The rocks of the Gjøvik area

by Hans - Jørgen Berg

Ametyst med dolomitt, Fjellhallen, Gjøvik. Samling: Jan Morten. Hagebakken Foto: STEIN/O.T.

Ametyst med kalsitt, Fjellhallen, Gjøvik. Samling: Jan Morten. Hagebakken Foto: STEIN/O.T.

The new Olympic Ice Hockey Hall in Gjøvik is build into a hill, Hovdetoppen, consisting of Precambrian gneisses. These gneisses belong to the most easterly part of the Kongsberg Precambrian terrain. North of Gjøvik there is allochtonous late Precambrian sediments, and in south fault related blocks of Cambro-Silurian sediments. In the east the Gjøvik area borders to the northern part of the Oslo-graben. This article presents briefly the geologic history of the Gjøvik area and which processes the rocks at the new rock cavern have been trough.

Regional metamorphosis

Most people are familiar with gneiss, but not which processes this rock type has been through to get the look and texture it has today. Gneiss is a rock type that has been through a regional metamorphosis. The original rock has been heavily folded and recrystallized under high temperature and pressure. Most textures in the original rock have disappeared. Only the chemistry of the altered rock may give clues to what the gneiss or other metamorphosed rock originally was before regional metamorphosis. Briefly the following processes occur during regional metamorphosis:

- **Dehydration.** Water and other volatiles disappear. Pore water is first squeezed out of the rock, then at increasing temperature and pressure the crystal water is removed from zeolites and other water containing minerals. The end product is a "dry" rock.
- **Recrystallization.** Existing mineral grains grows together such that the rock gets a more coarse texture. An example is the metamorphosis from sandstone to quartzite. The sand grains grow together when the temperature and pressure increases. The sandstone grows increasingly coarse, and the result may be a flinty massive quartzite. A phenomenon called pressure solution is common during this process. The separate mineral grain is dissolved at high pressure areas and precipitated at low pressure areas (Bard, 1986).
- **Precipitation of new minerals.** The original mineralogy in a rock may become

Ametyst med dolomitt, Fjellhallen, Gjøvik. Samling: Jan Morten. Hagebakken Foto: STEIN/O.T.

Ametyst, Fjellhallen, Gjøvik. Samling: Jan Morten. Hagebakken Foto: STEIN/O.T.

unstable when temperature and/or pressure increases. New minerals form at the expense of older. The following reaction is an example (Turner, 1981):

Zeolite -> Prehnite + Pumpellyite -> Pumpellyite + Actinolite

Increasing temperture/pressure ->

- **Foliation.** At increasing pressure tabular minerals have a tendency to recrystallize and orientate it self 90° on the direction of the highest pressure (Park, 1983). An example is slate, where the cleavage is caused by parallel oriented mica or chlorite flakes. The highest pressure direction is in this case at right angle of the cleavage.
- **Metamorphic differentiation.** This is a redistribution of minerals in rocks (Park, 1983). Gneissose banding is an example of this process.
- **Migmatitation.** A partial melting may occur when the temperature and/or pressure becomes high enough. It is common to classify the different degrees of transformation into something called metamorphic facies (Press & Siever, 1982; Turner, 1981):

Zeolite facies — low temperature
Greenschist facies ↓
Amphibolite facies ↓
Granulite facies ↓
Migmatittes — high temperature.

The different facies have their typical index minerals, depending on original rock type (Figure 2).

Rocks exposed to regional metamorphosis receives an appearance that is called metamorphic texture. I will concentrate only on rocks found in the Gjøvik area (a more detailed description is given in Press & Siever, 1982; Park, 1983):

Gneissose banding. The typical example is alternating bands with light and dark minerals. The minerals are usually quartz and feldspar, and biotite and amphibole.

In addition gneisses may have other metamorphic textures:

- **Augen gneiss.** The gneiss contains large porphyroblasts of quartz, feldspar or garnet.

Granitic gneiss. The texture is similar to granite, but at closer examination one usually are able to see a foliation. The mica flakes are parallel oriented, and often concentrated in layers.

Amphibolite. This is a dark, massive, medium coarse to coarse rock type. Amphibole makes up 50% or more of the rock. The foliation is made of parallel oriented crystals of amphibole, and may be very well developed. Porphyroblast of garnet occurs.

Regional metamorphic rocks are usually formed at collisions between two continents or a continent and an ocean plate. They are today the exposed roots of an eroded mountain chain.

Ametyst og barytt, Fjellhallen, Gjøvik. Samling: Jan Morten. Hagebakken Foto: STEIN/O.T.

Barytt, Fjellhallen, Gjøvik. Samling: Jan Morten. Hagebakken Foto: STEIN/O.T.

Kalsitt, Fjellhallen, Gjøvik. Samling: Jan Morten. Hagebakken Foto: STEIN/O.T.

Kalsitt og ametyst, Fjellhallen, Gjøvik. Samling: Jan Morten. Hagebakken Foto: STEIN/O.T.

Historical geology

The Gjøvik area is situated in the eastern part of the Kongsberg Precambrian terrain. In the east the area is parted from the south-eastern Norwegian Precambrian terrain by the northern part of the Oslo-graben. It is possible that the two Precambrian terrains were connected before the formation of the graben. The Kongsberg Precambrian terrain has the following history (Oftedal, 1981):

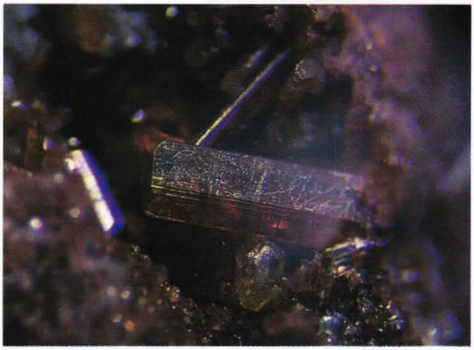
Permian diabase dykes. Silver mineralization in Kongsberg(?) 270 mill. years
Late stage of breccia ? mill. year
The Telemark metamorphosis. (mountain chain development) 1060 mill. years
Intrusion of the Meheia granite 1070 mill. years
Intrusion of the Helgevannet granite 1200 mill. years
Intrusion of the Vinor gabbro and diabase dykes 1200 - 1370mill. years

The Kongsberg metamorphosis (amphibolite facies)1500 - 1600 mill. years
Supracrustal complex 1580? mill. years
Quartz-feldspar gneisses ? mill. years
Amphibolite, fahl bands, etc. ? mill. years

The south-eastern Norwegian Precambrian terrain (Oftedal, 1981) consists, in the part closest to Gjøvik of, gneisses and granitic

Chabasitt, Totenåsen. Samling Bjørn Skår. Foto: STEIN/O.T.

Heulanditt fra Totenåsen. Samling: Bjørn Skår. Foto: STEIN/O.T.



Piemontitt, Hedemarken. Samling: Arne Moløkken Foto: STEIN/O.T.

Septerametyst, Fjellhallen. Samling: Johan Hagebakken. Foto: STEIN/O.T.

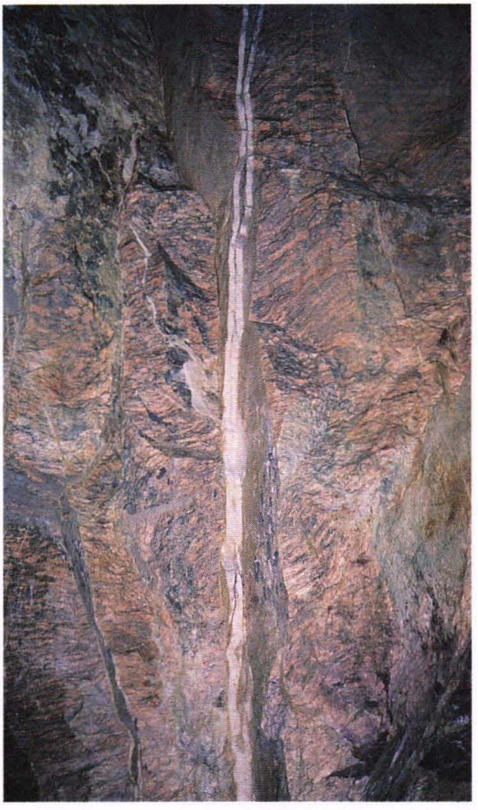
gneisses. Two larger mylonite zones strikes northwest-southeast through the area. The largest ends in Mjøsa, in the Stange area. It is believed to be a result of a collision between two continent plates (Oftedal, 1981). The age is about 1000 mill. years. The other mylonite zone ends at Øyeren. The age is also about 1000 mill. years. A fracture and/or fault zone may be followed to the north, to a certain degree all the way to Gjøvik area (Oftedal, 1981; Ramberg & Larsen, 1978).

Between Cambrian and Silurian the Gjøvik area was covered by sea, and a 1 km thick sequence of sediments was deposited (Henningsmoen, 1977).

During the Caledonian mountain range formation (~395 mill. years) the area as lifted up over sea level, and covered by allochtonous Cambrian and late Precambrian sparagmites. They are now eroded away from the Gjøvik area, but are found 3 km north of Gjøvik.

In Permian the area from the Oslofjorden area and northward sank down and formed the Oslo Graben (Dons & Larsen, 1978). South of Gjøvik this resulted in heavy volcanic activity and graben formation. In the Gjøvik area is block faulting the most visible result of the Permian activity. Some of the Precambrian faults were reactivated during this period. It is possible that the area was covered by exstrusives. They are in that case eroded away.

After Permian the only activity in the Gjøvik area has been erosion.



Lukket kvartsåre med en svak lilla sone i midten i Fjellhallen.
Quartz vein with a weakly purple coloured zone in the midle. Foto: STEIN/GHW

The geology of the rock cavern

The rock cavern in Gjøvik is built into Hovdetoppen that consists of Precambrian granitic gneisses. Two types are described (Morset & Løseth, 1993), one reddish and one grey. Both consist of 30% quartz, 65% feldspar and 5% chlorite, mica and hornblende. Some irregular lenses of amphibolite cut through the granitic gneiss (Figure 3 & 4). So does also multiple joints. Most of these strikes WSW-ENE and are nearly vertical. The joints are probably a result of Permian fault activity. Some of the joints are mineralised by crystals of calcite, epidote, chlorite, albite, baryte and quartz. A dextral fault also cuts through the gneisses. This fault is probably of Permian age.

It is difficult to definitively decide what the rocks from the Gjøvik Olympic Ice Hall originally was before the regional metamorphosis. They have been through one, probably two large metamorphic events where they have been heavily folded and deformed. The two granitic gneisses were probably originally granites of unknown age, which intruded into existing older gneisses. The amphibolites may be relics of diabase dykes or gabbro intrusives. A detailed chemical analysis is necessary to get an answer. No such analyses are as far I know done.