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The Role of AZGS in Mapping Earth Fissures in Arizona

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Introduction

In August 2005, torrential monsoon rains reactivated an earth fissure near Queen Creek, Maricopa County, Arizona. Overnight, the fissure became an open crevasse 5 to 10 ft wide, and up to 25 ft deep crossing two residential lots (Figure 1). In response to growing public outcry, the Arizona Legislature drafted legislation to map earth fissures in Arizona. Effective 21 September 2006, House Bill 2639 charges the Arizona Geological Survey (AZGS) with 1) comprehensive mapping of earth fissures throughout Arizona, and 2) delivering earth fissure map data to the State Land Department for posting online with other GIS map layers so the public can make customized maps. A complementary statute, A.R.S. 33-422, requires disclosure of earth fissures in non-incorporated areas as part of real estate transactions. To meet the task of mapping all the state's earth fissures, AZGS received continuing funds for hiring three staff geologists and one-time only funds to purchase high-precision Global Positioning System receivers and field-based computers.

Figure 1: Earth fissure near Chandler Heights, Maricopa County, August 2005. Earth fissures range from insipient, where they are characterized by discontinuous, pock-marked ground and hairline fractures, to mature features miles in length and hundreds of feet deep, with associated gullies at the surface that are more than 10 feet wide and several tens of feet deep. (Photo by Ray Harris)

Stage 1: Earth Fissure Planning Maps

The first priority of the fissure mapping program was to compile all extant maps, published literature, and reports on earth fissures from throughout Arizona. Additionally, we acquired aerial photographs of areas in the Cochise, Maricopa, Pima, and Pinal counties known for hosting earth fissures. Wherever possible we acquired high-resolution aerial photographs directly from the county governments, otherwise we acquired older, low-resolution photographs from the U.S. Geological Survey. As part of our stage 1 efforts, we performed a cursory examination of the four counties to explore for previously unmapped and unreported earth fissures. At the same time, the AZGS mapping team was trained in recognizing earth fissures on both aerial photographs and on the ground.

Stage 1 culminated in the production and distribution of 1:250,000 scale earth fissure planning maps showing the distribution of all known or reported earth fissures in Cochise, Maricopa, Pima, and Pinal counties. Earth fissures from the four counties were than assigned to one of 22 discrete study areas. To facilitate communication between scientists, local governments, realtors, and the general public, we assigned local geographic names to each of the study areas. The 22 study areas were then ranked for priority, high resolution mapping on the basis of three cri-

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, nonmetallic, 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.

TABLE 1. List of 22 priority areas for earth fissure mapping at 1:24,000 scale.

1) Chandler Heights / Queen Creek (Pinal & Maricopa)
2) Apache Junction (Pinal)
3) Luke (Maricopa)
4) Toltec Buttes (Pinal)
5) Picacho (Pinal)
6) Heaton (Pinal)
7) White Horse Pass (Pinal)
8) Signal Peak (Pinal)
9) Tator Hills (Pinal)
10) Greene Wash (Pinal)
11) Sacaton Butte (Pinal)
12) Scottsdale/NE Phoenix (Maricopa)
13) Pete's Corner (Pinal)
14) Santa Rosa Wash (Pinal)
15) Sulphur Springs North (Cochise)
16) Three Sisters Buttes (Cochise)
17) Bowie-San Simon (Cochise)
18) Dragoon Road (Cochise)
19) Wintersburg (Maricopa)
20) Marana (Pima)
21) Harquahala Plain (Maricopa)
22) Mesa (Maricopa)

teria: 1) proximity to an area of rapid development; 2) the presence of multiple fractures; and 3) basins characterized by rapid subsidence. Table 1 lists the study areas in order of mapping priority. Most of the highest priority study areas are in Pinal County where the density of known fissures is greatest and where new construction rapidly encroaches on known earth fissures.

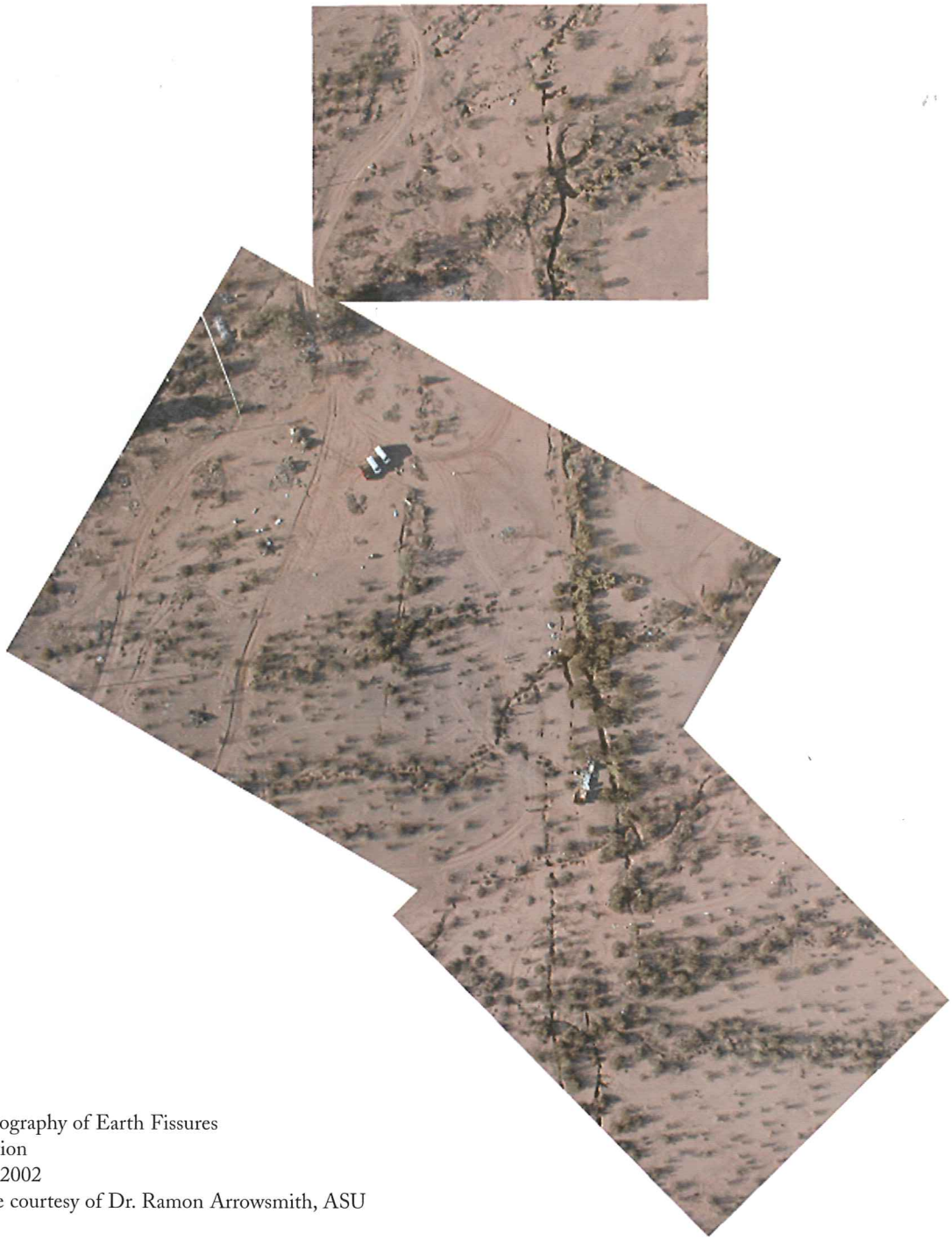
The 1:250,000 scale earth fissure planning maps are now available at the AZGS Bookstore in Tucson and at Department of Mines and Mineral Resources in Phoenix for $4.00 per map. Maps are accompanied by open-file report (OFR-01 2007), *Earth Fissure Mapping Program: 2006 Progress Report*. Both the maps and report are available free in pdf format at www.azgs.az.gov.

Stage 2: High Resolution Mapping

Stage 2 involves systematic, meter to sub-meter GPS mapping of earth fissures in priority study areas (Table 1). Given the large number of reported earth fissures, more than 250 in the four counties, and the likelihood of discovering new fissures, we anticipate it will take three to five years to complete detailed mapping. With input from members of the Arizona Land Subsidence Group and Dave Minkel with the US National Geodetic Survey, we established field protocols for using high-precision GPS receivers to map fissures and laboratory protocols for post-processing the GPS data.

Not all earth fissures have a through-going, well-defined surface expression. As a result, ground lineaments whose origin as earth fissures is questionable will be categorized as "possible fissures", to be shown as a dotted or dashed line on maps. After completing mapping of a study area, the processed GIS data will be handed off to the Arizona State Land Dept. (ASLD) for inclusion in an interactive, online GIS service with other 1:24,000 scale map layers so anyone can build customized maps at the ASLD website.

The earth fissure mapping team comprises AZGS geologists, Todd Shipman (research geologist & lead scientist), Mimi Diaz (Phoenix branch chief), and Michael Mahan (geologist). Additional AZGS staff are aiding with development of the digital database as needed.



Balloon Photography of Earth Fissures
Apache Junction
5 November, 2002
Mosaic image courtesy of Dr. Ramon Arrowsmith, ASU

Origin of earth fissures

The southern and western part of Arizona lies within the Basin and Range Province, which comprises deep sediment-filled basins separated by long narrow mountain ranges. These deep basins – comprising 6000 ft or more of sediment fill — hold large quantities of groundwater in storage. Pumping of groundwater in some basins may be hundreds of times faster than recharge. Where agriculture or municipalities rely extensively on groundwater, the groundwater tables have declined as much as 300 feet or more.

As groundwater tables lower, aquifer sediments undergo compaction leading to basin subsidence. In the Luke basin, immediately west of Phoenix, the land subsided about 18 feet by 1992. In the Picacho basin near Eloy, land subsided more than 15 feet between the 1920s and early 1980s. Earth fissures frequently develop around the margins of most Arizona basins where the land has subsided more than a few feet. Fissures propagate upward to the surface from the compacted aquifer sediments at or near the lowered water table depths. They preferentially form where there is a change in the mechanical or physical properties of the rocks, such as where the sediment layers intersect bedrock at basin margins, where buried bedrock highs poke up through the sediments, or where there are changes in the composition of sediment layers such as from clay/shale to sand/gravel.

Fissures may exist for months or years in the subsurface, extending their lengths for thousands of feet, before eventually breaking through to the surface. Thus, the absence of surface expression of earth fissures does not preclude their existence below ground.