

## **Annexe A: New/Revised Course Content in OBTL+ Format**

### **Course Overview**

|                                                            |                       |
|------------------------------------------------------------|-----------------------|
| Expected Implementation in Academic Year (New format)      | AY2026-2027           |
| Semester/Trimester/Others (specify approx. Start/End date) | Semester 2            |
| Course Author<br>* Faculty proposing/revising the course   | Euan Mutch            |
| Course Author Email                                        | euan.mutch@ntu.edu.sg |
| Course Title                                               | EARTH MATERIALS       |
| Course Code                                                | ES2002                |
| Academic Units                                             | 3                     |
| Contact Hours                                              | 65                    |
| Research Experience Components                             | Not Applicable        |

### **Course Requisites (if applicable)**

|                       |        |
|-----------------------|--------|
| Pre-requisites        | ES1003 |
| Co-requisites         | N/A    |
| Pre-requisite to      | ES3005 |
| Mutually exclusive to | N/A    |
| Replacement course to | N/A    |
| Remarks (if any)      |        |

## Course Aims

The course aims to provide students with a foundational understanding of magmatic, sedimentary, and metamorphic petrology, including the processes that form different rock types in various tectonic settings. It also seeks to develop practical skills in microscopic and SEM analysis, enabling students to identify rocks and minerals, interpret their origins, and connect observations to theoretical concepts. Additionally, the course introduces the societal and industrial relevance of rocks and minerals, including implications for human health and environmental issues. This course is designed for students in Geosciences, Earth Sciences, Environmental Sciences, or related fields who want to build essential skills in petrology and mineral identification. It is suitable for learners who need both theoretical understanding and hands-on analytical experience with microscopes and SEM.

Students should take this course because it provides:

- Core knowledge required for advanced studies in geology, mineralogy, tectonics, geochemistry, or Earth materials.
- Practical laboratory skills (microscopy, SEM) that are fundamental for careers in geoscience research, environmental assessment, natural resource exploration, and materials analysis.
- An understanding of the societal and industrial importance of rocks and minerals, useful for careers in mining, energy, environmental consultancy, and public health-related geoscience fields.
- Insight into how rock and mineral properties influence environmental pollution, human health, and industrial processes, making the course relevant for applied and interdisciplinary pathways.

## Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

|       |                                                                                                                                                     |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| ILO 1 | Identify magmatic, sedimentary, and metamorphic minerals and components under the optical microscope.                                               |
| ILO 2 | Recognize the geologic processes that produced a specific rock specimen.                                                                            |
| ILO 3 | Build connections between large scale tectonic processes, local scale chemical reactions and physical processes, and the characteristics of a rock. |
| ILO 4 | Use phase diagrams and rock classifications to understand and infer rock formation processes.                                                       |
| ILO 5 | Describe rocks, their constituents, texture, and geologic interpretation.                                                                           |

## Course Content

- Know the minerals and components that make magmatic, sedimentary and metamorphic rocks.
- Know the environmental conditions of formation of magmatic, sedimentary and metamorphic rocks.
- Know the physical and chemical processes that lead to the formation of these rocks and their expression in rocks.
- Know how to use the optical microscope to study rocks and their origin.
- Know how to use phase diagrams and rock classifications to study rocks and their origin.
- Know how to describe rocks and communicate the related implications of your findings.

## Reading and References (if applicable)

Klein C., and Philpotts, A. (2012) *Earth Materials Introduction to Mineralogy and Petrology*. Cambridge University Press.

Philpotts, A. R., & Ague, J. J. (2022). *Principles of Igneous and Metamorphic Petrology* (3rd ed.). Cambridge University Press

Dutrow, B., & Klein, C. (2024). *Manual of mineral science* (24th ed.). Wiley-Blackwell.

Deer, W. A., Howie, R. A., & Zussman, J. (2013). *An introduction to the rock-forming minerals* (3rd ed.). Mineralogical Society of Great Britain & Ireland

## Planned Schedule

| Week or Session | Topics or Themes                                              | ILO           | Delivery Mode | Activities                                                          | Readings |
|-----------------|---------------------------------------------------------------|---------------|---------------|---------------------------------------------------------------------|----------|
| 1               | Introduction to Earth Materials.                              | 3             | In-person     | Introduction to crystal structures and mineral classification.      | Varies   |
| 2               | Introduction to the optical microscope.                       | 1,3           | In-person     | Mineral identification criteria in plain and cross polarized light. | Varies   |
| 3               | Magmatic Rocks 1 - Classification of magmatic rocks           | 1,2,3,4,5     | In-person     | Components of magmatic rocks.                                       | Varies   |
| 4               | Magmatic Rocks 2 - Magma generation                           | 1, 2, 3, 4, 5 | In-person     | Mafic plutonic and volcanic rocks.                                  | Varies   |
| 5               | Magmatic Rocks 3 - Magma differentiation                      | 1, 2, 3, 4, 5 | In-person     | Felsic plutonic and volcanic rocks.                                 | Varies   |
| 6               | Sedimentary Rocks 1 - Components of sedimentary rocks         | 1,2,3,4,5     | In-person     | Components of sedimentary rocks.                                    | Varies   |
| 7               | Metamorphic Rocks 1 - Classification of metamorphic rocks (a) | 1,2,3,4,5     | In-person     | Components of metamorphic rocks (a).                                | Varies   |
| 8               | Metamorphic Rocks 2 - Classification of metamorphic rocks (b) | 1, 2, 3, 4,5  | In-person     | Components of metamorphic rocks (b).                                | Varies   |
| 9               | Metamorphic Rocks 3 - Metamorphic processes                   | 1,2,3,4,5     | In-person     | Regional metamorphism                                               | Varies   |
| 10              | Analytical Techniques - SEM                                   | 1,2,3,4,5     | In-person     | Thin Section project                                                | Varies   |
| 11              | Mineral Resources and Human Health                            | 1,2,3,4,5     | In-person     | Minerals in Society                                                 | Varies   |

| Week or Session | Topics or Themes                                            | ILO       | Delivery Mode | Activities                                              | Readings |
|-----------------|-------------------------------------------------------------|-----------|---------------|---------------------------------------------------------|----------|
| 12              | Course review - Magmatic, sedimentary and metamorphic rocks | 1,2,3,4,5 | In-person     | Magmatic, sedimentary and metamorphic rock descriptions | Varies   |
| 13              | Final practical and theory tests                            | 1,2,3,4,5 | In-person     | Final practical and theory tests                        | Varies   |

## Learning and Teaching Approach

| Approach                        | How does this approach support you in achieving the learning outcomes?                                                                                                                                                                                                                                                                                                                       |
|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lectures                        | There will be lectures at the beginning of each week covering the topics of all Learning Outcomes (LO 1-5). These will be done in an interactive way, involving your participation in the form of discussions and contributions to the whiteboard. These lectures will also be punctuated with demonstrations using the microscope and analog models of crystals.                            |
| Lab sessions                    | During labs, you will individually have access to microscopes and be encouraged to share your findings and observations with your classmates in order to discover rocks in thin section and describe them adequately (LO 1-3, 5). You will also be doing exercises and asked questions that help you build connections between theoretical processes and their expression in rocks (LO 3-4). |
| Group projects                  | You will have the opportunity to go to the Scanning Electron Microscope and acquire data in pairs for a thin section of your choice (LO 2). This will be part of a 6-week long project aiming at going in depth on one sample to fully discover how to recognize the expression of specific phenomenon in rocks (LO2-3) and how to present this in a professional way (LO 5).                |
| Active learning and discussions | Short MCQs at the beginning of each lecture, on the topic of the previous lecture, will facilitate content assimilation and ensure that you can discuss about a topic and learn in an active way. Some assignments will also be given for hands on application of the content covered during lectures (LO 4).                                                                                |

## Assessment Structure

Assessment Components (includes both continuous and summative assessment)

| No. | Component                                                                                            | ILO              | Related PLO<br>or<br>Accreditation | Weightage | Description of<br>Assessment<br>Component                                                                                    | Team/Individual | Rubrics  | Level of<br>Understanding |
|-----|------------------------------------------------------------------------------------------------------|------------------|------------------------------------|-----------|------------------------------------------------------------------------------------------------------------------------------|-----------------|----------|---------------------------|
| 1   | Continuous<br>Assessment<br>(CA):<br>Test/Quiz(Lab<br>exercises, rock<br>description<br>and quizzes) | 1, 2, 3, 4,<br>5 |                                    | 25        | Lab exercises,<br>rock<br>descriptions<br>and quizzes.<br>These will be<br>assessed<br>weekly<br>throughout the<br>semester. | Individual      | Analytic | Extended<br>Abstract      |

| No. | Component                                                | ILO           | Related PLO<br>or<br>Accreditation | Weightage | Description of<br>Assessment<br>Component                                                                                                                                                                                                                                                                                                                                                                                                            | Team/Individual | Rubrics  | Level of<br>Understanding |
|-----|----------------------------------------------------------|---------------|------------------------------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|----------|---------------------------|
| 2   | Continuous Assessment (CA): Project(Group Project)       | 1, 2, 3, 4, 5 |                                    | 25        | Group Project. Thin section project conducted in groups. This will involve using an optical microscope and SEM to identify all the components of a rock, describe its texture and thereby identify the rock. It will also allow you to understand any additional, process-related (or age related) interpretations that can be made from thin section observation and correlate with general knowledge about plate tectonics and geologic processes. | Team            | Analytic | Extended Abstract         |
| 3   | Continuous Assessment (CA): Test/Quiz(Final Theory Test) | 1,2,3,4,5     |                                    | 25        | Final Theory Test. A 2 hour test that is based on knowledge and skills gained in the lecture.                                                                                                                                                                                                                                                                                                                                                        | Individual      | Analytic | Extended Abstract         |

| No. | Component                                                      | ILO       | Related PLO or Accreditation | Weightage | Description of Assessment Component                                                                                                                                                                                | Team/Individual | Rubrics  | Level of Understanding |
|-----|----------------------------------------------------------------|-----------|------------------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|----------|------------------------|
| 4   | Continuous Assessment (CA):<br>Test/Quiz(Final Practical Test) | 1,2,3,4,5 |                              | 25        | Final Practical Test. A 2 hour test in which you will be expected to describe three rock thin sections, and apply the thin section description and interpretation skills you have developed throughout the course. | Individual      | Analytic | Extended Abstract      |

#### Description of Assessment Components (if applicable)

CA1: Lab exercises, rock descriptions and quizzes. These will be assessed weekly throughout the semester.

CA2: Group Project. Thin section project conducted in groups. This will involve using an optical microscope and SEM to identify all the components of a rock, describe its texture and thereby identify the rock. It will also allow you to understand any additional, process-related (or age related) interpretations that can be made from thin section observation and correlate with general knowledge about plate tectonics and geologic processes.

SA1: Final Theory Test. A 2 hour test that is based on knowledge and skills gained in the lecture.

SA2: Final Practical Test. A 2 hour test in which you will be expected to describe three rock thin sections, and apply the thin section description and interpretation skills you have developed throughout the course.

#### Formative Feedback

Your weekly activities (thin section descriptions, quizzes, assignments) will be graded and handed back the following week, with feedback in the form of a grade and comments on how to improve. These activities will help you build knowledge and understanding for the final theory and practical tests, which will be in a similar form. The weekly activities and feedback relate to learning outcomes 1-5.

You will work on a project in groups, and qualitative feedback will be provided on the project at the end of the semester (i.e. shortly after the project is due).



## NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

| Attributes/Competency | Level    |
|-----------------------|----------|
| Collaboration         | Advanced |
| Curiosity             | Advanced |
| Global Perspective    | Advanced |
| Problem Solving       | Advanced |
| Critical Thinking     | Advanced |

# Course Policy

## Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

## Policy (General)

You are expected to complete all assigned readings, activities, assignments, attend all classes punctually and complete all scheduled assignments by due dates. You are expected to take responsibility to follow up with assignments and course related announcements. You are expected to participate in all project critiques, class discussions and activities.

## Policy (Absenteeism)

In-class activities make up a significant portion of your course grade. Absence from class without a valid reason will affect your participation grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for in-class activities.

## Policy (Others, if applicable)

### Diversity and inclusion policy

Integrating a diverse set of experiences is important for a more comprehensive understanding of science.

It is our goal at ASE to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences, and that honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:

- If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety disorder or social phobia;
- If you feel like your performance in the class is being impacted by your experiences outside of class;
- If something was said in class (by anyone, including the instructor) that made you feel uncomfortable;

Please speak to your teaching team, a peer or senior, Janelle or Michel (either in-person or via email) about how we can help facilitate your learning experience.

As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the class are expected to adhere to the NTU anti-harassment policy. if you witness something that goes against this or have any other concerns, please speak to your instructors or an ASE faculty member.

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