UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Albuquerque, New Mexico

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A geophysical study of alluvial valleys in western Mora County, New Mexico

By

Jerry W. Mercer and Eric G. Lappala

Open-file report

Prepared in cooperation with the New Mexico State Engineer, the Four Corners Regional Commission, and the Soil Conservation Service

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Abstract

The seismic-refraction method of geophysical prospecting was used in western Mora County to determine the saturated thickness of alluvial deposits in the valley of the Mora River and its tributaries.

The study area was divided into river reaches: Chacon to Holman reach, Mora River; Cleveland to Buena Vista reach, Mora River; Golondrinas to Loma Padra reach, Mora River; Watrous to Shoemaker reach, Mora River; Guadalupita reach, Coyote Creek; Rainsville reach, Coyote Creek; and Cebolla River.

Seismic data obtained in the Chacon to Holman reach indicate a maximum thickness of alluvial deposits of 68 feet and a minimum thickness of 3 feet. Depths to the top of the saturated zone range from 4 to 9 feet.

Alluvial deposits in the Cleveland to Buena Vista reach range in thickness from 13 to 322 feet. The maximum of 322 feet is near the community of Mora and is the largest recorded thickness in the study area. Depths to the top of the saturated zone range from the land surface to a depth of 29 feet. Most of the alluvial deposits below Cleveland, in the center of the Mora River valley, are completely saturated causing water-logged conditions.

In the Golondrinas to Loma Parda reach alluvial deposits range in thickness from 14 to 79 feet. Depths to the top of the saturated zone range from 5 to 10 feet.

A maximum alluvial thickness of 182 feet and a minimum thickness of 8 feet is present in the Watrous to Shoemaker reach. Depths to the top of the saturated zone range from near land surface to 16 feet.

In the Guadalupita reach of Coyote Creek alluvial deposits range in thickness from 3 to 71 feet. Depths to the top of the saturated zone range from 3 to 8 feet.

Alluvial deposits in the Rainsville reach, Coyote Creek, range in thickness from 5 to 83 feet. The maximum thickness in the reach, however, does not occur in the present channel of Coyote Creek but in an adjacent valley, Los Chupaderas, where a thickness of 183 feet was recorded. Depths to top of the zone of saturation range from 3 to 13 feet.

In the Cebolla River reach, thickness of alluvial deposits range from 9 to 38 feet. Depths to the top of the zone of saturation range from 3 to 12 feet.

Introduction

Purpose and scope of the investigation

This report describes the results of the first phase of an investigation of the ground-water resources of Mora County, New Mexico. The investigation was requested by the Adelante Resources Conservation and Development Committee, an organization formed by the people in the area to develop the economic resources of Mora County. The investigation is being conducted as a cooperative effort of the U.S. Geological Survey, the U.S. Soil Conservation Service, the New Mexico State Engineer, and the Four Corners Regional Commission.

This report presents the basic data obtained by geophysical methods and summarizes geophysical interpretations of the areal extent and saturated thickness of alluvial deposits contained in the valleys of the Mora River and its tributaries in western Mora County. The report contains information specially requested by the Soil Conservation Service.

Seismic refraction studies were begun in November 1968 in the Mora River valley near the community of Mora. The completion of seismic refraction work in the remainder of the area was delayed until April 1969 due to climatic conditions--frequent snowfalls prevented the use of the land-laid electrical lines necessary for such seismic investigations.

Location and extent of the area

Mora County is in the northeast quarter of New Mexico. The alluvial valleys described in this report are those occupied by the Mora River and its tributaries in the western part of the county, upstream from the gaging station on the Mora River 4½ miles east of the community of Shoemaker (fig. 1).

The Mora River and its tributaries in western Mora County head in the Sangre de Cristo Mountains, which form the western boundary of the study area. The river system heads at altitudes of about 12,000 feet and drains an area of approximately 900 square miles above the gaging station which is at an altitude of 6,170 feet. The Mora River joins the Canadian River at an altitude of about 4,600 feet, 23 miles downstream from the gaging station east of Shoemaker.

The principal communities in western Mora County are located along the main stem of the Mora River and include Watrous; Mora, the county seat; Cleveland; Holman; and Chacon.

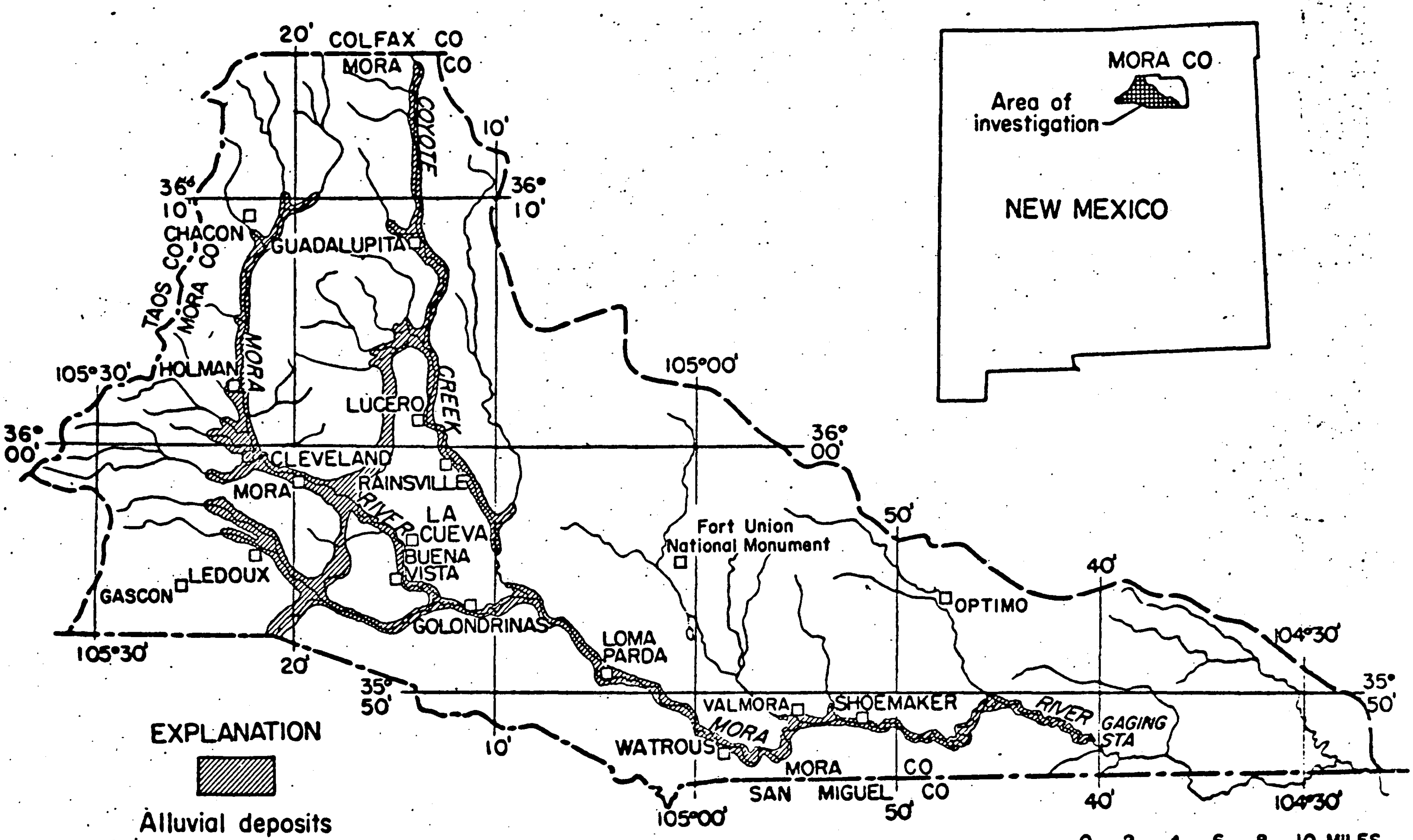


Figure 1.--Index map of alluvial deposits in western Mora County, N. Mex.

Acknowledgments

The authors wish to express their appreciation to William L. Shaffer of the U.S. Geological Survey for his assistance in data reduction and analysis of seismic records; to Richard Zbur of the U.S. Air Force Weapons Laboratory (WLDC), Kirtland Air Force Base, for the use of equipment and for technical assistance, and to personnel of the New Mexico State Engineer's Office, and the Soil Conservation Office for reviewing the report.

We wish also to thank the people of Mora County for granting access to their property during the field investigation.

General geology and hydrology

The core of the Sangre de Cristo Mountains is composed primarily of Precambrian igneous and metamorphic rocks (granite, gneiss, schist, and quartzite). The east flank of the mountains is overlain by eastward-dipping sedimentary rocks of late Paleozoic age. These rocks consist of interbedded sandstones, shales, siltstones and limestones. East of the main mountain mass the Paleozoic rocks are overlain by a sequence of eastward-dipping Mesozoic sediments--sandstones, siltstones, and mudstones--which form a series of north-trending ridges and valleys. Farther east, where dips are lower, the sandstones form mesas.

Alluvial deposits of silt, sand, gravel, and boulders of Quaternary age are present along the major stream courses. The alluvial deposits which contain ground water in most reaches of the stream valleys are recharged primarily by seepage from surface irrigation and rainfall. Recharge is supplemented by comparatively minor inflow from adjacent bedrock aquifers. The thickness of the alluvial aquifer generally is the result of erosional processes related to climatic changes in late Cenozoic time. However, some deposition in the east-southeast trending valleys occurred during Holocene time. Since Pleistocene time deposition in the main stream valleys and their tributaries has been negligible and in some places, the presence of gravel terraces indicates renewed downcutting. The major deposition occurred during Pleistocene time in a broad north-south valley extending from north of Black Lake south through the Las Quebraditas valley. The valley was occupied by a Pleistocene river whose course was controlled by Laramide fault zones. Capture by eastward-flowing streams such as the Mora River and Rito Cebolla established the present drainage system. Baltz and Read (1956, p. 71) refer to this Pleistocene river as the ancestral Coyote, named for Coyote Creek, which in its upper reaches flows in what is believed to be the ancestral channel.

The average annual precipitation within the upper part of the Mora River drainage basin ranges from about 15 inches at Valmora and Watrous to 25 inches or more in the mountains west of Holman. The distribution of both seasonal and areal precipitation varies. However, 30 to 40 percent of the average annual precipitation commonly falls as rain in July and August, and an equal amount falls as snow in the winter. Late spring and fall are characteristically dry.

Streamflow is typical of Rocky Mountain front-range drainage basins; the snowmelt peak occurs generally in late May, and another lesser streamflow peak occurs in August due to summer storms. Base flow is sustained by return irrigation water and natural ground water.

Two transmountain diversions, Rito de la Presa to Agua Fria Creek and Alamitos Creek to Vigil Canyon, augment natural streamflow for irrigation. Irrigation requirements based upon consumptive use values and delivery system losses have been computed by the Bureau of Reclamation (U.S. Dept. of the Interior, 1966). These requirements range from 1.98 acre-feet per acre near Holman to 2.78 acre-feet per acre near Watrous.

Methods of seismic investigation

The seismic-refraction method

The seismic-refraction method (fig. 2) used in the investigation of alluvial deposits in western Mora County makes use of the refraction of seismic waves, elastic vibrations in the earth at sudden or rapid changes in the character of the rock material at depth in the ground.

It is best adapted for, and finds its greatest application in situations where discontinuties are close to the surface and particularly where it is desired to determine the depth to the top of the saturated zone, to a consolidated layer, or to bedrock. These conditions are present along the alluvial valleys of the Mora River drainage basin.

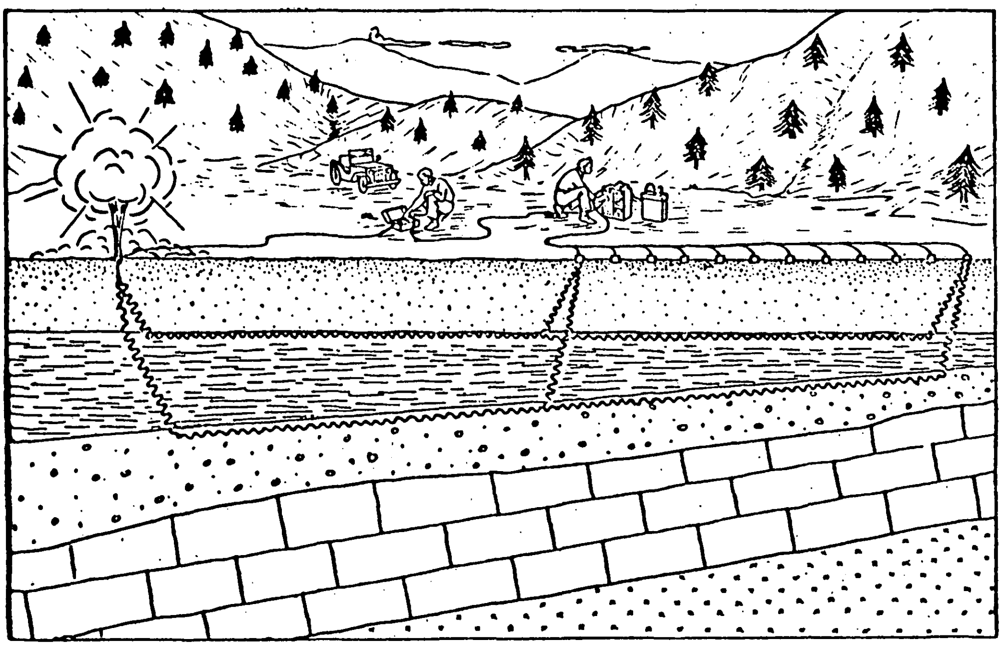


Figure 2.--Schematic representation of the seismic refraction method.

Theory of refraction

When a seismic wave AB (fig. 3-a) strikes a discontinuity in the ground the ray path crossing the interface is refracted; i.e., it is bent into direction BC (fig. 3-a). The amount of bending follows Snell's Law and may be expressed by the equation:

$$\frac{\text{Sin } i}{\text{Sin } r} = \frac{V_1}{V_2} \qquad (1)$$

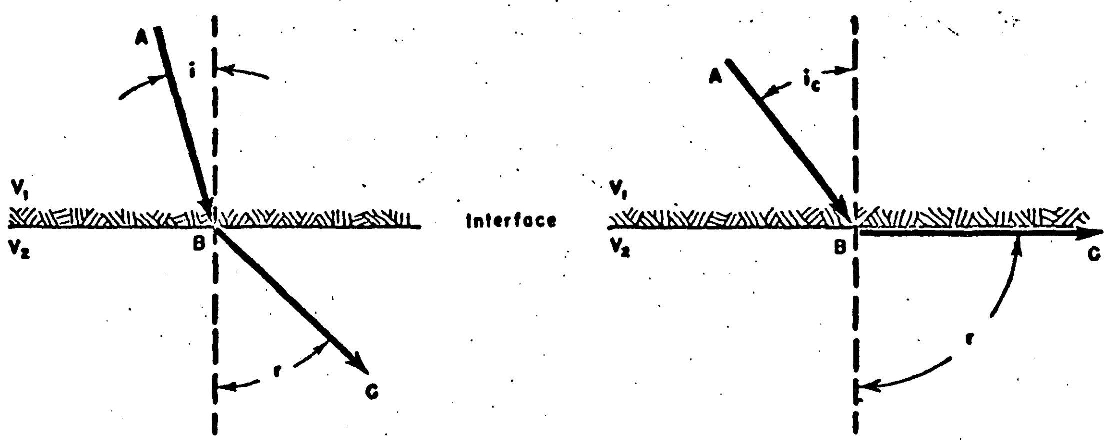
where i = angle of incidence (to the normal) of the wave incident on the interface

r = angle of refraction (to the normal) of the wave emergent from the interface

V_1 = velocity of transmission of the elastic wave in the incident medium

V_2 = velocity of transmission of the elastic wave in the emergent medium.

In special cases (fig. 3-b) where $r = 90^\circ$ then Sin $i = V_1/V_2$. When this occurs, the incident ray is said to strike the interface at the critical angle, i_c, and the refracted ray is actually traveling parallel to and very close to the interface. The refraction method of prospecting is based upon this phenomenon.



a. Refraction of elastic wave passing through two different velocity media.

b. Elastic wave striking interface at critical angle.

Figure 3.--Diagram of Snell's Law.

Seismic-refraction shooting

In seismic-refraction surveys, as represented in figure 4, a shot (explosive charge) is placed in a hole at the shot point A and the geophones (D-detectors), usually 12 in number, are spread on the surface of the ground in a straight line from A in intervals of 10 to 50 feet. This interval depends upon the depth of the bed it is desired to trace and the detail that is required.

Seismic waves are generated by setting off the charge at point A. By measuring the time it takes the first wave to reach a point a known distance away, it is possible to calculate the velocity at which the wave travels through the ground. As seismic waves travel through different materials at different velocities (table 1), the velocity (distance divided by the travel time) usually indicates the type of material beneath the surface. In the discussion that follows, assume the velocity in the material immediately adjacent to the surface is V_o, and the velocity in the medium underlying it is V_1, where V_1 is greater than V_o.

Table 1.--Velocities of seismic waves in rocks [1]

Material	Depth (feet)	Longitudinal wave velocity, V_L, ft/sec
Water (fresh)[2]		4,800
Water (saline)[2]		4,860
Granite	0	13,100-18,700
Basalt, Germany	0	18,300
Dolomite	0	16,200-20,200
Dolomitic limestone	0	19,600
Alluvium	0	1,640- 6,600
Alluvium	6,500	9,800-11,500
Clay	0	3,300- 9,200
Limestone		
Arbuckle (Cambrian and Ordovician)	0	17,400
Viola (Ordovician)	0	16,700
Viola (Ordovician)	4,000	20,000
Hunton (Devonian)	0	13,800
Hunton (Devonian)	4,600	17,500
Edwards (Cretaceous)	0	11,000
Edwards (Cretaceous)	3,300	13,500
Slate and shale	0	7,500-15,400
Sandstone	0	4,600-14,100
Shale and sandstone		
Devonian	2,000-3,000	13,400
Pennsylvanian	2,000-3,000	11,200
Permian	2,000-3,000	10,000
Cretaceous	2,000-3,000	9,300
Eocene	2,000-3,000	9,000
Pleistocene-Oligocene	2,000-3,000	7,200

[1] From Birch's "Handbook of Physical Constants," 1942.

[2] Oral communication, R. T. Zbur

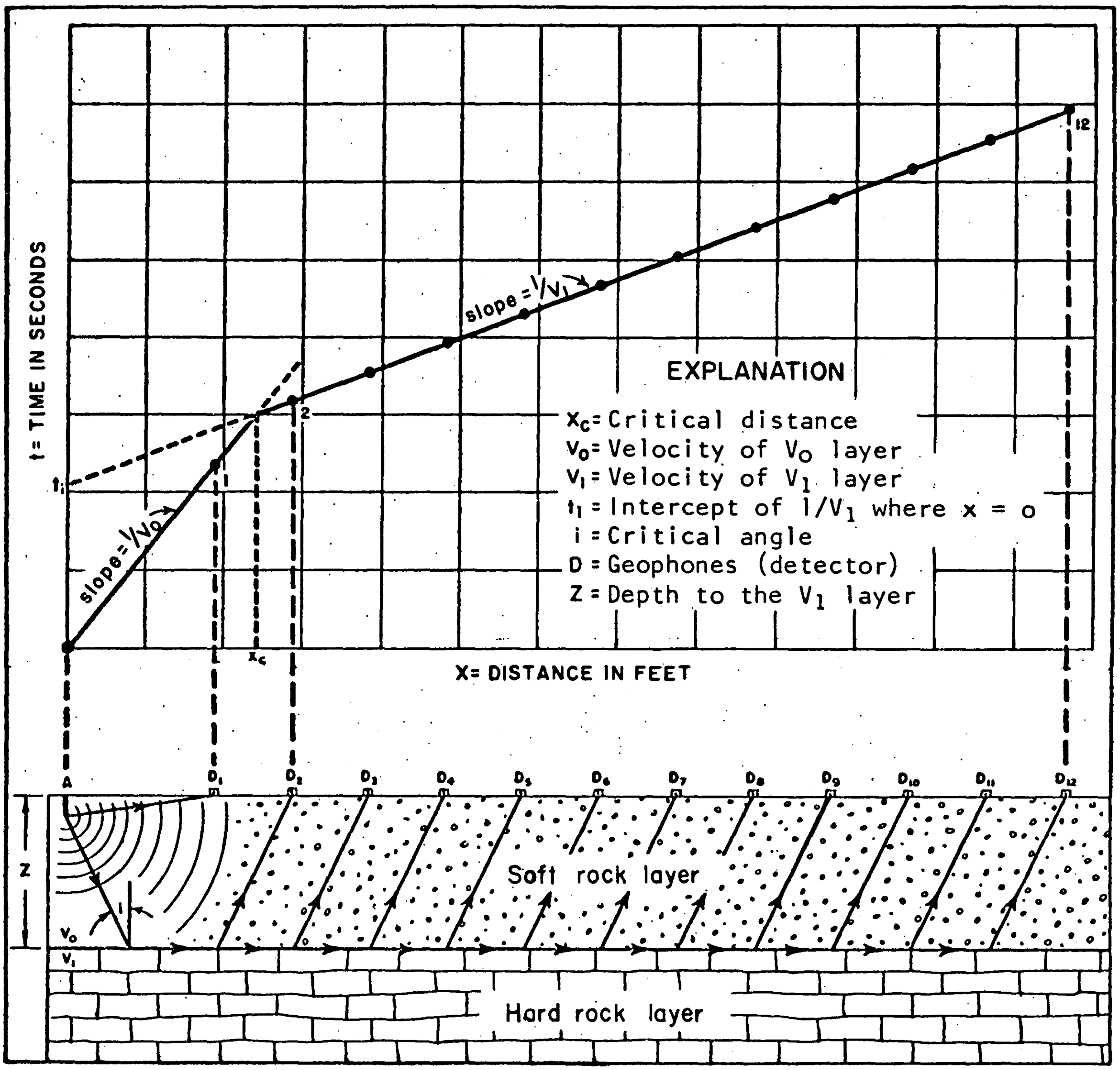


Figure 4.--Schematic representation of refraction of seismic energy and the resultant time-distance graph, for a two layer model.

When a shot is fired at A, the explosion generates shock waves which move out in all directions on an expanding spherical front, just as ripples spread from a pebble dropped into a pond. The energy travels on radial paths, like light beams from a point source. Only two paths, however, are likely to be traveled by the energy reaching the detectors first. It is this first energy which is of importance for making a depth calculation.

Some of the waves travel directly from the point of explosion to the detector as shown by the arrow from A to D_1 in figure 4. Other waves travel downward. If there is a layer of rock or dense material at some depth below the soil, part of the expanding wave front will eventually reach this layer. When the wave front strikes this discontinuity in the ground, a new series of wave fronts are created with their ray paths forming an angle with those of the incident wave front. Some of the rays will have their direction altered only slightly, and will pass on down into the earth. But waves striking the interface at the critical angle of Snell's Law will be refracted enough to travel horizontally along the surface of the interface (fig. 4). Portions of these waves will, in turn, be refracted upward at the same critical angle toward the surface again as shown for detectors D_2 - D_{12}.

The waves travel at a low velocity, while in the soil (V_o layer) but in rock (V_1 layer) the waves travel at a higher velocity. It is apparent that when a detector is close enough to the shot point, the slower wave following the direct path, takes a shorter time than the faster wave following the refracted path through the higher velocity medium; but as the separation between detector and shot increases, the disadvantage of having to travel down and up through the lower velocity medium is compensated by the advantage of being able to complete the path through the higher velocity V_1 material. At some distance from the shot, a point will be reached where the refracted waves will arrive at the phones first, represented by X_c (critical distance). This is shown as a break in slope on the "time-distance" plot in the upper part of figure 4. This graph is a plot of the time taken from the first arrivals of energy to reach any given detector in seconds versus the distance of the detector from the shot point in feet.

For detector D_1, the direct path through the V_o medium is the shortest; and the slope of the line drawn through the plot for this detector and extended to the origin, is equal to $1/V_o$.
In the case of detectors $D_2 - D_{12}$ the refracted path is the shorter and the slope of the line through the plots is equal to $1/V_1$.

Depth calculations

Refer to figure 4.

Let
- x = detector distance from the shot point
- t = time for energy to travel from shot point to detector
- Z = thickness of refracting bed
- V_o = velocity of transmission in the upper layer
- V_1 = velocity of transmission in the lower layer
- i_c = critical angle as defined by Snell's Law $\sin i_c = V_1 / V_2$

Then:

$$t = \frac{x}{V_1} + \frac{2Z\sqrt{V_1^2 - V_o^2}}{V_1 V_o} \qquad (1)$$

Now if $x = o$

$$t_i = \frac{2Z\sqrt{V_1^2 - V_o^2}}{V_1 V_o} \qquad (2)$$

where t_i is the intercept on the time axis.

Therefore

$$Z = \frac{t_i V_1 V_o}{2\sqrt{V_1^2 - V_o^2}} \qquad (3)$$

which gives us the thickness of the velocity layer under the shot point.

Instrumentation and field techniques

The seismic survey in Mora County included about 48,000 linear feet of seismic traverse. Most traverses were less than 500 feet; but in Mora valley near the community of Mora, lines as long as 12,000 feet were shot.

The field crew consisted of personnel from the U.S. Geological Survey, Water Resources Division, in Albuquerque. Additional support for the long seismic lines was obtained from the Air Weapons Laboratory (WLDC), Kirtland Air Force Base, Albuquerque.

Equipment included an ER-75 "porta seis", a portable 12-channel seismic amplifier unit which was used for most of the refraction profiles. The long profiles were shot with the Air Force Weapons Laboratory's (WLDC) 24-channel low-frequency refraction amplifiers. Travel times of first arrival waves emanating from the point of explosion and arriving at the geophones (or detectors) positioned along the surface of the ground were measured with the aid of an oscillograph recorder. The first arrival waves could be read to ± 0.001 second.

Shot holes were dug to a depth of about 4 feet with post-hole diggers. Each hole was loaded with either Dupont 400 grain primacord or Hercules Vibronite primers. Most charges had the energy equivalent of from 2 to 4 pounds of dynamite. Electrical seismic caps ("zero delay") were utilized to detonate the explosive charges.

The surface-refraction profiles were shot from both ends to compute the dip component. This procedure is necessary to compensate for possible dip in the formation beneath the surface. Updip apparant velocities are greater than true velocities and conversely downdip apparant velocities are less than true velocities. Shot points generally were located 10 feet from the end of the geophone line.

Profiles were run where access was available. Profile lengths were limited by access and time available for this phase of the project.

Some profiles were shot parallel rather than normal to the axis of the valleys. This was necessary where the width of the valley was less than three to four times the geophone spread. Under such circumstances, the physical conditions depart significantly from those presented in the theoretical model, i.e., planar portions of the interfaces required for the model are not long enough to receive energy from the second and third layers.

Analysis and results

Data reduction

All profiles were shot by conventional line-refraction methods. The velocity layering was determined beneath the geophone line on the assumption that the velocity of each seismic layer (constant velocity layer) increased with depth. Conventional intercept-time or critical-distance computing methods were used for determining the alluvial depths from the observed travel-time data (Dobrin, 1960, pp. 72-75).

It is difficult to estimate the accuracy of seismic refraction methods but, generally speaking, it is probably on the order of ± 10% for this study (±20% where the interfaces are dashed).

Results

To facilitate presentation of the thickness and extent of alluvial deposits in western Mora County, the study area has been subdivided into river reaches: Chacon to Holman, Mora River (fig. 5); Cleveland to Buena Vista, Mora River (fig. 9); Golondrinas to Loma Parda, Mora River (fig. 19); Watrous to Shoemaker, Mora River (fig. 21); Guadalupita reach, Coyote Creek (fig. 24); Rainsville reach, Coyote Creek (fig. 27); and Cebolla River (fig. 32).

All interfaces, including the top of the saturated zone, were determined from seismic data.

Chacon to Holman reach, Mora River

The extent of alluvial deposits and locations of seismic lines along the Chacon to Holman reach, Mora River is shown on figure 5. The seismic profiles (figs. 6-8) indicate the thickness of the alluvial deposits and the top of the saturated zone in the deposits. Depths to the base of the alluvial deposits and to the top of the saturated zone in the Chacon to Holman reach are summarized in the following table:

Depths to the base of alluvial deposits and to the top of the saturated zone along the Chacon to Holman reach, Mora River

Profile identification	Depth to base of alluvial deposits (in feet)		Depth to top of saturated zone (in feet)	
	Maximum	Minimum	Maximum	Minimum
1M - 2M	23	7	7	4
3M - 4M	?	40	9	7
5M	28	7	7	6
6M	10	4	?	?
7M	20	14	4	4
8M	5	3	?	?
9M	68	29	8	5
10M	9	7	?	?

The largest areal alluvial deposits are near the community of Chacon and the greatest thickness is near Holman. Depths to water in the alluvial deposits are deepest above Holman; in places near Chacon, water levels are near the surface causing water-logged conditions.

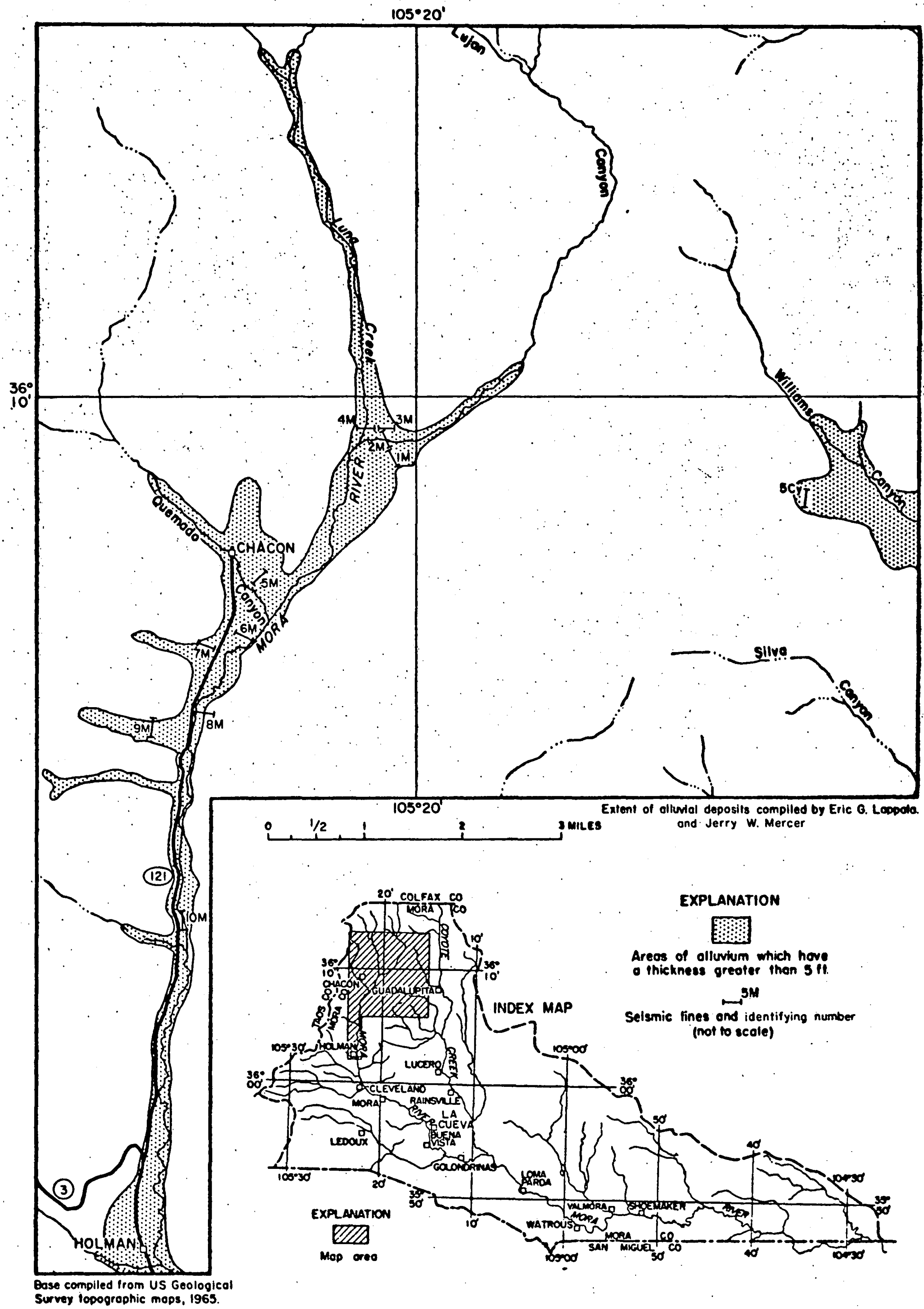


Figure 5.--Extent of alluvial deposits and locations of seismic lines along the Chacon to Holman reach, Mora River.

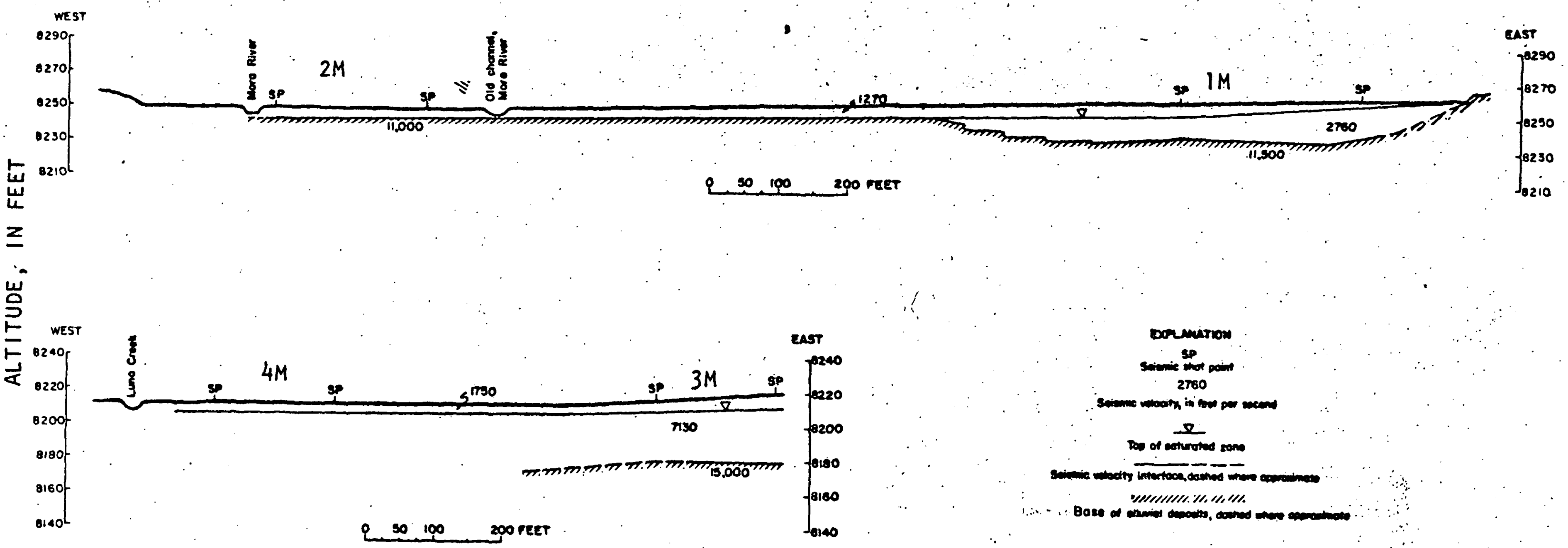


Figure 6.--Seismic profiles 1M, 2M, 3M, and 4M along the Chacon to Holman reach, Mora River.

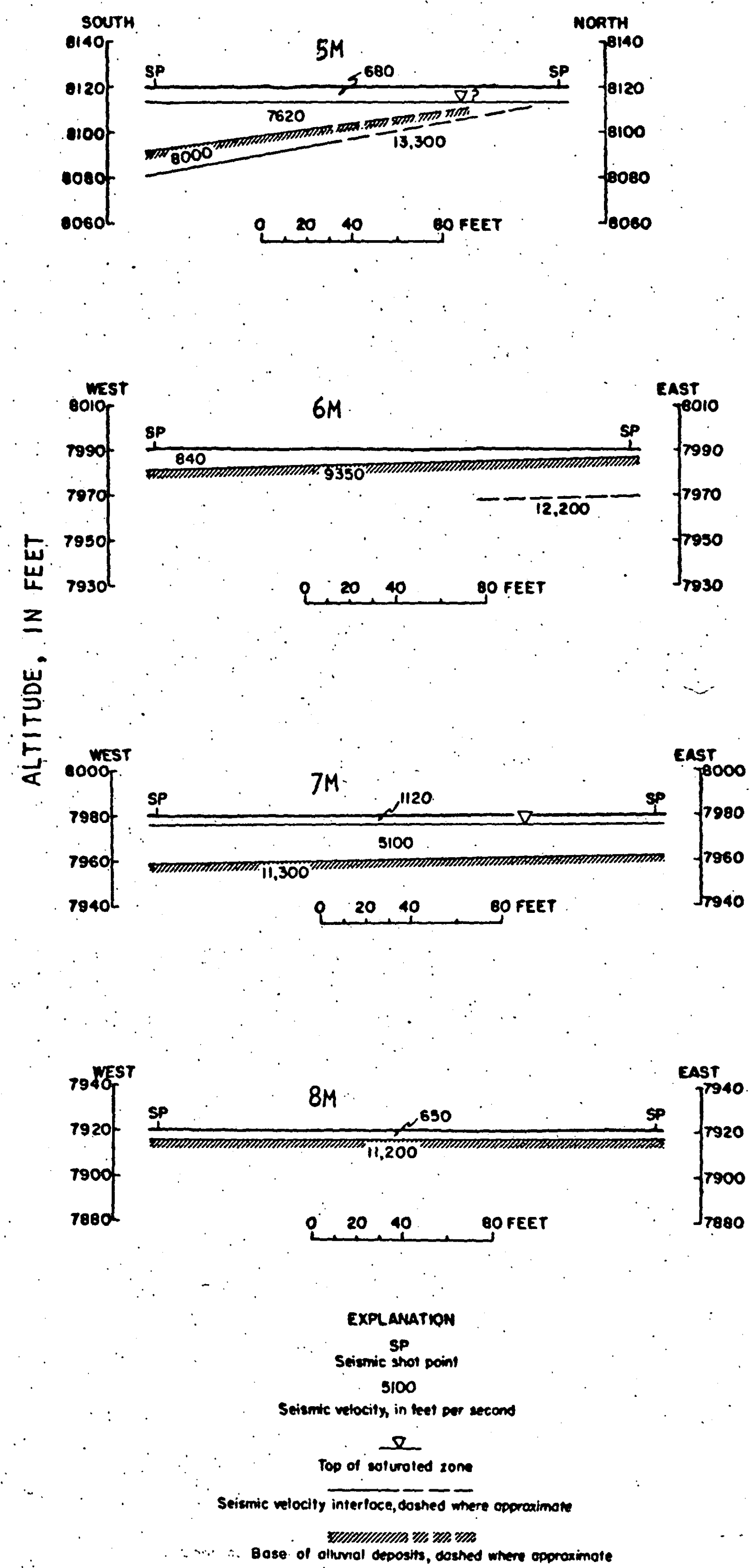


Figure 7.--Seismic profiles 5M, 6M, 7M, and 8M along the Chacon to Holman reach, Mora River.

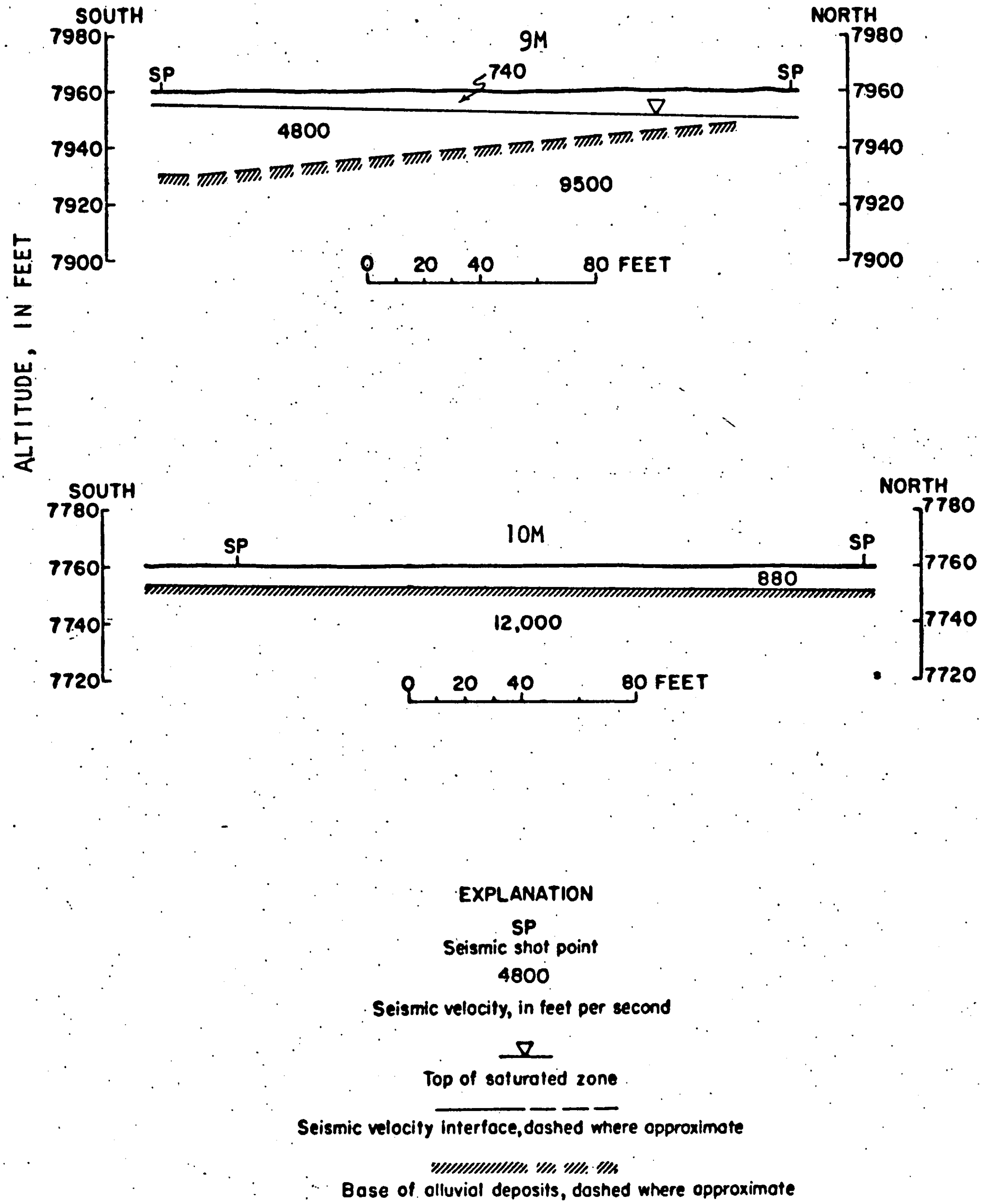


Figure 8.--Seismic profiles 9M and 10M along the Chacon to Holman reach, Mora River.

Cleveland to Buena Vista reach, Mora River

The extent of alluvial deposits and locations of seismic lines along the Cleveland to Buena Vista reach, Mora River is shown on figure 9. The seismic profiles (figs. 10-18) indicate the thickness of the alluvial deposits and the top of the saturated zone in the deposits. The greatest thickness of alluvial deposits occurs northeast of Mora; the deposits are the thinnest near Buena Vista. The greatest areal extent of alluvial deposits in the reach, and in the Mora River system, is also near Mora. Most of the alluvial deposits below Cleveland, in the center of the valley, are completely saturated, causing water-logged conditions. Depths to the base of the alluvial deposits and to the top of the saturated zone in the Cleveland to Buena Vista reach, are summarized in the following table:

Depths to the base of alluvial deposits and to the top of the saturated zone along the Cleveland to Buena Vista reach, Mora River

Profile identification	Depth to base of alluvial deposits (in feet)		Depth to top of saturated zone (in feet)	
	Maximum	Minimum	Maximum	Minimum
11M	48	28	11	9
12M	44	39	8	3
13M - 14M	97	13	22	4
15M	94	90	6	4
16M	?	?	11	4
17M	57	52	8	4
18M	157	133	22	11
19M	-	-	16	11
20M	120	56	20	7
23M	322	25	1/	
21M - 22M - 25M	210	30	1/	
24M	240	205	1/	
26M	320	55	1/	
27M	208	50	14	10
29M - 30M - 31M	?	80	29	22
32M	33	29	4	4
33M	31	19	4	3
34M	35	24	5	4
35M	36	23	7	6
51M	52 2/		4 2/	

1/ Top of saturation is at or near surface

2/ Profile incomplete

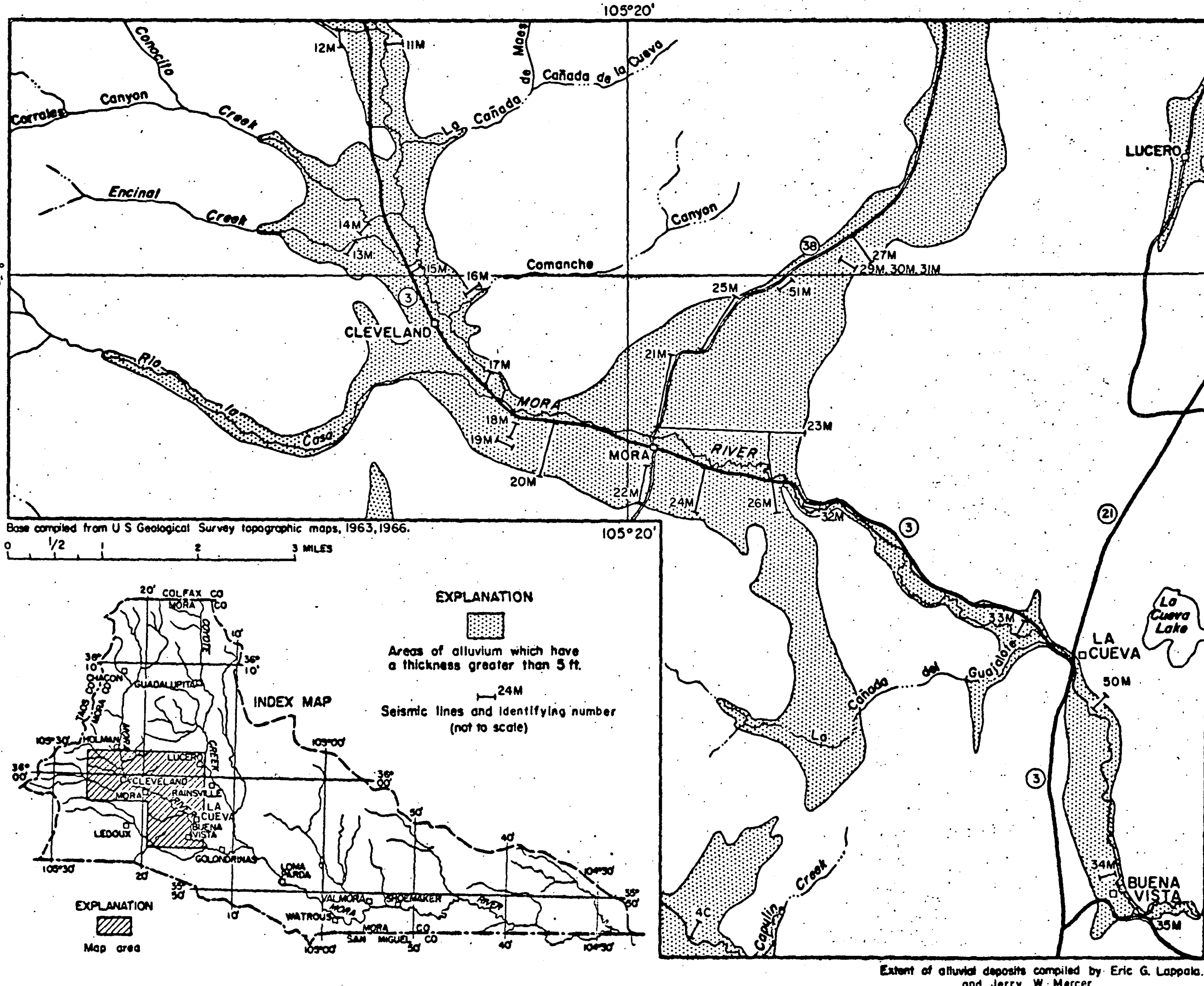


Figure 9.--Extent of alluvial deposits and locations of seismic lines along the Cleveland to Buena Vista reach, Mora River.

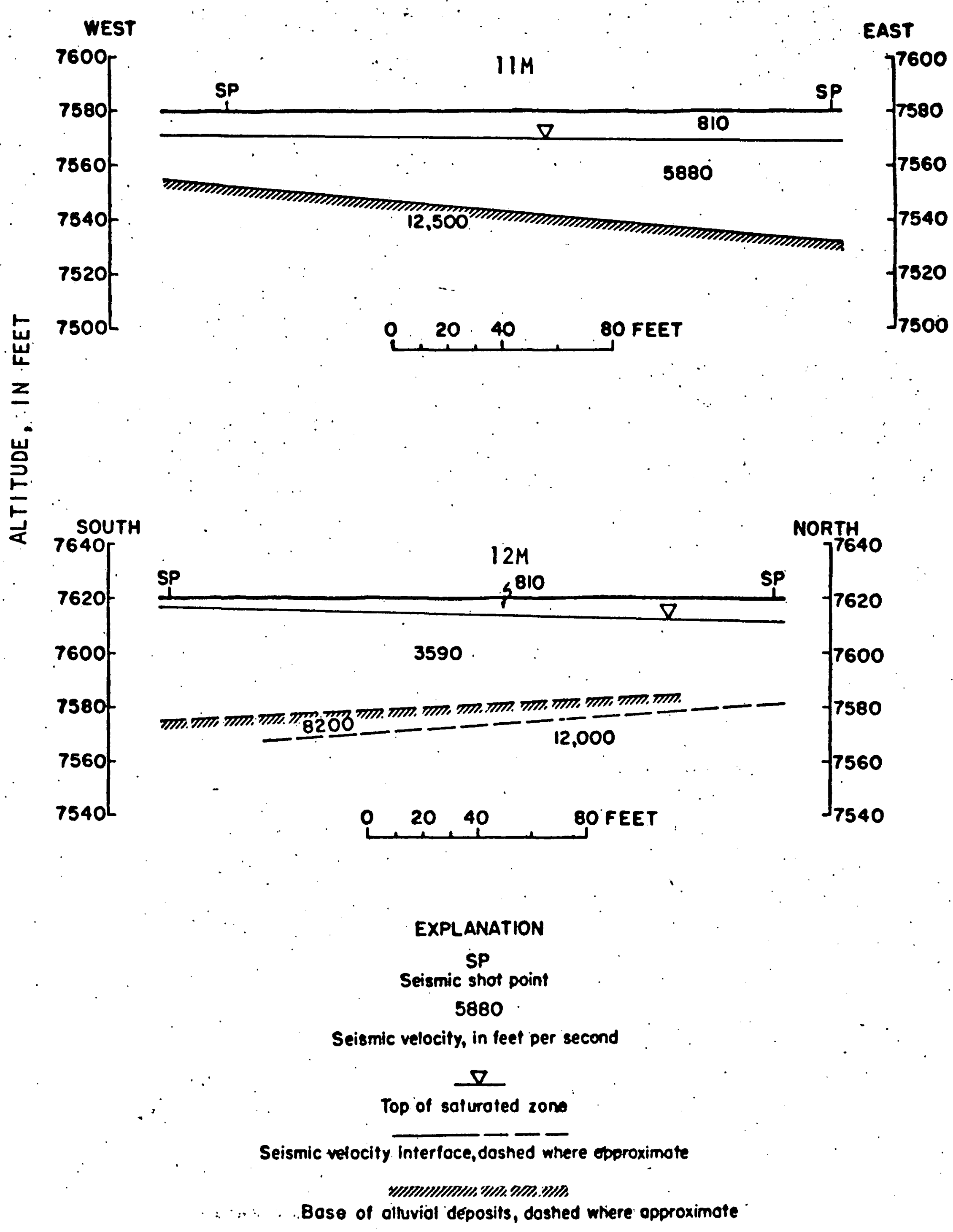


Figure 10.--Seismic profiles 11M and 12M along the Cleveland to Buena Vista reach, Mora River.

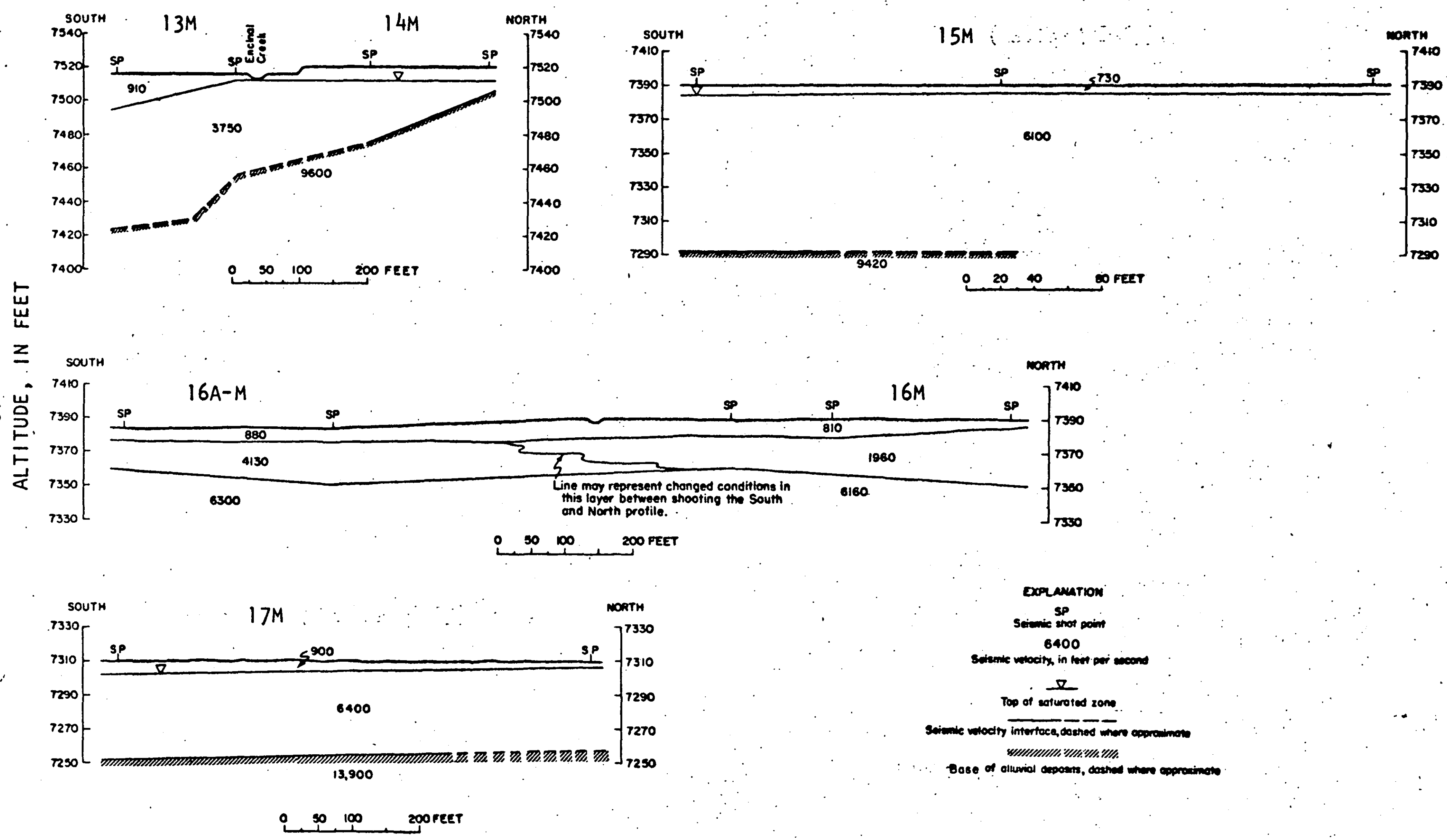


Figure 11.--Seismic profiles 13M, 14M, 15M, 16M, 16A-M, and 17M along the Cleveland to Buena Vista reach, Mora River.

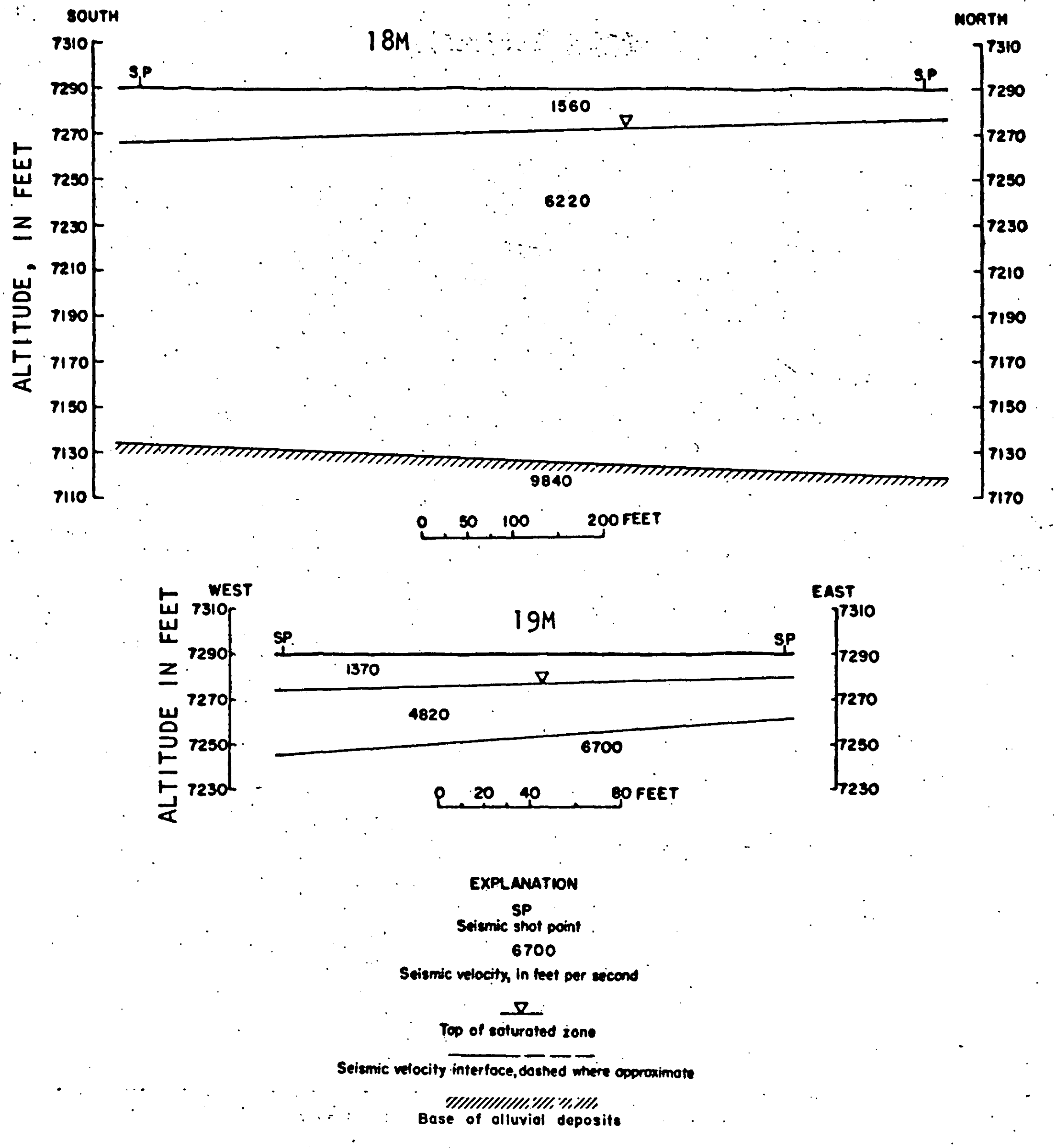


Figure 12.--Seismic profiles 18M and 19M along the Cleveland to Buena Vista reach, Mora River.

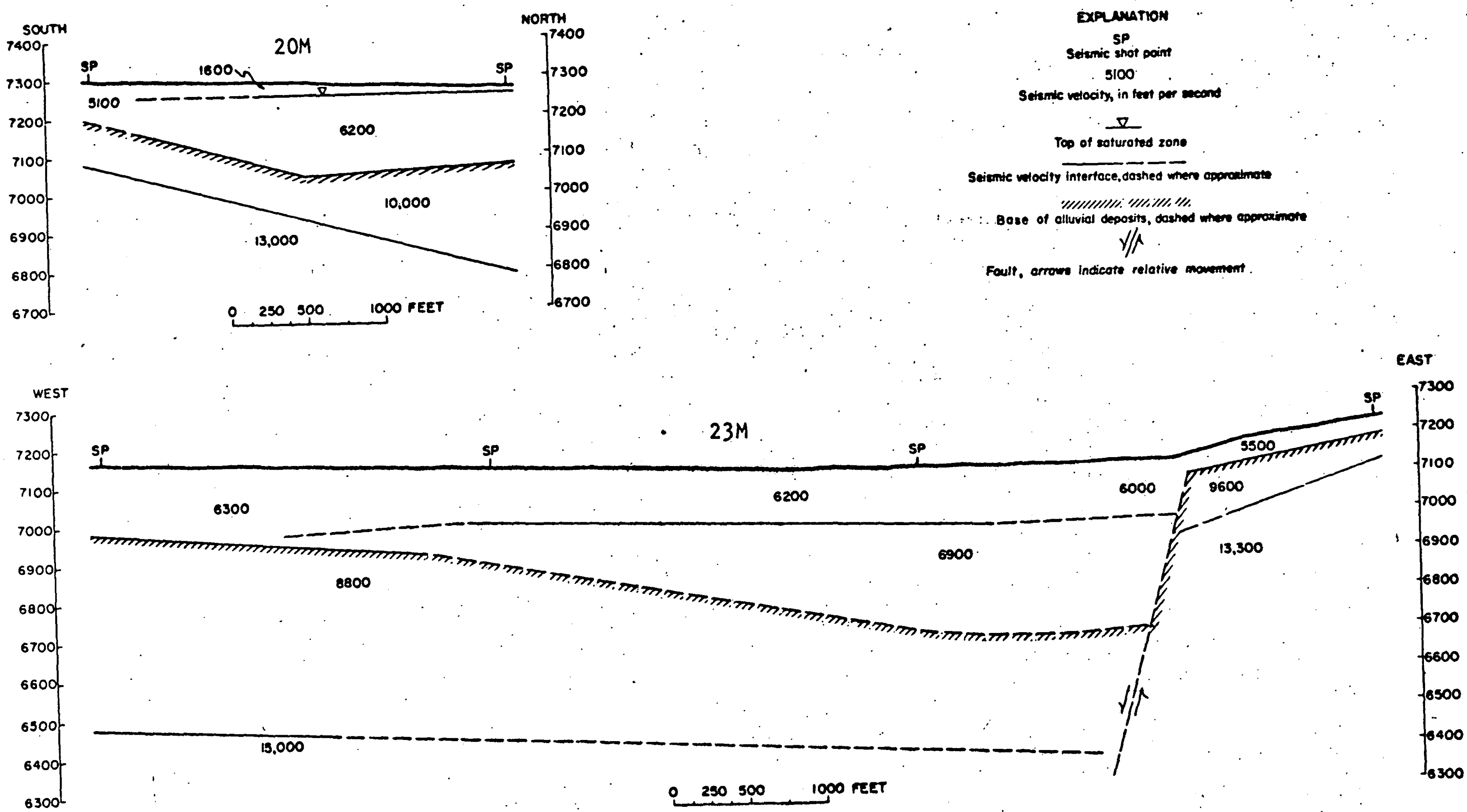
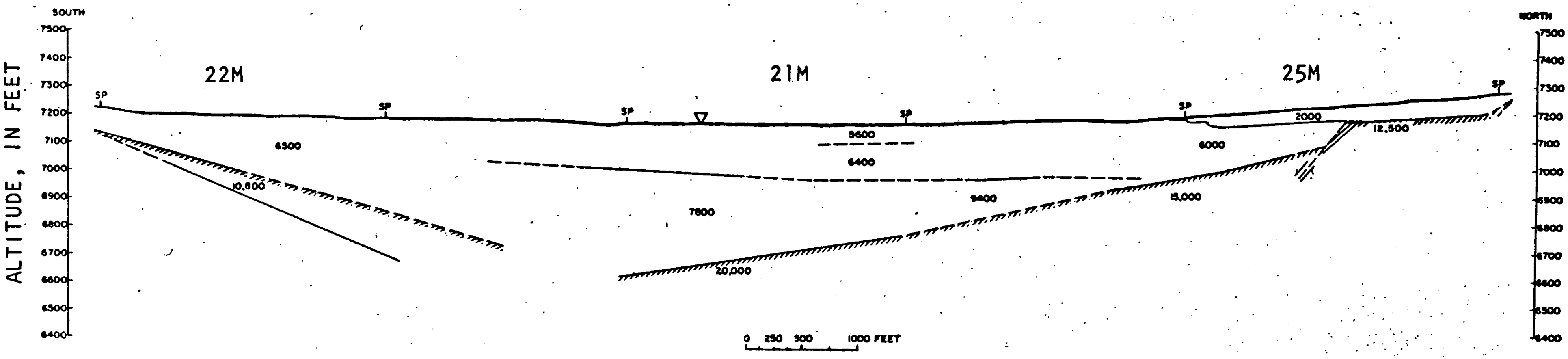


Figure 13.--Seismic profiles 20M and 23M along the Cleveland to Buena Vista reach, Mora River.



EXPLANATION

SP
Seismic shot point

7800
Seismic velocity, in feet per second

Seismic velocity interface, dashed where approximate

Base of alluvial deposits, dashed where approximate

Fault, arrows indicate relative movement

Top of saturated zone

Figure 14.--Seismic profiles 21M, 22M, and 25M along the Cleveland to Buena Vista reach, Mora River.

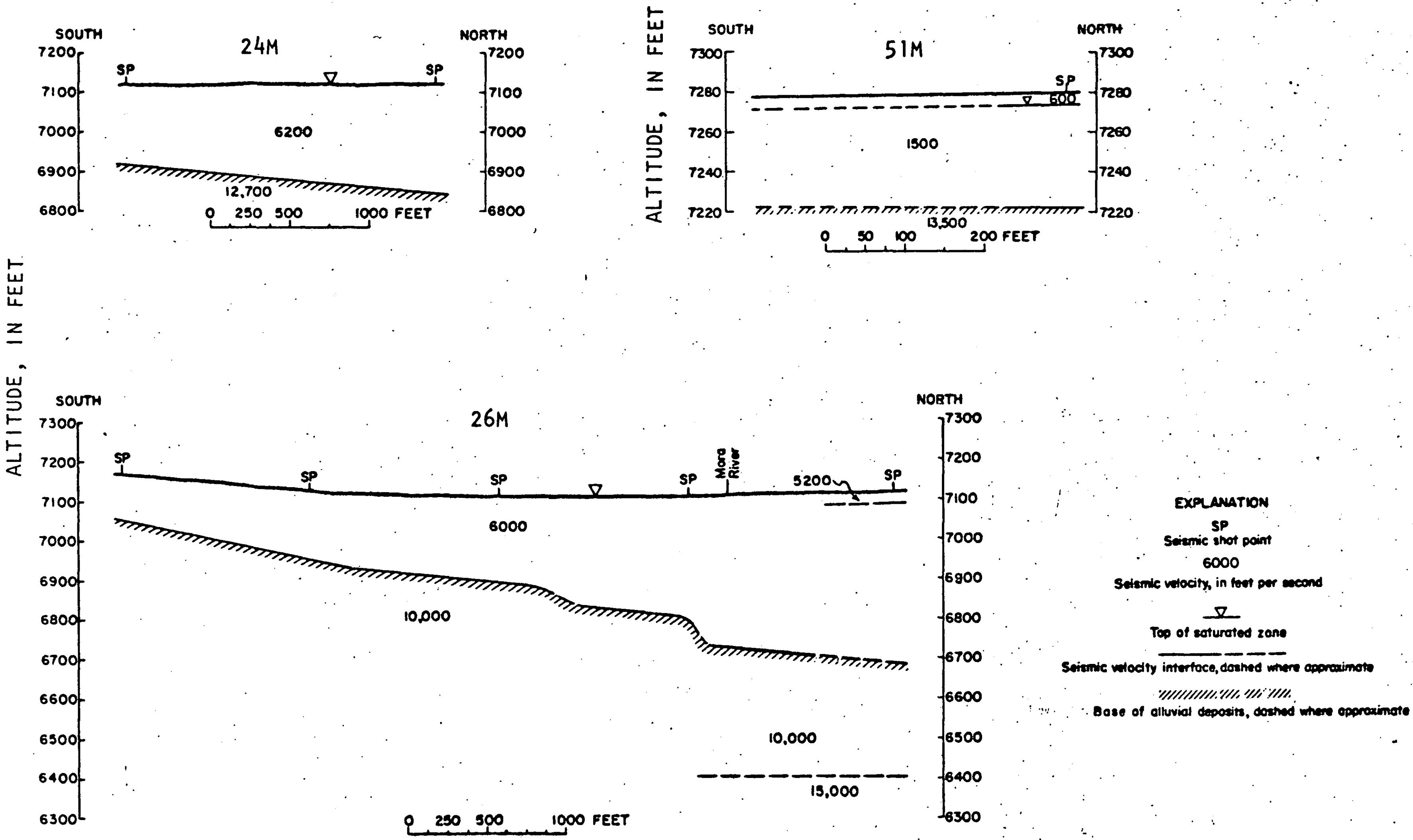


Figure 15.--Seismic profiles 24M, 26M, and 51M along the Cleveland to Buena Vista reach, Mora River.

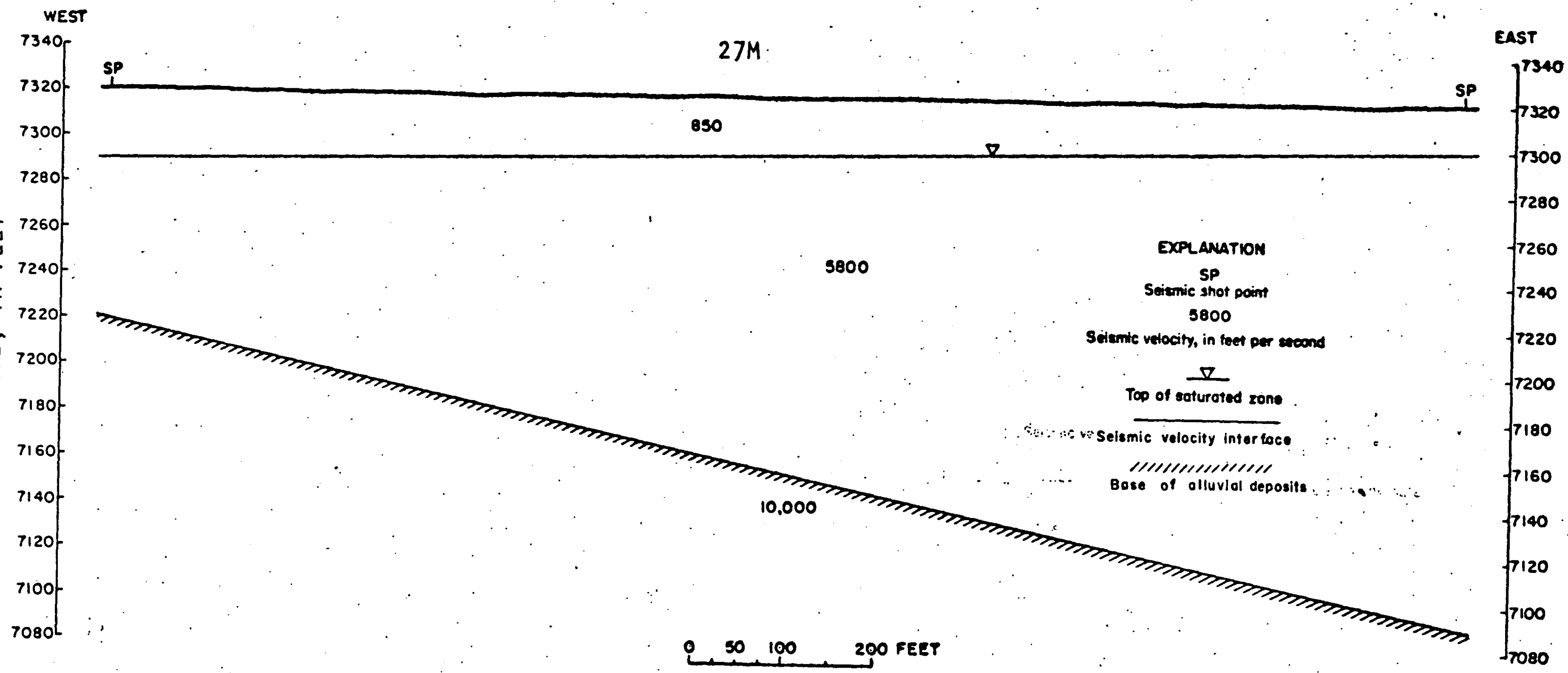


Figure 16.--Seismic profile 27M along the Cleveland to Buena Vista reach, Mora River.

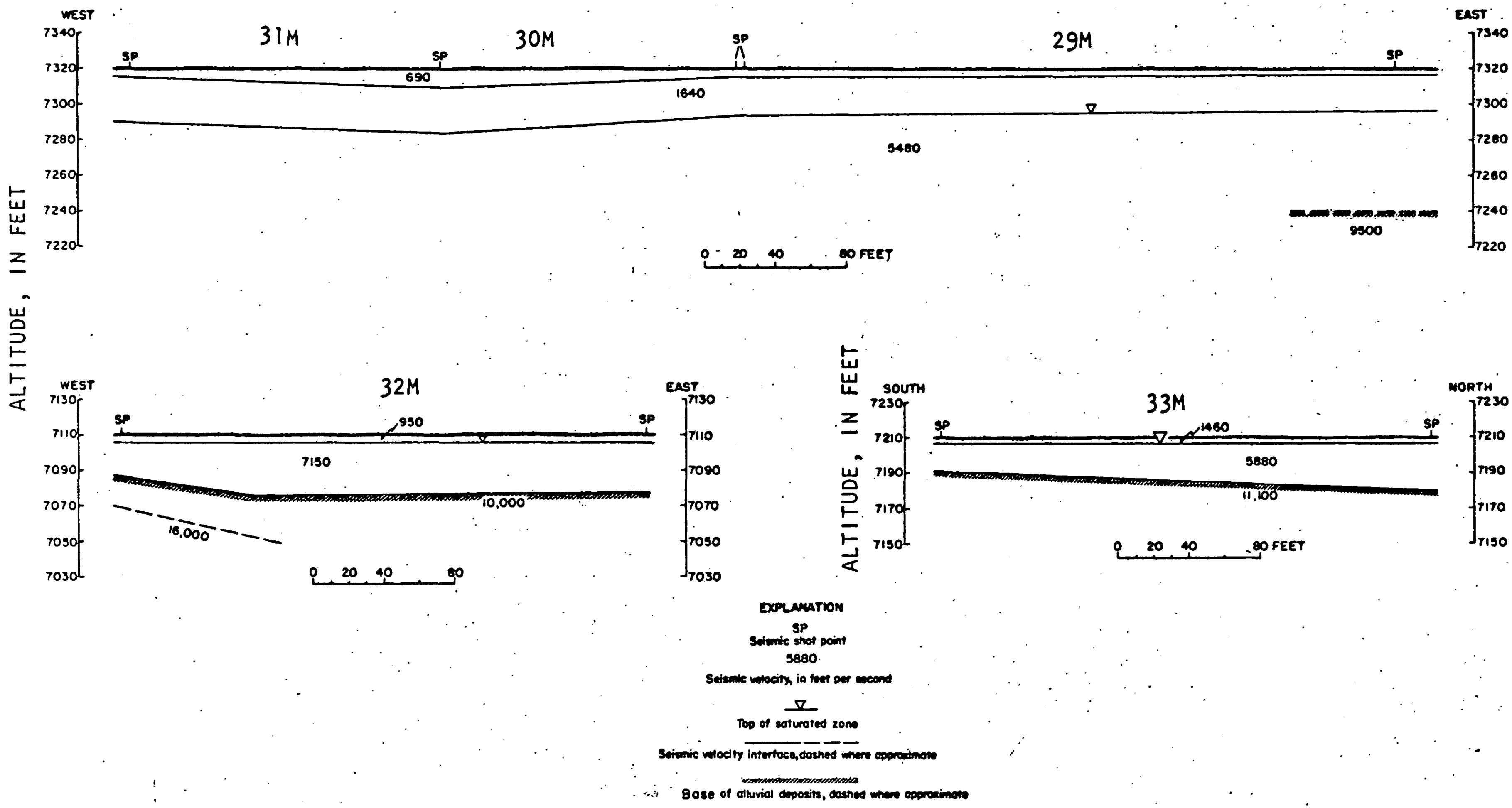


Figure 17.--Seismic profiles 29M, 30M, 31M, 32M, and 33M along the Cleveland to Buena Vista reach, Mora River.

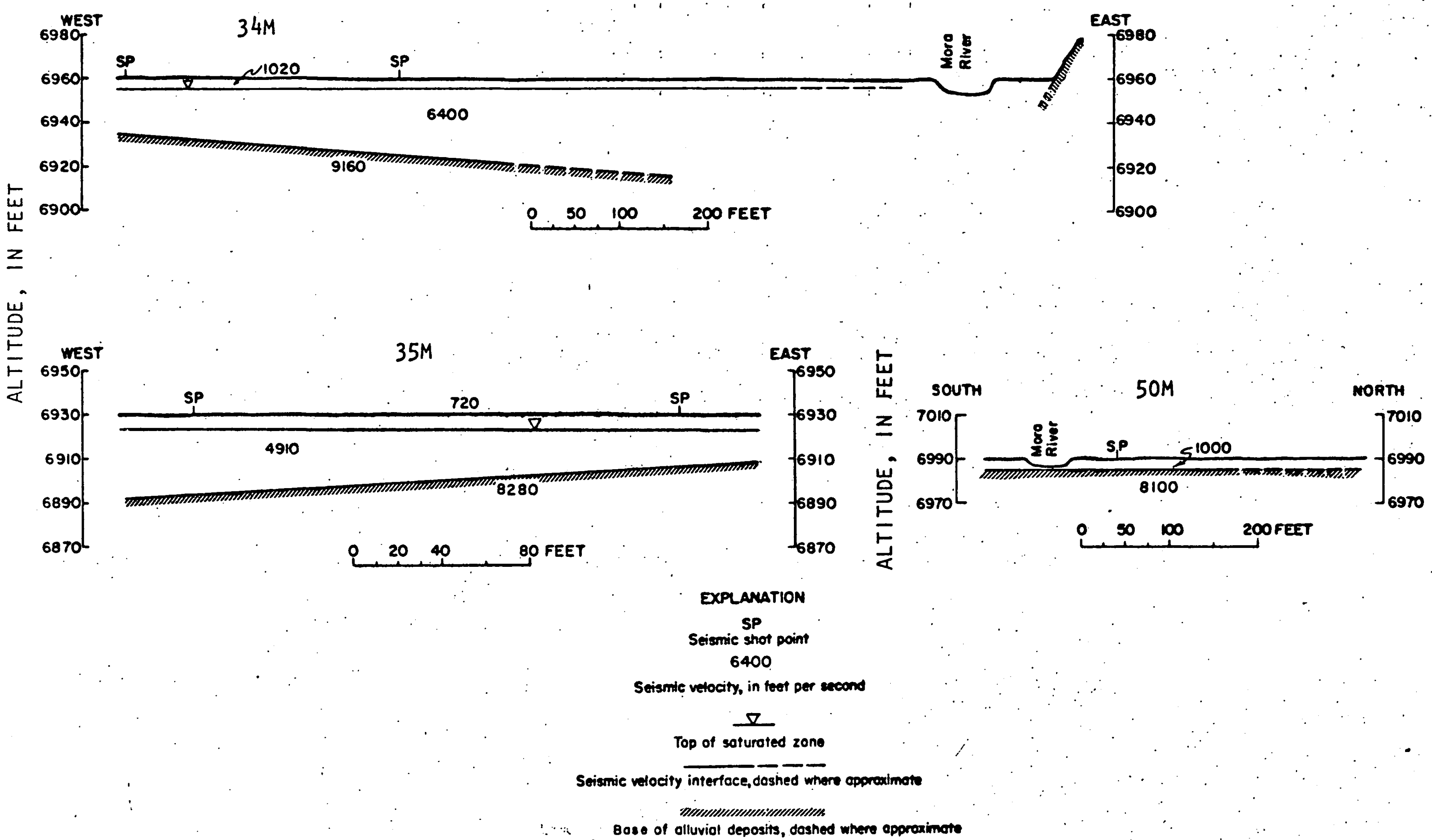


Figure 18.--Seismic profiles 34M, 35M, and 50M along the Cleveland to Buena Vista reach, Mora River.

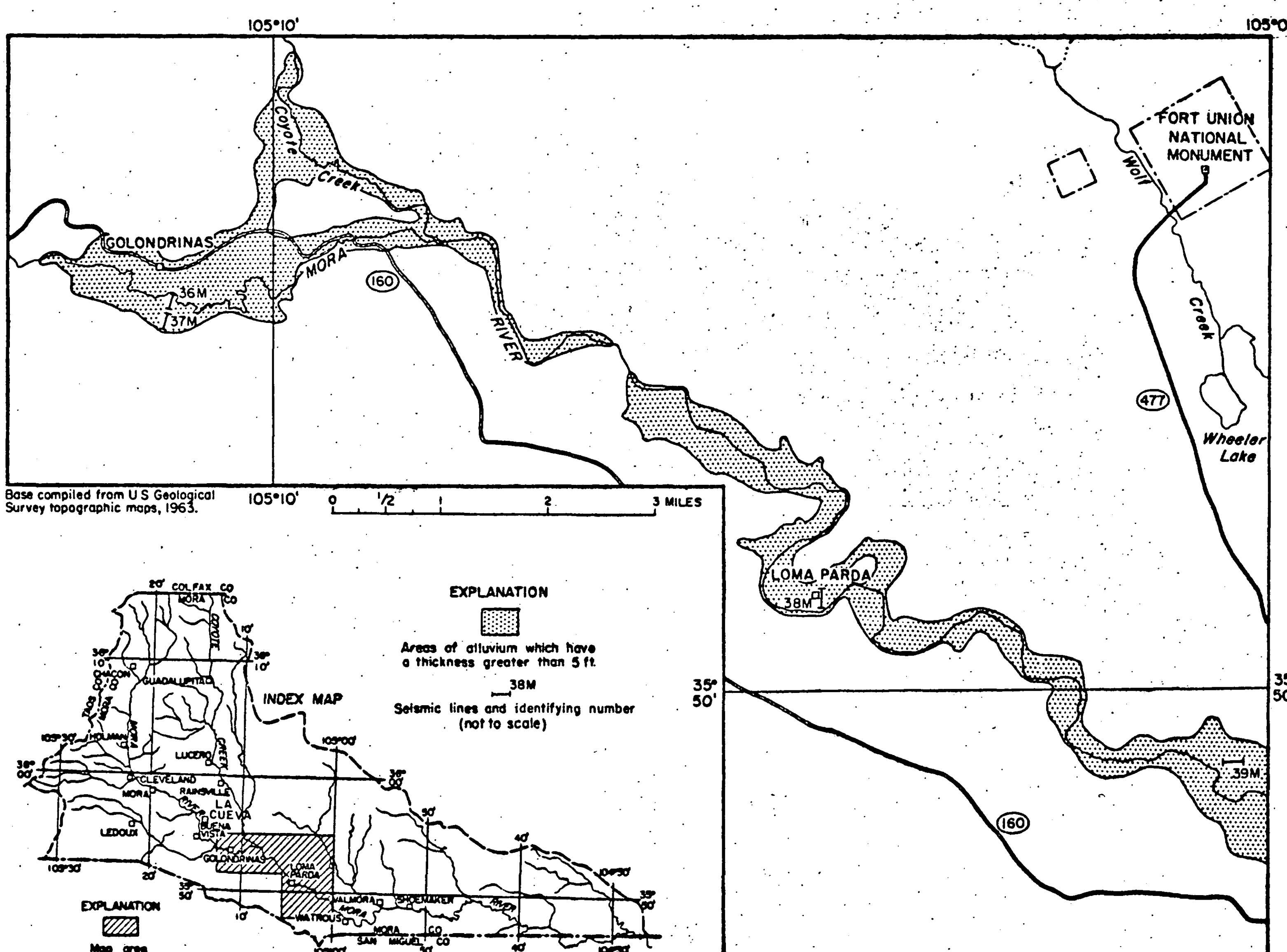
Golondrinas to Loma Parda reach, Mora River

The extent of alluvial deposits and locations of seismic lines along the Golondrinas to Loma Parda reach, Mora River is shown on figure 19. The seismic profiles (fig. 20) indicate the thickness of the alluvial deposits and the top of the saturated zone in the deposits. Depths to the base of the alluvial deposits and to the top of the saturated zone in the Golondrinas to Loma Parda reach are summarized in the following table:

Depths to the base of alluvial deposits and to the top of the saturated zone along the Golondrinas to Loma Parda reach, Mora River

Profile identification	Depth to base of alluvial deposits (in feet)		Depth to top of saturated zone (in feet)	
	Maximum	Minimum	Maximum	Minimum
36M - 37M	43	21	10	5
38M	79	60	9	6
39M	16	14	-	-

The alluvial deposits are confined to the flood plain of the Mora River except near the community of Golondrinas where some older deposits extend beyond and lie above the present flood plain.



Extent of alluvial deposits compiled by Eric G. Lappala and Jerry W. Mercer.

Figure 19.--Extent of alluvial deposits and locations of seismic lines along the Golondrinas to Loma Parda reach, Mora River.

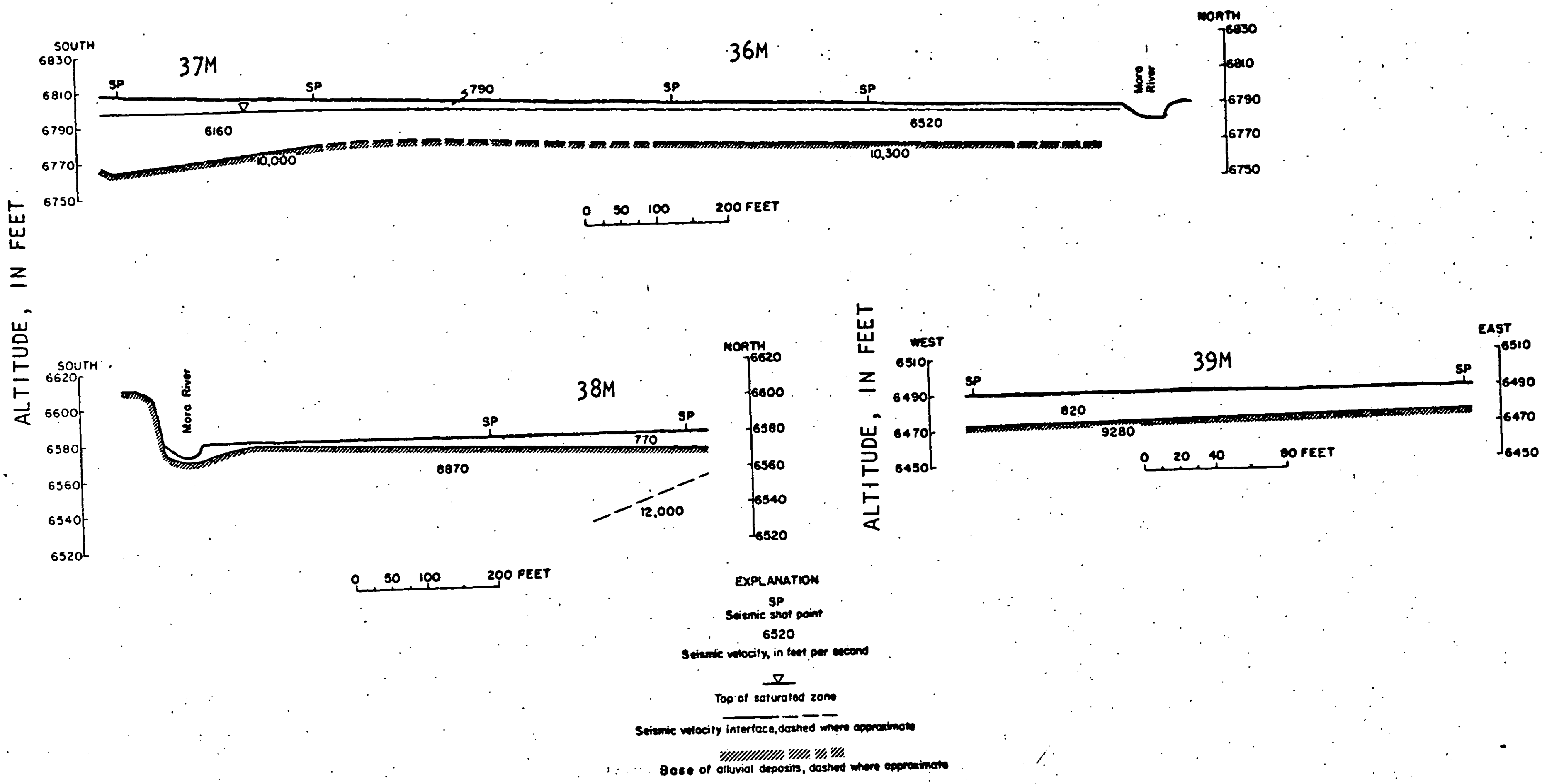


Figure 20.--Seismic profiles 36M, 37M, 38M, and 39M along the Golondrinas to Loma Parda reach, Mora River.

Watrous to Shoemaker reach, Mora River

The extent of alluvial deposits and locations of seismic lines along the Watrous to Shoemaker reach, Mora River is shown on figure 21. The seismic profiles (figs. 22 and 23) indicate the thickness of the alluvial deposits and the top of the saturated zone in the deposits. Depths to the base of the alluvial deposits and to the top of the saturated zone in the Watrous to Shoemaker reach are summarized in the following table:

Depths to the base of alluvial deposits and to the top of the saturated zone along the Watrous to Shoemaker reach, Mora River

Profile identification	Depth to base of alluvial deposits (in feet)		Depth to top of saturated zone (in feet)	
	Maximum	Minimum	Maximum	Minimum
43M	39	20	10	4
44M	45	30	16	4
40M	-	See 41M		
41M	182	130	12	6
42M	11	8	-	-

The greatest depths of alluvial deposits are near Watrous and at the confluence of Wolf Creek with the Mora River near Valmora. Near Shoemaker the deposits are confined to the flood plain of the Mora River.

Near the community of Watrous the shallow-water levels have caused some areas to become water logged.

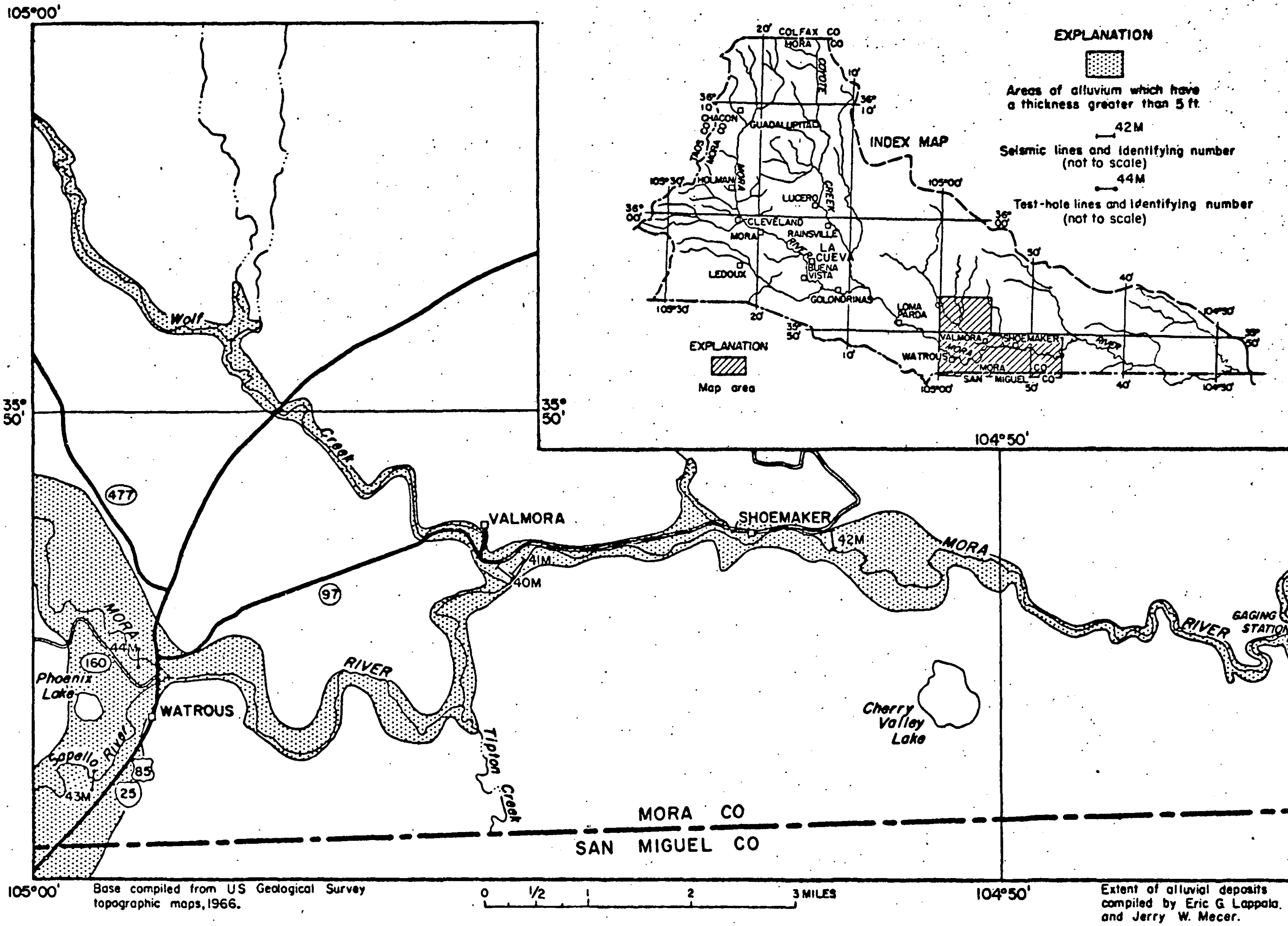


Figure 21.--Extent of alluvial deposits and locations of seismic lines along the Watrous to Shoemaker reach, Mora River.

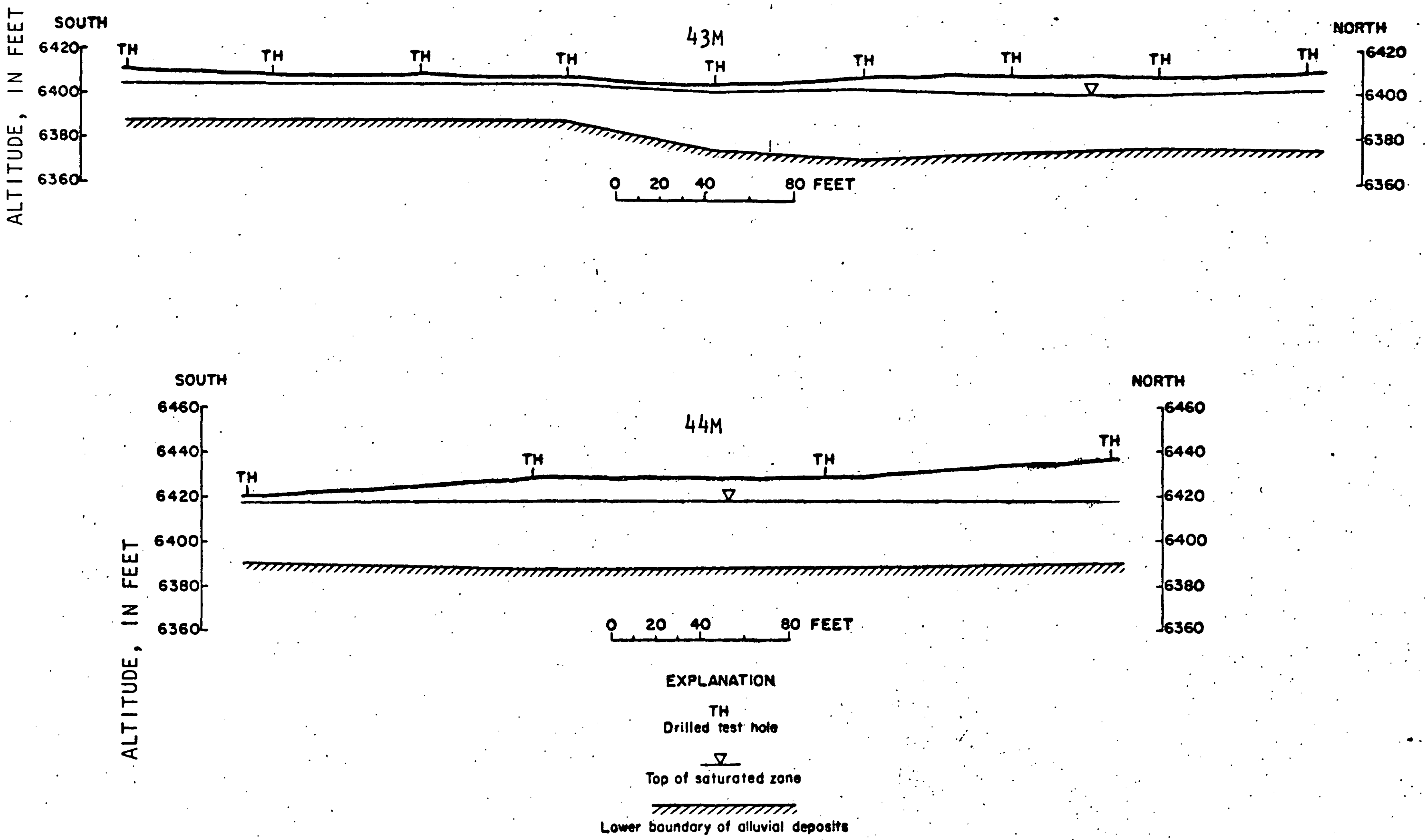


Figure 22.--Sections 43M and 44M along the Watrous to Shoemaker reach, Mora River. Drawn from test hole logs from New Mexico State Highway Dept. bridge site investigation.

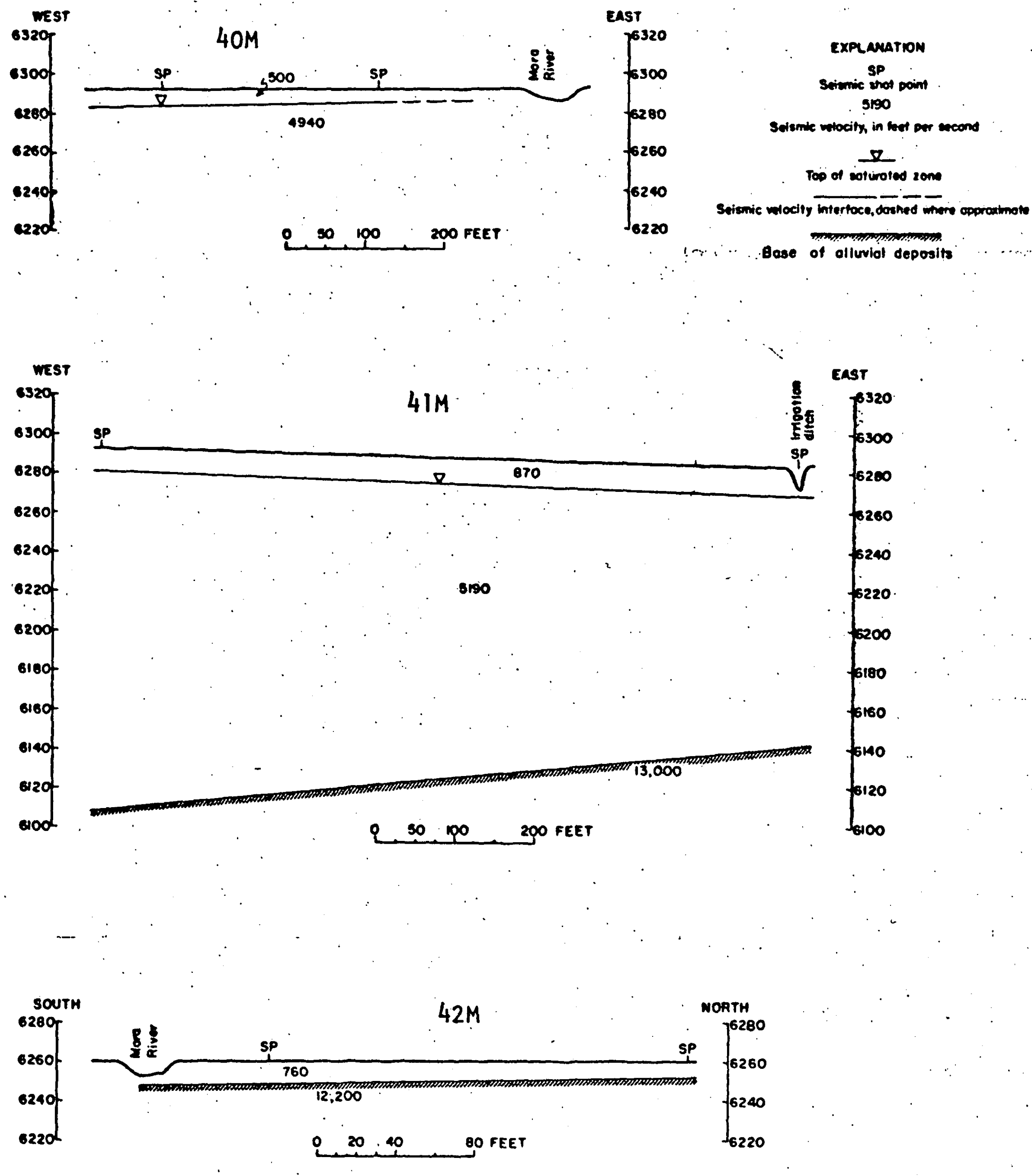


Figure 23.--Seismic profiles 40M, 41M, and 42M along the Watrous to Shoemaker reach, Mora River.

Guadalupita reach, Coyote Creek

The extent of alluvial deposits and locations of seismic lines along the Guadalupita reach, Coyote Creek is shown on figure 24. The seismic profiles (figs 25-26) indicate the thickness of the alluvial deposits and the top of the saturated zone in the deposits. Depths to the base of the alluvial deposits and to the top of the saturated zone in the Guadalupita reach are summarized in the following table:

Depths to the base of alluvial deposits and to the top of the saturated zone along the Guadalupita reach, Coyote Creek

Profile identification	Depth to base of alluvial deposits (in feet)		Depth to top of saturated zone (in feet)	
	Maximum	Minimum	Maximum	Minimum
1Cy	5	4	-	-
2Cy	4	3	-	-
3Cy - 4Cy	71	51	4	3
5Cy	40	27	7	3
6Cy	46	7	7	7
7Cy	5	4	-	-
24Cy	55	43	8	7

The largest area of alluvial deposits, and the thickest section in the reach is near Guadalupita. In the upper and lower portions of the Guadalupita reach, the deposits are confined to the flood plain of Coyote Creek.

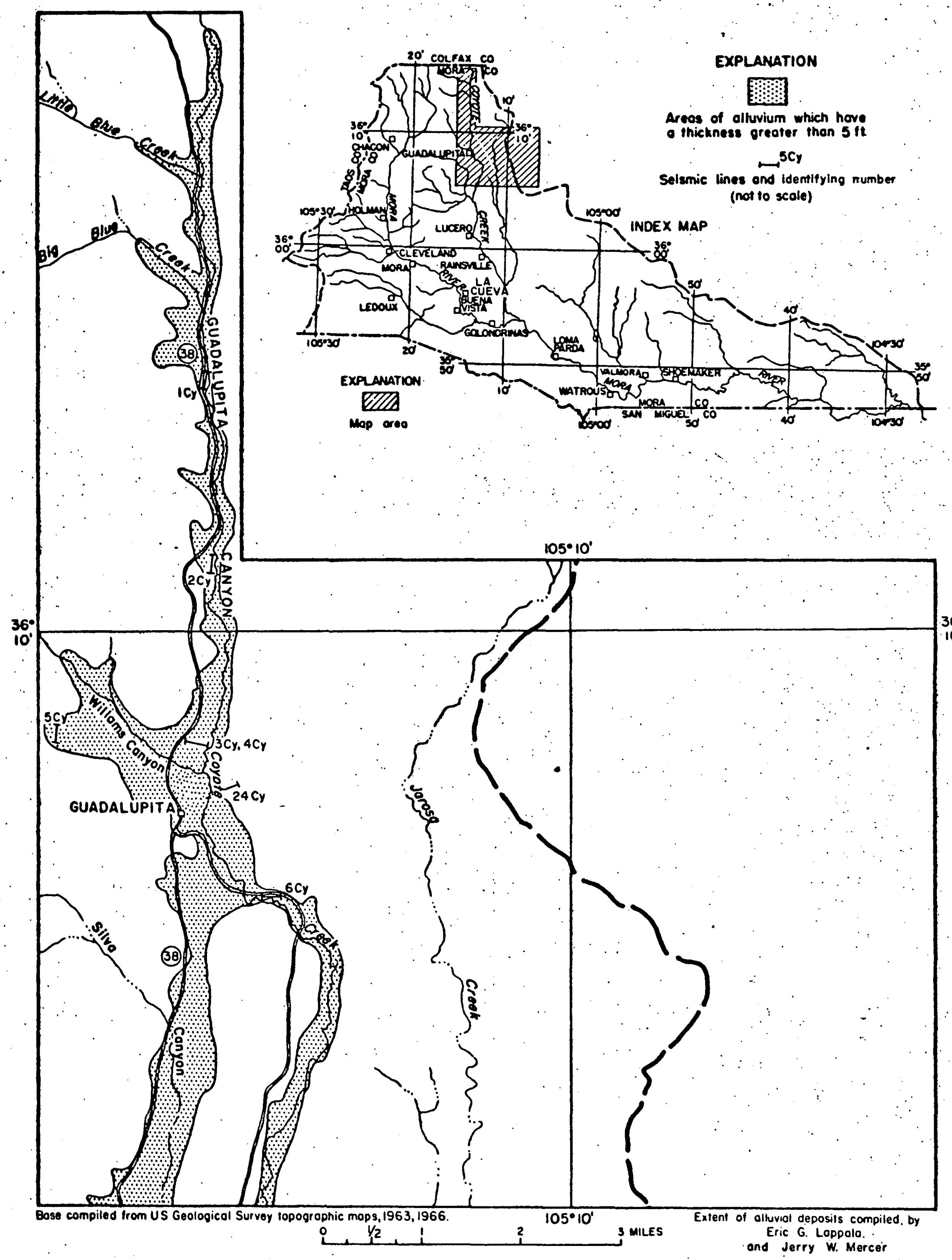


Figure 24.--Extent of alluvial deposits and locations of seismic lines along the Guadalupita reach, Coyote Creek.

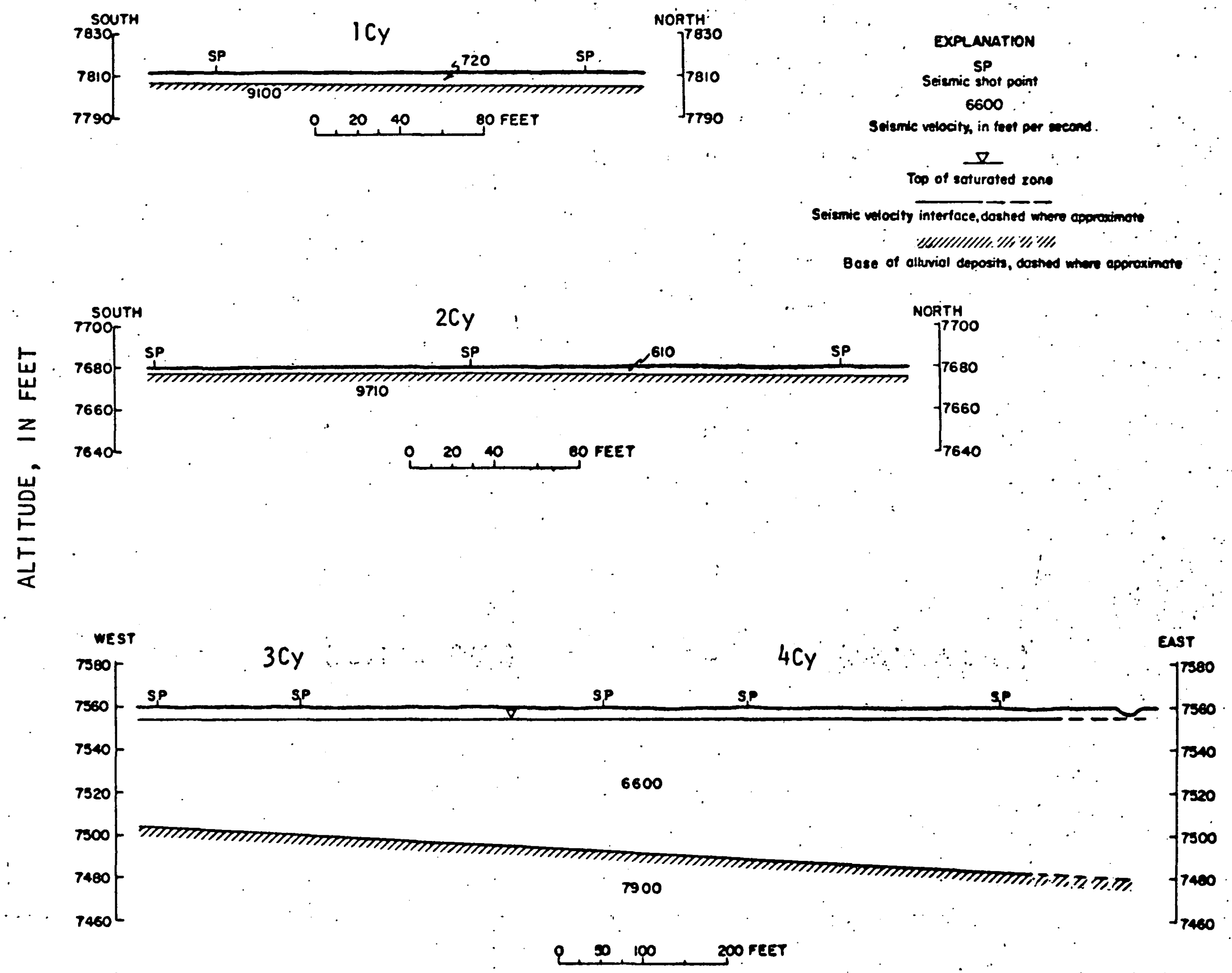


Figure 25.--Seismic profiles 1Cy, 2Cy, 3Cy, and 4Cy along the Guadalupita reach, Coyote Creek.

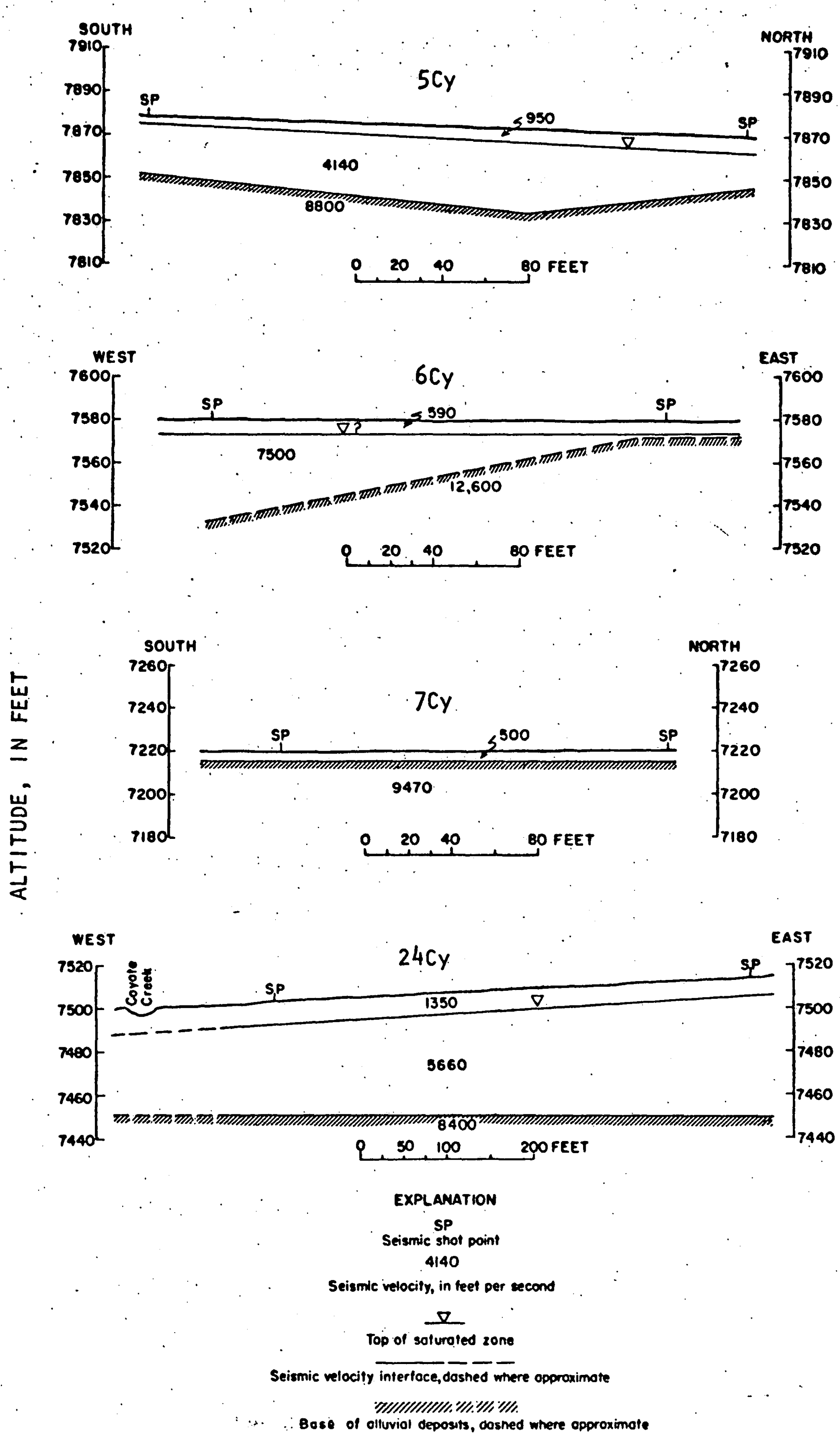


Figure 26.--Seismic profiles 5Cy, 6Cy, 7Cy, and 24Cy along the Guadalupita reach, Coyote Creek.

Rainsville reach, Coyote Creek

The extent of alluvial deposits and locations of seismic lines along the Rainsville reach, Coyote Creek, is shown in figure 27. The seismic profiles (figs. 28-31) indicate the thickness of the alluvial deposits and the top of the saturated zone in the deposits. Depths to the base of the alluvial deposits and to the top of the saturated zone in the Rainsville reach are summarized in the following table:

Depths to the base of alluvial deposits and to the top of the saturated zone along the Rainsville reach, Coyote Creek

Profile identification	Depth to base of alluvial deposits (in feet)		Depth to top of saturated zone (in feet)	
	Maximum	Minimum	Maximum	Minimum
10Cy	218	70	7	6
12Cy	6	5	-	-
13Cy	11	10	4	3
14Cy	57	28	7	6
15Cy - 16Cy - 19Cy	33	11	13	3
20Cy	5	5	1/	
23Cy	24	10	-	-
21Cy	19	7	6	5
17Cy - 18Cy - 22Cy	83	7	6	3

1/ Top of saturation is at or near land surface.

The thickest and most extensive alluvial deposits are along the Los Chupaderos and Turquillo valleys. Along Coyote Creek the deposits are confined to the flood plain. The deepest water levels are in the Los Chupaderos valley and the shallowest are below Rainsville.

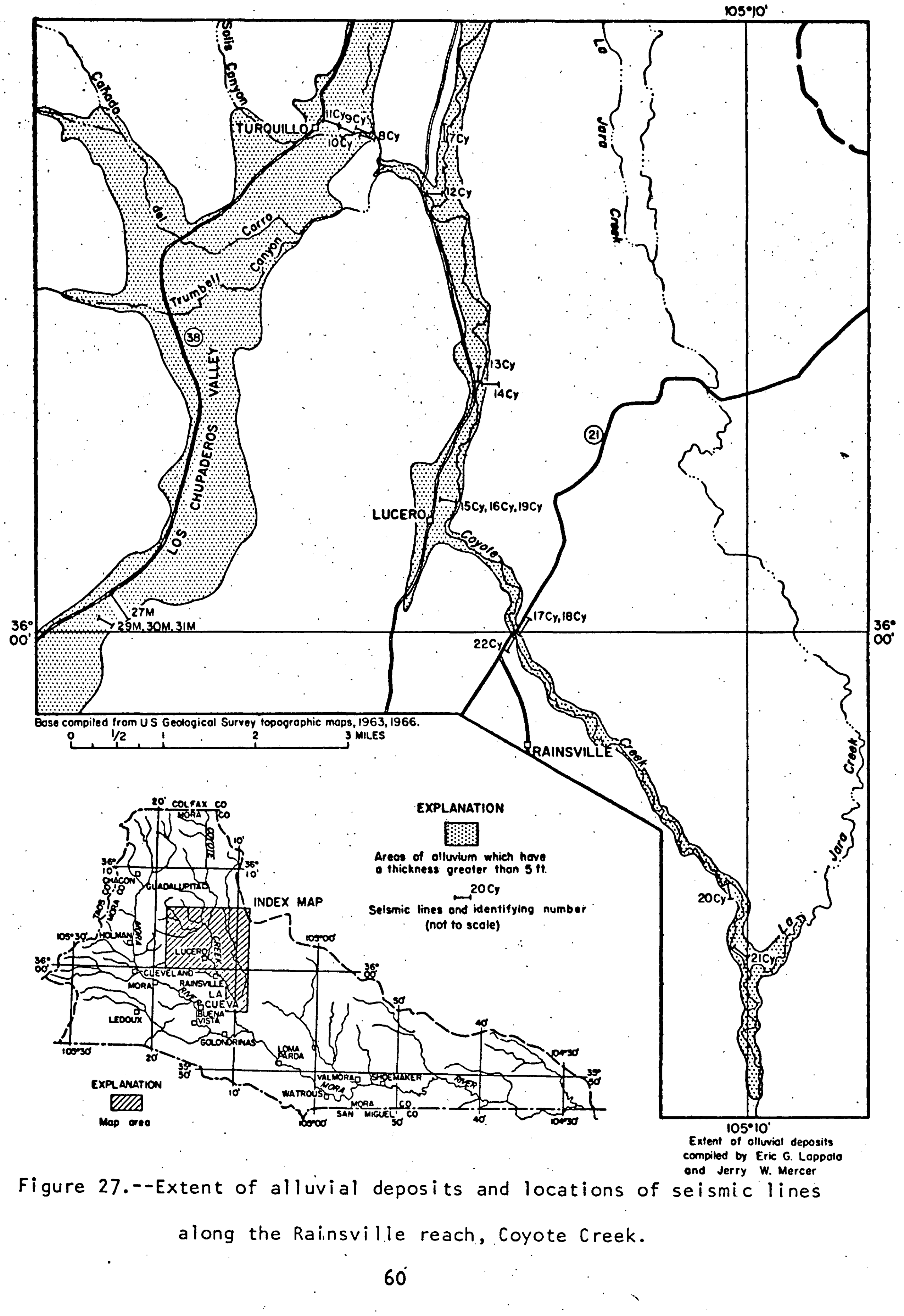


Figure 27.--Extent of alluvial deposits and locations of seismic lines along the Rainsville reach, Coyote Creek.

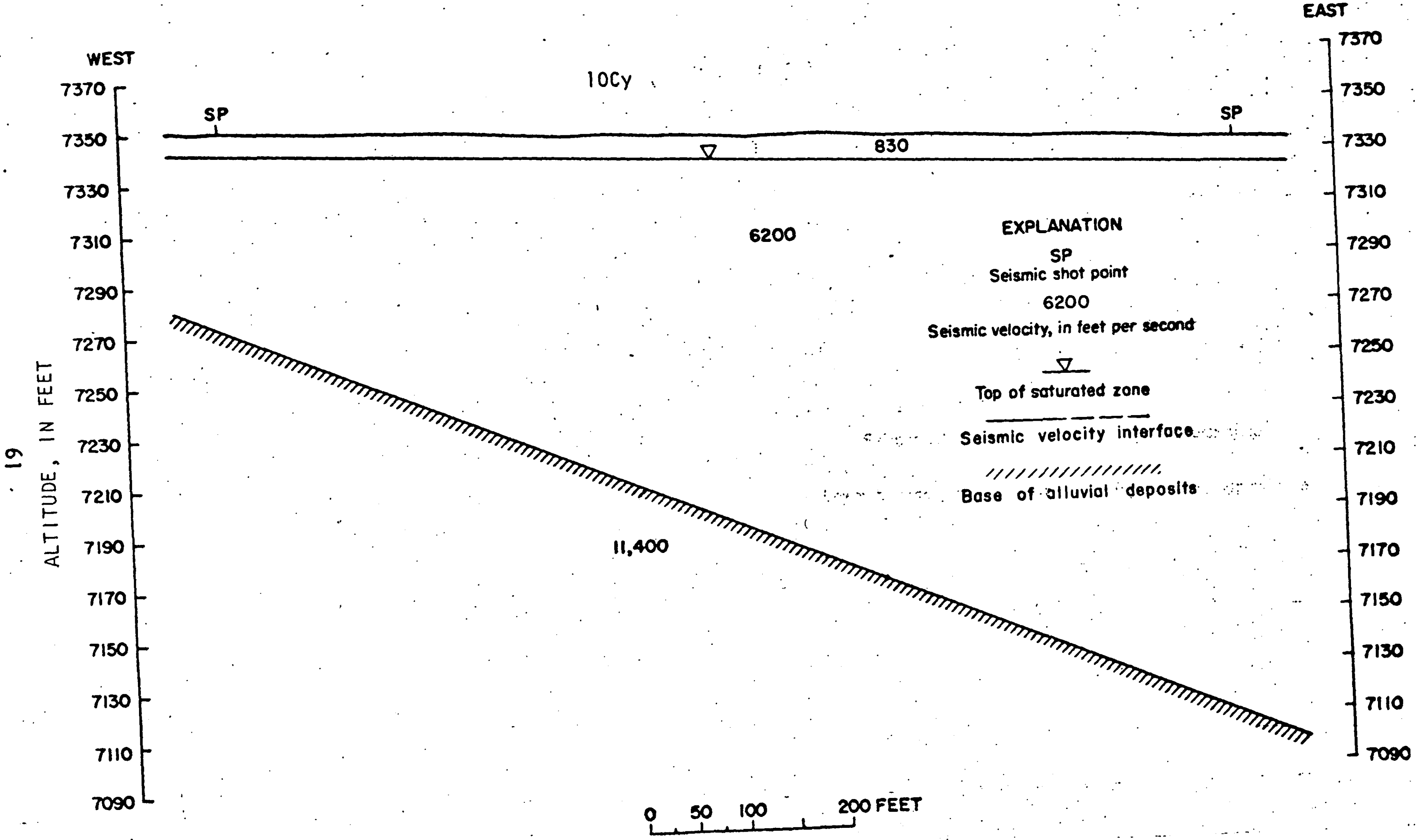


Figure 28.--Seismic profile 10Cy along the Rainsville reach, Coyote Creek.

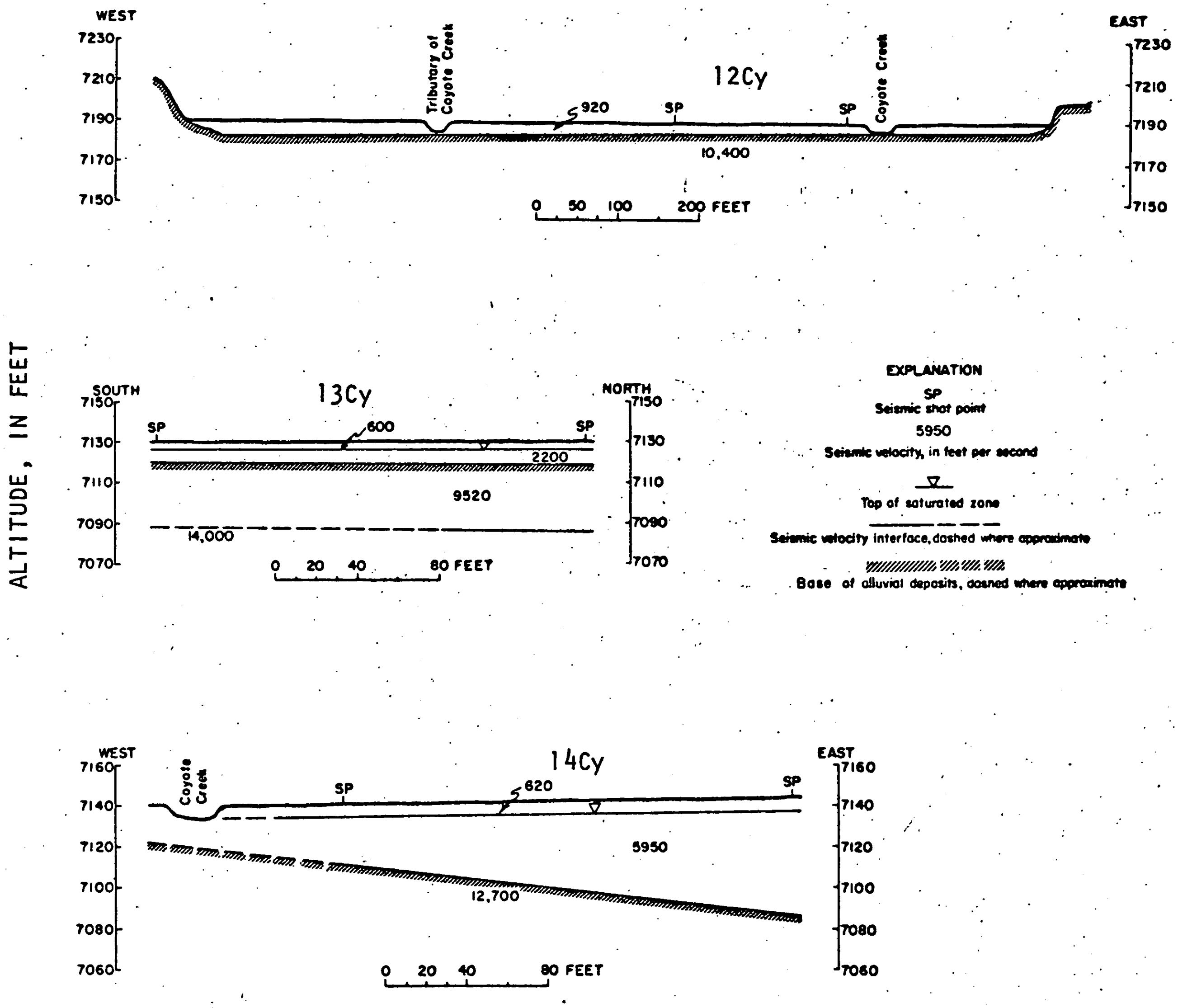


Figure 29.--Seismic profiles 12Cy, 13Cy, and 14Cy along the Rainsville reach, Coyote Creek

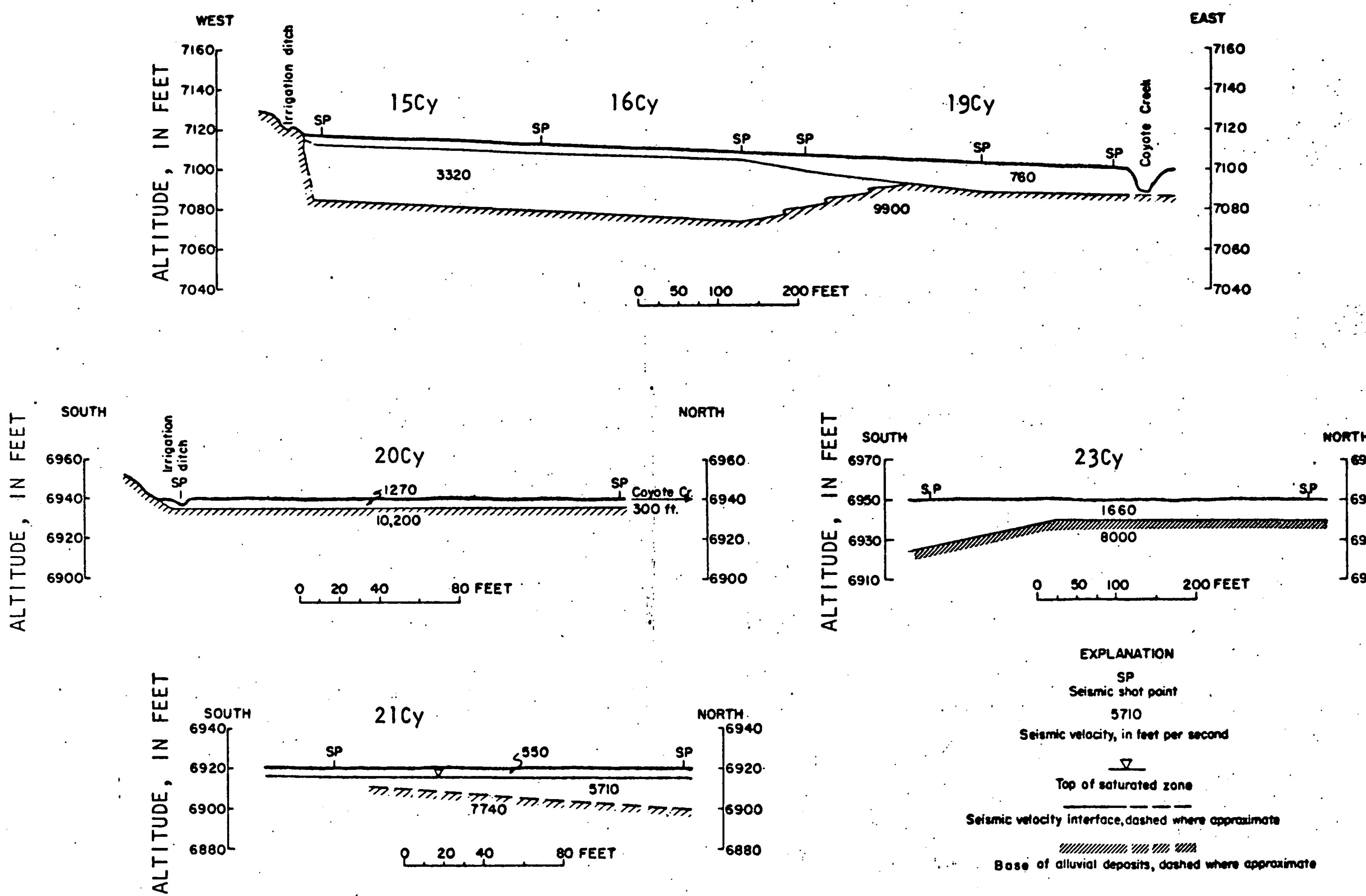


Figure 30.--Seismic profiles 15Cy, 16Cy, 19Cy, 20Cy, 21Cy, and 23Cy along the Rainsville reach, Coyote Creek.

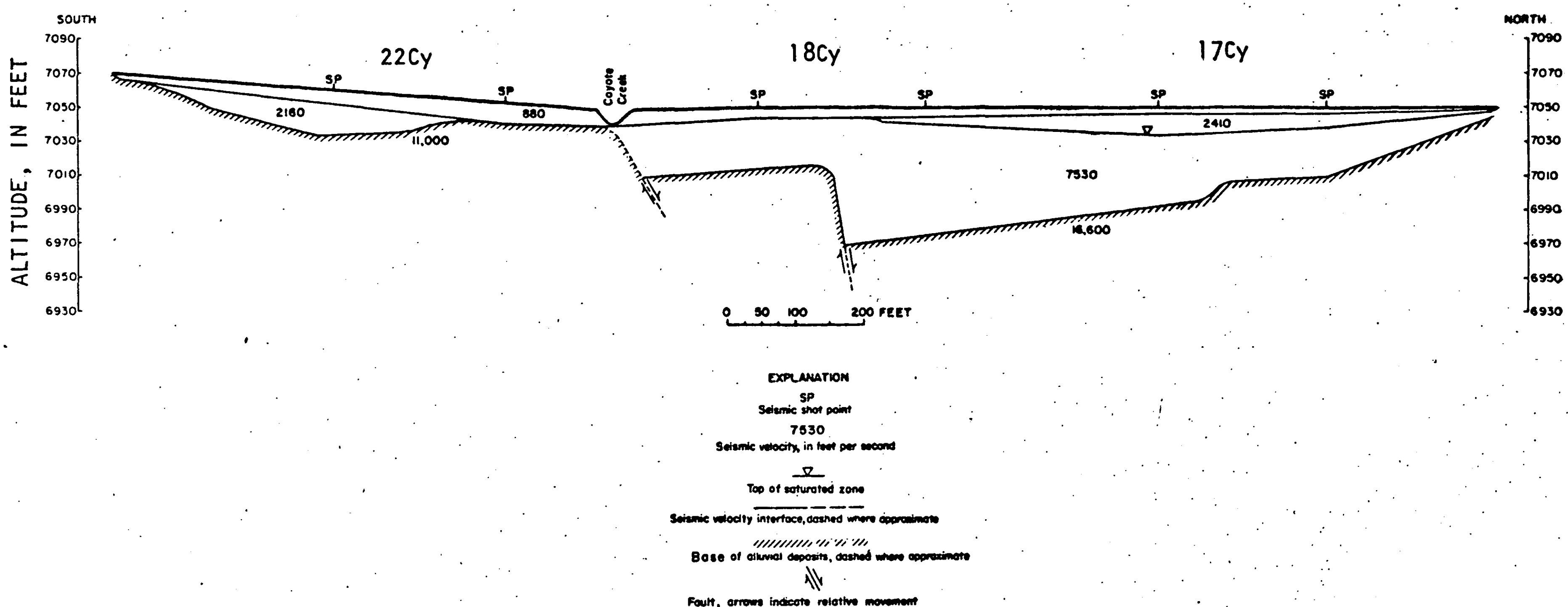


Figure 31.--Seismic profiles 17Cy, 18Cy, and 22Cy along the Rainsville reach, Coyote Creek.

Cebolla River

The extent of alluvial deposits and locations of seismic lines along the Cebolla River is shown in figure 32. The seismic profiles (figs. 33-34) indicate the thickness of the alluvial deposits and the top of the saturated zone in the deposits. Depths to the base of the alluvial deposits and to the top of the saturated zone along the Cebolla River are summarized in the following table:

Depths to the base of alluvial deposits and to the top of the saturated zone along the Cebolla River

Profile identification	Depth to base of alluvial deposits (in feet)		Depth to top of saturated zone (in feet)	
	Maximum	Minimum	Maximum	Minimum
1C	35	24	5	4
2C	?	?	5	5
3C	31 1/		3 1/	
4C	24	23	4	4
5C	11	9	-	-
6C	38	25	12	6

1/ only one end shot.

The greatest areal extent and thickness of alluvial deposits are east of Ledoux and west of the confluence of the Cebolla River with Capulin Creek. Below this point alluvial deposits are confined to the flood plain of the Cebolla River.

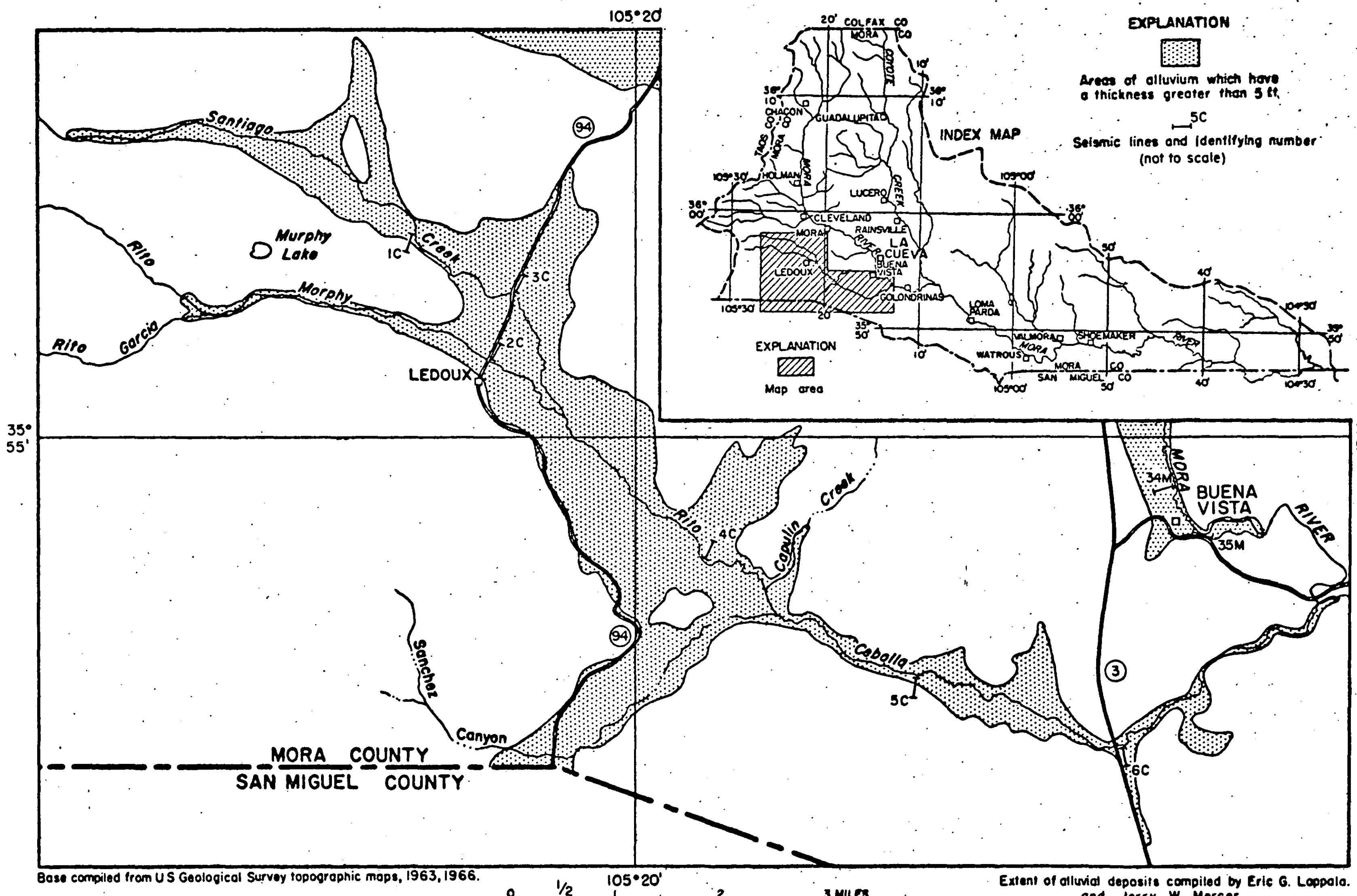


Figure 32.--Extent of alluvial deposits and locations of seismic lines along the Cebolla River.

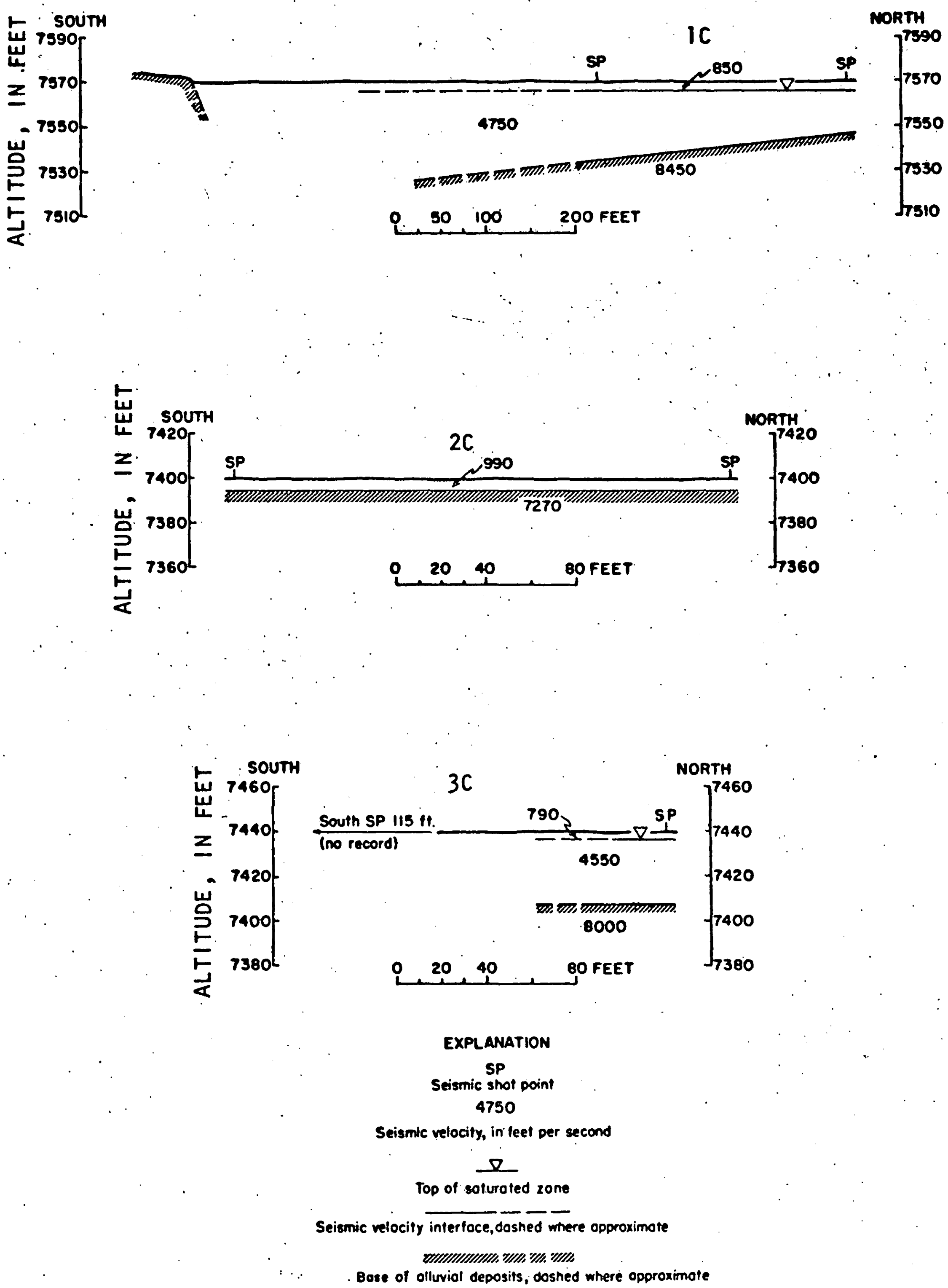


Figure 33.--Seismic profiles 1C, 2C, and 3C along the Cebolla River.

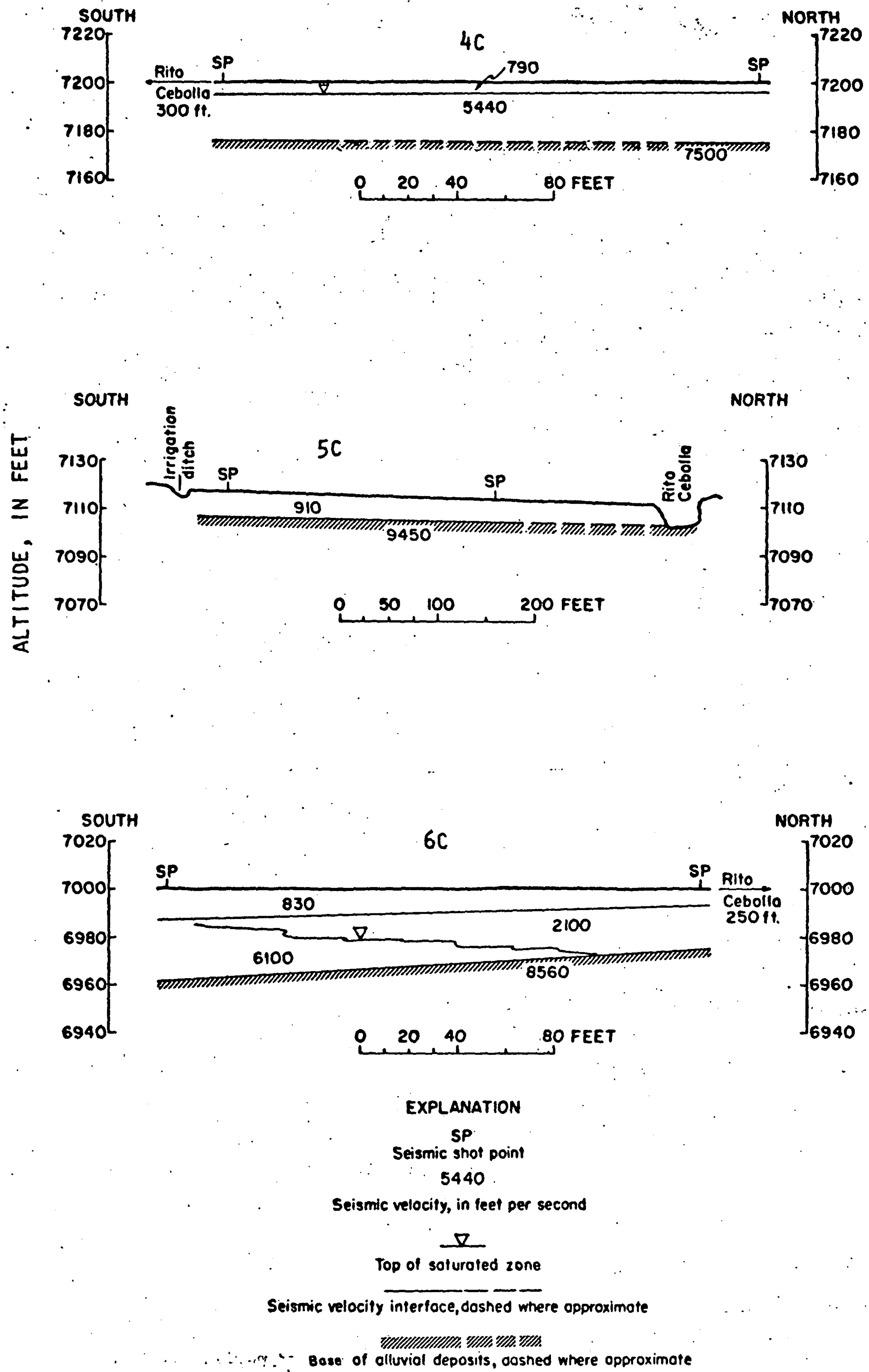


Figure 34.--Seismic profiles 4C, 5C, and 6C along the Cebolla River.

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