ANALYSIS OF GRAVEL IN GLEN-SAN JUAN CANYON REGION

UTAH AND ARIZONA

By

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INTRODUCTION

The sampling and analysis of gravel deposits which occur in Glen and San Juan Canyons and the surrounding regions is part of a comprehensive geologic study of the Glen Canyon reservoir area currently being made by the Museum of Northern Arizona in cooperation with and financed by the National Park Service. The area under study includes all of Glen Canyon, extending from Lees Ferry, Arizona to the mouth of the Dirty Devil River, a few miles upstream from Hite, Utah; and the long section of San Juan Canyon that is downstream from Mexican Hat, Utah. A total of 141 samples were taken from terraces and deposits overlying erosion surfaces from the river channels to the highest levels which are over 1, 500 feet above the river. All deposits on Late Tertiary (?) and Tertiary erosion surfaces were sampled in the area between the Kaibito Plateau in the northwestern part of the Navajo Indian Reservation to the southern High Plateaus of Utah in the vicinity of Escalante and Bryce Canyon National Park. In addition, several samples were taken of conglomerate at the base of the Wasatch formation, and from the Dakota sandstone, Salt Wash member of the Morrison formation, and the Carmel formation.

The objectives of the pebble study are: (1) to determine the composition of gravels deposited in the canyon area by the Colorado and San Juan Rivers; (2) to recognize individual types and assemblages; (3) to compare pebble assemblages of all units sampled for possible correlation; (4) to check the amount of re-working of older gravels; and (5) to obtain information concerning the distribution and general source directions of the pebble assemblages and individual types.

The author is grateful to William L. Chenoweth for his many suggestions concerning the preparation of this manuscript.

METHODS

In the selection of a site for a pebble count, the area was examined carefully in order to determine a location that is typical of size, sorting, and composition of the deposit. Excessively coarse or fine deposits were avoided in order to try to obtain average sedimentary conditions. In sampling a terrace the count was taken at the top or on the upper part of the slope in an area free of contamination from other gravels. For each regular pebble count, in order to obtain a quantitative estimate of the composition of the gravel, 100 pebbles were collected exercising special care to be sure that each consecutive pebble was included, thus avoiding possible error introduced by selective sampling. The count was restricted to sizes larger than one-half inch in the long dimension; exceptions had to be made in some of the counts and smaller sizes were included in deposits containing very limited quantities of pebbles. In the selective pebble counts an attempt was made to obtain all types of material which compose the gravel, regardless of size, concentration, and the number taken in each count.

The regular pebble counts indicated quantitative information concerning the various composition of the gravels. In addition to the regular counts, selective pebble counts were taken in order to obtain samples of all types of gravel in the deposit. The selective samples also served as a check on the regular counts in noting the presence or absence of certain rock types. All of the selective counts made in Glen and San Juan Canyons showed the same number of rock types as the regular counts, and no additional types were observed in the selective counts.

In the analysis, identification of the pebbles was made with a hand lens, and the types are grouped together under a general heading with many of the rarer types not specifically shown. A total number of 58 lithologic types was listed, which have been combined into 22 major and minor types. The major types, arbitraily defined, form greater than 10 per cent of the total count, and the minor types average less than 10 per cent and generally less than 5 per cent. Major types include granitics (granite and gneiss), porphyries of intermediate composition derived chiefly from laccolithic intrusions, chert, gray quartzite, buff quartzite, tuff, felsite, limestone, jasper, and sandstone. Of the major types only chert forms a significant percentage in all deposits. The minor types, some of which are diagnostic, include gray conglomeratic quartzite, chert-jasper conglomeratic quartzite, quartz, petrified wood from the Chinle formation, pegmatite, basalt, pebbles showing mineralization or alteration, schist, and subtypes of the major types. Table 1 contains the description, areal distribution, and possible source areas for the gravel, and Figure 1 summarizes the stratigraphic distribution of the major and minor gravel types.

ERRORS OF SAMPLING

In the following discussion most of the percentage figures and number of samples have been rounded off to 5 digit intervals because of the variations of local conditions which affected the interpretations of the analyses. After eliminating the analyses showing the more easily recognized local influences, I estimate that there is a 5 ± per cent error involved from local effects, and that carrying figures beyond a 5 digit interval would be misleading and perhaps be in error in the use of significant figures.

The probable error in sampling procedures and variations caused by natural sorting of the sediments was studied chiefly by inspection of the analyses of 73 regular pebble counts taken from terraces within Glen and San Juan Canyons. For example, typical percentage consistancies of rock types are indicated in two counts, taken about 100 feet apart, on a terrace 350 feet above the present channel of the Colorado River. The maximum variation for all of the major rock types in both counts was 12 per cent. Examination of 40 counts, which were deposited in the canyons and which are believed to be free from local source conditions, indicated that the range of maximum error is between 10 and 15 per cent.

The error of the minor lithologic types is chiefly less than 5 per cent of the total; however, this may represent as much as a 200 or 300 per cent variation in the amount of a particular rock type. The minor types, even those that have average percentages of only 2 or 3 per cent, are fairly consistent and are present in almost all of the counts that have not been affected by local influences.

Of all of the counts taken in the canyons, only one prominent example of local concentration of a rock type greater than 15 per cent was indicated. This count, one-quarter of a mile below the mouth of the Dirty Devil River and 100 feet above the river, contains an excessive amount of limestone pebbles which comprise 40 per cent of the total or approximately double the amount of limestone indicated from other counts taken in this part of Glen Canyon. This high percentage can be attributed to natural sorting by the river currents because the only source for this limestone is upstream, principally from Paleozoic formations which are exposed in Cataract Canyon. All other samples showing large variation in percentages can be traced to or associated with some local source condition.

In summary, the results obtained for sampling procedures indicate a 10 per cent maximum error for the major rock types in 75 per cent of the counts taken from river laid sediments in the canyons; 15 per cent error for 20 per cent of the samples; and as much as 25 per cent error in the remaining 5 per cent. Further analyses of these percentage figures suggest that for general sampling a minimum of one regular pebble count and one selective pebble count be made at a given locality; however, for more effective sampling and assurance that the sampled area has not been influenced by local conditions, two regular pebble counts and one selective count should be taken.

Description and distribution of rock types

The gravelly deposits in the Canyon country region can be divided into four groups or pebble assemblages. These are: (1) the gravel-capped terraces of Quaternary age which occur within or on the rim of Glen and San Juan Canyons; (2) scattered deposits of Tertiary(?) age that occur in the nearby areas of Glen Canyon; (3) gravel of Tertiary age which lie beneath the thick capping lavas on the summits of some of the High Plateaus of southern Utah, and the conglomerate at the base of the Wasatch formation; (4) the conglomeratic portions of the Dakota sandstone and the Salt Wash member of the Morrison formation; and (5) the pebbles contained within conglomerate units of the Chinle formation. Only the first four above mentioned groups were sampled and the following discussion is limited to rocks younger than those of Triassic age.

Quaternary gravels

The gravels from the channel to altitudes of 1,200 feet above river level in Glen and San Juan Canyons are composed of three predominant major rock types which constitute about 70-75 per cent of the deposit, but may range between 45 and 80 per cent. Depending upon local conditions, porphyries range from 20 to 30 per cent, gray quartzite from 15 to 25 per cent, and gray chert from 10 to 25 per cent. The remainder of the pebbles are primarily of granitic types, felsite, jasper, and limestone; these types are in varying percentages but each type is generally less than 10 per cent of the total. Quartz and basalt are in minor quantities and make up only 1 or 2 per cent. Sandstone, derived locally, ranges upwards to over 20 per cent. Agate, chalcedony, conglomeratic quartzite, and petrified wood were noted occasionally in the counts.

The gravels deposited by the Colorado and San Juan Rivers at all terrace levels are similar and in most counts the pebble assemblages of both rivers are practically indistinguishable from one another. However, slight differences are recognized; the San Juan River carries more grantic types, chiefly gneiss, and gray conglomeratic quartzite than the Colorado. No chert-jasper conglomeratic quartzite was found along the San Juan River. All of the other rock types are within the error of sampling for pebble counts with no significant variations in composition indicated.

Of the locally derived material deposited in the canyons, porphyry and sandstone show the greatest amount of variation. Tributary streams, Trachyte Creek, Smith Fork, Hansen Creek, and Bullfrog Creek, draining the Henry Mountains, bring in a large amount of porphyritic types, principally trachyte. Near the mouths of these streams porphyries make up as much as 75 per cent of the gravel. A strong increase of sandstone is shown by both the Colorado and San Juan Rivers in the stretches north and northwest of Navajo Mountain and southeast of the Kaiparowits Plateau. Here the gravels are chiefly composed of sandstone pebbles and boulders that range upwards to 85 per cent of the deposit. Most of the sandstone is derived from the Salt Wash member of the Morrison formation or the Carmel formation. Gravel from Cretaceous rocks form as much as 15 per cent of the total amount. Of the counts taken in this area one sample from San Juan Canyon had 84 per cent of sandstone and a sample from Glen Canyon had 73 per cent of sandstone. Other samples collected in this area ranged between 40 and 60 per cent of sandstone gravel.

The gravel of several counts taken in the Hite area average almost 20 per cent limestone types which have been eroded from the Hermosa and Rico formations which crop out in Cataract Canyon. In contrast to these high-limestone concentrations, counts made in the Clay Hills Crossing area, immediately downstream from the Goosenecks of the San Juan were the Hermosa and Rico formations are also exposed, contained less than 10 per cent of limestone. The limestone pebbles decrease in quantity downstream along both rivers and only a few scattered pebbles are present in the Lees Ferry area. Also in the Lees Ferry area small amounts of limestone pebbles derived from the Wasatch formation, and buff quartzite, black jasper, and other types re-worked from the conglomerate at the base of the Wasatch and from the gravel at the base of the lavas on the High Plateaus are recognized in the deposits.

Tertiary(?) gravels

A major break in the amount and type of pebbles is indicated between the terrace gravels within the Glen and San Juan Canyons and the deposits overlying erosion surfaces which have been formed during the pre-canyon stages of the Colorado River. Remnants of the surfaces occur at altitudes greater than 1,500 feet above the river. Reconstruction of these erosion surfaces show that they extend as a belt for more than 25 miles along the Colorado River and that they have altitudes between 4,600 and 6,500 feet depending on the distance from the river. Gravelly deposits on these surfaces are scarce with relatively pure caliche comprising the bulk of the sediments. The small quantity of pebbles that are generally present lie at the base of the caliche or are scattered throughout the deposit and consist chiefly of gray chert, with few pebbles composed of gray and buff quartzite, black jasper, and felsite. Near the base of Straight Cliffs the pebbles are composed of gravel re-worked from the Salt Wash member and the Dakota sandstone. On a high terrace west of Gray Mesa between The Rincon and the Great Bend of the San Juan River, sandstone pebbles make up over 99 per cent of the deposit. The sandstone types are chiefly those derived from the Navajo sandstone, but includes small amounts from the Carmel formation, Salt Wash member, and Upper Cretaceous rocks. One porphyry cobble and several chert and quartzite pebbles were found.

Most of these deposits have been derived from the nearby older Tertiary and Mesozoic bedrock units. However, a deposit which lies on the northeast corner of White Mesa, 35 miles southeast of Page, Ariz., contains some material that appears to have been brought in from a distant source. About one-fourth of the pebbles consist of quartz, quartzite, and chert, with three-fourths consisting of sandstone pebbles derived principally from Upper Cretaceous rocks and a few from the Salt Wash member of the Morrison. The quartzite types include pebbles of both buff and gray quartzite. Near Leche-e-Rock, about 10 miles southeast of Page, some gray and buff quartzite types and one gray conglomeratic quartzite pebble were collected from well-developed caliche.

Gravel of Tertiary age

The gravels that underlie the volcanic rocks on the High Plateaus and the conglomerate that occurs at the base of the Wasatch formation near Escalante, Utah, consist of an assemblage of four major rock types and forms a strong contrast to the pebble assemblage occurring on the Quaternary terraces within Glen Canyon. The major types are chert, tuff, black and buff jasper, and buff quartzite. The chert has been derived from Paleozoic rocks and many of the pebbles are fossiliferous. Chert-jasper conglomeratic quartzite, possibly a diagnostic type, is in small amounts present in the Tertiary deposits. This conglomeratic quartzite is believed to be re-worked material, where it occurs along the Colorado River. No gray quartzite or gray conglomeratic quartzite was recognized in any of the samples. Other major types not present are limestone and the porphyry from the laccolithic mountains. Many of the minor types which are present within Glen and San Juan Canyons are not present in the Tertiary gravels, and these types include all granitic forms, "lavender porphyritic felsite," basalt, Chinle type petrified wood, and possibly "siliceous phyllite."

The gravels overlying an erosion surface below lavas on the Aquarius and Table Cliffs Plateau near Escalante, Utah, are primarily composed of dark and light gray chert pebbles which range between 30 and 60 per cent of the total deposit. Black jasper ranges between 15 and 25 per cent, buff quartzite between 5 and 20 per cent, and tuff between 5 and 15 per cent. Felsite, chert-jasper conglomeratic quartzite, quartz, buff jasper, and other colored jaspers are fairly rare. Sandstone pebbles derived from upper Jurassic rocks are rare and no Upper Cretaceous rock types were recognized.

Conglomerate at the base of the Wasatch formation contains a high amount of tuff, felsite, and some pebbles that appear to be partly tuff and partly felsite; these types combined together form roughly 30 to 40 per cent of the total. The predominant major type is chert which is about 30 per cent. The conglomerate consists of 15 per cent jasper and between 20 and 25 per cent quartzite. The jasper is chiefly colored black which generally is equal in number to the other colored jaspers, of which there is a considerable amount of buff jasper. Sandstone types are fairly rare in the gravel, and no diagnostic types were identified.

Gravels of Upper Cretaceous and Jurassic rocks

The gravels of the younger Mesozoic rocks in the area near Glen Canyon are restricted primarily to the Dakota sandstone and the Salt Wash member of the Morrison formation and to one channel-type deposit in the Carmel formation that contained a few pebbles. Chert makes up about 90 per cent of the total in all of these deposits. The remaining 10 per cent consists of buff quartzite, black jasper, colored jaspers,, quartz, and a few mineralized pebbles. Most of the pebbles in the Carmel formation were too small for more than a genralized identification, but the composition of this gravel appears similar to the other bedrock units. The chert in the Dakota sandstone is principally of a "black and white" fractured type and contains in addition a minor amount of white chert. In contrast to this, much of the chert in the Salt Wash member is light-colored, which in some places, is about 75 per cent of the total deposit. The light-colored or white chert is believed to have been derived principally from the Kaibab limestone.

Interpretations

The study of gravel has given considerable information concerning the rocks which were exposed at the surface and which contributed material to the several gravel deposits. Interpretation of the pebble assemblages, integrated with other sources of information Baker (1936), Craig, Holmes, Cadigan, and others (1955) Gregory (1917), Gregory (1950), Gregory and Moore (1931), Hunt (1953), and Miser (1924), has given some additional insight into the origin, distribution, sedimentary environment, and stream patterns.

Stratigraphic studies made by many investigators of the Dakota sandstone and the Salt Wash member of the Morrison formation have established that these units were laid down by generally northeast-flowing streams originating from southwestern highlands. Thus, the source of black jasper, buff quartzite, and chert-jasper conglomeratic quartzite is believed to be from the west or southwest. White chert which is the predominant constituent of the Salt Wash member is chert that has been eroded from the Kaibab limestone when the limestone may have cropped out in a broad area to the west of the present exposures. The small amount of white chert in the Dakota sandstone either indicates a slight shift in a source area or more likely the Kaibab had been eroded off and the streams were attacking older Paleozoic limestones. Conversely, the small amount of fossiliferous gray chert in the Salt Wash member and the large amount in the Dakota sandstone indicates that only small areas of rocks containing the dark chert had been exposed during the deposition of the Salt Wash member, but these rocks may have had a wide surface distribution during the deposition of the Dakota sandstone. The absence of granite and gneiss pebbles was due to small surface areas of basement rocks, a long distance from the source, or the highlands were generally low and erosion was not sufficiently vigorous to form granitic gravel.

Major pebble types similar to those in the Dakota sandstone and Salt Wash member at the base of the Wasatch formation and below the lavas on the Aquarius Plateau and nearby plateaus suggest that the source of these gravels were in a generally western direction. A western source is also suggested by the lack of types which are abundant on the gravel-capped terraces in the San Juan and Glen Canyons. The lack of limestone may indicate that the material had been transported a considerable distance, and abrasion may have limited the limestone to areas not far distant from the source rocks. The black jasper pebbles which are crisscrossed by quartz or siliceous veins suggest that the jasper is associated with some phase of mineralization. Within the Wasatch formation, the gravel contains considerable percentages of tuff and felsite; these rocks perhaps record the first indications of Tertiary volcanic activity of the Canyon country.

The Tertiary(?) gravels lying on erosion surfaces at altitudes between 4,600 and 6,500 feet are composed of pebbles which can be recognized as re-worked material from the Tertiary and older gravels and of the types which were deposited within the canyons. The presence of gray quartzite, gray conglomeratic quartzite, and porphyry in some of the deposits indicates an eastern and northeastern source for much of the material, deposited by southwest-flowing streams possibly of the ancestral Colorado River system. The small quantity of siliceous types, the absence of granitic types, and the great predominance of sandstone gravel derived from Jurassic and Cretaceous rocks suggest that the Rocky Mountain region must have been rather low, and that the erosional processes were mild and not as vigorous as they were during the Quaternary and at the present time.

The Quaternary gravels deposited in the canyons by the Colorado and San Juan Rivers consist of an entirely different pebble assemblage than the gravels of Tertiary age and older deposits. The diagnostic types--porphyritic and granitic types, gray quartzite, and gray conglomeratic quartzite--of the terrace gravels, fortunately, can be traced to their sources in the Rocky Mountains and the laccolithic intrusions of the Colorado Plateau. Almost all of the limestone and chert have been derived from Cataract Canyon and the upper part of the San Juan Canyon with some of the chert brought in from areas farther upstream. The large quantities of quartzite, porphyry, and granitic types with the decrease of chert and locally derived sandstone may be attributed to overloading of the Colorado River system in the higher mountainous source areas. Vigorous erosional processes, including strong freezing and thawing action and glacial scouring, which attacked exposed sections of basement rocks is indicated from the considerable amount of granitic gravel that occurs on the river terraces.

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Figure 1. Chart showing distribution of the major and minor gravel types in the Glen Canyon region, Utah and Arizona.

Major types greater than 10 per cent of total

	Granitic	Intermediate composition laccolithic types	Chert, partly fossiliferous Paleozoic	Gray quartzite	Buff quartzite	Tuff	Felsite	Limestone Paleozoic types	Black jasper	Red-yellow-brown jasper
Quaternary gravel terraces in Glen and San Juan Canyons	R-C	C-A	C	C	R	R	R-C	R-C	R	R
Tertiary(?) deposits in the vicinity of Glen Canyon	-	R	A	R	R	R	R	VR	R	R
Tertiary gravel below lavas on High Plateaus	-	-	C-A	-	C	C	VR	-	C-A	R
Conglomerate at base of Wasatch formation	-	-	C-A	-	C	C	R-C	-	C-A	R-C
Dakota sandstone	-	-	A	-	R	-	-	-	R	R
Salt Wash member of the Morrison formation	-	-	A	-	R	-	-	-	R	R
Carmel formation	-	-	A	-	R	-	-	-	R	R

Fig. 1 -- Chart showing distribution of the major and minor gravel types in the Glen Canyon region, Utah and Arizona. (VR - very rare, less than 1 per cent; R - rare, 1-3 per cent; C - common, 3-25 per cent; A - abundant, greater than 25 per cent).

Minor types less than 10 per cent of total

Sandstone	Conglomeratic quartzite (all types)	Quartz	Chinle type petrified wood	"Siliceous phyllite"	Kaibab type chert	Lavender porphyritic felsite	Dark felsite	Pegmatite	Basalt	Mineralized	Schist
R-A	R	R	R	R	-	R	R-C	VR	R	VR	R
C-A	R	R	R	-	-	-	-	-	R	VR	-
R	R	R	-	-	-	-	-	-	R	VR	-
R	R	R	-	-	-	-	-	-	-	VR	-
-	-	R	-	-	R	-	-	-	-	VR	-
-	-	R	-	-	C	-	-	-	-	VR	-
-	-	R	-	-	-	-	-	-	-	-	-

Table 1. Description of the rock types which occur in gravel deposits in the Glen and San Juan Canyon region.

Type and subtype	Description	Distribution and probable source
Granitic, includes granite and gneiss	Composition ranges chiefly from granite to diorite, one gabbro found; typically "pink" to "gray"; medium- to coarse- grained; some pebbles show planer foliation and lineation.	In Glen and San Juan Canyons; from Rocky Mountain region.
Schist	Composed of orthoclase, quartz, biotite, muscovite, and chlorite; generally thinly foliated.	
Pegmatite	Coarse- and very coarse-grained granitic rock containing large crystals of orthoclase and muscovite with quartz; some contain tourmaline crystals.	
Basalt	Black, dense, very fine-grained; partly porphyritic; shows weathered surface.	In Glen and San Juan Canyons; multiple sources.
Porphyry	Chiefly granite to diorite composition; dark greenish gray to light greenish gray and light gray, some cream-colored, pinkish gray, porphyritic, chiefly feldspar and hornblende phenocrysts.	In area of Glen and San Juan Canyons; from laccolithic intrusions of the Colorado Plateau.
Felsite	Generally aphanitic and porphyritic, chiefly with feldspar but with some hornblende phenocrysts.	Distributed throughout Canyon country region; multiple sources.
"Lavender" porphyritic felsite	Grayish purple-brownish gray with variations of color; contains small feldspar phenocrysts.	"Lavender" porphyritic felsite may be restricted to a northeastern source.
"Dark" felsite	Dark greenish gray to greenish black; very fine-grained; partly porphyritic with small feldspar and hornblende phenocrysts.	
"Light green" felsite	Light greenish gray and greenish gray; few feldspar phenocrysts.	
Quartz	Generally "white", but occasionally some rose and iron-stained quartz; some quartz vein material.	Distributed throughout Canyon country region; multiple sources.
Quartzite	About all colores represented; very fine- to very coarse-grained; gray and buff-quartzites; very fine-grained dark gray types.	In San Juan and Glen Canyons and adjacent area; from Rocky Mountain region.

Type and subtype	Description	Distribution and probable source
gray quartzite	Grayish red purple, light gray to pale bluish gray, pinkish gray, light greenish gray, and pale red; generally fine- to coarse-grained; subangular to rounded quartz grains; some of grains exhibit an opal-like luster, a bluish or purplish color; elongation of grains and some gneissic structure developed.	
buff quartzite	Very pale orange, very light gray, pale yellowish brown, dusky yellowish brown, light brown and grayish red purple, lighter colors predominant; generally fine-grained; subrounded to rounded quartz; well-sorted.	Western part of Canyon country region; from western or southwestern source.
Conglomeratic quartzite		
Gray conglomeratic quartzite	Colors similar to gray quartzites; fine-to very coarse-grained matrix; pebbles of quartz, jasper, quartzite, and quartzitic sandstone; some of pebbles show elongation; gneissic structure developed on some samples; believed to represent facies of gray quartzite.	Principally in San Juan Canyon, but some in Glen Canyon; from Rocky Mountain region.
"Chert-jasper" conglomeratic quartzite	Generally a dark gray color; almost a chert breccia, but composed of subrounded chert and jasper pebbles; quartz grains in matrix.	Principally in western part of Canyon country, occurs in Glen Canyon as re-worked material, does not occur in San Juan Canyon; from western or southwestern source.
Chert	Generally light gray to dark gray; fairly dense, fossiliferous, chiefly crinoid stems but some brachiopods, bryozoa, fusulinids and other forms.	
Oolitic types	Light colored; oolities less than 1/8 inch in diameter.	Distributed throughout Canyon country region; no source indicated.
Grayish types	Derived from Rico and Hermosa formations and common in deposits within the confines of the canyons.	In Glen and San Juan Canyons; from Cataract and upper San Juan Canyon.
"Black-White" types	Partly fractured; grades into "moth-eaten" types.	In western part of Canyon country region from western source

Type and subtype	Description	Distribution and probable source
"White" types	Dense and partly altered.	In western part of Canyon country region; from west or southwest, derived from Kaibab limestone.
"Light greenish gray" types	Dense; found in Salt Wash member only.	In western part of Canyon country region; no source indicated.
Jasper	All colors common; generally dense and unfractured.	Multiple sources.
Black jasper	Some fractured, brecciated, and cut by network of thin quartz stringers.	Chiefly in western part of Canyon country region, re-worked in Glen and San Juan Canyons; from western and southwestern source.
Buff jasper	Dense, partly fractured.	Multiple sources.
Limestone		
Paleozoic types	Light to dark gray; generally fine-grained but partly medium-grained; cherty; fossiliferous, brachiopods, crinoid stems, bryozoa, coral, and few fusulinids.	In Glen and San Juan Canyons; from Cataract and upper San Juan Canyons.
Wasatch types	White to very light gray; cherty and siliceous, fragmental.	Locally derived material from Wasatch formation.
Tuff	Pale red to light red and dusky yellow, colors are chiefly shades of "pink"; very fine-grained; sandy and siliceous; some may have been interbedded with flows because part of the tuff is hard to identify from rhyolitic flows.	In western part of Canyon country region; from western or northwestern source.
"Siliceous phyllite"	Light greenish gray; dense, aphanitic siliceous material that shows very thin laminations.	In Glen and San Juan Canyons; from Rocky Mountain region.
Mineralized types	Chiefly composed of siliceous and iron-oxide materials; considerable hematite and hematite stained material; one specular hematite; pyrite and quartz vein material fairly common; unidentifiable siliceous vein material.	Distributed throughout region; multiple sources.