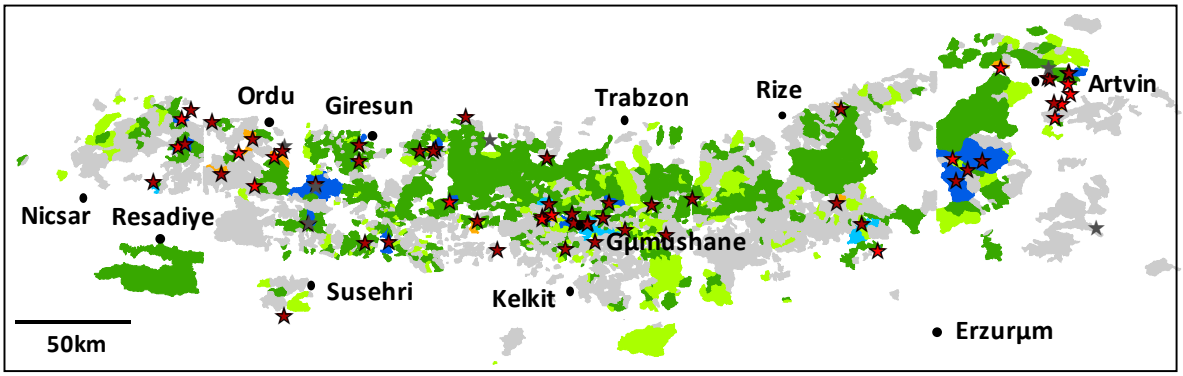
### Term 2, 2022

**6 units of credit**

## Important Dates

| WEEK | DAY | DATE | DETAILS |
|---|---|---|---|
| Wk 3 | Fri | 17-Jun | Assignment 1: Modelling with Minteq (due) |
| Wk 4 | Fri | 24-Jun | Assignment 2: Quality control (due) |
| Wk 5 | Fri | 1-Jul | Assignment 3: Geochemical mapping (due) |
| Wk 8 | Fri | 22-Jul | Assignment 4: Sunny Corner group exercise (due) |
| Wk 10 | Wed | 3-Aug | Assignment 5: Seminar (presentation made) |

| | Bkg | Marginal anom | Strong anom | % detect |
|---|---|---|---|---|
| Known deposit(s) | 14 | 6 | 24 | 100 |
| No known deposit(s) | 961 | 203 | 442 | |




**Au (ave)**
**<180 µm**
**Stream sed.**

# 1 INFORMATION ABOUT THE COURSE

## 1.1 General

| | |
|---|---|
| **Year of Delivery** | 2022 |
| **Course Code** | GEOS3281 |
| **Course Name** | Applied Geochemistry |
| **Academic Unit** | School of Biological, Earth and Environmental Sciences |
| **Level of Course** | III (undergraduate) |
| **Units of Credit** | 6 |
| **Session(s) Offered** | T2 |
| **Assumed Knowledge, Prerequisites or Co-requisites** | **Assumed knowledge:**<br>Courses: Level 1 GEOS or CHEM<br>Geology: Basic mineralogy;<br>Chemistry: HSC-level knowledge of the periodic table; bonding; pH-Eh, redox and acid-base reactions.<br>Maths: Basic statistics (e.g. MATH1041 or BEES2041). |
| **Hours per Week** | 6 (including online lecture component) |
| **Number of Weeks** | 10 |
| **Commencement Date** | Wednesday 1 June |

**Summary of Course Structure (for details see 'Course Schedule')**

| **Component** | **HPW** | **Time** | **Day** | **Location** |
|---|---|---|---|---|
| Lectures (recorded) | ~2 | | | Moodle |
| Laboratory 1 | 2 | 9:00 – 10:50 | Wednesday | Tch Lab 5 and online |
| Laboratory 2 | 2 | 11:10 – 1:00 | Wednesday | Tch Lab 5 and online |
| Field trip | | Not running this year | | Sunny Corner |
| **Total** | 6 | | | |
| **Special Details** | Course delivered in blended mode (online lectures and live labs) | | | |

## 1.2 Staff involved in the course

| **Staff** | **Role** | **Name** | **Contact Details** | **Consultation Times** |
|---|---|---|---|---|
| **Course Convenor and main lecturer** | | Prof David Cohen | Rm 202, Chancellery<br>d.cohen@unsw.edu.au | As agreed |
| **Additional Teaching Staff** | Lecturers | Dr Mira van der Ley<br>Dr Hamid Zekri | | |
| | Demonstrators | | | |
| | Technical staff | Dr Mira van der Ley | | |

## 1.3 Course details[1]

| | |
|---|---|
| **Course Description** | ***Overview***<br>The modern world is highly dependent on mineral resources, with a need to maintain exploration programs for new deposits. A consequence of industrialisation, new technologies and population growth, however, has been the progressive contamination of the environment, especially in urbanised regions. Metals have been relocated from parent rock to the surface environment and atmosphere, along with a wide variety of natural and synthetic organics. Geochemical surveys and modelling are important components in the discovery and use of resources, sustainable development and controls or remediation of environmental pollution. *Geochemistry* is a broad discipline grouping that integrates the knowledge and skills derived from various areas of science to investigate the source, fate and geochemical behaviour of various materials and the processes involved in geochemical systems operating in natural and human-altered environments.<br><br>***Scope***<br>This course examines the characteristics, source and fate of metals and other chemical species in natural and urban environments. Primary and secondary dispersion of elements and weather processes. Principles of vapour, water, soil, drainage sediments, rocks and vegetation geochemistry as applied to environmental assessments and mineral exploration; aqueous geochemistry and contaminant modelling, with reference to Australian case studies. Introduction to sampling, analytical techniques and design of environmental surveys. |
| **Course Aims** | The course provides students an introduction to the fundamental concepts and processes relating to geochemistry of surface environment with applications in environmental and exploration geochemistry. It provides an introduction to the design, implementation and interpretation of results from geochemical surveys and their use in fields ranging from environmental management to mineral exploration. It is designed to help prepare students for their honours year and/or professional practice. |
| **Student Learning Outcomes** | **Domains:**<br><br>Fundamental principles → Survey design and implementation → Data modelling and interpretation → Environmental policy and management; Mineral exploration<br>*Acquisition of knowledge* → *Application to theory* → *Application to practice* → *Communication to others*<br><br>Labwork will provide practical skills in a range of geochemical methods. The course also emphasises the development of:<br><br>Oral presentational skills and report writing<br><br>Project planning and management, including data handling<br><br>Group working, co-ordination and delegation<br><br>The various assignments will test the knowledge and understanding of geochemical processes and effects in the surficial environment, with a focus on geological sources of metals, as well as the urban environment. Practical skills in conducting field surveys, laboratory tests and data analysis will also be developed and tested in the course, as will oral and writing skills at communicating the results. The course will emulate the type of professional activities that students might be expected to undertake on graduation.<br><br>Specifics are set out in the table below. |

[1] UNSW Virtual Handbook: https://www.handbook.unsw.edu.au/undergraduate/courses/2020/GEOS3281

## 1.4 Knowledge, understanding and skills

(based on material from the University of Reading)

#### *1.4.1.1 Knowledge and Understanding*

**A. Students will develop knowledge and understanding of:**

1. The nature of geochemistry as a discipline
2. Relevant fundamentals of inorganic, organic and aqueous geochemistry
3. Geochemical cycles, transportation of contaminants
4. Data acquisition, data processing methods and geochemical mapping
5. Processes in the surface and near-surface environment, including interactions between the solid Earth, hydrosphere, atmosphere and biological agents, including man.
6. Environmental systems and issues
7. Applications of geochemistry in mineral exploration and environmental sciences
8. Selected case studies provided by staff and other students
9. Fieldwork safety issues and procedures

#### *Teaching and learning methods*

The framework will be provided by the lectures and directed readings, together with student seminars and practical exercises. Students will be directed towards appropriate references in the library and on the web and will be expected to undertake their own program of reading and reflection. Students will investigate some topics in depth as preparation for their essay and seminar, and this may be selected in view of future areas of specialization (e.g. honours projects).

#### *Assessment*

Knowledge will be tested through the reports and exercises.

#### *Skills and other attributes*

**B. Students will improve their intellectual skills by:**

1. Thinking logically and critically in a scientific manner
2. Undertaking study and investigations in areas of science outside those immediately familiar
3. Analysing and interpret environmental data, recognizing theoretical and practical limitations to the analysis and potential issues and problems
4. Organising tasks ranging from practical work to seminar presentations
5. Appreciating the current state of knowledge of the environment

**C. Students will develop further their practical skills** by:

1. Accurately observing, recording and interpreting earth materials and geochemical data
2. Acquiring geochemical and other data analysis skills using a variety of techniques
3. Conducting practical geochemical projects
4. Carrying out a risk assessment for fieldwork in a given area.

**D. Transferable skills**

1. Use of IT, including resource searching
2. Communicate scientific ideas in various formats
3. Work as part of a team

#### *Teaching/learning methods and strategies*

Intellectual skill development is embedded throughout the course, but is specifically addressed in a number of the topics and tasks. The ability to integrate and apply concepts and principles from one area of the subject to another are intrinsic to high-level performance in the program.

## 1.5 Graduate attributes developed in this course[2]

| Science Graduate Attributes | Level of Focus<br>*1 = minimal*<br>*2 = minor*<br>*3 = major* | Activities / Assessment |
|---|---|---|
| **Research, inquiry and analytical thinking abilities** | *3* | Literature reviews and critique of papers.<br>Interpretation of results of field and laboratory work |
| **Ethical, social and professional Understanding** | 1 | Role of geosciences in environmental management and resources |
| **Communication** | 2 | Seminar, Sunny Corner report and laboratory assignments |
| **Teamwork, collaborative and management skills** | 3 | Laboratory and assignment work |
| **Information literacy** | 2 | Use of information resources for essay and seminar |
| **Major Topics (Syllabus Outline)** | **See schedule below and Moodle** | |
| **Relationship to Other Courses within the Program** | The course is an option within earth science plans, with particular relevance to students undertaking environmental science or resource geology. The course is supported by:<br>level 1 courses in GEOS and CHEM<br>GEOS2181 Earth Materials<br><br>The course is complementary to the following courses:<br>GEOS2291 Earth Systems & Sustainability<br>GEOS2721 Aust Surface Environments and Landforms<br>GEOS3141 Mineral and Energy Resources<br>GEOS3911 Environmental Impact Assessment<br>CHEM3041 Analytical Chemistry<br>CHEM3901 Environmental Toxicology | |

[2] https://www.science.unsw.edu.au/future-students/graduate-attributes

## 1.6 Rationale and strategies underpinning the course

| | | |
|---|---|---|
| **Teaching Strategies** | The structure of the course is built around the lectures and associated readings indicated by the staff. This content will be supplemented by the student seminars on diverse geochemical topics. The concepts discussed in the lectures are then reinforced through both the laboratories and (in a normal year) fieldwork. | |
| **Rationale for learning and teaching in this course** | **Guidelines on teaching:** | ***Application to Course:*** |
| | A climate of enquiry should be developed where students fell challenged | *Emphasis of the complexity of geochemical systems – what is known and what is not known* |
| | Activities should be interesting and challenging | *Fieldwork involves students in planning. Focus on practical experiences.* |
| | Material must be perceived as relevant to future study or professional practice | *Lab and field exercises are based on typical projects that young professionals would undertake.* |
| | There must be dialogue/ interaction between lecturers and students | *Some of the teaching (especially labs) will follow a classical Greek dialectic approach* |
| | There should be multiple teaching methods | *Lectures, labs, fieldwork, readings* |
| | Goals, outcomes and requirements of the course must be clearly articulated | *The relevance of each topic and the purpose and outcomes of the prac work will be discussed* |
| | Students are to be encouraged to take responsibility for own learning | *"The pitch" and seminars require students to undertake largely undirected lit. review; students to determine nature of data analysis to be performed on prac data* |
| | Broad graduate attributes must be developed | *See above* |
| | Co-operative work with peers assists learning | *Some of the work is group-based, though reporting is individual (no exam)* |
| | There must be informative and timely feedback to students on progress. | *See how we go with the shortened term. Some formative assessments in weeks 2 and 3.* |

## 1.7 Course schedule

| Wk | Cpt | Lecture Component | Recorded lectures | Live session | Key readings | Lect | Wed | | | Assignment | Exercise | % | Due |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.1 | **Introduction to the course** | Course outline | Course outline | | DRC | **1-Jun** | 9:00 | 1:00 | | Ex 1. Regolith | | |
| | 1.2 | | Overview of applied geochem | | Smith & Huyck 1999 | | | | | | | | |
| | 2.1 | **Converting rocks to regolith** | Weathering processes | Intro to regolith exercise | Cudahy 2016 | | | | | | | | |
| | 2.2 | | Regolith and landform classif. | | Anand & Butt 2010 | | | | | | | | |
| | 2.3 | | Geochemical dispersion | | Butt et al. 2000 | | | | | | | | |
| 2 | 3.1 | **Geochemical processes in water** | Aqueous systems | Minteq recap | | DRC | **8-Jun** | 9:00 | 9:30 | Assignment 1. Modelling with Minteq | Quick look at Excel graphs | 15 | 17-Jun |
| | 3.2 | | Aqueous modelling | Modelling in Minteq (Lab intro) | Twiss et al 2001 | | | 9:30 | 1:00 | | | | |
| | 3.3 | | | | | | | | | | | | |
| 3 | 4.1 | **Sampling, analysis and quality control** | Sampling options | | Cohen et al 2005; Marshall & Bettenay 2006 | DRC | **15-Jun** | 9:00 | 10:30 | | ALS brochure | | |
| | 4.2 | | Analytical options | Intro to QC assignment | Sader & Ryan 2017; Lumiere | | | 10:30 | 1:00 | Assignment 2. Quality control | | 15 | 24-Jun |
| | 4.3 | | Quality control | | | | | | | | | | |
| 4 | 5.1 | **Geochemical mapping** | Geochemical mapping | Intro to geochem mapping | Reimann & Caritat 2017 | DRC and HZ | **22-Jun** | 9:00 | 1:00 | | Ex 2. Brief intro to ArcGIS (& QGIS) | | |
| | 5.2 | | Australian national soil atlas | | | | | | | | | | |
| | 5.3 | | NRAC stream sed atlas | | | | | | | Assignment 3. Geochemical mapping | | 20 | 1-Jul |
| | 5.4 | | Cyprus case study - background | | | | | | | | | | |
| | 5.5 | | - design | | | | | | | | | | |
| | 5.6 | | - some results | | Cohen et al. 2012 | | | | | | | | |
| 5 | 7.1 | **Acid and metalliferous drainage** | Geochemistry of AMD | | Johnson & Hallberg 2005 | MvdL / DRC | **29-Jun** | 9:00 | 10:00 | | Intro to SC data | | |
| | 7.2 | | Remediation approaches | | | | | 10:00 | 1:00 | Assignment 4. Sunny Corner gp exercise | | 25 | 22-Jul |
| | 7.3 | | Sunny Corner | Overview of Sunny Corner | Hager et al 2013 | | | | | | | | |
| 6 | | **FLEX WEEK** | | | | | | | | | | | |
| 7 | 10.1 | **Data analysis** | EDA and univariate methods | | Caritat & Grunsky 2017; Grunsky 2007 | DRC and HZ | **13-Jul** | 9:00 | 11:00 | Assignment 4 ctd. | | | |
| | 10.2 | | Multivariate methods | | Reimann et al. 2005; Cheng et al 1999 | | | 11:00 | 1:00 | | Ex 3. Data analysis | | |
| 8 | 9.1 | **Geochemistry in mineral exploration** | Introduction to GX | Introduction to GX | Cohen & Bowell 2007; Winterburn et al. 2017 | DRC | **20-Jul** | 9:00 | 1:00 | | Ex 4. Mineral exploration applications | | |
| | 9.2 | | Litho, soil and sediments in GX | | McClenaghan et al. 2000; Day & Fletcher 1986 | | | | | | | | |
| | 9.3 | | Problem of cover in GX | | Mokhtari et al 2009; Busgard et al 2017 | | | | | | | | |
| | 9.4 | | Biogeochemistry in GX | | Rinchval et al. 2019; Cohen et al. 2021 | | | | | | | | |
| | 8.1 | | Contamination in urban environs | | | | | | | | | | |
| 9 | 6.1 | **Isotope applications** | | | Kuyser et al. 2017 | MvdL | **27-Jul** | 9:00 | 11:00 | | Ex 5. Isotopes | | |
| | 6.2 | **Periodic Table - a tutorial** | The Periodic Table | | | | | 11:00 | 1:00 | | Ex 6. Iodine | | |
| 10 | 11.1 | **Student presentation** | Assignment 6. Seminars | | Hagan and Mort 2015 | DRC and HZ | **3-Aug** | 9:00 | 1:00 | Assignment 5. Seminars | | 25 | 3-Aug |

## 1.8 Course evaluation and development

Student feedback is gathered periodically by various means. Such feedback is considered carefully with a view to acting on it constructively wherever possible.

| Mechanisms of Review | Last Review Date | Comments or Changes Resulting from Reviews |
|---|---|---|
| **Major Course Review** | Feb 2011 | With the change from 14 to 12 weeks and increased class size, chemical laboratory work has been replaced by field testing techniques and a reduction in the number of case studies. Introduction of additional computer-based labs. |
| | Oct 2018 | Major revisions to topic balance following from the UNSW3+ transition. |
| | Oct 2019 | Revision to volume of summative assessments in favour of formative assessments. |
| | 2020 | Conversion of course to online mode due to COVID-19 |
| **CATEI or myExperience** | 2012 | Students were generally satisfied with all aspects of the course, including general subject content, delivery, field and laboratory work, assignments, assessment methods and implementation. There were no major concerns over the amount of assignment work. |
| | 2015 | As above but requesting closer links between lecture and lab content. |
| | 2017 | Increased use of in-class discussions. Modification of Sunny Corner assignment to maintain groupwork but limit group assessment. |
| | 2019 | No significant issues |
| | 2021 | No significant issues – online mode worked reasonably well. |
| **Other** | 2007 | Major course revision and discussion of course content with members of Association of Applied Geochemists. |
| | 2013 | Changes to field-based exercises with deletion of the Engine Pond sampling |
| | 2015 | Swap long essay for a lab exercise |
| | 2016 | Extended mineral exploration exercise and new isotopes exercise |
| | 2017 | Change of field exercise to test AMD neutralisation |
| | 2018 | Introduction of new lab on regolith mapping and geochemical interpretation |
| | 2019 | Slight modifications of schedule to the UNSW3+ model with reduction in lectures in favour of more practical work<br><br>Introduced “the pitch” exercise. |
| | 2020 | Main lecture content moved online. |
| | 2022 | Some additional background exercises (e.g. intro to QGIS) |

## 1.9 Other administration matters

| | | | |
|---|---|---|---|
| **Expectations of Students** | Viewing lectures, attending labs and (when run) the field excursions is required.<br>Computer labs are available (pending COVID-19 measures) for student use whenever the labs are not being used for teaching but software is available by remote access.<br>www.bees.unsw.edu.au/current/studentoffice.html and<br>www.bees.unsw.edu.au/current/ugradguidelines.html | | |
| **Assessment components** | Laboratory assignments (3) 50%<br>Sunny Corner report 25%<br>Seminar 25% | | |
| **Assignment Submissions** | Assignments and reports must be submitted on time. No extensions will be permitted (apart from the normal UNSW provisions).<br>Completed assignments must be submitted via Moodle **by the due date**.<br>Penalties for late submission apply and will be a reduction in the maximum mark of 10% per day, with assignments 7 days overdue not accepted. | | |
| WHS | **See Section 4** | | |
| **Field Excursion** | Not included in 2021 or 2022 delivery | | |
| **Assessment Procedures** | Normal UNSW rules apply to illness, misadventure or other situations which affect attendance at class or submission of assessment tasks. | | |
| **Equity and Diversity** | Students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss study needs with the course Convenor prior to the course commencing, or with the Equity Officer (Disability) in the Equity and Diversity Unit. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made. | | |
| **Grievance Policy** | **School Contact** | **Faculty Contact** | **University Contact** |
| | A/Prof Scott Mooney<br>Deputy Head of School<br>s.mooney@unsw.edu.au | A/Prof Alison Beavis<br>Deputy Dean (Education) | University Counselling Services<br>Tel: 9385 5418 |

# 2 ASSESSMENT

## 2.1 Assessment tasks and feedback

| Task | Knowledge & abilities assessed | Assessment Criteria | % of total mark | Date of | | Feedback | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Release | Submission | Who | When | Where |
| Lab Assignments | Use of software packages<br>Data manipulation and visualisation<br>Mathematical skills (to standards of BEES2041)<br>Modelling of simple aqueous systems<br>Interpretation of data in light of existing geological/geochemical theory and models<br>Technical report writing | See table below | 50 | Moodle | See page 2 | Lecturers | On return of assignments, etc | Written comments |
| Lab Exercises | Rapid synthesis of data<br>Presentation and argument skills | | 0 (formative) | | | | | |
| Field study report | Applications of geochemistry to acid mine drainage problems<br>Fieldwork skills (not in 2020 due to suspension of fieldwork)<br>Synthesis of data<br>Group work (but minimal group marking)<br>Concise technical report writing | | 25 | | | | | |
| Seminar | Scientific literacy and information acquisition<br>Synthesis of information<br>Visual presentation skills<br>Speaking skills | | 25 | | Schedule to be advised | | | |

## 2.2 General marking criteria

| *Component* | *Pass / Credit* | *Distinction / High Distinction* |
|---|---|---|
| ***Laboratories (50%)***<br><br>***Summative and formative exercises*** | Basic processing of data and demonstrated capacity to use software packages.<br>Adequate presentation of results.<br>Basic data interpretation and the drawing of conclusions from results.<br>Use of clear technical English in reports. Correct use of referencing. | Higher level processing, manipulation and modeling of results.<br>Superior skills in presentation of results.<br>Detailed interpretation of results drawing out most of the key features of the data as they relate to the problems posed.<br>Use of clear technical English in reports. Correct use of referencing. |
| ***The pitch (part of the laboratories)***<br>***(not included in 2022)*** | Basic synthesis of a complex dataset<br>Development and presentation of reasonable arguments in the pitch<br>Ability to answer basic questions | More critical analysis of the complex data and consideration of alternative interpretations<br>Strong arguments in the pitch taking the data and risks into accounts<br>Ability to handle more probing questions |
| ***Field Report (25%)*** | Adequate description of work done, in both field and laboratory.<br>Adequate presentation of results.<br>Basic data interpretation and the drawing of key conclusions from results.<br>Use of clear technical English and effective structure | Detailed description of all key aspects of work done in field and laboratory with some explanation of their significance in the study.<br>Superior skills in presentation of results.<br>Detailed interpretation of results drawing out most of the key features of the data and extending beyond the directions of course staff.<br>Reference to key literature to support interpretation.<br>Use of clear technical English and effective structure in reports. |
| ***Seminar (25%)*** | Some demonstration of capacity to generate own slides, with necessary clarity and relevance to topic.<br>Capacity to engage audience with the oral presentation.<br>Good technical content. Correcting timing.<br>Ability to answer questions. | Creation of high visual impact slide material.<br>Capacity to enthuse audience with the oral presentation.<br>High levels of technical content.<br>Good balance between components of presentation – introduction, data, and conclusions.<br>Correct timing.<br>Ability to answer questions. |

# 3 ADDITIONAL RESOURCES AND SUPPORT

## 3.1 Moodle

Online and recorded lectures, data for laboratories and key readings.

## 3.2 Journals and Websites

***Applied Geochemistry***

The official journal of the International Association of Geochemistry and Cosmochemistry. Geochemistry and cosmochemistry which have some practical application to an aspect of human endeavour, such as environmental monitoring, agriculture, health, waste disposal and the search for resources. Topics covered include: environmental geochemistry, hydrogeochemistry, surface water and groundwater, medical geochemistry, agricultural geochemistry, the search for energy and mineral deposits and waste disposal including the specific topic of nuclear waste disposal.

***Chemical Geology***

The official journal of the European Association for Geochemistry and covers the fields of organic and inorganic geochemistry, and chemical geology, including: low temperature geochemistry, organic/petroleum geochemistry, inorganic geochemistry, analytical techniques, isotope studies, environmental geochemistry, and experimental petrology and geochemistry. Its website provides contents lists and abstracts; access to full text is restricted to subscribers.

***Environmental geochemistry and health***

Official Journal of the Society for Environmental Geochemistry and Health, examines links between the chemical composition of rocks and minerals and the health of plants, animals and people. Bedrock geochemistry controls on the composition of soil, water and vegetation. Pollution, arising from the extraction and use of mineral resources, geochemical surveys of soil, water and plants, epidemiological studies.

***Geochimica et Cosmochimica Acta***

A journal of the Geochemical Society and the Meteoritical Society, which publishes research subject papers on terrestrial geochemistry, meteoritics, and planetary geochemistry. The main fields covered by the journal are: physical chemistry of gases, aqueous solutions, glasses, and crystalline solids; igneous and metamorphic petrology; chemical processes in the atmosphere, hydrosphere, biosphere, and lithosphere of the Earth; organic geochemistry; isotope geochemistry; meteoritics and meteorite impacts.

***Journal of Geochemical Exploration***

Published quarterly by Elsevier, covers environmental and economic geochemistry. It includes all aspects of the geochemistry of the environment and the application of geochemistry to the exploration and study of mineral resources and related fields. Its main topics are: geochemical exploration; sampling and analytical techniques and methods of interpretation; processes of geochemical dispersion in rocks, soils, vegetation, water and the atmosphere; and geochemical distributions in and around mineralised environments. Similar to GEEA in scope.

***Geochemistry: Exploration , Environment and Analysis***

The official journal of the Association of Applied Geochemists. Published quarterly by The Geological Society of London, covers environmental and economic geochemistry. It includes all aspects of the geochemistry of the environment and the application of geochemistry to the exploration and study of mineral resources and related fields. Similar to J. Geochem. Explor. in scope.

***Organic Geochemistry***

Official Journal of the European Association of Organic Geochemists and covers research on all phases of geochemistry in which organic compounds play a major role (including molecular and isotopic geochemistry); geology, biogeochemistry, environmental geochemistry, chemical oceanography and hydrology. The scope of the journal includes research involving petroleum (including natural gas) coal, organic matter in the aqueous environment and recent sediments, organic-rich rocks and soils and the role of organics in the geochemical cycling of the elements.

***Science of the Total Environment***

Papers covering changes in the natural level and distribution of chemical elements and compounds which may affect the well-being of the living world, and ultimately harm man himself. Emphasis is given to applied environmental chemistry. The subjects covered include: (a) application of techniques and methods of chemistry and biochemistry to environmental problems (b) pollution of the air, water, soil and

various aspects of human nutrition (c) environmental medicine, when the effect of abnormalities in the level and distribution of chemical elements and compounds are given prominence (d) the use of interdisciplinary methods in studies of the environment (e) environmental planning and policy.

**Geochemistry on the World Wide Web**

This site contains a broad set of links to geochemistry-based web sites. Categories include professional societies, journals, geochemical data, geochemical standards, government and university laboratories and cosmochemistry, astronomy and planetology. This site is a useful starting point for identifying web-based geochemistry resources in all geochemical fields, e.g. volcanology, organic, mineralogy, isotope geochemistry and cosmochemistry.
http://www.geo.cornell.edu/geology/classes/Geochemweblinks.HTML

## 3.3 Interactive periodic tables

http://www.ptable.com/ http://www.webelements.com/
http://www.rsc.org/chemsoc/visualelements/pages/pertable_fla.htm
http://www.appliedgeochemists.org/ChemElements/elements.html

## 3.4 References

Key papers are provided on the Moodle Website. These should be read ahead of the relevant section of the course.

A list of other references to material used in the course and other papers that may be of use are provided on the Moodle website.

| Section | Paper |
|---|---|
| 1.2 – Overview | Smith KS & Huyck HLO, 1999. An overview of the abundance, relative mobility, bioavailability, and human toxicity of metals. Reviews in Econ. Geol. 6A and 6B. Ch 2. 29-70. |
| 2.1 – Weathering processes | Cudahy T, 2016. Mineral mapping for exploration: An Australian journey of evolving spectral sensing technologies and industry collaboration. Geosciences, 6, 52. |
| 2.2 – Regolith and landforms | Anand RR & Butt CRM, 2010. A guide for mineral exploration through the regolith in the Yilgarn Craton, Western Australia. Australian Journal of Earth Sciences, 57, 1015–1114 |
| 2.3 – Geochemical dispersion | Butt CRM et al., 2000. Evolution of regoliths and landscapes in deeply weathered terrain - Implications for geochemical exploration. Ore Geology Reviews, 16, 167–183. |
| 3.2 – Aqueous modelling | Twiss MR et al., 2001. Coupling the use of computer chemical speciation models and culture techniques in laboratory investigations of trace metal toxicity. Chemical Speciation & Bioavailability, 13, 9-24 |
| 4.1 – Sampling | Cohen DR et al, 2005. Contrasting dispersion patterns for gold in stream sediments at Timbarra, NSW, Australia. Journal of Geochemical Exploration, 85, 1 –16<br>Marshall A & Bettenay L, 2006. RAB drilling and RAB geochemistry: An Australian perspective. Explore, 130, 1-7. |
| 4.2 – Analytical options | Sader & Ryan, 2017. Advances in ICP-MS technology and the application of multi-element geochemistry to exploration. Geochemistry: Exploration, Environment, Analysis, 20, 167-175.<br>Lumiere B & Uvarova YA, 2020. New developments in field-portable geochemical techniques and on-site technologies and their place in mineral exploration. Geochemistry: Exploration, Environment, Analysis, 20, 205-216. |

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| 5.2 – Geochemical mapping | Reimann D & Caritat P, 2017. Establishing geochemical background variation and threshold values for 59 elements in Australian surface soil. Science of the Total Environment, 578, 633–648 |
| 5.6 – Cyprus geochemistry | Cohen DR et al., 2012. Anthropogenic versus lithological influences on soil geochemical patterns in Cyprus. Geochemistry: Exploration, Environment, Analysis, 12, 349 –360 |
| 6.1 – Isotopes | Kuyser K et al., 2017. Advances in the use of isotopes in geochemical exploration: Instrumentation and applications in understanding geochemical processes. Geochemistry: Exploration, Environment, Analysis, 20, 199-204. |
| 7.1 – Acid and metalliferous drainage | Johnson & Hallberg, 2005. Acid mine drainage remediation options: a review. Science of the Total Environment, 338, 3– 14 |
| 7.3 – Sunny Corner | Hager et al, 2013. The silver mines of Sunny Corner, New South Wales. Australian Journal of Mineralogy, 17, 45-51. |
| 8.1 – Urban contamination | Johnson C & Anders EL, 2007. Urban geochemical mapping studies: how and why we do them.<br>Caritat P & Reimann C, 2000. Intrinsic flaws of Element enrichment factors (EFs) in environmental geochemistry. Environmental Science and Technology, 34, 5084-5091. |
| 9.1 – Intro to geochem. exploration | Cohen DR & Bowell R, 2007. Exploration Geochemistry. Treatise on Geochemistry. Elsevier Vol 13.<br>Winterburn P et al., 2017. Advances in exploration geochemistry, 2007 to 2017 and beyond. Geochemistry: Exploration, Environment, Analysis, 20, 157-166. |
| 9.2 – Litho, soils and seds in GX | McClenaghan MB et al., 2000. Till geochemical and indicator mineral methods in mineral exploration. Ore Geology Reviews, 16, 145–166<br>Day S & Fletcher K, 1986. Size and abundance of gold in selected stream sediments, southern British Columbia, Canada. Journal of Geochemical Exploration, 26, 203-214. |
| 9.3 – Problem of cover in GX | Mokhtari AR et al., 2009. Geochemical effects of deeply buried Cu_Au mineralization on transported regolith in an arid terrain. Geochemistry: Exploration, Environment, Analysis, 9, 227-236<br>Busgard J et al., 2017. Parts per trillion (ppt) gold in groundwater: can we believe it, what is anomalous and how do we use it? Geochemistry: Exploration, Environment, Analysis, 20, 189-198. |
| 9.4 – Biogeochemistry in GX | Rinchval M et al., 2019. Biogeochemical mapping of metal contamination from mine tailings using field-portable XRF. Science of the Total Environment, 662, 404–413<br>Cohen DR and Dunn CE, 2004. Form and distribution of trace elements in biomass for power generation. CRC for Coal in Sustainable Development. Rpt 48. |
| 10.1 – EDA | Caritat P & Grunsky EC, 2017. State-of-the-art analysis of geochemical data for mineral exploration. Geochemistry: Exploration, Environment, Analysis, 20, 217-232.<br>Grunsky EC, 2007. The Interpretation of Regional Geochemical Survey Data. Advances in Regional-Scale Geochemical Methods.<br>Proceedings Exploration '07. 139-182. |
| 10.2 – Multivariate | Reimann C et al., 2005. Background and threshold: critical comparison of methods of determination. Science of the Total Environment, 346, 1– 16<br>Cheng Q et al., 1999. Spatial and scaling modelling for geochemical anomaly separation. Journal of Geochemical Exploration, 65, 175–194 |
| 11.2 – Report writing | Hagan P and Mort P, 2015. Report Writing Guide. Mining Education Australia. 9th Ed. |

# 5 WORK HEALTH & SAFETY OBLIGATIONS

The School of BEES recognises its obligations to provide a safe working environment for all persons involved in School-related activities. To achieve this goal with regards to teaching and learning, the School adopts the UNSW Occupational Health and Safety Policy (2015). This policy stipulates that everyone attending a UNSW workplace must ensure their actions do not adversely affect the health and safety of others. This outcome is achieved through the establishment of a documented chain of responsibility and accountability for all persons in the workplace, extending from the Head of School through to the students undertaking courses offered.

As part of this chain of responsibility and accountability, the Course Authority is responsible for ensuring all activities associated with this course are safe. The Course Authority has undertaken detailed risk assessments of all course activities and identified all associated potential hazards. These hazards have been minimised and appropriate steps taken to ensure your health and safety. For each activity, clear written instructions are given and appropriate hazard warnings or risk minimisation procedures included for your protection.

It is the student's responsibility to prepare for all practical work. Students should be familiar with the written procedures scheduled for the practical class and identify all personal protection requirements needed to complete the exercise in a safe manner. Students must comply with all safety instructions given by the Course Authority and/or Laboratory / Field Demonstrator, and observe the Safety Information located outside or within teaching rooms. If you are unsure of any safe operating procedures or written instruction regarding safety, you should seek further information from the Course Authority and/or Laboratory / Field Demonstrator before attempting the task. Failure to comply with safety instructions may, in the first instance, be considered as a form of academic misconduct. If the outcome of a student's failure to comply with safety instructions results in personal injury, or endangers the health and safety of others, then the matter may be dealt with by WorkCover as a breach of the NSW OH&S Act (2000).

## 5.1 Conditions of entry to courses

To abide with Section 17 (1) (Persons in control of workplaces etc, used by non-employees to ensure health and safety) and Section 19 (Employees at work to take care of others and to co-operate with employer) of the **N.S.W. Occupational Health & Safety Act (1983):**

1. (a) All persons entering UNSW property are required to wear sturdy shoes at all times. Thongs, sandals and open toed shoes are not acceptable; porous topped footwear (e.g. canvas joggers) are not safe for wear in chemical laboratories.
   (b) Sturdy footwear is required on all field excursions and boots are strongly recommended.
2. (a) Safety glasses, masks, gloves, helmets and/or ear muffs must be worn when provided by supervising staff. Students must wear laboratory coats and safety glasses in chemical laboratories.
   (b) Students must be in possession of approved safety goggles and must wear them when within 3 metres of anyone hammering rocks.
3. Students will be required to complete medical forms ahead of field trips. This information will be strictly confidential to staff members.
4. All students taking field excursions are expected to have had a *Tetanus* injection within the last 10 years. These injections are readily available at the Student Health Centre.
5. (a) The University of New South Wales is a **smoke-free work environment,** which means that smoking is prohibited inside all Buildings in the University.
   (b) Alcohol and smoking are not permitted in University vehicles nor in vehicles hired by the University for field excursions.
6. Students are advised to lodge the name, address, email and telephone number of next of kin with the school.

Special conditions relating to the COVID-19 pandemic are in place, and may vary from time to time.

**ENTRY TO SCHOOL BUILDINGS, AND ATTENDANCE ON FIELD EXCURSIONS, WILL BE DENIED TO STUDENTS WHO DO NOT ABIDE BY THESE CONDITIONS.**

**Professor Alistair Poore, Head of School**

# 6 UNSW ACADEMIC HONESTY AND PLAGIARISM

**What is Plagiarism?**

Plagiarism is the presentation of the thoughts or work of another as one's own.
Examples* include:

- direct duplication of the thoughts or work of another, including by copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person's assignment without appropriate acknowledgement;
- paraphrasing another person's work with very minor changes keeping the meaning, form and/or progression of ideas of the original;
- piecing together sections of the work of others into a new whole;
- presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a tutor; and
- claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed.†

For the purposes of this policy, submitting an assessment item that has already been submitted for academic credit elsewhere may be considered plagiarism.

Knowingly permitting your work to be copied by another student may also be considered to be plagiarism.

Note that an assessment item produced in oral, not written, form, or involving live presentation, may similarly contain plagiarised material.

The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does *not* amount to plagiarism.

The Learning Centre website is main repository for resources for staff and students on plagiarism and academic honesty. These resources can be located via:

https://student.unsw.edu.au/**plagiarism** and https://student.unsw.edu.au/all-about-contract-cheating

The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- correct referencing practices;
- paraphrasing, summarising, essay writing, and time management;
- appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

Individual assistance is available on request from The Learning Centre.

Students are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting, and the proper referencing of sources in preparing all assessment items.

* Based on that proposed to the University of Newcastle by the St James Ethics Centre. Used with kind permission from the University of Newcastle. † Adapted with kind permission from the University of Melbourne

# 7 ASSIGNMENTS

A series of assignments will be complete during the laboratory sessions and outside lab time. Their objective is to provide practical experience with various aspects of geochemistry, including use of various computer packages.

The laboratory sessions set aside to assist with the assignments are designed to be done in pairs or even larger groups, however all assignments except the Sunny Corner reports need to be completed individually.

## 7.1 Laboratory assignments (50%)

**Assignment 1: MINTEQ aqueous modelling**

Objectives: To apply an aqueous speciation modeling package to interpret water geochemical data.

Submission: Individual students.

**Assignment 2: Analytical quality control**

Objective: To undertake a practical Ex in determining the analytical quality of geochemical datasets.

Submission: Individual students.

**Assignment 3: Mapping geochemical data**

Objective: To undertake a practical Ex in mapping geochemical data using ArcGIS.

Submission: Individual students

## 7.2 Report on Sunny Corner (25%)

Objectives: Investigate the environmental conditions of a former base metal mine, conduct a geochemical survey of the stream system in the vicinity of the mine.

Submission: Small groups (but individual assessment dominant).

## 7.3 Seminar (25%)

**Topic:** You will be presenting solo.

You are free to select a topic (by Wk 8) from any aspect of environmental or exploration geochemistry. The actual topic selected must be approved by Prof Cohen.

**Task:** For the selected topic present synopsis in a format that is informative and entertaining.

**Objective:** To improve skills at oral presentations.

**Time:** 10 minutes each (including questions and change-over). (Typically 10 to 12 slides max)

**Format:** Live presentation (or digital if you are off campus).

**Date:** Presentations to be made in Week or 10. Timeslot will be issued randomly.