Geology and Mines of Idaho

Dave Alt

The bedrock of Idaho is a diverse patchwork, each patch with its own geologic history, each with its distinctive landscape. The landscapes depend partly on their bedrock, partly on the geologic events of the past 50 million years, partly on the climates, which change. Some regions have supported significant mining, most have not.

Northern Idaho

Nearly all of the hard bedrock in northern Idaho and a large proportion of that in central Idaho is Belt rock, so named because it was first described in the Belt Mountains of central Montana. The Belt rocks are an absurdly thick stack of sedimentary formations that accumulated to a depth of at least 20 miles during late Proterozoic time, roughly between about 1350 and 700 million years ago. It is an extraordinary accumulation, baffling in the extreme.

Most of the Belt formations are roughly twice the age of the oldest known animal fossils. Nevertheless, plant fossils abound, all of them the remains of extremely primitive algae that most commonly manifest themselves as fine laminations in the rocks, commonly no thicker than a sheet of paper. In some places, the algae make conspicuous structures within the rocks called stromatolites, which may suggest brussel sprouts or cabbages—but of course they are not.

Most of the Belt rocks in northern and central Idaho are mudstones and sandstones, much harder and more resistant than those names may suggest. Although they come in a wide spectrum of colors, somber shades of gray strongly dominate. A rusty stain of iron oxide commonly develops on weathered surfaces. Numerous sills of a black igneous rock called diabase occur sandwiched between the layers of Belt rock. Most are a few hundred feet thick; one, the Moyie sill of northern Idaho and southeastern British Columbia, is as much as 1,400 feet thick.

The Belt formations and the sills they contain erode into fairly typical ridge and ravine landscapes with steep slopes and large topographic relief between ridge crests and valley floors. Those landscapes are typically very rugged and heavily forested, except that many of the south slopes are fairly open. In general, they do not express variations in the type of bedrock, or its structure. The main exception is the Purcell trench, a structural feature that extends north far into British Columbia, and southwest through Rathdrum Prairie. And a few streams eroded their valleys along the trends of major faults. The Coeur d'Alene River, for example, follows the trend of the Osburn fault zone through the Coeur d'Alene mining district.

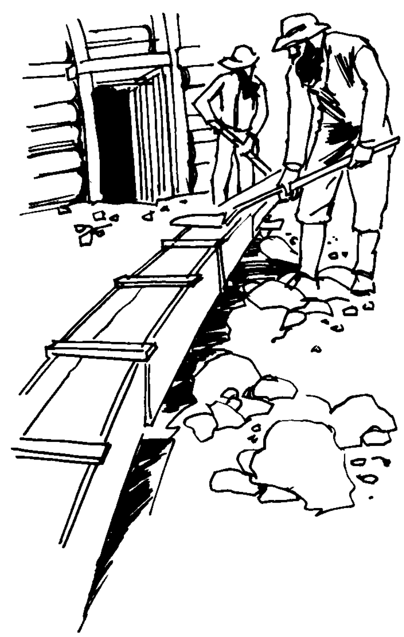
The diabase sills, igneous rocks that they are, prompt thoughts of economic mineralization. Minor copper deposits in numbers beyond counting occur in the Belt rocks along their margins. None of the innumerable prospect pits in those deposits has developed into a mine, and it seems unlikely at this late stage of exploration that any ever will.

The enormous sulfide ore body of the Sullivan Mine at Trail, British Columbia is in Belt sedimentary rocks just above the Moyie sill. It is easy to imagine that similarly large ore bodies may await discovery in northern Idaho, probably above the same sill.

The Coeur d'Alene mining district follows the Osburn fault zone between Coeur d'Alene and Mullan. It has produced silver and lead from the Belt formations for more than a century, and remains active, although on a greatly diminished and still dwindling scale. Silver and lead dominated development and land use along the valley of the Coeur d'Alene River from the 1880s into the 1970s. And they played a major role in the economic and political development of northern Idaho. Only two of the big mines are still working. Even so, an enormous amount of silver and lead remains in the ground, but very little of either is mineable at the low prices those metals have commanded in recent years. The prospect of a major revival now seems extremely remote.

Silver, which was the mainstay of the district, has not been a monetary metal for decades. It is now an industrial commodity used mostly in making photographic emulsions. The rapidly increasing application of digital image storage techniques, which do not consume silver, makes it hard to imagine a major resurgence of silver mining anytime soon.

The Coeur d'Alene mining district is now in various stages of transition to other kinds of economic activity, most notably recreation. Reclamation proceeds more or less fitfully, but with results that are conspicuously noticeable from one year to the next.



Glaciers of the most recent ice age filled the valleys of British Columbia with a sea of ice that submerged all but the higher mountains, and edged south well into northern Idaho.

One lobe of that regional ice filled the Purcell Valley as far south as Pend Oreille Lake, where it dammed the Clark Fork River to impound Glacial Lake Missoula. It was an enormous lake that flooded the Clark Fork drainage of western Montana to a maximum elevation of about 4,250 feet, when the water was about 2,000 feet deep at the ice dam in northern Idaho. Glacial Lake Missoula had no established outlet, so it rose year by year until it floated and broke the ice dam. Then the lake drained, as much as 500 cubic miles of water, in a catastrophic flood that swept across eastern Washington, and down the Columbia River. In the next few years, the constantly advancing ice established a new ice dam, impounding a new lake, which in due course floated its ice dam, and released aanother great flood. That happened several dozen times.

Each catastrophic drainage of Glacial Lake Missoula suddenly dumped hundreds of cubic miles of water into Rathdrum Prairie and thence into Glacial Lake Columbia. That was another ice dammed lake, which flooded the valleys of the Columbia and Spokane rivers from Grand Coulee east through the Spokane Valley, and into most of Rathdrum Prairie. Glacial Lake Columbia had an outlet through Grand Coulee, so its level never rose high enough to float its ice dam.

The enormous torrents of water that poured down Rathdrum Prairie when Glacial Lake Missoula floated its ice dam swept sheets of coarse gravel across its floor. Gravel filled the mouths of tributary streams to impound the series of lakes along both sides of Rathdrum Prairie, including Hayden, Hauser, Spirit, and Twin Lakes.

The same great dumps of gravel also dammed the Coeur d'Alene River to impound an early version of Coeur d'Alene Lake, which was much larger than the one we now see. The overflow from that lake established a spillway across the gravel, which eroded its bed to establish the present upper course of the Spokane River. As the spillway stream eroded through the gravel it missed the old course of the Coeur d'Alene River, and came down instead on hard bedrock, which now maintains the level of the modern lake. The rest of the Spokane River now follows the former course of the Coeur d'Alene River to its junction with the Columbia River.

Central Idaho: Granite Gneiss, and Volcanic Rocks

Belt formations also exist in substantial areas of central Idaho, but granite, metamorphic, and volcanic rocks dominate the region.

The ridge and ravine landscapes eroded on all those rocks are mazes of steep ridges and deep valleys in a randomly dendritic map pattern. Most of the mountains of central Idaho never felt the scrape of glacial ice. Only the higher ranges show evidence of ice age glaciation in their jagged skyline profiles and deeply gouged and straightened valleys. In general, those are the ranges that make their own weather today.

The Sawtooth Range from Stanley Basin in central Idaho. Photo by Warren Clary.

Until a few decades ago, geologists included all the granite in central Idaho in a single mass, the Idaho batholith. That was an excessively broad view.

The major part of the granite, the classic Idaho batholith, crystallized from magma that invaded the Belt formations during late Cretaceous time, between about 80 and 70 million years ago. It is in two major bodies. The northern one, the Bitterroot batholith, crystallized at a depth of approximately ten miles. The southern mass, the Atlanta batholith, crystallized at a depth of about seven miles.

Both of those masses of very deep granite appear to have been exposed as their original cover of Belt formations slid into western Montana. It seems likely that most of that movement happened during late Cretaceous time, while molten granite magma invaded the depths of a high mountain range made of Belt formations. The molten granite within the range provided a slippery base on which its superstructure detached and slid east, downhill. It moved as much as 50 miles, perhaps more.

Precambrian basement rocks cover a large area north and south of the Salmon River between the Bitterroot batholith to the north and the Atlanta batholith to the south. The rocks are mostly metamorphic gneisses and schists, but also include a considerable volume of granite.

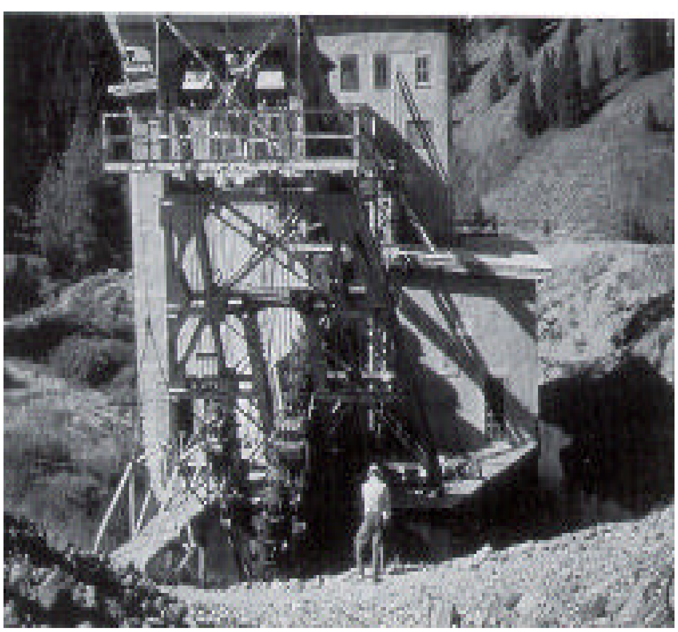
A second generation of granite magma invaded the Bitterroot and Atlanta batholiths about 50 million years ago, during middle Eocene time. In another aspect of the same event, the Challis volcanic pile erupted across the exposed older granites. It was, apparently, a matter of purest chance whether a mass of magma crystallized at shallow depth to become granite, or erupted through one of the Challis volcanoes to become a widespread sheet of pale rhyolite ash. Some of the volcanoes collapsed into large calderas as enormous volumes of lava erupted from the magma chamber below.

Crustal movements in Central Idaho are now creating a number of fault block mountain ranges and valleys, especially in the southern part of the region. Those mountains and valleys are distinctive in being linear, with a generally north trend. Occasional earthquakes, some quite strong, leave no doubt that the faults are active, raising the ranges while dropping the adjacent valleys. The Borah Peak earthquake of 1983 accompanied the most recent large movement.

Serious gold mining started in central Idaho during the Civil War with establishment of a number of placer districts. Old fashioned placer districts typically boomed for two years, then went into rapid decline. Miners spent the first summer clearing their claims, stripping overburden, and digging ditches. When the spring runoff came, they worked their claims to shovel depth. That skimmed the cream off the deposit, and the excitement off the district. Further work required serious capital and much more patience.

Large dredges reworked many of the placer deposits between the 1890s and 1942, when all gold mining stopped after the industry was classified as not essential for the war effort. Only a few dredges resumed operation after the war.

Many of the early placer districts went on to underground mining, which in some cases continued for decades. Most of those mines never resumed production after the enforced hiatus during the Second World War. Very few of them ever showed much profit. Cyanide leaching began revitalizing old gold mines early in the twentieth century, and still does. It also became profitable to leach some of the old mine spoil heaps and mill tailings.



Gold dredge on the Yankee Fork of the Salmon River between Stanley and Challis, Idaho. One of many large dredges that operated in the region between 1890 and 1942. Photo by Warren Clary.

Cyanide leaching has in recent years begun to cause strong environmental concern, so much so that a recent referendum in Montana outlawed new leaching projects. It is certainly true that the cyanide compounds involved are extremely poisonous. It is equally true that the process uses those compounds in very low concentration. The cyanide compounds are so unstable that contact with the atmosphere quickly breaks them down into harmless compounds, making the prospect of surface contamination seem fairly remote. Still, it must be said that most people consider the tailings of large leaching operations an eyesore and an insult to the environment, even if they do not pose much threat of poisoning.

People typically estimate the economic effect of gold mining by citing figures for the total production of a mine or district. They forget that those figures refer essentially to total cash flow, which may or may not have yielded a profit. Most of the old gold mines went bankrupt, many of them sooner rather than later. Very few of the people who worked the gold mines in any capacity made much money.

In the long term, gold mining had very little economic effect on central Idaho. A few of the early mining camps survive as thriving modern communities in no way dependent on mining, but most quickly degenerated into ghost towns. Much of the legacy of placer mining in central Idaho is painfully visible in formerly productive streams and floodplains converted to dredge fields, great expanses of raw gravel.

A number of small mines have produced a variety of metals from the rocks in the Salmon River arch, none in great quantity or with much profit. The extremely sparse population and nearly roadless condition of most of that area testify to their lack of economic impact. Nothing in the mining history or bedrock of the Salmon River arch suggests the existence of large and undetected mineral resources.

The Snake River Plain

The landscape of the Snake River Plain is almost entirely volcanic, basically an expanse of basalt erupted at widely different times with the Snake River slicing a deep canyon through it. The extent of soil and plant cover depends rather directly upon the age of the basalt. The older flows are deeply covered, mostly with windblown silt. The youngest flows are still raw expanses of jagged lava. Abrupt changes in soil and plant cover commonly mark the boundaries between flows.

Even though its surface is mostly basalt, the great bulk of the Snake River Plain consists of pale rhyolite. The province is the track of a deep hotspot that remained stationary as the earth's outer rind, its lithosphere, moved across it at an average rate of about 30 miles every million years. The hotspot melted the continental crust to produce large volumes of rhyolite magma. Eruptions began approximately 14 million years ago at the western end of the Snake River Plain, and have since stepped east to the Yellowstone volcano, which is still active.

Most of the pale rhyolite is buried under at least several hundred feet of younger black basalt, which appears to erupt at random timee and places. Small basalt shield volcanoes make broad swellings a mile or so in diameter and several hundred feet high on the surface of the Snake River Plain. Basalt cinder cones are smaller and much steeper. Either or both are generally within view. Here and there, large rhyolite domes punched through the surficial crust of basalt to make steep buttes of which Big Southern Butte is the most prominent.

Idaho tends to become drier southward, and the Snake River Plain is generally arid enough to make irrigation necessary. The basalt bedrock considerably exacerbates the natural aridity of the province. The same fracture pattern that defines the long palisades of vertical columns that make basalt so easy to recognize in cliffs or roadcuts also confers considerable vertical permeability. Surface water tends to sink along the fractures. The upper surfaces of basalt lava flows commonly break into a rubble of angular fragments of bubbly rock. The moving lava rafts its cover of rubble along, tips it over the front of the flow, then advances across it. That is why zones of rubble so commonly separate the individual flows. They store the surface water that sinks into them along the vertical fractures, commonly in quantities that make them good sources of irrigation water.

Two colleagues and I contend that the hotspot started at the site of an enormous impact crater in southeastern Oregon. If we are right, then the fireball that rose high out of the crater in the moments after impact instantly incinerated every living thing within its line of sight. That probably included all of Idaho. People concerned with the ecologic history of the region should consider the possibility that an impact explosion instantly reduced its biodiversity to zero one day about 17.2 million years ago.

Southern Idaho, Basin and Range

Most of Idaho south of the Snake River Plain is within the Basin and Range. The opposite ends of the province are at the Sierra Nevada front in eastern California and the Wasatch Front just east of Salt Lake City. It is as though they were being pulled apart with the rocks between sliding in great slices east and west, more or less symmetrically toward the center. Those in southern Idaho moved west. The slices move on faults that are nearly vertical where they break the surface, then flatten at depth. That makes them concave upward, so the moving fault slices rotate as they slip. Most of the broad valleys are on the dropped sides of the slices, the much narrower mountain ridges on the raised sides. All trend generally north.

The climate of the Basin and Range has been arid since sometime around 15 million years ago. Rain and snowfall do not provide enough water to maintain an integrated drainage net. No streams flow out of the region to carry sediment to the ocean. Instead, the streams carry eroded sediment from the mountains into the floors of the broad valleys that dropped during fault movement, then leave it there as they dry up. Only the tops of the raised ridges rise above the accumulating sea of valley fill sediment.

The mountains of southeastern Idaho contain large volumes of the Phosphoria formation, a deposit of late Permian time, about 250 million years ago, in round numbers. As its name implies, the formation contains phosphate. In fact, the Phosphoria formation of southeastern Idaho, western Wyoming, and southwestern Montana may well contain the world's largest reserves of phosphate rock.

Phosphate is a basic ingredient of fertilizer, many kinds of soap, various chemical products, and some of the nastier kinds of military ordnance. Demand grows. Meanwhile, the reserves in central Florida, now the principle North American source, are rapidly dwindling. Open pit mines have produced phosphate rock from southeastern Idaho since the 1920s. Production will almost certainly increase enormously in the next few decades. Phosphate mining has had considerable economic impact on southeastern Idaho, and will almost certainly have more in the future.

Some of the black shales in the Phosphoria formation are genuine oil shales, but efforts to produce oil from them have not proved economically inspiring. However, those same shales also contain large amounts of metals, including copper and chromium. Similar shales of the same age have been major sources of metals in Germany and Poland for more than a century. It is easy to imagine that the oil content of the Phosphoria formation may provide a large part of the energy needed to extract its metals.

Palouse

At first glance, the Palouse Hills look like a fairly ordinary rolling landscape. A more thoughtful inspection reveals a truly bizarre landscape in which the high points do not connect to make ridges, and the low areas do not connect to make valleys. This is not an ordinary erosional landscape. It is an expanse of dunes.

Enormous flood basalt flows covered much of the Pacific Northwest, including the western fringe of central Idaho, between 17.2 and about 15.5 million years ago. Streams eroded valleys into them, creating what must have been a fairly typical erosional landscape. Then, during some poorly known time, quite possibly during several poorly known times, the wind drove dunes of dust across that landscape. Those are the Palouse Hills.

The steep faces of dunes are invariably on their downwind sides. The Palouse Hills are typically steepest on their northeast flanks, so they evidently marched northeast, out of the southern part of eastern Washington. They nearly bury the older erosional landscape, except for the tops of a few of the higher hills. Those are easy to recognize because the basalt supports pine trees, but the Palouse soil does not.

Deposits of windblown dust invariably make extremely fertile agricultural land. The Palouse Hills consistently produce abundant crops of wheat, barley, peas, and lentils. Many of the large crops from the western part of the Snake River Plain grow on the windblown dust that blankets the lava flows.

Conclusion

The natural regions of Idaho closely correspond to the distribution of bedrock provinces. Each of those dates from a specific set of geologic events and processes.

Deposits of silver and lead played a major and obvious part in determining the patterns of settlement and development in the Coeur d'Alene mining district of northern Idaho. That district is still active on a dwindling scale. Its mines no longer dominate economic activity along the Coeur d'Alene River.

Gold mining was important in the early years of settlement in central Idaho, and has continued more or less sporadically ever since. Except in the early years of white settlement, when it was the only game in town, gold mining has never been as economically important as many people assume. The mystique of gold tends to magnify its importance in our minds.

Everyone likes to imagine what the future will bring even though the window that looks into it is always opaque. It is tempting to suggest that if present trends continue, the coming decades will bring a large increase in phosphate mining to southeastern Idaho, the final end to gold mining in the entire state, and the eventual end to silver and lead mining in the Coeur d'Alene district.

The author is with the Department of Geology, University of Montana.