East-Trending Structural Lineaments in Central Nevada

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A description of four east-trending structural lineaments inferred to be deep-seated crustal features

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EAST-TRENDING STRUCTURAL LINEAMENTS IN CENTRAL NEVADA

By E. B. Ekren, R. C. Bucknam, W. J. Carr, G. L. Dixon, and W. D. Quinlivan

ABSTRACT

Several east-trending topographic and structural lineaments in central Nevada coincide locally with lithologic boundaries, range and valley termini, caldera boundaries, and strong magnetic interruptions. Most of the observed magnetic anomalies or interruptions along the lineaments can reasonably be attributed to the deposition of volcanic rocks against easterly trending topographic highs, to the juxtaposition by faulting of rocks having different magnetic properties, or to plutonic rocks intruded into structures within the lineament trend. The tangential association of volcanic centers and cauldrons with the lineaments implies a deep-seated crustal control. Two of the lineaments can be traced from central Nevada into easternmost California; another extends into western Utah. Two lineaments appear to cross the Walker Lane without offset and bound a block of ground that is not greatly displaced by strike-slip faults of the Walker Lane system. Whether the lineaments are partly a result of conjugate faults developed at the inception of the Walker Lane and other major northwest-trending faults in the southwestern Great Basin, or whether they owe their origin to an even more regional or even continentwide fracture system is an unresolved question.

INTRODUCTION

Several throughgoing east-trending structures in central Nevada are suggested on the basis of lineaments expressed primarily by alinement of topographic features. Aeromagnetic data indicate that the topographic features coincide closely with east-trending magnetic lineaments in many areas, and recent mapping in Nevada by the authors and others has defined a local geologic basis for parts of these lineaments. The purpose of this paper is to call attention to the probable length, number, and importance of these features.

Field studies have shown that structures associated with the lineaments appear to (1) influence, if not control, the location of many volcanic centers; (2) consist of old zones of weakness, structural hinge lines, or strike-slip faults; (3) commonly exhibit strike-slip displacement that is almost everywhere left-lateral; (4) have strike-slip movements ranging in age from middle to late Tertiary; (5) be at least surficially discontinuous; and (6) coincide along parts of their lengths with marked magnetic discontinuities.

The possible regional extent of these structural lineaments is inferred largely from coincident topographic and aeromagnetic lineaments. The authors recognize that such speculation about regional structures is hazardous, as has been so aptly stated by King (1970):

> Drawing great linear and more or less hypothetical faults across a map is a favorite pastime of many geologists.*** One of the most troublesome problems of line drawings is the age relations of the features. Often, the lines "put too many eggs in one basket," connecting features whose ages might be anywhere from Precambrian to Cenozoic, depending on locality. The dedicated drawer of lines dismisses the problem by saying that the lines represent deep, fundamental crustal fractures, which might be manifested in the upper crust or at the surface by faults of different ages or different kinds, or even by no break at all.

East-west lineaments in the Basin and Range province are not confined to the area described herein. Zietz and others (1969) and Affleck (1970) discussed magnetic interruption north of 40° latitude as possible continuations of the Mendocino fracture zone of California. Slemmons (1967) briefly described three transverse trends in Nevada that are marked by low topography, appear to influence the pattern of faulting, and affect the regional patterns of tilting produced by faulting. The transverse trends described by Slemmons strike east-southeast and do not correspond to the lineaments described in this report. Cook and Montgomery (1974) described several east-west structural trends in Utah, based on topographic and gravity data from the eastern Basin and Range province, that they felt extend into Nevada. The most southerly of the east-trending lineaments described by Cook and Montgomery is at the approximate latitude of 38⅔°, the same as our Pancake Range lineament, and conceivably could be the same structural feature. If this is the case, the lineament in Nevada is at least surficially discontinuous with the lineament in Utah. The eastern part of the Great Basin, principally in Utah, has not been considered here, and it may or may not fit the structural pattern described in this report. Burke and McKee (1973) described two large, west-trending troughs in north-central Nevada that are pre–Basin and Range in age and are filled with extremely thick sections of Tertiary volcanic rocks. These troughs are as much as 72 miles (116 km) in length. Anderson (1973) has documented a major northeast-trending, left-lateral, strike-slip fault zone in southeastern Nevada.

In our view the lineaments discussed here are not lines of finite width but zones varying from a few miles to as much as 16 miles (25 km) wide. It is not our intent to address or solve all the problems associated with these complex structures in Nevada or those described by other authors but, rather, to document in detail the geologic evidence of the existence of a pervasive pattern of easterly trending structures in the central Great Basin.

The easterly trending structures of central Nevada appear to us to be concentrated in four zones, named from south to north:

1. Timpahute lineament,
2. Warm Springs lineament,
3. Pancake Range lineament, and
4. Pritchards Station lineament.

TIMPAHUTE LINEAMENT

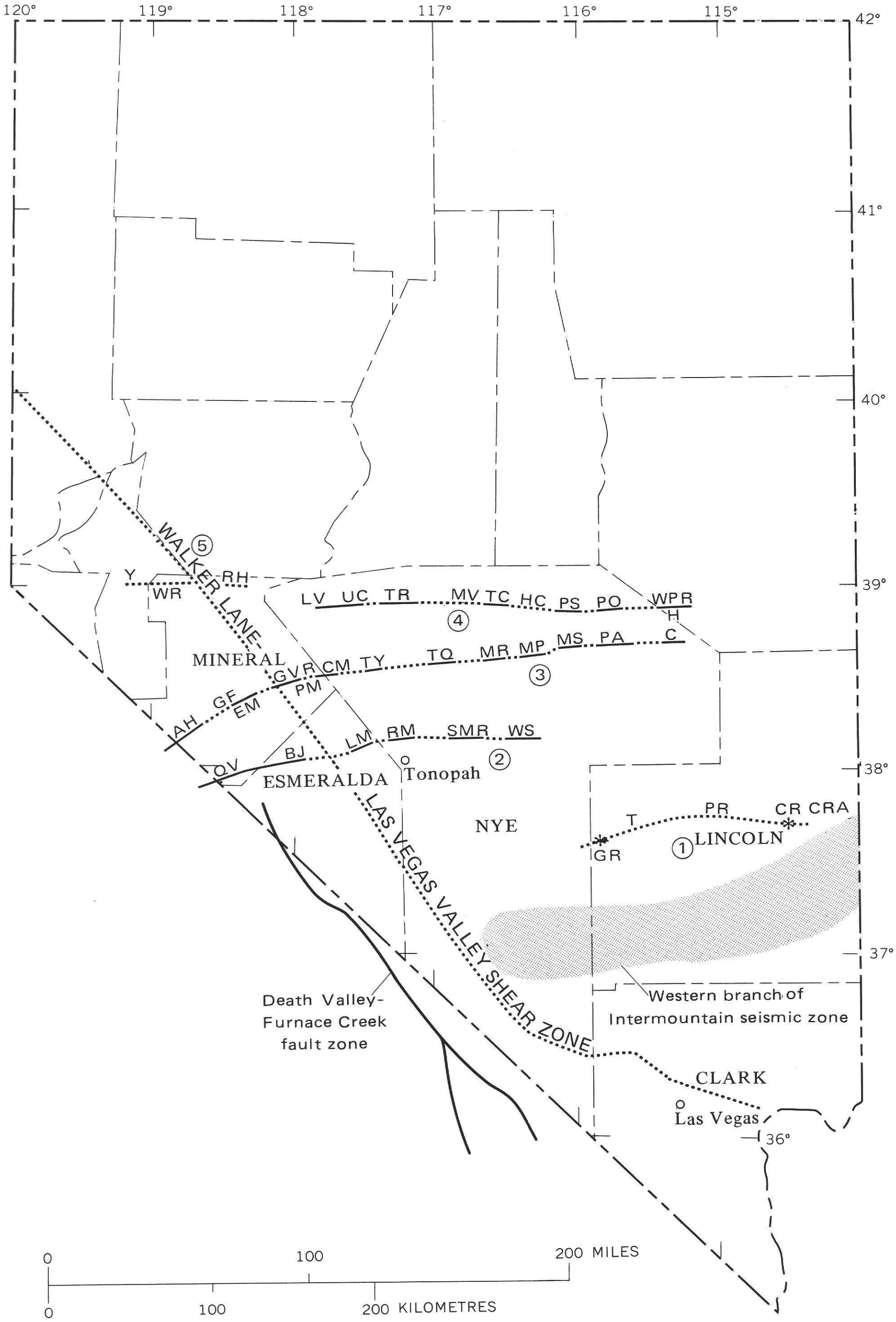
The Timpahute lineament extends across Lincoln County, Nev., into Utah (fig. 1). In western Lincoln County, the lineament is expressed by discontinuous east-northeast-trending topography from the Timpahute Range through the North and South Pahroc Ranges. In eastern Lincoln County, the lineament is expressed by easterly elongated and faulted rhyolite masses in the vicinity of the Utah State line. These features are conspicuous on Landsat (formerly called ERTS) photography (fig. 2). The Timpahute lineament is inferred to be a deep-seated structure that (1) controlled east-trending ranges or the relatively uplifted ground that extends from Sand Spring Valley eastward to Dry Lake Valley, (2) interrupts north-trending valleys and ranges, (3) separates areas of contrasting structural style, (4) controlled the location of several intrusive masses, (5) localized strike-slip faulting, and (6) is the locus of recent seismicity in the southern part of the North Pahroc Range. Importance of the topographic lineament in eastern Lincoln County as a structural element is also indicated by a marked magnetic discontinuity or interruption (U.S. Geological Survey, 1973) and by contrasting structural styles to the north and south. North of the lineament, discrete northerly trending basins and ranges dominate the topography; to the south, in contrast, for a distance of 20 miles (32 km), a broad platform of volcanic rocks is present. A west-southwest-trending zone of seismic activity (fig. 1) extending from the Intermountain seismic belt (Smith and Sbar, 1974) in Utah lies within this area. Gravity data (Department of Defense, 1975) show a very broad region of east-trending contours south of Caliente, having the gravity gradient down to the north, that contrasts with a pattern of highs and lows at the latitude of Caliente and northward.

Contrasting structural styles are apparent also across the lineament between the North and South Pahroc Ranges (E. B. Ekren, P. P. Orkild, K. A. Sargent, and G. L. Dixon, unpub. mapping, 1976). The North Pahroc Range is anticlinal and the range is complexly and intricately faulted by closely spaced north-striking faults. The South Pahroc Range dips consistently to the west and is only moderately faulted; east-trending normal faults are conspicuous here, but they are absent in the North Pahroc Range.

In addition to contrasting structure north and south of the Timpahute lineament, numerous igneous intrusive masses occur on or near the feature. These masses, from west to east (fig. 2), are rhyolite and granite plugs exposed at the north end of the Groom Range, the granite of Tempiute in the Timpahute Range, the diorite and granodiorite intrusives of the Chief Range near Caliente, and the dioritic and granitic masses of the Cedar Range. Still farther to the east, extending into Utah, are the previously mentioned large rhyolite masses that are elongated easterly and were undoubtedly fed from east-trending fissures.

The lineament is tangential to the northern boundary of a large cauldron complex in the vicinity of Caliente (fig. 2) that has previously been called the

FIGURE 1.—Map of Nevada showing lineaments described or referred to in this report. 1, Timpahute lineament: GR, Groom Range; T, Tempiute; PR, North and South Pahroc Ranges; CR, Chief Range; CRA, Cedar Range. 2, Warm Springs lineament: QV, Queen Valley; BJ, Blair Junction; LM, Lone Mountain; RM, Red Mountain; SMR, Southern Monitor Range; WS, Warm Springs. 3, Pancake Range lineament: AH, Anchorite Hills; EM, Excelsior Mountains; GF, Garfield Flat; GVR, Gabbs Valley Range; PM, Pilot Mountains; CM, Cedar Mountain; TY, Toiyabe Range; TQ, Toquima Range (Manhattan); MR, Monitor Range; MP, Morey Peak; MS, Moores Station; PA, Pancake Range; C, Currant. 4, Prichards Station lineament: LV, Lodi Valley; UC, East and West Union Canyons (Shoshone Range); TR, North Twin River (Toiyabe Range); MV, Monitor Valley (drill hole UCE-16); TC, Tulle Creek (Monitor Range); HC, Hot Creek Range; PS, Pritchards Station; PO, Portuguese Mountain (Pancake Range); H, Horse Range; WPR, White Pine Range. 5, Rawhide-Yerington lineament of Bingler (1971): Y, Yerington; WR, Wassuk Range; RH, Rawhide.



EXPLANATION

① Lineament — Dotted where not present at surface

* Intrusive on lineament

Caliente depression (Noble and others, 1968; Noble and McKee, 1972). The depression is considered to be related to extensive eruptions of tuffs and lavas that range in age from about 24 m.y. to 15 m.y. (Noble and McKee, 1972). The cauldron complex is centered farther south than the volcano-tectonic depression of the above authors and is considerably wider east to west.

Strike-slip faulting has occurred locally along the Timpahute lineament. It has been well documented only in the vicinity of the Timpahute Range. On the north flank of the range, two prominent faults occur. On the basis of drag, one fault (the more northerly) has moved left-laterally; the other has moved right-laterally. Major east-trending faults on the south side of the Timpahute Range probably also have significant strike-slip components (Tschanz and Pampeyan, 1970, p. 84), but their direction of lateral movement has not been determined.

The Timpahute lineament appears to be expressed seismically by an east-trending swarm of epicenters located across the south end of the North Pahroc Range from the south end of Coal Valley to Dry Lake (fig. 2; F. G. Fisher, written commun., 1973). The epicenters do not correlate well with mapped structure, and we feel that the seismic activity may be related to a deep-seated structure along the lineament.

WARM SPRINGS LINEAMENT

A pronounced east-trending structural and stratigraphic discontinuity, the Warm Springs lineament (fig. 1, No. 2), extends from Queen Valley, just north of Boundary Peak in the White Mountains on the Nevada-California border, eastward to the pass between the Hot Creek and Kawich Ranges southwest of Warm Springs in Nye County (fig. 3; pl. 1). U.S. Highway 6 follows this lineament rather closely. The lineament coincides with an east-trending magnetic interruption (fig. 4). F. J. Kleinhampl and

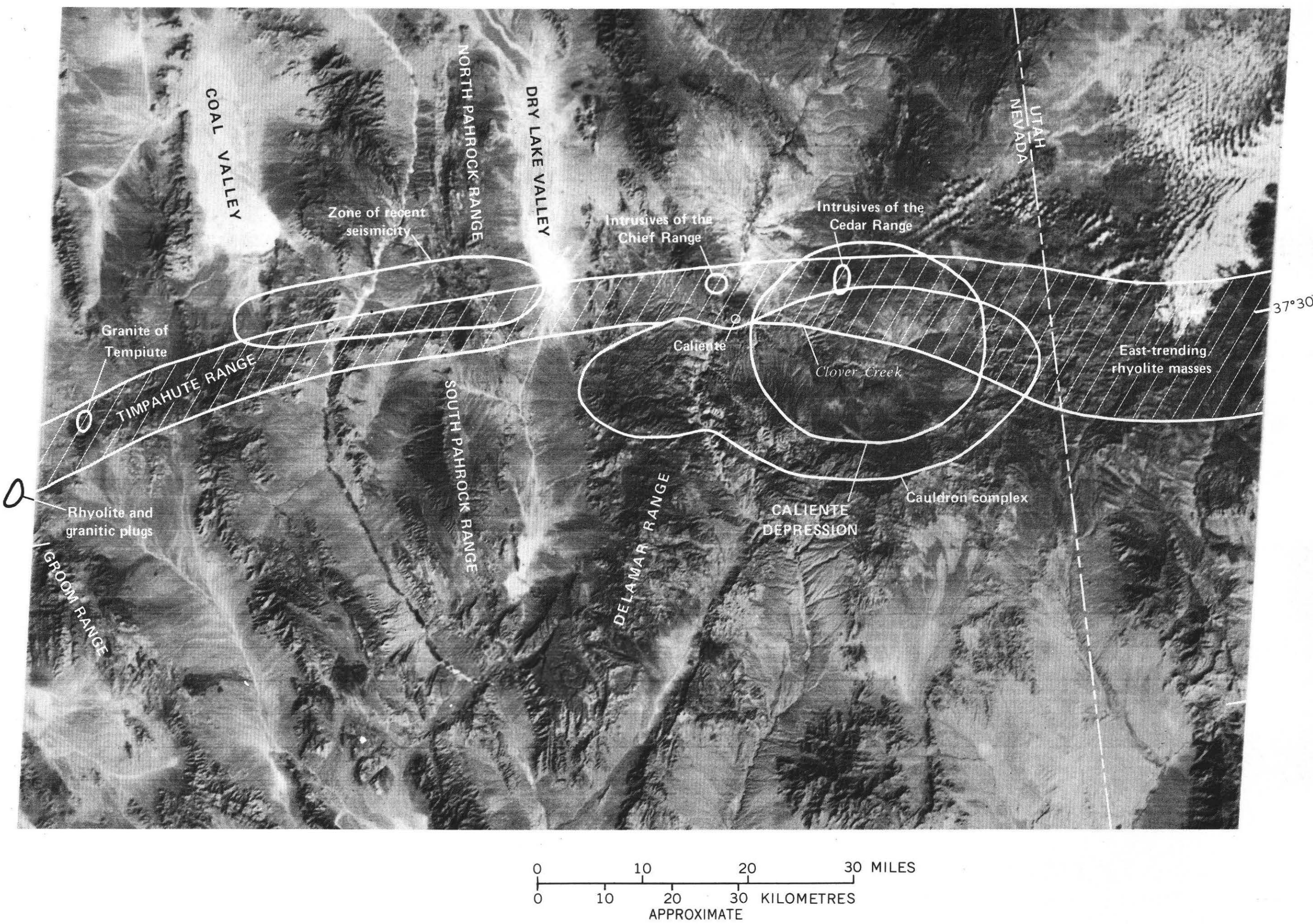


FIGURE 2. — Landsat photograph (NASA E-1106-17492-1, Nov. 6, 1972) of Lincoln County, Nev., and part of western Utah showing Timpahute lineament and adjacent Basin and Range topography.

J. I. Ziony (oral commun., 1963) noted the marked geologic discontinuity in the course of mapping northern Nye County. They considered the possibility that the feature was a strike-slip fault but found no evidence to confirm this concept or to define a possible direction of movement (oral commun., 1974).

HOT CREEK RANGE-KAWICH RANGE AREA

Reconnaissance mapping of the northern Kawich Range by E. B. Ekren and C. L. Rogers (unpub. data, 1966) suggested that the northern bulbous end of the Kawich Range was the resurged part of a large cauldron (pl. 1) whose northern boundary appears to coincide with the east-trending discontinuity suggested by F. J. Kleinhampl and J. I. Ziony (oral commun., 1974). The lineament along U.S. Highway 6 (pl. 1) contains irregular bodies of rhyolite and andesite. North of the lineament the exposed rocks along the east flank of the Hot Creek Range are middle Paleozoic in age, including Devonian strata in a lower plate and Mississippian and Devonian strata in an upper plate (Kleinhampl and Ziony, 1967). Volcanic rocks north of the lineament include cooling units assigned to the Shingle Pass Tuff (Cook, 1965). These units form extensive outcrops on the west flank of the Hot Creek Range. South of the lineament there are no Paleozoic outcrops, and the Shingle Pass Tuff occurs only in brecciated masses that have slid or have been thrust over ash-flow tuffs that form the northern terminus of the Kawich Range. The autochthonous tuffs include the Monotony Tuff (Ekren and others, 1971) and younger tuffs of the Kawich Range. The Monotony Tuff in the vicinity of the lineament strikes nearly east-west and dips steeply to the south or stands vertically. Whether the steep dips in the Monotony Tuff and the occurrence of detached or thrust-faulted masses south of the lineament relate to caldera collapse or to possible strike-slip movements along the east-trending discontinuity is undetermined, but these occurrences are strikingly similar to relationships observed elsewhere in central Nevada in proximity to strike-slip faults (Ekren, Quinlivan, and Marvin, 1974; Ekren, Rogers, and Dixon, 1973). The relationships that have been described suggest to us that the zone is a fault, probably a strike-slip fault.

MONITOR RANGE AND ADJACENT AREAS

No single east-trending fault or discontinuity comparable to the lineament between the Kawich and Hot Creek Ranges is known to occur in the ranges to the west between Tonopah and the Hot Creek-Kawich Ranges, but marked stratigraphic discontinuities strongly suggest that an east-trending lineament projects through this area. For example, near the southern terminus of the Monitor Range (pl. 1) in the vicinity of U.S. Highway 6, basalt outcrops are abundant south of about 38°07′ and are virtually absent north of this latitude (Kleinhampl and Ziony, 1967; R. E. Anderson, written commun., 1966). In addition, several large outcrops of pre-Tertiary rocks occur south of the lineament but are virtually absent to the north.

North of the lineament in the Monitor Range area, the Tertiary volcanic sequence appears to be very thick but large exotic blocks of quartzite and other Paleozoic rocks occur there that appear to be intercalated in the volcanic strata (R. E. Anderson, oral commun., 1966; F. J. Kleinhampl, oral commun., 1974; H. F. Bonham, Jr., 1975). According to Bonham the large blocks of Paleozoic rocks are as much as a city block in length; they are entirely enclosed in ash-flow tuff, and they probably owe their origin to landsliding during caldera collapse. Therefore, if Bonham's analysis is correct, the lineament coincides closely with the southern boundary of a large caldron complex (pl. 1). The boundary cannot project much farther south than the lineament because of the apparent thinness of the volcanic sequence there as indicated by the occurrence of large bedrock exposures of pre-Tertiary rocks.

TONOPAH AREA

The Warm Springs lineament is inferred to project nearly due west of the Silver Leaf mine (Hannapah mining area) to the vicinity of Red Mountain, north of Tonopah (pl. 1). In this area the lineament is expressed as the south boundary of a north-trending belt of pre-Tertiary rocks. North of the line, Mesozoic granite and Paleozoic rocks are exposed in a broad area, but to the south they are deeply buried beneath voluminous Tertiary lavas and tuffs that have been mineralized with silver ores and have been mined to depths in excess of 2,000 feet (610 m) (Bonham and Garside, 1974).

AREA WEST OF TONOPAH

West of Tonopah several options are open to the "dedicated drawer of lines." These options include the following: (1) On the basis of topography and magnetics, the lineament occupies a fairly wide zone that passes north of Lone Mountain and trends west-southwest toward Columbus Salt Marsh and Mono Lake (figs. 3, 5; pl. 1); (2) the lineament either ends at the Walker Lane west of Lone Mountain (fig. 1) or it is offset to some position north of the Columbus Salt Marsh; and (3) the Walker Lane is offset by the lineament (Albers and Stewart, 1972). If the lineament is drawn to follow the most prominent topographic break (option 1), it would parallel a set of

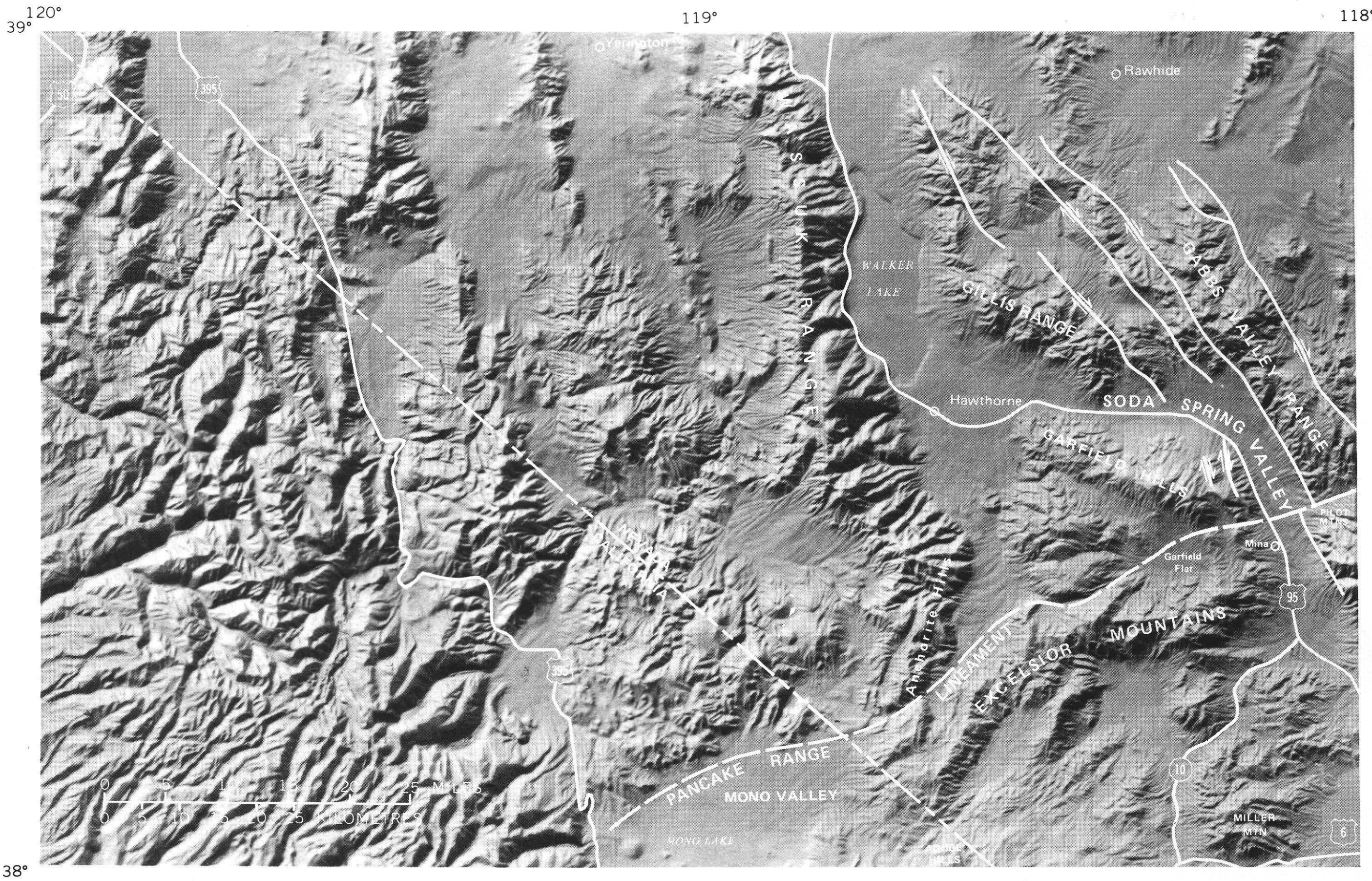


FIGURE 3. — Raised-relief map of eastern California and western Nevada showing parts of the Warm Springs, Pancake Range, and direction of relative movement along faults; dashes show traces of proposed lineaments. Base from U.S. Geological

east-trending faults at Blair Junction and in the Volcanic Hills that were mapped by Albers and Stewart (1972) and would approximately coincide with the south edge of the Adobe Hills volcanic center. Thus, most currently available evidence favors option 1, which implies no large offset by Walker Lane structures. The lineament shown on plate 1 is drawn to coincide approximately with the southern margin of the broad magnetic zone (fig. 5).

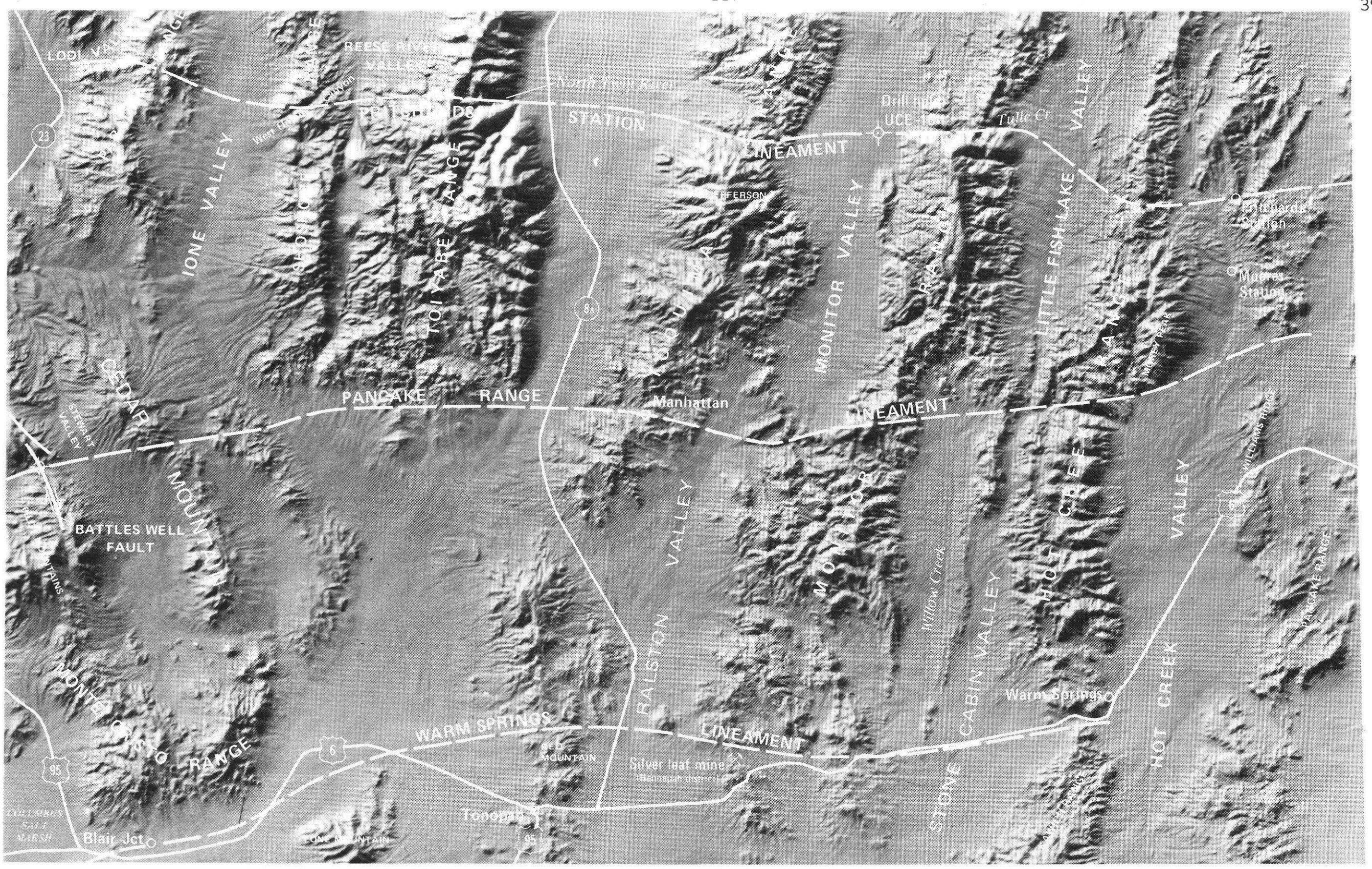
If the Walker Lane faults have large strike-slip displacements north and south of this latitude (38°), then the possibility exists that the lane itself is offset along this latitude, presumably as a result of large strike-slip displacements along the projection of the Warm Springs lineament. However, as will be explained later, this does not seem to be the case, because both the Death Valley–Furnace Creek fault zone (fig. 1) and the faults in the vicinity of Soda Spring Valley (pl. 1) appear to die out or splay out toward the proposed lineament, rather than end abruptly against it. Therefore, we do not concur with Albers and Stewart (1972, p. 42–44, fig. 9) that the Walker Lane is offset right-laterally at this latitude.

PANCAKE RANGE LINEAMENT

This lineament (fig. 1, No. 3) is partly defined by range and valley termini and shows as a distinct line on the raised-relief topographic map (fig. 3) and on Landsat photography. (See Aerial Photographers of Nevada, 1973.) In the Moores Station and Portuguese Mountain quadrangles, it coincides with a marked magnetic interruption (fig. 6). Several lines of evidence suggest that the lineament also coincides with deep-seated structural boundaries. As will be discussed on later pages, the lineament probably extends east of the Pancake Range as far as Currant, Nev. (fig. 1), and west of the Pilot Mountains as far as Mono Valley in California. The lineament is described from east to west.

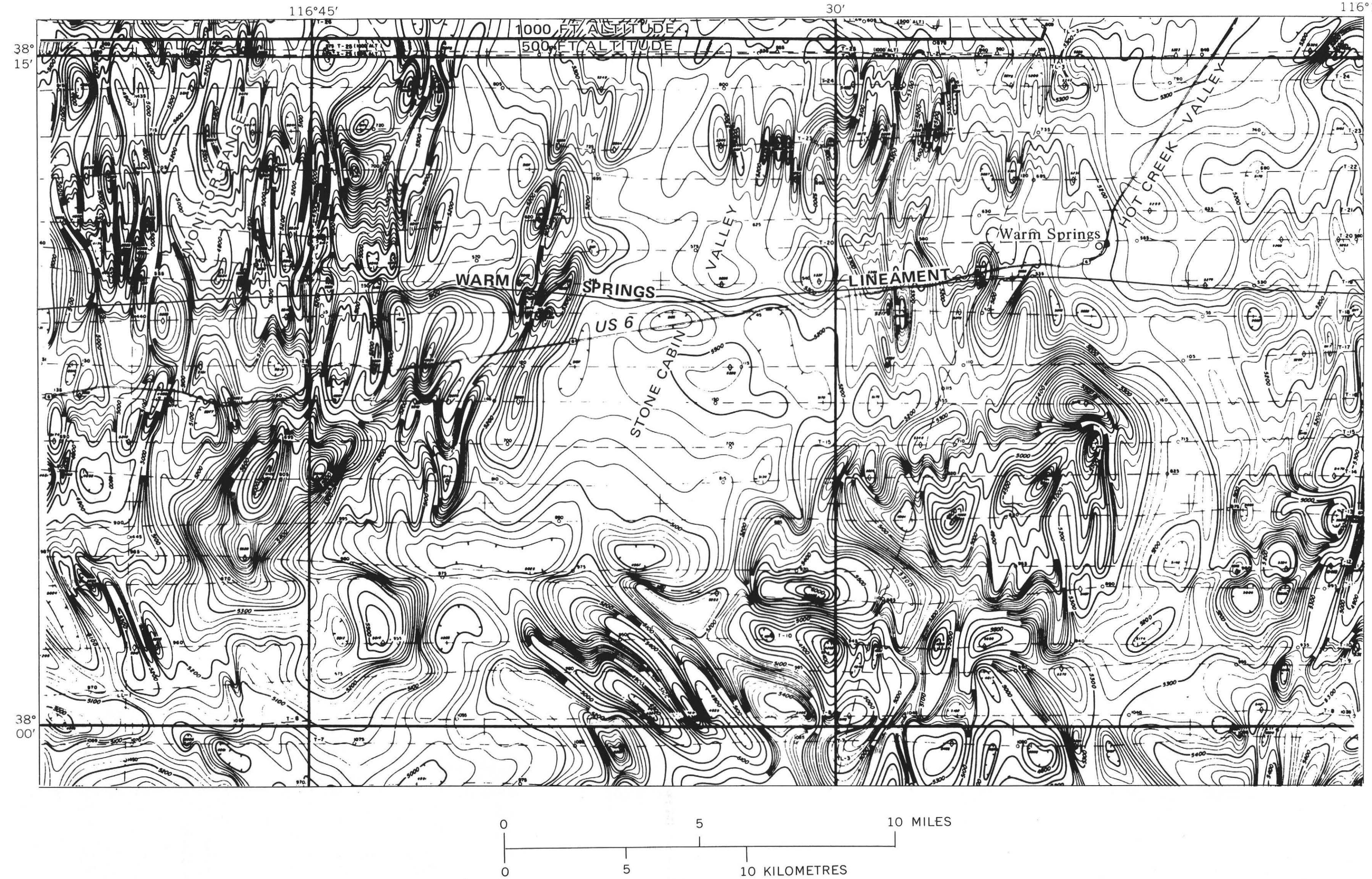
PANCAKE RANGE, MOORES STATION AREA, AND MOREY PEAK

The lineament, on the basis of both geologic and magnetic data (fig. 6, pl. 1) strikes about due west from Wood Canyon in the Pancake Range (pl. 1) through the Moores Station quadrangle (Ekren and others, 1973) to the southeast flank of Morey Peak. At



Pritchards Station lineaments. Four strike-slip faults in the Walker Lane east of Walker Lake are also shown. Arrows show Survey Walker Lake, 1957–69, and Tonopah, 1956–71, 1° by 2° topographic quadrangles, scale 1:250,000.

Wood Canyon a major east-trending fault zone places Mississippian and Upper Devonian rocks on the north against a block containing older Paleozoic rocks (Ordovician through Devonian) on the south (fig. 7). The most striking feature, however, is not the obvious stratigraphic throw across the fault zone but the marked difference in tectonic style across the zone. South of Wood Canyon the rocks are broken into a mosaic of small blocks by abundant normal faults, only a few of which are shown in figure 7. North of Wood Canyon, in contrast, few normal faults occur. Quinlivan, Rogers, and Dodge (1974; W. D. Quinlivan, oral commun., 1974) favored a strike-slip interpretation for the fault zone in order to account for the contrasting tectonic styles north and south of Wood Canyon. The strike-slip faulting occurred prior to the development of the north-trending horst that forms the backbone of the range in this area. East-trending faults are absent from volcanic rocks of late Oligocene and early Miocene age that crop out east and west of Wood Canyon. However, the east-trending aeromagnetic discontinuity (fig. 6) projects in both directions from Wood Canyon across areas occupied by these volcanic rocks. The discontinuity is defined by terminations or reductions in amplitude of various magnetic anomalies. These anomalies and their associated discontinuity perhaps could be partly induced by nearly east-west contacts between surface volcanic rocks or between these rocks and alluvium for 8–13 miles (5–8 km) east and west of Wood Canyon (fig. 7). However, no changes in rock type or character are present in volcanic rocks of late Oligocene age exposed across the discontinuity west of Wood Canyon in much of the western half of the Portuguese Mountain quadrangle. We believe, therefore, that the discontinuity must largely reflect the influence of buried igneous rocks, either older volcanics or intrusives, the distribution of which has been topographically or structurally controlled by a prominent east-trending feature continuous with the fault at Wood Canyon. The Wood Canyon fault and its buried lateral extensions in the Pancake Range thus appear to have been inactive since at least late Oligocene time, unless strike-slip movements at depth have not affected the exposed volcanic rocks.



EXPLANATION

—5500— Magnetic contours — Showing total intensity magnetic field of the earth in gammas relative to arbitrary datum. Hachured to indicate closed areas of lower magnetic intensity, dashed where data are incomplete. Contour interval 20 gammas

— — — Flight path — Showing number, location, and spacing of data

◊ Magnetic high

I Magnetic low

○ Check point

FIGURE 4. — Aeromagnetic map of the Warm Springs region showing magnetic discontinuity or interruption along the eastern part of Warm Springs lineament. From U.S. Geological Survey (1968).

A major east-trending fault in the Moores Station quadrangle occurs at about lat. 38°37′ within the Williams Ridge–Hot Creek Valley cauldron complex (Ekren and others, 1973) (pl. 1), essentially on the magnetic discontinuity, and displaces volcanic rocks of late Oligocene and early Miocene age. The fault could be a splay or an en echelon segment of the zone causing the aeromagnetic discontinuity. The aeromagnetic discontinuity extends along the southeast and south boundary of the Morey Peak resurged mass. There the anomaly is due to the southward termination of the welded tuffs of Morey Peak against Paleozoic rocks. This boundary trends nearly east-west, and, although it is undoubtedly an old cauldron wall, it is also associated, as at Wood Canyon, with a significant north-to-south change in Paleozoic rocks. Mapping by H. W. Dodge, Jr. and W. J. Carr (oral commun., 1974) indicates that several facies and thickness changes are apparent in Paleozoic rocks that are exposed north and south of Morey Peak. The most striking of these changes is the drastic thinning of rocks of Devils Gate Limestone age (Middle and Late Devonian) from 2,000 feet (610 m) north of Morey Peak to only about 100 feet (30 m) in Hot Creek Canyon, a few miles south of Morey Peak. This thinning appears to be most easily explained by strike-slip faulting, but more regional data are necessary to determine the sense and amount of displacement.

MOREY PEAK TO TOIYABE RANGE

Very little detailed geologic mapping has been done in the ranges west of Morey Peak (pl. 1), and some east-west structures may have been overlooked; however, the topographic and photographic expression of the lineament is locally pronounced. West of Morey Peak the lineament coincides with the south ends of Little Fish Lake Valley and Monitor Valley and the north ends of Stone Cabin and Ralston Valleys and Willow Creek and parallels a major east-trending fault in the Monitor Range west of Little Fish Lake Valley. R. E. Anderson (written commun., 1968) mapped this area in reconnaissance and considered that the broad bulbous part of the Monitor Range south of the lineament was a resurged segment of a large cauldron complex (pl. 1). If this is the case, the lineament coincides with the northern boundary of the cauldron segment, which appears to be outlined along half its perimeter by rhyolite domes and intrusive masses.

Near the south end of the Toquima Range the lineament has no topographic expression, but it shows as a distinct east-trending line on Landsat photography. The line appears to be due principally to contrasting colors between Paleozoic rocks to the south at Manhattan and volcanic rocks to the north. This contact zone trends nearly east-west (Kleinhampl and Ziony, 1967). Although mapped as a depositional contact rather than a fault, the contact must at least express a prevolcanic east-trending topographic high.

The lineament forms the south terminus of the Toiyabe Range (fig. 3, pl. 1), where only one east-trending fault has been mapped (pl. 1) but where other buried east-trending faults undoubtedly occur that control the range terminus. F. J. Kleinhampl and J. I. Ziony (oral commun., 1966) regard the southern domical part of the Toiyabe Range as a major center of ash-flow tuff volcanism, perhaps, in part, a resurged cauldron.

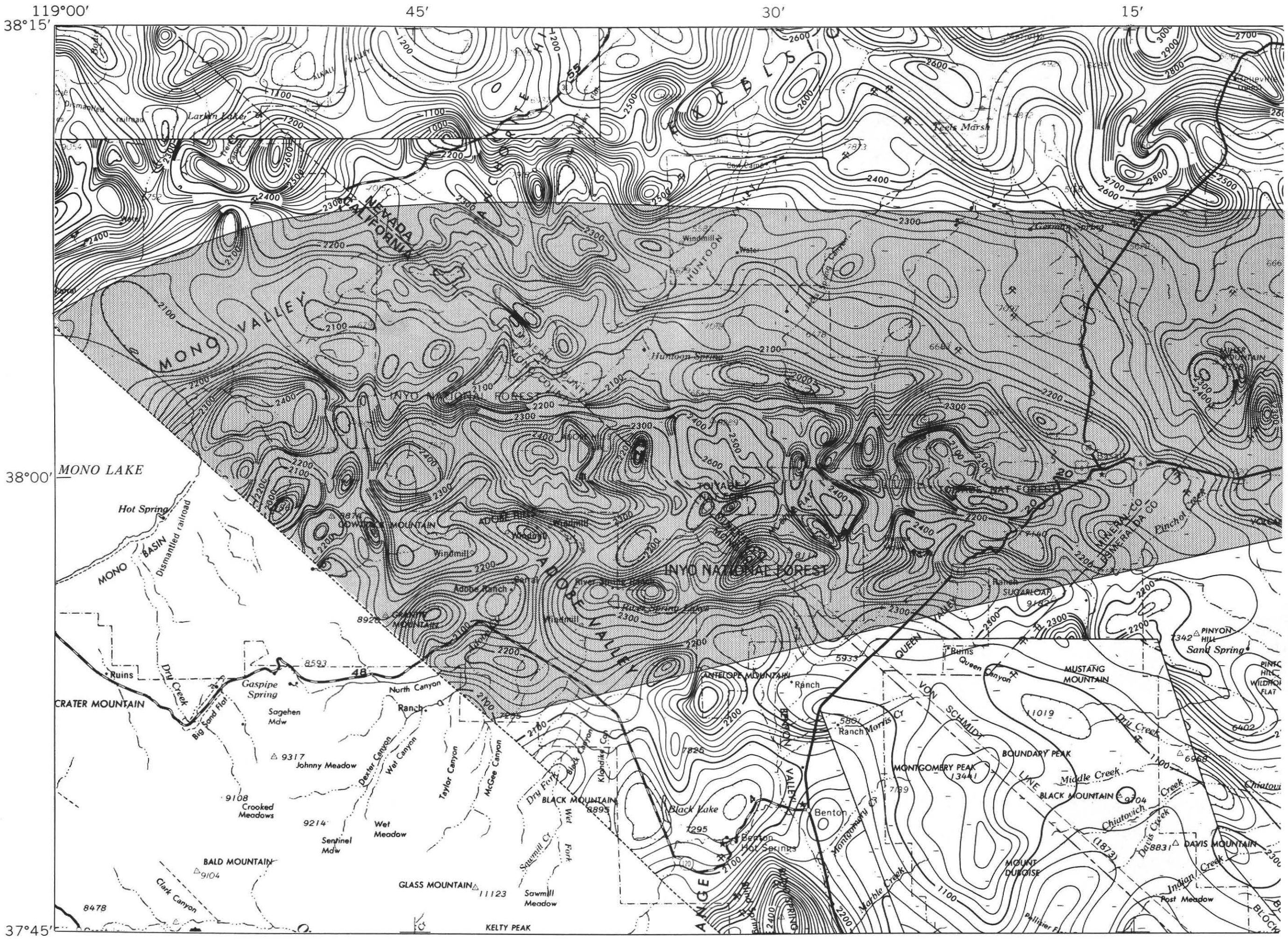
TOIYABE RANGE TO PILOT MOUNTAINS

Where the lineament projects across Cedar Mountain the range doglegs in a left-lateral sense (fig. 3, pl. 1); and the lineament separates a broad high range segment to the north from two narrow, topographically subdued segments to the south. In the vicinity of the line, both the pre-Tertiary and Tertiary rocks strike principally easterly. (Note the east-trending outcrop patterns on plate 1.)

West of Cedar Mountain, the lineament forms the east-trending topographic low between the Pilot Mountains and the Gabbs Valley Range (fig. 3; Ross, 1961). The pass is of both structural and erosional origin. Tertiary volcanic rocks, principally intermediate lavas but including a narrow zone of brecciated welded tuffs (not shown on plate 1), are faulted down in the pass against Mesozoic sedimentary rocks that make up the high rugged Pilot Mountains. Additional evidence of an east-trending structure between the Pilot Mountains and Gabbs Valley Range is found at the intersection of the lineament with the northwest-trending fault in Soda Spring Valley (pl. 1), which may be offset about 1 mile (2 km) by the lineament.

PILOT MOUNTAINS TO MONO LAKE

On both Landsat photography and the raised-relief map (fig. 3), the lineament appears to project west-southwestward from the Pilot Mountains across Soda Spring Valley and the Garfield Hills, along the northern boundary of the Excelsior Mountains, and thence through the Anchorite Hills to the north side of Mono Valley. If this is the case, the Pancake Range lineament merges with the north boundary of the broad Warm Springs lineament suggested by the magnetic data (fig. 5). This topographic and photographic lineament coincides with the northern part of a wide zone of west-southwest-trending geologic structure (pl. 1). For example, Gilbert and others (1968) have mapped



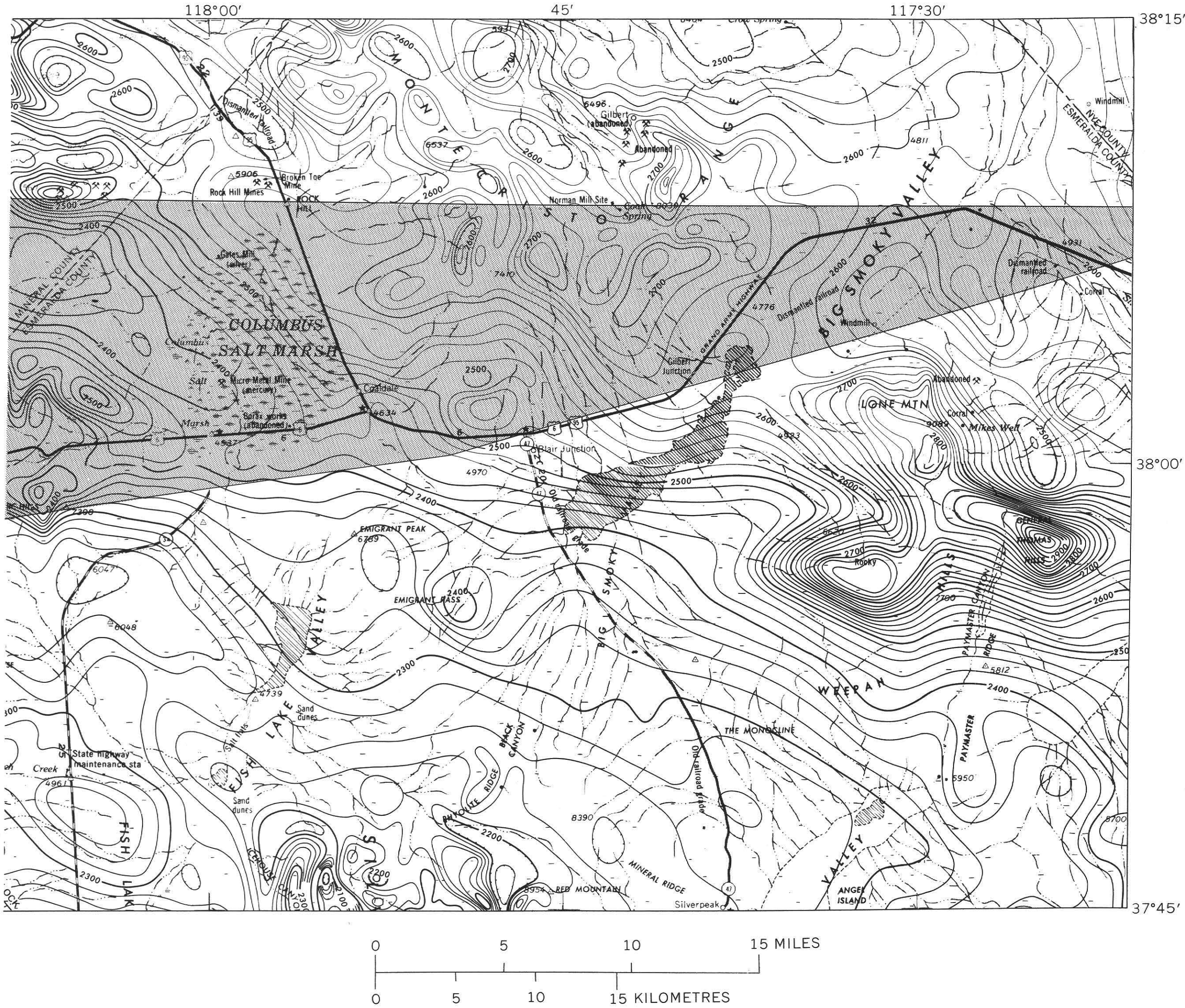
EXPLANATION

——2200—— Magnetic contours — Showing total intensity magnetic field of the earth in gammas relative to arbitrary datum. Hachured to indicate closed areas of lower magnetic intensity. Contour intervals are 20 and 100 gammas

– – – Flight path — Showing location and spacing of data

FIGURE 5. — Aeromagnetic map of the region between Lone Mountain and Mono Lake showing the westward projection of the Warm Springs lineament (patterned). From parts of three aeromagnetic maps (U.S. Geological Survey, 1971a, 1971b, 1971c).

colinear faults trending about S. 60° W. in the Anchorite Hills (pl. 1) east of Mono Lake, which they feel may have had as much as 985 feet (300 m) of left-lateral slip in the last 2.5 m.y. Along the north flank of the Excelsior Mountains, a prominent fault occurs that extends for 11 miles (17.7 km) on a trend of S. 75° W. (pl. 1). This fault has been studied recently by R. C. Bucknam (unpub. data, 1974), who determined that the fault forms rifts in basaltic andesite lava flows that have been dated at 5.6 m.y. (million years) (R. F. Marvin, written commun., 1974) and forms scarps in alluvium of probable Quaternary age. However, the occurrence of mylonite of prebasaltic andesite age in granitic rock adjacent to the fault indicates that the fault has been active for a long time. Other than the evidence of vertical movement shown by scarps in the alluvium, direct evidence of the sense of movement on this fault is lacking, but its relatively straight trace and the fact that no consistent upthrown side exists suggest that it is principally a strike-slip fault. Additional easterly and northeasterly trending fault segments and topographic lineaments (pl. 1) that probably are also strike-slip faults occur within and on both sides of the Excelsior Mountains (Ferguson and others, 1954). Correlation of the lineament with geologic features east of Garfield Flat in the Garfield Hills (pl. 1) is equivocal. The lineament, as defined, coincides with an east-trending thrust fault mapped by Ferguson, Muller and Cathcart (1954).



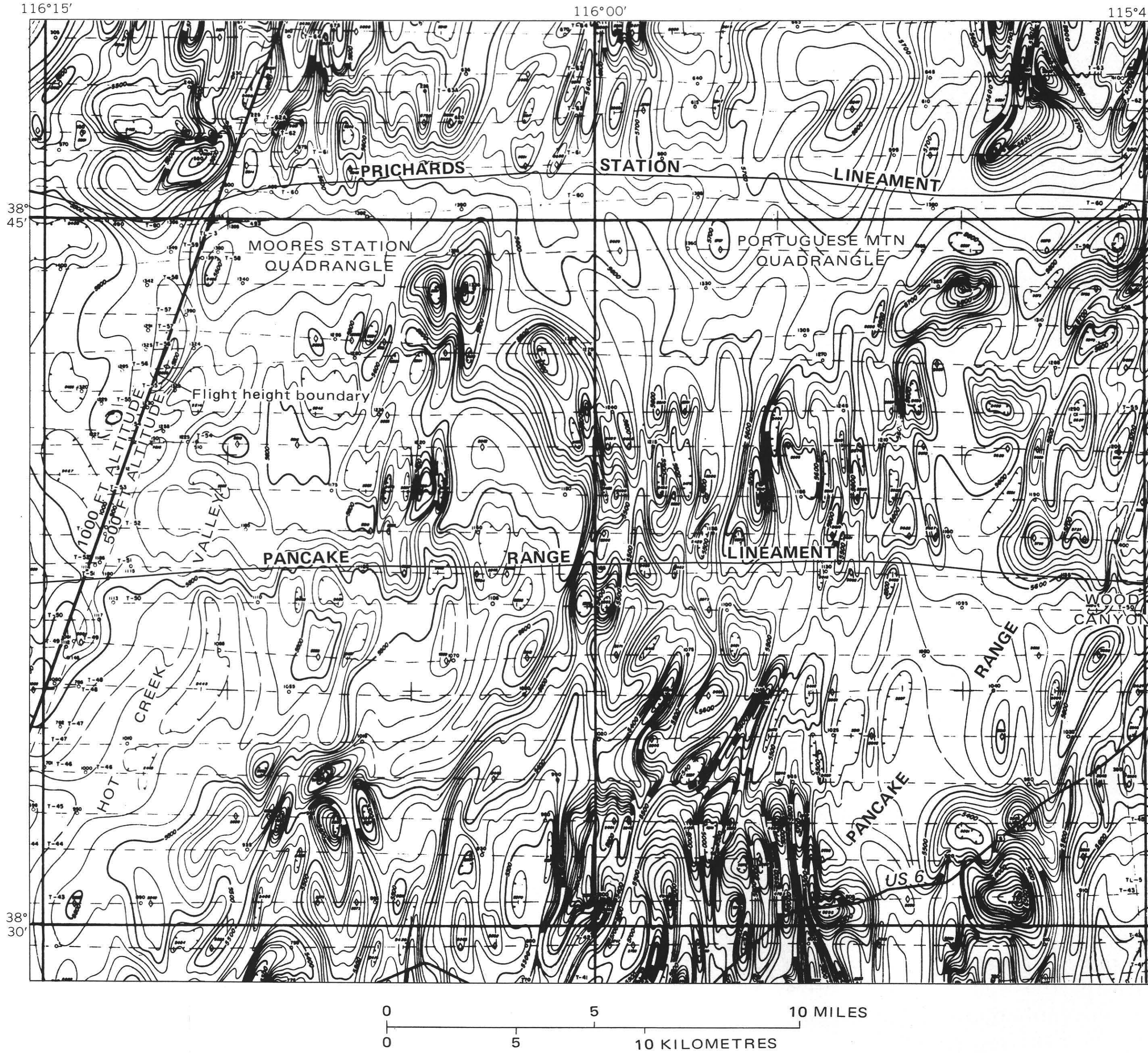
Epicenters determined by Alan Ryall and K. F. Priestly (written commun., 1974) using a dense seismograph network in the Excelsior Mountains area do not show well-defined alinements; however, composite focal mechanisms determined for the area by Ryall and Priestly and by Gumper and Scholz (1971) include an east-trending or northeast-trending fault plane having a component of left-lateral strike-slip displacement.

PROBABLE EXTENSION OF LINEAMENT EAST OF PANCAKE RANGE

We infer that the lineament extends east of the Pancake Range to coincide with faults in the Grant and Horse Ranges that occur about 7 miles (11 km) southeast of Currant (fig. 1). We suggest that the lineament there reflects several en echelon faults, including the following faults of Moores, Scott, and Lumsden (1968) (from north to south): the Ragged Ridge–Stone Cabin fault zone, the Blind Spring fault zone, and the Red Ridge fault zone. The overall strike-slip displacement along this system is left-lateral and may be as much as 5 miles (8 km). The Blind Spring fault, however, is inferred by Moores, Scott, and Lumsden (1968) to have right-lateral displacement, and this inference seems soundly based. Nearly the entire area mapped by Moores, Scott, and Lumsden (1968) appears to be strongly affected by the east-trending, strike-slip fault zones, including, in addition to the faults named above, the Currant Summit fault zone, which we consider to be an eastward continuation of the Pritchards Station lineament.

PRITCHARDS STATION LINEAMENT

This feature (fig. 1, No. 4) shows as a marked magnetic discontinuity in the Hot Creek Valley region (fig. 6), where it has been described in considerable detail (Ekren, Bath, and others, 1974); however, its expression west and east of the Hot Creek Valley region has not been described and will be briefly outlined here.



EXPLANATION

- Magnetic contours — Showing total intensity magnetic field of the earth in gammas relative to arbitrary datum. Hachured to indicate closed areas of lower magnetic intensity, dashed where data are incomplete. Contour interval 20 gammas
- Flight path — Showing number, location, and spacing of data
- ◊ Magnetic high
- I Magnetic low
- ○ Check point

FIGURE 6. — Aeromagnetic map of the Hot Creek Valley region showing the Pancake Range and Pritchards Station lineaments. The northern discontinuity is caused by the presence north of the line of thick andesitic lavas with normal polarity. These lavas are absent south of the line. The southern discontinuity cannot be explained by outcrop patterns of volcanic rocks, but it coincides locally with major east-west fault zones. From U.S. Geological Survey (1968).

The eastern part of the Pritchards Station lineament is fairly close to a marked east-trending lineament visible on the high-altitude aeromagnetic map of Zietz and others (1969), but neither this lineament nor the Pancake Range lineament to the south coincides exactly with any of the features described by Zietz and others (1969).

EXPRESSION WEST OF THE MONITOR RANGE

The Pritchards Station lineament is inferred to pass due west of Tulle Creek in the Monitor Range

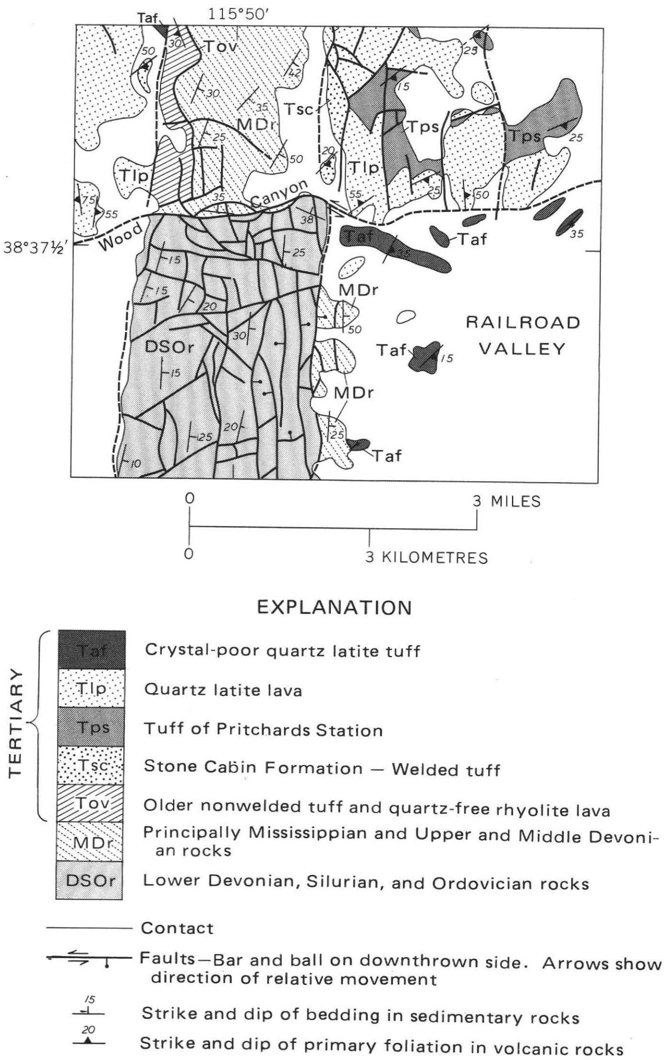


FIGURE 7.—Generalized geologic map of the Wood Canyon area, northern Pancake Range, showing contrasting structure and stratigraphy north and south of Wood Canyon. Modified from Quinlivan, Rogers, and Dodge (1974).

and projects toward drill hole UCE-16 (fig. 3), which was drilled for the U.S. Atomic Energy Commission (now U.S. Energy Research and Development Administration) in Monitor Valley. This drill hole encountered crystal-rich rhyolite at a depth of 1,471 feet (448.4 m) and bottomed in rhyolite at a depth of 4,353 feet (1,326.8 m). Rhyolite is absent in the immediately adjacent ranges and possibly is localized in Monitor Valley along the Pritchards Station lineament. The lineament crosses the Toquima Range just north of Mount Jefferson at about 38°50′ N. latitude, where there is a change in the strike of the range (from north to slightly east of north) and where the range abruptly narrows. Although no east-trending geologic structures have been mapped in this part of the range (Kleinhampl and Ziony, 1967), Mount Jefferson, a major volcanic center and possibly a resurged caldera (F. J. Kleinhampl, oral commun., 1966; D. L. Hoover, written commun., 1967), is tangent on the north to the projection of the lineament (fig. 3). In the Toiyabe Range to the west, the lineament coincides with an abrupt narrowing, a slight change in strike of the range, and an east-trending fault at North Twin River (fig. 3). This fault has about 2 miles (3 km) of left-lateral displacement according to Ferguson and Cathcart (1954). This area, however, has recently been studied by R. C. Speed (oral commun., 1975), who believes that the fault at North Twin River is the northern boundary of a caldera and is not a strike-slip fault. If this is the case, the lineament would be tangential to the north boundary of the caldera.

In the Shoshone Range, due west of the fault at North Twin River in the Toiyabe Range, an east-trending fault is present at East and West Union Canyons (fig. 3). Very large normal-fault displacement or about 1 mile (2 km) of left-lateral displacement can be inferred along this fault (Ferguson and Muller, 1949). Tertiary strata in the Shoshone Range do not appear to be displaced by this fault. Examination of the Landsat photographs suggests that the lineament projects west into the Paradise Range, where it bends northwestward, and thence into Lodi Valley (fig. 3). There are no obvious alinements of topographic or photographic features west of this area, but Bingler (1971) described an alinement of east-trending faults, small intrusives, and major metallic ore deposits extending west of Rawhide into the Mountainview district in the northern Wassuk Range (fig. 1). Possibly, therefore, the Pritchards Station lineament is continuous with the Yerington-Rawhide lineament of Bingler (1971).

EXTENSION OF LINEAMENT IN RANGES EAST OF PRITCHARDS STATION

On the basis of a marked aeromagnetic anomaly (fig. 6), we infer that the lineament continues eastward across the Pancake Range just north of 38°45′ latitude. No important east-striking faults have been mapped in this area, but the lineament in the Pancake Range separates a broad area of pre-Tertiary outcrops to the south from a broad area of Tertiary volcanic rocks to the north. The volcanic rocks north of the lineament include thick sections of andesite lavas and the Windous Butte Formation (welded tuff).

The lineament projects east of the Pancake Range and terminates the White Pine and Horse Ranges northeast of Currant (fig. 1). As mentioned previously, we infer that it coincides there with a major fault zone called the Currant Summit fault zone by Moores, Scott, and Lumsden (1968), who believed that it is (1) a wrench fault having approximately 8,000 feet (2,400 m) of left-lateral displacement; or (2) a structural discontinuity separating two areas that developed differently in response to different stress configurations.

The Currant Summit fault appears to be the easternmost obvious expression of the Pritchards Station lineament. There are no major photographic or topographic lines along the trend of the Currant Summit fault (38°48′). Widely spaced left-lateral faults span a considerable area both to the north and south of 39° latitude (Brokaw and Shawe, 1965; A.L. Brokaw, oral commun., 1974) in the Egan Range, which is east of the White Pine Range, but they are probably best interpreted as conjugate shears that formed simultaneously with right-lateral strike-slip movements (Shawe, 1965). These left-lateral faults are possibly not controlled by preexisting zones of weakness analogous to the lineaments described herein.

INTERSECTION OF THE LINEAMENTS WITH THE WALKER LANE

We have discussed the probable projections of the Pancake Range and the Warm Springs lineaments from central Nevada into western Nevada and California without consideration of their relations with the Walker Lane. We have done this because the lineaments reasonably may be projected across the lane without obvious offsets. Such a projection appears to be justified because there is little indication that any of the Walker Lane right-lateral strike-slip faults in the vicinity of the two lineaments have sufficiently large displacements to cause obvious offsets of the lineaments. For example, recent mapping by Ekren R. F. Hardyman, and F. M. Byers, Jr. (unpub. data, 1974), in the Gillis and Gabbs Valley Ranges north of Soda Spring Valley (just north of fig. 4 and within the Walker Lane as defined by Locke and others, 1940) shows that four northwest-trending strike-slip faults are present there (fig. 3), each of which has at least 1 mile (2km), and probably as much as 4-10 miles (6-16 km), of right-lateral displacement. The two westerly faults splay and die out abruptly in the Garfield Hills north of the projection of the lineament (fig. 3; pl. 1). The other two faults may die out in a similar manner, but this has not yet been conclusively determined. Nielsen (1965) theorized that one of the latter faults forms the east boundary of Soda Spring Valley (fig. 3; pl. 1), where it has a right-lateral displacement of possibly as much as 10 miles (16 km). If Nielsen (1965) is correct, then this fault in the Walker Lane should displace the lineament across Soda Spring Valley if this fault is younger than the lineament. Studies by R. C. Speed that are still in progress (oral commun., 1974), however, show that this much displacement is unlikely. Speed suggests that the pre-Tertiary rocks across Soda Spring Valley are not displaced right laterally more than a few miles. For example, the Jurassic Dunlap Formation (pl. 1) crops out in a broad arcuate belt centered on Mina in Soda Spring Valley, and this belt is not significantly offset across the valley. The Dunlap belt is considered to lie within a major deformational feature resulting from vertical rather than lateral propagation (Wetterauer, 1974). In contrast, however, the Walker Lane, as conceived of by Albers (1967), is a broad zone characterized by arcuate mountain ranges or "oroflexes," which he considered to result from right-lateral deformation. Albers (1967) and R. C. Speed and R. H. Wetterauer (oral commun., 1974) considered that the arcuate deformation (whether a result of vertical or lateral forces) is Mesozoic in age.

The fourth fault, which Nielsen termed the Batles Well fault (pl. 1), appears to project into the Pilot Mountains from the Gabbs Valley Range. Nielsen considered that this fault has at least 1 mile (2 km) of right-lateral displacement where it enters the Pilot Mountains. Recent mapping by F. M. Byers, Jr. (unpub. data, 1975), suggests that the main splay of this fault projects into Stewart Valley several miles north of the lineament and that there it has at least 2 miles (3 km) of right-lateral displacement (pl. 1). This displacement, together with the displacement of the fault at Battles Well, however, is not sufficient to offset the topographically low area that separates the Gabbs Valley Range from the Pilot Mountains.

Similarly, in the vicinity of Tonopah, Blair Junction, and Boundary Peak, no large strike-slip displacements of Tertiary age are indicated along the Walker Lane (pl. 1). The Death Valley–Furnace Creek fault zone, which we regard as part of the broad Walker Lane system, has large displacement farther south but dies out northward before the Warm Springs lineament is reached.

We speculate that the apparent lack of obvious offsets on either the Walker Lane or the lineaments in the area between Tonopah and Hawthorne could be accounted for by one or a combination of the following: (1) The Walker Lane is segmented in this area by conjugate shears (Shawe, 1965) that coincide, in part, with the lineaments; (2) some complex interaction takes place at the intersections of the structures, possibly in a manner similar to the intersection of the San Andreas fault and the Garlock fault in California or to the intersection of the San Andreas and the Mendocino escarpment in the oceanic crust; (3) fractures along the lineaments are younger than most of the northwest-trending strike-slip movements along the Walker Lane and, therefore, give rise to topographic lines that cross the lane without offset. Certainly some of the east-northeast-trending fractures are very young; for example, faults along the north and south flanks of the Excelsior Mountains that displace basaltic andesite dated at 5.6 m.y. and alluvium of probable Pleistocene age. Significantly, seismicity is currently concentrated in an east-northeast-trending belt between the two lineaments (Gumper and Scholz, 1971).

When more facts are in hand, it probably can be demonstrated that the two systems in the Walker Lane region tend to offset one another and are thus part of a conjugate system. In any case, the structural block roughly bounded by the Pancake Range lineament on the north and the Warm Springs lineament on the south did not favor throughgoing strike-slip faults of the northwest-trending Walker Lane system.

SUMMARY AND DISCUSSION

We believe the evidence presented in this report shows that an important series of east-northeast-trending structural lineaments is present in south-central Nevada. In most areas the lineaments appear to predate the Tertiary volcanism, but, locally, they have controlled the location of Cenozoic volcanic centers and faulting and probably influence the location of current seismicity. The presence of these lineaments athwart the major structural grain of the Great Basin and their possible continuity across the Walker Lane raise important questions about the tectonic framework of the entire region.

It seems relatively certain that the Nevada lineaments are an expression of fairly old, probably pre-Oligocene, structural trends. Most of the observed magnetic anomalies can reasonably be attributed to the deposition of volcanic rocks against easterly trending topographic highs, to the juxtaposition by faulting of rocks having different magnetic properties, or to plutonic rocks intruded into structures within the lineament trend. The tangential association of volcanic centers with the lineaments also implies a deep-seated crustal control. The authors speculate that the apparent outward spread of volcanism from a "core" area in central Nevada (Armstrong and others, 1969) may actually have occurred in a series of 30–60-mile (50–100-km)-wide belts bounded and controlled by the lineament system described in this paper. J. H. Stewart, W. J. Moore, and Isidore Zietz (written commun., 1975) have independently reached similar conclusions regarding the control of east-trending belts of volcanic strata and intrusive masses. The lineaments and belts between them have trends that are nearly at right angles to the axes of Miocene volcanism proposed by Noble (1972). It seems possible that the general southwestward migration of volcanism with time (Noble, 1972) in the southern Great Basin may have been a progression of diapirs or mantle plumes tracking already established deep-seated structural discontinuities. The distinct tendency toward younger faulting at the west and southwest ends of the lineaments near or west of the Walker Lane agrees in general with the southwestward decrease in the age of silicic volcanism. The onset of basin and range faulting throughout the Great Basin, however, appears to have been virtually simultaneous (Ekren, Bath, and others, 1974).

Whether the lineaments are partly a result of conjugate faults developed at the inception of the Walker Lane and other major northwest-trending faults in the southwestern Great Basin, or whether they owe their origin to an even more regional or even continentwide fracture system is an unresolved question. In any case, their presence should be considered in future attempts to integrate plate tectonics, local structure, and volcanism in the Great Basin.

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