May 31, 2021

Evaporites

"*You are the salt of the earth*" Matthew Ch. 5, v. 13.

Figure 1 - Blue Halite, Lanigan Mine, Saskatchewan, Canada

I am going to continue our look at rock forming minerals with a look at evaporites, also known as salts.

Origins of Evaporites

Evaporites originate in the evaporation of sea water. The salt content of sea water is the result of the erosion of rocks. Physical erosion breaks up rocks into smaller pieces, chemical erosion then dissolves the ions that make up the constituent minerals. These ions include sodium, calcium, and potassium cations as well as chloride and sulphate anions. When sea water evaporates, it leaves behind a salt deposit. Not all dissolved salts have the same solubility. Depending on the environment, and how often new water enters the system, evaporation of sea water can deposit gypsum/anhydrite (hydrous and anhydrous calcium sulphate), sylvite (potassium chloride) or halite, a.k.a. common salt (sodium chloride). The halite shown in Figure 1 is from the Middle Devonian Prairie Evaporite Formation; this formation of halite and sylvite was deposited in hyper-saline lagoons on the edge of an interior continental sea. Similar processes lead to the deposition of gypsum and anhydrite. Figure 2 shows some of the kinds of environments where evaporites can be deposited.

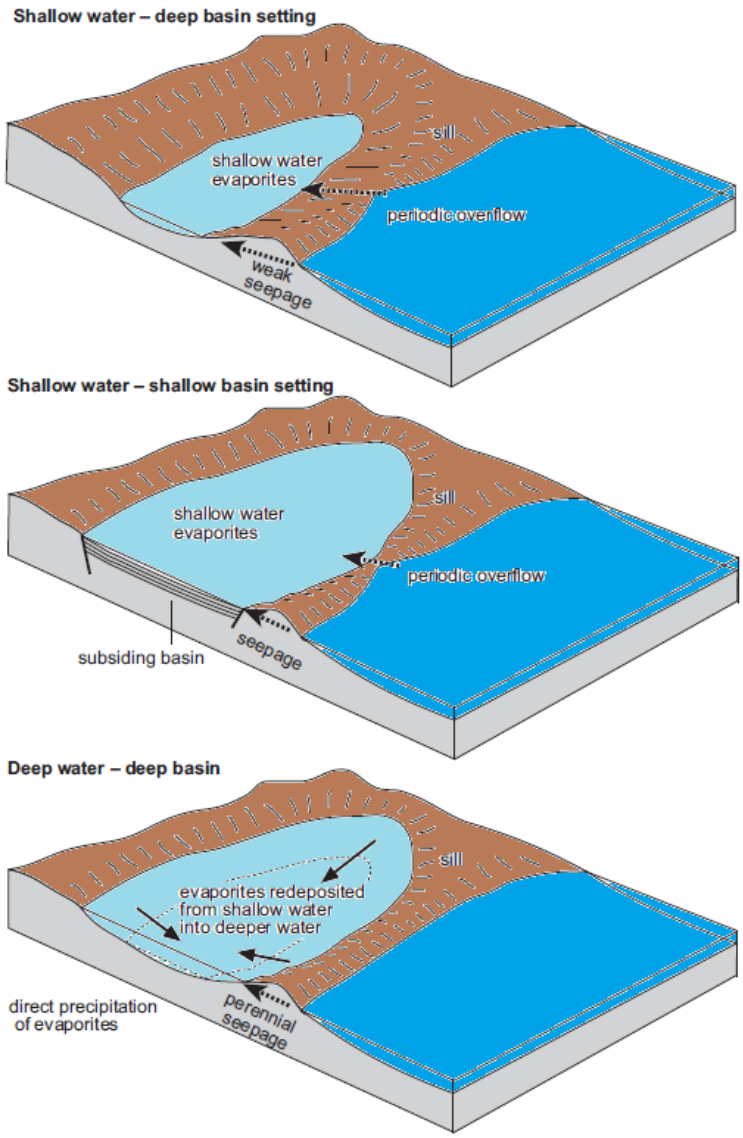

Figure 2 - Marine Evaporite Depositional Environments

Modified from Figure 15.19 in Nichols, G. *Sedimentology and Stratigraphy*, 2009, Wiley-Blackwell, Oxford U.K.

Extraction of Evaporite Minerals

Halite, sylvite and gypsum/anhydrite are mined from deposits formed in ancient seas. Sometimes the evaporite deposit contains more than one mineral, so let's look at the extraction methods before looking at the individual minerals.

Mining for halite and sylvite is a common practice. Ancient salt mines were dangerous places to work and the miners were often slaves. Modern mines are large scale industrial affairs with well

paid skilled labour. The largest underground common salt mine in the world is the Sifto Salt Mine in Goderich, Ontario as in Figure 3.

Figure 3 - Sifto Salt Mine, Goderich ON

Halite and sylvite can also be recovered by the process of solution mining. In this process, water is pumped down to the salt deposit, the water dissolves salt and is pumped back to the surface. Solution mining is used to mine sylvite in Saskatchewan; it is also used extensively to recover common salt, halite.

People also produce salt by mimicking the natural processes that lead to salt deposition. Figure 4 shows the salt production lagoons in the San Francisco Bay.

Figure 4 - Salt Ponds, San Francisco

Gypsum and anhydrite are almost always recovered through open pit mines. Mining methods are fairly straight forward: remove the overburden and then dig out the gypsum or anhydrite for processing elsewhere.

Not all gypsum comes from mines, however. Selenite crystals can precipitate out of soils that are rich in sulphates, a phenomena known as desert roses. When the Red River Floodway was constructed through thick glaciolacustrine clays, selenite crystals were found precipitating out of the clay. When the Wallace building for the Department of Geological Sciences at the University of Manitoba was completed, they left part of the basement unfinished with exposed clay walls. In the early 1990's I gave a talk to university students there on working in environmental geology and afterwards, a couple of professors took me into the basement of the building to show me the selenite crystals growing out of the clay walls.

Evaporite Minerals

Common Salt - Halite

Figure 5 - Halite, Trona, San Bernardino Co., California, USA

Common salt, halite, NaCl, is an everyday commodity and familiar to most people. The mineral varies in colour and can be colourless, whitish, yellow, red, purple or blue with a vitreous lustre. Halite has an isometric crystal structure and a hardness of 2.5 on Moh's Hardness Scale.

Salt is an important commodity. The United States Geological Survey (USGS) lists worldwide production figures for salt in 2020 of 270,000 thousand metric tons. The uses of salt include highway de-icing, industrial chemical production, together with food production and distribution. Production of salt during 2020 in the United States was: rock salt, 43%; salt in brine, 40%; vacuum pan salt, 10%; and solar salt, 7%.

Libraries of books have been written on the subject of salt. I found 40,000 entries in a search for "salt" in books on Amazon.ca. A Google search for "salt" yielded about 809,000,000 results. If you want to follow up on this subject, there is a deep well of information available.

Sylvite - Potash

Figure 6 - Sylvite, Esterhazy Saskatchewan

Sylvite, KCl, is most commonly mined for potash. It is typically red in colour with a vitreous lustre. It has an isometric crystal structure and a hardness of 1.5 to 2 on Moh's Hardness Scale.

Most sylvite is mined from massive evaporite beds, like the Prairie Evaporite Formation, noted above. The USGS lists worldwide production figures for potash of 43,000 thousand metric tons of K_2O equivalent, of which Canada is the largest producer. The main use for potash is agricultural as a potassium additive to fertilizer. Potash is also an important additive to glass and is used in the "salt" for water softeners. If you eat salted sunflower seeds, the sharp salty flavour may come from sylvite added to the salt mix.

An interesting irony is that potash is mostly in demand as a fertilizer component in wet, tropical climates. The major producer in Canada is Saskatchewan, which has a dry, cold, almost sub-arctic, climate.

Gypsum and Anhydrite

Figure 7 - Gypsum, var. selenite
Credit: Géry PARENT, public domain

Gypsum, $CaSO_4 \cdot 2H_2O$, and anhydrite, $CaSO_4$, are both varieties of calcium sulphate with gypsum being the hydrous variety. Both gypsum and anhydrite tend to be found in massive evaporite deposits. Gypsum seems to be the primary chemical precipitate from sea water. Following deposition and compaction, anhydrite was formed by the dehydration of gypsum after burial.

Gypsum varies in colour from colourless to white, with occasional tints of other colours due to impurities. It has a hardness of 2 on Moh's Hardness Scale and has a monoclinic crystal structure.

Anhydrite has a variety of colours including colourless, bluish, blue-grey, violet, burgundy-red, white, rose-pink, brownish, and grey. It has a hardness of 3 - 3.5 on Moh's Hardness Scale and has an orthorhombic crystal structure

The main use for gypsum and anhydrite is in agriculture and in building materials such as concrete, Plaster of Paris, and drywall. A typical new home in North America contains more than 7 metric tons of gypsum alone. The USGS lists worldwide production figures for gypsum and anhydrite at 150,000 thousand metric tons.

The Plaster of Paris that you buy in the hardware store is powdered calcium sulphate, anhydrite. Mixing the plaster with water turns it into hydrous calcium sulphate, gypsum.

Anhydrite and gypsum rock have historically been used as alabaster for building stone and decorative objects. For example, the walkways in the Canadian Museum for Human Rights in Winnipeg are lined with alabaster slabs, as in Figure 8, below.

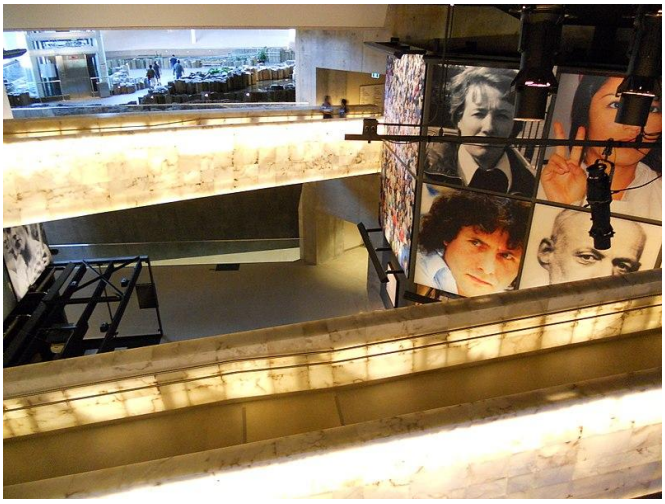

Figure 8 - Alabaster Lined Walkways at the Canadian Museum for Human Rights

Alabaster has also been used to carve bowls and containers. Figure 9 shows alabaster bowls from ancient Egypt.

Figure 9 - Alabaster Bowls

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.