Bauxite and Greenhouse Earth

Bauxite is a hard clayey material, generally white to red with dark spots or blotches called pisolites. It looks like it has an illness of some sort. This material was once described as a mineral ($Al_2O_3.2H_2O$). We now know it is a mixture of various aluminum hydroxide minerals (gibbsite, boehmite, diaspore) with minor amounts of clays and iron oxides. The reason one can still find it discussed in mineralogy classes is that once mineralogists describe something, they hate to let go of it. It is also a handy field name because one can't determine the specific mineral composition of bauxite without sophisticated analytical tests. Bauxite is our major source of aluminum. Aluminum is one of the most common elements in the earth's crust, but it usually occurs in minerals that are difficult to process, such as feldspar. Aluminum is handy stuff. It's light, relatively strong, and corrosion resistant. Charles Martin Hall, an industrial chemist and founder of what was later to become ALCOA, first learned to extract aluminum commercially in 1886. He used a rare mineral called cryolite, found mostly in Greenland. Cryolite was later supplanted by bauxite as the major aluminum source. The production of aluminum really expanded after World War II, when more uses were found for it.

Bauxite is a type of ancient soil or regolith. It requires tropic to sub-tropical climates in order to form. Bauxite will form only over rocks that are already rich in aluminum but poor in silica - such as nepheline syenites or clay-rich limestone. Then strong weathering is required over a long period of time. This leaches out anything even remotely soluble, leaving behind only the very insoluble aluminum hydroxides. Thus bauxite is a good indicator of areas that have in the past experienced very warm, moist climates. Not surprisingly many economic sources of bauxite are in tropic areas such as Surinam, Brazil, New Guinea and Jamaica.

Bauxite was first described in 1821 for deposits at Les Baux, St Remy, Bouches de Rhone, France. France is not known for a tropic climate, so a good question is why did bauxite form there? The answer is that the bauxite formed when the climate was much different from today.

Much bauxite worldwide formed during the Cretaceous and early Tertiary periods, from 50 million to 150 million years ago. This is when the large deposits in Arkansas formed. Often this is ascribed to the effects of plate tectonics. Areas that are not now in the tropics were moved through such climates as their plates shifted. During the Cretaceous, for example, Minnesota was at the same latitude as present-day Spain. But there is a second factor. During that period of geological time, the earth was experiencing a large-scale greenhouse effect.

A startling picture of this period of earth history is emerging from new studies of sediments laid down then on land and in the sea. During this time, CO_2 levels were over 1000 ppm and perhaps as high 4000 ppm. (For comparison today's values are about 380 ppm, and may go up to 750 ppm by the year 2100.) The source of this ancient CO_2 is thought to be from excessive volcanism. The world had a very different climate in Cretaceous and early Tertiary times. It was warm enough that continental temperatures may never have dropped below freezing. Crocodiles and palm trees grew at latitudes now occupied by the Arctic Ocean. There was likely no polar ice. Sea surface temperatures were very warm. In places in the equatorial oceans during the Cretaceous, sea surface temperatures was 95^{o}F, and locally as high as 107^{o}F. Today, sea surface temperatures at the equator are about 82^{o}F. At the latitudes of Newfoundland sea surface temperatures were about 86^{o}F, compared to 37-39^{o}F today. If this sounds good, realize also that the ocean often went stagnant for periods of time, and that sea level was 300 to 600 feet higher than today. This was enough to put a major seaway across the Dakotas, give Minnesota monsoons and cause Gulf of Mexico waves to lap at to the tip of Illinois. In such a warm climate, weathering conditions to make bauxite were much more widespread, and it's not surprising to find it formed in areas we think of as non-tropic.

Bauxite-like materials that formed at this time can be found in western Minnesota. Glaciers distribute this material widely in gravel pits where rock hounds often pick agates. This turns out not to be true bauxite. It's mostly clays (kaolinite), so weren't leached quite enough to get rid of the silicate minerals. Still, its formation in the local bedrock also speaks to this large-scale climate change, giving us a window into a very different past, and perhaps a model of the future.

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