Trip 17:

Bagdad, Bruce/Old Dick, Copper Basin, Bradshaw Mountains

October, 1994

Bootprints Along the Cordillera

Porphyry Copper Deposits from Alaska to Chile

Dear Field Trip Participants:

On behalf of the **Arizona Geological Society, Society for Mining, Metallurgy and Exploration Inc., and the U. S. Geological Survey**, we bid you welcome to the Bootprints Along the Cordillera field trip program. We have assembled a collection of field trips that portray the geologic and mineralogic diversity that exists along the cordillera of North and South America.

We wish to thank all of the field trip leaders who volunteered their time, effort, and expertise to organize their individual trips. We also want to thank collectively, all of the mining companies and staff who graciously allowed us to visit their properties. Without their cooperation, this program would not have occurred. A special thanks goes to Kathie Harrigan of Asarco for her help in the compilation of the field trip guides. We also want to thank Tucson Blueprint who underwrote the complete reproduction cost of the guides.

Mark Miller and Jim Briscoe
Field Trip Co-Chairmen
October 2, 1994

AGS FIELD TRIP TO BAGDAD, COPPER BASIN, AND THE BIG BUG STOCK

Field Trip Leaders: Patrick F. O'Hara, Kaaterskill Exploration
John Hawley, Cyprus Bagdad, Inc.

INTRODUCTION:

We will visit three mineralized Laramide intrusions located in the Transition Zone in central Arizona. These intrusions at Bagdad, Copper Basin, and Poland Junction intrude the Yavapai Supergroup, which is composed of 1.75 - 1.72 GA metavolcanic metasedimentary, and metaplutonic rocks. These metamorphosed units are also intruded by post-tectonic Proterozoic granitoids of two ages.

Our trip will proceed from west to east, first visiting Cyprus Bagdad's active porphyry copper mine. We will then visit Phelps Dodge Corporation's Copper Basin property, where porphyry copper mineralization has been delineated. We will complete our trip by visiting several mesothermal vein deposits located peripheral to the Big Bug stock near Poland Junction. If time allows we may visit Proterozoic massive sulfide systems that are exposed near Bagdad and Poland Junction.

Phil Blacet, John Hawley, and Chris Schmitz of Cyprus Bagdad will lead the Bagdad portion of the trip on the first day. Ed DeWitt of the U. S. Geological Survey contributed a field trip log for the Bagdad to Prescott portion of the trip. Mike Pawlowski and Ralph Ladner of Phelps Dodge Corp. will lead the Copper Basin portion of the trip. Nyal Niemuth of the Arizona Department of Mines and Mineral Resources summarized the elemental zoning in mesothermal veins associated with the Laramide stocks in the Groom Creek to Poland Junction area. George Ryberg of Rouge River resources and Pat O'Hara of Kaaterskill Exploration prepared the field trip log from Prescott to Poland Junction. Pat O'Hara will present an overview of the regional geology surrounding the Big Bug stock summarizing the previous work of many authors and will present the geology of the McCabe Gladstone vein system. George Ryberg will present the geology of the Little Jessie - Union vein system. Jed Maughn, one of our field trip participants, volunteered to discuss the oxidation of various mineral assemblages in the Big Bug stock, if time permits.

ROAD LOG AND TRIP GUIDE TO PROTEROZOIC MINERALIZATION IN THE BAGDAD AREA

BY ED DEWITT

Road Log from Bagdad, Arizona, to the Bruce mine, 5.2 miles Cumulative mileage 0.0 Copper Plaza in Bagdad. Proceed east on Arizona Highway 96 toward Hillside, Arizona. Drive past the basketball courts on the right and the small park past that.

0.4 Turn right at the sign for Warehouse A. Go across cattleguard.

0.5 Take the first right turn possible. Just past that turn, about 100 feet, is a paved road topped with gray gravel. Take that paved road, which turns off to the right from the housing subdivision that we are driving through. The paved road traverses the hillside slightly above the houses, then climbs through outcrops of Lawler Peak Granite and Hillside Mica Schist.

1.0 Housing subdivision on our left ends. Pavement also ends; continue on the gravel road around a hill and toward the Bruce mine. Outcrops on the left are Lawler Peak Granite that intrudes Hillside Mica Schist.

1.5 Low, rounded hills that we are crossing are Hillside Mica Schist intruded by Lawler Peak Granite. The schist is darkly desertvarnished and crops out poorly.

2.4 View to the right past the hills in the near foreground is of Proterozoic granitic rocks east of the Santa Maria River. On the skyline are high peaks in the Weaver Mountains north of Yarnell, Arizona.

2.6 "Y" in road; stay to the right. Left fork goes to the Kellis Ranch. Bouldery outcrops to the left are Lawler Peak Granite.

2.7 Buildings ahead on the right are at the Stukey mine, which is a Laramide vein adjacent to north-northwest-trending granodioritic dikes. Stukey mine is one of many small vein deposits in the Eureka metallic mineral district (Keith, Gest and others, 1983; Keith, Schnabel, and others, 1983), a Laramide copper porphyry district having peripheral base- and precious-metal-rich veins.

2.9 Roadcuts in Hillside Mica Schist continue to mileage 3.3. Continuing uphill at this point through Lawler Peak Granite and Hillside Mica Schist.

3.5 Crest of small ridge. Bouldery outcrops on right are Lawler Peak Granite. Mountain in the distance is Grayback Mountain, capped by Cretaceous rhyolite tuff that is intruded by Laramide diorite porphyry dikes.

3.8 Bold outcrops of Lawler Peak Granite.

4.0 Descending grade into Mountain Spring Wash. Crossing dark-colored metabasalt of the Bridle Formation. At the bottom of this grade we cross the Mountain Spring fault and are in metavolcanic rocks north of the Bruce mine.

4.2 Small trail on the left leads south to the Copper Queen mine, south of the Bruce mine. Dump on the right is from the Mountain Springs mine, a Laramide base-metal vein.

4.3 Mountain Spring Wash. Rocks are sheared along the north-trending, high-angle Mountain Spring fault, a post-1400 Ma structure that juxtaposes Lawler Peak Granite and Hillside Mica Schist on the east with metavolcanic rocks of the Bridle Formation on the west.

4.5 "Y" in road. Right hand fork goes to the Copper King mine, left fork to the Bruce mine; we stay to the left. Outcrops are metamoprhosed tuffaceous units and rhyolite flows of the Dick Rhyolite. Silver (1968) determined an age for the metarhyolite of 1720+15 Ma. A similar-appearing rhyolite in the Poachie Range, southwest of Bagdad (Bryant and Wooden, 1986) is 1709+8 Ma.

5.1 Approaching the Bruce mine, which is just over the hill to the south (fig. 36). "Y" in the road at crest of hill. Gate to the Bruce mine is ahead and to the left. Jeep trail leads to the right, up and over

Beyond the Bruce mine, on the horizon, are the Poachie Range in the middle distance, and the Harcuvar Mountains in the far distance (fig. 36). The crest of the Harquahala Mountains rises on the horizon to the left of the Harcuvar Mountains. In the middle distance to the left of the Harquahala Mountains are Tertiary volcanic strata near Ives Peak in the Black Mountains northeast of Date Creek.

5.2 Top of small hill, where we will assemble for an overview of the Proterozoic geology of the Bagdad area. In front of us, to the southwest, is Grayback Mountain, underlain by Cretaceous rhyolite tuff that overlies the Proterozoic metavolcanic rocks. The view back to the north is of the open pit at the Bagdad mine (fig. 37).

The open pit at Bagdad was one of the earliest ventures in large tonnage, low-grade mining in North America (Anderson and others, 1955). From 1929 through 1980 the open pit produced 86 million tons of ore that averaged 0.68% Cu and 0.008% Mo (Arizona Bureau of Geology and Mineral Technology, unpub. data, 1986). Reserves are variably estimated to be between 264 and 550 million tons of ore that would average about 0.5% Cu (Gilmour, 1982). The mineralization is Late Cretaceous, a minimum of 71 Ma (Damon and Mauger, 1966). The prominent peak north of the open-pit is Lawler Peak, elev. 4,750 ft, composed of the Middle Proterozoic Lawler Peak Granite.

STOP 4. Bruce mine. Short stop to discuss regional setting of Early Proterozoic volcanic stratigraphy, massive sulfide deposits, and alteration patterns. From here we will start a hike through metabasalt of the Bridle Formation that is stratigraphically beneath the Bruce massive sulfide deposit (fig. 38). Along the hike will be examples of chloritic alteration that is well documented underground in the Bruce mine (Larson, 1984), and silicification and development of epidote (fig. 38) in the metabasalt (Connelly, unpub. mapping, 1985; Conway and others, 1986; Conway, 1986; Robison, unpub. data, 1987).

Early studies of the Bruce and Old Dick mines (Baker and Clayton, 1968; Clayton and Baker, 1973) documented the chloritic alteration and described the massive sulfide ore, but did not conclude that the mineralization was syngenetic. Clayton (1978) reversed the conclusions of earlier papers and suggested that ore deposition was related to sea-floor volcanism. Mauger (1973), from isotopic data, concluded that sulfur in the deposits had come either from sea water or volcanic emanations. Larson (1984) investigated the alteration pipe of the Bruce mine, and from chemical and isotopic data, concluded that large amounts of seawater had interacted with basalt of the Bridle Formation to for the chloritic and sericitic alteration beneath the ore body.

Drive the vans down the jeep trail another 0.1 mile and park on a small drill pad. At the continuation of our hike, we will rejoin the vans at the drill pad for lunch and refreshments.

Four mines in the Old Dick district, the Old Dick, Bruce, Copper Queen, and Copper King, produced more than 95 percent of the massive sulfide ore. The district produced about 1,683,000 tons of ore that averaged 3.2% Cu, 0.09% Pb, 9.1% Zn, 0.002 oz/ton Au, and 0.39 oz/ton Ag (Keith, Gest, and others, 1983). During periods of greatest output, the massive sulfide deposits in the Old Dick district averaged 0.2% Pb, one of the highest concentrations of lead in any massive sulfide district in Arizona. However, the concentration of precious metals in the district was lower that any other Early Proterozoic massive sulfide district in Arizona (DeWitt, 1983). By comparison, massive sulfide deposits in the Mayer area, which we will be visiting tomorrow, averaged about 0.068 oz/ton Au and 2.37 oz/ton Ag. The impoverishment of precious metals in the Old Dick district may indicate that the tectonic setting of the volcanic belt was different from that in the Mayer and Jerome areas, and may suggest a primitive back-arc or open ocean basin setting for the Old Dick district.

STOP 5. Copper Queen mine (optional, depending on time). At the Copper Queen mine we will see a sequence of rocks very different from the metabasalt of the Bridle Formation. Interlayered, metamorphosed andesite, rhyolite, and argillaceous or tuffaceous sedimentary rocks are typical at the mine.

ROAD LOG AND TRIP GUIDE FROM BAGDAD TO PRESCOTT, AZ

BY ED DEWITT

Road Log from Bagdad, Arizona, to Prescott, Arizona: 66.8 miles Cumulative

mileage 0.0 Copper Plaza in Bagdad, Arizona. Proceed east on Arizona Highway 96 toward Hillside, Arizona.

0.4 Turnoff to the right to the Bruce mine. Outcrops ahead, on the left,and for the next one-half mile are Hillside Mica Schist intruded by Lawler Peak Granite.

1.0 Roadcut in Hillside Mica Schist intruded by Early Proterozoic foliated granodiorite.

1.2 Small creek from below the Cowboy mine enters Bridle Creek on the right. Outcrops are of dark metabasalt of the Bridle Formation (Anderson and others, 1955). Light-colored rocks are intrusive and extrusive metarhyolite. Roadcuts 0.4 miles ahead in light felsic metavolcanic rocks on the right, dark mafic metavolcanic rocks and Hillside Mica Schist on the left.

1.8 Eastern margin of of metavolcanic belt. Roadcuts in Hillside Mica Schist intruded by aplite-pegmatite.

2.3 Large roadcut contains Hillside Mica Schist intruded by numerous sills and dikes of aplite-pegmatite.

3.4 Tertiary fanglomerate in roadcut. Large dike of aplite-pegmatiteprojects across the highway. Outcrops ahead about one-quarter mile on the left are light aplite-pegmatite intruded by tan-weathering, ocher-stained, strongly jointed Lawler Peak Granite. On the right are outcrops of strongly jointed Lawler Peak Granite.

4.3 Junction of Arizona State Highways 96 and 97. Arizona State Highway

97 turns off to the right and connects with U.S. Highway 93 to Wickenburg and Phoenix. We continue along Arizona Highway 96 straight ahead through the roadcuts of Lawler Peak Granite. Road narrows through these roadcuts; please drive carefully. Most of the roadcuts are in Lawler Peak Granite, but some aplite-pegmatite is present.

5.2 Roadcut in Tertiary fanglomerate that locally covers Lawler PeakGranite. We are descending into the drainage of the Santa Maria River, paralleling Spring Wash on the right. Fanglomerate, which in Tertiary time covered all of this area, is being stripped by modern erosion. We are driving down an exhumed pediment toward the river.

5.7 Roadcuts in fanglomerate for next two-tenths of a mile. Past fanglomerate, low outcrops to the left and right are Lawler Peak Granite on which old pediment is cut.

6.1 At 10:00 in the near foreground is SH Mesa, capped with thin Tertiary basalt and underlain by fanglomerate and tuff. In the background on the horizon is

Bismarck Mountain (now renamed Thompson Peak, elev. 4,704 ft), northwest of Hillside. One-half mile ahead is roadcut in Hillside Mica Schist intruded by Early Proterozoic aplite-pegmatite. Both units are cut by minor amounts of Lawler Peak Granite.

6.8 Aplite-pegmatite in roadcut. Road ahead widens. Outcrops on right are predominantly aplite-pegmatite cut by minor amounts of Lawler Peak Granite.

7.3 SH Mesa straight ahead about one-quarter mile is capped by thin basalt flow. Interbedded tuff, fanglomerate, and playa deposits underlie the capping basalt. Most units below top of mesa obscured by basaltic debris in talus slopes. Gravel road on the left, which leads to the Muleshoe Ranch on the Santa Maria River, is the old Lawler Grade, the original road from Hillside to Bagdad.

7.6 Blue Mountain, Big Shipp Mountain, and Little Shipp Mountain are on the horizon to the left. Both Big Shipp and Little Shipp Mountains are underlain by aplite-pegmatite. Prominent northwest-trending Tertiary faults (fig. 32) are responsible for the steep, linear cliffs on the south side of both peaks. Small knob of ocher-stained Lawler Peak Granite in near foreground. Highway turn sharply to the right on the west side of SH Mesa and narrows again.

8.3 Roadcuts are predominantly in Lawler Peak Granite. Both biotite- and muscovite-rich phases (Anderson and others, 1955) are in these cuts.

8.6 Road turns to the right below basalt flow. Lawler Peak Granite is sheared along northwest-trending fault that probably parallels this segment of Little Shipp Wash. View ahead is into the Santa Maria River. Ahead on the horizon are coarse-grained, porphyritic plutonic rocks that may be Middle Proterozoic or Early Proterozoic. From this point another pediment surface can be seen across the Santa Maria River that is cut into the coarse-grained, porphyritic plutonic rocks.

9.1 Basalt flow in roadcut. Ahead on the right are tuffaceous rocks underlying basalt flows. At least three basalt flows are apparent in this Tertiary section.

9.6 Small mesa at 12:00 is underlain, at its base, by lake deposits and volcanic ash. Half way up the mesa is another basalt flow.

10.3 Roadcuts for next one-quarter mile in intercalated lacustrine and fanglomerate deposits. Crosby Mountain, elev. 4,344 ft, is the high peak to the right at 4:00. Turnoff to the right leads to the Crosby mine. The gold-rich vein at the mine is in a fault that dips to the east about 25 degrees. The mine, one of the larger deposits in the Crosby metallic mineral district, is typical of middle Tertiary gold-copper veins in the district.

10.7 Bridge over Santa Maria River. Mesas capped by basalt and underlain by lacustrine sedimentary rocks and and fanglomerate on the left, to the north. One-quarter mile farther along the highway is a view to the right of the Santa Maria River cutting through basalt flow downstream (fig. 32).

11.4 Crossing Quail Spring Wash, a small northwest-trending tributary to the Santa Maria River.

11.8 Driving uphill through Tertiary fanglomerate and fine-grained sedimentary rocks. View ahead of bouldery weathering Proterozoic granitic rocks in the McCloud Mountains west of Hillside. Mesas to the left are capped by basalt, which is underlain by tuff and fanglomerate. Tuff is visible as the white bands, low and halfway up the slopes, and near the valley bottoms. Apparently, the Quail Spring Wash area and this part of the Santa Maria River drainage must have been a small basin in Tertiary time.

13.3 Paralleling Quail Spring Wash on the left. Outcrops to the right are granite to granodiorite, some highly sheared along northwest-trending, high-angle faults (fig. 32). Outcrops ahead one-half mile on the right are deeply weathered, coarse-grained, porphyritic biotite granodiorite.

14.3 Fanglomerate in roadcuts for the next one-half mile contain very large angular blocks of subjacent bedrock.

14.8 Small hairpin turn. Deep roadcuts in Tertiary fanglomerate that is very poorly sorted and stratified. Ahead and to the right are low, rounded hills to of fanglomerate deposited on top of Proterozoic granite to granodiorite.

15.5 Large curve to the right. Outcrops to the left, about one mile away at 10:00 to 11:00, are very coarse-grained, bouldery weathering Proterozoic granite to granodiorite. Ahead two-tenths of a mile, the view back and to the right if of Grayback Mountain on the horizon, southwest of Bagdad.

16.1 Into relatively coarse-grained biotite granodiorite, highly sheared and faulted. Highway roughly parallels northwest-trending Tertiary fault zone. One-quarter mile farther are outcrops of coarse-grained porphyritic biotite granodiorite. The granodiorite is the major Proterozoic rock unit all the way to Yava and Kirkland Creek. The granodiorite, although sheared in these outcrops and roadcuts, is relatively undeformed in most outcrops. Because of its textural and compositional similarity to plutons dated as both 1700 and 1400 Ma, this pluton is shown as YXg (fig. 32).

17.4 Sharp turn to the right. Roadcuts in bouldery outcrops of coarse-grained porphyritic biotite granodiorite. Some outcrops to the left are tan to ocher-colored (possibly Lawler Peak Granite) material that intrudes? the coarse-grained granodiorite.

17.9 To the right, at approximately 1:00, on the crest of the McCloud Mountains, elev. 4,913, is a microwave relay station. Roadcut one-half mile ahead exposes Tertiary basalt dikes intruded along low-angle structure. Dikes may have been feeders for extensive basalt flows to the north (fig. 32).

19.0 Tawny-colored, jointed outcrops appear to be Lawler Peak Granite. Ahead one-quarter mile is rounded hill to the left that may be underlain by locally derived fanglomerate.

19.6 Crest of grade. Proceeding through low hills of coarse-grained biotite granodiorite cut by aplite and pegmatite dikes. Small intrusive bodies to the left may be Lawler Peak Granite.

20.6 Road parallels large northwest-trending fault or fracture. View at 12:00 is of the Weaver Mountains north of Yarnell, Arizona, which are composed of coarse-grained plutonic rocks similar to those between the Santa Maria River and here. Large, northwest-trending faults and fractures, similar to those in this area, cut the Weaver Mountains (DeWitt, unpub. mapping, 1979). There, the faults have minimal offset, but are intruded by large Tertiary rhyolite dikes. Tertiary volcanic rocks on Ritter Peak (fig. 39) in the Weaver Mountains are strikingly displayed at 12:00. The volcanic rocks have not been mapped, but are probably older than basalt in the low mesa in the foreground.

Figure 39. Weaver Mountains and Tertiary volcanic rocks at Ritter Peak. Weaver Peak, elev. 6,574 ft, is the high point on the left of the photograph. Bouldery weathering outcrops in Weaver Mountains are Proterozoic coarse-grained biotite granite to granodiorite. In front and to the right of Weaver Peak is Ritter Peak, elev. 5,688 ft, on the northwest side of the Weaver Mountains. Gently dipping Tertiary volcanic rocks underlie Ritter Peak. Broad, low plain in front of Ritter Peak is capped by Tertiary basalt. Low, brush-covered hills in foreground are coarse-grained biotite granite to granodiorite similar to that in the Weaver Mountains. View southeast from mileage 20.7 east of Bagdad.

21.7 Right turn leads to Hillside, Arizona, just south of the highway. Hillside is the railroad siding on the Atchison, Topeka, and Santa Fe Railroad from which ore concentrates from the Bagdad area massive sulfide deposits were shipped. Copper from the Bagdad copper porphyry open-pit mine used to be shipped from here also, but some is now trucked to other destinations.

21.8 Highway 96 turns north and starts a downgrade into Kirkland Creek and Thompson Valley.

22.1 View at 12:00 on the horizon is of Martin Mountain, elev. 6,433 ft, a vent area for rhyolite flows that protrude above the basalt flows in the foreground (fig. 40). The intrusive center is unmapped. Outcrops along the road and on the left are of coarse-grained granitic rocks similar to those seen the last 6 miles.

22.6 Basalt mesas at 12:00 terminate in a northwest-trending scarp caused by displacement on Tertiary normal fault (fig. 32). This fault is the eastward projection of the White Spring fault northeast of Bagdad (Anderson and others, 1955), and is the same structure that bounds Big Shipp and Little Shipp Mountains on the south. The fault can be traced for more than 30 miles.

23.5 View to the north at approximately 11:00 shows bouldery topography caused by coarse-grained porphyritic Proterozoic granite in recess between basalt flows.

24.9 Bridge over Kirkland Creek. Old settlement of Yava on the left.

25.6 Left turn leads west to the Mule Shoe Ranch along the Old Lawler Grade. Ahead one-quarter mile, at 12:00, is a view of Kirkland Peak. The tan-weathering, highly jointed peak is the easternmost outcrop of the Lawler Peak Granite (fig. 32). The highly jointed nature of the outcrops defines the eastern projection of the fault that extends southeast from Bagdad.

26.6 Low mesas to the right are capped by basalt flows that may be the down-dropped equivalent of basalt flows to the left on the mesa top. Sedimentary strata and tuff underlying the basalt are exposed on the hillsides to the left at 10:00, in the low cut at 11:00 in the near foreground, and over the ridge in the distance.

28.7 View to the left at 10:00 to 11:00 is of the vent area on Martin Mountain. Thick flow units are obvious in the view up Cottonwood Canyon, a drainage cut between the basalt mesas. Tuff units between basalt flows are visible as we descend the grade.

29.3 Crossing Ash Creek and entering Lower Kirkland Valley. Kirkland Creek cuts a small, but spectacular gorge through the basalt cover of Thompson Valley behind and to our right.

30.5 Highway crosses basalt flows. View on horizon, between basalt mesas, is of the northern end of the Weaver Mountains.

32.2 Kirkland Peak (fig. 41) is on the left at approximately 11:00. Prominent jointing in this easternmost outcrop of Lawler Peak Granite is well displayed on both topographic maps and air photos. Prominent west-northwest-trending joint pattern marks eastern end of 30-mile-long Tertiary normal fault (fig. 32). From here, Towers Mountain in the southern Bradshaw Mountains is visible on the horizon at 1:00.

32.9 Local relief in Tertiary time on the Lawler Peak Granite at Kirkland Peak is evident, at 9:00, by tuff that drapes over small hill of granite. Roadcut ahead one-quarter mine is red fine-grained Tertiary siltstone. Red color probably due in part to oxidation of Lawler Peak Granite. Kirkland Peak on the left.

33.6 Large ranches to the right in Lower Kirkland Valley. From 12:00 to approximately 2:00 are low-relief, brush-covered hills at the base of the Weaver Mountains. These hills are composed of the granodiorite of Peeples Valley (fig. 32), a relatively leucocratic Early Proterozoic pluton similar in composition to the 1750+15 Ma Government Canyon Granodiorite near Prescott (DeWitt, in press).

34.5 Roadcuts in Tertiary siltstone. Ahead one mile are small roadcuts in Tertiary lacustrine deposits and tuff. These rocks extend to Kirkland and north toward Skull Valley.

36.6 Castle-like landforms to the left are of tuff that is common in the Kirkland area. To the right are low hills underlain by the granodiorite of Peeples Valley. West of the granodiorite is a belt of Early Proterozoic pelitic schist that extends south to Yarnell. That schist belt is bordered on the east by Early Proterozoic metavolcanic units that include basalt and diorite, local gabbro, and some mafic tuff (DeWitt, unpub. mapping, 1979, 1986). That metavolcanic belt extends beneath us and north of Kirkland (fig. 32), into the area on the southeast side of Kirkland Peak.

37.3 Town of Kirkland, Arizona. Cross the Atchison, Topeka, and SantaFe Railroad tracks. Road to the left leads to Skull Valley andeventually into Prescott from the north; continue straight ahead to Kirkland Junction and intersection with U.S. Highway 89.

37.4 Bridge over Skull Valley Creek. To the left in the near foreground are cream to white Tertiary tuff units. Beneath these Tertiary volcanic rocks is the belt of Early Proterozoic pelitic schist and mafic metavolcanic rock that extends north from near Yarnell.

38.6 Roadcuts in Tertiary basalt and tuff. Ahead one-half mile, at 9:00, is Sierra Prieta. Cream-colored, bold cliffs are underlain by Prescott Granodiorite (fig. 42). West Spruce Mountain, the high, tree-covered peak on the left, is underlain by metamorphosed diorite and gabbro that intrude mafic metavolcanic rocks (DeWitt, unpub. mapping, 1979, 1986). Low, brush-covered hills to the right underlain by Early Proterozoic granodiorite of Peeples Valley. Mafic metavolcanic rocks and schist are to the right of the bouldery outcrops of granodiorite.

39.7 Mountains in the distance, on the horizon at 2:00, are the Weaver Mountains east of Yarnell. The range is composed of Tertiary basalt flows that dip to the north, toward us. The crest of the range may have been a local vent area for Tertiary basalt flows.

41.1 Subdued hills in the foreground, approximately two miles away, are Tertiary volcanic rocks of the same approximate age as the tuff and volcanic rocks at Kirkland.

41.5 Kirkland Junction. "Y" in the road; take the left fork. Right fork leads to Yarnell and U.S. Highway 93 south to Wickenburg.

41.7 Intersection with northbound U.S. Highway 89. View at 12:00 is of West Spruce Mountain, elev. ~7,160 ft, underlain by diorite and gabbro that intrude mafic metavolcanic rocks (fig. 43). Village of Wilhoit is visible in the distance at about 1:00 in the low hills at the base of the Bradshaw Mountains.

42.6 Highway turns gently to the right. Maverick Mountain, elev. 7,443 ft, is visible at 12:00 as the high, wooded peak in the Bradshaw Mountains. The high part of the Bradshaw Mountains seen from here is underlain by Early Proterozoic mafic metavolcanic rocks intruded by the Government Canyon Granodiorite.

43.6 Road ascends alluvial fan developed on southwest face of the Bradshaw Mountains. Outcrops at 3:00 are Tertiary volcanic rocks north of the Zonia mine, an Early Proterozoic disseminated sulfide deposit in tuffaceous rhyolitic metavolcanic rocks. The Zonia deposit differs from typical massive sulfide deposits, such as those at Bagdad, by lacking massive pyritic ore. However, it strongly resembles other Early Proterozoic deposits in metarhyolite in the Mayer area that we will be visiting tomorrow. Production data from the deposit are difficult to compare to other massive sulfide deposits, as Zonia was mined by open-pit methods. Also, no modern studies have been made of the deposit, and the existing production data do not include gold or silver. A view of the deposit and its extensive leach pads is farther up the highway.

44.5 Kirkland Peak visible on the left and slightly behind us at 8:30.

Large Tertiary basalt mesas west of Skull Valley at 9:00. Towers Mountain and the southern Bradshaw Mountains visible at 2:30.

45.3 At 9:00 in the far distance beyond the basalt mesas are Hide Creek Mountain and Camp Wood Mountain (both peaks slightly in excess of 7,000 ft) west of Camp Wood. Both peaks are capped by Cambrian Tapeats Sandstone (Krieger, 1967c), but Hide Creek Mountain, on the right, contains an erosional remnant of Tertiary andesite on its summit. The Camp Wood area contains the northeasternmost known exposures of the Middle Proterozoic Lawler Peak Granite (DeWitt, unpub. mapping, 1987).

The prominent mountain front of the Bradshaw Mountains that we are approaching is now a depositional contact of alluvial fan material on Proterozoic bedrock, but is inferred to have been a relatively large normal fault in Tertiary time. Upper Miocene and lower Pliocene sedimentary strata of the Milk Creek Formation (Plafker, 1956; Hook, 1956; Anderson and Blacet, 1972a) thicken and become finer-grained away (southward) from the mountain front in the Walnut Grove and Wagoner areas, about 12 miles to the south. Apparently, the modern valley that extends from Skull Valley on the left to Wagoner on the right was a half graben during Tertiary time that was bounded by a large normal fault on the northeast. This basin is, therefore, geometrically similar to the Big Chino Valley north of Prescott and the Verde Valley east of Jerome.

The Copper Basin district, a Laramide breccia pipe and vein system related to a large granodiorite to granite (fig. 43), is at 10:00, to the north of Wilhoit. Some of the landforms caused by the breccia pipes and intrusive rocks are visible from the highway.

47.7 Village of Wilhoit. Chaparral-covered, bouldery outcrops ahead are Government Canyon Granodiorite (fig. 43).

48.1 Gruss-covered outcrops are of coarse-grained granodiorite to tonalite phase of Government Canyon Granodiorite (DeWitt, in press). The granodiorite of Peeples Valley, which extends from near Wilhoit, southwest into the Weaver Mountains, intrudes the Government Canyon, but is probably genetically related to it.

48.5 View behind and to the right is into Peeples Valley, the valley between the granitic-weathering part of the Weaver Mountains north of Yarnell and the basalt-covered peaks east of Yarnell. The open pit of the Zonia mine is clearly visible at about 3:00, at the base of Tertiary basalt flows east of Yarnell (fig. 44). Slopes below 6,000 ft on this side of the Bradshaw Mountains are covered by dense growths of manzanita and brushy oak.

49.1 View to the south at approximately 3:00 is of the Hassayampa River valley near Wagoner. On the skyline are Seal Mountain, the pyramidal peak, and Wades Butte, the flat-topped mountain to the right of Seal Mountain. Both peaks are underlain by the granodiorite of Hozoni Ranch and the southern part of the Crooks Canyon Granodiorite, and are capped by Tertiary basalt (fig. 45). Both plutonic rocks are assumed to be about 1720-1740 Ma (DeWitt, in press).

Figure 44. Zonia mine and Weaver Mountains east of Yarnell. Open-pit operation at the Zonia mine visible at the base of Tertiary basalt flows in the Weaver Mountains on the left side of the photograph. Antelope Peak is the prominent mesa on the right side of the photograph. Yarnell is just out of view to the right. Tb, Tertiary basalt; Tv, Tertiary volcanic rocks; Ts, Tertiary sedimentary rocks and fanglomerate. Xp, Early Proterozoic granodiorite of Peeples Valley; Xmv, Early Proterozoic felsic metavolcanic rocks. All contacts are approximately located. View from mileage 48.7 east of Bagdad.

49.9 Towers Mountain and Horse Mountain clearly visible in the southern Bradshaw Mountains at 3:00 (fig. 46). Due to winding mountain road, the exact bearings to landmarks are only approximate along this stretch of highway.

51.0 Peak in the distance to the north is Mount Francis, underlain by the granodiorite of Peeples Valley and Government Canyon Granodiorite. Bouldery outcrops to the left of Mount Francis are underlain by the Prescott Granodiorite. Outcrops ahead of undeformed Government Canyon Granodiorite in outcrops.

52.0 Crossing Board Creek. To the right, between the highway and the canyon bottom of the Hassayampa River, is a Tertiary or Laramide rhyolite stock, originally thought by Light (1975) to be Proterozoic. Numerous dikes related to the stock project across the highway in the next few miles. The Little Copper Creek mineral district (Keith, Gest, and others, 1983) is centered on the stock, which has received extensive attention for its porphyry copper and molybdenum potential.

52.4 View straight ahead of Maverick Mountain, elev. 7,443 ft. Its chaparral slopes are underlain by Early Proterozoic mafic metavolcanic rocks and minor metarhyolite of the Green Gulch Volcanics. Intrusive contact of the Government Canyon Granodiorite is on the left shoulder of the peak where coniferous forest begins. Drill roads on the south flank of Mount Francis visible at 11:00. Numerous rhyolite dikes in roadcuts of Government Canyon Granodiorite.

53.3 Crossing Copper Creek. Gravel road to the left leads to the Copper Basin district (Johnston and Lowell, 1961), which contains 73-75 Ma intrusive rocks (Christman, 1978), breccia pipes, and vein deposits. The breccia pipe deposit at the Commercial mine has produced 95 percent of the copper-rich ore from district, and has known reserves of molybdenum. Peripheral vein deposits are rich in base and precious metals.

53.7 Numerous rhyolite dikes are in this roadcut, many intruded along low-angle fractures in the Government Canyon Granodiorite. Another large rhyolite dike at mileage 53.8. Mafic inclusions in rhyolite dike at mileage 54.0. Most dikes iron-stained from oxidation of abundant pyrite.

54.2 Large rhyolite dike crosses hill to the left at low angle. Grussy slopes underlain by Government Canyon Granodiorite.

54.6 Crossing Little Copper Creek.

54.7 Large rhyolite dike. Rounding bend to the left. Conifer forest on the horizon at 2:00 is in Ponderosa Park, the source of the Hassayampa River. Basin of Ponderosa Park underlain by Government Canyon Granodiorite.

56.2 Numerous rhyolite dikes and aplitic material. Ahead four-tenths of a mile is a deep roadcut in mafic metavolcanic rocks cut by rhyolite and aplite.

57.3 Rounding the bend in the road, an exceptional view of Ponderosa Park is ahead at 12:00.

57.5 Grade levels off. Elevation 6,000 ft. Highway has climbed 2,000 feet from Kirkland Junction. Mount Union, elev. 7,979 ft, the highest point in the Bradshaw Mountains, is at 2:00, to the left of Maverick Mountain. Ahead four-tenths of a mile on the right is the turnoff to Indian Creek, which leads into Ponderosa Park. Outcrops are predominantly Government Canyon Granodiorite.

59.7 Ponderosa pine forest underlain by gruss of Government Canyon Granodiorite.

59.9 Tourmaline veins in the roadcut on the left.

60.8 Forest Service Road 62 to the right to the White Spar Campground. Outcrops on the left are relatively undeformed Government Canyon Granodiorite.

61.1 Leaving Prescott National Forest. Ahead on the left are blasted outcrops of Government Canyon Granodiorite cut by tourmaline veins. Prescott city limits.

62.2 Outcrops on the left are Prescott Granodiorite, which intrudes Government Canyon Granodiorite.

62.7 Road to Copper Basin leads back and to the left at the Exxon station. Ahead one-quarter mile, U.S. Highway 89 turns north and becomes South Montezuma Street.

63.6 Stop light at the intersection of Goodwin Street and South Montezuma. Go straight to the next stop light and turn right on Gurley Street.

63.9 Traveling east on Gurley Street. Senator Highway, which leads to the right, was the old stage road from Prescott to Phoenix. It now crosses the high Bradshaw Mountains, goes through Crown King, and ends at Lake Pleasant, north of Phoenix.

64.6 Prescottonian Motel on the right. We will stay here tonight. This ends the second day of our field trip. Places for supper and refreshments in Prescott are numerous; enjoy the night.

GEOLOGY OF THE BAGDAD MINE
An Outline, June, 1994
by
P. M. Blacet, J. W. Hawley, and C. M. Schmitz

The Bagdad open pit mine is developed within and adjacent to a composite granodiorite- to quartz monzonite stock of Late Cretaceous age. Three Laramide plutons are recognized within the Bagdad pit, representing distinct magmatic pulses that intruded a predominately middle Proterozoic granitic and metamorphic terrane approximately 100 miles northwest of Phoenix, Arizona. Copper and molybdenum mineralization was spatially and genetically related to a porphyritic quartz monzonite marking the middle phase of this intrusive sequence. The hypogene Bagdad orebody is presently being mined at a rate of about 85,000 tons per day by the Cyprus Bagdad Copper Corporation, a subsidiary of Cyprus Amax Minerals Company. Mineable reserves are currently estimated at about 1.1 billion tons of sulfide ore averaging 0.37% TCu and 0.02% Mo.

In many respects, the 71 Ma Bagdad orebody is similar to other Arizona copper-molybdenum porphyry systems of Late Cretaceous age. Primary sulfide ore occurs within highly fractured rocks of Precambrian and Late Cretaceous age as an extensive stockwork of small, closely-spaced veins and veinlets consisting predominantly of quartz with variable amounts of pyrite, chalcopyrite and molybdenite. Very commonly in main-stage quartz veins molybdenite occurs as conspicuous symmetrical borders against the wallrock, with pyrite and chalcopyrite localized in irregular knots occupying the central parts of the vein. Calcite is a common gangue mineral, along with biotite, potassium feldspar and sericite. Locally, magnetite is conspicuous. Apatite is rarely intergrown with chalcopyrite and hydrothermal biotite, especially in local breccias. Nearly monomineralic fracture fillings of pyrite, chalcopyrite, and molybdenite occur widely throughout orebody. Deep drilling documents a general tendency for molybdenite to increase with depth.

Sphalerite, galena and tetrahedrite occur widely in relatively late quartz veins both within and peripheral to the Cu-Mo orebody. These polymetallic veins, often having higher than average silver values, are generally associated with phyllic alteration characterized by strong sericitic envelopes. Although of no economic significance in the Bagdad orebody, gold values tend to be elevated in these small, late-stage Zn-Pb-Ag veins. These polymetallic veins show a somewhat oval-shaped district zonal pattern, extending up to 3 miles out from the pit, and elongated slightly along a north-northwest structural trend defined by faulting and by a swarm of late quartz monzonite porphyry dikes.

From a district-wide perspective the Bagdad stock, and its cogenetic porphyry copper deposit, occupies an unique structural setting near the center of a 20 km long, east-northeast trending belt of Late Cretaceous plutons. The attached simplified geologic map, based largely on USGS (Anderson, 1955) and Cyprus mapping, shows that the Bagdad pit is located at the site of multiple intrusives, large-scale Cu-Mo mineralization, potassic alteration, and the centroid of widespread phyllic and propylitic alteration. Cyprus geologists largely concur with Anderson's conclusion that the localization of multiple intrusions and cogenetic mineralization was structurally controlled by the intersection of the north trending Mountain Spring fault zone and the ENE-trending Laramide intrusive belt. The Mountain Spring fault appears to represent a major shear zone whose intersection with the structural elements of the intrusive belt provided a weakened conduit through the upper crust for repeated magmatic pulses during the Late Cretaceous.

Conspicuous, disseminated indigenous chalcopyrite is restricted to a relatively late intrusion of porphyritic quartz monzonite (PQM) and a finer grained, quartz monzonite porphyry (QMP). Throughout most of the hypogene orebody sulfide mineralization was overwhelmingly structurally controlled, predominantly by a vast array of joints and fractures, by steeply dipping faults generally striking east-northeast and north-northwest, and to a lesser degree within intrusive breccias spatially associated with the margins of the PQM.

Because the PQM and QMP are rather convincingly cogenetic textural varieties of the same intrusive, with the finer grained quartz monzonite porphyry commonly representing a chilled border grading inward into PQM, these rock types are treated as a single unit within the geologic block model. Both of these rock types are cut by fine- to very coarsely crystalline secondary biotite that has a K/Ar date of about 71 Ma (Damon and Mauger, 1966). At the present mining elevations, the PQM forms a large, irregular, dikelike body trending east-northeast across the central part of the composite Bagdad stock.

The contoured perimeter of the Cu-Mo ore shell, defined by a somewhat arbitrary 0.2 % total Cu cutoff, demonstrates remarkable symmetry concentric around the PQM. The symmetrical geometry of the ore shell around a relatively low-grade core of PQM, and the restriction of truly disseminated blebs of chalcopyrite and localized concentrations of partially chalcopyrite filled miarolitic cavities to the PQM, constitutes compelling evidence that the PQM was the source of the copper bearing fluids which formed the Bagdad deposit. That the PQM represents a high level extension of a deeper stock of porphyritic quartz monzonite is documented by extensive drilling.. A well developed pyritic halo extends outward from the ore shell, as part of a well developed phyllic alteration zone concentric about the Cu-Mo orebody and the PQM.

Several lines of evidence indicate that the PQM was intruded into a subvolcanic environment and represents the upper part of a larger body of quartz monzonite that energized and introduced copper, molybdenum and other metals into a complex hydrothermal system developed in the strongly fractured rocks above and adjacent to the PQM. Supporting this genetic model is the symmetrical arrangement of the ore shell, pyritic halo, zonation of potassic, phyllic and propylitic rock alteration, as well as the district-wide distribution of polymetallic quartz veining around the PQM megadike.

Predating the PQM are two largely equigranular, fine- to medium-grained facies of the composite stock. The oldest of these intrusive units is a relatively biotitic, strongly potassically altered granodiorite. Hornblende, largely replaced by secondary biotite, is a minor but significant accessory mineral in this granodiorite facies of the Bagdad stock. For mapping and core logging purposes this more mafic facies has been informally designated QM_1, and appears to represent a slightly earlier comagmatic border facies of the main quartz monzonitic Bagdad stock. The QM_1 shows textural and mineralogical affinities to the Blue Mountain stock, a biotite-hornblende granodiorite and monzodiorite pluton exposed over approximately 8 square miles, centered about 5 miles east-northeast of the Bagdad pit. Hornblende is conspicuous in the Blue Mountain stock and recent K/Ar dating of biotite places its age at approximately 76 Ma (J.R. Lang, 1991), substantiating the interpretation by the authors that this stock represented the largest, most easterly, and least altered of several Late Cretaceous plutons along the 20 km long, east-northeast trending Bagdad intrusive zone. Although intense hydrothermal alteration of the granodioritic QM_1 has probably reset its K/Ar clock, the texture, compositional and general age relations suggest that the hornblende-bearing QM_1 is similar in age to the Blue Mountain stock. Probably because of its relatively high initial iron content and closely spaced fractures, the QM_1 border facies commonly acted as an especially favorable host rock for copper mineralization.

The predominant rock type within the composite stock is a medium-grained, nearly equigranular to weakly seriate-porphyritic quartz monzonite, informally designated QM_2. Contacts between QM_1 and QM_2 are generally obscure, and it appears likely that the granodioritic QM_1 represents a broad border zone grading imperceptibly inward to QM_2. The Laramide stock intruded a complex Precambrian terrain that commonly is strongly mineralized for several hundred feet away from the outward dipping intrusive contacts.

The youngest igneous rocks recognized within the Laramide intrusive sequence is large dike and small plug-like bodies of granite porphyry (GRP). Although the GRP is somewhat similar to some varieties of conspicuously porphyritic, quartz-phenocrystic QMP, the granite porphyry was clearly intruded after the end of main-stage copper and molybdenum mineralization. The GRP is generally unmineralized, except for minor late-stage quartz-pyrite-sphalerite-galena-tetrahedrite veins, and rare chalcopyrite veinlets. Pyrite is widely developed in the GRP, where it is associated with strong to pervasive phyllic and argillic alteration probably representing the waning stages of the hydrothermal system.

Rock alteration studies within and adjacent to the Bagdad stock indicate that Cu-Mo mineralization generally is associated with a zone characterized by overprinting of moderate to strong potassic alteration (defined by secondary biotite and K-feldspar) by a later superimposed phyllic alteration (defined by sericite). The shift from widespread potassic alteration to later phyllic alteration probably reflects an inward collapse of the temperature gradient during the declining stages of the hydrothermal system. Within the ore shell, Cu and Mo mineralization occurred during both the potassic and phyllic alteration phases, with the phyllic alteration generally diminishing in the deeper parts of the orebody. A strongly developed quartz-sericite-pyrite alteration halo surrounds the ore shell, dipping steeply away from the pit, and helping to define the geometry of the higher-grade portion of the orebody as an elliptical truncated cone increasing in diameter with depth.

Limited fluid inclusion studies of quartz in veins associated with mainstage Cu-Mo mineralization and phyllic alteration (Nash and Cunningham, 1974) indicate ore deposition from hydrothermal solutions of moderate to high salinity (8 to 35% NaCl equivalent) at temperatures ranging from 225° to 375° C. The presently exposed portion of the ore shell apparently formed at a depth of approximately 6,000 feet. Geological evidence and physical-chemical constraints indicated by fluid inclusion data suggest that the Bagdad Cu-Mo porphyry system developed beneath a Late Cretaceous volcanic center. The Grayback Mountain rhyolitic lithic tuff probably represents part of the complex volcanic edifice that once overlay the Bagdad district. Economic Cu-Mo mineralization was spatially and temporally associated with the intrusion of the 71-72 Ma porphyritic quartz monzonite (PQM), probably reflecting a complex interaction between magma-derived heat and metal-enriched hydrothermal fluids and groundwater. Widespread breccia piping and the occurrence of largely vapor filled fluid inclusions (Nash and Cunningham, 1974) suggest localized venting and boiling of this major hydrothermal system. Widespread mixed-lithology intrusive breccias, with angular to rounded clasts entrained in a finely comminuted rock flour matrix, and minor pebble diking support the interpretation of violent degassing. The western part of the GRP intrusive consists largely of intensely altered tuff-matrix intrusive breccia, with clasts primarily mineralized QM series and Precambrian rocks, again indicating explosive venting.

DESCRIPTION OF GEOLOGIC MODELING UNITS

Eight lithologic units are represented on the generalized geologic map of the pit area. For simplicity of block modeling, these units commonly include two or more lithologies.

Dumps and Tailings

Mine dumps and old mill tailings occur widely in the mine area. Because large tonnage's of these unconsolidated materials will have to be relocated in order to significantly expand the pit, they constitute an important modeling unit.

Sanders Basalt

A succession of Late Miocene, about 10 Ma, olivine basalt flows, up to about 100 feet thick, cap Sanders and Copper Creek Mesas, east and north of the pit. Separating the basalt from the underlying Gila Conglomerate is a conspicuous, white rhyolite tuff approximately 30 feet thick.

Gila Formation

This unit is loosely correlated with the Gila Formation elsewhere in Arizona, and consists of Middle to Late Miocene terrestrial sediments; largely tan to reddish brown, weakly to moderately consolidated alluvial gravel, and pebbly arkosic sandstone. Within the unit are several interbeds and channel fillings of rhyolitic tuff and poorly sorted tuffaceous sandstone and mudstone. The Gila Formation was deposited on an erosion surface with substantial topographic relief so that, in the mine area, its thickness varies from less than 100 feet to approximately 1,000 feet. Secondary chalcocite enrichment at Bagdad largely predates the Gila Formation, as evidenced by Gila-filled canyons dissecting the chalcocite blanket in the mine area.

Granite Porphyry (GRP)

White, generally intensely sericitized or argillically altered rhyolite or granite porphyry, with scattered K-spar phenocrysts mantled by sodic plagioclase up to more than an inch across. Bipyramidal quartz phenocrysts up to about half an inch are conspicuous.

Porphyritic Quartz Monzonite (PQM)

The PQM, together with its finer-grained equivalent QMP, represents an extremely important modeling unit. Even though this relatively late intrusive rock generally contains significant disseminated chalcopyrite, the abundance of this indigenous sulfide is highly variable and this rock largely coincides with low-grade ore and a central core of low-grade sulfide mineralization. Disseminated pyrite is ubiquitous within the PQM, but its abundance relative to chalcopyrite varies greatly; molybdenite commonly occurs as sparsely disseminated grains.

Texturally, the PQM ranges from distinctly porphyritic to seriate-porphyritic, with all gradation to finer-grained, conspicuously porphyritic QMP. Generally the PQM is light gray, but approaches white in varieties with less than 5 percent biotite.

A distinctive phenocryst population usually consists of 3-8% biotite (1-5 mm), 10-20% rounded quartz "eyes" (1-5 mm), 30-25% sodic plagioclase (2-10 mm), and 3-10% euhedral orthoclase (3-15 mm). These phenocrysts occur as an open mesh with a fine-grained interstitial groundmass of quartz and potassium feldspar.

Breccia Pipes

Weakly to strongly mineralized breccias are widely occurring in the mine area. The two largest, presumably pipelike bodies of breccia are shown on the generalized geologic map. These breccias consist largely of a highly mixed assortment of closely packed, angular to subrounded fragments of Pre-Cambrian and/or Laramide rock types in a strongly altered matrix of finer-grained breccia and comminuted rock. These breccias are unsorted, with fragments ranging in size from a few millimeters to more than a meter. Potassic alteration is strong to pervasive with crosscutting veinlets, alteration rims, and interstitial fillings of fine to coarsely crystalline biotite, K-feldspar, and quartz, commonly assuming an aplitic to pegmatitic aspect, with intergrown or disseminated chalcopyrite, pyrite, and minor molybdenite. Most of the sulfide mineralization occurs in quartz veinlets than crosscut both the fragments and matrix, indicating that the breccias formed prior to the culmination of the main stage of Cu-Mo mineralization. The age of the breccias is bracketed by the occurrence of rare Laramide quartz monzonite fragments and numerous crosscutting dikes and irregular stringers of PQM and QMP. A poorly defined spatial association between the breccias and the PQM suggests a genetic relationship.

Quartz Monzonite (QM)

Because vague or gradational contacts are common between the granodioritic facies of the Laramide quartz monzonite (QM_1) and the more widespread less biotitic quartz monzonite (QM_2), these two rock types have not been adequately delineated in the pit or subsurface. For this reason they have been combined to form a single modeling unit (QM). Both compositional and textural varieties are medium-grained, weakly seriate-porphyritic to hypidiomorphic-granular rocks. Biotite in the QM_1 occurs largely or entirely as leafy secondary biotite, commonly forming prismatic aggregates that may be pseudomorphs after hornblende. In the QM_2 biotite forms characteristic book-like phenocrysts or aggregates. Potassium feldspar is significantly more abundant in the QM_2, where it is largely intergrown with quartz to form a fine-grained interstitial mosaic. Sparse quartz eyes (1-2 mm) are commonly present in the QM_2, locally becoming conspicuous. Disseminated indigenous chalcopyrite has not been recognized in either variety of the QM.

Alaskite Porphyry (alp)

This leucocratic Precambrian rock is in contact with the composite stock along most of its western margin. This distinctive rock is composed almost entirely of quartz and feldspar. Irregular quartz phenocrysts (1-4 mm) are conspicuous, and along with twinned albite phenocrysts (1-3 mm) are set in a fine- to very fine-grained micrographic to myrmekitic ground-mass of interlocking quartz and potassium feldspar with some albite. This granophyric intrusive rock is essentially devoid of mafic minerals, and the very low initial iron content probably explains why it is an extremely poor host for copper mineralization.

Precambrian Complex

Because of the structural complexity of the Precambrian terrain adjacent to the Laramide composite stock, these intimately mixed and highly diverse rocks have been included in a single modeling unit. This complex consists predominantly of three metamorphosed Precambrian formations (Bridle Volcanics, Butte Falls Tuff, and Hillside Mica Schist) intruded by a wide assortment of igneous rocks ranging in composition from gabbro to granite, including pegmatite and aplite. Generally within the ore shell relatively high-iron rocks (Bridle Volcanics, gabbro, and quartz diorite) have acted as exceptionally favorable hosts for copper mineralization. Conversely, molybdenite mineralization seems to be independent of the host's initial iron content, and may in fact be localized in silicic rocks low in iron.

General Description of Field Trip Destinations

Stop 1 East pit floor, 2450 to 2500 elevation: Walk over QM_1 exposures cut by aplite dikes, and flesh colored K-feldspar and secondary biotite (potassic) alteration veinlets. Classic stockwork vein mineralization averaging 0.40 to 0.45 % total copper hosted by the oldest Laramide plutonic rock identified in the intrusive sequence.

Stop 2 Giroux-North cut, 2800 to 2850 elevation: Walk over PQM exposures with pervasive potassic alteration. Notice that the bulk of the sulfide mineralization is disseminated and magmatic in character with only minor stockwork veining.

Stop 3 Giroux-North cut, 3000 to 3050 elevation: Walk over granite porphyry (GRP) breccia exposures with pervasive phyllic/argillic alteration veinlets. Notice that the vast majority of the sulfide mineralization is clast hosted with quartz + sulfide veins truncated at clast margins. Only rarely (relative to adjacent Laramide rocks) is sulfide veining found cutting the breccia matrix. Walking to the southeast, dike exposures of less altered granite porphyry exhibit a rapakivi texture.

Stop 4 Crystal Mountain breccia, 3,000 feet northwest of pit area. Walk over leached and weathered sulfide mineralized crackle breccia on natural hillside. Breccia is hosted by Precambrian felsic metavolcanic rocks. Breccia character is of 6 to 8 inch, open vugs lined with clear to cloudy quartz crystals to 2 cm, occasionally rutilated, coated with limonite pseudomorphs after pyrite to 3 cm, or dusted with K-feldspar crystals to 2 mm.

Stop 5 Blue Mountain stock, 3 miles northeast of pit area. Walk over leached and weathered road cut exposure of weakly mineralized biotite-hornblende granodiorite. Area of weak geochemical anomaly drilled during the 1960's.

Safety Requirements

- Hard hat and safety glasses must be worn at all times when outside the vehicles.
- No shorts, sleeveless shirts or sandals can be worn during the tour.
- Please limit your sample collecting to the lower reaches of the talus pile.
- Always keep a respectful distance from either the bench crest or toe.

COMMON MINERALS IN THE BAGDAD ORE

The ability to identify the most common sulfide minerals should make it possible, with a little practice, for career miners to recognize at least moderate- to high-grade ore. The following minerals are the most abundant constituents in the Bagdad ore body:

Pyrite (FeS_2) is composed of iron and sulfur atoms bonded together in the ratio 1 atom of iron (Fe) to 2 atoms of sulfur (S). Pyrite is by far the most common of the sulfide minerals. It is light, brassy-yellow in color and looks metallic. Even though it is too hard to be scratched with a knife, and is easily pulverized with a hammer, it has often been mistaken for gold, so it is commonly called "fool's gold". Pyrite has no value, so it must be efficiently separated to produce copper-rich concentrate.

Chalcopyrite ($CuFeS_2$) looks even more like gold than pyrite, and can be scratched with a knife. Unlike gold, however, chalcopyrite cannot be cut with a knife and is easily shattered and pulverized with a hammer. This sulfide mineral is composed of copper, iron and sulfur bonded together in the ration 1 atom of copper (Cu) and 1 atom of iron (Fe) to 2 atoms of sulfur (S). Chalcopyrite contains 34% copper by weight, and is by far the most common ore mineral of copper. It has a deeper gold-yellow color than pyrite, often appearing slightly greenish when compared to pyrite.

Molybdenite (MoS_2) is a bluish-silver-gray mineral that is very soft and tends to form platy crystals. As the chemical formula indicates, it is made up of molybdenum and sulfur bonded together in the ration 1 atom of molybdenum (Mo) to 2 atoms of sulfur (S). This ration means that it is 60% molybdenum by weight. Molybdenite, often called "moly", is an important co-product of our copper (chalcopyrite) mining operation.

Chalcocite (Cu_2S) is a black or dark, steely-gray copper sulfide that forms by natural weathering and copper enrichment processes that result in "secondary replacement" of chalcopyrite. Because chalcocite is 80% copper, while chalcopyrite is only 34% copper, this secondary enrichment can produce very rich ore in a relatively thin "blanket" below the weathered zone where blue and green "oxide copper" minerals are formed. Between this blue-green oxide zone and the chalcocite blanket, there is commonly a very thin zone where "native copper" and "cuprite" (Cu_2O), red copper oxide, are mixed together.

Chrysocolla (blue copper silicate) and malachite (green copper carbonate) are the most abundant of the acid soluble oxide copper minerals, and provide most of the copper going to the SX system.

Other common minerals in the "primary", or unweathered, sulfide zone include "quartz" (silica), "calcite: (calcium carbonate), "feldspar" (potassium and sodium silicate), "sphalerite" (zinc sulfide), "galena" (lead sulfide), and "tetrahedrite" (a complex copper, antimony and arsenic sulfide). Although tetrahedrite is not abundant, it is widely distributed in the ore body and probably contains most of the silver that is recovered at the smelter.

Note: Almost all of the copper mined from the "primary ore zone" below the oxidized zones of weathering, occurs as chalcopyrite within small quartz veins or "veinlets", where it is associated with pyrite and usually with molybdenite and calcite. Only in the relatively copper-poor quartz monzonite porphyry, to which the whole ore deposit owes its existence, is there substantial, widely disseminated, chalcopyrite that is unrelated to vein or veinlet mineralization.

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ROAD LOG FROM BAGDAD, ARIZONA, TO PRESCOTT, ARIZONA: 64.6 MILES
Reprinted from ***Proterozoic Ore Deposits of the Southwestern U.S.***
by: Ed DeWitt

MILEAGE

Cumul	Mile post	
0.0	0.0	Copper Plaza in Bagdad, Arizona. Proceed east on Arizona Highway 96 toward Hillside, Arizona.
0.4	0.4	Turnoff to the right to the Bruce mine. Out crops ahead, on the left, and for the next one-half mile are Hillside Mica Schist intruded by Lawler Peak Granite.
1.0	1.0	Roadcut in Hillside Mica Schist intruded by Early Proterozoic foliated granodiorite.
1.2	1.2	Small creek from below the Cowboy mine enters Bridle Creek on the right. Outcrops are of dark metabasalt of the Bridle Formation (Anderson and others, 1955). Light-colored rocks are intrusive and extrusive metarhyolite. Roadcuts 0.4 miles ahead in light felsic metavolcanic rocks on the right, dark mafic metavolcanic rocks and Hillside Mica Schist on the left.
1.8	1.8	Eastern margin of metavolcanic belt. Roadcuts in Hillside Mica Schist intruded by aplite-pegmatite.
2.3	2.3	Large roadcut contains Hillside Mica Schist intruded by numerous sills and dikes of aplite-pegmatite.
3.4	3.4	Tertiary fangolomerate in roadcut. Large dike of aplite-pegmatite projects across the highway. Outcrops ahead about one-quarter mile on the left are light aplite-pegmatite intruded by tan-weathering, ocher-stained, strongly jointed Lawler Peak Granite.
4.3	4.3	Junction of Arizona State Highways 96 and 97. Arizona State Highway 97 turns off to the right and connects with U.S. Highway 93 to Wickenburg and Phoenix. We continue along Arizona Highway 96 straight ahead through the roadcuts of Lawler Peak Granite. Road narrows through these roadcuts; please drive carefully. Most of the roadcuts are in Lawler Peak Granite, but some aplite-pegmatite is present.
5.2	5.2	Roadcut in Tertiary fanglomerate that locally covers Lawler Peak Granite. We are descending into the drainage of the Santa Maria River, paralleling Spring Wash on the right. Fanglomerate, which in Tertiary time covered all of this area, is being stripped by modern erosion. We are driving down an exhumed pediment toward the river.
5.7	5.7	Roadcuts in fanglomerate for next two-tenths of a mile. Past fanglomerate, low outcrops the left and right are Lawler Peak Granite on which old pediment is cut.
6.1	6.1	At 10:00 in the near foreground is SH Mesa, capped with thin Tertiary basalt and underlain by fanglomerate and tuff. In the background on the horizon is Bismarck Mountain (now renamed Thompson Peak, elev. 4,704 ft), northwest of Hillside. One-half mile ahead is roadcut in Hillside Mica Schist intruded by Early Proterozoic aplite-pegmatite. Both units are cut by minor amounts of Lawler Peak Granite.

ROAD LOG FROM BAGDAD, ARIZONA, TO PRESCOTT, ARIZONA: 64.6 MILES
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MILEAGE Cumul	Mile post	
6.8	6.8	Aplite-pegmatite in roadcut. Road ahead widens. Outcrops on right are predominantly aplite-pegmatite cut by minor amounts of Lawler Peak Granite.
7.3	7.3	SH Mesa straight ahead about one-quarter mile is capped by thin basalt flow. Interbedded tuff, fanglomerate, and playa deposits underlie the capping basalt. Most units below top of mesa obscured by basaltic debris in talus slopes. Gravel road on the left, which leads to the Muleshoe Ranch on the Santa Maria River, is the old Lawler Grade, the original road from Hillside to Bagdad.
7.6	7.6	Blue Mountain, Big Shipp Mountain, and Little Shipp Mountain are on the horizon to the left. Both Big Shipp and Little Shipp Mountains are underlain by aplite-pegmatite. Prominent northwest-trending Tertiary faults are responsible for the steep, linear cliffs on the south side of both peaks. Small knob of ocher-stained Lawler Peak Granite in near foreground. Highway turn sharply to the right on the west side of SH Mesa and narrows again.
8.3	8.3	Roadcuts are predominantly in Lawler Peak Granite. Both biotite- and muscovite-rich phases (Anderson and others, 1955) are in these cuts.
8.6	8.6	Road turns to the right below basalt flow. Lawler Peak Granite is sheared along northwest-trending fault that probably parallels this segment of Little Shipp Wash. View ahead is into the Santa Maria River. Ahead on the horizon are coarse-grained, porphyritic plutonic rocks that may be Middle Proterozoic or Early Proterozoic. From this point another pediment surface can be seen across the Santa Maria River that is cut into the coarse-grained, porphyritic plutonic rocks.
9.1	9.1	Basalt flow in roadcut. Ahead on the right are tuffaceous rocks underlying basalt flows. At least three basalt flows are apparent in this Tertiary section.
9.6	9.6	Small mesa at 12:00 is underlain, at its base, by lake deposits and volcanic ash. Half way up the mesa is another basalt flow.
10.3	10.3	Roadcuts for next one-quarter mile in intercalated lacustrine and fanglomerate deposits. Crosby Mountain, elev. 4,344 ft, is the high peak to the right at 4:00. Turnoff to the right leads to the Crosby mine. The gold-rich vein at the mine is in a fault that dips to the east about 25 degrees. The mine, one of the larger deposits in the Crosby metallic mineral district, is typical of middle Tertiary gold-copper veins in the district.
10.7	10.7	Bridge over Santa Maria River. Mesas capped by basalt and underlain by lacustrine sedimentary rocks and fanglomerate on the left, to the north. One-quarter mile farther along the highway is a view to the right of the Santa Maria river cutting through basalt flow downstream.
11.4	11.4	Crossing quail Spring Wash, a small northwest-trending tributary to the Santa Maria River.
11.8	11.8	Driving uphill through Tertiary fanglomerate and fine-grained sedimentary rocks. View ahead of bouldery weathering Proterozoic granitic rocks in the McCloud Mountains west of Hillside. Mesas to the left are capped by basalt,

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		which is underlain by tuff and fanglomerate. Tuff is visible as the white bands, low and halfway up the slopes, and near the valley bottoms. Apparently, the Quail Spring Wash area and this part the the Samta Maria River drainage must have been a small basin in Tertiary time.
13.3	13.3	Paralleling Quail Spring Wash on the left. Outcrops to the right are granite to granodiorite, some highly sheared along northwest-trending, high-angle faults. Outcrops ahead one-half mile on the right are deeply weathered, coarse-grained, porphyritic biotite granodiorite.
14.3	14.3	Fanglomerate in roadcuts for the next one-half mile contain very large angular blocks of subjacent bedrock.
14.8	14.8	Small hairpin turn. Deep roadcuts in Tertiary fanglomerate that is very poorly sorted and stratified. Ahead and to the right are low, rounded hills of fanglomerate deposited on top of Proterozoic granite to granodiorite.
15.5	15.5	Large curve to the right. Outcrops to the left, about one mile away at 10:00 to 11:00, are very coarse-grained, bouldery weathering Proterozoic granite to granodiorite. Ahead two-tenths of a mile, the view back and to the right of Grayback Mountain on the horizon, southwest of Bagdad.
16.1	16.1	Into relatively coarse-grained biotite granodiorite, highly sheared and faulted. Highway roughly parallels northwest-trending Tertiary fault zone. One-quarter mile farther are outcrops of coarse-grained porphyritic biotite granodiorite. The granodiorite is the major Proterozoic rock unit all the way to Yava and Kirkland Creek. The granodiorite, although sheared in these outcrops and roadcuts, is relatively undeformed in most outcrops. Because of its textural and compositional similarity to plutons dated as both 1700 and 1400 Ma, this pluton is shown as YXg.
17.4	17.4	Sharp turn to the right. Roadcuts in bouldery outcrops of coarse-grained porphyritic biotite granodiorite. Some outcrops to the left are tan to ocher-colored (possibly Lawler Peak Granite) material that intrudes? the coarse-grained granodiorite.
17.9	17.9	To the right, at approximately 1:00, on the crest of the McCloud Mountains, elev. 4,913, is a microwave relay station. Roadcut one-half mile ahead exposes Tertiary basalt dikes intruded along low-angle structure. Dikes may have been feeders for extensive basalt flows to the north.
19.0	19.0	Tawny-colored, jointed outcrops appear to be Lawler Peak Granite. Ahead one-quarter mile is rounded hill to the left that may be underlain by locally derived fanglomerate.
19.6	19.6	Crest of grade. Proceeding through low hills of coarse-grained biotite granodiorite cut by aplite and pegmatite dikes. Small intrusive bodies to the left may be Lawler Peak Granite.
20.6	20.6	Road parallels large northwest-trending fault or fracture. View at 12:00 is of the Weaver Mountains north of Yarnell, Arizona, which are composed of coarse-

MILEAGE Cumul	Mile post	
		grained plutonic rocks similar to those between the Santa Maria River and here. Large, northwest-trending faults and fractures, similar to those in this area, cut the Weaver Mountains (DeWitt, unpub. mapping, 1979). There, the faults have minimal offset, but are intruded by large Tertiary rhyolite dikes. Tertiary volcanic rocks on Ritter Peak in the Weaver Mountains are strikingly displayed at 12:00. The volcanic rocks have not been mapped, but are probably older than basalt in the low mesa in the foreground.
21.7	21.7	Right turn leads to Hillside, Arizona, just south of the highway. Hillside is the railroad siding on the Atchison, Topeka, and Santa Fe Railroad from which ore concentrates from the Bagdad area massive sulfide deposits were shipped. Copper from the Bagdad copper porphyry open-pit mine used to be shipped from here also, but some is now trucked to other destinations.
21.8	21.8	Highway 96 turns north and starts a downgrade into Kirkland Creek and Thompson Valley.
22.1	22.1	View at 12:00 on the horizon is of Martin Mountain, elev. 6,433 ft, a vent area for rhyolite flows that protrude above the basalt flows in the foreground. The intrusive center is unmapped. Outcrops along the road and on the left are of coarse-grained granitic rocks similar to those seen the last 6 miles.
22.6	22.6	Basalt mesas at 12:00 terminate in a northwest-trending scarp caused by displacement on Tertiary normal fault. This fault is the eastward projection of the White Spring fault northeast of Bagdad (Anderson and others, 1955), and is the same structure that bounds Big Shipp and Little Shipp Mountains on the south. The fault can be traced for more than 30 miles.
23.5	23.5	View to the north at approximately 11:00 shows bouldery topography caused by coarse-grained porphyritic Proterozoic granite in recess between basalt flows.
24.9	24.9	Bridge over Kirkland Creek. Old settlement of Yava on the left.
25.6	25.6	Left turn leads west to the Mule Shoe Ranch along the Old Lawler Grade. Ahead one-quarter mile, at 12:00, is a view of Kirkland Peak. The tan-weathering, highly jointed peak is the easternmost outcrop of the Lawler Peak Granite. The highly jointed nature of the outcrops defines the eastern projection of the fault that extends southeast from Bagdad.
26.6	26.6	Low mesas to the right are capped by basalt flows that may be the down-dropped equivalent of basalt flows to the left on the mesa top. Sedimentary strata and tuff underlying the basalt are exposed on the the hillsides to the left at 10:00, in the low cut at 11:00 in the near foreground, and over the ridge in the distance.
28.7	28.7	View to the left at 10:00 to 11:00 is of the vent area on Martin Mountain. Thick flow units are obvious in the view up Cottonwood Canyon, a drainage cut between the basalt mesas. Tuff units between basalt flows are visible as we descend the grade.

ROAD LOG FROM BAGDAD, ARIZONA, TO PRESCOTT, ARIZONA: 64.6 MILES
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Cumul	Mile post	
29.3	29.3	Crossing Ash Creek and entering Lower Kirkland Valley. Kirkland Creek cuts a small, but spectacular gorge through the basalt cover of Thompson Valley behind and to our right.
30.5	30.5	Highway crosses basalt flows. View on horizon, between basalt mesas, is of the northern end of the Weaver Mountains.
32.2	32.2	Kirkland Peak is on the left at approximately 11:00. Prominent jointing in this easternmost outcrop of Lawler Peak Granite is well displayed on both topographic maps and air photos. Prominent west-northwest-trending joint pattern marks eastern end of 30-mile-long Tertiary normal fault. From here, Towers Mountain in the southern Bradshaw Mountains is visible on the horizon at 1:00
33.6	33.6	Large ranches to the right in Lower Kirkland Valley. From 12:00 to approximately 2:00 are low-relief, brush-covered hills at the base of the Weaver Mountains. These hills are composed of the granodiorite of Peeples Valley, a relatively leucocratic Early Proterozoic pluton similar in composition to the 1750_+ 15 Ma Government Canyon Granodiorite near Prescott (DeWitt, in press).
34.5	34.5	Roadcuts in Tertiary siltstone. Ahead one mile are small roadcuts in Tertiary lacustrine deposits and tuff. These rocks extend to Kirkland and north toward Skull Valley.
36.6	36.6	Castle-like landforms to the left are of tuff that is common in the Kirkland area. To the right are low hills underlain by the granodiorite of Peeples Valley. West of the granodiorite is a belt of Early Proterozoic pelitic schist that extends south to Yarnell. That schist belt is bordered on the east by Early Proterozoic metavolcanic units that include basalt and diorite, local gabbro, and some mafic tuff (DeWitt, unpub. mapping, 1979, 1968). That metavolcanic belt extends beneath us and north of Kirkland, into the area on the southeast side of Kirkland Peak.
37.3	37.3	Town of Kirkland, Arizona. Cross the Atchison, Topeka, and Santa Fe Railroad tracks. Road to the left leads to Skull Valley and eventually into Prescott from the north; continue straight ahead to Kirkland Junction and intersection with U.S. Highway 89.
37.4	37.4	Bridge over Skull Valley Creek. To the left in the near foreground are cream to white Tertiary tuff units. Beneath these Tertiary volcanic rocks is the belt of Early Proterozoic pelitic schist and mafic metavolcanic rock that extends north from near Yarnell.
38.6	38.6	Roadcuts in Tertiary basalt and tuff. Ahead one-half mile, at 9:00, is Sierra Prieta. Cream-colored, bold cliffs are underlain by Prescott Granodiorite. West Spruce Mountain, the high, tree-covered peak on the left, is underlain by metamorphosed diorite and gabbro that intrude mafic metavolcanic rocks (DeWitt, unpub. mapping, 1979, 1986). Low, brush-covered hills to the right underlain by Early Proterozoic granodiorite of Peeples Valley. Mafic

MILEAGE Cumul	Mile post	
		metavolcanic rocks and schist are to the right of the bouldery outcrops of granodiorite.
39.7	39.7	Mountains in the distance, on the horizon at 2:00, are the Weaver Mountains east of Yarnell. The range is composed of Tertiary basalt flows that dip to the north, toward us. The crest of the range may have been a local vent area for Tertiary basalt flows.
41.1	41.1	Subdued hills in the foreground, approximately two miles away, are Tertiary volcanic rocks of the same approximate age as the tuff and volcanic rocks at Kirkland.
41.5	41.5	Kirkland Junction. "Y" in the road; take the left fork. Right fork leads to Yarnell and U.S. Highway 93 south to Wickenburg.
41.7	289.3	Intersection with northbound U.S. Highway 89. View at 12:00 is of West Spruce Mountain, elev. =7,160 ft, underlain by diorite and gabbro that intrude mafic metavolcanic rocks. Village of Wilhoit is visible in the distance at about 1:00 in the low hills at the base of the Bradshaw Mountains.
42.6	290.2	Highway turns gently to the right. Maverick Mountain, elev. 7,443 ft, is visible at 12:00 as the high, wooded peak in the Bradshaw Mountains. The high part of the Bradshaw Mountains seen from here is underlain by Early Proterozoic mafic metavolcanic rocks intruded by the Government Canyon Granodiorite.
43.6	291.2	Road ascends alluvial fan developed on southwest face of the Bradshaw Mountains. Outcrops at 3:00 are Tertiary volcanic rocks north of the Zonia mine, an Early Proterozoic disseminated sulfide deposit in tuffaceous rhyolitic metavolcanic rocks. The Zonia deposit differs from typical massive sulfide deposits, such as those at Bagdad, by lacking massive pyritic ore. However, it strongly resembles other Early Proterozoic deposits in metarhyolite in the Mayer area that we will be visiting tomorrow. Production data form the deposit are difficult to compare to other massive sulfide deposits, as Zonia was mined by open-pit methods. Also, no modern studies have been made of the deposit, and the existing production data do not include gold or silver. A view of the deposit and its extensive leach pads is farther up the highway.
44.5	292.1	Kirkland Peak visible on the left and slightly behind us at 8:30. Large Tertiary basalt mesas west of Skull Valley at 9:00, Towers Mountain and the Southern Bradshaw Mountains visible at 2:30. Towers Mountain, elev. 7628 ft, is the high, dark, tree-covered mountain on he horizon. The peak is underlain by a large body of metamorphosed Early Proterozoic gabbro (DeWitt, 1976, 1979). Horse Mountain, elev. 7,078 ft, is slightly to the right of Towers Mountain, is underlain by Early Proterozoic granitic rocks and pegmatite bands visible in the distance as bouldery weathering outcrops. Phoenix, Arizona, is 50 miles past Horse Mountain, in a straight line from us.
45.3	292.9	At 9:00 in the far distance beyond the basalt mesas are Hide Creek Mountain and Camp Wood Mountain (both peaks slightly in excess of 7,000 ft) west of Camp Wood. Both peaks are capped by Cambrian Tapeats Sandstone (Krieger, 1967c), but Hide Creek Mountain, on the right, contains an erosional remnant of

MILEAGE Cumul	Mile post	
		Tertiary andesite on its summit. The Camp wood area contains the northeasternmost known exposures of the Middle Porterozoic Lawler Peak Granite (DeWitt, unpub.mapping, 1987). The prominent mountain front of the Bradshaw Mountains that we are approaching is now a depositional contact of alluvial fan material on Proterozoic bedrock, but is inferred to have been a relatively large normal fault in Tertiary time. Upper Miocene and lower Pliocene sedimentary strata of the Milk Creek Formation (Plafker, 1956; Hook, 1956; Anderson and Blacet, 1972a) thicken and become finer-grained away (southward) from the mountain front in the Walnut Grove and Wagoner areas, about 12 miles to the south. Apparently, the modern valley that extends from Skull Valley to the left to Wagoner on the right was a half graben during Tertiary time that was bounded by a large normal fault on the northeast. This basin is, therefore, geometrically similar to the Big Chino Valley north of Prescott and the Verde Valley east of Jerome. The Copper Basin district, a Laramide breccia pipe and vein system related to a large granodiorite to granite, is at 10:00, to the north of Wilhoit. Some of the landforms caused by the breccia pipes and intrusive rocks are visible from the highway.
47.7	295.3	Village of Wilhoit. Chaparral-covered, bouldery outcrops ahead are Government Canyon Granodiorite.
48.1	295.7	Gruss-covered outcrops are of coarse-grained granodiorite to tonalite phase of Government Canyon Granodiorite (DeWitt, in press). The granodiorite of Peeples Valley, which extends from near Wilhoit, southwest into the Weaver Mountains, intrudes the Government Canyon, but is probably genetically related to it.
48.5	296.1	View behind and to the right is into Peeples Valley, the valley between the granitic-weathering part of the Weaver Mountains north of Yarnell and the basalt-covered peaks east of Yarnell. The open pit of the Zonia mine is clearly visible at about 3:00, at the base of the Tertiary basalt flows east of Yarnell. Slopes below 6,000 ft on this side of the Bradshaw Mountains are covered by dense growths of manzanita and brushy oak.
49.1	296.7	View to the south at approximately 3:00, is of the Hassayampa River valley near Wagoner. On the skyline are Seal Mountain, the pyramidal peak, and Wades Butte, the flat-topped mountain to the right of Seal Mountain. Both peaks are underlain by the granodiorite of Hozoni Ranch and the southern part of the Crooks Canyon Granodiorite, and are capped by Tertiary basalt. Both plutonic rocks are assumed to be about 1720 -1740 Ma (Dewitt, in press).
49.9	297.5	Towers Mountain and Horse Mountain clearly visible is the southern Bradshaw Mountains at 3:00. Due to winding mountain road, the exact bearings to landmarks are only approximate along this stretch of highway.
51.0	298.6	Peak in the distance to the north is Mount Francis, underlain by the granodiorite of Peeples Valley and Government Canyon Granodiorite. Bouldery outcrops to

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		the left of Mount Francis are underlain by the Prescott Granodiorite. Outcrops ahead of undeformed Government Canyon Grandiorite in outcrops.
52.0	299.6	Crossing Board Creek. To the right, between the highway and the canyon bottom of the Hassayampa River, is a Tertiary or Laramide rhyolite stock, originally thought by Light (1975) to be Proterozoic. Numerous dikes related to the stock project across the highway in the next few miles. The Little Copper Creek mineral district (Keith, Gest, and others, 1983) is centered on the stock, which has received extensive attention for its porphyry copper and molybdenum potential.
52.4	300.0	View straight ahead of Maverick Mountain, elev. 7,433 ft. Its chaparral slopes are underlain by Early Proterozoic mafic metavolcanic rocks and minor metarhyolite of the Green Gulch Volcanics. Intrusive contact of the Government Canyon Granodiorite is on the left shoulder of the peak where coniferous forest begins. Drill roads on the south flank of Mount Francis visible at 11:00. Numerous rhyolite dikes in roadcuts of Government Canyon Granodiorite.
53.3	300.9	Crossing Copper Creek. Gravel road to the left leads to the Copper Basin district (Johnston and Lowell, 1961), which contains 73-75 Ma intrusive rocks (Christman, 1978), breccia pipes, and vein deposits. The breccia pipe deposit at the Commercial mine has produced 95 percent of the copper-rich ore from district, and has known reserves of molybdenum. Peripheral vein deposits are rich in base and precious metals.
		Early Proteozoic auriferous quartz veins of the Finch district in the Copper Basin area are cut by the Laramide deposits, which are in turn cut by Tertiary rhyolite dikes, plugs, and minor flows. Mercury mineralization south of the Copper Basin district may be related to this episode of Tertiary volcanism.
53.7	301.3	Numerous rhyolite dikes are in this roadcut, many intruded along low-angle fractures in the Government Canyon Granodiorite. Another large rhyolite dike at mileage 53.8. Mafic inclusions in rhyolite dike at mileage 54.0. Most dikes iron-stained from oxidation of abundant pyrite.
54.2	301.8	Large rhyolite dike crosses hill to the left at low angle. Grussy slopes underlain by Government Canyon Granodiorite.
54.6	302.2	Crossing Little Copper Creek.
54.7	302.3	Large rhyolite dike, rounding bend to the left. Conifer forest on the horizon at 2:00 is in Ponderosa Park, the source of the Hassayampa River. Basin of Ponderosa Park underlain by Government Canyon Granodiorite.
56.2	303.8	Numerous rhyolite dikes and aplitic material. Ahead four-tenths of a mile is a deep roadcut in mafic metavolcanic rocks cut by rhyolite and aplite.
57.3	304.9	Rounding the bend in the road, an exceptional view of Ponderosa Park is ahead at 12:00.

ROAD LOG FROM BAGDAD, ARIZONA, TO PRESCOTT, ARIZONA: 64.6 MILES

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MILEAGE		
Cumul	Mile post	
57.5	305.1	Grade levels off. Elevation 6,000 ft. Highway has climbed 2,000 feet from Kirkland Junction. Mount Union, elev. 7,979 ft, the highest point in the Bradshaw Mountains, is at 2:00, to the left of Maverick Mountain. Ahead four-tenths of a mile on the right is the turnoff to Indian Creek, which leads into Ponderosa Park. Outcrops are predominantly Government Canyon Granodiorite.
59.7	307.3	Ponderosa pine forest underlain by gruss of Government Canyon Granodiorite.
59.9	307.5	Tourmaline veins in the roadcut on the left.
60.8	308.4	Forest Service Road 62 to the right to the White Spar Campground. Outcrops on the left are relatively undeformed Government Canyon Granodiorite.
61.1	308.7	Leaving Prescott National Forest. Ahead on the left are blasted outcrops of Government canyon Granodiorite cut by tourmailine veins. Prescott city limits.
62.2	309.8	Outcrops on the left are Prescott Granodiorite, which intrudes Government Canyon Granodiorite.
62.7	310.2	Road to Copper Basin leads back and to the left and the Exxon station. Ahead one-quarter mile, U.S. Highway 89 turns north and becomes South Montezuma Street.
63.6	311.1	Stop light at the intersection of Goodwin Street and South Montezuma. Go straight to the next stop light and turn right on Gurley Street.
63.9	311.4	Traveling east on Gurley Street. Senator Highway, which leads to the right, was the old stage road from Prescott to Phoenix. It now crosses the high Bradshaw Mountains, goes through Crown King, and ends at Lake Pleasant, north of Phoenix.
64.6	312.1	Prescottonian Motel on the right. We will stay here tonight. This ends the second day of our field trip. Places for supper and refreshments in Prescott are numerous; enjoy the night.

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VEIN ZONATION OF LARAMIDE STOCKS IN THE GROOM CREEK - POLAND JUNCTION AREA, YAVAPAI COUNTY, AZ

revised from a paper published in AGS Digest 19

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REGIONAL GEOLOGY

Early Proterozoic metavolcanic and metasedimentary rocks of the Big Bug Group (Anderson and others, 1971) crop out within the area described in this field trip guide. The metavolcanic rocks in the Poland Junction-Groom Creek area crystallized at 1,775 +/- 10 Ma and are suggested to form the earliest of three major volcanic cycles in the Prescott volcanic belt. These rocks are isoclinally folded and are cut by the Chaparral Shear Zone (CSZ) which is a Proterozoic right lateral ductile shear zone (Berg and Karlstrom, 1992). This structure thins and offsets but does not break continuous rock units. Brittle faults are present on both boundaries of the CSZ (Anderson and Blacet, 1972). Pre-syntectonic calc alkalic to alkali calcic granodiorites, diorites, and gabbros intrude the Big Bug Group in this area (DeWitt, 1989).

Three stocks of post-tectonic granodiorite intrude Proterozoic rock between Groom Creek and Poland Junction (Figure 1). The Walker stock has been dated at 64 Ma and the Big Bug stock has been dated at 70 Ma using K-Ar isotopic techniques on biotites (Anderson, 1968). Tertiary Hickey Basalt crops out on Big Bug Mesa and covers the southeast portion of the study area. Quaternary stream sediments are present locally and contain placer gold concentrations derived from Laramide veins.

LARAMIDE MINERALIZATION

Laramide veins are present in all or parts of the Ticonderoga, Walker, Mount Union and Groom Creek metallic mineral districts. Sturdevant (1975) described the distribution of alteration surrounding the Big Bug stock. Propylitic alteration assemblages are associated with northeast and northwest striking fractures. Anderson and Blacet (1972) describe the veins as typical fissure veins with well defined straight and narrow walls. Quartz, which contains drusy and comb textures and is locally vuggy, is the dominant vein mineral. Gangue mineral assemblages vary through out the district from quartz dominant to quartz-ankerite +/- barite veins. Primary fluid inclusions from quartz in the McCabe vein suggest a formation temperature of 335° C (Clements and others, 1991). Although sulfide vein minerals include pyrite, arsenopyrite, sphalerite, galena, chalcopyrite, tetrahedrite, and ruby silver (Anderson and Blacet, 1972) most production was from the oxidized zone of the veins.

Clements (1991) analyzed Pb-Pb isotopic systematics on galena from the McCabe vein. He suggested that the lead originated in the Proterozoic host rocks and was remobilized during a post-Proterozoic event. These isotopic age constraints plus field observations of veins cross-cutting Laramide stocks indicate that these veins post-date stock emplacement.

ZONATION PATTERNS

One hundred fifty-one mines and prospects in the Arizona Mineral Industry Location System (AZMILS) database are known or suspected mesothermal Laramide veins in the Poland Junction and Groom Creek 7.5 minute quadrangles. Zonation patterns are based upon the distribution of primary commodities in the AZMILS database, namely: gold, silver, and the base metals; copper, lead, and zinc (Ryberg and others, 1991). Polynomial trend surface analysis is used to generate contour maps illustrating trends in the original primary commodity data (Figures 2, 3 and 4).

A continuous gold zone extends from the eastern edge of the Big Bug stock to an area west of Walker and south of Groom Creek. Isolated areas of primary gold mineralization occur north of the Walker stock and east of Groom Creek. Primary silver zones are present as isolated localities distal to the Big Bug and Walker stocks. Silver mineralization is also present east and southwest of Groom Creek along potential N20-30E linear features. Base metal zones overlie the southern lobe of the Big Bug stock and the center of the Walker stock. Trends of base metal and gold zones are similar, although areas of peak intensity are slightly offset. A base metal zone west of Groom Creek is located along a potential N20E lineament and a U-shaped base metal zone overlies the Chaparral Fault southwest of the Walker Stock. This base metal zone encloses and is distal to a gold-silver zone. This locally anomalous pattern suggests that two ages of mineralization may be associated with the Walker stock.

An isolated gold zone without an associated base metal zone surrounded by a silver zone in the southwest portion of the study area suggests that a Laramide stock may be present at depth.
Table 1 illustrates the production data for the 4 metallic mineral districts (Keith and others, 1983). The Ticonderoga produced the highest tonnage with the highest gold grade. Silver grades in all four districts are similar, while base metal grades are higher in the Walker and Mt. Union metallic mineral districts. The average ore grades for each district suggest that deeper portions of the hydrothermal system(s) is exposed in the Walker and Mt. Union districts. Higher portions of the hydrothermal system(s) may be present in the Ticonderoga (Big Bug stock) and Groom Creek districts.

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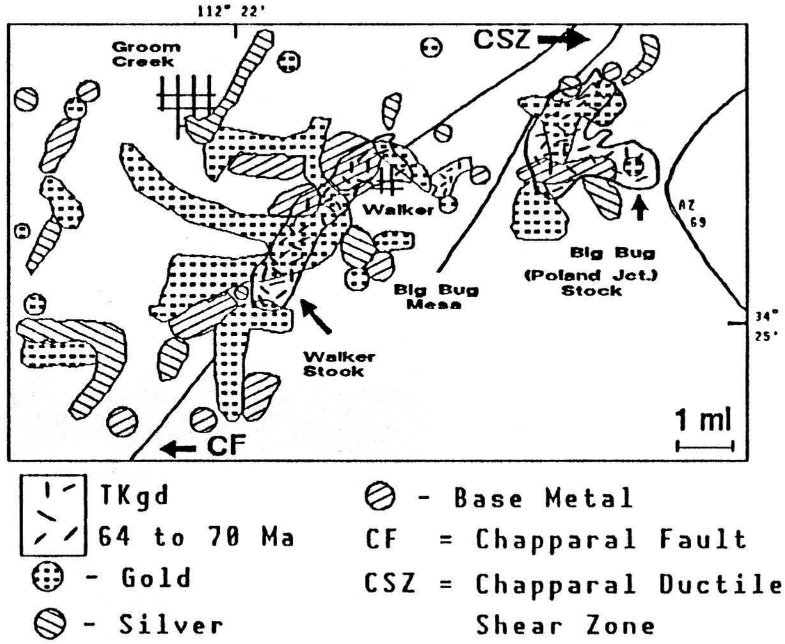
Figure 1. Map illustrating Laramide vein primary gold, silver, and base metal zonation about the Walker and Big Bug stocks in the Groom Creek and Poland Junction quadrangles.



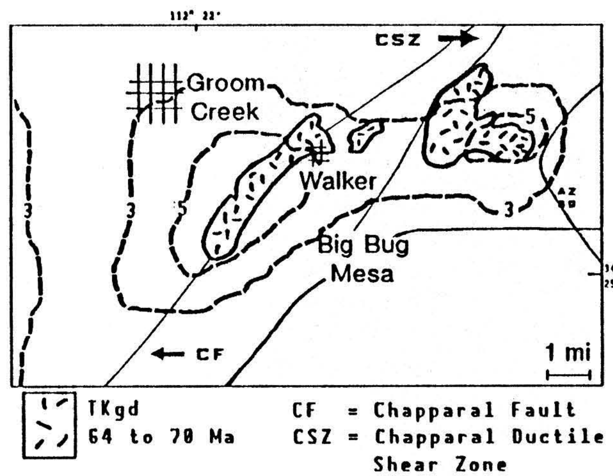


Figure 2. Sixth polynomial trend surface map of gold vein distribution about the Walker and Big Bug stocks in the Groom Creek and Poland Junction quadrangles.

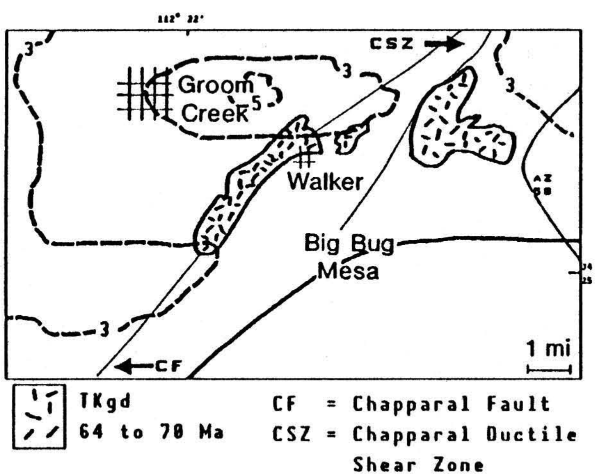


Figure 3. Sixth order polynomial trend surface map of silver vein distribution about the Walker and Big Bug stocks in the Groom Creek and Poland Junction quadrangles.

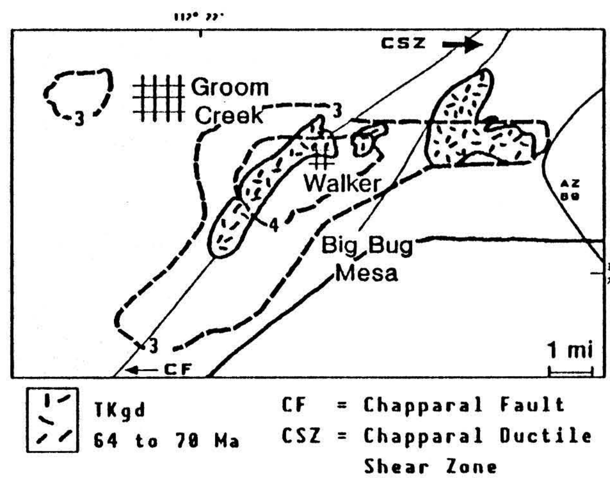


Figure 4. Sixth order polynomial trend surface map of base metal vein distribution about the Walker and Big Bug stocks in the Groom Creek and Poland Junction quadrangles.

TABLE 1. PRODUCTION DATA FOR METALLIC MINERAL DISTRICTS IN THE POLAND JUNCTION-WALKER-GROOM CREEK AREA
(From Keith and others, 1983)

District	Ticonderoga	Walker	Groom Creek	Mount Union
Tons	336,000	213,000	15,000	108,000
Gold (ozs.)	189,000	65,000	5,200	51,700
Silver (ozs.)	1,575,000	871,000	86,000	593,000
Copper (lbs.)	2,593,000	3,940,000	51,000	1,663,000
Lead (lbs.)	3,219,000	4,473,000	25,000	1,827,000
Zinc (lb.)	29,000	524,000	6,700	485,000
Gold (oz/ton)	0.56	0.31	0.35	0.47
Silver (oz/ton)	4.70	4.08	5.73	5.49
Copper (%)	0.38	0.9	0.2	0.77
Lead (%)	0.48	1.1	0.1	0.85
Zinc (%)	0.04	0.12	0.02	0.22
Au/Ag	0.12	0.08	0.06	0.09

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ROADLOG FOR THE POLAND JUNCTION FIELD TRIP

By: George E. Ryberg and Patrick F. O'Hara

Mileage Cum.	Inc.	
0.0	0.0	Start today's field trip to the Big Bug stock leaving from the Prescottonian parking lot. Government Canyon granodiorite is overlain by Tertiary gravels.
0.1	0.1	Turn right on Route 69 and pass a cemetery on the right. Government Canyon is to the right.
0.3	0.2	On the left-hand side of the road there are outcrops of the Government Canyon granodiorite.
0.7	0.4	Outcrops of Government Canyon granodiorite are on the left.
1.5	0.8	Just pass the sign for the Bradshaw Ranger Station. Outcrops of Government Canyon granodiorite.
1.9	0.4	Outcrops of Government Canyon granodiorite.
2.1	0.2	Tertiary gravels
2.7	0.6	At the top of Bullwacker Hill, outcrops of Tertiary basalt associated with the Glassford Hill Tertiary volcanic complex.
3.2	0.5	Road heading off to the right leads to Lynx Lake. Outcrops on the left side of the road are of Government Canyon granodiorite.
3.8	0.6	Outcrops of the rocks of the Green Gulch Volcanics of the Big Bug Group.
4.1	0.3	Entrance on the left to Yavapai Hills.
4.4	0.3	Outcrops on the left are of the Green Gulch Volcanics of the Big Bug Group.
4.8	0.4	Outcrops of Tertiary gravels.
5.4	0.6	Outcrops on the left side of the road are of the Green Gulch Volcanics.
5.8	0.4	Hills off to the left are made up of basalts from Glassford Hill, and they overlie Tertiary gravels.
6.4	0.6	Entrance to the town of Prescott Valley. Straight ahead in the distance are

the Black Hills and Mingus Mountain.

6.7	0.3	On the right side of the road the hills are made up of the Crooks Canyon Complex. The rocks are a series of premetamorphic, pretectonic granodiorite similar to the Prescott granodiorite and the Government Canyon granodiorite.
8.7	2.0	Town center Prescott Valley.
9.5	0.8	Leaving town of Prescott Valley. The valley is underlain by Tertiary and Quaternary gravels.
12.4	2.9	Outcrops of Tertiary sediments on both sides of the road.
12.6	0.2	Entrance to the Prescott Country Club on the right.
13.3	0.7	Bible Training Center.
13.6	0.3	View off to the Southwest at 2:00 o'clock. The rounded hill is Spud Mountain, type locality of Spud Mountain Volcanics. Off to the right at 3:00 o'clock are the outcrops of the Crooks Canyon granodiorite complex, and in between the two is the Chaparral shear zone, which has a right-lateral component of movement. This ductile shear zone may be a controlling influence on the emplacement of the Laramide Walker and Big Bug stocks.
15.1	1.5	Route 169 intersects Route 69 on the left side of the road.
15.6	0.5	The hills off to the left from 3:00 to 12:00 o'clock are the northern extent of the Iron King Volcanics.
15.9	0.3	Outcrops of Tertiary or Quaternary gravels.
16.7	0.8	Off to the left is the stack of the old Humboldt smelter.
17.0	0.3	To the left is the turnoff to the town of Humboldt.
17.1	0.1	At 1:00 o'clock note the tailings from the Iron King mine.
17.5	0.4	Turn right onto the road to the Iron King mine.
17.6	0.1	Old railroad cut off to the left.
17.7	0.1	Tertiary Quaternary gravels.
17.9	0.2	Off to the right are the tailings of the Iron King mine.

18.1	0.2	STOP 1. The Iron King assay office. Pat O'Hara will summarize Proterozoic regional geology, Proterozoic mineralization, and Laramide regional geology.
18.9	0.3	Spud Mountain at 12:00.
19.4	0.5	Mine Dump adjacent to road on right. Note mine dumps along mineralized zones on south and east side of Spud Mountain. The upper set of workings delineates the trend of the Kit Carson vein while the lower set of workings are located on the Silver Belt vein. The Silver Belt vein may be the northern extension of the McCabe - Gladstone vein system. Both the Silver Belt and Kit Karson veins can be traced northward under cover using soil geochemistry.
20.1	0.6	Mine building on dump at 9:00.
20.3	0.2	Small headframe and dump on left side of road.
21.0	0.7	McCabe Mine at 12:00. Turn right on Little Jessie Mine road.
21.3	0.3	Turn left at wash..
21.6	0.3	McCabe townsite. Stop here for view of McCabe Mine.
21.9	0.3	California Mine at 11:00.
22.0	0.3	Cross contact between schistose Spud Mountain Volcanics and Big Bug granodiorite.
22.2	0.2	Dump at 3:00 is on east extension of Little Jessie vein.
22.4	0.2	Little Jessie dump at 1:00.
22.6	0.2	Road to right leads to base of Little Jessie dump. Continue straight ahead.
22.8	0.2	Turn right to Little Jessie Mine. George Ryberg will discuss the geology of the Little Jessie - Union vein systems.
24.6	1.8	Return to McCabe mine site. Pat O'Hara will discuss the geology and geochemistry of the McCabe - Gladstone - Rebel - Little Kicker vein systems.
26.5	1.9	Return to Iron King Assay. If time allows Pat O'Hara will lead a traverse through the Proterozoic Iron King mineralization and alteration.

Also, if time allows, Jed Maughn may be persuaded to discuss the oxidation of various mineral assemblages at various levels within the Big Bug stock. Jed is scheduled to be on the trip and indicated that he would be willing to dicsuss the results of his M. A. thesis. His thesis field work was conducted in the vicinity of our field trip stops.

GEOLOGY AND MINERALIZATION
OF THE
LITTLE JESSIE MINE
YAVAPAI COUNTY, ARIZONA

By

George E. Ryberg

The Little Jessie Mine is located in the Big Bug Mining District, Yavapai County, Arizona. Access is by Highway 69 to Humboldt and then by following a gravel road four miles southwesterly to the mine site.

The Little Jessie Mine was discovered in 1867 and was operated more or less continuously during the periods 1890-1898 and 1903-1915. Elsing and Heinman (1936) report that the total value of gold and silver production through 1935 was approximately $1,000,000. Lindgren (1926) notes that the mine was developed to the 600 level and that gold values ran between $10 and $20 (0.5 to 1.0 ounces) per ton.

In the Little Jessie area the Precambrian Spud Mountain Volcanics is intruded by a fine to medium grained granodiorite which was originally mapped by Anderson and Creasey (1958) as Precambrian. Later Anderson and Blacet (1972) mapped this area as a lobe of the Big Bug pluton and assigned an age of 70 m. y. based on a K-Ar date on a sample taken from a location along Big Bug Creek to the southwest. Schistosity along the granodiorite-schist contact and along shear zones in the intrusion suggest that the granodiorite is of Precambrian age (Ochs, 1983; O'Hara, 1985; Ryberg, 1985).

In general there is a strong northeasterly fabric to the rocks in the area. The schistosity in the volcanic rocks strikes northeasterly and the dip is near vertical. The mineralized shears and the intrusive contact also strike northeasterly with a near vertical dip. Diabase dikes and massive quartz lenses with a northeasterly strike also cut the granodiorite. In addition to the strong northeasterly trend a strong northwesterly fracture trend is present in the area.

Alteration is generally weak away from the shear zones. Near the shear zones the granodiorite becomes noticeably schistose and alteration becomes more intense with the addition of calcite, quartz and sericite. Mineralized shear zones up to tenfeet wide consist of a quartz-sericite alteration assemblage which is locally silicified. This alteration is commonly cut by quartz-pyrite veinlets and up to five percent disseminated pyrite is present. Arsenopyrite and chalcopyrite are present locally.

In the Little Jessie area much of the mineralization occurs at the intersection of the northwest trending fractures with the northeast trending shear zones. Most of the gold mineralization is probably associated with the quartz veinlets which crosscut the quartz-sericite alteration although some of the mineralization is probably associated with the disseminated pyrite.

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Phelps Dodge Copper Basin Deposit
Geological Tour, October 9, 1994
Arizona Geological Society
Bootprints along the Cordillera
Tour Leaders:
Michael R. Pawlowski, Senior Geologist
Ralph G. Ladner, Copper Basin Liaison

The Copper Basin copper deposit is located approximately 10 miles southwest of Prescott, Arizona in the Sierra Prieta Mountains. The deposit is a large tonnage, low-grade porphyry copper deposit with copper and molybdeneum mineralization hosted in multilithological breccia pipes. Copper Basin is an erosional depression formed in the Laramide stock adjacent to more resistant Precambrian rocks.

The deposit occurs in a northeast-trending Laramide composite stock and in cross-cutting breccia pipes. The stock appears to intrude parallel to the Precambrian foliations, and at the junction of three Precambrian plutons. The mineralization occurs on the west-central edge of the 5-mile long, Laramide equigranular granodiorite-quartz monzonite stock, in a 5,000-foot by 7,000-foot area. K-Ar age dates on primary biotite yield an age of 75.5 m.y. and K-Ar age dates on sericite yield an age of 72.8 m.y. The sequence of intrusions began with equigranular quartz diorite, granodiorite, and quartz monzonite followed by older quartz latite porphyry and younger quartz latite porphyry dikes which contain large feldspar and biotite phenocrysts.

Copper mineralization is most closely related to the older quartz latite porphyry that has been cut by approximately 25 known breccia pipes. The breccia pipes range from 200 to 600 feet in diameter and contain rotated fragments of Precambrian foliated quartz diorite, granodiorite, quartz monzonite and older quartz latite porphyry. Angular fragments are dominant near the outer margin of the hydrothermal breccia pipes and subrounded fragments occur in the central zone. A younger quartz latite porphyry intrudes and cross-cuts the breccia pipes. The breccia fragments and matrix are partially replaced and cemented by quartz, secondary orthoclase and sulfides including pyrite-chalcoprite and bornite. The contacts between the brecia pipes with wallrock may be sharp or may grade into crackle breccia or stockwork zone. The breccia pipes appear to coalesce at depth.

Primary copper and molydeneum mineralization is associated with potassic alteration of secondary biotite and orthoclase followed by late quartz-sericite veins. Chalcopyrite and molybdenite replace mafic sites. Disseminated hornblende is replaced by secondary biotite altered to sphene, rutile, allanite and apatite. Thin veinlets of quartz-orthoclase-calcite and apatite are cross-cut by quartz sericite-pyrite-anhydrite veins. Quartz-sericite pyrite assemblages increase outward from the central zone to over 3-5 weight percent pyrite, before decreasing in the epidote-chlorite zone.

Secondary copper mineralization is controlled by the abundance of pyrite and erosional level. Leached capping which consists of goethite-jarosite is developed in the permeable and higher pyritic breccia pipes. Oxide copper mineralization is underlain by supergene-enriched chalcocite-covellite that was developed by the old mines at the Commercial Mine, Smelter Hill Breccia Pipe, Aztec Breccia, Loma Prieta Mine, Quartz Hill Pipe, Victoria Pipe and Copper Hill Mine. Oxide copper minerals consist of azurite, malachite, cuprite, brochantite and chrysocolla.

Gold grades are very low in the Copper Basin porphyry copper deposit but higher grade placer deposits occur in an older caliche cemented gravel and in recent stream gravels.

Drive from Prescott via Iron Springs Road (Highway 69) to Skull Valley. Head east on Copper Basin Road to Copper Basin Wash.

Stop 1: 8:30 a.m. to 9:15 a.m.

Copper Basin Wash south of Smelter Hill Breccia.

Examine stockwork - veins in Laramide older quartz latite porphyry and crackle breccia and younger quartz latite porphyry in Copper Basin Wash. Rhyolite Hill to the south has been dated by K-Ar methods at 14.94 m.y. Copper Basin Wash cemented gravels and recent wash gravels host wire gold nuggets.

Stop 2: 9:20 a.m. to 10:30 a.m.

Commercial Hill Mine and Breccia Pipe. Please use safe practices on steep hill and around old mine workings.

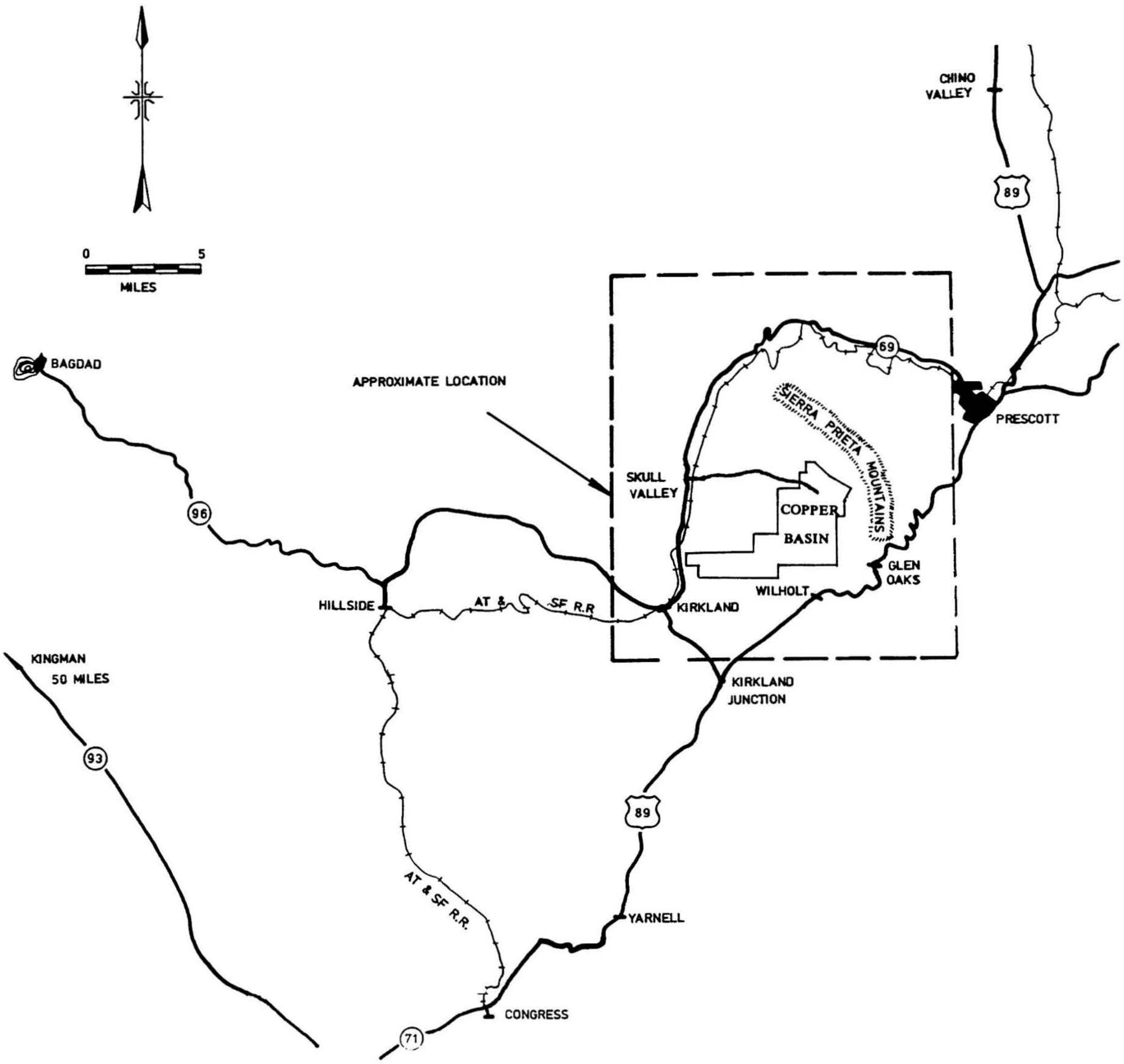
Long traverse will examine oxide copper mineralization and/or breccia pipe at the Commercial Hill Mine. Walk up steep hill to contact of the Breccia Pipe and quartz latite porphyry wallrock. Continue to walk approximately 600 feet through Breccia Pipe to the west contact with Precambrian wall rocks. Traverse copper mineral workings with malachite, azurite, cuprite and native copper exposed.

Optional stop to Aztec Breccia Pipe to northeast and/or Smelter Hill Breccia Pipe to southeast.

Stop 3: 10:40 a.m. to 11:30 a.m.

Copper Hill Breccia Pipe along Copper Basin County Highway.

Examine old Copper Hill Mine dump with oxide copper and chalcopyrite molybdenite bearing veins and disseminations. The Copper Hill Breccia Pipe is about 300 feet in diameter and occurs northeast on the adjacent hill and intrudes hornblende quartz diorite.


0
5
MILES
BAGDAD
96
APPROXIMATE LOCATION
CHINO VALLEY
89
69
SIERRA PRIETA MOUNTAINS
PRESCOTT
SKULL VALLEY
COPPER BASIN
GLEN OAKS
WILHOLT
HILLSIDE
AT & SF R.R
KIRKLAND
KINGMAN 50 MILES
KIRKLAND JUNCTION
93
89
AT & SF R.R.
YARNELL
CONGRESS
71

COPPER BASIN FIELD TRIP STOPS