Everest Education Expedition Curriculum

Classroom Activity: Research Gear and Equipment
The Rocks and Minerals of Everest

Created by Montana State University Extended University and Montana NSF EPSCoR
www.montana.edu/everest

Scientific research on the geology of Mount Everest was a significant component of the 2012 Everest Education Expedition, as it was with the first American expedition to Everest in 1963. Previous research in the Everest region is limited in scope due to the obvious difficulties of conducting fieldwork under extreme conditions of elevation and topography. The research agenda of Montana State University's Dr. David Lageson was directed towards:

- gaining a better idea of the age of Mount Everest and rocks that comprise the massif;
- collecting a suite of samples to better date and describe the fossil-bearing marine limestones that form the summit pyramid of Everest;
- studying the major faults that cut through Mount Everest to better understand how and when they formed (in particular, the Qomolangma and Lhotse detachment faults);
- and, hopefully, measuring a new GPS-based elevation of the summit of Mount Everest with the most modern and accurate equipment available.

Read more about the scientific research at http://www.montana.edu/everest/about/research.htm

Some of the common rocks and minerals found on Mount Everest are granite, limestone, garnet and schist. These are also commonly found in Montana!

Download the Geologic Map of Montana at
http://www.mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?pub_id=30081&
Exploring Montana's Roadside Geology is available at Montana Governor Brian Schweitzer and the First Lady's Math and Science Initiative http://www.mathscience.mt.gov/ or go directly to http://www.mathscience.mt.gov/pages/roadsigns.htm

GRANITE

Granite is a common igneous rock found on the lower slopes of Mount Everest and throughout the Everest region. Ama Dablam also has extensive outcrops of granite on its upper slopes; this is the beautiful peak the 2012 Everest Education Expedition passed on its trek into Everest Base camp (EBC). The most visible outcrops of granite in the Everest area are found on Nuptse (7861 m), immediately southwest of Everest. The “Nuptse leucogranite,” meaning light-colored granite, is approximately 24 million years old based on isotope dating techniques. Granite is a type of intrusive igneous rock composed of the common minerals quartz and orthoclase feldspar, with lesser amounts of plagioclase feldspar, mica (muscovite and biotite) and dark amphibole (hornblende). Because of the elemental composition of these minerals, granite is overall high in silica and poor in iron and magnesium. Also, due largely to the quartz and feldspar minerals, granite is typically light in color, ranging from light gray to pink. The Nuptse leucogranite, as the name implies, is light gray to almost white in color.

Typical granite showing light-colored minerals (quartz, feldspar, muscovite) and dark (biotite, hornblende)

LIMESTONE

Limestone is a biogenic (biological) sedimentary rock composed of calcium-carbonate ($CaCO_3$). As such, these rocks are often called “carbonate” sedimentary rocks. Carbonate sediments are often deposited in shallow, warm, tropical marine environments, such as the Bahamas and coast of Belize in the western Caribbean. Calcium-carbonate is a common constituent of shells of marine invertebrate animals. In the open ocean, tiny *planktonic foraminifera* also build their microscopic shells out of calcium-carbonate; when they die, the shells settle through the water column and either dissolve on the way down due to pressure, or settle on the ocean floor on the shallow flanks of mid-ocean spreading ridges. On Mount Everest, limestone is found on the summit pyramid, comprising a formation that geologists call the Mount Qomolangma Formation. The limestone beds are 470 million years old and were deposited during the Ordovician Period of the Paleozoic Era (refer to a geologic time scale if you have one). These rocks were deposited in the Tethys Ocean north of the Gondwana Supercontinent, long before the plate collision that uplifted the Himalaya. Therefore, the highest rock outcrop on Earth is an ancient seafloor with fossils of marine invertebrate rocks! The rocks provided in the Montana teachers' kit are from Montana and are slightly older (Cambrian – about 500 million years old). Try to identify some fossils in these rocks!

Climbers near the summit of Everest. Photograph courtesy of Conrad Anker.

GARNET and SCHIST

Garnet is a mineral, not a rock! Garnet is a common metamorphic mineral composed of iron, magnesium, manganese or calcium chemically bonded to aluminum and SiO_4. The common crystal form is a “dodecahedron” – look this up on the web and draw a picture of it. In the Everest area, garnet is commonly found in the metamorphic rock **schist**, in addition to other rock-forming minerals such as staurolite, muscovite, biotite, plagioclase, chlorite and sometimes andalusite. Metamorphic rocks are derived (*metamorphosed*) from preexisting rocks through heat, pressure, and chemically active solutions. The preexisting rock (protolith) of schist is mudrock or shale, which are common sedimentary rocks. Schist and sillimanite-grade **gneiss** are common metamorphic rocks of the Greater Himalayan Sequence (sometimes locally called the Rongbuk Formation), being a sequence of high-grade metamorphic rocks comprising the base of Everest, the bulk of Lobuche west of the Khumbu Glacier, and the lower slopes Nuptse, Island Peak and other peaks to the south. These metamorphic rocks extend for many kilometers southward from Everest to the Main Central Thrust (MCT) south of Lukla, where the 2012 Everest Education Expedition trek to Everest Base Camp began. The MCT is a major thrust fault responsible for the uplifting the **Greater Himalaya**.

Photo of purple garnet crystals in mica schist. From *RocksForKids.com* (http://www.rocksforkids.com/R&M/mica.htm)