

Arizona Geology

Vol. 34, No. 2
SUMMER 2004

Published by the Arizona Geological Survey

THE STATE AGENCY FOR GEOLOGIC INFORMATION

MISSION

To inform and advise the public about the geologic character of Arizona in order to increase understanding and encourage prudent development of the State's land, water, mineral, and energy resources.

ACTIVITIES

PUBLIC INFORMATION

Inform the public by answering inquiries, preparing and selling maps and reports, maintaining a library, databases, and a website, giving talks, and leading fieldtrips.

GEOLOGIC MAPPING

Map and describe the origin and character of rock units and their weathering products.

HAZARDS AND LIMITATIONS

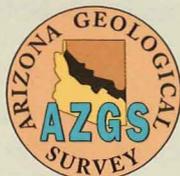
Investigate geologic hazards and limitations such as earthquakes, land subsidence, flooding, and rock solution that may affect the health and welfare of the public or impact land and resource management.

ENERGY AND MINERAL RESOURCES

Describe the origin, distribution, and character of metallic, non-metallic, and energy resources and identify areas that have potential for future discoveries.

OIL AND GAS CONSERVATION COMMISSION

Assist in carrying out the rules, orders, and policies established by the Commission, which regulates the drilling for and production of oil, gas, helium, carbon dioxide, and geothermal resources.



Giant Desiccation Cracks in Arizona

Raymond C. Harris
Arizona Geological Survey



Figure 1. This crack in a Graham County road in southeastern Arizona looks like an earth fissure caused by groundwater pumping, but is actually part of a network of polygonal desiccation cracks.

Since 1998, the Arizona Geological Survey has received numerous reports of new cracks in the ground in widely scattered localities around the state. Prior to the mid-1990s most cracks reported were of a familiar type, that is, earth fissures caused by land subsidence resulting from groundwater pumping. Most of the newer cracks, however, proved to be of a different origin, that of drying out or desiccation of clay-rich soil and sediment (Figure 1). Mapping of the reported cracks and inspection of aerial photos revealed that these "giant desiccation cracks" are much more common than previously recognized, and are more widespread than earth fissures from groundwater pumping. A study was recently completed to document the results of reconnaissance mapping of giant desiccation cracks in the state. (Harris, R.C., 2004).* This article summarizes that report.

Giant desiccation cracks (GDCs) are similar to mud-cracks or large soil cracks, but on an enormous scale.

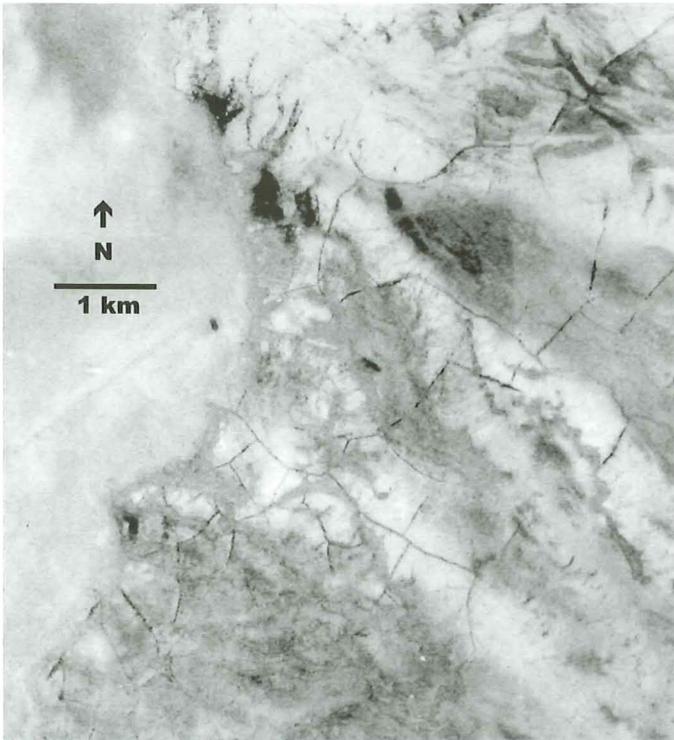


Figure 2. Aerial photo of giant desiccation polygons on Red Lake Playa north of Kingman in northwestern Arizona.

The cracks themselves are up to 3 ft (1 m) wide, up to 9 ft (3 m) deep (apparent depth), and a few are on the order of 1,000 ft (300 m) long (Figure 2). They form polygonal blocks that look identical to the shape of mudcracks, but the polygons are characteristically 150–600 ft (50–200 m) across, whereas typical mudcracks form polygons 4–8 in (10–20 cm) across and large soil cracks form polygons 2–6 ft (0.5–2 m) across.

Some GDCs are large enough to be mistaken for earth fissures that are caused by subsidence from groundwater pumping. To distinguish GDCs from earth fissures one must map the features to determine their size and geometry. In general, earth fissures from groundwater pumping are longer, straighter, and deeper than GDCs. The definitive difference is that GDCs form polygons (Figure 3).

Formation of giant desiccation cracks. The processes that result in opening of GDCs are complex; no single model satisfactorily explains all occurrences. The giant cracks develop in clay-rich layers that were deposited in lakes or playas in internally drained basins. Clay minerals, especially sodium-rich montmorillonite, common in Arizona, undergo shrink-swell cycles in response to drying and wetting. When wet, these clays swell, and upon drying they shrink. In pure sodium-rich montmorillonite expansion may be as much as a thousand percent when water is added. Because soils and alluvium are usually not composed entirely of clay minerals, and are not always at

the sodium end of the composition range, expansion and contraction with changing moisture conditions is typically much less than in pure clay.

GDCs form at depth and develop upward toward the land surface. Some cracks on California playas formed at depths as great as 50 ft (15 m). The most common form of a desiccation crack at the surface is one of a linear collapse feature.

When the voids of sufficient size approach the surface, wetting of the ground triggers collapse of the surface. Desiccation cracks typically open at the surface following a major rain that produces sheetflow runoff. Runoff wets the top few feet of soil and sediment, saturates the clay minerals, and reduces their cohesion. This causes the surface material to lose structural strength and collapse into the open crack below. It is ironic that drying causes these cracks to form beneath the surface, but wetting causes them to open at the surface.

Thick mesquite, brush, and grass might slow the opening of desiccation cracks at the surface because the abundance of intertwined roots adds structural support to soil and hinders collapse of the surface. In newly formed large cracks and sinkholes, tunnels are commonly seen extending from the collapsed zone, with no crack or depression at the surface between them. Such bridging is evidence that the surface has not pulled apart.

One factor that is common to all newer cracks (those formed since the mid-1990s) is that they are all in areas, usually at the toes of alluvial fans, that are inundated by sheetflow during heavy rain. Sheetflow is much more effective at wetting the surface than is runoff restricted to incised channels.

Lowering of the groundwater table by pumping may have been the trigger for some GDCs but not for all. Although some GDCs occur in agricultural areas where groundwater levels have dropped because of pumping, others are present on remote playas where no groundwater pumping has occurred. Furthermore, GDCs appeared in several places in Arizona (e.g. Willcox and San Simon) around the turn of the 20th century, before large-scale groundwater pumping began.

The areas with desiccation cracks studied in this report have groundwater levels typically 100 ft deep or more. Once groundwater levels have dropped below 50–100 ft, further declines are essentially irrelevant to near-surface desiccation. In places where groundwater levels began to drop by the 1950s (e.g., Casa Grande area, Picacho Basin, San Simon Valley, Willcox area, Luke Basin, Chandler-Mesa area) the development of desiccation cracks in the past 40 years can no longer be blamed on continuing groundwater declines.

In some locations multiple episodes of cracking have occurred. The reactivation of cracks indicates that they respond to long-scale precipitation cycles. In this sense,



Figure 3. Recently opened desiccation cracks that are part of the same polygonal network shown in Figure 1.

GDCs undergo shrink-swell cycles rather than being the result of a one-time-only desiccation subsequent to deposition of the clay. The newest phase of cracking is believed to be the result of a severe ongoing drought.

Conclusions. Although the scientific community, land planners, and developers are familiar with earth fissures caused by groundwater pumping, they know less about the occurrence of giant desiccation cracks. As the current severe drought in Arizona persists, and development encroaches on the margins of desert basins, GDCs are likely to be encountered with increasing frequency. They may present hazards and mitigation requirements similar to those of earth fissures from groundwater pumping.

Open-File Report 04-01, based largely on reconnaissance mapping, shows what we know about the location of giant desiccation cracks. They are probably much more widely distributed. If you've seen any large cracks in the ground that you believe might have been caused by desiccation, please inform us so we can include their locations in our database. Much work remains to be done to characterize the cracks and determine how they can best be mitigated.

*Harris, R.C., 2004, Giant desiccation cracks in Arizona: Arizona Geological Survey Open-File Report 04-01 (OFR 04-01), 93 p. \$21.00 plus shipping and handling (p. 6).

ARE GIANT DESICCATION CRACKS NATURAL OR HUMAN CAUSED?

Factors suggesting human influence:

- ◆ Desiccation cracks are present in agricultural areas where groundwater levels have dropped because of pumping.
- ◆ Desiccation cracks occur in same areas as earth fissures, and earth fissures are known to be the result of groundwater decline.
- ◆ The trend of some cracks is influenced by roads.

Factors pointing to natural causes:

- ◆ Desiccation cracks are present on remote playas where no groundwater pumping has occurred; groundwater levels are controlled by long-period climate changes.
- ◆ Desiccation cracks appeared in several places in Arizona before major groundwater pumping began.
- ◆ Large polygonal cracks in many places open periodically or appear in multi-decade cycles, whereas groundwater levels have not fluctuated enough to be responsible for these cycles.
- ◆ Filled cracks ("clay veins") are found in old alluvial deposits.
- ◆ Cycles of desiccation crack formation in some places can be correlated with periods of drought in Arizona.