# Cartography at the Montana Bureau of Mines and Geology

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This paper shows two of the Montana Bureau of Mines and Geology's most recent publications. Each map was originally created in ArcInfo7 then transferred to FreeHand10 for final layout.

The Lewis and Clark map in its final form has 10 layers of information. Each layer was exported as an .ai file from ArcInfo and imported into FreeHand. Tic marks common to each layer were used to register the layers. The line weights/colors, and font style/color were set in FreeHand and the relief map was added. City, mountain range and stream names, and the photographs, captions, main text, legend, and collar information were added in FreeHand.

The Butte mine map with over 65 layers was imported layer by layer into FreeHand using MAPublisher5. The line weights and colors were set as each layer was imported. The headframes, text on the map, legend, graphics, main text file, and collar information were added in FreeHand.

## MAP 1

Entitled "The Route and Campsites of Lewis and Clark in Montana: A Geologic Perspective", by Robert N. Bergantino and Kenneth L. Sandau, this publication features a large map of Montana showing a detailed depiction of the Expedition's route and campsites (Figure 1). There is also a sidebar of text explaining the geology of the Expedition, and nine photographs of specific landmarks as Lewis & Clark would have seen them, with appropriate quotes from their journals.

## MAP 2

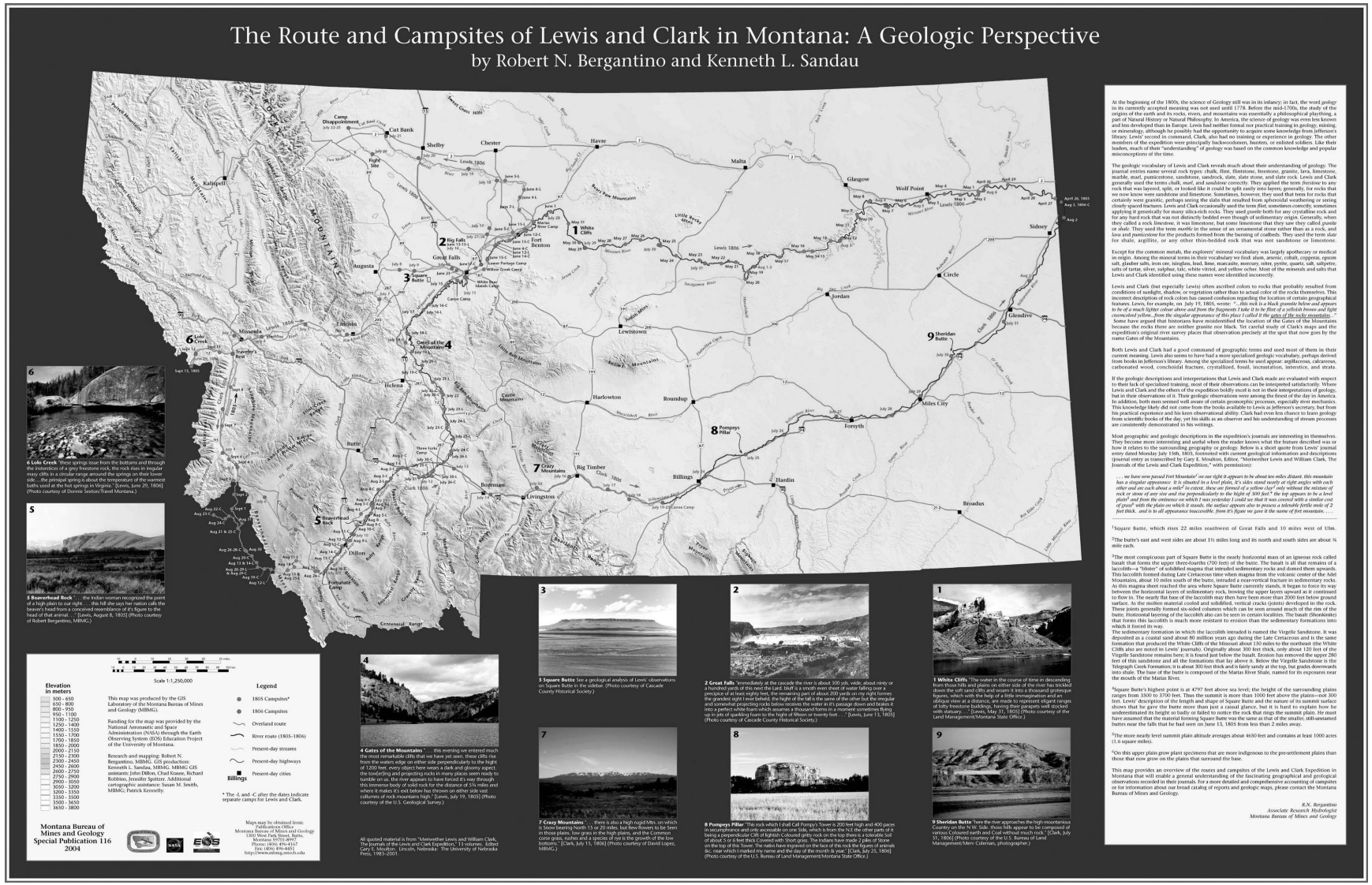
Entitled "Butte, Montana, Richest Hill on Earth; 100 Years of Underground Mining", by Ted Duaime, Patrick J. Kennelly, and Paul Thale, this map is a compilation of previously unpublished historical information about the underground mines in Butte, as mapped by the Anaconda Copper Mining Company (Figure 2). The mine workings were plotted over an existing City of Butte base map showing existing streets, the outline of the Berkeley Pit, and the historical location of the Silver Bow Creek stream channel. The names and locations of seventy-four of the major mines are shown on the map. These mines are 1000 feet or more in depth and constitute over 80 percent of the total depth of the Butte mines. Also shown on the map are locations of the fourteen remaining headframes.

Please see our website (http://www.mbmg.mtech.edu/) for other publications. Many of them are available as PDF files.

## REFERENCES

Bergantino, R.N., and Sandau, K.L., 2004, The route and campsites of Lewis and Clark in Montana: a geologic perspective: Montana Bureau of Mines and Geology Special Publication 116, scale 1:1,250,000.

Duaime, Ted, Kennelly, P.J., and Thale, Paul, 2004, Butte, Montana, richest hill on Earth; 100 years of underground mining: Montana Bureau of Mines and Geology Miscellaneous Contribution 19, scale 1:9,000.




At the beginning of the 1800s, the science of Geology still was in its infancy; in fact, the word *geology* in its currently accepted meaning was not used until 1778. Before the mid-1700s, the study of the origins of the earth and its rocks, rivers, and mountains was essentially a philosophical plaything, a part of Natural History or Natural Philosophy. In America, the science of geology was even less known and less developed than in Europe. Lewis had neither formal nor practical training in geology, mining, or mineralogy, although he possibly had the opportunity to acquire some knowledge from Jefferson's library. Lewis' second in command, Clark, also had no training or experience in geology. The other members of the expedition were principally backwoodsmen, hunters, or enlisted soldiers. Like their leaders, much of their "understanding" of geology was based on the common knowledge and popular misconceptions of the time.

The geologic vocabulary of Lewis and Clark reveals much about their understanding of geology. The journal entries name several rock types: chalk, flint, flintstone, freestone, granite, lava, limestone, marble, marl, pumicestone, sandstone, sandrock, slate, slate stone, and slate rock. Lewis and Clark generally used the terms *chalk*, *marl*, and *sandstone* correctly. They applied the term *freestone* to any rock that was layered, split, or looked like it could be split easily into layers; generally, for rocks that we now know were sandstone and limestone. Sometimes, however, they used that term for rocks that certainly were granitic, perhaps seeing the slabs that resulted from spheroidal weathering or seeing closely spaced fractures. Lewis and Clark occasionally used the term *flint*, sometimes correctly, sometimes applying it generically for many silica-rich rocks. They used *granite* both for any crystalline rock and for any hard rock that was not distinctly bedded even though of sedimentary origin. Generally, when they called a rock *limestone*, it was limestone, but some limestone that they saw they called *granite* or *shale*. They used the term *marble* in the sense of an ornamental stone rather than as a rock, and *lava* and *pumicestone* for the products formed from the burning of coalbeds. They used the term *slate* for shale, argillite, or any other thin-bedded rock that was not sandstone or limestone.

Except for the common metals, the explorers' mineral vocabulary was largely apothecary or medical in origin. Among the mineral terms in their vocabulary we find: alum, arsenic, cobalt, copperas, epsom salt, glauber salts, iron ore, isinglass, lead, lime, marcasite, mercury, niter, pyrite, quartz, salt, saltpetre, salts of tartar, silver, sulphur, talc, white vitriol, and yellow ocher. Most of the minerals and salts that Lewis and Clark identified using these names were identified incorrectly.

Lewis and Clark (but especially Lewis) often ascribed colors to rocks that probably resulted from conditions of sunlight, shadow, or vegetation rather than to actual color of the rocks themselves. This incorrect description of rock colors has caused confusion regarding the location of certain geographical features. Lewis, for example, on July 19, 1805, wrote: "…*this rock is a black granite below and appears to be of a much lighter colour above and from the fragments I take it to be flint of a yellowish brown and light cinnamkolred yellow…from the singular appearance of this place I called it the gates of the rocky mountains*…" Some have argued that historians have misidentified the location of the Gates of the Mountains because the rocks there are neither granite nor black. Yet careful study of Clark's maps and the expedition's original river survey places that observation precisely at the spot that now goes by the name Gates of the Mountains.

Both Lewis and Clark had a good command of geographic terms and used most of them in their current meaning. Lewis also seems to have had a more specialized geologic vocabulary, perhaps derived from books in Jefferson's library. Among the specialized terms he used appear: argillaceous, calcareous, carbonated wood, conchoidal fracture, crystallized, fossil, incrustation, interstice, and strata.

If the geologic descriptions and interpretations that Lewis and Clark made are evaluated with respect to their lack of specialized training, most of their observations can be interpreted satisfactorily. Where Lewis and Clark and the others of the expedition boldly excel is not in their interpretations of geology, but in their observations of it. Their geologic observations were among the finest of the day in America. In addition, both men seemed well aware of certain geomorphic processes, especially river mechanics. This knowledge likely did not come from the books available to Lewis as Jefferson's secretary, but from his practical experience and his keen observational ability. Clark had even less chance to learn geology from scientific books of the day, yet his skills as an observer and his understanding of stream processes are consistently demonstrated in his writings.

Most geographic and geologic descriptions in the expedition's journals are interesting in themselves. They become more interesting and useful when the reader knows what the feature described was or how it relates to the surrounding geography or geology. Below is a short quote from Lewis' journal entry dated Monday July 15th, 1805, footnoted with current geological information and descriptions (journal entry as transcribed by Gary E. Moulton, Editor, "Meriwether Lewis and William Clark, The Journals of the Lewis and Clark Expedition," with permission):

*. . . we have now passed Fort Mountain[1] on our right it appears to be about ten miles distant, this mountain has a singular appearance. It is situated in a level plain, it's sides stand nearly at right angles with each other and are each about a mile[2] in extent, these are formed of a yellow clay[3] only without the mixture of rock or stone of any size and rise perpendicularly to the hight of 300 feet.[4] the top appears to be a level plain[5] and from the eminence on which I was yesterday I could see that it was covered with a similar coat of grass[6] with the plain on which it stands, the surface appears also to possess a tolerable fertile mole of 2 feet thick. and is to all appearance inaccessible, from it's figure we gave it the name of fort mountain. . . .*

[1]Square Butte, which rises 22 miles southwest of Great Falls and 10 miles west of Ulm.

[2]The Butte's east and west sides are about 1½ miles long and its north and south sides are about ¾ mile each.

[3]The most conspicuous part of Square Butte is the nearly horizontal mass of an igneous rock called basalt that forms the upper three-fourths (700 feet) of the butte. The basalt is all that remains of a laccolith—a "blister" of solidified magma that intruded sedimentary rocks and domed them upwards. This laccolith formed during Late Cretaceous time when magma from the volcanic center of the Adel Mountains, about 10 miles south of the butte, intruded a near-vertical fracture in sedimentary rocks. As this magma sheet reached the area where Square Butte currently stands, it began to force its way between the horizontal layers of sedimentary rock, bowing the upper layers upward as it continued to flow in. The nearly flat base of the laccolith may then have been more than 2000 feet below ground surface. As the molten material cooled and solidified, vertical cracks (joints) developed in the rock. These joints generally formed six-sided columns which can be seen around much of the rim of the butte. Horizontal layering of the laccolith also can be seen in certain localities. The basalt (Shonkinite) that forms this laccolith is much more resistant to erosion than the sedimentary formations into which it forced its way.
The sedimentary formation in which the laccolith intruded is named the Virgelle Sandstone. It was deposited as a coastal sand about 80 million years ago during the Late Cretaceous and is the same formation that produced the White Cliffs of the Missouri about 130 miles to the northeast (the White Cliffs also are noted in Lewis' journals). Originally about 300 feet thick, only about 120 feet of the Virgelle Sandstone remains here; it is found just below the basalt. Erosion has removed the upper 280 feet of this sandstone and all the formations that lay above it. Below the Virgelle Sandstone is the Telegraph Creek Formation; it is about 300 feet thick and is fairly sandy at the top, but grades downwards into shale. The base of the butte is composed of the Marias River Shale, named for its exposures near the mouth of the Marias River.

[4]Square Butte's highest point is at 4797 feet above sea level; the height of the surrounding plains ranges from 3500 to 3700 feet. Thus the summit is more than 1000 feet above the plains—not 300 feet. Lewis' description of the length and shape of Square Butte and the nature of its summit surface shows that he gave the butte more than just a casual glance, but it is hard to explain how he underestimated its height so badly or failed to notice the rock that rings the summit plain. He must have assumed that the material forming Square Butte was the same as that of the smaller, still-unnamed buttes near the falls that he had seen on June 13, 1805 from less than 2 miles away.

[5]The more nearly level summit plain altitude averages about 4650 feet and contains at least 1000 acres (1.6 square miles).

[6]On this upper plain grow plant specimens that are more indigenous to the pre-settlement plains than those that now grow on the plains that surround the base.

This map provides an overview of the routes and campsites of the Lewis and Clark Expedition in Montana that will enable a general understanding of the fascinating geographical and geological observations recorded in their journals. For a more detailed and comprehensive accounting of campsites or for information about our broad catalog of reports and geologic maps, please contact the Montana Bureau of Mines and Geology.

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**6 Lolo Creek** "these springs issue from the bottoms and through the interstices of a grey Freestone rock, the rock rises in irregular many cliffs in a circular range around the springs on their lower side…the primipal spring is about the temperature of the warmest baths used at the hot springs in Virginia." [Lewis, June 29, 1806] (Photo courtesy of Donnie Sexton/Travel Montana.)

**5 Beaverhead Rock** "…the Indian woman recognized the point of a high plain to our right . . . this hill she says her nation calls the beaver's head from a conceived resemblance of it's figure to the head of that animal. . . ." [Lewis, August 8, 1805] (Photo courtesy of Robert Bergantino, MBMG.)

**3 Square Butte** See a geological analysis of Lewis' observations on Square Butte in the sidebar. (Photo courtesy of Cascade County Historical Society.)

**2 Great Falls** "Immediately at the cascade the river is about 300 yds. wide, about ninty or a hundred yards of this next the Lard. Shelf is a smooth even sheet of water falling over a precipice of at least eighty feet, the remaining part of about 200 yards on my right formes the grandest sight I ever beheld. the hight of the fall is the same of the other but the irregular and somewhat projecting rocks below receives the water in it's passage down and brakes it into a perfect white foam which seems a thousand forms in a moment sometimes flying up in jets of sparkling foam to the hight of fifteen or twenty feet . . . " [Lewis, June 13, 1805] (Photo courtesy of Cascade County Historical Society.)

**1 White Cliffs** "The water in the course of time in descending from those hills and plains on either side of the river has trickled down the soft sand cliffs and wearn it into a thousand grotesque figures, which with the help of a little immagination and an oblique view at a distance, are made to represent elegant ranges of lofty freestone buildings, having their parapets well docked with statuary. . . ." [Lewis, May 31, 1805] (Photo courtesy of the Land Management/Montana State Office.)

**4 Gates of the Mountains** ". . . this evening we entered much the most remarkable cliffs that we have yet seen. these cliffs rise from the waters edge on either side perpendicularly to the hight of 1200 feet. every object here wears a dark and gloomy aspect. the towering and projecting rocks in many places seem ready to tumble on us. the river appears to have forced it's way through this immense body of solid rock for the distance of 3¼ miles and where it makes it's exit below has thrown on either side vast collumns of rock mountains high." [Lewis, July 19, 1805] (Photo courtesy of the U.S. Geological Survey.)

**7 Crazy Mountains** ". . . there is also a high rugid Mtn. on which is show bearing north 15 or 20 miles. but few flowers to be Seen on these plains. low grass on the high plains, and few Cerrinos. colders, rabits and a species of rye is the growth of the low bottoms." [Clark, July 15, 1806] (Photo courtesy of David Lopez, MBMG.)

**8 Pompeys Pillar** "This rock which I shall Call Pompy's Tower is 200 feet high and 400 paces in secumference and only accessable on one Side, which is from the N.E the other parts of it being a perpendicular Cliff of lightish Coloured gritty rock on the top there is a tolerable Soil of about 5 or 6 feet thick Covered with Short grass. The Indians have made 2 piles of Stone on the top of this Tower. The natives have ingraved on the face of this rock the figures of animals &c. near which I marked my name and the day of the month & year." [Clark, July 25, 1806] (Photo courtesy of the U.S. Bureau of Land Management/Montana State Office.)

**9 Sheridan Butte** "here the river approaches the high mountainous Country on the N.W. Side, those hills appear to be composed of various Coloured earth and Coal without much rock." [Clark, July 15, 1806] (Photo courtesy of the U.S. Bureau of Land Management/Merv Coleman, photographer.)

All quoted material is from "Meriwether Lewis and William Clark, The Journals of the Lewis and Clark Expedition," 13 volumes, Edited Gary E. Moulton, Lincoln, Nebraska: The University of Nebraska Press, 1983–2001.

**Figure 1.** Map 1, The Route and Campsites of Lewis and Clark in Montana.

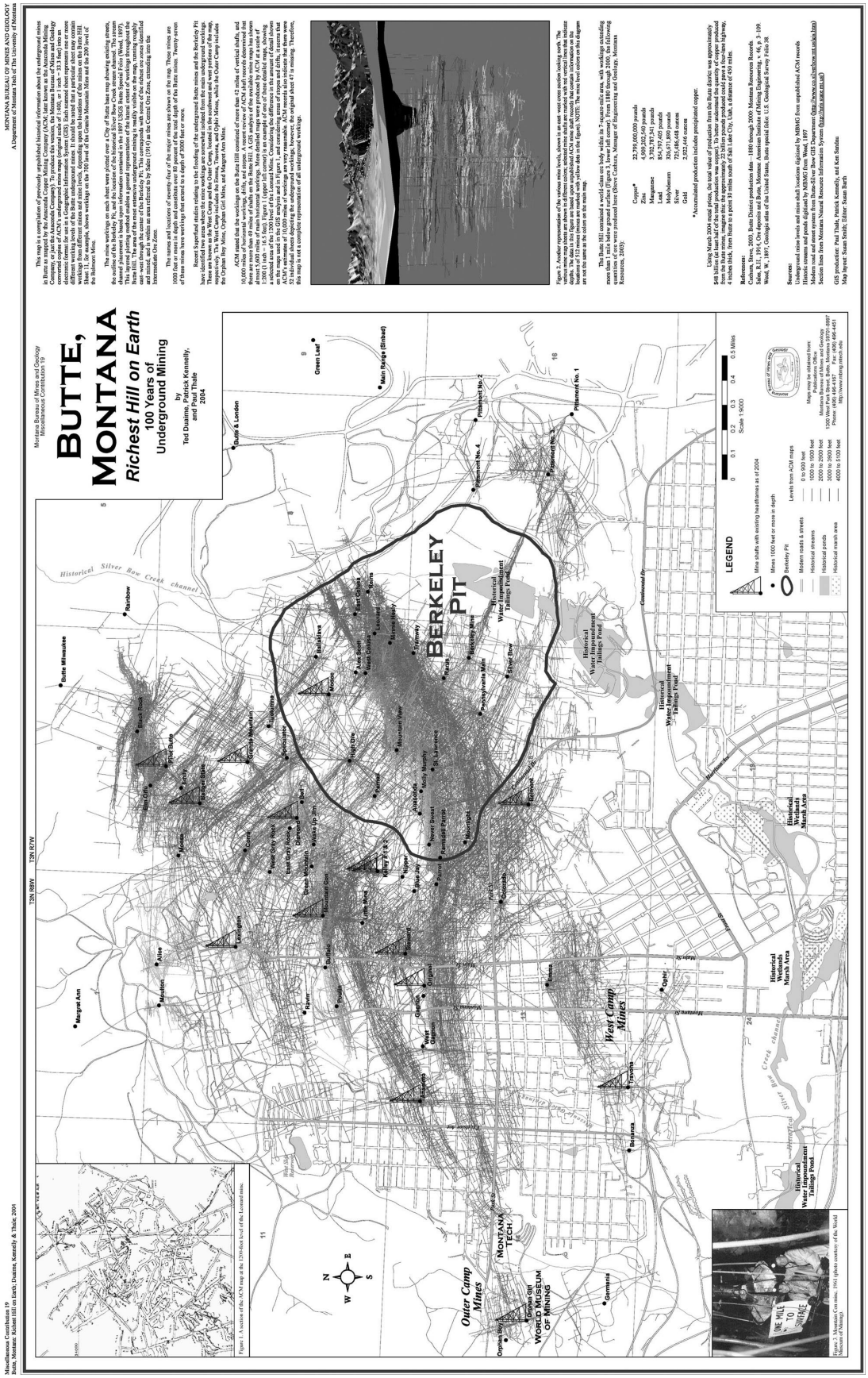


Figure 1. A section of the ACM map at the 1250-foot level of the Leonard mine.

Figure 3. Mining c. 1900 (photo courtesy of the World Museum of Mining).

**Figure 2.** Map 2, Butte, Montana, Richest Hill on Earth.