

OCCURRENCE OF LINEARS IN THE TUCSON SOUTH QUADRANGLE,  
PIMA COUNTY, ARIZONA

By

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ABSTRACT

Linears in the Tucson basin occur as straight-line traces on aerial photographs and as erosional features and vegetation alignments in the field. The linears are described by characteristics and a plot of their location and distribution is included. The longest of these features extends over a distance of 11 miles.

Building fractures in the area under study were found to be spatially related to the linears.

The evidence obtained from the investigation indicates that the linears are of two possible origins: (1) structural activity present in the subsurface stratum or basement rock, and (2) differential compaction in ancient alluvial-fan deposits.

INTRODUCTION

This study constitutes initial research on the nature and origin of recently discovered linear features expressed in soils of the middle portion of the Tucson south quadrangle. The term "linear" is used to describe the features, which occur in two distinct directions and are located in a band approximately 12 miles in length and 5 miles in width.

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PHYSICAL DESCRIPTIONS OF THE LINEARS

Original discovery of the linears was made from aerial photographs taken by the Soil Conservation Service at the approximate scale of 2 inches to the mile (1:31,680).

## Photographic Characteristics

The linears are identified on aerial photographs by a dark-gray to black tone, a remarkably straight trace, and a fine and even texture. Other distinctive features are a finer texture and lighter tone than the majority of the drainage pattern in the area. In those places where a more dense trellis-type drainage pattern encroaches from the north, the linears are positioned in a distinct grouping that is contrary to the general drainage pattern.

## Surficial Characteristics

The most common surface expressions of the linears are gullies ranging from 3 to 5 feet in width and from 1-1/2 to 2 feet in depth (fig. 1).

In those areas that lack the necessary gradient to develop differential erosion, the traces are marked by a concentrated growth of vegetation. Such vegetation is usually more dense than that flanking the linears (fig. 2).

Where the linears are not marked by gullies, they are made up of a thick growth of alkali grass of from 6 to 10 feet in width. The effect of this grass in marking the trace of the features is accentuated by the absence of vegetation on the flanks of the linears (fig. 2). Other varieties of plants that are generally concentrated along the traces are sage, mesquite, palo verde, cat's claw, and cholla.

Although the linears are generally marked by single gullies, they are sometimes found to consist of three or more subparallel gullies. These parallel features are in the form of tributaries, and total length from inception to convergence with the main gully is generally not more than 150 feet.

The linears can be traced from one soil type to another on both the aerial photographs and on the ground and are often marked by a change in form and associated vegetation.

Magnetic bearing of the linears is essentially constant over each individual trace but varies considerably for short distances.

## AERIAL EXTENT OF THE LINEARS

The extent of the linears is shown on figure 3 and represents locations plotted from aerial photographs. Cultural features, such as railroads and highways, are generally parallel to the linears, which lie in a band about 5 miles in width and 12 miles in length. The most dense occurrence of linears occurs within the confines of the Davis-Monthan Military Reservation.

## PATTERNS OF LINEARS

Set No. 1: This group of linears is by far the most numerous in occurrence, exhibits an approximate bearing of N. 50° W., and includes 26 of

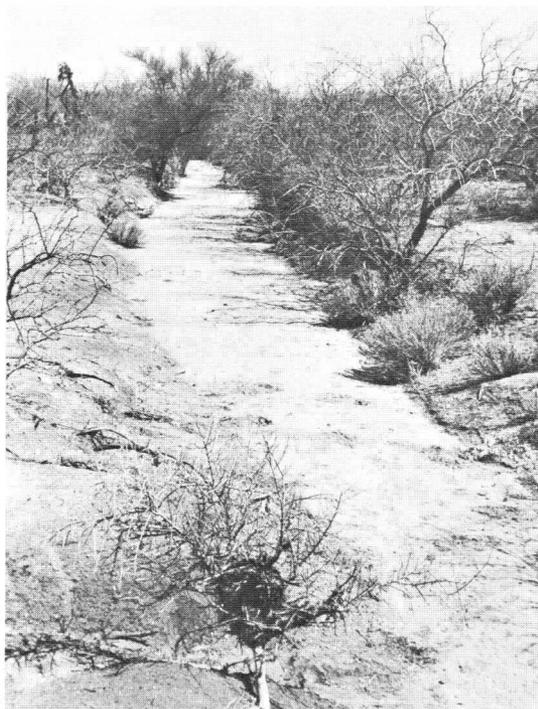


Figure 1. --Typical surface expression of the linears.

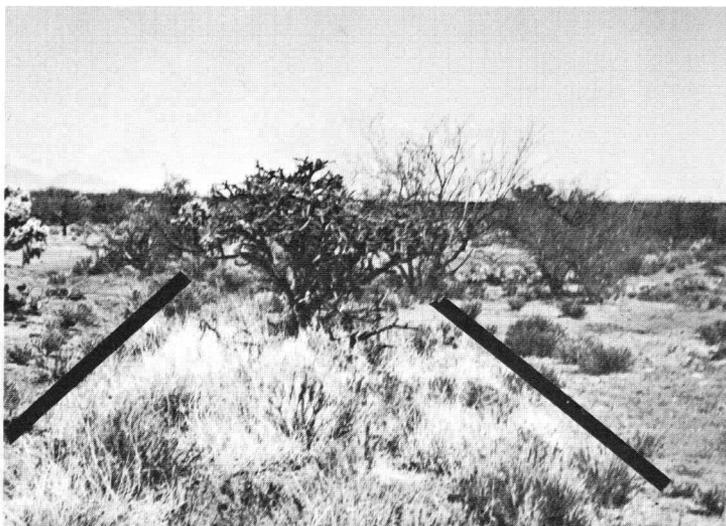


Figure 2. --Alkali grass marking the trace of a linear in the absence of a gully feature. (Black lines denote width of the linear.)

the 29 features included in the study. Within this belt there are two distinct groupings separated by a distance of about 1-1/2 miles. Both groupings are approximately parallel to the two railroad grades and to the Benson Highway (U. S. 80).

Set No. 2: This set is made up of three linears with an average bearing of N. 10° W. Two of these linears lie closely together, and the other is about 5 miles to the east and south. The most prominent linear of the set is more than 9,000 yards in length and intersects five linears of the first set. There is no offset detectable at these points.

### ORIENTATION AND TRENDS OF THE LINEARS

Bearings and magnitudes of the linears are tabulated in table I, and a cumulative length-azimuth diagram showing their relative distribution is included in figure 3.

TABLE I  
TABULATION OF LINEARS BY BEARING AND MAGNITUDE

#### Set No. 1

N. 37° W.	800 Yards	N. 60° W.	3,500
N. 42° W.	1,000		4,500
N. 45° W.	6,400	N. 61° W.	1,000
N. 50° W.	1,400	N. 65° W.	4,400
N. 54° W.	10,700	N. 67° W.	4,400
N. 56° W.	10,300		4,400
N. 57° W.	500	N. 70° W.	4,600
	2,800		19,800
	3,500	N. 73° W.	600
	3,500		1,500
N. 58° W.	900		2,400
	12,600	N. 75° W.	3,000
N. 59° W.	1,000		
	5,200		

#### Set No. 2

N. 12° W.	1,400
N. 15° W.	9,300
N. 29° W.	1,200

### POSSIBLE ORIGIN OF THE LINEARS

#### Structural Control

Perhaps the most striking character of the linears is their uniformity of bearing, as observed on the aerial photographs. The linear traces suggest a structurally controlled origin; however, no indication of horizontal or vertical displacement has been observed. Appearance of the linears on the aerial

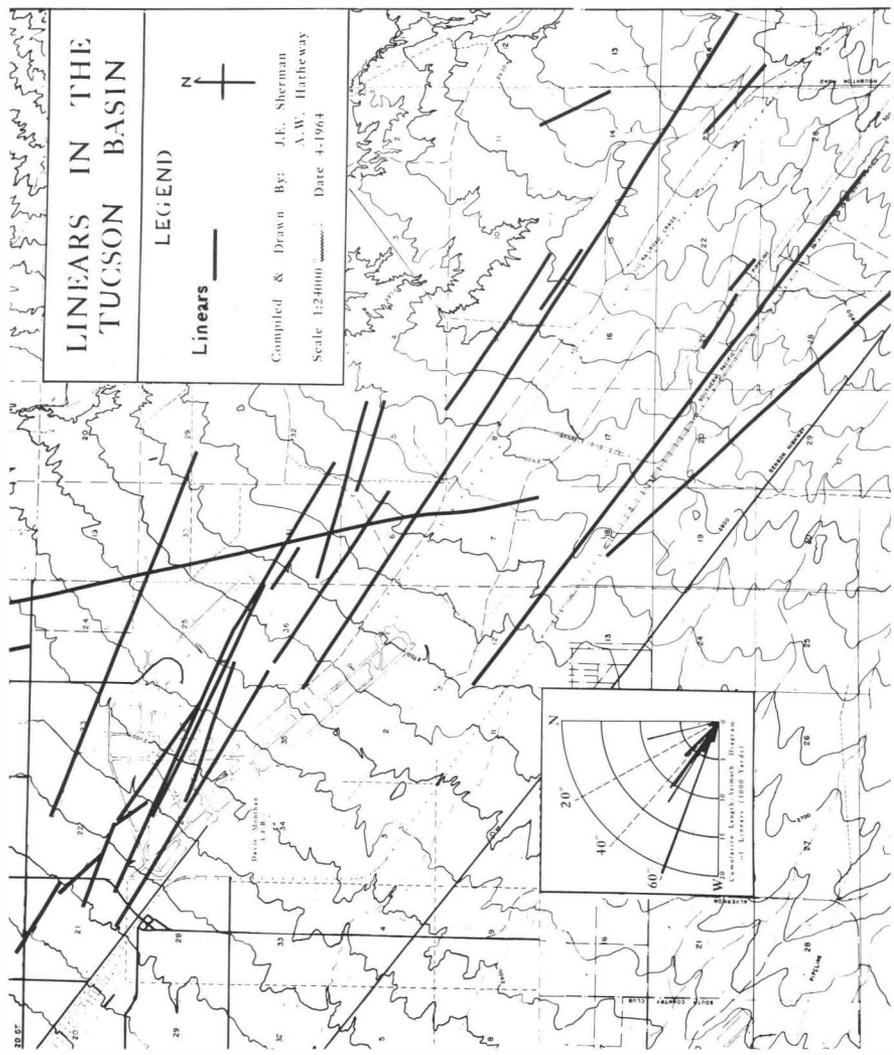


Figure 3. --Linears in the Tucson basin.

photographs is quite similar to the classic appearance of a fault trace in alluvium.

### Subsidence

Due to the large amount of ground water that has been withdrawn from the Tucson basin over the years, subsidence is being experienced in this area. Formation of building cracks is said to have been caused by this type of movement. It is possible that subsidence may have some effect on the formation of the linears.

### Differential Compaction Along Paleodrainage

Ancient drainage could have deposited fine sediment in channels separated by coarser materials in the form of tongues within the drainage system. Differential compaction could have produced an elevation difference between the two units, and the character of the drainage might have yielded straight traces along these boundaries.

### Roads

One of the most obvious possibilities for the origin of the linears was that a previous road net from territorial days existed in this area. Since the railroad grades and U. S. Highway 80 parallel the linears, this was taken into consideration. Positions of former roads, from 10 government maps ranging in date from 1872 to 1957, were plotted over the linears in order to obtain an accurate composite of all roads in the area under discussion. It was concluded from this plot that the straight appearance of the linears does not conform with the pattern of the old roads. These roads were sinuous and probably avoided all obstacles of both topography and vegetation.

## BUILDING FRACTURES

The existence of fractures in structures and foundations throughout the area of linears was confirmed on inspection of several sites.

### Site 1

#### Abandoned Section Station at Esmond

The principal structure at this location is a 40 to 50-year-old bunkhouse with 2-foot walls. Tensional fractures located in walls and window casements and at roof line around junctures with beams are grouped around N. 65° E. to N. 70° E. and around N. 25° E. to N. 30° E., with various dips. Separation along fractures is slight, in no case being more than a quarter of an inch in magnitude. Concrete slabs nearby are dated 1920 and bear many fractures, which are parallel to the dimensions of the foundations and trend N. 45°

W. and N.  $45^{\circ}$  E. Vertical separation ranges to a quarter of an inch, and horizontal displacement reaches three-fourths of an inch in one instance.

Site 2  
Lazy Heart Ranch

Ranch headquarters is made up of a cluster of adobe buildings constructed about 1935. Hairline fractures in the walls of the building center around N.  $70^{\circ}$  W., with one instance of fracturing in a concrete slab at the well with a bearing of N.  $35^{\circ}$  E.

Site 3  
Southern Pacific Section Station West of Esmond

The main structure at this location is a bunkhouse constructed by the El Paso and Southwestern Railroad about 1890. The building is made of red brick and shows no adverse effects from fracturing, but major fractures occur in the concrete foundation. All these fractures range in bearing from N.  $45^{\circ}$  W. to N.  $55^{\circ}$  W. The building is oriented with its major axis at about N.  $55^{\circ}$  W., and all tensional fractures in its walls are located on the northeast and southwest walls. This grouping of fractures lies, then, at N.  $35^{\circ}$  E.

Site 4  
Downtown Airport

Fractures here are numerous in hanger slabs and aprons. In all cases, fractures are either parallel or perpendicular to the long axis of the buildings. The long axis trends N.  $55^{\circ}$  W. Separation along the fractures measures up to a quarter of an inch in some cases.

### SIGNIFICANCE OF BUILDING FRACTURES

The building fractures that were examined could have resulted from any number of causes; however, the frequency of their occurrence in the northwest and southeast trends indicated that they may be related to the linears. The examination of building fractures was not exhaustive, and a more detailed analysis of distribution and properties is necessary before any valid conclusions as to their origin can be derived.

### CONCLUSIONS

The evidence obtained from the preliminary investigation of aerial photographs and fieldwork conducted in the area southeast of Tucson indicated that structural activity present in the subsurface stratum or bedrock is reflected on the surface as linears and oriented drainage patterns. The authors believe that the parallel features termed "linears" are not the result of

pre-existent road or trail networks. It is not determined if the linear pattern resulted from subsidence due to differential deposition and compaction of ancient alluvial fans or if the structural activity of the buried pediment has been transmitted to the surface.

The occurrence of the linears, as a research topic, remains open to investigation, and only until then can more conclusive results be obtained.