UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources
in cooperation with
National Park Service

Plate 7
Utah Geological Survey Special Study 133
Zion National Park Geologic-Hazard Study Area, Washington and Kane Counties, Utah

EXPANSIVE-SOIL-AND-ROCK HAZARDS
ZION NATIONAL PARK GEOLOGIC-HAZARD STUDY AREA

By

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2010

This geologic-hazard map was funded by the Utah Geological Survey and the U.S. Department of the Interior, National Park Service. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

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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

EXPANSIVE SOIL

High Hazard – Soils classified by the NRCS as having high hazard for volumetric change. These soils are typically clay rich and have a LL ≥35, PI ≥15, and/or SCT value of ≥3 percent swell (Mortensen and others, 1977; Chen, 1988; Nelson and Miller, 1992). Soils having these characteristics are of limited aerial extent in the study area, and are typically associated with the Petrified Forest Member of the Chinle Formation, other clay-rich bedrock units, and some weathered basalt flows.

Moderate Hazard – Soils classified by the NRCS as having moderate hazard for volumetric change (LL 25–55, PI 5–35). The LL and PI values in this category overlap at their upper ends with soils in the high hazard category. Chen (1988) recognized that while PI is an indicator of expansive potential, other factors also exert an influence, and therefore reported a range of PI values when categorizing a soil's capacity to shrink or swell.

Low Hazard – Soils classified by the NRCS as having low hazard for volumetric change (LL 0-40, PI from nonplastic to 15). The LL and PI values in this category overlap at their upper ends with soils in the moderate hazard category. However, the low hazard category includes soils with highly variable potential for volumetric change that do not fit easily into the moderate or high categories.

No Data – Unconsolidated alluvial deposits in areas of upper Zion Canyon, Hop Valley, and LaVerkin Creek that may contain some clay-rich horizons subject to volumetric change, but a lack of information about the physical characteristics of the deposits precludes hazard categorization. These deposits are not included in the geotechnical database, and are mapped by the NRCS as chiefly Rock Outcrop (NRCS soils-map unit RT) or Fluvaquents and Torrifluvents (NRCS soils-map unit FA) for which soil property estimations and engineering tests were not performed. Due to the variable nature of these deposits and a general lack of geotechnical data for them, we recommend site-specific testing for expansive soil for all proposed construction within map areas having no data.

EXPANSIVE ROCK

High Hazard – Bedrock units with high shrink/swell hazard, which include claystone horizons in the Virgin Limestone Member of the Moenkopi Formation, the Petrified Forest Member of the Chinle Formation, and the lower red beds of the Dinosaur Canyon Member and the Whitmore Point Member of the Moenave Formation. We include landslides mapped within these rock units in the high-hazard category because the landslides contain debris from high-hazard bedrock units. These bedrock units contain an abundance of expansive clay minerals and are commonly associated with expansive rock problems throughout southwestern Utah.

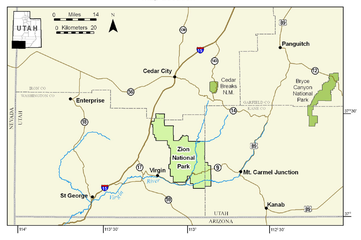
Moderate Hazard – Bedrock units with moderate shrink/swell hazard, which include the Shnabkaib and lower, middle, and upper red members of the Moenkopi Formation; the Sinawava Member of the Temple Cap Formation; and the lower unit of the Co-op Creek Member and the Crystal Creek Member of the Carmel Formation. These rock units are chiefly fine grained and contain alternating strata of shale, claystone, mudstone, siltstone, sandstone, and limestone. Not all or even the majority of these strata contain expansive clay minerals; however, past experience in southwestern Utah has shown that a sufficiently high percentage of strata do contain expansive clay that shrink/swell problems are often associated with these bedrock units. We include landslides mapped within moderate-hazard rock units in this category.

Low Hazard – Bedrock units with low shrink/swell hazard, which include the Timpoweap Member of the Moenkopi Formation, the Kayenta Formation, and the Winsor Member of the Carmel Formation. We consider these units to have a lower hazard than the bedrock units identified above; however, low-hazard units contain some fine-grained, clay-rich strata that may cause shrink/swell problems locally.

CONCEALED HIGHLY EXPANSIVE SOIL OR ROCK

Concealed – Area suspected of having highly expansive soil or rock (≥3 percent swell) in the shallow subsurface (≤20 feet), with little or no evidence of such material at the ground surface. The likely presence of highly expansive materials in the shallow subsurface is based on the outcrop pattern of the Petrified Forest Member of the Chinle Formation, which indicates that the Petrified Forest Member likely underlies thin unconsolidated deposits in those areas. The Petrified Forest Member typically contains highly expansive shale and claystone, and past experience in southwestern Utah has shown that when wetted, highly expansive soil or rock can cause damaging differential displacements at the ground surface even when overlain by as much as 20 feet of nonexpansive material (Lund and others, 2008). Therefore, we consider areas where the Petrified Forest Member may be present in the shallow subsurface to have a potential for highly expansive soil and rock problems despite the lack of surface evidence of such materials.

Map Location



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

Approximate mean declination, 2009

DISCUSSION

Expansive soil and rock increase in volume (swell) as they get wet, and decrease in volume (shrink) as they dry out. Expansive soil and rock contain a significant percentage of clay minerals that can absorb water directly into their crystal structure when wetted. Some sodium-montmorillonite clay can swell as much as 2000 percent upon wetting (Costa and Baker, 1981). The resulting expansion forces can be greater than 20,000 pounds per square foot (Shelton and Prouty, 1979), and can easily exceed the loads imposed by most structures, resulting in cracked foundations and pavement, structural damage, and other building distress.

Several bedrock formations in the Zion National Park Geologic-Hazard Study Area consist in whole or part of shale, claystone, or mudstone containing expansive clay minerals. These rock units and the expansive soils derived from them are capable of significant expansion and contraction when wetted and dried, causing structural damage to buildings; cracked roads and driveways; damage to curbs, gutters, and sidewalks; and heaving of roads and canals. Expansive soils are chiefly derived from the weathering of clay-bearing rock formations and may be residual (formed in place) or transported (usually a short distance) and deposited in a new location. The principal transporting mechanisms are water or wind, but soil creep and mass-wasting processes may play important roles locally.

For additional information about expansive 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 or suspected expansive soil and rock in the Zion National Park Geologic-Hazard Study Area. The map is intended for general planning and design purposes to indicate where expansive soil and rock may exist and special investigations should be required. Site-specific investigations can resolve uncertainties inherent in generalized mapping and help identify the need for special foundation designs, site grading and soil placement, or mitigation techniques. The presence and severity of expansive soil and rock, along with other geologic hazards should be addressed in these investigations. If expansive 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 hazard categories are approximate and subject to change as new information becomes available. The hazard from expansive soil and rock 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. 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 expansive 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, expansive soil and rock are present in some of the most heavily developed parts of the study area, and 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 and IRC Section R401.4 contain requirements for soil investigations in areas where expansive soil may be present. Where the presence of expansive soil or rock is confirmed, possible mitigation techniques include soil removal and replacement with noncohesive, compacted backfill; use of special foundation designs such as drilled pier deep foundations, grade beam foundations, or stiffened slab-on-grade construction; moisture barriers; chemical stabilization of expansive clays; and careful site landscape and drainage design to keep moisture away from buildings and expansive soils (Nelson and Miller, 1992; Keller and Blodgett, 2006).

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