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WEEKLY REPORT #3 TO ALTAROCK ENERGY INC.

PROCESSING OF INDUCED EARTHQUAKES ASSOCIATED WITH THE NEWBERRY EGS INJECTION STARTING SEPTEMBER 2014

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Brief summary

Difficulties with transferring the complete data from the ISTI system to our computers still have not been fully resolved. Approximately 10% of the data are lacking from the files provided to us.

We made some progress with relative relocations and have identified a high-quality subset of 177 earthquakes which we are exploring futher.

We derived an additional nine moment tensors, bringing the currently available set to 24. As part of the moment-tensor derivation process, we pick arrival times of P- and S-waves extremely carefully, rotating the seismograms to the epicenter and re-examining post-location residuals in a number of passes. The locations cluster very tightly in two clusters separated in depth by a ~ 200 m zone within which no earthquakes occurred. It will be interesting to see if this pattern is maintained when more earthquakes are processed.

Moment tensors fall in the range +Dipole to -Dipole with approximately equal numbers of earthquakes showing crack-opening and crack-closure. The T-axes, which gives an indication of the direction of σ_3*, cluster sub-horizontally S±20˚ or so. The P- and I-axes are more scattered.*

1 Task 1 – Planning, conference calls, discussion of work, correspondence, followup

We continued to exchange frequent emails with other team members, primarily ISTI (Paul Friberg and Stefan Lisawski) as we worked to improve the completeness of the data. We participated in an AltaRock conference call 10/22.

2 Task 2 – System Setup

We are still experiencing difficulties with incomplete data, including missing earthquakes and missing channels. Our seismic processing methods use digital seismograms stored in AH format, which is machine-independent and easily generated from any other commonly used seismic format (miniseed, SAC, SEGY, etc.). In attempts to deal with problems of incompleteness and timing errors, we used to date several methods for obtaining data. None of these have proven to be entirely satisfactory:

- SAC-format files from AltaRock via VPN. These data often are truncated (traces beginning too late or ending too early) and/or have gross timing errors.
- "AH-format" files from AltaRock via VPN. These files are not in proper AH format and cannot be read.
- SEISAN-format files transferred via web browsers using the **Dropbox** facility. These data have damaged channel codes, which require time-consuming manual correction.
- AH files generated automatically by ISTI and stored on the server **icedragon**. This is the source of most of the data we have processed, but the files still contain many errors.

Appendix 1 shows the number of traces currently available for each station and for all triggered earthquakes between Sept. 26 and Oct. 19, 2014. Out of a total of 13,872 expected traces (292 triggers

× 48 traces/trigger), 1506 are missing altogether. Many others (which are difficult to count automatically) are truncated or have gross timing errors.

Dealing with these problems has occupied quite a lot of time, and the most troublesome problems have been ironed out. Nevertheless, as can be seen from the figures quoted above, about 10% of the data continue to be elusive.

We have pressed on with the data processing despite this data leakage. The high quality of the recordings has meant that many good and excellent moment tensors have been obtainable despite the problems. 24 moment tensors have been calculated to date, with earthquakes as small as magnitude M 0.68 yielding excellent solutions. It is likely that the ~ 100 moment tensors originally requested by AltaRock will be calculable.

3 Task 3 – Quality control of prepicked MEQs and preparation for relocation and moment tensor calculation

We continued to derive moment tensors, prioritorising the largest earthquakes. We continue to use the same procedure as described in our Weekly Report #1. We report here an additional nine moment tensors. The entire list of earthquakes processed to date is given in Table 1. We have provided the locations and moment tensor decomposition data to Trenton Cladouhos of AltaRock electronically, by email attachment.

Table 1: The 24 earthquakes for which moment tensors have been obtained. Locations given below are from the webpage http://fracture.lbl.gov/Newberry/locations.txt.

jday	month	day	hour	minute	sec	lat	lon	depth	magnitude
273	9	30	21	30	43.689	43.72667	-121.313	0.387	**0.972**
274	10	1	1	3	14.64	43.7239	-121.30957	0.714	**0.987**
274	10	1	8	8	58.215	43.72623	-121.31412	1.196	**0.848**
274	10	1	10	50	55.229	43.72275	-121.30868	1.051	**0.787**
274	10	1	12	3	16.881	43.72658	-121.3158	1.587	**1.086**
274	10	1	14	53	5.102	43.72545	-121.31355	0.613	**1.381**
274	10	1	15	1	55.056	43.72775	-121.31227	0.923	**0.682**
274	10	1	16	56	11.256	43.72232	-121.30712	1.65	**0.901**
274	10	1	19	5	16.377	43.72662	-121.31117	0.517	**1.259**
275	10	2	6	38	47.428	43.7243	-121.31328	1.153	**0.951**
275	10	2	6	47	52.916	43.72632	-121.31322	1.323	**1.117**
275	10	2	7	7	11.646	43.72488	-121.31192	0.708	**1.378**
275	10	2	11	1	48.042	43.72567	-121.31168	0.666	**1.22**
275	10	2	12	39	9.082	43.7264	-121.31438	1.332	**0.852**
275	10	2	18	53	48.447	43.72082	-121.31372	1.671	**0.957**

275	10	2	20	36	50.997	43.72377	-121.31323	1.499	**0.991**
276	10	3	6	6	22.727	43.72528	-121.31493	0.928	**1.157**
276	10	3	15	27	57.912	43.72257	-121.31562	1.054	**0.919**
276	10	3	18	54	54.199	43.72678	-121.31125	0.647	**1.021**
277	10	4	5	29	8.347	43.72578	-121.31068	0.946	**0.922**
277	10	4	17	32	52.716	43.72207	-121.31693	0.376	**1.521**
277	10	4	18	51	11.991	43.72295	-121.31227	0.496	**1.97**
278	10	5	4	7	30.446	43.725	-121.31322	0.659	**1.696**
278	10	5	23	22	16.638	43.72368	-121.3116	1.055	**0.931**

4 Task 4 –Improved locations and relative locations

4.1 Absolute locations

We updated our relocation of the earthquakes using **qloc**, our in-house location program. The epicentral locations up to Oct. 20 are shown in Figure 1, and a depth vs. time plot for the same locations is shown in Figure 2.

Figure 3 shows the week-by-week development of the seismic sequence.

Figure 4 shows ISTI epicentral locations for comparison with Figure 1.

The general picture has not changed with the addition of ~ 15 earthquakes. The cluster is still centered centered 100 to 200 m north of the bottom of well NWD 55-29 and is quasi-circular with a diameter of ~ 500 m.

Figure 5 shows the locations of the MEQs for which moment tensors were derived. These earthquakes are the largest and best-located, have been subject to the most careful processing and outlier-rejection. They are the most accurately located earthquakes available to date. They cluster in two very tight clusters near the bottom of well NWD 55-29, a shallower cluster slightly to the north of the well and a deeper cluster slightly to the south. An expanded view of these epicenters is shown in Figure 6. The depth distribution is shown in Figure 7. The earthquakes clearly fall into two depth intervals - one shallower than 1 km b.s.l. and the other deeper. There is a depth interval of ~ 200 m within which no earthquakes occurred.

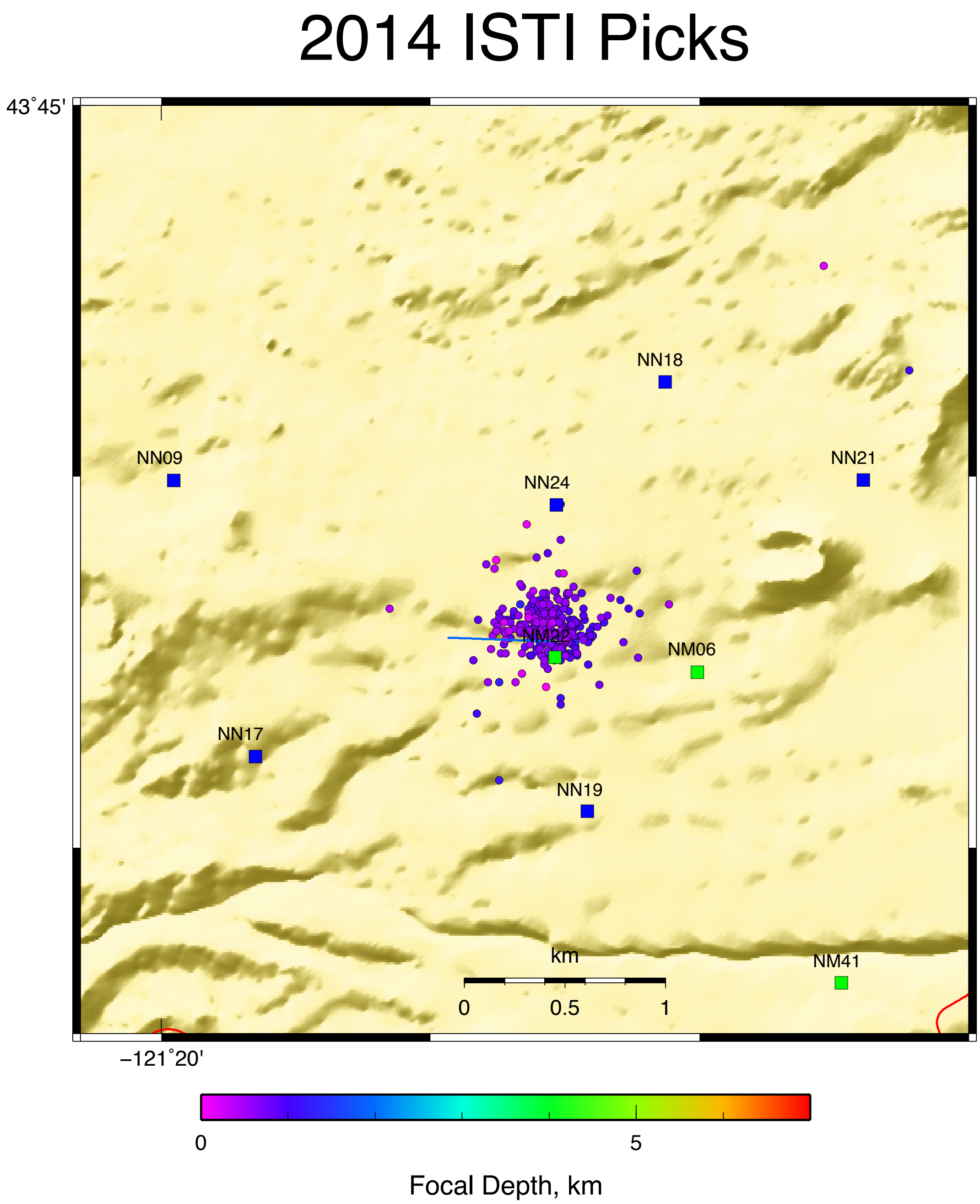

Figure 1: Estimated hypocenters of 287 microearthquakes between Sept. 26 and Oct. 20, 2014 within the NMSA network. Most events lie within a circle about 500 m in diameter and centered 100 to 200 m north of the bottom of well NWD 55-29, which is shown in blue. These locations were obtained by using the **qloc** program to invert *P*- and *S*-phase arrival times measured by personnel of the ISTI Corporation on digital seismograms from the NMSA network.

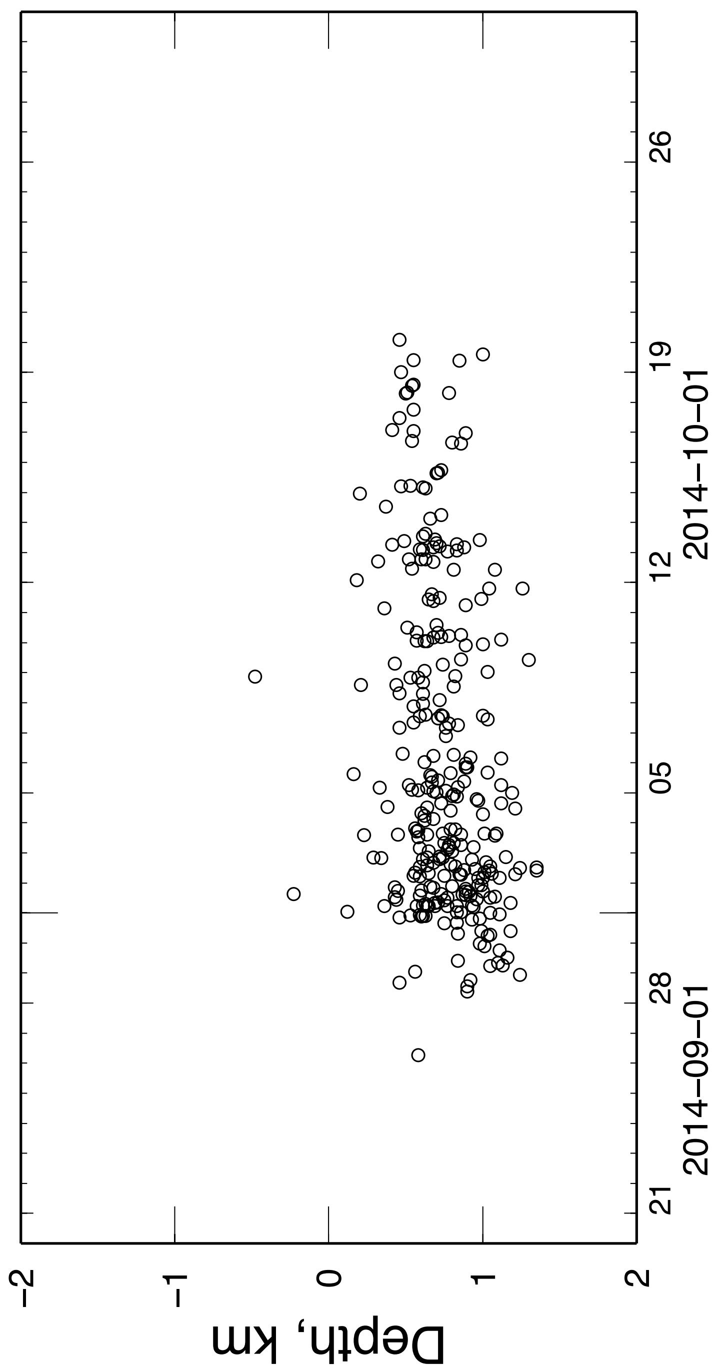

Figure 2: Estimated depths, with respect to sea level, of 287 microearthquakes within the NMSA network as a function of time. The average depth decreases slightly with time because of a decrease in the number of deeper events. These depths were obtained by using the **qloc** program to invert *P*- and *S*-phase arrival times measured by personnel of the ISTI Corporation on digital seismograms from the NMSA network.

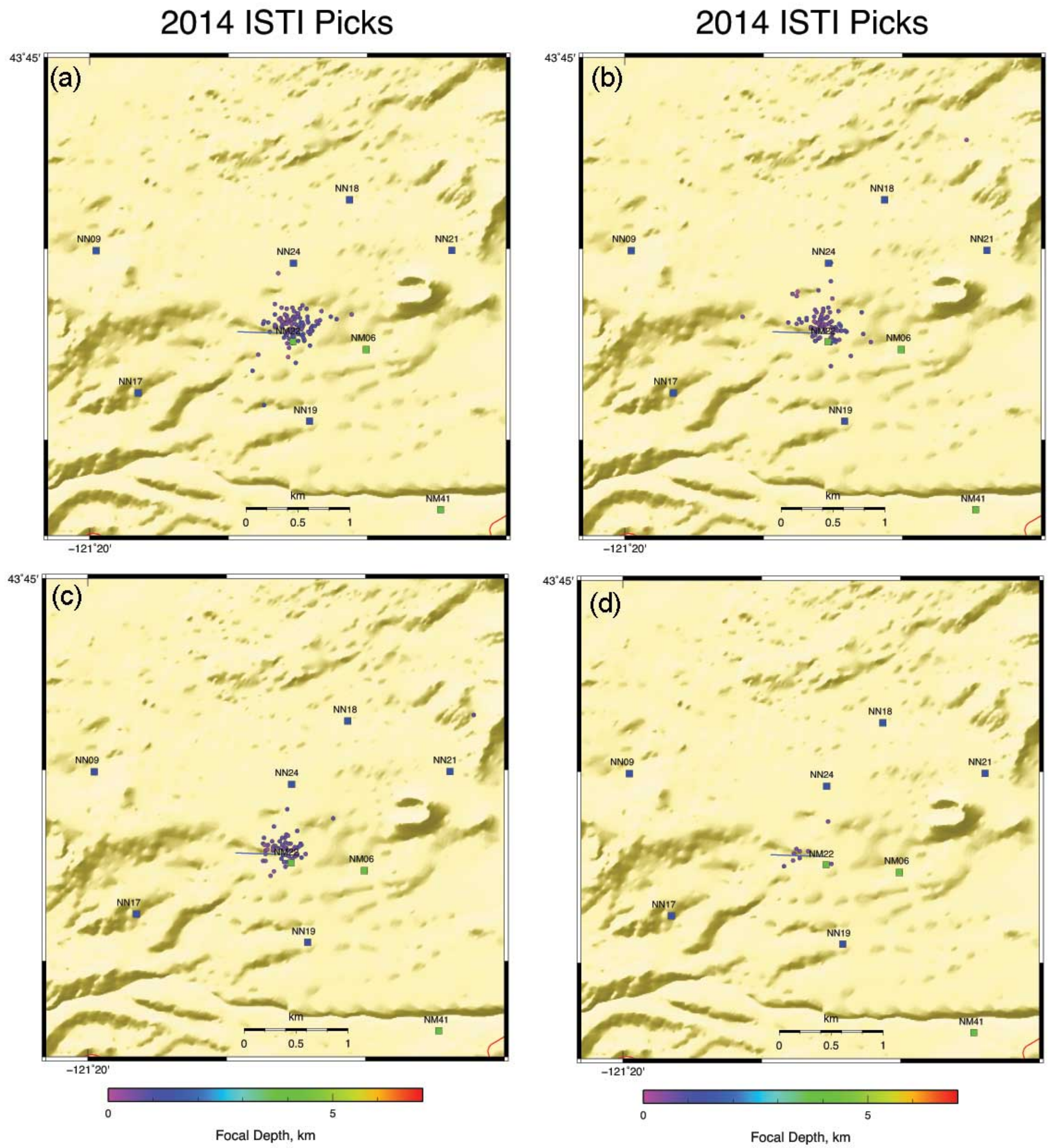
2014 ISTI Picks
2014 ISTI Picks
43°45′
(a)
(b)
(c)
(d)
NN18
NN09
NN21
NN24
NM22
NM06
NN17
NN19
NM41
km
0
0.5
1
−121°20′
0
5
Focal Depth, km

Figure 3: Estimated hypocenters of microearthquakes within the NMSA network as a function of time. (a) 2014 Sept. 26 – Oct. 02; (b) Oct. 03 – Oct. 09; (c) Oct. 10 – Oct. 16; (d) Oct. 17 – Oct. 19 (shorter interval). There is no clear tendency of events to migrate with time.

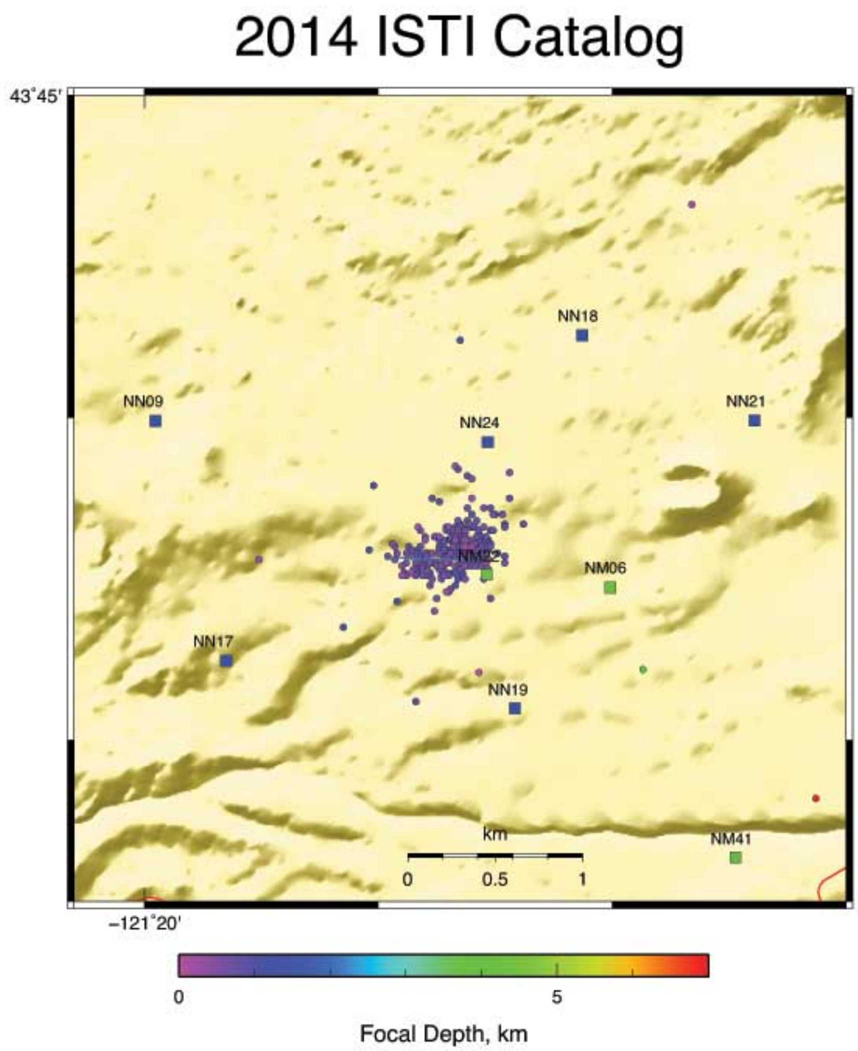

Figure 4: Estimated hypocenters of 298 microearthquakes between Sept. 26 and Oct. 20, 2014 within the NMSA network, as given in the earthquake catalog of the ISTI Corporation. These locations are slightly but significantly west of those shown in Figure 1, which were derived from substantially the same seismic data but using a different computer program. Well NWD 55-29 is shown in blue.

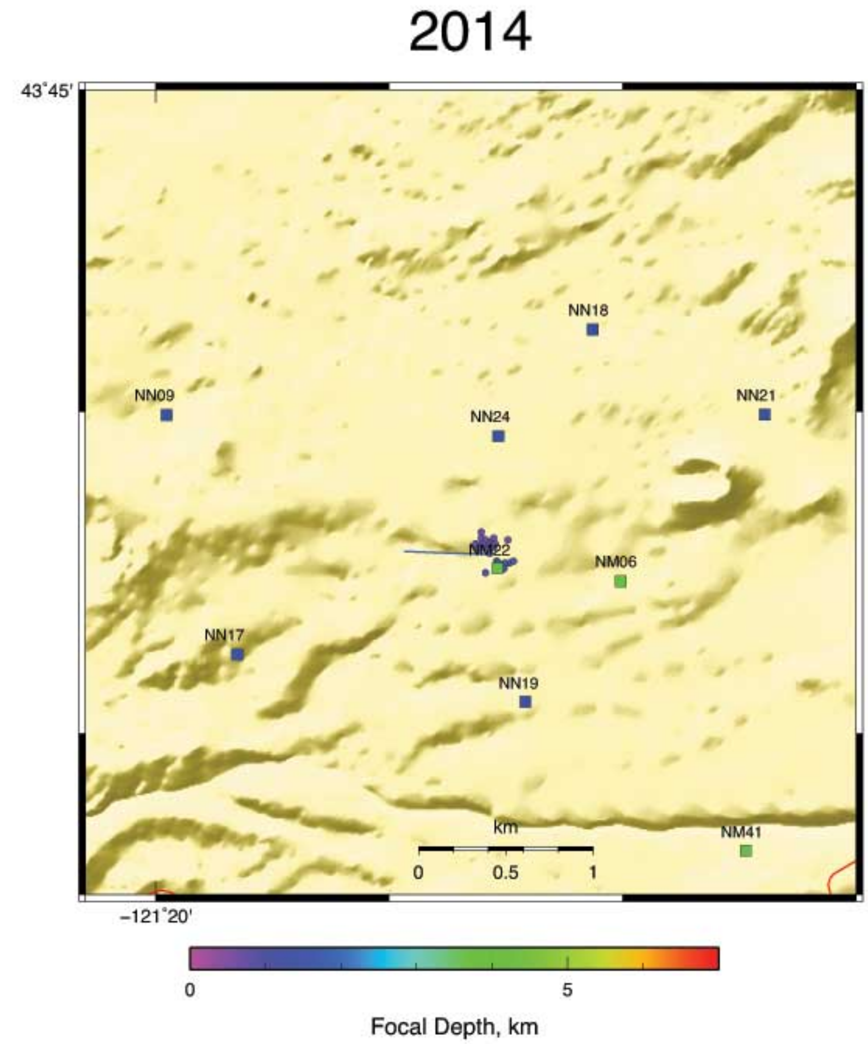

Figure 5: High quality estimated hypocenters of 24 microearthquakes that occurred between Sept. 30 and Oct. 05, 2014, and for which moment tensors were derived. These locations are computed using arrival times measured carefully in connection with the moment-tensor analysis. Well NWD 55-29 is shown in blue.

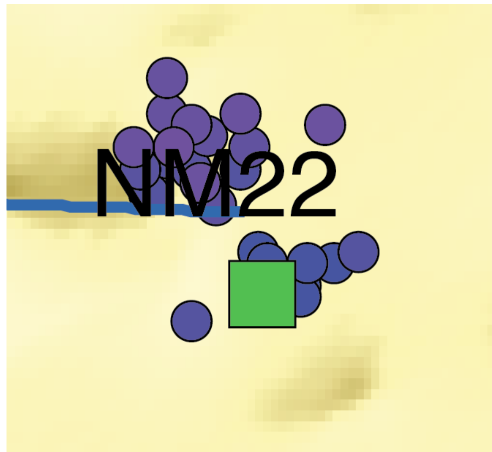

Figure 6: Expanded view of the area of the locations of the earthquakes for which moment tensors were derived.

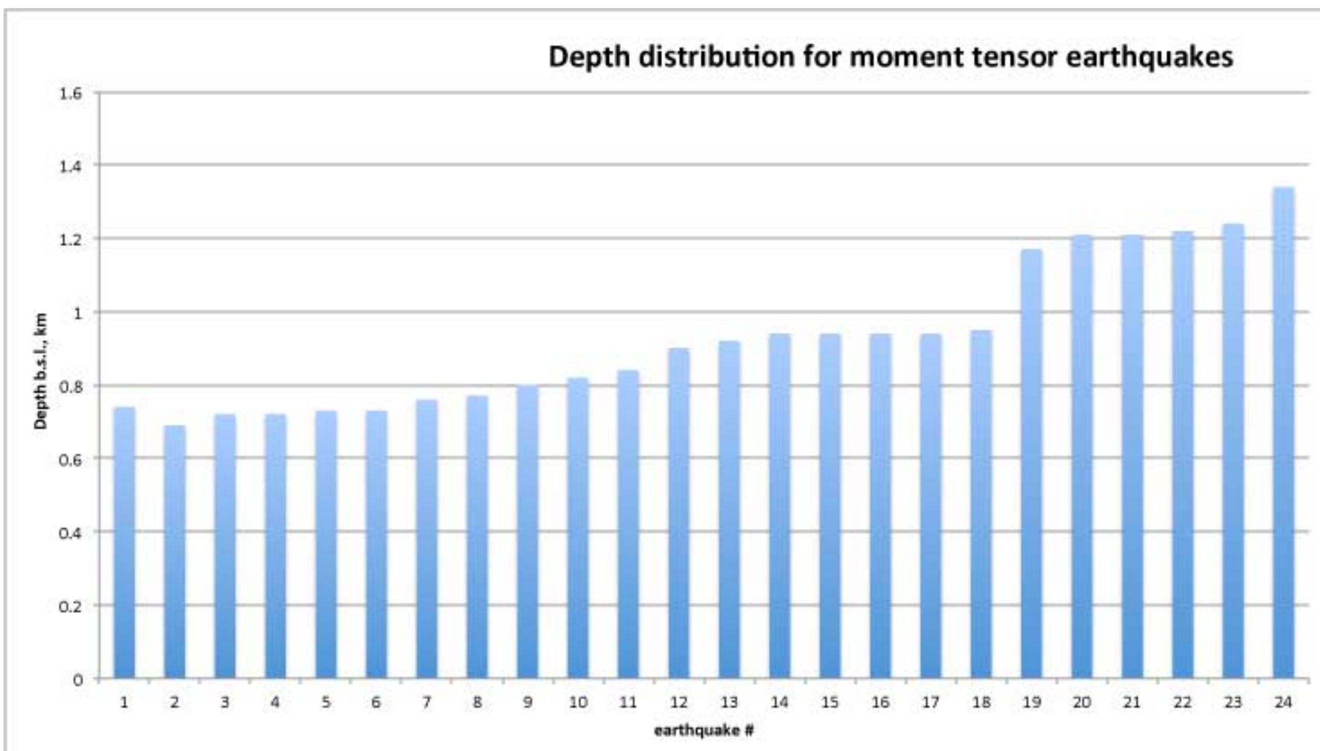

Figure 7: Depth distribution for moment-tensor earthquakes.

4.2 Relative locations

Our relative loction work is still at a preliminary stage because a great deal of time has been spent dealing with data difficulties. We show our very first results here.

Figure 8 shows a subset of the highest quality earthquakes extracted by the relative location program from the entire 287 set. This subset contains 177 earthquakes. These are the earthquakes that are “linked” to neighboring events by the largest number of “links”, i.e., they are recorded on the largest number of common stations. We are currently exploring the behavior of this high-quality subset.

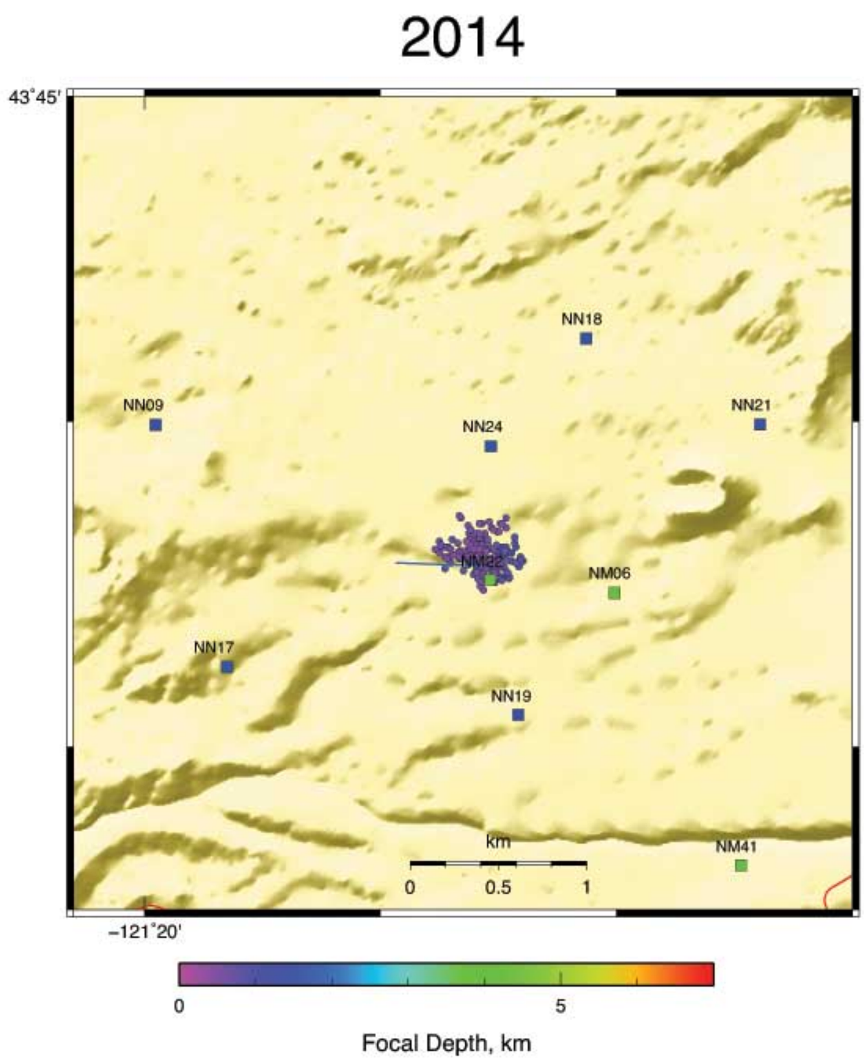

Figure 8: Subset of 177 earthquakes that are well linked to one another and which will be used to calculate relative locations.

5 Task 5 Moment tensor calculations

Moment tensors were derived for an additional nine earthquakes using the same procedure as described in Weekly Report #1. There is no shortage of events that yield good or excellent results. The numerical results of the catalog to date are given in

Table 2. Graphical results are shown in Appendix 2.

The source types for the entire 24-event set are shown in source-type space in Figure 9. The events form a distribution from the +Dipole to the -Dipole points, indicating a mixture of crack-opening and crack-closing events in approximately equal numbers.

Figure 10 shows a plot of the P-, T- and I-axes, approximately corresponding to the directions of σ_1, σ_3 and σ_2. Most notable is that the T axes cluster quite systematically subhorizontally and to the S ±20° or so. The orientations of the P- and I-axes are more scattered.

Table 2: Numerical moment tensor results for the 24 MEQs studied to date. N=North, E=East, D=Down.

NN	NE	EE	ND	ED	DD	Year	Mo	Day	Hr	min	Sec	Quality
1.578e-01	3.466e-02	6.671e-02	2.482e-01	6.317e-02	8.338e-02	2014	10	01	14	53	05.23	excellent
2.172e-01	-3.673e-02	-6.417e-02	2.346e-01	7.204e-02	3.184e-02	2014	10	01	19	05	16.54	excellent
8.713e-02	1.262e-01	-4.193e-02	1.814e-01	8.429e-02	8.722e-02	2014	10	04	18	51	12.00	excellent
-1.029e-01	1.325e-01	-1.185e-01	1.480e-01	5.508e-02	1.074e-01	2014	10	04	17	32	52.76	excellent
-1.165e-01	1.705e-01	-1.989e-01	1.394e-01	-2.430e-02	1.639e-02	2014	10	02	07	07	04.16	excellent
2.406e-01	-7.298e-02	-9.789e-02	1.731e-01	4.297e-02	8.349e-02	2014	10	02	11	01	42.38	excellent
-1.461e-02	9.643e-02	-3.978e-01	2.595e-02	1.691e-01	-4.693e-03	2014	10	02	06	47	52.94	excellent
6.066e-03	-2.231e-01	-9.157e-02	1.941e-01	3.367e-02	-6.184e-04	2014	10	03	06	06	22.76	excellent
-5.772e-02	-1.655e-01	-1.427e-01	1.464e-01	7.811e-02	-1.952e-02	2014	10	03	18	54	53.93	fair
2.004e-01	-1.410e-01	-1.461e-01	1.400e-01	-8.713e-03	7.412e-02	2014	10	01	12	03	16.94	good
5.304e-02	6.783e-02	-1.175e-01	1.615e-01	7.508e-02	2.206e-01	2014	10	05	04	07	20	excellent
-1.777e-01	-1.053e-01	-1.512e-01	7.111e-02	1.063e-01	1.057e-01	2014	10	01	01	03	14.49	excellent
-2.667e-01	1.320e-01	-6.399e-02	6.063e-02	1.031e-01	7.787e-02	2014	09	30	21	30	43.503	excellent
-1.871e-01	8.995e-02	-9.473e-02	-1.446e-01	-2.491e-02	1.992e-01	2014	10	05	23	22	16.499	good
1.684e-01	-3.350e-02	-9.826e-03	2.952e-01	3.542e-02	9.350e-02	2014	10	04	05	29	08.258	fair
2.449e-01	-8.111e-02	-1.972e-01	1.741e-01	1.624e-02	1.507e-02	2014	10	03	15	27	57.661	good
-2.209e-01	-8.132e-02	-2.190e-02	-1.520e-01	3.521e-02	2.201e-01	2014	10	01	16	56	11.343	good
1.477e-01	-1.175e-01	-1.492e-01	1.577e-01	-3.130e-02	9.546e-02	2014	10	01	08	08	57.998	excellent

-3.263e-02	2.220e-01	-3.373e-01	1.644e-02	7.162e-02	9.879e-03	2014	10	01	10	50	55.107	excellent
-1.038e-01	1.463e-01	-2.541e-01	1.246e-01	-1.332e-02	7.335e-02	2014	10	01	15	01	54.950	excellent
2.306e-03	-1.802e-01	-9.214e-02	2.203e-01	-4.354e-03	9.593e-02	2014	10	02	18	54	03.152	good
1.619e-01	4.200e-02	-2.041e-01	2.158e-01	-2.044e-02	7.759e-02	2014	10	02	06	39	02.998	excellent
-6.570e-02	-1.851e-01	-1.140e-01	1.691e-01	4.183e-02	2.826e-02	2014	10	02	12	39	24.317	good
1.420e-01	-1.373e-01	-1.638e-01	1.721e-01	1.076e-02	5.384e-02	2014	10	02	20	37	06.043	good

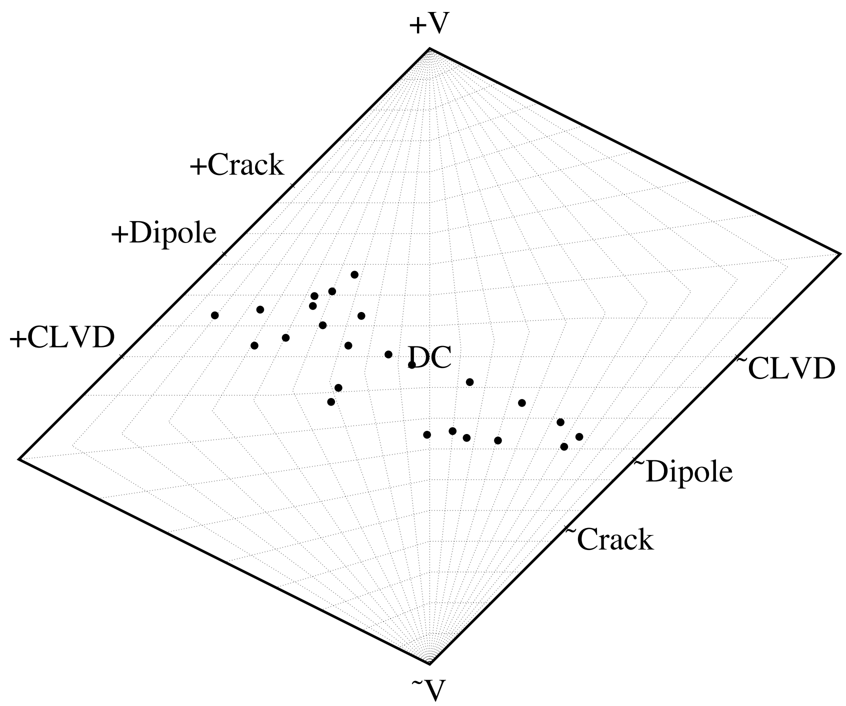

Figure 9: Source-type plot showing all the 24 earthquakes for which moment tensors have been derived to date.

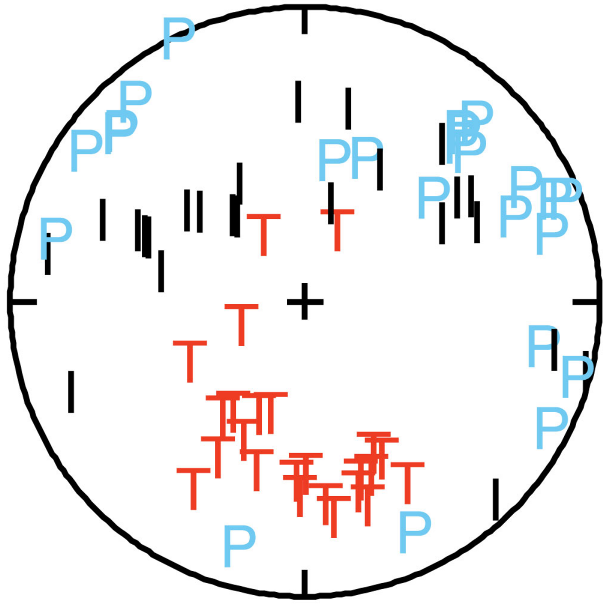

Figure 10: Plot of pressure (P ~ σ_1) and tension (T ~ σ_3) and intermediate (I ~ σ_2) axes for the 24 earthquakes for which moment tensors have been derived to date.

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Moment tensors fall in the range +Dipole to -Dipole with approximately equal numbers of earthquakes showing crack-opening and crack-closure. The T-axes, which gives an indication of the direction of σ_3, cluster sub-horizontally S±20˚ or so. The P- and I-axes are more scattered.

Appendix 1: Chart showing number of traces provided, by station, for each earthquake. The expected number is three. Zero traces are available for many earthquake/station.

	NM03	NM06	NM08	NM22	NM40	NM41	NM42	NN07	NN09	NN17	NN18	NN19	NN21	NN24	NN32	NNVM
20140926061705	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140928090818	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140928131725	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140928161535	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140928182631	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140928222127	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140929011049	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140929052635	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140929055720	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140929081510	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140929095744	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140929121221	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140929180327	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140929213023	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	0
20140929232125	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930054454	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930064450	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930071948	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930092338	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930094101	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930153542	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930162122	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930184543	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930192934	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930201338	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930210938	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930213033	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930213626	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930221203	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930222007	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930230115	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20140930235511	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001001817	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001002656	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001010304	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001044941	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001052153	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001052528	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001052613	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001053324	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001053402	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001053703	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001054145	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001055819	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001060220	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001065850	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
20141001080121	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
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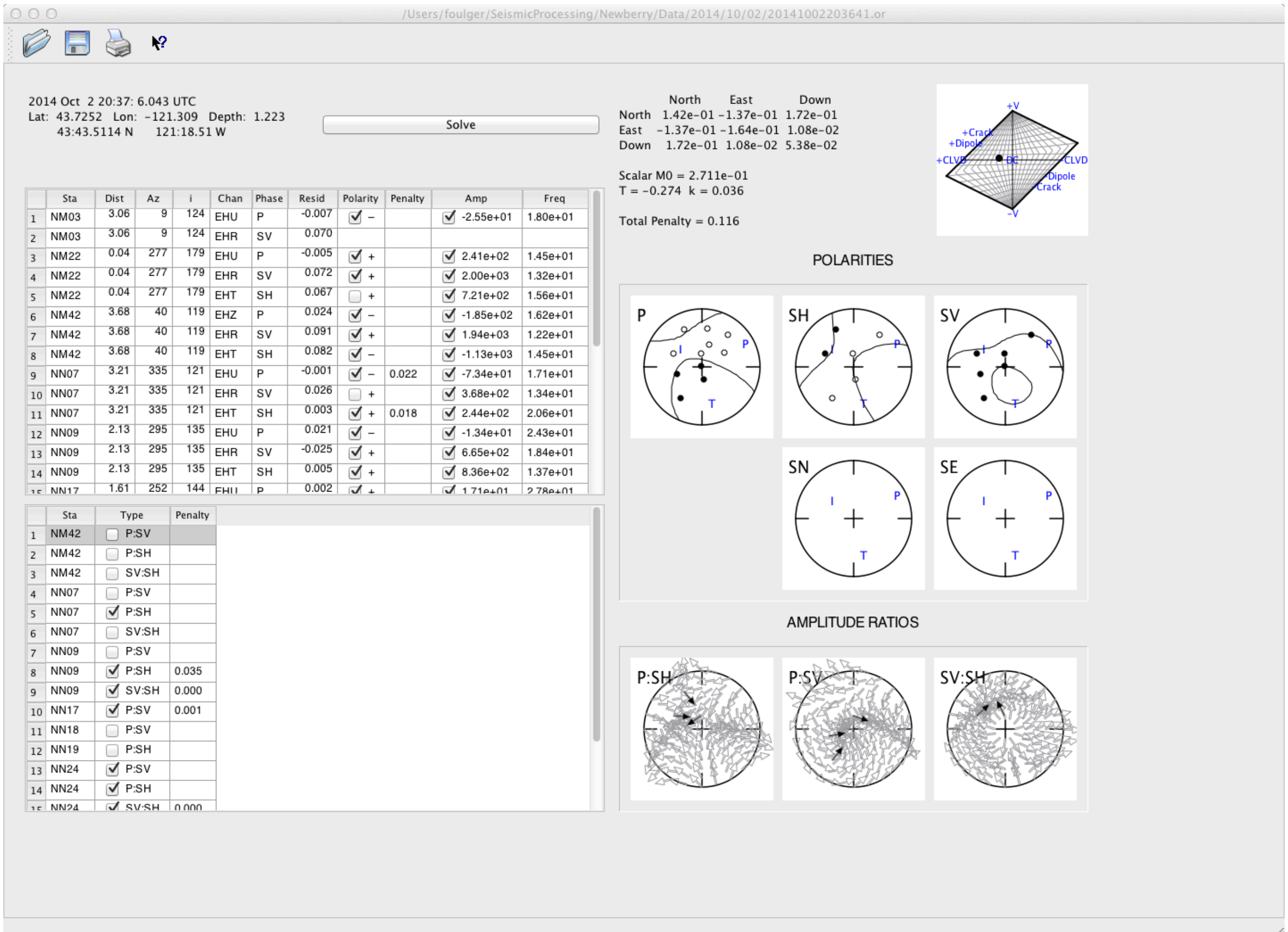
20141013041254	3	0	3	3	0	0	3	3	3	3	3	3	3	3	3	0
20141013050159	3	0	3	3	0	3	3	3	3	3	3	3	3	3	3	0
20141013061048	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	0
20141013064026	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	0
20141013072843	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	0
20141013090835	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	0
20141013095054	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	0
20141013102229	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	0
20141013125725	3	3	3	3	0	3	0	3	3	3	3	3	3	3	3	0
20141013144526	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	0
20141014030216	3	0	3	3	0	3	3	3	3	3	3	3	3	3	3	0
20141014054614	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	0
20141014123246	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	0
20141014224914	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	0
20141015032138	3	0	3	3	0	3	3	3	3	3	3	3	3	3	3	3
20141015034943	3	0	3	3	0	3	3	3	3	3	3	3	3	3	3	3
20141015045400	3	0	3	0	0	3	3	3	3	3	3	3	3	3	3	3
20141015050800	3	0	3	0	0	3	3	3	3	3	3	3	3	3	3	3
20141015150344	3	0	3	0	0	3	3	3	3	3	3	3	3	3	3	3
20141015153725	3	0	3	0	3	3	3	3	3	3	3	3	3	3	3	3
20141015174342	3	0	3	0	3	3	3	3	3	3	3	3	3	3	3	3
20141016145015	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3

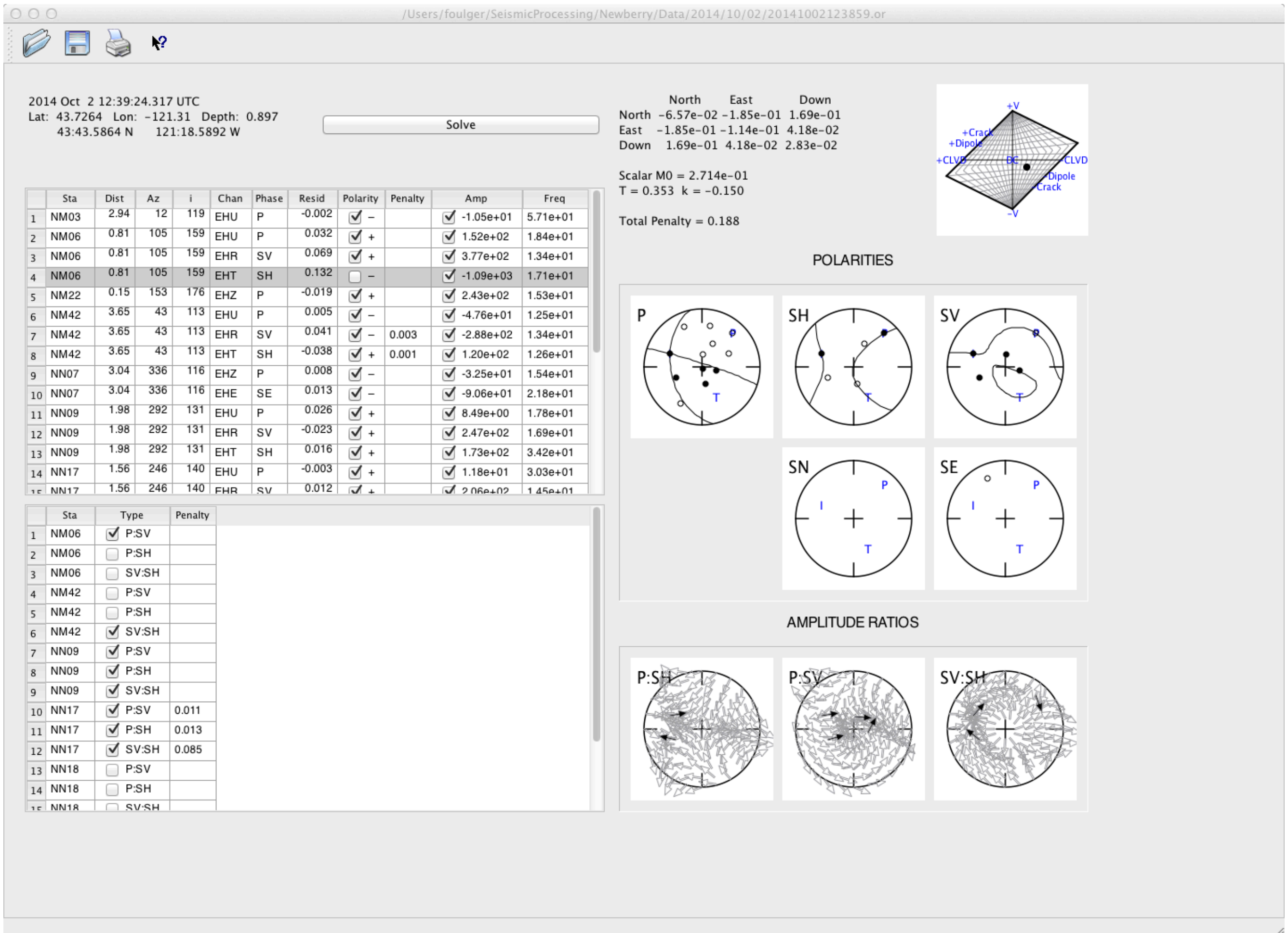
20141016155219	1	0	3	3	0	3	3	3	1	1	1	3	3	1	1	0
20141016165327	3	0	3	3	0	3	3	3	3	3	3	3	3	3	3	3
20141016230835	3	0	3	3	0	3	3	0	3	3	3	3	3	3	3	3
20141017010108	3	0	3	3	0	3	3	3	3	3	3	3	3	3	3	3
20141017015400	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3
20141017111637	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3
20141017181339	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3
20141018132039	3	3	3	3	0	3	0	3	3	3	3	3	3	3	3	3
20141018135721	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3
20141018235703	3	0	3	3	0	3	3	0	3	3	3	3	3	3	3	3
20141019090750	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3
20141019092649	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3

Appendix 2: The additional nine moment tensors derived over the reporting week.



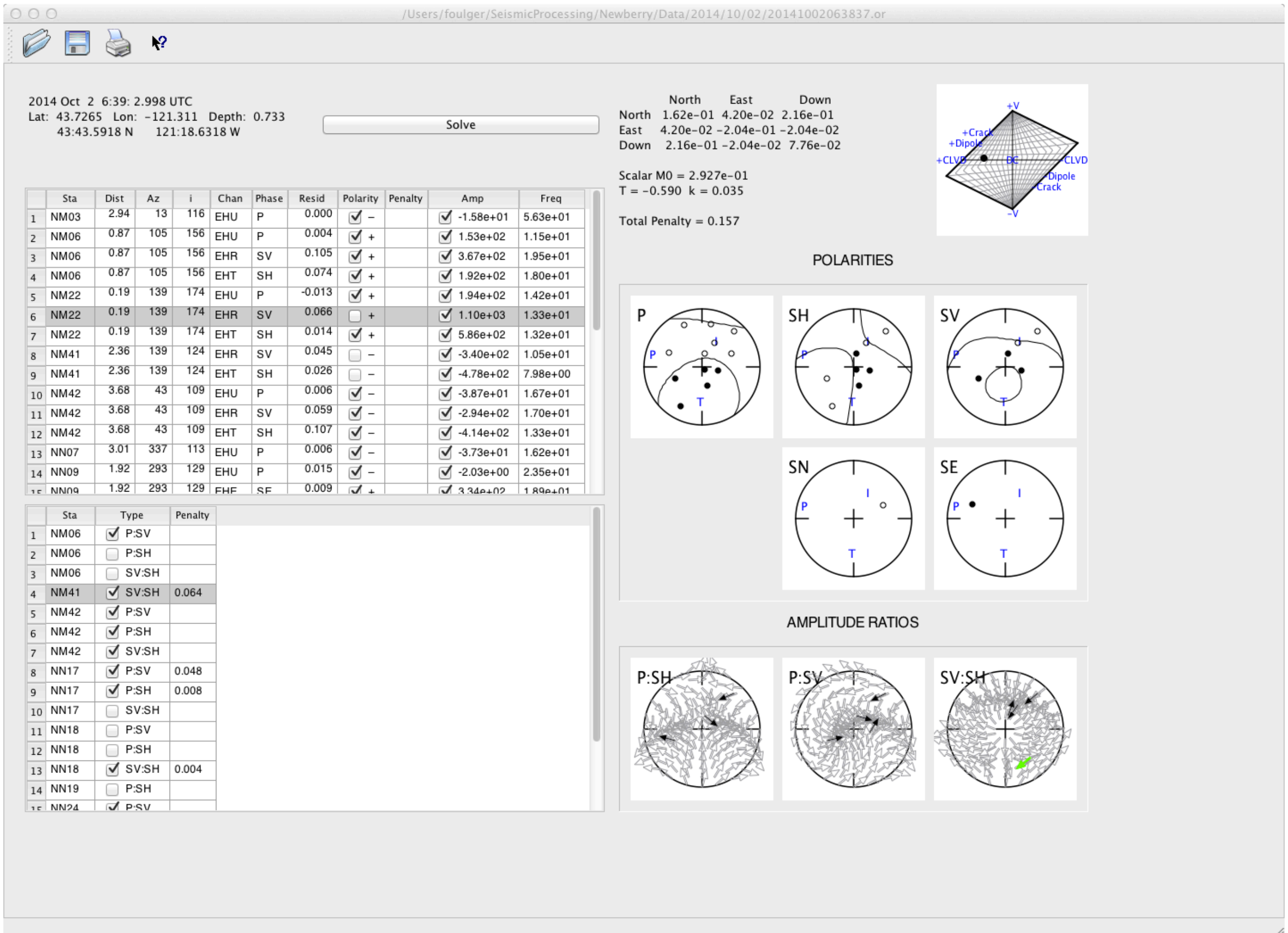
	Sta	Dist	Az	i	Chan	Phase	Resid	Polarity	Penalty	Amp	Freq
1	NM03	3.06	9	124	EHU	P	-0.007	☑ –		☑ -2.55e+01	1.80e+01
2	NM03	3.06	9	124	EHR	SV	0.070				
3	NM22	0.04	277	179	EHU	P	-0.005	☑ +		☑ 2.41e+02	1.45e+01
4	NM22	0.04	277	179	EHR	SV	0.072	☑ +		☑ 2.00e+03	1.32e+01
5	NM22	0.04	277	179	EHT	SH	0.067	☐ +		☑ 7.21e+02	1.56e+01
6	NM42	3.68	40	119	EHZ	P	0.024	☑ –		☑ -1.85e+02	1.62e+01
7	NM42	3.68	40	119	EHR	SV	0.091	☑ +		☑ 1.94e+03	1.22e+01
8	NM42	3.68	40	119	EHT	SH	0.082	☑ –		☑ -1.13e+03	1.45e+01
9	NN07	3.21	335	121	EHU	P	-0.001	☑ –	0.022	☑ -7.34e+01	1.71e+01
10	NN07	3.21	335	121	EHR	SV	0.026	☐ +		☑ 3.68e+02	1.34e+01
11	NN07	3.21	335	121	EHT	SH	0.003	☑ +	0.018	☑ 2.44e+02	2.06e+01
12	NN09	2.13	295	135	EHU	P	0.021	☑ –		☑ -1.34e+01	2.43e+01
13	NN09	2.13	295	135	EHR	SV	-0.025	☑ +		☑ 6.65e+02	1.84e+01
14	NN09	2.13	295	135	EHT	SH	0.005	☑ +		☑ 8.36e+02	1.37e+01
15	NN17	1.61	252	144	EHU	P	0.002	☑ +		☑ 1.71e+01	2.78e+01

	Sta	Type	Penalty
1	NM42	☐ P:SV	
2	NM42	☐ P:SH	
3	NM42	☐ SV:SH	
4	NN07	☐ P:SV	
5	NN07	☑ P:SH	
6	NN07	☐ SV:SH	
7	NN09	☐ P:SV	
8	NN09	☑ P:SH	0.035
9	NN09	☑ SV:SH	0.000
10	NN17	☑ P:SV	0.001
11	NN18	☐ P:SV	
12	NN19	☐ P:SH	
13	NN24	☑ P:SV	
14	NN24	☑ P:SH	
15	NN24	☑ SV:SH	0.000



	Sta	Dist	Az	i	Chan	Phase	Resid	Polarity	Penalty	Amp	Freq
1	NM03	2.94	12	119	EHU	P	-0.002	✓ –		✓ -1.05e+01	5.71e+01
2	NM06	0.81	105	159	EHU	P	0.032	✓ +		✓ 1.52e+02	1.84e+01
3	NM06	0.81	105	159	EHR	SV	0.069	✓ +		✓ 3.77e+02	1.34e+01
4	NM06	0.81	105	159	EHT	SH	0.132	☐ –		✓ -1.09e+03	1.71e+01
5	NM22	0.15	153	176	EHZ	P	-0.019	✓ +		✓ 2.43e+02	1.53e+01
6	NM42	3.65	43	113	EHU	P	0.005	✓ –		✓ -4.76e+01	1.25e+01
7	NM42	3.65	43	113	EHR	SV	0.041	✓ –	0.003	✓ -2.88e+02	1.34e+01
8	NM42	3.65	43	113	EHT	SH	-0.038	✓ +	0.001	✓ 1.20e+02	1.26e+01
9	NN07	3.04	336	116	EHZ	P	0.008	✓ –		✓ -3.25e+01	1.54e+01
10	NN07	3.04	336	116	EHE	SE	0.013	✓ –		✓ -9.06e+01	2.18e+01
11	NN09	1.98	292	131	EHU	P	0.026	✓ +		✓ 8.49e+00	1.78e+01
12	NN09	1.98	292	131	EHR	SV	-0.023	✓ +		✓ 2.47e+02	1.69e+01
13	NN09	1.98	292	131	EHT	SH	0.016	✓ +		✓ 1.73e+02	3.42e+01
14	NN17	1.56	246	140	EHU	P	-0.003	✓ +		✓ 1.18e+01	3.03e+01
15	NN17	1.56	246	140	EHR	SV	0.012	✓ +		✓ 2.06e+02	1.45e+01

	Sta	Type	Penalty
1	NM06	✓ P:SV	
2	NM06	☐ P:SH	
3	NM06	☐ SV:SH	
4	NM42	☐ P:SV	
5	NM42	☐ P:SH	
6	NM42	✓ SV:SH	
7	NN09	✓ P:SV	
8	NN09	✓ P:SH	
9	NN09	✓ SV:SH	
10	NN17	✓ P:SV	0.011
11	NN17	✓ P:SH	0.013
12	NN17	✓ SV:SH	0.085
13	NN18	☐ P:SV	
14	NN18	☐ P:SH	
15	NN18	☐ SV:SH	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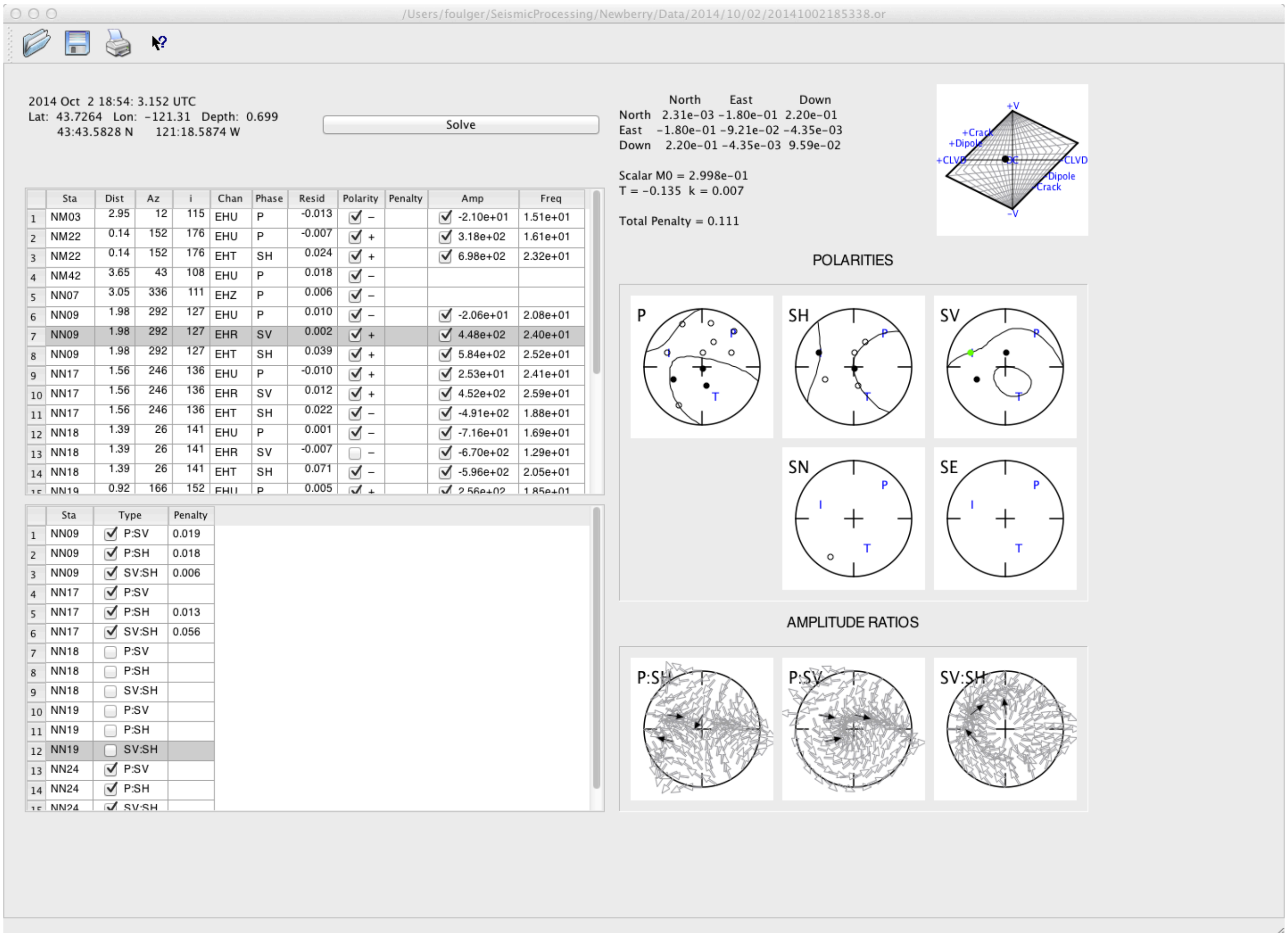
2014 Oct 2 6:39: 2.998 UTC
Lat: 43.7265 Lon: -121.311 Depth: 0.733
43:43.5918 N 121:18.6318 W
Solve
Sta Dist Az i Chan Phase Resid Polarity Penalty Amp Freq
1 NM03 2.94 13 116 EHU P 0.000 – -1.58e+01 5.63e+01
2 NM06 0.87 105 156 EHU P 0.004 + 1.53e+02 1.15e+01
3 NM06 0.87 105 156 EHR SV 0.105 + 3.67e+02 1.95e+01
4 NM06 0.87 105 156 EHT SH 0.074 + 1.92e+02 1.80e+01
5 NM22 0.19 139 174 EHU P -0.013 + 1.94e+02 1.42e+01
6 NM22 0.19 139 174 EHR SV 0.066 + 1.10e+03 1.33e+01
7 NM22 0.19 139 174 EHT SH 0.014 + 5.86e+02 1.32e+01
8 NM41 2.36 139 124 EHR SV 0.045 – -3.40e+02 1.05e+01
9 NM41 2.36 139 124 EHT SH 0.026 – -4.78e+02 7.98e+00
10 NM42 3.68 43 109 EHU P 0.006 – -3.87e+01 1.67e+01
11 NM42 3.68 43 109 EHR SV 0.059 – -2.94e+02 1.70e+01
12 NM42 3.68 43 109 EHT SH 0.107 – -4.14e+02 1.33e+01
13 NN07 3.01 337 113 EHU P 0.006 – -3.73e+01 1.62e+01
14 NN09 1.92 293 129 EHU P 0.015 – -2.03e+00 2.35e+01
Sta Type Penalty
1 NM06 P:SV
2 NM06 P:SH
3 NM06 SV:SH
4 NM41 SV:SH 0.064
5 NM42 P:SV
6 NM42 P:SH
7 NM42 SV:SH
8 NN17 P:SV 0.048
9 NN17 P:SH 0.008
10 NN17 SV:SH
11 NN18 P:SV
12 NN18 P:SH
13 NN18 SV:SH 0.004
14 NN19 P:SH
North East Down
North 1.62e-01 4.20e-02 2.16e-01
East 4.20e-02 -2.04e-01 -2.04e-02
Down 2.16e-01 -2.04e-02 7.76e-02
Scalar M0 = 2.927e-01
T = -0.590 k = 0.035
Total Penalty = 0.157
+V
+Crack
+Dipole
+CLVD
DC
-CLVD
-Dipole
-Crack
-V
POLARITIES
P
SH
SV
SN
SE
AMPLITUDE RATIOS
P:SH
P:SV
SV:SH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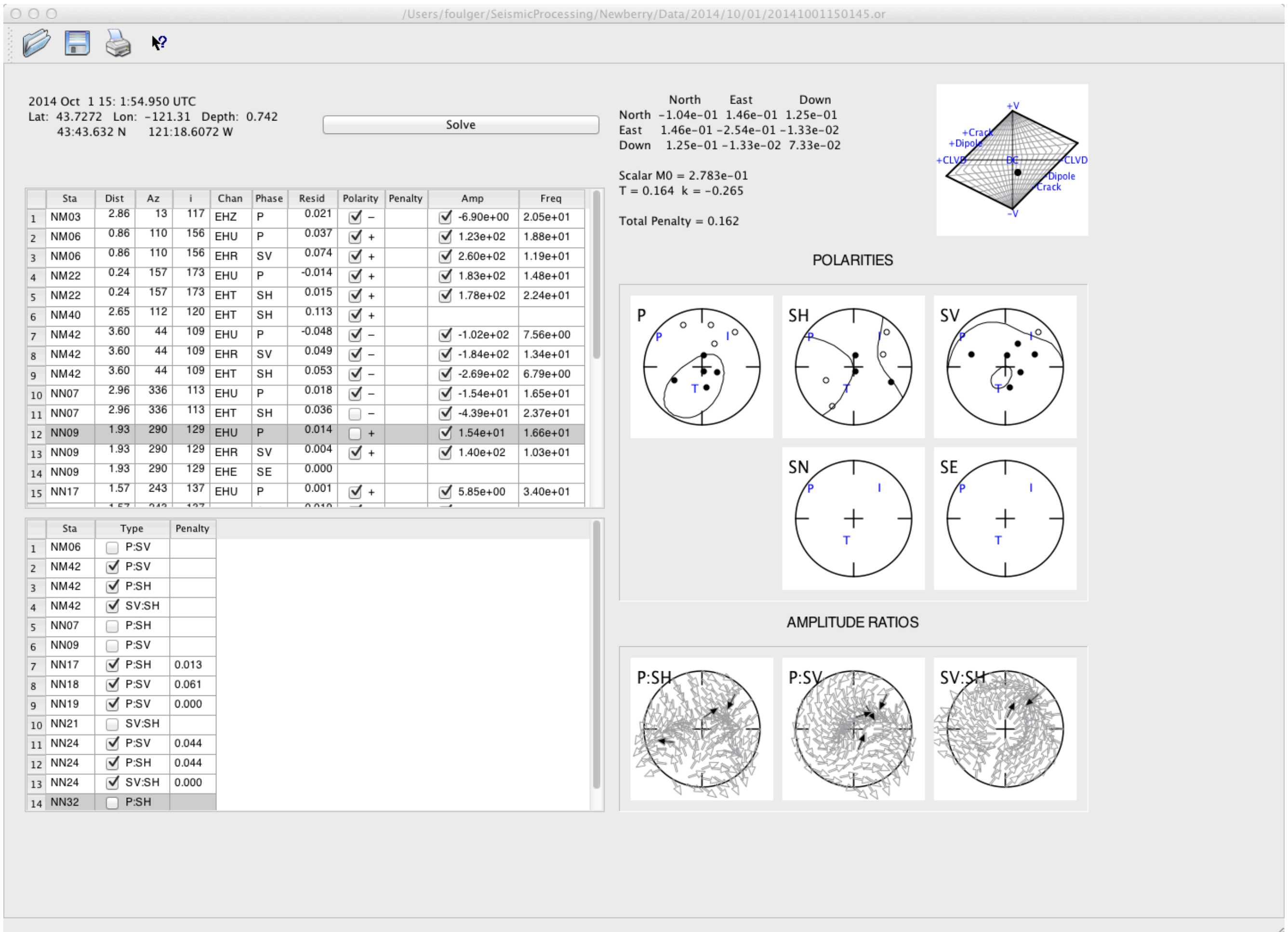
43:43.5828 N 121:18.5874 W
Solve
Sta Dist Az i Chan Phase Resid Polarity Penalty Amp Freq
1 NM03 2.95 12 115 EHU P -0.013 – -2.10e+01 1.51e+01
2 NM22 0.14 152 176 EHU P -0.007 + 3.18e+02 1.61e+01
3 NM22 0.14 152 176 EHT SH 0.024 + 6.98e+02 2.32e+01
4 NM42 3.65 43 108 EHU P 0.018 –
5 NN07 3.05 336 111 EHZ P 0.006 –
6 NN09 1.98 292 127 EHU P 0.010 – -2.06e+01 2.08e+01
7 NN09 1.98 292 127 EHR SV 0.002 + 4.48e+02 2.40e+01
8 NN09 1.98 292 127 EHT SH 0.039 + 5.84e+02 2.52e+01
9 NN17 1.56 246 136 EHU P -0.010 + 2.53e+01 2.41e+01
10 NN17 1.56 246 136 EHR SV 0.012 + 4.52e+02 2.59e+01
11 NN17 1.56 246 136 EHT SH 0.022 – -4.91e+02 1.88e+01
12 NN18 1.39 26 141 EHU P 0.001 – -7.16e+01 1.69e+01
13 NN18 1.39 26 141 EHR SV -0.007 – -6.70e+02 1.29e+01
14 NN18 1.39 26 141 EHT SH 0.071 – -5.96e+02 2.05e+01
Sta Type Penalty
1 NN09 P:SV 0.019
2 NN09 P:SH 0.018
3 NN09 SV:SH 0.006
4 NN17 P:SV
5 NN17 P:SH 0.013
6 NN17 SV:SH 0.056
7 NN18 P:SV
8 NN18 P:SH
9 NN18 SV:SH
10 NN19 P:SV
11 NN19 P:SH
12 NN19 SV:SH
13 NN24 P:SV
14 NN24 P:SH
North East Down
North 2.31e-03 -1.80e-01 2.20e-01
East -1.80e-01 -9.21e-02 -4.35e-03
Down 2.20e-01 -4.35e-03 9.59e-02
Scalar M0 = 2.998e-01
T = -0.135 k = 0.007
Total Penalty = 0.111
+V
+Crack
+Dipole
+CLVD
-CLVD
-Dipole
-Crack
-V
POLARITIES
P
SH
SV
SN
SE
AMPLITUDE RATIOS
P:SH
P:SV
SV:SH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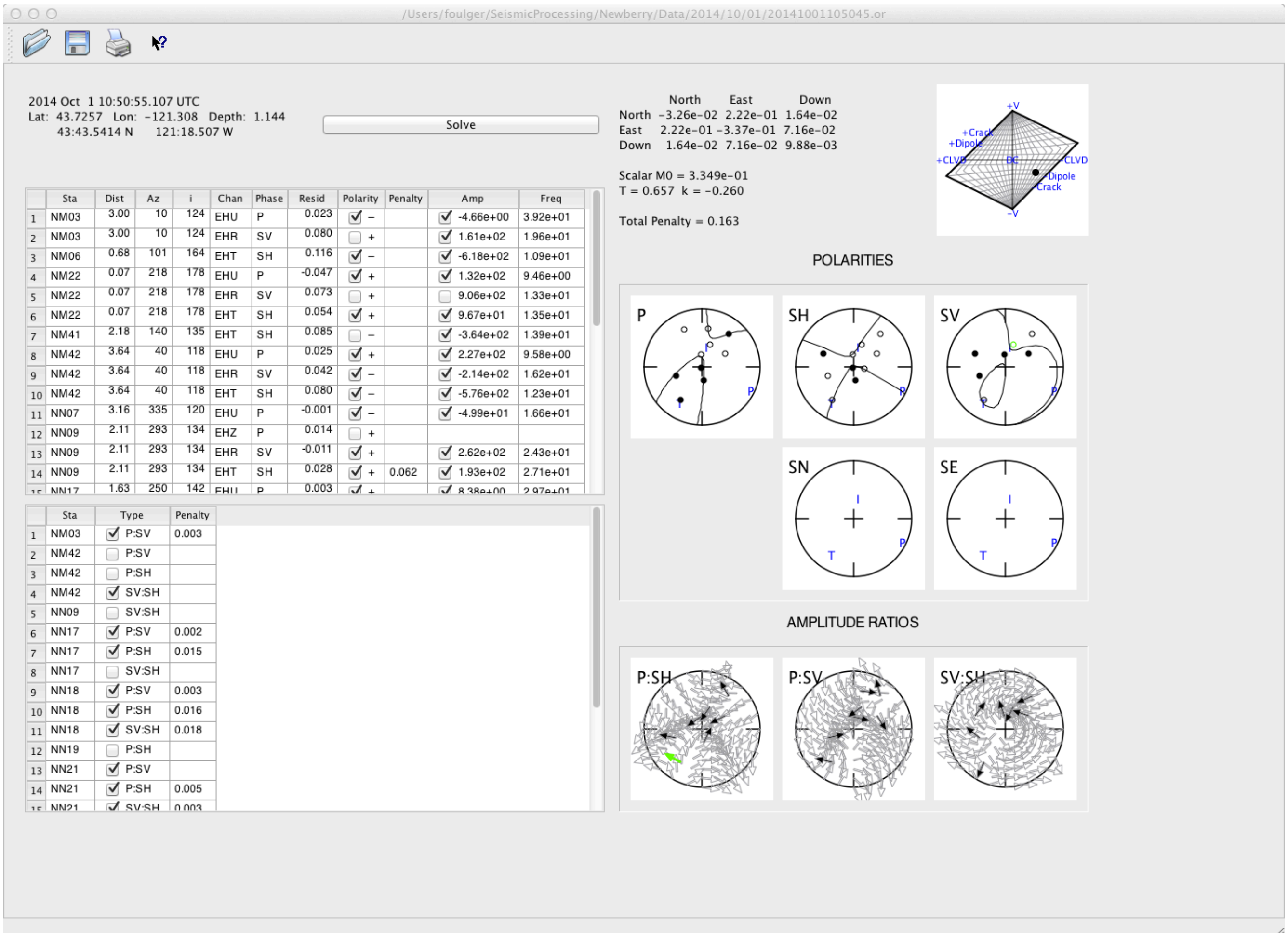
43:43.632 N 121:18.6072 W
Solve
North East Down
North -1.04e-01 1.46e-01 1.25e-01
East 1.46e-01 -2.54e-01 -1.33e-02
Down 1.25e-01 -1.33e-02 7.33e-02
Scalar M0 = 2.783e-01
T = 0.164 k = -0.265
Total Penalty = 0.162
+V
+Crack
+Dipole
+CLVD
DC
-CLVD
Dipole
Crack
-V
Sta Dist Az i Chan Phase Resid Polarity Penalty Amp Freq
1 NM03 2.86 13 117 EHZ P 0.021 – -6.90e+00 2.05e+01
2 NM06 0.86 110 156 EHU P 0.037 + 1.23e+02 1.88e+01
3 NM06 0.86 110 156 EHR SV 0.074 + 2.60e+02 1.19e+01
4 NM22 0.24 157 173 EHU P -0.014 + 1.83e+02 1.48e+01
5 NM22 0.24 157 173 EHT SH 0.015 + 1.78e+02 2.24e+01
6 NM40 2.65 112 120 EHT SH 0.113 +
7 NM42 3.60 44 109 EHU P -0.048 – -1.02e+02 7.56e+00
8 NM42 3.60 44 109 EHR SV 0.049 – -1.84e+02 1.34e+01
9 NM42 3.60 44 109 EHT SH 0.053 – -2.69e+02 6.79e+00
10 NN07 2.96 336 113 EHU P 0.018 – -1.54e+01 1.65e+01
11 NN07 2.96 336 113 EHT SH 0.036 – -4.39e+01 2.37e+01
12 NN09 1.93 290 129 EHU P 0.014 + 1.54e+01 1.66e+01
13 NN09 1.93 290 129 EHR SV 0.004 + 1.40e+02 1.03e+01
14 NN09 1.93 290 129 EHE SE 0.000
15 NN17 1.57 243 137 EHU P 0.001 + 5.85e+00 3.40e+01
Sta Type Penalty
1 NM06 P:SV
2 NM42 P:SV
3 NM42 P:SH
4 NM42 SV:SH
5 NN07 P:SH
6 NN09 P:SV
7 NN17 P:SH 0.013
8 NN18 P:SV 0.061
9 NN19 P:SV 0.000
10 NN21 SV:SH
11 NN24 P:SV 0.044
12 NN24 P:SH 0.044
13 NN24 SV:SH 0.000
14 NN32 P:SH
POLARITIES
P
SH
SV
SN
SE
AMPLITUDE RATIOS
P:SH
P:SV
SV:SH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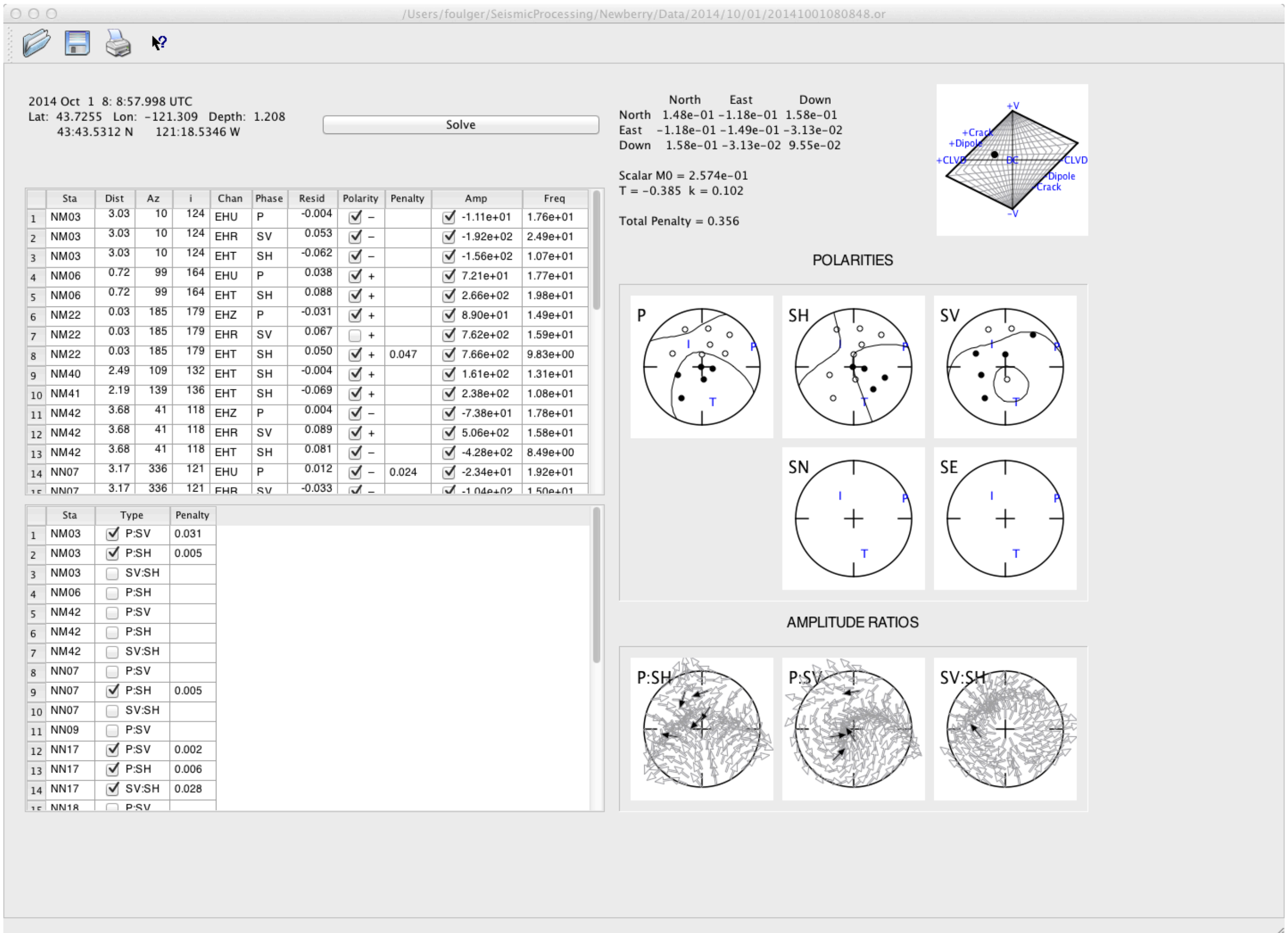
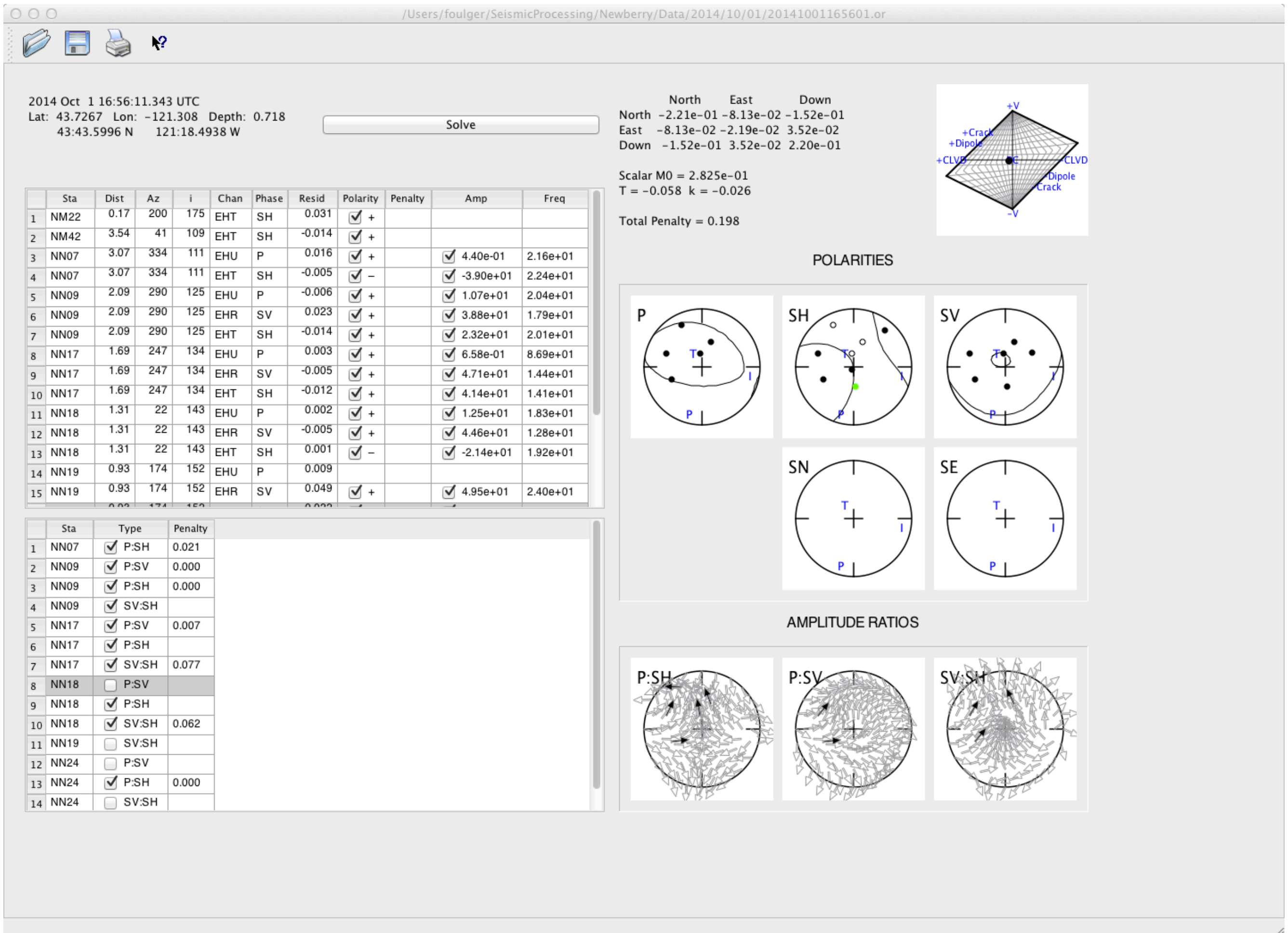
43:43.5414 N 121:18.507 W
Solve
North East Down
North -3.26e-02 2.22e-01 1.64e-02
East 2.22e-01 -3.37e-01 7.16e-02
Down 1.64e-02 7.16e-02 9.88e-03
Scalar M0 = 3.349e-01
T = 0.657 k = -0.260
Total Penalty = 0.163
+V
+Crack
+Dipole
+CLVD
DC
-CLVD
-Dipole
-Crack
-V
Sta Dist Az i Chan Phase Resid Polarity Penalty Amp Freq
1 NM03 3.00 10 124 EHU P 0.023 – -4.66e+00 3.92e+01
2 NM03 3.00 10 124 EHR SV 0.080 + 1.61e+02 1.96e+01
3 NM06 0.68 101 164 EHT SH 0.116 – -6.18e+02 1.09e+01
4 NM22 0.07 218 178 EHU P -0.047 + 1.32e+02 9.46e+00
5 NM22 0.07 218 178 EHR SV 0.073 + 9.06e+02 1.33e+01
6 NM22 0.07 218 178 EHT SH 0.054 + 9.67e+01 1.35e+01
7 NM41 2.18 140 135 EHT SH 0.085 – -3.64e+02 1.39e+01
8 NM42 3.64 40 118 EHU P 0.025 + 2.27e+02 9.58e+00
9 NM42 3.64 40 118 EHR SV 0.042 – -2.14e+02 1.62e+01
10 NM42 3.64 40 118 EHT SH 0.080 – -5.76e+02 1.23e+01
11 NN07 3.16 335 120 EHU P -0.001 – -4.99e+01 1.66e+01
12 NN09 2.11 293 134 EHZ P 0.014 +
13 NN09 2.11 293 134 EHR SV -0.011 + 2.62e+02 2.43e+01
14 NN09 2.11 293 134 EHT SH 0.028 + 0.062 1.93e+02 2.71e+01
15 NN17 1.63 250 142 EHU P 0.003 + 8.38e+00 2.97e+01
Sta Type Penalty
1 NM03 P:SV 0.003
2 NM42 P:SV
3 NM42 P:SH
4 NM42 SV:SH
5 NN09 SV:SH
6 NN17 P:SV 0.002
7 NN17 P:SH 0.015
8 NN17 SV:SH
9 NN18 P:SV 0.003
10 NN18 P:SH 0.016
11 NN18 SV:SH 0.018
12 NN19 P:SH
13 NN21 P:SV
14 NN21 P:SH 0.005
15 NN21 SV:SH 0.003
POLARITIES
P
SH
SV
SN
SE
AMPLITUDE RATIOS
P:SH
P:SV
SV:SH



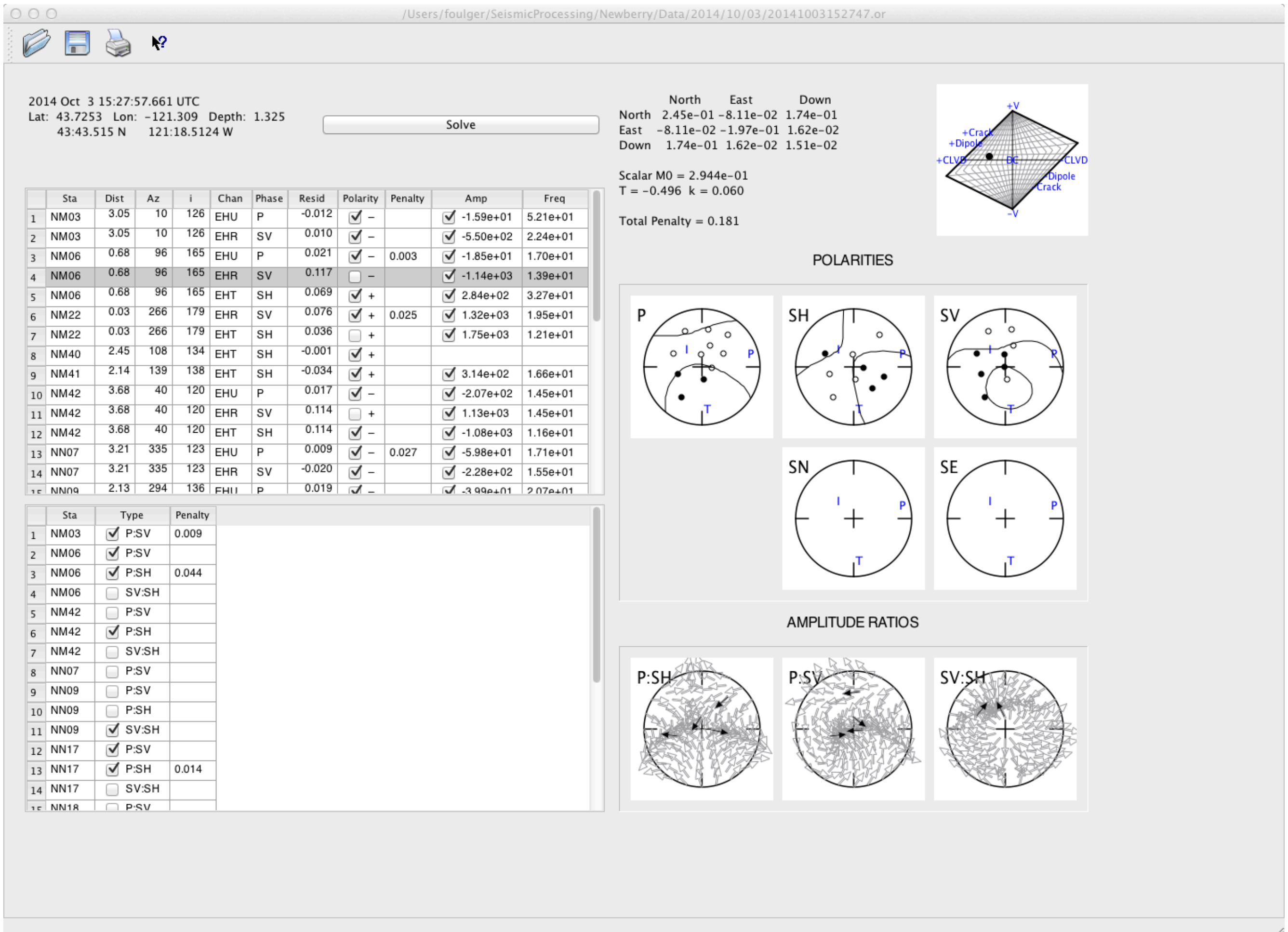
	Sta	Dist	Az	i	Chan	Phase	Resid	Polarity	Penalty	Amp	Freq
1	NM03	3.03	10	124	EHU	P	-0.004	✓ –		✓ -1.11e+01	1.76e+01
2	NM03	3.03	10	124	EHR	SV	0.053	✓ –		✓ -1.92e+02	2.49e+01
3	NM03	3.03	10	124	EHT	SH	-0.062	✓ –		✓ -1.56e+02	1.07e+01
4	NM06	0.72	99	164	EHU	P	0.038	✓ +		✓ 7.21e+01	1.77e+01
5	NM06	0.72	99	164	EHT	SH	0.088	✓ +		✓ 2.66e+02	1.98e+01
6	NM22	0.03	185	179	EHZ	P	-0.031	✓ +		✓ 8.90e+01	1.49e+01
7	NM22	0.03	185	179	EHR	SV	0.067	☐ +		✓ 7.62e+02	1.59e+01
8	NM22	0.03	185	179	EHT	SH	0.050	✓ +	0.047	✓ 7.66e+02	9.83e+00
9	NM40	2.49	109	132	EHT	SH	-0.004	✓ +		✓ 1.61e+02	1.31e+01
10	NM41	2.19	139	136	EHT	SH	-0.069	✓ +		✓ 2.38e+02	1.08e+01
11	NM42	3.68	41	118	EHZ	P	0.004	✓ –		✓ -7.38e+01	1.78e+01
12	NM42	3.68	41	118	EHR	SV	0.089	✓ +		✓ 5.06e+02	1.58e+01
13	NM42	3.68	41	118	EHT	SH	0.081	✓ –		✓ -4.28e+02	8.49e+00
14	NN07	3.17	336	121	EHU	P	0.012	✓ –	0.024	✓ -2.34e+01	1.92e+01
15	NN07	3.17	336	121	EHR	SV	-0.033	✓ –		✓ -1.04e+02	1.50e+01

	Sta	Type	Penalty
1	NM03	✓ P:SV	0.031
2	NM03	✓ P:SH	0.005
3	NM03	☐ SV:SH	
4	NM06	☐ P:SH	
5	NM42	☐ P:SV	
6	NM42	☐ P:SH	
7	NM42	☐ SV:SH	
8	NN07	☐ P:SV	
9	NN07	✓ P:SH	0.005
10	NN07	☐ SV:SH	
11	NN09	☐ P:SV	
12	NN17	✓ P:SV	0.002
13	NN17	✓ P:SH	0.006
14	NN17	✓ SV:SH	0.028
15	NN18	☐ P:SV	



	Sta	Dist	Az	i	Chan	Phase	Resid	Polarity	Penalty	Amp	Freq
1	NM22	0.17	200	175	EHT	SH	0.031	✓ +			
2	NM42	3.54	41	109	EHT	SH	-0.014	✓ +			
3	NN07	3.07	334	111	EHU	P	0.016	✓ +		✓ 4.40e-01	2.16e+01
4	NN07	3.07	334	111	EHT	SH	-0.005	✓ –		✓ -3.90e+01	2.24e+01
5	NN09	2.09	290	125	EHU	P	-0.006	✓ +		✓ 1.07e+01	2.04e+01
6	NN09	2.09	290	125	EHR	SV	0.023	✓ +		✓ 3.88e+01	1.79e+01
7	NN09	2.09	290	125	EHT	SH	-0.014	✓ +		✓ 2.32e+01	2.01e+01
8	NN17	1.69	247	134	EHU	P	0.003	✓ +		✓ 6.58e-01	8.69e+01
9	NN17	1.69	247	134	EHR	SV	-0.005	✓ +		✓ 4.71e+01	1.44e+01
10	NN17	1.69	247	134	EHT	SH	-0.012	✓ +		✓ 4.14e+01	1.41e+01
11	NN18	1.31	22	143	EHU	P	0.002	✓ +		✓ 1.25e+01	1.83e+01
12	NN18	1.31	22	143	EHR	SV	-0.005	✓ +		✓ 4.46e+01	1.28e+01
13	NN18	1.31	22	143	EHT	SH	0.001	✓ –		✓ -2.14e+01	1.92e+01
14	NN19	0.93	174	152	EHU	P	0.009				
15	NN19	0.93	174	152	EHR	SV	0.049	✓ +		✓ 4.95e+01	2.40e+01

	Sta	Type	Penalty
1	NN07	✓ P:SH	0.021
2	NN09	✓ P:SV	0.000
3	NN09	✓ P:SH	0.000
4	NN09	✓ SV:SH	
5	NN17	✓ P:SV	0.007
6	NN17	✓ P:SH	
7	NN17	✓ SV:SH	0.077
8	NN18	☐ P:SV	
9	NN18	✓ P:SH	
10	NN18	✓ SV:SH	0.062
11	NN19	☐ SV:SH	
12	NN24	☐ P:SV	
13	NN24	✓ P:SH	0.000
14	NN24	☐ SV:SH	


/Users/foulger/SeismicProcessing/Newberry/Data/2014/10/03/20141003152747.or
2014 Oct 3 15:27:57.661 UTC
Lat: 43.7253 Lon: -121.309 Depth: 1.325
43:43.515 N 121:18.5124 W
Solve
North East Down
North 2.45e-01 -8.11e-02 1.74e-01
East -8.11e-02 -1.97e-01 1.62e-02
Down 1.74e-01 1.62e-02 1.51e-02
Scalar M0 = 2.944e-01
T = -0.496 k = 0.060
Total Penalty = 0.181
+V
+Crack
+Dipole
+CLVD
DC
-CLVD
-Dipole
-Crack
-V
Sta Dist Az i Chan Phase Resid Polarity Penalty Amp Freq
1 NM03 3.05 10 126 EHU P -0.012 – -1.59e+01 5.21e+01
2 NM03 3.05 10 126 EHR SV 0.010 – -5.50e+02 2.24e+01
3 NM06 0.68 96 165 EHU P 0.021 – 0.003 -1.85e+01 1.70e+01
4 NM06 0.68 96 165 EHR SV 0.117 – -1.14e+03 1.39e+01
5 NM06 0.68 96 165 EHT SH 0.069 + 2.84e+02 3.27e+01
6 NM22 0.03 266 179 EHR SV 0.076 + 0.025 1.32e+03 1.95e+01
7 NM22 0.03 266 179 EHT SH 0.036 + 1.75e+03 1.21e+01
8 NM40 2.45 108 134 EHT SH -0.001 +
9 NM41 2.14 139 138 EHT SH -0.034 + 3.14e+02 1.66e+01
10 NM42 3.68 40 120 EHU P 0.017 – -2.07e+02 1.45e+01
11 NM42 3.68 40 120 EHR SV 0.114 + 1.13e+03 1.45e+01
12 NM42 3.68 40 120 EHT SH 0.114 – -1.08e+03 1.16e+01
13 NN07 3.21 335 123 EHU P 0.009 – 0.027 -5.98e+01 1.71e+01
14 NN07 3.21 335 123 EHR SV -0.020 – -2.28e+02 1.55e+01
Sta Type Penalty
1 NM03 P:SV 0.009
2 NM06 P:SV
3 NM06 P:SH 0.044
4 NM06 SV:SH
5 NM42 P:SV
6 NM42 P:SH
7 NM42 SV:SH
8 NN07 P:SV
9 NN09 P:SV
10 NN09 P:SH
11 NN09 SV:SH
12 NN17 P:SV
13 NN17 P:SH 0.014
14 NN17 SV:SH
POLARITIES
P
SH
SV
SN
SE
AMPLITUDE RATIOS
P:SH
P:SV
SV:SH