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Lab 11: FIELD DESCRIPTION OF METAMORPHIC ROCKS

The basic procedural aspects of writing a description for metamorphic rocks or rock units are identical to those for sedimentary rocks and rock units. The main difference is, of course, terminology. With this in mind, today's lab focuses on common terms that are used to describe metamorphic rock textures, fabrics, structures and mineralogy, as well as some working descriptions of commonly used metamorphic rock names.

What is a "good" description? We will consider two underlying purposes as most important: 1) what does the rock or rock unit look like? and 2) what features must be described to interpret its history?

For metamorphic rocks, the first question is answered by a **rock name** and descriptions of obvious characteristics, e.g. **color**, **grain size**, **mineralogy, compositional layering**, **veins** or other textural or structural features. The second question is addressed by describing the rocks **fabric** - the spatial distribution and geometric orientation of all its elements. Below are definitions for descriptive terms that encompass commonly encountered characteristics. Read them carefully before writing your descriptions.

I. The Jargon

A. Grain Size:

fine-, **medium-**, **coarse-grained** - these modifiers are useful for all metamorphic rocks except slates and phyllites, where a fine grain size is implied by the name. Size are for **fine-grained < 0.75 mm**, for **medium grained 0.75-1 mm**, and for **coarse-grained 1-2 mm** and **very coarse-grained > 2 mm**.

Porphyroblastic - containing crystals (**porphyroblasts**) that are larger than the enclosing matrix. The words porphyroblast and phenocryst are not synonymous; the latter refers to crystals formed from a melt. **Augen** are large, eye-shaped porphyroblasts that are common in some gneisses. **Megacryst** is a generic term for a large crystal.

Granoblastic - composed of crystals of the same size. Fine- to medium-grained metamorphic rocks that are Al-poor (quartzites, marbles) are commonly granoblastic.

Porphyroclastic - Coarse, **relict**, deformed crystals (**porphyroclasts**) set in a fine grained, sometimes mylonitic matrix. Porphyroclasts may be relict porphyroblast, phenocryst or clastic grains. Porphyroclasts may be augen or may have asymmetric "tails".

B. Layering:

One the most common, obvious features in metamorphic rocks is some kind of layering. Except at low metamorphic grades or in contact metamorphic aureoles, this *layering is commonly not original bedding*. Layering in metamorphic rocks can be produced by a variety of mechanism (metamorphic differentiation, mylonitization, shearing of veins and dikes) in rocks that were not originally layered at all! Unless there are relict sedimentary or igneous structures (eg. cross bedding, graded bedding, vesicular vs. non vesicular layering, etc.), nongenetic terms for layering in metamorphic rocks are appropriate. The most general nongenetic term for layering in metamorphic rocks is **foliation**.

Foliation - Any layering in a metamorphic rock. The term as we will use it has no genetic implication; it can be equally applied to surfaces that may be relict bedding or to surfaces that are purely the consequence of deformation and/or recrystallization. Metamorphic rocks that are not layered are called **massive** or **isotropic**. There are several types of foliations:

Compositional layering - Foliation defined by alternating layers composed of different minerals. Always easily recognized by differences in color of layers.

Gneissosity - compositional layering in which granoblastic layers of roughly equidimensional grains (e.g. quartz, feldspar) alternate with more schistose layers of platy or elongate grains, or with other granoblastic layers.

Schistosity - Foliation defined by aligned, inequant minerals, commonly those that are platy (micas, chlorite, aluminosilicates) or prismatic (amphibole, tourmaline). Minerals defining a schistosity are said to possess a "preferred orientation". Paradoxically, gneisses (see below) may posses a schistosity.

Cleavage - Schistosity surfaces that are planar, or nearly so, along which the rock may break (**cleave**) into tabular or platy fragments. Cleavage is usually defined by aligned fine-grained mica or chlorite; it is therefore most common in aluminous, low-grade metamorphic rocks. There are a myriad of cleavage types and adjectives used to describe them, but we will concern ourselves with only two, **slaty cleavage** and **crenulation cleavage**. **Slaty cleavage** is perfectly planar cleavage defined by extremely fine-grained mica and/or chlorite in slates and phyllites. **Crenulation cleavage** is cleavage defined by aligned mica and/or chlorite on the limbs of cm-to mm-scale periodic folds (**crenulations**).

Mylonitic layering or Mylonitic foliation - foliation defined by layers of 1) microbreccia with a glassy appearance and/or 2) highly-strained and elongate (ribbon-like) grains of quartz and/or feldspar. This is a genetic term for a very

distinctive type of foliation that is produced by grain size reduction and dynamic recrystallization during shearing.

C. Metamorphic Rock Names

Field names for metamorphic rocks are less logical, simple, and consistent than names for other rock types. Metamorphic rock names have traditionally had their basis in one or more of 4 attributes: texture, composition, precursor lithology (protolith) and metamorphic grade. These criteria are not mutually exclusive and thus most names have taken on more than one connotation or meaning. This "mixed" terminology can be a never-ending source of confusion, inasmuch as there are multiple uses for single names, or several names used for rocks that are texturally (and in some cases chemically) identical. This is clearly undesirable from a descriptive standpoint, and if we are to use these names they need to be precisely defined. Although we will adhere to definitions that emphasize texture and composition, it is important to realize that there has never been a consensus on the precise definition of most metamorphic rock names and that others may use them differently.

Slate, **Phyllite**, **Schist** - We will use these as *grain size names for micaceous or chloritic metamorphic rocks that possess a foliation*. **Slates** have individual mica grains that are not visible at 10X magnification and are thus not lustrous. Individual micas in **phyllites** are visible at 10X and impart a sheen to foliation surfaces in strong sunlight. **Schists** have individual mica grains that are visible to the naked eye. All can (and should!) be prefixed by the dominant and/or porphyroblastic minerals present e.g. Garnet-staurolite-andalusite schist. Minerals should be listed from most to least abundant in the prefix.
The names **psammite**, **semipelite** and **pelite** are nongenetic compositional terms for quartzose to aluminous rocks; Psammite for quartz-rich, semipelite for quartzose and aluminous rock, and pelite for highly aluminous rock. They are used as prefixes for schists e.g. **pelitic schist**, **semipelitic schist**, to connote how much mica is present.

Gneiss - any rock possessing a gneissic foliation (see above), in which individual grains are visible to the naked eye or easily seen at 10X magnification. The name can be prefixed by the dominant and/or porphyroblastic minerals present, e.g. Muscovite-biotite gneiss, and/or by the word **augen** when appropriate. The prefixes **para** and **ortho** connote a sedimentary or igneous precursor, respectively, but should be used only when the protolith is known with certainty.

Marble - any foliated or non-foliated metamorphic rock composed of > 50% calcite or dolomite. Usually granoblastic, with or without a foliation defined by compositional layering. The name can be prefixed by any other minerals present, or by the dominant carbonate present, e.g. tremolite marble, dolomite marble, calcite marble.

Calc-schist - foliated metamorphic rock composed of >50% calcium silicate minerals (e.g. tremolite, diopside, grossular, wollastonite, etc.) in a carbonate host. Non-foliated rocks of this mineralogy should be referred to **calc-silicate rock**, or preferably by a more specific name e.g. tremolite-diopside rock.

Quartzite - foliated or non-foliated granoblastic metamorphic rock composed of > 90% quartz. Foliation if present can be defined by either elongation of quartz grains and/or aligned, sparse micas. Bedding/crossbedding may be preserved in the form of darker heavy mineral layers (e.g. magnetite). The name can be prefixed by any porphyroblasts or other minerals present (e.g. garnet-quartzite, muscovite-quartzite).

Mafic Schist - foliated *or nonfoliated* rock of any grain size composed predominately of mafic minerals (particularly chlorite, epidote, amphibole, pyroxene) and plagioclase. These are invariably green, black and, more rarely, blue in color. This general name encompasses rocks that are also referred to as **greenschist**, **greenstone**, **amphibolite**, **blueschist**, and **eclogite**. All are undesirable as rock names, inasmuch as they also connote a metamorphic facies, which may or may not correspond to the mineralogy of the rock! As descriptive terms **greenschist** and **greenstone** have been used as names for fine-grained schistose or granoblastic rocks composed of mostly chlorite, epidote, actinolite and plagioclase. **Amphibolite** is a widely used term for rock composed of mostly black amphibole and plagioclase, **blueschist** for blue to blue-green rocks containing blue (Na) amphibole, and **eclogite** for rocks containing grass-green pyroxene (omphacite) and red, Mg-rich garnet. Other names in wide use are **metagabbro** (coarse-grained foliated or isotropic plagioclase-amphibole rock) and **metabasalt** (nondescript, fine-grained black or gray rock, of mafic composition), which are also undesirable unless a clear indication of the protolith is present, which is rarely the case.

Serpentinite - foliated or non-foliated rock contain > 50% serpentine. Though often used as such, this is not strictly a metamorphic rock name (there are sedimentary serpentinites, and serpentine can form at temperatures that most would consider within the realm of diagenesis).

Migmatite - literally "mixed rock"; intimately interleaved metamorphic and igneous rock. The igneous portion may itself be metamorphosed.

Hornfels - fine-grained, granoblastic rock of any composition that was *produced by contact metamorphism*. Should be prefixed by dominant mineral(s) present e.g. hornblende hornfels. This genetic definition is the most widely accepted one, however the term is also sometimes used for any fine-grained rock with a granoblastic texture.

Finally, for low-grade metamorphic rocks *that retain primary textures or structures*, the adjective "meta" can be used in front of a sedimentary, volcanic or igneous rock name (e.g. metatuff, metachert, metadiorite, metabasalt, metagabbro, metagraywacke, etc.) as a rock name. When the protolith is uncertain, one of the textural or compositional names above is preferable.

II. Writing a Description

All rock or rock unit descriptions begin with a rock name. If the rock is from a unit that has a formal stratigraphic name, then the description usually begins with this, followed by the rock name (e.g. Valley Spring Gneiss - garnet-biotite schist; Packsaddle Schist - dolomite marble).

Following the rock name should be a description of the most obvious characteristics; the grain size, fresh and weathered color, rough estimates of the percents of each major mineral, range of sizes of any porphyroblasts, and any surviving primary textures or structures (e.g. bedding, sed. structures, igneous textures). After this the orientation of the minerals of the rock and any folds are described. Pay particular attention and carefully describe any cross cutting relations among fabric elements and/or folds if present.

Keep in mind that some rocks will require greater description than others. Try to keep your descriptions as short and concise and possible without leaving out any major features.

III. Example Description

Sample #C269 - feldspar-biotite gneiss

Medium-to fine-grained, pink-and black-banded gneiss. Compositional layering is defined by submillimeter, discontinuous, planar, biotite (+ muscovite?) laminae and 1-2 mm-thick, fine-grained, granoblastic pink K-feldspar + quartz layers. Biotite is aligned with basal cleavage parallel to compositional layering, but does not define a lineation on foliation surfaces.

IV. Exercise

Write rock descriptions for 5 of the numbered samples.