Blank = Tertiary and Quaternary

Ji = intrusives

Jd = Dunlap fm.

$\overline{R}$J = Gabbs + Sunrise fms.

$\overline{R}$l = Luning fm.

$\overline{R}$e = Excelsior fm.

$\overline{R}$g = Grantsville fm.

$\overline{R}$c = Candelaria fm.

Pv = Permian volcanics

Pq = Quartzite and slate

Dl = Devonian limestone

Os = Ordovician slate, limestone, chert

Єq = Quartzite, limestone, slate

they do in the northern part of the Pilot Mountains. The East Ridge thrust lacks the "thrust conglomerate" which is so prominent along the plane of the New York Canyon thrust, but if this conglomerate depends upon the coincidence of accidents of topography and intermittent movement on the thrust, it could not be expected to occur along all parts of the thrust plane.

Later folding and tilting.—The thrust plane appears to have been somewhat deformed after movement along it ceased, and prior to the Tertiary faulting and tilting. The change in dip, from northward on Volcano Peak to southward at the south end of the fenster (pl. 5), was possibly accentuated by tilting associated with Tertiary movement but may be largely due to the impeding of forward movement in this sector. Or the change in dip may be coincident with the emergence of the thrust plane at the surface, as suggested by the presence of the thrust conglomerate at the southern border of the fenster (p. 26).

In the region south of Sunrise Flat there has been warping distinct from Tertiary tilting. South of the flat and just east of the overlapping Tertiary lava, the sharp southward reëntrant of the outcrop of the thrust marks the position of a gentle fold. East of the southern end of Sunrise Flat, the outcrops of the eastern segment of the thrust, here two parallel thrust planes a few feet apart, bend at nearly right angles, and the planes are irregularly crumpled and fluted. Above the upper plane the dolomite of the Luning formation, though crumpled close to the thrust, seems in general to be folded with the thrust. It is possible, however, that Tertiary tilting may have played some part, accentuating the eastward dip of the lower plane by tilt of the uplifted fault block.

The southward decrease in altitude of the outcrop of the thrust, in the western part of the range, however, corresponds closely with the gentle south to southwest dips of the overlying Tertiary lava.

In the central part of the range, a fault which continues the direction of the fault scarp bordering the range to the south, crosses the range diagonally (pl. 1). Within the range, however, Tertiary rhyolite lies northeast of the granodiorite along the southeastern part of the fault. Although the net stratigraphic downthrow therefore is to the northeast, the fault line is marked by a steep southwestward-facing scarp of pumiceous rhyolite. As the rhyolite is more readily eroded than the granodiorite, it is improbable that the scarp is a reversed scarp due to erosion.

It seems reasonable to suppose that the relative positions of rhyolite and granodiorite are a result of dominantly horizontal movement on the fault, the northeast block moving to the southeast. If this possibility were susceptible of definite proof, it would furnish evidence for late Tertiary movement on the inferred Soda Spring Valley flaw.

The present relations may, however, also be explained by inferring two periods of movement along the fault—an earlier movement that resulted in downthrow on the northeast and a later one in downthrow on the southwest to a smaller extent—sufficient to give the present topographic expression and to continue the fault scarp of the Gabbs Valley Range. The position of the andesite that flanks the eastern slope of the range, east of the fault, accords with this explanation; but, as the surface on which the andesite was erupted is highly irregular, it is not conclusive.

PILOT MOUNTAINS

The Pilot Mountains contain a large area of essentially unmetamorphosed Mesozoic rocks. The steep scarp on the western front and the deep dissection in the central part of the range offer exceptional opportunities for study of the complex folding and thrusting near the margin of the Luning embayment.

The east and west fronts of the range are steep fault scarps, that on the west is higher and probably the more recent. The central part of the range is cut by Dunlap and Cinnabar Canyons and their tributaries. These drain northwestward to the low gap between the Pilot Mountains and Gabbs Valley Range. South of the heads of these canyons a high ridge culminates in Pilot Peak. The range is horseshoe-shaped, open to the north; and the arms will be referred to as the East and West Ridges and the base, as the South Ridge.

The geology of that part of the range north of the Excelsior contact, including roughly the East and West Ridges and parts of the South Ridge, was mapped in some detail; but, except for two traverses south from Pilot Peak, the southern part of the range is known only from reconnaissance.

ROCKS EXPOSED

Excelsior formation.—The Excelsior formation occupies the entire southern part of the range and occurs in small thrust wedges in the complex northwestern part. The main mass of Excelsior consists essentially of dark massive chert, fine-grained silicified tuff interbedded with coarser tuff, and a little dark tuffaceous sandstone (pl. 6*B*). The thickness is uncertain, but 10,000 feet is probably a minimum estimate. Greenstone, greenstone breccia, and felsite are present in some places and for the most part, underlie the chert and tuff. Diabase dikes and sills and a few basic intrusive rocks cut the Excelsior but do not cut the Luning and higher formations. The thrust wedge of Excelsior north of Mac Canyon is composed of greenstone, greenstone breccia, and a little bedded tuff but contains no chert.

Luning formation.—The Luning formation occupies the northern part of the range and includes two limestone units, each about 2,500 feet thick, separated by a slate and conglomerate unit having a maximum thickness of about 3,000 feet. The upper massive dolomite elsewhere present at the top of the Luning is not present in this range, and such dolomite as is present in the upper limestone is probably the result of secondary alteration. A few slate belts occur in the upper limestone. The character of the rocks in the different thrust plates varies slightly.

Sunrise formation.—The Gabbs formation, which normally overlies the Luning, does not crop out in the Pilot Mountains, and the only exposure of the younger Sunrise formation is a small area in the lower part of Mac Canyon below the folded Mac thrust. The rocks are thin-bedded limestone underlain by dark slate. The total thickness exposed may be 600 to 800 feet.

Dunlap formation.—The lower part of the Dunlap formation consists of red cross-bedded sandstone and a varying amount of chert conglomerate which is most abundant near the unconformable contact with the Excelsior formation and is also present in small lenses throughout the sandstone. In contrast to the thick section of volcanic rocks in the Dunlap of the Gabbs Valley Range, only a little greenstone and greenstone breccia is found in the upper part of the sandstone in the Pilot Mountains. Beds and lenses of dolomite and limestone at and near the top of the sandstone, though not continuous, probably mark approximately a single horizon. The upper part of the Dunlap consists principally of coarse conglomerate largely composed of limestone and dolomite pebbles derived from the upper unit of the Luning formation. There is similar conglomerate along the plane of the overturned Mac thrust, which carries the upper unit of the Luning above the Sunrise. The thickness is highly variable; as much as 5,000 feet may be present in the vicinity of Dunlap Canyon, with the upper part concealed beneath the overthrust Luning.

Intrusive rocks.—Granitic rocks occupy a relatively small area in the Pilot Mountains. Several masses, chiefly of granodiorite, cut the Excelsior on the west flank of the range and the Luning on the east flank. Dikes of aplite in places follow the thrust planes, and small masses of aplite cut the Excelsior and Dunlap on the west front of the range and near the head of Dunlap Canyon. A dike of peridotite, less than 100 feet wide and cutting both aplite and granodiorite, was traced southward from the head of Mac Canyon 2¼ miles across the granodiorite south of Spearmint Canyon.

STRUCTURE

The structure in the Pilot Mountains is the most complex in the area. The writers are by no means confident that they have everywhere reached the correct explanation. Each time during several field seasons that the area was revisited, new complications were discovered, and restudy of previously mapped areas brought new interpretations.

The Excelsior formation of the South Ridge was strongly folded and overturned to the north prior to the warping and sinking that permitted the deposition of the Luning, Gabbs, and Sunrise formations. The lower part of the Dunlap formation was deposited in a basin, which overlapped the contact of Luning and Excelsior. The beginning of the Jurassic folding was marked by the formation of a local trough within this basin. This trough received the conglomerate and fanglomerate from the rising folds and incipient thrusts to the north. Apparently local deepening of this trough accompanied the early folding and thrusting in the area now included in the northwestern part of the range. The earlier folds and thrusts, including the Mac and Spearmint thrust planes (pls. 3, 7, 8), were themselves strongly folded by pressure from the north that developed a large recumbent fold and additional thrusts in the hills north of Mac Canyon. This folding and thrusting appears to have been local and determined by the position of the trough that received the detritus from the Luning formation on the north while the early folding and thrusting were in progress. The deformation may have been complicated by irregularities in the original surface of deposition, as suggested by the mass of Excelsior north of Mac Canyon.

It is believed that the northwestern part of the range, compacted by early close folding, was uplifted and acted as a partial obstruction to later more widespread folds. This obstruction forced the folds to deflect around it thus changing their trends and resulting in local overturn to the north near the mouth of Dunlap Canyon. The Dunlap Canyon and South Fork thrusts were later than a part of this folding, but the Dunlap Canyon thrust plane is folded along the same general trends as the folds in its upper plate. The amount of movement on these thrusts is probably not large, as the rocks involved do not show any differences in facies. The Cinnabar Canyon thrust appears to be later than the early folding and thrusting; and, like the Garfield Flat thrust in the Garfield Hills, it carried rocks previously thrust and folded, southward against the marginal Excelsior and Dunlap.

The East Ridge thrust, of later date and greater magnitude, brought gently and regularly folded Luning above the Cinnabar Canyon thrust block. The uplifted area of more complex folding on the northwest, seems to have forced the thrust to move along an irregular plane locally steeply inclined. The more westerly segments which moved southward at higher altitudes are now removed by erosion.

Granitic intrusion was confined to the east and west flanks of the range and had no apparent effect on the structure.

Faults of Tertiary and later age are present on the east and west fronts and in part bound the older rocks on the north. To some extent movement along faults initiated during the Jurassic folding may have been renewed in the Tertiary.

The structural history of the range will be described in the following approximately chronological order: (1) The pre-Jurassic folding of the Excelsior of the southern part of the range; (2) the deposition of the Dunlap sediments; (3) the early folding and thrusting in the northwestern part of the range; and (4) later thrusting.

PRE-JURASSIC FOLDING

Both the Luning and Dunlap formations overlie the Excelsior with a high degree of angular unconformity. The Luning on the west front of the range, south of Spearmint Canyon (pls. 7, 8), dips from 50°–70° N., whereas the dip of the underlying chert of the Excelsior formation varies from 80°–65° S. On the northern flank of the South Ridge the prevailing dip of the Dunlap formation near the Excelsior contact is to the northeast and the underlying Excelsior dips irregularly but in the vicinity of Pilot Peak generally to the south; therefore if the original condition that existed during the Dunlap sedimentation were restored, the Excelsior near the contact would dip more steeply.

Traverses from Pilot Peak southward revealed that the folds in the Excelsior formation generally trend east. The principal syncline is overturned to the north (pl. 2, sec. *H–H′*), in contrast to the southward thrusts and associated folds in the Luning formation.

DEPOSITION OF THE DUNLAP SEDIMENTS

The sediments of the Dunlap formation record the first stages of the Jurassic diastrophism. The widespread basal conglomerate composed of chert pebbles indicates that the lower part of the Dunlap was derived from the Excelsior rocks, which lay to the south. The basal conglomerate ranges in thickness from a few feet to more than 200 feet, and lenses of chert conglomerate occur throughout the lower part of the formation.

Near the contact the attitude of the Dunlap parallels the trend of the contact, but exceptional clifflike exposures in which angular talus at the base of the Dunlap border steep north trending segments of the contact suggest that the basin in which the Dunlap was deposited was deepened in places by faulting transverse to the general westerly trend.

The thin beds of marine limestone and dolomite near the top of the sandstone appear to mark roughly a single horizon. If so, the amount of the depression must have varied greatly, for the underlying sandstone attains a thickness of 2,500 feet or more on the West Ridge (pl. 7), whereas, 3 miles east at the head of Cinnabar Canyon, only 700 feet of sandstone underlies 500 feet of interbedded limestone and sandstone.

The beginning of folding to the north is reflected in the change in character of the Dunlap above the limestone horizon. The material that forms the conglomerates and fanglomerates of the upper part of the Dunlap is largely derived from the Luning. The rising folds of the upper limestone of the Luning formation, from which the overlying rocks had been eroded, and the thrusts toward the trough yielded the coarse material which makes up the upper part of the Dunlap. Conditions were presumably similar to those in the southeastern Garfield Hills, but in the Pilot Mountains the depositional contact of Luning and Dunlap is concealed by later thrusts.

Folding was less intense in the area underlain by Dunlap than it was to the north. The upper conglomerate of the Dunlap outlines two northwesterly synclines, with superposed minor folds. Overturned folds are confined to the vicinity of the overriding thrust plates, and in general the dips become more gentle to the south, near the Excelsior contact.

EARLY JURASSIC FOLDING AND THRUSTING

Outline of structural development.—The northern part of the Pilot Mountains (pls. 3, 7, 8) consists of a succession of thrust plates, each containing folded rocks, chiefly of the Luning formation. The structure of individual plates becomes increasingly complex downward.

This early folding and thrusting was the result of pressure from the north and is correlated with the local development of the trough in which the upper conglomeratic part of the Dunlap formation was deposited. The great thickness of conglomerate derived from the north indicates that sedimentation in this trough went on at an accelerated rate during the early stages of folding and during the early thrusting on the Mac and Spearmint thrusts. Initial folding of the thrusts, which moved over erosion surfaces, must have taken place under a very shallow cover. Erosion during folding and thrusting of the massive upper limestone and dolomite units of the Luning formation, yielded the conglomerates of the upper part of the Dunlap in the trough to the south. The shale and shaly limestone of the overlying Gabbs and Sunrise formations did not yield recognizable fragments.

The Mac thrust carried the gently folded upper limestone and slate members of the Luning above an erosion surface cut on the Sunrise formation, itself folded and broken by a minor thrust. The warping of the plane of the Mac thrust, as the Dunlap trough continued sinking, and the accumulations of debris in front of the thrust eventually prevented further movement. A new break formed further to the north along which the

Spearmint thrust carried the lower limestone of the Luning and slices of the overlying Excelsior basement over the new erosion surface.

Probably the recumbent fold in the upper limestone of the Luning and its accompanying thrusts were developed when the folding, which buckled the Spearmint thrust (pls. 7, 8), had compacted the area between the Mac and Spearmint thrusts, forcing the development of new folds just to the north. The actual involution that caused the peculiar reversal of dips was presumably later, possibly contemporaneous with the compression that resulted in the formation of the Northwest thrust.

The mass of greenstone of the Excelsior formation north of Mac Canyon may have been a contributing factor in the localization of this complex structure. If, as is likely, the Excelsior basement was an irregular surface at the time of Luning deposition, protuberances of Excelsior would have been sheared off by the early thrusts and these less compressible masses would locally complicate the structure. The resistance to folding offered by such a mass as that north of Mac Canyon may have caused the formation of the Northwest thrust.

The total shortening of the rocks north of Spearmint Canyon cannot be determined but must amount to several times the present width of the area (pl. 3). The extreme compression was confined, however, to a relatively narrow belt. Tertiary and Pleistocene lava and gravel conceal the older rocks north of the area mapped; and the nearest outcrop of Mesozoic rocks to the north is 5 miles away, in the New York Canyon area of the Gabbs Valley Range where the upper plate of the New York Canyon thrust, which is probably equivalent to the East Ridge thrust of the Pilot Mountains, covers most of the exposed area. The rocks below the New York Canyon thrust are not greatly folded, however, and the Dunlap rests on the Sunrise with only moderate erosional unconformity. It is inferred, therefore, that intense compression was largely localized and that the roots of the folds and thrusts are concealed under the lava and gravel in the area between the northwestern part of the Pilot Mountains and the southern part of the Gabbs Valley Range. Movement on individual thrusts was probably small, possibly a few miles at most.

Mac thrust.—The Mac thrust, which brings the Luning above the Sunrise near the mouth of Mac Canyon and above the Dunlap in the small fensters a mile to the east, is folded into a closely compressed and overturned anticline. On the north wall of the canyon the upright part of the thrust plane dips north; but about half a mile above the mouth the plane bends sharply (pls. 6*C*, 9*A*), and on the south wall of the canyon the thrust plane is nearly vertical close to the bend but is overturned as much as 40° N. near the canyon mouth.

There is conglomerate derived from the now overturned Luning between the Luning and Sunrise formations indicating that the overturned thrust plane was originally an erosion surface. This "thrust conglomerate" (pl. 9*B*) consists of dolomite pebbles similar to those in the conglomerate in the upper part of the main mass of Dunlap a mile to the southeast, and lacks pebbles derived from the Sunrise formation. The conglomerate is sheared but is not faulted at the contact with the Luning, and in only a few places is there shearing at the contact with the underlying Sunrise formation. The pebbles, though closely pressed together, are not stretched. For the most part bedding planes are lacking, but in places lenses of sandstone indicate a dip essentially parallel to the thrust plane, contrasting with the complexly folded Luning, which has overridden the conglomerate but now lies beneath it.

This gravel must have lubricated the movement of the upper plate, for where the conglomerate is lacking, the dolomite close to the thrust is minutely fractured (pl. 9*C*). Where there is conglomerate along the thrust, the bedding of the dolomite is well preserved though occasional dikelike apophyses of sand and small dolomite fragments have been injected several feet into fractures in the dolomite (pl. 9*B*). Some movement may have occurred along the irregular shear planes within the conglomerate, but for the most part, the rolling and dragging of unconsolidated gravel have left no evidence of movement. There is also local shearing between the conglomerate and the Sunrise formation of the lower plate, but no continuous fault contact. No evidence is found here, as in the Gabbs Valley Range, of periods of forward movement alternating with periods of erosion. The present distribution of the conglomerate must have been determined by accidents of the prethrust topography and of the varying speed of movement of the upper plate. The "thrust conglomerate" crops out continuously from the thrust contact of Luning and Sunrise on the south wall of the Canyon, southward and up the ridge nearly to the crest. Its presence south of and above the outcrop of the Sunrise formation of the lower plate thus indicates the degree of overturn of the fold in the Mac thrust as well as the position of the crest of this overturned fold. "Thrust conglomerate" is also exposed in two small fensters in the Mac thrust 4,000 to 5,000 feet from the mouth of Mac Canyon.

The Sunrise formation below the thrust is folded, approximately parallel with the thrust, into a steep anticline that is broken by a thrust on the northern limb.

Stratigraphically the upper limestone unit of the Luning in the upper plate and the Sunrise formation in the lower plate are only a few hundred feet apart, but the total movement on the thrust presumably exceeds the distance represented by the folded thrust plate exposed in Mac Canyon and the length from north to south of the portion of the upper plate exposed between Mac and Spearmint Canyons.

The upper limestone unit of the Luning, which forms the upper plate of the Mac thrust, is overridden by later thrusts, so that on the north side of Mac Canyon a small sliver only is exposed (pl. 9*C*). South of Mac Canyon, complexly folded Luning underlies most of the hill between the mouths of Mac and Spearmint Canyons (pl. 6*D*). For the most part the Luning consists of the upper limestone unit containing much dolomite, probably largely secondary, and several bands of slate. The slate unit of the Luning formation, which is distinct from the small bands of slate within the upper limestone unit, crops out in three tightly folded bands between the Mac and Spearmint thrusts. These outcrops mark the crests of anticlines modified by subordinate thrusts. Elsewhere, lack of identifiable key beds prevented the deciphering of the structure of the highly folded limestone, and scattered observations of attitude cannot be correlated satisfactorily.

Spearmint thrust.—The Spearmint thrust carries the greenstone of the Excelsior formation and the lower limestone unit of the Luning above the upper limestone in the upper plate of the Mac thrust; the plane is also folded, though less closely than that of the Mac thrust and not symmetrically with it (pl. 8). On the low ridge between the forks of Mac Canyon the thrust plane is overlapped by the Dunlap Canyon thrust, but near the head of Mac Canyon the plane bends but much less sharply than the Mac thrust. South of this bend across the ridge between Mac and Spearmint canyons the thrust plane holds a fairly straight course, the easterly dip steepening to vertical south of the crest. Near Spearmint Canyon the strike changes sharply to the west, and the steeply overturned plane dips to the north (pl. 9*D*); and on the cliff facing Soda Spring Valley the upper plate contains greenstone of the Excelsior overlain by the lower limestone unit of the Luning.

On the divide between Mac and Spearmint Canyons there are at least two nearly parallel thrust planes so that the lowest unit in the upper plate is a complexly sheared narrow belt of the lower limestone overthrust by the greenstone. Where the Spearmint thrust crosses the low ridge between the forks of Mac Canyon it overrides minutely contorted sandstone of the Dunlap formation containing a little conglomerate (pl. 10*A*), which is unconformable on the Luning of the lower plate. The intricate contortion suggests that the sandstone was unconsolidated at the time of movement along the thrust.

In a north-south direction the maximum extent of the exposed portion of the lower plate of the Spearmint thrust exceeds 6,000 feet, and movement must have been much greater than this because greenstone of the Excelsior and the lower limestone of the Luning formation are thrust over the upper unit of the Luning.

The inferred development of the Mac and Spearmint thrusts is shown diagrammatically in plate 3. It is believed that, as the upper plate of the Mac thrust moved southward into the trough in which the Dunlap sediments were being deposited, continued depression of the trough, accumulation of waste in front of the thrust plate, and uplift at its northern border combined to warp the plane so that further movement became impossible. Compression was contemporaneous with the depression of the trough, and a new break, the Spearmint thrust, was formed, extending from the north limb of the folded Mac thrust to the surface. Starting on this fracture, the Spearmint thrust moved southward over the erosion surface cut on the upper plate of the Mac thrust until it too was folded and new thrusts formed to the north. Thus, if the Dunlap trough were being constantly deepened and received the sediments from the thrust plates as they moved southward, these thrusts probably "bogged down" within the Dunlap trough and never reached the "buttress" of chert of the Excelsior formation. Consequently, the pressure was relieved first by folding and later by the formation of higher thrusts.

The Mac and Spearmint thrusts crop out close together on the north wall of Mac Canyon, so that west of the sharp bend in the Mac thrust, there is only a thin sliver of the much fractured upper unit of the Luning formation (pl. 9*D*). This pinches out to the west near the mouth of the Canyon where the Spearmint thrust merges with the Mac thrust and brings greenstone of the Excelsior in contact with the Sunrise formation of the lower plate of the Mac thrust.

Above the Spearmint thrust on the north wall of the Mac Canyon the greenstone of the Excelsior is faulted against the lower limestone of the Luning. The fault dips steeply to the east and must be a tear fault as it does not cut the underlying Spearmint thrust (pls. 7, 8). On the west and north, the Excelsior is overlain by the lower limestone of the Luning on a normal unconformable contact.

Northwest thrust.—The area north of Mac Canyon, including the range front on the west and the 6,500-foot hill north of the head of the canyon on the east, consists of two thrust slices separated by the Northwest thrust. The rocks in both plates are folded, those of the upper plate to an unusual extent, but the thrust plane does not show the extreme folding which characterizes the underlying Mac and Spearmint thrusts.

Except for the greenstone of the Excelsior and the small sliver of slate of the Luning above the Spearmint thrust, the lower limestone unit of the Luning forms the exposed portion of the plate below the Northwest thrust. The thin-bedded limestone east of the tear fault is highly crumpled and fractured, and its structure is not determinable.

The Northwest thrust in general strikes west, and at the outcrop dips gently north. Along the western part of its outcrop the slate unit of the Luning formation is thrust over the lower limestone. To the east limestone is on both plates so that the plane cannot be traced eastward with certainty. It is probably overlapped by the Dunlap Canyon thrust (pls. 7, 8).

The thrust plane is broken into three segments by two faults, which strike north-northeast and dip steeply west. The plane of the eastern fault is well exposed and shows grooves that pitch 65° SW.; but the relation of the displacement of the overturned upper limestone in the upper plate to the apparent offset of the gently dipping thrust plane is such that it appears very doubtful if the major movement, particularly along the western fault, could have been in this direction. It seems likely that these breaks originated as tear faults in the upper plate of the Northwest thrust, and that the grooves resulted from more recent movement. A well-developed fault scarp fronts the range southward from Mac Canyon, and small scarps were observed also in the gravel bordering the range front. North of the area shown in plate 7, the scarp in the tilted Pleistocene gravels bordering the range is a prominent feature of the topography; however, no recent faulting along the range front between Mac Canyon and the northern limit of the mapped area is indicated. Therefore, Tertiary and later movement along this part of the range may well have followed those existing faults that were favorably alined.

The upper plate of the Northwest thrust consists of highly folded upper limestone and slate of the Luning formation. The outcrops of the upper limestone mark the crest of an involuted fold, that is, the trough of a recumbent syncline, which has been so rotated by later folding that it now appears as an anticline in part upright and in part overturned to the south. The upper limestone on the 6,500-foot hill dips beneath the slate except for a short distance along the southern border where the dip is about vertical. In places the beds are overturned to as much as 10° from horizontal. In the two segments to the west, the upper limestone dips beneath the slate on the north but is thrust over the slate on the south. These thrusts are probably small, as there is no appreciable break in the normal stratigraphic sequence. The degree of overturn decreases eastward and the gentle overturned dips steepen eastward from the 6,500-foot hill and approach the vertical at the contact of the slate and lower limestone. This steepening of dip in part may be due to later upwarp superposed on the earlier folds.

The lower limestone on the ridge north of the upper part of Mac Canyon, just above the Northwest thrust, is overturned along its western and part of its northern border and the slate member dips beneath the limestone, possibly marking the position of the complementary involuted anticline.

The apparent variation in thickness of the slate unit as measured in different directions from the outcrop of the upper limestone on the 6,500-foot hill must be due to flow, disharmonic folding, and minor thrusting within the slate. On the top of the 6,500-foot hill, individual conglomerate beds in the slate unit can be traced around and parallel to the contact of the upper limestone. On the south side of the hill, where the attitude of the lower contact changes from overturned to normal and again to overturned, the conglomerate beds are irregularly spaced within the slate. Two beds close together in one place, if traced a short distance, may be several hundred feet apart. Similarly the individual beds are discontinuous and appear to have been broken apart when the more plastic slate was deformed.

No folding of the plane of the Northwest thrust is evident from the trace of its outcrop; but the Dunlap Canyon thrust, which apparently overlaps the Northwest thrust, is moderately folded. The plane of the Northwest and Spearmint thrusts, therefore, may also be folded inasmuch as folding with an easterly trend would not be evident from the outcrop.

The extent of the Northwest thrust beneath the Dunlap Canyon thrust and the magnitude of movement are unknown. The intense folding is probably concentrated, however, in a rather narrow belt; and, therefore, since the Northwest thrust carries highly folded rocks, its displacement is probably small.

Dunlap Canyon thrust.—The name, Dunlap Canyon thrust, is applied to a group of closely spaced thrust planes that partly surround the area of close folding just described. The major thrust plane of this group overlaps the Northwest thrust and in turn is overlapped by the South Fork thrust. To the south it is cut off by the Cinnabar Canyon thrust.

Over much of the area traversed by the Dunlap Canyon thrust, thin-bedded limestone of the lowest unit of the Luning on both plates is crumpled and fractured. Consequently, except where the more massive limestone near the top of this unit is present, the thrust planes are not easily traced, and they may be more numerous than shown on the map.

The thrust planes for the most part dip away from the area of intense folding (pl. 8), thereby suggesting that continued uplift warped the area deformed by early folding and thrusting. The isolated segments of what is assumed to be the same thrust plane dip to the north in the extreme northwest part of the area, and to the east along the outcrop east of the 6,500-foot hill. To some extent the trends of the folds in the upper plate parallel the attitude of the thrust planes, but the dips are generally steeper. Uplift of the intensely folded area might account at least in part for the approximate parallelism of the folds in the upper plate of the Dunlap Canyon thrust with the folded thrust plane itself. The uplift may in part have preceded movement on the Dunlap Canyon thrust, and the resistance to the thrust offered by this local uplift may partly account for the change in trend of the folds above the Dunlap thrust and the local backfolding of the anticline in Dunlap Canyon (sec. *B–B′*, pl. 7).

The outcrop of this thrust is traceable from the point where it is overlapped by the South Fork thrust, to Spearmint Canyon where it is cut off by the later Cinnabar Canyon thrust. Southward from the saddle east of the 6,500-foot hill, there is lower limestone on both plates; and the thrust zone is probably less simple than is shown on the map, for the slaty thin-bedded limestone is highly sheared and much crumpled, and the beds of more massive limestone that border the slate unit in the upper block are broken and discontinuous near the thrust.

Probably no large movement occurred along the Dunlap Canyon thrust. Rather, it seems to be the result of intense compression largely concentrated in the incompetent lower limestone unit of the Luning formation. The maximum distance from the northern to southern outcrops is about 2 miles, but the total movement may be less than this.

South Fork thrust.—The upper plate of the South Fork thrust (pls. 7, 8) is represented only by klippen of the lower limestone unit of the Luning. The smaller klippe east of South Fork rests on the slate unit of the Luning, the larger, extending northwestward from South Fork, carries the lower limestone above slate and lower limestone and overlaps the Dunlap Canyon thrust. The smaller klippe is in large part obscured by Tertiary rhyolite so that neither the attitude of the thrust plane nor the structure of the upper plate could be determined. In the larger klippe the thrust plane appears to dip gently inward from the margins.

On the larger klippe, the inverted position of the "cabbage head" corals in a distinctive bed of coralline limestone indicates that, at the eastern end, the structure is the overturned syncline-like crest of a completely involuted anticline (sec. *B–B′*, pl. 7). The coral-bearing beds normally occur near the top of the lower limestone. Except for a narrow zone of drag, the thrust does not appear to have disturbed the underlying structure.

No direct estimate of the amount of movement on the South Fork thrust is possible, but the involuted structure on the upper plate suggests that the movement may have been small and confined to the belt of highly folded rocks that border the Dunlap trough. The klippen can scarcely be outliers of the East Ridge thrust sheet, for the distinctive massive coral limestone beds in the lower limestone of the klippe are characteristic of all the lower thrust plates including that of the klippe, but not of the lower limestone above the East Ridge thrust.

LATER THRUSTING

The Cinnabar Canyon, West Ridge, and East Ridge thrusts are believed to be of later date than the intense folding associated with the thrusts just described, and to have ruptured the previously folded rocks. The Cinnabar Canyon thrust, like the Garfield thrust in the Garfield Hills, departs from the usual stratigraphic sequence of thrusts in that it carried the folded thrust blocks from the northwest part of the range southward over the gently folded Dunlap formation. Movement on the West Ridge thrust was to the north and may have been earlier than or contemporaneous with the Cinnabar Canyon thrust. The East Ridge thrust is probably of greater magnitude than any of the others as it overlaps the Cinnabar Canyon thrust and has carried the folded Luning formation southward across the Dunlap to the Excelsior contact, along alternating gently and steeply dipping planes. The East Ridge thrust may be the same as the New York Canyon thrust of the Gabbs Valley Range (p. 26).

Cinnabar Canyon thrust.—The outcrop of the Cinnabar Canyon thrust (pls. 3, 7) extends from Soda Spring Valley eastward to East Ridge where it is overlapped by the East Ridge thrust. Along the Cinnabar Canyon thrust, the Luning formation is thrust over the marginal Dunlap, which overlies the Excelsior.

The western part of the thrust crops out along Spearmint Canyon. For a mile upstream from the mouth of the canyon the average strike is about northeast. The dip near the mouth of the canyon is 70° NW., changing to nearly vertical 3,000 feet from the canyon mouth and again to about 60° NW. in the upper part of the canyon. The Cinnabar Canyon thrust may have followed the folded plane of the Spearmint thrust (pls. 3, 8), along the steeply dipping part near the mouth of Spearmint Canyon for the attitude of the underlying Dunlap is there roughly parallel to the plane, whereas farther east the folds of the Dunlap are moderately truncated and locally overturned. Possibly however, the steepening dip together with the presence here of the opposing West Ridge thrust indicate local impeding of the southward movement.

From near the head of Spearmint Canyon westward to the point where the thrust is concealed beneath the Tertiary lava in Dunlap Canyon (pl. 2), the strike is about west and the dip generally less than 45°.

The Cinnabar Canyon thrust reappears in the southern part of Cinnabar Canyon, south of the area underlain by Tertiary, and follows a general easterly course, dipping 20°–30° N., to the point where it is overlapped by the steeply dipping segment of the East Ridge thrust (pl. 2). The local change of dip on the low ridge between Dunlap and Cinnabar Canyons is probably the result of doming by the Tertiary intrusive andesite which occupies a large part of the Tertiary area in Dunlap Canyon.

Movement on the Cinnabar Canyon thrust was probably not large but cannot be directly estimated. The upper part of the Dunlap formation in the lower plate contains coarse conglomerate whose pebbles were derived from the Luning, suggesting that the original northern border of the Dunlap trough may not have been far distant. The distribution of the conglomerate within the slate unit of the Luning formation in the upper plate also suggests a marginal facies and consequently small movement. Above the southernmost outcrop of the thrust, between Dunlap and Cinnabar Canyons, the slate unit is highly conglomeratic and contains large partly subangular chert pebbles. The proportion of conglomerate decreases to the north; and in the northern outcrops of the slate unit, the small and well-rounded pebbles occur in thin, though numerous, beds. The large area underlain by slate north of the 7,900-foot hill north of West Ridge was not studied in detail, but one syncline trending west-northwest was noted south of Dunlap Canyon. An anticline trending northeastward overturned to the southeast, is outlined by the lower limestone, which crops out on the west wall of Dunlap Canyon close to the contact with the Teritary.

East of Dunlap Canyon the folds of the upper plate trend eastward and are overturned to the south. Close to the outcrop of the thrust the transitional beds between the slate and lower limestone units crop out in the core of an overturned anticline. Farther north the upper limestone marks the trough of an overturned syncline, and a parallel overturned anticline with a core of lower limestone is overlapped by the East Ridge thrust (pl. 2).

West Ridge thrust.—On the West Ridge thrust movement was to the north or northeast (pls. 7, 8). The intense folding of the rocks in the northwestern part of the range indicates that in this area the southward movement was impeded, and, therefore, minor opposed thrusting on the opposite side of the trough may have taken place at the same time. On the other hand, as the steep western segment of the Cinnabar Canyon thrust lies between the West Ridge thrust and the area of intense folding, the West Ridge thrust may have been a counter movement that resulted from impeding the Cinnabar Canyon thrust.

The thrust has an average northwesterly strike, swinging westward at its northern end, and the dip is generally steep, from 50°–75° SW. The upper plate contains slate and basal conglomerate of the Luning, resting on the Excelsior formation with marked angular unconformity, the lower limestone unit being absent. On the lower plate the Dunlap is likewise unconformable on the Excelsior. Southeast of Telephone Canyon there is Excelsior on both walls, and the extension of the thrust in this direction was not followed.

The total movement is unknown but is not necessarily large. The fact that in this locality the lowest unit of the Luning formation is slate and conglomerate rather than limestone does not indicate major movement, for the northern plates carrying the limestone as the lowest unit of the Luning moved southward along the Cinnabar Canyon and other thrusts.

East Ridge thrust.—The East Ridge thrust seems to have moved south along a combination of segments, some striking northward and dipping steeply eastward, others striking westward and dipping gently northward (pl. 2). The easternmost of the two major gently dipping segments crops out about 2 miles south of the western, and a northward projection of its plane would be at a considerably lower altitude.

At its most northerly outcrop, east of the lower part of Cinnabar Canyon, the thrust has a northerly strike and steep east dip. The fault trace is obscure where both walls are in lower limestone of the Luning formation, but a belt of intense shearing and contortion in the limestone connects with the northward dipping thrust plane to the east. Eastward nearly to the crest of East Ridge, the thrust has a gentle northerly dip, probably about 20°. Along the wide valley west of East Ridge the upper plate is bordered on the west for over 2 miles by a steeply dipping plane which strikes a few degrees west of north. Later normal faulting may have taken place along this segment, parallel to the normal faults further to the east. The steeply dipping fault plane, however, could not be traced beyond its junctions with the adjoining segments which dip gently to the north. The segment crossing East Ridge strikes about N. 60° E. on the crest of the ridge; and dips about 35° to the north.

The alternation of steeply and gently dipping segments suggests movement under a light load; and the conglomerate of the Dunlap above the slate on the crest of East Ridge indicates erosion of the upper part of the Luning prior to thrusting and, therefore, movement of a relatively thin plate. There is, however, no direct evidence of movement over an actual erosion surface such as is furnished by the thrust conglomerate on the plane of the New York Canyon thrust in the Gabbs Valley Range. The stepping down to the east along the steeper segment may be the result of continued uplift of the area of early thrusting and close folding in the northwest corner of the range.

The rocks of the upper plate are less intensely folded than those of the lower thrust plates in the northwestern part of the range. The lower limestone in the western segment of the upper plate is compressed into an anticline overturned to the south (sec. *H–H'*, pl. 2). The structure of the upper plate on East Ridge and along the east front of the range was not studied in detail. At least the larger of the slate belts may represent the keels of synclines overturned to the south; if so, there must be complementary anticlines in the limestone. To some extent, however, the slate and limestone intertongue. The slate to the north overlies the lower limestone and dips moderately northward to northwestward except through a short distance where the upper slate has overridden the limestone for about 2,000 feet along a small thrust whose plane bends sharply from a gentle northerly dip to nearly a vertical attitude. The upper limestone north of the slate shows a series of open folds with easterly trend.

It is likely that the downwarp in the northern part of the range, partly concealed by Tertiary and Pleistocene formations (sec. *H–H'*, pl. 2), is an extension of the syncline in Cedar Mountain, 6 miles to the east.

Movement on the East Ridge thrust is believed to have been of greater magnitude than on the lower thrusts. The most southerly outcrop is about 3 miles distant from the most northerly; but it is probable that the total movement was considerably greater, as the rocks of the upper plate are less folded than those below the thrust. The different lithology of the two lower units of the Luning in the upper and lower plates also suggests considerable movement on the thrust. In the lower plate the lower limestone unit is shaly and thin-bedded, but near the top in a zone about 200 feet thick, massive beds of blue-gray coral-bearing limestone attain a maximum individual thickness of about 50 feet. Above the thrust the lower limestone is on the whole more massive, and the coral-bearing beds are less well defined than in the lower thrust plates and are not as definitely concentrated in the upper part of the limestone unit. In the lower plate the slate unit of the Luning consists of a brown to dark-gray silicious slate and argillite containing varying amounts of conglomerate, a little quartzite, and a few thin limestone beds. The increase southward in amount of conglomerate and in the size of the chert pebbles suggests near-shore deposition. Above the East Ridge thrust, on the other hand, the slate member contains only a few conglomerate lenses, and the upper 500 feet is composed of fossiliferous gray slate containing calcareous layers, a facies not present in the slate unit in the lower thrust plates. The transition to the upper limestone unit is also more gradual than below the thrust. Identity of the East Ridge thrust with the New York Canyon thrust of the Gables Valley Range (sec. *G–G'* and *H–H'*, pl. 2) seems a reasonable assumption, but is not capable of proof.

NORMAL FAULTING

The present relief of the range is the result of Tertiary and Quaternary faulting. Both the east and west fronts are fault scarps, the western being the simpler and higher.

The downthrown block of the fault along the west front is exposed only south of Telephone Canyon (pl. 2) where Dunlap resting on Excelsior at the base of the scarp indicates vertical displacement of at least 1,500 feet. To the north the fault scarp ends abruptly at Mac Canyon, but Tertiary or Quaternary movement probably occurred on the two northeastward-striking faults west of the 6,500-foot hill; though these faults probably originated during the earlier movement on the Northwest thrust (p. 34). A late normal westward-trending fault forms the boundary between the Mesozoic and Tertiary in the lower part of Cinnabar Canyon. A parallel fault to the north involves Pleistocene gravel, but no similar normal faults were found within the area underlain by Mesozoic rocks.

Tertiary lavas are faulted against the older rocks along most of the eastern front of the range; and the normal faults within the Mesozoic rocks of the East Ridge are also probably of Tertiary age, though, in part, this later movement may have taken place along older fault planes including possibly the steeply dipping segment of the East Ridge thrust.

The northwestward-striking fault along the east flank and crest of East Ridge (pl. 2) is a normal fault whose essentially vertical downthrow on the east is indicated by the drag on both walls and the lack of any significant thrusting in the block to the east. The displacement decreases sharply to the south. A throw of 4,000 feet or more at the northern border of the pre-Tertiary is indicated by the displacement of the northward-dipping contacts of upper limestone and slate; this decreases to 1,500 feet at the contact of slate and lower limestone a mile to the south, to not more than 300 feet where the slate bands cross the lower limestone on the crest of the ridge, and the displacement fades out near the 8,900-foot peak.

The Tertiary andesite overlaps the older rocks immediately east of this fault; but a short distance farther east the andesite is in fault contact with the Luning. This fault, over most of its traced extent, strikes about west, but at its eastern end near Graham Spring the strike swings sharply to the south. To the west, several smaller faults striking N. 30°–70° W. displace the contact of slate and limestone. A mile to the east at Graham Spring there is an isolated area of the upper limestone unit of the Luning along the front of the small scarp bordering Stewart Valley. Slight movement on this fault in the 1932 earthquake greatly increased the flow of the spring.

The two parallel normal faults in the central part of the range near the head of Dunlap Canyon (pl. 2) may be of pre-Tertiary age for they do not offset the contact of the Tertiary rocks and are not found north of the area underlain by Tertiary. The western fault may have determined the position of the andesite intrusion which lies along its northern extension. The clifflike promontory of the Excelsior where it is in contact with the Dunlap formation (p. 31) just west of the western fault suggests that it may be the result of renewed movement on a fault plane which was in existence at the time of Dunlap deposition.

CEDAR MOUNTAIN

Cedar Mountain (pl. 1) lies east of the Pilot Mountains and the southern part of the Gabbs Valley Range, and south of the Paradise Range. The geology is known only from reconnaissance. Two areas are underlain by pre-Tertiary rocks.

ROCKS EXPOSED

The Excelsior formation crops out only in the southern part of the range, east of the southern Pilot Mountains. Greenstone appears to overlie chert, which dips to the south.

The Luning formation in the northern part of the range consists principally of limestone, which is probably equivalent to the upper limestone unit of the Luning in the Pilot Mountains. The present study has shown that the fossils formerly regarded as Middle Triassic are of Upper Triassic age and belong to the Luning formation. The Luning formation south of the southern granodiorite mass, consists of 2,500–3,000 feet of argillite interbedded with quartzite and conglomerate and overlain by an equal or somewhat greater thickness of limestone. The lower part of the limestone is somewhat shaly, the upper part is more massive and, in places, grades into dolomite near the top.

Knopf [18] has reported a pre-Tertiary lava, the Simon quartz keratophyre, associated with the Triassic sediments in the vicinity of the Simon mine in the northern part of the range and cut by porphyry and aplite dikes. This appears to be a fine-grained intrusive rock similar to others characterized by nearly aphanitic texture referred to as aplite in this report; but the field relations are obscure, and this rock may be a lava flow within the Luning. It can hardly be a part of the Excelsior unless the structure is completely overturned, for Knopf's section through the Simon mine shows the quartz keratophyre overlying limestone.

The Dunlap formation rests on the Luning in a narrow syncline at the southern end of the northern area, and also crops out in the southern part of the range where it rests on Excelsior. In the northern area the Dunlap consists largely of red sandstone, red sandy shale, and a little limestone conglomerate near the base. No fanglomerate or thick conglomerate unit is present. Red sandstone is predominant likewise in the southern areas underlain by the Dunlap but here the conglomerate is composed principally of chert pebbles, and there are also thin beds of limestone.

Besides the granodiorite, which forms the principal intrusive masses, there are a large number of porphyritic and fine-grained dikes, both silicic and basic. Those in the vicinity of the Simon mine, in the northern part of the range, have been described by Knopf.[19]

STRUCTURE

Scattered observations on the Luning in the northern part of the northern area suggest rather gentle folding trending generally northwest. Southward the folds seem to be steeper, and one possible minor thrust was noted. According to Knopf,[20] the ore body of the Simon mine follows a steep reverse fault along which a dike of alaskite porphyry was intruded prior to mineralization. In the southern part of the northern area the prevailing trend is westerly. The principal syncline contains the Dunlap and is in part overturned to the north, contrary to the general direction of overturning in the Pilot Mountains. The dip on the overturned southern limb is at one place as flat as 20° with minor overthrusting near the western end but steepens to about vertical within short distances to the east and west. The alinement of the syncline with the parallel folding in the Pilot Mountains to the west and in the hills 8 miles to the east suggests continuity of folded structure beneath the Tertiary and Quaternary deposits.

In the southern area the Dunlap above the Excelsior is highly folded. Northwesterly trends seem to prevail, but at one place Excelsior overlain by Dunlap is apparently thrust from the north over the Dunlap formation.

Faults of premineral and postmineral age are present in the Simon mine,[21] whose ores are probably pre-Tertiary; and, over much of the northern area, the abundance of silicified zones in the limestone of the Luning suggests that there is considerable local faulting within the Mesozoic rocks. Tertiary faults bound the area of Mesozoic rocks along a part of the west flank of the range. Knopf [22] noted the fault border of the Tertiary volcanics near Simon and the major northward-dipping fault within the Tertiary lavas on the ridge to the north. The complex faulting in the Simon mine [23] is of postmineral age. The numerous zones

[18] Knopf, Adolph, Ore deposits of Cedar Mountains, Mineral County, Nevada: U. S. Geol. Survey Bull, 725, p. 363, 1921.

[19] Knopf, Adolph, op cit., pp. 365–366.

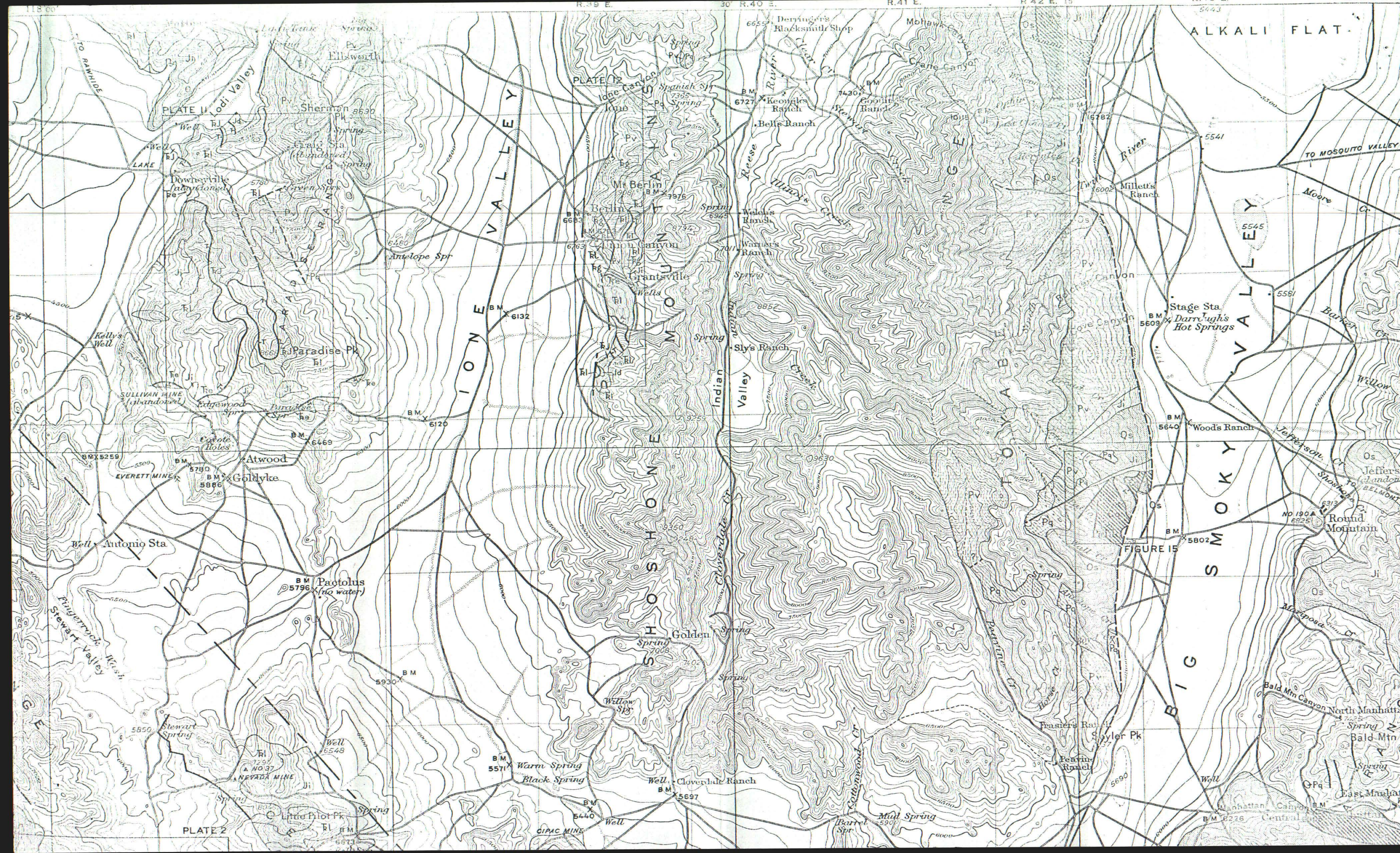
[20] Knopf, Adolph, op. cit., p. 370.

[21] Knopf, Adolph, op. cit., p. 375.

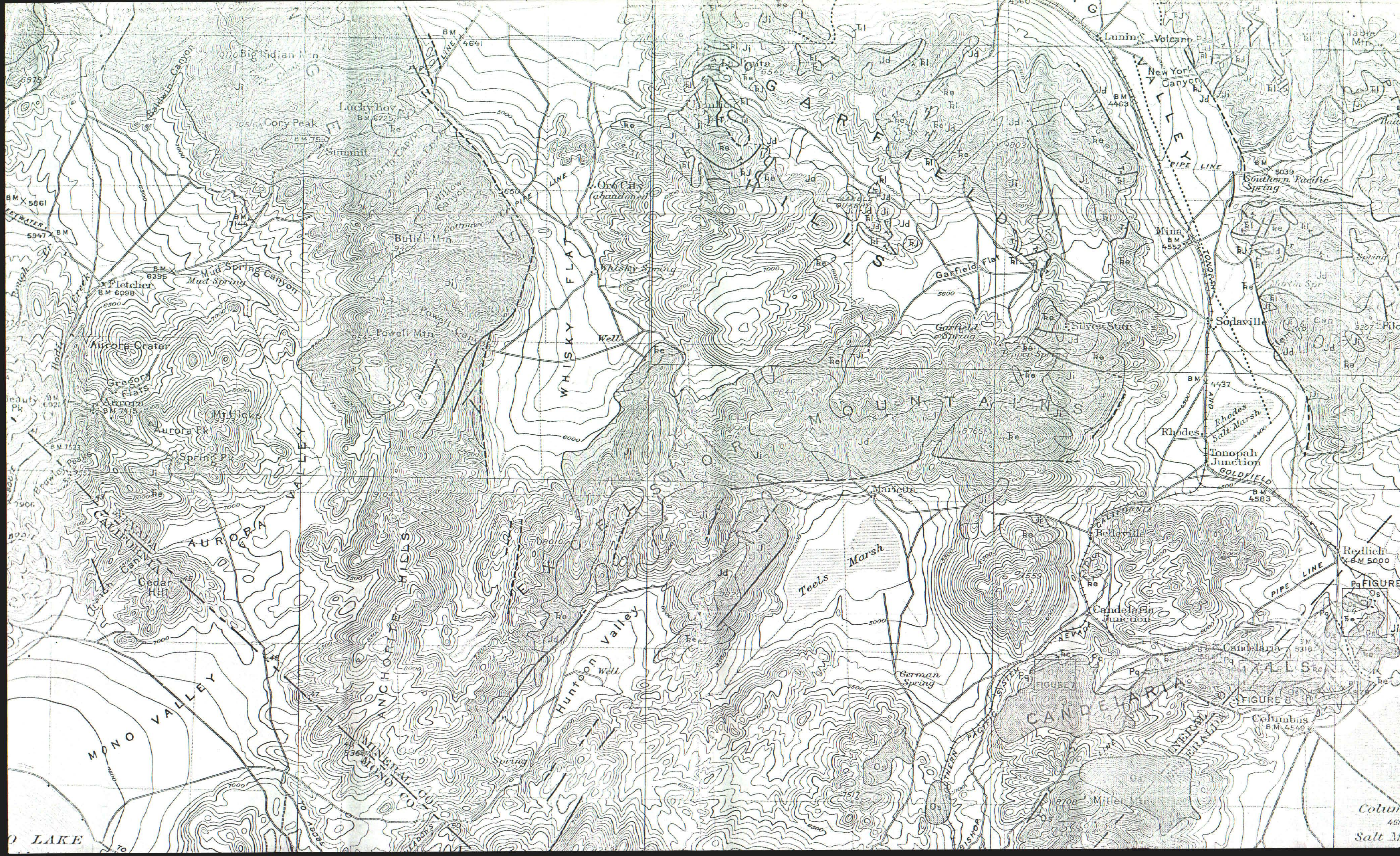
[22] Knopf, Adolph, op. cit., pp. 367–368.

[23] Knopf, Adolph, op. cit., pp. 375–376.

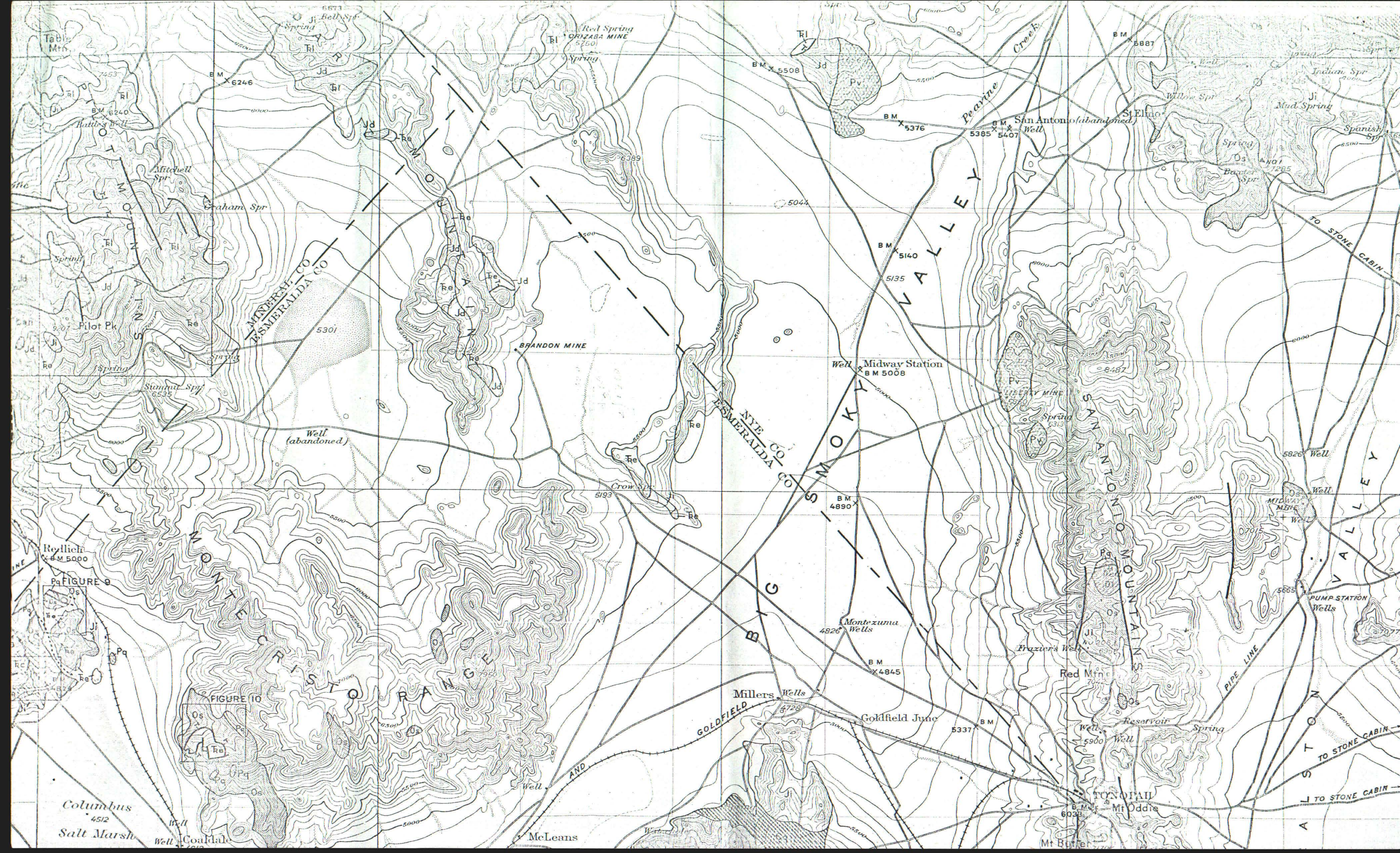
TO RAWHIDE
Double Spring
BM 4056
BM 4157
Schurz
BM 4128
Black Mtn
SOUTHERN PACIFIC SYSTEM
RIVER
BM 4112
Modoc Siding
Reese River Canyon
Penrod Canyon
BM 4174
Copper Hill
Gillis
Bald Mtn
W A S S U K R A N G E
WALKER LAKE
4083
BM 4161
FIGURE 2
Buckley Camp (abandoned)
Copper Canyon
Butler Mtn
Dry Creek
BM 4112
Walker
BM 4116
Dutch Creek
Chipmunk Spring
Cottonwood Creek
Wheeler Pass
Rose Creek
Montelle
Mt Grant
Morgan's Ranch
Lapon Canyon
Thorne
BM 4132
NEVADA AND CALIFORNIA
Dover Siding
Kinkaid Siding
BM 4348
HAWTHORNE
BM 4326
Acme Tank
BM 4398
Acme
BM 4560
S O D A S P R I N G
BM 4299
BM 4108
Monte Cristo (abandoned)
Murphy's Well
A L K A L I F L A T
Cold Spring
Hot Spring
BM 4130
Deadhorse Well
BM 4182
NYE CO
MINERAL CO
BM 4262
Warrens Well
BM 4364
G A B B S V A L L E Y
Bovard
Wildhorse Canyon
Midway
G A B B S V A L L E Y R A N G E
Sargents Well
Rabbit Spring
Indian Spring
Redrock Canyon
Wildhorse Spring
Petrified Spring
Fingerrock Wash
Stewart Valley
Tank



R.39 E.
R.40 E.
R.41 E.
R.42 E.
ALKALI FLAT
TO RAWHIDE
PLATE 11
Lodi Valley
Sherman
Ellsworth
LAKE
Downieville
PARADISE RANGE
Antelope Spr
Paradise Pk
Kelly's Well
SULLIVAN MINE (abandoned)
Edgewood
Coyote Holes
Atwood
EVERETT MINE
Goldyke
Antonio Sta
Pactolus (no water)
Stewart Valley
Fingerrock Wash
Stewart Spring
NEVADA MINE
Little Pilot Pk
PLATE 2
IONE VALLEY
PLATE 12
Ione
Ione Canyon
Spanish Spr
Mt Berlin
Berlin
Union Canyon
Grantsville
SHOSHONE MOUNTAINS
Golden
Willow Spr
Warm Spring
Black Spring
Cloverdale Ranch
Cloverdale Cr
CIPAC MINE
Indian Valley
Sly's Ranch
Reese River
Keoughs Ranch
Bells Ranch
Welchs Ranch
Warners Ranch
Derringer's Blacksmith Shop
Mohawk Canyon
Crane Canyon
TOIYABE RANGE
Millett's Ranch
Stage Sta
Darrough's Hot Springs
Wood's Ranch
FIGURE 15
Frasier's Ranch
Peavine Ranch
Peavine Cr
Toiyabe Pk
Mud Spring
Barrel Spr
Cottonwood Cr
BIG SMOKY VALLEY
TO MOSQUITO VALLEY
Moore Cr
Barker Cr
Willow
Jefferson Cr
Round Mountain
Mariposa Cr
Bald Mtn Canyon
North Manhattan
Bald Mtn
Manhattan Canyon

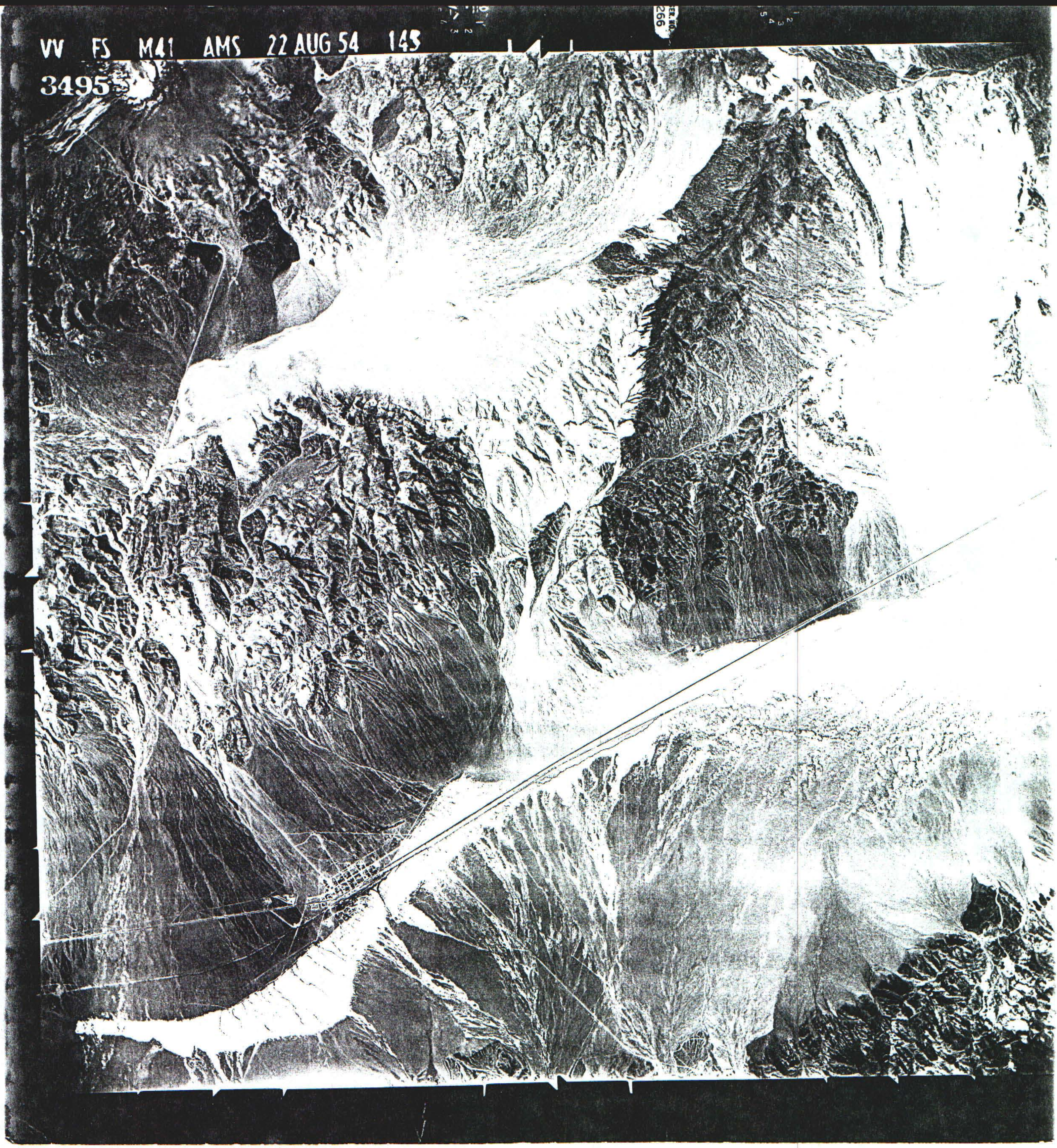


Big Indian Mtn
Cory Peak
Lucky Boy
Summit
Oro City
Pipe Line
Whisky Flat
Whisky Spring
Well
Garfield Hills
Garfield Flat
Garfield Spring
Luning
New York Canyon
Southern Pacific Spring
Mina
Sodaville
Silver Star
Rhodes
Rhodes Salt Marsh
Tonopah Junction
Goldfield
Marietta
Teels Marsh
Belleville
Redlich
Candelaria Junction
Candelaria
Candelaria Hills
Figure 7
Figure 8
Columbus
German Spring
Huntoon Valley
Anchorite Hills
Excelsior Mountains
Aurora Valley
Mono Valley
Aurora Crater
Gregory Flats
Aurora
Mt Hicks
Aurora Pk
Spring Pk
Fletcher
Mud Spring Canyon
Mud Spring
Butler Mtn
Powell Mtn
Cedar Hill
Nevada
California
Mineral Co
Mono Co
Miller Mtn



MONTE CRISTO RANGE
BIG SMOKY VALLEY
SAN ANTONIO MOUNTAINS
MINERAL CO.
ESMERALDA CO.
NYE CO.
ESMERALDA CO.
FIGURE 9
FIGURE 10
Pilot Pk
Redlich
BM 5000
Columbus
Salt Marsh
Coaldale
McLeans
Millers
Wells
Goldfield Junc
GOLDFIELD
AND
Montezuma Wells
Midway Station
BM 5008
BRANDON MINE
LIBERTY MINE
ORIZABA MINE
Red Spring
San Antonio (abandoned)
St Elmo
Pearyne Creek
Crow Spr
Well (abandoned)
Graham Spr
Mitchell Spr
Summit Spr
Fraziers Well
Red Mtn
Reservoir
PIPE LINE
PUMP STATION Wells
TO STONE CABIN
TONOPAH
Mt Oddie
Mt Butler
Mud Spring
Indian Spr
Spanish Spr
Willow Spr
Baxter Spr


2709
SUNRISE FLAT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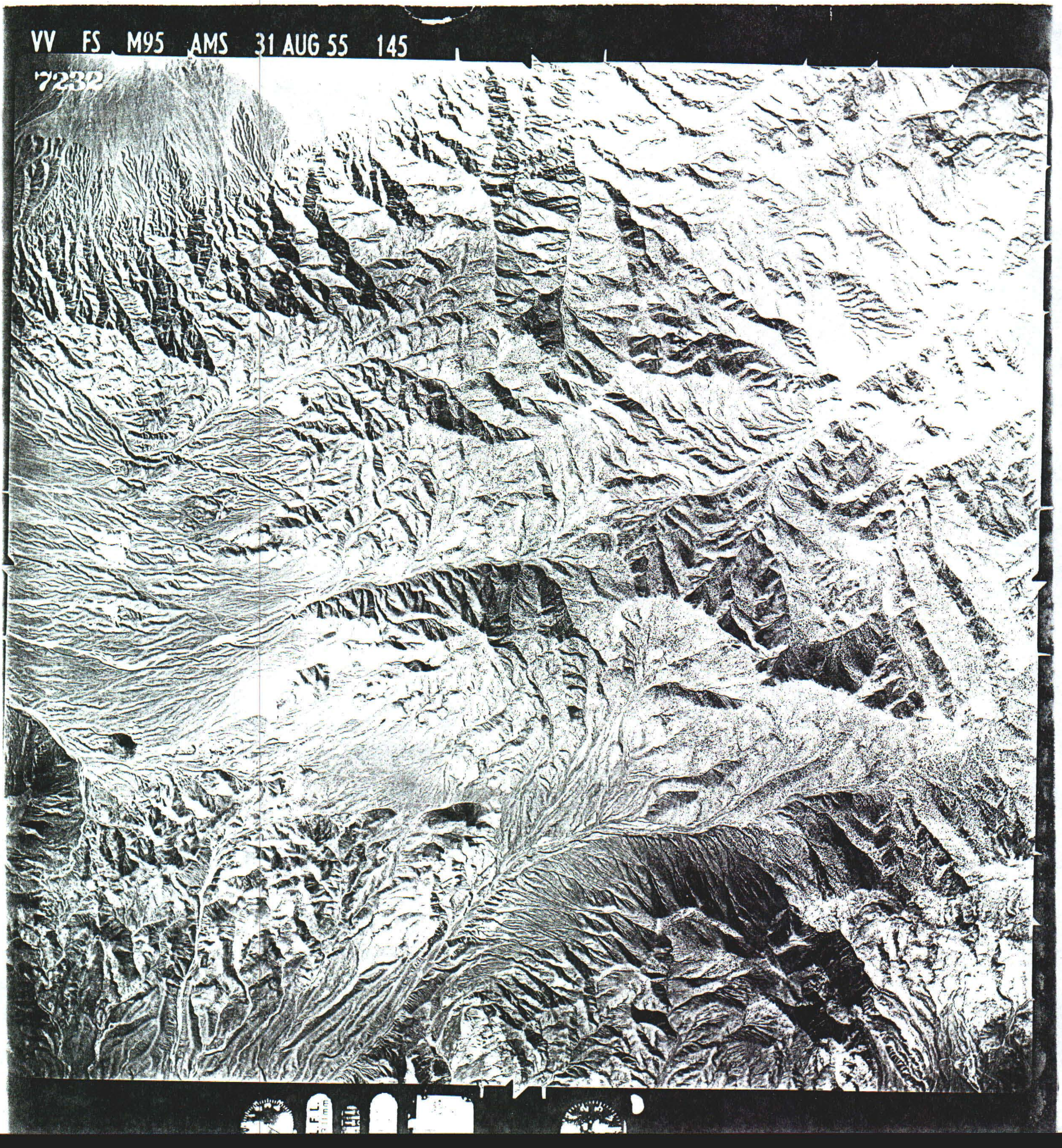
3495


VV FS M95 AMS 31 AUG 55 145
7232


VV FS M41 AMS 22 AUG 54 145
3499
E Pilot Mtn


VV FS M95 AMS 31 AUG 55 145
MINA


VV FS M32 AMS 16 AUG 54 145
2706
1- HH HALLOWAY- CHALLENGE #1
2- ATOM 1956
LUNING

SODA SPRING VALLEY
RANGE
GARFIELD HILLS
MOUNTAINS
WHISKY FLAT
PILOT MOUNTAINS
HAWTHORNE
Thorne
Dover Siding
Kinkaid Siding
Acme Tank
Acme
NEVADA AND CALIFORNIA
Luning
Volcano Peak
New York Canyon
Table Mtn
Petrified Spring
Indian Spring
Stewart Valley
Fingerrock Wash
Stewart Spring
Pactolus (no water)
Well 6548
Little Pilot Pk
Bell Spr
PLATE 2
Battles Well
PIPE LINE
Southern Pacific Spring
Mitchell Spr
Graham Spr
Mina
Garfield Flat
Whisky Spring
Oro City (abandoned)
Sodaville
Silver Star
Garfield Spring
Pepper Spr
Martin Spr
Pilot Pk
Summit Spr
Well (abandoned)
MINERAL CO
ESMERALDA CO
Rhodes
Rhodes Salt Marsh
Tonopah Junction
TONOPAH
GOLDFIELD
Marietta
Belleville
Marsh
Redlich
FIGURE 9

Geology by H.G. Ferguson and S.W. Muller, 1931-1936.