Moon Mineral Found on **Earth**

When the Apollo astronauts accomplished the first moon landing, geologists were excited about seeing the first rocks returned from our nearest neighbor in space. The rocks turned out to be like those known on earth. There were basalt lavas like those in Hawaii, gabbros and anorthosites like those in Duluth, MN and breccias from meteor impacts like those at Meteor Crater, AZ Detailed study of the "moon rocks" did find a new mineral that was named armalcolite. The name derives from the first letters of the names of the Apollo 11 astronauts, Armstrong, Aldrin and Collins, who, as the paper first describing armalcolite put it wryly, "were responsible for the collection and return of the Apollo 11 material".

Armalcolite had never been found on earth. It is, however, easy to overlook. Nothing was overlooked in the moon rocks - ever speck was carefully examined. Armalcolite is an opaque metallic mineral with a gray to bluish-gray color. Its formula is $(Fe,Mg)Ti_20_5$. It forms very tiny rectangular grains no more than .008 inches across in lunar basalts. It is intergrown with ilmenite $(FeTi0_3)$, a mineral well known on earth. Armalcolite, apparently, needs very reducing conditions to form, which are not likely on the earth with its oxygen-rich atmosphere.

But, not long after its discovery in the moon rocks, armalcolite was found in several "earth rocks". It turned up in igneous dikes at Smoky Butte in Garfield County, Montana, in basalts in the Ukraine and in the diamond-bearing kimberlite pipes in South Africa. Armalcolite has also been found in Greenland, and a study of the Greenland occurrence illustrates how unusual conditions on earth can occur that duplicate the chemical conditions which formed armalcolite on the moon.

On the island of Disko, on the west coast of Greenland, armalcolite is found with ilmenite, sulfides and native iron in lava flows. The armalcolite grains, are again very tiny. The lava flows are full of chunks of sedimentary rock that the lava tore loose on its way to the surface. These sedimentary rocks were rich in coal and other hydrocarbons. In chemical reactions more typical of an industrial blast furnace than a volcano, the hot coal formed highly reducing conditions that smelted the rock naturally. Iron, which is usually tied up in oxides such as magnetite or silicates such as olivine or biotite, formed instead pure native masses. Native iron, generally unheard of in crustal rocks, solidified as blobs and masses, some weighing several tons. These weathered out and were found lying loose on the beach, where they were picked up and worked into tools by the early Nordic colonists.

The extreme reducing conditions which formed the iron also allowed armalcolite to form. It occurs in the volcanic rocks as microscopic grains with blocky to prismatic habits forming locally 1% of the rock. It forms both as a primary mineral forming directly from the magma and as a secondary mineral replacing previously formed ilmenite. The armalcolite is associated in these lavas with a host of rare minerals that are more typically found in meteorites including troilite (FeS), cohenite [(Fe,Ni,Co)C] and schreibesite $[(Fe,Ni)_3P]$.

Although this find will not produce gorgeous specimens for the collector, it is important in that it shows that the same chemical and physical processes that formed the rocks of the moon and meteorites are the same ones we see on earth.

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