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GEOLOGICAL SURVEY

Physical characteristics of alluvium and geochemistry of pebbles and cobbles from the alluvium in drill core above the Rabbit Creek gold deposit, Getchell mining district, Humboldt County, Nevada

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ABSTRACT

Core samples of a 460-foot (140-m) section of alluvium from a hole drilled in section 19, T. 39 N., R. 43 E., were studied to determine the nature and the source of partly consolidated, metal-enriched sediment and to determine whether the detritus could have introduced metals to the alluvium above the Rabbit Creek gold deposit in Humboldt County, Nevada. Three- to nine-inch (8-24 cm) samples of core were taken at 20-foot (6-m) intervals and described. The samples were disaggregated and sieved to study grain-size distribution, mineralogy, and the lithology and chemical composition of pebbles and cobbles. We did this study in conjunction with an intensive geochemical study of the same samples (Detra and others, 1989; Theobald and others, 1990), which was done in order to determine if buried ore deposits can be found by studying the geochemistry of overlying alluvium.

Hand samples of the core lacked obvious size grading and cross stratification and appeared to be matrix supported. Petrographic study showed that the alluvium is mostly clast supported at that smaller scale.

Sieving and grain-size analysis of each sample shows that the alluvium is a very poorly sorted, variably indurated conglomerate, which has a graphic mean grain size of very coarse sand (-0.91ϕ) and a mean inclusive graphic standard deviation of 3.07ϕ (phi). Mean grain size ranges from medium-grained sand to pebble. The degree of sorting decreases upward from a mean standard deviation of 2.70ϕ in the lower 160 ft (49 m) of the section to a mean of 3.32ϕ in the upper 300 ft (91 m).

The cobbles and pebbles were separated according to lithology and weighed to determine the proportions of each lithology in each sample. The proportions of the most commonly identified pebble lithologies vary upward in the stratigraphic section, as shown by a comparison of mean abundances of selected lithologies between the lower 160 ft (49 m) and top 300 ft (91 m) of the alluvial section: siltstone and foliated metasedimentary rocks (54%, 26%); sandstone (3%, 1%); conglomerate (1%, <0.01%); limestone (5%, 35%); mafic volcanic and/or hypabysssal rocks (4%, 7%); silicified rocks (4%, 10%); and secondary calcium carbonate (caliche) that forms clasts (2%, 4%).

About two-thirds of the silicified rock clasts and one-third of the other rock clasts that were separated from the pebble and cobble fractions of the sediment are enriched in metals: Ag (as much as 20 ppm, mean 0.7ppm), Ti (as much as 1.4%, mean 0.3%), As (as much as 1760 ppm in one sample), W (>1% in one sample), and Ge (as much as 20 ppm in one sample). About three-fourths of the silicified and mineralized-looking clasts are enriched in Au (as much as 123 ppb in one sample, mean 3.9 ppb). The metal-enriched clasts could have been derived from nearby mineralized systems along the northern part of the Getchell gold belt. Some enriched metals in the alluvium occur in readily soluble form, and their source is less certain (Detra and others, 1989; Theobald and others, 1990). The soluble metal suite notably lacks Ag, which is enriched in many pebbles. The lack of Ag suggests that a source in addition to the alluvial detritus might have contributed metals to the alluvium. Some metals may have migrated in solution upward or laterally from mineralized bedrock of the Rabbit Creek gold deposit.

On the basis of our study, we conclude that some of the rock clasts were eroded from mineralized systems along the northern extension of the Getchell gold belt, and that such detritus could have contributed some metals to the alluvium. We also conclude that the alluvial section records a significant change in the proportions of clast types at a depth of about 300 ft (91 m), including a significant increase in the proportion of limestone clasts. The change in clast types could be due to progressive unroofing of underlying units, a geographic change in the source area, an overlapping of fans fed by streams eroding different geologic units, or a decrease in precipitation in the source area. Drying of the climate would have allowed more limestone to survive chemical weathering in the source area and to be available as detritus.

INTRODUCTION

Interest in concealed mineral deposits has been growing as deposits exposed at the surface become harder to find and as known deposits are exhausted. However, geologic and geochemical studies generally are directed at bedrock in the mountain ranges, rather than at basin fill in the intervening basins of the Basin and Range province. There may be geologic and geochemical information in the basin fill that can help to prospect for buried deposits such as the Rabbit Creek gold deposit. The deposit was concealed by alluvium at the time of its discovery, and the geology was known only from drilling and geophysical data.

The Rabbit Creek deposit occurs with other, (exposed) gold deposits along the Getchell gold belt, on the east side of the Osgood Mountains in Humboldt County, Nevada (figure 1). Parratt and others (1989) described the host rocks of the Rabbit Creek deposit as Lower Ordovician shale, limestone, and basalt. About 2 mi (3 km) to the north of the Rabbit Creek deposit is the Chimney Creek deposit, which is hosted in siliciclastic and carbonate rocks of the Middle Pennsylvanian-Lower Permian Etchart Limestone (Osterberg, 1989) and in basalt of uncertain age. The Getchell gold mine, located about 4 mi (6.4 km) to the southwest of the Rabbit Creek deposit, is hosted in Cambrian and Ordovician strata of the Preble and possibly the Comus Formations (Joralemon, 1951; Hotz and Willden, 1964; Berger and Taylor, 1980). The Pinson and Preble gold mines, described by Kretschmer (1984, 1986), occur 9 mi (14.5 km) and 19 mi (30.6 km) to the south, respectively, of the Rabbit Creek deposit. The Preble deposit occurs in the Lower Cambrian-Lower Ordovician Preble Formation (Madden-McGuire and Carter, 1988; Madden-McGuire, 1989) and the Pinson deposit occurs in the Upper Cambrian and Lower Ordovician Comus Formation.

The purpose of this study was to determine the nature and origin of the alluvium, and to find out if any of the metals, such as Au, Ag, and As, were derived from mineral deposits in the source area of the alluvium and introduced mechanically as alluvial detritus to the metal-enriched basin fill above the Rabbit Creek gold deposit. We examined core samples from one drill hole in section 19, T. 39 N., R. 43 E (figure 2). We made the assumptions that this drill hole provided a representative sample of the alluvium, and that our core samples, approximately 0.5 ft (0.15 m) for every 20 ft (6.1 m), adequately represented the total drill-hole section. We studied 21 samples of the alluvial core in conjunction with an intensive geochemical study of finer size fractions of the same samples (Detra and others, 1989; Theobald and others, 1990). (The associated geochemical study was designed to determine whether metals were derived from underlying bedrock and whether buried ore deposits could be found by studying the geochemistry of the alluvium). This is the first such intensive public study of the geology and geochemistry of basin-fill deposits above a concealed gold deposit along the Getchell gold belt.

Specific questions regarding the nature and source of the basin-fill deposits were studied. (1) Where was the source area for the alluvium? What geologic units were exposed there? These questions were best answered by studying the types of pebbles and cobbles found in the gravel. (2) Could the alluvial detritus have contributed to the metal enrichment of the alluvium? Some of the alluvium may have been mechanically derived from nearby mineralized systems along the northern part of the Getchell gold belt, and some of the alluvium may have been chemically changed (grains coated) in situ by upward migration of metals from mineralized bedrock of the underlying Rabbit Creek gold deposit. To evaluate the possibility that soluble metals were leached from detritus, we studied the geochemistry of selected pebbles. (3) What were the depositional and climatic conditions during formation of the alluvium? Are the gravels water-laid or debris-flow deposits, and can this be determined from limited sampling of one core hole, without outcrops and lateral facies data? Was the climate always dry during deposition? (4) What is the age of the alluvium, and what could age data tell us about regional and local tectonics?

These questions were addressed by doing basic geologic description and interpretation of the core, grain-size analysis from sieve data, and studies of the mineralogy of sand and silt and lithology and geochemistry of pebbles.

METHODS OF STUDY

We examined and analyzed 21 samples of alluvial core, each sample 3-9 in (7.5 - 22.5 cm) long, from core hole 313A, sec. 19, T. 39 N, R. 43 E., at the site of the Rabbit Creek gold deposit (figure 2). We labeled the samples so that their numbers increase with depth in the alluvium. The samples were wrapped in aluminum foil while still wet, then transported and photographed. We allowed them to air dry for several days before examining them.

We did a visual examination of the core samples with a hand lens and a binocular microscope. The examination resulted in a brief description of the content, shape, and proportions of the clasts, as well as the degree of induration, nature of matrix, presence and nature of the cementing medium, and color of the core. We described color with the aid of a standard soil color chart.

Following visual examination, we placed pieces of core in a beaker of 3N HCl and water and described the nature of the subsequent reaction. After acidification of each sample in HCl, the finer grained, sand-size material was decanted several times during successive washings. We noted the presence of quartz and other minerals in this sand-size fraction. The descriptions of the core samples are given in Appendix A.

Two pieces of each sample were submitted to make thin sections. Some of the thin sections were difficult to make, because of the varying degrees of induration of the core samples. Descriptions of thin sections are given in Appendix B. Minerals that could not be identified in thin section were identified by X-ray diffraction.

The remainder of each core sample was disaggregated and sieved in preparation for studies of grain-size distribution, mineralogy, and geochemistry of the various sieve fractions. Before disaggregation, the samples were weighed. During disaggregation, great care was taken not to break cobbles and pebbles. The softer clasts were removed when they were noted. The disaggregated samples were reweighed and sieved.

The samples were sieved into seven size fractions by using a Rototap Sieve Shaker that ran for 20 minutes per sample. The size fractions generated were as follows: +4 mesh (+4.75 mm), -4/+8 mesh (+2.36 mm), -8/+20 mesh (+0.85 mm), -20/+60 mesh (+0.25 mm), -60/+100 mesh (+0.15 mm), -100/+250 mesh (+0.63 mm), and -250 mesh (-0.63 mm). Each size fraction was weighed and the raw-weight data (table 1) from the various size fractions were used for grain-size analysis. Additional size fractions were generated by further hand sieving of the coarsest material (+4 mesh, +4.75 mm), which represented more than 30% of the weight of most samples. The additional size fractions are as follows: +50 mm, +45 mm, +31.5 mm, +25 mm, +19.1 mm, +12.7 mm, and +9.52 mm. Data that were generated by hand-sieving are shown in table 2.

Grain-size analysis was done by constructing cumulative curves from the sieve data. Sieve data from selected samples are illustrated in histograms and cumulative frequency curves in figure 3. The coarse ends of the cumulative curves were constructed from the additional data points that were generated by hand sieving. These additional points allowed us to better determine graphic percentiles. Linear combinations of the percentiles were used to calculate graphic statistical parameters of grain size. The parameters that were calculated by the graphic method are graphic mean grain size, graphic standard deviation, inclusive graphic skewness, and graphic kurtosis (Folk and Ward, 1957). The selected percentiles and calculated parameters are listed in table 3.

We examined the mineralogy of heavy minerals from two size fractions, the -100/+250 mesh (coarse silt to fine sand) and the -20/+60 mesh (medium to very coarse sand). We separated the heavy minerals in bromoform, with a specific gravity of 2.85. The lighter minerals, with specific gravities of less than 2.85 (clays, quartz, feldspar), were removed and the heavy minerals were rinsed in acetone and air dried. The heavy minerals then were placed in contact with the surface of a large electromagnet (in this case a modified Frantz Isodynamic Separator) and separated into three fractions: (1) a strongly magnetic fraction consisting mostly of magnetite, (2) a weakly magnetic fraction consisting mostly of manganese- and iron-oxide minerals, and ferromagnesian silicates, and (3) a very weakly magnetic to non-magnetic fraction, containing zircon, apatite, barite, and most of the sulfides and native-element minerals. Each of the magnetic fractions of the heavy minerals was examined with a binocular microscope to determine the occurrence and approximate abundance of each mineral. Several identifications were confirmed by X-ray diffraction. The mineralogic data were reported by Detra and others (1989) and are illustrated in figure 4. The mineral abundances are expressed in parts per million of the particular size fraction of the alluvium.

X-ray diffraction analyses were made of various size fractions of the alluvium in order to identify the major minerals and to look for variations in mineralogy with size and depth of the sample. The size fractions that were analyzed were as follows: -20/+60 mesh, -60/+100 mesh, -100/+250 mesh, and -250 mesh. A small split of each size fraction was ground to about -300 mesh and prepared as a smear on a glass slide for X-ray diffraction analysis. X-ray patterns were generated with copper-K_α radiation at a goniometer speed of 2° 2Θ- per minute and chart speed of 2° per minute. The peak heights were measured in arbitrary units above background at 9° 2Θ- (mica), 12.5° (kaolinite), 20.9° quartz, 28° feldspar, and 43.2° calcite. The area of the peak at 6° was used as a measure of the amount of montmorillonite. The measurements show, in a semiquantitative manner, the change in amounts of various minerals with depth, as illustrated in figure 5.

We studied the +4-mesh pebbles and cobbles separately. We sorted them by lithology with the aid of binocular and petrographic microscopes and X-ray diffraction of selected clasts. The various clast types then were weighed to determine the percentage by weight of each type in each sample. The weights and percentages of the more common clast types are shown in tables 4 and 5. The mean abundances of each of these clast types were determined for the entire section, the top 300 ft (91 m), and the bottom 160 ft (49 m) of the alluvium, table 6. Figure 6 shows the proportions of various clast types in bar graphs, and figure 7 illustrates some of the clast types in photomicrographs.

GEOLOGICAL ASPECTS OF CORE SAMPLES

Descriptions of core samples

Our examinations show that the alluvium is generally comprised of muddy, sandy polymictic gravel to conglomerate, which varies in color from predominantly light tan to gray in the top 300 ft (91 m) to yellow, brown, and red in the bottom 160 ft (49 m). The alluvium contains a large pebble and cobble fraction; the +4.75-mm fraction makes up more than 30% of most samples. The angular to subrounded pebbles and cobbles (clasts) occur in a matrix of sand-size rock and mineral grains with some clay-size material. Quartz dominates the matrix material. A very fine grained mixture of calcium carbonate and clay minerals is interstitial to the rock fragments and mineral grains. This mixture probably represents matrix as well as cement, and it may even contain clasts of caliche that were deformed between harder framework clasts. Such deformation was seen locally in thin sections and in hand specimens, where clasts of caliche partially wrap around other framework clasts.

The degree of induration varies through the section such that the alluvium ranges from a friable sediment to a well-indurated rock; also, the abundance of calcium carbonate cement varies through the alluvial section, and calcium carbonate cement is missing entirely in some samples. For example, samples 14 (323 ft, 98 m depth) and 15 (342 ft, 104 m depth) are clast-supported conglomerates that contain interstitial clay matrix and more limonite and hematite than the other samples, but lack interstitial calcium carbonate. Samples 20 (422 ft, 129 m depth) and 21 (449 ft, 137 m depth) also lack interstitial calcium-carbonate cement and contain a tuffaceous-looking clay matrix. Voids that are as much as 1 cm in diameter occur in about half of the samples that were studied. The clast-supported nature of the alluvium was seen in slabbed samples and in thin section.

Petrographic study of the core samples provided information about rock fabric, clast types, nature of matrix and cement, and the presence of secondary minerals. The results showed that at the scale of a thin section much of the alluvium is clast supported and locally in slabbed core. This is particularly true of samples below number 4 (83 ft, 25 m depth). The packing of the framework clasts is especially tight in samples below number 9 (202 ft, 62 m depth).

The alluvium contains clasts of limestone, silicified rocks (such as diagenetic chert and jasperoid), siltstone, foliated metasedimentary rocks, sandstone, conglomerate, iron-stained gossan, mafic volcanic/hypabyssal rocks, round clasts of sedimentary quartzite (quartz arenite), round clasts of detrital caliche, and similarly round coatings of caliche on various clast types. Some clast types are shown in photomicrographs in figure 7.

Volcanic material occurs in the alluvium. Well preserved shards of volcanic glass (fig. 7L) are apparent in samples 8 (176 ft, 54 m depth) and 12 (275 ft, 84 m depth). The shards (200μm) are best preserved within thick caliche coatings (1200μm) on clasts, but also preserved within the interstitial matrix and cement. The clasts that in hand samples had originally resembled biotite-bearing tuff were probably caliche clasts containing black shards of volcanic glass, as seen in thin section.

Within some of the limestone clasts, we recognized crinoid columnals, pelloids, late Paleozoic endothryid forams, scraps of bryozoa, fusulinids, and echinoid spines (fig. 7A). Locally, crinoid fragments within these clasts are micritized. The crinoids contain microscopic, mud-filled "borings" of endolithic algae as discussed in Bathurst (1971). This micritization indicates that deposition of the original limestone unit occurred in a shallow-water environment within an ancient photic zone.

The foliation in the metamorphic clasts (fig. 7F), especially those that are only weakly foliated, was most easily recognized in thin section. The volcanic textures of the mafic volcanic or hypabyssal rocks also became apparent in thin sections (fig. 7 G-I), and the calcic compositions of their plagioclase microlites were determined by the microlite method (Heinrich, 1965).

The secondary minerals noted in thin sections include grains of goethite, which replace secondary, euhedral (pyritohedral) pyrite (fig. 7M-N). There are also tiny grains of fresh, relict, pyritohedral pyrite (the same shape as the goethite-replaced grains). Locally, there is an abundance of secondary calcium carbonate that filled voids and possibly even expanded the rock during in situ growth in sample 11 (249 ft, 76 m).

Grain-size analysis

The alluvium consists mostly of variably indurated conglomerate that is very poorly sorted, finely skewed, and platykurtic in its grain-size distribution. Gravel content of the alluvium averages 51%, sand content averages 41%, and mud (silt plus clay) content averages 8%. Most of the samples are muddy, sandy gravel, but one sample is gravelly, muddy sand (figure 8). Selected percentiles and statistical parameters of grain size are shown in table 3. The graphic mean grain size of the alluvium ranges from lower medium-grained sand in sample 20 (1.81ϕ) to pebble in sample 5 (-2.16ϕ). Most mean grain sizes fall in the range of very coarse sand, from 0ϕ to 1ϕ. Very poor sorting is indicated by high graphic standard deviations of 2.4-3.6ϕ. This is consistent with the empirical observations that sorting is worst in sediments that have mean grain sizes in the very coarse sand range (0-1ϕ) and best in the fine-sand range (2-3ϕ) (Folk, 1980). None of the Rabbit Creek alluvial samples have mean grain sizes in the fine-sand range of 2-3ϕ. The fine-sand fraction (2-3ϕ) is relatively low in all samples, which suggests that the source area lacked extensive exposures of granular rocks (such as the granodiorite of the Osgood Mountains stock exposed to the southwest in the Osgood Mountains), which would break down to sand-size detritus.

The alluvium above the Rabbit Creek gold deposit shows a change in grain-size distribution at about 300 ft (91 m). The alluvium is more poorly sorted in the top 300 ft (91 m) than in the bottom 160 ft (49 m) (tables 3 and 7). The mean standard deviation is 3.2ϕ in the top and 2.7ϕ in the bottom of the alluvial section. We suggest that the upward decrease in the degree of sorting could have resulted indirectly from a decrease in precipitation.

The alluvium is finely skewed (0.01-0.39), which means that grain-size distributions generally have tails in the fine grain sizes and strongest modes in the coarse sizes. Kurtosis, a measure of the ratio of sorting in the tails and in the central part of the grain-size distribution, of most samples is platykurtic (flat curve) to mesokurtic (normal curve) (1.07-0.7). Only one sample, number 18, has a leptokurtic (peaked) curve and kurtosis of 1.17. The platykurtic curves indicate that sorting is best in the tails.

Some strongly platykurtic curves are actually bimodal, and some of the alluvium from the core hole has a bimodal grain-size distribution. The modes generally occur in the very coarse sand-size range (0ϕ to -1ϕ) and very fine sand-size range (3ϕ to 4ϕ). These modes may result from the size distribution of materials that were available in the source area, near or at their original rock outcrops. The bimodal grain-size distributions do not appear to be mixtures of log-normal populations, but rather, mixtures of immature materials that were not sorted and had not travelled far.

In summary, grain-size analysis shows that the alluvium has a graphic mean grain size ranging from lower medium-grained sand to pebble, with most mean sizes falling into the very coarse sand range (0-1ϕ). The alluvium is very poorly sorted, positively skewed, and mesokurtic to platykurtic in grain-size distribution. The degree of sorting decreases upward in the alluvial section. Some samples have a bimodal grain-size distribution, which is probably due to the size of materials available in the source area.

Studies of alluvial fans in other areas include a very comprehensive study that was done in western Fresno County, California by Bull (1960, 1964). Bull distinguished mudflows (debris flow), intermediate, and water-laid stream and flood deposits in surface outcrops, and he found that the deposit types differed in their grain-size distributions enough that they could be recognized in the subsurface by analyzing the grain size of local core. A comparison of the grain size distributions of the alluvium above the Rabbit Creek gold deposit and in Fresno County is shown in table 7. Generally, there are no comparable deposit types between the two areas because of the great differences in mean grain size between areas.

Clast types

The most common clast types in the alluvium are siltstone, foliated metasedimentary rocks, limestone, silicified rocks (diagenetic chert and jasperoid), and basalt with microlites of calcic plagioclase. In addition, the proportions of the most commonly identified pebble and cobble lithologies vary stratigraphically in the alluvium (figure 6, tables 4-6). The most obvious changes in proportions of clast types occur at about 300 ft (91 m), between samples 13 and 14, so we selected that horizon as the stratigraphic boundary between the top 300 ft (91 m) and bottom 160 ft (49 m) of the alluvium for convenience in discussion. The changes are shown by a comparison of mean abundances of selected lithologies between the bottom 160 ft (49 m) and top 300 ft (91 m) of the alluvial section. The mean abundances of the bottom and top of the hole are shown respectively in parentheses, following each clast type: siltstone and foliated metasedimentary rocks (54%, 26%); sandstone (3%, 1%); conglomerate (1%, <0.01%); limestone (5%, 35%); mafic volcanic and/or hypabysssal rocks (4%, 7%); silicified rocks (4%, 10%); and detrital secondary calcium carbonate (caliche) (2%, 4%). Siltstone and metasedimentary rock clasts were grouped together, because they were difficult to distinguish without petrographic study where foliation was weak. The mean abundances of clast types show that in an upward direction the proportions of limestone, mafic igneous rocks, silicified rocks, and caliche increase, and the proportion of siliciclastic rocks decreases.

Comparison with the finer size fractions of the alluvium shows that there is a correspondence between changes in clast type and changes in mineralogy. For example, as the siliciclastic clasts (siltstone, sandstone, and conglomerate) decrease, the abundance of quartz in the clay-size fraction decreases (and feldspar increases). As mafic volcanic clasts increase in abundance, so do medium-sand-size pumpellyite and fine-sand- to silt-size pyroxene in the heavy-mineral fraction of the sediment.

Heavy minerals

Examinations of heavy minerals in silt-to-sand-sized fractions of the disaggregated sediment showed great variations in the abundances of some minerals. Some of these variations reflect presence and proportions of rock types exposed in the source area during formation of the alluvium, whereas others reflect abundances of secondary minerals and possibly the effects of diagenetic processes that operated within the alluvium after its deposition.

Exposures of mafic rocks such as basalt flows, sills, and volcaniclastic rocks may have been more extensive during accumulation of the upper part of the alluvium. This is suggested by an increase in the proportions of silt-to-sand-size pumpellyite and hornblende above 275 ft (84 m) and pyroxene above 200 ft (61 m).

Detritus from volcanic tuff and possibly from plutonic rocks may be especially concentrated in five intervals that contain relatively great abundances of zircon, apatite, or biotite, e.g. 0-83 ft (0-25 m), 124 ft (38 m), 200-250 ft (61-76 m), 342 ft (104 m), and 380-422 ft (116-129 m). Some horizons within these intervals contain relatively great abundances of two or all three of these minerals, e.g. 60 ft (18 m), 342 ft (104 m), 380 ft (116 m), and 421 ft (128 m). These intervals may record either the reworking of volcanic airfall deposits or erosion of plutonic rocks in the source area. Grain-size analyses show a low abundance of fine-sand size material, suggesting that there were not extensive exposures of plutonic rocks in the source area. It is likely that the zircon, apatite, and biotite are from volcanic tuffs.

The silt- and sand-sized fractions of the sediment vary in their contents of phosphates. We found that the proportion of phosphates in the silt-sized fraction varies inversely with that of limestone clasts in the +4-mesh fraction of the sediment (figure 9). This inverse relationship may be due to the types of facies that were exposed in the source area, or to climatic change during deposition of the alluvium.

Phosphates occur in sandstone and dolomitic-sandstone of the Adam Peak Formation (Upper Pennsylvanian-Lower Permian), which is now exposed only to the south of the source area (Hotz and Willden, 1964). The Adam Peak Formation, which contains shale, siltstone, dolomitic sandstone, chert, and limestone, is coeval with parts of the Etchart Limestone of the Dry Hills.

Perhaps the abundances of phosphates and limestone clasts in the alluvium were controlled by facies that were eroded in the source area. If this were the case, then high limestone abundance and low phosphate abundance in the alluvium reflects exposure and erosion of the Etchart Limestone, whereas high phosphate and low limestone abundances in the alluvium reflect erosion of more siliciclastic and phosphate-bearing Adam Peak facies in the Dry Hills.

An alternative explanation for the inverse relationship between phosphates and limestone in the alluvium is that their relative abundances reflect climatic change in the source area. The phosphates in the alluvium may be residues of dolomitic sandstone, and perhaps limestone, which was attacked by chemical weathering either in the source area or in the alluvium during diagenesis. Thin-section study showed no clear, textural evidence for dissolution of dolomitic sandstone or limestone pebbles within the alluvium, although there is evidence for such dissolution very locally in mine exposures. It is possible that such dissolution occurred, in part, in the source area during wetter climatic intervals. Stratigraphic horizons within the alluvium that contain relatively great abundances of phosphates may record wetter climatic periods. During such periods, chemical weathering would have been more active in the source area and phosphates would have been weathered out of outcrops and concentrated in valley-fill sediment.

Secondary barite occurs as fragile crystals grown around magnetite, as well as other grains. The barite is most abundant at 323 ft (99 m), but also at 83 ft (25 m), 149 ft (45 m), and 402 ft (123 m). Interpretation of grain shapes suggests that the barite occurs as a secondary mineral filling voids in the alluvium rather than as detrital grains. Barite was not observed in thin sections, and it may have been overlooked or plucked out during grinding of the thin sections.

Specular hematite is most abundant in the bottom 160 ft (49 m) of the alluvium, where it occurs as euhedral plates. Being a hard and resistant mineral, it may be detrital and eroded from iron-enriched zones upslope, or it may be diagenetic.

Magnetite abundance shows a bimodal distribution with modes between 342 ft and 421 ft (104-128 m) and between 60 ft and 224 ft (18-68 m). The magnetite is interpreted as mostly detrital and the significance of its distribution is uncertain.

Geology of the source area

The Dry Hills, and outcrops of Paleozoic, siliciclastic, sedimentary rocks that extend northeast from the Dry Hills (Stewart and Carlson, 1978), constitute the most likely source areas for the alluvium. These areas are nearby and upslope from the Rabbit Creek deposit, and the alluvium consists of pebbles and cobbles that resemble Paleozoic and Tertiary rocks that are exposed there. There are no paleocurrent data available from most of the alluvial section, although limited data from the upper 30 m (100 ft) indicate current to the southeast (Madden-McGuire, unpub. field data, 1989). The rocks in the source areas can be subdivided into four gross stratigraphic units: lower Paleozoic (Cambrian and Ordovician) sedimentary and metasedimentary rocks, upper Paleozoic (Pennsylvanian to Permian) units of the overlap assemblage (Antler sequence) of Roberts and others (1958), upper Paleozoic (Mississippian to Permian) siliceous sediments and basalts that are thrust over the units of the Antler sequence, and Tertiary basalt and andesite that are intercalated with rhyolite and sedimentary rocks in the northern Dry Hills.

The lower Paleozoic units in the northern Osgood Mountains, south of the Dry Hills, were mapped and described by Hotz and Willden (1964). These strata consist of the Preble Formation (Lower Cambrian to Lower Ordovician; Madden-McGuire and Carter, 1988; Madden-McGuire, 1989), Comus Formation (considered in 1989 to be Upper Cambrian and Lower Ordovician), and Valmy Formation (Ordovician). The Preble Formation consists of regionally metamorphosed phyllitic shale, which contains some interbedded limestone and quartzite. The Preble is thermally metamorphosed where it is adjacent to the Cretaceous plutons in the Osgood Mountains, south of the source areas for the alluvium. The Preble Formation is not exposed in the Dry Hills. The Comus Formation consists of dolomite, limestone, and shale with subordinate chert, siltstone, and tuff. In addition to the sedimentary rocks, Berger and Taylor (1980) grouped intermediate to mafic volcanic rocks in the Comus Formation. These volcanic rocks were originally considered to be Valmy Formation by Hotz and Willden (1964). Shale in the Comus Formation is locally metamorphosed to phyllite in exposures at the top of the range in the northern Osgood Mountains. Hotz and Willden (1964) mapped the Valmy Formation near the Getchell mine. The Valmy Formation is mainly chert and shale, but greenstone east of the Getchell mine was mapped as Valmy by Hotz and Willden (1964). The contacts between the mafic volcanic rocks and adjacent, lower Paleozoic units are faults or covered. It is uncertain whether the original contacts between the mafic volcanic rocks and sedimentary rocks of the Preble and Comus Formations were depositional or tectonic in the northern Osgood Mountains and Dry Hills area.

The upper Paleozoic strata of the Antler sequence have been mapped and described by Hotz and Willden (1964). These strata include the Battle Formation (Middle Pennsylvanian), the Etchart Limestone and siliciclastic Adam Peak Formation (Upper Pennsylvanian and Lower Permian), and thrust blocks which consist of distal siliciclastic deposits of the Farrel Canyon Formation (Pennsylvanian? to Permian?) and mafic volcanic rocks of the Goughs Canyon Formation (Mississippian). The Battle Formation is a boulder conglomerate, which contains clasts of sedimentary quartzite (quartz arenite). The Etchart Limestone is a shallow-water deposit of limestone and sandy limestone. The Adam Peak Formation, exposed along the crest of the Osgood Mountains to the south of the source area for the alluvium, is a sequence of shale and siltstone, with lesser sandstone and dolomitic sandstone. The sandstone characteristically contains phosphate (collophane) as pellets and irregularly shaped particles in the matrix (Hotz and Willden, 1964). Similar, phosphate-bearing, siliciclastic facies within the coeval Etchart Limestone may have provided phosphates to the alluvium. The Farrel Canyon Formation consists of sandstone, shale, siltstone, chert, and volcanic rocks consisting of andesite to dacite. The andesitic to dacitic rocks are weakly metamorphosed. The Goughs Canyon Formation consists of altered pillow lavas and coarse volcanic breccia, which are only exposed on the west side of the Osgood Mountains.

The Tertiary volcanic rocks are chiefly andesite and basaltic andesite flows that are locally underlain by rhyolitic tuff (Hotz and Willden, 1964). Olivine basalt flows occur locally. Hotz and Willden (1964) described highly vesicular flows with twisted, bulbous appearance and slightly ropy surfaces in the area. A few such ropy-looking clasts occur among the volcanic clasts within the alluvium.

Another possible source area for the alluvium lies to the northeast of the Rabbit Creek deposit in the Snowstorm Mountains and upper Kelly Creek, where the exposures of basalt and siliciclastic Paleozoic rocks are not all shown on published maps (A.R. Wallace, oral commun., 1989). The Snowstorm Mountains expose middle Miocene mafic to felsic volcanic flows and pyroclastic rocks covered by rhyolite flows, peralkaline ash-flow tuffs, and crystal-rich rhyodacite domes and upper Miocene and Pliocene basalt flows, with Paleozoic sedimentary rocks exposed in erosional windows (Wallace, 1989). These rock types have not been found in abundance in the alluvium sampled above the Rabbit Creek gold deposit, but the Snowstorm Mountains cannot be completely ruled out as a source area.

GEOCHEMISTRY OF PEBBLES AND COBBLES

We analyzed pebbles and cobbles of silicified rocks, gossan, and apparently unaltered rocks as a possible detrital source for metals in the metal-enriched alluvium. We selected individual pebbles from the +4-mesh size fraction for chemical analyses; most of these pebbles looked altered. No pebbles were analyzed from sample 20, because of the small size of the +4-mesh fraction of that sample. Seventy-eight pebbles were analyzed by semi-quantitative direct-current arc emission spectrography (Grimes and Marranzino, 1968). The analytical data are shown in Detra and others (1989) and statistical estimates from the analytical results are summarized in tables 8 and 9 of this paper. About two-thirds of the silicified clasts and one-third of the visually unaltered clasts were enriched in a number of metals, including Ag (as much as 20 ppm, mean 0.7 ppm) Ti (as much as 1.4%, mean 0.3 %), As (as much as 1760 ppm in one sample), W (>1% in one sample), Ge (as much as 20 ppm in one sample), and Au (as much as 123 ppb in one sample, mean 3.9 ppb). Bar graphs in figure 10 show the maximum values of various enriched elements selected from the analytical results of several individual pebbles from each core sample. It is not known if the position of the water table at 323 ft (100 m) has had any effect on the chemical compositions of pebbles and cobbles; the water table might affect the compositions of coatings on clasts.

The semi-quantitative analytical results from 62 altered-looking pebbles were separated into two groups of samples so as to compare the results between the bottom and top of the alluvium. Table 9 shows estimates of geometric means for elements from which there are sufficient data, and analytical detection ratios for all elements that were analyzed. Comparison shows that there are slight enrichments in many metals in the altered-looking pebbles from the bottom 160 ft (49 m) of the alluvium (Fe, Ti, Ag, B, Cr, Cu, Ni, Sc, V, Y, and Zr, and possibly As, Be, Co, Ga, Ge, and W). Other elements are relatively enriched in the top 300 ft (91 m) of the alluvium (Ca, Ba, Mn, Mo, and Sr, and possibly P). The significantly greater abundance of Ca, and slightly greater abundances of Ba and Sr in altered pebbles from the top of the alluvium may be due to increased exposure of limestone in the source area.

Forty-three pebbles of silicified, altered rocks were analyzed for Au by electrothermal atomic absorption spectroscopy (O'Leary and Meier, 1986). More than three-quarters of these pebbles proved to be Au enriched, containing as much as 123 ppb; the values range from as low as <1 ppb. Thirty-three of the 43 values were unqualified (within the detection limits of the method of analysis). The estimated geometric mean of the 43 qualified and unqualified values is 3.9 ppb. Pebbles from the bottom 160 ft (49 m) of alluvium appear to be slightly more enriched in Au than pebbles from the top 300 ft (91 m) (figure 10).

Nine pebbles of siltstone and gossan were analyzed for species of As. The values for As(+3) ranged from <1 ppm to 89 ppm, with an estimated geometric mean of 7.3 ppm. The values for As(+5) ranged from 16 ppm to 1760 ppm, with a geometric mean of 265.2 ppm. Because so much As occurred in an oxidized, soluble form, some of the altered-looking pebbles were studied with an oxalic-acid-leaching experiment. The results of this experiment suggest that some major elements and trace metals occur in a soluble form either within weathered clasts or as coatings on clasts: Fe, Ca, Mg, As, Mo, Pb, Sb, Ti, Zn, Zr, Mn, and possibly Cu, Co, W, Ba, and K. It is of interest that Ag was not among these elements. The details of these results are shown in Detra and others (1989).

Enrichments in metals such as Au, As, Ba, and W suggest that the mineralized pebbles in the alluvium could have come from exposed disseminated gold deposits along the northern extension of the Getchell gold belt. Bagby and Berger (1985) and Kretschmer (1984, 1986) reported enrichments of these elements in exposed gold deposits to the south. The Ag may or may not also be related to gold deposits. Joralemon (1951) found native Ag in ore at the Getchell mine; however, Kretschmer (1986) did not find Ag enrichment in ore from the Pinson mine. The pebbles could have come from Ag-enriched, sub-economic parts of gold deposits that were exposed along the northern part of the Getchell gold belt, or syngenetic lower Paleozoic exhalative mineralization associated with exhalative bedded barite exposed in the Osgood Mountains.

The ratios of Au/Ag in the mineralized pebbles are relatively low, and generally do not resemble those of the Au-enriched ore in mines along the Getchell gold belt. Hill and others (1986) reported values of Au and Ag from the mines at Getchell, Pinson, and Preble. We calculated the Au/Ag ratios for individual samples from their data, as follows: Getchell (range, 0.005-0.17; mean 0.04), Pinson (range, 0.2-8.0; mean, 1.64), and Preble (range, 0.05-0.6; mean 0.18). The mineralized pebbles in the alluvium above Rabbit Creek contain less Au than most of the samples from the mines. Ratios of Au and Ag are not available from any one individual pebble, because of the small size of each of the pebbles analyzed. However, we suggest that the ratios of Au/Ag for individual pebbles are low, around 0.006 or lower, based on mean abundances of Au (3.9 ppb) and Ag (0.7 ppm) that were estimated from the qualified and unqualified analytical results from many pebbles.

The geochemical data from pebbles indicate that mineralized rocks were exposed and eroded in the source area. Alluvial detritus could have contributed some of the metals to the alluvium, including those metals enriched in authigenic coatings on grains in the finer size fractions of the alluvium. For example, some of the Au, As, Ba, W, Zr, Ge, and other metals could have been introduced as alluvial detritus to the basin-fill sediments. However, metals also could have been derived from mineralized bedrock below the alluvium and precipitated in coatings on detritus. This is suggested by the nature of the suite of readily soluble metals, possibly associated with goethite, that are enriched in the sand-size fraction of the alluvium (Detra and others, 1989). This latter suite of metals notably lacks Ag. If the readily soluble metals were entirely derived from alluvial detritus, then the suite of soluble metals should include Ag, which is enriched in many of the mineralized pebbles. The lack of Ag in the soluble-metal suite suggests that either the detritus was not a significant source for the soluble metals, or that the Ag in the detritus was not as soluble as other metals. If the former, then there might be another source, or sources, of soluble metals. For example, the Rabbit Creek gold deposit, which is hosted in underlying bedrock, may be a significant source for the enriched metals that occur in soluble form in the alluvium.

CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY

The purpose of this project was to determine the nature and origin of the alluvium and to find out if detrital material could have contributed some of the metals to the metal-enriched alluvium above the Rabbit Creek gold deposit. This was done as part of a study to determine if buried ore deposits create a geochemical signature in overburden, and if we can find buried deposits by studying the geochemistry of overlying basin-fill sediment. In this part of the project, we wanted to answer questions about the basin-fill alluvium above the Rabbit Creek gold deposit. For example, we attempted to find out the nature and direction of the source area for the alluvium by studying the types of pebbles and cobbles in the sediment. We found that they consist mostly of siltstone, foliated metasedimentary rocks, limestone, jasperoid, and basalt with microlites of calcic plagioclase, which are all rock types that are exposed in the northern Osgood Mountains, Dry Hills, and outcrops of Paleozoic rocks that extend northeast of the Dry Hills (Hotz and Willden, 1964; Willden, 1964; and Stewart and Carlson, 1978). The source area probably was to the north and northwest of the Rabbit Creek deposit.

The proportions of common clast types vary with depth in the alluvium. The most obvious changes in clast types, as well as in mineralogy and sorting of the alluvium, occur at about 300 ft (91 m). We therefore selected that horizon as a stratigraphic boundary between the top and bottom of the section, for convenience in discussion. The most striking variations in clast type occur in the proportions of limestone and siltstone. Limestone clasts make up 35% of the +4-mesh clasts in the top 300 ft (91 m) of the alluvium, but only 5% in the bottom 160 ft (49 m); whereas siltstone and foliated metasedimentary rocks make up only 26% of the clasts in the top 300 ft (91 m) and 54% in the bottom 160 ft (49 m). The upward increase in limestone and the corresponding decrease in siliciclastic clasts could be due to any of a number of factors: (1) the source area may have changed geographically if the apex of an alluvial fan shifted so as to head in an area that exposed more limestone; (2) the core hole may have been located in an area of overlap between fans that were fed by streams eroding different geologic units; (3) the units exposed in the source area may have changed as more limestone was unroofed by erosion; or (4) a decrease in precipitation in the source area may have increased the amount of limestone that survived dissolution and was available for erosion and transport, as the action of chemical weathering became less important.

The Dry Hills, and outcrops of poorly known siliciclastic, Paleozoic rocks exposed northeast of the Dry Hills, constitute likely source areas for the alluvium. The Dry Hills are mostly underlain by the Etchart Limestone, the Farrel Canyon Formation, the Valmy Formation, and Tertiary basaltic and andesitic rocks. These units probably account for most of the clasts in the alluvium above the Rabbit Creek gold deposit. The Etchart Limestone underlies most of the high, southeastern parts of the Dry Hills today, and probably provided the fossiliferous, shallow-water limestone clasts to the alluvium. Siliciclastic rocks of the Farrel Canyon Formation are thrust over the Etchart Limestone in the Dry Hills and northern Osgood Mountains. These rocks could account for a substantial proportion of the siliciclastic clasts: siltstone, sandstone, and possibly the conglomerate. In addition to the siliciclastic rocks of the Farrel Canyon Formation, facies similar to those in the siliciclastic Adam Peak Formation may have been eroded from areas to the north of the Rabbit Creek mine. The Adam Peak Formation is coeval with the Etchart Limestone and may interfinger with the limestone to the north. Pebbles and cobbles of siliciclastic rocks occur throughout the alluvial section, and are especially abundant in the bottom 160 ft (49 m). The presence of foliated metamorphic rocks in the alluvium suggests either the erosion of the Preble Formation in the source area, (where it is not mapped and appears to be eroded off or buried), or else the erosion of other units that have a local metamorphic foliation. Hotz and Willden (1964) noticed foliation in phyllite of what they mapped as Comus Formation on a thrust plate in the northern Osgood Mountains, and they found weakly metamorphosed volcanic rocks within the Farrel Canyon Formation. Siliciclastic Paleozoic rocks show a metamorphic fabric in exposures northeast of the Rabbit Creek mine (A.R. Wallace, oral commun., 1989). These and other exposed units with local metamorphic foliation may have been exposed in the source area.

Rounded grains of quartz and clasts of sedimentary quartzite (quartz arenite) occur in the alluvium. The degree of roundness of these grains contrasts with the less rounded nature of the softer clasts of limestone and siltstone, which tend to round faster during transport. This anomalous roundness relationship is typical of sediments derived from a variety of rock types (Folk, 1980). The rounded clasts of quartzite (quartz arenite) in the alluvium probably came from a pre-existing conglomerate such as the Battle Formation or equivalent pebble conglomerate in the Etchart Limestone, as mapped by Willden (1964). Such strata occur in the Chimney Creek mine to the north.

The mafic volcanic or hypabyssal clasts in the alluvium could have come from Paleozoic rocks mapped as Valmy Formation or Comus Formation, or from Tertiary volcanic rocks. Parratt and others (1989) reported that there are Lower Ordovician volcanic rocks in underlying, mineralized bedrock of the Rabbit Creek gold deposit, and Osterberg (1988) reported basalt in the Chimney Creek gold deposit, which is about 2 mi (3 km) to the north. The alluvium along the range front therefore might cover an extensive sequence of Paleozoic basalt. During the deposition of the alluvium, the basalt could have been exposed along fault scarps on the east side of the present mountain front, where it was weathered and eroded to contribute to the alluvial gravel. Another Paleozoic-rock source for mafic volcanic rocks might have been the Goughs Canyon Formation. Although it is now restricted to the west side of the Osgood Mountains, the Goughs Canyon Formation could have been more extensive and provided mafic volcanic clasts to the alluvium during uplift and erosion of the Osgood Mountains.

The round clasts of caliche and similarly round coatings of caliche on various clast types could have formed in situ as originally round clasts and coatings, or they may have been rounded by abrasion during transport. If the caliche became rounded during transport, then the alluvium contains reworked, Neogene gravel. The coated clasts could have been covered in situ with caliche in a previous gravel deposit, then eroded and transported a short distance to the present site of deposition. The presence of soft clasts of caliche indicates brief transport.

We suggest that there could be a number of possible origins for the interstitial calcium carbonate that occurs in many samples, particularly in the top 300 ft (91 m) of the alluvium. This material may represent (1) deformed clasts of soft caliche that were crushed between harder framework grains, (2) cement that formed in situ as part of a soil profile, (3) fine-grained, water-transported material that was carried in suspension and deposited between framework clasts during waning current, or (4) windblown calcium carbonate that was especially abundant during dryer periods.

Besides the Dry Hills, another possible source area for the alluvium lies to the northeast of the Rabbit Creek deposit, in the Snowstorm Mountains and upper Kelly Creek. The western Snowstorm Mountains and northern Kelly Creek area expose basalt and siliciclastic Paleozoic rocks that are not entirely shown on published geologic maps (A. R. Wallace, oral commun., 1989). However, the Snowstorm Mountains are largely covered by Miocene and younger volcanic rocks such as rhyolite and dacite (Willden, 1964), which have not been found in any abundance in the alluvium. Therefore, although a source in the Snowstorms cannot be ruled out, a source area in the Dry Hills is considered more likely.

In addition to changes in source area, climatic drying could have caused the increase in the abundance of limestone clasts above about 300 ft (91 m) in the alluvium. The upward increase in the abundance of clasts of caliche, from 2% to 4%, and of interstitial matrix material and secondary calcium carbonate, may also be due to drying of the climate. The interstitial caliche may have formed in part from limy eolian dust that was blown from limestone units exposed in adjacent or distant mountain ranges.

Drying of the climate may also be responsible for the upward decrease in degree of sorting of the alluvium. Decrease in precipitation might lead to aggradation, development of steeper gradients, more sporadic and violent storms of shorter duration and covering small areas, and an increase in deposition of more poorly sorted sediment by debris flows high on fans and streamflood and sheetflood lower on fans. Present data do not indicate exactly where on the fan the alluvium above the Rabbit Creek gold deposit might have formed. To identify the types of deposits in the alluvial section and suggest where on the fan they formed would require examination of the alluvium in mine-pit walls.

We examined the pebbles and cobbles of silicified rocks, gossan, and apparently unaltered rocks to evaluate the possibility that some of the metals enriched in the alluvium were mechanically introduced from the source area. We selected individual clasts for geochemical study and found that about two-thirds of the silicified clasts and one-third of the apparently unaltered clasts from the pebble and cobble fraction of the sediment are enriched in Au, Ag, As, Ba, Fe, Ga, Ge, Mn, Mo, Ti, and W. More than three-quarters of the clasts analyzed for Au are enriched above average abundances for sedimentary rocks, containing as much as 123 ppb. The ratios of Au/Ag are probably lower than those reported from the Getchell, Pinson, and Preble mines by Hill and others (1986) and Joralemon (1951). The mineralized clasts may therefore represent parts of mineralized systems that are different from the parts exposed to the southwest in known deposits. The clasts could have come from subeconomic parts of gold-mineralized systems to the northwest of the Rabbit Creek deposit, or even from different types of mineralization, e.g., syngenetic exhalative deposits. It appears that some metals, including Au, Ag, and As, could have been mechanically introduced into the alluvium as mineralized detritus derived from the source area. However, metals could have come from mineralized bedrock at depth, as well. This is suggested by the nature and abundance of readily soluble metals, possibly associated with authigenic goethite, in the sand-size fraction of the alluvium (Detra and others, 1989). The suite of soluble metals enriched in the sand-size fraction lacks Ag, which is abundant in mineralized pebbles. This suggests that either some of the soluble metals were derived from a source other than the alluvial detritus, or that the Ag in the detritus is not soluble.

We tried to characterize and interpret grain-size distributions and textural features so as to determine what we could about depositional and climatic conditions. The alluvial deposits are mostly very poorly sorted, polymictic gravel to conglomerate, except for one sample of very poorly sorted gravelly muddy sand and reworked volcanic tuff at a depth of 422 ft (129 m). Studies of alluvial fans in other areas have shown that debris-flow processes are dominant above the mid-fan point and that water-laid deposition by streams, stream floods, and flash floods is dominant below the mid-fan point (Hooke, 1967). Alluvial fans in western Fresno County, California consist of mudflows (debris flows), intermediate deposits, and water-laid stream and flood deposits that are distinguishable based on grain-size characteristics (Bull 1960, 1964). We cannot determine the details of depositional and climatic conditions in the alluvium above Rabbit Creek based on the present information. We need to examine mine-pit exposures, identify depositional units in outcrop, determine grain-size distributions of known deposit types, then apply that knowledge to core-hole data.

In order to obtain age control in the alluvial strata, we searched the core for interbedded volcanic flows and ash-fall deposits, which might provide us with a radiometric age. We found a reworked volcanic tuff containing euhedral biotite and minor zircon at a depth of 422 ft (129 m) and submitted it for an age determination by $^{40}Ar/^{39}Ar$ age-spectrum dating of the biotite. However, we do not yet have results. Additional radiometric ages from the alluvium might also be obtained from zircon, apatite, and biotite found in the heavy-mineral fraction of sand and silt, particularly where two or more of these minerals occur in one sample, e.g. at depths of 60 ft (18 m), 342 ft (104 m), 380 ft (116 m), and 421 ft (128 m). Such samples might best be collected in the Rabbit Creek mine, where exposures should show lenses of volcanic material in the alluvium.

Ages from the alluvium would affect our interpretations regarding the age of the basin, provenance of the alluvium, and timing of tectonism. The generation and preservation of a great thickness of gravelly alluvium indicates relatively great topographic relief and the presence of tectonic activity in the area. Ages from the alluvium would provide us with a general date for fault movement that created much of the topographic relief. It is not known which faults were active immediately before and during deposition of the thick section of conglomerate; however, these faults may have been associated with the Getchell fault system, which has been active, although not necessarily continuously, since the Cretaceous (Berger and Taylor, 1980).

Knowledge about the sedimentology and provenance of basin-fill alluvium, particularly about the direction of the source area from paleocurrent data, combined with geochemical analyses of selected, mineralized rock clasts, can help in exploration for concealed mineral deposits, which are buried beneath coarse-grained conglomerate along the margins of basins in the arid regions of the Basin and Range province. For example, the presence of mineralized pebbles and cobbles in the alluvium adjacent to the Rabbit Creek deposit indicates that mineral deposits occur in bedrock in the direction of the source area of the alluvium. The source of the alluvium in the core hole is probably to the north and west, in the directions of the Chimney Creek deposit (3mi, 5km, north) and the northern part of the Rabbit Creek deposit.

Most important to this work would be the future, continuing study of the physical stratigraphy of the basin-fill deposits in core and in the open-pit mine wall at Rabbit Creek. Study of the sedimentary structures, especially paleocurrent indicators, and also of grain size distributions in the open pit of the Rabbit Creek gold mine, will add to our study of the one core hole. We may be able to tell more about Neogene stratigraphy, paleoclimate, and tectonics by determining the horizontal and lateral facies relationships in the pit.

A study such as this could take a number of additional directions. One thing that is needed is the production of new geologic maps for the basin and adjacent range-front areas, showing mappable basin faults, relative ages of pediment surfaces and extent of pediment versus alluvial areas, and radiometric ages of surfaces or of deposits near the surface if any datable volcanic rocks can be found in trenches. With the availability of new geophysical data and new and different types of aerial photographs, a better understanding of basin morphology might be achieved.

It would also be of value to study drill-hole and geophysical data to define the three-dimensional geometry of the basin, estimating its approximate depth and continuity.

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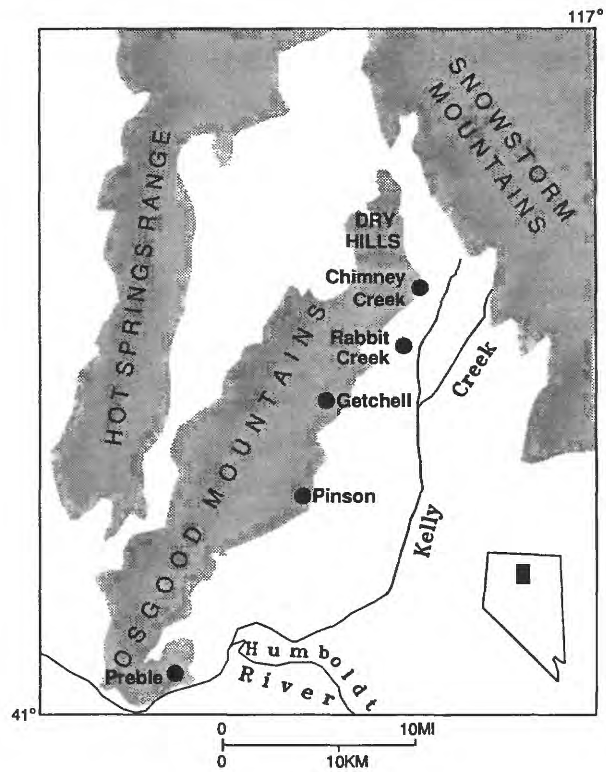

Figure 1.--Location of the Rabbit Creek gold deposit and other gold deposits (●) along the Getchell trend, Humboldt County, Nevada.

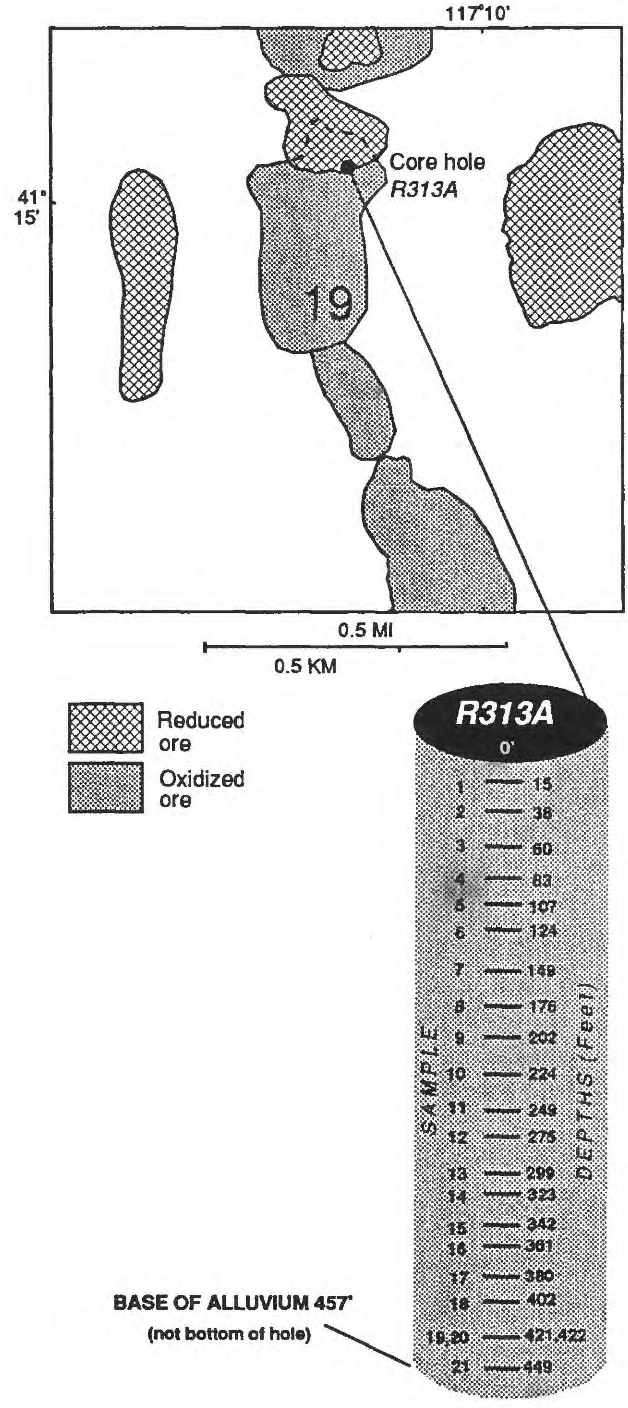

Figure 2.--Location of core hole R313A and distribution of concealed Rabbit Creek gold deposits in underlying bedrock as determined by drilling in section 19, T. 39 N., R. 43 E.

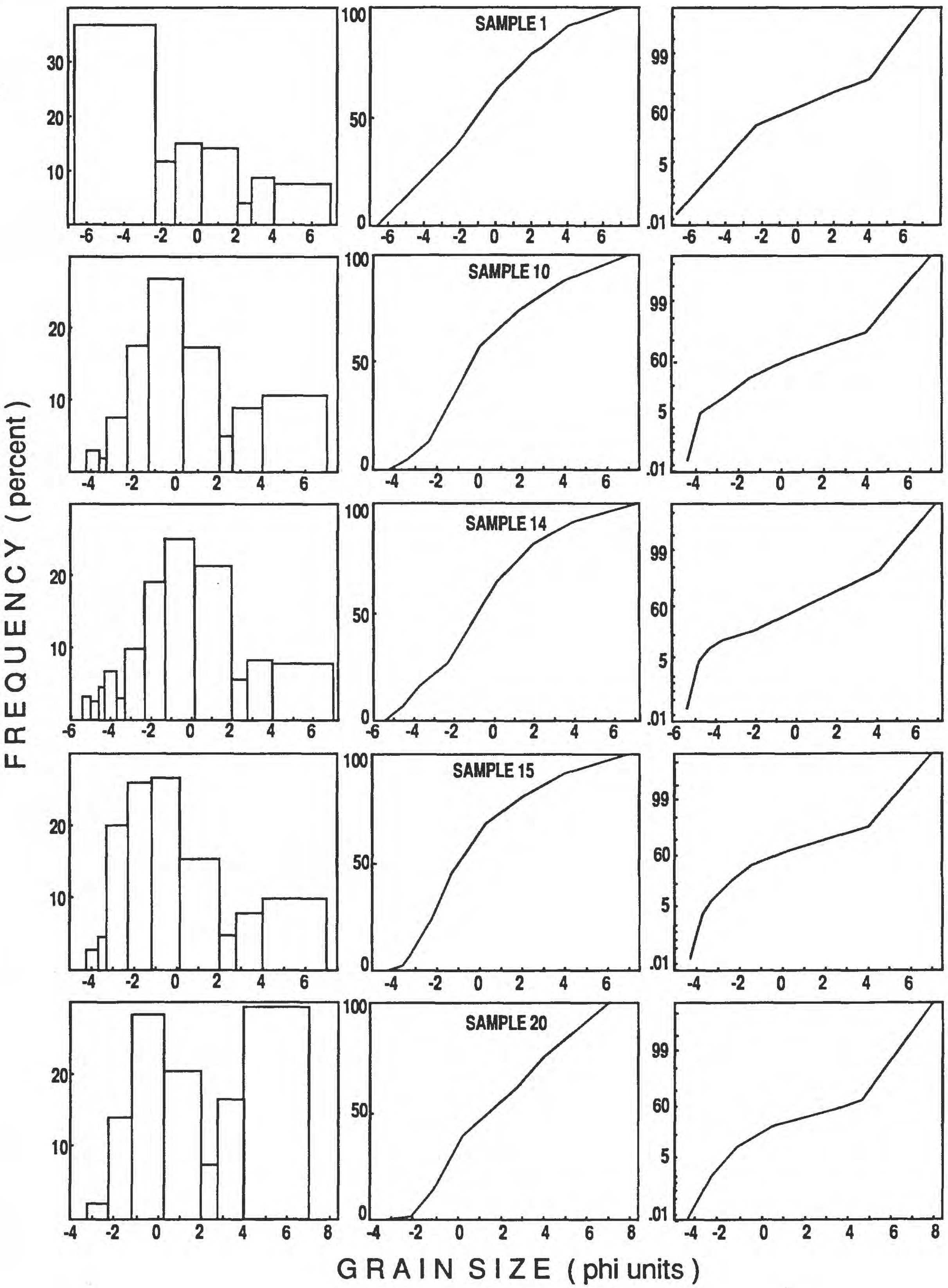

Figure 3. --Grain-size distribution of the alluvium shown in histograms and cumulative-frequency graphs (on arithmetic and probability paper) of sieve data from selected samples above the Rabbit Creek gold deposit. Data are listed in tables 1 and 2; selected percentiles and statistical parameters are listed in table 3.

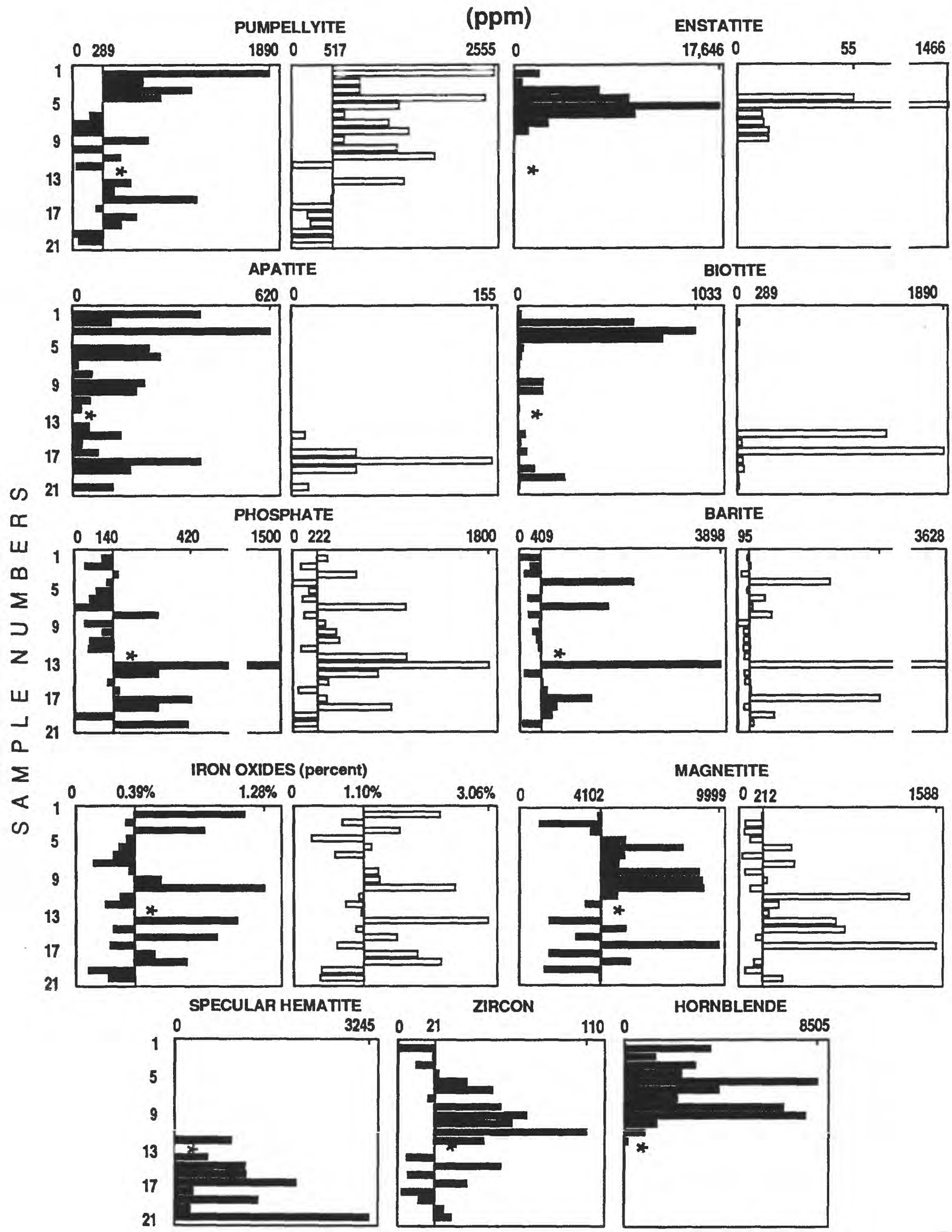

Figure 4.--Abundances of various minerals in the heavy-mineral fractions of the fine-grained sand to coarse-grained silt fraction (-100/+250 mesh, in fill pattern) and the coarse- and medium-grained sand fraction (-20/+60 mesh, in open, unfilled pattern) of alluvium above the Rabbit Creek gold deposit. Asterisk denotes no sample 13 available in finer mesh size. Abundances of some minerals are shown relative to their geometric mean abundance (pumpellyite, phosphate, barite, iron oxides, magnetite, and zircon).

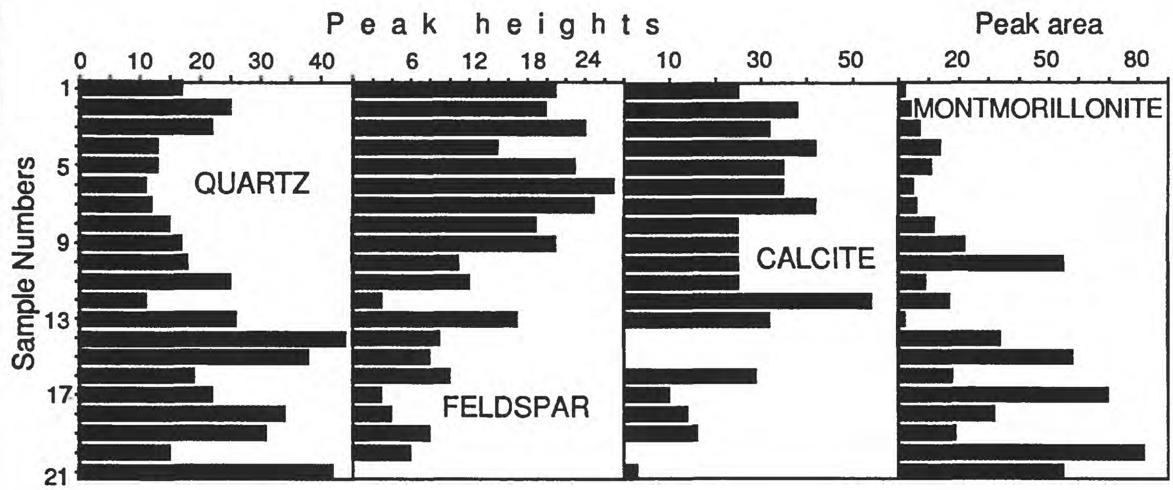

Figure 5.--Relative abundances of quartz, feldspar, calcite, and montmorillonite in the silt- and clay-size (-250 mesh) fraction of alluvium above the Rabbit Creek gold deposit, based on x-ray diffraction analyses. Peak areas were used to estimate the abundances of montmorillonite, whereas peak heights were used to estimate the abundances of the other minerals. Peak heights and areas were measured in arbitrary units above background.

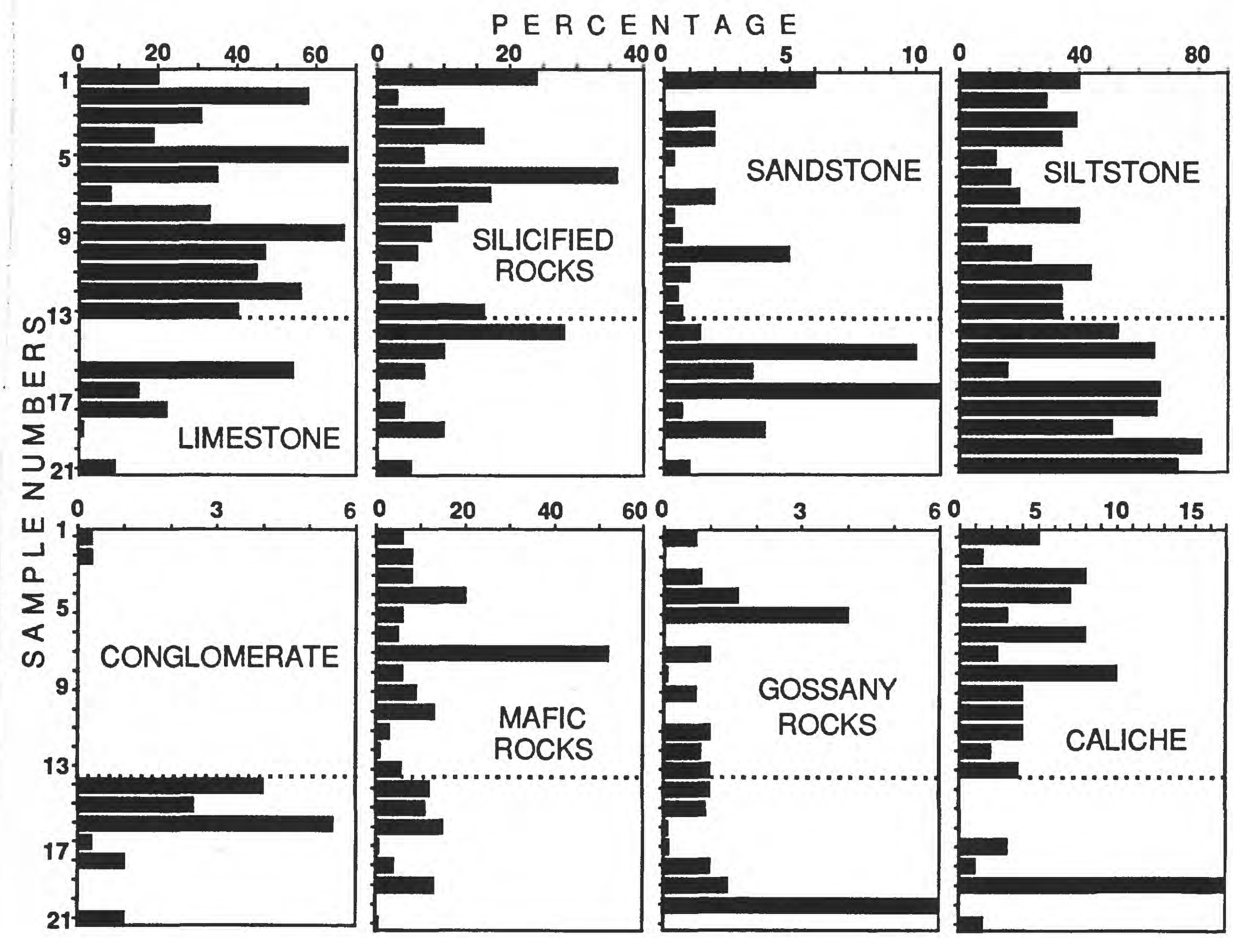

Figure 6.--Percentages of the most common clast types in the pebble and cobble fraction (+4 mesh) of alluvium above the Rabbit Creek gold deposit. Dotted line shows where significant change in the proportions of clast types exists in stratigraphic section. Ranges and means of percentages are listed in table 6.

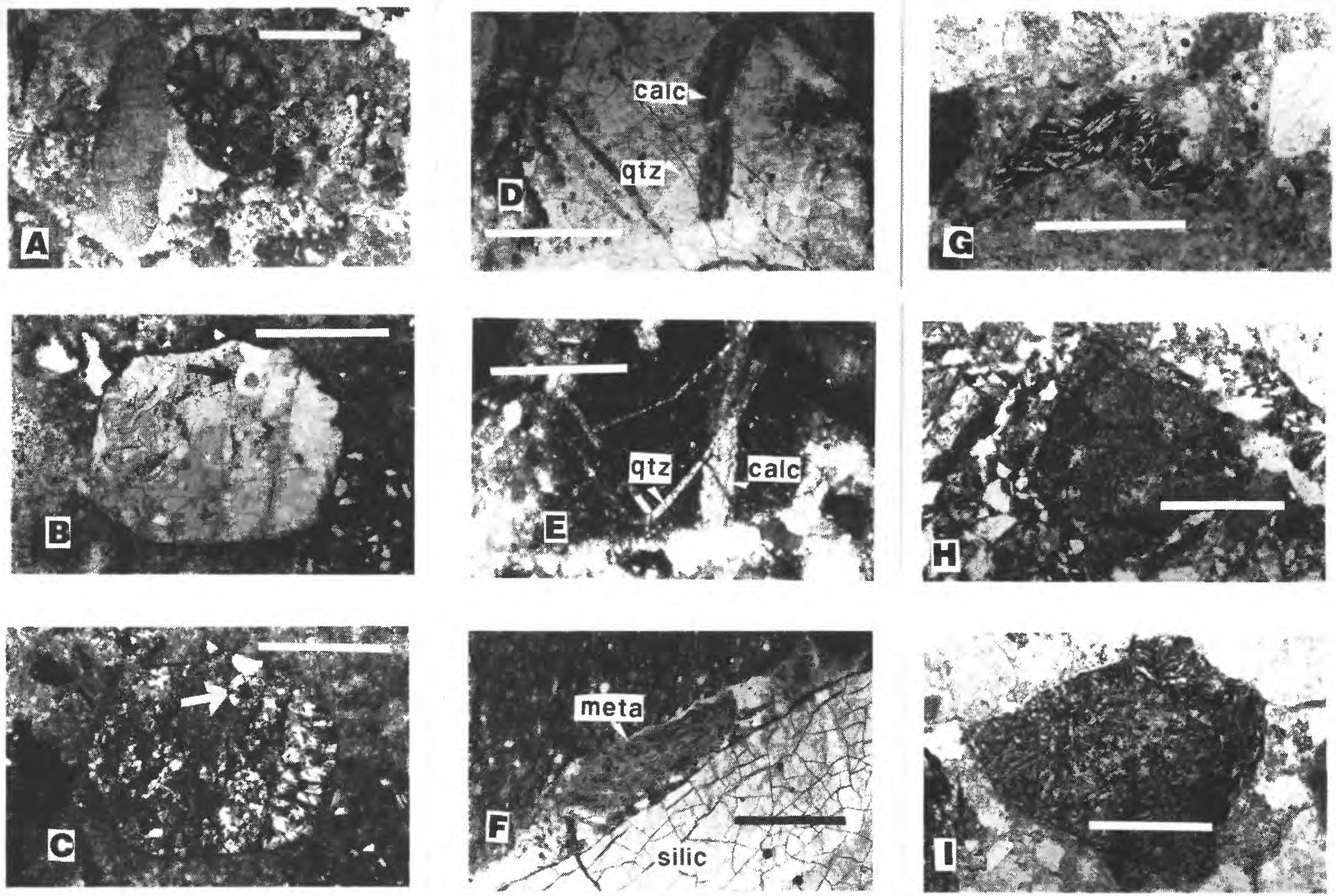

Figure 7.--Photomicrographs of alluvium. Bar scales are all 0.5 mm. (a) Clast of shallow-water limestone containing a forminifer, micritized crinoid, and echinoid spine, plane light; (b,c) diagenetic chert replacement of a crinoid-bearing limestone, plane light (b), crossed polars (c); (d,e) jasperoid? with veins of quartz and calcite, plane light (d), crossed polars (e); (f) clasts of metamorphic rocks and chert, plane light; (g-i) clasts of volcanic rocks, plane light, showing microlites (g,h) and devitrification texture (i);

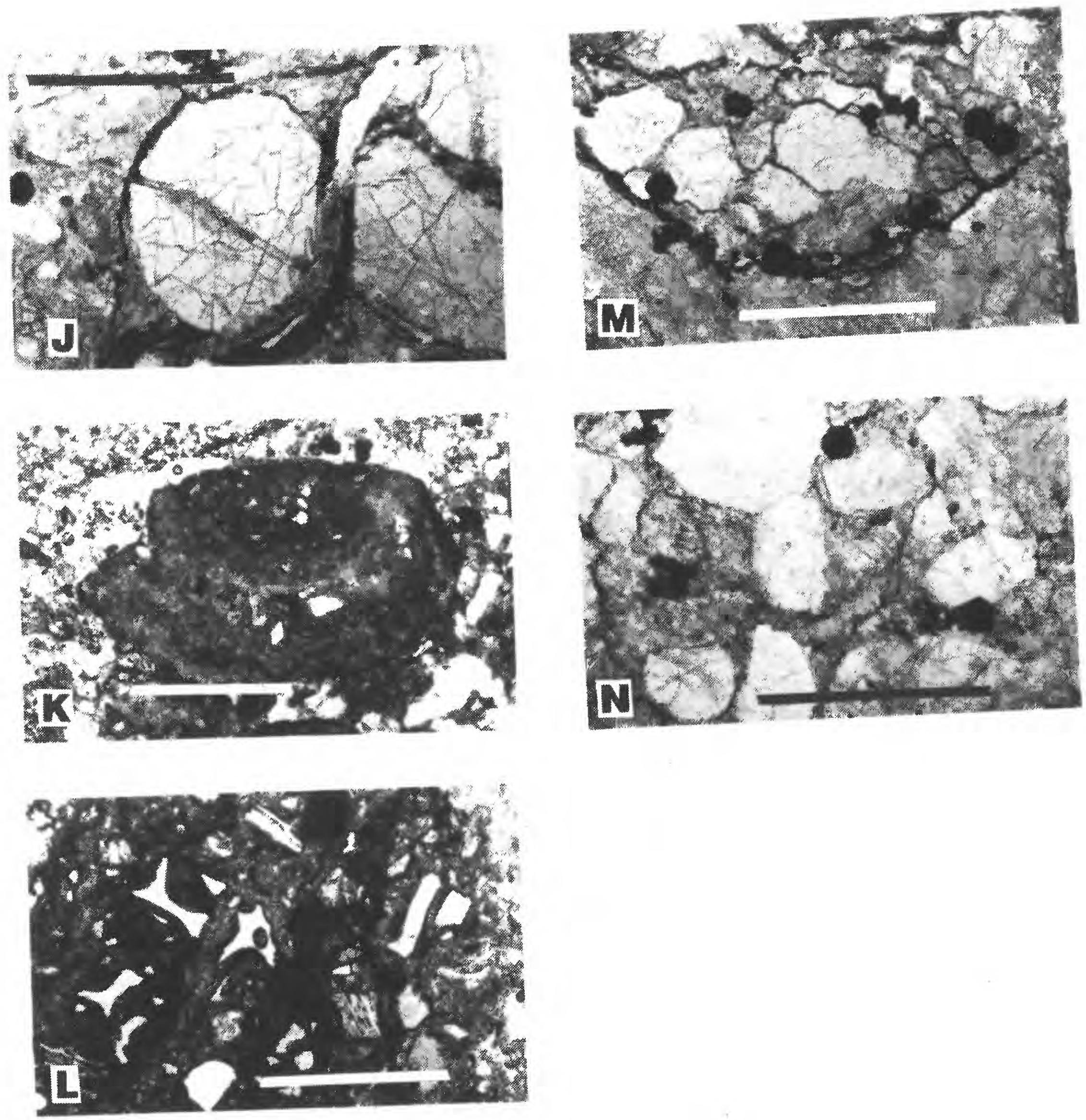

Figure 7, continued: (j) rounded grain of quartz, plane light; (k) clast of caliche, plane light; (l) glass shards in caliche, plane light; and (m,n) opaque-looking goethite as a replacement of secondary pyrite.

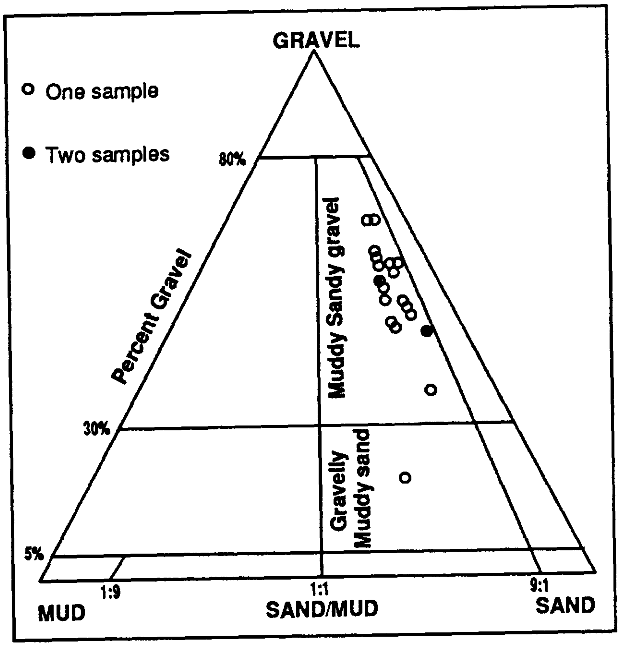

Figure 8.--Triangular gravel-sand-mud diagram showing the relative proportions of the grain sizes in alluvium above the Rabbit Creek gold deposit. Most samples plot in the area of muddy sandy gravel; one sample plots in the area of gravelly muddy sand.

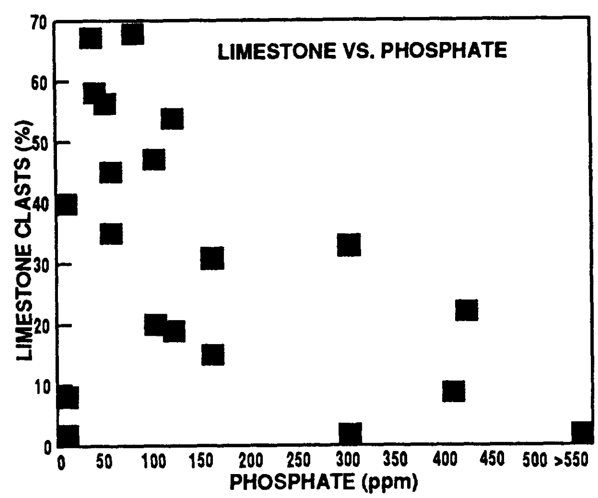

Figure 9.--Graph showing the inverse relationship between the percentages of limestone clasts in the pebble-and-cobble (+4-mesh) fraction and phosphate abundances in the sand-and-silt (-100/+250-mesh) fraction of the alluvium.

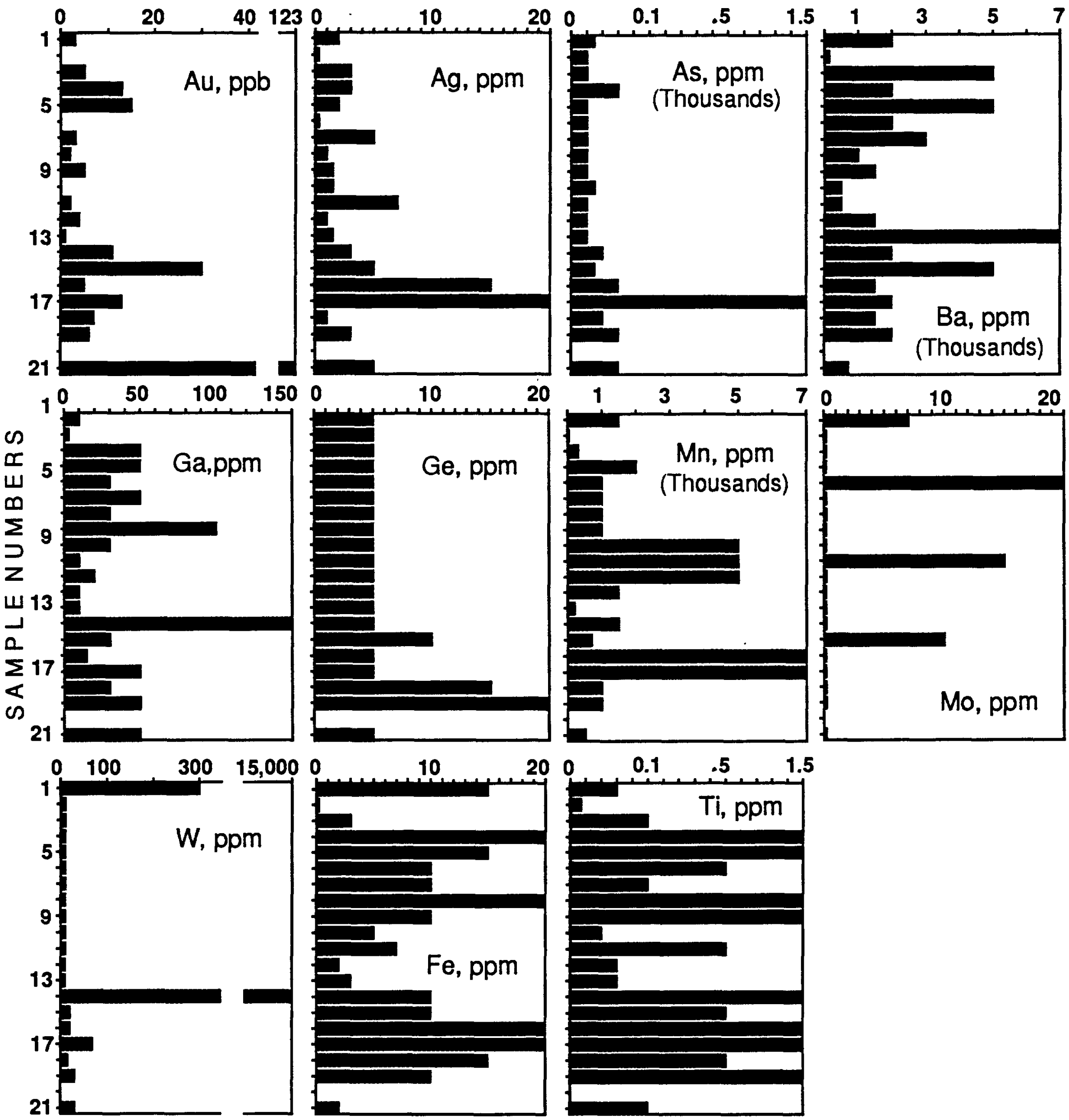

Figure 10.--Selected, maximum abundances of various elements from the results of direct-current arc emission spectrographic analyses of pebbles (and graphite-furnace atomic absorption spectroscopy for Au). We selected and plotted the maximum value of each element from the analytical results of several pebbles that were picked from each sample of alluvium. Results are truncated by upper and lower limits of determination.

Table 1.--Weight in grams of sieve fractions from the Rabbit Creek alluvial core samples, hole 313A

Sample number	Core-sample description	Sample weight	Weight after disaggregation	Sample loss during disaggregation	Sieve fraction weights +4 mesh +4.75 mm	+8 mesh +2.36 mm	+20 mesh +0.85 mm	+60 mesh +0.25 mm	+100 mesh +0.149 mm	+250 mesh +0.063 mm	-250 mesh -0.063 mm	Total sample wt. after sieving	Loss during sieving
1	9" at 15'	1161	1157	4	425.8	138.1	175.2	166.2	52.6	104.9	91.4	1154.2	2.8
2	8" at 38'	952	949	3	397.4	105.0	137.9	130.1	34.9	62.1	80.5	947.9	1.1
3	9" at 59.5'	1230	1228	2	376.2	201.9	238.8	175.8	44.4	88.3	100.3	1225.7	2.3
4	7" at 83.2'	1044	1041	3	333.9	218.2	179.1	100.1	35.3	80.7	91.3	1038.6	2.4
5	9" at 107'	1188	1184	4	642.4	121.8	137.7	103.9	35.6	70.2	70.0	1181.6	2.4
6	7" at 124'	990	987	3	375.2	114.1	121.7	101.0	50.2	118.4	102.8	983.4	3.6
7	7" at 149'	784	781	3	331.5	81.9	117.1	88.8	29.1	58.1	73.2	779.7	1.3
8	8" at 176'	1252	1249	3	532.2	168.6	174.8	137.2	42.1	87.7	104.5	1247.1	1.9
9	6" at 201.8'	771	764	7	338.2	98.7	97.3	80.4	27.5	53.1	66.2	761.4	2.6
10	6" at 224'	491	490	1	63.0	85.7	133.0	85.4	24.7	44.8	52.4	489.0	1.0
11	9" at 249'	1075	1068	7	317.4	158.0	207.3	158.8	42.3	75.4	106.0	1065.2	2.8
12	7" at 275'	1062	1058	4	359.8	113.0	165.9	164.6	57.0	95.3	99.8	1055.4	2.6
13	6" at 299'	549	534	15	240.7	70.5	78.2	56.5	16.3	28.0	41.4	531.6	2.4
14	6" at 323'	754	752	2	197.2	120.4	158.0	134.5	37.5	54.0	48.8	750.4	1.6
15	8" at 342'	1080	1075	5	250.2	235.3	239.5	139.0	44.0	73.8	89.8	1071.6	3.4
16	7" at 361'	939	936	3	393.8	137.0	152.5	123.9	32.4	44.4	50.0	934.0	2.0
17	9" at 380'	879	849	30	337.9	136.5	149.8	115.1	28.5	38.9	39.2	845.9	3.1
18	8" at 402'	1264	1262	2	431.1	263.9	245.4	141.2	38.8	66.2	72.4	1259.0	3.0
19	8" at 421'	628	627	1	114.2	145.8	143.6	103.1	30.0	42.9	40.8	620.4	6.6
20	3" at 422'	339	337	2	6.1	40.3	80.1	57.6	21.7	47.3	82.6	335.7	1.3
21	6" at 449'	805	803	2	409.1	114.3	102.3	68.4	20.9	37.8	48.9	801.7	1.3
Estimated weighing error........		+/-1	+/-1	+2/-2	+/-.1	+/-.1	+/-.1	+/-.1	+/-.1	+/-.1	+/-.7	±/-1.7	

Table 2. Weights in grams of coarsest size fractions that were sieved by hand from the Rabbit Creek core samples, hole 313A
[(--) denotes no data]

Sample number	Core-sample description	Additional coarse sieve-fraction weights								
		+2" (50 mm)	+1 3/4" (45 mm)	+1 1/4" (31.5 mm)	+1" (25.0 mm)	+3/4" (19.1 mm)	+3/4" (19.1 mm)	+1/2" (12.7 mm)	+3/8" (9.52 mm)	-3/8"/+4 mesh (4.75 mm)
1	9" at 15'	--	--	--	--	--	--	--	--	--
2	8" at 38'	--	--	--	--	--	--	--	--	--
3	9" at 59.5'	--	--	--	--	--	--	--	--	--
4	7" at 83.2'	--	--	--	--	--	--	--	--	--
5	9" at 107'	--	--	--	--	--	395.45	101.38	34.09	111.48
6	7" at 124'	--	28.64	0	23.77	134.33	--	49.1	60.44	78.93
7	7" at 149'	31.99	0	0	17.65	130.26	--	47.55	30.57	73.42
8	8" at 176'	--	--	30.16	17.14	176.55	--	115.01	36.42	156.92
9	6" at 201.8'	--	29.07	27.81	19.99	122.72	--	20.56	26.38	91.64
10	6" at 224'	--	--	--	--	--	--	15.67	9.93	37.40
11	9" at 249'	--	--	27.65	19.16	51.11	--	72.45	33.53	113.51
12	7" at 275'	--	--	31.25	19.23	169.44	--	43.19	11.22	85.45
13	6" at 299'	--	--	--	20.00	69.40	--	40.88	31.47	78.95
14	6" at 323'	--	--	21.63	17.73	30.35	--	44.97	20.04	62.54
15	8" at 342'	--	--	--	--	--	--	26.86	42.70	180.64
16	7" at 361'	--	--	--	28.94	152.32	--	103.41	43.81	65.36
17	9" at 380'	--	--	19.51	0	33.45	--	79.93	47.38	157.64
18	8" at 402'	--	--	--	22.92	58.2	--	60.92	68.32	220.76
19	8" at 421'	--	--	--	--	--	---	3.15	17.67	93.38
20	3" at 422'	--	--	--	--	--	---	---	---	---
21	6" at 449'	--	--	--	30.43	149.35	--	48.95	45.3	135.1
Estimated weighing error...		±0.01	±0.01	±0.01	±0.01	±0.01	±0.01	±0.01	±0.01	+/-.1

Table 3. Selected percentiles and statistical parameters of grain size, Rabbit Creek core samples, hole 313A

Sample number	Core-sample length and depth	Percentiles (ϕ)								Statistical parameters[1]					
										Mean (ϕ)		Standard deviation (ϕ)		Skewness	Kurtosis
		1%	5%	16%	25%	50% (median)	75%	84%	95%	Graphic	Moment	Graphic	Moment	Graphic	Graphic
1	9" at 15'	-6.58	-6.10	-4.77	-3.68	-1.13	1.58	2.88	5.10	-1.00	-0.93	3.6	3.3	0.08	0.87
2	8" at 38'	-6.59	-6.17	-5.00	-4.05	-1.51	1.19	2.55	5.23	-1.32	1.21	3.6	3.3	.13	.89
3	9" at 59.5'	-6.55	-5.97	-4.38	-3.07	-1.02	1.26	2.62	5.16	-0.93	-0.82	3.4	3.1	.08	1.05
4	7" at 83.2'	-6.56	-6.01	-4.48	-3.24	-1.39	1.08	2.84	5.29	-1.01	-0.96	3.5	3.2	.17	1.07
5	9" at 107'	-6.63	-6.33	-5.53	-4.87	-2.71	0.07	1.77	4.46	-2.16	-2.08	3.5	3.4	.28	.90
6	7" at 124'	-5.59	-4.69	-4.34	-3.60	-1.21	2.38	3.42	5.56	-0.71	-0.57	3.5	3.4	.26	.70
7	7" at 149'	-6.44	-4.85	-4.42	-4.07	-1.53	1.31	2.89	5.40	-1.02	-1.02	3.4	3.3	.28	.78
8	8" at 176'	-5.28	-4.61	-4.31	-3.81	-1.70	1.00	2.62	5.20	-1.13	-1.04	3.2	3.1	.33	.84
9	6" at 201.8'	-5.60	-5.33	-4.50	-4.28	-1.81	1.04	2.68	5.27	-1.21	-1.18	3.4	3.2	.29	.82
10	6" at 224'	-4.07	-3.30	-2.07	-1.55	-0.81	1.99	3.27	5.59	0.34	0.36	2.7	2.6	.30	1.03
11	9" at 249'	-5.29	-4.59	-3.67	-2.70	-0.83	1.53	2.93	5.49	-0.52	-0.42	3.2	3.0	.20	.98
12	7" at 275'	-5.32	-4.64	-4.37	-3.64	-0.75	1.87	3.09	5.41	-0.68	-0.52	3.4	3.2	.13	.75
13	6" at 299'	-4.89	-4.61	-4.28	-3.63	-1.89	0.53	2.03	5.07	-1.38	-1.19	3.0	3.0	.34	.95
14	6" at 323'	-5.31	-4.68	-3.55	-2.40	-0.70	1.38	2.40	4.68	-0.62	-0.47	2.9	2.8	.01	1.02
15	8" at 342'	-4.02	-3.41	-2.69	-2.17	-0.93	1.23	2.61	5.20	-0.33	-0.26	2.6	2.6	.38	1.04
16	7" at 361'	-4.87	-4.60	-4.34	-3.96	-1.71	0.48	1.68	4.19	-1.46	-1.32	2.8	2.8	.23	.81
17	9" at 380'	-5.27	-4.38	-3.65	-3.05	-1.62	0.39	1.56	3.89	-1.24	-1.11	2.6	2.6	.28	.98
18	8" at 402'	-4.79	-4.38	-3.31	-2.78	-1.49	0.28	1.70	4.38	-1.03	-0.93	2.6	2.6	.31	1.17
19	8" at 421'	-3.59	-3.14	-2.41	-1.96	-0.72	1.29	2.36	4.71	-0.26	-0.16	2.4	2.4	.34	.99
20	3" at 422	-2.70	-1.98	-1.10	-0.55	1.50	3.95	5.04	6.39	1.81	1.79	2.8	2.6	.16	.76
21	6" at 449'	-4.89	-4.62	-4.39	-4.01	-2.31	-0.12	1.47	4.53	-1.74	-1.57	2.9	2.9	.39	.97

[1]The statistical parameters were determined from graphic measures (percentiles read from cumulative curves). In addition, the means and standard deviations were determined by moment measures, directly from sieve data (a computational rather than graphic measure). Where data were sufficient, the graphic parameters were based on three to five percentiles according to the method of Folk and Ward (1957) and Folk (1980). Where data were insufficient, the graphic parameters were determined from fewer percentiles according to the method of Inman (1952).

Table 4.--Weight in grams of the +4-mesh fraction of the most common clast types found in 21 samples of alluvium from core-hole 313A.

[Clasts types are denoted by letter symbols as follows: A, limestone; B, silicified rocks, some mineralized; C, siltstone, calcareous siltstone, and foliated metasedimentary rocks; D sandstone; E, conglomerate; F, weathered, iron-stained, gossan; G, mafic volcanic/hypabyssal; H, caliche clasts and clast coatings; I, miscellaneous, including unidentified clasts; and J, lost in processing.]

Sample number	A	B	C	D	E	F	G	H	I	J
1	84.5	101.7	168.7	26.1	1.3	2.9	23.2	9.9	0	9.9
2	222.7	10.5	111.9	0.0	1.0	0.0	29.2	5.4	1.1	15.6
3	116.8	37.2	146.8	6.9	0.0	2.7	30.9	29.4	2.2	3.3
4	60.8	52.6	111.0	4.8	0.0	5.4	66.4	22.9	3.3	6.7
5	432.4	46.1	75.8	2.4	0.0	22.3	39.9	20.0	0.2	3.3
6	129.1	132.8	64.6	0.0	0.0	0.0	16.7	29.7	0.3	2.0
7	25.3	54.7	62.8	6.7	0.0	3.1	166.8	7.5	0	4.6
8	175.4	60.6	209.0	1.9	0.0	0.5	28.0	52.4	0	4.4
9	224.3	27.2	30.1	2.2	0.0	2.1	30.1	13.5	3.5	5.2
10	29.2	4.0	14.9	3.0	0.0	0.0	8.1	2.7	0	1.1
11	140.8	6.2	136.5	3.1	0.0	3.3	8.7	12.4	0.9	5.5
12	198.0	21.9	119.3	1.6	0.0	2.6	3.9	6.6	0	5.9
13	94.6	38.3	80.3	1.6	0.0	2.7	13.6	6.1	0.7	2.8
14	0.0	55.7	104.1	2.7	7.1	2.6	22.7	0.0		1.4
15	0.0	25.0	160.9	24.7	6.2	2.3	26.6	0.0	1.1	3.4
16	210.8	25.2	60.8	13.7	21.6	0.3	57.0	0.0	0.4	4.0
17	51.3	6.4	224.4	38.2	1.2	0.4	2.3	10.6	0.0	3.1
18	91.8	17.8	276.0	2.8	5.6	4.2	17.9	4.2	0.6	10.2
19	1.5	11.2	55.0	4.6	0.0	1.5	13.9	18.2	1.4	6.9
20	0.0	0.0	4.3	0.0	0.0	0.31	0.0	0.0	0.6	0.9
21	35.8	18.5	290.7	4.2	5.1	0.0	2.4	6.0	32.3	14.1

Table 5.--Percentages of the most common clast types found in 21 samples of the +4-mesh fraction of alluvium from core-hole 313A.

[Clast types are denoted by letter symbols as follows: A, limestone; B, silicified rocks, including mineralized clasts; C, siltstone and foliated metasedimentary rocks; D, sandstone; E, conglomerate; F, gossan-type rocks; G, mafic volcanic/hypabyssal; and H, caliche clasts and caliche coatings on clasts; I, other clast types including unidentified clasts]

Sample number	A	B	C	D	E	F	G	H	I
1	20	24	40	6	0.3	0.7	6	5	2.0
2	58	3	29	0.0	0.3	0.0	8	1.4	0.3
3	31	10	39	2	0.0	0.8	8	8	1.2
4	19	16	34	2	0.0	1.6	20	7	0.4
5	68	7	12	0.4	0.0	4	6	3	0.4
6	35	36	17	0.0	0.0	0.0	5	8	1.0
7	8	17	19	2	0.0	1	50	2	1.0
8	33	11	39	0.4	0.0	0.1	5	10	1.5
9	67	8	9	0.7	0.0	0.7	9	4	1.6
10	47	6	24	5	0.0	0.0	13	4	1.0
11	45	2	44	1	0.0	1	3	4	0
12	55	6	33	0.4	0.0	0.7	1	2	1.9
13	39	16	33	0.7	0.0	1	5.7	2.5	2.1
14	0.0	28	53	1.4	4	1	12	0.0	0.6
15	0.0	10	65	10	2.5	0.9	11	0.0	0.6
16	54	6	15	3.5	5.5	0.1	15	0.0	0.9
17	15	0.2	67	11	0.3	0.1	0.7	3	2.7
18	22	4	66	0.7	1	1	4	1	0.3
19	1	10	51	4	0.0	1.4	13	17	2.6
20	0.0	0.0	81	0.0	0.0	6	0.0	0.0	13.0
21	9	5	73	1	1	0.0	0.6	1.5	8.9

Table 6.--Ranges and means of percentages of clast types in 21 samples of alluvium from core-hole 313A.

[Clast types are denoted by letter symbols, as follows: A, limestone; B, silicified rocks; C, siltstone and foliated, metasedimentary rocks; D, sandstone; E, conglomerate; F, gossan; G, mafic volcanic/hypabyssal rocks; and H, caliche clasts; ---, insufficient data]

	A	B	C	D	E	F	G	H
Range..........	0-67	0.1-36	9-81	0.4-11	0-55	0-6	0-52	0-10
Geometric mean (G.M.)....	16.1	6.9	34.6	1.6	1.0	0.8	5.7	3.0
G.M. samples 1-13...	35.4	9.5	26.2	1.2	---	0.9	7.2	4.2
G.M. samples 14-21..	4.5	4.1	54.1	2.5	1.4	0.7	3.8	1.7
Arithmetic mean (A.M.)....	29.9	10.8	40.4	2.5	0.7	1.1	9.5	4.1
A.M. samples 1-13...	40.5	12.5	28.9	1.6	0.05	0.9	11.0	4.8
A.M. samples 14-21..	12.6	8.0	59.0	4.0	1.8	1.3	7.0	2.8

Table 7.--Sorting indices and mud and clay content of alluvium from the Rabbit Creek gold deposit and from water-laid, intermediate, and mudflow deposits of a alluvial fans in western Fresno County, California from Bull (1960)

Alluvium above Rabbit Creek	So[1]	QDϕ[2]	δϕ[3]	% Mud) (silt and clay)
Samples 1-13	5.50	2.43	3.34	8.78
Samples 14-21	3.69	1.86	2.69	8.49
Samples 1-21	4.80	2.10	3.09	8.67
Western Fresno County fans			δϕ[4]	% Clay
Water-laid deposits	1.8	0.8	1.4	6
Intermediate deposits	4.0	2.0	3.9	17
Mud flow deposit	9.7	3.1	4.7	31

[1]So, Trask sorting coefficient, $So = \sqrt{\dfrac{mm_{25} \text{ (larger quartile diameter)}}{mm_{75} \text{ (smaller quartile diameter)}}}$

[2]QDϕ, quartile deviation, $QD\phi = \dfrac{\phi 75 - \phi 25}{2}$

[3]δϕ, Standard deviation, $\delta\phi = \dfrac{\phi 84 - \phi 16}{2}$ (Inman, 1952)

[4]δϕ, inclusive graphic standard deviation $\delta\phi = \dfrac{\phi 84 - \phi 16}{4} + \dfrac{\phi 95 - \phi 5}{6.6}$, (Folk and Ward, 1957)

Table 8.--Univariate statistical estimates for direct-current arc emission spectrographic data from 78 pebbles (altered and unaltered looking) selected from alluvial core above the Rabbit Creek gold deposit. Estimates are expressed in parts per million, except for Ca, Fe, Mg, Na, P, and Ti, which are expressed in percent. Qualified values were replaced in order to make estimates.

Element	Detection ratio[1]	Estimated minimum	Estimated maximum	Geometric mean	Gemetric deviation
Ca%	0.97	0.07	29	1.4	4.5
Fe%	1	0.1	20	1.8	4.4
Mg%	1	0.03	7	0.5	3.5
Na%	0.21	0.1	7	--	--
P%	.18	0.1	1.5	--	--
Ti%	.87	0.02	1.4	0.3	2.9
Ag	.56	0.3	20	0.7	3
As	.15	100	1500	--	--
B	.92	5	150	24.9	2.4
Ba	.99	50	7143	630.0	2.6
Be	.09	0.5	2	--	--
Co	.41	5	70	--	--
Cr	.95	7	500	51.8	3.4
Cu	.96	2.5	200	24.5	2.7
Ga	.60	2.5	150	7.7	3.1
Ge	.04	5	20	--	--
La	.22	25	150	--	--
Mn	.95	7	7143	244.8	5.6
Mo	.08	2.5	20	--	--
Nb	.01	15	50	--	--
Ni	.82	2.5	300	24.7	4.3
Pb	.39	5	150	--	--
Sb	.01	70	150	--	--
Sc	.56	2.5	30	6.2	2.3
Sr	.62	50	1000	114.8	2.3
V	.97	7	3000	103.4	3.2
W	.10	10	14286	--	--
Y	.83	5	300	17.8	2.1
Zn	.04	100	300	--	--
Zr	1	15	1000	105.2	2.2

[1]The number of unqualified values divided by the number of samples analyzed. Statistical values are shown only for elements with detection ratios of at least 0.5.

Table 9.--Univariate statistical estimates for direct-current arc emission spectrographic data from 62 pebbles of altered-looking rocks, 25 pebbles from the bottom 160 ft (49m) of alluvium and 37 pebbles from the top 300 ft (91 m) of alluvium above the Rabbit Creek gold deposit. Estimates are expressed in parts per million, except for Ca, Fe, Mg, Na, and P, which are expressed in percent.

	Bottom 160 ft (49 m) of alluvium			Top 300 ft (91 m) of alluvium		
Bottom element	Detection ratio	Geometric mean	Geometric deviation	Detection ratio	Geometric mean	Geometric deviation
Ca%	1.00	.6	4.7	1.00	2.0	3.8
Fe%	1	1.7	4.5	1	1.5	4.1
Mg%	1	.4	3.4	1	.4	3.5
Na%	.12	--	--	.162	--	--
P%	.12	--	--	.24	--	--
Ti%	.96	.3	2.5	.92	.2	2.9
Ag	.72	1.1	3.6	.54	.7	2.7
As	.32	--	--	.03	--	2.2
B	1	27.1	2.3	.97	26.7	2.6
Ba	1	524.8	2.5	.97	712.4	--
Be	.12	--	--	.08	--	--
Co	.44	--	--	.32	--	--
Cr	.96	47.8	3.1	.92	36.5	3.4
Cu	1	27.5	2.6	.95	23.8	3
Ga	.68	9.3	3.4	.43	--	--
Ge	.12	--	--	--	--	--
La	.20	--	--	.19	--	--
Mn	.92	206.9	5.7	.97	220.1	5.9
Mo	.04	--	--	.14	--	--
Nb	--	--	--	.03	--	--
Ni	.96	23.3	4.1	.73	19.7	3.9
Pb	.36	--	--	.38	--	--
Sb	--	--	--	.03	--	--
Sc	.60	5.9	2.3	.41	--	--
Sr	.44	--	--	.65	107.6	2
V	1	113.7	3.3	.95	83.3	3.2
W	.16	--	--	.03	--	--
Y	.92	18.1	1.9	.70	13.1	1.9
Zn	.04	--	--	.05	--	--
Zr	1	111.2	1.9	1	86.4	2.4

Appendix A--Descriptions of hand samples of alluvium from core at the Rabbit Creek gold deposit

Sample Number: 1. Size and Depth of Core Sample: 9 in at 15 ft. Name: Sandy conglomerate with calcite cement, probably greater than 10%. Color: Light tan/gray Hue 10 YR 8/3. General Description: Very poorly sorted. Matrix is largely sand sized material, not much in the way of fine silt or clay sized material. The interior of the segment contains voids that are clustered around the pebbles. Maximum dimension of spaces about 4 mm. Well indurated, but still friable. Clast Characteristics: Clasts are subangular and subrounded with a maximum size of about 5 cm. There are numerous small, white, rounded, and subrounded clasts - tuff, with biotite crystals and small rock fragments, or perhaps clasts of caliche with black, volcanic glass. Perhaps 5% by volume, with a maximum size of about 1 cm. Clasts defined by size greater than 2 mm. Character of Matrix: Sand size material mostly, 2 mm to about 1/20 mm. Matrix has a carbonate cement. After acidification, matrix is porous. Reaction with HCl (1:4): Strong. Description of sand and silt-size matrix mineralogy: Dominantly quartz, rock fragments, iron oxides, some muscovite, feldspar, biotite, and hornblende(?). Other: Very strong diesel odor - probably from water-soluble oil used in drilling fluid. All of the core samples have this smell.

Sample Number: 2. Size and Depth of Core Sample: 8 in at 38 ft. Name: Sandy conglomerate with calcite cement greater than 10%. Color: Light tan/gray HUE 10 YR 8/2. General Description: Very poorly sorted and strongly indurated. Segment contains voids throughout. The voids are up to 5 mm in longest dimension. Estimate about 10% porosity due to these voids. Induration due to cementation by calcite. Clast Characteristics: Clasts angular to subrounded, with maximum size up to 6 cm. These are matrix supported and estimated to make up about 20% to 25% by volume (+2 mm size). Just a few tuff (or caliche?) clasts as seen in sample number 1. Character of Matrix: Sand size mostly, to coarse silt. Range is about 2 mm to about 1/50 mm. A very fine grained, granular calcite cement is present in the matrix. Reaction with HCl (1:4): Very strong. Description of sand- and silt-size matrix mineralogy: Dominantly quartz, rock fragments, and iron oxides with some biotite flakes and sphene(?). Quartz approximately equivalent to rock fragments. Quartz grains strongly iron-oxide coated. Other: Induration is so hard that some clasts break when rock is hit with a hammer, rather than disaggregate from the matrix.

Sample Number: 3. Size and Depth of Core Sample: 9 in at 59.5 ft. Name: Sandy conglomerate with calcite cement greater than 10%. Color: Light tan/gray Hue 10 YR 8/3. General Description: Very friable, disaggregated while sitting around. Poorly sorted. Clast Characteristics: Clasts are subangular and subrounded with +2 mm making up about 30% to 40% by volume, possibly 50%. Matrix supported where more cohesive, but cannot be certain about the naturally disaggregated parts of sample. Clasts are up to 3 cm maximum size. Character of Matrix: Mostly sand size, 2 mm to 1/50 mm. There are some white clots of calcite cement up to 3 or 4 mm across. Limonitic clots up to about 1 cm across are also present. Reaction with HCl (1:4): Very strong, in spite of the poor induration. Description of sand- and silt-size matrix mineralogy: Dominantly quartz, with iron oxides, biotite, rock fragments, and some muscovite.

Sample Number: 4. Size and Depth of Core Sample: 7 in at 83.2 ft. Name: Sandy (tuffaceous) conglomerate, with calcite cement greater than 10%. Color: Light gray/tan Hue 2.5 YR 8/1. General Description: Poorly sorted, indurated but moderately friable. There are irregular open spaces or voids with maximum dimension about 1 cm. There are tuffaceous (or caliche?) clasts and layers, subparallel to the core diameter, which partially wrap around clasts. Clast Characteristics: Clasts subangular and subrounded, majority are subrounded. Maximum size to about 2 cm, makeup about 25% to 30% by volume - matrix supported. Tuffaceous clasts present. Character of Matrix: Mostly sand with abundant calcite cement, but the friability (hence cementation) vary. There are some very "rock like", far more indurated parts of this sample, which suggests irregular distribution of the calcite cement. Disaggregation was not complete with acid, which probably means some other cementation medium, such as silica or sulfates, is present. Reaction with HCl (1:4): Very strong, but again, as above, disaggregation was not complete.

Description of sand- and silt-size matrix mineralogy: Sand-sized material is mostly quartz, with iron oxide grains, feldspars, some muscovite, biotite, epidote(?), garnet, and hornblende. **Other:** Tuffaceous matrix (white) is more common this segment than in the higher samples, but it also has an abundance of calcite. It is not crumbly caliche, but tuffaceous material as it includes a lot of biotite and quartz crystals in it - similar to the smaller tuff (or caliche?) clasts. Perhaps it represents smeared-out larger tuff (or caliche?) clasts.

Sample Number: 5. **Size and Depth of Core Sample:** 9 in at 107 ft. **Name:** Sandy breccia with calcite cement greater than 10%. **Color:** Light gray/tan Hue 2.5 YR 8/1. **General Description:** Very poorly sorted, large clasts, very hard, and well indurated (almost a rock). There is considerable vug or pore space between grains in spite of dense cementation. **Clast Characteristics:** Clasts angular and subangular up to 7 cm, maximum dimension. Due to angularity, this is more of a breccia. Some well indurated tuffaceous (or caliche?) clasts to 1 cm, which contain biotite and quartz crystals up to 1 mm size. Numerous large clasts in this segment. Clast proportion about 50%, matrix supported. **Character of Matrix:** Sandy to tuffaceous, probably some calcium carbonate. Abundant granular carbonate cement gives matrix a vitreous lustre. Small white clots appear to be caliche patches - irregular, very fine grained. **Reaction with HCl (1:4):** Very strong, but disaggregation incomplete, so may be some silica or sulfate cement as well. **Description of sand- and silt-size matrix mineralogy:** Quartz, with iron-oxide aggregates and grains, rock fragments, epidote(?), hornblende(?), possibly some fluorite. **Other:** Sample would be very hard to disaggregate.

Sample Number: 6. **Size and Depth of Core Sample:** 7 in at 124 ft. **Name:** Sandy conglomerate with calcite cement greater than 10%. **Color:** Light gray/tan Hue 2.5 YR 8/2. **General Description:** Very poorly sorted, hard, well indurated, but disaggregates easier than previous sample. **Clast Characteristics:** Angular and subangular clasts make up about 20 to 30% by volume, with maximum size to about 5 cm. Matrix supported. Some clasts are tuffaceous (or caliche?) up to about 2 cm in size. Some carbonate clasts have caliche rims up to 3 mm thick, which are banded. **Character of Matrix:** Sandy mostly, with a abundant calcite cement. **Reaction with HCl (1:4):** Strong, but disaggregation not complete, so may contain silica or sulfate as well as calcite. **Description of sand- and silt-size matrix mineralogy:** Dominantly quartz, with rock fragments, iron oxides as aggregates and single grains, hornblende, minor biotite.

Sample Number: 7. **Size and Depth of Core Sample:** 7 in at 149 ft. **Name:** Sandy conglomerate with calcite cement greater than 10 percent. **Color:** Light tan Hue 2.5 Y 8/1. **General Description:** Very poorly sorted, well indurated. A clot of organic(?) material about 1-2 cm wide, 1-2cm thick, parallel with core diameter, having a resinous luster, containing sand grains, forms part of the matrix. Matrix also has smaller clots of similar character. The segment contains voids, in spite of being well cemented. **Clast Characteristics:** Angular and subangular up to 6 cm, most considerably smaller makeup 20 to 30% by volume, matrix supported. Some tuffaceous (or caliche?) clasts with biotite and quartz phenocrysts up to 3 cm across. **Character of Matrix:** Sand, mostly with carbonate cement. Caliche and hyalite (secondary, clear silica) also present. **Reaction with HCl (1:4):** Strong. **Description of sand- and silt-size matrix mineralogy:** Mostly quartz, followed by rock fragments and iron oxide aggregates and grains, feldspar, minor epidote(?). Organic clots of sand size with smaller grains. **Other:** The resinous, organic(?) clot is brownish. Fractures in large clasts and matrix boundaries with clasts contain caliche and hyalite. This was the only noted occurrence of silica in matrix/fractures seen in the core segments.

Sample Number: 8. **Size and Depth of Core Sample:** 8 in at 176 ft. **Name:** Sandy conglomerate with calcite cement greater than 10%. **Color:** Light tan/yellow Hue 10 YR 8/3. **General Description:** Very poorly sorted, well indurated, and clast rich (almost a rock). The segment looks porous, but does not have large voids seen previously. **Clast Characteristics:** Clasts subangular and subrounded, estimate 30 to 40% by volume, greater than 2 mm, in sandy matrix. Maximum size to 6 cm. Tuff (or caliche?) clasts with quartz, biotite and garnet crystals are present, up to about 1 cm size. **Character of Matrix:** Sandy, mostly with a calcite cement. **Reaction with HCl (1:4):** Strong. **Description of sand- and silt-size matrix mineralogy:**

Dominantly quartz and iron oxides - euhedral magnetite crystals present. Some possible tourmaline, epidote(?) and hornblende(?).

Sample Number: 9. **Size and Depth of Core Sample**: 6 in at 201.8 ft. **Name:** Sandy conglomerate with calcite cement greater than 10%. **Color:** Light tan/gray/brown Hue 7.5 YR 8/3. **General Description:** Poorly sorted - moderately and variably indurated. **Clast Characteristics:** Clasts subangular and subrounded, maximum size up to 6 to 7 cm, most much smaller. A few tuffaceous (or caliche?) clasts, generally less than 1 cm in size, some smaller elongate clots of this material. **Character of Matrix:** Sandy matrix, carbonate cement visible as fine-grained vitreous interstitial material. **Reaction with HCl (1:4):** Strong. Disaggregation not complete with acid, indicates silica and/or sulfates present as well as calcite in the cement. **Description of sand- and silt-size matrix mineralogy:** Quartz with abundant feldspars; hornblende, epidote(?), biotite, and feldspars more common than in previous samples. Iron oxides.

Sample Number: 10. **Size and Depth of Core Sample**: 6 in at 224 ft. **Name:** Sandy conglomerate with cement greater than 10%. **Color:** Tan/yellow Hue 10 YR 8/4 more of a limonite color than previous. **General Description:** Poorly sorted, very pebbly; contains large amounts of tuff (or caliche?) clasts and the smaller clasts are distinctly rounded. Relatively friable in comparison with higher samples. **Clast Characteristics:** Clasts subangular and rounded up to 3.5 cm. Most of the smaller ones distinctly round. The clasts are 40 to 50% by volume. Tuff (or caliche?) clasts are common, and relatively rounded in comparison with other clast types. They contain biotite (or black volcanic glass?) and lithic fragments - of variable composition. Carbonate clasts which are present have no caliche overgrowths. **Character of Matrix:** Sandy, but with more fines than previously seen. Size ranges from 2 mm to 1/100 mm. **Reaction with HCl (1:4):** Strong, and produced cloud of fines, more so than previously seen in higher samples. **Description of sand- and silt-size matrix mineralogy:** Dominantly quartz, iron oxides, and rock fragments. Iron oxides include magnetite. Rock fragments and feldspars common. Some hornblende. **Other:** Although the matrix is dominantly sandy, there appear to be more clays within it than previously described.

Sample Number: 11. **Size and Depth of Core Sample**: 9 in at 249 ft. **Name:** Sandy conglomerate with calcite cement greater than 10%. **Color:** Light tan/gray Hue 10 YR 8/2. **General Description:** Poorly sorted, well indurated. **Clast Characteristics:** Clasts subangular and subrounded up to 5 cm size, matrix supported, make up about 40% by volume of the rock. Numerous tuff (or caliche?) clasts present, to about 1 cm in maximum dimension. **Character of Matrix:** Sandy; vitreous carbonate cement in matrix. Common, clear, equant, striated grains about 1 mm in size occur in matrix. These are probably calcite, as they disappear on acidification. Matrix size 2 mm to 1/50 to 1/100 mm; fines present but not much below silt (as usual). **Reaction with HCl (1:4):** Strong. **Description of sand- and silt-size matrix mineralogy:** Dominantly quartz with minor iron oxide aggregates and single grains. Magnetite present. Some quartz grains are very well rounded. Some rock fragments. **Other:** The striated crystals, tentatively identified as calcite, might be salt (NaCl) as they appear to have a very salty taste. However, the taste could be from material in the matrix. The crystals are soft and dissolved on acidification. In this particular specimen they also appeared to disappear when water was poured on the sample. This was not the case for some lower samples.

Sample Number: 12. **Size and Depth of Core Sample**: 7 in at 275 ft. **Name:** Sandy conglomerate with calcite cement greater than 10%. **Color:** Light tan/gray Hue 10 YR 8/1, but variable to 8/4; areas of carbonate cement are lighter. **General Description:** Indurated but relatively friable. The sandy matrix contains some irregular voids, which are 2 to 3 mm in maximum dimension. Some Mn-oxides present on what appears to be internal fractures in the segment. **Clast Characteristics:** Clasts are subangular and subrounded up to about 5 cm size and makeup about 30% by volume. Matrix supported. One large limonite clast broke up, about 2.5 cm; may represent oxidized organic material? **Character of Matrix:** Sandy, mostly, but down to about 1/50 mm, some even smaller. Calcite cement is present, smooth looking, interstitial; however, not evenly distributed. **Reaction with HCl (1:4):** Very strong. **Description of sand- and silt-size matrix mineralogy:** Dominantly quartz and feldspar, and iron oxides. Common euhedral magnetite.

Other: Induration is variable as the calcite cement is not uniform throughout the segment. The calcite rich zones are the hardest.

Sample Number: 13. **Size and Depth of Core Sample**: 6 in at 299 ft. **Name:** Sandy conglomerate with calcite cement greater than 10%. **Color:** Light tan/yellow/gray Hue 10 YR 8/3. **General Description:** Variably indurated, poorly sorted. Evidently the calcite cement is again variable in the segment. Lots of internal porosity, particularly open spaces around the pebbles up to 1 cm maximum dimension. Some equant voids 3 mm across. **Clast Characteristics:** Clasts subangular and subrounded up to 5 cm across makeup 30 to 40% by volume. Matrix supported. Tuff (or caliche?) clasts present up to about 1 cm across. These contain biotite (or black volcanic glass?). **Character of Matrix:** Sandy, with interstitial carbonate cement which gives a resinous lustre. Again, glassy crystals present in matrix in clusters which disappear when wet and have a weak salty taste. Could these be halite, or calcite? **Reaction with HCl (1:4):** Very strong. Disaggregation not complete on acid; probably some silica and or sulfate in cement. **Description of sand-and silt-size matrix mineralogy:** Dominantly quartz, quartz-aggregates and rock fragments. A few very rounded quartz grains, magnetite, and other iron-oxide grains. Lots of iron-oxide stain on quartz and aggregate quartz grains.

Sample Number: 14. **Size and Depth of Core Sample**: 6 in at 323 ft. **Name:** Sandy conglomerate. **Color:** Tan/yellow Hue 10 YR 8/6, but with limonitic splotches up to about a cm in size. **General Description:** Poorly sorted, coherent, but generally friable. Matrix has large amount of limonite and hematite stained spots. **Clast Characteristics:** Clasts subangular or subrounded, up to about 3 cm; matrix supported. These makeup about 30% to 40% by volume of the sample. Tuff (or caliche?) clasts present, but sparse. Probably contained biotite, now FeOx spots. **Character of Matrix:** Sandy, but with lots of limonite and hematite stain. Very fine grained silty and clay-rich aggregates, limonitic and hematitic zones occur in it. **Reaction with HCl (1:4):** None. **Description of sand- and silt-size matrix mineralogy:** Dominantly quartz with feldspar, rock fragments, and iron oxides, including magnetite grains. **Other:** First sample with no carbonate matrix.

Sample Number: 15. **Size and Depth of Core Sample**: 8 in at 342 ft. **Name:** Sandy, silty(?), conglomerate. **Color:** Mottled, tan/brown/yellow Hue 10 YR 8/4 to 10 YR 6/8, very variable. **General Description:** Poorly sorted, fairly friable. Has lots of limonitic and hematitic mottling. Some hematitic material probably oxidized clasts. **Clast Characteristics:** Clast subangular and rounded, many rotten and friable, up to 3 cm and make up 30% to 40% by volume. Matrix supported. Some small tuff (or caliche?) clasts, fairly common. Some of these clasts are smeared out and bent around adjacent pebbles of harder material. **Character of Matrix:** Sandy but appears to have more fines than previously noted. Hematitic and limonitic zones as noted above. **Reaction with HCl (1:4):** None, however, the sample disaggregated to produce a large cloud of fine material and a coarser residue. The cloud of fine material was floated off. **Description of sand- and silt-size matrix mineralogy:** Dominantly quartz, feldspar, and iron oxide grains with large of magnetite fraction. Aggregate limonite and hematite and rock fragments (these may be same thing).

Sample Number: 16. **Size and Depth of Core Sample**: 7 in at 361 ft. **Name:** Sandy, silty conglomerate with calcite matrix greater than 10%. **Color:** Upper two-thirds are 7.5 YR 8/2 light tan/gray, lower one-third is 10 YR 8/3 light tan/yellow/gray. **General Description:** Poorly sorted and variably indurated. Top 2/3 is rock like, bottom 1/3 is friable due to differences in cementation. Clasts also larger and sparser at top. **Clast Characteristics:** Upper-part clasts subangular and subrounded to 5 cm size, larger and sparser than the subrounded lower ones. Overall about 30% of rock is clasts, matrix supported. Tuff (or caliche?) clasts present, to about 1 cm in size. **Character of Matrix:** Upper part sandy to tuffaceous with carbonate cement, lower part is sandy. Clay clots occur in the sand fraction. Limonitic and hematitic splotches occur in the matrix of the lower part, as described for other samples above this zone. **Reaction with HCl (1:4):** Variable. Stronger for upper part but still had reaction for lower as well. Acidification produced a cloud of fine material, which was decanted, and a coarser residue. **Description of sand- and silt-size matrix mineralogy:** Dominantly quartz with iron oxides and rock fragments. Some magnetite in the iron oxide fraction. **Other:** This segment shows variation in just 7 in, with very different induration characteristics due to differing amounts of carbonate cementation. Some variations in degree of cementation have been noted in samples from higher in the section as well.

Sample Number: 17. **Size and Depth of Core Sample**: 9 in at 380 ft. **Name:** Sandy conglomerate with calcite cement, less than 10% (?). **Color:** Variable; Tan/yellow/gray 10 YR 8/4 to 7/4. **General Description:** Well indurated, but variably so. Poorly sorted. Flatter clasts show an imbrication, parallel to the core diameter. Color is mottled again due to limonitic rich clots and zones. **Clast Characteristics:** Subangular and subrounded clasts up to 6 cm size make up 30% to 40% of the segment and are matrix supported. A few tuff (or caliche?) clasts are present. **Character of Matrix:** Mostly sandy, but with mottled, hard limonitic zones or clots. No distinctly obvious carbonate cement. **Reaction with HCl (1:4):** Variable, moderately strong in places. **Description of sand- and silt-size matrix mineralogy:** Sand fraction dominantly quartz with rock fragments and iron oxides, a good deal of which is magnetite grains. Some aggregate iron oxides which may be oxidized rock fragments. Lots of clear feldspar and some muscovite, noted also sphene, epidote(?) or pyroxene(?).

Sample Number: 18. **Size and Depth of Core Sample**: 8 in at 402 ft. **Name:** Sandy, silty conglomerate with greater than 10% calcite cement. **Color:** Mottled, light brown to reddish brown due to hematitic splotches and clasts, Hue 10 R 4/8 (red splotches), 10 YR 8/4 to 8/8 other areas. **General Description:** Poorly sorted, well indurated but still relatively friable. Lots of hematitic splotches and clasts. Voids are abundant, particularly along boundaries of clasts and matrix. Voids have maximum dimension of 1 cm. **Clast Characteristics:** Clasts subangular and subrounded, maximum size to 6 cm, matrix supported, makeup 40% of segment. Some of the hematitic zones are actually clasts, up to about 4 mm size. Some tuff clasts, up to about 1 cm size, that contain magnetite. Estimate hematite zones to be about 10-15%. **Character of Matrix:** Sandy mainly but particle size down to 1/50 to 1/100 mm. Some hematitic areas in matrix are clayey. Estimated 10 to 15% hematitic zones. This segment has a lot of iron. **Reaction with HCl (1:4):** Very strong (and unexpected, as matrix was not obviously carbonate cemented). Dissolution gave a lot of fines which were decanted. **Description of sand- and silt-size matrix mineralogy:** Mostly quartz and quartz-aggregate rock fragments, iron oxide grains, with some magnetite. Some quartz very rounded. **Other:** Voids around some of the clasts are filled with clear, striated crystals. Possibly halite again, as they taste a bit salty. This material was included in the thin section blank. It did fizz on acidification, which suggests that the material is really calcite or that there is calcite around these crystals that is producing the fizz. The crystals did not completely disappear when acidified. Another possibility is that these crystals are gypsum.

Sample Number: 19. **Size and Depth of Core Sample**: 8 in at 421 ft. **Name:** Sandy conglomerate with calcite matrix greater than 10% (?). **Color:** Tan to reddish yellow. Hue 10 YR 7/4 to 10 R 4/8. **General Description:** Poorly sorted, indurated, but relatively friable. Matrix again has hematitic zones, but not as many as previously. Distinctly full of voids, with open spaces around the pebbles and more equant than previous sample. Again, lined with clear striated crystals, which could be either halite, gypsum, or calcite. **Clast Characteristics:** Very clast rich; subangular and rounded, about 40% by volume perhaps as high as 50; matrix supported. Maximum clast size 5 cm. Hematitic clasts probably less than 5%. Tuff (or caliche?) clasts present, largest to 1 cm, most are smaller. **Character of Matrix:** Sandy, same approximate size distribution as before. **Reaction with HCl (1:4):** Moderately strong. Acidification produced a heavy cloud of fine material, although not as much as in some of the higher samples, and also a coarser residue. The finer material was decanted. **Description of sand- and silt-size matrix mineralogy:** Mostly quartz, with feldspar, quartz aggregate rock fragments, iron oxides, with a lot of magnetite which is generally pretty fine grained. Some large clear quartz crystals.

Sample Number: 20. **Size and Depth of Core Sample**: 3 in at 422 ft. **Name:** Moderately poorly sorted, epiclastic, medium-fine grained sand. **Color:** Tan/yellow/brown, Hue 10 YR 8/3 to 8/4. **General Description:** A sandy zone, continuous with the last segment. Moderately poorly sorted, well indurated sand. **Character of Matrix:** Grain size of sand approximately 0.5 mm to 1/50 to 1/100 mm. Some 1 mm tuffaceous (or caliche?) clasts, rounded, some rock fragments in coarser fraction as well. Magnetite rich. **Reaction with HCl (1:4):** None, but lots of fines were produced by solution which were decanted. **Description of sand- and silt-size matrix mineralogy:** Sand is mostly quartz or quartz-feldspar aggregates, stained with iron oxide, and containing fine magnetite. Just a few discrete quartz crystals and sand-sized rock fragments, largely quartz aggregate or quartzite. Some magnetite crystals. This may be a reworked tuff with some fine material present. **Other:** In thin section, check for shards. The aggregate texture of the grains and their fine dusting of magnetite suggests tuff.

Sample Number: 21. **Size and Depth of Core Sample**: 6 in at 449 ft. **Name:** Tuffaceous conglomeratic sand, fine to medium grained. **Color:** Light brown/yellow 10 YR 8/6. **General Description:** Poorly indurated, relatively friable, sandy conglomerate. **Clast Characteristics:** Clasts are angular and subrounded, up to about 6 cm, forming 20% by volume, matrix supported. One large clast is a fine grained, well indurated tuff (or caliche?) fragment. About 5% to 10% hematitic clasts and clots. Few clasts are below 5 mm in size; which differs from previous samples. **Character of Matrix:** Sandy, much like the sand of the previous sample. Size range about 0.5 mm to 1/50 to 1/100mm. Much iron oxide dusting (magnetite?). **Reaction with HCl (1:4):** Very slight. Lots of fines produced by fluid which were decanted. **Description of sand- and silt-size matrix mineralogy:** Mostly quartz aggregate probably quartz-feldspar aggregate, some individual quartz crystals, lots of magnetite. Again, this resembles tuffaceous material and should be checked for shards.

APPENDIX B --Descriptions of thin sections and polished sections of alluvium from core at the Rabbit Creek gold deposit.

Sample 1 (Depth, 15 ft)

Deformed, quartz-rich rock containing small clasts (< 0.5mm) of chert?, silicified rocks veined with quartz, metamorphic rocks that are mica rich, and basalt. Most clasts lack distinct boundaries. The rock contains veins of cockscomb-textured quartz with vague boundaries.

Sample 2 (Depth, 38 ft)

Slide 1 Matrix- and cement-supported conglomerate containing rock fragments (many are +1 cm) and mineral grains floating in a matrix of very fine grained calcium carbonate, quartz, and feldspar. The composition of the matrix was confirmed by x-ray diffraction analysis. Rock fragments include limestone, metamorphic rocks (0.5 mm), and basalt (0.3 mm); mineral grains include angular quartz (0.2 mm), angular plagioclase (60μm), biotite, white mica, and opaque minerals.

Clasts of limestone consist of fossil crinoid columnals with rim cement (40-50% of the rock), pelloids, endothyrid forams, scraps of Bryozoa, silt-sized quartz, and possibly fragments of chert, all cemented with sparry calcite. The constituents listed above suggest that this limestone was deposited in shallow water. Evidence for solution compaction can be seen along some calcite grain boundaries, where the rim cement surrounding crinoid stems has been dissolved and grains have compacted together.

Slide 2 Cement- and matrix-supported conglomerate with rock fragments and mineral grains floating in sand- to clay-size matrix of very fine grained calcium carbonate, quartz, and feldspar. The rock fragments include detrital caliche (>1 mm), metasedimentary rocks (>1 mm), siltstone, silicified rocks with faint foliation, some intensely foliated metasedimentary rocks, and altered basalt (0.5 mm); mineral grains include quartz (100μm), plagioclase (including An_{50}), hornblende, calcite, and clinopyroxene.

Sample 3 (Depth, 60 ft)

Clast- and matrix-supported conglomerate containing rock fragments (+1-cm size) floating in sand- to clay-size matrix and calcium carbonate. The rock fragments include metamorphic rocks (>1 mm), basalt with plagioclase microlites, detrital caliche, calcareous siltstone containing fine-sand-sized angular quartz (200μm) and pelloids, limestone with detrital quartz (50μm), recrystallized quartzite, limestone with coating of caliche, and silicified limestone. Mineral grains include rounded (reworked) quartz (300μm), strained quartz, plagioclase, and opaque minerals. Interstitial material between the +1-cm rock fragments is very fine grained calcium carbonate cement.

A clast of silicified rock contains a cross section of a silicified crinoid columnal, proving that the rock is a silicic alteration of limestone rather than a true chert.

Sample 4 (Depth, 83 ft)

Mixture of local clast-supported (clasts +1 cm) and local matrix- and cement-supported conglomerate containing rock fragments of basalt with fresh plagioclase microlites, recrystallized quartzite, igneous rock containing epidote, detrital caliche, micaceous metasedimentary rock, and limestone. Mineral grains include quartz, plagioclase, hornblende, and epidote. Clasts of detrital caliche are soft and have been deformed around harder clasts of limestone. The cement is very fine grained calcium carbonate (caliche).

Sample 5 (Depth, 107 ft)

Slide 1 Clast-supported conglomerate contains rock fragments (+0.5 cm) of caliche-coated limestone (with detrital quartz grains that are 300μm), detrital caliche, basalt with microlites of calcic plagioclase(composition of An_{63-73}), foliated metasedimentary rocks, recrystallized quartzite, serpentinite?, and silicified rocks. Mineral grains include quartz, clinopyroxene, hornblende, plagioclase, calcite, mica, and opaque minerals. Interstitial caliche, fine-grained rock fragments, and mineral grains are matrix and cement. The coatings (0.5mm) of caliche on various larger rock clasts are distributed asymmetrically, such that the coating is thicker on one side of a clast than on the other side.

Slide 2 Clast-supported conglomerate contains rock fragments of limestone, basalt, metasedimentary rocks, silicified and quartz-veined rocks, and ultramafic rocks containing clinopyroxene, orthopyroxene, and serpentine. Mineral grains include quartz, plagioclase, orthopyroxene, hornblende, white mica, and glass shards. Interstitial calcium carbonate is probably the cement.

Sample 6 (Depth, 124 ft)

Mixture of local clast-supported (clasts +4 cm) and matrix- and cement-supported conglomerate in fine sand matrix of mineral grains and fine-grained rock fragments. Conglomerate contains caliche-coated rock fragments of limestone, calcareous siltstone, metasedimentary rocks, basalt, detrital caliche, and silicified rocks. Mineral grains include quartz, plagioclase, and hornblende. Cement is probably a secondary calcium carbonate.

Some limestone clasts contain fossils, including crinoids that are surrounded by rim cement, endothyrid forams, fusulinids, and echinoid spines. Locally, crinoids contain the mud-filled borings of endolithic algae, which indicates that deposition occurred in the photic zone. The above constituents suggest shallow-water deposition of the original limestone unit.

Sample 7 (Depth, 149 ft)

Slide 1 Unusually well consolidated rock, which contains an abundance of silicic rock fragments. Clast-supported conglomerate contains fragments of recrystallized quartzite, siltstone/mudstone, foliated metasedimentary rocks, and silicified rocks. Mineral grains include more angular quartz, rounded (reworked) quartz (350μm), and goethite as a replacement of euhedral pyrite. The boundaries between clasts and cements are vague, so that the clasts are difficult to distinguish from cement in thin section. The cement is a coarse secondary calcium carbonate. The rock contains a vein of calcite and clusters of goethite pseudomorphs of euhedral, pyritohedral pyrite.

Slide 2 Clast-supported conglomerate containing clasts of quartzite and siltstone/mudstone (300-1200μm). Mineral grains include quartz, and cement is probably a secondary calcium carbonate. Rock is veined by calcium carbonate and contains clusters of goethite.

Polished section Goethite replacement of euhedral, pyritohedral pyrite (<0.1 mm). If the original euhedral pyrite was detrital, then it did not travel far, because the crystals show no effects of abrasion. Fresh and finely disseminated, relict pyrite (<4μm) occurs, some of which is pyritohedral in form.

Sample 8 (Depth, 176 ft)

Slide 1 Clast-supported conglomerate containing rock fragments (+0.5 cm) of limestone, basalt, foliated metasedimentary rocks, detrital caliche, coarse-grained siltstone with quartz 125μm, limestone with detrital quartz silt (40μm), and silicified rock veined with quartz. Limestone clasts contain tangential sections of fusulinids and cross section of a spine (200μm) that is well preserved. Mineral grains include quartz, calcite, plagioclase, and hornblende. Matrix and cement are the very fine grained clays and calcium carbonate that occur interstitially.

Slide 2 This sample is dominated by a large clast of what is a siltstone to fine-grained sandstone, which contains quartz grains 40-70μm. The largest clast is surrounded by a thick (1200μm) coating of caliche. Within the caliche coating there are well-preserved glass shards. The other clasts in the slide are smaller fragments of limestone, basalt with plagioclase microlites, very fine grained sandstone with quartz grains that are up to 50μm, angular glass shards (200μm), red chert, plagioclase (+240μm), quartz, and hornblende.

Sample 9 (Depth, 202 ft)

Slide 1 Clast-supported conglomerate containing rock fragments (+0.5 cm) of basalt, detrital caliche, igneous rock altered to chlorite, very fine grained sandstone with quartz grains 200μm, silty limestone (+2 mm) with quartz grains 40μm, serpentinite?, metasedimentary rocks with quartz grains 600μm, and quartz-veined siltstone. Interstitial material is more abundant than in sample 8, and consists of mineral grains of quartz, plagioclase, hornblende, and unidentified opaque minerals, and fine-grained rock fragments. The cement is caliche.

Slide 2 Clast-supported conglomerate containing clasts of basalt with local clinopyroxene preserved, limestone, siltstone, metasedimentary rocks, silty limestone, silicified rocks, and detrital caliche. Mineral grains include quartz, plagioclase, hornblende, and opaque minerals, which are packed together in the caliche cement with tiny rock fragments. The cement is secondary calcium carbonate (caliche).

Sample 10 (Depth, 224 ft)

Slide 1 Clast-supported, tightly packed conglomerate that contains clasts with very sharp boundaries, which are easily distinguishable in thin section. Clasts include limestone, siltstone with 60-μm quartz, metasedimentary rocks, some intensely foliated metamorphic rocks, detrital caliche, silicified rocks that are veined with quartz and calcium carbonate, and basalt. Mineral grains include very coarse, strained quartz, hornblende, and plucked-out material of unknown composition. The cement is calcium carbonate.

A clast of very altered mafic volcanic/hypabyssal rock (>1 mm) contains a variolitic texture. Another clast of mafic volcanic/hypabyssal rock contains calcic plagioclase with a composition of An_{70}.

Slide 2 Clast-supported conglomerate with easily distinguishable clasts, as above. Clasts consist of fine-grained quartz-rich sandstone with rounded, second-generation, grains of quartz, partly silicified limestone, basalt, limestone, metasedimentary rocks, detrital caliche, completely silicified rocks, and siltstone. Mineral grains include quartz and plagioclase. Cement consists of equant grains of calcium carbonate.

Sample 11 (Depth, 249 ft)

Slide 1 Clast-supported, tightly packed conglomerate containing clasts (+0.3 cm) of limestone, siltstone, metamorphic rocks, chert, basalt, silicified rocks, and detrital caliche. Locally cement-supported conglomerate. Locally, secondary calcium carbonate pushed apart rock fragments and/or filled open spaces. Mineral grains include quartz, fresh biotite, and hornblende. The cement is calcium carbonate. No halite was noted in thin section, although it was tentatively identified in hand sample.

Slide 2 Clast-supported conglomerate containing clasts of calcite-veined siltstone, altered basalt, siltstone, detrital caliche, calcareous siltstone, limestone, silicified rocks veined with quartz, quartzite?, and metamorphic rocks. The rock appears to be clast supported and to lack obvious matrix or cement. Interstitial material may not have survived diagenesis or grinding and polishing of the thin section.

Sample 12 (Depth, 275 ft)

Slide 1 Cement- and matrix-supported conglomerate that contains clasts (+4 cm) of metamorphic rocks, veined and silicified rocks, chert, igneous rock consisting of plagioclase (800μm) and clay minerals, limestone (or caliche), and siltstone. Matrix contains sand-sized rocks and minerals, and caliche cement, which appears as calcite in the x-ray pattern. The slide is dominated by a large clast of siltstone. Clasts of the other lithologies occur adjacent to the siltstone clast.

Slide 2 Cement- and matrix-supported rock. The clasts include quartzite (or quartz siltstone), jasperoid, glass shards, limestone, altered basalt or diabase, metamorphic rocks, and quartz in a cement of secondary calcium carbonate.

Sample 13 (Depth, 299 ft)

Clast-supported rock containing clasts (0.5-3.0 cm) of metasedimentary rocks, calcareous siltstone, quartzite with rounded grains of quartz that are up to 300μm, jasperoid or silicified rock, siltstone, altered mafic igneous rock (basalt?), and quartz-veined siltstone in cement of secondary calcium carbonate. Some clasts are coated with caliche, which is probably part of the detrital clast. Matrix consists of minerals and fine-grained rock fragments. No halite was noted in thin section.

Sample 14 (Depth, 323 ft)

Clast-supported, tightly packed conglomerate containing clasts of metamorphic rocks, rounded (reworked) clasts of basalt that consists of radial aggregates of acicular and fibrous minerals, coarser grained igneous rock with plagioclase that is 275μm, serpentinite?, siltstone, chert or jasperoid that is veined with quartz, quartzite (coarse), quartz, plagioclase, fresh brown biotite, and opaque minerals that are up to 1200μm. The matrix is a green material that consists of clay (montmorillonite?) and quartz, as indicated by X-ray diffraction patterns. There is no obvious calcium-carbonate cement.

Polished section Goethite occurs as a replacement of pyrite?, but there is no relict pyrite in the sample. The pyrite? replaced by goethite is not euhedral, as it is in sample 7. Instead, it is corroded or abraded.

Sample 15 (Depth, 342 ft)

Clast-supported, very tightly packed rock containing clasts (0.5-2.0 cm) of metamorphic rocks, siltstone, quartzite, basalt with microlites of calcic plagioclase (An_{74}), jasperoid, only one limestone clast, quartz, plagioclase, and clay minerals?. There is no calcium-carbonate cement in this rock. X-ray diffraction analyses indicate that the interstitial material consists of clay minerals and quartz. The clay may be matrix material, or deformed and crushed fragments of an altered, labile rock.

Sample 16 (Depth, 361 ft)

Slide 1 Clast-supported conglomerate with interstitial fine-grained rocks and mineral fragments. Contains clasts of limestone, quartzite, siltstone, metamorphic rocks, jasperoid, quartz, plagioclase, biotite, and white mica in a cement of secondary calcium carbonate.

Silde 2 Clast- and cement-supported rock containing clasts of limestone, siltstone, metamorphic rocks, micaceous quartzite, silicified rocks or chert, mildly foliated metamorphic rocks, altered volcanic rocks (basalt?), quartz, white mica, and calcite in a cement of secondary calcium carbonate.

Sample 17 (Depth, 380 ft)

Clast-supported, tightly packed conglomerate with clasts (0.5-+3 cm) of siltstone, limestone, recrystallized quartzite or quartz- vein material, altered mafic igneous (basalt?) rocks, chert?, calcareous siltstone, metamorphic rocks, jasperoid?, quartz, plagioclase, and mica. Matrix consists of fine-grained rocks and mineral grains, in cement of secondary calcium carbonate. The basalt? contains the radial aggregates of acicular and fibrous minerals that are seen in other samples.

Sample 18 (Depth, 402 ft)

Clast-supported rock containing clasts (0.5-2+ cm) of limestone, altered basalt, siltstone, metamorphic rocks, chert?, and recrystallized quartzite or quartz-vein material. The interstitial material consists of quartz, calcium carbonate, and clay, according to x-ray diffraction analyses, and minor plagioclase appears in the thin section. Clasts of altered igneous rocks (basalt?) are particularly abundant in this sample. Siltstone clasts may be more abundant than metamorphic clasts. No halite was noted in thin section.

Sample 19 (Depth, 421 ft)

Clast-supported, very tightly packed rock containing clasts (<0.5-+1 cm) of metamorphic rocks, siltstone, silicified rocks or chert?, quartz-vein material, altered basalt?, minor limestone, quartzite, quartz, and biotite that shows only a pale pleochroism. Metamorphic rocks and siltstone are particularly abundant. There is no obvious matrix or cement. Neither halite nor gypsum were noted in thin section.

Sample 20 (Depth, 422 ft)

Matrix material, nearly opaque, Matrix contains tiny grains of quartz, silicified rocks (chert?), metamorphic rocks (125 μm), mica, and siltstone. No limestone observed. X-ray diffraction analysis indicates that the matrix material consists of quartz, impure calcite, and clay (montmorillonite?). Glass shards were not observed.

Sample 21 (Depth, 449 ft)

Clast-supported rock containing clasts (<0.5-+3 cm) of moderately foliated metasiltstone, altered basalt, metamorphic rocks, minor limestone or detrital caliche, slightly calcareous siltstone, jasperoid, volcanic glass?, and silicified rocks that may be recrystallized quartzite or quartz-vein material, clay, silt-sized quartz, and biotite. Siltstone and metamorphic rocks predominate in this sample. There is no calcium-carbonate cement in this sample. X-ray diffraction analysis indicates that the interstitial material consists of quartz and clay (montmorillonite?). The clay looks similar to that in sample 15. Glass shards were not observed in thin section.