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# PRELIMINARY RESULTS IN THE COMPARISON OF SKYLAB, ERTS AND RB-57 IMAGES FOR THE DETECTION OF LINEAMENTS AND FRACTURES IN PRECAMBRIAN, PALEOZOIC, AND LATE TERTIARY ROCKS ON AND NEAR THE COLORADO PLATEAU, NORTH-CENTRAL ARIZONA

By

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Lineament and fracture systems have been mapped for an area of about 9400 $km^2$ in north-central Arizona, south of Flagstaff. The area investigated includes a part of the southern margin of the Colorado Plateau physiographic province and an adjacent structurally similar transition region that lies to the south. In the transition region, most of the nearly flat-lying Paleozoic strata have been removed, exposing a variety of Precambrian rocks and Precambrian structures. Much of the region is well known geologically, having been mapped by standard field techniques at scales of 1:62,500 and larger. Lineaments were mapped at 1:200,000 scale for the entire study area from ERTS and Skylab multispectral spacecraft images (80m resolution) using an Analytic Plotter Coordinograph; for part of the area, faults and joints, as well as lineaments, were mapped at 1:24,000 scale from high-resolution (~ 3m), high-altitude (19 km) aircraft images.

Analysis of the regional and detailed maps has revealed that common sets of nearly orthogonal lineament and fracture systems (pairsets) occur in Precambrian and Phamerozoic rocks in the transition region, and in Paleozoic and late Tertiary rocks on and near the margin of the Plateau. Six major pairsets are recognized. Four of the pairsets occur in one group that has an 18° azimuthal range in the interval 294° - 312° and 24° - 42°; the fifth and sixth pairsets

are oriented 320° and 50°, and NS and EW, respectively. Directions of known fracture and fault systems are concordant with lineament systems mapped from orbital images, reflecting a close relationship. Moreover, the pattern of lineaments in part coincides with aeromagnetic discontinuities that reflect apparent structural and compositional discontinuities in the basement.

Strongly developed north-and northeast-trending faults, fractures, and lineaments occur in the moderately deformed Precambrian rocks, some laterally extensive faults, fractures, and lineaments of the same trends also occur in little-deformed suprajacent rocks of Paleozoic and Tertiary age. We conclude that several widely spaced, through-going Precambrian fracture systems have served to control the later development of fractures in the Paleozoic and late Tertiary rocks. On the basis of frequency, northwest-trending fracture and lineament systems are more strongly developed in rocks of Paleozoic and Tertiary age than in Precambrian rocks, we interpret that this reflects structural adjustments related to Tertiary deformation in and near the Colorado Plateau. Effects of Tertiary deformation are not relatively obvious in Precambrian rocks because Tertiary deformation has been much less severe than Precambrian deformation.

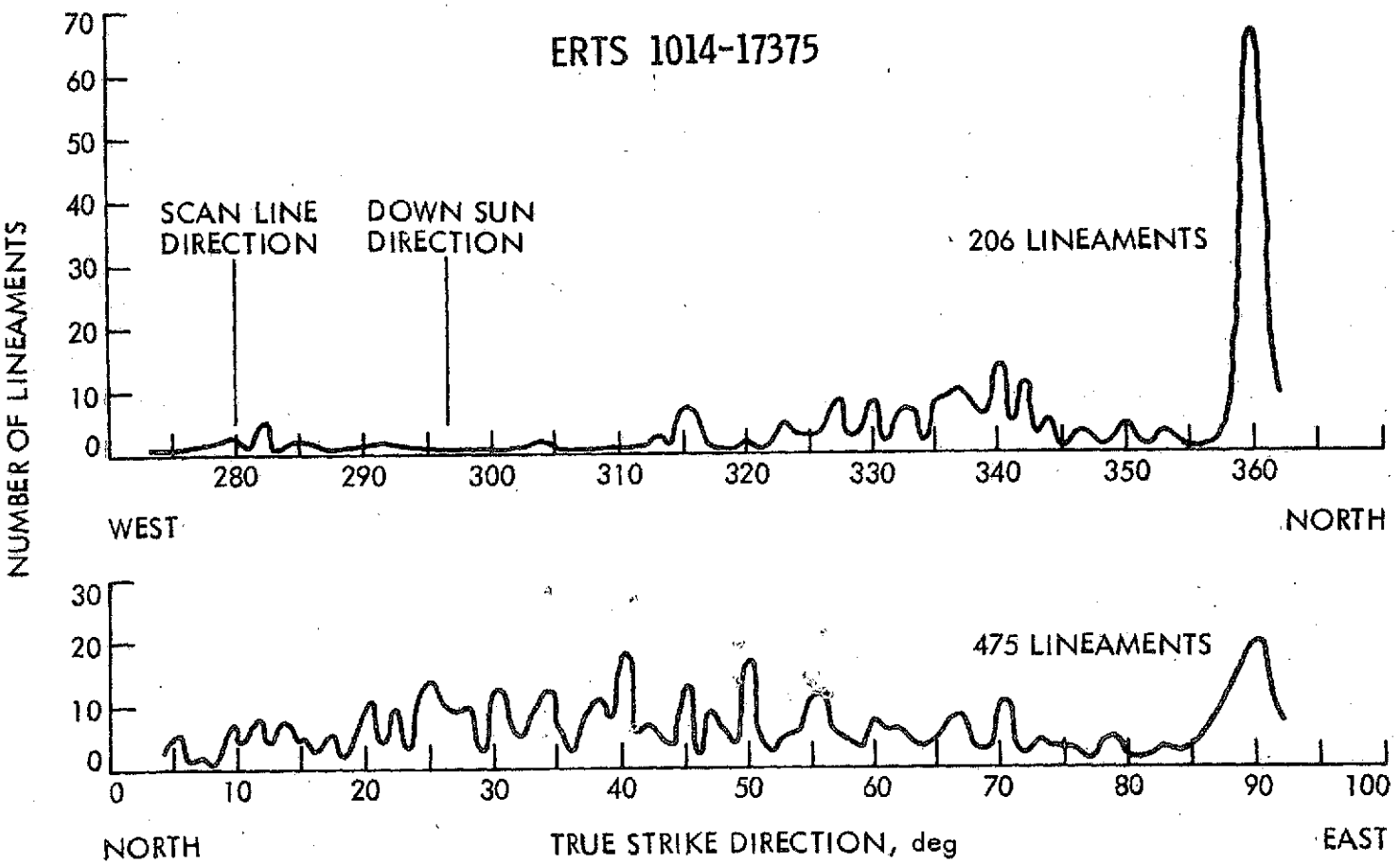
Azimuthal and frequency data for lineaments and fractures have been plotted (Fig. 1) using a cartesian system in which the vertical axis represents the number of lineaments, and the horizontal axis represents the trend. Each plot has a common vertical axis for the northwest (270° - 360°) and northeast (0 - 90°) quadrants, which are arranged one above the other so that lineament systems which are near-orthogonal to one another can be easily identified. The distribution of lineaments was measured, and plotted, to the nearest degree. Azimuthal frequency plots for the ERTS, Skylab, and RB-57 images are shown, respectively, in Figures 1a, b, and c. A cursory examination reveals that a number of lineament systems in the northwest quadrant have nearly orthogonal equivalents in the northeast quadrant. Particularly prominent are near-orthogonal pairs of

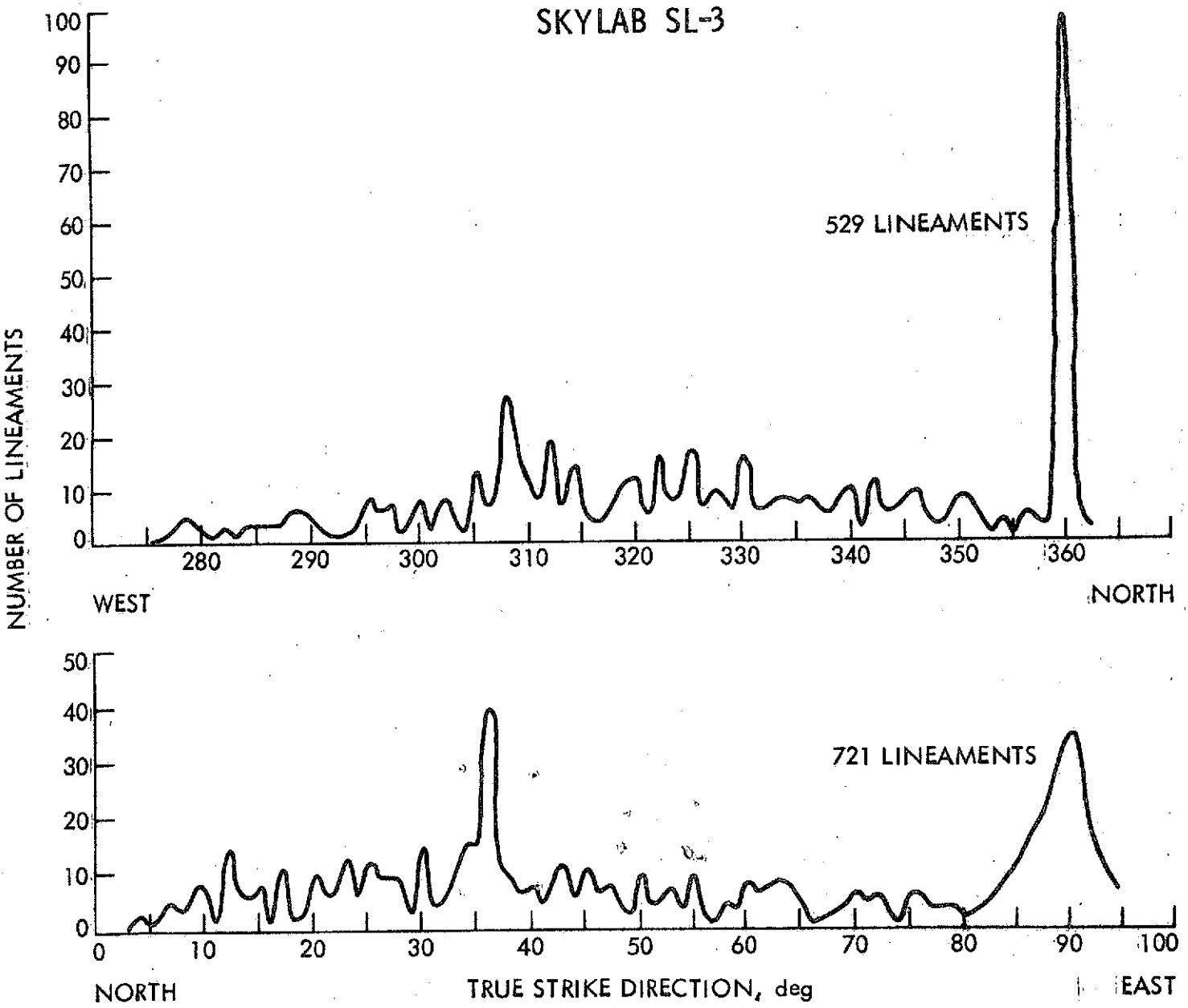
lineaments that trend north-south and east-west, and north-east and north-west. Peaks in the northeast and northwest quadrants of the plots which represent sets of lineaments that are essentially orthogonal to one another are here called pairsets.

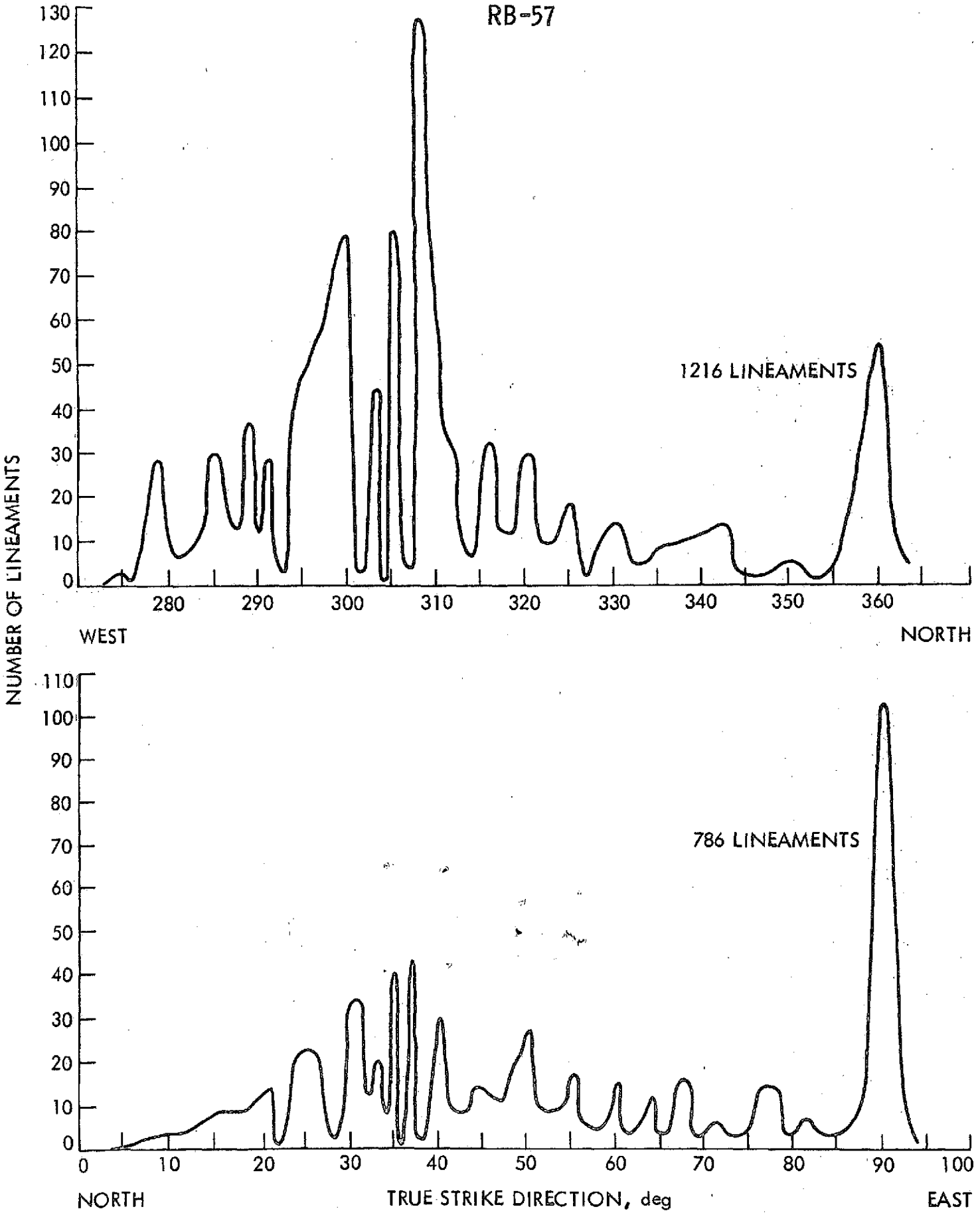
In the analysis of the ERTS images (Fig. 1a), 671 lineaments were measured and counted; of these, 475 trend northeast, and 196 trent northwest. The Skylab map (Fig. 1b) contains 1350 lineaments, of which 721 trend northeast, and 529 trend northwest. A minimum of ten, and a possible maximum of seventeen pairsets can be recognized in these satellite images. The RB-57 map of the Sedona area (Fig. 1c) contains a total of 2302 linear elements, of which 1216 trend northwest, and 786 trend northeast. Twelve pairsets are recognized in the Sedona area from these high-resolution aircraft images.

The late Paleozoic strata of the Sedona area, from analysis of the RB-57 images (Fig. 1c), exhibit a greater percentage of lineaments of northwest trend compared to the more regional aspect of orbital images in which northeast lineament directions are dominant. For the ERTS images, photographed at about 1000 hours local time, about one half of this is an effect of sun angle. Shadows reflecting structural grain are minimized, and contrast is lost, in a downsun (northwest) direction, and this presumably has led to a deficiency of northwest-trending lineaments resolved in the down-sun direction (Fig. 1a). That this deficiency is the consequence of illumination is seen by the comparison of ERTS data with data obtained from Skylab images, photographed very near noon at a time of minimum shadow. The Skylab images, however, still display more northeast-trending than northwest-trending lineaments when compared to lineaments detected in the RB-57 images. A solution to this apparent discrepancy, we believe, lies with the structural character and relative ages of the rocks. Precambrian rocks exposed south of the Mogollon Rim are comparatively strongly deformed and have strongly developed north-and northeast-trending lineament systems. In contrast,

northwest-trending lineaments and fractures are most obviously developed in structurally little deformed Paleozoic rocks. We propose that the comparatively homogeneous Paleozoic strata, which contain a basic population of northwest and northeast, and north-and east-trending lineaments and fractures inherited from major fracture system in Precambrian rocks, display relatively enhanced northwest-trending lineament systems because these reflect the strongest directions of post-Paleozoic (later Tertiary) structural adjustments in the Colorado Plateau Province and transition region adjacent to the Basin and Range Province.


ERTS 1014-17375
NUMBER OF LINEAMENTS
70
60
50
40
30
20
10
0
SCAN LINE DIRECTION
DOWN SUN DIRECTION
206 LINEAMENTS
280
290
300
310
320
330
340
350
360
WEST
NORTH
30
20
10
0
475 LINEAMENTS
0
10
20
30
40
50
60
70
80
90
100
NORTH
TRUE STRIKE DIRECTION, deg
EAST


SKYLAB SL-3
NUMBER OF LINEAMENTS
100
90
80
70
60
50
40
30
20
10
0
529 LINEAMENTS
280
290
300
310
320
330
340
350
360
WEST
NORTH
50
40
30
20
10
0
721 LINEAMENTS
0
10
20
30
40
50
60
70
80
90
100
NORTH
TRUE STRIKE DIRECTION, deg
EAST


RB-57
NUMBER OF LINEAMENTS
1216 LINEAMENTS
786 LINEAMENTS
WEST
NORTH
NORTH
EAST
TRUE STRIKE DIRECTION, deg