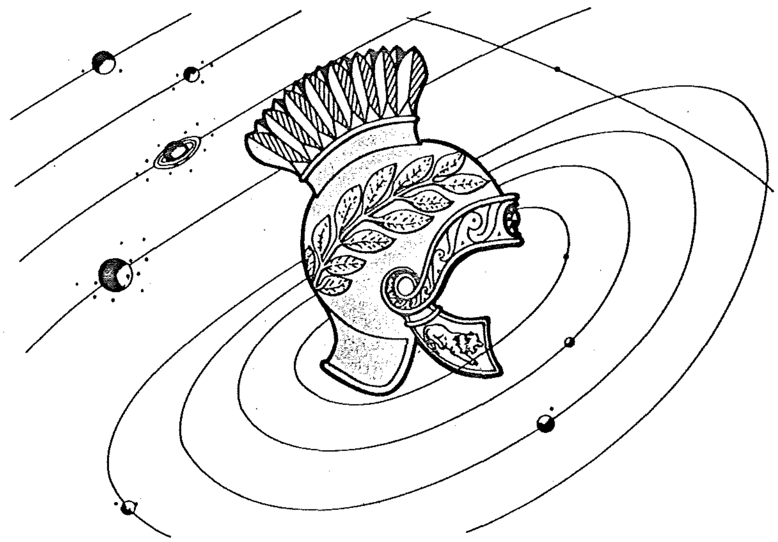

BIEBER II

for

INTERCONTINENTAL ENERGY CORPORATION


*SENTURION SCIENCES, INC.*

TULSA, U.S.A.

BIEBER II

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# BIEBER II

## Introduction

Seismicity and "wiggle" investigations were evaluated to determine the potentialities of geothermal activity near Bieber, California. Two arrays, Figure 1, were used to detect the events: the larger, 6-station radio telemetry (RF) array was approximately 16 km. in diameter whereas the other, a 0.6 km. diameter cable system array, was located near the center of the larger telemetry array. Data acquisition was continuous from September 18 through September 28, 1973.

Previous microseismic monitoring observations were conducted in the Bieber area during the latter part of June, 1973. The 7.2 km. diameter, Bieber I array was centered between the present cable system and RF #6 station. The original study revealed 51 events over a ten day period, and the second Bieber survey recorded 24 events common to all twelve stations and they are listed in Table 1.

## Wiggle Investigations

The primary objectives of the Bieber II survey was to resolve the origin of wiggles and, hopefully, determine their correlation to geothermal regions. Wiggle characteristics are: (Figures 2A, 2B, 3A and 3B)

1) They are low frequency (≈0.5 to 2 Hz). Virtually all energy is contained within frequencies below 4 Hz.

2) Wiggles have impetus onsets and signal durations greater than 20 seconds.

3) Wiggles have apparent velocity vectors which are parallel and near equal in velocity magnitude with each solution.

4) Wiggle velocities (12 to 23 km./sec.) are greater than those known for crustal rocks. These suggest high emergent angles of the wave fronts.

5) Wiggle amplitudes tend to be a function of the lithology beneath the seismometer station and yet, wiggles have not been observed to cause the tape recorder FM discriminators to "rattle" as is observed with high amplitude earthquakes. This suggests there is a maximum limit to the amplitude of wiggles.

6) As revealed by this survey, wiggles are recorded with radio telemetry and cable connected seismometer systems. The RF system has a completely different type of amplifiers and seismometers from the cable system (RF seis = 2000Ω Cable = 360Ω)

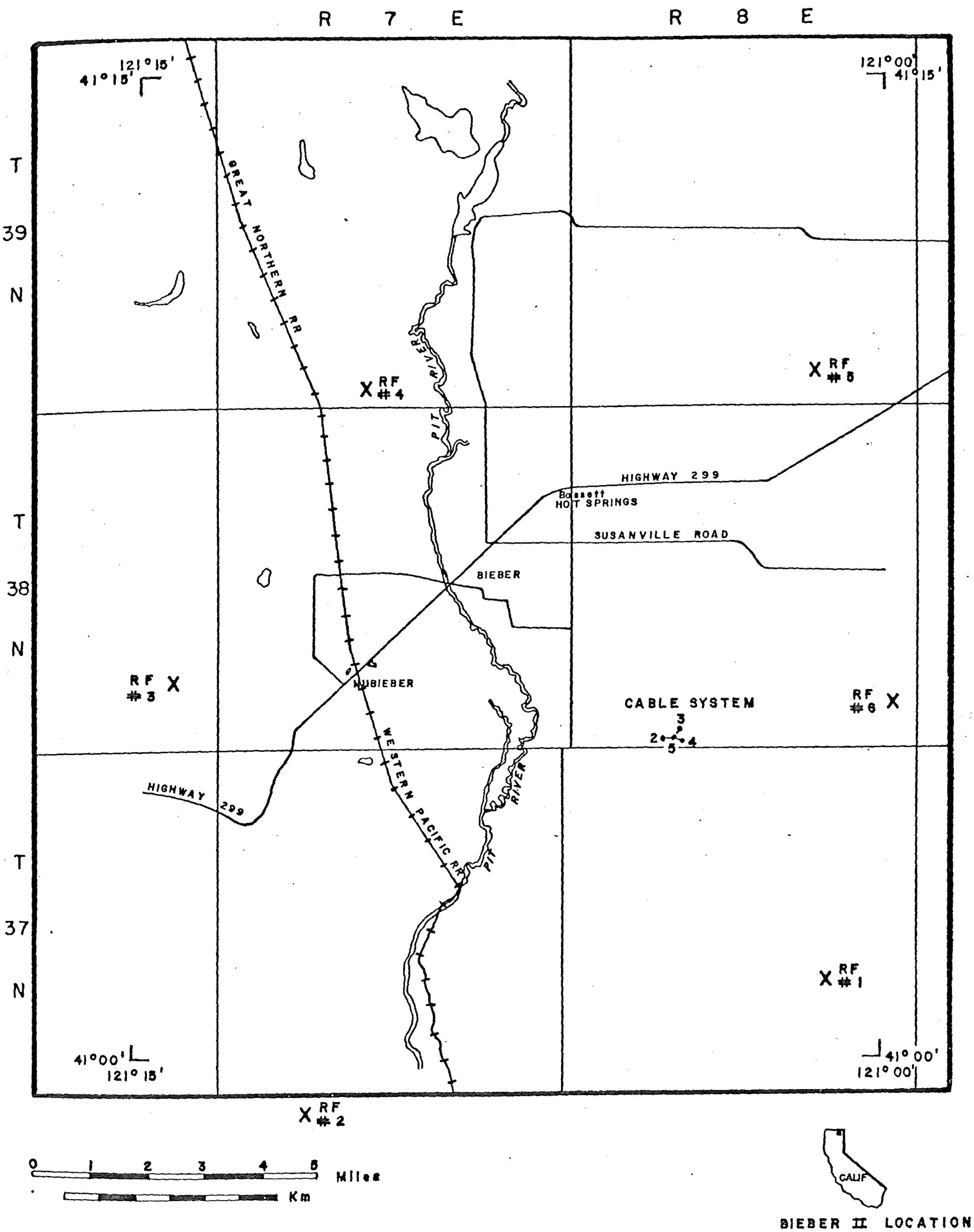



Figure 1. Locations of the Bieber II radio telemetry seismometers (e.g., RF #1 and RF #6) and the small, central cable system array.

le 1. Significant events recorded with the 16 km. (diameter) and .6 km. Bieber II arrays during September 19
ough September 29, 1973. (Directions and distances are referenced with respect to the center station of the cable
km.) array.)

| nt | Time (GMT) | Direction @ Array (° Azimuth) | Distance From Array (km) | (miles) | Apparent Velocity (km/sec) | (Kft/sec) | Comments |
|---|---|---|---|---|---|---|---|
| 1 | 262/23/05 | 279 | 22.0 | 13.7 | 5.2 | 17 | Earthquake. |
| 2 | 262/23/50 | 125 | | | 14.6 | 48 | Wiggle. |
| 3 | 268/02/23 | 170 | | | 20.4 | 67 | Wiggle. |
| 4 | 263/18/08 | ? | ~65 radius | ~40 radius | ? | ? | Emergent earthquake (direction not apparent). |
| 5 | 264/02/33 | 304 | | | 20.4 | 67 | Wiggle. |
| 6 | 264/05/43 | - | - | - | - | - | Sonic. |
| 7 | 264/07/22 | 158 | | | 13.7 | 45 | Wiggle. |
| 8 | 264/07/44 | 160 | | | 14.3 | 47 | Wiggle. |
| 9 | 264/10/41 | 315 | | | 13.8 | 45 | Wiggle. |
| 0 | 264/10/59 | 120 | 48 | 30 | 6.4 | 21 | Two earthquakes within 10 seconds. |
| | 264/19/40 | 250 | | | 22.9 | 75 | Wiggle. |
| | 265/03/58 | 88 | | | 14.3 | 47 | Wiggle. |
| | 265/09/38 | 298 | | | 20.1 | 66 | Wiggle. |
| | 265/13/33 | 174 | ~50 | ~30 | 6.4 | 21 | Earthquake (noisy P arrivals). |
| | 265/13/46 | 115 | 56 | 35 | 6.4 | 21 | Earthquake. |
| | 265/17/47 | ? | | | ? | ? | Wiggle observed on small array (large array not |
| | 265/18/43 | ? | | | ? | ? | " " " " " " recording). |
| | 268/04/33 | ? | | | ? | ? | " " " " " " " |
| | 268/06/19 | - | | | - | - | Sonic. |
| | 269/01/46 | 117.5 | 37 | 23 | 5.43 | 17.8 | Earthquake. |
| | 269/03/10 | - | | | - | - | Suspected sonic, too noisy to pick. |
| | 269/07/49 | - | | | - | - | " " " " " " |
| | 269/07/54 | 22 (?) | ~60 | ~35 | 5.2 (?) | 17 (?) | Earthquake. (only 3 noisy stations recorded |
| | 269/10/14 | 176 | 160+ | 100+ | 7.0 | 23 | Distant earthquake. emergent event.) |
| | 269/06/19 | - | - | - | - | - | Sonic. |
| | 270/19/11 | 115 | 60 | 37 | 5.33 | 17.5 | Earthquake. |
| | 272/00/55 | 320 | ~10000 | ~6500 | 21.3 | 70 | Sea of Japan earthquake (mag. = 7.01) |
| | 272/10/41 | 188 | 48 | 30 | 6.4 | 21 | Earthquake. |
| | 272/10/47 | 177 | ~25 | ~15 | 6.58 | 21.6 | Earthquake. |
| | 266/20/02 | 250 | 160+ | 100+ | 8.5 | 28 | Distant earthquake. |

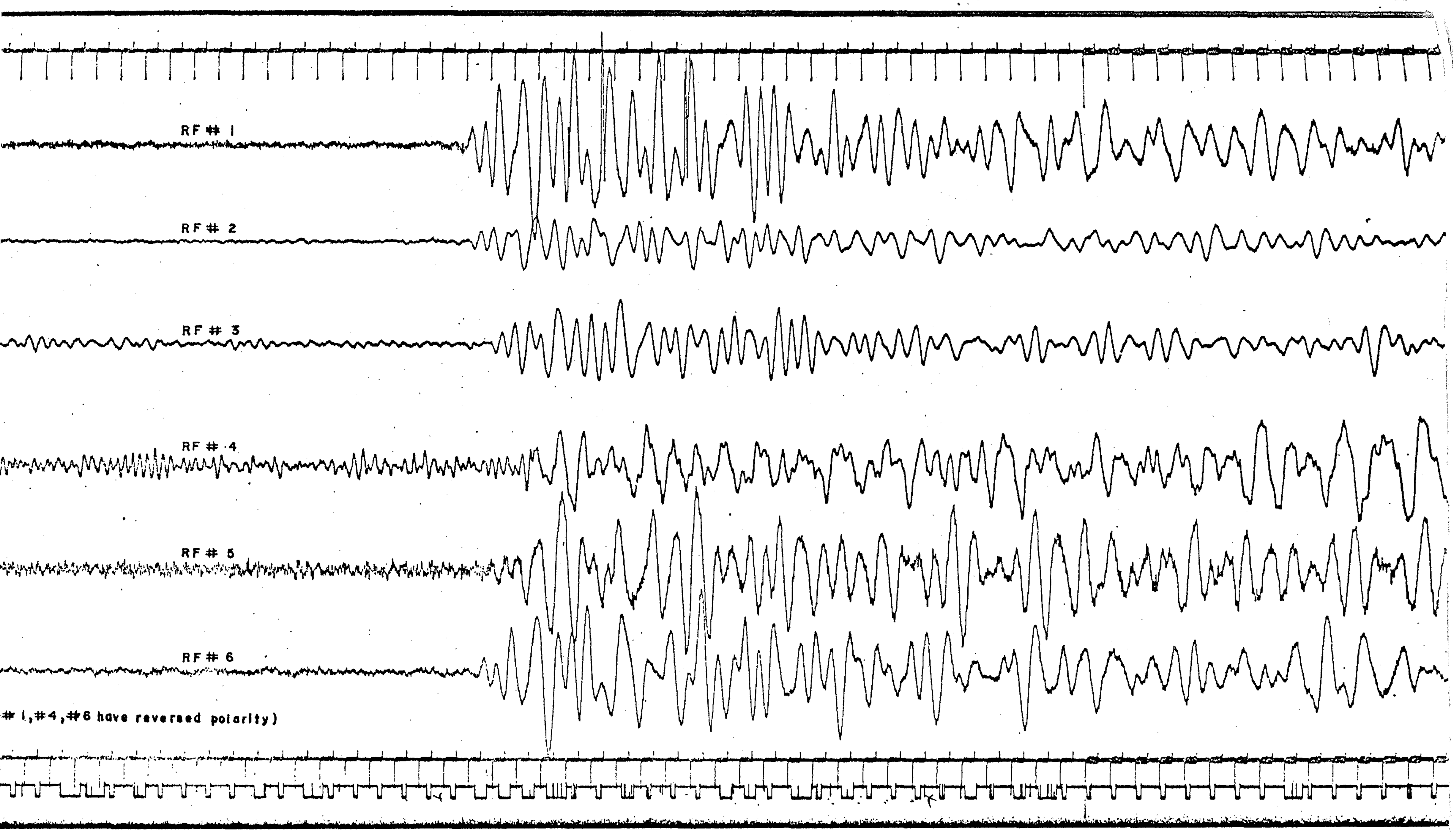



Figure 2A. Wiggle (event #7) originating from a direction of 158.5 degrees ±2.6 degrees with an apparent velocity of 13.70 ±0.41 km./sec. (44.93 ±1.35 Kft/sec.). Note that amplitude attenuation with distance which seems apparent on this record is contradicted by the observations of Figure 3A (event #9).

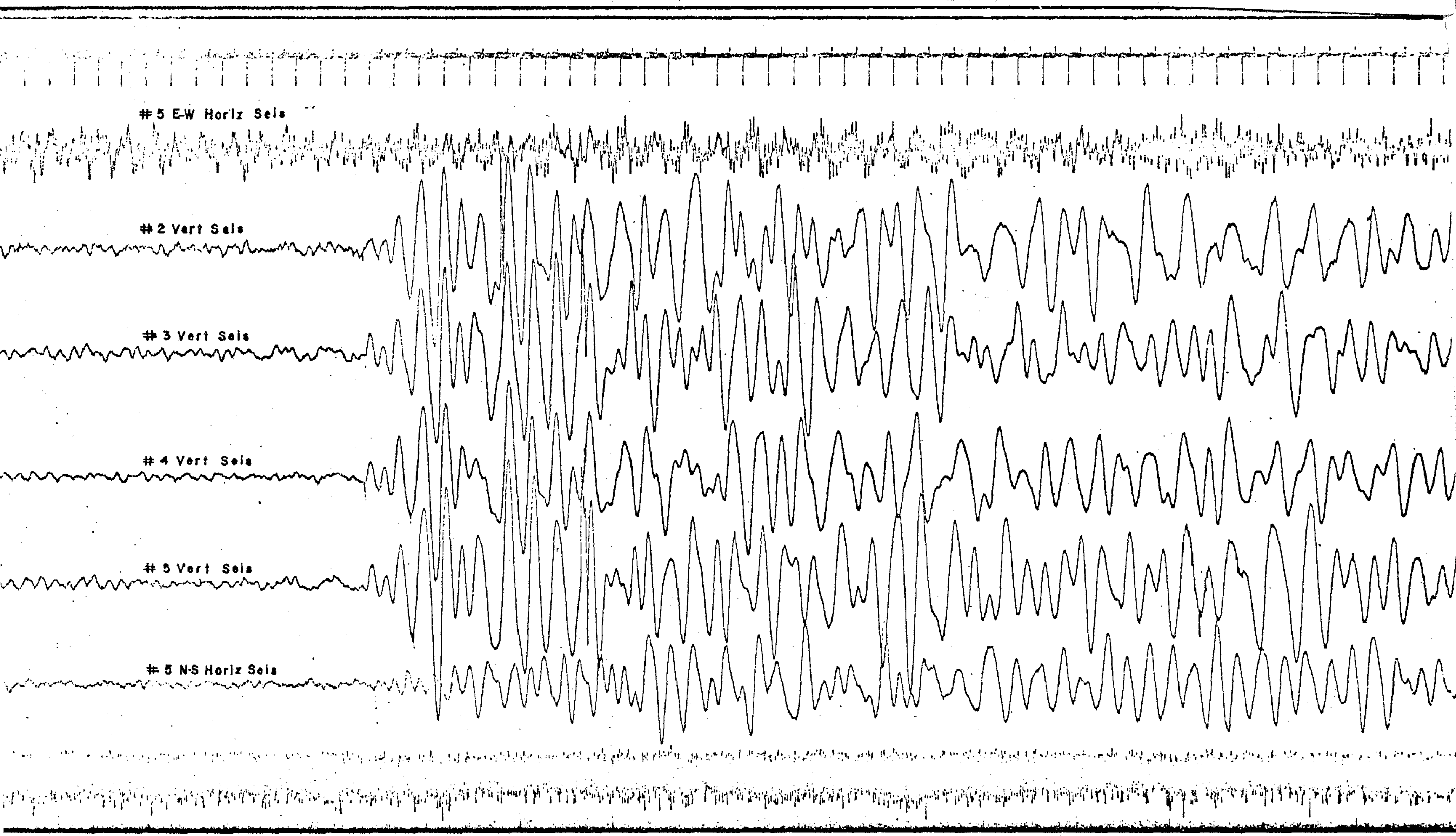



Figure 2B. Wiggle (event #7) recorded by the central cable system 0.6 km. array. Note that the wiggle has horizontal components which are of different form than the vertical components (E-W horizontal seis at #5 was not working correctly).

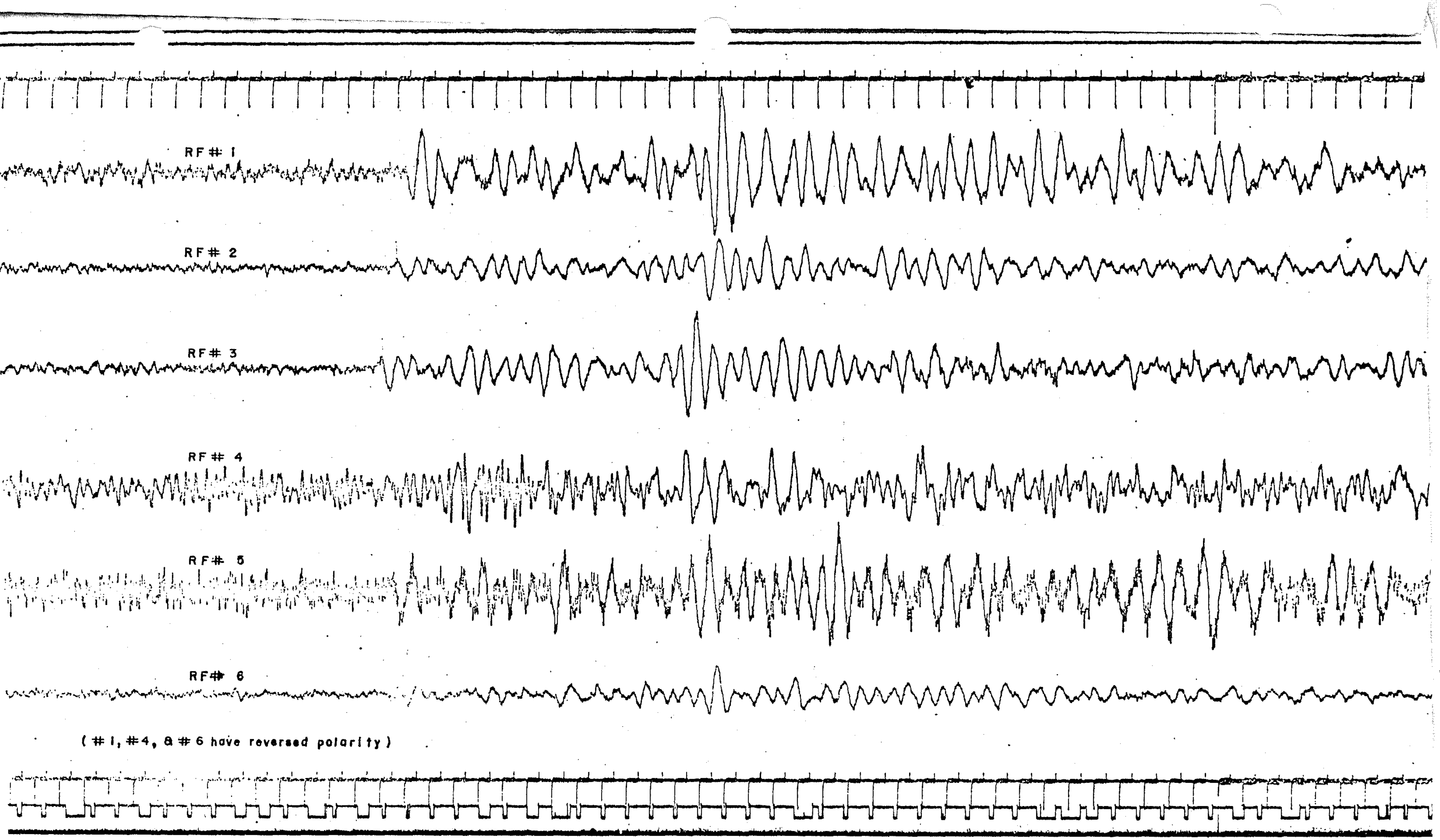



Figure 3A. Wiggle (event #9) arriving from a direction of 314.7 degrees ±4.8 degrees with an apparent velocity of 13.82 ±1.44 km./sec. (45.33 ±4.74 Kft/sec.).

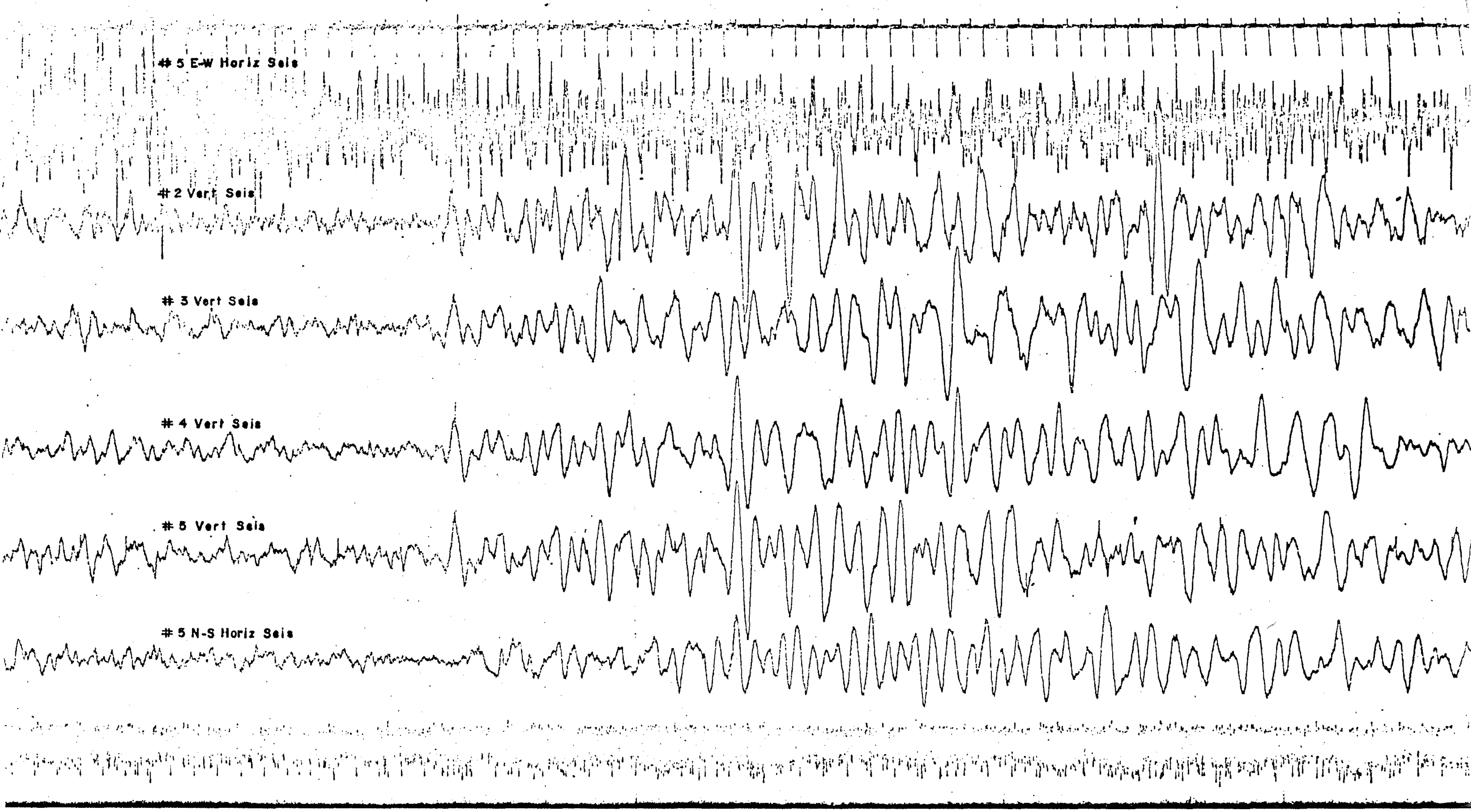



Figure 3B. Wiggle (event #9) recorded on the central cable system. Horizontal components are of a different character than those recorded by the vertical seismometers.

7) Wiggles possess horizontal energy. These components have a different appearance than those measured with the vertical seismometers.

8) Wiggles are observed during periods when a characteristic wiggle background noise level prevails. Background wiggle noise is characterized by a predominance of larger than normal, white spectrum groundnoise preceding and following all wiggles.

During Bieber I investigation it had been speculated that wiggles originated within a few 10's of kilometers of this array. The present Bieber II results indicate that wiggles are distant events or that, in some fashion, the valley responds as though it were a single plate oscillating in response to some subsurface activity.

Suspected wiggle sources and discussions concerning these thoughts include:

1) Deep sources beneath the array related to magmatic and low deep seated fault activity. Under these circumstances these stress changes would have occurred at depths which are at least 3 times the array dimensions (i.e. ≈3 x 16 km. = 48 km.) to account for the parallel vectors. From Figure 4, Events #7 and #9 would have emergent angles of ≈64° assuming the velocity of the media was ≈6 km./sec. Magmatic sources to depths of 50 km. are not difficult to conceive although Baker, Oregon wiggles would require depths ≈120 km. to account for the observed parallel vectors in that area.

Another possible cause for the high apparent velocity vectors would be to consider a layered earth model where a very low velocity media overlies a dipping, high velocity basement (this was considered for the Bieber I array). This latter model can account for high apparent velocities but Figures 4 and 5 indicate wiggle origin direction and this reveals multiple source directions. The dimensions of the larger Bieber II array assure the reliability of the wiggle source directions (Figure 4). The number of wiggles recorded during the second survey (9 wiggles) is considerably less than those obtained during the first period (29 wiggles). Consequently, it is not altogether clear whether most wiggles were observed from the west to northwest during Bieber II observations (as was observed during Bieber I), or whether wiggles were almost evenly distributed between the northwest and southeast quadrants.

During the survey there occurred a Richter Magnitude 7 event in the Sea of Japan and this event has many of the characteristics of wiggles, i.e. high apparent velocity (21.3 km./sec.) and parallel vectors and two hertz signal. Of course, this event was recorded world wide while wiggles are not detected by closeby observations. Therefore, the Bieber seismometers were sensing normal macroseismicity, microseismicity and were being influenced by wiggles.

2) Tuned harmonic plate movements. This assumes some source has triggered a harmonic oscillation of a large rigid plate floating on a fluid substrata. This situation would require a model similar to a cork bobbing in a lake with a frequency (f) defined by

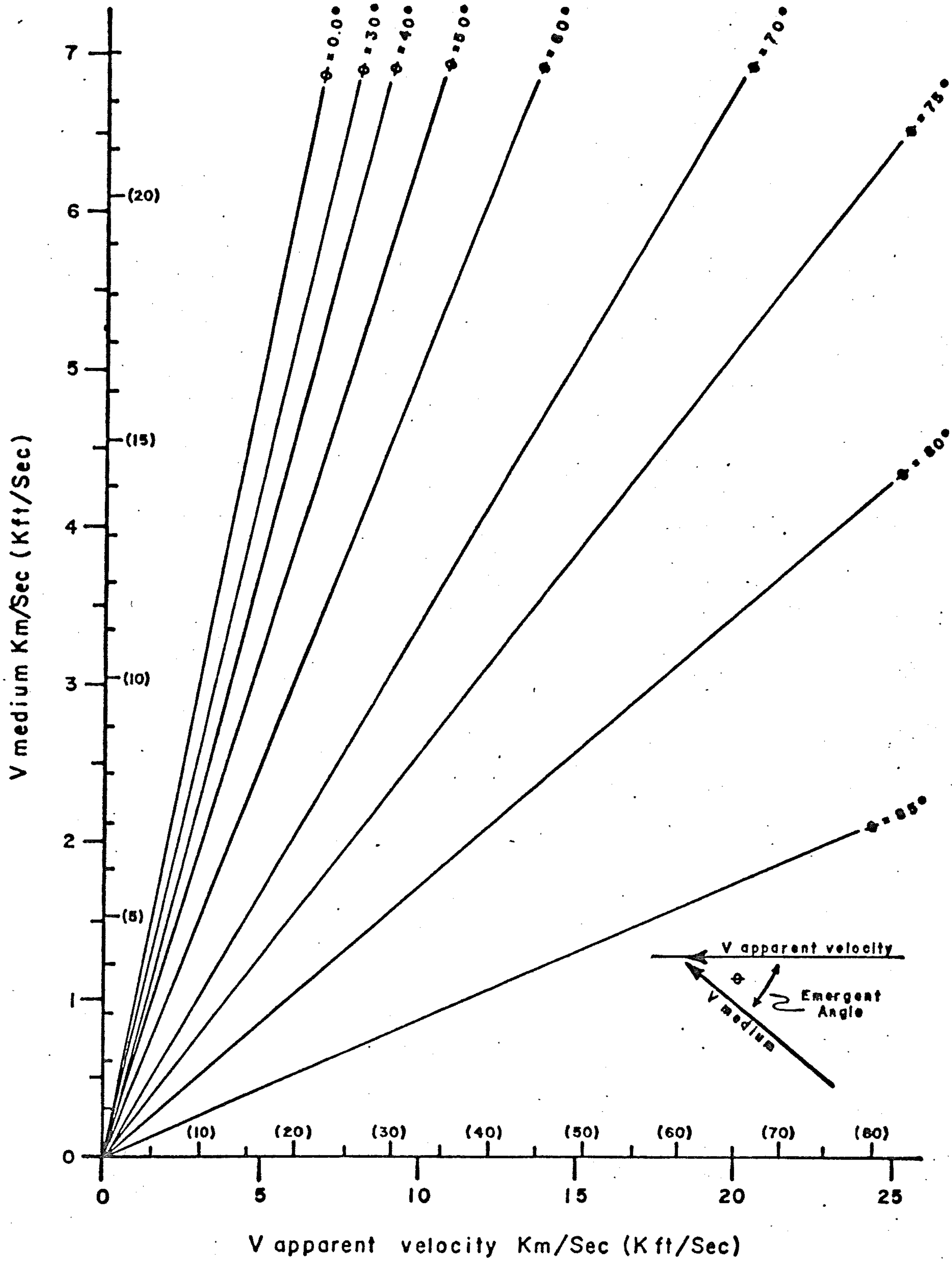



Figure 4. Emergent angle as a function of the apparent velocity measured at the surface and the velocity of the medium.

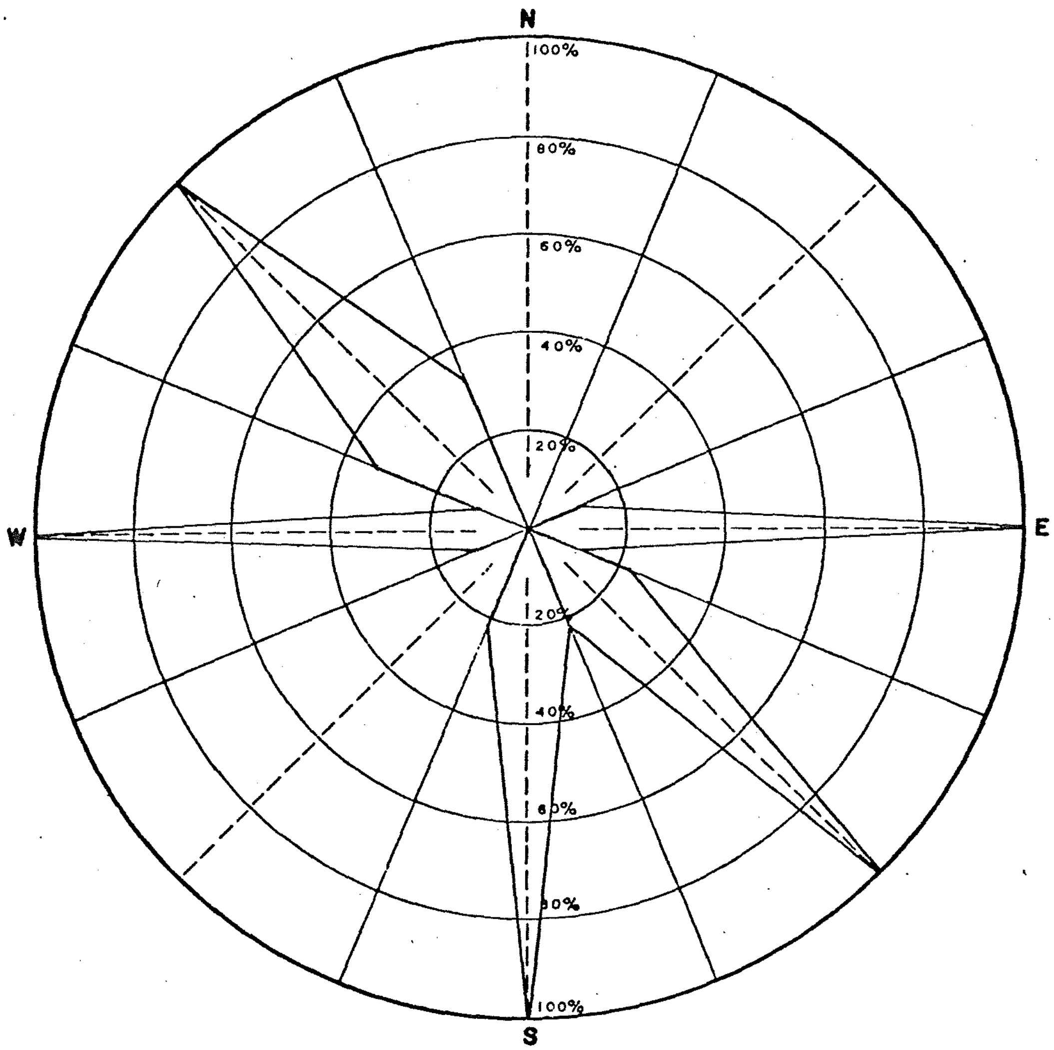



Figure 5. Bieber II, California percentage distribution of wiggles by azimuth (9 events).

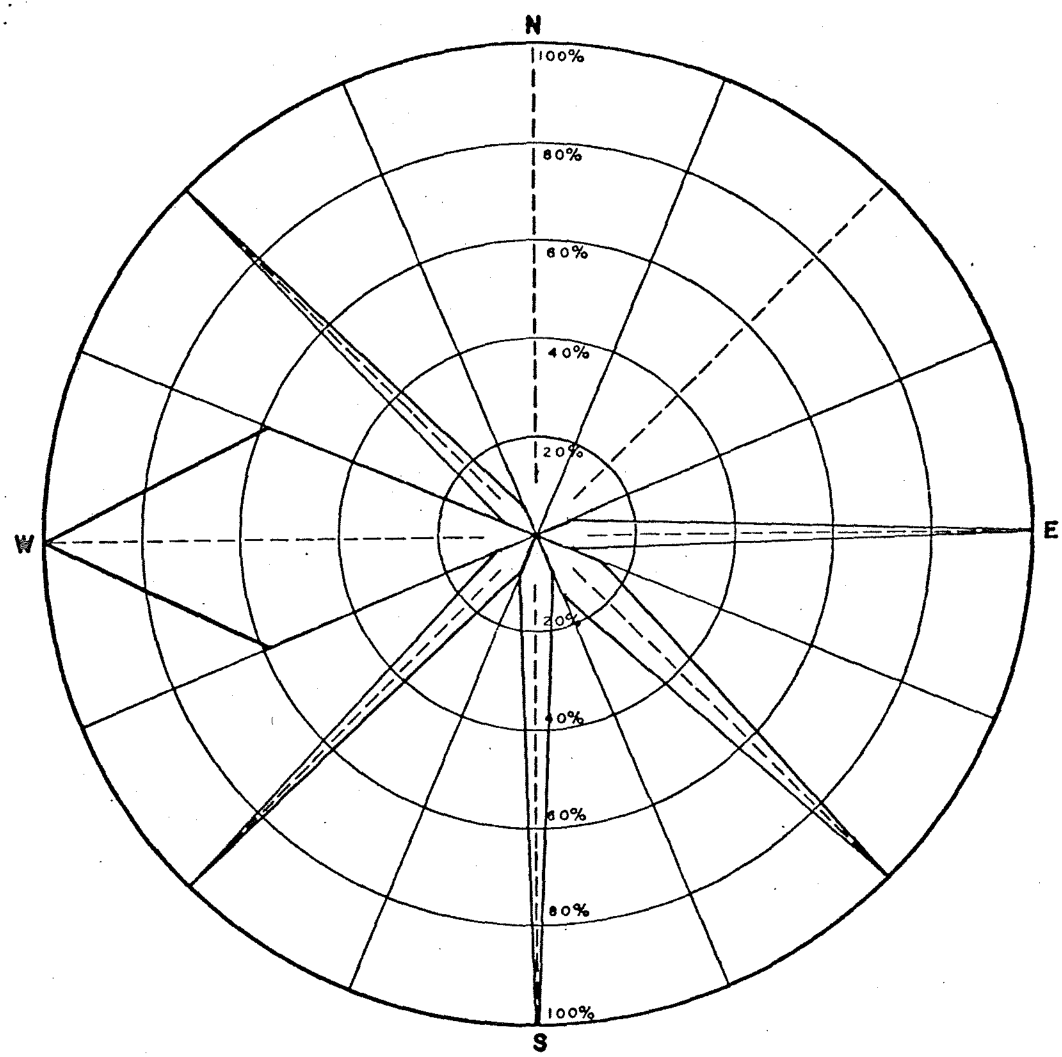



Figure 6. Bieber I, California percentage distribution of wiggles by azimuth (29 events).

$$f = \Delta\sqrt{pg/p_b h}\,/(2\pi) \qquad (1)$$

where $\Delta p$ = density difference between the fluid and the oscillating body.

$g$ = acceleration due to gravity.

$p_b$ = density of the solid body.

$h$ = thickness or height of the solid body.

Solving (1) for the height ($h$),

$$h = \Delta pg/\{(2\pi f)^2 p_b\} \qquad (2)$$

Assuming 2 hz oscillations of an alluvium valley ($p_b \simeq 1.5$) floating in a basalt liquid ($\Delta p \simeq 1.5$), the thickness of the alluvium would only be 6 cm. thick.

Equation (2) is inadequate for a realistic geologic situation. In fact, one is reminded to use equations which consider the propagation of waves through a media and to also consider higher modes of oscillation than the fundamental.

If the entire area beneath the seismometers is oscillating in response to vertical P-wave resonance, closed organ pipe equations are applicable as a first approximation, i.e.

$$h_i = k_i(V_p/4f) \qquad (3)$$

where $k_i$ = 1, 3, 5, 7 .....

$k_i$ is regarded to be the particular resonance mode recorded by the seismometers. Various depths ($h_i$) for resonance of various 2 hz, P-wave modes through media of different velocities are listed in Table 2.

Table 2. Theoretical depths of a resonating valley in response to 2 hz, P-waves at different modes.

| Velocity of P-Wave (km/sec) | (Kft/sec) | P-Wave Mode | Depth ($h_i$) (km) | (Kft) |
|---|---|---|---|---|
| 4 | 13.12 | 1 | .5 | 1.64 |
| | | 3 | 1.5 | 4.92 |
| | | 5 | 2.5 | 8.20 |
| 5 | 16.40 | 1 | .63 | 2.05 |
| | | 3 | 1.88 | 6.15 |
| | | 5 | 3.13 | 10.25 |
| 6 | 19.68 | 1 | .75 | 2.46 |
| | | 3 | 2.25 | 7.38 |
| | | 5 | 3.75 | 12.30 |

Equation (3) provides reasonable depths for resonance of a plate with dimensions which are at least as large as a seismometer array. Under these circumstances one could explain high apparent velocities and parallel vectors. Unfortunately, a resonating plate with the dimensions of the 40 km. Baker, Oregon array should have been detected by the nearby Blue Mountain Observatory unless the wiggle signals to Senturion's network are highly filtered by high impedance sequences and the signals transmitted to Blue Mountain are 10-15 hz signals in which case they would be 48 db down in gain at Blue Mountain due to the response of their seismometer.

3) Electromagnetic coupling into the seismometers. The basic problem with the 2 previous concepts regarding the high apparent velocity and parallel wiggle vectors is that dimensionally large plates are required to oscillate. These large plate movements probably would have been detected at other seismometer observatories. If the wiggles are regarded to be electrically induced into the seismometer or seismometer amplifier by either earth currents or extraterrestrial sources, wiggle vector characteristics can be explained. Consider the equation for the velocity of an electromagnetic wave through a conductive media:

$$v = \sqrt{4\pi f\rho/u} \qquad (4)$$

where $\rho$ = resistivity (ohm - meters)

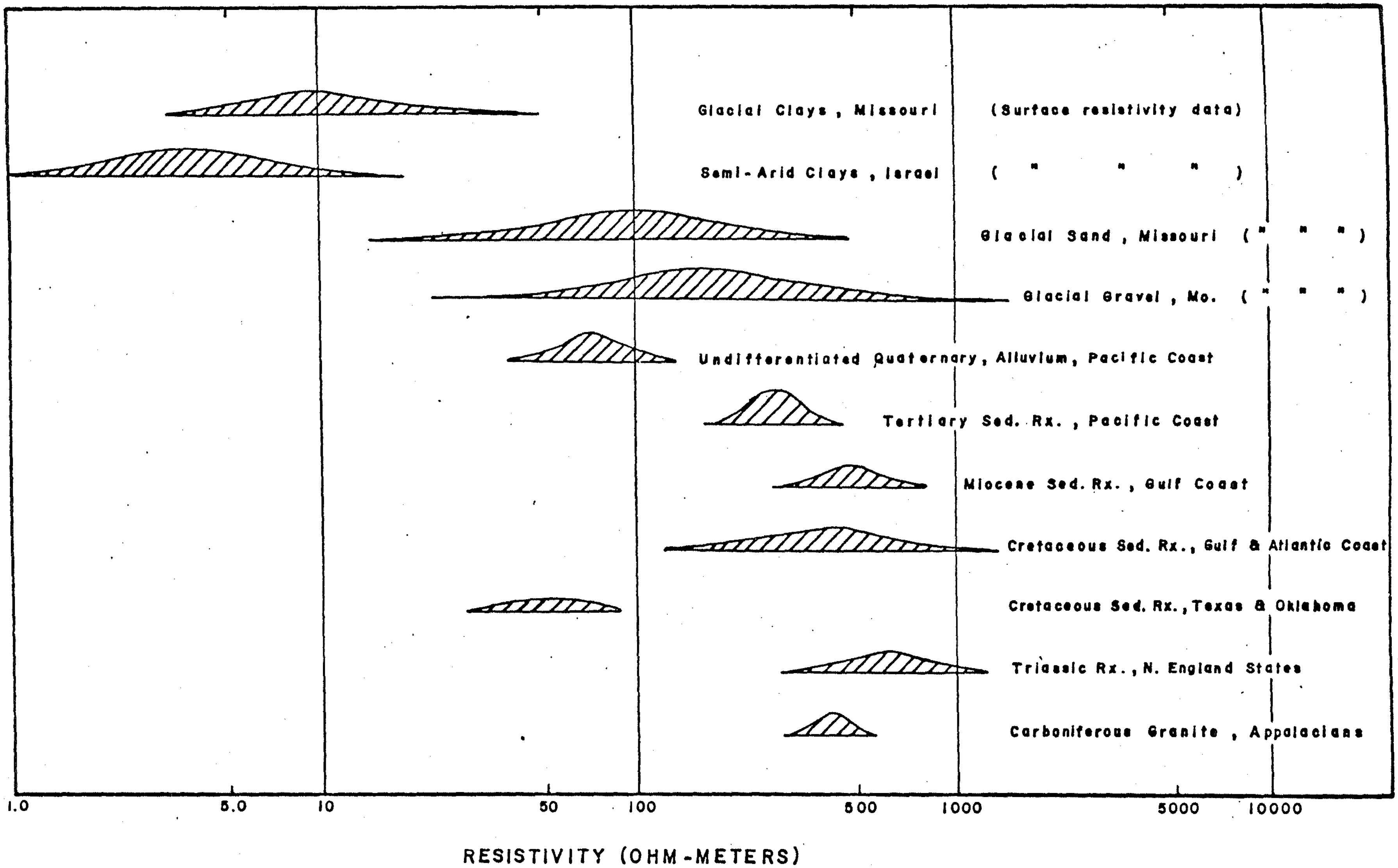
$u = 4\pi \times 10^{-7}$ henries/meter

Surficial rock resistivities vary from ≈1 to ≈25 ohm meters (Figure 7). Table 3 shows the anticipated velocities detected by seismometers and/or amplifiers which are somehow responsive to induced 2 hz currents.

Table 3. Anticipated electromagnetic wave velocities through surficial rocks based on equation 4.

| Resistivity (ohm-meters) | Velocity (km/sec) | (Kft/sec) |
|---|---|---|
| 1.0 | 4.47 | 14.67 |
| 5.0 | 10.00 | 32.81 |
| 10.0 | 14.14 | 46.39 |
| 15.0 | 17.32 | 56.82 |
| 20.0 | 20.00 | 65.61 |
| 25.0 | 22.36 | 73.35 |

The velocities given in Table 3 are within the range of those observed for wiggles provided one assumes wiggles are electromagnetic waves traveling within a very few meters of the surface. Basalt resistivities tend to be an order of magnitude or two greater than those listed in Table 3 which indicates electromagnetic wiggles could




RESISTIVITY RANGES FOR VARIOUS ROCK TYPES (Meidav & Keller & Frishknecht)

Figure 7.

not penetrate deep beneath the surface. However, the means by which such currents are or could be induced into the present seismometer-amplifier system is not known. Also wiggle velocities do vary greatly for any given site.

Another speculation for wiggle origins has been to consider them as an isolated phase of surface waves. Surface waves can have velocities exceeding those of the surface layers, but they can not exceed deeper layer velocities.

Low frequency, unresolved, "volcanic tremors" have been reported, but the authors have failed to indicate the nature of the apparent velocity vectors. It has been stated that some "volcanic tremor" locations were possible provided exceptionally low, assumed velocities were used. Exceptionally low velocities would be required to locate wiggles provided one denies the apparent velocity vectors.

Senturion offers the model in Figure 8 as the type of geologic complexity which could partially explain wiggle phenomena. Presume the event occurs at some depth within a graben and chooses to be a guided wave through most of its travel within the graben; upon reaching the terminus of its guided path Huguen's radiation proceeds and it enters the zone of differing impedance sandwiched between two zones of similar impedance values and the energy commences to ring or reverberate. Should the top zone be a high density floating plate in a sea of squash and the multiples become additive, then the floating plate may quiver and should there be a slab resting upon the plate it could also resonate. Obviously, the fundamental resonance will be ultra low frequency, but the 6th or 10th higher mode may just match our optimum frequency of 2-3 hz.

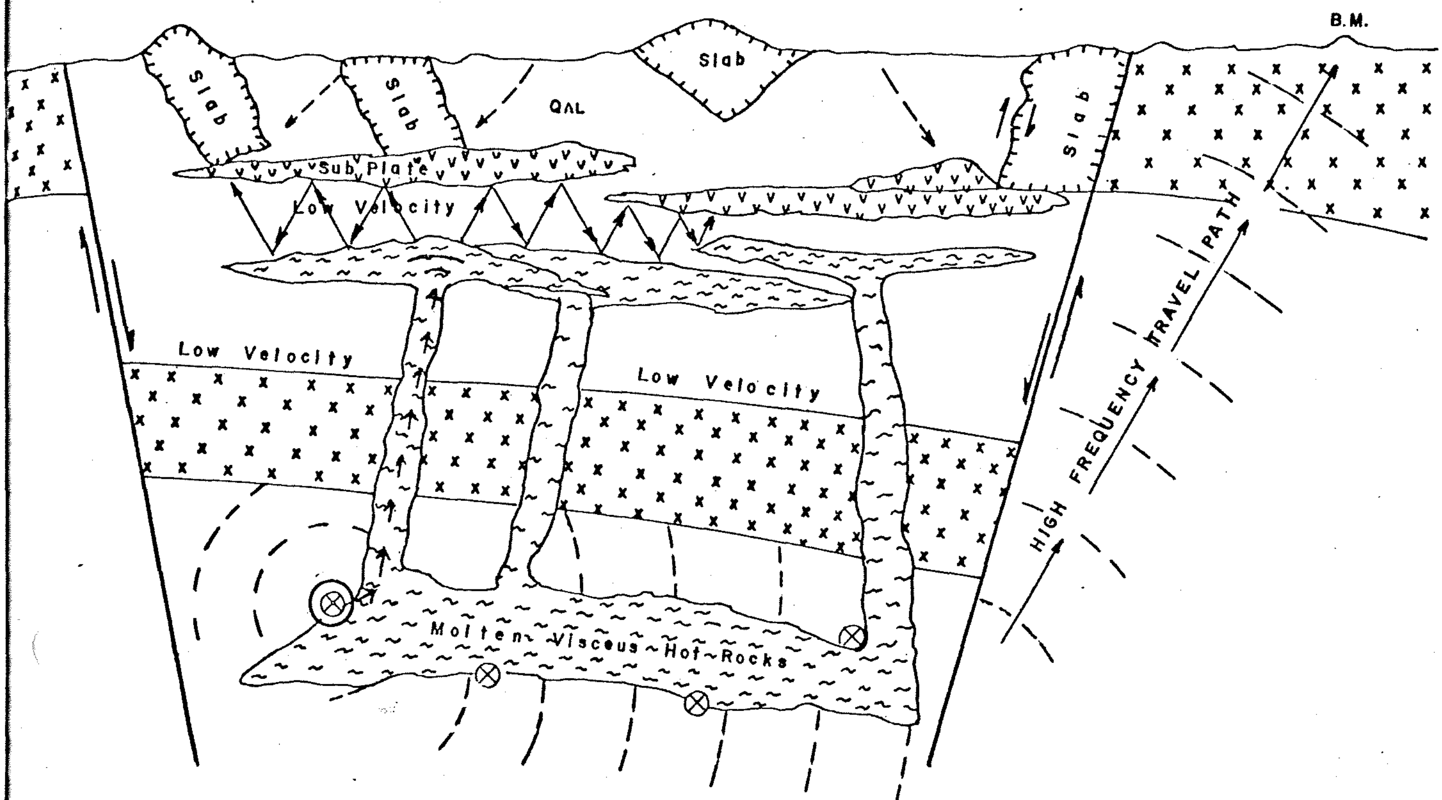
Should the travel path outside the graben be competent it is likely the signal frequency at 10 to 20 miles will be between 10 hz and 15 hz, which puts their frequency 36 to 48 db down in seismometers possessing responses similar to Blue Mountain. Assign the event as being a Richter Magnitude 1 or 2 and there is little chance outside observatories will detect or identify such signals. Yet guided energy of that magnitude would establish considerable epicentral ground motion.

Unfortunately, the origin of wiggles is still highly speculative and their relationship to volcanic or geothermal areas can only be shown by correlation at this time. Senturion does, however, assure Intercontinental that wiggles and their origin will continue to be reported and their correlation to any significant parameter will be noted on all of Senturion's tasks.

Seismicity, on the other hand, is known to be associated with geothermal regions!

<u>Bieber II Seismicity</u>

The known seismic events listed in Table 1 are shown on the polar plot in Figure 9. This figure also includes Bieber I events which have been




⊗ SEISMIC EVENT FOCUS

Slabs were once coherent solidified flow material

Sub Plates probally high density intrusives

Low Velocity - Ash and/or QAL and/or sediments

Figure 8.

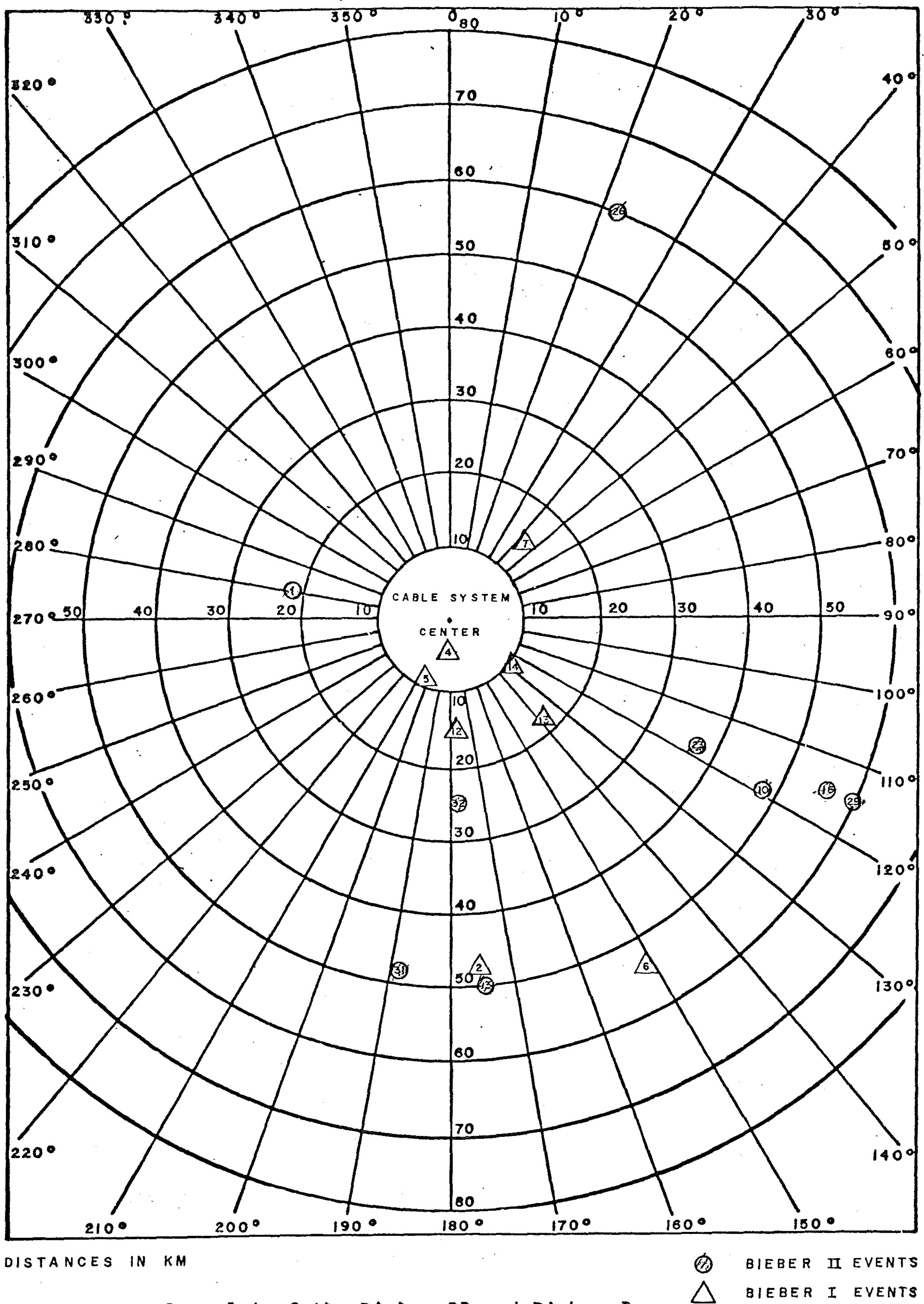



Figure 9. Polar plot of the Bieber II and Bieber I events referenced with respect to the Bieber II cable system center station.

referenced with respect to the Bieber II cable system center (Table 4). It is significant that the seismicity results do not correlate between the two surveys. It is postulated that seismicity being charted is tectonic seismicity rather than seismicity emanating from heated zones. Should the stresses due to tectonic forces possess any focus and if there are abnormally heated rocks, then their stress relief is via some other mechanism such as groundnoise, groundnoise burst, wiggles and/or a combination of all three.

Figure 10, event #1, is the closest event observed with the Bieber II array. It is characterized by different apparent velocity vectors in the vicinity of the event and an S-P time of approximately 2 seconds from RF #3 station. Figure 11 is the signature recording of the double event #10 which is estimated to be ≈48 km. (30 miles) from the center of the array. Event 10A and 10B both have parallel apparent velocity vectors with magnitudes equal to velocities beneath the Moho. Most of the Bieber II seismic events have similar signatures.

Conclusions

Bieber wiggles were observed during both periods of investigation. Their apparent velocity vectors are difficult to explain because the vectors are parallel and at velocities greater than those within the crust of the earth. Complex seismic models might explain the origin of the wiggles. Electromagnetic wave propagation requires that currents be induced into the seismometer - amplifier system. Tests plus humbucking arrangements of the seis coils seem to disprove this. Consequently, wiggle origins remain unresolved and their relationship to geothermal regions uncertain.

Bieber seems to have all the attributes of a geothermal area, but in a total of twenty days in the vicinity a swarm failed to evolve. Senturion has noted very large groundnoise differences in the PSD's of the 12 sites and by assuming the greatest impedance contrast likely in "mother earth" the groundnoise differences are still significant. Therefore it is our opinion that stresses are being relieved via rheid deformation, creep and major tectonic release (Richter magnitude 1 and greater which are infrequent).

Table 4. Bieber I events referenced to the center station of the Bieber II cable system.

| Bieber I Event No. | Direction from cable system (degrees azimuth) | Distance from cable system (km) | (miles) |
|---|---|---|---|
| 1 | 70.7 | 83.9 | 52.2 |
| 2 | 175.7 | 48.2 | 30.0 |
| 3 | 138.4 | 106.8 | 66.4 |
| 4 | 180.2 | 6.1 | 3.8 |
| 5 | 203.3 | 9.2 | 5.7 |
| 6 | 151.5 | 54.5 | 33.9 |
| 7 | 42.5 | 21.7 | 13.5 |
| 8 | 123.8 | 107.5 | 66.8 |
| 9 | 119.0 | 115.7 | 71.9 |
| 10 | 128.3 | 83.2 | 51.7 |
| 11 | 112.9 | 83.7 | 52.0 |
| 12 | 177.0 | 15.7 | 9.7 |
| 13 | 139.7 | 18.0 | 11.2 |
| 14 | 127.8 | 10.4 | 6.5 |

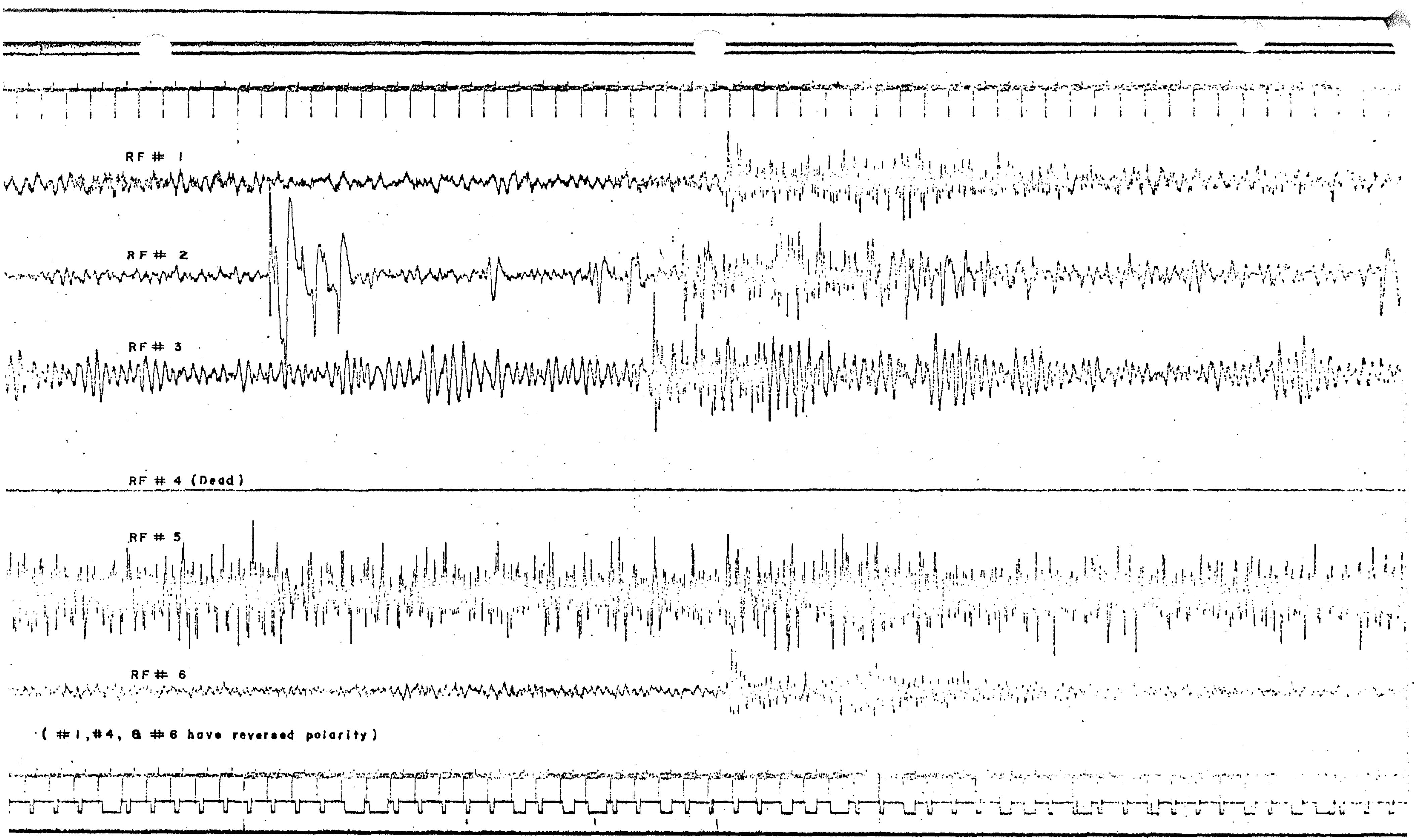



Figure 10. The closest event recorded by the Bieber II array. It occurred 22 km. from the cable system center at 279 degrees azimuth.

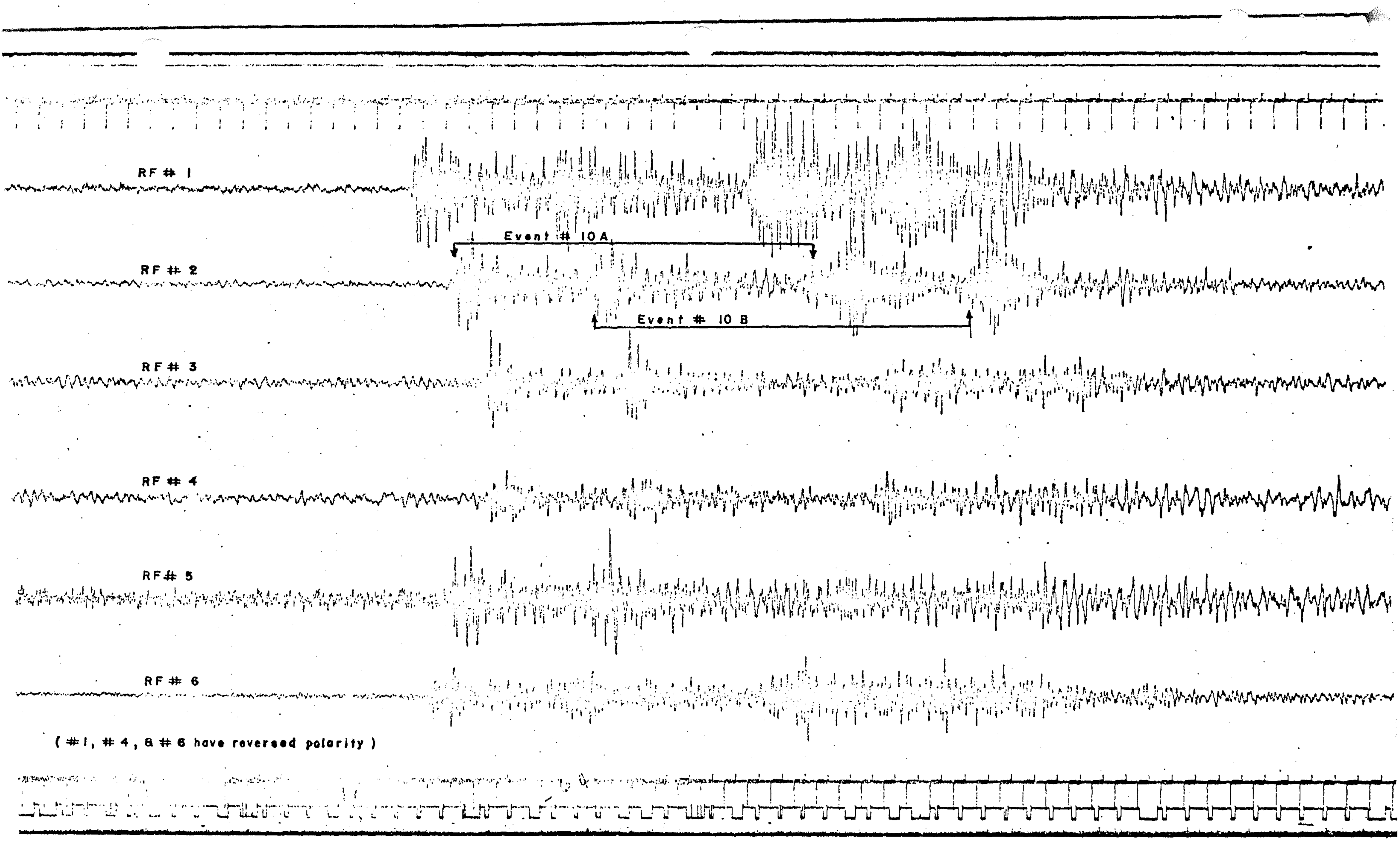



Figure 11. The double event #10 which occurred ≈48 km. from the center of the cable system at a direction of 120 degrees azimuth. Approximate S-P time intervals are indicated by the length of the bans identifying the two events.