The Changing Face of the East Mojave Desert

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The Franklin Wells Hectorite Deposit, Inyo County, California

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Introduction

Hectorite, the rare lithium smectite mineral, is mined at only four locations on earth. One of these is near Franklin Wells in the western Amargosa Valley of California, on the eastern flank of the Funeral Mountains Wilderness Study Area (Figure 1). The mineral occurs in lake beds as a hydrothermal alteration product of volcanic ash along a fault zone. The deposit was originally named the Hectorite Whiting Pit. In this report it is referred to it as the Franklin Wells Hectorite Deposit.

History

Mining for carbonate on the subject claims occurred as early as the 1920s. "The deposit was first mined in the 1920's as a source of whiting, or whitewash," according to Jack Mayhew, former IMV (Industrial Minerals Ventures) geologist. (Hay, 1985, p.57; see also Wright and others; 1953). Mining at Hector, California (the site from which "hectorite" was named) did not commence until 1931 (Rheox, Undated; Foshag and Woodford, 1936,).

The Franklin Wells area presently mined was originally located for limestone placers on December 21, 1931, by IMV. The commodity of interest at the time of location was white lacustrine limestone for use as decorative rock and as a paint pigment.

The original mining for white limestone in the 1930s was replaced in 1974 by interest in hectorite-bearing clays positioned stratigraphically above the limestone (Hay, 1985, p.57). These clays found applications in the drilling mud and paint industries. Specialized markets for hectorite in the manufacture of rapid-speed printing inks, personal care products (e.g. shampoo), pharmaceutical and organoclay industries arose in the 1970s.

IMV corporation mined the deposit for hectorite between 1974 and 1991. The ore was beneficiated at the IMV plant in Nye County, Nevada, 1.5 miles north of the deposit. The present operator is Southern Clay Products, Inc. who develops a wide range of applications for hectorite in the organoclay industry. It is used in specialty applications such as drilling muds, polyester and fiberglass resins, and industrial coatings. An ortho-photograph of the mine area is shown in Figure 2.

Location

The Franklin Wells Deposit is in the Amargosa Valley approximately ½ mile west of Franklin Wells and nine miles northwest of Death Valley Junction in Inyo County, California. The hectorite deposit is partially within the Upper Amargosa Valley Area of Critical Environmental Concern and two miles east of the western boundary of the Funeral Mountains Wilderness Study Area.

The deposit is situated on the lower western flank of the Amargosa Valley. The relief is nearly horizontal, transected by occasional arroyos 1 to 10 feet deep.

The surface geology consists of alluvial fans and pediment surfaces. Most of the surface above the deposit is desert pavement. Vegetation is sparse, high-desert flora dominated by moderate-diversity creosote brush scrub of the northern Mojave floristic zone. In this area, the lowest portions of alluvial fans are dominated by shadscale, desert holly, and mesquite, with an understory of saltgrass (BLM,1998).

Wildlife in the mine area are reptiles (whiptail lizards, zebra-tailed lizards, sidewinder rattlesnakes), small mammals (pocket mice, Meriam's kangaroo rats, antelope ground squirrels, desert woodrats), and birds (prairie falcons, golden eagles). No threatened and endangered species, significant archaeological sites or other sensitive resources are known to occur in the mine area (BLM, 1998).

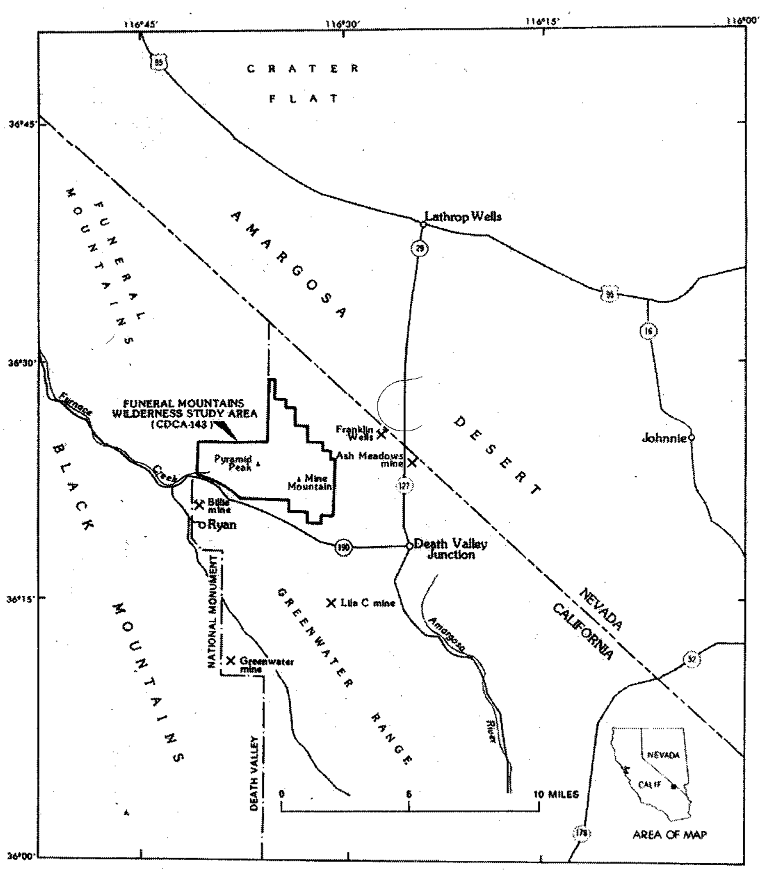

Figure 1. Location of Franklin Wells. From Armstrong and others, 1987.

Regional Geology

The Amargosa Valley is a basin-and-range structure with the Greenwater Range and Funeral Mountains to the west and the Amargosa Desert to the east. The Greenwater/Funeral mountains are fault-controlled with narrow interior valleys and are bounded by broad, coalescing alluvial fans (Armstrong et al., 1987).The Greenwater/Funeral mountains are composed of lower Paleozoic marine and metamorphic rocks (Streitz and Stinson, 1974).

Bestram (1985:9) who performed a mining claim validity examination of the Ash Meadows clay deposits 8 miles east of the Southern Clay property, summarized the regional geology for the area of the Franklin Wells Hectorite deposit:

> Rocks of lower Paleozoic and Tertiary age make up the highlands and mountains; the lowlands are mantled by various types of Quaternary deposits. Tuffs and tuffaceous sandstones make up the bulk of the Tertiary rocks found in the northern most part of the [Lathrop Wells] quadrangle. Basalt is found, commonly capping ridge tops.
>
> Structurally, the area was effected by two major periods of deformation. During the late Mesozoic-early Tertiary phase, compressional deformation predominated. Large easterly-directed thrust faults, accompanied by folding and strike-slip faulting, were the rule. About 17 million years ago, a major change occurred in the tectonic setting of the region with the onset of extensional faulting and volcanic activity (Stewart, 1980). Basin and range faulting, which began in the Miocene and continued to the Holocene, is responsible for the topography and geology seen today. It is suggested by Denny and Drews (1965) and Khoury (1978) that during the Pleistocene much of the lowlands in the Lathrop Wells and Ash Meadows quadrangles were covered intermittently by perhaps a series of pluvial lakes. Significant amounts of lacustrine sediments were deposited in the area during this period as well as the continuing influx of fluvial clastics.

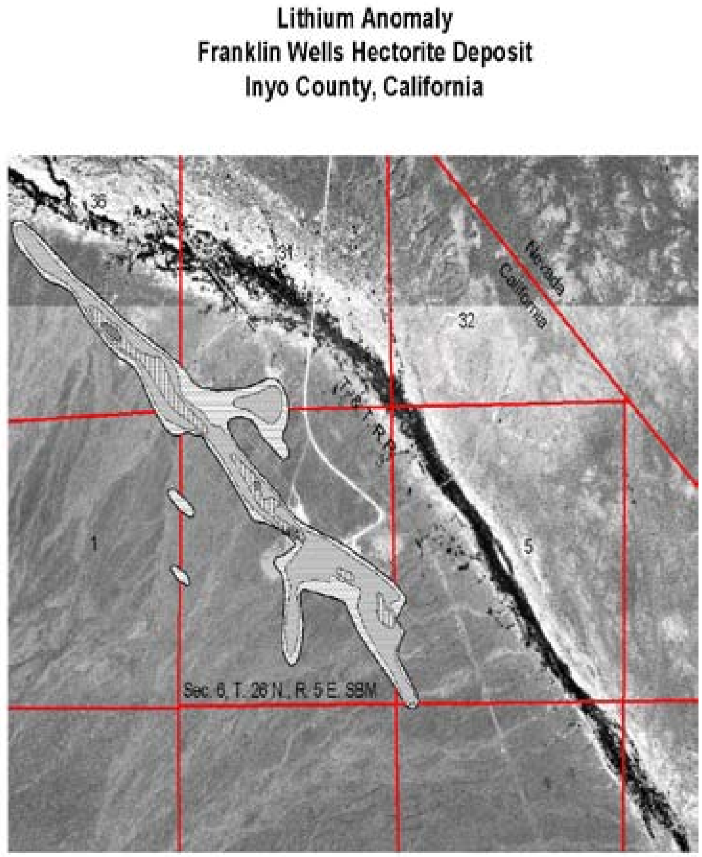

Figure 2. Orthophotograph of the Southern Clay mine at the Franklin Wells Hectorite Deposit and Lithium/Fluorine anomaly. The orthophotograph is a digital, elevation-corrected image based on U.S. Geological Survey aerial photography. The Lithium/Fluorine anomaly is from a map produced during development of the White King claim group. The Bureau of Land Management discovered the map in archives from the Floosy Doosy-White King drilling program of the 1960s during a examination of the deposit.

Regional geology is also described by Hay and others (1986:1489-1490):

> The Amargosa Desert is an intermontane basin in the western part of the Basin and Range province. It drains southward into Death Valley drainage system. Highly folded and faulted Paleozoic rocks of Cambrian to Devonian age underlie the basin and form highlands around its east, south and west sides. Miocene volcanic rocks of the Timber Mountains-Oasis Valley caldera complex border the basin on the north (Christiansen and others, 1977) and extend southward beneath the basin fill, with exposures locally in the southern part of the basin. Most of the volcanic rocks are silicic ignimbrites between 9.5 and 16 m.y. in age (Christiansen and others 1977). The volcanic rocks are overlain by a varied assemblage, including fanglomerates, siltstones, limestone and tuff. These deposits are moderately to highly deformed and have been correlated with the Furnace Creek Formation of Death Valley (Naffe, 1973) which has been dated at 5.3 to 6.5 Ma (Fleck, 1970).
>
> Relatively undeformed Pliocene and Pleistocene sediments fill the present geomorphic basin. The bulk of the basin fill is Pliocene and contains the large deposits of Mg clays. Exposed Pliocene deposits consist largely of clays and carbonate rocks that crop out widely in the eastern half of the basin and at relatively few places in the western half. The maximum exposed thickness, at Fairbanks Butte, is about 50 m, but as much as 295 m. of presumed Pliocene deposits have been penetrated by drilling in the Ash Meadows Area (Naffe, 1973) … The clay-rich Pliocene sequence probably ranges from 2 to 4 m.y. in age.

Local Geology

The geology in the Ash Meadows area is described as follows:

> The deposit mined in the Amargosa Valley region of California (in the same area as Hector) [sic, not accurate because Hector is near Newberry Springs] forms part of a thick sequence of smetcite layers. In addition to hectorite, there are extensive deposits of sepiolite and saponite—a magnesium rich smectite which matches some properties of sodium bentonite. ("IM" Oilwell Drilling Survey, 1978, p 52).
>
> Unusual and economically important clays of late Pliocene age have been found in the Amargosa Desert of southeastern Nevada. These include sepiolite, magnesium silicate , and bentonite. The sepiolite is relatively pure and contains little aluminum. The magnesium smectite is mostly stevensite with interlayered kerolite but includes

hectoritic and probably sapionitic varieties (Eberl et al, 1982, Khoury et al, 1982). The bentonite is a volcanic ash altered to dioctahedral (sic) smectite. The clays are mined by Industrial Mineral Ventures (IMV)." (Hay and others, 1989). Stevensite and hectorite are both trioctahedral smectite minerals (Jackson, 1997, p. 293 & 623).

The Amargosa Desert is now and has for at least the past 3.2 m.y. been a spring-fed hydrologic basin. Present discharge is about 58,000 m^3/day (17,000 acre ft/yr), and the Pliocene discharge was substantially greater than this. The water is of a $Ca\text{-}Mg\text{-}Na\text{-}HCO_3$ type and receives its solutes from recharge areas in the Paleozoic carbonate rocks and Miocene silicic volcanic rocks. The magnesium-silicate clays were precipitated by evaporation of spring water in playas, ponds, and related environments. Bentonite was formed by alteration of ash in ponds. Salinities in the ponds and playas were never high, judging from the isotopic composition of calcite and dolomite associated with the magnesium-silicate clays (Khoury and others, 1982).

Additional descriptions of the local geology are found in Cemen and others (1982), Hay and others (1986), Naffe (1973) Neumann (1984), Taylor (1986)

Deposit Geology

The Franklin Wells Hectorite Deposit has been described in the following way:

Hectorite, a lithium-rich clay, and mineral whiting $CaCO_3$ are mined by Industrial Mineral Ventures, Inc. west of Franklin Well. Hectorite is used in the manufacture of cosmetics and ceramics. Mineral whiting is used in the paper industry. Industrial Mineral Ventures has at least 36 claims here, and has applied for patents on some of the claims. BLM estimates this deposit contains 33,000,000 tons of hectorite reserves and another 33,000,000 short tons of resources valued at $1,330,000,000. Both clinoptilolite and hectorite probably formed from alteration of volcanic sediments. Anaconda has traced the 30-500 ft. thick clinoptilolite beds in southeast dipping Tertiary or Quaternary ash flow tuff. Hectorite is in the Quaternary sediments (Marcus, 1980, p. 5).

On the western flank of the Amargosa Valley of Nye County in Nevada [but in California], Industrial Mineral Ventures exploits a mixed hectorite/calcium carbonate deposit that extends a distance of about two miles and averages about 700 feet in width. Thickness of the deposit varies from the thin feathery edges of the deposit to around 40 feet at the center—an average thickness of 15 feet overall. The deposit consists of about 25% hectorite and 75% calcium carbonate although accessory quantities of silica also occur (Clarke, 1989a, p. 77).

This [Hectorite Whiting Pit, Franklin Wells Deposit] mine, on the west side of the [Amargosa] basin, is in a caliche breccia about 3 km (1.9 mi) long, 0.6 km (0.4 mi) wide, and, locally at least 6 m (20 ft) thick. It formed by precipitation of calcite (whiting) and magnesium-silicate clay (hectorite) as nodules in the vadose zone within the playas (?) clays. Growth of new nodules displaced the older nodules upward, resulting in masses of brecciated nodules that disrupted the overlying clays. Sheared veins of magnesium-silicate clay are not uncommon. Samples of the clay have been identified as hectorite, but some other samples are lower in lithium and fluorine than is typical of hectorite"(Hay,1985, p. 57).

The hectorite, in zones zero to twenty feet thick, is dispersed in carbonate "breccia" overlain by zero to thirty five feet of gravel and underlain by a layer of hard limestone. Hectorite-bearing carbonate is exposed in some arroyos around the mine. The hectorite occurs in a linear band that parallels the structural axis of the Funeral Mountains to the west.

There is extensive evidence of hydrothermal activity along the surface expression of the Franklin Wells fault, including massive sinter deposits southeast of the current mine area.

At the Franklin Wells Hectorite Deposit, the valuable minerals are hectorite and some stevensite which makes up 5 to 35% (averaging 13%) of the ore. Gangue consists of other associated clay minerals, carbonate and silica. The ore body is tabular, 3 km (1.9 mi) long, 0.6 km (0.4 mi) wide, and, locally at least 6 m (20 ft) thick (Hay,1985, p. 57).

The ore body is defined by a Lithium/Fluorine geochemical anomaly, which clearly delineates the position of the Franklin Wells fault zone (Figures 2 and 3).

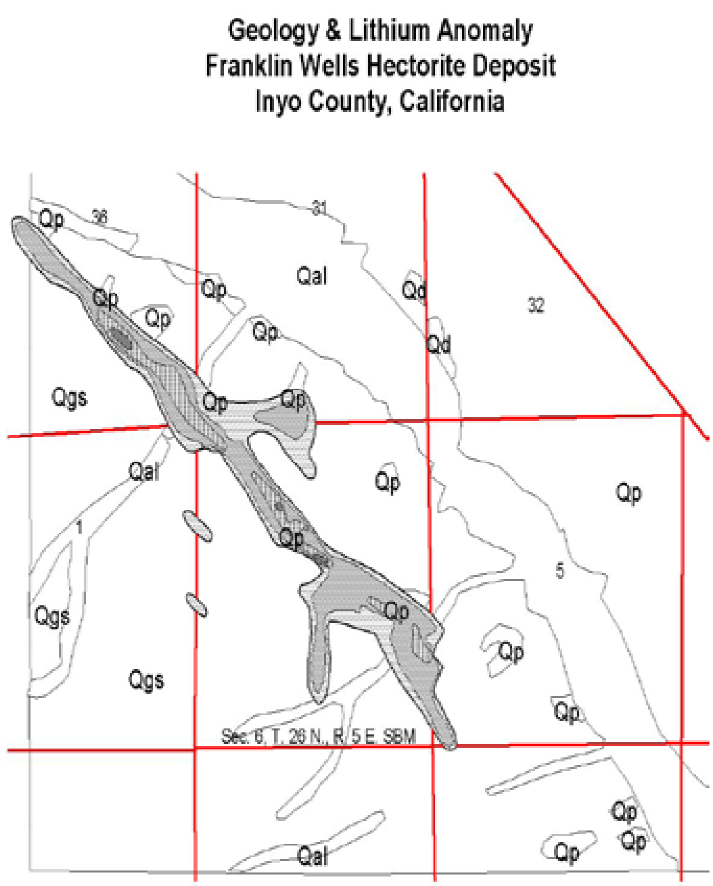

Figure 3. Geologic map of the Franklin Wells Hectorite Deposit and Li/F anomaly. Note that the anomaly is not reflected in surface geology, but is sub-parallel to a straight segment of the Amargosa River. The anomaly marks the position of the Franklin Wells fault zone. This zone is one of a series of basin-and-range faults in Amargosa Valley, which influence the position and alignment of the Amargosa River.

Mining Activity

Southern Clay Products, Inc. currently mines about 5,000 tons a year of hectoritic calcite "breccia" by open-pit methods. The material is dried on site and trucked to Las Vegas, where it is shipped by rail to the Southern Clay Products' Gonzales, Texas plant for beneficiation.

Deposit Genesis

Models for hectorite genesis are found in Asher-Bolinder (1991) where hectorite is identified as a product of hydrothermal alteration. At the Franklin Wells deposit, the hectorite is an alteration product of volcanic ash in the carbonate breccia and formed from hot spring activity along a fault More specifically, hectorite mineralization occurred as the replacement of Li for Mg in the montmorillonite crystal lattice of volcanic (dacite) ash grains during hydrothermal (spring) activity. This alteration is most pronounced along a fault zone, which we name the Franklin Wells Fault. Some hydrothermal alteration creates lens-like bodies below the overlying gravels/carbonate contact and reflects the original geometry and composition of the ash beds in the lacustrine sequence.

The three controlling factors in hectorite genesis are the presence of dacitic ash beds, a fault conduit system and lithium-rich hydrothermal activity. Such ingredients are common throughout the Basin-and-Range. The fortuitous overlapping in space and time of these conditions make hectorite a rare and valuable specialty mineral.

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