Deformation and Metamorphism of Crystalline Rocks (GEOS F694)

3 Credits
Prerequisites: Graduate standing; OR permission of instructor.
Location: 237 Reichardt
Meeting Time: TBA

Instructor: Dr. Jochen Mezger
Office: 308a Reichardt
Office Hours: Monday 10-12 am; Wednesday 2-4 pm
Telephone: 474-7809
Email: jemezger@alaska.edu

Required textbook:

Required supplementary reading:

Recommended supplementary reading:

Course Description
A variety of crystalline rocks, schists, ortho- and paragneisses, igneous rocks, are studied in thin sections and hand samples, with respect to their metamorphism and deformation. Different microstructures, fabrics of rocks and individual minerals, are observed and described, their development explained, and their bearing on the history of a particular sample revealed. The relative timing of metamorphic and deformational events can be reconstructed to develop a reasonable tectonic model by just looking at thin sections. The general understanding of crystalline rocks in the field will increase by knowing what to look for. Successful participation requires some basic knowledge of optical petrography, mineralogy/petrology (e.g. GEOS F214) and structural geology (e.g. GEOS F314).

From the course catalog
GEOS F694  Deformation and Metamorphism of Crystalline Rocks
3 Credits  Offered Spring
Identification, description and interpretation of metamorphic and/or microstructural fabrics of crystalline rocks. The class provides theoretical and practical tools to understand the interaction of metamorphism and deformation that most metamorphic and
plutonic rocks experience; crucial for the development of tectonic models. Laboratory exercises include studies of rock thin sections with optical microscopes and hand specimen. Students are encouraged to bring samples from their own thesis. Prerequisites: Graduate standing; OR permission of instructor. (2 + 3)

Course Goals
This course is about as much, if not more, getting practical experience using the optical microscope and examining rock samples, as it is gaining theoretical knowledge. The more time you invest studying thin sections, the more you will be able to discover and interpret microstructures, and connect the terminology of the lectures with real images. You will eventually get a sharp eye for tell-tale fabrics of rock deformation and metamorphism. During this course you will:

- learn about the way rocks and individual minerals react under plastic deformation,
- and recognize the resulting microstructures in thin sections and hand samples;
- observe how rock composition determines how a rock is deformed and what metamorphic minerals can grow;
- find out how metamorphic reactions change the shape of minerals and which minerals are formed at the expense of others,
- and be able to identify them under the optical microscope;
- hone your drawing skills by sketching key microstructures;
- combine metamorphic and deformation microstructures to establish the relative history of a given piece of hard rock;
- be astonished to find out how much information you can get out of a thin section of a schist or a gneiss by thorough microscope studies, without spending a huge amount of money on fancy analyses.

Student Learning Outcomes
After completing this course, you should be able to:

- recognize the main microstructures in thin sections and hand samples;
- determine if observed metamorphic fabrics indicate a prograde or retrograde path;
- present the crucial microstructures by drawing and sketching, allowing you better understand and demonstrating them;
- approximate the metamorphic P-T conditions;
- integrate deformation and metamorphism to develop a tectonometamorphic model of a certain geologic region;
- decide which analytical methods (e.g. geochemistry, geochronology) will provide additional quantitative data (protolith provenance, age, etc.);
- develop a sampling strategy for your own research project;
- be confident in addressing rocks and get an answer from them. After all, it should be exciting and a lot of fun!
**Instructional Methods**
The course is designed in such a way that the laboratory sections are commonly the practical application of the theory covered in the lectures. The lectures may include some experiments and presentations with a microscope. Questions are welcome at all time. Ask if you don’t understand. The labs predominantly feature working with optical microscopes. Most of the study material (thin sections, hand samples) is from my own collection, however, students are welcome and encouraged to bring their own thin sections/samples along to every lab. The more we see (including myself), the more we learn. There is no such thing as a geologist who knows it all! Throughout the lab you are encouraged to discuss what you see with fellow students. You will use sketches of rocks and thin sections to concentrate on the crucial microstructures that tell the story of that sample. Case studies discussed in lectures and labs will give you an idea how integrated deformation-metamorphism studies are used to solve problems in tectonics, plate reconstruction and orogeny. There will be weekly assignments that are arranged in such a way that they can be completed during the lab period, and commonly include description – written and sketched – of one or more thin sections with a metamorphic and structural interpretation.

**Course Calendar (tentative)**
See attached sheets.

**Course Policies**
Your success in the course depends largely on your active presence, looking at rocks. You gain experience with every hour spent at the microscope. Presence during lab period is therefore CRUCIAL. Let me know ahead of time if you know you will miss a lab or not be able to finish an assignment. In principle, I can only accept conference attendances (as a presenter) or documented medical appointments as excuses. I will then try to accommodate missed labs by arranging make-up time or extend an assignment deadline.

While I encourage open discussion among students, it is in your very own interest that you do your assignment yourself. Plagiarism will NOT be tolerated. Since thin sections or hand samples used for the assignments are unique, there is no point in copying the work of fellow students or the WWW. However, should I find that you have copied a significant portion of material, e.g. duplicate a thin section sketch or copied several sentences word-by-word, you will receive 0 points for that assignment. A second act of plagiarism will automatically have you failed the course. In addition, the **Student Code of Conduct** (in Academics and Regulations chapter of the UAF Catalog) outlines your rights and responsibilities, as well as prohibited forms of conduct. Please be aware of the contents of the code.

**Evaluation**
There is no written exam since it is a hands-on class. All you learn will be reflected in the quality of the weekly assignments and a final project. The final project, which will be assigned several weeks ahead, includes, but is not restricted to, microscopic analyses and a geological interpretation. Sample material from your own research project can be used.

- Weekly assignments (70%), due at the beginning of the next lab
- 10-15 min oral presentation of final project (10%) given in the last lab session
- Written presentation of final project (20%), due at the scheduled time of final exam.

The final grade will be based on the percentage of the total points from the weekly assignments and the final project (written and presentation) according to the following scale:

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-99%</td>
<td>A+</td>
</tr>
<tr>
<td>98-92%</td>
<td>A</td>
</tr>
<tr>
<td>91-90%</td>
<td>A-</td>
</tr>
<tr>
<td>89-88%</td>
<td>B+</td>
</tr>
<tr>
<td>87-82%</td>
<td>B</td>
</tr>
<tr>
<td>81-80%</td>
<td>B-</td>
</tr>
<tr>
<td>79-78%</td>
<td>C+</td>
</tr>
<tr>
<td>77-72%</td>
<td>C</td>
</tr>
<tr>
<td>71-70%</td>
<td>C-</td>
</tr>
<tr>
<td>69-68%</td>
<td>D+</td>
</tr>
<tr>
<td>67-62%</td>
<td>D</td>
</tr>
<tr>
<td>61-60%</td>
<td>D-</td>
</tr>
<tr>
<td>&lt;60%</td>
<td>F</td>
</tr>
</tbody>
</table>

**Support Services**

Optical microscopes are set up and available in the Petrography Lab (REIC 311) for use outside the regular lab hours. Time permitting, I am available for consultation of thin sections and rock samples.

**Disabilities Services**

The Office of Disability Services implements the Americans with Disabilities Act (ADA) and ensures that UAF students have equal access to the campus and course materials. I will work with the Office of Disability Services (208 Whitaker Bldg., 474-5655) to provide reasonable accommodation to students with disabilities. Please let me know at the beginning of the course if accommodations should be provided.
<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture</th>
<th>Lab</th>
<th>Reading</th>
</tr>
</thead>
</table>
| 1    | Refresher:  
- Types of metamorphism, metamorphic facies  
- Types of deformation; flow and deformation | Introduction to using an optical microscope; Review of rock forming minerals: quartz, feldspars, micas | V&C 1.1, 1.8  
P&T 2 |
| 2    | Formation and characteristics of major metamorphic minerals | Petrography of aluminosilicates, garnet, staurolite, cordierite and other common metamorphic phases | V&C 6.2, 6.3  
P&T 2  
V 5.3 |
| 3    | Deformation Mechanisms | Microstructures of intracrystalline deformation, recrystallization, deformation of rock forming minerals | V&C 2.1-2.3, 3.4 |
| 4    | Foliations: cleavage and schistosity, influence of rock composition | Foliations of different metamorphic grade and rock types | V 5.8  
P&T 4 |
| 5    | Nucleation and growth of metamorphic minerals: grain size and shape; porphyroblasts | Different size and shapes of important metamorphic minerals: garnet, staurolite, andalusite, sillimanite, cordierite, micas | V&C 3.1-3.3  
V 4.1-4.5 |
| 6    | Growth sequence of metamorphic minerals: petrogenetic grids, textural relationships, metamorphic parageneses, monometamorphism vs. polymetamorphism | Decoding the growth sequence of metamorphic minerals in various metasedimentary rocks, recognition of metamorphic parageneses | V&C 2.1-2.3, 3.4 |
| 7    | Inclusions in porphyroblasts, porphyroblast-matrix relations, relative sequence of deformation events, | Inclusion trails in garnets, staurolite, andalusite, microstructures in porphyroblasts and matrix; sequence of structures with respect to mineral growth | V&C 3.5, 3.6  
V 4.13  
P&T 7.3-7.6 |
| 8    | Deformation partitioning, influence of compositional layering on deformation and metamorphism, metamorphism during deformation | Observe how compositional layering causes inhomogeneous deformation and controls nucleation of metamorphic minerals | V 5.5-5.7 |
| 9    | Shear zones, mylonites, shear sense indicators | Shear bands, rotated porphyroblasts, deflected foliation | P&T 5 |
| 10   | Deformation of high-grade metamorphic rocks, migmatites, igneous rocks | Microstructures of migmatites and metagranites | V 5.11 |
| 11   | Tectonometamorphic models in a complexes with different rock types; sampling strategies | Develop a model for the tectonic and metamorphic history of an exemplary metamorphic region using rocks of various composition and structures | V&C 2.4 |
| 12   | Pressure-temperature conditions, thermobarometry | Calculating P-T conditions using simple geothermometers and geobarometers with a given set of mineral analyses (computer lab) | N/A |
| 13   | Auxiliary methods:  
- Special technics to study deformation fabrics (e.g. EBSD, Quartz C-axes)  
- Dating deformation and metamorphic events | Recap of various microstructures in thin section and hand samples; students show and tell, BYO sample or thin section | N/A |
| 14   | Case Studies | Recap of various microstructures in thin section and hand samples; students show and tell, BYO sample or thin section | N/A |
| **Final exam** | Discussion on course and student feedback | | |