UTAH GEOLOGICAL SURVEY
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GYPSUM SUSCEPTIBILITY
ZION NATIONAL PARK GEOLOGIC-HAZARD STUDY AREA

By

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Base map consists of U.S. Department of Agriculture 2006 National Agricultural Imagery Program natural color aerial photography and shaded relief generated from digital elevation data acquired from the Utah Automated Geographic Reference Center.

Universal Transverse Mercator Projection, zone 12
North American Datum of 1983

SYMBOLS

- Zion National Park Geologic-Hazard Study Area boundary
- Zion National Park boundary
- County boundary
- State highway
- Minor road
- Foot trail
- Existing park structure
- Area not studied

EXPLANATION

GR_A Bedrock units that contain abundant gypsum, often in laterally continuous horizons as much as several feet thick. These units and the soils derived from them are commonly associated with dissolution and collapse features. This category includes the Shnabkaib Member of the Moenkopi Formation and the Paria River Member of the Carmel Formation.

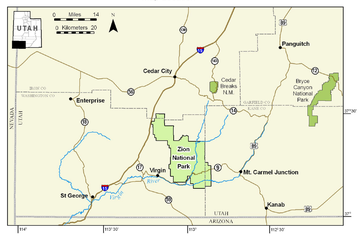
GR_B Bedrock units that lack massive gypsum horizons, but contain thin to medium beds and veins of gypsum interspersed with other rock types. These units and the soils derived from them may contain sufficient gypsum locally to cause foundation or other problems. This category includes the lower red, middle red, and upper red members of the Moenkopi Formation; the Moenkopi Formation undivided; and the Crystal Creek Member of the Carmel Formation.

Geologic Units Known or Likely to Contain Abundant Gypsum

Bedrock Units[1]	Geologic Map Symbols	Gypsiferous Rock Category
Shnabkaib Member, Moenkopi Formation; Paria River Member, Carmel Formation	TRms, Jcp	GR_A
lower red, middle red, and upper red members, Moenkopi Formation; Moenkopi Formation undivided; Crystal Creek Member, Carmel Formation	TRml, TRmm, TRmu, TRm, Jcx	GR_B

[1]See chapter 1, figure 1.4 in accompanying text for complete geologic unit names.

Map Location



Approximate mean declination, 2009

SCALE 1:24,000

1 0.5 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 0.5 0 1 KILOMETER

DISCUSSION

Gypsum-bearing soil and rock are subject to dissolution of the gypsum ($CaSO_4 \cdot 2H_2O$), which causes a loss of internal structure and volume. Where the amount of gypsum is ≥10 percent, dissolution can result in localized land subsidence and sinkhole formation (Mulvey, 1992; Muckel, 2004; Santi, 2005). Dissolution of gypsum may lead to foundation problems and may affect roads, dikes, underground utilities, and other infrastructure. Gypsum dissolution can be greatly accelerated by application of water, such as that provided by reservoirs; septic-tank drain fields; street, roof, or parking lot runoff; and irrigation (Martinez and others, 1998). Gypsum is also a weak material with low bearing strength and is not well suited as a foundation material. Additionally, when gypsum weathers it forms dilute sulfuric acid and sulfate, which can corrode and weaken unprotected concrete and metals. Type V or other sulfate-resistant cement is typically required in such areas, as is corrosion protection for metals.

SOIL

Information on gypsiferous soil in the study area is limited. Mortensen and others (1977) mapped and described the soils in Zion National Park, and did not report the presence of pedogenic gypsum in their soil profiles. The absence of gypsum in the soil is likely due to the higher average annual precipitation in the study area (10-20 inches; see chapter 6 – Introduction – in accompanying text) than in the more arid St. George area where average annual precipitation is 8.25 inches and pedogenic gypsum is common (Lund and others, 2008). Because of limited information, no areas of gypsiferous soil are shown on this map. Although unmapped in the study area, we anticipate that locally high concentrations of pedogenic gypsum are present in residual soils formed on gypsum-rich bedrock and in colluvial soils derived from gypsum-bearing rock units.

ROCK

In the Zion National Park Geologic-Hazard Study Area, gypsum is an important component of the Shnabkaib Member of the Moenkopi Formation and the Paria River Member of the Carmel Formation. Gypsum is present in lesser amounts in the lower red, middle red, and upper red members of the Moenkopi Formation, and the Crystal Creek Member of the Carmel Formation. Additionally, residual and colluvial soils derived from these bedrock units may contain locally significant pedogenic gypsum. However, because gypsum is typically concentrated in subsurface horizons by soil-forming processes, problem soils may be difficult to recognize in the absence of subsurface exploration.

We grouped gypsum-bearing bedrock units into two susceptibility categories (GR_A and GR_B) on this map based on the relative amount of gypsum present in the bedrock units that constitute each category. While there is a general decrease in the amount of gypsum present from GR_A to GR_B, both hazard categories may contain abundant gypsum locally, and have a significant potential for dissolution and collapse. Therefore, the classification system presented here employs a relative susceptibility ranking as opposed to a hazard-severity ranking.

For additional information about gypsiferous soil and rock in the Zion National Park Geologic-Hazard Study Area, refer to the Problem Soil and Rock Hazards chapter in this report.

USING THIS MAP

This map shows the location of known and suspected gypsiferous rock in the Zion National Park Geologic-Hazard Study Area. The map is intended for general planning and design purposes to indicate where gypsiferous rock conditions may exist and special investigations, including sodium sulfate testing to determine the presence of corrosive soil or rock, should be required. Site-specific investigations can resolve uncertainties inherent in generalized mapping and help identify the need for special design or mitigation techniques. The presence and severity of gypsiferous rock units and gypsum-rich soils derived from them, along with other geologic hazards, should be addressed in these investigations. If gypsiferous soil or rock is present at a site, appropriate design and construction recommendations should be provided.

MAP LIMITATIONS

This map is based on limited geologic and geotechnical data; site-specific investigations are required to produce more detailed geotechnical information. The map also depends on the quality of those data, which may vary throughout the study area. The mapped boundaries between susceptibility categories are approximate and subject to change as new information becomes available. The susceptibility may be different than shown at any particular site because of variations in the physical properties of geologic deposits within a map unit, gradational and approximate map-unit boundaries, and the small map scale. Additionally, gypsum-bearing bedrock units are locally covered by a thin veneer of unconsolidated deposits. Such areas may be susceptible to sinkhole development or collapse; however, because subsurface information is generally unavailable, those areas are not identified on this map. The map is not intended for use at scales other than the published scale, and is designed for use in general planning and design to indicate the need for site-specific investigations.

HAZARD REDUCTION

Although potentially costly when not recognized and properly accommodated in project design and construction, problems associated with gypsiferous soil and rock rarely are life threatening. As with most geologic hazards, early recognition and avoidance are the most effective ways to mitigate potential problems. However, avoidance may not always be a viable or cost-effective option.

In Utah, soil-test requirements are specified in chapter 18 (Soils and Foundations) of the 2009 IBC (International Code Council, 2009a) and chapter 4 (Foundations) of the 2009 IRC (International Code Council, 2009b), which are adopted statewide. IBC Section 1803.3 contains requirements for soil investigations in areas where questionable soil (soil classification, strength, or compressibility is in doubt) is present. IRC Section R401.4 states that the building official shall determine whether to require a soil test to determine the soil's characteristics in areas likely to have expansive, compressible, shifting, or other unknown soil characteristics. Where the presence of gypsiferous soil or rock is confirmed, possible hazard-reduction techniques include use of Type V or other sulfate-resistant cement for concrete; corrosion protection for metals; soil removal and replacement with noncohesive, compacted backfill; careful site landscape and drainage design to keep moisture away from concrete and gypsum-bearing deposits; and the use of a vapor barrier beneath concrete slabs to prevent sulfate migration (Keller and Blodgett, 2006). Where gypsum problems are particularly acute, design recommendations should be provided by a qualified corrosion engineer.

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