Geologic hazards in New Mexico--Part 2

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Geologic hazards in New Mexico—part 2

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Abstract

Potential geologic hazards in New Mexico include earthquakes; land subsidence caused by collapsing soils, ground-water withdrawal, limestone and evaporite karst, and collapse of abandoned mine workings; earth fissures; expansive soils; slope instability; radon availability; and volcanism. As the state agency responsible by law for original investigations of geology and mineral resources in the state, the New Mexico Bureau of Mines and Mineral Resources has an active interest in the identification, assessment, and remediation of geologic hazards. Although the nature and general location of many potential hazards are well known, many detailed questions about potentially hazardous geologic processes remain unanswered. Unfortunately, a general lack of interest in the use of geologic information in planning decisions means that the state's response to geologic hazards is one of reaction rather than prevention.

Introduction

Why worry about geologic hazards? Better yet, why spend tax dollars to study them? One reason is that the cost of ignorance is far higher. For instance, five people were killed and 14 injured on September 12, 1988, when a large boulder struck a bus traveling through the Rio Grande gorge along NM–68. Less than three years later, the same highway was closed by landslides, debris flows, and floods mobilized during heavy storms in late July 1991. Parts of southern Rio Arriba and northern Santa Fe Counties were declared disaster areas in December 1984 when a number of homes east of Española were condemned because of damage caused by hydrocompactive soils. The appearance of a large earth fissure interrupted construction of I–25 near San Marcial in 1981. A June 1990 debris flow near the town of Cordova temporarily diverted the Rio Quemado and destroyed several acres of prime pasture land. Land south of Deming has been subsiding at a rate of about 1 cm per year since the 1950s, creating large earth fissures in at least 13 locations, related to agricultural ground-water withdrawal. The list of geologic hazards, as well as the number of New Mexicans affected by them, goes on.

Purpose

This paper is a generalized survey of hazardous and potentially hazardous geologic processes occurring throughout the state, emphasizing work by the New Mexico Bureau of Mines and Mineral Resources (NMBMMR) and cooperating agencies. References are generally limited to published documents that an interested reader should be able to obtain through interlibrary loan. This means that some occurrences have been omitted because much of the information about geologic hazards within the state exists only in unpublished reports or, worse, in the memories of practicing geologists and engineers. Because this is not an exhaustive inventory, there are no doubt authors whose published work has been inadvertently overlooked. Some important hazards, such as flooding, water quality, and the natural occurrence of potentially toxic chemicals (with the exception of radon), are not covered at all. Finally, this highly generalized overview is not a substitute for field investigations by qualified engineering geologists or geotechnical engineers and must not be used as a basis for planning, design, or construction.

We at NMBMMR often receive telephone calls and letters asking if a specific geologic hazard occurs in a certain area and whether we have maps available showing the locations of earthquake faults, sinkholes, and so forth. Although at first the notion seems to be an attractive one, this paper does not include small-scale maps showing the distribution of geologic hazards in New Mexico. There are three primary reasons for this. First, there are relatively few published reports about geologic hazards in New Mexico, so information, where it exists at all, is spotty and inconsistent. Second, the preparation of useful hazard maps is an expensive and time-consuming chore and one that is well beyond the scope of this overview. Existing hazard maps are cited in the text where appropriate. Third, quickly produced and highly generalized small-scale hazard maps are by and large useless for serious geological work and could be misused by those in search of quick and easy answers to difficult questions. Readers with questions about specific geologic hazards in specific areas are urged to contact NMBMMR for more information, (505) 835-5420.

Economics

Although there is no detailed estimate of the total costs associated with geologic hazards in New Mexico, collateral evidence suggests that they are significant. Brabb (1989) estimated that slope stability problems caused at least $4 million damage to state roads and private property in New Mexico between 1973 and 1983. The National Research Council (1991) estimated losses of up to $1 million per year from mining-induced subsidence, up to $1 million per year from sinkholes, and between $1 million and $10 million per year from hydrocompactive soils in New Mexico. Robinson and Spieker (1978) estimated losses from floods, earthquakes, landslides, coastal erosion, expansive soils, and other geologic hazards to be about $4.9 billion per year in the United States. Assuming a 5% average rate of inflation, their estimate projects $9.3 billion per year, or about $37 per person per year, in 1991. If flood damage is excluded, the last two figures drop to $6.0 billion per year and $24 per person per year. Based upon these national figures, annual damage costs in New Mexico are estimated to be on the order of tens of millions of dollars. ☞

Also in this issue

Experience in other states suggests geologic hazards in New Mexico can be avoided or alleviated through careful land-use planning and engineering design. In a study of geologic hazards in California, Alfors et al. (1973) concluded that up to 90% of landslide damage costs could be eliminated by a combination of geologic investigation, engineering design, and enforcement of zoning laws. Subsequent research has shown that this three-tiered strategy has reduced the costs of landslide damage associated with new construction in California by 92% to 97% (National Research Council, 1985). Bernknopf et al. (1988) conducted a study to assess the potential effectiveness of different planning strategies on landslide damage in the Cincinnati, Ohio area. They concluded that if grading provisions specified in Chapter 70 of the Uniform Building Code were enforced without regard to site-specific details, the benefit:cost ratio would be 0.98:1. However, if Chapter 70 provisions were enforced only in areas with steep slopes, the benefit:cost ratio would increase to 1.82:1. Finally, if both slope and bedrock type were taken into account, the benefit:cost ratio would rise even further, to 2.21:1. Simply put, enforcement of only the most basic grading requirements would save more than twice as much money as it would cost.

Sources of information

The primary source of geologic information about New Mexico is NMBMMR, which is also the Office of State Geologist and the state agency responsible by law for original investigations of geology and mineral resources in New Mexico. NMBMMR maintains a small environmental and engineering geology staff, which is responsible for 1) determining potential environmental impacts caused by intensive development of mineral, water, and land resources; 2) evaluating the hazard potential of natural geologic processes such as landslides, debris flows, earthquakes, and ground subsidence; 3) siting waste management facilities; and 4) developing a comprehensive database, including reports and maps, on these subjects. Lists of publications and open-file reports, as well as the quarterly *New Mexico Geology*, are available from the NMBMMR publications office.

Other sources of engineering geologic and geotechnical engineering information include the New Mexico State Highway Department Geotechnical Section, the New Mexico Water Resources Research Institute, the U.S. Geological Survey, the U.S. Soil Conservation Service, the State Engineer Office, and geology departments and geological engineering programs as the University of New Mexico, New Mexico State University, and the New Mexico Institute of Mining and Technology (New Mexico Tech). Additional sources are included in Johnpeer (1986). The Geology Section of the New Mexico State Highway Department has produced a series of geologic and aggregate source atlases of considerable interest to those involved in construction. Guidebooks compiled for the annual fall field conferences and other special publications of the New Mexico Geological Society constitute a valuable source of basic geologic information, as well. Sources for maps, aerial photographs, satellite imagery, thermal imagery, and radar imagery covering the state are listed in Rex (1991).

General issues related to geologic hazards and land use planning are discussed at an introductory level by Robinson and Spieker (1978) and Hays (1981), and at a more advanced level by Cooke and Doornkamp (1990). Hawley and Love (1981) presented a generalized summary of geology as related to environmental concerns in New Mexico, and Hawley and Longmire (1991) discussed geologic considerations bearing on hazardous-waste site selection and characterization in New Mexico. The engineering and environmental geology of the Albuquerque area is summarized by Lambert et al. (1982), Clary et al. (1984), and Hawley and Love (1991, p. 134–144). Johnpeer and Hamil (1983) provided a similar synopsis of the Socorro area. Johnpeer et al. (1987) and Barrie (1987) summarized the engineering geology of the northern Estancia basin with regard to siting of a proposed superconducting supercollider. The book *New Mexico in Maps* (Williams, 1986) contains a collection of thematic maps covering both the geography and geology of New Mexico. NMBMMR is currently beginning to compile maps for a county atlas series, which will consist of 1:500,000 thematic maps of interest to county planners, elected officials, and residents. Map themes will include generalized geology, mineral resources, geologically young faults and volcanic deposits, 100-year floodplains, depth to water, water chemistry, ground-water pollution potential, slope instability potential, collapsible and/or expansive soil potential, and other topics.

Geologic hazards and geologic events

The distinction between a geologic **hazard** and a geologic **event** (e.g., Rahn, 1986) is an important one. A geologic event is the occurrence of any geologic process, perhaps a landslide or an earthquake. A geologic hazard, on the other hand, is a geologic event which has a significant impact upon humans or their works. In many respects this distinction is analogous to the adage of a tree falling in a forest with no one to hear the sound. Thus, a large landslide in a remote area would be classified as an event, whereas the same landslide in a heavily developed mountain resort would be classified as a hazard. It is also useful to define potential hazards and potential events as those which geologic evidence suggests may have occurred in the past, and which may occur in the future, but for which there is little or no evidence of recent activity. Examples of potential hazards or potential events might include dormant volcanoes or landslide complexes. This distinction has practical significance for states such as New Mexico, in which limited resources must be used largely to address specific problems rather than to compile state-wide inventories covering vast, sparsely populated areas.

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Expansive soils

Expansive soils (Fig. 8) of the order Vertisol present foundation design problems in urbanized areas such as Albuquerque and Las Cruces (Hacker, 1977; Bulloch and Neher, 1980). Gustavson (1991) described the occurrence, pedogenesis, and age of buried vertisols in the Fort Hancock Formation, Hudspeth County, Texas. In an earlier paper (Gustavson, 1975) he reviewed identification microtopographic features (gilgai) and engineering problems associated with vertisols along the Texas coastal plain. Much of this work can be applied to New Mexico, where the most severe problems are caused by smectitic soils such as those of the Armijo Series. Armijo soils form in alluvial loams and clays deposited along the Rio Grande floodplain and the clays, in particular, have high shrink-swell indices.

In other cases, smectitic shale bedrock has caused highway construction problems, for example in Cretaceous Morrison Formation shales excavated along I–40 between Santa Rosa and Tucumcari (Kelley and Kelley, 1972). This section of highway was graded, rolled, and sealed with an asphalt membrane to prevent moisture infiltration.

Geotechnical exploration procedures in areas where expansive soils may be a problem should include a review of county soil surveys and analysis of clay mineralogy in order to estimate the general potential for shrink-swell problems. Once areas of expansive soils have been identified, laboratory testing of shrink-swell potential can yield quantitative information useful for foundation design. Remedial measures include removal of shallow problem soils, pre-compaction or pre-wetting, deep foundations, and elimination of moisture sources (Das, 1984, pp. 460–474).

Slope instability

Evidence for past slope instability

Slope instability is not currently a significant geologic hazard in most parts of New Mexico although landslides, debris flows, and rockfalls are a persistent problem along some mountain highways. In places where slope stability is a problem, however, the cost is high both in terms of dollars and of human lives. Regional landslide inventories based upon aerial photograph and topographic map interpretation (Cardinali et al., 1990; Guzetti and Brabb, 1987) show evidence of past slope instability throughout much of New Mexico. In many cases, the evidence was limited to nearly vertical escarpments subject to rockfalls and topples. In other cases, evidence of large landslide and debris flow deposits was identified. Although Brabb (1989) rated the landslide hazard in New Mexico as "moderate" and the landslide inventory coverage as "high," landslide susceptibility coverage is described as nonexistent and general landslide knowledge is rated as "poor." Brabb et al. (1989) conducted a series of computerized statistical analyses of landslide deposits and slope angles derived from digital elevation models and found that the occurrence of landslide deposits could be correlated with slope angle. Shallow landslide deposits were reported most likely to occur on slopes of about 22°, whereas deep landslide deposits were reported most likely to occur on slopes of about 10°. Brabb et al. (1989) also reported that earlier, nationwide maps of landslide susceptibility (Krohn and Slosson, 1976; Radbruch–Hall et al., 1981) seriously underestimated the occurrence of landslides in New Mexico.

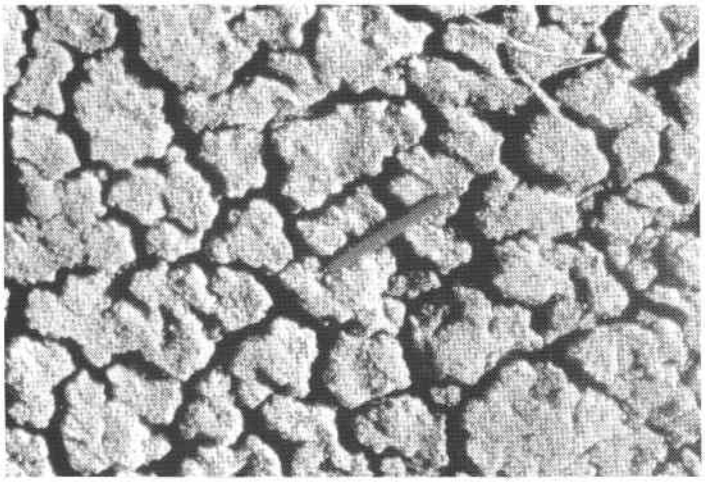

FIGURE 8—"Popcorn" texture characteristic of vertisols subjected to repetitive wetting and drying. In addition to qualitative criteria, standard soil mechanics procedures to quantitatively estimate the shrink-swell potential of clay-rich soils are described in soils and foundation engineering textbooks (e.g., Das, 1984).

Evidence of past slope instability is one of the key elements in the delineation of potentially hazardous areas (Nilsen, 1986; Hansen, 1984); therefore, even if slope instability is not currently a significant hazard, the possibility should be incorporated into long-term planning decisions in areas of prior instability. Reactivation of large landslide complexes in Utah during the 1980s, for example, has been attributed to a relatively sudden and historically unprecedented reversal of a long-term drying trend (Fleming and Schuster, 1985). Similarly, Reiche (1937) and Watson and Wright (1963) inferred a colder, wetter Pleistocene climate during movement of large slump blocks capped by resistant Miocene sandstone (regionally referred to as Toreva blocks, after the type locality near Toreva, Arizona) in northwestern New Mexico and northern Arizona. The costs associated with the reactivation of a large landslide complex can be sobering: Fleming et al. (1988), for example, estimated total costs of nearly $2 million to repair damage and prepare for future movement when the Manti landslide in Utah, some 6.5 km from the nearest dwelling, was reactivated in 1974.

At this point, the types and magnitudes of weather and/or climate change that would be necessary to reactivate large landslides in New Mexico cannot be predicted. However, it is clear that above-average amounts of rainfall can reactivate dormant landslide complexes. For example, a Toreva block slide occurred along an outlier of the High Plains escarpment, known as Twin Mesa, in De Baca County during early September 1991 (Fig. 9). The failure mass consisted of Chinle Formation siltstone capped by a 1-m-thick calcrete, and highly weathered blocks along the base of the mesa suggest that Toreva block sliding has been a significant agent of slope retreat in the past. The surface area of the reactivated slide was about 200 × 200 m, with a 2- to 3-m-high arcuate head scarp and 3 to 4 m of lateral displacement along the flanks. Damage was limited to offset and cracking of an unimproved ranch road, as well as buckling of buried PVC water pipes. Precipitation during the previous year had been well above average, and approximately 50 cm of rain had fallen in nearby Ft. Sumner during late summer 1991 (B. Russ, 1991, personal communication). Researchers such as Haneberg (1991) have quantified the theoretical relationship between storm intensity, storm duration, pre-storm soil-moisture content, and the hydrologic response of landslides to rainfall. The time-dependency of pre-storm soil-moisture content, however, makes it difficult to predict the response of a given landslide (or potential landslide) to a given storm.

Human activity, especially road building in mountainous areas, can create or exacerbate slope-stability problems. Bennett (1974) described widespread slope-stability problems in nearly saturated landslide debris, derived from Pleistocene outwash deposited over Cretaceous Mancos Shale along 30 km of US–64 between Tierra Amarilla and Tres Piedras in eastern Rio Arriba County. These failures are concentrated in cut and fill slopes along the right of way, and Bennett notes that only preliminary geologic studies,

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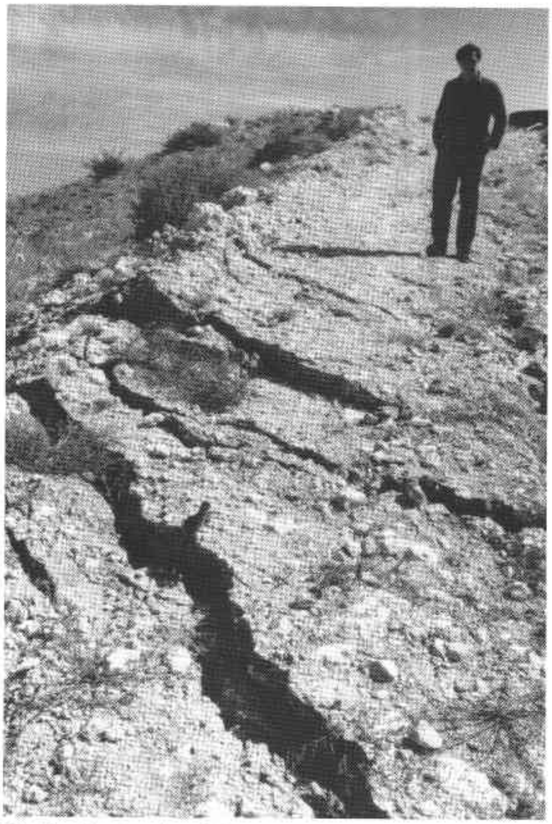

FIGURE 9—Cracks developed in an unimproved dirt road during a September 1991 landslide north of Ft. Sumner, in De Baca County. Approximately 50 cm of rain, well above the average, had fallen during late summer 1991. Highly weathered landslide deposits in the area indicate that landsliding has been common in the past. De Baca County Disaster Preparedness Coordinator Bobby Russ is included for scale.

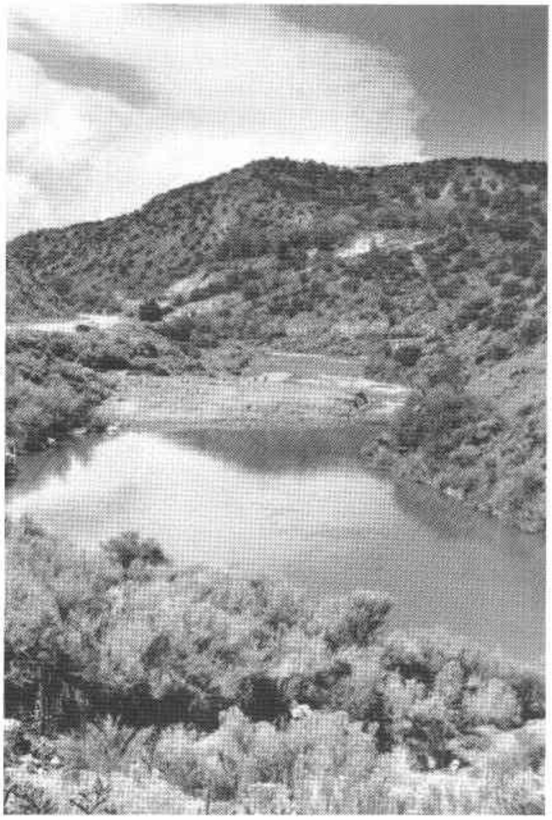

FIGURE 11—Remains of a debris flow along the Rio Grande that occurred during a storm in late July 1991. The unsorted, bouldery, lower portion of the deposit, which is characteristic of debris flows, could be traced across the river after the flow, suggesting that the Rio Grande was temporarily dammed. Even though the dam was quickly breached, the resulting constriction continued to limit flow when this photo was taken in September 1991. Other debris flows and flood flows clogged box culverts and blocked NM–68 during the same storm.

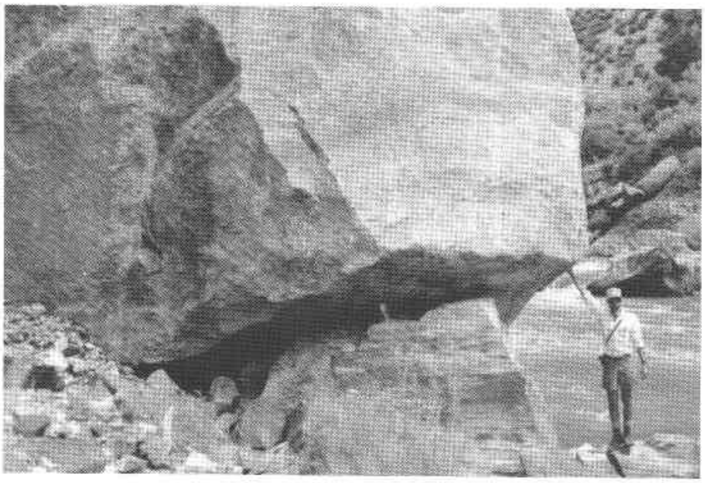

FIGURE 10—This large boulder slid and rolled from the top of the Rio Grande gorge, left a crater in NM–68, and came to rest along the opposite bank of the river during a July 1991 storm. This is only one of many large boulders along the course of the Rio Grande, which portend the continued occurrence of potentially fatal rockslides. NMBMMR field geologist Paul Bauer is included for scale.

FIGURE 12—Aftermath of the Cordova debris flow of June 1990. Approximately 10,000 cubic meters of sand, gravel, and cobble stream-terrace deposits were transformed into a flowing mass of debris when an over-irrigated pasture failed as a landslide. The barren head scarp of the original failure is visible in the middle ground. Coarse granular soils, such as those along stream terraces near Cordova, have high mobility indices and are likely to mobilize into fast-moving flows if the soils are saturated and shear.

with no provisions for slope-stability analysis, were conducted prior to construction. Another reactivation of an obvious landslide complex occurred in Cretaceous shales and limestones capped by Quaternary basalts during construction of I–25 between Springer and Raton in Colfax County (Lovelace, 1976). A large landslide, apparently reactivated by seepage from abandoned mine workings, affected a number of homes near the Taos ski valley in 1979; remedial measures included installation of horizontal drains and diversion of surface water, which increased the preslide factor of safety of 0.92 to 1.28 (Bennett, 1979).

An abundance of large boulders suggests that rockfalls have been a common occurrence along the Rio Grande gorge between Rinconada and Pilar. To help mitigate the hazard, the New Mexico State Highway and Transportation Department has installed rockfall protection nets in Quaternary landslide debris along NM–68 near Embudo. Several miles farther north, five people were killed and fourteen injured when a commercial bus struck a basalt boulder along NM–68 in September 1988, and a 270,000 kg boulder (Fig. 10) left a $5 \times 5 \times 14$ m crater in the highway after a July 1991 rockslide. Dynamic analysis suggests that the 1991 boulder was traveling at a velocity of about 21 m/s and struck the highway with an estimated kinetic energy of 10^8 N·m (Bauer and Haneberg, 1992), which is several hundred times the capacity of commercially available rockfall protection nets. The same storm produced at least 11 debris flows (Fig. 11) and an unknown number of smaller rockfalls, which trapped 20 automobiles along the highway and temporarily dammed the Rio Grande. NM–68 was closed for 19 hours and cleanup costs were approximately $75,000 (P.W. Bauer, personal communication 1992).

Potentially hazardous slope failures can also occur in areas with no evidence of past instability. In June 1990, a debris flow was mobilized from a small landslide in Holocene stream terrace deposits east of Española near the town of Cordova in Rio Arriba County (Fig. 12; also see Haneberg and Tripp, 1990, 1991). Neither the Guzetti and Brabb (1987) regional map nor visits to the site suggested evidence of past slope instability in the area. Failure was apparently caused by long-term accumulation of perched water along one of several fine-grained, buried soil horizons within the coarse-grained terrace deposits, and laboratory test results show that the debris mobilization could have been predicted on the basis of soil properties. Gradient reversals and small leaks in an unlined irrigation ditch above the failure suggest that progressive failure had been occurring for some time, although the pre-dawn debris flow was rapid. The volume of debris was not great, on the order of 10,000 m^3, and the only damage was burial of an unimproved dirt road, diversion of a small stream, and loss of pasture land. However, the existence of untold miles of community irrigation ditches, many dating back several centuries, in steep terrain makes future irrigation-induced failures in northern New Mexico a potential hazard.

Radon

The widespread occurrence of uraniferous sedimentary and igneous rocks makes inhalation of radon gas a potential hazard in many parts of the state. As part of a preliminary state-wide assessment, McLemore and Hawley (1988) used aerial radiometric surveys to compile radon availability ratings for the 33 counties in New Mexico. Radon availability ratings in the McLemore and Hawley (1988) study of New Mexico were defined as follows:

High radon availability—Greater than 2.7 ppm uranium on aerial radiometric maps and, in general, well-drained and permeable soils. Counties falling into this category are Doña Ana, Hidalgo, Los Alamos, Luna, McKinley, Rio Arriba, Sandoval, Santa Fe, Socorro, and Taos.

Moderate radon availability—2.3 to 2.7 ppm uranium on aerial radiometric maps and, in general, moderately permeable soils. Counties falling into this category are Bernallilo, Catron, Cibola, Chavez, Colfax, Eddy, Grant, Lea, Lincoln, San Juan, Sierra, Quay, and Union.

Low radon availability—Less than 2.3 ppm uranium on aerial radiometric maps and, in general, low-permeability soils. Counties falling into this category are Curry, De Baca, Guadalupe, Harding, Mora, Otero, Roosevelt, San Miguel, Torrance, and Valencia.

It is important to emphasize that these ratings are preliminary estimates of radon availability averaged over entire counties, and not the actual radon concentrated within a given building at a given time. Therefore, it is possible for homes in high-availability counties to have low indoor radon values, and for homes in low-availability counties to have high indoor radon values. Site-specific details such as soil type and moisture content, soil or bedrock fracture systems, foundation type, ventilation, and time of year can all produce widely scattered indoor radon readings in nearby buildings.

Brookins (1988, 1991) measured radon concentrations throughout the Albuquerque area. He found that nearly 30% of homes had indoor radon levels above the EPA action level of 4 pCi/l, and that soil radon levels were 2 to 4 times the national average of approximately 100 pCi/l. The higher soil radon values were measured during the summer, whereas the lower soil radon levels were measured during the winter. Brookins noted correlations between 1) soil radon and indoor radon concentration, 2) soils developed over bedrock and indoor radon concentration, and 3) proximity to the Sandia Mountains and indoor radon concentration. He also found a weaker correlation between summer soil radon concentrations and soil infiltration rates, and no correlations between soil radon concentrations and soil texture or moisture content.

Volcanism

Geologically young volcanic rocks, the product of at least 700 eruptions over the past 5 Ma (Limburg, 1990), cover large areas of New Mexico. Using these figures, the average state-wide recurrence interval for volcanic eruptions is about 7,000 years. Although there is an apparent increase in the number of eruptions through time during the past 5 Ma, it is almost certainly caused by the difficulty in discovering and dating the remnants of older eruptions. A map by Callender et al. (1983) shows the distribution and ages of known Quaternary and upper Pliocene volcanic rocks (less than 5 Ma), volcanic centers, and geothermal waters. Most of the young activity has been in the form of effusive basaltic eruptions, presenting little danger beyond the loss of property. The presence of the rhyolitic Jemez volcanic center in north-central New Mexico, as well as numerous maars and tuff rings throughout the state, suggests that the possibility of a violent eruption cannot be ignored completely. In addition to the potential hazards posed by a blast, heavy snowpacks in mountainous areas such as the Jemez could give rise to catastrophic debris flows and floods in the event of a winter or spring eruption. A 19-km-deep mid-crustal magma body of unknown composition (Sanford 1983) between Socorro and Bernardo may also pose a long-term volcanic hazard, although there is no evidence to suggest that eruptions will occur in the near future.

Volcanologists I. Yokoyama, R.I. Tilling, and R. Scarpa (cited in Scott, 1989) have proposed a numerical rating scheme for the identification of high-risk volcanoes, based upon a combination of magma type, recent eruptive activity, and the number of people at risk. High-risk volcanoes are defined as those receiving scores of 10 or above. Using this rating system, the Jemez volcanic complex would receive a score of 2, whereas the Socorro magma body would receive a score of 3 to 5, depending on magma composition and the number of people affected. Mt. St. Helens and Kilauea, the two most recently active volcanoes in the United States, rate

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scores of 15 and 13, respectively. Other high-risk volcanoes in the United States, each rating a score of 10, are Lassen Peak, Mauna Loa, and Mono–Inyo Craters. This rating system is susceptible to failure if information on historical activity is scanty or nonexistent, as shown by the catastrophic 1985 eruption of Nevado del Ruìz in Colombia, which was not on the original list of high-risk volcanoes prepared by Yokoyama and his colleagues. Compared to other areas of the world, however, volcanic hazards in New Mexico appear to be minor and of consequence to only the most sensitive of facilities, for example national laboratories and nuclear-waste facilities.

Summary

Actual and potential geologic hazards in New Mexico cover a broad spectrum from earthquakes to collapsible soils to landslides. No estimates of economic impact are available, but hydrocompactive (collapsible) soils are probably the most significant actual geologic hazard in the state. However, the most significant potential hazard is probably a large earthquake on the order of magnitude $M = 7$, with an estimated recurrence interval on the order of 10^3 years. Recent experiences in Utah have shown that landslide and debris-flow hazards, along with damage costs, can also be expected to increase significantly during wet periods. A wealth of unanswered questions concerning the distribution, mechanisms, and mechanics of hazards makes New Mexico fruitful ground for basic and applied research on potentially hazardous geologic processes.

Considering the wealth of practical experience with geologic hazards in New Mexico, it was disappointing to find that many case histories have never been adequately described in the scientific and engineering literature. The communication of technical information is a professional responsibility, no less important than the classifying of rocks or the making of maps. Although internal memoranda and conversations may be adequate for day-to-day project work, they can be practically useless to those who come afterwards. Even the abstracts and proceedings volumes of so-called national meetings may be effectively impossible, at least for those outside a small circle of attendees, to find and cite.

There is, in theory, no reason why economic losses associated with geologic hazards could not be virtually eliminated in New Mexico. Hazards brought on by human activity—for example, landslide reactivation during construction, hydrocompaction, and subsidence caused by fluid withdrawal—can be predicted using well-known methods of hazard zonation and geotechnical site investigations. Other hazards, such as earthquakes and volcanic eruptions, can only be anticipated and prepared for, making reduction of damage somewhat more difficult. The consequences of unprecedented activities such as over-irrigation, intensive logging, or construction in previously undeveloped areas cannot be anticipated from past experience alone. Therefore, field and laboratory investigations by qualified engineering geologists or geotechnical engineers should become a routine part of the planning and development process in New Mexico. Site investigations typically add only 1% or 2% to total project costs, and incorporation of even the most elementary geologic knowledge into planning and zoning decisions can result in significant long-term savings. In short, it costs less to identify geologic hazards and take corrective action than it does to repair the damage later. However, many New Mexicans have yet to grasp the fact that geologic hazard assessment and avoidance can be an integral part of sustained economic growth, and the role of agencies such as NMBMMR will probably be one of reaction rather than prevention well into the foreseeable future.

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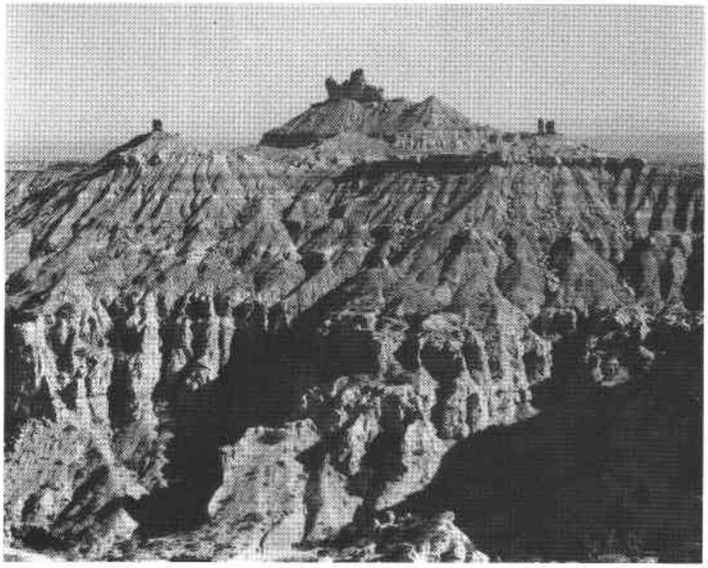
New Mexico Geological Society

1992 Field Conference

San Juan Basin IV



The 43rd Field Conference will be held September 30—October 3, 1992 in northwestern New Mexico. The conference will focus on the varied geology of the region, especially Laramide tectonism and sedimentation in the San Juan Basin; sequence stratigraphy of Upper Cretaceous strata; the Cretaceous–Tertiary boundary; coal and coalbed methane resources; the Rio Puerco necks of the Mt. Taylor volcanic field; geomorphology and hydrogeology; and Late Cretaceous and early Tertiary paleontology. Headquarters for each trip leg will be in Cuba, New Mexico, a small town at the foot of the Nacimiento Mountains.

The field conference will journey by caravan to the badland country of the southern San Juan Basin, the spectacular volcanic necks of the Rio Puerco region, and along the eastern margin of the Colorado Plateau north to Abiquiu Dam.

Trip participants will arrive on Wednesday, September 30, for the opening-night icebreaker, hosted by the New Mexico Geological Society.

Day one, October 1, features travel south on NM–44 to San Luis, west to the Rio Puerco valley near Cabezon Peak, north along the southern edge of Mesa Portales to Torreon Trading Post, and then northeast to Cuba. An evening barbecue will follow the first day's trip.

Day two, October 2, begins by journeying west on NM–44 past Lybrook to Huerfano Trading Post, south on NM–371 to the De-Na-Zin and Bisti badlands and the Fossil Forest, then retraces the route back to Cuba. The annual banquet will be held in Cuba on Thursday night with Dr. Dag Nummedal of Louisiana State University as speaker.

Day three, October 3, is by caravan north on NM–96 to Llaves, then east on NM–112 to Abiquiu Dam. Participants may leave the conference on NM–112 east toward Santa Fe or west toward Cuba or on NM–44 toward Albuquerque.

Principal field-trip leaders are Brian Brister, Gretchen K. Hoffman, Adrian P. Hunt, David W. Love, Spencer G. Lucas, Larry N. Smith, and Thomas E. Williamson. The guidebook is edited by Adrian P. Hunt, Barry S. Kues, Spencer G. Lucas, and Thomas E. Wiliamson.

We look forward to your attendance at the 1992 New Mexico Geological Society fall field conference. For more information contact Orin J. Anderson, Registration Chairman, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801, (505) 835–5122.

—Spencer G. Lucas, Thomas E. Williamson
Field Conference Co-Chairmen