A Search for the 38th Parallel Lineament near Green Bank, West Virginia

P. D. Lowman, Jr., W. J. Webster, Jr., and R. J. Allenby

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Abstract

A field reconnaissance was carried out near Green Bank, West Virginia, to assess the possibility that active faults might produce movements which would introduce errors to geodetic results of Very Long Baseline Interferometry (VLBI) measurements carried out with radio telescopes at the National Radio Astronomy Observatory (NRAO). The 38th parallel lineament, a zone of strike-slip faults and other features, has been proposed by several authors to pass through the Green Bank area and to extend to the Blue Ridge in Virginia. This study, based on Landsat photogeologic mapping, found no evidence for the existence of the lineament in exposed Paleozoic rocks, and a seismometer emplaced at the NRAO detected no activity that could be related to the lineament. It is concluded that the 38th parallel lineament, though well-documented in the midcontinent region, does not extend this far east and that it is probably a purely intracontinental structure unrelated to oceanic fracture zones of the Atlantic.

Introduction

THE term "38th parallel lineament" was proposed by Heyl (1972) for a zone of faults, igneous intrusions, and other features extending from Virginia to Missouri approximately along the 38th parallel. Dennison and Johnson (1971) had referred to the same features as the "thirty-eighth parallel fracture zone." The 38th parallel lineament is of particular interest to NASA because its supposed trace (Heyl, 1972, fig. 2) passes a few kilometers south of the National Radio Astronomy Observatory (NRAO) at Green Bank, West Virginia. Radio telescopes at the observatory are being used for Very Long Baseline Interferometry (VLBI) to measure plate motion and deformation with a precision approaching 3 cm over distances of several thousand kilometers. Interpretation of such measurements requires an assessment of potential local tectonic movements that might affect the data. Our findings, presented in detail elsewhere (Webster et al., 1979), have implications for the extent and nature of the 38th parallel lineament.

Previous Work

The extensive literature covering the tectonics of the midcontinent region has been reviewed by Hinze et al. (1977). The main studies of the 38th parallel lineament are those of Dennison and Johnson (1971), Heyl (1972), and Lidiak and Zietz (1976). Dennison and Johnson summarized the evidence for the "thirty-eighth parallel fracture zone" in Virginia and West Virginia: Eocene igneous intrusions, high ground-water temperatures, maximum uplift of the Schooley erosion surface, and a negative Bouguer gravity anomaly. Heyl (1972) presented evidence for the lineament as a whole: east-trending right-lateral wrench faults, narrow belts of changes in formation thickness, igneous intrusions, and mineral deposits. He interpreted the lineament as a right-lateral basement fault zone expressed in the overlying rocks as various structural, stratigraphic, and igneous features. He also described the Stanley and related faults in Virginia, 120 km east of Green Bank, as having major right-lateral displacement, and interpreted these faults as the eastern end of the lineament. Lidiak and Zietz (1976) presented aeromagnetic and gravity evidence for several east-trending lineaments in the central and eastern United States between latitudes 37° and 38° N. They reported that the 38th parallel lineament could be recognized in magnetic lineaments, anomaly trends, or interruptions of magnetic patterns. They suggested that, although this and related lineaments originated in Precambrian time, segments in western Virginia might still be active. Sykes (1978) suggested that the Eocene igneous intrusions in western Virginia and the central Virginia seismic zone were related instead to a northwest-trending zone reactivated during the opening of the Atlantic. Sykes' interpretation is one of several (e.g., Lidiak and Zietz, 1976) that consider intraplate fracture zones related to fracture zones of the ocean basins.

The specific problem addressed by this paper is whether the 38th parallel lineament continues eastward from Kentucky through West Virginia into west-central Virginia. If it does, it forms a

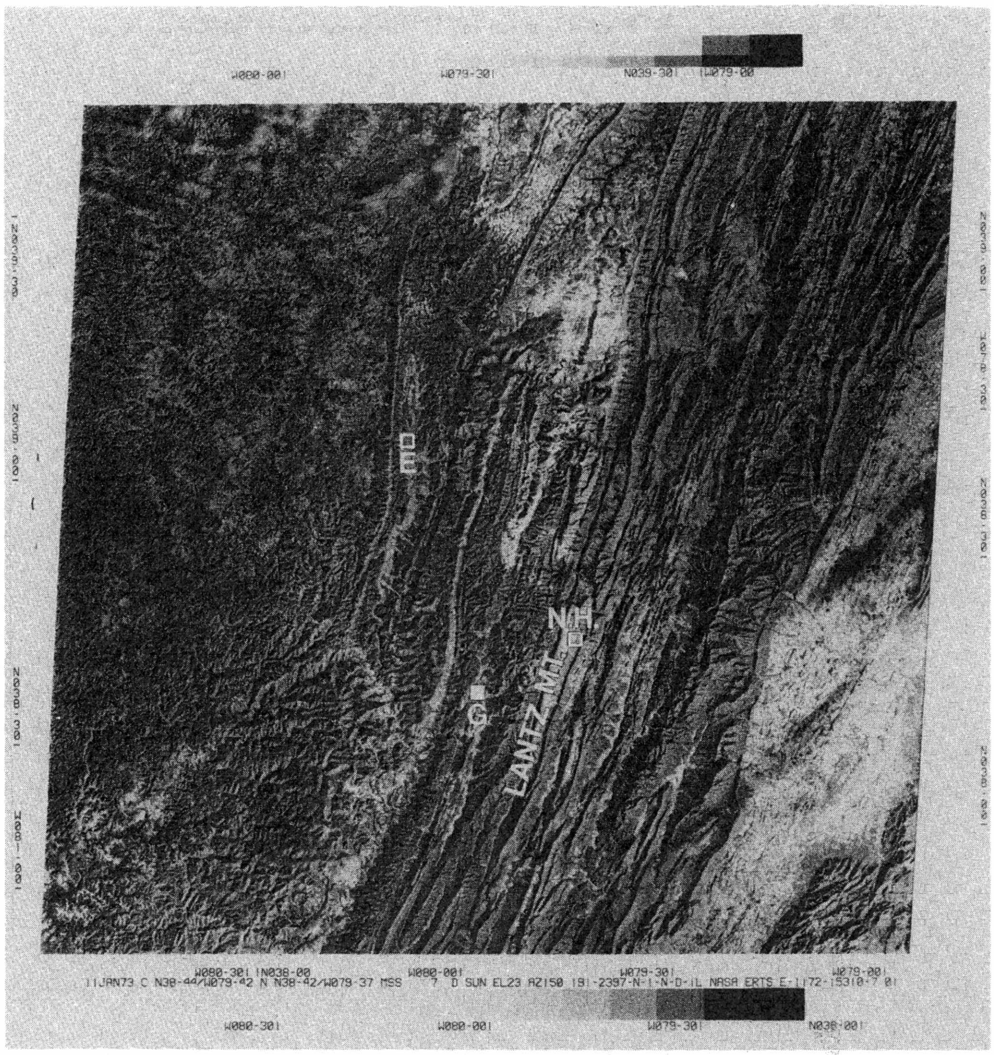

FIG. 1. Landsat image of Green Bank area; scene number 1172–15310, acquisition date January 11, 1973. Location squares are "G" for Green Bank (NRAO), "E" for Elkins, and "NH" for New Hampden. See Figure 2 for details.

continuous continental lineament more than 1,300 km in length. The fact that Woodward's map (Cardwell et al., 1968) of West Virginia's surface structures does not indicate such a trend is not surprising in view of Gwinn's (1964) argument that most of the folding in the central Appalachians is surficial and does not involve basement rocks. In this case one is dependent on geophysical data to furnish the structural details of crystalline basement. Using such data, Woodward (Cardwell et al., 1968) suggested that the 38th parallel lineament in eastern Kentucky runs northeast across West Virginia and Maryland and connects into a 40th parallel fault zone in Pennsylvania. He characterized this feature in West Virginia as a broad belt, up to 40 km in width, of parallel, right lateral en echelon faults.

Kulander and Dean (1978) compiled detailed gravity and magnetic maps of the Allegheny plateau and Valley and Ridge province in West Virginia and vicinity. They found no geological or geophysical evidence in West Virginia of extensive strike-slip faulting along either the 38th parallel or Woodward's northeast-trending fault zone.

Regional Geology

The Green Bank area is geologically in a transition zone. It is roughly 10 km northwest of the Allegheny Front, the boundary between the Ridge

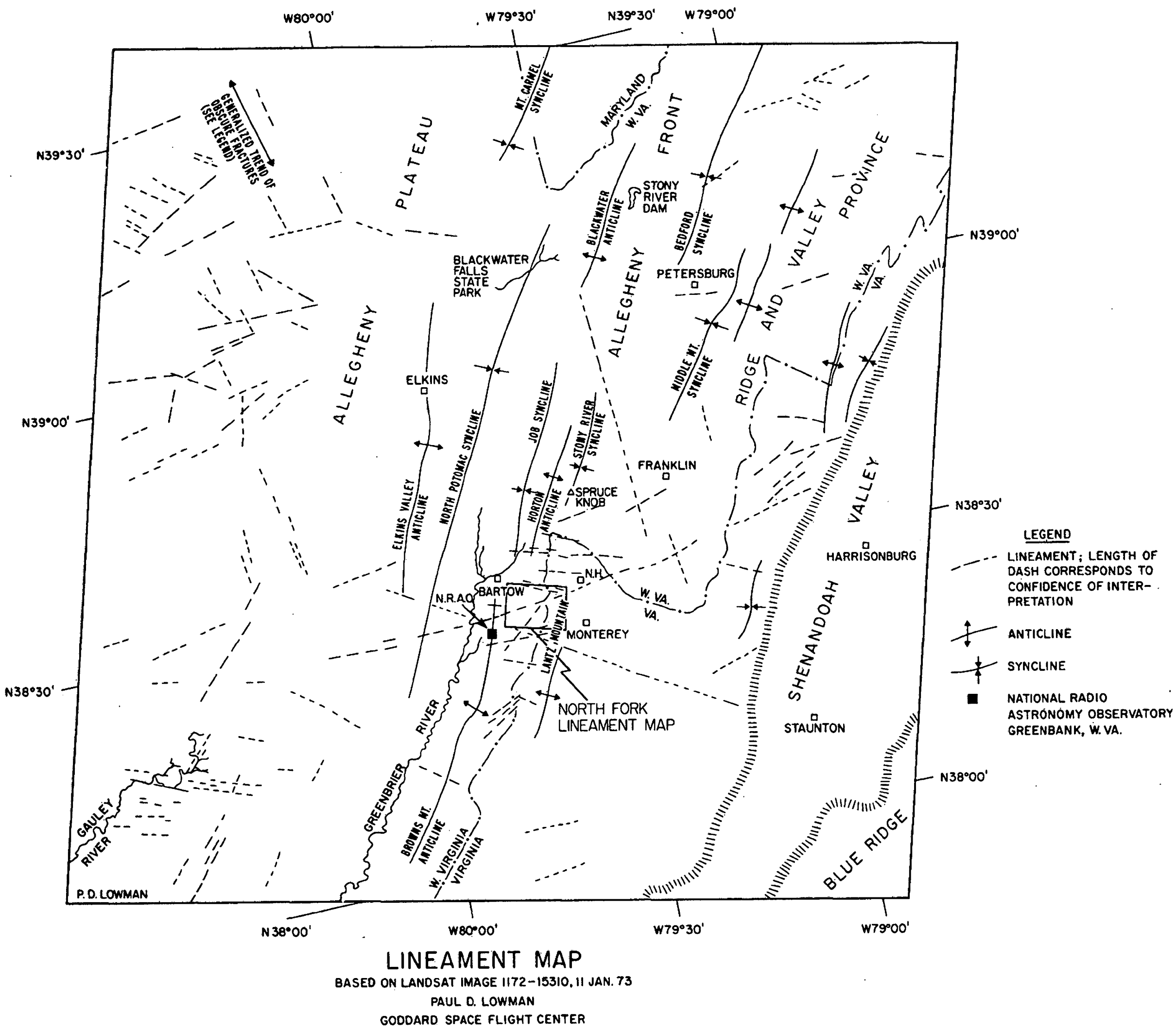

FIG. 2. Lineament map drawn from Landsat image, Figure 1. The Allegheny Front and Lantz Mountain are the boundary between the Ridge and Valley Province and the Allegheny Plateau.

and Valley province and the Allegheny plateau. In addition, the Green Bank area marks an apparent transition along strike, from relatively open folds to the northeast in Maryland and Pennsylvania to the much tighter folds to the southwest. Physiographically, both these transitions are quite real. However, Gwinn (1964) has given strong evidence that the along-strike transition is primarily the result of depth of erosion and that there is little difference structurally.

Rocks of the Green Bank area are practically all Paleozoic, ranging from Ordovician to Pennsylvanian. Pennsylvanian units cap the higher parts of the plateau; Silurian and Devonian units make up most of the valleys and ridges, with Ordovician units exposed only in the cores of larger anticlines. A number of Eocene igneous dikes occur nearby in Highland County, Virginia, and Pendleton and Pocahontas Counties, West Virginia. The local stratigraphic section is well described in the legend accompanying the Geologic Map of West Virginia (Cardwell et al., 1968). The units with which this survey was primarily concerned are described below.

The Silurian Tuscarora sandstone, about 100 m of sandstone and orthoquartzite, is the principal ridge-former in this part of the Appalachians. Lantz Mountain, an important feature for lineament study, is largely Tuscarora sandstone. The Devonian system near Green Bank includes, among other units, the Brallier Formation (a marine shale with some siltstone), the Chemung Group (chiefly marine sandstone and shale), and the Hampshire Formation (nonmarine sandstones and siltstones). The Mississipian system, totaling about 700 m in this area, includes the Pocono Group, Macrady Formation (shales and sandstones), the Greenbrier Group (chiefly marine limestones), and the Mauch Chunk Formation (varicolored sandstones and shales).

Field Investigations

Using a low sun-angle (winter) Landsat image (Fig. 1), a single frame synoptic lineament map was prepared (Fig. 2). All visible lineaments within 48 km of Green Bank were plotted on USGS 1:250,000 (Charlottesville) and 1:24,000 (Cass, Spruce Knob, and Monterey quadrangles) topographic maps and checked on NASA RB-57 aircraft and Skylab S-190B photographs. As previous work has shown, the photolineaments proved to be zones, generally from several hundred meters to over a kilometer wide, of various features such as stream valleys, gaps, and ridge ends, parallel and spaced closely enough to constitute a single line on the Landsat picture.

A field reconnaissance was undertaken to: verify the existence of structures corresponding to the photolineaments, investigate their details, and find out whether there has been appreciable offset along any of them. Emphasis was given to horizontal offset since precise horizontal measurements are a primary objective of the VLBI experiments; however, when distinctive marker horizons with shallow dip were exposed, evidence of vertical offset was looked for.

We concentrated on locating intersections of ridges with lineaments both east and west of Green Bank, bracketing the observatory site. Lantz Mountain, a vertically dipping to overturned ridge of Tuscarora sandstone, offered the best opportunities for this. Five lineament-ridge intersections along Lantz Mountain were therefore examined in the field. Three were related to northeast-trending lineaments: one at Mick Run (near Cherry Grove), one near Snowy Mountain, and one near the divide on the headwaters of Straight Fork. At the first two sites, sharp erosional notches occur at the places where the lineaments cross the ridge; however, there is no apparent lateral offset.

At the third site, 8 km west of New Hampden, Virginia, there is no such gap and no outcrops were found. This site is of particular interest, since the lineament going through it appears to be, though coincidentally emphasized by a cloud shadow, the most likely candidate for a 38th parallel lineament feature. It is one of the longest transverse features visible on the Landsat picture, and its trend, N 80° E, is close to that of the lineament indicated by Heyl (1972), although it is a few kilometers north of the trace shown on Heyl's map (Fig. 2). Accordingly, the photolineament was investigated at its intersection with U. S. 250 near the head of North Fork (Fig. 3). The structure proved to be an extension of the Stony River syncline past its extent as shown on the Virginia state map (1963). The trend of North Fork appears to be controlled by a zone of

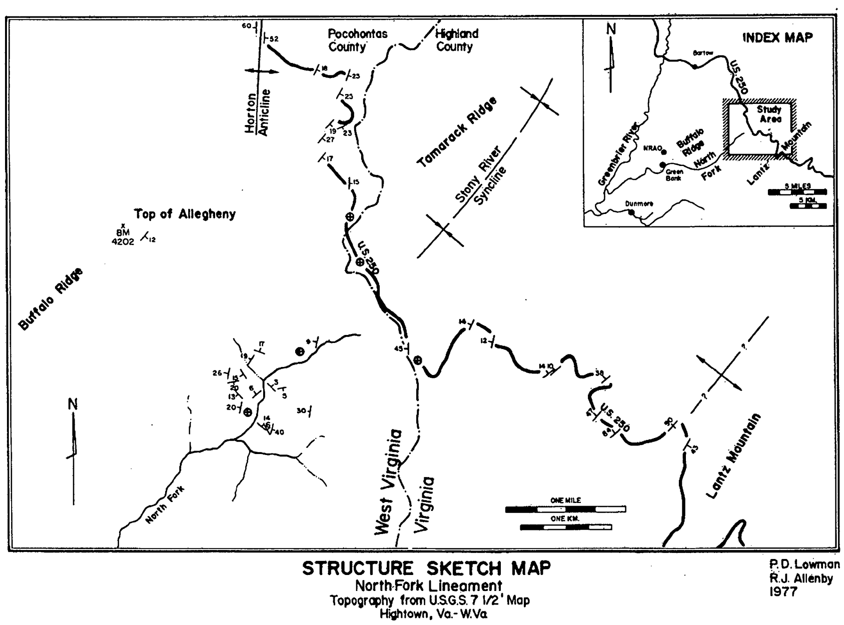

FIG. 3. Sketch map of structure northeast of Green Bank area. Note well-defined fold exposed along U. S. 250.

randomly oriented fractures on the synclinal axis; similar structural control was also found for a similar trend on Knapp Creek to the south. However, there was no evidence of any N 80° E fracture zone corresponding to the 38th parallel lineament, such as faults, joints, or minor fold axes.

The remaining two Lantz Mountain sites are both related to northwest-trending lineaments. Both were erosional gaps but neither showed any lateral offset of the Tuscarora sandstone ridge.

The prominent northwest-trending lineament passing just north of the NRAO site (Fig. 1) was studied in more detail, since it is one of the longer lineaments and corresponds to one of the transverse tear faults shown by Gwinn (1964, fig. 16) with a N 70° W trend. The photolineament trends N 60° W, but this difference is not significant because Gwinn's map was based on broad stratigraphic features such as fold terminations. Near the intersection of the photolineament with Lantz Mountain, several outcrops in Tuscarora sandstone showed prominent steeply dipping or vertical joint sets trending between N 60° W and N 70° W. This would appear consistent with Gwinn's interpretation, although it should be pointed out that northwest-trending joints are common in the Green Bank-Monterey area. The lineament was also investigated west of Green Bank, where it is expressed as a gap through Little Mountain near the Greenbrier River. A series of sandstones, belonging to the Chemung Group, dips about 45° NW and showed no lateral offset across the gap.

During the field survey an SPZ seismometer operating at a magnification of about 30,000 at 1 Hz was established on the grounds of the NRAO (National Earthquake Information Service station identification code GBV). The sensor is at a depth of about 0.5 m in the Quaternary alluvium which overlies the Brallier Formation. Observations have been made since November 15, 1976, and in nearly 30 months no seismic activity within a 20 km radius of the observatory has been detected.

The known active areas in Virginia, West Virginia, and western Maryland (Bollinger, 1969) yielded a total of 15 regional events in this period, all of which were detected at GBV. Although it is difficult to detect very weak events on week days due to mine and quarry blasting in Appalachia, the very low local noise levels at GBV would have made it very unlikely that local events at night, on weekends, or on holidays would be missed.

Summary and Conclusions

We found no surface evidence that the 38th parallel lineament passes through the Green Bank area. There is only one photolineament of any significant length with the proper trend near Heyl's (1972) location of the 38th parallel lineament, and its existence is questionable because it is conspicuous on only one of several Landsat frames examined and is partly obscured by cloud shadows. Further, there is no evidence for the lineament in outcrop where it is most prominent on the picture (between Bartow, West Virginia, and Monterey, Virginia). Finally, there is no lateral offset of any of the steeply dipping stratigraphic units in the area (i.e., the ridge-forming Tuscarora sandstone on Lantz Mountain).

It should be noted that Heyl (1972) considered the Stanley fault, with several kilometers apparent lateral displacement of Precambrian and lower Paleozoic sedimentary rocks, to be the eastern end of the 38th parallel lineament. However, the 1:500,000 Geologic Map of Virginia (1963) shows that the Stanley fault does not extend westward across the Shenandoah Valley; i.e., it is not continuous with any structure near Green Bank. When considered together with the apparent absence of strike-slip transverse faulting in the Green Bank area, we conclude that the lineament does not extend this far east.

This conclusion, of course, assumes the lineament to be a fault. As pointed out by a reviewer, a lineament is not necessarily a fault. The AGI *Glossary of Geology* defines the term, in reference to photogeology, as (essentially) a structurally controlled line; possible structures include strata, igneous contacts, or various kinds of fractures. However, the 38th parallel lineament was specifically interpreted by Heyl (1972) as a "wrench-fault zone in the basement." Dennison and Johnson (1971) use the more general term "fracture."

We cannot exclude the possiblity that the 38th parallel lineament is, in the Green Bank area, purely a basement structure of Precambrian age. However, the features considered part of the lineament both west and east of Green Bank, such as the Kentucky River fault zone and the Stanley fault, were active in the Paleozoic or later (Heyl, 1972). It seems unlikely that the intervening segments would have remained inactive since the Precambrian.

We conclude that the 38th parallel lineament, though well-documented farther west, does not extend eastward through West Virginia into Virginia. If this conclusion is correct, it supports the suggestion of Sykes (1978) that the central Virginia seismic zone and the Eocene intrusives of Virginia are the expression of a different fracture zone—related, in Sykes' (1978) view, to the fractures of the Atlantic Ocean. More generally, our results imply that the 38th parallel lineament is a purely continental structure, having no genetic connection with the Atlantic structures.

Geophysics Branch
NASA Goddard Space Flight Center
Greenbelt, Maryland 20771
July 13, November 16, 1979

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