Seismicity

This report covers the four-month period of May-August 1999. As usual, the plots and corresponding discussions will focus on two-month blocks of time (i.e. May-June and July-August 1999). A minor change has been made to the seismicity plots in the Shishaldin/Westdahl regions. The plots for Shishaldin and Westdahl are now more detailed (i.e. cover a smaller area). A third plot was included that covers the entirety of Unimak Island. These changes should allow better resolution in the vicinity of these two volcanoes while also helping to alleviate some of the confusion resulting from events being split between the Shishaldin and Westdahl maps as was the case with the March 4, 1999 M_L=5.0 aftershock sequence (see previous Bimonthly Report).

Spurr/Strandline Lake Region
May-June 1999:
During May-June 1999 there were a total of 27 earthquakes, the largest of which had a magnitude of M_L=1.3, located in the Spurr area (figs. 5a, 23a and 24a). Of these 27 events, a total of 15 earthquakes were located within 10 km of the summit of Spurr. The M_L=1.3 event was located 6 km west of Spurr and had a shallow hypocentral depth. Five other earthquakes were located in the same general area (i.e. ~5-9 km west of Spurr). Another three of the "proximal" events were located 5-7 km southeast of Spurr and had shallow hypocentral depths. Two other events had relatively deep hypocentral depths. These earthquakes had relatively low frequency waveforms and were located ~8 km south-southeast of Spurr at hypocentral depths of 24 and 26 km. Although not an everyday occurrence, relatively deep earthquakes are fairly common in this area. The remaining four proximal events were located ~1-4 km north of the summit of Spurr. One of these events had a shallow hypocentral depth while the other three had depths of 1-4 km. The number of proximal events located during this two-month period was slightly greater than that of March-April 1999. This value was, in turn, slightly lower than the number predicted from the five-year mean seismicity rate (i.e. 16 proximal events). Most of the remaining 12 distally located earthquakes were probably regional tectonic events unrelated to the volcanic activity in this area. The four most northerly of these events were also plotted on the Strandline Lake seismicity map (fig. 6a) and thus, should be considered as such.

There were a total of 21 earthquakes located in the Strandline Lake region during May-June 1999 (fig. 6a). The largest of these events had a magnitude of M_L=1.5 and was located 8 km southwest of station STLK (~12 km east-northeast of NCG) at a hypocentral depth of 9 km. The number of earthquakes located in the Strandline Lake area was lower than the 32 such events located during March-April 1999.

July-August 1999:
Twenty-five earthquakes were located in the Spurr region during July-August 1999 (figs. 5b, 23b and 24b). A total of 13 events were located within 10 km of the summit of Spurr. The largest of these events had a magnitude of M_L=1.9, which was located 2 km north of the summit and had a hypocentral depth of 1 km. Another five events were located ~2-3 km north of the summit at hypocentral depths of 1-3 km. Five other "proximal" Spurr earthquakes were located in the area extending from 7 km to nearly 10 km west of the summit. Four of these events had hypocentral depths of ~3-5 km while the fifth event had a depth of about 11 km. Two proximal earthquakes had relatively large hypocentral depths. One of these events was located a little under 10 km south-southwest of Spurr at a hypocentral depth of 18 km. The other "deep" earthquake was located 6 km southeast of the summit and had a hypocentral depth of 27 km. The number of proximal events located during this two-month period was lower than the 15 such events located during the May-June. The number of proximal events was also a bit lower than the 16 such events predicted from the 5-year mean seismicity rate. Of the remaining 12 distal Spurr events the three most northerly were also plotted on the Strandline Lake seismicity map (fig. 6b) and thus, should be considered part of the ongoing swarm of activity in that area. The final nine earthquakes were all located to the south of the Chakachatna River and are probably regional tectonic earthquakes not related to volcanic activity at Spurr.

There were a total of 22 earthquakes located in the Strandline Lake area during July-August 1999 (figs. 5b and 6b). The largest Strandline Lake event had a magnitude of M_L=1.5 and was located 9 km north-northeast of seismic station NCG (~13 km west-southwest of STLK). The number Strandline Lake earthquakes located during July-August was nearly the same as that of May-June (22 vs. 21 located events).

Redoubt
May-June 1999:
Twelve earthquakes were located in the Redoubt area during May-June 1999 (figs. 7a, 23a and 24a). Seven of these events were located within 10 km of the summit of Redoubt. The largest Redoubt earthquake located during this two-month period was one of these events. This earthquake had a magnitude of M_L=0.8, was located 6 km north-northeast of the summit, and had a hypocentral depth of 4 km. It formed a tight cluster with three other events located 5-6 km north-northeast of the summit with hypocentral depths of ~4-5 km. Another of these events was located 6 km north-northwest of the summit and had a hypocentral depth of 4 km. The sixth proximal event was located 7 km northwest of the summit at a depth of 5 km. The final such earthquake was located 4 km west-southwest of the summit and had a shallow hypocentral depth. The number of earthquakes located within 10 km of the summit of Redoubt during May-June 1999 was half that of the previous two-month period as well as half the number of events predicted from the Redoubt mean seismicity rate. The five "non-proximal" earthquakes probably represent normal regional tectonic activity and thus may not have been related to the volcanic activity in this region.

July-August 1999:
Only two earthquakes were located in the Redoubt region during July-August 1999 (figs. 7b, 23b and 24b). The largest of these events had a magnitude of M_L=0.4 and was located 7 km northwest of the summit of Redoubt at a hypocentral depth of ~6 km. The other earthquake was located 5 km south-southeast of the summit and had a hypocentral depth of about 5 km. The number of located events during July-August was much lower than that of the previous two-month period. This value was also considerably lower than the 14 proximal events predicted from the 56-month mean seismicity rate. The loss of some key stations in the Redoubt seismic network due to circuit problems, the Sterling circuit in particular, and/or station outages, resulted in far fewer Redoubt events being located than was usually the case. The effect of the outages can also be seen on the Helicorder event counts (fig. 23b). The station employed for the event counts (i.e. RDN) was one of the stations affected by the circuit outage which necessitated its replacement with another station (i.e.

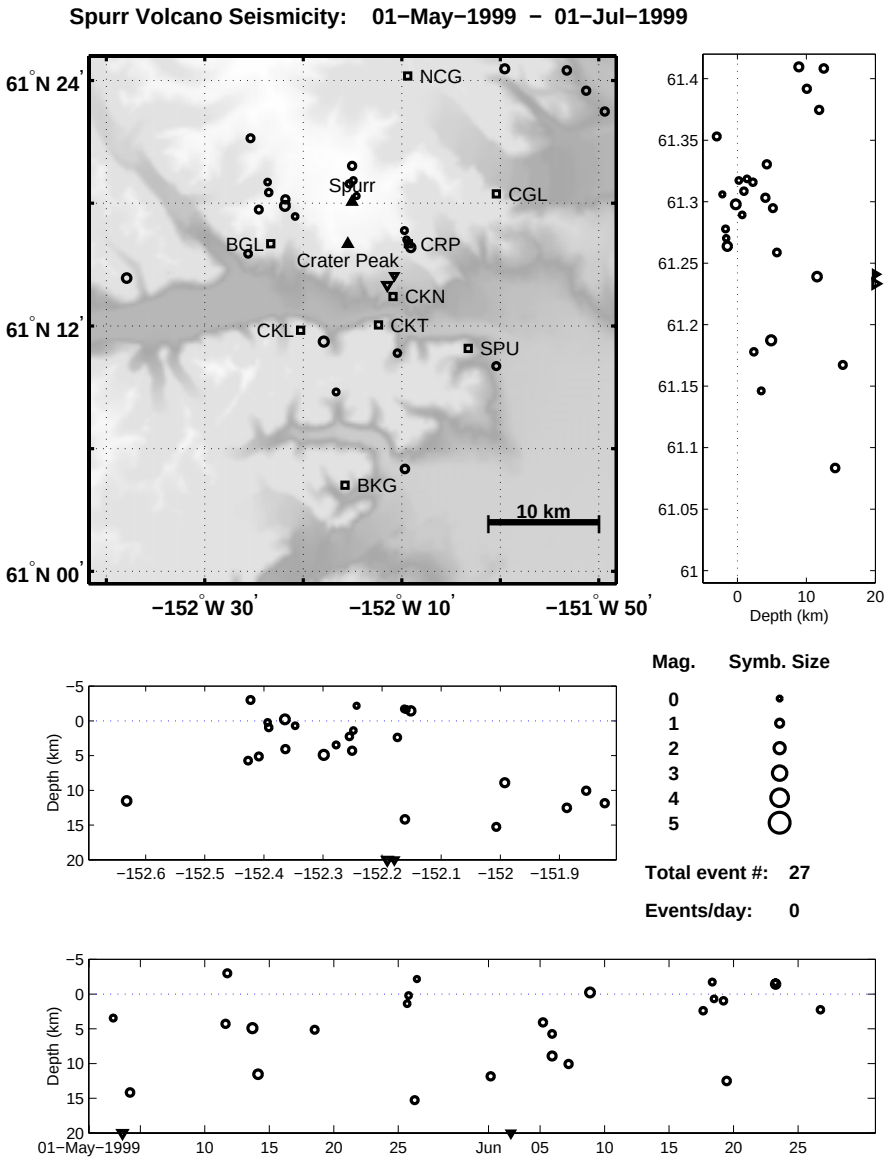

Figure 5a: Locatable Spurr seismic events in space and time for May through June.

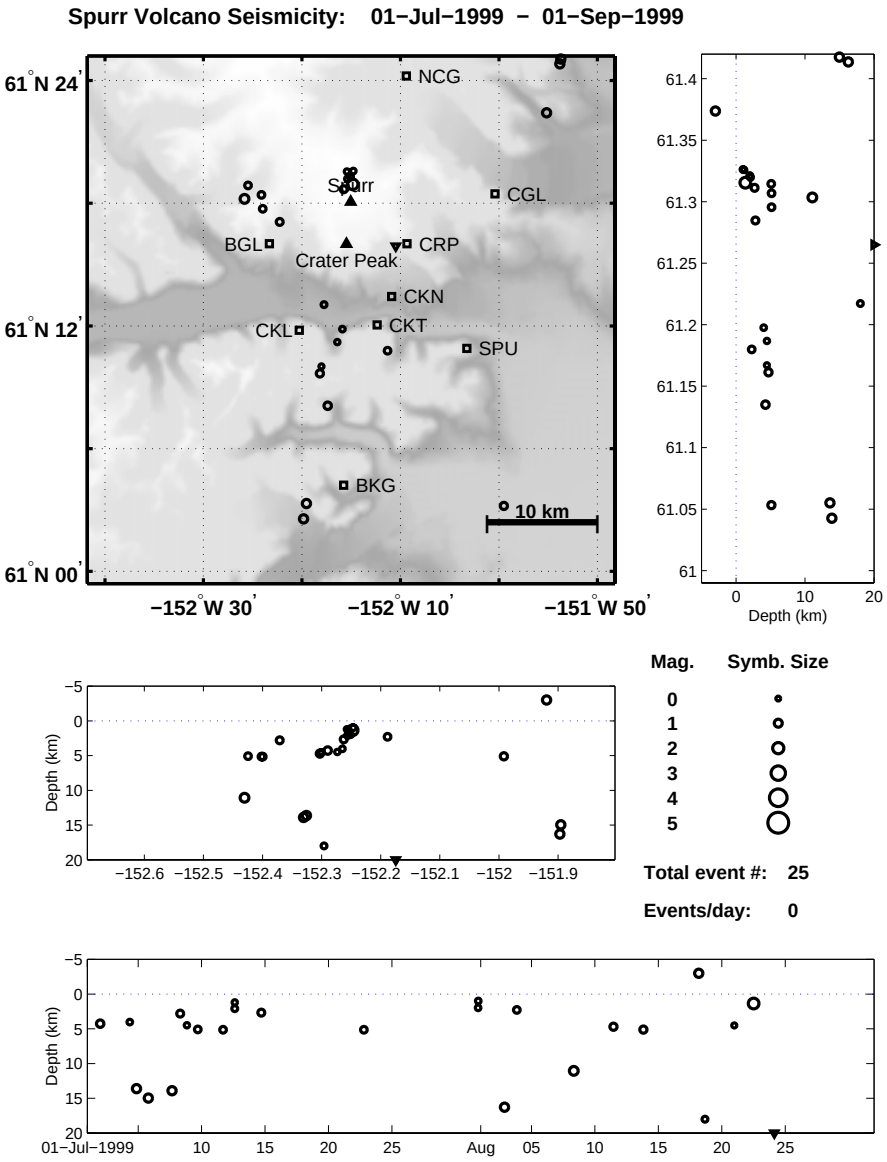

Figure 5b: Locatable Spurr seismic events in space and time for July through August.

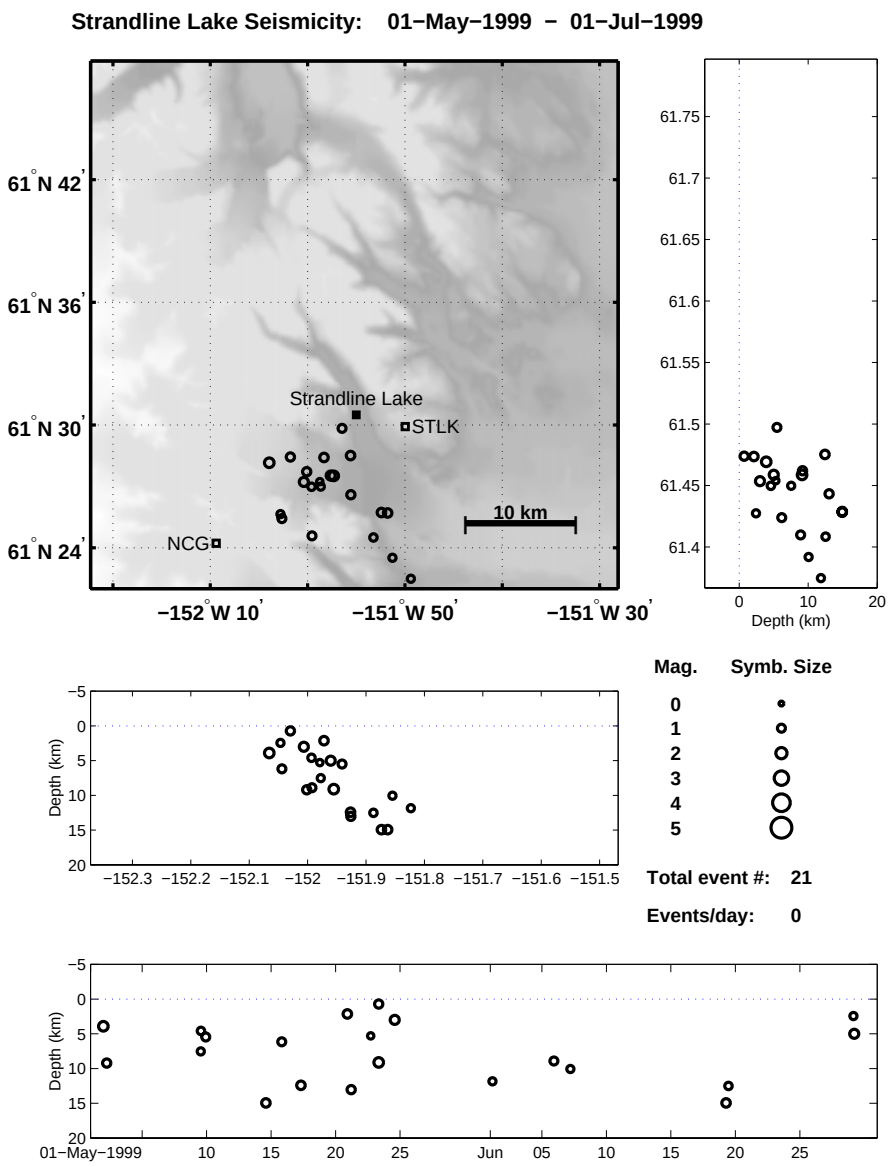

Figure 6a: Locatable Strandline Lake seismic events in space and time for May through June.

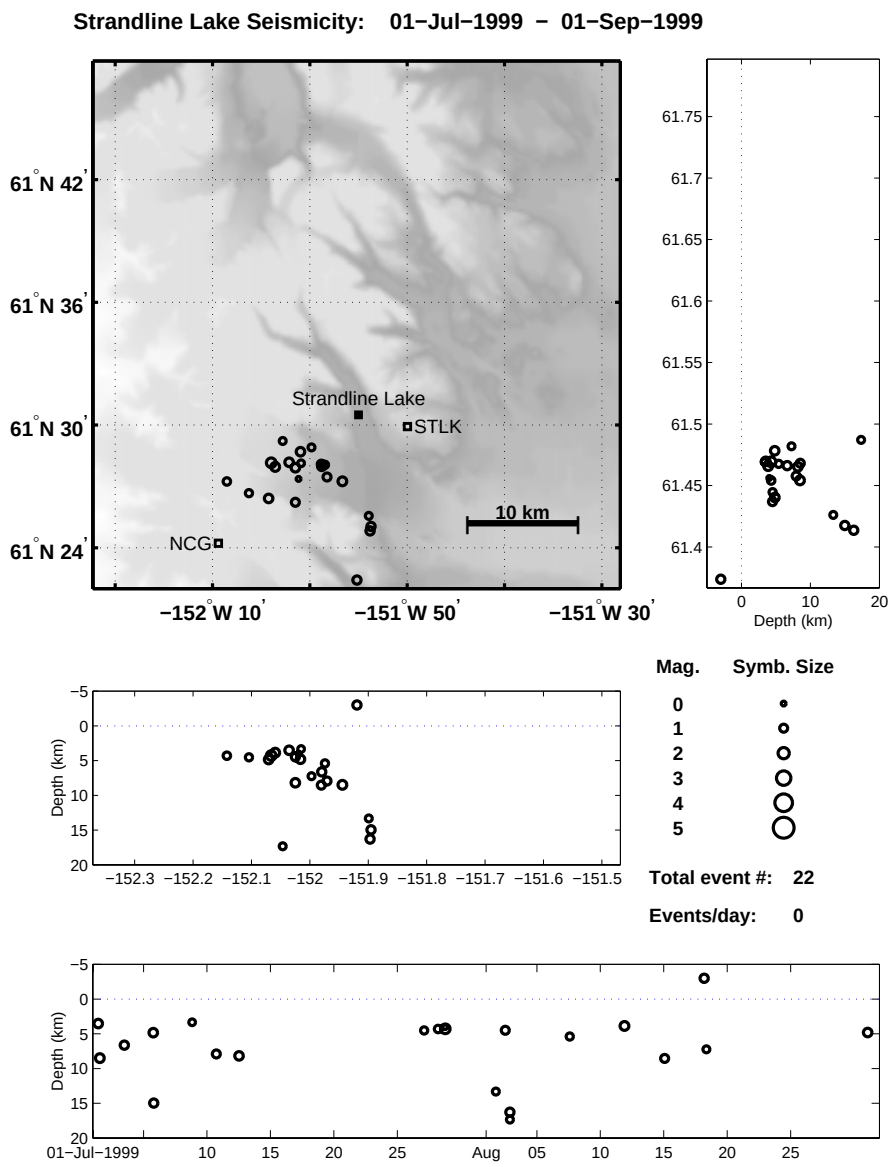

Figure 6b: Locatable Strandline Lake seismic events in space and time for July through August.

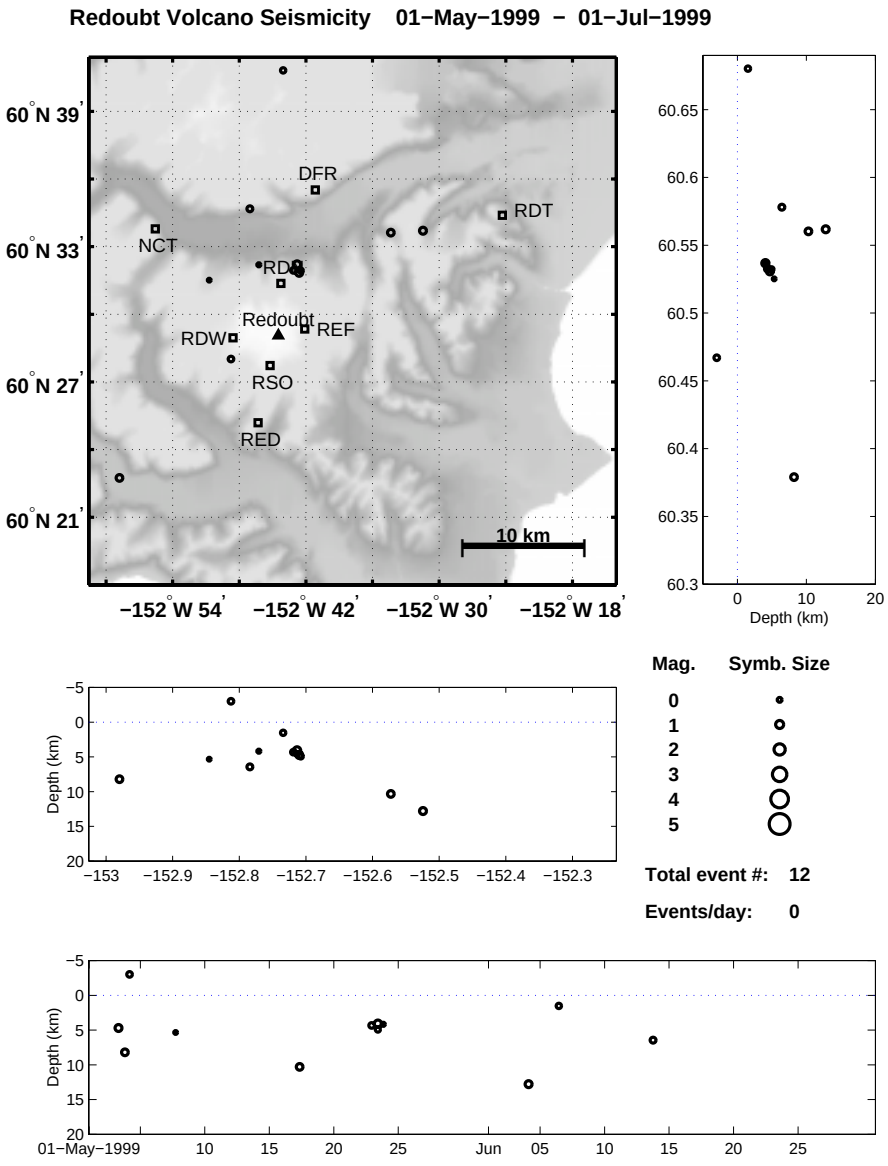

Figure 7a: Locatable Redoubt seismic events in space and time for May through June.

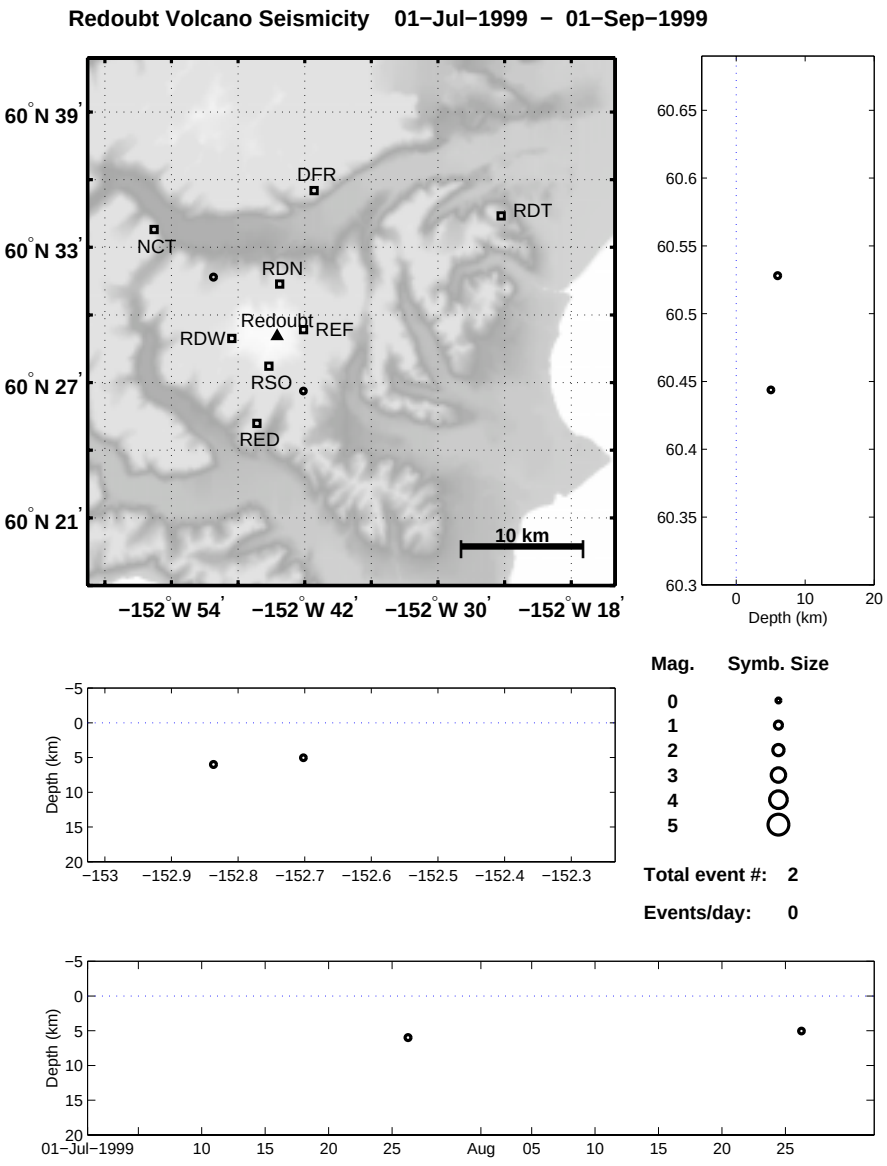

Figure 7b: Locatable Redoubt seismic events in space and time for July through August.

RED) in late June. RED was farther away from the most seismically active area and its response was such that it was not nearly as sensitive to events in this area as was the case with RDN. Therefore, many of the earthquakes recorded on RED did not meet or exceed the event counting criteria, which resulted in fewer Helicorder event counts.

Iliamna

May-June 1999:

A total of seven earthquakes, the largest of which had a magnitude of M_L=1.6, were located in the general vicinity of Iliamna during May-June 1999 (figs. 8a, 23a and 24a). Two of these events were located nearly 25 km away from Iliamna. Due to their relatively great distance from the volcanic center these two events were probably tectonic earthquakes and therefore should not be included in the Iliamna earthquake tally. The M_L=1.6 earthquake was located 7 km southeast of the summit of Iliamna. The remaining four Iliamna earthquakes were located much closer to the summit area. One event was located 1 km south-southeast of the summit while the other three events were located 1 km east-northeast of the summit. All five of the genuine Iliamna events had shallow hypocentral depths. The number of Iliamna earthquakes located during May-June 1999 was greater than that for the previous two-month period (5 vs. 3 located events) but was less than half of the 14 Iliamna events predicted from the 1-year mean seismicity rate.

July-August 1999:

A total of nine earthquakes were located in the Iliamna region during July-August 1999 (figs. 8b, 23b and 24b). Two of these events were located nearly 15 km northwest of the summit of Iliamna. Because of their fairly great distance from Iliamna these two earthquakes were probably regional, tectonic earthquakes not related to volcanic activity. The largest of the seven events actually associated with Iliamna had a magnitude of M_L=0.9 and was located 6 km south-southeast of the summit and had a hypocentral depth of 1 km. The remaining six earthquakes were located much closer to the summit and all had shallow hypocentral depths. One of these events was located 1 km south of the summit while the other five events were located in a ~1 km long linear zone extending from 1 km northeast of the summit to 2 km east-northeast of the summit. The number of events located in the Iliamna area during this two-month period was a little greater than the five earthquakes located during May-June but was half the number of located events predicted from the 1-year mean seismicity rate.

Augustine

May-June 1999:

During May-June 1999 there were a total of seven earthquakes located in the Augustine area (figs. 9a, 23a and 24a). All of seven of these earthquakes were located in a zone extending from 1 km east to 1 km south of the summit of Augustine and had shallow hypocentral depths. The largest such event had a magnitude of M_L=0.6 and was located 1 km southeast of the summit. The number of events located at Augustine during this two-month period was somewhat greater than the five events located there during the previous two-month period. This value, however, was considerably lower than the 75 located earthquakes predicted from the 10-month mean seismicity rate. The relatively low number of located Augustine events during March-April and May-June 1999 was probably the result of outages and/or intermittent operation of many of the summit stations (see the January-April 1999 Bimonthly Report for more information). Alternatively, the activity was high one year ago and has now returned to normal.

July-August 1999:

Twenty-two earthquakes, the largest of which had a magnitude of M_L=0.9, were located in the Augustine region during July-August 1999 (figs. 9b, 23b and 24b). All of these events were located within 1 km of the summit and had shallow hypocentral depths. The number of events located at Augustine during July-August was much greater than the seven such earthquakes located during the previous two-month period. The number of located earthquakes was, however, much lower than the number of located events predicted from the mean seismicity rate. Maintenance of the Augustine seismic network and the resultant improved detection/location capabilities was probably responsible for the relative increase in seismicity during July-August.

Katmai/Valley of Ten Thousand Smokes Region

May-June 1999:

Two-hundred and thirty-one earthquakes were located in the Katmai/Valley of Ten Thousand Smokes region during May-June 1999 (figs. 10a—15a, 23a and 24a). The largest earthquake located in this region during this two-month period had a magnitude of M_L=2.6 and was located 2 km north of Trident at a hypocentral depth of 3 km. An attempt was made to assign this earthquake and the other 230 events to one of the various volcanoes in this region. Assignment was made on the basis of the distances between the earthquake epicenters and the volcanoes. Earthquakes were designated as being associated with a volcano if the distance separating them was $\leq$ 5 km and no other volcanoes were closer to the epicenter. Earthquakes were assigned to the closest volcano in the case of an earthquake being located within 5 km of more than one volcano. The number of events thus assigned to each of the Katmai/Valley of Ten Thousand Smokes volcanoes is summarized in Table 1.

A total of 221 of these earthquakes were assigned to at least one volcano in this region. The number of events located in the entire map area and those associated with each of the volcanoes for May-June 1999 were much greater than those for March-April 1999. During May-June a number of stations in the Katmai network were still out or experienced intermittent operation. However, several of these “problematic” stations either once again started operating or became more reliable during this time which would account for some of the differences. Also contributing to this was the fact that there appears to have been a small swarm of seismicity during the May-June period. This swarm was in the Martin/Mageik region and appears to have started about May 20 and continued until June 7 or perhaps as late as June 13. Because of this seismic swarm the number of earthquakes associated with Martin and Mageik during May-June was much greater than that predicted from the Katmai mean seismicity rate. In the case of the other volcanoes the predicted values were either the same (i.e. Griggs and Trident) or much larger than those for May-June 1999. The latter was likely the result of fewer events being detected and located because of station outages.

Ten earthquakes were not assigned to volcanoes. Most of these events were located along the volcanic axis so at least some of them may still be volcanically related; for those earthquakes located relatively close to the volcanoes a slight mislocation may have resulted in their non-assignment. This may be particularly true of those events located to the east of Griggs. Eight of the ten unassigned earthquakes were located in this area (fig.11a). The locations of these events were not well constrained; the lack of seismic stations to the south and/or east of Snowy and Stellar resulted in a relatively large azimuthal gap in station coverage which, in turn, produced fairly large location errors. It is possible that the true

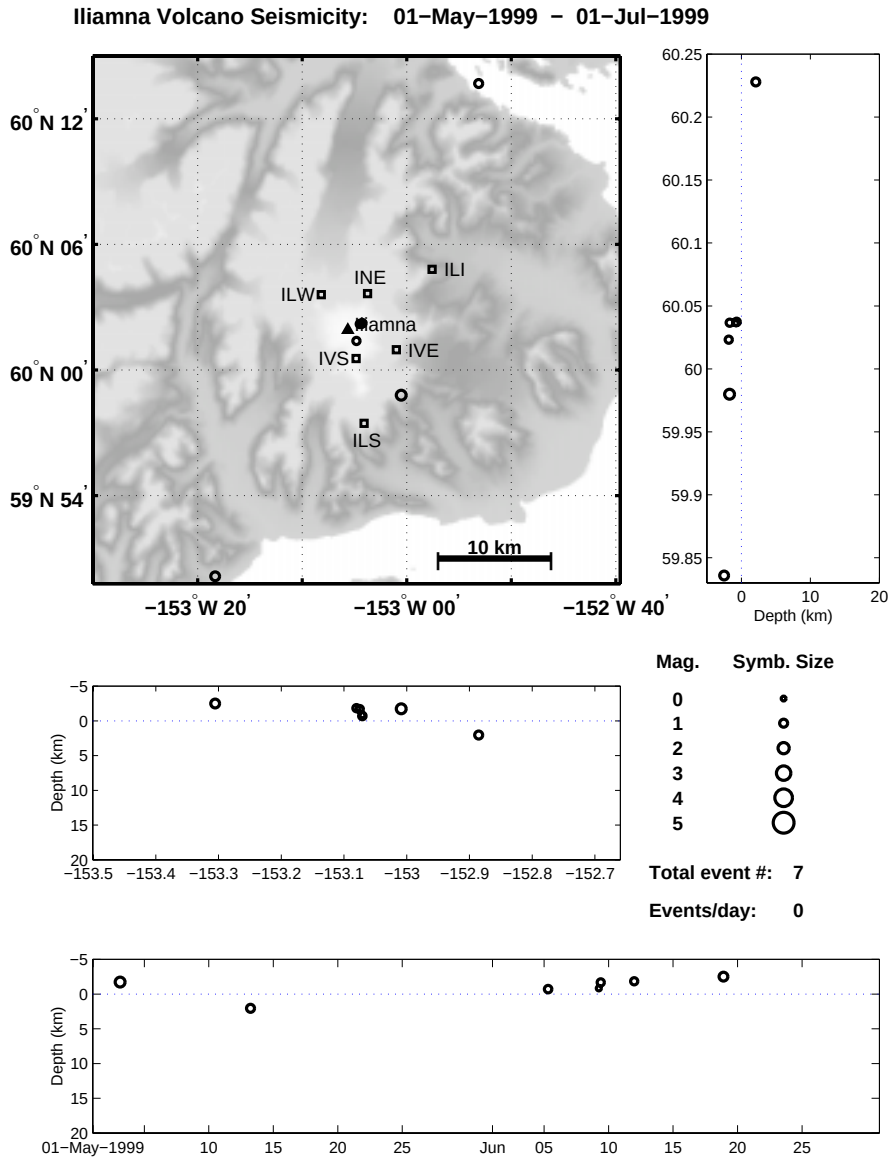

Figure 8a: Locatable Iliamna seismic events in space and time for May through June.

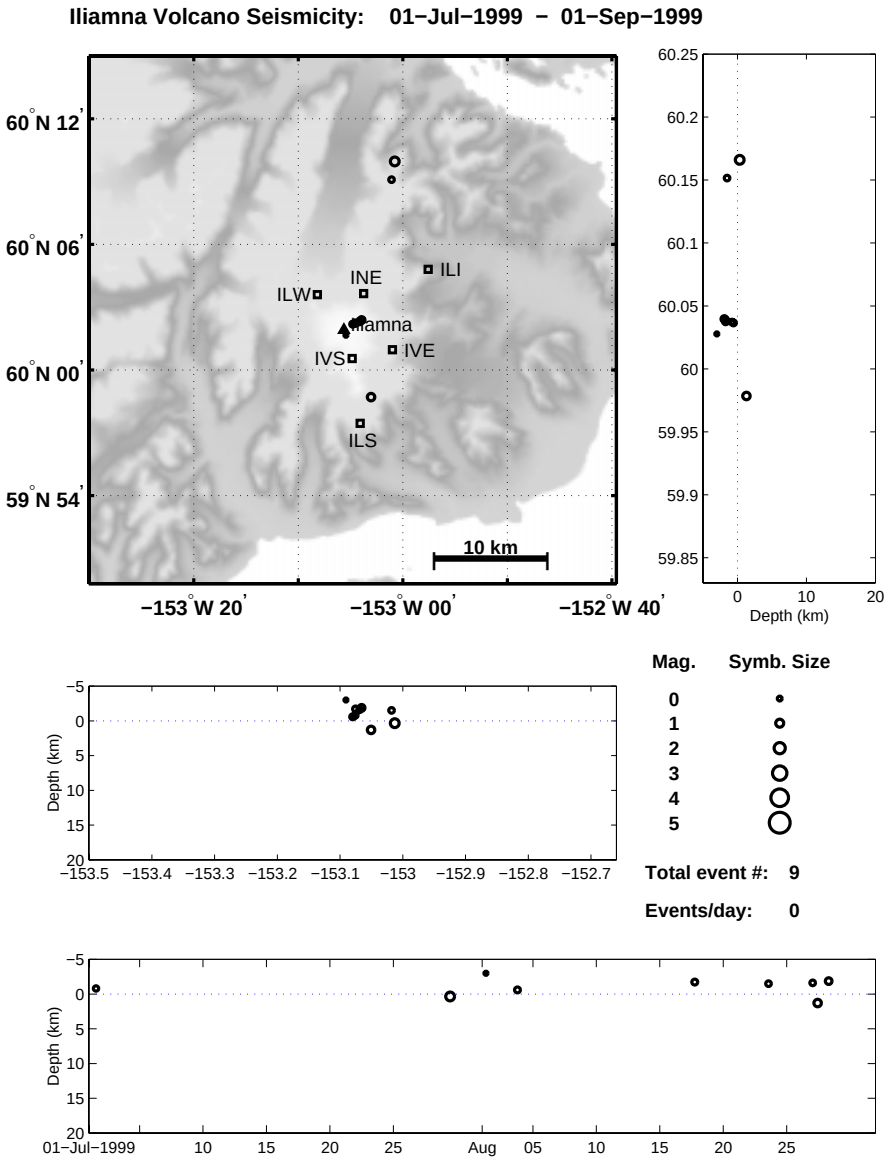

Figure 8b: Locatable Iliamna seismic events in space and time for July through August.

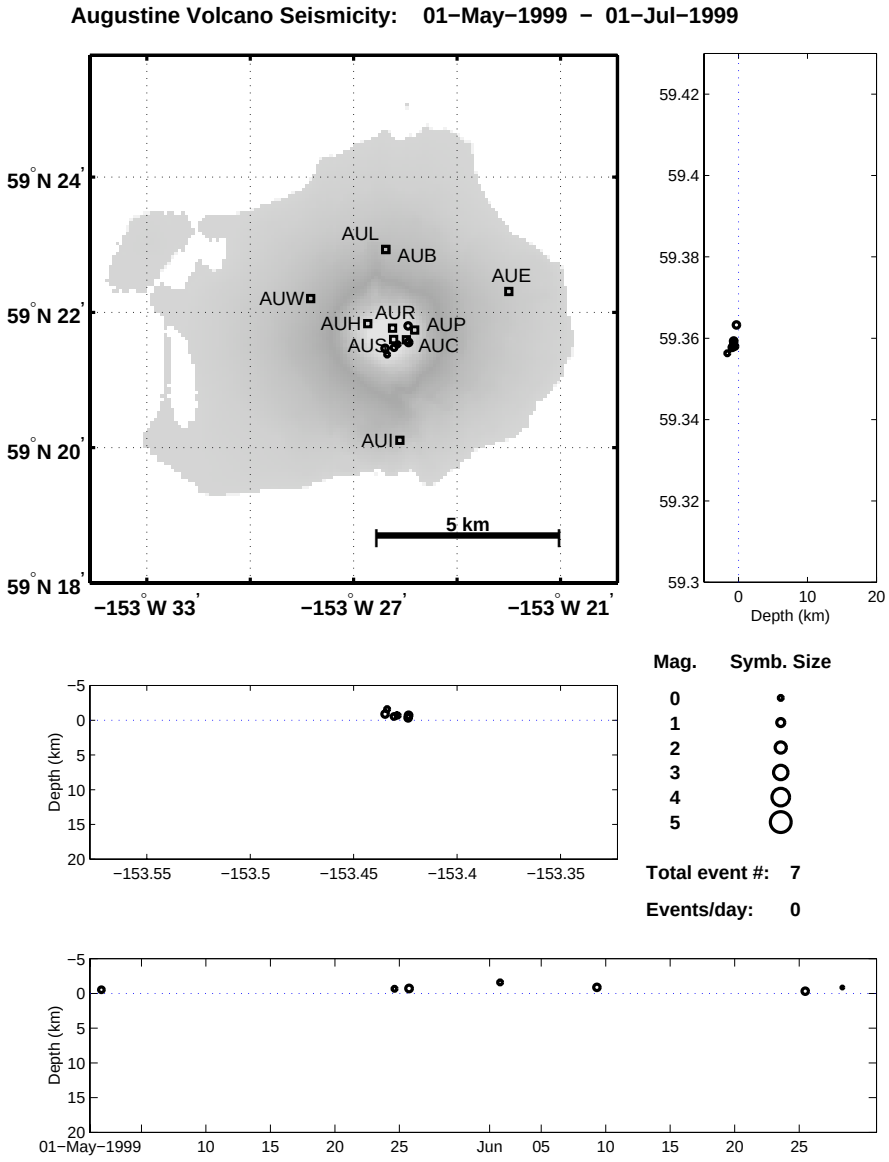

Figure 9a: Locatable Augustine seismic events in space and time for May through June.

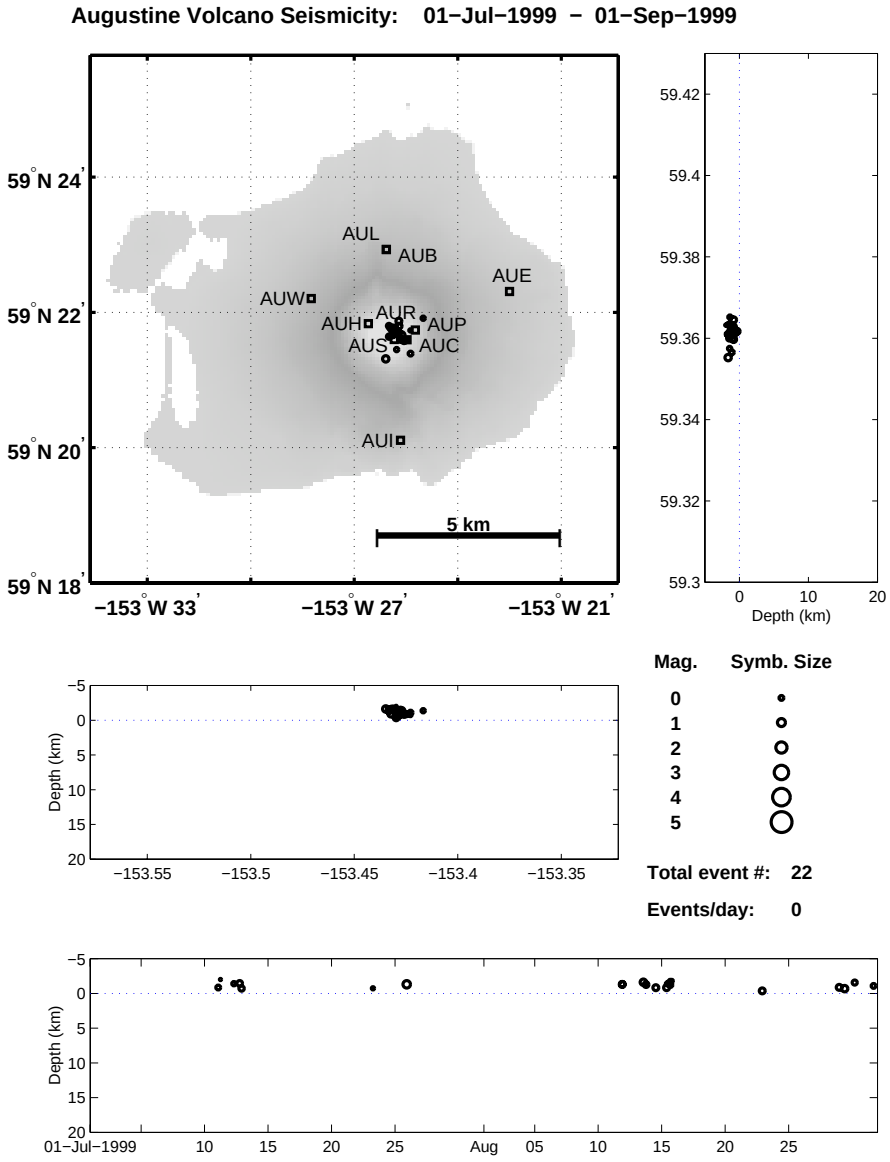

Figure 9b: Locatable Augustine seismic events in space and time for July through August.

locations of some of the unassigned earthquakes were much closer to the volcanoes than the location program (i.e. Hypoellipse) computes. Of course, it is also possible, that even with an improved station distribution these events may still remain located outside of the 5 km distance cutoff for volcano association.

July-August 1999:

A total of 211 earthquakes were located in the Katmai/Valley of Ten Thousand Smokes region during July-August 1999 (figs. 10b—15b, 23b and 24b). The largest earthquake located during this two-month period had a magnitude of M_L=2.3. There were two earthquakes which had this magnitude. One of these events was located a little over 1 km north-northwest of Martin and had a hypocentral depth of 2 km. The other M_L=2.3 event was located some distance off the volcanic axis (nearly 30 km southeast of Snowy Mountain) and was probably a regional tectonic earthquake. Once again the earthquakes were assigned to the various volcanoes in the Katmai region on the basis of epicentral distances. In this way, a total of 196 earthquakes from July-August were assigned to volcanoes. The numerical breakdown of how many events were assigned to each of the Katmai/Valley of Ten Thousand Smokes volcanoes is summarized in Table 1. The number of events located within the map area during July-August was a little lower than that of the previous two-month period (i.e. 211 vs. 231 events). This value was, however, larger than the number of earthquakes predicted from the mean seismicity rate (i.e. 211 vs. 168 events). The number of earthquakes associated with Martin and Mageik for July-August was lower than for May-June. This was not unexpected since there was a small swarm of activity in this area during the previous two-month period. The July-August values were much larger than the number of such events predicted from the Martin and Mageik mean seismicity rates. Although the level of activity in this area may have been elevated during July-August, this is not obvious on the time-depth plots (figs. 11b and 12b). The number of earthquakes located in the Mount Katmai and Novarupta areas during this two-month period was much greater than the corresponding values for May-June but was reasonably close to the number of events predicted by the respective mean seismicity rates for these two areas. The single Snowy Mountain event located during July-August was in agreement with the mean seismicity rate but no such events were located during the previous two-month period. The number of earthquakes located closest to Trident during July-August was twice the number of

Table 1 – Number of Earthquakes (for this reporting period)

Volcano/Region	March-April	May-June	July-August	Predicted from the Mean Seismicity Rate
Entire Map Area	79	231	211	168
Griggs	0	0	0	0
Katmai	2	3	11	18
Mageik	13	84	57	31
Martin	49	115	81	62
Martin/Mageik	62	199	138	93
Novarupta	5	12	32	26
Snowy Mountain	0	0	1	1
Trident	1	7	14	7
Not Assigned*	9	10	15	——-

**Events located > 5.0 km from any of the seven volcanoes listed.*

Trident events predicted from the seismicity rate as well as the number of these events located during May-June.

Aniakchak

May-June 1999:

No earthquakes were located in the Aniakchak region during May-June 1999. The histograms of both the Helicorder (fig. 23a) and the detected (fig. 24a) event counts had no earthquake counts for Aniakchak during this two-month period.

July-August 1999:

A total of four earthquakes were located in the Aniakchak region during July-August 1999 (figs. 16b, 23b and 24b). These events all occurred within about a 2 1/2 minute burst on August 16. The largest event had a magnitude of M_L=2.2 and was located about 15 km southeast of Vent Mountain. All four events had relatively deep hypocentral depths of ~17-18 km which were probably responsible for the low frequency contents of their waveforms. One of the remaining three Aniakchak earthquakes was located 2 km west of Vent Mountain while the other two events were located ~8-9 km southwest of Vent Mountain. No Aniakchak earthquakes were located during the previous two months. The number of located events during July-August also exceeded the 5-month mean seismicity rate prediction of one event.

Pavlof

May-June 1999:

There were no earthquakes located in the Pavlof area during May-June 1999. During this time no local earthquakes were detected by the acquisition system for Pavlof (fig. 24a). Furthermore, no events were large enough to appear on the histogram of Helicorder event counts for Pavlof (fig. 23a).

July-August 1999:

Three earthquakes were located in the Pavlof region during July-August 1999 (figs. 17b, 23b and 22b). All three of these events occurred on August 4 within a period of eight hours. The largest Pavlof event had a magnitude of M_L=1.9 and was located 6 km west of the summit of Pavlof. These three Pavlof events all had shallow hypocentral depths and were designated as being b-type events due to the relatively low frequency content of their waveforms. The combination of the shallow hypocentral depths with the low frequency content suggests that these earthquakes may have been glacial events (i.e. icequakes). The number of events located in the Pavlof area during July-August was greater than the two such events predicted from the 2-year mean seismicity rate.

Dutton

May-June 1999:

As was the case with the Aniakchak and Pavlof regions, no earthquakes were located in the Dutton area during May-June 1999. There were, however, a few events plotted on histograms of the Helicorder (fig. 23a) and detected (fig. 24a) event counts. The seismicity appears to be at background levels.

July-August 1999:

The level of activity at Dutton was unchanged during July-August 1999; the seismicity continued to remain low and at background levels. No events were sufficiently large to trigger the acquisition system (fig. 24b). One event was, however, large enough to be a part of the Helicorder event counts (fig. 23b). Based upon the 2-year Dutton mean seismicity rate

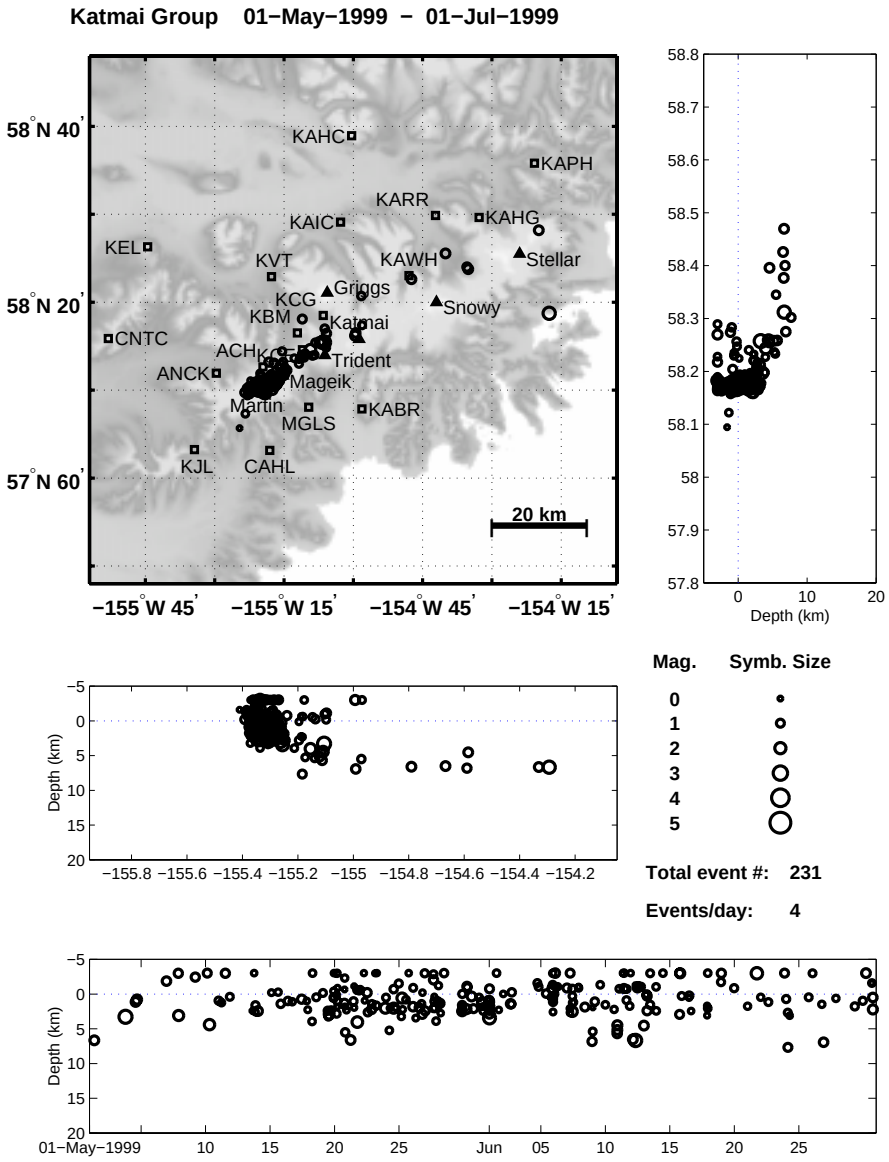

Figure 10a: Locatable Katmai Group seismic events in space and time for May through June.

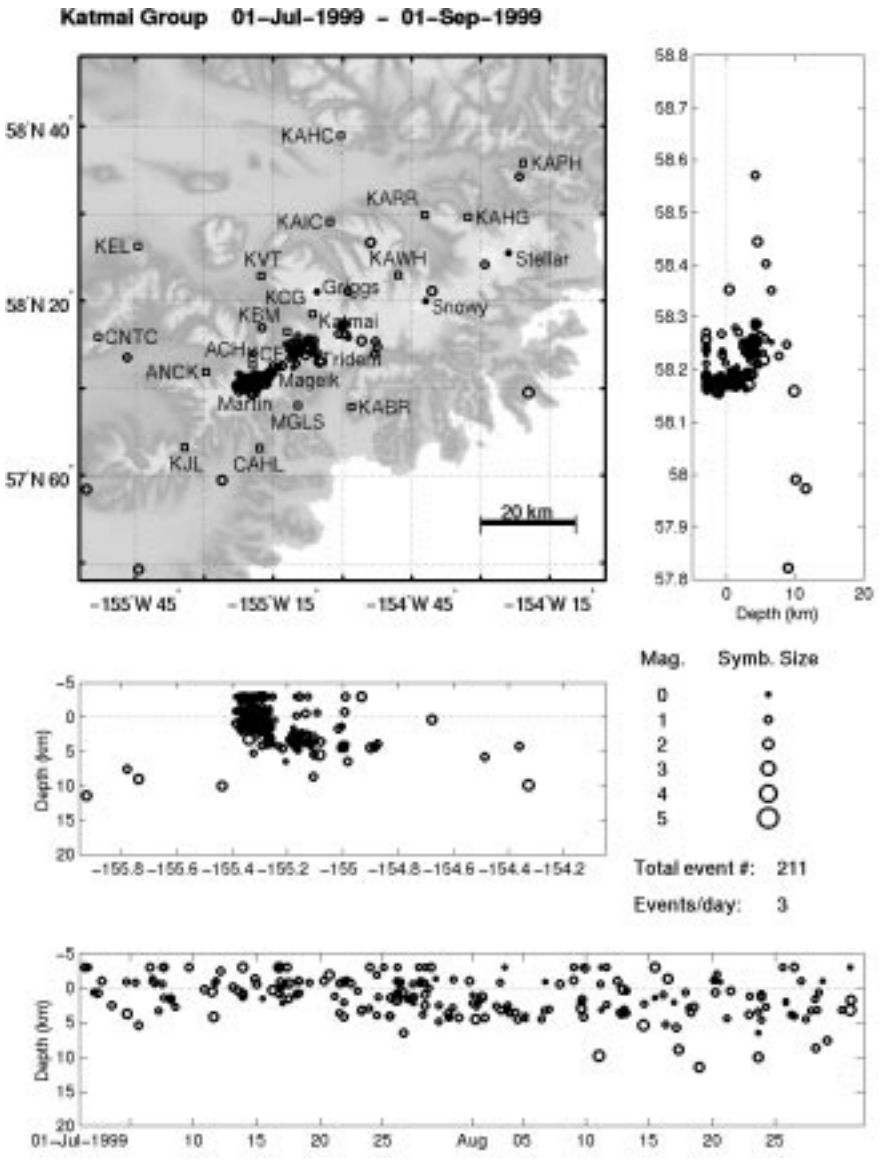

Figure 10b: Locatable Katmai Group seismic events in space and time for July through August.

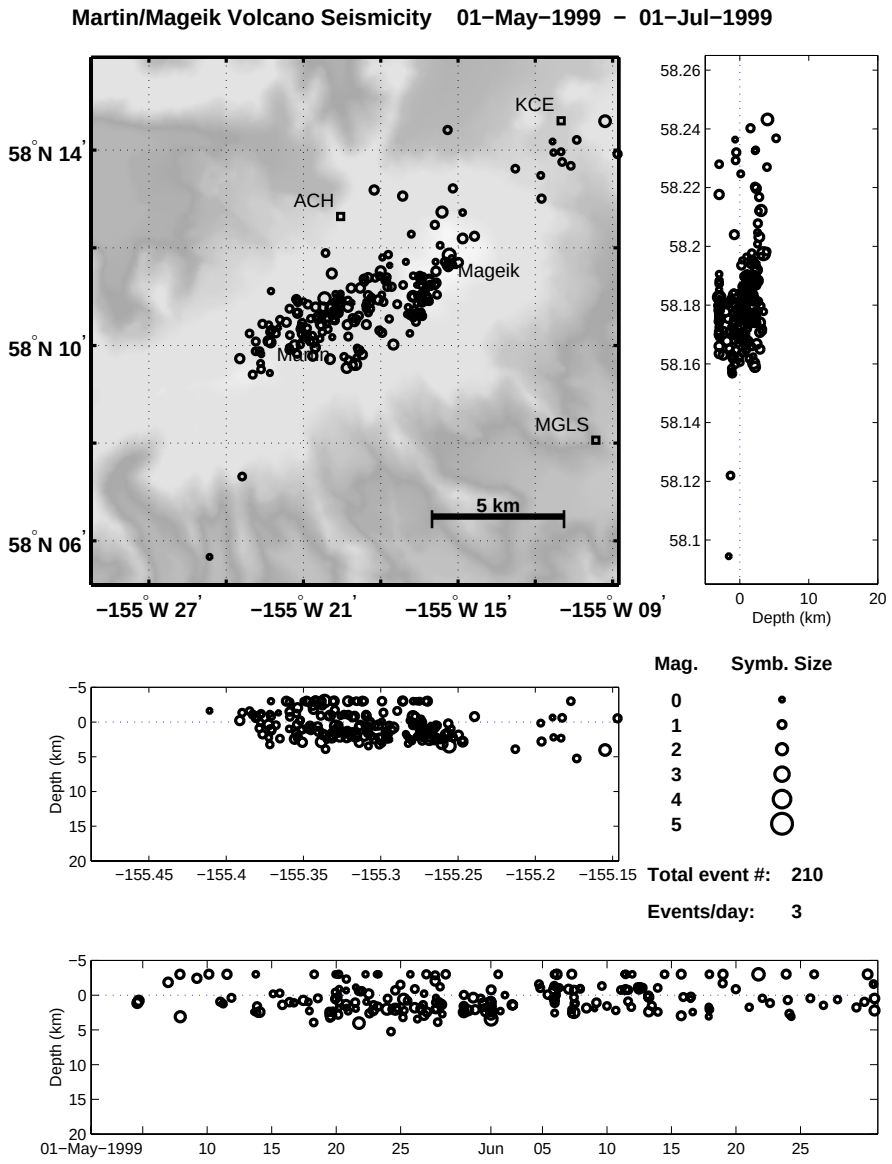

Figure 11a: Locatable Martin/Mageik seismic events in space and time for May through June.

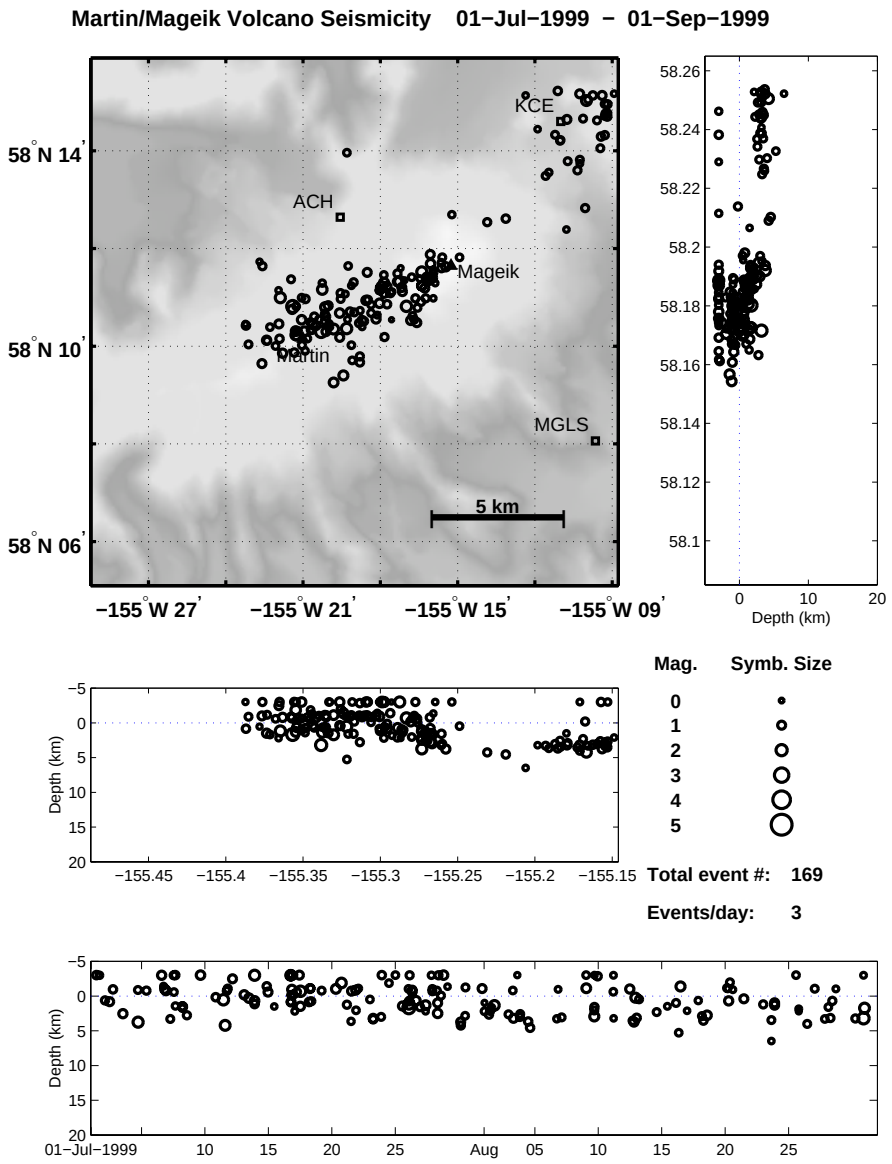

Figure 11b: Locatable Martin/Mageik seismic events in space and time for July through August.

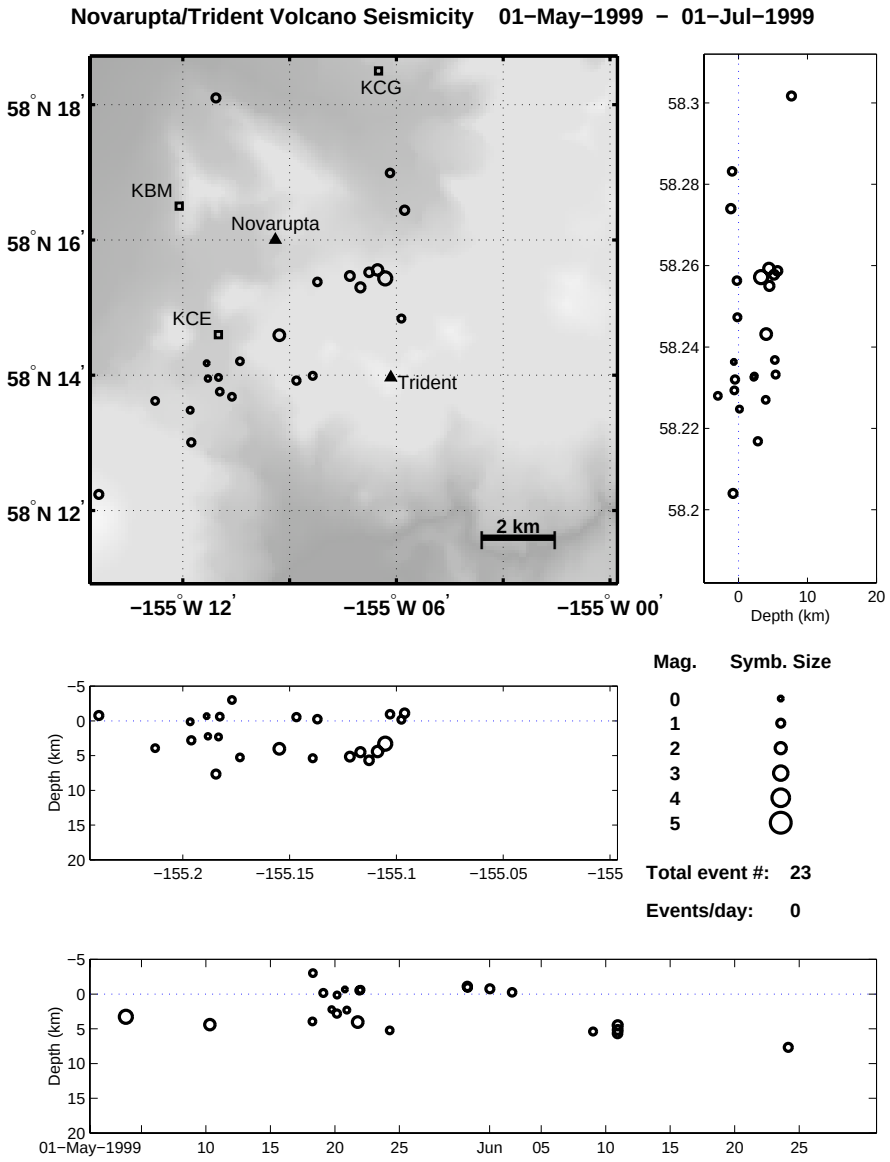

Figure 12a: Locatable Novarupta seismic events in space and time for May through June.

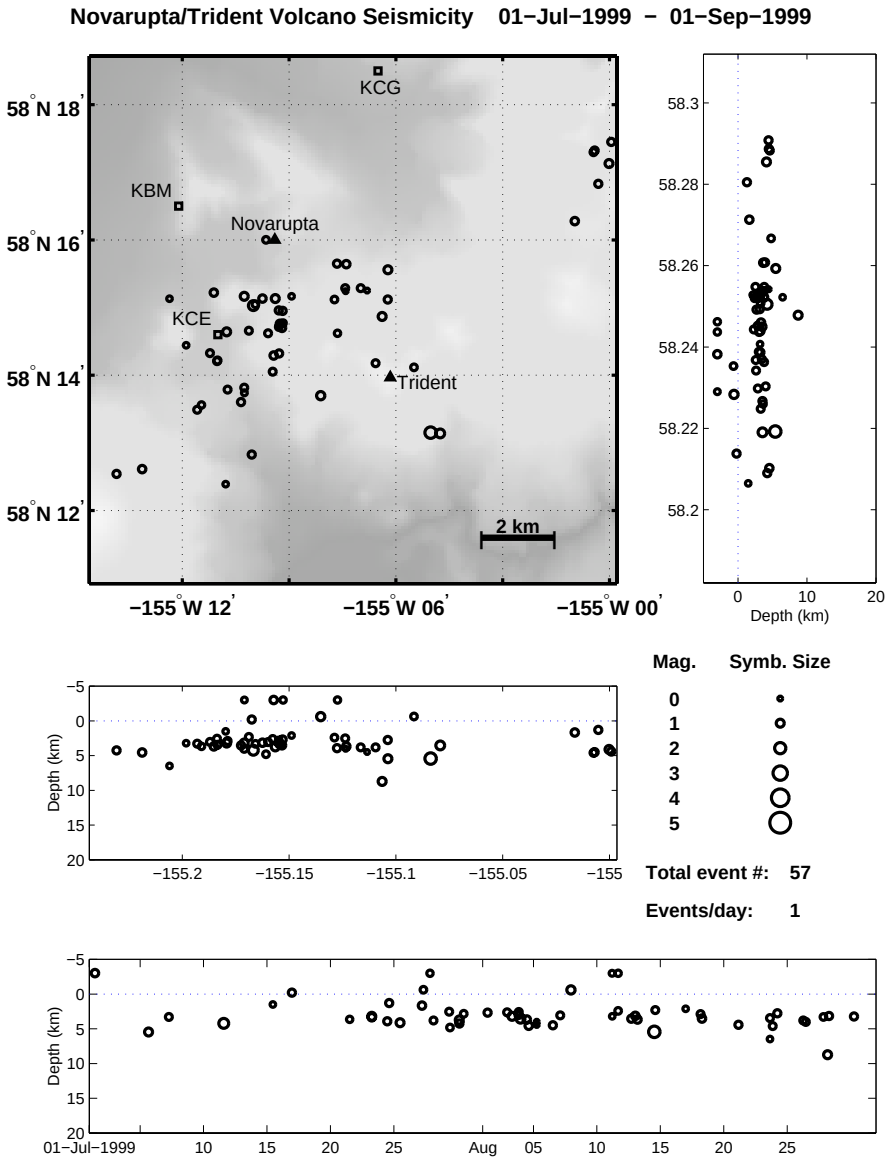

Figure 12b: Locatable Novarupta seismic events in space and time for July through August.