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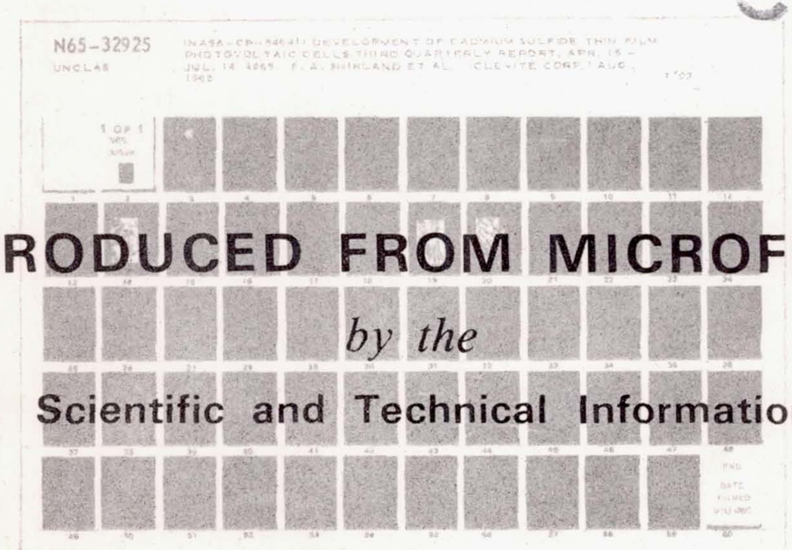

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MAJOR LINEAMENTS AND POSSIBLE CALDERAS DEFINED BY SIDE-LOOKING AIRBORNE RADAR IMAGERY, ST. FRANCIS MOUNTAINS, MISSOURI

CRES TECHNICAL REPORT 118-12

October 1968

Prepared by the University of Kansas Center for Research, Inc., Engineering Science Division, Lawrence, Kansas, for the National Aeronautics and Space Administration (NASA) under NASA Contract No. NAS 9-7175

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

CRES CENTER FOR RESEARCH, INC. · ENGINEERING SCIENCE DIVISION
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ILLUSTRATIONS

ABSTRACT

Side-looking radar imagery in the St. Francois Mountains of southeast Missouri has revealed many structural features which are obscure or only poorly depicted on aerial photos. This superiority of radar imagery over aerial photographs is discussed.

Linear structural features depicted on the radar imagery represent faults or fractures. Most prominent among these is the previously unrecognized Roselle lineament, which is excellently portrayed. When correlated with structural and topographic features north and south of the limits of radar coverage, the Roselle lineament can be traced for over 135 miles. Its relationships to mineral localization in the Bonne Terre-Fredericktown area may be of importance.

Circular patterns were also observed on the radar imagery. Their origin is obscure but ancient astroblemes or calderas are suggested as working hypotheses.

MAJOR LINEAMENTS AND POSSIBLE CALDERAS DEFINED BY SIDE-LOOKING AIRBORNE RADAR IMAGERY, ST. FRANCOIS MOUNTAINS, MISSOURI

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Previous studies by personnel at CRES (1, 2, 3, 4) have indicated that lineaments -- linear features of the terrain -- are detected on SLAR which do not appear on aerial photos of the terrain, or are obscure if present. Many of these, also, are difficult to identify on the ground, and thus have been overlooked or neglected in geologic mapping and geologic studies. Recognition of them may alter the emphasis of geologic interpretations.

Some lineaments have no known geologic implications, but many reflect structure patterns, faults, geologic boundaries, structural attitude of rock, and other geologically important characteristics. The signatures of these geologic phenomena on radar result from differences in physical, chemical, and dielectric properties of the rock masses and associated soils, and from the incidence angle of radar impulses. These include differences in (1) moisture content of rock and soil, caused by differences in porosity, permeability, and absorptive qualities; (2) vegetation supported by rock and soil; (3) topographic expression; and (4) roughness, both small- and large-scale, resulting partly from weathering and rock alteration, and partly from the size of the constituent mineral and rock particles. More obscure features, such as the metallic content of the soil and rock and the internal atomic structure of constituent minerals, may be unknown parameters which affect the signature.

Studies of radar imagery of the Southeastern Missouri mineral district were made to ascertain what geologic features, obscure or difficult to recognize either on aerial photographs or the ground, were recorded on the radar imagery. The study contrasted with recent CRES studies of various areas

in western and southwestern United States (3), in that the southeastern Missouri area is largely covered by deciduous forest. The radar imagery was taken in July, 1966 when the ground was most obscured by the forest vegetation.

Most of the information was derived from an examination of like- and cross-polarized side-looking (SLAR) AN/APQ-97 K-band radar imagery which covered most of the areas examined. Additional small areas, partly overlapping this imagery, were covered by like-polarized AN/APQ-102 imagery.

The area covered in this study included most of St. Francois, Madison, Iron, and Reynolds Counties and portions of Ste. Genevieve, Washington, and adjacent counties, Missouri (Figure 1). It included the southern part of the old "Lead Belt" around Fredericktown and Iron Mountain, and the new "Lead Belt" in western Iron and Reynolds Counties (Figure 1). Detailed studies were made in the new "Lead Belt," in the area between Iron Mountain and Annapolis, and the vicinity of Fredericktown.

Geologic mapping within the area covered by radar imagery is very incomplete. Except for the State Geologic Map, the only published maps available for most of the area are the very inadequate maps published prior to 1900. The more recent Ste. Genevieve County (5), and Potosi-Edgehill Quadrangle (6) maps cover only small parts of the area. Unpublished maps included as parts of M.S. theses and Ph. D. dissertations were examined, but these mostly cover small areas. The unpublished manuscript copy of Tolman and Robertson's map of the Precambrian rocks of Missouri (7) does not include any Post-Precambrian rocks. Very few structural features were shown on the maps examined, although a few hypothetical faults were delineated on worksheets in the files of the Missouri Geological Survey.

Within the area studied, numerous lineaments can be observed on the radar imagery (Figures 2,3). Although most of these are a result of the alignment and straightness of course of drainage, others show no drainage control. In addition, circular patterns, also marked in part by drainage, are noticeable (Figures 10, 11). Differences in lithology are indicated by differences in the pattern and concentration of drainage, and, indirectly,

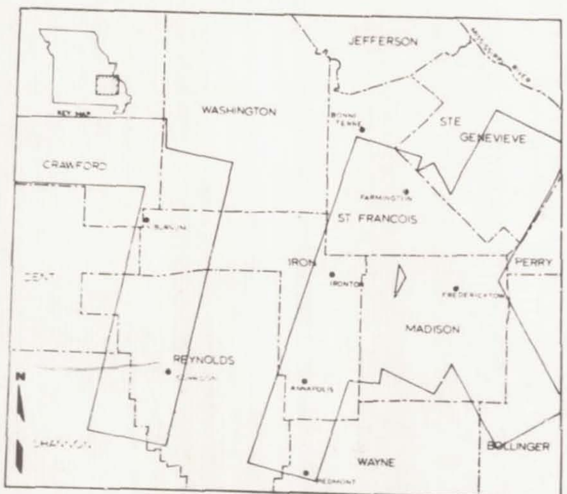


Figure 1 Map showing location of radar imagery

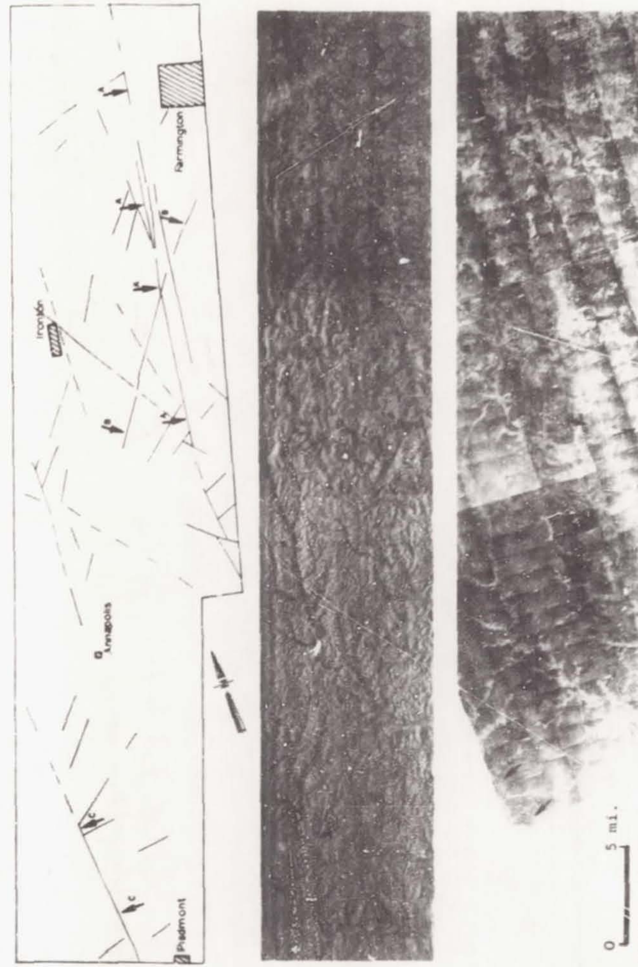


Fig. 2
RADAR IMAGERY, AERIAL PHOTO, AND LINEAMENTS OF THE IRONTON AREA.

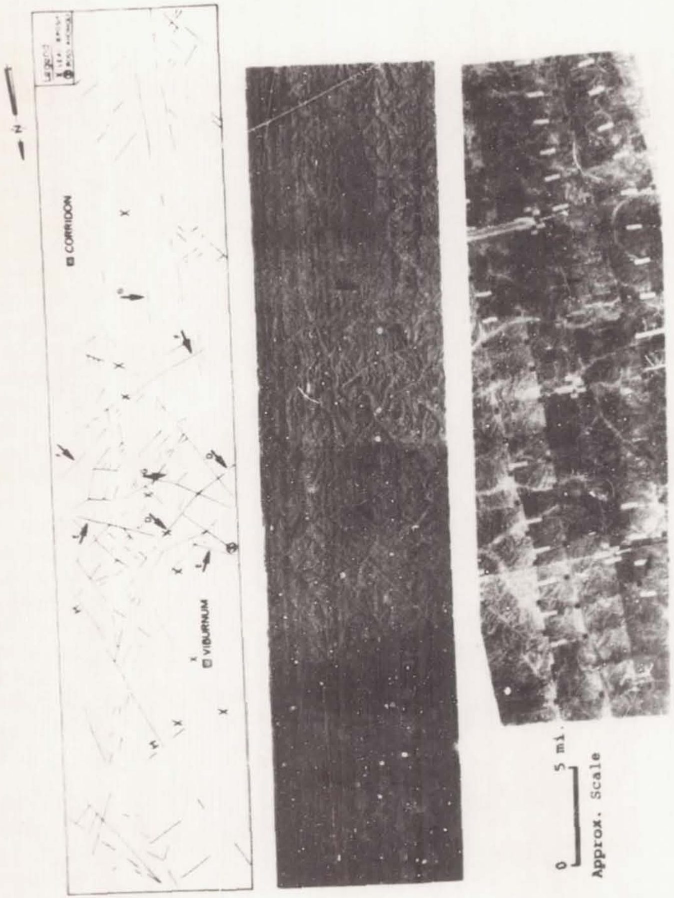


Fig. 3
RADAR IMAGERY, AERIAL PHOTO, AND LINEAMENTS OF THE VIBURNUM - CORRIDON AREA.

by variation in gray tones. The latter reflect differences in vegetation cover, which is at least partically determined by lithologic character.

The superiority of radar imagery over aerial photography for the identification of lineaments is well illustrated by the corresponding pairs of aerial photo and radar imagery (Figures 2 and 3). Lineaments identified on the radar imagery are indicated on Figures 2 and 3. Corresponding lineaments on aerial photo, radar imagery, and the lineament plot are indicated by AA, BB, etc. Lineaments DD and EE in Figure 3 show no correlation to drainage, and, although observable on radar imagery, they cannot be identified on the aerial photos. Lineament FF, which almost wholly follows drainage, is more easily identified on the aerial photo. Lineament GG, which follows drainage only partially, is clearly defined on radar, but was distinguished on the aerial photo only after it had first been identified on the radar imagery.

The dominant trends of lineaments are northeast and northwest, conforming to the known fracture pattern of the area. The pattern is much more distinct on radar imagery than it is on aerial photographs. Shorter lineaments, represented by the shorter tributary streams, mostly represent single fractures. These are more abundant where the surficial rocks are sedimentary rather than igneous, and they give such areas a checked appearance. (Contrast the radar imagery of Figure 2 where the surficial rocks are mostly igneous, with that of Figure 3 where surficial rocks are all sedimentary.)

Longer lineaments probably represent faults. Many of these are obscure or absent from aerial photographs; hence, they have not previously been identified as faults. This is particularly true in areas where Precambrian rocks crop out, and in the area between Viburnum and Corridon in the new "Lead Belt." Some of these were hypothecated by Graves (8) and others. Most of the longer lineaments are northeast-trending, but a few trend northwest.

One very prominent lineament, which trends slightly east of north, can be traced on the imagery through the western parts of Madison and St. Francois Counties. Beginning near the southwestern corner of Madison

County, it extends northward past Roselle to just southeast of Doe Run in St. Francois County, a distance of about 25 miles (Figure 2). Doubtful extension of the lineament can be made for an additional 5 miles northward almost to the north limits of radar coverage about 3 miles northwest of Farmington. This lineament, presumed to be a fault, has not been previously recognized. It cuts across Precambrian rocks throughout most of its length, but is not shown on Tolman and Robertson's outcrop map of Precambrian rocks (7), nor does the map show any offsetting of rock units which might suggest a fault. However, the map does show, south of State Highway 70, a small fault which is offset at Rock Creek Valley, down which the lineament extends. The lineament is not shown on any geologic map of the area, and no mention is made of it in the literature, although it extends through the Southeast Missouri Lead Belt. It is extremely difficult to identify on aerial photography, even though in its southern part it is marked by an alignment of drainage. The lineament trends slightly east of north, and is well-defined on the radar imagery except in the northern part of the area covered. The lineament, with its extensions north and south as described below, is named the Roselle lineament.

The lineament is marked in the southern part of the imagery by the alignment of Mill Creek, an unnamed creek, and segments of Little Rock Creek, Lower Rock Creek, Barren Hollow, and Rock Creek (Figure 4). It crosses Missouri State Highway 70 about two miles east of Roselle, at the St. Francois River Bridge. North of the highway, the lineament parallels the valley of Washita Creek for about six miles to near Doe Run, but lies about one-half mile west of the valley. North of Doe Run it is obscure, possibly because of the clutter of cultural features, but it can be traced indistinctly as mentioned before to about three miles northwest of Farmington.

A parallel lineament, one mile east of the major zone, extends northward for about six miles beginning at point three miles south of Highway 70. Shorter parallel sublineaments within a half-mile of the major zone are present in the area between Highway 70 and Doe Run.

Preliminary field reconnaissance in the area north of Highway 70 along the Roselle lineament, has revealed an elongated exposure of LaMotte

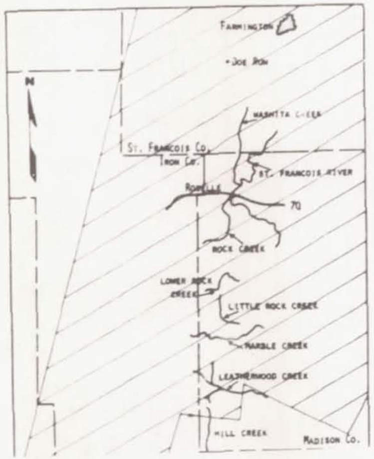


FIG. 4

ALIGNMENT OF DRAINAGE ALONG THE ROSELLE LINEAMENT WITHIN THE AREA COVERED BY RADAR IMAGERY.

0 5 10
MILES

sandstone occupying a valley between two granite hills. The Roselle lineament, and the parallel lineament to the east form the approximate lateral limits of the exposure. The coincident relationship of the sandstone remnant and the lineaments appear to be more than fortuitous and suggest faulting. The sandstone may occupy an old Precambrain valley positioned by faulting and modified by erosion prior to deposition of the LaMotte, or its presence may be the result of post-LaMotte faulting. The irregular nature of the lateral boundaries of the exposure strongly suggests the first hypothesis and indicates a pre-LaMotte age for the Roselle lineament. The recognition of the lineament as bounding a high-standing block of Precambrain rocks southeast of Piedmont, as described below, reinforces this conclusion.

South of the imagery, alignment of drainage and topography along the extension of the lineament is striking. The trend continues southward for 18 miles along the southern portion of Mill Creek, a saddle south of Big Creek, the lower reaches of Camp Creek, additional saddles, and a segment of Lake Creek, to a point about 7 miles southeast of Piedmont in Wayne County (Figure 5).

About four miles south of this point the steep front of the subsurface Precambrain basement (as interpreted by Hayes (9)) turns abruptly southward and follows a straight course for five miles before turning abruptly once again to the west (Figure 6). This steep east-facing scarp is aligned with the Roselle lineament, and marks its position to a point 12 miles southeast of Piedmont, beyond which it could not be identified. The recognition of the lineament as bounding a high-standing block of Precambrain rocks strongly suggests its initiation prior to the beginning of Upper Cambrian deposition, most probably in the Precambrian.

North of Doe Run, culture obscures the trace on the imagery for the few remaining miles of coverage, although tentative identification of the lineament can be made for an additional five miles northward. The northwest-trending Palmer Fault zone, consisting of numerous subparallel faults, extends across the area north of Doe Run, is also the northern limit of Precambrain exposures. These two factors, plus the presence of culture, may account for the obscurity of the lineament in this area.

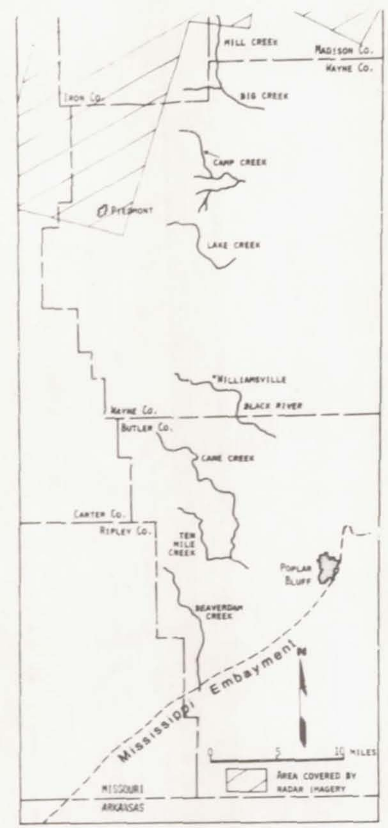


FIG. 5
ALIGNMENT OF DRAINAGE ALONG THE ROSELLE LINEAMENT SOUTH OF THE AREA COVERED BY RADAR IMAGERY.

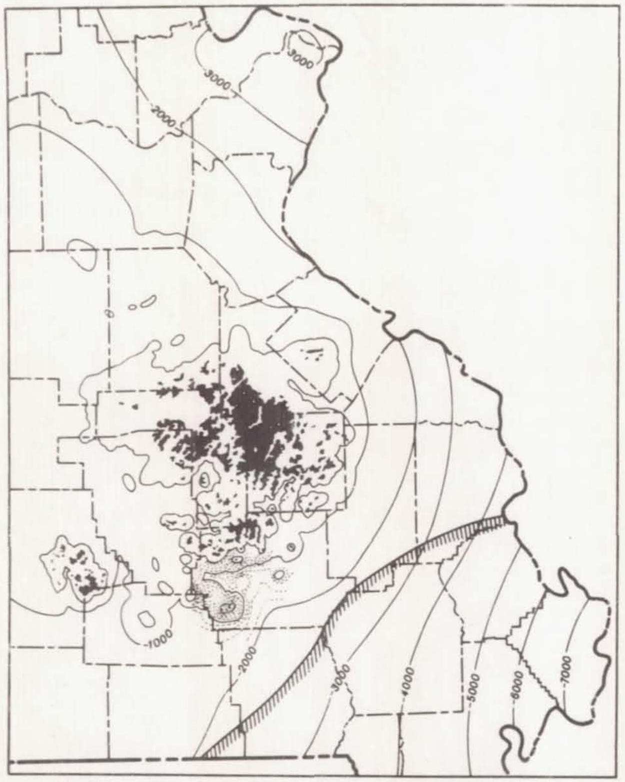


FIG. 6
PRECAMBRIAN SURFACE (FROM HAYES, WM. C., MAP SHOWING CONFIGURATION OF THE PRECAMBRIAN SURFACE SHOWING MAJOR LINEAMENTS, MO. GEOL. SURVEY AND WATER RESOURCES, 1962.)

North of the Palmer fault zone, the Plattin anticline has been mapped as extending from a point 1 1/2 miles south of the Franklin-St. Francois County line and 11 miles north of the limits of radar coverage, northward along the valley of Plattin Creek for 15 miles to the Mississippi River at Crystal City (10). At Crystal city the Mississippi River bends sharply north-northeast and extends in a straight course for 46 miles before turning sharply northwestward 15 miles north of St. Louis.

The lineament distinguished by radar, its southern extensions, the Plattin anticline, and the straight course of the Mississippi are all aligned (Figure 7). Only within the Palmer Fault zone, a distance of about 15 miles in an area not covered by radar imagery, is there no feature or structure defined. If the Plattin anticline and the straight course of the Mississippi River are in fact features which reflect and mark the position of the lineament, as is strongly suggested, then the Roselle lineament is almost continously traceable for 135 miles, from southeast of Piedmont, Missouri, to north of St. Louis, Missouri.

The Roselle lineament is, therefore, a major structure of this part of the earth's crust, heretofore unrecognized. Its dominantly northward trend sets it apart from most other major lineaments of the area. It is believed to be an ancient Precambrian lineament along which there has been recurrent adjustment, and it may have implications in the interpretation of the regional geologic history of southeast Missouri. Because it traverses the southeast Missouri Lead Belt it also may have been important in the localization of the ore deposits. Note for example, the pattern of ore deposition in the Bonne Terre-Flat River-Fredericktown area with reference to the lineament. The Bonne Terre-Flat River district, the most productive part of the Lead Belt, lies mostly west of the lineament. The isolated Fredericktown-Mine LaMotte district to the south is east of the lineament (Figure 8).

A second prominent lineament (lineament BB, Figure 2) trends northeastward through eastern Iron County and across Madison and St. Francois County, from a point about six miles east of Glover to about three miles south-southeast of Farmington. This lineament intersects the Roselle lineament approximately where both lineaments cross state Highway 70, one and one-half miles east of Roselle. The southern part of this lineament was hypothe-

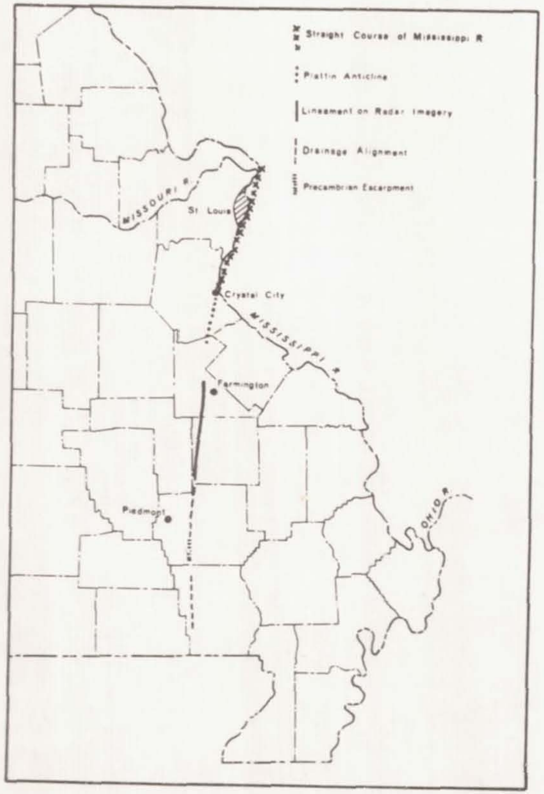


Figure 7 : The Roselle Lineament

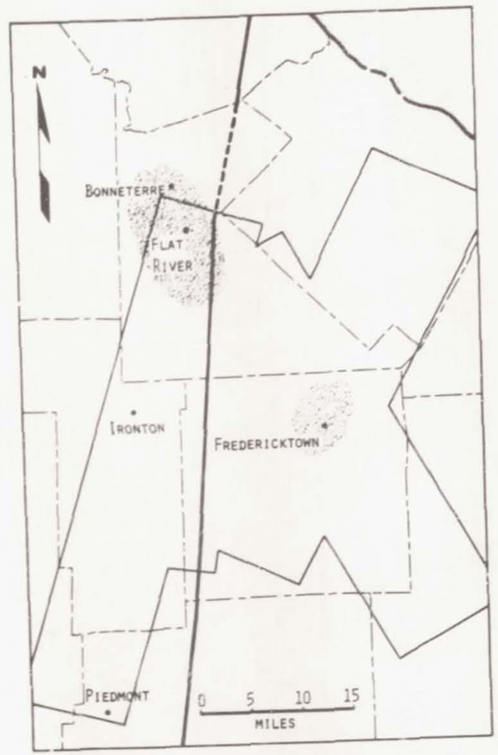


FIG. 8 LOCATION OF BONNETERRE AND FREDERICKTOWN MINING DISTRICTS WITH REFERENCE TO THE ROSELLE LINEAMENT.

cated as a fault on unpublished manuscript maps of part of the Ironton Quadrangle (11), but the northwestern part in the Fredericktown Quadrangle has not been previously identified. The total length of the lineament traceable on radar imagery is 20 miles. A projection of this lineament to the southwest would lie along the boundary between outcropping Precambrian rocks and Cambrian sediments, in a re-entrant within the area of Precambrian outcrops. If such a projection was present, however, it was not discernible on the radar imagery.

In southeastern Reynolds County, a previously unrecognized lineament (lineament CC, Figure 2) extends 12 miles (to the limit of radar coverage) north-northwest from a point about 2 miles west of Piedmont. Northwest of the imagery segments of the Black River lie along a projection of this lineament as far as Lesterville, an additional 9 miles, and beyond this the east fork of the Black River follows this same alignment (Figure 9). A few miles north of Lesterville, sheeting, jointing, and rock types have been found to differ on either side of what would be a projection of the lineament, or probable fault (J. E. Anderson, Personal Communication).

A northwesterly-trending lineament discernible on the radar imagery east of Viburnum (lineament HH, Figure 3) is undoubtedly the extension of the Black fault mapped by Bridge (12) in the Edgehill Quadrangle to the east of the imagery. The Black fault can be extended southeastward to Lesterville, when it merges or joins with the fault described above. The zone of faulting marked successively by the lineament west of Piedmont, the Black fault, and the latter's extension to the northwest into Crawford County covers at least 50 miles, and approximates for much of this distance, the southwesterly boundary of outcropping Precambrian rocks.

In the area between Viburnum and Corridon, a comparison of aerial photos and radar imagery (Figure 3) emphasized the superiority of the radar imagery in the presentation of lineaments. The sharpness of the pattern produced by radar, due at least partly to the elimination of minor stream irregularities and a consequent de-emphasis of detail, tends to accentuate the alignment of linear features, and aids in their recognition.

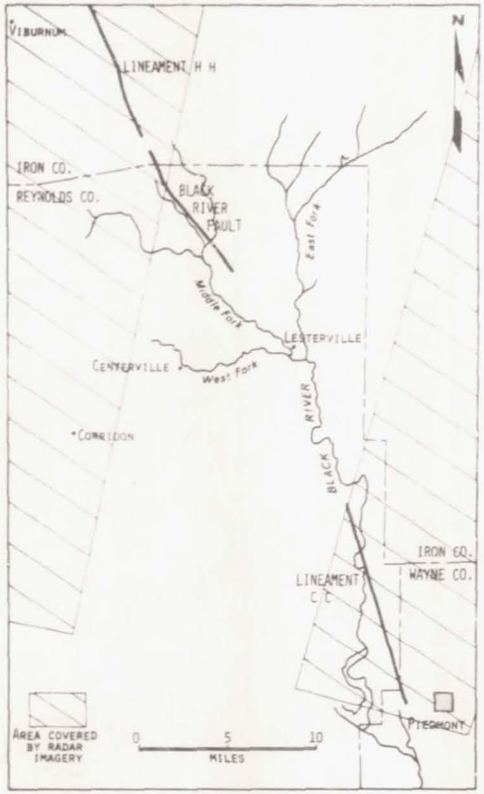


FIG. 9

LINEAMENTS C C AND H H, AND THE BLACK RIVER FAULT

Not all lineaments in this area are due to alignment of drainage features. The northeast-trending lineament (DD) which passes through Buick bears almost no relationship to drainage, although in places it appears to follow ridge crests. There is no indication of this lineament on aerial photos. The lineaments represent fractures and faults in the Cambrian sediments. Some of the more persistent can be correlated with aligned drainage features both east and west of the imaged areas; these represent major faults, a few of which have been recognized in the field.

The recently discovered and developed lead deposits within the Viburnum-Corridon area lie along, or in close proximity to, the longer and more persistent of the lineaments defined on the imagery (Figure 3). These may well be faults which acted as channelways for the movement of the ore solutions. The ease of recognition of these lineaments through the study of radar imagery suggests that radar could be an important tool in future exploration for mineral deposits, in this area and perhaps in others.

Only the more significant lineaments defined by radar have been described above. Numerous others have been identified. In the few areas where faults are depicted on published or unpublished maps, these faults show on the radar imagery as easily distinguishable lineaments. In some places, the lineaments defined on radar form bounding limits between outcropping areas of Precambrian and Cambrian rocks. Many of the lineaments, if projected beyond the limits of the imagery, are aligned with drainage, with previously mapped faults, or with previously identified geologic boundaries. Most of the lineaments defined on radar are obscure or are not identifiable as continuous lineaments on aerial photos.

Anomalous circular patterns, marked principally by drainage, stand out distinctively on the radar imagery in four areas, and less distinctively in one other (Figures 10 and 11). The more prominent circular patterns are southwest of Marquand in southeastern Madison County (11A), east and south of Annapolis (11B, 11C) in southern Iron County, and south of Viburnum in Iron, Dent, and northern Reynolds County (11D). The less prominent pattern is west of Corridon in western Reynolds County (11E). The circular structure south of Viburnum is about 10 miles in diameter, that south of Annapolis about three

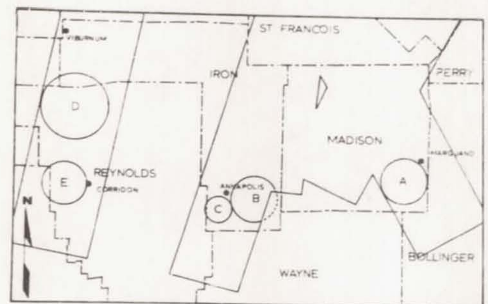
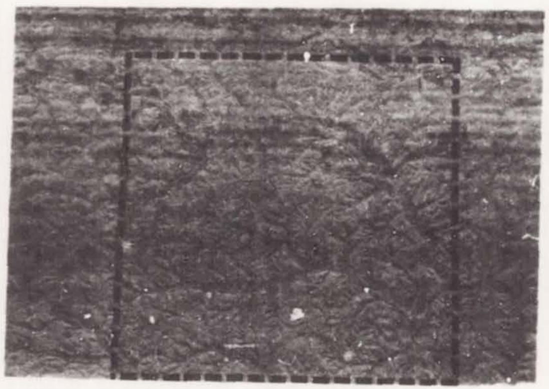
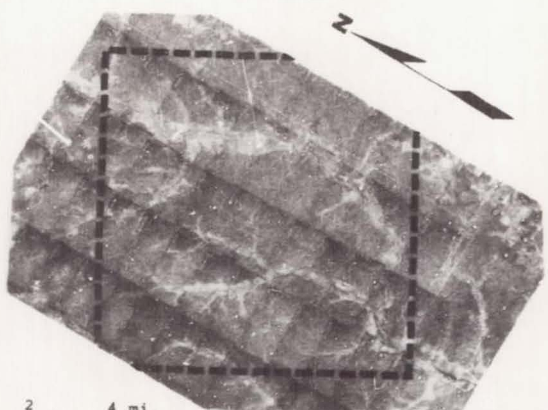


Figure 10 Location of circular structures



Radar Imagery



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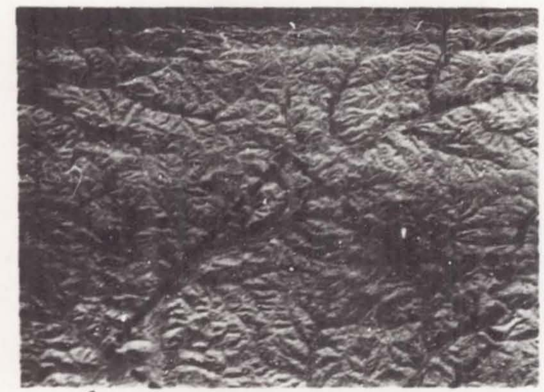
Approx. Scale

Aerial Photograph

Fig. 11A Circular structure southwest of Marquand.



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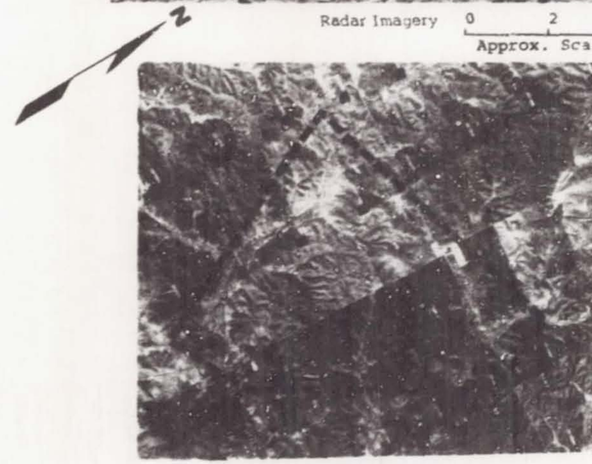

Aerial Photograph

Fig. 11B Circular structure east of Annapolis.

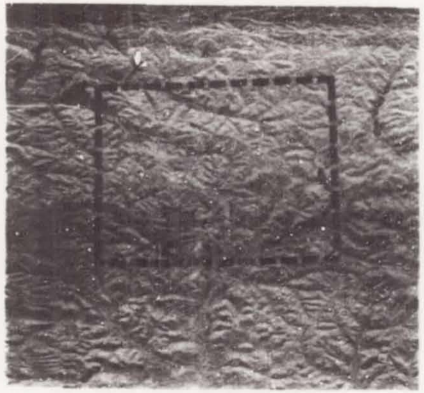

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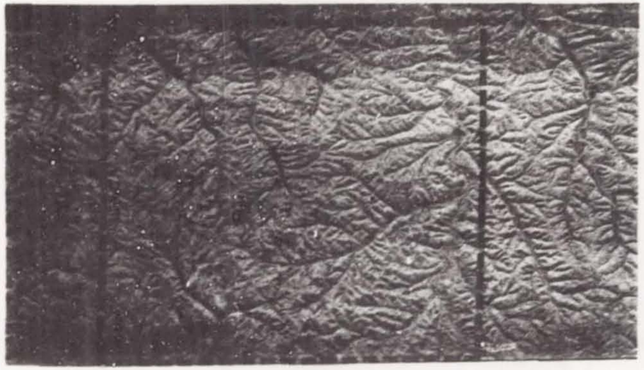
Fig. 11C Circular structure south of Annapolis.



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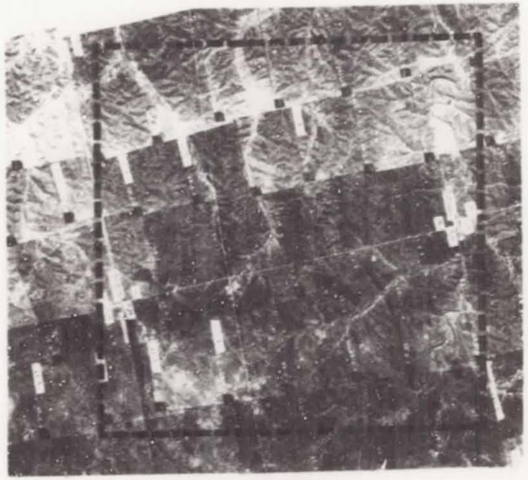

Aerial Photograph

Fig. 11D Circular structure south of Viburnum.

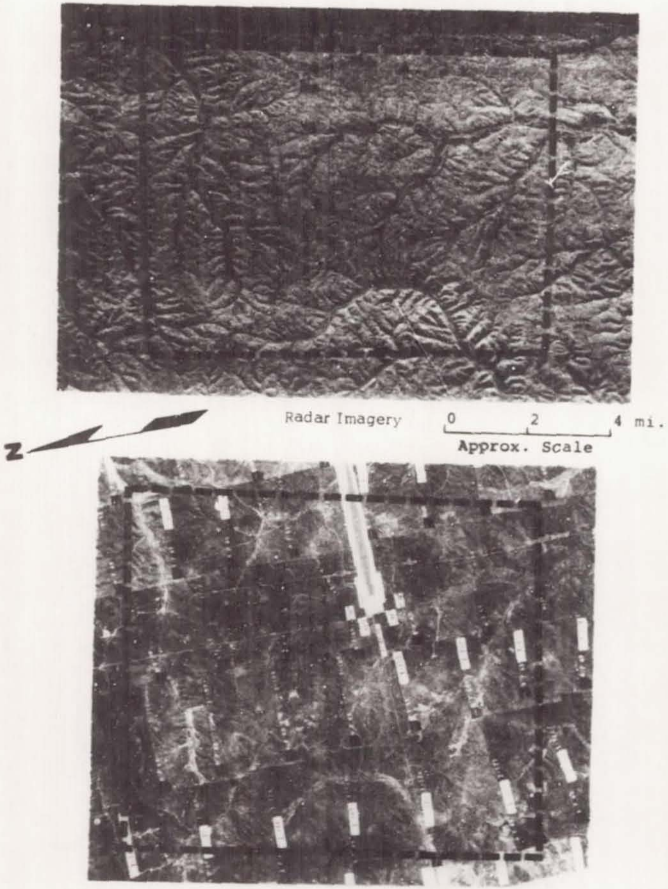

Fig. 11E Circular structure west of Corridon.

mile in diameter, and the other three are 6-7 miles in diameter. Topographically, these areas are not separable from adjacent areas, nor does available information reveal any differences in rock units from adjoining areas. Cultural features are of no importance in delineating the areas.

The circular patterns are less discernible on aerial photographs. Although curved segments of streams show on the photographs, the total pattern is lacking, or is so obscured as to be unidentifiable. This is illustrated on Figure 11 by radar imagery showing the circular structures and the corresponding areas covered by aerial photos. Topographic maps are even less satisfactory for identifying the patterns. On radar imagery, the combination of curved stream segments, curved ridge crests, and (in places) subsidiary streams perpendicular to the curved stream segments contrasts strongly with the regional pattern of terrain features.

An annular drainage pattern is imperfectly developed in the circular structures. This is best exhibited in the structure south of Annapolis and the one west of Corridon. South of Viburnum, segments of streams form discontinuous concentric annular rings. Southwest of Marquand, only the drainage around the rim of the circle has a circular configuration. This circular-rim drainage pattern is distinctive east of Annapolis also, but in addition, a few small segments of an annular pattern can be identified within the structure.

At some of the circular structures, notably the one south of Annapolis, the smaller tributaries which drain into the annular stream enter at right angles or nearly so. In addition, those flowing inward are longer -- indicative of a longer, more gentle slope on the inward side of the ridges. This is not as distinct elsewhere. The structures southeast of Marquand, east of Annapolis, and west of Corridon are breached by major streams, and drainage tends to be dendritic.

The interruption of the regional fracture pattern by these circular patterns emphasizes the anomalies. This is particularly well shown southwest of Marquand, where three northeast-trending lineaments that traverse the area adjoining the circular structure are interrupted by the structure. They are prominent northeast of the structure and probably to the southwest, although the limit of the radar imagery makes this observation difficult. Parallel north-trending lineaments appear to be tangent to the southeast and northwest sides of the circular pattern, actually forming its boundary for short distances on these sides. Elsewhere, the interruption of the regional structure pattern is less noticeable.

The significance of the circular structures is difficult to ascertain. They are in areas where Cambrian sedimentary rocks crop out, but they lie close to the southern margin of the main Precambrian exposure. They do not reflect present topography, nor are they due to apparent difference in surface geology. They do not correlate with magnetic anomalies. They may be reflections of geologic or topographic differences of the underlying Precambrian terrain. Buried Precambrian knobs with outward-dipping sediment on their flanks could cause such patterns. Examination of maps of the Precambrian surface (9) failed to show highs in these areas. Drill-holes are spotty, however, and it is possible that these do represent heretofore unknown buried knobs. They may perhaps represent buried reefs which encircled island in Precambrian or Cambrian sediments. Sediments deposited in arch-like form over and around the reefs may have given rise to the circular patterns upon erosion. Both buried knobs and buried reefs are associated with lead deposits in southeast Missouri. Investigation by drilling to ascertain whether they are reefs or knobs might be economically important.

The circular patterns may reflect structures analogous in origin to the Crooked Creek cryptoexplosive structure (13,14,15) which lies about 25 miles northwest of the structure south of Viburnum. This may be a cryptovolcanic structure, the result of underground explosion (15), but Hendricks (13 ,14) believes it has many of the aspects on an impact crater. If Crooked Creek is truly an astrobleme, and if the circular patterns defined on radar are analogous to it in origin, a cluster of astroblemes in the St. Francois Mountains is an exciting possibility.

An alternate hypothesis is that the circular structures overlie the sites of Precambrian calderas. Much of the Precambrian rock of the St. Francois Mountains is volcanic in origin and has been mapped as rhyolitic lava flows.

Recent studies strongly suggest that these may not be lava flows, but are instead ash-flows and ash-falls (16). In areas where comparable quantities of similar rocks are present, calderas, representing the sites of explosive activity, have been identified. Calderas, representing the source areas of the tuffs, should be present in the St. Francois Mountains. They have not been previously identified, but it is highly possible that they are in areas now covered by Cambrian sedimentary rocks. The circular structures may overlie these sites, with the circular fracture pattern reflecting compaction or subsidence, due either to differences in the physical characteristics of rocks within the vent compared to those forming the walls, or to greater thicknesses of rocks within the calderas.

A preliminary field reconnaissance of the circular structures southwest of Marquand, east of Annapolis, and south of Viburnum was undertaken in an attempt to identify, in the field, any geologic relations that would help in an understanding of the significance of the patterns. The results were inconclusive. The thick residium, containing numerous chert fragments, which covered the area southwest of Marquand obscured all bedrock, and precluded the obtaining of any information. In the other areas outcrops were almost as scarce. A few exposures showing initial dips off Precambrian highs, and some more steeply-dipping rocks probably representing slump structures, were observed, but no steeply-dipping structures analogous to the Crooked Creek cryptoexplosive structure was recognized. Much more detailed geologic work, including subsurface information needs to be done before the significance of the circular patterns can be established.

CONCLUSIONS

The study of radar imagery of the St. Francois Mountains of southeast Missouri was begun as an attempt to compare, on radar imagery and aerial photographs, the portrayal of some geologic features in areas of deciduous forest cover. As an auxiliary purpose, the possible importance of radar in mineral exploration was of interest. The study of the geology of the area, *per se*, was incidental to the primary goals.

Linear features, believed mostly to represent faults, fractures, and circular features of possible structural significance (perhaps calderas) appear on radar imagery in a manner superior to their portrayal on aerial photographs. Many of the features identified on radar imagery are not distinguishable on the air photos; others are obscure or only poorly depicted. Contacts between rock types cannot be readily distinguished on the radar imagery except in a few isolated places; however, this is equally true for aerial photos.

The superiority of radar over the aerial photographs in the recognition of the structural features is believed to be due at least partly to the accentuation by radar of the gross features of the terrain, and the consequent suppression of fine detail. This is coupled with the radar's ability to depict a large area on one photographic strip. The regional pattern is thus emphasized over local features and irregularities. Interruptions of the regional pattern are glossed over and broad relationships are stressed. The large, whole picture rather than the small, partial picture is portrayed.

The use of radar in mineral exploration is linked to this ability to portray the broader regional pattern, and to the accentuation of structural features which may be recognizable only with difficulty, if at all, by other reconnaissance methods. Most mineral deposits are closely associated with structural features, so the identification of these features becomes extremely important. In the St. Francois Mountains, particularly within the new Lead Belt, heretofore unmapped faults and fractures which were identified on the radar imagery appear to be associated with the localization of mineral deposits.

The identification of a major lineament, which prior to imaging by radar had gone unrecognized, further emphasizes the value of radar. The correlation of this lineament (believed to be a fault) with structural and topographic features to the north and south with which it is aligned, suggests a major zone of adjustment that can be traced over 135 miles from near Piedmont to north of St. Louis. The position of this zone relative to the Bonne Terre and Fredericktown districts of the old Lead Belt may be significant.

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