October 4, 2021

News and notes

Before continuing with our look at metamorphic rocks, here are some news items that I thought were interesting:

- Lost in the desert: Missing Arizona geologist's dad pleads for safe return: 'I will continue to fight for him'. The geoscience profession is not without its risks, let's hope that he is found alive and well.

- Online conference focuses on the vital role of geoscience in managing radioactive waste. Whether we expand the use of nuclear power, or not, we will still have to find a safe place to bury the waste.

- A study into the geology of the continental shelf offshore of Newfoundland: Structural characterization offshore Newfoundland; lot of neat geoscience, such as 2D and 3D analysis of the seismic data.

- Tunisia's new Prime Minister, Najla Bouden Romdhane, formerly taught geology at the National School of Engineers in the capital Tunis. She holds a doctorate in geology from the Paris School of Mines in earthquake engineering.

- Volcanoes erupting this past week: La Palma, Canary Islands, Spain; Suwanose-jima Ryukyu Islands, Japan; Kilauea, Hawai'i, U.S.A; Popocatépetl, Mexico; Fuego, Guatemala; Sangay, Ecuador; Reventador, Ecuador; Sabancaya, Peru; Nevados de Chillán, Chile; Nyiragongo, Democratic Republic of the Congo.

- More on Kilauea, neat web cam footage

- Scientists use nuclear physics to probe Floridan Aquifer threatened by climate change: using radioactive isotopes to trace groundwater flow in the aquifer beneath Florida

- Shades of Jurassic Park: Potential Remnants of Original Dinosaur DNA Discovered in Exquisitely Preserved Dinosaur Cells. The remains date from the Early Cretaceous.

- He could grow up to be a geologist: 6-year-old boy in Michigan picks up a Mastodon molar while hiking.

- Cutbacks to geoscience education in Australia. Not a good move for a country with a large resource sector.

- From the U.S. Energy Information Administration, the U.S. Energy Atlas. It's a "comprehensive reference for data and interactive maps of energy infrastructure and resources in the United States".

- If you like heavy duty geoscience papers, check out: New Geology articles published online ahead of print in September. Eureka Alert comes out every month.

October 4, 2021

Metamorphic Facies and Index Minerals

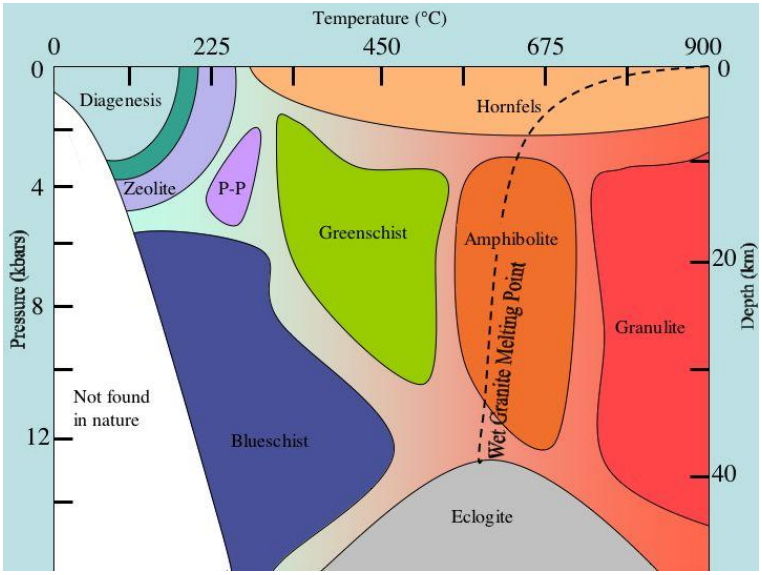

Figure 1 - Metamorphic Facies
Credit: David Magrass, public domain

As I noted in last week's, the kinds of minerals found in a metamorphic rock will depend on the heat and pressure that form the rock. These mineral assemblages are organized into metamorphic facies, as in Figure 1. Let's look at these metamorphic facies and the minerals they commonly contain. After that, we can look at an example from the field.

Table 1 shows the mineral assemblages for the various facies and is organized by the whether the metamorphic rock is derived from:

- sedimentary rocks, such as shale, sandstone or limestone;

- igneous mafic rocks such as basalt, gabbro, diorite and tonalite; or from
- ultramafic rocks, such as pyroxenite and peridotite.

Table 1 - Mineral Assemblages for Metamorphic Facies

Facies	Derived from Sedimentary Rock	Derived from Mafic Rocks	Derived from Ultramafic Rocks
Zeolite Facies			
Present together	illite/phengite + chlorite + quartz	zeolite + chlorite + albite + quartz	lizardite/chrysotile + brucite + magnetite
May also be present	Kaolinite, paragonite	prehnite, analcime, pumpellyite	chlorite, carbonate minerals
Prehnite-pumpellyite Facies			
Present together	phengite + chlorite + quartz	prehnite + pumpellyite + chlorite, albite + quartz	lizardite/chrysotile + brucite + magnetite
May also be present	pyrophyllite, paragonite, alkali feldspar, stilpnomelane, lawsonite	actinolite, stilpnomelane, lawsonite	antigorite, chlorite, carbonate minerals, talc, diopside
Greenschist Facies			
Present together	muscovite + chlorite + quartz	chlorite + epidote + albite	antigorite + diopside + magnetite
May also be present	biotite, alkali feldspar, chloritoid, paragonite, albite, spessartine	actinolite, biotite	chlorite, brucite, olivine, talc, carbonate minerals
Amphibolite Facies			
Present together	muscovite + biotite + quartz	plagioclase + hornblende	olivine + tremolite
May also be present	garnet, staurolite, kyanite, sillimanite, andalusite, cordierite, chlorite, plagioclase, alkali feldspar	epidote, garnet, orthoamphibole, cummingtonite	antigorite, talc, anthopyllite, cummingtonite, enstatite
Granulite Facies			
Present together	alkali feldspar + plagioclase + sillimanite + quartz	orthopyroxene + plagioclase	olivine + diopside + enstatite
May also be present	biotite, garnet, kyanite, cordierite, orthopyroxene, spinel, corundum, sapphirine	clinopyroxene, hornblende, garnet	spinel, plagioclase
Blueschist Facies			
Present together	phengite + chlorite + quartz	glaucophane/crossite + lawsonite/epidote	antigorite + olivine + magnetite
May also be present	albite, jadeite, lawsonite, garnet, chloritoid, paragonite	pumpellyite, chlorite, garnet, albite, aragonite, phengite, chloritoid, paragonite	chlorite, brucite, talc, diopside
Eclogite Facies			
Present together	phengite + garnet + quartz	omphacite + garnet + rutile	olivine
May also be present			

Figure 2 illustrates how these various metamorphic facies are formed at a subduction zone, where one tectonic plate is being pushed under another.

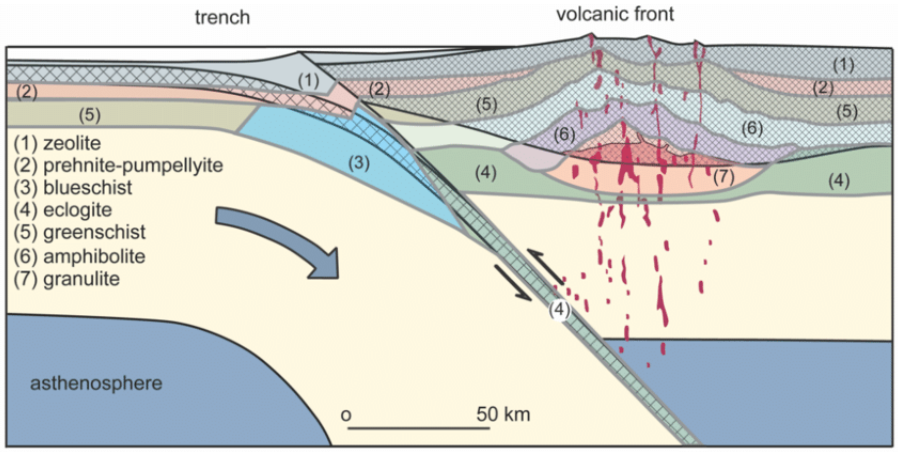

Figure 2 - Schematic Cross-Section of Subduction Zone
Credit: After Ernst (1976) 1

Index Minerals and an Example from the Field

As you can see in the lists of minerals above in Table 1, there is quite a bit of overlap in the minerals found in the various facies. When a geologist studies a geological feature, it's probably more convenient to organise the findings based on index minerals that reflect the various grades of metamorphism. Figure 3 shows some common minerals in metamorphic, arranged in order of the temperature ranges that they were formed in and remained stable.

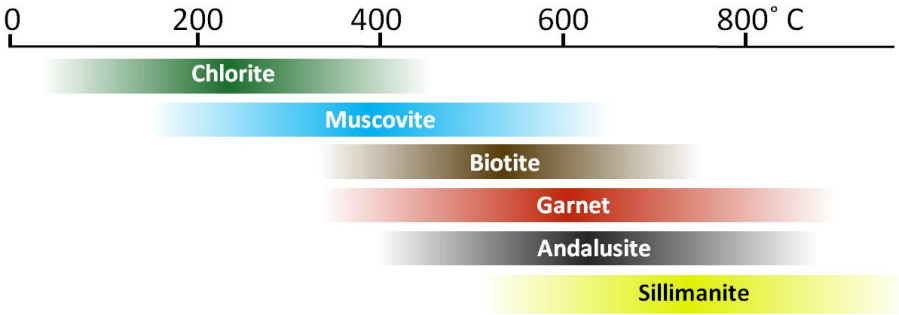

Figure 3 - Index Minerals
Credit: Steven Earle, CC BY 4.0,

An example of how to use index minerals is shown in the Meguma Terrane of Nova Scotia. First , let look at shows a geological map of the Meguma Terrane, Figure 4.

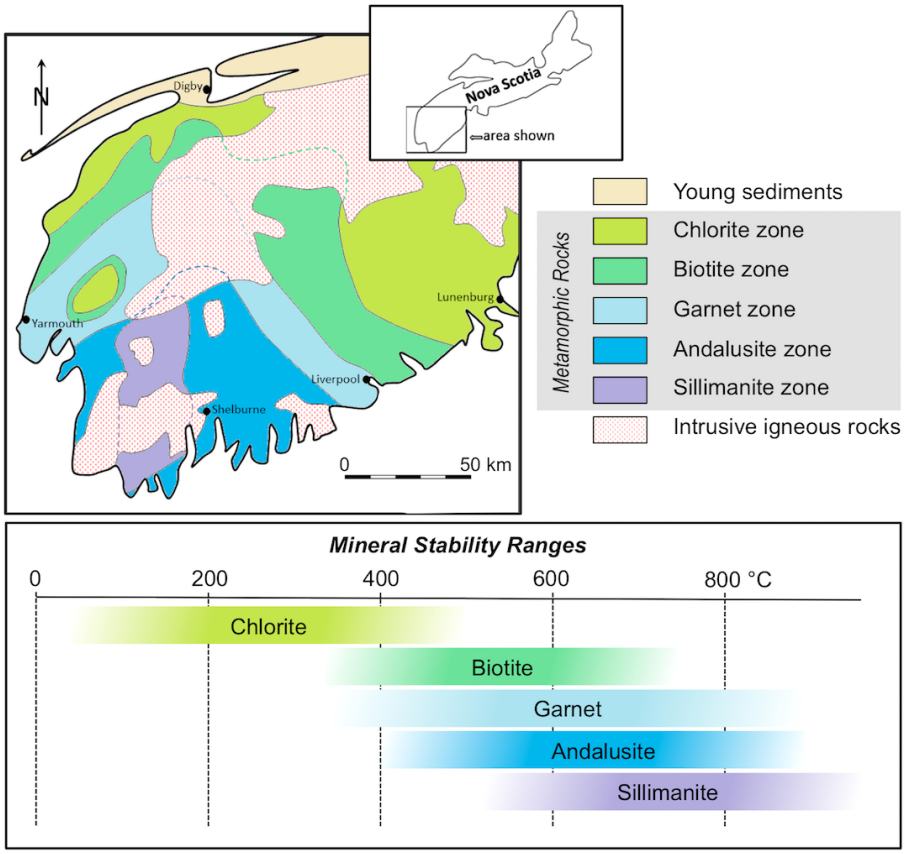

Figure 4 - Meguma Terrane, Nova Scotia
Credit: after Keppie & Muecke (1979) 2 and White & Barr (2012) 3

The metamorphic rocks in Southwest Nova Scotia were formed by the collision of a relatively small tectonic plate, the Meguma Terrane, with the North American Plate during the Devonian Acadian Orogeny. One explanation for the current geology of the Meguma Terrane is that the rocks were metamorphosed into a series of metamorphic zones. These zones were formed depending on how deep the rocks were buried and how hot the rocks got. Subsequent erosion and uplift exposed the metamorphic zones. Figure 5 illustrates this scenario.

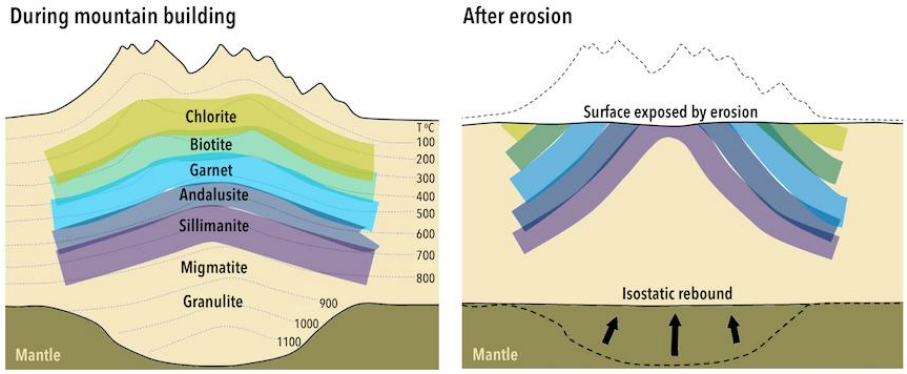

Figure 5 - Formation of the Meguma Terrane
Credit: Karla Panchuk, CC BY 4.0

In next week`s posting, we`ll look at a few examples of common metamorphic rocks.

Standard Caveat

The purpose of my weblog postings is to spark people's curiosity in geology. Don't entirely believe me until you've done your own research and checked the evidence. If I have sparked your curiosity in the subject of this posting, follow up with some of the links provided here. If you want to, go out into the field and examine some rocks on your own with the help of a good field guide. Follow the evidence and make up your own mind.

In science, the only authority is the evidence.

References

1. Ernst, W.G., 1976, *Petrologic Phase Equilibria*, W.H. Freeman, San Francisco
2. Keppie, D., & Muecke, G., 1979, *Metamorphic map of Nova Scotia*, Nova Scotia Department of Mines and Energy, Map 1979-006.
3. White, C. E., & Barr, S. M., 2012. *Meguma Terrane Revisited: Stratigraphy, Metamorphism, Paleontology and Provenance*. Geoscience Canada 39(1), https://journals.lib.unb.ca/index.php/GC/article/view/19450/21005