

INTER-OFFICE MEMORANDUM

SUBJECT: Seismicity Monitoring on the Best Project

DATE May 7, 1976

TO: W. M. Dolan, H. J. Olson, J. Roth, G/T Staff

FROM: A. L. Lange

The AMAX dual-channel seismograph was installed in a mine in Salt Cove, near Roosevelt Hot Springs, on 24 February 1976 (Figure 1). This initiated an extended program of reconnaissance-seismic monitoring to determine the presence of seismicity in the vicinity of the Mineral Range and areas peripheral to our property position.

Method of Analysis:

Thus far, 28 days of records have been analysed and events of interest identified. An attempt has been made to determine direction of arrival from the two traces; however, the stepout resulting from 150m of seismometer separation is not adequate. Distances to the foci, however, can be approximately calculated using the time interval between P- and S-wave arrivals. Using a nearby crustal model of seismic velocities (Figure 2), and assuming that the foci lie at depths of 5km*, a distance range has been determined for each of the legible events based on the mean P-velocity of 4.76km/sec. The loci of the ranges form concentric rings around each observing station. By plotting as a bar graph the number of events versus range from a particular station, concentrations of seismic activity can be identified. Then by superimposing and rotating the bar graphs from each observatory, the most likely seismic areas can be determined.

The analysis could not be made for all possible directions, so I concentrated on two; a) the line running SW from Minersville through the Black Mountains, a zone of major earthquakes recorded in 1973; and b) the line running NNE from Minersville, between the Mineral Range and the Cove Fort/Dog Valley seismic zone. We cannot be certain that all of the seismicity comes from one direction or the other, and most likely does not; but the plot provides us with a first approximation to the likely seismic zones.

*The depth assumption does not introduce significant error except in the case of very nearby sources--within 10km.

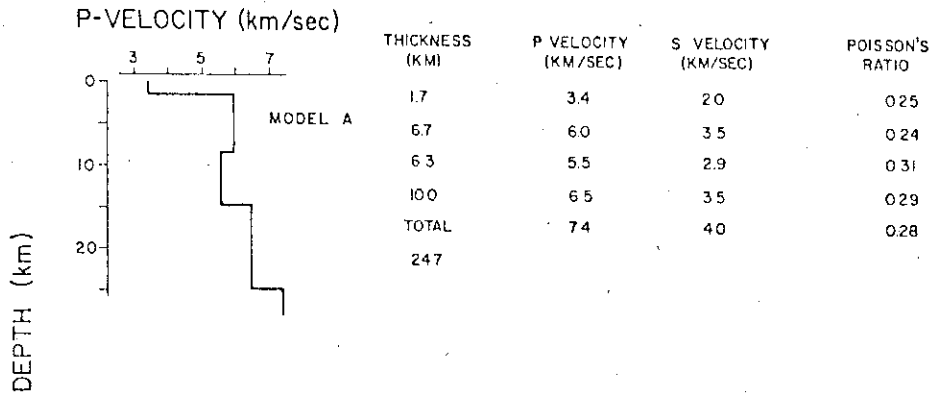


Figure 2. Velocity-depth model from vicinity of Delta, Utah (Mueller & Landisman, 1971).

Sites:

Stations occupied and their recording intervals are given in Table 1. Their locations are shown in Figure 1. All of the sites were established in mines to insure good coupling to bedrock and to avoid surface noises, such as that of wind, rain, airplanes. In addition to operation at higher gains than on the surface, we enjoyed the dividend of a controlled environment favorable to instrumentation and operators. All of the sites except that in Salt Cove were in dense limestone or crystalline marble. That of Salt Cove was in altered or weathered Tertiary (?) granite.

Table 1. Monitoring Schedule

<u>Site</u>	<u>Interval</u>	<u>Days</u>	<u>Local Events</u>	<u>Events/day</u>
Salt Cove Mine	Feb. 24-28	4	4	1.0?
Lower Lincoln Mine	Feb. 29-Mar. 15	14	24	1.7
Paystreak Mine	Mar. 24-29	5	10	2.0
Beaver View Mine	Mar. 30-Apr. 5	5	8	1.6
Blue Star Mine	Apr. 5-19	10	18	1.8

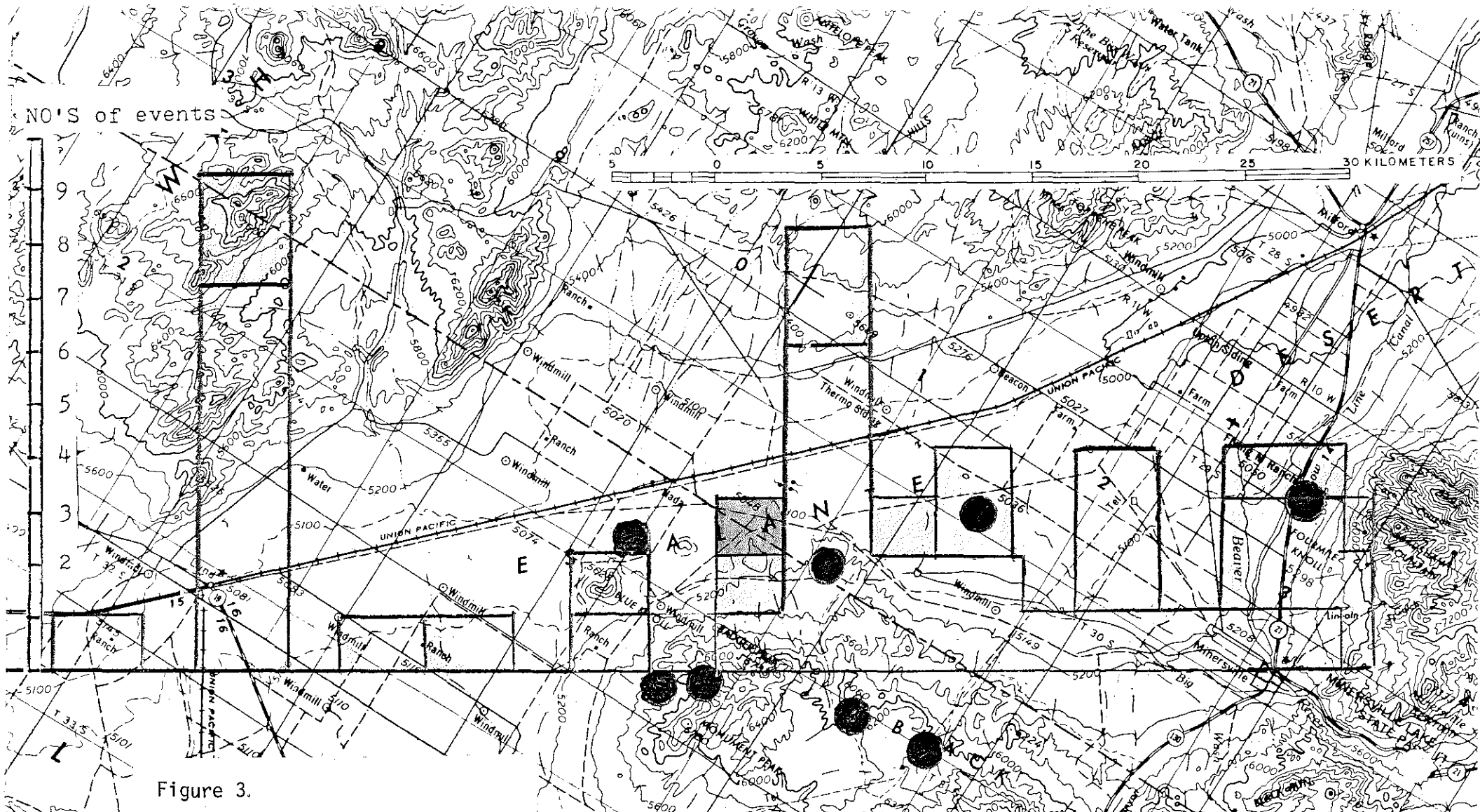
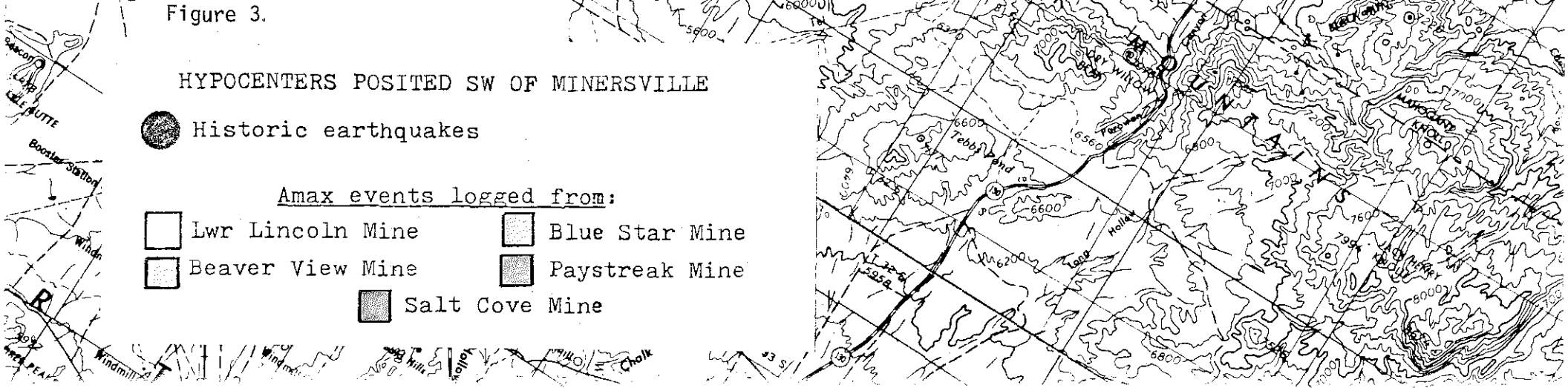


Figure 3.

HYPOCENTERS POSITED SW OF MINERSVILLE

- Historic earthquakes
- Amax events logged from:
- | | |
|--------------------|------------------|
| □ Lwr Lincoln Mine | □ Blue Star Mine |
| □ Beaver View Mine | □ Paystreak Mine |
| ■ Salt Cove Mine | |



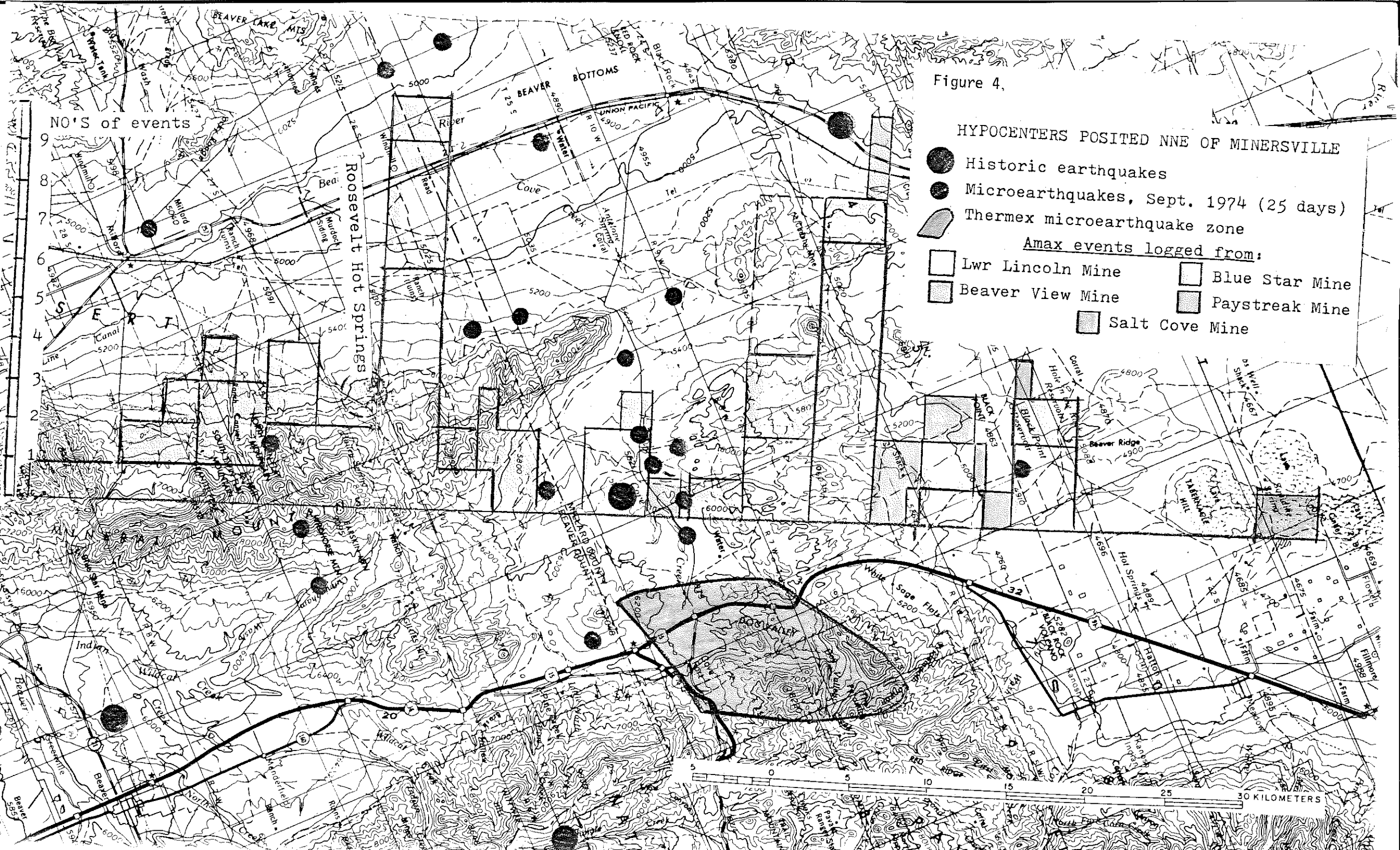
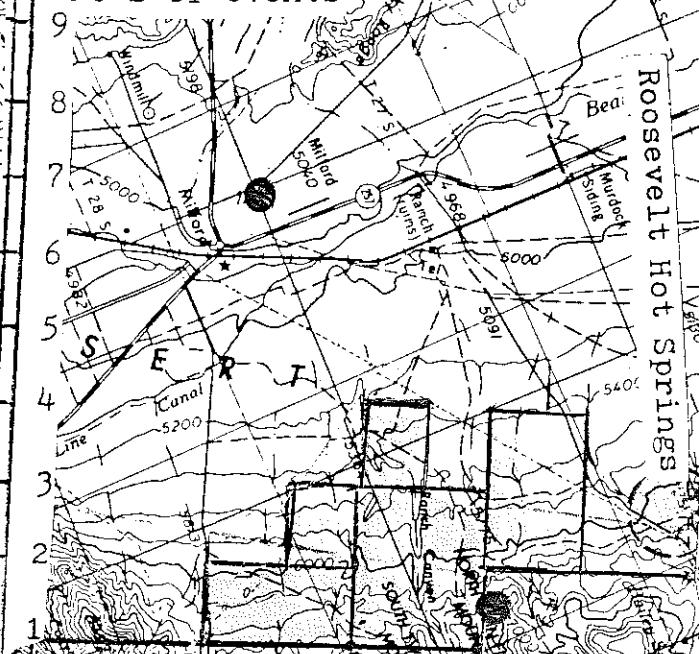


Figure 4.

HYPOCENTERS POSITED NNE OF MINERSVILLE

- Historic earthquakes
 - Microearthquakes, Sept. 1974 (25 days)
 - ▭ Thermex microearthquake zone
- Amax events logged from:
- | | |
|--------------------|------------------|
| ▭ Lwr Lincoln Mine | ▭ Blue Star Mine |
| ▭ Beaver View Mine | ▭ Paystreak Mine |
| | ▭ Salt Cove Mine |

NO'S of events



Roosevelt Hot Springs

30 KILOMETERS

Results:

If all the events observed originated in the region extending southwest from Minersville, the composite activity chart of Figure 3 depicts the source ranges. Peaks of activity fall in the earthquake region of the Black Mountains and on an arc through Lund. Several events fall in the vicinity of Minersville.

If, on the other hand, all the events originated from a sector north-northwest of Minersville, the activity clusters in the manner shown in Figure 4. A major concentration of events falls in the vicinity of Roosevelt Hot Springs and another on an arc passing through the Cove Fort/Dog Valley seismic zone. Unusual events observed at the Salt Cove site are omitted from this picture.

Interpretation:

In Figure 3, the activity observed between Minersville and the Black Mountains is reasonable, in view of the major earthquakes reported, and the microearthquakes recorded by Thermex over their property in the north flank of the Black Mountains. On the other hand, these events might have originated from the Roosevelt area and a microearthquake zone through Wildhorse Mountain (Figure 4). I must regard either direction as being likely. The events centered at the range of Lund, however, when projected northward in Figure 4, fall in the seismic zone around Cove Fort/Dog Valley; hence, I must regard the latter direction as being the more likely origin in that case.

Three unique events were observed at the Salt Cove site immediately north of Roosevelt Hot Springs. They are characterized by a series of sharp shocks occurring at intervals of 1 to 4 seconds, similar to sequential mine blasts observed elsewhere (Figure 5). There was no mining or, to our knowledge, blasting going on in the area, however. The events took place on one day in late afternoon and evening (1741, 1756 and approximately 2000). No discernible shear phase is evident, and from their individual durations, the sources must have originated within about 3km of the station.

I have seen similar events exhibited by Combs from Coso Hot Springs, California. "Explosive-like" events (that is, lacking shear waves) are reported by the U.S.G.S. from the Geysers. Furthermore, John Bailey informs me that Senturion Sciences has logged similar events around Roosevelt; in contradiction to the experience of the University of Utah, who found very few events in the area. Either we and Senturion observed a rare swarm of activity, or the University sites were insensitive to the activity. If their sites straddle the Dome Fault, as they report, they would have been operating on alluvium, and hence might have been unable to resolve the events from noise.

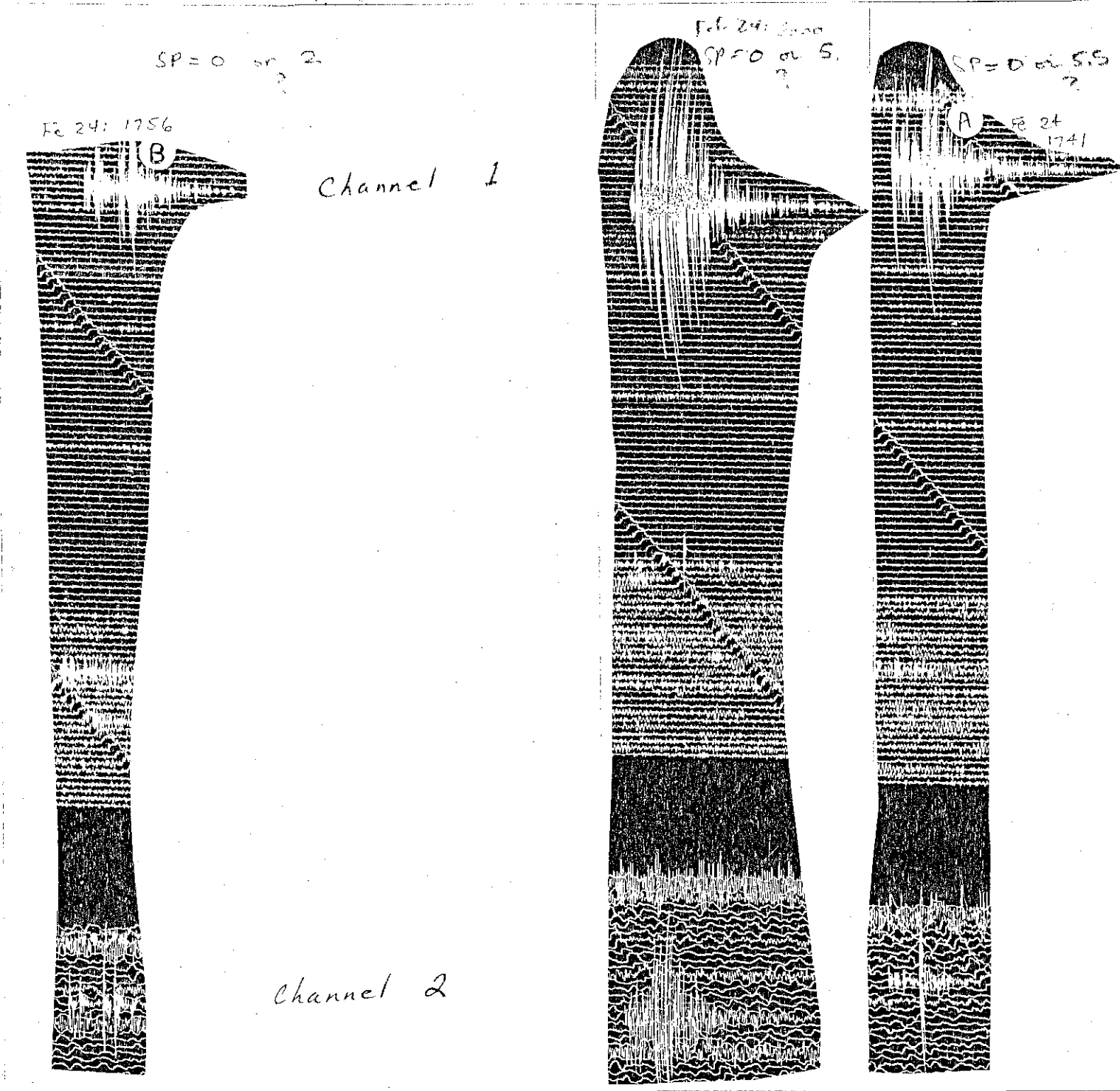


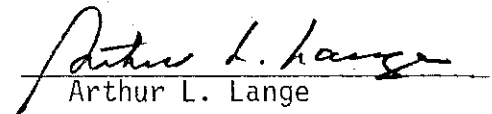
Figure 5. Sequential shocks observed at Salt Cove mine, near Roosevelt Hot Springs.

Conclusions:

Seismicity around the Mineral Range is occurring at Roosevelt Hot Springs and in the area around Cove Fort/Dog Valley and possibly westward to Black Rock. Another likely source is that of the Black Mountains. The seismograph is currently being operated in the Black Mountains and will also be operated in the Cove Fort area to verify these sources (though the latter hardly needs verification). I plan also a longer interval of operation in the Salt Cove Mine in order to better understand the seismicity observed there.

Recommendations:

Except for the monitoring mentioned above, I do not recommend a micro-earthquake survey on the basis of the 1 1/2 to 2 events per day observed. If the roving station detects a high incidence of activity in the Black Mountains and Cove Fort, we might consider a full-scale survey for these areas. If the Cove Fort property is acquired, such a survey could provide valuable information on deep structure and movements in the environs of the conjectured reservoir.


Arthur L. Lange

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