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INTER-OFFICE MEMORANDUM

SUBJECT: SEISMIC WAVE TRAP AROUND COVE FORT, UTAH DATE November 16, 1976

TO: W. M. Dolan, H. J. Olson, H. D. Pilkington, J. Roth, Geothermal Staff

FROM: A. L. Lange

Two microearthquake surveys were conducted by the University of Utah: 20 days during September 1974 and 28 days during June and July 1975 (Olson and Smith, 1976). Smoked-paper seismographs were utilized at the stations of Figure 1. A total of 163 events were recorded for which hypocenters could be computed (Figure 2). The major clustering took place at Cove Fort and Dog Valley; only 6 events were recorded on the west margin of the Mineral Range. Distribution of events vs. focal depth is shown in Figure 3. Olson and Smith show in their report three cross-sections in the Cove Fort area in which the hypocenters seem to depict fault planes at depth (their Figure 8 and Plate 2). These conventional results demonstrate that the Cove Fort area is tectonically very active.

Of greater interest, and more pertinent to our geothermal objectives, is the after-the-fact study made by Olson and Smith of P- and S-wave delays and attenuations. I have mentioned frequently the fact that seismic waves passing through magma or partial melt are slowed down and attenuated. Since shear cannot be sustained in a viscous medium, S-waves are either severely attenuated or completely absorbed when passing through such a body. These phenomena have been utilized for mapping hot bodies at Mt. Katmai, Alaska (Matumoto, 1971); Yellowstone National Park, Wyoming (Eaton, et al., 1975); Socorro, New Mexico (Sanford, 1976); Coso Hot Springs (Young & Ward, 1976), and Long Valley, California (Steeples & Iyer, 1976). A recent refraction profile across the Geysers in California showed total absorption of seismic signal across the steam zone relative to the adjacent land (pers. communication). In like wise, the evidence from Utah points toward the existence of an absorbing body that alternates, deforms and retards seismic waves passing through.

Olson and Smith plot travel-time residuals at four stations, computed from the widespread seismic networks of Figure 1. In their plots (Figure 4), late arrivals (positive delays) are shown above the horizontal axis, and early arrivals below. I have replotted these in the form of azimuthal charts around each station (Figure 5). The blue sectors represent numbers of delays, yellows are advances, and greens depict overlaps; that is, equal numbers of delays and advances. When the source directions of the delays are projected, they intersect in the yellow area around Cove Fort, the local hotbed of seismicity. Four stations (green triangles) exhibited more or less equal positive and negative delays, while the station at Sulphur Creek (SLF) showed a predominance of early arrivals, which Olson and Smith attribute to the negative biasing of the least-squares data by the delayed arrivals to the west. (In other words, shifting of the foci due to the late arrivals makes the arrivals at SLF appear early, whereas actually they are probably normal).

Olson and Smith conclude that the arrivals at the three western stations in my Figure 5 are being delayed by a body of magma or partial melt intervening somewhere between 112°40' West Longitude (the yellow meridian in Figure 5) and the Mineral Range, based on the observation that the arrivals at the green stations are generally well-behaved. The vector intersections of Figure 5, however, show quite conclusively that the disturbing medium must lie under Cove Fort. No amount of refraction could move the raypaths through the Mineral Range up to Twin Peaks.

Olson and Smith show an additional property of the waves arriving at Ranch Canyon. For this station alone they analysed S-wave arrivals (Figure 6). Those originating in the Cove Fort area and beyond (See Figure 5 again), were predominantly weak or absent entirely. Thus a viscous medium appears to intervene between Cove Fort and Ranch Canyon. I say, Why not under Cove Fort?

The questions remains: Why do the arrivals at the medial green stations exhibit equal amounts of positive and negative delay, if the disturbing body lies under Cove Fort? Since the seismic activity probably originates above a zone of melt, the short raypaths to these stations do not penetrate the melt; only those longer, descending parts experience delay (Figure 7). A detailed analysis of focal depths and raypaths potentially could be used to map the surface of the body, as Sanford has done in the case of the magma chambers under Socorro Mountain, New Mexico. The University, of course, would like to find a magma chamber beneath the Mineral Range to explain a salient gravity low in the area, as well as the hot waters. Perhaps one exists there; but if so, another seems to reside under Cove Fort. A profound magnetic low in the latter case substantiates this--but this is another story.

The delineation of the "wave trap" beneath the Cove Fort area is best accomplished by a survey specifically designed for the purpose. Rather than relying on microearthquakes for such information, one should examine the arrivals of distant refracted waves from known sources; in particular mine blasts. One clear signal each day is available from blasts at Bingham, Utah; and our records show other regional events, as well as teleseisms. These signals have the advantage that they are rising almost vertically upward to the station; hence, contours of arrival times and attenuations across a dense network centering around Cove Fort should depict the boundaries and thicknesses of the underlying medium. This is the kind of survey that is being drafted by Microgeophysics Corporation for our participation.

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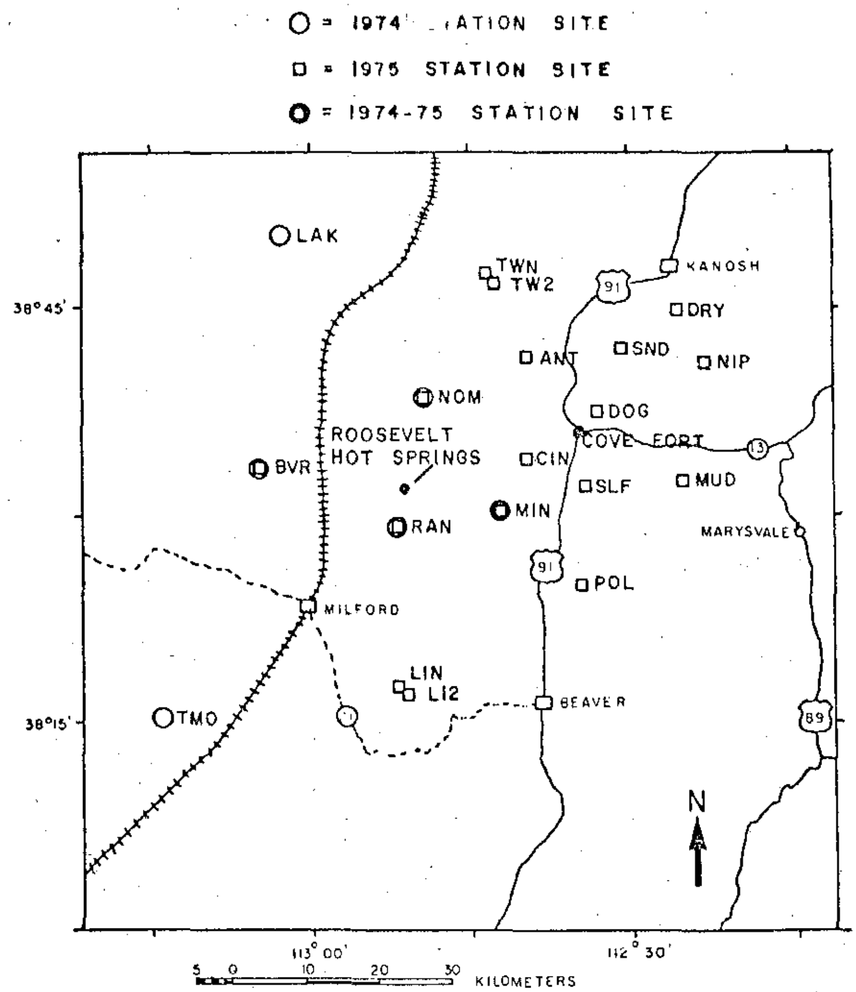


Figure 1. Station locations for 1974-75 surveys.

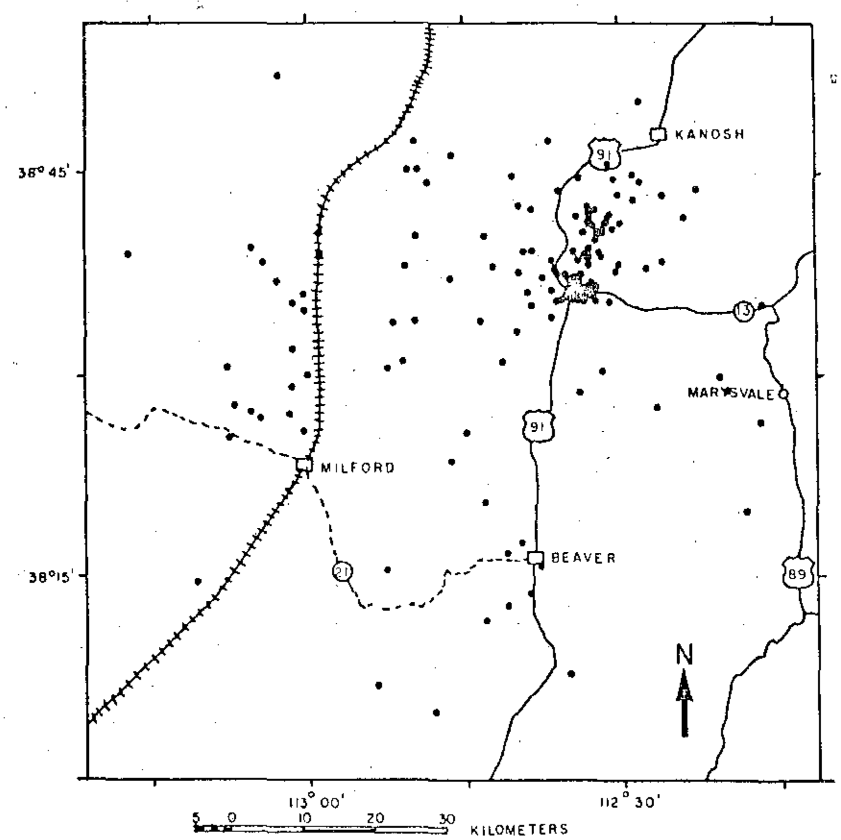


Figure 2. Epicenter map for the Roosevelt Hot Springs and Cove Fort areas.

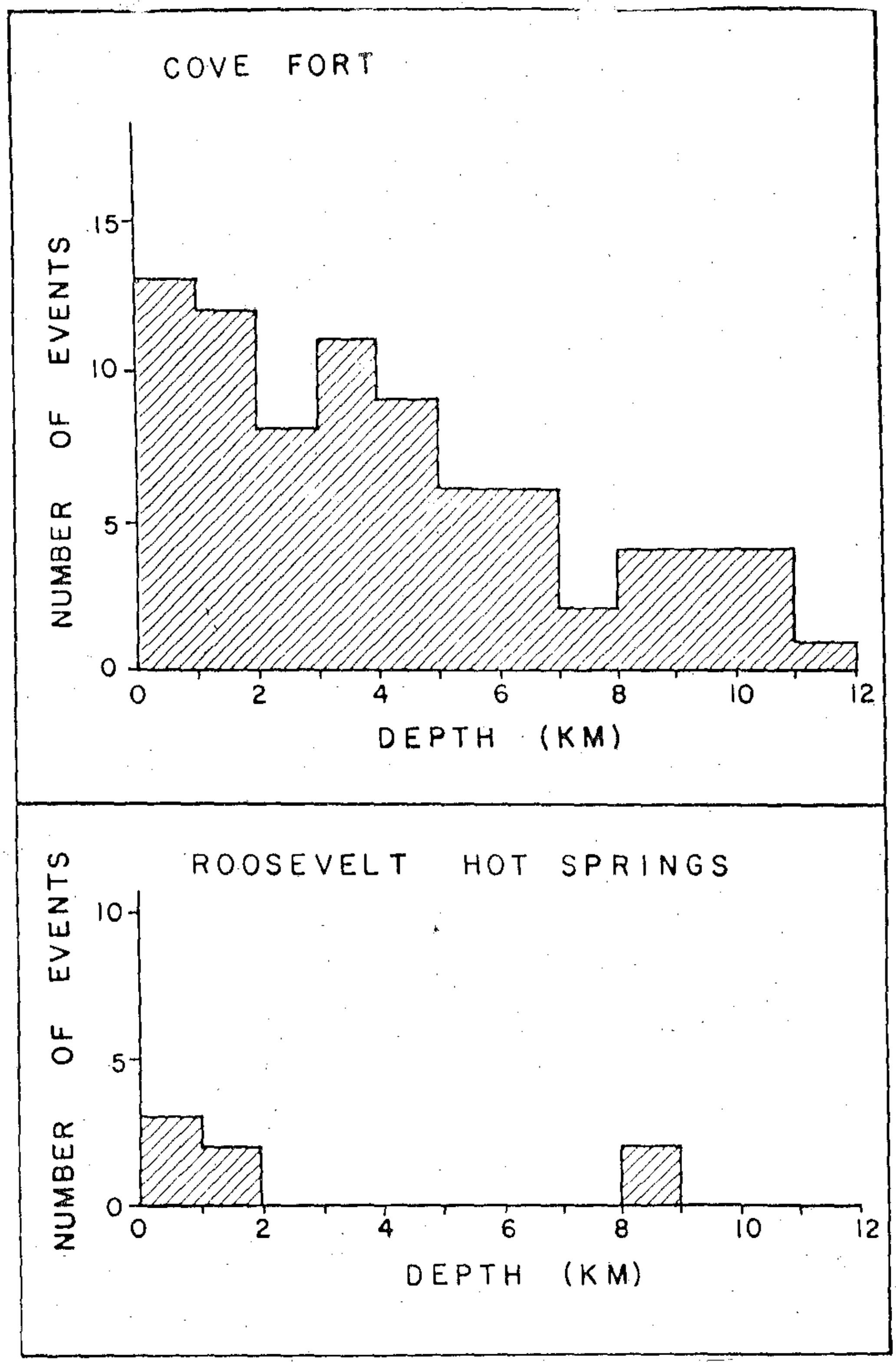


Figure 3. Earthquakes versus focal depth.

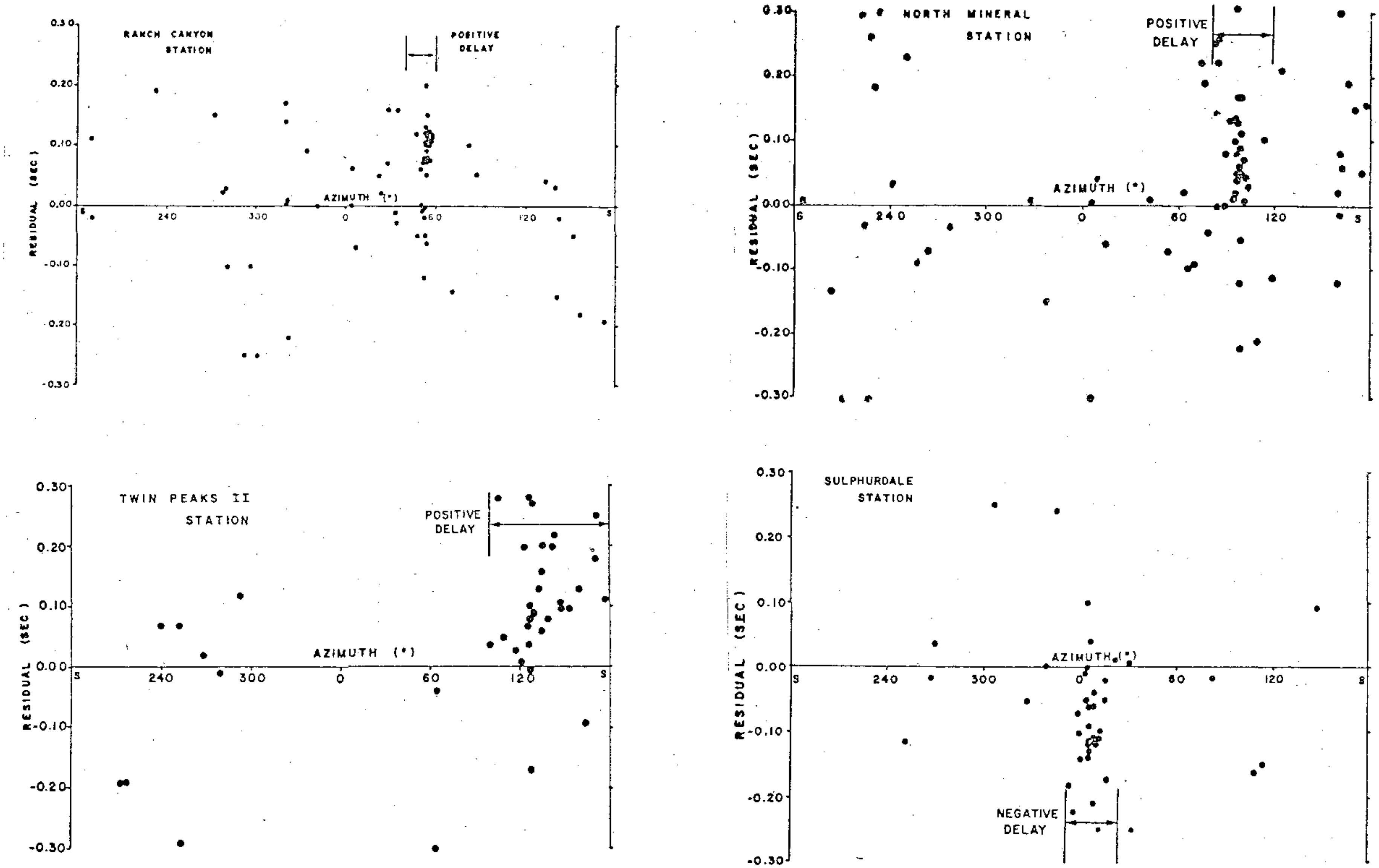


Figure 4. P-wave delays (+) and advances (-) for Stations RAN, TW2, NOM, and SLF, plotted against azimuth.

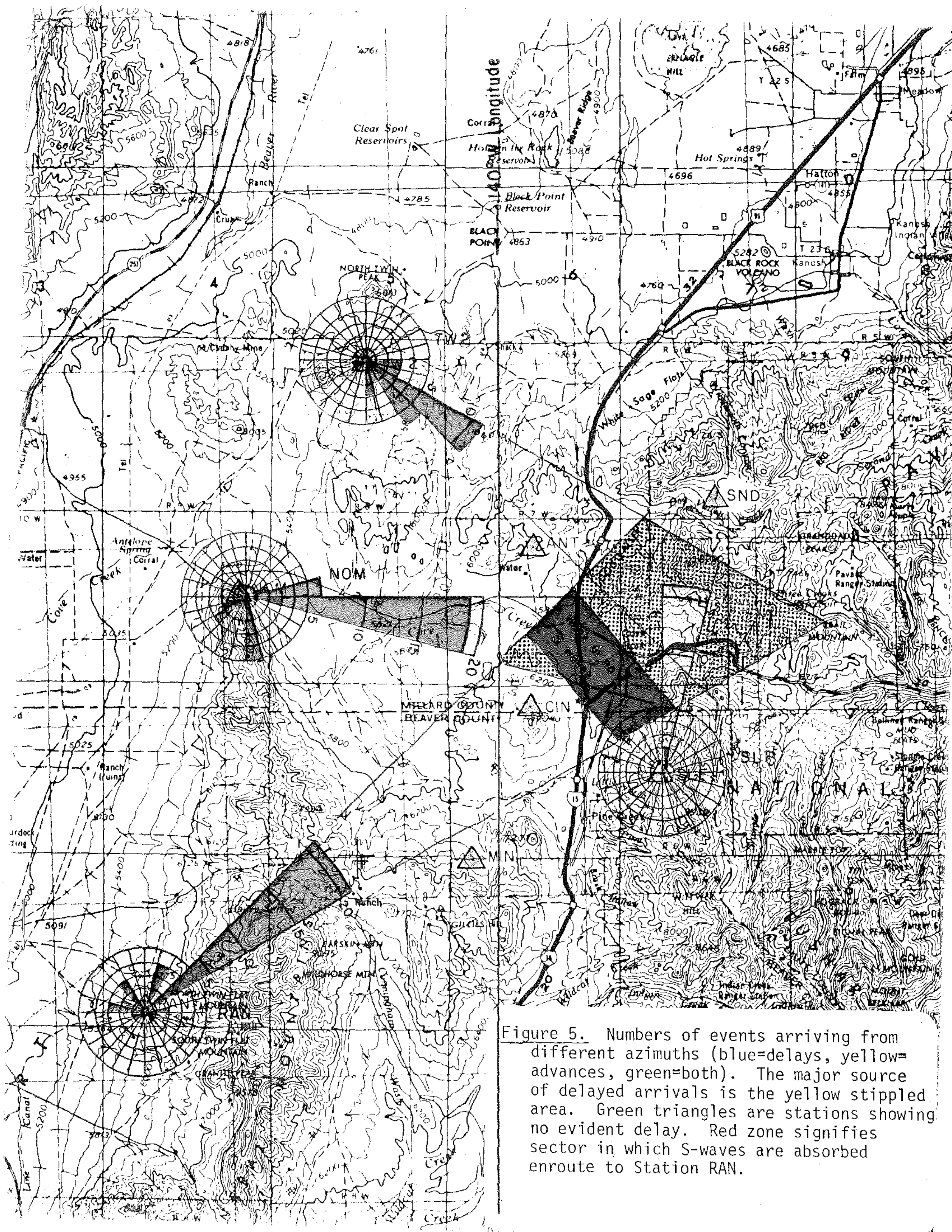
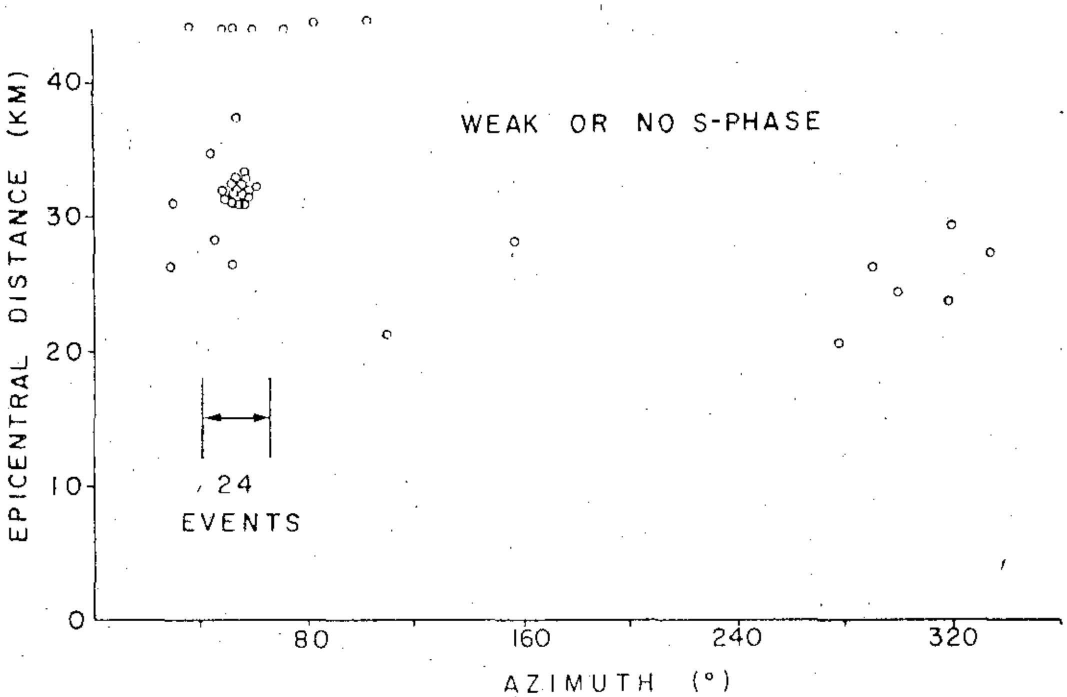


Figure 5. Numbers of events arriving from different azimuths (blue=delays, yellow= advances, green=both). The major source of delayed arrivals is the yellow stippled area. Green triangles are stations showing no evident delay. Red zone signifies sector in which S-waves are absorbed enroute to Station RAN.



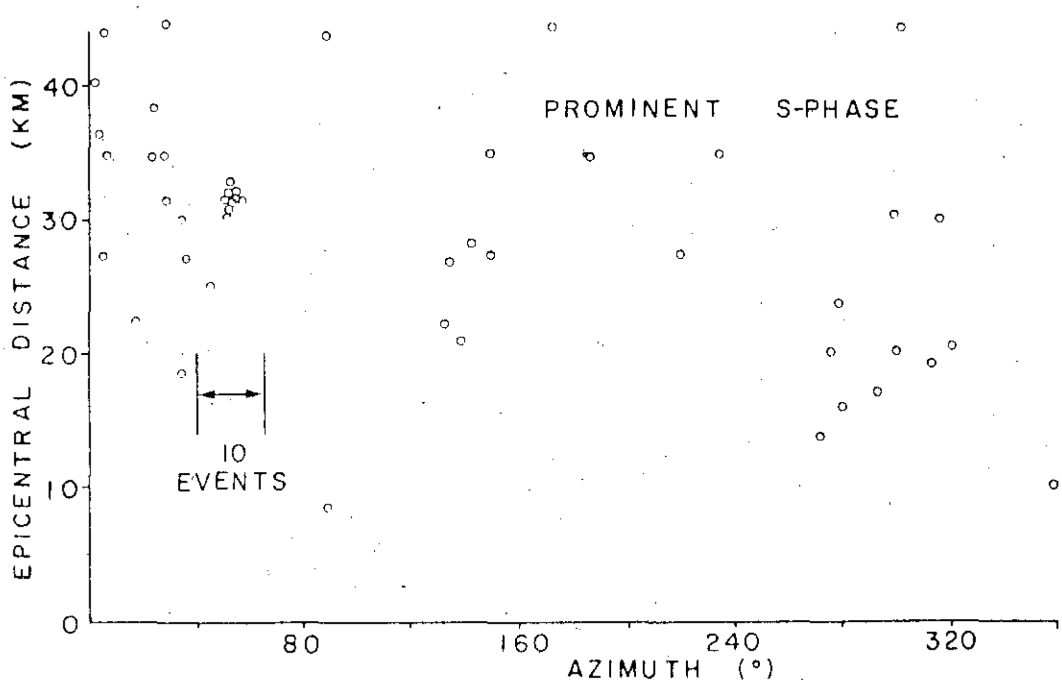


Figure 6. Weak and prominent S-phases at the Ranch Canyon Station.

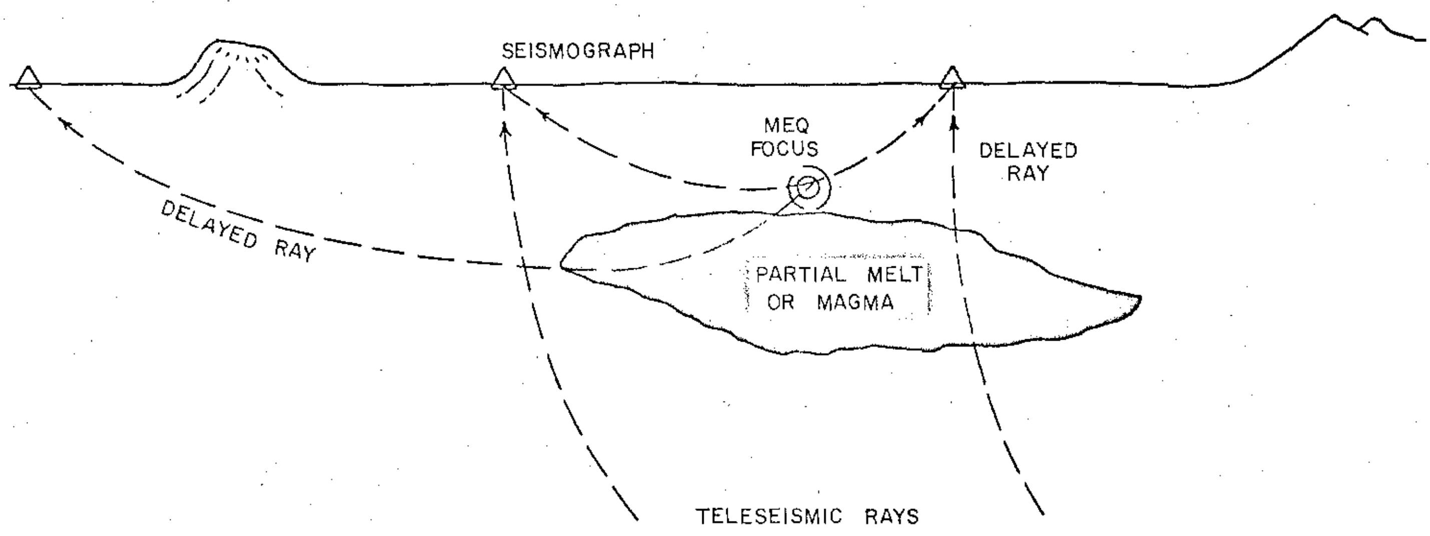


Figure 7. Effect of a magma body on seismic waves. Microearthquakes originating above chamber are delayed only along paths to more distant stations, when they pass through the melt. Ascending teleseismic waves are delayed and attenuated only where they pass through the magma.