EFFECTS OF URANIUM DEVELOPMENT ON EROSION AND ASSOCIATED SEDIMENTATION IN SOUTHERN SAN JUAN BASIN, NEW MEXICO

BY

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PREFACE

This is one of a series of reports prepared as part of the San Juan Basin Regional Uranium Study, which is under the leadership of the Bureau of Indian Affairs (BIA). The reports were used as source material in the preparation of the Regional Study, which is available for public examination at BIA offices in Albuquerque, New Mexico, and Washington, D.C.

The reports listed below are a part of the series that was prepared by the U.S. Geological Survey. These reports have been open filed by the Survey and can be examined by the public at the Survey offices in Denver, Colorado; Albuquerque, New Mexico; and Reston, Virginia.

- Water Use in the San Juan Basin---------------------Open File Report 79-1500
- Surface-water Environment of the San Juan Basin------Open File Report 79-1499
- Regional Geohydrology of the San Juan Hydrologic Basin of New Mexico, Colorado, Arizona, and Utah---Open File Report 79-1498
- Reconnaissance Study of Selected Environmental Impacts on Water Resources due to the Exploration, Mining, and Milling of Uraniferous Ores in the Grants Mineral Belt, Northwest New Mexico---------------------------------------Open File Report 79-1497
- Effects of Uranium Development on Erosion and Associated Sedimentation in Southern San Juan Basin, New Mexico---------------------------Open File Report 79-1496
- Depths of Channels in the San Juan Basin of New Mexico, Colorado, Arizona, and Utah----------Open File Report 79-1526

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SOME OBSERVATIONS CONCERNING EFFECTS OF URANIUM DEVELOPMENT ON EROSION AND ASSOCIATED SEDIMENTATION IN SOUTHERN SAN JUAN BASIN, NEW MEXICO

By Maurice E. Cooley

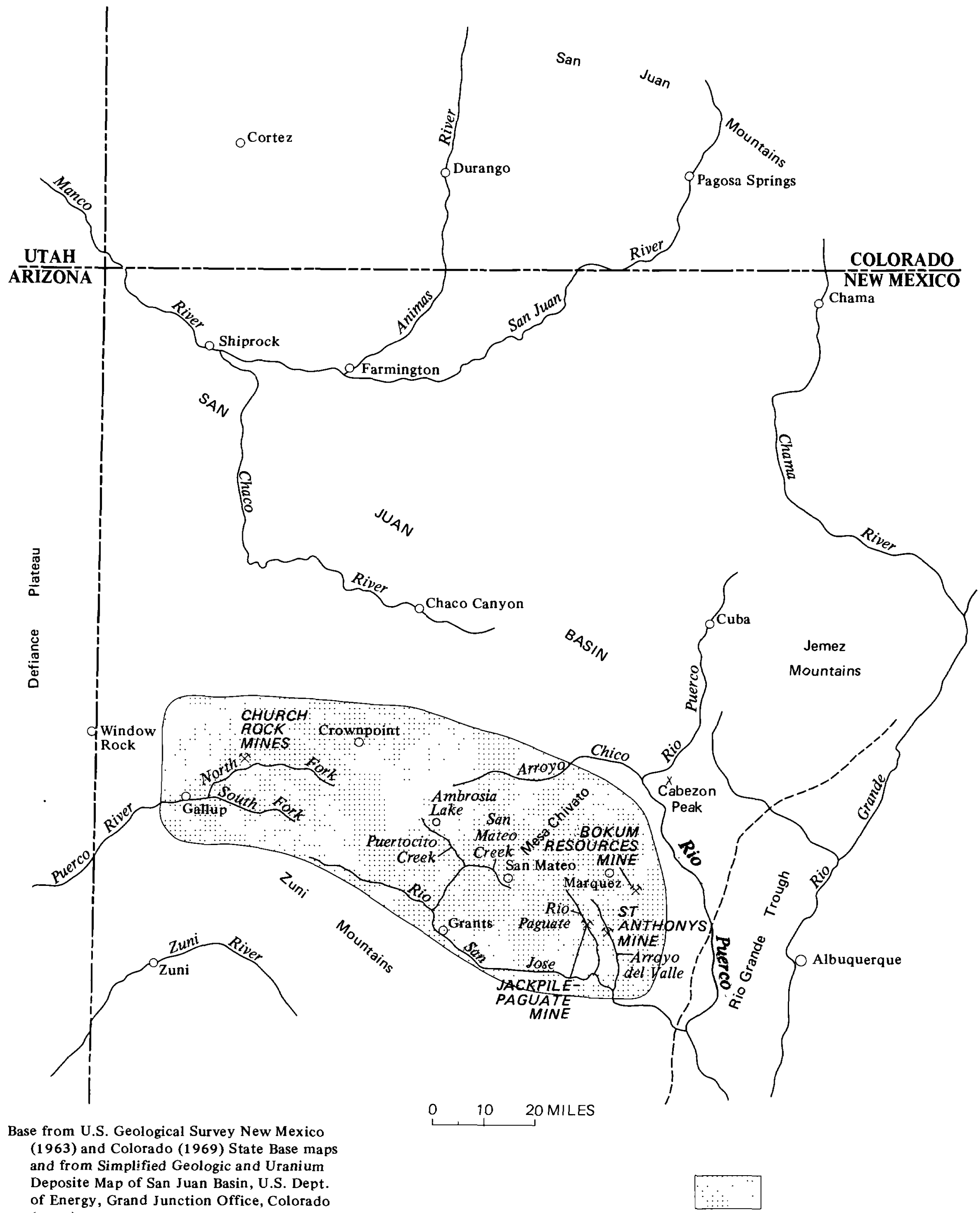
Abstract

A reconnaissance was made of some of the effects of uranium development on erosion and associated sedimentation in the southern San Juan Basin, where uranium development is concentrated. In general, the effects of exploration on erosion are minor, although erosion may be accelerated by the building of access roads, by activities at the drilling sites, and by close concentration of drilling sites. Areas where the greatest effects on erosion and sedimentation from mining and milling operations have occurred are: (1) in the immediate vicinity of mines and mills, (2) near waste piles, and (3) in stream channels where modifications, such as changes in depth have been caused by discharge of excess mine and mill water. Collapse of tailings piles could result in localized but excessive erosion and sedimentation.

Introduction

A reconnaissance investigation was made of some of the effects of uranium development on erosion and associated sedimentation in the southern San Juan Basin, where uranium development is concentrated (fig. 1). This report is based on field observations made during December 1977 and January 1978. It is not a comprehensive investigation as not all of the mines and mills in the area were studied. The report describes only those phases of uranium development--exploration, mining, and milling--that directly effect erosion and related deposition. Erosional effects of towns, communities, highway construction, and other factors that may be partly associated with the uranium development are not discussed. Neither are the effects of erosion on the movement of radionuclides discussed in this report; however, some of these effects are discussed in Supporting Document 22 (Kunkler, 1979).

The valleys and broad gentle slopes of the southern San Juan Basin are largely mantled by generally unconsolidated, easily erodable alluvial deposits. Stream channels, locally referred to as arroyos, have entrenched into the alluvial deposits. In places, these channels have cut through the alluvium and are entrenching the underlying consolidated sedimentary rocks. Most of the arroyos were cut to their approximate present depths several decades before the onset of uranium mining. Additional information concerning arroyo trenching is contained in Part B, Supporting Document 11 (Cooley, 1979).



Base from U.S. Geological Survey New Mexico (1963) and Colorado (1969) State Base maps and from Simplified Geologic and Uranium Deposite Map of San Juan Basin, U.S. Dept. of Energy, Grand Junction Office, Colorado (1977).

Figure 1.—Location of the San Juan Basin and adjoining area, New Mexico, Colorado, Arizona, and Utah.

With the exception of Rio San Jose the streams of the area are ephemeral and flow only in response to rainfall or snowmelt. They are subject to flash flooding resulting from thunderstorms which are especially common during the summer. Additional information on streamflow is in Supporting Document 19 (Geohydrology Associates Inc., 1979).

Exploration

In general, the effects of uranium exploration on erosion are minor, although erosion may be accelerated locally by the building of access roads and by activities at the drilling sites especially where drilling sites are closely concentrated. Bulldozing of roads, which disturbs the vegetation and soil, may cause some gullying. Gullying is minimal if the vegetation is re-established after roads have been abandoned. Little additional erosion occurs along existing roads or trails that have not been bulldozed. Tramping and vehicular movement denudes the vegetation and loosens the usually dry soil around the drilling sites thereby increasing blowout activity by wind and sheet erosion by water. Because the vegetation and soil are not stripped away at relatively level uranium exploration sites, vegetation (not necessarily the original species) is soon re-established by natural processes. Little opportunity for gullying occurs unless the drilling site is adjacent to an existing arroyo (fig. 2). On the steep slopes, however, the sites are leveled before drilling begins. This leveling disturbs the soil and vegetation mantle. Accelerated sheet erosion and gullying are probable before new vegetation becomes established on sites where vegetation has been disturbed or removed.

Figure 2. Old mud pit about 2 feet deep at exploratory test well near the Church Rock mines. Vegetation was re-established at this site before effects of accelerated erosion could occur. Vegetation is partly re-establihsed in the pit and on the two rounded debris piles at opposite ends of the pit. Little sediment is now being eroded from the debris piles. The mud pit is slowly being filled. Most mud pits have only slight effects on runoff, erosion, or sedimentation.

Abandoned, unfilled mud pits about 2 feet deep at drilling sites (fig. 2) also have only slight effects on erosion. In some cases drilling mud is allowed to run off into arroyos, a condition that increases sediment content of streamflow.

Where uranium deposits occur near the surface, shallow test pits, excavations ranging from a few tens of feet to as much as 200 feet across and as much as 25 feet deep, mar the landscape. Usually such pits have little effect on erosion, although excavation destroys vegetation. Some of the pits have steep, nearly vertical sides which are subject to slumping particularly when wet; these steep sides are potential hazards to humans and livestock. Erosion of the unconsolidated debris pile obtained from the pits, which are much larger than the debris piles shown in Figure 2, may increase the sediment content of the runoff from the pitted area. Some of the runoff is ponded in the test pits.

Mining

The main erosional impact in the area is from the mining, particularly open pit operations where large volumes of rock are removed and piled. In open pit operations drainages are obliterated, blocked, or diverted by the excavations and waste piles. In shaft mining, where the waste piles are substantially smaller, the effect on the local drainage is considerably less. In both types of mining, the main causes of erosion are mining and associated activities in the immediate area of the mine including mine water discharge in stream channels in the vicinity of the mine and downstream. The results of this erosion are sediment derived from mine and mill areas and from mine waste piles, and deepened stream channels.

During the operation of a mine many other activities take place in the mine area; roads are built or relocated, pipelines are laid, powerlines are strung, parking areas and warehouse sites are leveled, buildings are constructed, and drainage ditches are excavated. All these activities greatly disturb the soil and vegetation and many cause some severe erosional problems. Sheet erosion and minor wind erosion attack areas denuded of vegetation. Local gullying and sheet erosion, with the accompanying increase of sediment to streams, occur along slopes of any unconsolidated fill that is present.

The mine waste piles present some erosional problems. The piles are composed mostly of coarse-grained rubble including cobbles and boulders. Runoff from the waste piles is small and does not remove the coarse material. However, the runoff does remove some clay, silt, and sand, which, depending on the proximity to stream channels, may be transported and deposited downstream. Some of this fine material is deposited as a narrow alluvial apron around the piles. Mine waste piles bordering stream channels such as those at the Jackpile-Paguate and St. Anthony's mines, may be subject to severe lateral cutting by streams. Considerable material is removed during floods (fig. 3). Slumping may also occur on the steep sides of the mine waste piles, particularly on those bordering streams.

Erosional effects of mining operations are more severe on relatively steep slopes or near main drainages than at relatively level sites. Steeply sloping areas are more unstable and are therefore favorable locales for initiating or accelerating sheet or gully erosion (fig. 4) with the associated increase of the sediment content of the runoff.

Runoff originating in the mining area could be diverted by dikes in order to reduce runoff rates and to prevent the formation of new gullies or the expansion of old ones. Sediment will accumulate upstream of erosion control dams built across channels.

Mining operations on alluvial flats and gentle slopes such as are in the Ambrosia Lake area do not present severe erosional problems. Around many of the abandoned mines in such areas vegetation has been re-established and erosion is now negligible.

Figure 3. Channel of Rio Paguate through the Jackpile-Paguate mine area. View downstream (southeast) from northern edge of mine area. Before the mining operations, Rio Paguate flowed in a channel or arroyo that was about 40 feet deep and 100-300 feet wide. Dumping of mine debris has caused some narrowing of the channel. Erosion of the unconsolidated debris adds considerable bedload and suspended sediment to the river. During large flows the river cuts laterally into debris piles. Cobbles and boulders in the mine debris help retard cutting, but they are moved during large floods. Vegetation growing in the channel, the absence of fresh scars on the lower slopes of the debris piles, the distribution of boulders along the base of the debris piles, and the configuration of the low-flow channel is evidence that large floods have not occurred recently. Narrow bands of ice (white) are along the edges of the low-flow channel. An exposure of dark gray Cretaceous shale is at lower left.

Figure 4. Erosion along a newly bulldozed road that was caused by flow discharged from the Bokum Resources mine near Marquez. This mine road, located in sec. 7, T. 12 N., R. 3 E., has been in operation for only a short time. Easily erodable grass-covered alluvial slopes beyond the bulldozed area do not contain arroyos or gullies. Sustained flow along the road and on the slopes will eventually form gullies. View is northward toward the volcanic Cabezon Peak.

Near Ambrosia Lake, collapse features are visible at the land surface. These features formed as a result of settling due to the removal of ore from underground mines. Some runoff is diverted underground through collapse openings. The collapse features, a minor erosional but a major land-subsidence hazard, were not studied during this brief investigation.

Milling

Few uranium mills are presently operating in the southern San Juan Basin. Because of their limited numbers and the small area involved, their overall impact on erosion has been slight. Effects on erosion from milling result from: activities such as building of roads, parking lots, warehouse areas, pipelines, and other support activities as described previously for mining operations; from the milling operations tailings ponds; and discharge of excess water, which are described in the following section.

Tailings covering as much as a few tens of acres of ground have been built up from the accumulation of liquid transported sediment into settling ponds, obtained from the milling of uranium ores. The sediment consists mainly of clay to sand. Some of the tailings piles are as much as 100 feet above the adjoining ground level. Usually, the tailings piles have steep sides. Sediment derived from sheet and gully erosion of the steep slopes is deposited as an alluvial apron flanking the tailings (fig. 5).

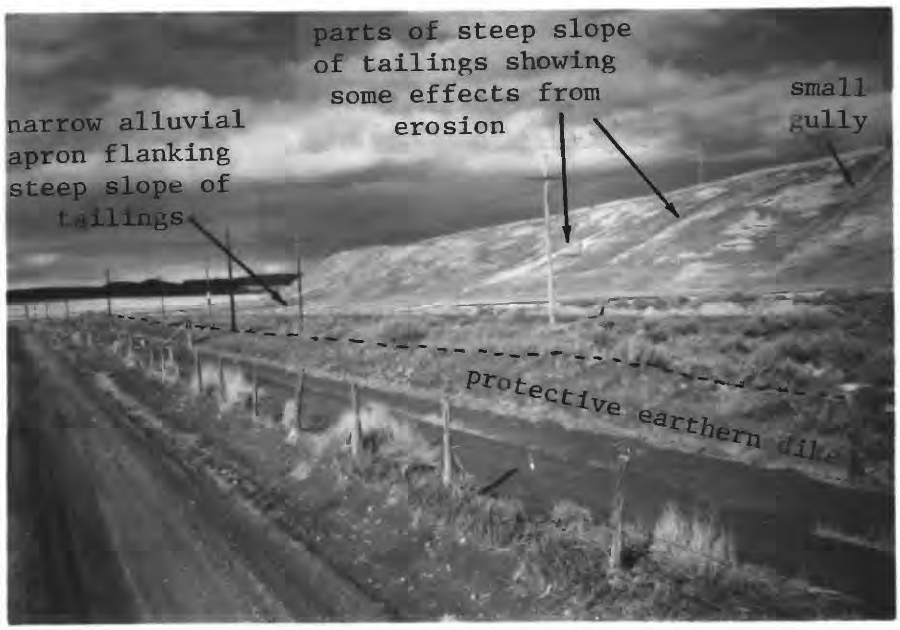


Figure 5. View of the steep slopes of a large tailings pond near Grants. Steep slopes of side of tailings pond show the development of small gullies. A narrow alluvial apron, consisting of fine-grained sediment eroded from the tailings, flanks the steep slope of the tailings pond. A low, protective earthen dike is present around the tailings pond. Area between the earthen dike and alluvial apron is largely unaffected by erosion and accompanying deposition of the tailings.

The fine sediment size and steep slopes of the tailings present potential caving and erosion problems. To localize such problems, low earthen dikes were built around most of the tailings piles. On nearly flat slopes most of the sediment resulting from the breach of the tailing ponds or collapse of tailings piles would remain in the local area, even if the surrounding dikes were breached. However, on relatively steep slopes or along stream channels collapse of tailings and subsequent breaching of the dikes may affect broader areas because the sediment would move into nearby stream channels. Sediment that entered stream channels would be carried long distances downstream--especially by flood flows.

Erosional effects of mine and mill water discharge on stream channels

In 1978, most of the observed erosional effects of uranium development were related to the discharge of mine and mill water into the nearby stream channels. Information concerning the quantity and distribution of mine and mill discharge is in Supporting Document 32 (Busby, 1979). Spreading of mine and mill water was observed only in the Ambrosia Lake area.

Water obtained from the Church Rock mines is discharged into an unnamed tributary arroyo of the North Fork of the Puerco River. Near the mine the flow has deepened the arroyo as much as 8 feet. The flow of the mine water extends downstream along the North Fork and main stem of the Puerco River through Gallup, New Mexico, to beyond the New Mexico-Arizona State line. The flow has caused some aggradation and widening of the arroyo upstream from Gallup. Since 1971, about 2 feet of channel filling has ocurred.

Water from the Bokum Resources mine near Marquez has caused some headcutting of discontinuous arroyos (fig. 6) since the mine has been in operation. In about 1 year, two of the arroyos about 1 mile downstream from the mine have extended headward about 25 and 8 feet, respectively. In the area near the mine, no appreciable downcutting or filling of arroyos was observed.

In the Ambrosia Lake area, part of the excess mine and mill water has caused a lush stand of cattails and tall grasses to grow in the bed of Puertocito Creek that drains the area. Part of this water flows out of the area and enters San Mateo Creek. The vegetation has caused sediment to accumulate in the arroyo. Much of the sediment is derived from a tailings pile that adjoins the creek. Owing to the absence of pre-mining depth-of-channel measurements, the thickness of the newly deposited fill is not known.

Part of the water obtained from the mines and mills in the Ambrosia Lake area is spread over and irrigates gentle grass-covered slopes that are characteristic of the area (fig. 7). These irrigated slopes support a dense stand of tall grasses and a few shrubs, whereas adjacent non-irrigated slopes are mantled by only short grasses. The gradients of the slopes are low and virtually no erosion occurs. The water that is not used by plants is evaporated or seeps into the alluvial deposits that underlie the slopes.

Figure 6. Flow from Bokum Resources mine cascading over a headcut of a discontinuous arroyo. The arroyo has a maximum depth of 16.5 feet. The main headcut at upper left and the smaller headcut at upper right have extended by about 25 and 8 feet, respectively. Freshly scarred, vertical arroyo walls are evidence of the headward cutting.

Figure 7. Mine and mill effluent spread out on an undissected alluvial valley floor in Ambrosia Lake area. The effluent supports a dense stand of tall grasses and a few shrubs whereas the adjacent slopes are mantled by short grasses. Virtually no erosion occurs in the flood area due to the low gradient of the slope and lack of channels. The water not used by plants is evaporated or infiltrates the underlying alluvium. None of the water reaches streams as overland flow.

The Church Rock mines, the Jackpile-Paguate mine, and the St. Anthony's mine are near arroyos that are 20 to 40 feet deep. Mine-waste deposits and earthworks associated with the mining activity have modified severely or diverted the stream channels. A series of dams built upstream from the main area of mine-mill activity of the Church Rock mines has caused partial filling of the arroyo. At places in the area of mine-mill activity, the arroyo is nearly obliterated, even though the present channel approximately follows its old course (fig. 8). The channels of Rio Paguate through the Jackpile-Paguate mine (fig. 3) and Arroyo del Valle through St. Anthony's mine are now confined between huge piles of mine wastes. Large floods through the mine areas would cause much lateral cutting and associated slumping of the unconsolidated rubble and would transport sediment from the mine areas. The amount of sediment obtained from the mine areas is not known, but it is believed by the author to be substantial. For example, sediment derived from waste piles of the Jackpile-Paguate mine has resulted in the buildup of broad sandbars as much as 4 feet high in the channel of Rio Paguate downstream from the mine.

Figure 8. View of some of the operations at the Church Rock mines. View is southeastward across valley that is underlain by easily erodable fine-grained alluvium. Main arroyo, a tributary of the North Fork of the Puerco River, is nearly obliterated by dikes, road fills, tailings pond, and other features. Pipeline leading from the mill to the tailings pond crosses the arroyo at center. All disturbed areas are subject to sheet erosion, possibly gully erosion, and some wind deflation. Small rills have formed along an old dirt road at lower right. Runoff from the disturbed areas transports relatively large amount of sediment to the main arroyo.

Conclusions

The areas where the greatest effects on erosion and sedimentation of uranium mining and milling operations have occurred are: (1) in the immediate vicinity of mines and mills; (2) near waste piles; and (3) in stream channels where modifications, such as changes in depth have been caused by discharge of excess mine and mill water. Little erosion is attributed to exploration activities. Breach of tailing ponds or collapse of tailings piles potentially could result in major erosion and sedimentation problems, particularly, for piles situated on relatively steep slopes or near stream channels. Earthen dikes around most of the tailings piles localize deposition of sediment eroded from the steep sides of the tailings piles. Properly constructed dikes would also localize the area affected by any collapse of the tailings piles or ponds. Except in areas closely adjoining the mines and mills, development of uranium in the southern San Juan Basin through 1977 apparently had had slight effect on erosion and associated sedimentation.

However, a general lack of data precludes accurate quantification of the effects of the uranium operations on erosion and related sedimentation--especially the effects of the unconsolidated tailings and mine-waste deposits. Therefore, studies should be made to help quantify the impacts of the uranium operations on the erosion and associated sedimentation. Recommendations for such future studies should included: (1) detailed geomorphic studies of the present mines and mills and of future mine and mill sites; (2) a monitoring program, including photography, of changes in depths, widths, and configuration of channels, and of any erosion that occurs on slopes or deposition of sediment on valley floors adjacent to the mines and mills; and (3) studies of erosional processes that are taking place on the slopes of mine-waste deposits and tailings ponds, including the monitoring of the amount of erosion and change that occurs on these slopes.

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