

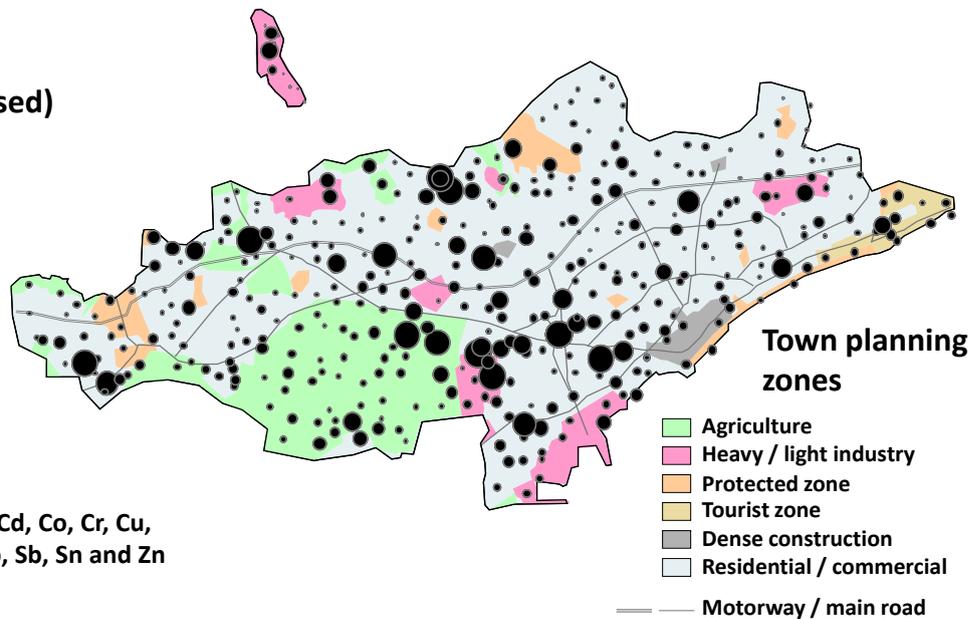


FACULTY OF SCIENCE
SCHOOL OF BIOLOGICAL, EARTH
and ENVIRONMENTAL SCIENCES

CPI Index (Sr normalised)

- <2 Low
- 2 - 4 Moderate
- 4 - 8 High
- 8 - 16 Very High
- >16 Extreme to ultra high

Element suite: Ag, As, Bi, Cd, Co, Cr, Cu,
Hg, Mo, Pb, Sb, Sn and Zn



GEOS3281

Applied Geochemistry

Course Manual

Term 2, 2021

Prof David Cohen, course convener

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

GEOS3281

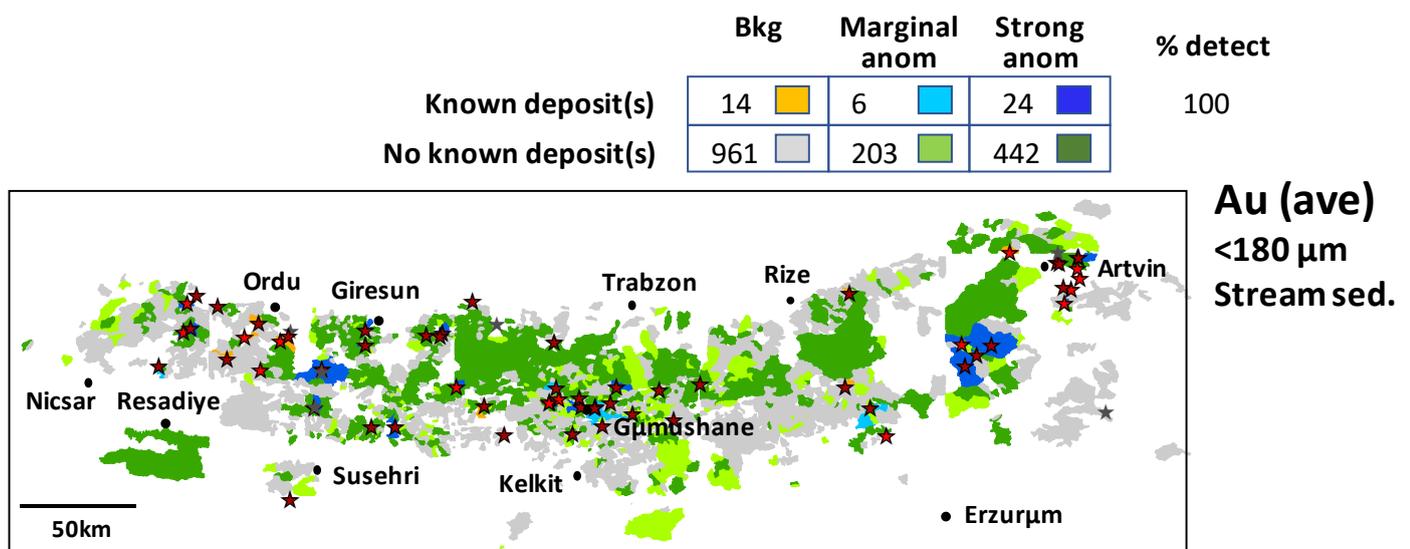
Applied Geochemistry

Term 2, 2021

6 units of credit

Important Dates

WEEK	DAY	DATE	DETAILS
Wk 3	Fri	18-Jun	Assignment 1: Modelling with Minteq (due)
Wk 4	Fri	25-Jun	Assignment 2: Quality control (due)
Wk 5	Fri	2-Jul	Assignment 3: Geochemical mapping (due)
Wk 8	Fri	23-Jul	Assignment 4: Sunny Corner group exercise (due)
Wk 9	Wed	28-Jul	Assignment 5: The Pitch (presentation made)
Wk 10	Wed	4-Aug	Assignment 6: Seminar (presentation made)



1 INFORMATION ABOUT THE COURSE

1.1 General

Year of Delivery	2021			
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: Courses: Level 1 GEOS or CHEM Geology: Basic mineralogy and lithology; Chemistry: HSC-level knowledge of the periodic table; bonding; pH-Eh, redox and acid-base reactions. Maths: Basic statistics (e.g. MATH1041 or BEES2041).			
Hours per Week	6 (including online lecture component)			
Number of Weeks	10			
Commencement Date	Wednesday 2 June			
Summary of Course Structure (for details see 'Course Schedule')				
Component	HPW	Time	Day	Location
Lectures (recorded)	~2			Moodle
Laboratory 1	2	10:00 – 11:50	Wednesday	Tch Lab 5
Laboratory 2	2	12:10 – 2:00	Wednesday	Tch Lab 5
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 d.cohen@unsw.edu.au	As agreed
Additional Teaching Staff	Lecturers	Mira van der Ley		
	Demonstrators			
	Technical staff	Mira van der Ley		

1.3 Course details¹

<p><u>Course Description</u></p>	<p>Overview</p> <p>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. <i>Geochemistry</i> 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.</p> <p>Scope</p> <p>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.</p>
<p><u>Course Aims</u></p>	<p>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.</p>
<p><u>Student Learning Outcomes</u></p>	<p>Domains:</p> <p>Fundamental principles → Survey design and implementation → Data modelling and interpretation → Environmental policy and management; Mineral exploration</p> <p><i>Acquisition of knowledge</i> → <i>Application to theory</i> → <i>Application to practice</i> → <i>Communication to others</i></p> <p>Labwork will provide practical skills in a range of geochemical methods. The course also emphasises the development of:</p> <ul style="list-style-type: none"> Oral presentational skills and report writing Project planning and management, including data handling Group working, co-ordination and delegation <p>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. Specifics are set out in the table below.</p>

¹ UNSW Virtual Handbook: <https://www.handbook.unsw.edu.au/undergraduate/courses/2020/GEOS3281>
 GEOS3281 Manual – 2019

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 course²

<u>Science Graduate Attributes</u>	Level of Focus <i>1 = minimal</i> <i>2 = minor</i> <i>3 = major</i>	Activities / Assessment
Research, inquiry and analytical thinking abilities	3	Literature reviews and critique of papers. 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	<p>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: level 1 courses in GEOS and CHEM GEOS2181 Earth Materials</p> <p>The course is complementary to the following courses: GEOS2291 Earth Interconnections GEOS2721 Aust Surface Environments and Landforms GEOS3141 Mineral and Energy Resources GEOS3911 Environmental Impact Assessment CHEM3041 Analytical Chemistry CHEM3311 Environmental Chemistry</p>	

² <https://www.science.unsw.edu.au/future-students/graduate-attributes>
GEOS3281 Manual – 2019

1.6 Rationale and strategies underpinning the course

<p>Teaching Strategies</p>	<p>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.</p>	
<p>Rationale for learning and teaching in this course</p>	<p>Guidelines on teaching:</p> <p>A climate of enquiry should be developed where students feel challenged</p> <p>Activities should be interesting and challenging</p> <p>Material must be perceived as relevant to future study or professional practice</p> <p>There must be dialogue/ interaction between lecturers and students</p> <p>There should be multiple teaching methods</p> <p>Goals, outcomes and requirements of the course must be clearly articulated</p> <p>Students are to be encouraged to take responsibility for own learning</p> <p>Broad graduate attributes must be developed</p> <p>Co-operative work with peers assists learning</p> <p>There must be informative and timely feedback to students on progress.</p>	<p>Application to Course:</p> <p><i>Emphasis of the complexity of geochemical systems – what is known and what is not known</i></p> <p><i>Fieldwork involves students in planning. Focus on practical experiences.</i></p> <p><i>Lab and field exercises are based on typical projects that young professionals would undertake.</i></p> <p><i>Some of the teaching (especially labs) will follow a classical Greek dialectic approach</i></p> <p><i>Lectures, labs, fieldwork, readings</i></p> <p><i>The relevance of each topic and the purpose and outcomes of the prac work will be discussed</i></p> <p><i>“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</i></p> <p><i>See above</i></p> <p><i>Some of the work is group-based, though reporting is individual (no exam)</i></p> <p><i>See how we go with the shortened term. Some formative assessments in weeks 2 and 3.</i></p>

1.7 Course schedule

Wk	Cpt	Lecture Component	Recorded lectures	Live session	Key readings	Lect	Wed		Assignment	Exercise	Discussion	Assessment		Due		
												Form	Summ			
1	1.1	Introduction to the course	Course outline	Course outline	Smith & Huyck 1999	DRC	2-Jun	10:00 11:00			DDT debate					
	1.2		Overview of applied geochem								Pb in Rome					
	2.1	Converting rocks to regolith	Weathering processes	Intro to regolith exercise	Cudahy 2016			11:00 2:00			Ex 1. Regolith mineralogy and geochem				Discussion	X
	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	Modelling in Minteq (Lab intro)	Twiss et al 2001	DRC	9-Jun	10:00 10:30	Minteq recap				15	18-Jun		
	3.2		Aqueous modelling												10:30 2:00	Assignment 1. Modelling with Minteq
	3.3															
3	4.1	Sampling, analysis and quality control	Sampling options	Intro to QC assignment	Cohen et al 2005; Marshall & Bettenay 2006	DRC	16-Jun	10:00 10:30	ALS brochure				15	25-Jun		
	4.2		Analytical options												10:30 2:00	Assignment 2. Quality control
	4.3		Quality control													
4	5.1	Geochemical mapping	Geochemical mapping	Intro to geochem mapping assignment	Reimann & Caritat 2017	DRC	23-Jun	10:00 11:00					20	2-Jul		
	5.2		Australian national soil atlas													
	5.3		NRAC stream sed atlas													
	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	Overview of Sunny Corner	Johnson & Hallberg 2005	MvdL / DRC	30-Jun	10:00 11:00	Intro to SC data				20	23-Jul		
	7.2		Remediation approaches						11:00 2:00						Assignment 4. Sunny Corner gp exercise	
	7.3		Sunny Corner													
6	FLEX WEEK															
7	6.1	Isotope applications			Kuyser et al. 2017	MvdL	14-Jul	10:00 11:00	Assignment 4. ctd							
	6.2	Periodic Table - a tutorial	The Periodic Table					11:00 1:00	Ex 3. Isotopes						X	
8	9.1	Geochemistry in mineral exploration	Introduction to GX	Introduction to GX	Cohen & Howell 2007; Winterburn et al. 2017 McClenaghan et al. 2000; Day & Fletcher 1996 Mokhtari et al 2009; Busgard et al 2017 Rinchval et al. 2019; Cohen et al. 2021	DRC	21-Jul	10:00 2:00						X		
	9.2		Litho, soil and sediments in GX													
	9.3		Problem of cover in GX													
	9.4		Biogeochemistry in GX													
	8.1		Contamination in urban environs													
9	10.1	Data analysis	EDA and univariate methods		Caritat & Grunsky 2017; Grunsky 2007	DRC	28-Jul	10:00 11:00	Assignment 5. The Pitch				10	28-Jul		
	10.2		Multivariate methods						12:00 2:00						Ex 6. Data analysis	X
10	11.1	Project design	Pulling it all together			DRC	4-Aug	10:00 2:00	Assignment 6. Seminars				20	4-Aug		
	11.2	Student presentation	Assignment 6. Seminars		Hagan and Mort 2015											

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 an 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
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 Introduced “the pitch” exercise.
	2020	Main lecture content moved online.

1.9 Other administration matters

Expectations of Students	Viewing lectures, attending labs and (when run) the field excursions is required. 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. www.bees.unsw.edu.au/current/studentoffice.html and www.bees.unsw.edu.au/current/ugradguidelines.html		
Assessment components	Laboratory assignments (4)	60%	
	Sunny Corner report	20%	
	Seminar	20%	
Assignment Submissions	Assignments and reports must be submitted on time. No extensions will be permitted (apart from the normal UNSW provisions). Completed assignments must be submitted via Moodle by the due date . 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 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.		
<u>Grievance Policy</u>	School Contact	Faculty Contact	University Contact
	A/Prof Scott Mooney Deputy Head of School s.mooney@unsw.edu.au	A/Prof Alison Beavis Deputy Dean (Education)	University Counselling Services 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 Data manipulation and visualisation Mathematical skills (to standards of BEES2041) Modelling of simple aqueous systems Interpretation of data in light of existing geological/geochemical theory and models Technical report writing	See table below	60	Moodle	See page 2	Lecturers	On return of assignments, etc	Written comments
Lab Exercises	Rapid synthesis of data Presentation and argument skills		0 (formative)					
Field report	Applications of geochemistry to acid mine drainage problems Fieldwork skills (not in 2020 due to suspension of fieldwork) Synthesis of data Group work (but minimal group marking) Concise technical report writing		20					
Seminar	Scientific literacy and information acquisition Synthesis of information Visual presentation skills Speaking skills		20					

2.2 General marking criteria

Component	Pass / Credit	Distinction / High Distinction
<p>Laboratories (60%)</p> <p>Summative and formative exercises</p>	<p>Basic processing of data and demonstrated capacity to use software packages.</p> <p>Adequate presentation of results.</p> <p>Basic data interpretation and the drawing of conclusions from results.</p> <p>Use of clear technical English in reports.</p> <p>Correct use of referencing.</p>	<p>Higher level processing, manipulation and modeling of results.</p> <p>Superior skills in presentation of results.</p> <p>Detailed interpretation of results drawing out most of the key features of the data as they relate to the problems posed.</p> <p>Use of clear technical English in reports. Correct use of referencing.</p>
<p>The pitch (part of the laboratories)</p>	<p>Basic synthesis of a complex dataset</p> <p>Development and presentation of reasonable arguments in the pitch</p> <p>Ability to answer basic questions</p>	<p>More critical analysis of the complex data and consideration of alternative interpretations</p> <p>Strong arguments in the pitch taking the data and risks into accounts</p> <p>Ability to handle more probing questions</p>
<p>Field Report (20%)</p>	<p>Adequate description of work done, in both field and laboratory.</p> <p>Adequate presentation of results.</p> <p>Basic data interpretation and the drawing of key conclusions from results.</p> <p>Use of clear technical English and effective structure</p>	<p>Detailed description of all key aspects of work done in field and laboratory with some explanation of their significance in the study.</p> <p>Superior skills in presentation of results.</p> <p>Detailed interpretation of results drawing out most of the key features of the data and extending beyond the directions of course staff.</p> <p>Reference to key literature to support interpretation.</p> <p>Use of clear technical English and effective structure in reports.</p>
<p>Seminar (20%)</p>	<p>Some demonstration of capacity to generate own slides, with necessary clarity and relevance to topic.</p> <p>Capacity to engage audience with the oral presentation.</p> <p>Good technical content. Correcting timing.</p> <p>Ability to answer questions.</p>	<p>Creation of high visual impact slide material.</p> <p>Capacity to enthuse audience with the oral presentation.</p> <p>High levels of technical content.</p> <p>Good balance between components of presentation – introduction, data, and conclusions.</p> <p>Correct timing.</p> <p>Ability to answer questions.</p>

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/geochemistry/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 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. 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.

5.2 – Geochemical mapping	Reimann D & Caritat P, 2017. Establishing geochemical background variation and threshold values for 59 elements in Australian surface soil. <i>Science of the Total Environment</i> , 578, 633–648
5.6 – Cyprus geochemistry	Cohen DR et al., 2012. Anthropogenic versus lithological influences on soil geochemical patterns in Cyprus. <i>Geochemistry: Exploration, Environment, Analysis</i> , 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. <i>Geochemistry: Exploration, Environment, Analysis</i> , 20, 199-204.
7.1 – Acid and metalliferous drainage	Johnson & Hallberg, 2005. Acid mine drainage remediation options: a review. <i>Science of the Total Environment</i> , 338, 3– 14
7.3 – Sunny Corner	Hager et al, 2013. The silver mines of Sunny Corner, New South Wales. <i>Australian Journal of Mineralogy</i> , 17, 45-51.
8.1 – Urban contamination	Johnson C & Anders EL, 2007. Urban geochemical mapping studies: how and why we do them. Caritat P & Reimann C, 2000. Intrinsic flaws of Element enrichment factors (EFs) in environmental geochemistry. <i>Environmental Science and Technology</i> , 34, 5084-5091.
9.1 – Intro to geochem. exploration	Cohen DR & Howell R, 2007. <i>Exploration Geochemistry. Treatise on Geochemistry. Elsevier Vol 13.</i> Winterburn P et al., 2017. Advances in exploration geochemistry, 2007 to 2017 and beyond. <i>Geochemistry: Exploration, Environment, Analysis</i> , 20, 157-166.
9.2 – Litho, soils and sed in GX	McClenaghan MB et al., 2000. Till geochemical and indicator mineral methods in mineral exploration. <i>Ore Geology Reviews</i> , 16, 145–166 Day S & Fletcher K, 1986. Size and abundance of gold in selected stream sediments, southern British Columbia, Canada. <i>Journal of Geochemical Exploration</i> , 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. <i>Geochemistry: Exploration, Environment, Analysis</i> , 9, 227-236 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? <i>Geochemistry: Exploration, Environment, Analysis</i> , 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. <i>Science of the Total Environment</i> , 662, 404–413 Cohen DR and Dunn CE, 2004. Form and distribution of trace elements in biomass for power generation. <i>CRC for Coal in Sustainable Development. Rpt 48.</i>
10.1 – EDA	Caritat P & Grunsky EC, 2017. State-of-the-art analysis of geochemical data for mineral exploration. <i>Geochemistry: Exploration, Environment, Analysis</i> , 20, 217-232. Grunsky EC, 2007. The Interpretation of Regional Geochemical Survey Data. <i>Advances in Regional-Scale Geochemical Methods. Proceedings Exploration '07.</i> 139-182.
10.2 – Multivariate	Reimann C et al., 2005. Background and threshold: critical comparison of methods of determination. <i>Science of the Total Environment</i> , 346, 1– 16 Cheng Q et al., 1999. Spatial and scaling modelling for geochemical anomaly separation. <i>Journal of Geochemical Exploration</i> , 65, 175–194
11.2 – Report writing	Hagan P and Mort P, 2015. <i>Report Writing Guide. Mining Education Australia. 9th Ed.</i>

4 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).

4.1 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.

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

5 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

6 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.

6.1 Laboratory assignments (60%)

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

Assignment 4: Geochemical exploration – *the pitch*

Objective: To synthesis geochemical data and pitch for drilling funds

Submission: Pairs.

6.2 Report on Sunny Corner (20%)

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).

6.3 Seminar (20%)

Topic: You will be presenting solo.

You are free to select a topic (by Wk 7) 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: 15 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.