ERTH 401: Introduction to Mineral Physics

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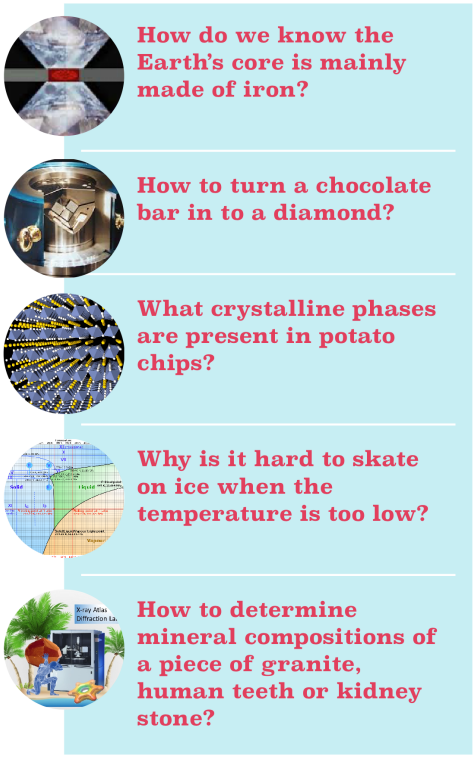
Class location and time: POST 733 (M: 1:30-3:20pm; W: 12:30-1:20 pm)

ERTH 401 Introduction to Mineral Physics (3) Scientific study of the materials that make up the Earth and other planets or moons. Properties and behaviors of minerals under high-pressure and temperature conditions found in Earth and planetary interiors. Pre: ERTH 301 and PHYS 272, or consent. (Alt. years) (Cross-listed as ERTH 701) **DP**

ERTH 701 Physics of the Earth's Interior
(3) Interpretation of geophysical and laboratory data to understand elastic and anelastic properties, composition, phase relationships, temperature distribution in the Earth. Pre: consent. (Alt. years)

Pre: ERTH 301, Mineralogy (4), PHYS 272, Physics II, or consent

Diversification courses
DP = Physical Science



Course Description

The great majority of the Earth and other Earth-like planets or moons is inaccessible to direct sampling. Our knowledge on the physics and chemistry of Earth's and planetary interiors has relied on multidisciplinary investigations from seismology, geodynamics, and geochemistry, as well as mineral physics. Mineral physics plays a central role in Earth and planetary sciences by linking materials properties of planetary constituents with large-scale geological and planetary processes and seismic and astronomical observations. It provides essential information on materials properties for the understanding of the nature and dynamics of planetary interiors. Beyond geology, it has many relevant connections with development of new advanced materials for technological applications, such as superconductors, ferroelectrics, abrasives, etc. This course will (1)review the current models and unsolved problems/questions regarding the composition and dynamics of the deep interiors of the terrestrial planets and terrestrial-like planetary bodies, (2) introduce the relevant experimental, theoretical, and analytical techniques in mineral physics and experimental petrology, (3) offer Practical knowledge of the X-ray diffraction instrumentation and novel computational methods for reliable identification of minerals in rock samples, organic and inorganic solids, and determination of their crystal structure; (4) involve mineral physics modeling using Python or Jupyter notebook, first-

principles calculations of materials properties using Quantum Espresso and/or VASP, and hands-on research projects in the Multi-Anvil Press Laboratory (MAPLab) and X-ray Atlas Laboratory. The course will be a hybrid lecture, discussion, and hands-on exercises format: organized lectures given by the instructor alternating with group discussion of classical and current papers and group or individual modeling/computation and laboratory projects.

Main Text and References

1. Theory of the Earth (Don L. Anderson), free electronic version is available at http://authors.library.caltech.edu/25018/.
2. Poirier J.-P (2000) Introduction to the Physics of the Earth's interior. Cambridge University Press.

Student Learning Objectives (SLOs)

The course aims to focus on the following student learning objectives established by the Department of Earth Sciences:

- SLO2: Students can apply technical knowledge of relevant computer applications, laboratory methods, field methods, and the supporting disciplines (math, physics, chemistry, biology) to solve real-world problems in geology and geophysics;
- SLO3: Students use the scientific method to define, critically analyze, and solve a problem in Earth science;
- SLO4: Students can reconstruct, clearly and ethically, geological knowledge in both oral presentations and written reports;
- SLO5: Students can evaluate, interpret, and summarize the basic principles of geology and geophysics, including the fundamental tenets of the sub-disciplines, and their context in relationship to other core sciences, to explain complex phenomena in geology and geophysics.

In particular, students will employ mineral physics software packages and write their own programming codes to construct mineral physics or thermodynamic models for the Earth's and planetary interiors (SLO2, SLO3). They will also lead literature discussion and reports on classical and recent mineral physics publications (SLO4) and review the uncharted areas and unanswered questions in the field (SLO5). The course will also offer opportunities for students to conduct class project(s) using the computational, experimental, and analytical facilities related to mineral physics research and apply the mineral physics knowledge for the understanding of some specific problems on the physics and chemistry of the Earth and planetary interiors (SLO2, SLO3, SLO4, SLO5).

Assessment and Grading

Course grades will be based on class participation (20%), homework assignments (30%), final presentation (20%), and final term paper (30%).

Course Schedule

Week	Date	Content
1	1/11	Organization meeting; Introduction of Mineral Physics; High pressure and temperature techniques (LVP, DAC, shock wave); Extreme condition experiments at in-house and synchrotron facilities
	1/13	Elasticity: X-ray diffraction, ultrasonic, Brillouin, ISS, NRIXS
2	1/18	*Holiday, Martin Lutehr King, Jr. Day*
	1/20	Solar system formation, origin and bulk composition of the planets, core-mantle differentiation
3	1/25	Layered structures of planetary bodies in the solar system: Different "onions"; C Burnman modeling on elasticity and anisotropy (1)
	1/27	Thermal history and thermal profiles of Earth and planetary interiors
4	2/1	C Mineral physics modeling: BurnMan-A lower mantle mineral physics toolkit (2)
	2/3	Transport properties of rocks; Viscosity: falling sphere method, microtomography, melt; thermal conductivity of planetary materials
5	2/8	C Mineral physics modeling: BurnMan-A lower mantle mineral physics toolkit (3)
	2/10	Mineralogy of upper mantle, transition zone, lower mantle, and the core; chemical boundary layers in deep Earth
6	2/15	*Holiday, President's Day*
	2/17	First-principles computation – an overview
7.	2/22	C Hands-on first-principles calculations (1)
	2/24	First-principles computation – applications to planetary sciences
8.	3/1	C Hands-on first-principles calculations (2)
	3/3	Crystallography – description of crystal structure & symmetry, thermoelastic properties and acoustic wave propagation
9.	3/8	L Crystallography – single crystal experiment data collection and data processing
	3/10	Crystallography – experimental methods
10.	3/15	*Spring Recess*
	3/17	*Spring Recess*
11.	3/22	C Crystallography – single crystal structure refinement
	3/24	Crystallography – single crystal structure refinement
12.	3/29	C Crystallography – single crystal structure solution
	3/31	Crystallography – crystal structure solution
13.	4/5	L Crystallography – powder diffraction experiment and phase identification
	4/7	Crystallography – powder diffraction analysis
14	4/12	C Crystallography – powder diffraction Rietveld analysis
	4/14	Crystallography – Non-ambient experiments

Week	Date	Content
15	4/19	L Crystallography – non ambient experiment and data analysis
	4/21	Plate tectonics and subduction; hydrogen in Earth and planetary interiors; discussion of the final projects
16	4/26	Proposals for the MAPLab, X-ray Atlas, and computational group/individual projects
	4/28	Final projects
17	5/3	Final projects
	5/5	Final projects
18	5/10	Final project presentations
	5/12	Final project presentations (cont.), final paper due

The University of Hawai'i is committed to providing a learning, working and living environment that promotes personal integrity, civility, and mutual respect and is free of all forms of sex discrimination and gender-based violence, including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence, and stalking. If you or someone you know is experiencing any of these, the University has staff and resources on your campus to support and assist you. Staff can also direct you to resources that are in the community. Here are some of your options:

As members of the University faculty, your instructors are required to immediately report any incident of potential sex discrimination or gender-based violence to the campus Title IX Coordinator. Although the Title IX Coordinator and your instructors cannot guarantee confidentiality, you will still have options about how your case will be handled. Our goal is to make sure you are aware of the range of options available to you and have access to the resources and support you need.

If you wish to remain ANONYMOUS, speak with someone CONFIDENTIALLY, or would like to receive information and support in a CONFIDENTIAL setting, use the **confidential resources available here**:
http://www.manoa.hawaii.edu/titleix/resources.html#confidential

If you wish to directly REPORT an incident of sex discrimination or gender-based violence including sexual assault, sexual harassment, gender-based harassment, domestic violence, dating violence or stalking as well as receive information and support, contact: Dee Uwono Title IX Coordinator (808) 956-2299 t9uhm@hawaii.edu.