

EARTH FISSURES IN THE
BOWIE - SAN SIMON AREA,
COCHISE COUNTY, ARIZONA

by
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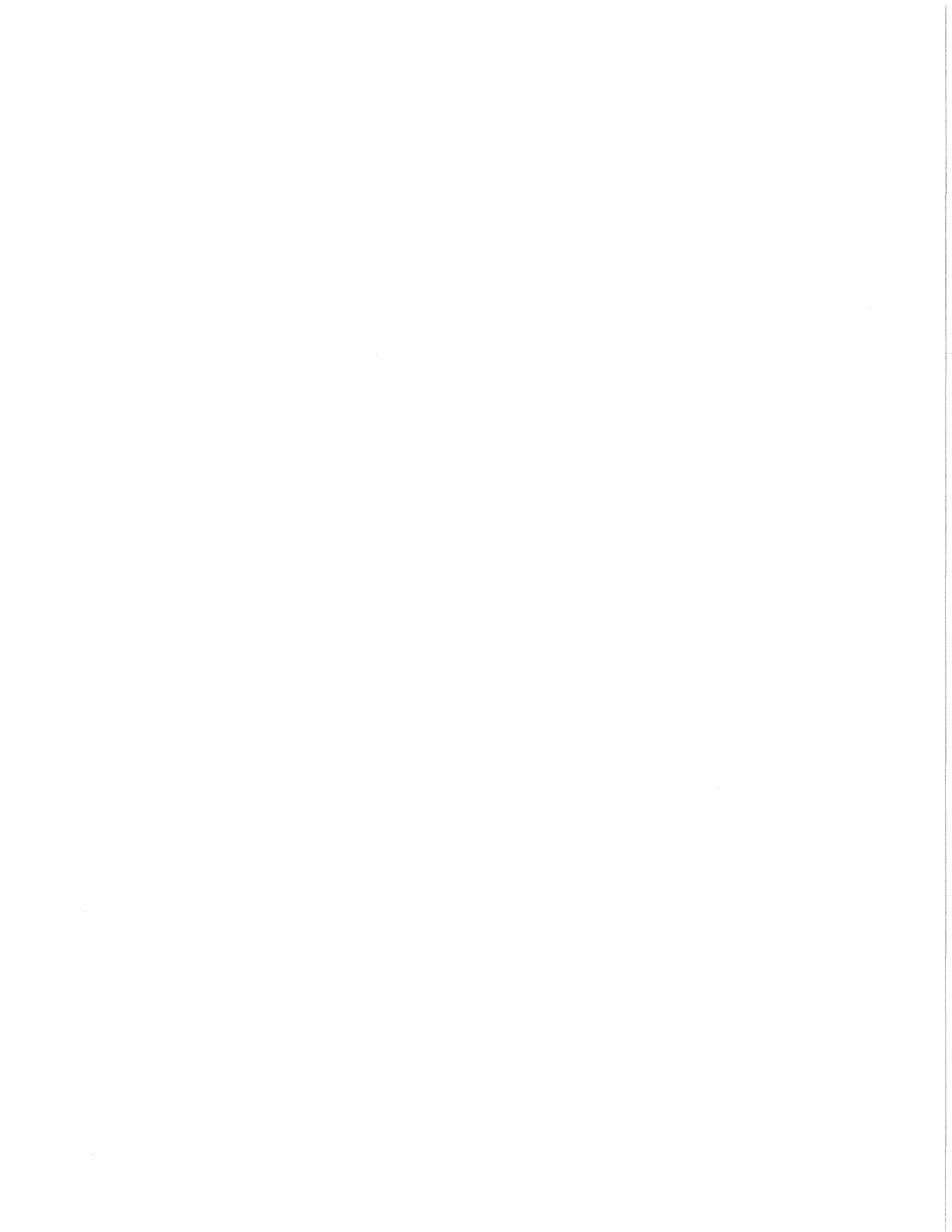
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Includes 10 pages text; 1:24,000 scale map)

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**This report is preliminary and has not been edited or reviewed
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INTRODUCTION

Earth fissures are tension cracks that result from land subsidence caused by groundwater withdrawal. In Arizona, fissures are common in large alluvial basins where extensive pumping has lowered groundwater tables as much as several hundred feet. Subsidence can cause flooding of lowered areas, and can change drainage gradients and directions, thereby disrupting storm drains, sewers, and canals. Earth fissures can cause significant damage to structures such as buildings, roads, pipelines, and aqueducts. Fissures can provide a conduit for surface pollution to reach aquifers. Land subsidence and earth fissures are serious geologic hazards and their impacts will increase as Arizona's population continues to grow.

Groundwater pumping, largely for agriculture, has lowered groundwater levels in the Bowie and San Simon areas of Cochise County (Figure 1). Land subsidence is occurring and earth fissures have formed as a result.

METHODS

Earth fissures in the Bowie-San Simon area were delineated by first examining detailed air photos. Photo coverage at a scale of 1:6000 (1989) was obtained from the Cochise County Highway and Floodplain Department. A strip of photos (1:20,000; 1970) along Interstate 10 was obtained from the Arizona Department of Transportation (ADOT). Locations of possible earth fissures were compiled from the photos, followed by field checking.

EARTH FISSURES

Bowie-San Simon Area

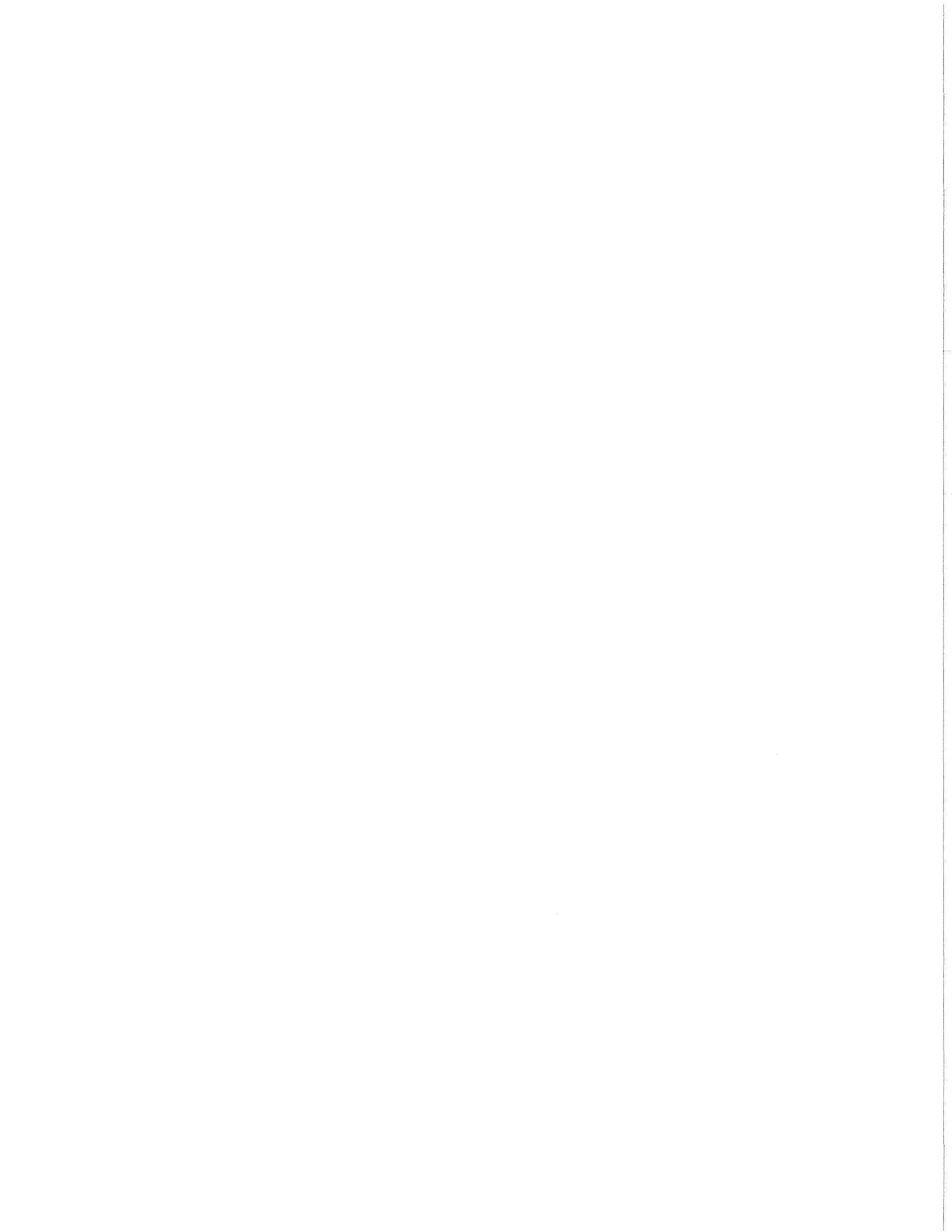
Earth fissures

A large zone of earth fissures extends from northeast of Bowie to south of San Simon (Plate 1). This nearly linear trend stretches from the northeastern edge of a cone of water table lowering centered at Bowie to the southwestern edge of a similar cone of depression at San Simon.

Earth fissures result from dewatering and differential compaction of fine-grained sediments caused by lowering of groundwater levels (Holzer and others, 1979; Jachens and Holzer, 1982; Schumann and others, 1985). Differential subsidence produces stresses that can cause fractures in sediments, usually at the edge of a cone of depression of groundwater.

Groundwater levels at Bowie have declined as much as 211 feet from 1952 to 1987 (Barnes, 1991). At Olga, between Bowie and San Simon, the water table has lowered 110 to 150 feet. Water levels have declined by about 94 feet in the San Simon area. This lowering of the groundwater table has caused land subsidence of 5.8 feet at Bowie and 1.3 feet at San Simon from 1952 to 1980 (Strange, 1983). In the years since those measurements, groundwater lowering and land subsidence have continued. Earth fissures have formed and continue to grow in the Bowie-San Simon area as a result.

Several man-made structures are intersected by large fissures in the valley. Two sets of large fissures cross Interstate 10 and the railroad, in T13S, R29 E, section 16, and T14S, R30E, section 21. A major gas pipeline south of San Simon is intersected by a set of four fissures in T14S, R31E, section 20, 1.5 miles west of Portal Road. The underground pipeline is clearly exposed in the open fissures. Another pipeline to the north is intersected by a fissure, perhaps the oldest one in the valley, at the section line between sections 15 and 22, T13S, R29E, just south of where that fissure crosses the freeway.



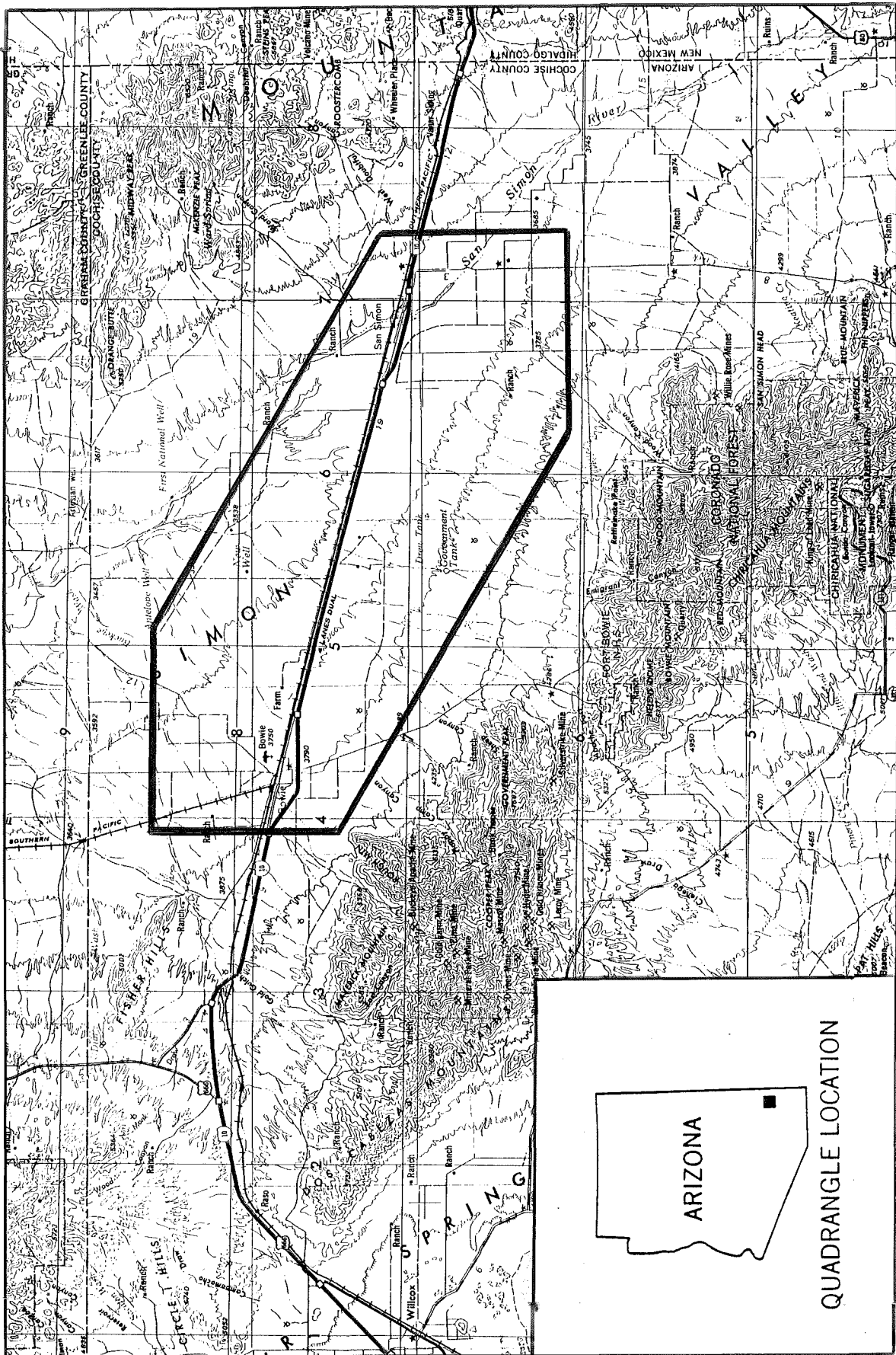


Figure 1. Location of study area

Polygonal cracks

In addition to large earth fissures are arrays of lineaments defined by dense vegetation that define polygons 50 to 200 feet in diameter. These polygonal cracks occupy the same general trend as the earth fissures. Although the polygons are obvious on air photos, on the ground they usually show no apparent crack, depression or other surface expression. In some cases, however, the polygonal cracks do show recent activity in the form of aligned depressions, surface cracks, or obviously enhanced vegetation. The zone of polygonal cracks is underlain by extremely fine-grained basin-fill sediment consisting of clay and silt.

Polygonal cracks were plotted by Holzer (1980). Parts of his map are reproduced in Appendix A for convenience. A comparison of Holzer's map and 1970 ADOT photos with the 1989 photos indicates that there has not been any obvious increase in the number or size of the polygonal cracks. No attempt was made in this study to re-map all of the polygons. Several of the larger, reactivated cracks were visited and are shown on Plate 1.

One possible explanation for the apparent reactivation of the polygonal cracks is a change in gradient of drainage caused by subsidence. As the land surface at Bowie subsides, the gradient of drainage (from SW to NE) is significantly reduced, allowing for ponding and greater infiltration of runoff. Eaton (1969) reported an area of uplift coinciding with the center of the fissure zone (also the edge of the Bowie cone of groundwater depression), which he ascribed to faulting in the bedrock below. This uplift -if it is real- would contribute to the diminishing gradient. Poor drainage and ponding are evidenced in the areas of polygonal cracking by extremely dense vegetation and deposits of clay and silt from dried mud puddles. Cycles of wetting and drying would cause polygonal cracks to reopen. Calcium carbonate, present in the fissure zone as clay-marl sediment as well as secondary caliche, may play a role in polygonal cracking by acting as a flocculant (Langer and Kerr, 1966).

Identical polygonal cracks are present in the Willcox Valley (Anderson, 1978). Those cracks are visible on air photos that predate the start of large-scale groundwater pumping in the Sulphur Springs Valley, and so are thought to be natural features.

Similar giant desiccation cracks have been noted on at least 35 playas in Arizona, New Mexico, Oregon, Nevada, and California (Lang, 1943; Neal and others, 1968; Willden and Mabey, 1961). In these playas, groundwater pumping has not taken place. Cracking is the result of a general lowering of groundwater in the region as a result of a drier climate since the end of the last Ice Age, 10,000 years ago. The studies on playas indicate that polygonal cracks extend to depths of 10 to 20 feet.

Safford Area

Agriculture in the Safford Valley depends mostly upon Gila River water for irrigation. Well water is generally used only when the Gila is not flowing. The city of Safford obtains most of its water from Bonita Creek for municipal use. Records of water levels in wells in the Safford Valley (Black, 1991), and on the San Carlos Indian Reservation (Brown, 1989) show that groundwater levels have not declined over the past 50 years, despite use of well water for irrigation, indicating that the shallow aquifer tapped by these irrigation wells is replenished by infiltration of river water during periods of flow. Depth to groundwater in the center of the valley ranges from 7 feet to about 50 feet, generally increasing with distance from the river. Because groundwater levels have not declined in the Gila River Valley, land subsidence has not occurred, and earth fissures have not formed.

Duncan Valley

As with the Safford area, water in the Duncan Valley comes directly or indirectly from the Gila River. Hydrographs of water levels in selected wells (Remick, 1989) indicate no decline in water levels over the last 50 years. In fact, in some of the wells, water levels have increased slightly since 1960. Groundwater is encountered at depths as shallow as 3 feet in wells along the Gila River. Subsidence has not been experienced in the Duncan area because water levels have not declined, and earth fissures have not formed.

CONCLUSIONS AND RECOMMENDATIONS

Earth fissures are common in the Bowie-San Simon area, and are the result of a lowering of the groundwater surface due to pumping. Differential subsidence is the cause of the fissures, and they may extend to depths of several hundred feet. These fissures could provide a conduit for contaminants to enter the subsurface and groundwater.

Desiccation of the basin fill alluvium appears to be the cause of the polygonal cracks. Continued wetting and drying from runoff events may be responsible for the active appearance of some of the polygonal cracks. The polygonal cracks probably are 10 to 30 feet deep. These cracks are not as important as fissures in allowing contaminants to reach the groundwater.

Periodic field checking of the Bowie-San Simon area would provide information on the evolution of the fissures, such as any increase in length of existing fissures with time, or the development of new fissures with continued lowering of the water table. Monitoring might help determine the effects of heavy rainfall or runoff on fissures and polygonal cracks.

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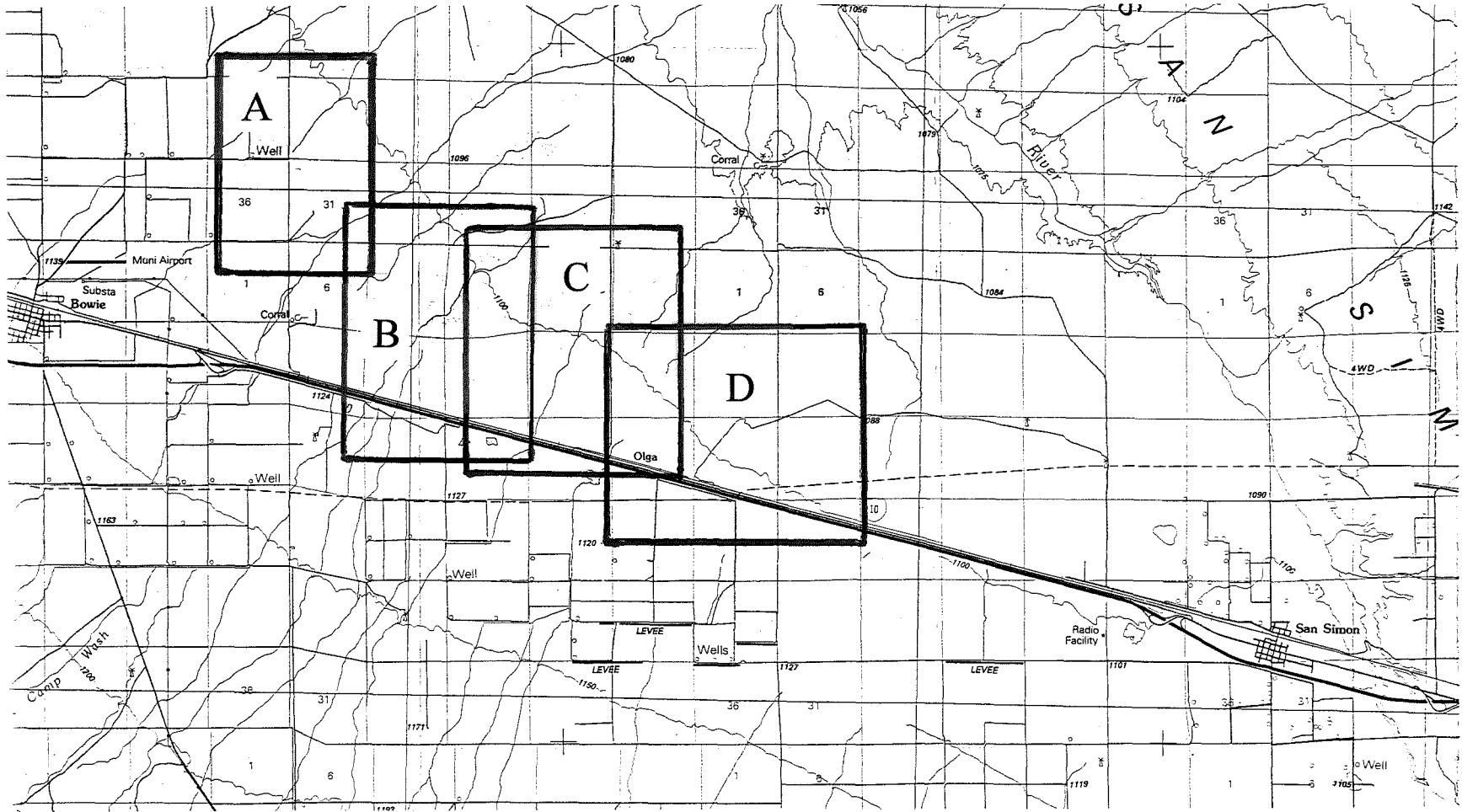
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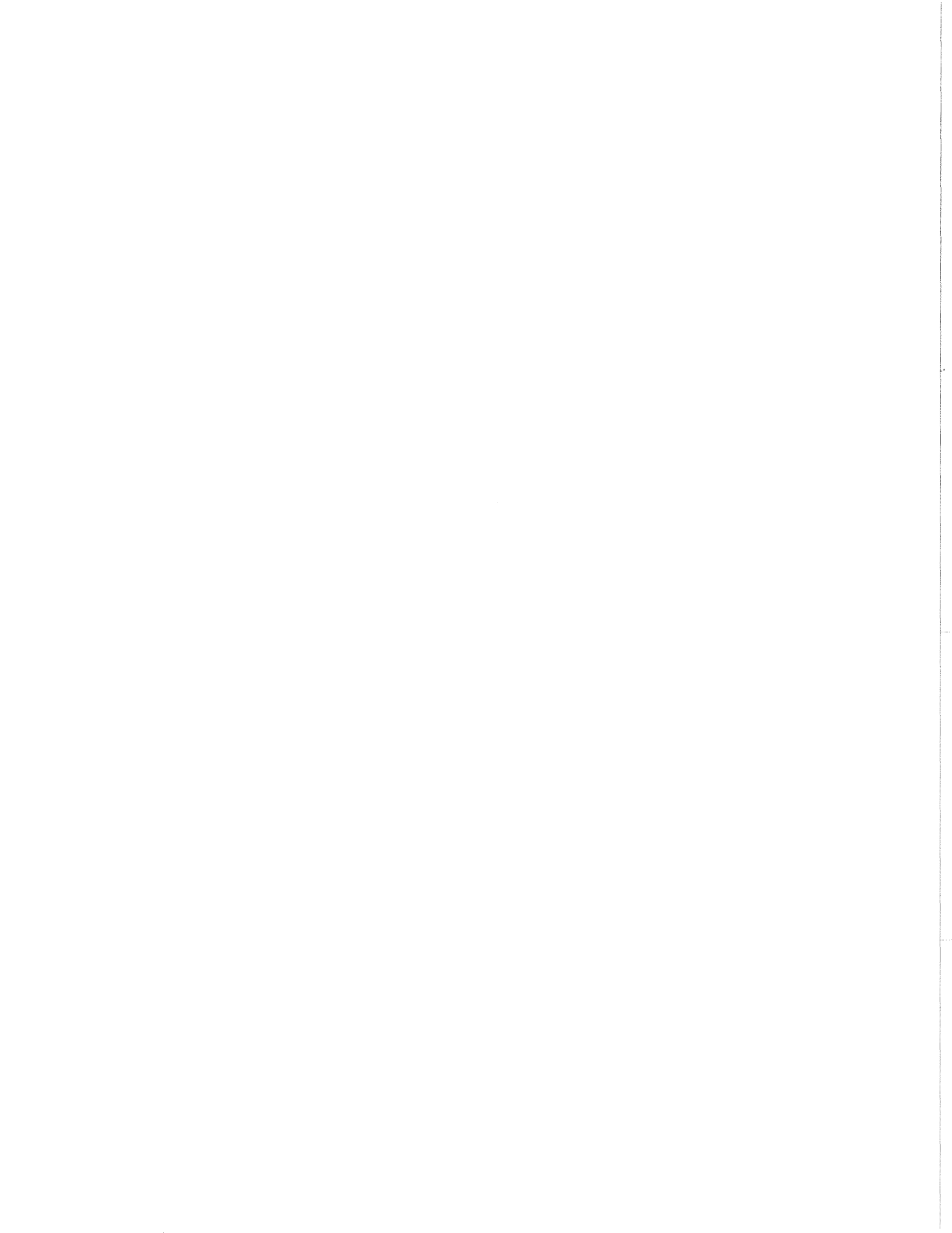
APPENDIX A

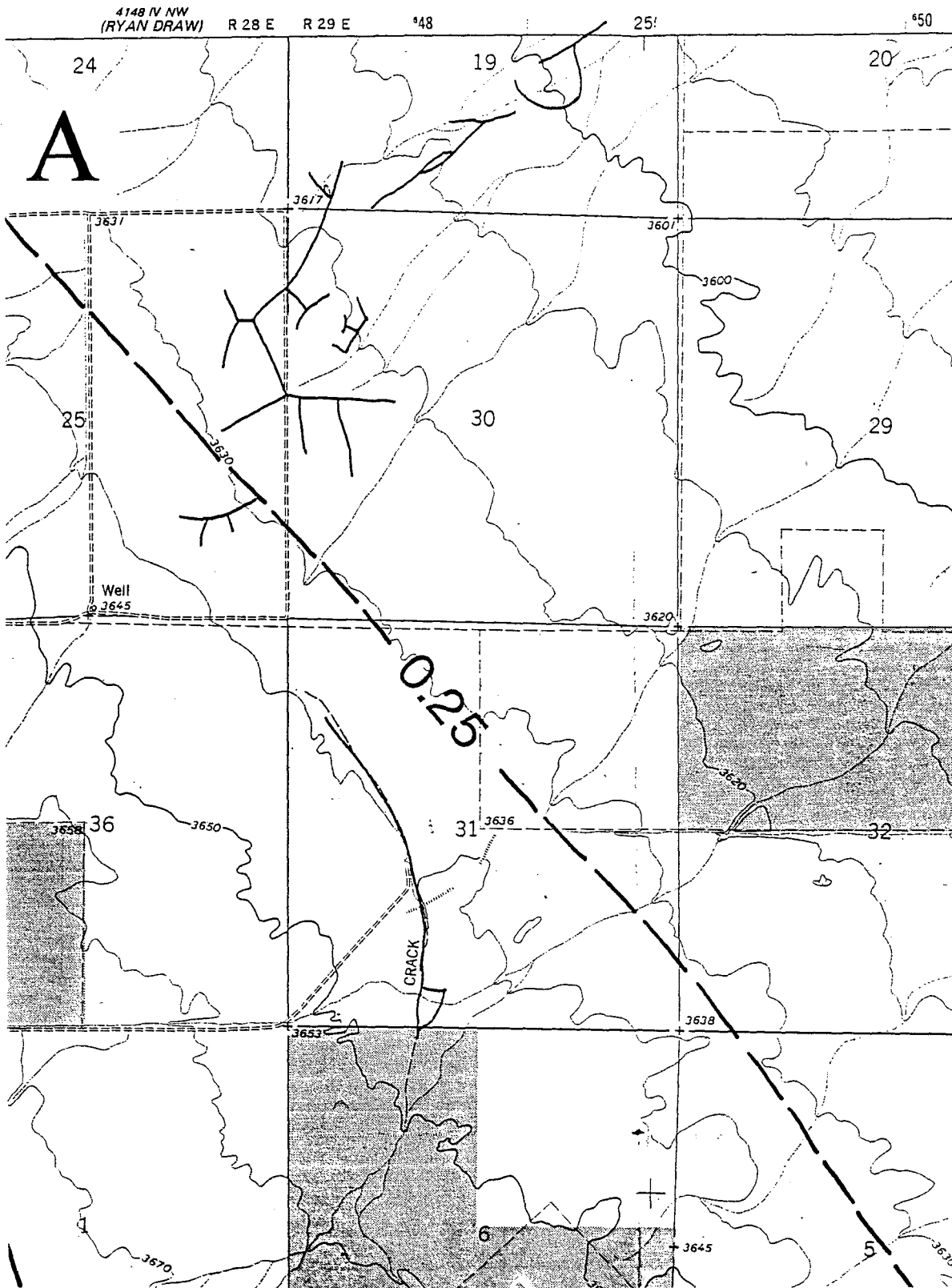
Polygonal fissures in the Bowie - San Simon area.

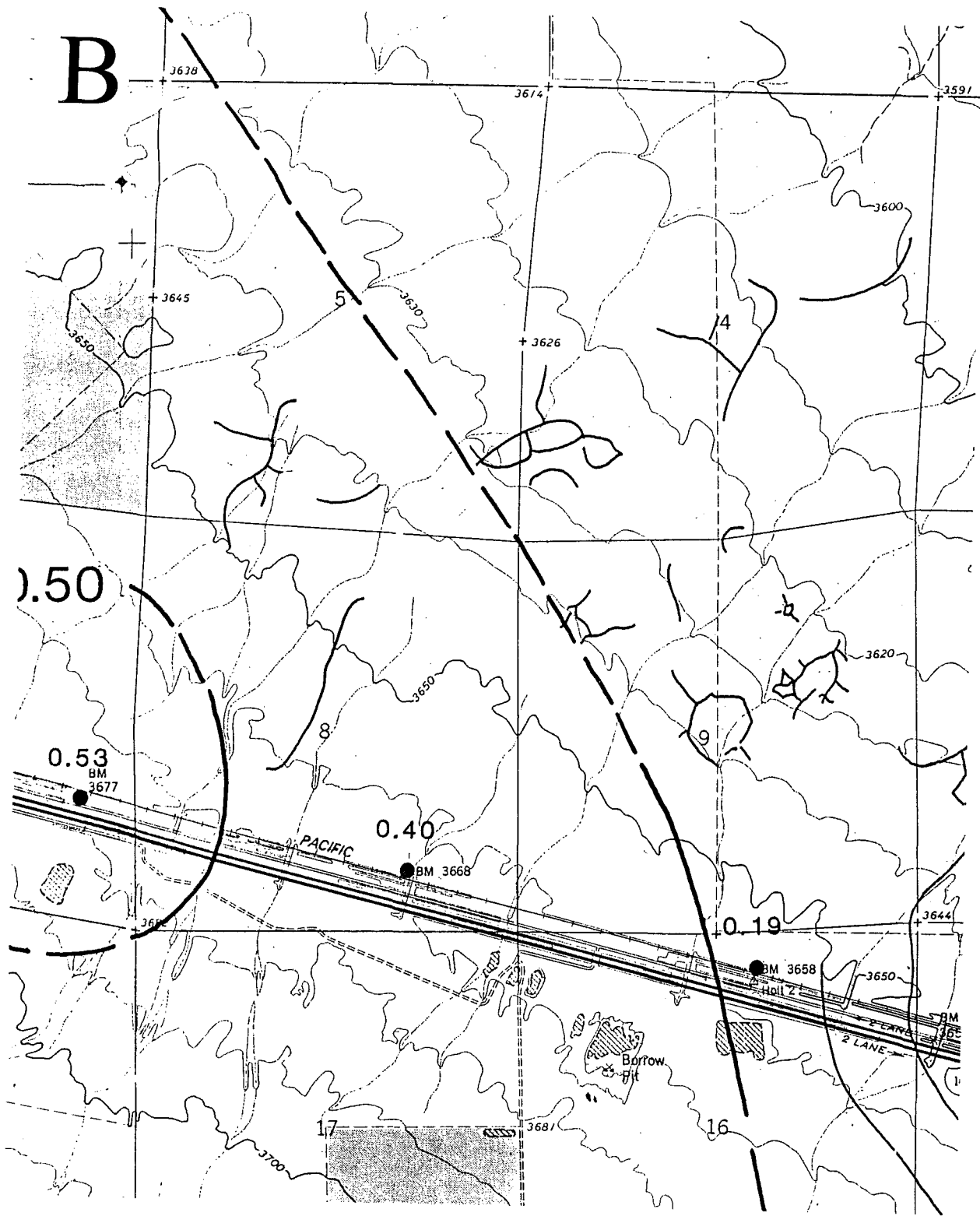
Taken from US Geological Survey Miscellaneous Field Studies Map MF-1156, by T.L. Holzer, 1980



Index of Appendix A







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