# MINERALOGY (EESC35)

Dear all,

Welcome to the 'Mineralogy' (EESC35) course! This course will bring to you the rich and colourful world of minerals, rocks and their associations. We shall have a look at basic ideas of crystallography, describe the mineral (and rock) forming processes and practice mineral identification procedures (both instrumental and non-instrumental). Below you'll find a basic outline of the course, a detailed syllabus, reading materials and marking scheme. By the end of the course you should have a solid knowledge of basic concepts in crystallography (particularly crystal morphology), be able to recognize/describe most common minerals, understand mineral systematization and their forming processes and stability, and be familiar with petrographic microscopy and other basic instrumental techniques used in mineralogy an earth science.

## Course Outline

Mineralogy course is required for all of you who want to become registered as Professional Geoscientist in Ontario. The material, however, is relevant to many areas of science and industry. Crystallography is a major tool in modern science, particularly for all areas of chemistry and material science. We shall have a brief look at symmetry, crystal morphology and learn the basics of crystal structure descriptions. These should be enough for you to navigate through the crystallographic concepts you might encounter in the future. From crystallography we shall move to mineralogy, and we shall look at the physical and chemical properties of minerals as well as the systematic and determinative mineralogy (mineral classification and procedures used to determine mineral species).

A prior knowledge of the basic chemistry concepts is very helpful in this course. We shall cover them briefly as we go through the material, but it would be not a bad idea if you could refresh your memory with the following:

- Elements, atoms and atomic structure (nucleus, electrons, atomic orbitals)
- Cations and anions
- Periodic table of the elements (groups of periodic table, metallic, non-metallic and metalloids; sizes of atoms and ions)

- Basic chemical bonding (ionic, covalent and molecular bonds; van der Waals and hydrogen bonds)

Every good general chemistry textbook would be sufficient for this review. Your notes from 'Introduction to planet Earth' (EESA06) and the relevant texts should also be useful for this course! Many of these concepts and ideas we shall revisit during our lectures and tutorials but what you know from before is always a helpful and useful starting point. Now, do not get scared if you are not familiar with the points above – we'll help you and cover them during the lectures/tutorials.

## Topics:

1. **Introduction**
    a. Crystallography, mineralogy and petrology – what are they?
    b. Mineral vs. rock – is there a difference? (Basic definitions)
    c. Mineralogy and petrology in relations to earth and other sciences
2. **Crystallography**
    a. External symmetry of crystals
    b. Crystal morphology
    c. Crystal systems
    d. Crystallographic notation
    e. Crystallographic forms
    f. Crystallographic projections
3. **Internal order and symmetry**
    a. Internal symmetry
    b. Bravais' lattices
    c. Point groups
4. **Crystal structures**
    a. Crystal growth, defects and intergrowths (twinning)
    b. Coordination of ions
    c. Isostructuralism and polymorphism
    d. Representing crystal structures and most common simple structure types
    e. Describing and understanding of more complex structures

5. **Chemical composition of minerals**
    a. Composition of the Universe, the planets and the Earth
    b. Mineral compositions
    c. Determination of mineral compositions and mineral formulae
    d. Graphical representations of mineral compositions
6. **Mineral stability and phase diagrams**
    a. Basic thermodynamic values and stability
    b. The phase rule
    **c.** Phase diagrams (one, two and three component diagrams)
7. **Mineral and rock forming processes**
    a. Rock cycle
    b. Igneous processes and intro to igneous petrology
    c. Sedimentary processes and intro to sedimentary petrology
    d. Metamorphic processes and intro to metamorphic petrology
8. **Mineral identification techniques I: Physical properties**
    a. Colour and mineral identification
    b. Mechanical properties and mineral identification
    c. Mass related mineral properties and mineral identification
    d. Other mineral properties commonly used in identification
9. **Mineral identification techniques II: Instrumental techniques**
    a. Techniques based on X-rays (powder and XRF)
    b. Techniques based on other radiation (IR and Raman techniques)
    c. Techniques for surface imaging
10. **Descriptive mineralogy**
    a. Mineral taxonomy
    b. Chrystal chemistry and descriptive mineralogy of selected native elements
    c. Chrystal chemistry and descriptive mineralogy of selected sulfides and sulfosalts
    d. Chrystal chemistry and descriptive mineralogy of selected hydroxides, oxides and halides
    e. Chrystal chemistry and descriptive mineralogy of selected carbonates, nitrates, sulfates and related minerals
    f. Chrystal chemistry and descriptive mineralogy of selected silicates

**11. Mineral identification techniques III: Optical microscopy**

a. Polarized light and its interaction with minerals
b. Isotropic and anisotropic crystals
c. Uniaxial crystals (minerals)
d. Biaxial crystals (minerals)
e. Extinction angle and sign of elongation
f. Interference figures

## A note on the tutorials for EESC35

Officially, this course has three hours of lectures (Fridays, 9:00 am – noon) and one hour of tutorials (Tuesdays, 1:00 pm – 2:00 pm), held at the same classroom (SW 313). We shall not have our tutorial during the first week of classes: the first tutorial will be on Tuesday, January 15$^{th}$. The material in this course and the size of our class are, however, specific: small class and availability of models and samples in the classroom will enable us to have a hands-on lectures and tutorials in parallel. The tutorials are still important and mandatory: during tutorials you will have a chance to work more independently in order to strengthen your knowledge; during the lectures you'll receive more guidance throughout the material. Also, we'll have tutorial quizzes as described further below.

Office hours should ideally be held in the classroom (and not in the office) because we'll need many gadgets from the classroom to work with. The exact time-slot for this type of office hours will be provided to you as soon as the full schedule for our classroom is revealed. This does not mean that I will not see you in my office if you need help: you are very much encouraged to bring your problems and questions to me during my office hours (or set up an appointment if you have a conflict with my office hours) in SW313 or anywhere else!

Here are some tools and gadgets that you should have for the course (both in class and for homework) – I know some of you might find them odd:

1. A drafting compass (for drawing cycles and arcs)
2. A drafting ruler
3. A notebook for tutorials and practice (having some simple drafting paper, without lines or squares, is also very useful for this course)
4. Useful would be also a structure model kit (if you have one from any chemistry course!)

5. **Important point:** our classroom is classified as a *laboratory* – this means that we all **should be dressed in lab coats – please bring them for both lectures and tutorials and wear them at all times**. Another consequence: **there is no eating or drinking in the lab**. The lectures are three hours in the morning and we shell have a longer break during this three hour period to grab a coffee or a bite outside the classroom. There is also a desk in front of SW313 where you can leave your snacks and drinks.

**You should have these tools form the first class!**

The tutorials will have a bit different dynamics. There is no 'lab manual' for this course and every tutorial is going to rely on previous lectures. Bring your lecture notes and textbook to tutorials – **tutorials are another time when we learn so everything and anything that can help us in the process is welcome on the desk**! You can work in groups, help each other, and your faithful instructor is going to be present to help along the way. There are no tutorial quizzes or 'surprise' tests! There are tutorial tests (described below) but they are a different story.

## Textbook, reading materials and web resources

*Our textbook is:*

Klein, Cornelis, and Barbara Dutrow. 'Manual of Mineral Science.' 23rd ed. John Wiley and Sons, 2008.

It should be in the UTSC bookstore soon. You can also purchase an electronic version at a (VERY) reduced price through CourseSmart. The choice is yours! However, the purchase of the e-textbook gives you only a limited subscription to this text. Additional reading material will be provided to you during the course either on the intranet or in form of hand–outs during the class. A very useful website (and you are encouraged to explore it and visit it frequently during the course) is: www.webmineral.com .

Lecture notes for the course will be posted on the course intranet site at least 24 h in advance of each lecture. They are your starting point – go over the notes, then read the assigned parts of your textbook. We do expect knowledge of both lecture notes and textbook material from you people!

**Marking scheme**

Your progress in this course will be evaluated as follows:

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|---|---|
| Two tutorial tests (10% each) | 20% |
| Term test | 25% |
| Term paper | 15% |
| Final exam | 40% |
| **TOTAL** | **100%** |

*Tutorial tests.* Two tutorial tests (*not* necessarily conducted during the tutorials – they might be scheduled during the lectures as well) are designed to test the material we specifically concentrate on during tutorial practice. The exact dates will be announced but the first test should be before and the second one should be after the term test. The first tutorial test will cover crystallography (particularly crystal morphology and related concepts). You will be given two to three crystal forms and you task will be to correctly classify each, determine the symmetry and do the projection (you'll have about 30 min to write this test).

The second tutorial test will look at the descriptive mineralogy. This time you'll be given two or three minerals. Your task is to identify each sample, classify it and briefly explain how you determined what you had been given. Again, you'll have about 30 min to write this test.

*Term test*. Term test will be scheduled outside of lecture and tutorial hours. It depends on the campus administration when exactly the test will be scheduled. The test will cover the material from the lectures – you will not be given any crystal, mineral or rock samples for this test. The questions will have a short answer format. In this case your knowledge and understanding of basic concepts will be tested.

*Term paper*. You will be asked to write a short paper (1250 – 1500 words) on two to three mineral species you saw in the Royal Ontario Museum and found interesting. The format and other details will be posted on the intranet. The due date will be *after* the term test (exact date will be announced in class/on intranet).

*Final exam*. Our final exam is cumulative. Similarly to the term test, you will not be given any crystal models or mineral/rock samples. Rather, it is going to test you r knowledge and understanding of basic concepts and ideas covered in the course.