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Environmental Geology  September
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February, 1994

Volume 31, Number 2

The Professional GEOLOGIST

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Figure 1. Landsat thematic mapping image of the altered ring fracture system at Goldfield (yellow/orange color). Blue dots at the southwest end of the ring fracture are Main District mine dumps. Goldfield townsite is southwest of the mines. A 2,000,000 ton tailings pile is located west of the ring fracture. Black and orange area in the southwest corner of the image is the Malapal Basalt. —George H. Bennett, CPG-8672
Ore Discovery At Goldfield, An Historical Perspective And Look To The Future

George H. Bennett, CPG-8672

The Goldfield district is part of a Tertiary volcanic center located in west central Nevada, midway between Reno and Las Vegas. Figure 1 is a Landsat thematic mapping image of the Goldfield district, showing a highly altered ring fracture system (yellow/orange) coincident with the volcanic center which has been interpreted as a caldera.

History

It is interesting to note that Goldfield was the last great gold camp to be discovered in the western U.S., in spite of the intense alteration of the area (visible in the Landsat image). Prospectors from Virginia City's Comstock lode had crossed this area since the 1860's, and a number of gold and silver discoveries had been made within about a 20-mile radius of Goldfield including Montezuma, Lida, and Silver Peak. At Goldfield however there was nothing to hold the gold seeker's eye. Rusty, siliceous outcrops were abundant, but those carrying gold were sufficiently hidden among a multitude of barren occurrences to prevent their discovery. In addition, there were no placer occurrences, which had served as infallible trails to the discovery of other mining camps. According to Locke (1912) the remarkable fact is not that the Goldfield deposits were so long undiscovered, but that they were discovered at all.

From the mid-1870's to 1900 the west-central Nevada area has been all but abandoned by explorationists as they rushed on to greener pastures of the Yukon and Seward Peninsula. It took a local rancher/prospector named Jim Butler, who happened upon the Mizpah lode at Tonopah in 1900 about 30 miles north of Goldfield, to renew interest in the area. Within one year Tonopah was a significant silver producer, and like other new discoveries it was soon overflowing with people. Within two years float gold was uncovered on the east flank of what is now known as Columbia Mountain (1/2 mile east of the existing tailings dump). A stampede resulted, but by 1903 most of this first wave of prospectors were quickly discouraged and soon departed.

A few prospectors remained, and in May of 1903 a location was made on the Combination claim. This was the last vacant land near the initial discovery of float gold, and it contained a large quartz outcrop. A shallow cut near the base of the outcrop exposed high grade gold ore. Almost from the start the ore body developed automatically, thus paying for its own exploration. The discovery of the Combination was soon followed by discoveries of the Florence and

Figure 2. Reportedly the richest shipment of ore ever to reach a smelter. This 40 ton shipment contained 25,000 ounces of gold and 3,000 ounces of silver.
Jumbo claims in 1904. By the end of 1904 the district had produced nearly 117,000 ounces of gold from about 8,000 tons of ore.

In 1906 the Mohawk mine was opened and subsequently became known as one of the richest mines in the world. Figure 2 shows a 1907 photograph of what was reportedly the highest grade ore shipment ever sent to a smelter. The bank guards are guarding sacks of direct shipping ore from the Mohawk that contained 40 tons of ore which yielded 25,000 ounces of gold and 3,000 ounces of silver (609.61 ounces of gold and 75.38 ounces of silver per ton of ore).

The high grade nature of the Goldfield ore gave rise to widespread theft known as "high-grading", where miners would carry off "samples" in lunch buckets, pans, pockets, etc., and several assay labs existed in the district existed only for the purchase of illicit ore. No one will ever know how much gold was spirited away in this fashion, but the total "recorded" production for the Goldfield district from 1902-1960 is 4,190,133 ounces of gold, 1,450,258 ounces of silver and 7,669,666 pounds of copper. This production came from about 3,900,000 short tons of ore (Albers, 1972).

**Geology and Ore Deposits**

Two distinct periods of volcanism are recognized in the Goldfield district; the oldest volcanic rocks are rhyolite and latite flows and tuffs of Oligocene age (31 m.y. before present), which cover a flat-lying erosional surface consisting of Ordovician metasedimentary rocks and Mesozoic plutonic rocks. The dips of the Oligocene rocks suggest that the caldera/ring fracture system developed at this time. A thick sequence of dominantly andesitic rocks of early Miocene age unconformable over the older Oligocene volcanic units and fill a "moat" within the caldera/ring fracture system. A porphyritic rhyodacite intrudes and overlies the andesite, forming a group of flow-dome complexes along the southern and eastern edges of the ring fracture system and represents the last phase of the early
Miocene (intermediate) volcanism. Widespread, intense, hydrothermal alteration and mineralization are closely associated in time with the rhyodacite volcanism, but the alteration can affect any of the rock units older than about 20 m.y. before present.

Ore deposition, which is dated at 20-21 m.y. before present, is closely associated with the rhyodacite-andesite volcanism. Generally the host rocks are highly bleached and have been intensely argillized, alunitized and silicified. Typically the most silicified and alunitized rocks form linear ledges within softer argillized rocks. The Goldfield district contains more than 20 square miles of alteration, and hundreds of silicified ledges crop out within the ring fracture. Nearly all of the gold production, however, came from only a few ledges within a 0.7 square mile area in the south-west portion of the ring fracture system known as the Main District (Figure 1).

The Main District mineralization is not continuous within a ledge. It is structurally controlled by a eastward dipping listric normal fault system with dip-slip displacements known as the Columbia Mountain fault. This fault has been traced for more than two miles in a north-south direction, forming the western edge of the ring fracture system. Dips on this fault range from nearly 70 degrees in its upper portion, northwest of the Main District, to 10 degrees in its lower end in the deepest workings on the east side of the Main District.

High grade gold mineralization in the Main District occurs both as a breccia matrix, and as open-space vug fillings contained within lower-grade, pervasively silicified but unbrecciated, host rocks. Approximately 15 ore bodies were classified as "bonanzas" and all were in the Main District. The overall average grade of the bonanza ore bodies was about 2.9 ounces of gold per ton. Based on tonnages mined, bonanza ores accounted for approximately 51% of total tonnage. Typical dimensions of bonanza ore bodies

Figure 4a Red Top pit looking west. Ore zone has been downfaulted to the west and is covered by post mineral Siebert Tuff.

Figure 4b Early open pit mine looking SE along the main ledge. Headframe in upper left corner is the Combination mine, its numerous mine dumps along the main ledge. Much of this area has now been developed by open pit. The town of Goldfield is in the upper right and the Malapai Basalt can be seen capping the plateau in the background.
were about 200 feet on strike by about 300 feet on dip and 20 feet wide. Production from these bonanzas generally included 100,000 tons of ore and 100,000 to 500,000 ounces of gold.

In addition to the stockwork/brecia ore bodies at Goldfield, where ore fluids were concentrated along zones of structural weakness, a unique disseminated deposit occurs at the Adams mine, located 2 miles north of the Main District. Here gold deposition was controlled to a large extent by host rock lithology, and mineralization is best developed in a finely laminated, rhyolite tuff (Oligocene age Sandstorm Formation). Liesegang banding in the Adams ore suggests that ore deposition occurred in a more passive environment than in the Main District. The Adams produced about 4,000 ounces of gold from 36,000 tons of ore in 1982 (unpublished records Blackhawk Mines Inc.).

Present Operations

In the early 1980's, when the price of gold peaked at historic high levels, gold production resumed in the Goldfield district. All recent production has come from open pit, heap leach operations where the gold ore is crushed to about one inch, agglomerated with cement and/or lime, stacked atop an impermeable liner, and leached with a dilute sodium cyanide solution. Gold is recovered from the solution by passing it through activated carbon. When the carbon is loaded with adsorbed gold it is stripped in a concentrated cyanide solution, and gold is plated out through electrowinning on a steel wool cathode. The gold-plated cathode is then melted down in a muffle furnace and a dore bar is poured for shipment to a refiner.

The open pit gold ore presently mined at Goldfield consists of "low grade" which overlies and surrounds high grade areas previously mined by underground methods. In many cases the waste rock material from the older underground mines contained ore grade values and was also placed in the heap leach. Small lenses of high grade ore are occasionally found, as shown in Figure 3a and 3b, however this material will typically not be recovered in a heap leach operation. The ore in Figure 3a is too coarse-grained to react sufficiently with the cyanide solution. The gold in Figure 3b is encapsulated by tetrachloroauric acid (CuCl₂Sb₄S₁₃) and is unable to react with cyanide. Ores which react best with cyanide are highly oxidized and contain very fine-grained gold. Oxidized ore containing 1-2 ppm gold is commonly profitable in a heap leach operation.

Future Discoveries

The enigma of Goldfield has always been why so much gold was concentrated in such a small portion of the more than 20 square miles of alteration and silicification. However, recent open pit exposures suggest that gold localization is due to distinct structural controls (related to regional wrench faulting). Therefore, future exploration should concentrate on locating similar structural

---

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conditions elsewhere in the Goldfield vicinity. Many areas which contain the favorable structural conditions, however, may be covered by younger post-mineral rocks or alluvium.

The mineralization in the Main District terminates abruptly to the west against younger rocks (Siebert Tuff) which underlie the Goldfield townsite. Open pit and underground exposures indicate that this abrupt termination is fault controlled (as shown on the landsat image). Figure 4a illustrates a faulted contact where the main ore zone is terminated to the west against younger downfaulted rocks. Such post-mineral downfaulting is now exposed in pits throughout the Main District. In some instances large blocks of younger non-mineralized rock form grabens within the main ore zone.

Additional evidence of downfaulting is seen in the present topography of the Main District, which occupies a topographic low compared to the rest of the ring fracture. These and other facts suggest that the entire Main District has been down-faulted after mineralization occurred though a series of normal faults. The lack of placer trails to Goldfield suggests that the mineralization which outcropped, and was therefore discovered, had only been recently uncovered due to its low topographic position. Perhaps the regional structural features which localized the ore deposition were reactivated after mineralization and also led to the down-faulting of the mineralization and its subsequent burial by later sediments and tuffs. If this is true, substantial gold mineralization may lay buried and undetected.

The search for gold deposits with no evidence of mineralization at the surface will require a comprehensive program which may include remote sensing, geophysics, geochemistry, and drilling, as well as sound geologic reasoning. Such a program can look at areas that were for the most part passed over by the early prospectors. Like the original discoveries at Goldfield, any new discoveries will be remarkable not because they were so long undiscovered, but that they were discovered at all.

Selected References
Locke, Augustus, 1912, The Ore Deposits of Goldfield-I: Eng. and Mining Jour., v. 94, no. 17, pp. 797-802.
Sears, Fred Jr., 1948, A Contribution to the Published Information on the Geology and Ore Deposits of Goldfield Nevada: Nevada Univ. Bull. v. 42, no. 5, Geol. and Mining Ser. no. 48, 24 p.

NASBOG

NASBOG, the National Association of State Boards of Geology (see ASBOG), is evolving uniform examinations for the use of its member boards. One is the Fundamentals examination for entry level. The other is the Principles and Practices examination for licensure/registration.

As part of this process, they have compiled a list of 88 tasks which are performed by Geologists. It probably goes without saying that not all Geologist perform all of these tasks. However, the examinations are designed to take this into account.

The Examination Committee is seeking additional questions to be used to test applicants' knowledge of the following identified tasks. Questions are multiple-choice, with one correct answer and three distractors. They are designed to test the individual's understanding of, and competence to, perform the task. The questions go into a pool from which questions are drawn each time the examinations are given.

The tasks for which more questions are currently sought are:

In Geochemistry:
- Evaluate geochemical data
- Make recommendations based upon results of geochemical analyses

In Structural Geology:
- Identify structural features and their interrelationships
- Map structural features
- Interpret structural features

In Geophysics:
- Perform geophysical investigations in the field

In Mining Geology:
- Perform economic analyses/appraisals

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Of Teamwork, Concealed Terrain And Applied Integrated Exploration Methods

Walter E. Heinrichs, Jr., CPG-0688

From time to time we hear references made about the pros and cons of so-called "integrated exploration". Sometimes, even today, older mining geologists are heard making serious derogatory remarks about the real value of applied geophysics, geochemistry, remote sensing, etc., to the discovery process. But, as these die-hard old-timers retire and the exposed deposits become more and more scarce, this sort of comment is heard less and less, and the phrase "integrated methods" is heard more and more. Part of the negative feelings among the older geologist is born out of habits developed or evolved during the past one hundred years or so. Integrated methods in mining exploration did not really begin to appear until after World War I.

Historically, from strictly a geological point of view, in many cases, first came the placer deposits and then the lode deposit. Later on mining geologists learned to recognize the numerous different degrees and modes that exposed lodes and their adjacent environments might take, and the meaning that these rather subtle factors could have in relation to where ore might exist. Petroleum explorationists, on the other hand, were forced to use integrated methods much sooner than the miners because the relatively few surface oil occurrence quickly ran out. Moreover, big oil bonanzas were soon being discovered under what could be compared to the mining equivalent of concealed terrain. But wildcat drill-
ing was still expensive, and many dry holes suggested that applying geological methods alone was not enough. Consequently, geophysics began to be added to most programs and almost right away proved to be beneficial. Since then, there has been relatively little use of the term "integrated methods" around the oil patch and, except for some true wildcat drilling, most oil exploration work has almost always utilized integrated methods. Because of the relative target size and geologic simplicity, the seismic method has been extremely successful in oil exploration, but gravity, magnetics and soil and gas analysis (geochemistry) have also been helpful. Electrical and radiation methods, so far, have not been too helpful, but they continue to be researched.

Because mining geology is generally much more complex than petroleum geology and because ore deposits and related targets are often smaller than most oil fields and are usually much less distinctly separated from their host environment, the application of integrated methods to mining is considerably more difficult. In addition, the economic odds, time factors and incentives are quite different, perhaps by as much as several orders of magnitude. For example, the type of heavy investment in modern petroleum seismology cannot be justified in most mining ventures. But, these odds are not static and the economic factors do change. For example, good modern seismology can now be used in many mining applications for about the same cost as most of the newest electrical methods used in mining geophysics.

During April 1993, the Society of Economic Geologists, with others, held a successful international conference in Denver, Colorado titled: Integrated Methods in Exploration and Discovery. The keynote address at this conference was titled: The Multidisciplinary Team Approach to Successful Mineral Exploration, and was given by Roy Woodall, Director of Exploration, Western Mining Corporation Limited of Australia. A better example of successful, truly integrated, mineral exploration could hardly be found than that represented in this address. A published version of the address is contained in the Society of Economic Geologists SEG Newsletter of July 1993, Number 14. This article should be required reading for any and all involved in mineral prospecting of any kind but, especially, in concealed terrain prospecting.

Doubtless, as Woodall points out in his article, there remain surface exposed "Ertisberg" type deposits still to be discovered by strictly surface methods. Certainly this will remain
the case, especially in the extremely inaccessible areas of the world such as Indonesia and New Guinea. But, in heavily explored and accessible areas such as Australia, United States and Canada the future will belong to those who can successfully explore over concealed terrain. In order to maximize success in concealed terrain exploration, a thoroughly integrated multidisciplinary approach is required. Even in areas where mineralized rocks are generally well exposed, as in the numerous copper provinces of the South American Andes Cordilleras, multidisciplinary concealed terrain methods have already resulted in significant economic discoveries.

However, knowing just how to successfully integrate the various disciplines so as to achieve maximum effectiveness and efficiency is quite difficult, and require a degree and mix of artistic talent and common sense often not available or applied in many mining exploration programs. Since World War II, most mining exploration companies and groups actually have relied on multidisciplinary methods to one degree or another. Almost all of the majors employ some geologists, geophysicists, geochemists and drillers, etc., but getting all of these disciplines pulling together most effectively as a team is not easy. Often because of human nature this objective requires much interdisciplinary cooperation and a large dose of applied communication skills and psychological management not always natural to many people trained in earth sciences.

Perhaps that partly explains why so many exploration programs aren’t more successful. Too many explorationists seem entirely happy to remain blithely and completely immersed, stewing solely in the juice of their own specializations, and with too little regard for what is going on in the other related exploration disciplines of their own team associates. Of course, research aspects and interdisciplinary competition is always a factor, but that should never be allowed to interfere with the ultimate applied ore finding objective of the whole exploration team. What that principle tends to help define is the crucial difference between the many “hunting” explorationists and the relatively few “finding” explorationists. Again, to quote or paraphrase Woodall, “More and more, only the smart geochemists working closely with geologists will succeed and, increasingly, geophysics must be used to resolve geological problems and identify ore, not just to find anomalies”.

A steadily persevering and understanding management and consistent and constant source of financial backing is also an essential ingredient in successful mineral exploration. Adequate demonstration of this is represented by the Woodall team’s 1976 Olympic Dam discovery in South Australia which, according to Woodall, followed a multidisciplinary team-effort-trail of 3800 km (2400 miles) for 20 years, costing $30 million and even so, very nearly failed! The result we know now however, is a world-class deposit, the first of its type ever found, containing 2000 million tonnes of ore averaging 1.6% Cu, 0.6 kg U and 0.6g Au per tonne.

This represents one of the world’s largest known deposits of copper, absolutely the world’s largest known uranium deposit and one of Australia’s largest gold deposits.

Those of us who are responsible for finding ore for our modern civilization could easily do worse than trying to emulate the exploration philosophy and methods of Western Mining Corporation of Australia.

Walter E. Heinrichs, Jr., CPG-0688, Exploration Concept & Program Management, Geological Engineer & Geophysicist, P.E. & CPG.
Tungsten As A Strategic Resource In Japan, The Koreas And Mongolia

Karl A. Riggs. CPG-2740

Introduction

At the start of the Korean War in 1950, China dominated the world tungsten market. China has continued to do through to the present. Presumably North Korea could have obtained adequate supplies of tungsten from China, whose main tungsten resources are in southern and especially southwestern China. However this would have made North Korea strategically dependent on China which shares one long border with North Korea.

Of course North Korea wanted to unite the two Koreas, and most of the Tungsten mines of the Korean Peninsula are located near or in South Korea. Apparently these two motives as well as many other economic, ideological and psychological factors led to the invasion of South Korea by the North Koreans.

Production of tungsten in these four countries (Japan, the Two Koreas and Mongolia) is uneven. In 1992 South Korea still had significant tungsten production. North Korea has had very little tungsten production in recent years. Japan has considerable tungsten production, but Mongolia has only minor tungsten production.

Japan

About 30 to 40 polymetallic tungsten-bearing skarns of various types have been mined for a variety of metals. Many of these deposits have been mined for copper ([chalcocpyrite, CuFeS₂]), iron, ([magnetite, Fe₃O₄] and [hematite, Fe₂O₃]), etc., but scheelite (CaWO₄) has not been economic by itself.

The Fujigatani mine, Kuga district, Yamaguchi prefecture, is about 50 km. southwest of Hiroshima which is in southeastern Japan. It is a major deposit which is quite typical of the numerous tungsten deposits of the area. The Fujigatani and the Kiwada mines are tungsten mines with almost no copper minerals. Scheelite and quartz veins occur in both of these mines. Drilling indicates that granitic rock is about 300 meters below the surface of the Fujigatani mine. At the Kuga mine, about 6 km. northwest, veins of scheelite and quartz fill tension cracks on the crest of a plunging anticline. Scheelite is the ore mineral, but wolframite ([Fe,Mn]WO₄) is present. Granite occurs about 7 to 8 km. to the south and east of the Kuga mine.

About 80 km. northwest of Kyoto, in Kyoto prefecture, the Ohtani and Kanekoichi mines have tungsten veins in a granodiorite stock. Wolframite is absent. Scheelite is the only tungsten ore mineral in the Ohtani mine. The Kanekoichi mine consists of veins, in a dome structure, which have a maximum strike length of 500 meters and a mean width of 30 to 50 cm. The vein minerals are: wolframite, scheelite, cassiterite (SnO₂) and sulfides.

About 110 km. north-northeast of Tokyo in Ibaragi prefecture is the Takatori mine. The deposit is in quartz veins with wolframite, cassiterite and sulfides. The mine produces
tungsten and copper in an area of sandstones, claystones and quartzite. Granitic rocks occur about 4 km. northeast of the mine.

Mongolia

The mining of tungsten is done on a small scale. Tin and tungsten are mined at the Modot, Tsagaandavaa and the Ulaan-Ul deposits. In 1990 the production totalled 500 tonnes of tungsten metal.

Republic of Korea

South Korea has important tungsten production. In fact this probably was one reason why North Korea invaded South Korea in 1950. The total reserves of tungsten ore are about 31 million tonnes of 0.46% wolfram (WO3) grade. About 20 million tonnes of tungsten reserves occur in the Sangdong mine area.

Scheelite is mined at Sangdong mine, which is located in Kangwon province. This has been known as one of the largest tungsten producers in the world since 1951, but it was discovered in 1916. Sangdong mine is in southeastern Korea about 45 km. west of the coast and about 170 km. east-southeast of Seoul. The area is quite mountainous, but it was overrun by the North Korean troops early in the Korean war.

Sangdong mine occurs in a belt of granitoids which extend into southern China. It is one of the most intensively studied tungsten skarns in the world.

At Sangdong, a 1,700 tonne/day mill treats 0.53% WO3 run-of-mine ore and converts it to APT (ammonium para-tungstate). The mill has been in continuous operation since 1951. In recent years, South Korea has had the capacity to produce 3600 tonnes of tungsten concentrates per year. South Korea no longer exports concentrates. Rather it uses its production for intermediate and end products.

South Korea had 8 other operating tungsten mines which were closed in 1983 because of declining tungsten prices. Another mine is the Ilkwang mine which was known as Nikko to the Japanese. This mine is located in a stock which is about 1 kilometer in diameter. The ore consists of wolframite, scheelite, reinite (wolframite after scheelite) and sulfides.

Democratic Republic In Korea

North Korea has produced as much tungsten in some years (1959-1961) as South Korea. During those years the two Koreas, together, produced about 15% of the world’s tungsten. In 1990 North Korea produced only 500 tonnes of tungsten metal.

Otherwise little information is available on the tungsten deposits of North Korea. Possibly four tungsten mines exist, and 3 of these are near the southern border. The tungsten deposits are mainly quartz veins that contain wolframite, some cassiterite, molybdenite (MoS2) and some other sulfides.

Conclusion

The above on North Korea implies that tungsten has played a sensitive role in the military strategy and tactics of the Korean War. Apparently among other reasons, North Korea judged itself threatened in terms of tungsten reserves in 1950. By uniting the two Koreas it would have become self-sufficient in tungsten.

Three of the four known tungsten deposits of North Korea are near the border with South Korea. Other significant tungsten deposits exist in South Korea. Most important of all, Sangdong is one of the world’s largest tungsten mines and is located in southeastern South Korea. It would seem that tungsten was a factor in the various causes of the Korean War.

Japan also has significant tungsten deposits, but Mongolia has only token known tungsten reserves. Exploration may locate more tungsten reserves and resources in Japan, the Two Koreas and Mongolia.

Selected References


Karl A. Rigs, CPQ-2740, Associate Professor, Geosciences, Geologic Services and Consultant, Mississippi State, MS.
Mining Geology In Argentina - 1970

Ben H. Parker Jr., CPG-0212

Mining exploration often brings up special situations -- not all related to geology.

The Pachon porphyry copper deposit is in Argentina in south-western San Juan province a few kilometers from the Chilean boarder, in a glaciated valley at about 3600 meters elevation, flanked by mountains which rise to 4500 meters. During one summer the district was visited by Frank Whiting after he heard reports of Lago Azul--Blue Lake. He initiated claiming a large block of concessions and conducted an IP survey in the valley. Because of topographic constraints, the survey was limited to an area which proved to be essentially off the ore body on its heavily pyritized southern flank. I directed surface mapping and prospecting drilling campaigns during two seasons. The discovery was made in 1970, the middle of the second drill season. The following development drilling and evaluation of the project was directed by Bert Renzetti.

Soon after the drilling was begun, we found that reliable copper assays could not be made in Mendoza. The only laboratory available was part of a plant making copper sulfate for the vineyards about the city, and in that windy area dust from the high-grade ore and copper sulfate product piles contaminated the drill samples during analysis. Since sample shipment took two to three weeks, assaying at the Aguilar mine was not suitable to provide control during a drilling program.

A soil geochemical laboratory had been set up to support exploration activities elsewhere, and it was decided to try soil geochemical analysis methods on the drill samples. Hot acid extraction followed by routine copper soil analysis proved rapid and satisfactory. For the core samples, results up to about 0.8 percent copper were very comparable to those for conventional analyses and suitable to control drilling. Because of dilution problems, results above that grade were erratic, but no matter, they demonstrated when holes should be continued! (Needless to say each sample--project evaluation was based on conventional analysis.)

The outcrops above the ore body show a faint purple coloration, but this was only recognized after the discovery when I chanced to make a flight to the camp from the east just after sunrise. The coloration is only visible under these particular lighting conditions.

Before the discovery, several holes were drilled in an area which proved to be downflow from the supergene ore body area. The holes were cased, and the rods were often left in the holes overnight to gain an hour's drilling time each day. The holes were mysterious-sludge samples ran a percent of copper or better but the cores ran one or two tenths copper or less. Core recoveries were good and there was no suggestion of copper mineralization or mineralized zones which might have been ground up to selectively enrich the sludge.
At the end of the season the casing and rods were pulled and sent to Mendoza for storage. (The drilling equipment was removed from Pachon at the end of each season to avoid possible snowslide damage.) When the casing and rods were cleaned, some rust that had formed on them was found to contain several percent copper. The next season water from the holes was tested and found to have a Ph of 1 or a little less. The sludge had been contaminated from copper and copper salts deposited on the steel.

Prospecting and early development drilling was supported at Pachon by 2 and later 3, Bell XB5 helicopters and by mule trains. One way by helicopter took 50 minutes and by mule train took five days. Helicopter freighting was difficult because of the frequent, very strong winds. Over the season flights could be made only one day in three or four, and the helicopters had less than a 200 kilo payload, so each load and each kilo were precious. During the season the helicopters carried personnel, mail, emergency replacement parts and limited fresh food to the camp; moved drills and equipment between drill sites at the camp and brought personnel and core back. The loads for every flight during the season were planned before the season began, and these plans were pretty much adhered to.

The mule strings varied in number. One season there were more than 200—probably the largest working string in the western hemisphere then. The mules carried personnel, staples, tools and construction materials. Since the trip was five days each way over trails that exceeded 4000 meters elevation at places, the mules tired and needed five days or more to recover from the trip. They soon ate the limited food along the trail and an airlift had to be set up to drop feed and hay to them along the way.

Unusual situations and techniques were not limited to Pachon or to work. At one prospect area in Patagonia daily entry was on horseback, with the crew guided and the horses cared for by a local man. The trail crossed a stream not quite two meters wide inhabited by one or two kilo trout. In the evenings the crew fished the stream on their way back to camp, so they set out each morning with rods cases and tackle boxes tied behind their saddles. The local man laughed at all this gear. He had a number ten tin can with both ends cut out and with a piece of sapling jammed inside so that he could put his hand inside and use the sapling for a handle. He had wrapped come 15 or 20 meters of leader around the can and attached a spinner and someskinners to it. To fish, he would pull some line from the can and twirl it overhead like a lasso into the stream. Frequently he would hook a trout before the crew had their rods assembled. He didn’t fish at every opportunity and often gave away the trout he caught. Like many country folk in Patagonia, he preferred perpetual mutton to an occasional trout.

Alaska Opens Lands To Minerals

Alaska Governor Walter J. Hickel announced at the recent annual convention of the Alaska Miners Association that the State Department of Natural Resources will soon open more than 550,000 acres of Alaska State lands to mineral entry. These lands have been closed to mineral entry (claim staking) by administrative orders during the past 18 years.

Governor Hickel’s announcement came as a pleasant surprise to the mining industry. Steve Borell, Executive Director of the Alaska Miners Association said “We knew that a review was in process but we did not realize the magnitude of the project.” Borell continued, “This is precisely the kind of message that we want to send to the international minerals industry. For too long Alaska has been seen as an unfriendly place to do business and that has changed.”

This action by the Hickel Administration is an on-going effort by Alaska to encourage mineral development. During the previous session of the Alaska Legislature, a bill was passed that limits the amount of land that can be administratively closed to mineral entry to not more than 640 contiguous acres.

Once the mineral openings announced by Governor Hickel and the remaining state land selections are processed, the amount of state-owned land open to mining will total more than 96 million acres - nearly as much as the entire State of California. Additionally, the 12 Alaska Regional Native Corporations own more than 44 million acres of land, and they are actively seeking mineral development with major mining companies.

Borell also noted, “We are seeing a real shift in public opinion regarding mining. Most Alaskans, along with the majority of Legislators, now realize that mining is the sleeping giant of the Alaskan economy, and they are doing all they can to wake him up!”

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New Oil and Gas Map Available from Wyoming Geological Survey

The Geological Survey of Wyoming has published a new oil and gas map of southeastern Wyoming. Existing oil and gas fields in this part of Wyoming are being expanded and new fields developed through horizontal drilling methods, especially in Laramie County. Recent horizontal drilling has led to the expansion of the Silo Field (northeast of Cheyenne), as well as some smaller fields in the vicinity, and has turned southeastern Wyoming into the State's major area of production from horizontal drilling. More than one million barrels of oil has been produced from Silo Field alone since the first horizontal drill hole was completed in 1990.

The map is the fifth in a series of regional oil and gas maps of Wyoming published by the Geological Survey of Wyoming and completes coverage of the state by these maps. Previous maps included the Powder River Basin Greater Green River Basin, Wind River Basin, and Big Horn Basin. Map Series 42, entitled Oil and Gas Fields Map of Southeastern Wyoming Basins is authored by R.H. DeBruin and S.D. Hostetler. The map is at a scale of 1:316,800, or 1 inch equals 5 miles. The map is available from the Geological Survey of Wyoming, located on the campus of the University of Wyoming, P.O. Box 3008, University Station, Laramie, Wyoming, 82071. It is also available at the Oil and Gas Conservation Commission in Casper, Wyoming. The map sells for $5.00 prepaid and is available either folded or rolled (add $1.50 for mailing rolled). Wyoming addresses add 6% sales tax.
TODAY IN WASHINGTON

F. B. "Ted" Mullin, CPG-1716

This month brings to a close the yearly review of the Federal Registers for 1993. By December 30, 1993, 66884 pages have been printed and distributed to a whole bunch of people, libraries, organizations, and other Federal agencies. Somehow it begs the question—is it really necessary? To those who review the document on a regular basis, probably not. To those who utilize the document to inform the public about the rules and regulations they wrote—they are indispensable. I think that it is only fitting to close out the year of the 1993 Federal Register with an indication of what is to come.

So, now to some of that indispensable information from the Feds—

Vol. 58, No. 233, 12-7-93, pg 6448. Department of Transportation, FAA -14 CFR Part 71. Alteration of Kansas City Class B Airspace area. There is an amazing revelation shown on page 64448. It seems that the FAA has not only located the whereabouts of NOAA's ARC, but they have also officially noted the location on a Class B Airspace map. It was found approximately 6 NM southwest of the Kansas City International Airport. Watch for it the next time you fly over KC.

Vol. 58, No. 242, 12-20-93. pg 66967-67302. Part V, The President, Proclamation 6641—To implement the North American Free Trade Agreement, and for other purposes. If you are interested, most major libraries carry the Federal Registers. This document explains the NAFTA Program. For instance, on page 66888 you will find the following definition—

"(g) Fungible goods and materials. For purposes of determining whether a good is an originating good—

(i) where originating and non-originating fungible materials are used in the production of a good, the determination of whether the materials are originating need not be made through identification of any specific fungible material, but may be determined on the basis of any of the inventory management methods set out in regulations promulgated by the Secretary of the Treasury; and"...And I bet they are just about as clearly written. And hot on the heels of the previous Proclamation.


Here is where we really get into the "nuts and bolts of NAFTA. For example:

On page 69520 is an example—

"Example 1
Nuts and bolts provided for in heading 7318 are imported from outside the territories of the NAFTA countries and are used in the territory of a NAFTA country in the production of a light-duty automotive good referred to in section 9(1). Heading 7318 is not listed in Schedule IV so the nuts and bolts are not traced materials. Because the nuts and bolts are not traced materials the value, under section 9(1), of the nuts and bolts is not included in the value of the non-originating materials used in the light-duty automotive good even though the nuts and bolts are imported from outside the territories of the NAFTA countries.

The value, under section 9(9) [b], of the nuts and bolts is included in the net cost of the list-duty automotive good for the purposes of calculating, under section 9(1), regional value content of the motor vehicle."

AND, YES, IT DOES GET WORSE---
I think the whole program is NUTS. Watch out folks, these are the people who will be writing the health care program.

Ethics Committee Seeks Members

The National Ethics Committee is seeking new members. The Committee has four principal duties. First, to review complaints and initiate and administer appropriate grievance proceedings. Two, to encourage papers, articles, and other presentations on ethical issues to the Institute’s membership. Three, to respond to individual member’s requests for advice and counsel on specific ethical questions. And four, to review the grievance procedures, related bylaws, etc. to identify areas for improvement. Fortunately, experience has shown that dealing with complaints, while very important, is not that common and most of those duties fall initially to the Ethics Committee Chair rather than the Committee members. Institute members interested in joining the Committee are encouraged to call or write the Committee Chair, David M. Abbott, Jr., CPG-4570, at (303) 391-6900, 1801 California St. #21, Denver, CO 80202-2614.

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When To Have Done

William V. Knight, CPG-0153

"There is endless merit in a man's knowing when to have done." - Thomas Carlyle Francia (1845)

The following scenario is posed, with the question, "Why?"

A geological consultant, a citizen of Colorado and a "Registered" Geologist in several states, being rather gregarious, decided to visit friends and relatives on an automobile tour of the southeastern United States.

He flew to Mobile, rented a car and began his tour.

First, he visited an elderly aunt in Pensacola. It happened that she had a problem with water under her house. So, she asked her geologist nephew to examine it and advise her. This he did.

After a few other stops, he found himself in the St. Petersburg area. His host there asked him what he thought of the chances of finding potable fresh water on some rural land he was considering buying. He checked some records, looked at the site, made some local inquiries and gave a preliminary opinion.

He drove on to Ft. Meyers, Miami and Key West, taking in the sights and seeing old friends. Along the way, people asked him questions about the local geology and he answered as best he could. When he thought it appropriate, he recommended they retain a local geologist to give more complete answers.

Traveling north, he was asked about karst problems in the Orlando area, and beach erosion near Charleston. In both cases he gave professional advice to the level requested.

In none of these instances did he accept the offered cash payment, but suggested to his hosts that they consider his services as a "bread and butter" gift.

Returning his rental car in Mobile, after a month, he found that he had driven several thousand miles in four states. He had been involved in no accidents, nor had he seen any. He reflected on the fact that, by traveling on the highways that long and that far, he probably had put a million people at risk (merely by his presence). Yet, none of the four states had required him to obtain its driver's or automobile license. His Colorado driver's license and the car's Alabama tag had been sufficient.

Meanwhile, he had engaged in the "practice" of professional geology in two states.** He observed that his consultation likely affected only the property of the individuals who requested his services and presented only minimal risk to the public. Nevertheless, for the "preservation of the health, safety and welfare of the public.", he was required to have been "registered", "licensed" or "permitted" ahead of time in the states in which these services were rendered, at an aggregate cost of several hundred dollars.

So, his question is, "Why can I legally put a million people at risk on the highway without a local driver's license, and at the same time legally practice my profession without a local geologist's license? Isn't it time to have done with all of this interstate bickering and turf protection and let geologists and other professionals cross state lines as readily as drivers?"

It is worth noting that he did not question the principle of registration, only the bureaucracy, red tape and related costs.

**The registration statutes in the two states are excerpted as follows:

Florida (492.102.): "(7) 'Practice of professional geology' means the performance of, or offer to perform, geological services... Any person who...holds himself out as able to perform or does perform any geological services or work recognized as professional geology, shall be construed to be engaged in the practice of professional geology."

South Carolina (40-77-10.): "5. 'Public practice of geology' means the performance of geological work... A person is construed to practice or offer to practice geology within the meaning of this chapter who...holds himself out as able to perform or does perform any geological service or work...recognized by educational authorities as geology..."
Dear Editor:

I am absolutely unable to express the horror and shock I felt when I saw this article reprinted without comment in what purports to be the voice of THE geologic organization concerned only with professionalism.

I am aware that this article expresses the viewpoint of some members. There are also some members who believe the earth can only be 6,000 years old, or that the Devil indeed came out of a northern Alaskan oil well blowout, a picture and the news of which was featured in a tabloid newspaper not too long ago.

If these latter items had been featured in TPG with the assumed "professional" blessing of AIPG, my wonderment would be no less than my present feelings of shame to be associated with such an organization.

The Anchorage Times newspaper was for many years, the premier newspaper of Alaska. The consistency of their intelligence-insulting editorial policy of development hyperbole largely resulted in the paper's failure and it was sold to the owner of the largest oil service company in Alaska who further amplified the destructive editorial policy. The Anchorage Times soon folded completely, and their only life now is that they are allowed, by agreement, the space of one-half page in the present premier newspaper of Alaska, the Anchorage Daily News. This reprinted article was from this 1/2 page gasp and it beautifully illustrates how a newspaper can go broke - and how a geologic professional organization can lose all semblance of professionalism!

Gerald Ganopole, CPG-0103

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Dear AIPG Colleague:

RE: CHANGES TO THE US MINING LAW COULD COST GEOLOGISTS’ JOBS

The U.S. House and Senate passed radically different mining law reform bills in 1993. A House-Senate Conference Committee will attempt to negotiate a compromise between these divergent bills this year. Significant changes to the U.S. Mining Law are anticipated as the result of the Conference Committee negotiation. Many of the proposed changes will create a very unfavorable business climate for the domestic mining industry, and will cost many mining industry geologists their jobs. As a fellow geoscientist and AIPG member, I am asking for your help in contacting your Congressional delegation.

The U.S. Mining Law of 1872 defines how hardrock mineral rights are held on non-acquired public lands (mainly federal lands west of the Mississippi). Staking a claim under this law entitles the claimant to limited private property rights, and provides some land security to those who explore for and develop hardrock minerals on federal land. This law has been amended many times, and all federal environmental laws establish environmental protection criteria which condition the way in which mining can occur on federal lands.

The mining industry supports the reasonable and responsible changes to the mining law proposed in the Senate bill (S. 775, the Craig Bill) which updates and modernizes the existing law in order to address all legitimate concerns. The Craig bill increases revenues to the federal government through filing fees, holding fees, a reasonable 2% net royalty, and payments of fair market value for the surface of claims to be patented. This bill creates an Abandoned Mine Reclamation Fund, and incorporates existing federal environmental laws into the mining law. S. 775 will allow the mining industry to remain competitive in the international arena, and will keep mining industry geologists employed.

In contrast, the House version, H.R. 322 (the Rahall Bill), will cost many geologists, and other mining professionals, their jobs. This bill repeals and goes far beyond what is necessary to update and improve the existing law. The Rahall bill imposes a burdensome 8% gross royalty, abolishes patenting of claims, and greatly increases the complexity and uncertainty of the mine permitting regulatory process. The many onerous provisions in the Rahall bill will inhibit future exploration, will encourage the mining industry to move overseas, will increase America’s reliance on foreign sources of mined materials, and will worsen our foreign trade deficit. An August, 1993 Department of Interior analysis of hardrock mining royalties concludes that in the next three years, an 8% gross royalty will cost jobs and will result in an annual net loss to the federal treasury of at least $11 million. A comparable industry study shows that losses will increase tenfold by the end of the decade.

Deciding between a net versus a gross royalty will be one of the key issues to be resolved in the Conference Committee. The mining industry is ready and willing to pay a fair royalty, and supports the Craig royalty proposal which levies royalties on the value of unrefined ore at the mine mouth. This royalty structure is similar to the federal royalty levied on crude oil and gas at the wellhead. The Rahall bill proposes a royalty which would be comparable to paying a federal oil and gas royalty on the value of the refined product such as gasoline.

Another key issue is unsuitability. H.R. 322 would give federal land managers broad discretionary authority to classify federal lands as unsuitable for mining, creating de facto land withdrawals. The Rahall unsuitability proposal is unnecessary because unsuitability reviews are intrinsic to existing environmental permitting requirements for mining. All proposed mining projects must demonstrate compliance with environmental protection standards and regulatory requirements in order to obtain permits. Additionally, there are already numerous land use decision mechanisms for withdrawing land from mining. To date, these mechanisms have withdrawn 263 million acres of federal land.

The Craig bill recognizes that mining is an essential American industry which produces the raw materials we use daily. Accord-

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### THE MINE MOUTH ROYALTY PROPOSED IN S.775 IN ANALOGOUS TO THE FEDERAL OIL & GAS ROYALTY

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<tr>
<th>OIL</th>
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<td>Mine Mouth Value of Ore</td>
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<td>S.775 Royalty Would Be Applied on Unrefined Ore</td>
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<td>Steps Involved In Making a Useable Product From Crude Petroleum or Hardrock Ore</td>
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<td>Refining</td>
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<tr>
<td>Marketing</td>
<td>Marketing</td>
</tr>
<tr>
<td>Final Saleable Product as Gasoline, Diesel, etc.</td>
<td>Final Saleable Product as Refined Metal</td>
</tr>
<tr>
<td>No Federal Royalties on the Finished Product</td>
<td>H.R.322 Royalty Would Be Applied on the Finished Product</td>
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A HARDROCK MINING ROYALTY SHOULD BE ON THE RAW PRODUCT AS PROPOSED IN S.775, AND NOT ON THE FINISHED PRODUCT AS PROPOSED IN H.R.322.
ing to the U.S. Bureau of Mines, in 1992, processing raw minerals into useable commodities like steel, copper, and aluminum contributed $310 billion to the U.S. economy. By the time these materials were manufactured into consumer goods like automobiles and appliances, over $5 trillion was added to the nation's economy.

The Conference Committee has the difficult task of negotiating a compromise between the House and Senate bills. During upcoming Conference Committee discussions, it is important that members of Congress from all parts of the country hear from constituents on this issue. Please write or phone your Senators and Representative to let them know that you support the responsible mining law reform measures proposed in S. 775, and that you oppose the radical and unnecessary changes proposed in H.R. 322.

Your time could help save many geologists' jobs, as well as preserving a viable domestic mining industry - an industry committed to sustainable, environmentally responsible development and stewardship of this country's mineral resources. Thank you for your help and consideration. Please do not hesitate to contact me if you would like to discuss this issue in more detail.

Kathleen M. F. Benedetto, CPG-7853

THE WOMEN'S MINING COALITION
ENVIRONMENTAL LAWS REGULATING MINING


- The National Environmental Policy Act of 1969 - Environmental Assessments (EAs)/Environmental Impact Statements (EISs) studies of air quality, historical and cultural resources, wildlife, vegetation, threatened and endangered species, surface water and ground water hydrology, geology, visual resources, socioeconomics, soils, reclamation, public health and safety.

- The Clean Water Act - Surface Water Quality Protection Permits

- The Clean Air Act - Air Quality Protection Permits

- The Safe Drinking Water Act - Ground Water Quality Protection

- The National Historic Preservation Act - Cultural/Archaeological Resources Protection

- The Endangered Species Act - Sensitive Species Protection

- The Mine Safety and Health Act - Worker Health and Safety

- Other Federal Regulations - The Atomic Energy Act, the Emergency Planning and Community Right to Know Act, the Forest and Rangeland Renewable Resources Planning Act, the Resources Conservation and Recovery Act, the Toxic Substances Control Act, and the Uranium Mill Tailings Regulation Control Act

- State Regulatory Requirements - Plans of Operation, Reclamation Plans and Bonds, Surface Water Protection Permits, Ground Water Protection Permits, Air Quality Protection Permits, Cultural Resources Protection,

- Local Regulatory Requirements - Zoning and Special Use Permits

For more information contact: the WOMEN'S MINING COALITION at 702/356-0616
# WOMEN'S MINING COALITION

## MINING LAW FACT SHEET COMPARING PROPOSED LEGISLATION

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<tr>
<td><strong>Land Tenure Provisions:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abolition of Concept of Patenting</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Cut-Off Date for Patent Applications</strong></td>
<td>January 5, 1993</td>
<td></td>
</tr>
<tr>
<td><strong>Prohibits Non-mining Surface Occupancy</strong></td>
<td>n/a</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Claim Configuration</strong></td>
<td>40 ac - must conform to public land survey system ends distinction between lode, placer, and millsite claims</td>
<td>20 ac (i.e., no change) retains distinction between claim types</td>
</tr>
<tr>
<td><strong>Royalties &amp; Fee Provisions:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proposed Royalty</td>
<td>8% of gross income (i.e., on refined product)</td>
<td>2% of minerals at point of extraction (i.e., on unrefined product)</td>
</tr>
<tr>
<td>Patenting Purchase Price</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td>Fees for Claim Location</td>
<td>$25 per claim</td>
<td></td>
</tr>
<tr>
<td>Claim Maintenance Fee</td>
<td>$200 per claim/year for new claims $100 per claim/year for converted claims</td>
<td>$100 per claim/year adjusted every 5 years for inflation</td>
</tr>
<tr>
<td>Fee Reduction for Development Expenses</td>
<td>Credited against royalty</td>
<td>No</td>
</tr>
<tr>
<td>Fee Reduction for Small Miners</td>
<td>May be waived for holders of 10 claims or fewer</td>
<td>If assessment work done: waived for 10 claims or less, reduced to $25 per claim/yr for 10 to 50 claims</td>
</tr>
<tr>
<td>Authority to Reduce Royalty</td>
<td>No</td>
<td>Secretary may reduce based on need</td>
</tr>
<tr>
<td>Commission to Review Royalties</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>User Fees to Offset Cost to Administer Legislation</td>
<td>Yes - new fees established</td>
<td>Maintains existing fees</td>
</tr>
<tr>
<td>Allocation of Fee Proceeds</td>
<td>100% to Abandoned MIne Reclamation Fund</td>
<td>2/3 to Treasury, 1/3 to the State for Abandoned Mine Reclamation Fund</td>
</tr>
<tr>
<td>Allocation of Royalty Proceeds</td>
<td>100% to Abandoned MIne Reclamation Fund minus amounts needed to administer the Act</td>
<td>2/3 to Treasury, 1/3 to the State for Abandoned Mine Reclamation</td>
</tr>
<tr>
<td><strong>Reclamation &amp; Environmental Provisions:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reclamation Standards Applied</td>
<td>New federal standards, preempts existing state reclamation laws Establishes unilateral and prescriptive standards</td>
<td>Maintains existing state and federal standards Based on site specific characteristics</td>
</tr>
<tr>
<td>Reclamation Bond Required</td>
<td>Yes - must cover all reclamation costs</td>
<td>Yes - must cover all reclamation costs</td>
</tr>
<tr>
<td>Responsibility for Reclamation</td>
<td>Federal Program</td>
<td></td>
</tr>
<tr>
<td>Federal Administrative Responsibility</td>
<td>Secretary of Interior or Agriculture</td>
<td></td>
</tr>
<tr>
<td>Review of Public Lands' Suitability for Mining</td>
<td>Yes - uses &quot;special characteristics&quot;, does not evaluate based on compliance with existing environmental laws</td>
<td>Yes - must meet environmental protection criteria in existing laws</td>
</tr>
<tr>
<td>Citizen Suits</td>
<td>Authorizes greatly expanded citizen intervention</td>
<td>Retains legal and administrative procedures in existing laws for citizen intervention</td>
</tr>
<tr>
<td>Incorporates Federal Environmental Statutes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Abandoned Mine Reclamation Program</td>
<td>Federally Administered</td>
<td>Administered by States using federal grants</td>
</tr>
<tr>
<td>Creates Applicant Violator System</td>
<td>Yes - modeled after SMCRA coal program</td>
<td>No</td>
</tr>
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*For more information contact: the WOMEN'S MINING COALITION at 702/356-0616*
Geology Of Quarrying

Figure 1. Green quartzite quarry (surrounded by trees) located at an altitude of 11,000 feet in the Medicine Bow Mountains of southeastern Wyoming.

Ray E. Harris, CPG-7446, Geological Survey of Wyoming

Introduction

The classification "mining geology" includes all kinds of mines: deep underground mines for precious metals, large strip mines for coal, gravel pits, or one-man diggings for jade. A less commonly visualized "mine" is quarry from which large (10' x 10' x 5') blocks of decorative stone are removed.

The Geological Survey of Wyoming is tasked with studying the mineral resources of Wyoming. In accomplishing this task, I have been involved in several projects with the goal to promote the development of an industrial mineral commodity. One of these studies is an ongoing project on the decorative stone resources of Wyoming. As a direct result of this study, one company has opened two quarries in southeastern Wyoming, and there are at least eight...
quarry sites that are currently being examined by six companies with the object of future production. Also, a fabricating plant, where quarried blocks are cut and polished, is under construction. This paper is a description of the decorative stone industry in Wyoming from exploration for a quarry site development, through production, fabrication, and end use.

A Case History; The Wyoming Raven Granite Quarry

I began exploring Wyoming for decorative stones after a request to locate a light green quartzite that had been produced in the past for decorative aggregate. With the help of Jon King, now with the Utah Geological Survey, I located the old quarry at an elevation of 11,000 feet in the Medicine Bow Mountains west of Laramie (Figure 1). Another company, Granitech, of Fairfield, Iowa, asked about other colors, and before long I had a collection of about 150 different granites, marbles, quartzite, limestones, onyx, and other varieties of stone all from Wyoming.

When representatives of Granitech came out to see what I had found, I was told that my collection rivaled, if it did not surpass, the collection of granites and marbles produced from the rest of the world, including Italy, Canada, South Africa, Brazil, India, and the like.

Rumors spread rapidly in any minerals-based industry. Soon, several companies had contacted the Survey and had visited the state. I showed them some of the sites I had sampled. Some couldn’t be quarried, according to the experts, so I set out to get an education in stone quarrying. Several individuals, especially Ted Coppola and Werner Naeve, took some of their time to teach this geologist new tricks. During the course of the study, I also talked with numerous quarry masters and visited stone quarries in South Dakota and Minnesota.

While I was learning about stone quarrying, I received a grant from the Wyoming Department of Commerce, Division of Economic and Community Development, to publish a colored report on the stone potential here, including site descriptions and photographs of the stone. This study was published as the Geological Survey of Wyoming Public Information Circular 31 in October of 1991.

Meanwhile, Toby SerVoss, a sales representative for decorative stone, decided to invest in the state’s resources. He was able to acquire an economic development grant from the Wyoming Department of Commerce to explore, locate, and develop a quarry. As part of this grant, the Geological Survey of Wyoming was contracted to locate the blackest “granite” possible. In the stone industry, “granite” refers to almost any kind of crystalline igneous rock, irrespective of its petrologic name. About three possible sites were tested before a quarriable amphibolite was located on the Vale Ranch in northern Albany County.

Later, I mapped this deposit, and calculated the resources of the quarriable black rock. Toby formed the company Sunrise Stone, and over the course of the next two years, developed a quarry on the location. This quarry is now producing black “granite” for monuments as fast as a small crew can produce them (Figure 2). Later, he shipped some of the wall rock, a pink and grey swirled gneiss, to his buyer, who liked the product. Just a couple of months ago, Sunrise opened a second quarry in this pink gneiss. Marketing is as much a key to a successful decorative stone operation as is the rock itself, and the names Toby selected for the rock, “Wyoming Raven” for the black, and “Fantastica”, for the gneiss, help sell the product.

Quarry geology and economics

Stones are selected on the basis of appearance, which includes grain size, color, patterning, and the like. Different architects prefer different colors, and different colors are popular in various parts of the world. Black and red granites and white and dark gray marble are generally universally popular. Green rock, both marble and granite, are preferred in Japan, but green is the color of poverty in Taiwan and China, and is never used there. Earth tones were popular ten years ago, but are in disfavor now, except in California. Mexico and other central and South American countries prefer bright
colors and patterned rock, and patterned rock is becoming more popular in the U.S. European countries prefer uniform shades of white, grey, or black.

Decorative stone occurrences must be investigated to determine if they are economical to quarry, even if the stone is perfect in appearance. Quarry economics vary with the physical nature of the deposit, including fractures, veins, inclusions, etc., but sometimes a quarry can be developed in a highly fractured or soft rock, if the rock's appearance is unique and popular enough to demand a high price. One of the most famous quarries in the world, the Blue Pearl granite quarry in Norway, ships only 5% of the rock quarried (Hobæk, 1993), while the remaining 95% is thrown away as waste (or 'grout', in midwestern U.S. terminology). Fortunately, Sunrise Stone is able to ship 20% of the Wyoming Raven quarried. This compares with higher yields from common variety buff-colored to gray granites, such as the Rockville gray granite from Minnesota, where over 90% of the rock quarried is shipped to fabricators, or Georgia gray granite. Currently, quarried rock sells for US$50 ft$^3$ (US$13.00 m$^3$) to US$50.00 ft^3$ (US$1,350.00 m^3$) or more depending on the demand for the particular rock or color. Buff or gray limestones (French limestone or Indiana limestone) are at the low end of the price scale, while granites (especially black, blue and red) are at the high end. Marble, in general, is less costly than granite, and is also declining in demand. Finished tile sells from less than US$1.00 /ft$^2$ for buff limestone to cover over US$120.00 ft$^2$ for high quality black or blue finished pieces.

Quarrying is as much of an art as mining can be. It is important to maximize the yield, so quarry masters select the location of each block to be quarried individually, based upon what they know of the color, fracturing, and veining in the deposit. In order to minimize fracturing, quarry operations usually cut, saw, drill, or use feather-and-wedge techniques to produce blocks, rather than explosives. If blasting is necessary, black powder or other slow explosives are used. Large quarries, such as the Dakota Granite Company's Dakota Mahogany Quarry near Milbank, in eastern South Dakota (Figure 3) represent the typical maximum size of a decorative stone quarry. These cover about 100 acres including support facilities, roads, building, and the like. In general, a decorative stone quarry can operate near residences, without causing disturbances.

Blocks cut from the rock body may be trimmed on site. Trimmed sized blocks are sold to fabrication plants for cutting and polishing into a number of finished products. These include monuments of all kinds, tile (1' x 1' x 1/4"), panels (4' x 8' x 3/4"), or other pieces. Surfaces may be polished, honed, or flamed for different effects. The finished pieces are used in building exteriors and interiors.
flooring, counters, sinks, and many other places. Look at the surfaces of stone on many buildings in our cities, and look at the different varieties of stone used in store fronts in most U.S. shopping malls. Certain paved areas, such as the Nicollet Mall in downtown Minneapolis, are floored with natural stone. Each stone was once a part of a rock mass before being quarried, fabricated, finished, and used as an article of beauty.

Reference:


JANUARY TPG CORRECTION

In the January, 1994 issue of The Professional Geologist the last paragraph of the article entitled "Some Thoughts On Mineral Economics" should have been the last paragraph for the article entitled "A Mining Geologist." Our apologies to both authors.

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