Appendix 13

The characteristics of Rim Gravel

In this appendix, I will delve into more details of the Rim Gravel of northern Arizona. The Rim Gravel is located at two widely spaced locations along and near the Mogollon Rim. The first location described is in northwest Arizona on the eastern Hualapai Indian Reservation, and the second is in east-central Arizona southwest of the town of Heber (see Figure 24.2 for locations).

Figure A13.1. Rim Gravel on Arizona Highway 18 from the eastern Hualapai Indian Reservation about 31 miles (50 km) northeast of Peach Springs, Arizona.

Gravel on the Hualapai Indian Reservation

Valley gravels are common along Highway 18 on the eastern Hualapai Indian Reservation (Figure A13.1). They are considered the Robbers Roost gravel by Koons,[1] not Rim Gravel. Robbers Roost gravel is mostly sandstone from local "Paleozoic" deposits. The gravel deposits I observed were mostly clast-supported, generally cemented, and poorly sorted with fine sand or sandstone interbeds or lenses.

True Rim Gravel covers the highest point along Highway 18 about 27 miles (45 km) northeast of Highway 66. It represents part of an extensive deposit on the Coconino Plateau found on the eastern Hualapai Indian Reservation and eastward. It contains about 30 to 40% exotic well-rounded quartzite. The largest rock was about 12 inches (30 cm) in diameter. Some of the boulders have percussion marks (Figure A13.2) indicative of a very energetic depositional environment.[2]

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[1] Koons, D., 1948. Geology of the eastern Hualapai [sic] Reservation. *Museum of Northern Arizona Bulletin (Plateau)* 20(4):53–60.

[2] Klevberg, P. and M.J. Oard, 1998. Paleohydrology of the Cypress Hills Formation and Flaxville gravel; in, Walsh, R.E. (editor), *Proceedings of the Fourth International Conference on Creationism*, technical symposium sessions, Creation Science Fellowship, Pittsburgh, PA, pp. 361–378.

Figure A13.2. Well-rounded quartzite rock with percussion marks from the Rim Gravel shown in Figure A13.1.

Figure A13.3. Matrix-supported Rim Gravel at the top of the Mogollon Rim at the junction of forest roads 512 and 291, southwest of Heber, Arizona.

Rim Gravel on the East-Central Mogollon Rim

The Rim Gravel on the east-central Mogollon Rim is the most impressive. It is thick with boulders.[3] On ridges near the Mogollon Rim, the gravel forms a flat surface (see Figure 24.4). The deposit extends southward down the valley leading to the town of Young (see Figure 24.2 for locations). The deposit is clast supported in some places, and matrix supported in others (Figure A13.3). The rocks were around 50 to 70% exotic quartzite, 15 to 25% local sandstones, less than 2% granites with rare conglomerate, quartz, chert, gneiss, and other igneous and metamorphic lithologies. Some of the granites and gneisses

[3] Elston, D.P. and R.A. Young, 1991. Cretaceous-Eocene (Laramide) landscape development and Oligocene-Pliocene drainage reorganization of transition zone and Colorado Plateau, Arizona. *Journal of Geophysical Research* 96(B7):12,389–12,406.

were well weathered and rotten. The quartzites were large, well-rounded and had percussion marks (see Figure 24.5 and 24.6). The largest quartzite I saw had a long axis of about 24 inches (60 cm). The sandstone boulders were even larger, mostly up to 3 feet (1 m) long axis. One sub-rounded sandstone boulder lay on top of the very coarse gravel (Figure A13.4) and was 6.5 feet (2 m) long. It is possible this large rock was deposited when the road was built. The size of the rocks decreased from the top of the Mogollon Rim down the valley toward the town of Young. One likely reason the rocks are so large in the east-central Mogollon Rim compared with the northwest Rim could be due to the closer source area for the east-central Mogollon Rim.

Characteristics of Rim Gravel

Uniformitarian scientists have known about the Rim Gravel for at least 80 years.[4] Since this time, many observations and reports have been published. Even yet, there are conflicting interpretations on the ages and origins of the deposits.[5]

Figure A13.4. Outcrop of very coarse, clast-supported gravel with very large sandstone boulder up to 6.5 feet (2 m) long on top. Location is 4.5 miles (7 km) south of Arizona Highway 260 on forest road 512, southwest of Heber, Arizona.

Geomorphologic Setting

The Rim Gravel in northern and central Arizona is often found on the *highest* terrain of the Mogollon Rim, generally on ridge crests.[6] Some claimed Rim Gravels are also in valleys and ancient canyons on the Colorado Plateau, as well as on pediments and lava-capped mesas.[5] There is a question of whether gravels in the valleys and canyons should be considered Rim Gravels.[7] This was discussed in Chapter 24. The Rim Gravels

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[4] Koons, D., 1948. High-level gravels of western Grand Canyon. *Science* 107:475–476.

[5] Holm, R.F., 2001. Cenozoic paleogeography of the central Mogollon Rim-southern Colorado Plateau region, Arizona, revealed by Tertiary gravel deposits, Oligocene to Pleistocene lava flows, and incised streams. *GSA Bulletin* 113:1,467–1,485..

[6] Scarborough, R., 1989. Cenozoic erosion and sedimentation in Arizona; in, Jenney, J.P. and S.J. Reynolds (editors), *Geologic Evolution of Arizona, Arizona Geological Society Digest 17*, Arizona Geological Society, Tucson, AZ, pp. 515–537.

[7] Peirce, H.W., P.E. Damon, and M. Shafiqullah, 1979. An Oligocene (?) Colorado Plateau edge in Arizona. *Tectonophysics* 61:1–24.

represent a high-energy deposit.[8] Some have been covered by lava flows that were common to the region.[9] For example, basalt covers a gravel outcrop in Oak Creek Canyon (see Figure 24.3). This is a deep canyon perpendicular to the Mogollon Rim where the city of Sedona is located.[10]

There is a bewildering number of names applied to all the gravels in the area because of their many locations. For the sake of simplicity, I will focus mainly on the gravel at and near the top of the Mogollon Rim. This gravel has been called the Blue Mountain gravel by Koons,[1,4] who described the gravel from the northwest Mogollon Rim on and near the Hualapai Indian Reservation. He later changed the name of this gravel to the Frazier Wells gravel.[11] It is also called the Music Mountain Formation.[12] Koons noted the gravel contains the highest percentage of exotic clasts of quartzite and other igneous and metamorphic lithologies. Koons noticed many of the granite and gneiss rocks are greatly weathered or rotten.[1] His lower gravel, called the Robbers Roost gravel, is found in valleys or basins and is mostly derived from local rock types like the Coconino Sandstone. Another gravel was named Cataract Creek Gravel by Koons,[11] while others referred to it as the Coyote Springs Formation.[12]

There are other named gravels in the study area, but these are generally valley fill so will not be mentioned. Some of these valley gravels probably contain exotic rocks eroded from the Rim Gravel. The valley fill gravels have been given various names in the literature, such as the Beavertail gravels, the Gila conglomerates, the Paulden formation, Hicky gravels, Slide Rock gravels, Oak Creek gravels, Cherry Conglomerate, etc.[5]

A number of geologists have noted that the Rim Gravels lie on top of an erosion surface that usually truncates the "Paleozoic" rocks of the Mogollon Rim.[3,7,8] This erosion surface was dissected in spots to form canyons and valleys. Interestingly, the hard and soft rocks of the erosion surface are cut as if they were the same hardness, at least in the Sycamore Canyon area.[13]

Rock Types

The rock types in the Mogollon Rim Gravel vary considerably. A significant proportion of exotic quartzite is in the coarse gravels as well as a large percentage of local "Paleozoic" rocks, especially sandstone. It is claimed that there are no local basalt boulders in the Rim Gravel, but rare exotic basalts were carried from afar.[3] Basalt boulders were not found in the two field areas included in this study. They are present in Sycamore and Oak Creek Canyons just off the southwest edge of the Mogollon Rim,[9]

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[8] Young, R.A., 1979. Laramide deformation, erosion and plutonism along the southwest margin of the Colorado Plateau. *Tectonophysics* 61:25–47.

[9] McKee, E.D. and E.H. McKee, 1972. Pliocene uplift of the Grand Canyon region—time of drainage adjustment. *GSA Bulletin* 83:1,923–1,932.

[10] Holm, R.F. and R.A. Cloud, 1990. Regional significance of recurrent faulting and intracanyon volcanism at Oak Creek Canyon, southern Colorado Plateau, Arizona. *Geology* 18:1,014–1,017.

[11] Koons, D., 1964. Structure of the eastern Hualapai Indian Reservation, Arizona. *Arizona Geological Society Digest* 7:97–114.

[12] Billingsley, G.H., K.J. Wenrich, and P.W. Huntoon, 2000. Breccia-pipe and geologic map of the southwest part of the Hualapai Indian Reservation and vicinity, Arizona. *U. S. Geological Survey Geologic Investigation Series I-2643 pamphlet*, Washington, D.C.

[13] Price, W.E., 1950. Cenozoic gravels on the rim of Sycamore Canyon, Arizona. *GSA Bulletin* 61:501–508.

however; these canyon gravels should be excluded from the definition of Rim Gravels. A lack of basalt boulders in the Rim Gravels on top of the Mogollon Rim would imply whatever spread the coarse gravel did it before the widespread volcanism and surficial basalt flows of the region. Inclusion of these rocks in the Rim Gravel would imply the contemporaneity of the extrusion and deposition, but the gravel preceded extensive lava extrusion. Nonetheless, the extrusion happened in an environment where boulders could be ripped off and rounded and then incorporated into other gravels, before the basalt had a chance to flow over them and cap them. The volcanism is attributed to uplift of the Colorado Plateau and Basin and Range Province extension in southwest Arizona by uniformitarian geologists.[14]

Several gravel samples collected during this investigation contain rocks exhibiting mineralization or evidence of hydrothermal alteration. Particularly prominent were hematite, limonite, malachite, and lesser amounts of other copper minerals.

Source Areas

The closest source for quartzite and other igneous and metamorphic exotic rocks of the Rim Gravel in the northwest Mogollon Rim is around the Prescott area, about 50 miles (80 km) south,[4,11] but, they could be from a number of locations to the south and west where the exotic rock types outcrop.[15,16,17] Some geologists once believed the quartzites and cherts eroded from the Shinurump Conglomerate.[13] However, the rock size in the Shinurump Conglomerate is too small, and the types of rocks do not match.[18]

It is interesting the land south and west of the Mogollon Rim is *at a much lower elevation*. Apparently, this difference is *not* due to significant faulting near the Mogollon Rim, since the rim is considered *erosional*.[5] While faults with vertical offsets are present in the Verde Valley area, Elston and Young state:

> The northern margin of the Transition Zone in central Arizona is an essentially unfaulted, south facing erosional escarpment known as the Mogollon Rim … Faulting is not responsible for most of this escarpment.[19]

The vertical uplift along the Aubrey Fault west of the Mogollon Rim is about 500 feet (150 meters) or less, and uplift on the Diamond Rim Fault east of Payson is less than 1,000 feet (300 meters) and forms a secondary scarp. The base level for the Mogollon escarpment near the east end of the Mogollon Rim is the Payson Granite.

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[14] Young, R.A. and E.H. McKee, 1978. Early and middle Cenozoic drainage and erosion in west-central Arizona. *GSA Bulletin* 89:1,745–1,750

[15] Conway, C.M. and L.T. Silver, 1989. Early Proterozoic rocks (1710-1615 Ma) in central and southeastern Arizona. In, Jenney, J.P. and S.J. Reynolds (editors). *Geologic Evolution of Arizona, Arizona Geological Society Digest 17*, Arizona Geological Society, Tucson, AZ, pp. 165–186.

[16] Anderson, J.L., 1989. Proterozoic anorogenic granites of the Southwestern United States. In, Jenney, J.P. and S.J. Reynolds (editors). *Geologic Evolution of Arizona, Arizona Geological Society Digest 17*, Arizona Geological Society, Tucson, AZ, p. 211–238.

[17] Wrucke, C.T., 1989. The middle Proterozoic Apache Group, Troy quartzite, and associated diabase of Arizona. In, Jenney, J.P. and S.J. Reynolds (editors), *Geologic Evolution of Arizona, Arizona Geological Society Digest 17*. Arizona Geological Society, Tucson, AZ, pp. 239–258.

[18] Cooley, M.E., 1962. Geomorphology and the age of volcanic rocks in northeastern Arizona. *Arizona Geological Society Digest* 5:97–115.

[19] Elston and Young, Ref. 3, p. 12,393.

The low elevations south and west of the Mogollon Rim, where the coarse gravel likely originated, indicate the land was once higher and tremendous erosion occurred south of the Rim during the uniformitarian "Cenozoic" Era.[20] This postulated higher terrain south of the Mogollon Rim has resulted in the belief that the once Mogollon Highlands have eroded to the mountains and valleys observed in the area today.[6,21]

A very minor amount of rotten granites may indicate a nearby source, assuming they were weathered before they were transported. If weathering happened after transport, they may have actually been from much farther away.

[20] Dumitru, T.A., I.R. Duddy, and P.F. Green, 1994. Mesozoic-Cenozoic burial, uplift, and erosion history of the west-central Colorado Plateau. *Geology* 22:499–502.

[21] Cooley, M.E. and E.S. Davidson, 1963. The Mogollon Highlands: their influence on Mesozoic and Cenozoic erosion and sedimentation. *Arizona Geological Society Digest* 6:7–35.