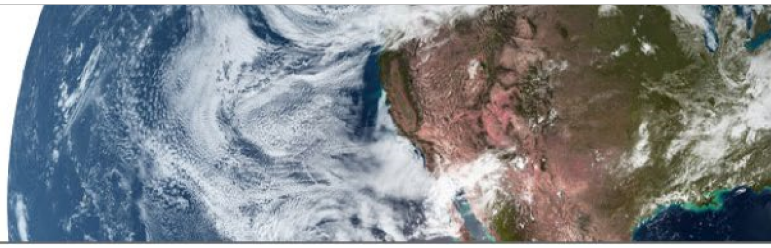

Stanford University BPSM Industrial Affiliates Program Field Trip to Black Diamond Mines Regional Preserve

November 13, 2019

Schedule:

7:30-7:45am	Meet at Lot 39 behind Tresidder Memorial Union at Stanford
8am	Depart Stanford University
9:30am	Arrive Black Diamond Mines Regional Preserve. Park in upper parking lot (not at park office). Restroom and snack break. Unload lunches in mine vehicle and transport to Greathouse portal.
10am-2pm	Tour Black Diamond Mines (see details below)
2:15pm	Depart Black Diamond Mines
4pm	Arrive Stanford University

Group Itinerary: 16 people per group

<table>
<tr><th>Group 1</th><th>Group 2</th></tr>
<tr><td>10-10:45am: Meet naturalist at parking lot gate. Walking tour & slide show with naturalist.</td><td rowspan="2">9:45am Walk from parking lot to Hazel Atlas Portal for mine tour with Steve Graham. Tour starts at 10am. End at 11:30am at Greathouse visitor center.</td></tr>
<tr><td>10:45-11:30am Sacramento Basin petroleum systems talk in Greathouse visitor center, followed by exploring the museum.</td></tr>
<tr><td colspan="2">11:30am-12:15pm Both groups have lunch in Greathouse visitor center or outside, weather permitting.</td></tr>
<tr><td rowspan="2">12:15-1:45pm Walk to Hazel Atlas portal for mine tour with Steve Graham. End at Greathouse visitor center.</td><td>12:15-1pm Sacramento Basin petroleum systems talk in Greathouse visitor center and explore museum.</td></tr>
<tr><td>1-1:45pm Slide show & walking tour with naturalist from Hazel Atlas portal to parking lot.</td></tr>
<tr><td colspan="2">2pm Both groups meet at parking lot for final restroom and snack break.</td></tr>
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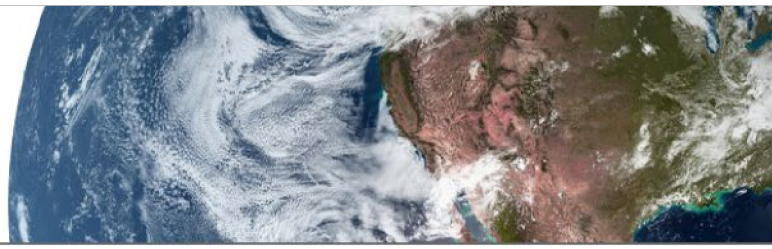


The petroleum systems of the Sacramento Basinand adjacent area, California

Leslie B Magoon[1], Allegra Hosford Scheirer[1], and Paul Lillis[2]
[1] Stanford University, [2] U.S. Geological Survey

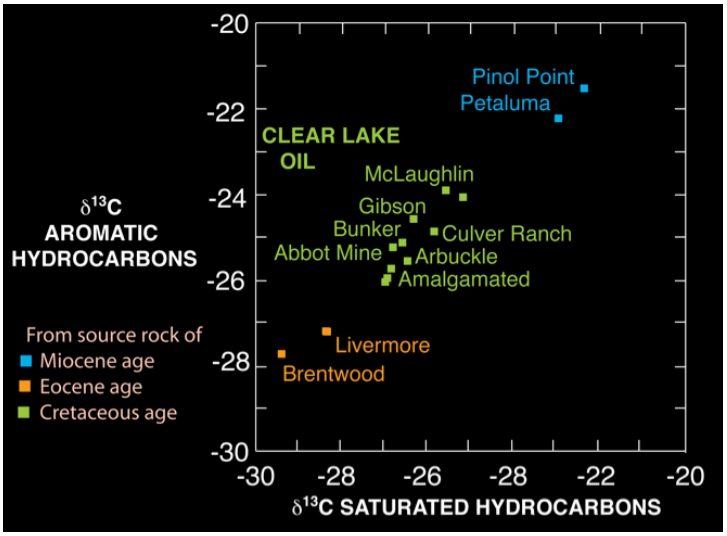
There are three oil and two gas petroleum systems in and around the Sacramento Basin. The Black Diamond Mines Regional Preserve, located on the present-day west flank of the basin, is dug into the Eocene Domengine sandstone of such high purity that it was used to make glass; it also contains a low rank coal. This non-marine to shallow marine deposit extends over much of the San Joaquin and Sacramento basins. It underlies an Eocene organic-rich source rock known as the Kreyenhagen Formation in the San Joaquin Basin and the equivalent, suspected source rock, the Nortonville Formation, in the Sacramento Basin. The Domengine sandstone is the major gas reservoir rock in the youngest petroleum system in the Sacramento Basin, containing 55% of the total gas.

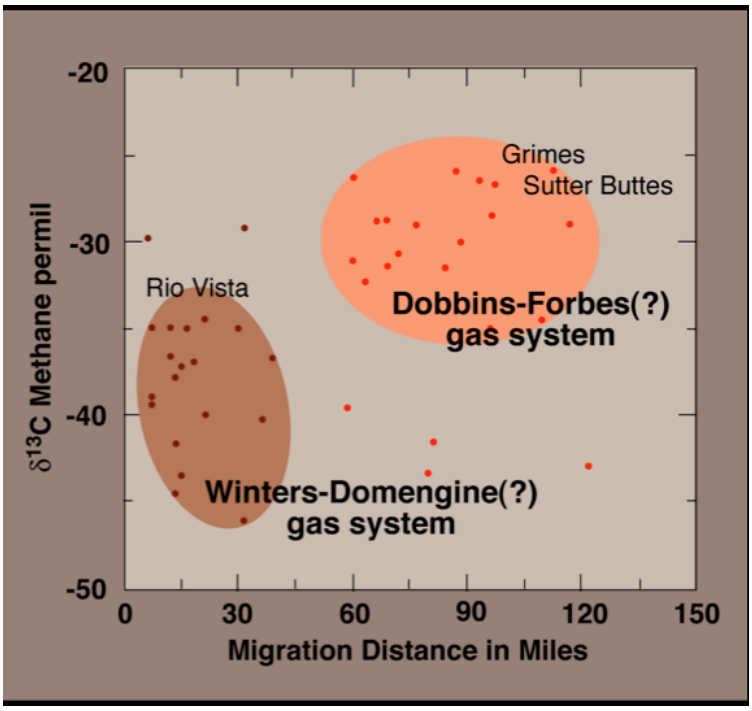
A minimum of three oil systems are defined from three oil types using carbon isotopic composition of saturated and aromatic hydrocarbons, but are poorly understood because only one system contains commercial oil and the other two include only seeps and recovered oil from wells. The commercial oil fields include the Brentwood and Livermore fields and contain an oil type from an Eocene source rock, presumably the Nortonville because this oil type is like Kreyenhagen oil in the San Joaquin Basin. The reservoir rock for the Brentwood field in the Sacramento Basin is 4,000 feet deep and is Upper Cretaceous and Paleocene in age with the seal rock being the overlying thin shale. The reservoir rock for the Livermore field in the nearby Livermore Basin is 1,500 feet deep and is Upper Miocene in age and is sealed by thick shale. The pod of active source rock is expected to be between these fields. A complex timing and migration history for this oil charge is suspected since these fields are in different basins with different aged reservoir rocks.

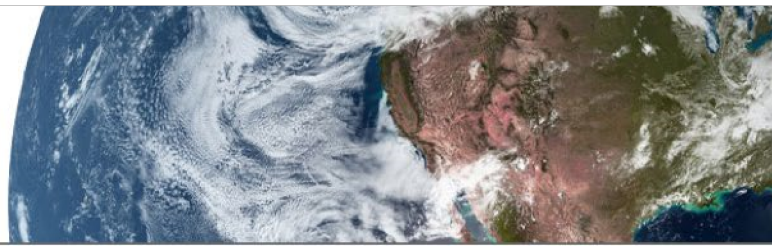
The other two oil types originated from a Cretaceous and a Miocene source rock, respectively. The Cretaceous oil shows and seep samples are located in the fold and thrust belt of the Coast Ranges and in a few wells on the west flank of the Sacramento Basin. The oil charge supposedly originates from an unidentified source rock of Cretaceous age because the isotopic values are the same as the Moreno oil from the San Joaquin Basin. The Miocene oil samples found adjacent to San Pablo Bay have the same heavy isotopic composition as the oil from the Monterey source rock in the San Joaquin Basin.

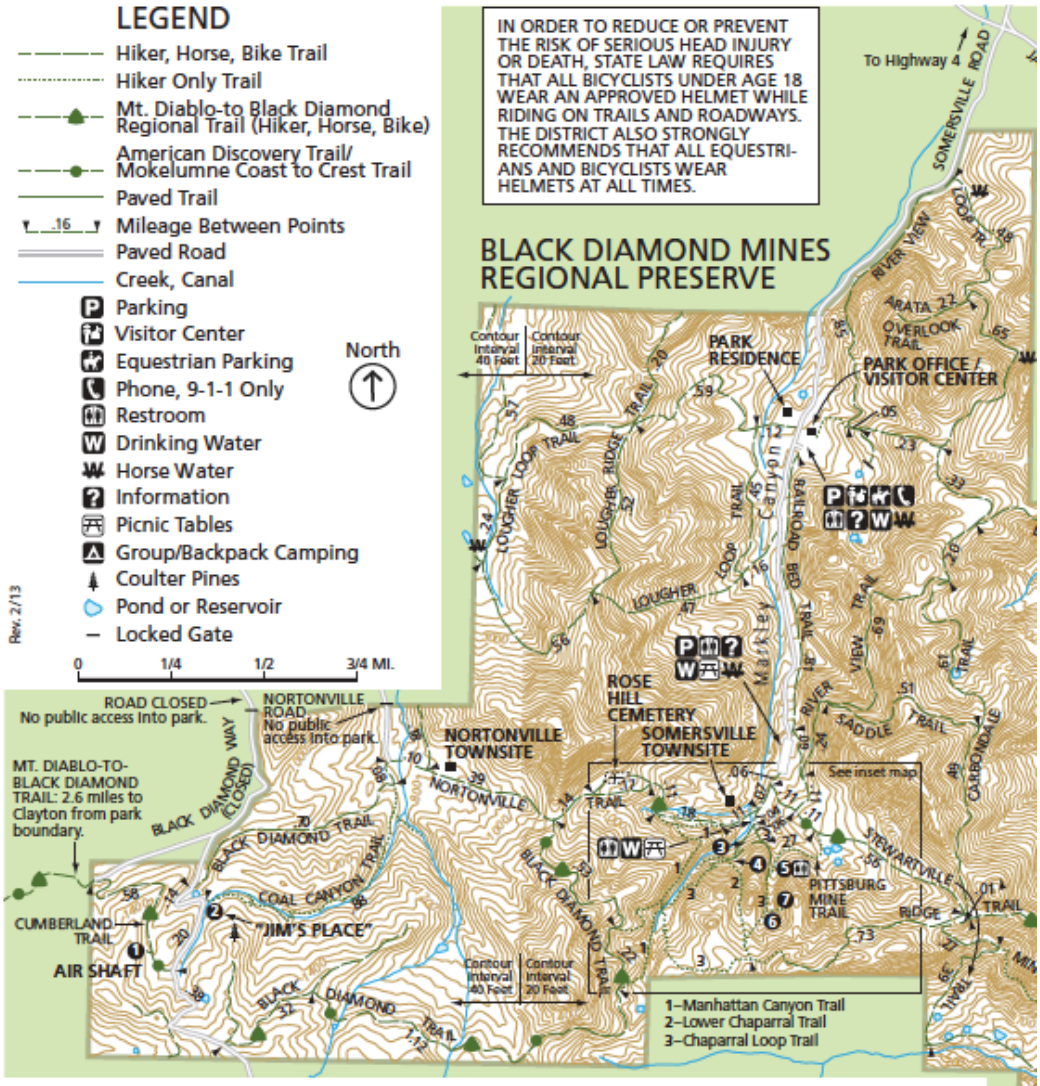
The two gas petroleum systems are differentiated using the carbon isotope of methane. The impermeable Sacramento Shale separates the gas systems from each other. The deeper system has a carbon isotopic value of -28 per mil plus or minus 5 per mil whereas the shallower, larger gas system has a normal thermogenic gas signature of -40 per mil with a range of 5 per mil. The shallower system contains condensate that decreases in concentration relative to total gas from the Rio Vista gas field to the periphery of the petroleum system. The condensate contains only saturated hydrocarbons with a carbon isotopic value of about -26 per mil. Gas wetness decreases in a similar pattern to the condensate such that the gas is pure methane at the extremity of the system. Nitrogen

content also increases, showing that this gas moved faster and farther to fill the distal traps with high concentrations of this inert gas. Based on presumed source rock and the higher proportion of petroleum in a given reservoir rock, the older deeper gas system is named the Dobbins-Forbes(?) and the larger, younger system is the Winters-Domengine(?)





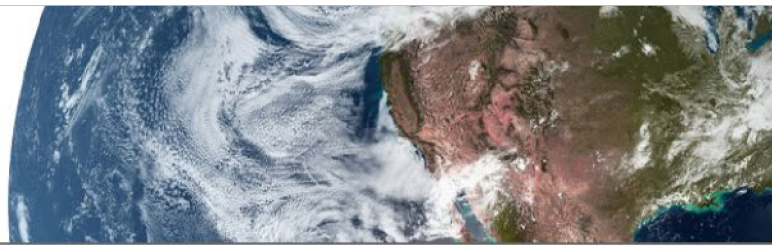




MINING FEATURES as numbered on map:

1. AIR SHAFT: This air shaft (once 150 feet deep and reached here by a short tunnel) was used to keep a coal mine ventilated and free from dangerous gases. The marks left by miners' picks are still evident on the excavation sides.
2. "JIM'S PLACE": This little underground dwelling is of unknown origin. Notice the square skylight, round stovepipe hole, and shelf opening.
3. GREATHOUSE VISITOR CENTER: This portal was the original opening into the sand mine.
4. EUREKA SLOPE: This inclined shaft was the entrance to the Eureka Coal Mine. Between 1860 and 1895, more than 150,000 tons of coal were hoisted to the surface. The slope is 290 feet long and descends at a pitch of 32 degrees.
5. HAZEL ATLAS PORTAL: This mine supplied sand used for glass making in the 1920s through the 1940s.
6. POWDER MAGAZINE: This small excavation was used to store explosives during the sand mining era.
7. STOPE: This huge chamber was blasted out of sandstone by miners extracting rock for glass making.
8. PROSPECT TUNNEL: This tunnel was driven in the 1860s by miners in search of commercial-quality coal. Two hundred feet of the 400-foot tunnel are open for exploration. Bring a light.
9. STAR MINE: This barred tunnel once served as the entrance to the Star Mine, one of the last active coal mines in the area.

East Bay Regional Park District
2950 Peralta Oaks Court,
P.O. Box 5381
Oakland, CA 94605-0381
1-888-EBPARKS www.ebparks.org
Rev. 2/13



Discover Black Diamond

INDIANS have lived in the greater Bay Area for thousands of years. Black Diamond was located in the backcountry between three tribes: Chupcan (Concord), Volvon (Clayton), and Ompin (Pittsburg). All spoke the Bay Miwok language. With the arrival of Spanish, Mexican, and American settlers after 1772, the Bay Miwok way of life was rapidly transformed. However, in spite of pressure to the contrary, many California Indians still practice the traditions of their ancestors.

COAL MINING From the 1850s to the early 1900s, the coal mining towns of Nortonville, Somersville, Stewartville, West Hartley, and Judsonville thrived in the Black Diamond area. As California's largest coal mining operation, nearly four million tons of coal ("black diamonds") were mined. People from all over the world were drawn to the area, and their lives were characterized by hard work and long hours. As many as 900 miners, some as young as eight years old, labored in hundreds of miles of underground workings. At the peak of operations the coalfield was reported to have been the population center of Contra Costa County.

The coal mines had a significant impact on California's economy. By the time operations ceased due to rising production costs and the exploitation of new energy sources, much of California's economy had been transformed from a rural to an industrial base.

SAND MINING In the 1920s underground sand mining began near the deserted Nortonville and Somersville townsites. The Somersville mine supplied sand used in glass production by the Hazel-Atlas Glass Company in Oakland, while the Nortonville mine supplied the Columbia Steel Works in Pittsburg with foundry (casting) sand. Competition from Belgian glass sand and the closing of the steel foundry ended the sand mining by the late 1940s. Altogether, more than 1.8 million tons of sand had been mined.

RANCHING Until the discovery of coal, cattle ranching was the major industry in this area. After the mines closed, some miners found a new career in ranching. Abandoned buildings became barns, railroad ties were used as fence posts, and boilers were converted into water troughs. Descendants of original mining families still graze cattle in the Preserve.

POLICE, FIRE, MEDICAL EMERGENCY	**9-1-1**
EBRPD HEADQUARTERS	**1-888-EBPARKS**
PARK OFFICE	**1-888-EBPARKS, option 3, ext. 4506**
VISITOR CENTER	**(510) 544-2750**
CAMPING	**1-888-EBPARKS, option 2**
TDD	**(510) 633-0460**

A REGIONAL PRESERVE The East Bay Regional Park District began acquiring land for the Preserve in the early 1970s. Today, most of the mining district is within the Preserve's nearly 6,096 acres. The area is an ideal location for hiking and picnicking. Naturalists conduct a variety of programs related to the Preserve's natural and historic resources. For more information, call the Visitor Center at (510) 544-2750.

VEGETATION The Preserve's 60+ miles of trails traverse areas of grassland, foothill woodland, mixed evergreen forest, chaparral, stream vegetation, and exotic plantings. Notable among the latter are several tree species introduced by the coal miners, including black locust, pepper tree, almond, eucalyptus, and tree of heaven.

Black Diamond is noted as the northernmost location of Coulter pine, black sage, desert olive, and dudleya. In addition, several species that are restricted to the Mount Diablo area occur here, including the Mt. Diablo globe lily, Mt. Diablo helianthella, and Mt. Diablo manzanita. The hills are covered with remarkable springtime wildflower displays.

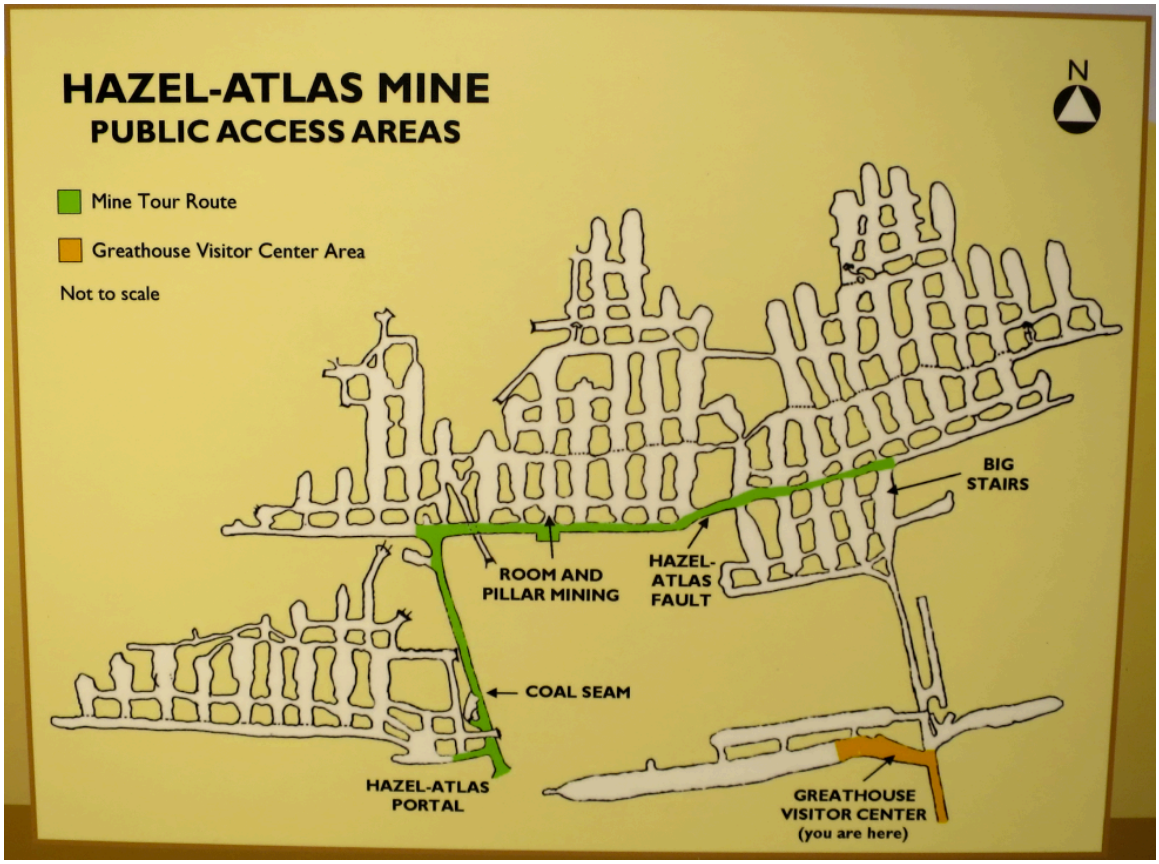
WILDLIFE The Preserve supports a healthy wildlife population, and it is not uncommon for the observant hiker to see the tracks of raccoons, skunks, opossums, rabbits, and deer. Mountain lions, bobcats, foxes, and coyotes are occasionally spotted, while birds of prey soar overhead. Over 100 species of birds have been seen, from the rare golden eagle to the ever-present meadowlark.

The side-blotched lizard has its northern limit in the Preserve, and several rare animal species have been found here, including the white-tailed kite, the Alameda striped racer, the red-legged frog, and the California tiger salamander.

ROSE HILL CEMETERY Although little remains of the coal mining communities themselves, a historic cemetery serves as a monument to the lives of the former residents. Buried here are children who died in epidemics, women who died in childbirth, and men who died in mining disasters. Although more than 10 nationalities resided in the mining area, Rose Hill was a Protestant cemetery that served as the burial ground for many of the Welsh residents.

WON'T YOU HELP US? Over the years, vandalism has taken its toll on the cemetery, which the Park District is attempting to restore. If you have information concerning people buried here, or the locations of missing gravestones, please call the Black Diamond office at 1-888-EBPARKS, option 3, ext. 4506.

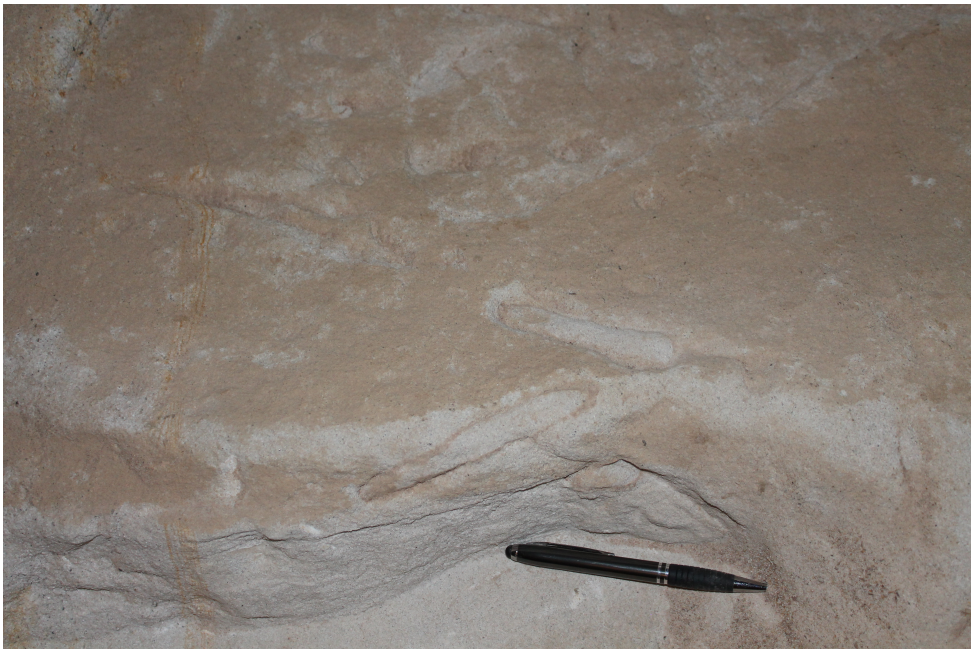
Sheriff: 651 Pine St, 7th Floor, Martinez, CA 94553; David O. Livingston: (925) 335-1500
Highway Patrol: 4999 Gleason Dr, Dublin, CA 94568; (925) 828-0466
Level 1 Trauma Center: San Francisco General Hospital, 1001 Potrero Ave, San Francisco, CA 94110; (415) 206-8000



Mine Glossary

Portal	The surface entrance to a tunnel or adit.
Adit	A passageway or opening driven horizontally into the side of a hill generally for the purpose of exploring or otherwise opening a mineral deposit. An adit is open to the atmosphere at one end.
Stope	An excavation in a mine from which ore is being or has been extracted.
Drift	A horizontal passage underground that follows along the length of a vein or rock formation.
Room and Pillar (from Wikipedia)	Also called pillar and stall. A mining system in which the mined material is extracted across a horizontal plane, creating horizontal arrays of rooms and pillars. The ore is extracted in two phases. In the first, "pillars" of untouched material are left to support the roof overburden, and open areas or "rooms" are extracted underground. The technique is usually used for relatively flat-lying deposits, such as those that follow a particular stratum.

Hazel-Atlas portal and adit.



Trace fossils. Top photo shows cross beds in the upper part of the White Sandstone Member of the Domengine Formation. Organic rich mud drapes are common. Numerous *Ophiomorpha nodosa* burrows are seen in the sandstone beds. These represent the dwelling burrows of decapod crustaceans, including species of shrimp. [Explanation from field trip guidebook of Northern California Geological Society by Ray Sullivan et al.]

An example of a stope illustrating room and pillar mining.

Fault with shale smear.

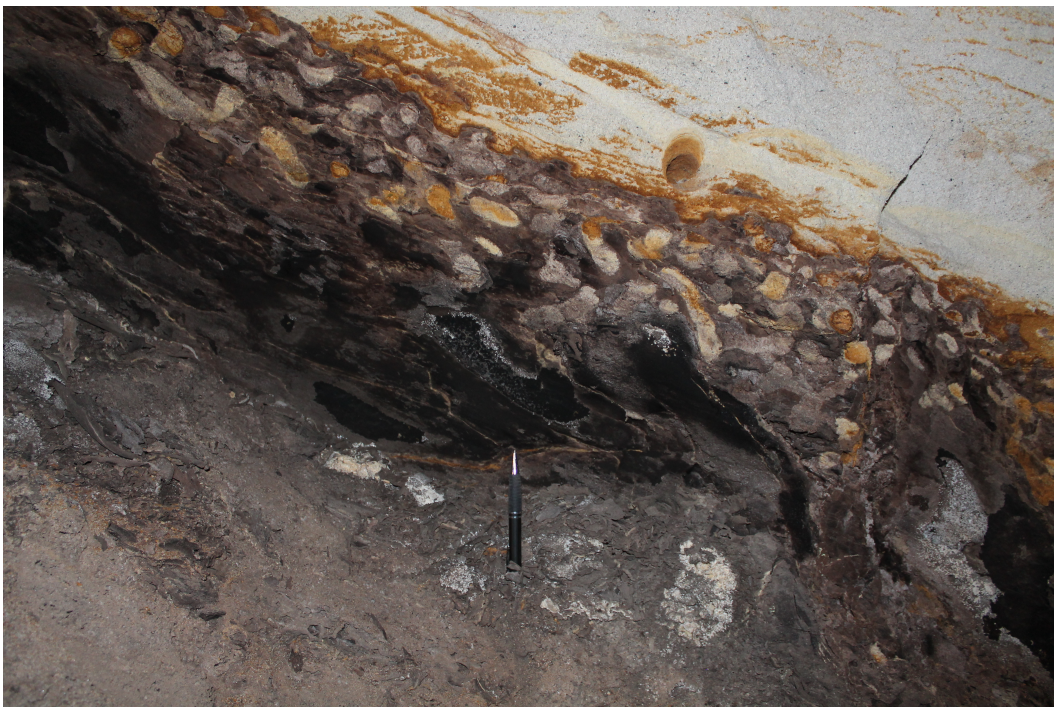
Stair leads down to Greathouse visitor center.

From http://seismo.berkeley.edu/annual_report/ar98_99/node5.html

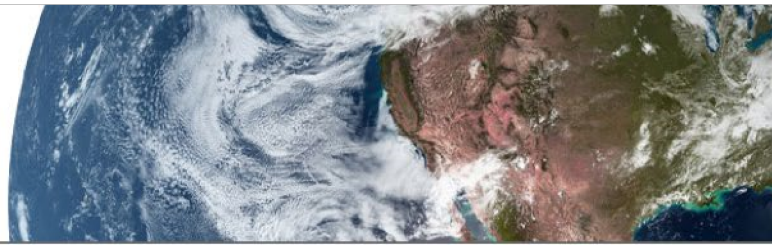
The Berkeley Digital Seismic Network (BDSN) is a regional network of very broadband and strong motion seismic stations spanning northern California and linked to UC Berkeley through continuous telemetry. During the summer of 1998, a new broadband station was added at the Black Diamond Mines, East Bay Regional Park, south of Antioch. Under permit from the Park District, the addition of the seismographic equipment in an area of the mine not open to public tours is in keeping with the educational and research goals of the Park. The instruments are located approximately 150 meters from the daylight entrance to the mine. Approximately 100 meters of sandstone, shale, and coal overburden cover all the instruments. The overburden is sufficient to limit thermal variations. Additionally, the seismometers are covered with 7 centimeters of foil-faced, closed-cell foam. Differential GPS was used to precisely locate a reference outside the mine, and traditional surveying methods then located the instrument offset from the GPS determined coordinates. Station BDM features a Q4120 data logger, STS-2 broadband seismometers, FBA-ES-T accelerometers and 56 Kbit/s continuous telemetry to Berkeley. A GPS clock provides reference timing. Low loss co-axial cable (<2 dB per 100 feet) was used to minimize the attenuation of the signal and corresponding loss of external clock source.

Immediately below the low-grade coal seam are black, filamentous, sometimes downward-bifurcating features. These are root casts, that is, roots penetrating downward into a soil. These are common features beneath coal seams, but seldom seen so clearly.

Mine-collapse horizon. After coal seams were mined out and the pillar pulled, the mines sometimes collapsed. Later, when they cut new tunnel for sand mining, they intersected some of the old collapsed coal adits.



The black layer is a low-grade coal that was flooded by marine waters in which the overlying white sand dunes were deposited. The burrows at the interface belong to the trace fossil assemblage *teredolites*, which reflect burrowing by certain marine organisms into woody/peaty substrate.



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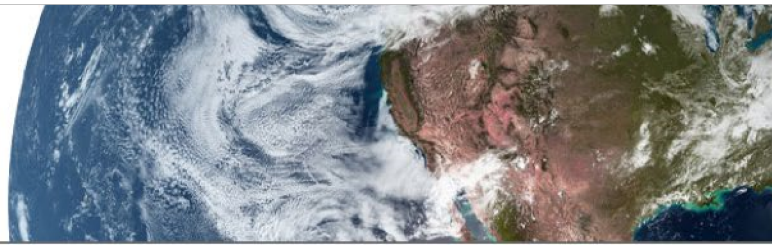

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