Name: KEY **Exploration Geophyiscs**

Seismic Refraction Analysis: Trans-California Seismic Profile Show your work and turn in any matlab scripts or excel spreadsheets you use.

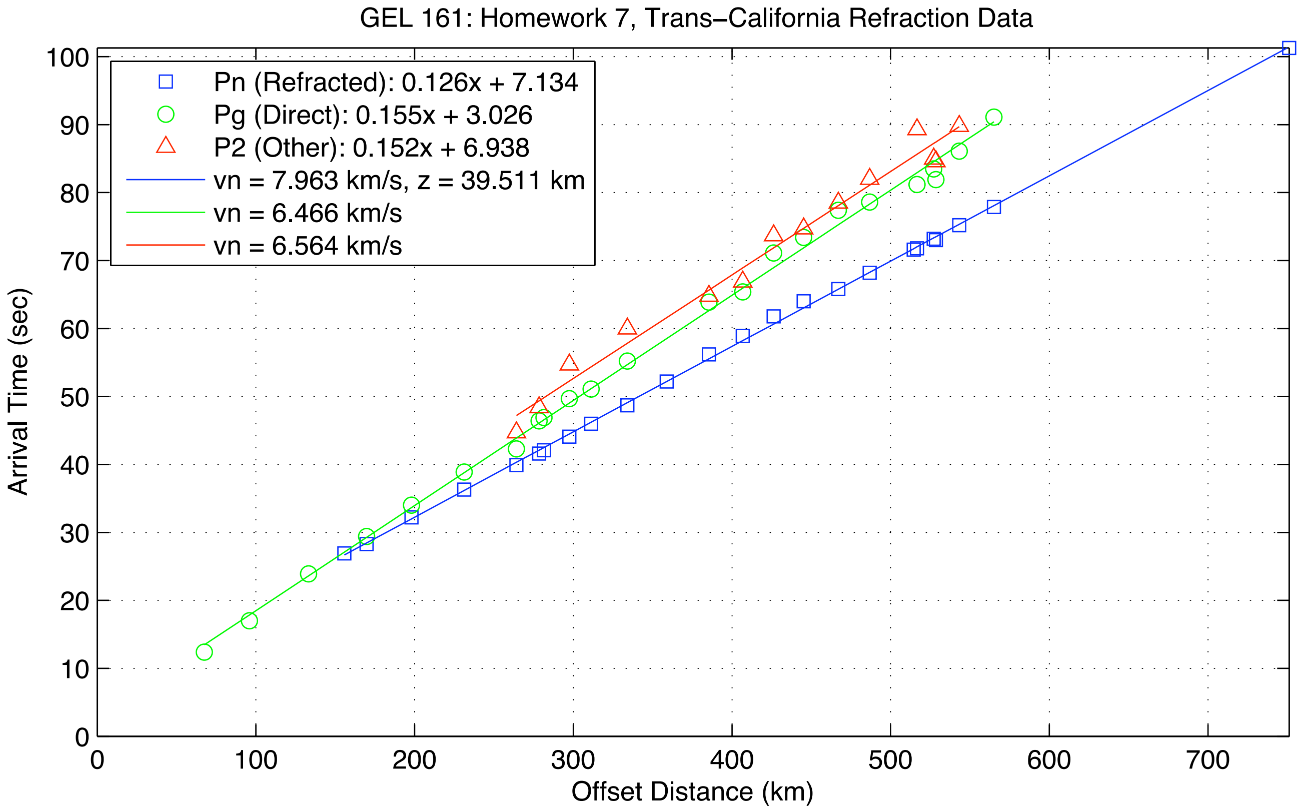
During the the 1960s, testing of nuclear bombs provided high energy seismic sources, that provided an unintended, but incredibly useful means for studying the structure of the continental crust in western North America. Below you will find 1) the abstract and introduction from a paper reporting on observations from 4 nuclear explosions, 2) a map showing the location of the profile of stations, and 3) a table that includes the distance, Δ, between the explosions (shot) and the station, the time to an arrival called P_n, the time to another arrival called P_g, and the time to a third arrival called P_2.

1. Plot the data from the table on a travel-time diagram (distance versus time). Please use a different plot symbol for each of the three arrivals (e.g., circles for P_n, squares for P_g and triangles for P_2), but plot all the data on one plot.
   See attached

2. By looking at the travel-time diagram, determine whether each of the arrivals can be fit to a line (just by looking, you don't need to do a line fit), a hyperbola or "can't tell". Use this information to identify each set of arrivals as either the direct wave, refracted wave, reflected wave or unidentified.
   All three lines appear linear, so there are no reflected waves.
   P_g is the direct wave, it has the smallest intercept time (should be zero, but there could be some topographic effects that are not completely accounted for).
   P_n is a refracted wave off of the deepest interface with the largest velocity contrast.
   P_2 is another refracted wave off a shallower layer with a very small velocity contrast compared to the upper layer (these have very similar slopes).

3. Assuming a simple two-layer structure (single interface), use the travel-time diagram to determine the velocity of the two layers, v_1 and v_2, and the thickness of the layer above the reflector.
   From the travel time diagram, measure the slopes of the direct (m_g) and refracted (m_n) wave and the intercept time (t_i) for the refracted wave.
   $v_1 = 1/m_g = 6.466$ km/s
   $v_2 = 1/m_n = 7.963$ km/s
   $t_i = 7.134$ sec
   Then calculate the layer thickness:
   $z = \frac{t_i v_1 v_2}{2\sqrt{v_2^2 - v_1^2}} = 39.51$ km

4. Based on the layer velocities and layer thickness, what lithospheric structure is imaged by the profiles. Explain your answer. You may need to visit books from your introductory geology courses or use the web to find the answer.
   The velocity of the deepest layers is almost 8 km/s compared to the lower $\sim$ 6.5 km/s thickness of the shallower layers. This indicates that the fast deep layer is in the mantle, while the slower shallower layers are in the crust. Also, the layer thickness of 40 km is a typical value for continental crustal thickness. Therefore, the P_n arrival is a refraction off the crust-mantle boundary called the Mohorovičić Boundary, or the Moho.



GEL 161: Homework 7, Trans−California Refraction Data
Pn (Refracted): 0.126x + 7.134
Pg (Direct): 0.155x + 3.026
P2 (Other): 0.152x + 6.938
vn = 7.963 km/s, z = 39.511 km
vn = 6.466 km/s
vn = 6.564 km/s
Arrival Time (sec)
Offset Distance (km)
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
700

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TRANS-CALIFORNIA SEISMIC PROFILE—PAHUTE MESA TO SAN FRANCISCO BAY

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ABSTRACT

Seismologists from the University of California at Berkeley and the ESSA Earthquake Mechanism Laboratory at San Francisco cooperated in an experiment to record seismic waves along a profile from the Nevada Test Site to San Francisco Bay, by utilizing four high-yield nuclear explosions detonated under the Pahute Mesa in Nevada as energy sources. The selected profile includes the Yosemite Valley and California's Central Valley a few miles south of Stockton, and instrumental coverage included 18 temporary and nine permanent seismographs in addition to local coverage in the source area and the Lamont-Doherty ocean bottom seismometer off Point Arena. P_n travel times along the profile may in general be represented by the equation

$$t = (6.2 \pm 0.1) + \Delta/(7.88 \pm 0.02)$$

with deviations from this under the Central Valley probably because of deep sediments, and under Owens Valley and the White Mountains probably as a result of a thickened crust. Early travel times to stations located in the Sierra Nevada do not permit an appreciable root under the Sierra Nevada portion of the profile unless the material of that root, if it exists, has a relatively high velocity. Crustal layers under the Central Valley, the Pahute Mesa, and the Sierra Nevada have total thicknesses approximating 30 km and thicknesses of 35 to 40 km under Owens Valley and the White Mountains. Because of high source energies, temporary stations located in the Central Valley were able, for the first time, to record from artificial sources initial seismic waves above heavy local noise.

Introduction

Four underground nuclear tests with equivalent earthquake magnitudes near 6 were detonated at Pahute Mesa on the Nevada Test Site (NTS) in 1968 and 1969. The U. S. Atomic Energy Commission named these explosions BOXCAR, BENHAM, JORUM, and PIPKIN. To take advantage of the high seismic energy release from these explosions, seismologists at the University of California Seismographic Station at Berkeley (UC) and ESSA's Earthquake Mechanism Laboratory at San Francisco (EML) began a joint program to investigate the crustal and upper mantle structure under the Sierra Nevada Mountains and California's Central Valley (northern San Joaquin Valley).

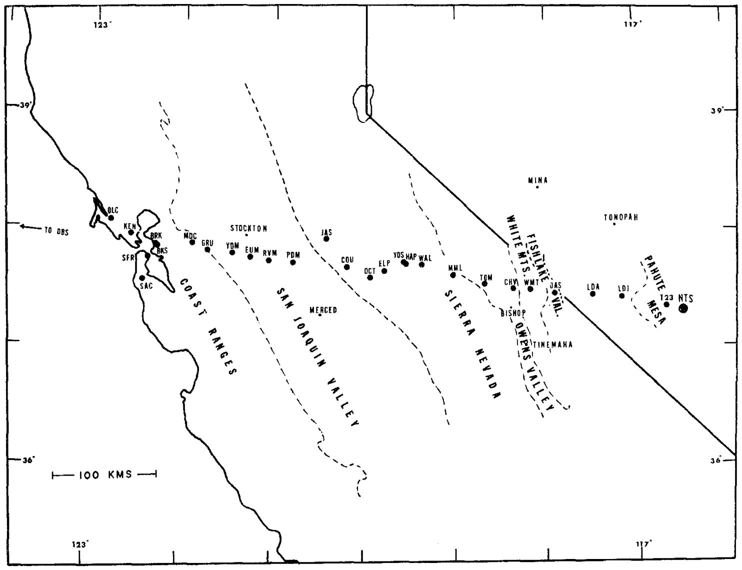

Fig. 1. Locations of the principal seismographic stations used for the profile.

TABLE 2

Travel Time Data

Station	Δ, Distance (km)	t, P_n time (sec)	Shot	$t - (\Delta/7.88 + 6.2)$*	P_g, P_2 times (sec)†
LDJ	67.4	—	4	—	12.4
LDA	95.9	—	4	—	17.0
OAS	133.1	—	4	—	23.9
WMT	155.7	26.9	4	+0.9	—
CHV	169.7	28.3	3	+0.6	29.4
TOM	198.0	32.2	3	+0.9	34.0
MML	231.2	36.3	2	+0.8	38.9
WAL	264.6	39.9	3	+0.1	42.3, 44.7
HAP	278.5	41.6	2	+0.1	46.4, 48.4
YOS	281.5	42.1	1	+0.2	46.9
ELP	297.2	44.1	1	+0.2	49.7, 54.7
OCT	311.3	46.0	2	+0.3	51.1
COU	334.1	48.7	1	+0.1	55.2, 60.0
JAS	358.9	52.2	1	+0.5	—
PDM	385.5	56.2	1	+1.1	63.9, 64.8
RVM	406.8	58.9	1	+1.1	65.4, 66.9
EUM	426.2	61.8	1	+1.5	71.1, 73.7
YDM	445.2	64.0	1	+1.3	73.4, 74.7
GRU	467.1	65.8	1	+0.3	77.4, 78.5
MDC	486.8	68.2	1	+0.2	78.6, 82.0
BKS	514.5	71.6	1	+0.1	—
BRK	516.7	71.8	1	+0.0	81.2, 89.3
SFR	527.2	73.2	1	+0.1	83.5, 85.0
SAC	528.5	73.0	1	−0.3	81.9, 84.6
KEN	543.2	75.2	1	+0.1	86.1, 89.8
OLC	565.1	77.9	1	+0.0	91.1
OBS	751.0	101.3	1	−0.2	—