The Study of Hydrothermal Venting Systems

# TIME SERIES, TRACE METALS AND EVENT RESPONSE: AN AII / ALVIN EXPEDITION TO THE JUAN DE FUCA RIDGE

ATLANTIS II / ALVIN
CRUISE # 131-16
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CRUISE REPORT COMPILED BY
JULIA GETSIV & BOB EMBLEY

# CREW LIST

| | | |
|---|---|---|
| CoChief Scientists: | Bob Embley | NOAA, Newport, OR |
| | John Trefry | Florida Inst. of Tech., Melbourne, FL |
| Scientific Party: | Andra Bobbitt | CIMRS, Newport, OR |
| | David Butterfield | NOAA/PMEL, Seattle, WA |
| | William Chadwick | CIMRS, Newport, OR |
| | Hank Chezar | USGS, San Francisco, CA |
| | Michael Devany | NOAA/PMEL, Seattle, WA |
| | Leigh Evans | CIMRS, Newport, OR |
| | Ken Feldman | WHOI, Woods Hole, MA |
| | Laurie Ferioli | Moss Landing, CA |
| | James Gendron | NOAA/PMEL, Seattle, WA |
| | Julia Getsiv | CIMRS, Newport, OR |
| | James Holden | College of Ocean., U W, Seattle, WA |
| | Randy Koski | USGS, San Francisco, CA |
| | Geoff Lebon | NOAA/PMEL, Seattle, WA |
| | John Lupton | NOAA, Newport, OR |
| | Gary Massoth | NOAA/PMEL, Seattle, WA |
| | Simone Metz | Florida Inst. of Tech., Melbourne, FL |
| | Michael Perfit | U Florida, Gainesville, FL |
| | Kevin Roe | NOAA/PMEL, Seattle, WA |
| | Robert Trocine | Florida Inst. of Tech., Melbourne, FL |
| Alvin Crew: | Patrick Hickey | Expedition Leader, WHOI, Woods Hole, MA |
| | Robert Grieve | Chief Pilot, WHOI, Woods Hole, MA |
| | Matthew Heintz | Pilot, WHOI, Woods Hole, MA |
| | Robert Williams | Pilot, WHOI, Woods Hole, MA |
| | Socrates Carelo | PIT, WHOI, Woods Hole, MA |
| | Paul McCaffrey | Tech, WHOI, Woods Hole, MA |

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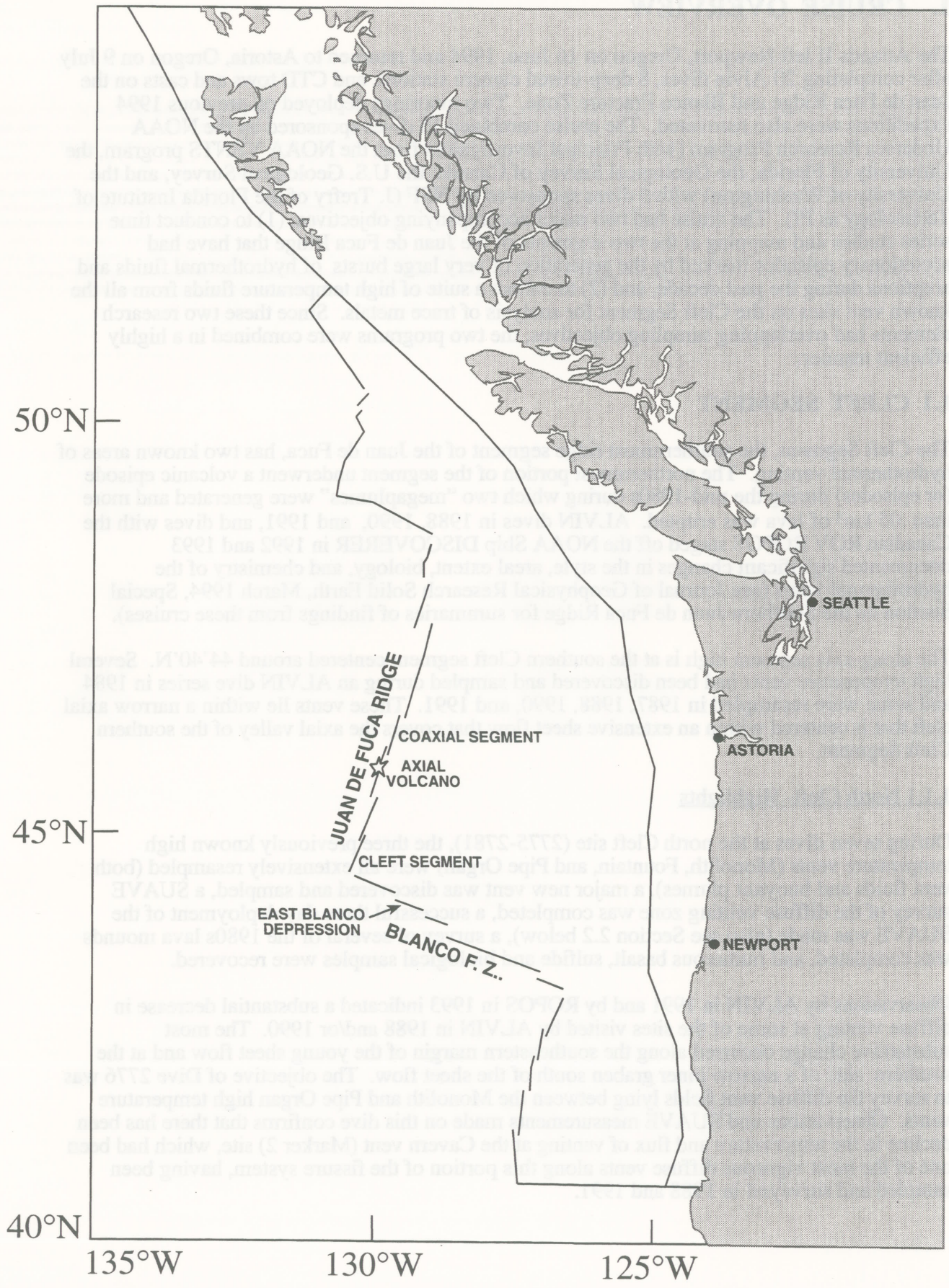
50°N
45°N
40°N
135°W
130°W
125°W
SEATTLE
ASTORIA
NEWPORT
JUAN DE FUCA RIDGE
COAXIAL SEGMENT
AXIAL VOLCANO
CLEFT SEGMENT
EAST BLANCO DEPRESSION
BLANCO F. Z.

# 1. CRUISE OVERVIEW

The Atlantis II left Newport, Oregon on 16 June, 1994 and returned to Astoria, Oregon on 9 July after completing 20 Alvin dives, 8 deep-towed camera stations, and CTD tows and casts on the Juan de Fuca Ridge and Blanco Fracture Zone. Two moorings deployed on previous 1994 expeditions were also recovered. The cruise combined 15 dives sponsored by the NOAA Undersea Research Program (with Principal Investigators from the NOAA VENTS program, the University of Florida, the Geological Survey of Canada, the U.S. Geological Survey, and the University of Washington) with 5 dives sponsored by NSF (J. Trefry of the Florida Institute of Technology as PI). The cruise had two major accompanying objectives: (1) to conduct time series studies and mapping at the two segments of the Juan de Fuca Ridge that have had accretionary episodes marked by the generation of very large bursts of hydrothermal fluids and eruptions during the past decade, and (2) to collect a suite of high temperature fluids from all the known vent sites on the Cleft Segment for analysis of trace metals. Since these two research elements had overlapping sampling objectives, the two programs were combined in a highly efficient manner.

## 1.1 CLEFT SEGMENT

The Cleft Segment, the southernmost ridge segment of the Juan de Fuca, has two known areas of hydrothermal venting. The northernmost portion of the segment underwent a volcanic episode (or episodes) during the mid-1980s during which two "megaplumes" were generated and more than .05 $km^3$ of lava was erupted. ALVIN dives in 1988, 1990, and 1991, and dives with the Canadian ROV ROPOS staged off the NOAA Ship DISCOVERER in 1992 and 1993 documented significant changes in the style, areal extent, biology, and chemistry of the hydrothermal vents (see Journal of Geophysical Research Solid Earth, March 1994, Special Section on the Southern Juan de Fuca Ridge for summaries of findings from these cruises).

The along-axis segment high is at the southern Cleft segment centered around 44°40'N. Several high temperature vents had been discovered and sampled during an ALVIN dive series in 1984 and some were resampled in 1987, 1988, 1990, and 1991. These vents lie within a narrow axial cleft that is centered within an extensive sheet flow that covers the axial valley of the southern Cleft Segment.

### 1.1.1 North Cleft- Highlights

During seven dives at the north Cleft site (2775-2781), the three previously known high temperature vents (Monolith, Fountain, and Pipe Organ) were all extensively resampled (both vent fluids and buoyant plumes), a major new vent was discovered and sampled, a SUAVE survey of the diffuse venting zone was completed, a successful three day deployment of the SUAVE was made (also see Section 2.2 below), a survey of several of the 1980s lava mounds was completed, and numerous basalt, sulfide and biological samples were recovered.

Observations by ALVIN in 1991 and by ROPOS in 1993 indicated a substantial decrease in diffuse venting at some of the sites visited by ALVIN in 1988 and/or 1990. The most substantive change occurred along the southeastern margin of the young sheet flow and at the southern side of a narrow inner graben south of the sheet flow. The objective of Dive 2776 was to survey the diffuse vent fields lying between the Monolith and Pipe Organ high temperature vents. Observations and SUAVE measurements made on this dive confirms that there has been decline in the temperature and flux of venting at the Cavern vent (Marker 2) site, which had been one of the most vigorous diffuse vents along this portion of the fissure system, having been sampled and surveyed in 1988 and 1991.

There is no apparent change in the intensity of venting from the high temperature vents at on the north Cleft segment, although no quantitative measurements of high-temperature venting have ever been attempted here. A new vent (Aquarius) was discovered on Dive 2787 along the graben that lies between the first 1980s lava mound and the Fountain Vent. The vent is an isolated structure venting fluids at up to 193°C. A luxuriant biological community covers the underlying sphalerite chimney.

1.1.2 South Cleft

During five dives (2782-2786) at the southern part of the Cleft Segment, water and buoyant plume samples were taken at the Plume, Vent 3 , and Vent 1 sites. Many markers put down during the U.S.G.S. dive series in 1984 were observed (although some were obscured by fouling). Approximately 6.5 km of the neovolcanic zone was traversed during the five dives, from Plume vent at ~44°38'N to 44°42'N. Dive 2782 conducted SUAVE surveys in the vicinity of Vent 3 and mapped and sampled the cleft northward to about 44°42'N. No active venting north of Vent 3 was observed. The highest temperature measured during the dives was 342°C at Vent 1, which is within 10°C of previous measurements at this site in 1988 (350°C), 1990 (332°C) and 1991 (332°C). Temperature measurements prior to 1988 were below 300°C everywhere on South Cleft.

## 1.2 COAXIAL SEGMENT

1.2.1 Background

The CoAxial Segment had a well-documented dike injection and eruption episode in June-July of 1993 which was detected and monitored by the NOAA/Navy real-time T-wave monitoring system. Two "event plumes" were found over the axial valley centered around 46°30'N where the T-waves had concentrated during the latter part of the episode. This site (which subsequently was known as the Flow site) became the target for dives with the Canadian remotely operated vehicle ROPOS off the NOAA R/V DISCOVERER in mid-July, 1993, during which a fresh, venting lava flow 2.5 km long was discovered, mapped and sampled. The lava flow was erupted on a ridge just north of an older volcano cone on the median volcanic ridge. Extensive venting was also found southward from the cone for about 4 km within a small graben. ROPOS recovered rock samples, some water samples, and took temperature measurements. Subsequent NSF/NOAA Alvin dives in October, 1993 (J. Delaney and R. Embley, Co-Chief Scientists) recovered several high quality vent fluid samples and left prominent markers at the sample sites. A magnetics and gravity survey was also conducted at the Flow site during the October dive series (P. Johnson, M. Tivey, and M. Holmes P.I.s).

In the latter part of the DISCOVERER cruise, ROPOS also discovered large quantities of white floc (thought to be bacterial in origin) in the water column and on the seafloor centered around 46°19'N. In September of 1993, a Scripps Institution of Oceanography expedition on R/V Melville conducted Deep-tow sidescan and CTD operations in this area and discovered seafloor temperature anomalies at 46°18'N. Night time CTDT/chemical surveys off the AII in October of 1993 discovered very intense attenuation and high methane plumes and several zones of diffuse venting associated with high bacterial production along a fissure zone that cut through older pillows and sheet flow lavas between approximately 4617'N and 46 1°9.5'N. This area became known as the "Floc" site. The biological system was, at that time, characterized entirely by prodigious bacterial productivity, similar to that observed at in 1991 (Haymon et al., 1993) and at the north Cleft site in the late 1980s. A time-lapse camera and temperature probe was emplaced at one of the sites (R. McDuff, PI), several vent fluid and biological samples were recovered, and markers were left at several of the vent sites.

CTD tow-yos made during the night operations of the October, 1993 cruise discovered plumes

centered over a ridge in the southern part of the CoAxial Segment centered around 46°09'N. This site became known as the Source site because of an hypothesized relationship to the original source of the T-waves (although it is located several miles south and east of the center of the original T-wave swarm. During the last dive of the 1993 series, a high-temperature vent system was found at 46°09'N along the eastern axial volcanic ridge (the shoalest point in the segment). The two chimneys visited in 1993 vented almost smokeless fluids that formed almost pure anhydrite edifices.

The 1994 CoAxial dives were a continuation of the exploration of the geological, chemical and biologic manifestations of the CoAxial Event and of the time-series studies begun in 1993. Three dives were conducted at the Floc site, three at the Lava Flow, and two at the Source Vent site

1.2.2 The Flow Site - 1994

The fresh lava flow at three previously marked sites (Dive 2670) was revisited and sampled on Dive 2788. Only one of the sites was visibly venting; the 36°C site had completely stopped. A very preliminary impression is that the venting is now confined to the thickest portion of the flow (which may also be the main volcanic vent). No macrofauna had colonized the Flow site. Two other dives (2792, 2794) were focussed on mapping the northern tip of the lava flow and adjacent structures related to dike intrusion and mapping and sampling of a slightly older flow to the east.

1.2.3 Floc Vent Site - 1994

The Floc site, so named because of the extensive floccular plume clouds that occur there (they appear to have diminished since October, 1993), lies about 16 km northeast of the Source site and is probably the most fascinating site in terms of event response. The venting occurs along the probable path of dike propagation on a braided fissure system cutting through old lavas. The 1994 along-axis CTD tow at Floc site showed a strong attenuation anomaly but with a reduced rise height of plumes compared to 1993. Dives 2789, 2791, and 2793 resurveyed and resampled about 2.5 km of the hydrothermally active fissure zone visited on three dives made during the NSF/NOAA Event Response cruise in October, 1993. At that time, there were extensive bacterial mats along the fissure and floccular clouds being released. In 1994, the apparent mean temperature of the system appears to have dropped from 20°+ to <10°C and there was a qualitative decrease in the production of floc (observed both in the plume data and on the seafloor) and venting flux along part of the system (Marker 3A and north). At the same time, the biological community over a section of the fissure had persevered and matured, with small tubeworms colonizing the walls of the fissure amongst the ubiquitous bacterial mats. A small area within an intensive diffuse venting section along the fissure south of the Marker 3A site was chosen as a site for long-term chemical and biologic time series studies. Dive 2791 carried out careful video/camera and SUAVE chemical scanner surveys at this site and left two markers (2 and 6). The intention is to leave the area around the Marker 2 site unsampled. About 1 km north at the Marker 11 site, a U. Wash. time lapse-camera and a temperature probe was deployed in October and recovered on this dive series. The Marker 11 site is particularly interesting because of the temporal information from the U. Wash. instruments and because it is one of the few places where tubeworms were found in 1994, but definitely none were observed in 1993. We recovered some samples from Marker 11 on our last dive, but the site obviously deserves more attention. There was also a red worm with possible egg cases sampled there. Obviously, the Floc site offers opportunities hitherto not presented for understanding vent community development and, combined with the studies being done at 9° N, may herald a new understanding of the succession of colonization at newly formed vents. Since it has apparently cooled off significantly and over the past year, resurveying and resampling the site in 1995 is a high priority.

1.2.4 The Source Vent Area- 1994

There are three major vents (two of these, Beard and Church, were discovered in 1993) and a number of minor ones situated over about 100 m along a west-facing scarp at a depth of about 2262 m. The scarp is actually the east side of a (approx.) 15 m wide fissure that bisects a constructional pillow lava ridge on the west side of the small axial valley. Smaller chimneys occur on the slope beneath the major vents and appear to line up at oblique angles to the primary fracture system (which is at about 030°). The fluids (up to 294°C) are metal poor, almost smokeless, and are currently forming anhydrite with some sphalerite and iron sulfides. A 12 m high anhydrite chimney (Mongo), which had a prodigious flow rate, fell over between our two dives.
Probably the most fascinating biologic aspect of the Source site is the presence of corals. There are distinctive "bottle-brush" corals that are present around the vents (they are obviously associated with the vent field; there is a sharp dropoff in their numbers away from the vent field. Another type of white coral is present on the basal mounds of the chimneys. Tubeworms are also found at Church vent.

Whereas there was clear evidence for a decline of venting at the Flow and Floc sites, the Source site seemed to be at about the same level of activity as last year. A maximum temperature of 294°C was measured there. All the vents to date observed at the Source site were emanating clear fluids in the 270° to 294°C temperature range. On-board determination of chloride endmembers for the Source site showed no detectable change between October, 1993, and July 1994. Thus, although the Source vent has interesting chemical and biological characteristics, the effect (if any) of the 1993 CoAxial accretion event on this site is unclear.

# 2.0 DISCIPLINE SUMMARIES

## 2.1 VENT FLUID AND BUOYANT PLUME PROGRAM *(J. Trefry and D . Butterfield )*

As part of the time-series study of hydrothermal fluids on the Cleft Segment, more than 50 individual samples were collected from all of the major sites previously studied: Monolith, Fountain, and Pipe Organ on North Cleft, and Plume, Vent 1, and Vent 3 on South Cleft. In addition, a new focussed vent (Aquarius), north of Fountain, was found and sampled. Subsamples were taken for major ions, dissolved gases, trace metals, and a variety of isotopes. Initial results of shipboard analyses indicate that the chlorinity of North Cleft focussed vent fluids has continued to decrease since initial sampling in 1990. This change in chemical composition is believed to be related to the evolution of the hydrothermal system following the seafloor volcanic eruption at North Cleft in the 1980's. The significant changes in composition indicate that continued efforts to sample N. Cleft vent fluids would be useful in understanding the hydrothermal response to volcanic events. In addition to the vent fluid samples, about 35 Niskin samples were collected by Alvin in the buoyant plumes at each of the vent sites, with special emphasis at Pipe Organ and Vent 1. The plume samples were filtered aboard ship to obtain particulate and dissolved fractions. We now have a set of samples encompassing 10 years of work on the Cleft Segment.

At the Coaxial segment we collected a total of 24 samples from diffuse and focussed vents. Four focussed vents were sampled at the Source site (Church, Beard, Mongo, and Twin Spires), ranging in temperature from 225 to 293°C. Good diffuse fluid samples were obtained at the Floc site, where active venting continued, but not at the Flow site, where venting had nearly ceased. Overall, the vent and plume samples collected on this cruise extend over a wide range of temperatures and environments, and provide ample quantities of

fluids for analyses for new elements from all locations. The time-series monitoring of chemical composition of volcanically perturbed systems is yielding important information that will be used to evaluate hypotheses relating to evolution of hydrothermal systems on mid-ocean ridges.

## 2.2 PMEL SUAVE CHEMICAL SCANNER *(G. Massoth)*

The PMEL SUAVE chemical scanner was used in three separate modes during the cruise. It was used on: (1) many of the CTD casts/tows, (2) on (four) dives at North Cleft, South Cleft, CoAxial Flow site, and Floc site, and (3) in a remote mode for several days at North Cleft, being deployed and recovered by ALVIN.

The PMEL SUAVE (an *in situ* chemical analyzer that also measures temperature) was deployed at 1004h PDST during ALVIN dive 2777 at transponder net coordinates 1363X/1424Y and depth 2273 m. The deployment site was within visual range of Marker 40, placed by NOAA scientists in 1991, and was at the edge of an outward jutting ledge on the lava lake collapse rim which overlooked the tops of the five Pipe Organ vent spires. The area was bathed in ubiquitous diffuse flow which percolated through several cm of semi-encrusted iron oxyhydroxide type sediments at temperatures of 20-30°C, with an extreme value of 56°C measured directly in the sediments. The intake orifice of the SUAVE chemical analyzer and the temperature probe were placed directly in shimmering fluids venting adjacent to SUAVE. Chemical determinations of dissolved Mn, Fe(II), and $H_2S$ were made each 5 seconds throughout the deployment. A series of three standards for Mn, two for Fe(II), and one for $H_2S$ were measured at 5 hour increments by using selection valves to effect *in situ* standardization. All data was recorded internally by an onboard computer that also controlled and monitored SUAVE performance. At 1045 on ALVIN dive 2780 SUAVE was recovered from the seafloor. The data was examined upon return to the surface where it was determined that SUAVE performed perfectly throughout the deployment. All three chemical species were measurable providing more than three days of continuous data along with a matching temperature record.

The initial results suggest that diffuse fluids near Pipe Organ Vent are markedly variable in thermal and chemical properties over the time scale of this experiment. Temperatures ranged from about 3°C (one degree above ambient seawater temperature) to 10°C with periods of high or low temperature lasting from 5 to 10 hours, often overprinted by brief excursions to the opposite extreme in temperature. Chemical anomalies for Mn and Fe followed this general pattern with maximum values for Mn being about 25µmol, and Fe(II) being at least 5-fold in excess of the highest standard for Fe (40 µmol). Hydrogen sulfide was measurable but at very low concentrations of about 3 µmol or less making it difficult to assess temporal variability. The successful outcome of this experiment marks the first useful deployment of a chemical analyzer on the deep seafloor in a monitoring mode.

## 2.3 VOLCANOLOGY *(R. Embley , W. Chadwick, and M. Perfit)*

### 2.3.1. Mapping

The geology/volcanology program for the 1994 dive series concentrated on mapping the structures associated with the venting and the dike injection/eruptions at the north Cleft and CoAxial sites. Of particular interest was mapping the grabens that are associated with the eruption of the pillow mounds at the two sites. Determining the exact dimensions of such structures allows comparisons to models of deformation produced from the injection of dikes on subaereal volcanic rift zones. Detailed geologic mapping of the volcanic and structural features associated with the recent magmatic episodes were made on dives 2778 and 2779 at the northern Cleft site and on dives 2789-94 at the CoAxial Segment. The mapping was greatly aided by the

scanning Mesotech sonar system, a high-resolution swath mapping sonar with a single down-looking beam that sweeps back and forth through an angle from one side of the Alvin to the other. We were unable to collect any Mesotech data during the first 14 dives because the instrument was delayed at the factory. However, after the sonar was delivered to us on the ship (thanks to the R/V New Horizon) it was used on the last 6 dives (dives 2789-2794, all at the CoAxial segment). The sonar was used to conduct fine-scale bathymetric surveys (with the sonar in profile mode) of small areas of interest. The high spatial resolution of the sonar gives it the unique capability to map geologic features and structures over distances of tens to hundreds of meters.

We conducted Mesotech surveys at our 3 areas of interest at CoAxial, Flow, Floc, and Source sites. Each survey typically took about one hour of dive time. At the Flow site (dives 2792 & 2794) we concentrated on mapping the northern end of the 1993 lava flow where it was erupted from a well-defined graben. This data will complement a similar survey along the graben at the south end of the flow conducted during Dive 2671 in October, 1993. At the Floc site, (dives 2789, 2791 & 2793) the Mesotech surveys were designed to map the structural setting of the newly created vent sites, which are localized along a fissure system. At the Source site (dive 2790), a Mesotech survey was made to map the structural setting of this high-temperature vent site. When using the sonar, there are trade-offs between data density and the size of the area surveyed. One must consider factors such as sub speed and altitude as well as sonar sweep angle and range for a particular survey. For example, driving the Alvin relatively fast allows the sub to cover more area during a survey, but at a lower data density and resolution. During this cruise we tended to favor spatial coverage over resolution. We flew relatively high off the bottom (altitude 25-30 m) and fast (15-25 m/min), with a sweep angle of 120 degrees and a range of 50 m. This means that the Alvin was out of sight of the bottom and the pilot flew predetermined lines from endpoint to endpoint. The usefulness of the Mesotech sonar data for mapping of course depends heavily on the quality of the Alvin navigation. For the most part our navigation was very good during this cruise.

### 2.3.2 Basalt Chemistry

As part of a long-term collaborative program, documented sampling and analyses of basalts was an integral part of the mapping program. Investigations of samples from the well-documented Cleft segment eruptives and preliminary analyses of samples from the CoAxial Flow site indicate that, while individual flows exhibit only slight chemical variations, lava chemistry varies significantly between different eruptive units, facilitating the use of basalt geochemistry as an effective mapping tool. During the 1994 dives, 23 samples were taken on the north Cleft dives, 20 on the CoAxial sequence, and an additional 14 on the dives at south Cleft.

## 2.4 SULFIDE SAMPLES *(R. Koski)*

Thirty-two sulfide samples were collected in the dive series including 14 from north Cleft, 12 from south Cleft, and 6 from the CoAxial-Source site. Most samples are from active or very recently active chimneys, the exception being pyritic (Type IV) chimneys from two older and inactive sites between the Fountain and Aquarius vents at north Cleft. Chimney pieces with Type IV compositions were also collected at the relatively low temperature (180°C) Aquarius vent at north Cleft.

Co-existing vent fluids were sampled with many of the chimneys, and fluid temperatures were also measured. The active chimney types are variable in composition, but most fall into three categories. High-temperature zoned and copper-rich chimneys (Type I) were sampled at Monolith, Pipe Organ, and Vent 1 sites. The zonation consists of chalcopyrite + isocubanite +/- pyrrhotite in the inner wall, and wurtzite + sphalerite + anhydrite in the outer wall, and a thin surficial crust of pyrite + marcasite. Co-existing fluid temperatures ranged from 284° to 342°C.

Zn sulfide-rich chimneys were sampled at Monolith, Vent 1, Vent 3, and Plume sites. Fluid temperatures measured concurrently at those sites ranged from 140° to 270°C. At Pipe Organ and Vent 1, composite chimneys constructed of both Cu-rich tubular and Zn-rich beehive sections were sampled.

Chimney fragments that are predominantly sulfate were sampled at Mongo, Beard, Church, and Twin Spires vents at the CoAxial Source site as well at Monolith, Pipe Organ, and Vent 1 at the Cleft segment. The Source site samples consist largely of anhydrite with minor amounts of wurtzite, sphalerite, and chalcopyrite. The chimneys have a chaotic internal structure consistent with a large volume of hydrothermal fluid flow and turbulent mixing with seawater. Temperatures of clear fluids discharging at these sulfate-dominant vent sites range from 270° to 285°C.

## 2.5 BIOLOGY (*J. Holden)*

### 2.5.1 Mesophile Microbiology:

Bacterial mats were observed in various forms at all sites visited. Bacterial mats were the most dominant forms of life at both the Floc and Flow sites on the CoAxial Segment. The only vent-associated form of life found at the Flow site was the brown mat which appears to be identical to the mat collected from this site in October 1993. The mat material at the Marker 3A diffuse vent at the Floc site was more brown and gray in appearance relative to observations made in October. At other regions along the Floc site, brilliant white mat was the predominant bacterial mat found associated with the diffuse venting. No novel or unusual mats were observed at the other dive sites. A sample of the white and gray-brown mats from the Floc site and the brown mat from the Flow site was collected using a slurp gun. The samples were either frozen at -80°C or preserved in 1-2% EM-grade glutaraldehyde. The samples will be sent to Dr. Kim Juniper for analysis.

### 2.5.2 Thermophile and Hyperthermophile Microbiology:

Anaerobic thermophile and hyperthermophile media were inoculated with vent fluids ranging in temperature from 7 to 299°C. The media were incubated at 55 and 90°C. Media also were inoculated with wurtzite-and-sphalerite-rich sulfide material and *Paralvinella* sp. worms and incubated at 55 and 90°C. The numbers of viable autotrophic and heterotrophic thermophiles and hyperthermophiles in the venting fluids were determined using the three-tube most-probable-number technique and thermophile and hyperthermophile activities were measured by incubating vent fluid with $^{14}$C-leucine and $^{14}$C-bicarbonate. The incubations were at 55 and 90°C. The organisms within vent fluid aliquots were preserved with 1-2% glutaraldehyde. In most instances, the number of viable cells was below the level of detection (0.3 cells per ml) and no activity could be measured. Enrichment for thermophilic and hyperthermophilic microorganisms did result in turbid media, including one tube which was inoculated with fluid from the Floc site and showed flocculant material in the tube after 24-36 hours of incubation at 55°C. Isolation and characterization of these thermophilic and hyperthermophilic microorganisms will occur in the lab of Dr. John Baross at the University of Washington.

### 2.5.3 Macrobiology:

Most macrofauna samples from sites at North Cleft, South Cleft and CoAxial were collected and either frozen at -80°C or preserved in 1-2% EM-grade glutaraldehyde. None of the sites had been sampled extensively prior to this cruise. The samples from the Aquarius site at North Cleft, all the sites sampled at South Cleft, and the Beard site at CoAxial were composed primarily of limpets, *Ridgia* -type tubeworms and *Paralvinella* -type sulfide worms. Clam shells

were collected from Vent 1 on South Cleft. Small red non-Alvinellid worms were collected from the Floc site which had never been seen anywhere before by any of the scientists on board. One of these worms appears to have an egg mass attached to its exterior. These worms were preserved in 1-2% glutaraldehyde. A 'bag creature' also was sampled from the Floc site. This life form had been observed previously at the Cleft Segment, but is no longer at the site. This specimen was neither frozen nor preserved and will be brought to the University of Washington for analysis. Distinctive 'bottle brush' corals were collected from the Source site of the CoAxial segment. No vent-associated macrofauna was observed at the Flow site on CoAxial. The macrofauna samples will be sent to Dr. Verena Tunnicliffe at the University of Victoria for analysis.

The *Ridgia* -type tubeworms, the Paralvinella-type sulfide worms and the unknown red worms collected from the Floc site at CoAxial are unique since none of these organisms were found at the site in October 1993. It appears the organisms have colonized the region since then. Observation of the colonization of a new vent site by these macrofauna has rarely been done, if at all. A biological preserve was established at a new marker site (Marker triangle-2) at the southern end of the Floc region. A thorough SUAVE chemical (sulfide, iron, manganese and silica) and temperature survey was made of the area surrounding the marker site.

## 2.6 NIGHT OPERATIONS SUMMARY *(J. Gendron)*

### 2.6.1 CTD/Rosette

All of the objectives for the CTD/Rosette operations were successfully completed during the cruise. In addition to the planned time series work at south Cleft segment, north Cleft segment and CoAxial, one tow was made east of Axial volcano near the area of recent seismic activity. However, due to a malfunction of the rosette tripping system on that tow, only three water samples were collected there. A total of 10 'vertical' casts and 8 tow-yo's were completed at night. The following table lists the total number of samples collected for salinity (sal), nutrients (nutr), dissolved trace metals (DTM), and particulate metals (XRF):

| | sal | nutr | DTM | XRF |
|---|---|---|---|---|
| Tows + verticals | 51 | 172 | 163 | 163 |
| Niskins on dives | 34 | 68 | 32 | 76 |
| Grand Totals | 85 | 240 | 195 | 239 |

### 2.6.2 Towed Camera

Eight camera tows were conducted using the U.S. Geological Survey's autonomous camera sled whose use they contributed to the 1994 expedition. On this cruise the sled operated autonomously, remotely recording both stills and video. Height off bottom (5-10 m) was monitored acoustically while towed from the ship's trawl cable. The sled contains a 35mm system capable of recording up to 3200 frames and a video system which has two Hi8 camcorders programmed to operate at a predetermined time and duration. The tows made on the 1994 cruise were from 6-9 hours in duration and all successfully recorded 4 hours (two tapes) of video which were viewed on board. The film was developed subsequent to the cruise.

Two tows (1 and 4) were conducted south of the Plume site at south Cleft and designed to supplement the extensive data set that exists to the north. These tows revealed several new

diffuse vents associated with the center of the neovolcanic zone. Tows 2 and 3 were made within the East Blanco Depression on the western part of the Blanco Fracture Zone where a T-wave swarm in January, 1994, similar characteristics to the 1993 CoAxial event, indicated a possible eruption. These tows revealed extensive basaltic volcanism within the basin (but nothing young enough to be erupted in 1994) and an active vent. The final four tows were made in the CoAxial segment as part of an ongoing mapping program of the neovolcanic zone.

# 3.0 NAVIGATION

## 3.1 OVERVIEW

All dives were navigated using long baseline transponder nets (six separate nets) and the ALVIN in-sub program was operating on all the dives. Calibration was conducted on a transponder to transponder basis, rather than a whole net of transponders, using the ALVIN group's Minotaur program. Each transponder was calibrated by gathering data from four survey points forming a diamond shape around the transponder. Data were collected for fifteen minutes at each survey point, for a total of one hour per transponder, and then the data were crunched in a program called GPSCal. Depending on the number of transponders being calibrated, plus the transit time between each transponder, calibration could take several hours to complete, and thus was normally done at night. A significant improvement in the software and the acquisition of P-Code (undithered) GPS during the cruise led to a significant increase in the calibration accuracy relative to previous years.

ALVIN navigation was acquired in the sub (on all dives) using two transponders at a time, setting the sub's position to one side of the transponder baseline. The ALVIN's position was also monitored from the surface using the ACNAV program. Positions along navigation tracks, in the samples table, in dive summaries, etc. are reported in three different ways: ALVIN X/Y, Lat/Long, and UTM X/Y. Each navigation net contains a set number of transponders and has assigned to it an "origin", listed below in both lat/long and UTM X/Y coordinates. The origins were chosen to be south and west of the dive area in question so that the ALVIN X/Y's would all be positive values for that area. ALVIN X/Y's were converted to Lat/Long by the ALVIN group's program called Makelat. The origin for a particular dive area is entered into this program, along with a navigation file containing data reported in time, ALVIN X and ALVIN Y. The program then converts the X/Y's to lat/long, keeping the time signature. An example of such a conversion would be as follows: In the **North Cleft Net** *Vent Areas* , an ALVIN X/Y position of 0/0 would be equal to a Makelat Lat/Long of 44° 57.47'N/130° 13.79'W, and any position with X/Y values greater than zero would be found to the North and East of 44° 57.47'N/130° 13.79'W.

## 3.2 FINAL CALIBRATED POSITIONS

**North Cleft Nets:**

*Vent Areas (Aquarius/Fountain/Monolith/Pipe Organ):*
Origin: 44°57.47'N/130°13.79'W (403000X/4979000Y UTM)

| Transponder | ALVIN-X | ALVIN-Y | ALVIN-Z | Makelat Lat/Long |
|---|---|---|---|---|
| 10.0kHz(G) | 3657.6 | 6257.7 | 2128.3 | 45°00.849'N/130°11.009'W |
| 10.5kHz(D) | 3163.8 | 4077.0 | 2091.8 | 44°59.671'N/130°11.384'W |
| 11.5kHz(H) | 3371.6 | 2937.9 | 2122.5 | 44°59.056'N/130°11.226'W |
| 12.5kHz(E) | 1620.5 | 3082.5 | 2114.2 | 44°59.134'N/130°12.558'W |
| 9.5kHz(C) | 1115.7 | 2262.2 | 2123.0 | 44°58.691'N/130°12.942'W |
| 13.0kHz(F) | 669.4 | 867.7 | 2118.9 | 44°57.938'N/130°13.281'W |
| (9.5 recovered/redeployed to replace 10.5 in the Fountain area due problems with the 10.0 for Dive 2781) | | | | |
| 9.5kHZ(C) | 3220.6 | 4508.5 | 2110.6 | 44°59.904'N/130°11.341'W |

*New Lava Mounds Area:*
Origin: 45°4.522'N/130°10.891'W (407000X/4992000Y UTM)

| | | | | |
|---|---|---|---|---|
| 9.5kHz(B) | 3120.9 | 3459.2 | 2138.5 | 45°06.390'N/130°8.513'W |
| 10.5kHz(D) | 2645.3 | 1222.7 | 2149.5 | 45°05.182'N/130°8.875'W |

**South Cleft Nets:**

*All Areas:*
Origin: 44°38'N/130°24.0'W (388957X/4943171Y)

| | | | | |
|---|---|---|---|---|
| 9.5kHz(C) | 4284.2 | 5761.3 | 2081.1 | 44°41.111'N/130°20.760'W |
| 10.0kHz(D) | 3675.7 | 3848.2 | 2060.2 | 44°40.078'N/130°21.221'W |
| 10.5kHz(E) | 3196.8 | 2268.3 | 2058.5 | 44°39.225'N/130°21.583'W |
| 11.0kHz(H) | 2513.9 | 542.3 | 2058.4 | 44°38.293'N/130°22.099'W |

**CoAxial Nets:**

*Flow Area:*
Origin: 46°28.493'N/129°37.516'W (452000X/5147000Y)

| | | | | |
|---|---|---|---|---|
| 9.5kHz(C) | 2568.8 | 5465.2 | 2297.0 | 46°31.443'N/129°35.509'W |
| 10.0kHz(D) | 3480.8 | 7353.7 | 2255.8 | 46°32.462'N/129°34.797'W |
| 10.5kHz(E) | 5184.1 | 6267.1 | 2329.0 | 46°31.876'N/129°33.466'W |

*Floc Area:*
Origin: 46°14.931'N/129°47.480'W (439001X/5121999Y)

| | | | | |
|---|---|---|---|---|
| 9.5kHz(B) | 7954.7 | 7219.4 | 2093.4 | 46°18.828'N/129°41.291'W |
| 10.5kHz(D) | 7160.7 | 5609.4 | 2115.4 | 46°17.959'N/129°41.909'W |

*Source Area:*
Origin: 46°05.718'N/129°52.006'W (433000X/5104999Y)

| | | | | |
|---|---|---|---|---|
| 11.5kHz(X) | 5240.8 | 6986.3 | 1967.0 | 46°09.489'N/129°47.940'W |

(11.5X is the expendible RIDGE transponder and this is its October 1993 calibrated position)

| | | | | |
|---|---|---|---|---|
| 11.0kHz(H) | 4863.8 | 5642.1 | 1968.4 | 46°08.764'N/129°48.232'W |

**.NIT Files (Parameter files used for ACNAV)**

| .NIT | Net | Area | Dives | Transponder Freq. |
|---|---|---|---|---|
| 131-16AS | N.Cleft | Monolith/Aquarius | 2775/2778 | 10.0/10.5/11.5 |
| 131-16BS | N.Cleft | M2/Pipe Organ | 2776/2777/2780 | 12.5/9.5/13.0 |
| 131-16CS | N.Cleft | Mounds | 2779 | 09.5/10.5 |
| 131-16DF | N.Cleft | | CTD | |
| 131-16ES | N.Cleft | Fountain/Aquarius | 2781 | 10.0/9.5/11.5 |
| 131-16FS | N.Cleft | | CTD (not used) | |
| 131-16GS | S.Cleft | Vent 3 | 2782/2784 | 9.5/10.0/10.5 |
| 13116HS | S.Cleft | Vent1/Plume | 2783/2785/2786 | 11.0/10.0/10.5 |
| 131-16IS | CoAxial | Source | 2787/2790 | 11.5/11.0 |
| 131-16JS | CoAxial | Flow | 2788/2792/2794 | 9.5/10.0/10.5 |
| 131-16KS | CoAxial | Floc | 2789/2791/2793 | 9.5/10.5 |

**Final At-Sea Navigation File Information**

Original indicates values as logged in-sub during dive with bad and some duplicates removed; replay indicates file was reconstructed post-dive due to some problem with original X/Y's.

| Dive | Status | Comment |
|---|---|---|
| 2775 | replay | Logger used "new" depth; replay used "old" depth; gap10:17-10:23. |
| 2776 | original | Switch of transponder pair gave a jump in X of 120m at 14:40:45. |
| 2777 | original | Need replay at beginning to recover dive up to 09:40. |
| 2778 | original | Initially in-sub using wrong transponder pair. |
| 2779 | original | Fairly clean. |
| 2780 | replay | Major reconstruction, transponder switching and a lot of bad nav. |
| 2781 | original | Clean, small gap 12:06-12:12:30. |
| 2782 | replay | Clean, small gap at end of dive. N. Cleft instead of S Cleft origin was entered in in-sub computer, so original Lat/Lngs wrong. |
| 2783 | replay | No original nav due to computer crash; replay poor. |
| 2784 | original | Clean. |
| 2785 | replay | Used other transponder pairs to fill in some small gaps. |
| 2786 | original | Clean. |
| 2787 | original | Clean (targets were offset from 1993 by 40X and -50Y), gap at beginning. |
| 2788 | original | Clean (targets were offset from 1993 by 50X and -65Y). |
| 2789 | original | Clean (targets matched 1993 fairly well), gap at 10:47 in fissure. |
| 2790 | original | Clean, major gaps in fissures. |
| 2791 | original | Clean, gaps in fissures on East wall. |
| 2792 | replay | Clean, gaps at end of dive over 82-91 flow. Replayed with new transponder positions from 2794 post-processing. |
| 2793 | original | Clean; gap 11:31:45-11:49:00. |
| 2794 | replay | Baseline problem in original; transponder positions moved and dive replayed. |

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# OPERATIONS SUMMARY

| DAY | | | | NIGHT | | |
|---|---|---|---|---|---|---|
| Date | Dive # | Location | Divers | Tow-Yo CTD/ Camera | Cast | Locations |
| 18-Jun-94 | 2775 | Monolith | Butterfield & Gendron | | | |
| 19-Jun-94 | 2776 | Monolith to Pipe Organ | Massoth & Grieves | | | |
| 20-Jun-94 | 2777 | Pipe Organ | Trefry & Metz | 94CAM1 | | S Cleft |
| 21-Jun-94 | 2778 | Fountain to Mounds 1 | Embley & Koski | | S94B01 | N Cleft |
| 22-Jun-94 | 2779 | Mounds 5 & 6 | Chadwick | | S94B02,2R | N Cleft |
| 23-Jun-94 | 2780 | Pipe Organ & Monolith | Butterfield & LeBon | T94B01 | S94B03,4 | N Cleft |
| 24-Jun-94 | 2781 | Aquarius & Fountain | Bobbitt & Lupton | T94B03 | S94B05 | S Cleft |
| 25-Jun-94 | 2782 | Vent 3 | Massoth & Perfit | | | |
| 26-Jun-94 | 2783 | Vent 1 | Butterfield | 94CAM2 | | E Blanco Depression |
| 27-Jun-94 | 2784 | Vent 3 | Trefry & Trocine | 94CAM3 | | E Blanco Depression |
| 28-Jun-94 | 2785 | Plume | Lupton & Roe | T94B04 | S94B06 | S Cleft |
| 29-Jun-94 | 2786 | Vent 1 | Metz & Koski | 94CAM4 | S94B07 | S Cleft |
| 30-Jun-94 | 2787 | Source Site | Embley & Holden | | S94B08 | CoAxial |
| 01-Jul-94 | 2788 | Flow Site & Mooring | Ferioli & Getsiv | T94B05 | | CoAxial |
| 02-Jul-94 | 2789 | Floc Site | Chadwick | T94B06 | | Axial |
| 03-Jul-94 | ********** no Alvin dive ********** | | | T94B07,94CAM5 | S94B09 | CoAxial |
| 04-Jul-94 | 2790 | Source Site | Chezar & Lupton | 94CAM6 | | Axial |
| 05-Jul-94 | 2791 | Floc Site | Holden & Massoth | T94B08 | S94B09R | CoAxial |
| 06-Jul-94 | 2792 | Flow Site | Chadwick & Perfit | | | |
| 07-Jul-94 | 2793 | Floc Site | Devany & Embley | 94CAM7 | S94B10 | CoAxial |
| 08-Jul-94 | 2794 | Flow Site | Perfit | 94CAM8 | | CoAxial |

# VENTS/MARKERS SUMMARY TABLE

## CLEFT SEGMENT

### NORTH CLEFT

VENT POSITIONS (known active vents as of 1994)

| Vent | Found year | Found vehicle | Found dive # | | Position determined year | Position determined vehicle | Position determined dive # | | x | y | z | lat | long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AQUARIUS VENT | 1994 | ALVIN | 2778 | | 1994 | ALVIN | 2778 | 14:58 | 405937 | 4984210 | 2269 | 45° 00.307' | 130° 11.614' |
| FOUNTAIN VENT | 1991 | ALVIN | 2429 | | 1994 | ALVIN | 2781 | 09:35 | 405527 | 4983027 | 2255 | 44° 59.665' | 130° 11.913' |
| TABLE I VENT | 1990 | ALVIN | | | 1994 | ALVIN | 2775* | * | 405333 | 4982577 | 2253 | 44° 59.420' | 130° 12.055' |
| TABLE II VENT | 1990 | ALVIN | | | 1994 | ALVIN | 2775* | * | 405333 | 4982577 | 2253 | 44° 59.420' | 130° 12.055' |
| MONOLITH VENT | 1990 | ALVIN | 2258 | | 1994 | ALVIN | 2775 | 11:37 | 405331 | 4982065 | 2258 | 44° 59.414' | 130° 12.057' |
| CAVERN VENT | 1988 | ALVIN | 2077 | | 1994 | ALVIN | 2776 | 10:10 | 405036 | 4981866 | 2272 | 44° 59.034' | 130° 12.273' |
| PIPE ORGAN VENT | 1991 | ALVIN | 2437 | | 1994 | ALVIN | 2776 | 14:56 | 404377 | 4980407 | 2280 | 44° 58.241' | 130° 12.758' |

*positions calculated based on relation to Monolith Vent

MARKER POSITIONS

| Marker | location/ description | Deployed year | Deployed vehicle | Deployed dive # | | Position determined year | Position determined vehicle | Position determined dive # | | x | y | z | lat | long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 (triangle) | AQUARIUS - Single sulfide mound with diffuse venting | 1994 | ALVIN | 2778 | | 1994 | ALVIN | 2778 | 14:34 | 405940 | 4984210 | 2268 | 45° 00.307' | 130° 11.612' |
| 44 | At extinct sulfides northeast of FOUNTAIN | 1991 | ALVIN | 2435 | 14:29 | 1991 | ALVIN | 2435 | 14:29 | 405756 | 4983581 | 2252 | 44° 59.966' | 130° 11.745' |
| 42 | Next to FOUNTAIN | 1991 | ALVIN | 2435 | 11:02:40? | 1994 | ALVIN | 2781 | 09:35 | 405503 | 4983029 | 2247 | 44° 59.666' | 130° 11.931' |
| 880-8812 | At FOUNTAIN - small markers for biology | 1993 | ROPOS | hys229 | 13:27-20:35 | 1994 | ALVIN | 2781 | * | 405527 | 4983027 | 2255 | 44° 59.665' | 130° 11.913' |
| 10 | MONOLITH east side | 1990 | ALVIN | 2261 | no notes | 1994 | ALVIN | 2780 | 13:10 | 405321 | 4982541 | 2260 | 44° 59.401' | 130° 12.064' |
| 11 | MONOLITH west side | 1990 | ALVIN | 2261 | no notes | 1994 | ALVIN | 2780 | 13:10 | 405321 | 4982541 | 2260 | 44° 59.401' | 130° 12.064' |
| 2 | On lava spire few m's west of CAVERN | 1988 | ALVIN | 2077 | | 1994 | ALVIN | 2776 | 10:10 | 405036 | 4981866 | 2272 | 44° 59.034' | 130° 12.273' |
| M | On DIFFUSE VENT a few m's east of main fissure | 1990 | ALVIN | 2267 | 12:55 | 1991 | ALVIN | 2443 | 11:45:45-12:04 | 404895 | 4981540 | 2262 | 44° 58.857' | 130° 12.377' |
| 8 | On extinct sulfide chimney west of main fissure | 1988 | ALVIN | 2094 | | 1994 | ALVIN | 2780 | 11:38 | 404821 | 4981515 | 2269 | 44° 58.843' | 130° 12.433' |
| 4 | On DIFFUSE VENT just west of main fissure | 1988 | ALVIN | 2077 | 14:53 | 1994 | ALVIN | 2776 | 13:09 | 404837 | 4981372 | 2274 | 44° 58.766' | 130° 12.419' |
| 3 | TRIPOD (extinct-1991) ~10 m north from M6 along fissure through young sheet flow | 1988 | ALVIN | | | 1991<br>1991 | ALVIN<br>ALVIN | 2437<br>2443 | 14:14:45(see them) | | | 2277 | | |
| 6 | TRIPOD - On fissure at site of tripod flow monitor (deployed and recovered 1988) | 1988 | ALVIN | | | 1994 | ALVIN | 2776 | 13:44 | 404297 | 4980521 | 2281 | 44° 58.302' | 130° 12.820' |
| 40 (foam block) | PIPE ORGAN - 5 m east of vent | 1991 | ALVIN | 2437 | 13:00 | 1994 | ALVIN | 2777 | 09:32 | 404378 | 4980399 | 2279 | 44° 58.237' | 130° 12.757' |
| 46 | Only lead weight, which was retrieved by ROPOS during dive | 1991 | ALVIN | 2431 | no notes | 1991 | ALVIN | 2444 | 09:31 | 404169 | 4979532 | 2270 | 44° 57.766' | 130° 12.906' |
| 1 | DIFFUSE VENT - Near eruptive fissure on southeastern part of young sheet flow | 1988 | ALVIN | 2076 | 14:06 | 1991 | ALVIN | 2444 | 13:29 | 403843 | 4978331 | 2274 | 44° 57.116' | 130° 13.141' |
| 22 | Diffuse vent (almost extinct 1993) | 1990 | ALVIN | 2264 | 12:48 | 1990 | ALVIN | 2264 | 12:48 | 402698 | 4974763 | 2280 | 44° 55.180' | 130° 13.970' |

### SOUTH CLEFT

VENT 3 MARKER POSITIONS

| Marker | location/ description | Deployed year | Deployed vehicle | Deployed dive # | | Position determined year | Position determined vehicle | Position determined dive # | | x | y | z | lat | long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .+ (circle) | Hydrothermal mound along west wall of cleft | 1984 | ALVIN | | | 1994 | ALVIN | 2782 | 11:10 | 392767 | 4948668 | 2249 | 44° 41.003' | 130° 21.188' |
| 3- (rectangle) | Valley floor east of cleft | 1984 | ALVIN | | | 1984 | ALVIN | USGS | | 392721 | 4948292 | | 44° 40.800' | 130° 21.218' |
| 8- (rectangle) | Small lopsided conical chimney visible from marker 1- | 1987 | ALVIN | | | 1987 | ALVIN | USGS | | 392670 | 4948290 | | 44° 40.798' | 130° 21.256' |

VENT 1 MARKER POSITIONS

| Marker | location/ description | Deployed year | Deployed vehicle | Deployed dive # | | Position determined year | Position determined vehicle | Position determined dive # | | x | y | z | lat | long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 (rectangle) | Inactive sulfide atop basalt column | 1984 | ALVIN | | | 1984 | ALVIN | USGS | | 392127 | 4946807 | | 44° 39.993' | 130° 21.649' |
| ? (rectangle) | Near a smoking chimney, "vik" on side of marker covered with "slime" | | | | | 1994 | ALVIN | 2783 | ~13:20 | 391861 | 4945998 | | 44° 39.553' | 130° 21.840' |
| 1/ (rectangle) | 283°C black smoker | 1984 | ALVIN | | | 1984 | ALVIN | USGS | | 391826 | 4945987 | | 44° 39.547' | 130° 21.866' |
| 12 (triangle) | Two ~340°C chimneys joined at base | 1994 | ALVIN | 2783 | 09:56 | 1994 | ALVIN | 2786 | 09:56 | 391828 | 4945963 | 2222 | 44° 39.534' | 130° 21.864' |
| /0 (rectangle) | Small chimneys within couple meters of base of 9m chimney | 1984 | ALVIN | | | 1984 | ALVIN | USGS | | 391783 | 4945934 | | 44° 39.518' | 130° 21.898' |
| 1 (circle) | Low temp vents with biology | | ALVIN | | | | ALVIN | USGS | | 391669 | 4945601 | | 44° 39.337' | 130° 21.980' |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .- (circle) | Sparse field of tubeworms & clam shells in hydrothermal sediment | 1984 | ALVIN | | | 1994 | ALVIN | 2783 | 09:45 | 391706 | 4945589 | | 44° 39.331' | 130° 21.952' |
| 2/ | In cleft near west wall, non-vent area | 1984 | ALVIN | | | 1994 | ALVIN | 2785 | 13:35 | 391660 | 4945408 | 2234 | 44° 39.233' | 130° 21.984' |

PLUME MARKER POSITIONS

| Marker | location/ description | Deployed year | vehicle | dive # | | Position determined year | vehicle | dive # | | x | y | z | lat | long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1V (rectangle) | Inactive sulfide chimney at northern end of PLUME SITE | 1984 | ALVIN | | | 1984 | ALVIN | USGS | | 391300 | 4944357 | | 44° 38.661' | 130° 22.243' |
| 8X (rectangle) | Large area of active black smokers on a shelf inside the cleft | 1984 | ALVIN | | | 1984 | ALVIN | USGS | | 391192 | 4944116 | | 44° 38.531' | 130° 22.322' |
| 1X (rectangle) | Just east of the east wall of the cleft | 1984 | ALVIN | | | 1984 | ALVIN | USGS | | 391123 | 4943888 | | 44° 38.407' | 130° 22.371' |

# COAXIAL SEGMENT

## FLOW SITE MARKERS

| Marker | location/ description | Deployed year | vehicle | dive # | | Position determined year | vehicle | dive # | | x | y | z | lat | long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 (triangle) | On top of small constructional hill in center of fissure | 1994 | ALVIN | 2794 | ~12:30 | 1994 | ALVIN | 2794 | ~12:30 | 456586 | 5154498 | 2460 | 46° 32.560' | 129° 33.974' |
| 13 (bucket lid) | Extensive floc/mats on new flow | 1993 | ALVIN | 2670 | 14:41 | 1993 | ALVIN | 2670 | 14:41 | 455652 | 5152934 | 2398 | 46° 31.712' | 129° 34.696' |
| 6A (square) | 1993 once venting area of new flow | 1993 | ALVIN | 2670 | 14:11 | 1994 | ALVIN | 2788 | 13:48 | 455622 | 5152721 | 2393 | 46° 31.597' | 129° 34.718' |
| 0 (triangle) | 1993 venting area area of new flow | 1993 | ALVIN | 2670 | 13:07 | 1994 | ALVIN | 2788 | 12:48 | 455518 | 5152455 | 2389 | 46° 31.453' | 129° 34.798' |
| 7A (square) | West of flow ridge, thick mats, yellow pptes | 1993 | ALVIN | 2670 | 10:40 | 1994 | ALVIN | 2788 | 13:18 | 455495 | 5152430 | 2395 | 46° 31.439' | 129° 34.816' |
| P1 | DIFFUSE VENTING area in fresh lava | 1993 | ROPOS | hys234 | 11:10 | 1993 | ROPOS | hys234 | 11:10 | 455454 | 5152400 | 2380 | 46° 31.423' | 129° 34.846' |
| 4A (square) | Old lava | 1993 | ALVIN | 2672 | 10:23 | 1993 | ALVIN | 2672 | 10:23 | 455118 | 5152382 | 2422 | 46° 31.412' | 129° 35.11' |
| Y10 | Sulfur-stained drainouts in new lava | 1993 | ROPOS | hys219 | 22:52 | 1993 | ROPOS | hys219 | 22:52 | 455496 | 5152296 | 2379 | 46° 31.367' | 129° 34.814' |
| 11 (bucket lid) | Extensive mats | 1993 | ALVIN | 2672 | 12:30 | 1993 | ALVIN | 2672 | 12:31 | 455376 | 5152288 | 2383 | 46° 31.362' | 129° 34.908' |
| 14 (bucket lid) | Minor staining | 1993 | ALVIN | 2672 | 11:58 | 1993 | ALVIN | 2672 | 11:58 | 455401 | 5152280 | 2397 | 46° 31.358' | 129° 34.889' |
| Y2 | Alterations/new fractures in fresh lava | 1993 | ROPOS | hys221 | 05:16 | 1993 | Ship | hys221 | 05:16 | 455049 | 5151449 | 2371 | 46° 30.907' | 129° 35.159' |
| Y15 | Weak venting, floc, new pillows | 1993 | ROPOS | hys221 | 04:26 | 1993 | ROPOS | hys221 | 04:28 | 455062 | 5151144 | 2358 | 46° 30.743' | 129° 35.147' |
| 5A (square) | Diffuse vent site, old lava, in graben | 1993 | ALVIN | 2671 | 13:21 | 1993 | ALVIN | 2671 | 13:43 | 454796 | 5150855 | 2395 | 46° 30.586' | 129° 35.353' |

## FLOC SITE MARKERS

| Marker | location/ description | Deployed year | vehicle | dive # | | Position determined year | vehicle | dive # | | x | y | z | lat | long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 (triangle) | SNOWBLOWER VENT | 1993 | ALVIN | 2676 | 13:45 | 1993 | ALVIN | 2676 | 13:45 | 445997 | 5130080 | 2299 | 46° 19.330' | 129° 42.090' |
| 9 (triangle) | At high point 30m W of vent | 1993 | ALVIN | 2676 | 11:52 | 1993 | ALVIN | 2676 | 11:52 | 445719 | 5129227 | 2234 | 46° 18.868' | 129° 42.301' |
| 11 (triangle) | Small mound in front of DIFFUSE VENT | 1993 | ALVIN | 2676 | 11:40 | 1994 | ALVIN | 2789 | 13:20 | 445812 | 5129171 | 2239 | 46° 18.838' | 129° 42.228' |
| 3A (square) | Old pillows, extensive mats | 1993 | ALVIN | 2673 | 13:53 | 1994 | ALVIN | 2789 | 10:58 | 445519 | 5128653 | 2241 | 46° 18.557' | 129° 42.453' |
| 2 (triangle) | 4-5m below rim of fissure on the gently sloping talus near the fissure | 1994 | ALVIN | 2791 | 13:00 | 1994 | ALVIN | 2791 | 13:00 | 445424 | 5128376 | 2287 | 46° 18.407' | 129° 42.525' |
| 6 (triangle) | On the west rim of fissure above Marker 2 | 1994 | ALVIN | 2791 | ~14:17 | 1994 | ALVIN | 2791 | ~14:17 | 445424 | 5128376 | 2285 | 46° 18.407' | 129° 42.525' |
| 10 | Active DIFFUSE VENT | 1994 | ALVIN | 2793 | 10:52 | 1994 | ALVIN | 2793 | 10:52 | 445276 | 5128033 | 2276 | 46° 18.221' | 129° 42.638' |

## SOURCE SITE VENTS

| Vent | Found year | vehicle | dive # | | Position determined year | vehicle | dive # | | x | y | z | lat | long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONGO VENT | 1994 | ALVIN | 2787 | 12:00 | 1994 | ALVIN | 2787 | 12:00 | 437474 | 5111608 | 2053 | 46° 9.312' | 129° 48.586' |
| CHURCH VENT | 1993 | ALVIN | 2681 | 13:07 | 1994 | ALVIN | 2787 | 12:36 | 437456 | 5111571 | 2065 | 46° 9.292' | 129° 48.599' |
| BEARD VENT | 1993 | ALVIN | 2681 | 11:32 | 1994 | ALVIN | 2787 | 09:38 | 437443 | 5111538 | 2058 | 46° 9.274' | 129° 48.609' |

## SOURCE SITE MARKERS

| Marker | location/ description | Deployed year | vehicle | dive # | | Position determined year | vehicle | dive # | | x | y | z | lat | long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | On a small basalt mound, 3-4m south of MONGO VENT | 1994 | ALVIN | 2787 | 11:42 | 1994 | ALVIN | 2787 | 11:42 | 437468 | 5111601 | 2055 | 46° 9.308' | 129° 48.590' |
| 8A | North side of CHURCH VENT | 1993 | ALVIN | 2681 | 13:07 | 1994 | ALVIN | 2787 | 09:42 | 437451 | 5111558 | 2058 | 46° 9.285' | 129° 48.603' |

# CLEFT SEGMENT:
# NORTH CLEFT

# NORTH CLEFT
# DIVE SUMMARIES

**Video set-up for all dives:**

high 8 mm recorder #1: recorded video from the 3-chip camera, the two Alvin color 1-chip cameras and the black/white down-looking sit camera.

high 8 mm recorder #2: recorded the 3-chip camera exclusively.

*All depths are TOTAL water depth, unless otherwise noted.

## DIVE 2775: Monolith Vent

June 18, 1994
Pilot: Matt Heintz
Port Observer: Dave Butterfield (author of this transcript)
Stbd. Observer: Jim Gendron

Objectives:

Time series sampling of fluids, particles, and sulfides from Monolith. We wanted to sample and measure temperatures on a s many of the high-temperature chimneys on Monolith as possible. This dive was the first of a series intended to sample all the known high-temperature sites on the Cleft segment: Fountain, Monolith, Pipe Organ, Vent 3, Plume, and Vent 1.

Dive Summary:

08:28 in water.
08:55 manifold sampler checked out ok.
09:40 touched down on the seafloor, 2205x/3340y.

Station 1 We dropped very near a contact between fresh and old lava, with newer lava to the west. Our drop target was SE of Monolith Vent, so we tried to work our way along the contact to the north. Lost sight of the newer lava after a few minutes, kept driving north and slightly west.
10:06 Now on older sheet flow, passed a large fissure to port. Total depth 2264.
10:10 Surface called down that we were about 100 m from target bearing 020. We changed our heading to ~015, following the trend of a fissure. 2137x/3303y/2262 m.
10:23 Passing extinct sulfides, heading 339. Came upon a dive weight shortly afterward. We came up out of the large fissure that we had followed for more than 100 m, over a ridge on an eastward heading. We had to come up about 20-30 meters (to depth 2245) out of the one large fissure (25 m wide) with a steep wall to our west, then down into a parallel fissure (about 20 m wide). After coming over the ridge down into the parallel fissure, we soon came upon some rope on the bottom of the fissure. I guessed that this was the remains of a sediment trap mooring that had been deployed just SW of Monolith. We then drove up a block of basalt NE for a bout 15 m and found the vent. (Didn't find out until 12:15 that the gyro was not working. This probably caused considerable confusion in trying to locate the target. Perhaps the gyro was working at first, in which case we were confused of our own accord.) Our in-sub fix at Monolith is 2280/3593. Target was 2228/3597.

Station 2 Niskin sampling over Monolith.
10:45:56 tripped forward Niskin 1 mav at Monolith (2281x/3591y).
10:46:25 tripped middle Niskin 3 mav (2283x/3593y).

10:47:00 tripped aft Niskin 7 mav (2284x/3593y).

Following the Niskin samples we circled around and did a video survey of Monolith, then tried to find what had previously been the hottest vent, located on the SW side near the base.

Station 3 11:30 positioning for water sampling at first chimney, 2279/3597, depth 2256 m. Measured temperature with the Alvin probe at max 308°C.

11:37 took double major with 2 blue stripes (D5 and D16) at 2279x/3599y. One bottle filled more quickly than the other.

11:41 took piece of sulfide from in front of chimney that we sampled at 2278x/3597y. This piece was not part of the actively venting chimney from which we sampled fluids.

11:53 Took discrete gas-tight sample black #7, in same orifice (2279x/3600y). Tried to take manifold samples here, but could not keep the sub stable. We moved away and could not get back to this vent.

Station 4 Moved to the SE to a second smoker on the southern end of Monolith, sub depth 2255 m, total 2260 m, 2282x/3593y.

12:28 Took double major (D15 and D6) in second black smoker orifice on southern end. This was a beehive, excavated prior to sampling. Temperature 285°C.

Some fragments of this beehive fell into the front starboard part of the basket while we were sampling. At this point the gyro indicated a heading of 294 while the magnetic compass gave 060. I tried to ignore the gyro after this discovery, and ask the pilot for magnetic headings periodically.

13:10 Put a piece of smoker in middle of the basket (not in either milk crate). Sample was dark gray on exterior.

Pilot could not pick up the last discrete sampler. we tried to get in position to use the manifold sampler, but had difficulties. Manifold sampler arm was dropped, and the temperature probe cable was broken off while picking up the arm. At this point we were low on power.

Station 5 x/y 2283/3582. We triggered all three bottles on the manifold to test them and collect background water. These samples contained chimney debris from the attempt at using the manifold at the Station 4 chimney.

~13:30 Weights away

## DIVE 2776: Cavern to Pipe Organ Vent

June 19, 1994
Pilot: Bob Grieve
Port Observer: Bob Trocine
Stbd. Observer: Gary Massoth (author of this transcript)

General Objectives:

This dive repeats seafloor observations made in 1988, 1990, and later during ALVIN dive 2443 (1991) and ROPOS dive 232 (1993). On the latter two dives, the PMEL SUAVE chemical scanner was used as it was here, thus providing a three-point time series that extends over 4 years for continuous heat and chemical venting assessments made directly on the seafloor. A major objective was therefore to observe temporal changes in the thermochemical properties of fluids being vented at north Cleft segment. This is important because recent literature estimates for heat and chemical fluxes at north Cleft segment suggest that about two-thirds of the heat, one-third of the total Mn, and substantial amounts of Fe are vented by diffuse flow (Baker *et. al, EPSL,* 1993).

SUAVE measurements of all of these critical properties were made during each of the three deployments. Hydrogen sulfide, a critical and limiting chemical for many biological species found at vents was also measured during this dive (and in 1993). Other objectives were to observe changes in biological community along the dive path and to establish the position of Pipe Organ vent within the navigation net being used for this dive series. If time permitted, a video survey of Pipe Organ, measures of high-temperature fluid temperatures, and collection of those fluids both at vent orifices and with the rising plume were planned.

Dive Chronology:

ALVIN was lowered into the water at 0825 and was on the bottom at 0931 at approximate coordinates 2115x/2851y, depth 2241 (corrected algorithm)/2251 (old algorithm, seen on video overlay). We drove approximately 120 m NW to our first target at Marker 2 (Cavern Vent), located on the system of en echelon fissures that were to be our guide south to the Pipe Organ vent site. Marker 2 was located at 1994x/2900y on the west wall overlooking the Cavern vent, located at the base of a narrow (ALVIN width) depression at depth 2273 m. Shimmering water was observed in several places, usually near clumps of what looked like dead tubeworms that were black in color. Facing north we sampled this flow with SUAVE from about 1010 to 1034 with a maximum temperature of about 13°C. No hydrogen sulfide was detected although about 20 µmol Mn and < 5 µmol Fe were sensed. Insufficient flow was observed to justify using the manifold sampler at this site, and other sites that were visible required repositioning ALVIN to face south, which was done (1992x/2895y, 2272 m). A preliminary SUAVE survey of this more vigorous diffuse flow at about 1100 gave a higher temperature of 17°C, a maximum hydrogen sulfide concentration of about 30µmol, Mn 25µmol, and Fe 15µmol. The submersible stirred-up bottom sediments so greatly that it was not possible to see to sample with the manifold sampler. Therefore, further sampling at this site was aborted and we began our trek south along the fissure system. We continued to observe shimmering water, but in such diffuse volumes that sampling was not possible at several places where we briefly settled. Just south of Cavern we observed an area of what appeared to be fractured and altered basalts where we collected one small piece at 1993x/2913y, 2272 m. We continued southwest to our next target (Marker M, 1858x/2569y) where we observed a light coating of white bacterial mat surrounding numerous dead (?) tubeworms. This site looked like the area sampled in 1991 as Marker M, but the coordinates were slightly different from the target (1867x/2558y, 2259 m). It is possible that the offset in the navigation net (-100 m X/-30 m Y at Pipe Organ vent) could account for the position disparity. No other venting was observed nearby the Marker M site sampled at 1216 h with SUAVE (maxima: ~16°C, 45µmol hydrogen sulfide, 22µmol Mn, and <5µmol Fe. A major sample (port manifold, at 1228 h, 11.3-13.5°T1, 8.8-9.8°T2) and a gas-tight sample (starboard manifold, 1231 h, 13.2°T1, 11.1°T2) were also collected at the Marker M site. We then continued southwest to the Marker 4 site at 1802x/2401y, which was also marked by the white bacterial mat. At 1309 we performed our third SUAVE survey with a maxima of ~15°C, 45µmol hydrogen sulfide, 25 µmol Mn, and 10 µmol Fe. Numerous blips along the dive path other than those noted above were detected for heat and chemistry, but none were as large as the measurements at the three stop points. After leaving the Marker 4 site we continued to follow the fissure until losing sight of it in a lobate flow just before coming on to the western edge of the Tripod vent site, which was identified first by the moderate covering of iron oxyhydroxide sediments on the sheet flow and second by the siting of Marker 6 (flag with lead weight) mostly covered with biology (1275x/1542y, 1344 h). From here we proceeded about 100 m directly south where we observed current meter mooring M80 deployed nearest to the Pipe Organ vent by Glenn Cannon (1239x/1473y). After this, we continued to the coordinates of the nav net target for Pipe Organ. We passed through these coordinates three times and saw only old lobates suggesting that we were east of the contact on which the vent was located. We then searched to the west, crossing the contact but not seeing the collapse area that brackets the Pipe Organ vent per my previous visit to this site. We then searched north, still finding little. At 1427 h we came upon a relict chimney of 2-4 m height at coordinates 1274x/1364y. This was in an area southwest of Marker 6, which I knew was a correct relation, thus discarding the nav net. We began coming back into more patches

of hydrothermal sediment. Finally, at 1433 we changed nav nets to use B-C vs. the A-B pair we had been using exclusively until this point. At about 1448 (1368x/1438y) we came onto Pipe Organ and at 1459 the dive ended. In those 11 minutes we conducted a brief video survey of paired 10-11 m tall sulfide structures with much biological life and a beehive top structure (1355x/1429y, top 2268 m). We tripped Niskins at 1 m, 3 m, 5 m, and 10 m above the vent top, drifting out of heavy smoke after the 1 m sample and w-sw with the buoyant plume.

## DIVE 2777: Pipe Organ Vent

June 20, 1994
Pilot: Pat Hickey
Port Observer: John Trefry (author of this transcript)
Stbd. Observer: Simone Metz

Objectives:

1. Deploy the SUAVE chemical scanner at the base of Pipe Organ vent.
2. Survey around Pipe Organ noting the chimney count and heights.
3. Take Niskin samples in the plume above Pipe Organ
4. Take three Single Majors, two single Gas-Tights, one Paired Major in a chimney.
5. Take three Majors and two Gas-Tights with the Manifold sampler in a chimney.
6. Take sulfide samples of chimney pieces.
7. Collect basalt samples in both the old pillows region above the lava lake and a piece of the crust from the new lobate sheet flow.

Dive Summary:

The dive began at 0817 on June 20, 1994 and we reached bottom at 2281 m (x 1227, y 1397) at 0920. We then headed east toward Pipe Organ vent, traveling across a terrain of basalt sheet flow. At 0932, Marker 40 was observed from the starboard side and the Pipe Organ chimneys were visible from the forward porthole. We set down on the bottom at Marker 40 and checked the position of Marker 40 using (a) the 9.5 and 13.0 transponders (x 1368, y 1427) and (b) the 9.5 and 12.5 transponders (x 1228, y 1397). Marker 40 is on a ledge above a collapsed pillow mound to the east of the Pipe Organ vents. Diffuse venting was observed throughout the ledge area.

The Marker 40 site seemed ideal for deployment of SUAVE. A temperature check using the ALVIN probe indicated temperatures of 20-30°C at the surface of a crack from which diffuse flow was emanating. A maximum temperature of 56°C was measured at a depth of about 20-30 cm in the crack. SUAVE ("Proud Gary") was deployed at 1004 at x 1364 and y 1426 with the intake wand adjacent to the unit in shimmering water. We left "Proud Gary" bathed in warm waters at the Edge of the Ledge with an excellent view of Pipe Organ vent.

A survey of the Pipe Organ vent field showed 6 chimneys, all with varying degrees of venting; the tallest structure was 6.8 m high. The chimneys are aligned along a NNE-SSW trajectory. We numbered the chimneys I-IV from south to north. We then sampled the plume above the second chimney from the south (Chimney II) with Niskin samplers at 0.5, 3 and about 10 m above the vent, with the plume wafting to the north. Then, vent fluid (T 299°C) was collected from Chimney II using the manifold with two major and one gas-tight samplers and then with a pair of discrete major and one discrete gas-tight sampler. Sulfide samples were also recovered from this chimney. Vent fluid sampling continued at Chimneys III (268°C), V (289°C), and VI (289°C). Four major samples and two gas-tight samples were taken, as shown in the sample log. Additional sulfide samples were collected from Chimneys V and VI. We then took a final Niskin sample above Chimney II at a height of about 13 m above the vent, this time with the plume moving to the south.

Basalt samples were collected at three locations. First, a hydrothermally altered sample

was collected from Edge of the Ledge where the SUAVE was deployed (x 1361, y 1434). Second, a sample was taken from an area of collapsed pillows to the east (x 1401, y 1373). Third, we sampled a sheet flow to the west (x 1315, y 1421).

We departed from the bottom about 1410 and surfaced at about 1540.

## DIVE 2778: N of Fountain Vent to Mound 1

June 21, 1994
Pilot: Matt Heintz
Port Observer: Bob Embley (author of this transcript)
Stbd. Observer: Randy Koski

Objectives: (1) to map and sample a zone of large fallen chimneys north of the Fountain Vent, (2) map the area between the fallen chimneys as far north as possible along the graben structure south of the southernmost 1980s lava mound (Mound 1).

Summary: ALVIN reached bottom at 09:47 at a depth of 2260 m and began heading toward the Fallen Chimneys field at 09:50. At 09:55, a change in heading to 300° was made and it was realized that the gyro compass was giving spurious readings. ALVIN crossed older sheet flow cut by fissures until 10:05. Soon after reaching an east-facing slope, a field of extinct sulfide chimneys was encountered at 10:05:40. Samples from two of the fallen chimneys (2778-1S1 and 1S2) were taken between 10:15-10:30 at a depth of 2256 m (2686x; 4614y). A survey north and south along the fissure revealed that the chimney field was smaller than originally thought, perhaps only 20-30 m. The chimneys were not relocated, so at 11:08 ALVIN headed northwest up the east side of the hill, encountering a large fissure (~ 5 m wide) at the crest at 11:09. This fissure, which had been encountered on previous dives (2258 and 2435) reveals a section characterized by thick flows of columnar-jointed basalt capped by jumbled sheet flow (which covers the whole ridge). Two samples were taken within the fissure, 3R1 was taken at 2236 m near the top of the west side of the fissure (2647x;4670y); 3R2 was taken at 2243 m (2655x; 4682y) inside the fissure from one of the columns (Note: when examined on the surface, this sample was very vesicular, with vesicles up to ~ 5 mm in diameter. ALVIN then moved northeast along the fissure and again stopped to sample basalt from the wall at 11:50 (4R; 2711x; 4754y). A more east-west trending fissure was then followed and a survey of lava flows was conducted where the sidescan showed a possible sheet flow emanating from the junction of two fissure systems. Sample 5R was taken from a sheet flow in this area at 12:35 (2717x; 4635y). Another attempt to relocate the fallen chimneys was successful at 12:42. A camera survey was conducted of the chimneys (excellent video of chimney cross-section at 13:04-13:07) and samples of chimneys (6S1 and 6S2 at 2689x; 4618y) were taken at 12:59-13:09. At 13:22, ALVIN headed northeast to survey north of the fracture junction within the graben structure that leads northward into the southernmost lava mound. A stop was made at 13:29 to sample some (apparently) altered lava (sample 2778-7R at 2663x; 4686y). Three major samplers were also tripped here in bottom water (samples 8M1-3). ALVIN then headed at about 020° in a zig-zag pattern to the NW then back to NE between 13:50 and 13:55 to follow. At 14:00 a course change to the NE was made and a broad zone of fissured lobate flows was traversed until 14:17. It appeared that two freshly broken fractures were crossed at 14:00 and 14:13 which appears to define the borders of a graben identified on a Sea MARC II sidescan image. ALVIN recrossed the zone and passed some small extinct sulfide chimneys at 14:23. A few minutes after turning to the northeast (at 14:27) to follow the west side of the graben (or fissure swarm identified by white-stained rocks), an active vent was encountered on the east side of a fissure (later name the Aquarius Vent). This vent consisted of a single sulfide mound characterized by diffuse venting (up to 165°C measured on this dive). Live tubeworms were observed on the surface bathed in the diffuse fluid. Samples 9S (top of chimney), 9G1, and 9G2 were taken at this vent. Marker 13 (triangle) was left here (2862x; 5255y). Dive 2778 was terminated at 15:05.

## DIVE 2779: Mounds 5.5 & 6

June 22, 1994
PIT: Socrates Carelo
Pilot: Bob Grieve
Observer: Bill Chadwick (author of this transcript)

Dive Summary:

The location of this dive was mid-way along the 17-km long line of pillow-lava mounds that were erupted along the north Cleft segment sometime between 1983 and 1987. Previous dives had been made to the southern-most pillow mounds (Mounds 1 and 2 on dives 2262 and 2432) and the northern-most pillow mound (Mound 8 on dive 2430). This dive began at a latitude of about 45 06'N, just east of mound 6. This area was chosen because the middle part of the line of pillow mounds has many small lava flows (most not detected by SeaBeam, but identified by camera tows in 1989 and 1991), and therefore presented an opportunity to observe the structures adjacent to the flows, including distinctive patterns of faults and fissures that may have formed during the dike intrusion and eruption. These kinds of structures are usually buried by larger lava flows. The goal of the dive was to sample and map in detail this section of the line of pillow mounds and document the relationship between the small lava flows and the surrounding structures.

The dive began east of mound 6 in the older surrounding lavas. We first sampled the old lava (station 1: 2280x/3956y/2338 m). Since this was a PIT dive sampling took longer than normal. Next we traversed west to the mound 6 lavas and sampled them (station 2: 2161x/3908y/2329 m). Mound 6 was found to be separated into several small flows at its southern end. We made several traverses across the southern end of mound 6, and observed graben structures immediately adjacent to the flows. We then did a zig-zag traverse about 800 m to the south, crossing the axis of the eruption many times. We crossed many recent faults and fissures along the axis, and found them to be larger and more pronounced near where lava was actually erupted. Near the end of the dive we encountered lavas of mound 5.5, again clearly erupted out of a deep graben on their north side. We made several traverses to document the structural relationships then took a sample of this flow (station 3: 1935x/3039y/2328 m). After dropping weights we continued driving west while the altimeter was still within 100 m of the bottom to continue an east-to-west profile across the flow.

The deep grabens that are adjacent to these small flows apparently formed as the underlying dike was nearing the surface and were then only partially buried by the erupting lava. Theses grabens are in-effect the eruptive vents for these pillow mounds. Since the structural indicators of the north Cleft dike can be followed between the individual pillow mounds, a detailed sidescan survey of this area could map these structures along the entire pillow-mound chain.

Navigation (using the Alvin 9.5 and 10.5 transponders) was very good, and the sub's gyro functioned normally during the entire dive. We tried to use the laptop program NAV92, which can plot real-time navigation dive tracks on a laptop display, but found that the new depth sensor arrangement is incompatible with the program as it is currently written (the depth data is now output at PSI, but the program expects depth in meters, so the x/y fixes are mis-calculated).

# DIVE 2780: Pipe Organ & Monolith Vents

June 23, 1994
Pilot: Pat Hickey
Port Observer: Dave Butterfield (author of this transcript)
Starboard Observer: Geoff Lebon

Objectives:
to sample basalt, particles, vent fluids, and sulfides from Pipe Organ vent, then drive to Monolith for more sampling of fluids and sulfides.

Navigation working well on descent. Manifold sampler main pump not working. Flush pump ok. T1 not working, T2 ok.

09:15 On bottom in old pillow terrain. x/y 1345/1305. We are south and slightly west of Pipe Organ.

09:21 Station 1. 1350/1303. Broke off baseball size piece of basalt from old pillow. Sample was dropped behind basket, but lodged on top of the manifold sampler plate and was recovered at end of dive. The fix puts this sample about 130 meters due south of Pipe Organ.

Strobes had a ground that required them to be turned off. Bow cameras were operated with sub lights only for a while. Had to turn off bow camera altogether on way to Monolith due to a second ground problem.

09:28 At Pipe Organ vent, SUAVE in view (1371x/1426y).

Station 2, Plume over Pipe Organ vent. Top of vent at 2271 meters.
09:33:40 Tripped yellow Niskin at 2263 meters or 8 mav (1357x/1427y).
09:40:05 Tripped orange Niskin at 2265 m or 6 mav (1359x/1429y).
09:41:58 Tripped blue Niskin at 2251 m or 20 mav (1348x/1338y).
09:43:37 Tripped green Niskin (aft) at 2241 m or 30 mav (1343x/1345y).
09:45 1338x/1450y

09:49 Back on seafloor, in lava drain-back area.

09:55 Manifold sampler on, background temperature 1.9 to 2.0°C

10:01 Station 3. 1359x/1425y. First black smoker site. Took port major sample with T2= 265°C. Maximum temperature on Alvin probe was 296.2°C after sampling. This is the same vent that was sampled on a previous dive with 299°C maximum temperature.

10:05 Took middle manifold sample. T2 was 258°C at start, 140°C at end.

10:11:30 Fired starboard gas-tight on manifold in same vent. T2 was 257°C.

10:26 Station 4. 1354x/1428y. Second black smoker chimney. Depth 2269 m. Took discrete major #16. Quickly moved on to the SUAVE for sampling and recovery.

~10:33 Station 5. 1365x/1433y. SUAVE site near Marker 40 on ledge above Pipe Organ. Took discrete major #6 with snorkel tip touching the inlet to the SUAVE. Alvin temperature probe measured 5.0°C at this point.
10:45 Manifold sampler on at SUAVE site. Took sample with probe down in crack below suave inlet. Temperature on T2 was 4.6°C. Took starboard major at 10:47-10:48. 1364x/1432y.

Tmax in crack was 18°C on Alvin probe.
10:52 SUAVE recovered in ~ 2 minutes. We started driving toward Monolith.

11:02 1388x/1469y on way to Monolith. Changed videotapes at 11:05 during transit.

11:38 Station 6. 1784x/2544y. Saw Marker 8. A few seconds later we ran head-on into a 12 meter tall chimney. The chimney did not fall over.

11:44 Ropy sheet flow, thin sediment cover, some glassy surfaces.

11:46 1804x/2824y. We switched transponder nets several times before we finally got to Monolith. Large offsets were noted between the different pairs.

11:59 Not sure where we are. Took bearing and distance from ship.

12:15 Ran into a second dead chimney. Shortly after this, it seemed to me that we must be east of Monolith, based on the flat terrain and the depth. Saw Marker V7 bucket lid down in a fissure in sheet flow.

13:01 Found Monolith vent by driving west to the large fissure, first driving north (wrong choice), then turning around and driving back south. We first saw the white staining of the low diffuse vents and followed their line along the eastern edge of the fissure right to Monolith.

13:10 Station 7. 2269x/3579y. Marker 10 visible out port side. We are on the east side of Monolith, approximately mid-way between N and S ends, about 2 m down from top. Depth 2259 m total, 2256 m sub. Took discrete major 11 in 303.5°C vent at 13:14. Took discrete gas-tight #7 in same orifice at 13:18.

13:30 Station 8. 2269x/2274y. Sampled another vent that was about 20 cm further in toward the center of the structure, at about the same elevation as the first smoker. Temperature was 305.5°C. Took discrete major #15 at 13:30. Took discrete gas-tight sample #3 in same orifice at 13:37.

13:48 Station 9. 2263x/2272y. Moved to the southern end of Monolith, to vents about 1.5 m down from the top. Marker 10 was now visible out the starboard viewport. Gyro heading 041, magnetic 042. Gyro working ok now. Took port side gas-tight with T2=246°C, maximum temperature with Alvin probe was 288°C. Took discrete major #5 in the same orifice. The smoker sampled is in the center of the video at 14:01, just prior to end of dive. We took some fixes with 12.5 kHz on 1 and 11.5 kHz on 2 before leaving.

~14:05 Out of power. Weights away.

## DIVE 2781: Fountain & Aquarius Vents

June 24, 1994
Pilot: Matt Heintz
Port Observer: John Lupton
Stbd. Observer: Andra Bobbitt (author of this transcript)

Dive Summary:

Alvin landed on the bottom slightly NE of target #1 at 0918 (2381x/4128y). We were on jumbled sheet flow at a depth higher than Fountain Vent, z=2234. It was relatively flat, one of the series of fissures and "plateaus" stepping up along the west wall near Fountain Vent. Alvin headed

towards the target (SW) and we crossed 2 fissures, a large graben, with jumbled sheet flow in between. After crossing the graben we saw staining on the rocks (2454x/4068y/2246 m) at 0933. At 0935 we sighted Fountain Vent and Marker 42 (2444x/4067y). With the sub facing south we began sampling the east chimney (old depth 2254, new depth 2247), 2467x/4074y. Above the east chimney (Little Sister) we took a Niskin sample 1 and 3 meters above the chimney. We then moved to the west chimney (Big Brother), with the sub facing south, and began water sampling. Majors 5, 9, 11 and gas tight #7 were tripped. The pilot felt these samples were not clean so he broke off the top of the vent to allow better water flow. The pilot was able to position directly into the orifice and Major 6 was tripped. The Alvin temperature probe reached ~201°C before breaking off, wires dangling. Gas tight #3 was tripped, then the manifold was put into the orifice, the highest temperature reached was 253°C. The manifold was repositioned to an opening next to this orifice but the temperature only reached 236°C. The pilot felt this orifice was not as open as the 253°C hole. The pilot attempted to sample another chimney at the top of the west vent. The top of the chimney was broken off, fell away from the sub, and the water pumped out freely. Unfortunately the orifice faced away from us and towards another chimney. The pilot felt he would be unable to sample it from the other side as well. We decided to leave Fountain Vent and move to our second target, Aquarius Vent. Marker 880 (biology marker) was spotted outside of the starboard porthole, partially covered, west of the west chimney. The other biology markers at Fountain, the "chain" and PVC tripods, had become heavily buried in either floc or biological growth. The ends of the chain, at the base and top of the west chimney were clearly visible.

The gyro was not working on the drive between Fountain and Aquarius, however the insub navigation was working consistently. We drove at approximately 014° magnetic. We crossed many fissures where in between were jumbled flows of ropy lava. Some areas appeared to be large blocks that became fractured like puzzle pieces. As we travelled north, the jumbled flows appeared to retain more ropy characteristics. The ropy flows trended with the fissure trend, about 5-10° further than our track. At 1132 out of the port side, Lupton and the pilot observed a distinct contact between sheet flow and jumble flow (2489x/4302y). At 1136 we were travelling 028° magnetic following ridges and fissures. At 1146 we passed over a fallen extinct chimney with the base exposed revealing the orifice. At 1203 we crossed a feature trending perpendicular to our track (and the previous flow trends) and another perpendicular feature (fissure?) at 1205. At 1207 we observed lobate flows and now the bottom was trending downwards slightly along our path. The flatter areas appeared to have more sheet-like flows, then in places with a slight slope the flows became more lobate. The sediment cover also became thicker as we travelled NNW. At 1215 the trend in the lobates appeared to be about 20° to our path. 1216 we crossed ropy collapsed slabs.

We arrived at our target (2865/5244) at ~1225 but the vent wasn't there and we were 10 m higher than its depth. We were on jumbled flow at the edge of a fissure. We first searched to the north then circled back to the same position before moving east where the vent was spotted at 1235, 2883x/5250y. We had stirred up a lot of sediment and decided to wait 10 minutes for the dust to settle.

At 1255 (2890x/5247y) we began to video survey the vent using the 3-chip camera. We circled the vent in a counter-clockwise direction from above with the 3-chip pointed downwards. We began the survey with a magnetic heading of 070. At 1312 we began water sampling from the area of highest visible water flow, firing the middle Niskin. Our magnetic heading was 198 when we took a sulfide sample ~1/3 down from the top of the vent, 2889/5241, depth=2266. (The sulfide came from a visible high flow, whereas the top of the vent did not appear to be as vigorous.) We then used the manifold to get a temperature reading of T1 181°C and T2 143°C, the pilot believed it was the same orifice but could not see the damage of taking a sulfide). 3 Majors were tripped, a bio/worm grab, 2 gas-tights and another major were collected at this site. The sub repositioned slightly and 2 more sulfide pieces were collected and another gas-tight. We backed away from the vent a few meters (2875x/5237y) to the edge of the fissure and collected 2 basalt samples from the jumbled flow at the top of the fissure. The fissure wall seemed to be composed of massive blocks of basalt, no pillows overtopping the edge. The basalts added some extra ballast to the sub and 1 weight was dropped as we drove north at 330 magnetic. We attempted to reach

the bottom again by pumping water, however the sub continued to rise and at 1435 we headed for the surface.

## SAMPLE NOMENCLATURE GUIDELINES

**Example: ALV2775-1N2-3**

The sample names will contain four to five parts in the following order:

1. **Dive Number** i.e. ALV2775, followed by a hyphen.
2. **Station Number** i.e. 1
3. **Sample Type** i.e. N (for Niskin)
   - **N**: Niskin
   - **G**: Gas-tight
   - **D**: Discrete
   - **M**: Manifold
   - **U**: SUAVE
   - **R**: Rock
   - **B**: Biology
   - **S**: Sulfide (includes chimney samples, talus, chimney fragments)
   - **SM**: Sulfide Miscellaneous (chips from unknown source)
   - **C**: sediment/push Core
4. **Sample Number** i.e. 2, followed by a hyphen.
   Samples will be numbered in the order they were taken beginning with number one at each new station.
5. **Sub-Sample Number** i.e. 3
   If a sample is further divided, this is where such a division would be noted.

# NORTH CLEFT DIVE STATIONS: SAMPLES/MARKERS

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alvin Dive 2775: Monolith Vent, Origin 44° 57.47' / 130° 13.79'** | | | | | | | | | | | |
| ALV2775-2N1 | 10:45:56 | 2261 | 2281 | 3591 | 44° 59.409' | 130° 12.055' | | | | Niskin-5 liter | 1 m above vent in plume |
| ALV2775-2N2 | 10:46:25 | 2262 | 2283 | 3593 | 44° 59.410' | 130° 12.053' | | | | Niskin-5 liter | 3 m above vent in plume |
| ALV2775-2N3 | 10:47:00 | 2260 | 2284 | 3593 | 44° 59.410' | 130° 12.053' | | | | Niskin-5 liter | 7 m above vent in plume |
| ALV2775-3D | 11:37:35 | 2258 | 2279 | 3600 | 44° 59.414' | 130° 12.057' | | | 308°C | double major Ti | Lower part of Monolith struc., Southwest side, small high T° chimney |
| ALV2775-3S | 11:41:00 | 2258 | 2278 | 3597 | 44° 59.412' | 130° 12.058' | | | ~308°C | sulfide chimney fragment | |
| ALV2775-3DG | 11:53:00 | 2258 | 2279 | 3600 | 44° 59.414' | 130° 12.057' | | | 308°C | gas-tight | |
| ALV2775-4D | 12:28:00 | 2261 | 2282 | 3593 | 44° 59.410' | 130° 12.055' | | | 285-295°C | discrete double majors #15 & 6 | Southern end of Monolith |
| ALV2775-4S1 | 13:10:00 | 2260 | 2281 | 3594 | 44° 59.410' | 130° 12.055' | | | | sulfide chimney fragment | ~10 cm wide, high T° sulfide minerals |
| ALV2775-4S2 | 12:15-13:20 | 2260 | 2282 | 3593 | 44° 59.410' | 130° 12.055' | | | | "beehive" fragments | |
| ALV2775-5M1 | 13:20 | 2261 | 2283 | 3594 | 44° 59.410' | 130° 12.054' | | | ambient | discrete major #10 | Triggered the bottle on manifold for test, ambient seawater w/ entrained chimney debris |
| ALV2775-5M2 | 13:20 | 2261 | 2283 | 3594 | 44° 59.410' | 130° 12.054' | | | ambient | discrete major #12 | Triggered the bottle on manifold for test, ambient seawater w/ entrained chimney debris |
| ALV2775-5M3 | 13:20 | 2261 | 2283 | 3594 | 44° 59.410' | 130° 12.054' | | | ambient | discrete major #13 | Triggered the bottle on manifold for test, ambient seawater w/ entrained chimney debris |
| **Alvin Dive 2776: Cavern to Pipe Organ Vent, Origin 44° 57.47' / 130° 13.79'** | | | | | | | | | | | |
| ALV2776-1U1 | 10:10 | 2272 | 1994 | 2897 | 44° 59.034' | 130° 12.273' | 2 | | 13°C | SUAVEscan | Of dissolved Fe, Mn, sulfide and Si from a diffuse vent |
| ALV2776-1U2 | 10:59 | 2275 | 1992 | 2895 | 44° 59.033' | 130° 12.275' | 2 | | 8-17°C | SUAVEscan | Of dissolved Fe, Mn, sulfide and Si from a diffuse vent |
| ALV2776-2R | 11:20 | 2272 | 1993 | 2913 | 44° 59.042' | 130° 12.274' | | | ambient | basalt | In transit from Cavern to Tripod Vents |
| ALV2776-3U | 12:16 | 2260 | 1867 | 2559 | 44° 58.851' | 130° 12.370' | *M | | T1=13.2°C, T2=11.1°C | SUAVEscan | Of dissolved Fe, Mn, sulfide and Si from a diffuse vent *Marker M not seen, but site resembles area sampled in 1991 |
| ALV2776-3M | 12:28 | 2268 | 1867 | 2558 | 44° 58.851' | 130° 12.370' | *M | | T1=13.5 to 11.3°C, T2=8.8 to 9.8°C | manifold: major | From diffuse vent (for trace metals, etc.) |
| ALV2776-3G | 12:31 | 2267 | 1867 | 2560 | 44° 58.852' | 130° 12.370' | *M | | T1=13.2°C, T2=11.1°C | manifold: gas-tight | From diffuse vent (for Helium) |
| ALV2776-4U | 13:09 | 2274 | 1802 | 2401 | 44° 58.766' | 130° 12.419' | 4 | | ~15°C | SUAVEscan | Of dissolved Fe, Mn, sulfide and Si from a diffuse vent |
| ALV2776-5N1 | 14:56:10 | 2279 | 1355 | 1429 | 44° 58.241' | 130° 12.758' | | | | Niskin #4 | ~1 m above Pipe Organ Vent, over beehive structure 10-11 m tall (base 2278, top 2268) |
| ALV2776-5N2 | 14:56:28 | 2279 | 1354 | 1427 | 44° 58.240' | 130° 12.759' | | | | Niskin #2 | ~3 m above Pipe Organ Vent, over beehive structure 10-11 m tall (base 2278, top 2268) |
| ALV2776-5N3 | 14:57 | 2278 | 1354 | 1426 | 44° 58.240' | 130° 12.760' | | | | Niskin #3 | ~5 m above Pipe Organ Vent, over beehive structure 10-11 m tall (base 2278, top 2268) |
| ALV2776-5N4 | 14:57:30 | 2277 | 1350 | 1425 | 44° 58.239' | 130° 12.763' | | | | Niskin | ~10 m above Pipe Organ Vent, over beehive structure 10-11 m tall (base 2278, top 2268) |
| ALV2776-6 | 13:44 | 2281 | 1275 | 1542 | 44° 58.302' | 130° 12.82' | 6 | | | station | At Marker #6 on West edge of Tripod Vent, Marker heavily encrusted with biology, moderately sedimented with oxyhydroxides |
| **Alvin Dive 2777: Pipe Organ Vent, Origin 44° 57.47' / 130° 13.79'** | | | | | | | | | | | |
| ALV2777-1U | 10:04:00 | 2279 | 1363 | 1425 | 44° 58.240' | 130° 12.753' | 40 | Foam block | 2.7°C | SUAVE Deployment | Deployed in diffuse flow (20-30°C), will remain on seafloor for 2 to 3 days, T° 1° warmer than typical |
| ALV2777-3N1 | 10:45:00 | 2276 | 1358 | 1421 | 44° 58.237' | 130° 12.757' | | | | Niskin #2 | ~0.5 m above Pipe Organ Vent-Chimney II |
| ALV2777-3N2 | 10:50:00 | 2278 | 1360 | 1425 | 44° 58.239' | 130° 12.755' | | | | Niskin #5 | ~3 m above Pipe Organ Vent-Chimney II |

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2777-3N3 | 10:53:00 | 2275 | 1359 | 1421 | 44° 58.237' | 130° 12.756' | | | | Niskin #3 | ~10 m above Pipe Organ Vent-Chimney II |
| ALV2777-4M1 | 11:15:00 | 2276 | 1360 | 1424 | 44° 58.239' | 130° 12.756' | | | T1 295-283°C,T2 259°C | manifold: port major #10 | Chimney II, T1 fell to 283°C |
| ALV2777-4M2 | 11:20:00 | 2276 | 1360 | 1424 | 44° 58.239' | 130° 12.756' | | | T1 299°C,T2 261°C | manifold: middle major #12 | Chimney II |
| ALV2777-4G | 11:25:00 | 2276 | 1360 | 1424 | 44° 58.238' | 130° 12.756' | | | T1 299°C,T2 265°C | manifold: starboard gas-tight | Chimney II |
| ALV2777-4S | 11:30:00 | 2276 | 1362 | 1424 | 44° 58.239' | 130° 12.754' | | | 299°C | chimney sulfide | Type I sulfide |
| ALV2777-4D | 11:38:00 | 2278 | 1358 | 1423 | 44° 58.238' | 130° 12.757' | | | 299°C | discrete major pair #15 & 6 | Chimney II |
| ALV2777-4DG | 11:47:00 | 2279 | 1358 | 1423 | 44° 58.238' | 130° 12.757' | | | 299°C | discrete gas-tight #7 | Chimney II |
| ALV2777-5D | 12:09:00 | 2280 | 1355 | 1423 | 44° 58.238' | 130° 12.760' | | | 268°C | discrete major #16 | Chimney III |
| ALV2777-5DG | 12:09:00 | 2280 | 1355 | 1423 | 44° 58.238' | 130° 12.760' | | | 268°C | discrete gas-tight #3 | Chimney III |
| ALV2777-6M | 12:36:00 | 2280 | 1354 | 1428 | 44° 58.241' | 130° 12.760' | | | T1 289°C,T2 262°C | manifold: starboard major #13 | Chimney V |
| ALV2777-6G | 12:39:00 | 2280 | 1355 | 1428 | 44° 58.241' | 130° 12.759' | | | T1 289°C,T2 259°C | manifold: port gas-tight | Chimney V |
| ALV2777-6D | 12:48:00 | 2278 | 1358 | 1433 | 44° 58.244' | 130° 12.757' | | | 289°C | discrete major #5 | Chimney V, temp. from manifold |
| ALV2777-6S | 12:53:00 | 2278 | 1358 | 1434 | 44° 58.244' | 130° 12.757' | | | 289°C | chimney sulfide | Chimney V, temp. from manifold |
| ALV2777-7S | 12:59:00 | 2276 | 1361 | 1434 | 44° 58.244' | 130° 12.755' | | | 289°C | chimney sulfide | Chimney VI |
| ALV2777-7D | 13:10:00 | 2279 | 1356 | 1433 | 44° 58.244' | 130° 12.759' | | | 289°C | discrete major #11 | Chimney VI, temp. from Alvin probe |
| ALV2777-8R | 13:17:00 | 2276 | 1361 | 1434 | 44° 58.244' | 130° 12.755' | | | | basalt | Coated with metalliferous oxides/sulfides, w/in 1 m of SUAVE on ledge East of Pipe Organ Vent |
| ALV2777-9N | 13:24:00 | 2274 | 1362 | 1417 | 44° 58.235' | 130° 12.754' | | | | Niskin #4 | In plume ~13 m above Pipe Organ, Chimney II |
| ALV2777-10R | 13:36:00 | 2277 | 1401 | 1373 | 44° 58.211' | 130° 12.725' | | | | basalt | Collapsed pillows |
| ALV2777-11R | 14:05:00 | 2281 | 1315 | 1421 | 44° 58.237' | 130° 12.790' | | | | basalt | From new sheet flow |

## Alvin Dive 2778: Fallen Timbers to Aquarius Vent, Origin 44° 57.47' / 130° 13.79'

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2778-1S1 | 10:15:00 | 2259 | 2686 | 4614 | 44° 59.961' | 130° 11.746' | 44 | | | sulfide (inactive chimney) | Tip of inactive sulfide chimney, the middle spire of three on sulfide pinnacle, near old Marker 44 |
| ALV2778-1S2 | 10:30:22 | 2261 | 2686 | 4614 | 44° 59.961' | 130° 11.746' | 44 | | | sulfide (inactive chimney) | The second spire from the same pinnacle |
| ALV2778-2R | 10:37:45 | 2250 | 2693 | 4657 | 44° 59.984' | 130° 11.742' | | | | basalt | Volcanic rock on West side of fissure |
| ALV2778-3R1 | 11:17:00 | 2248 | 2647 | 4670 | 44° 59.991' | 130° 11.777' | | | | basalt | Massive lavas near top of West wall of fissure |
| ALV2778-3R2 | 11:26:46 | 2249 | 2655 | 4682 | 44° 59.998' | 130° 11.771' | | | | basalt | Massive lava near base of West wall, same fissure as 3R1 |
| ALV2778-4R | 11:50:43 | 2254 | 2711 | 4754 | 45° 00.029' | 130° 11.730' | | | | basalt | Elongate slab from massive, thick lava flow |
| ALV2778-5R | 12:35:45 | 2264 | 2717 | 4635 | 44° 59.972' | 130° 11.724' | | | | basalt | Broken sheet flow |
| ALV2778-6S1 | 12:59:00 | 2259 | 2687 | 4622 | 44° 59.965' | 130° 11.747' | | | | sulfide | Pieces from edge of fallen sulfide chimney, near cross-section break |
| ALV2778-6S2 | 13:09:21 | 2262 | 2689 | 4618 | 44° 59.963' | 130° 11.745' | | | | sulfide | Outer wall of large fallen chimney |
| ALV2778-7R | 13:29:00 | 2249 | 2663 | 4686 | 45° 00.000' | 130° 11.764' | | | | basalt | Massive lava with surface alteration |
| ALV2778-7M1 | | | | | | | | | | | Bottom water |
| ALV2778-7M2 | | | | | | | | | | | Bottom water |
| ALV2778-8M1 | 13:38:30 | 2244 | 2669 | 4698 | 45° 00.006' | 130° 11.760' | | | ambient | manifold: starboard major | Filled with bottom water |
| ALV2778-8M2 | 13:38:30 | 2244 | 2669 | 4698 | 45° 00.006' | 130° 11.760' | | | ambient | manifold: middle major | Filled with bottom water |
| ALV2778-8M3 | 13:38:30 | 2244 | 2669 | 4698 | 45° 00.006' | 130° 11.760' | | | ambient | manifold: port major | Filled with bottom water |
| ALV2778-9S | 14:34:25 | 2268 | 2863 | 5256 | 45° 00.307' | 130° 11.612' | 13 | Triangle | 165°C | sulfide | Fragments from top of worm-covered mound at Aquarius Vent |
| ALV2778-9G1 | 14:58:20 | 2269 | 2862 | 5255 | 45° 00.307' | 130° 11.614' | 13 | Triangle | 165°C | manifold: gas-tight | From clear fluid venting |
| ALV2778-9G2 | 14:58:20 | 2269 | 2862 | 5255 | 45° 00.307' | 130° 11.614' | 13 | Triangle | 165°C | manifold: gas-tight | From clear fluid venting |
| ALV2778-#13 | | 2269 | 2862 | 5255 | 45° 00.307' | 130° 11.614' | 13 | Triangle | | Marker #13 deployment | |

## Alvin Dive 2779: Mounds 5.5 & 6, Origin 45° 4.552' / 130° 10.891'

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2779-1R | 10:26 to 10:51 | 2338 | 2280 | 3956 | 45° 06.658' | 130° 09.154' | | | | basalt | In older lava, East of line of pillow mounds erupted in mid-1980's, ~100 m East of Mound 6: (1) volleyball-sized pillow bud (2) irregular head-sized piece, sub moved slightly between samples |

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2779-2R | 11:42 | 2329 | 2161 | 3908 | 45° 06.632' | 130° 09.245' | | | | basalt | In new lava of pillow Mound 6 (near contact): (1) fist-sized piece, from large pillow (2) head-sized pillow bud, sub moved slightly between samples |
| ALV2779-3R | 13:50 | 2328 | 1935 | 3039 | 45° 06.163' | 130° 09.417' | | | | basalt | In new lava of pillow Mound 5.5 (1st one South of Mound 6): fist-sized sample |

## Alvin Dive 2780: Pipe Organ & Monolith Vents, Origin 44° 57.47' / 130° 13.79'

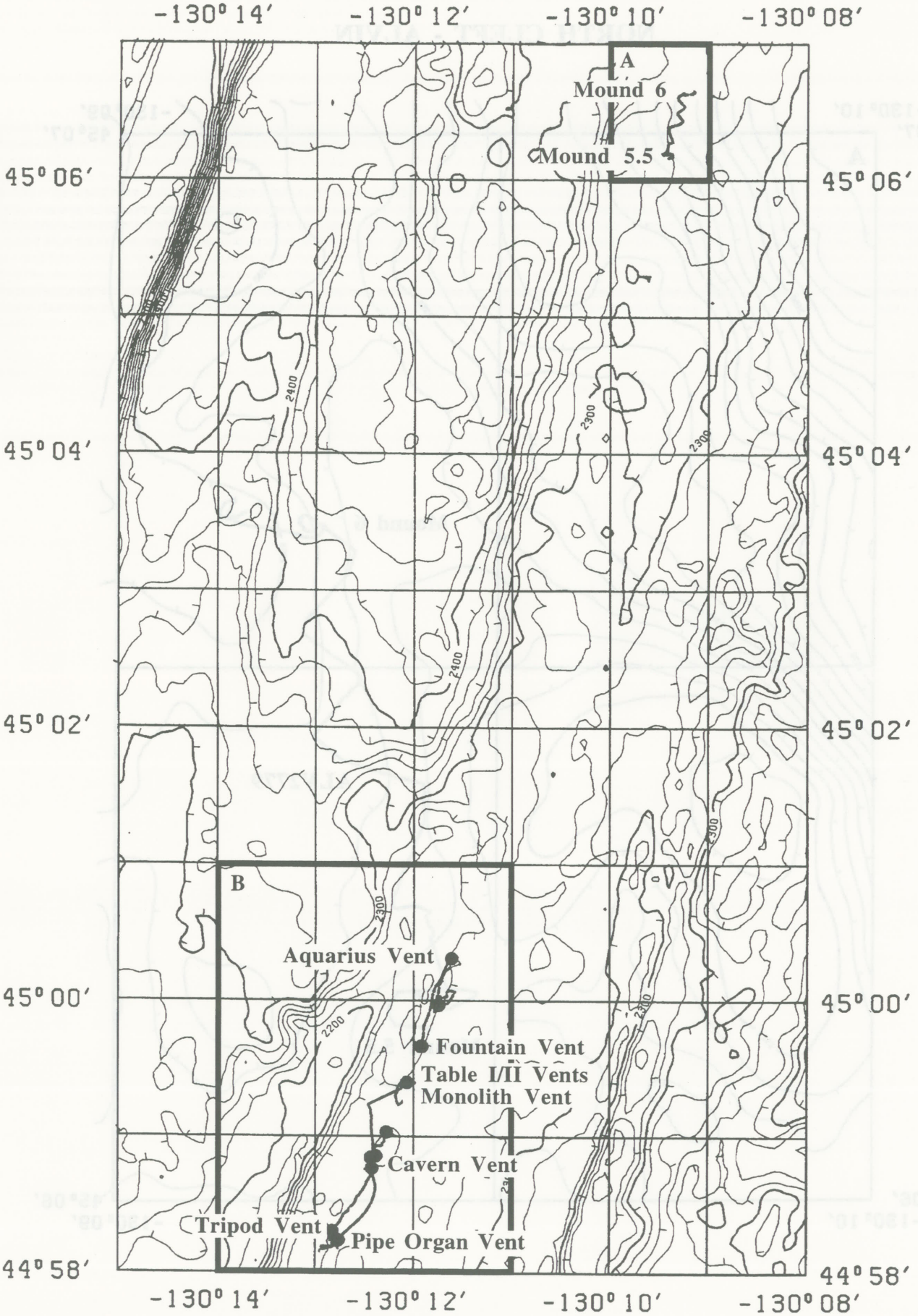
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2780-1R | 9:21 | 2270 | 1350 | 1301 | 44° 58.172' | 130° 12.763' | | | | basalt | Southwest of Pipe Organ vent near landing site, broke off small piece of old pillow, baseball size, sample dropped behind basket onto manifold sampler |
| ALV2780-2N1 | 9:33:40 | 2272 | 1357 | 1427 | 44° 58.240' | 130° 12.758' | | | | Niskin: 5 liter, yellow #1 | ~8 m above in plume over Pipe Organ vent, 299°C orifice |
| ALV2780-2N2 | 9:40:05 | 2273 | 1359 | 1429 | 44° 58.241' | 130° 12.757' | | | | Niskin: 5 liter, orange #2 | ~7.5 m above in plume over Pipe Organ vent, 299°C orifice |
| ALV2780-2N3 | 9:41:58 | 2274 | 1348 | 1438 | 44° 58.246' | 130° 12.765' | | | | Niskin: 5 liter, blue #3 | ~20 m above in plume over Pipe Organ vent, 299°C orifice |
| ALV2780-2N4 | 9:43:37 | 2269 | 1343 | 1445 | 44° 58.251' | 130° 12.769' | | | | Niskin: 5 liter, #4 | ~30 m above in plume over Pipe Organ vent, 299°C orifice |
| ALV2780-3M1 | 10:01 | 2275 | 1359 | 1425 | 44° 58.239' | 130° 12.757' | | | T2 265°C, Alvin 296°C | manifold: port major #10 | Southern end of Pipe Organ vent, this was station #6 on ALV2776 |
| ALV2780-3M2 | 10:05 | 2275 | 1362 | 1426 | 44° 58.240' | 130° 12.754' | | | T2 258°C, Alvin 296°C | manifold: middle major #12 | |
| ALV2780-3G | 10:11:30 | 2275 | 1359 | 1424 | 44° 58.239' | 130° 12.757' | | | | manifold: starboard gas-tight | |
| ALV2780-4D | 10:26 | 2279 | 1354 | 1428 | 44° 58.241' | 130° 12.760' | | | Alvin 270°C | discrete major #16 | Next chimney to the North of station #3 |
| ALV2780-5D | 10:40 | 2275 | 1365 | 1433 | 44° 58.243' | 130° 12.752' | 40 | Foam Block | Alvin 5°C | discrete major #6 | Near Marker 40, site of SUAVE deployment near Pipe Organ vent, this sample taken with snorkel intake touching the SUAVE temperature probe/fluid intake |
| ALV2780-5M | 10:47 | 2276 | 1364 | 1432 | 44° 58.243' | 130° 12.752' | | | T2 4.6°C | manifold: starboard major #13 | SUAVE recovered at 10:52 |
| ALV2780-7D | 13:14 | 2260 | 2269 | 3577 | 44° 59.401' | 130° 12.064' | 10 | | 303.5°C | discrete major #11 | Monolith vent, Marker 10 visible out port side, gyro 201° on East side, northern quadrant, mid-height |
| ALV2780-7DG | 13:18 | 2259 | 2269 | 3577 | 44° 59.401' | 130° 12.064' | 10 | | Alvin 303.5°C | discrete gas-tight #7 | Same vent orifice as above |
| ALV2780-8D | 13:30 | 2262 | 2269 | 3574 | 44° 59.399' | 130° 12.064' | | | Alvin 303.5°C | discrete major #15 | This vent orifice was about 10-20 m further in toward center of Monolith structure |
| ALV2780-8DG | 13:37 | 2262 | 2269 | 3574 | 44° 59.399' | 130° 12.064' | 10 | | Alvin 303.5°C | discrete gas-tight #3 | Same vent orifice as above |
| ALV2780-9G | 13:48 | 2262 | 2263 | 3572 | 44° 59.398' | 130° 12.069' | 10 | | T2 246°C, Alvin 288°C | manifold: port gas-tight | Southern end of Monolith, near top, ~1.5 m down, Marker 10 visible out starboard viewport, gyro 041°, magnetic 042° |
| ALV2780-9M | ~13:50 | 2262 | 2263 | 3572 | 44° 59.398' | 130° 12.069' | 10 | | | discrete major #5 | Same orifice as ALV2780-8DG, 288°C smoker is in center of video at 14:01, just prior to dropping dive weights |

## Alvin Dive 2781: Fountain & Aquarius Vents, Origin 44° 57.47' / 130° 13.79'

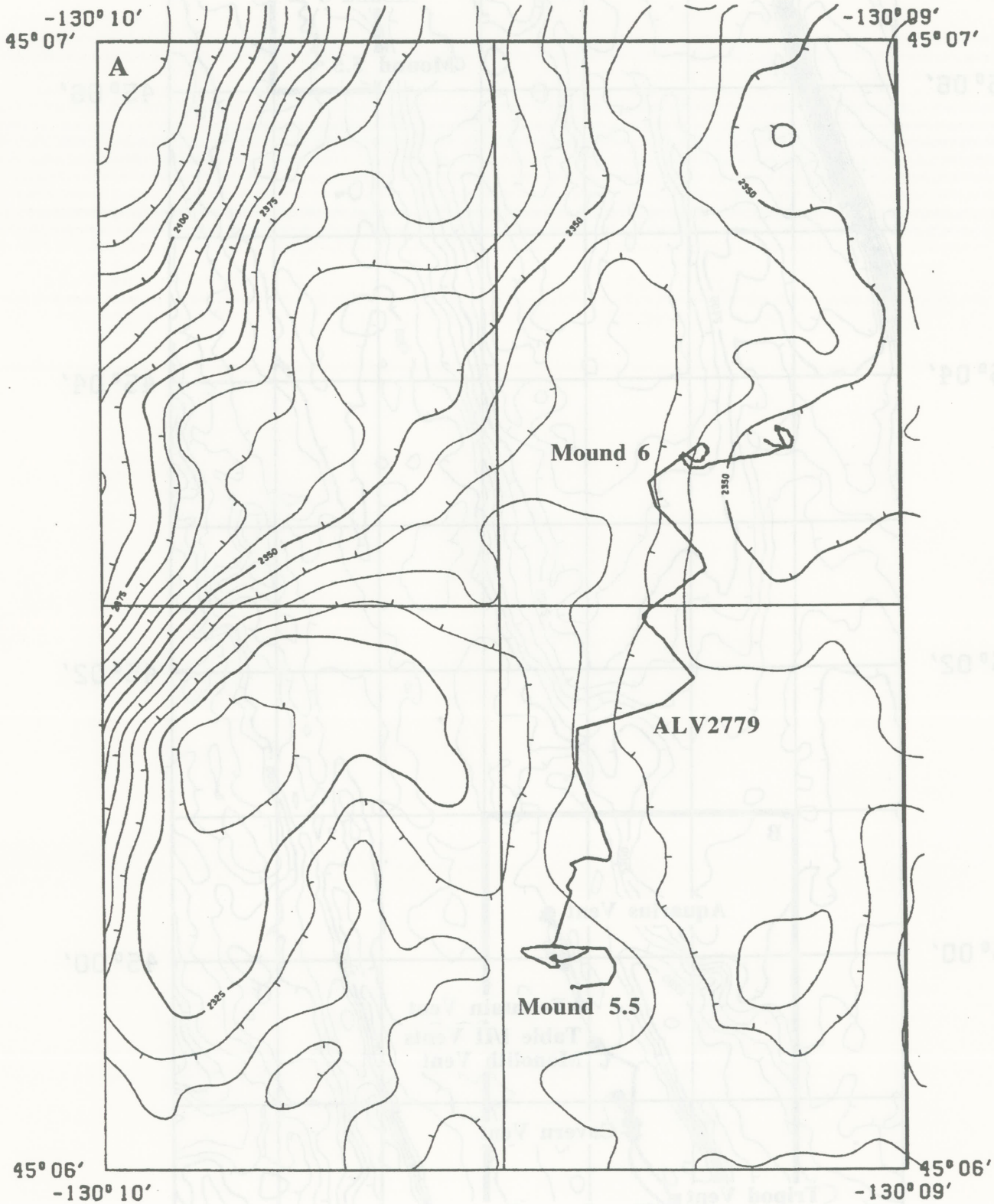
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2781-1N1 | 9:43 | 2254 | 2461 | 4072 | 44° 59.665' | 130° 11.913' | | | | Niskin | ~1 m above Fountain Vent, East chimney |
| ALV2781-1N2 | 9:46 | 2255 | 2461 | 4072 | 44° 59.667' | 130° 11.919' | | | | Niskin | ~3 m above Fountain Vent, East chimney |
| ALV2781-2D1 | 10:05 | 2255 | * | * | * | * | | | | discrete major #5 | Sub facing South at H 262°, West chimney |
| ALV2781-2D2 | 10:05 | 2255 | * | * | * | * | | | | discrete major #9 | Sub facing South at H 262°, West chimney |
| ALV2781-3D1 | 10:19 | 2255 | * | * | * | * | | | | discrete major #11 | Loose nozzle, H 260°, West chimney |
| ALV2781-3DG1 | 10:25 | 2255 | * | * | * | * | | | | discrete gas-tight #7 | Seven black stripes on sampler, West chimney |
| ALV2781-3D2 | 10:29 | 2255 | * | * | * | * | | | | discrete major #6 | Clean sample of West chimney |
| ALV2781-3DG2 | 10:39 | 2255 | * | * | * | * | | | | discrete gas-tight #3 | West chimney |
| ALV2781-4N1 | 13:12 | 2267 | 2888 | 5239 | 45° 00.298' | 130° 11.594' | | | | Niskin | Above Aquarius Vent |
| ALV2781-4N2 | 13:12 | 2267 | 2888 | 5239 | 45° 00.298' | 130° 11.594' | | | | Niskin | Above Aquarius Vent |
| ALV2781-5S | 13:18 | 2268 | 2888 | 5242 | 45° 00.300' | 130° 11.594' | | | | sulfide coated with tubeworms | Taken from top of a diffuse chimney (down a bit from the top of the vent) |
| ALV2781-5M1 | 13:26 | 2268 | 2889 | 5241 | 45° 00.299' | 130° 11.592' | | | T1=181°C, T2=143°C | manifold: starboard major | At above sampling site |
| ALV2781-5M2 | 13:28 | 2269 | 2890 | 5241 | 45° 00.299' | 130° 11.593' | | | | manifold: middle major | At above sampling site |

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2781-5M3 | 13:29 | 2269 | 2889 | 5241 | 45° 00.299' | 130° 11.593' | | | | manifold: port major | At above sampling site |
| ALV2781-5G1 | 13:31 | 2268 | 2890 | 5241 | 45° 00.299' | 130° 11.592' | | | | manifold: gas-tight | At above sampling site |
| ALV2781-5G2 | 13:31 | 2268 | 2890 | 5241 | 45° 00.299' | 130° 11.592' | | | 188°C | manifold: gas-tight | At above sampling site |
| ALV2781-5B | 13:38 | 2268 | 2890 | 5241 | 45° 00.299' | 130° 11.592' | | | | tubeworms et. al | At above sampling site |
| ALV2781-5D | 13:45 to 13:55 | 2268 | 2889 | 5241 | 45° 00.300' | 130° 11.593' | | | | major #14 | Loose nozzle (second one that's been loose, switch arms) not sure when tripped in time range |
| ALV2781-6S1 | 14:10 | 2268 | 2883 | 5241 | 45° 00.299' | 130° 11.597' | | | | sulfide | |
| ALV2781-6S2 | 14:10 | 2268 | 2883 | 5241 | 45° 00.299' | 130° 11.597' | | | | sulfide | |
| ALV2781-6B | 14:10 | 2268 | 2883 | 5241 | 45° 00.299' | 130° 11.597' | | | | biology | Recovered by divers, from same place as above sulfides |
| ALV2781-6DG | 14:20 | 2269 | 2882 | 5240 | 45° 00.299' | 130° 11.598' | | | 144°C | discrete gas-tight #2 | From same place as above sulfide, two green stripes on sampler |
| ALV2781-7R1 | 14:27 | 2270 | 2875 | 5238 | 45° 00.298' | 130° 11.604' | | | 2°C | basalt | |
| ALV2781-7R2 | 14:27 | 2270 | 2875 | 5238 | 45° 00.298' | 130° 11.604' | | | 2°C | basalt | |

# NORTH CLEFT - ALVIN



# NORTH CLEFT - ALVIN



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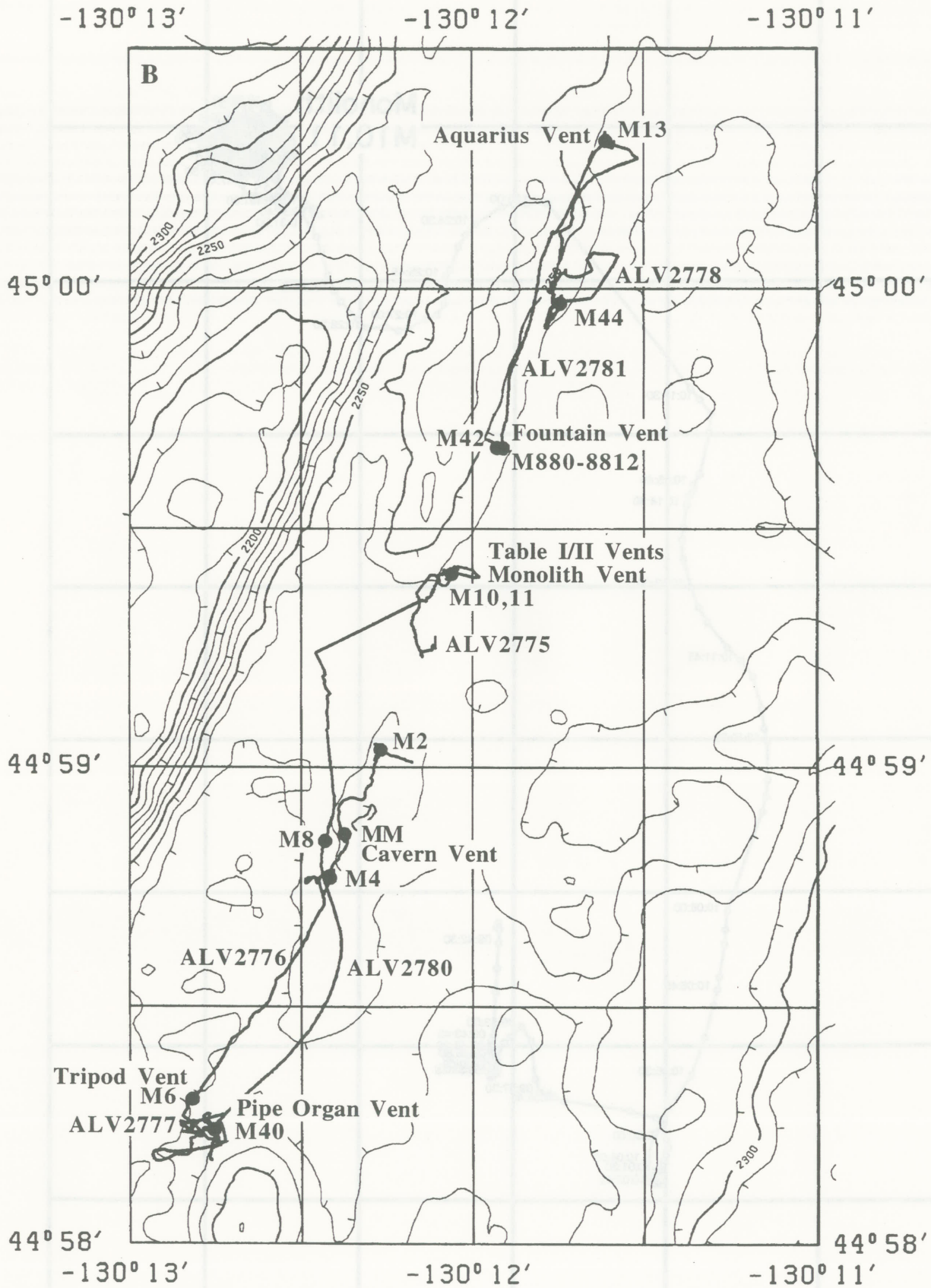
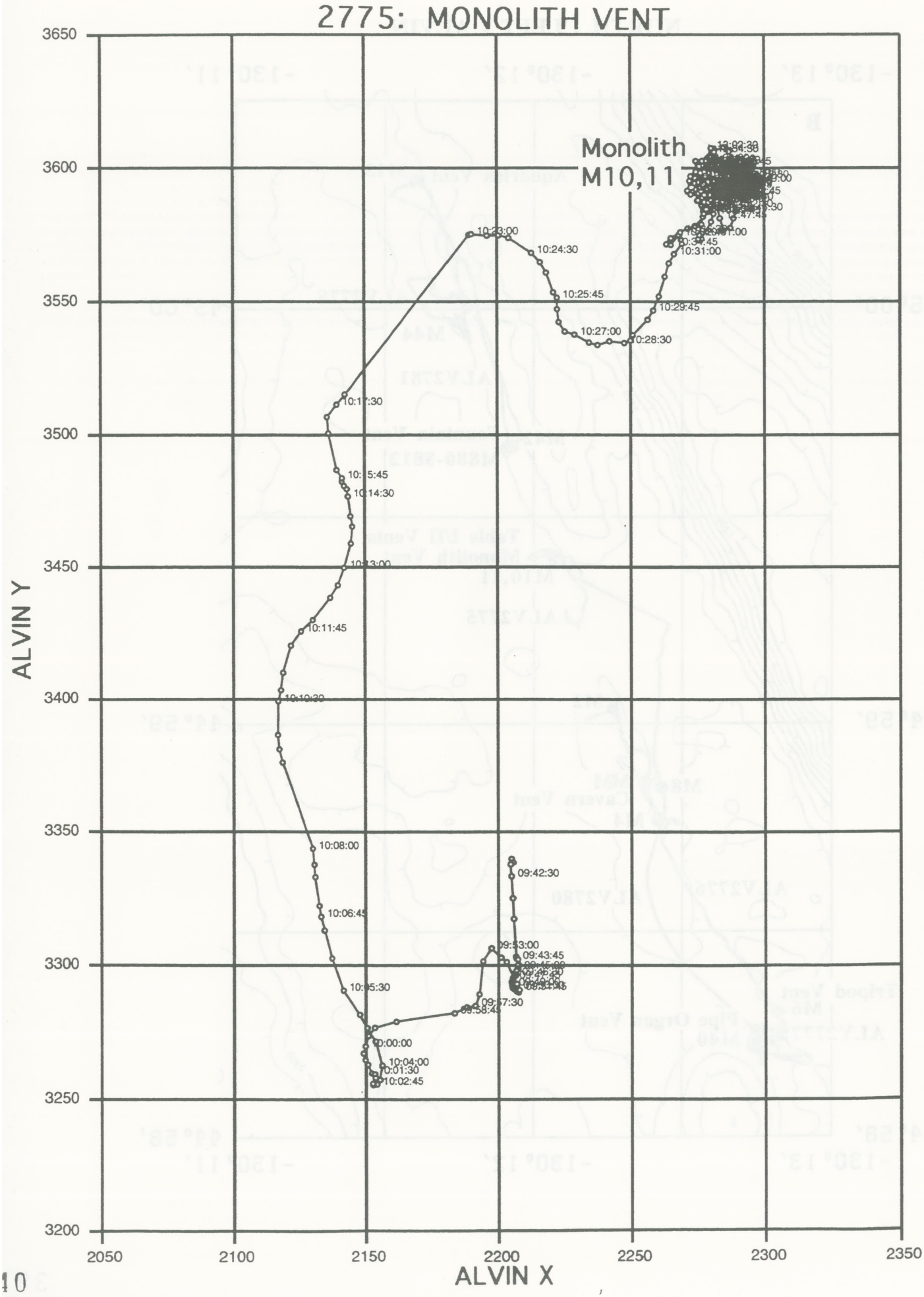
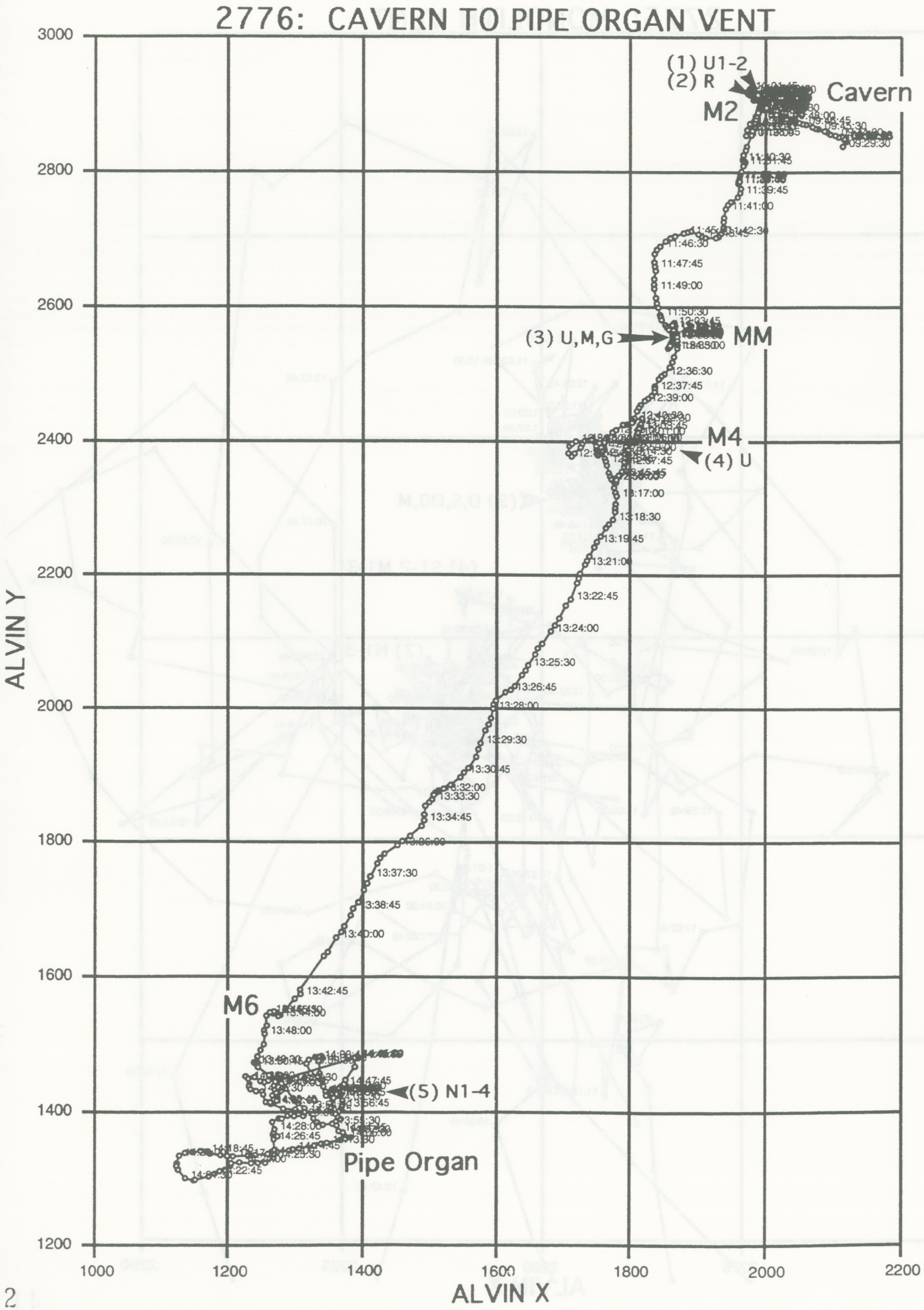
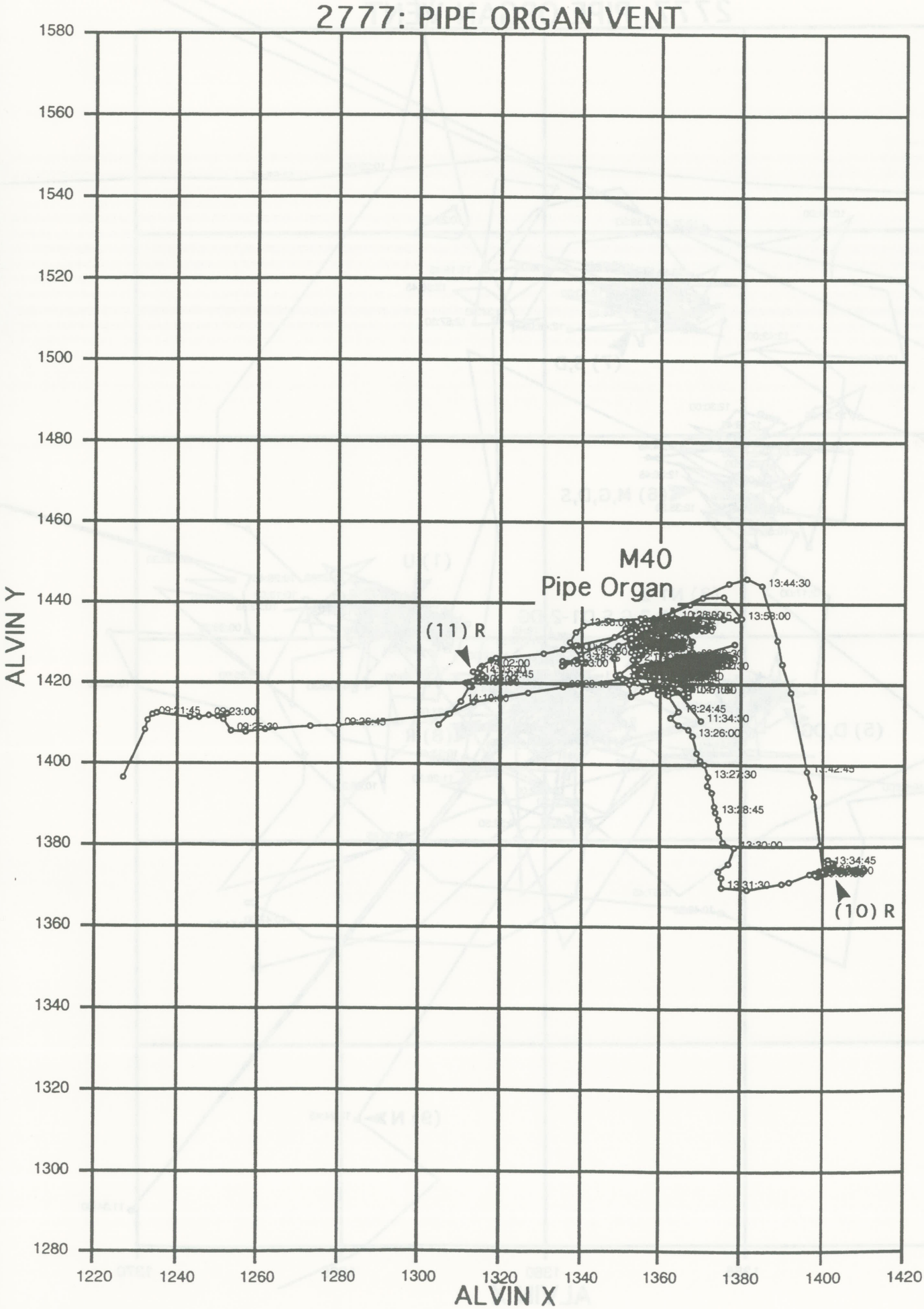
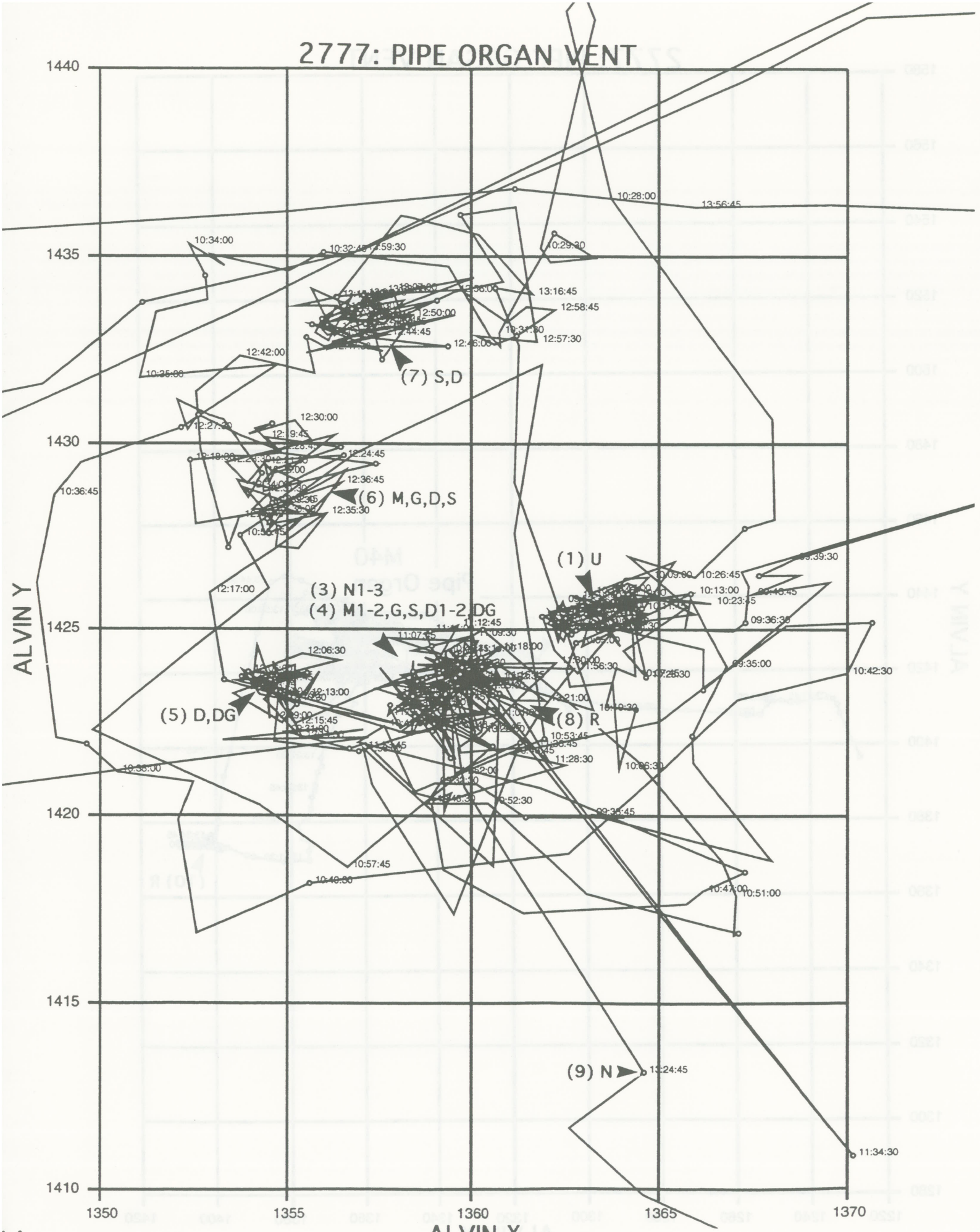


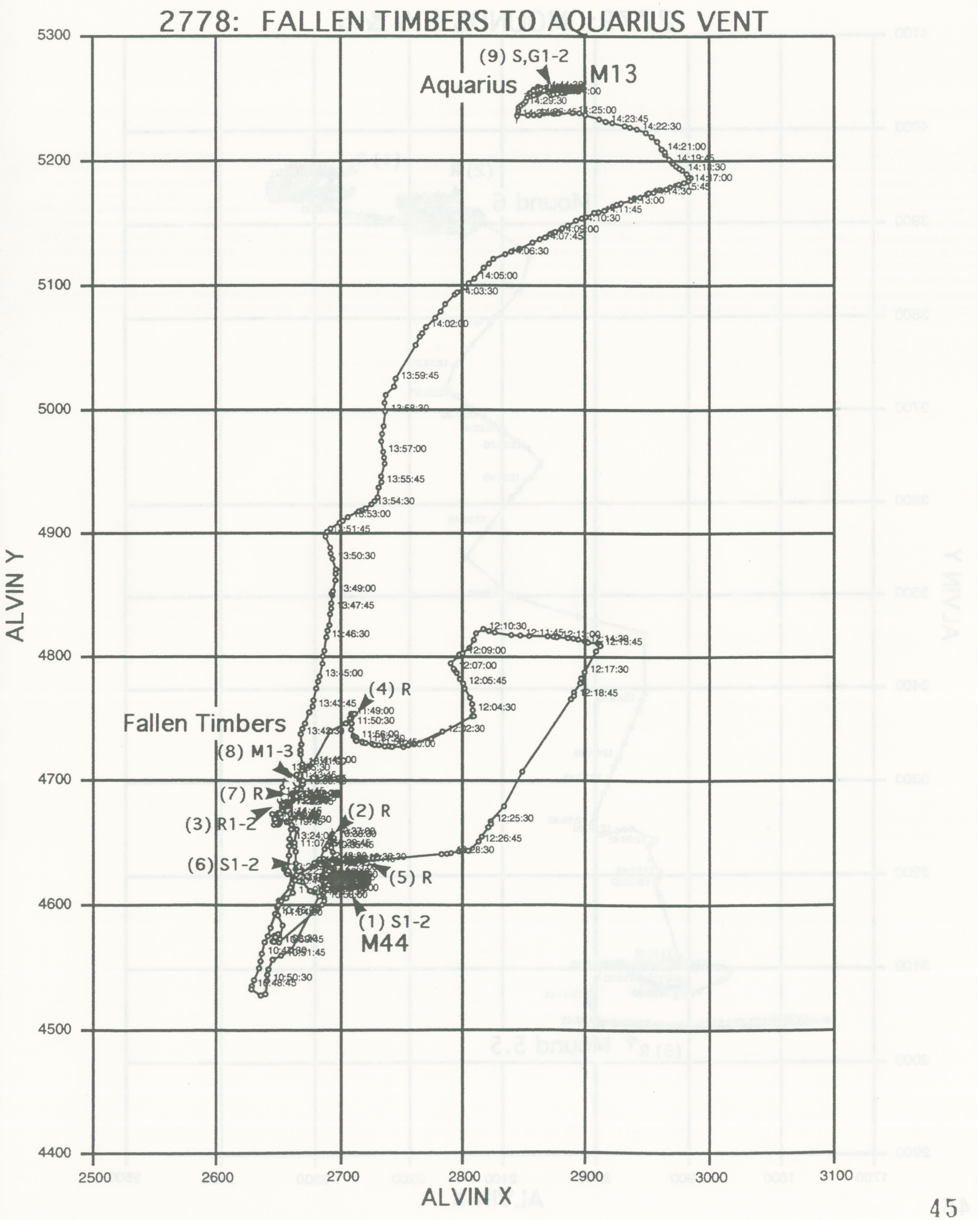

2775: MONOLITH VENT
Monolith
M10,11
10:23:00
10:24:30
10:25:45
10:27:00
10:28:30
10:29:45
10:31:00
10:17:30
10:14:30
10:11:45
10:08:00
10:06:45
10:05:30
10:04:00
10:02:45
09:42:30
09:43:45
09:57:30
ALVIN Y
ALVIN X
3650
3600
3550
3500
3450
3400
3350
3300
3250
3200
2050
2100
2150
2200
2250
2300
2350

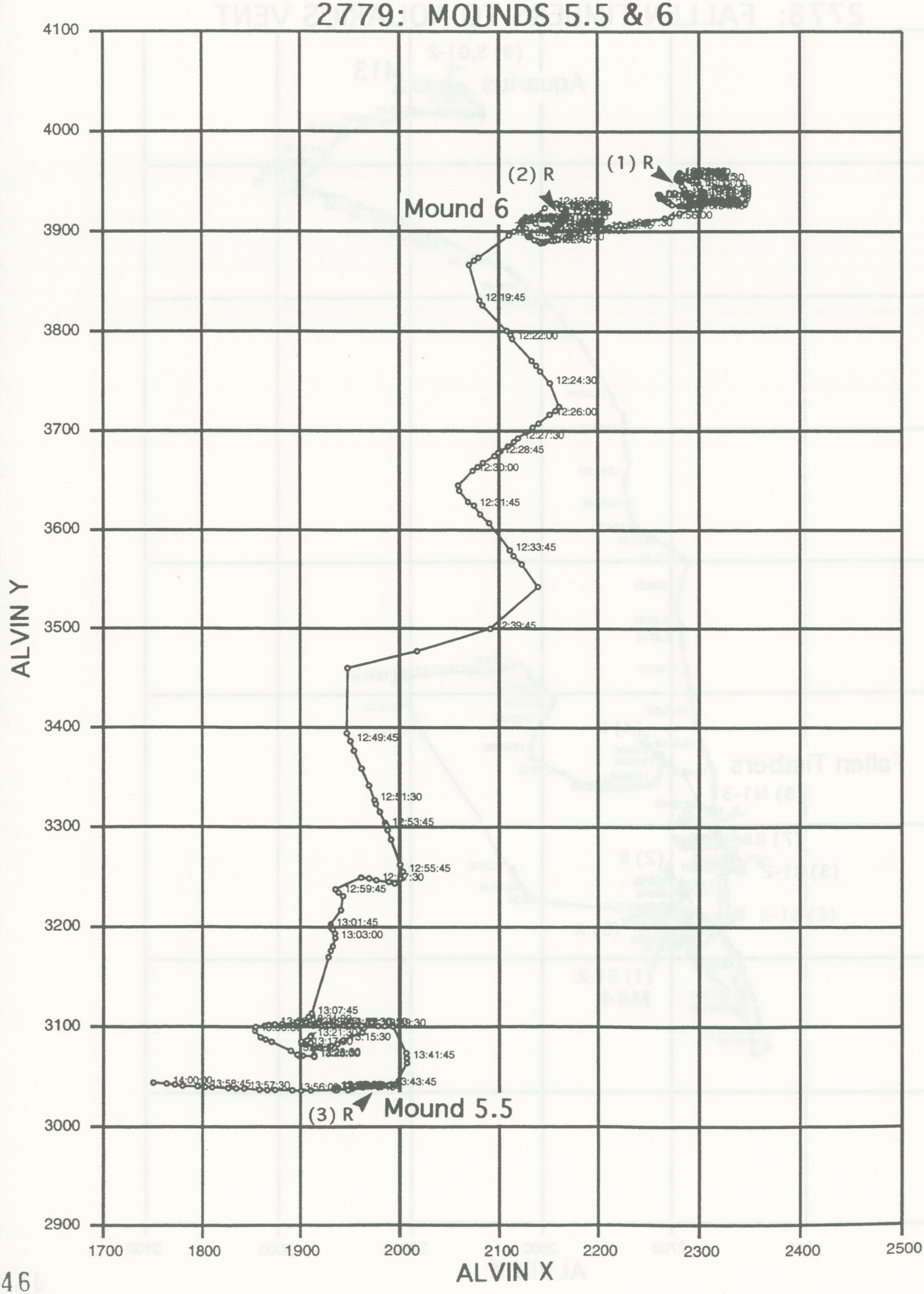
2775: MONOLITH VENT
3610
3605
3600
3595
3590
3585
3580
2270
2275
2280
2285
2290
ALVIN Y
ALVIN X
(3) D,S,DG,M
(4) S1-2,M1-3
(2) N1-3
13:02:30
13:01:00
11:55:00
11:53:45
11:10:30
11:11:45
12:05:45
13:03:45
1:39:00
1:37:45
1:35:00
1:45:45
10:47:45
12:53:00
11:18:30
13:14:30
12:55:45
12:14:30
13:26:30
13:22:30
13:05:00
12:59:45
11:09:00
10:45:00
12:51:45
10:54:30
11:07:45
11:06:30
11:02:30
10:43:45
12:46:30
10:39:45
12:47:45

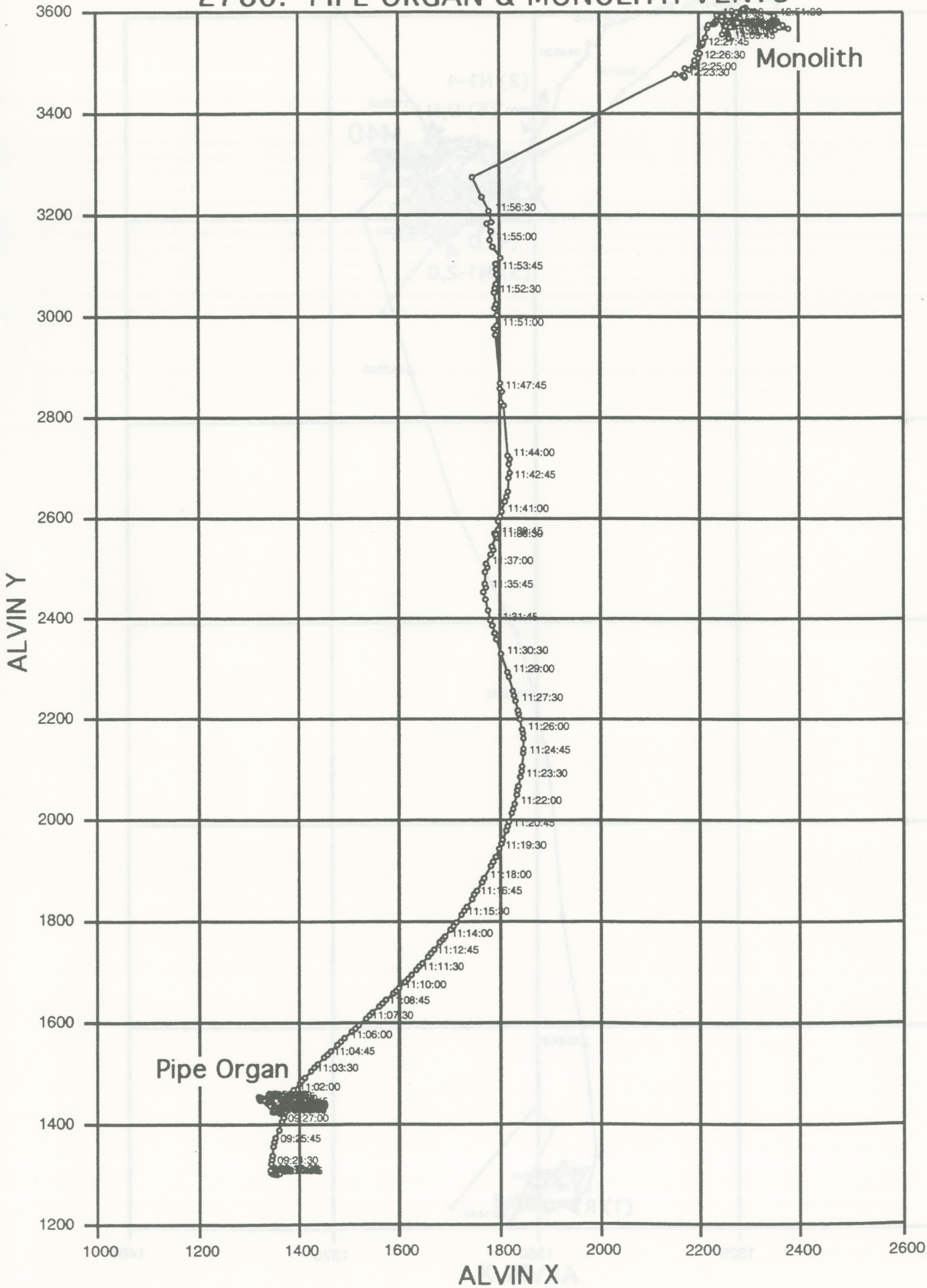

2776: CAVERN TO PIPE ORGAN VENT
(1) U1-2
(2) R
Cavern
M2
(3) U,M,G
MM
M4
(4) U
M6
(5) N1-4
Pipe Organ
ALVIN Y
ALVIN X
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
1200
1400
1600
1800
2000
2200

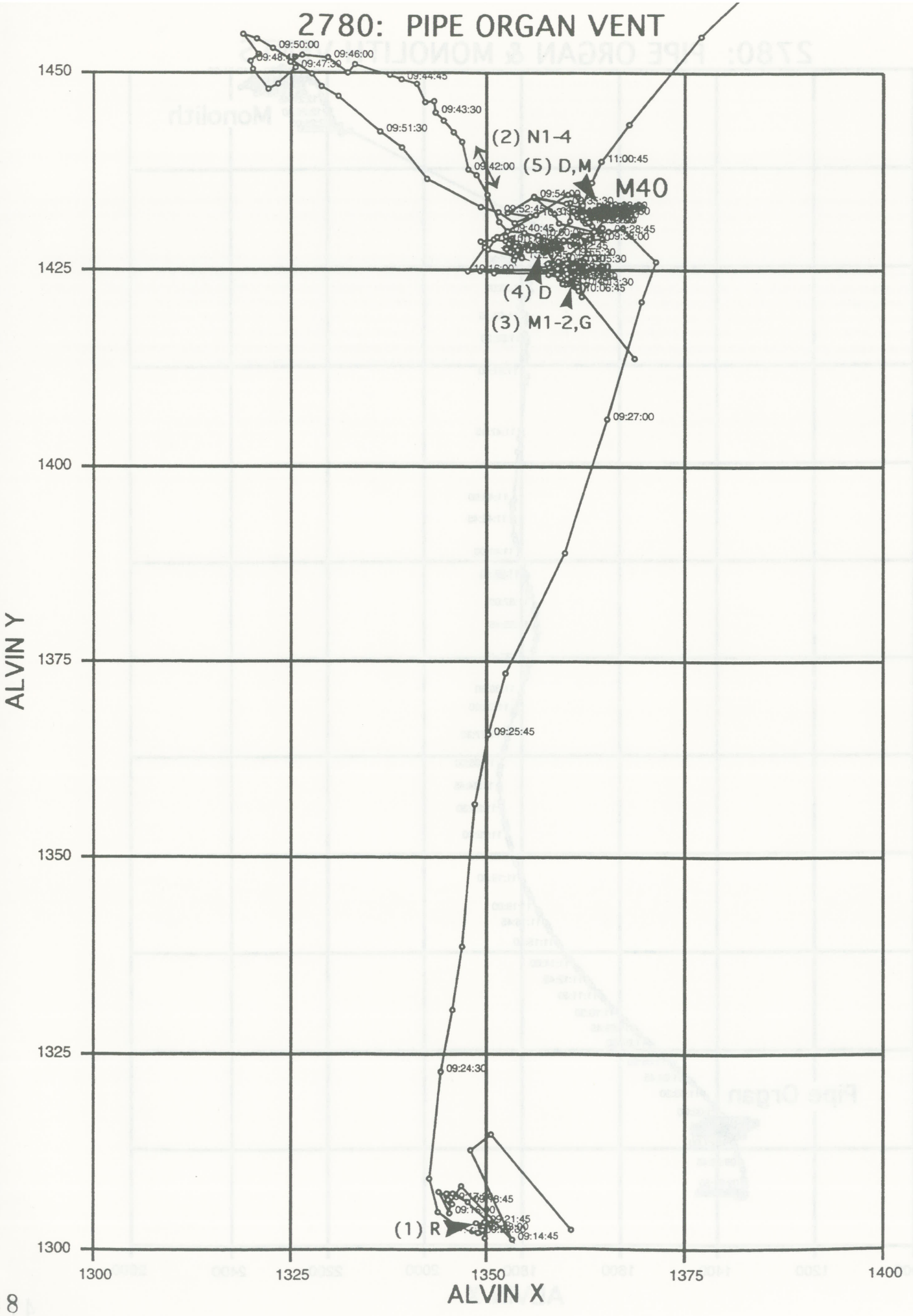

2777: PIPE ORGAN VENT
M40
Pipe Organ
(11) R
(10) R
13:44:30
13:53:00
13:24:45
11:34:30
13:26:00
13:27:30
13:28:45
13:34:45
13:31:30
09:21:45
09:23:00
09:26:45
ALVIN Y
ALVIN X
1580
1560
1540
1520
1500
1480
1460
1440
1420
1400
1380
1360
1340
1320
1300
1280
1220
1240
1260
1280
1300
1320
1340
1360
1380
1400
1420

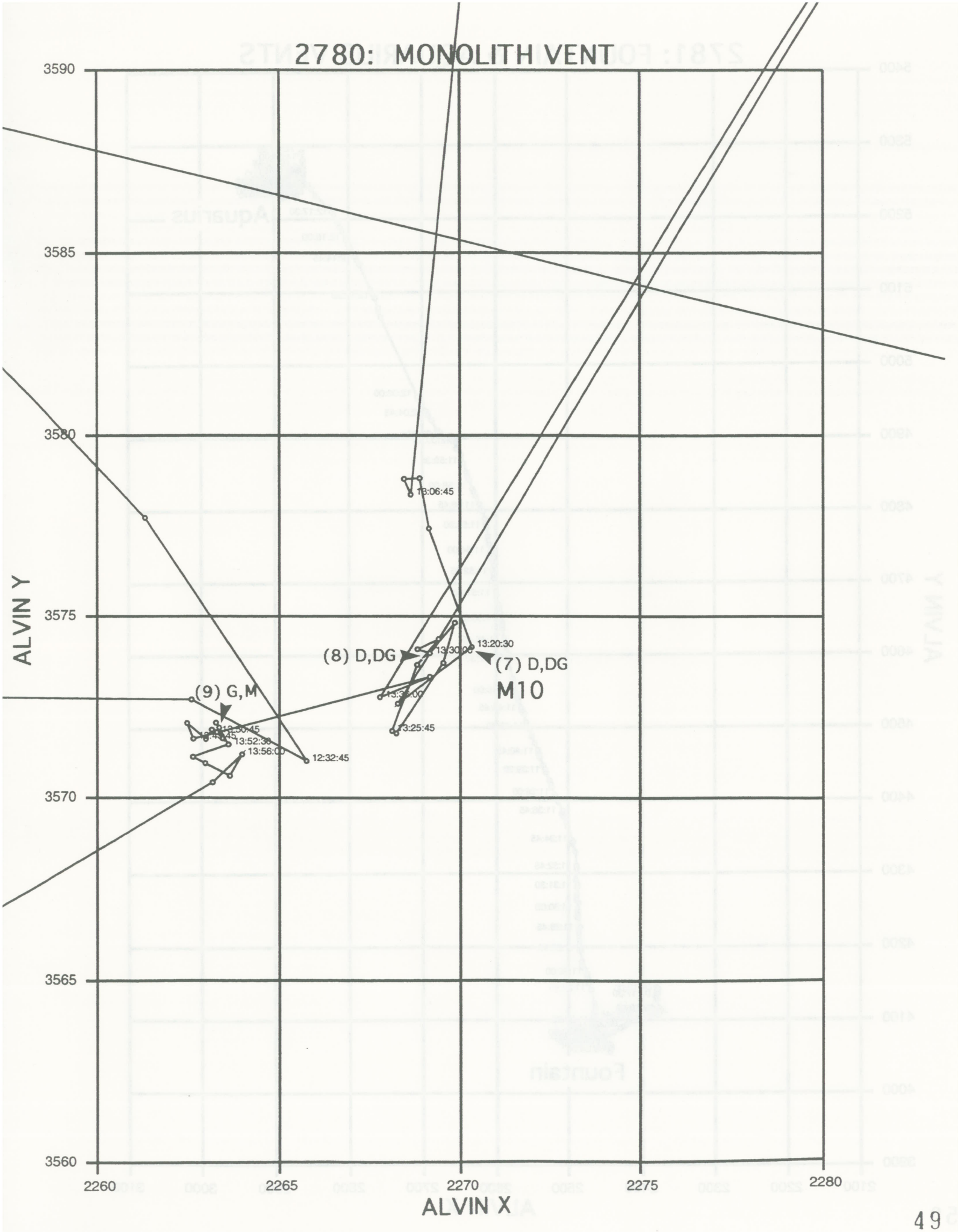

2777: PIPE ORGAN VENT
ALVIN Y
ALVIN X
1440
1435
1430
1425
1420
1415
1410
1350
1355
1360
1365
1370
(1) U
(3) N1-3
(4) M1-2,G,S,D1-2,DG
(5) D,DG
(6) M,G,D,S
(7) S,D
(8) R
(9) N
10:28:00
13:56:45
10:34:00
10:29:30
13:16:45
12:58:45
12:57:30
12:50:00
12:42:00
12:30:00
12:24:45
12:36:45
12:35:30
10:36:45
12:17:00
12:06:30
12:13:00
12:15:45
10:38:00
10:57:45
10:40:30
10:26:45
10:13:00
10:23:45
09:36:30
09:35:00
10:42:30
10:53:45
11:28:30
10:06:30
10:52:30
09:35:45
10:47:00
10:51:00
13:24:45
11:34:30

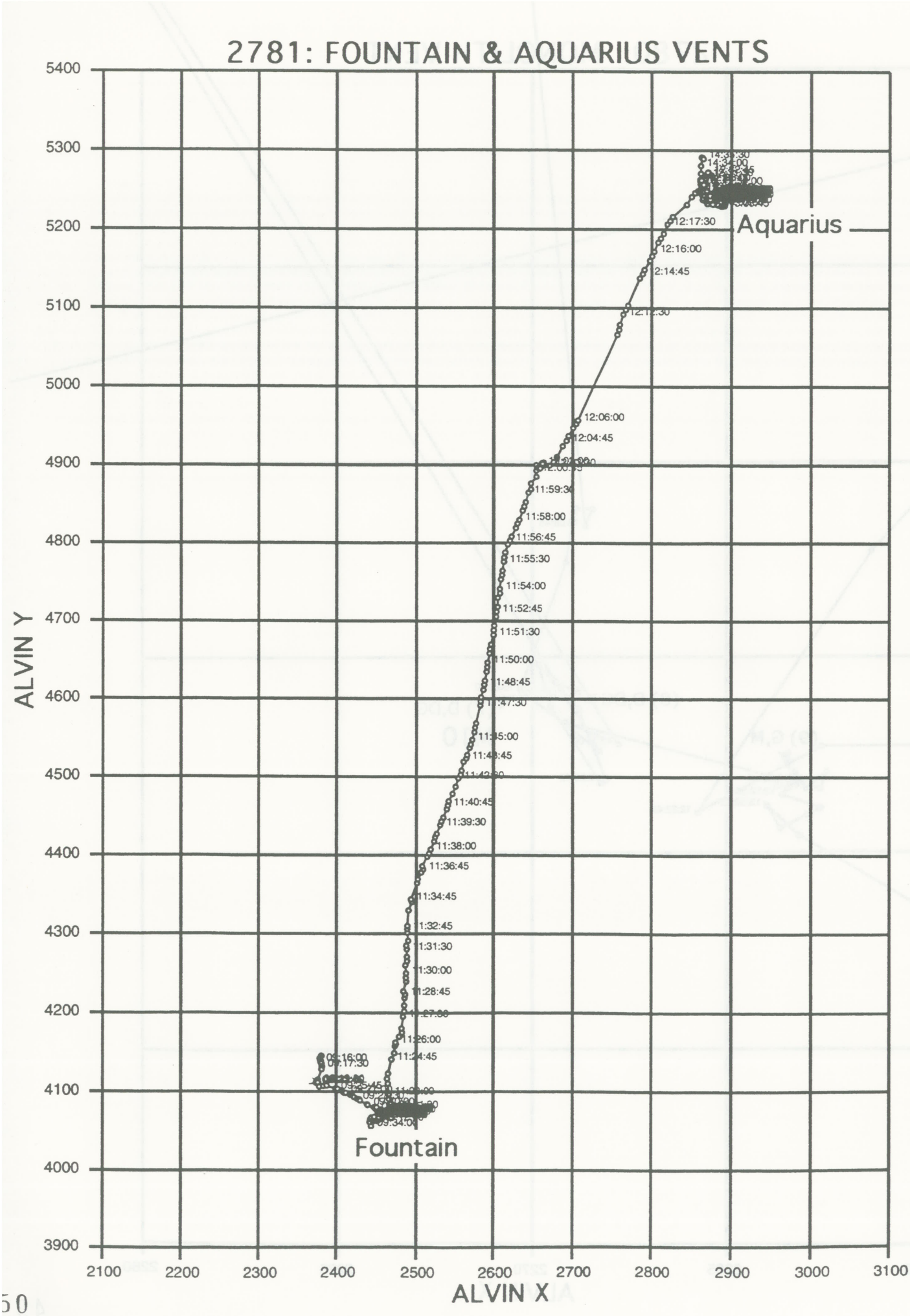

2778: FALLEN TIMBERS TO AQUARIUS VENT
(9) S,G1-2
Aquarius
M13
(4) R
Fallen Timbers
(8) M1-3
(7) R
(3) R1-2
(2) R
(6) S1-2
(5) R
(1) S1-2
M44
ALVIN Y
ALVIN X
5300
5200
5100
5000
4900
4800
4700
4600
4500
4400
2500
2600
2700
2800
2900
3000
3100


2779: MOUNDS 5.5 & 6
(1) R
(2) R
Mound 6
(3) R
Mound 5.5
12:19:45
12:22:00
12:24:30
12:26:00
12:27:30
12:28:45
12:30:00
12:31:45
12:33:45
12:39:45
12:49:45
12:51:30
12:53:45
12:55:45
12:59:45
13:01:45
13:03:00
13:07:45
13:41:45
13:43:45
14:00:00
13:58:45
13:57:30
ALVIN Y
ALVIN X
4100
4000
3900
3800
3700
3600
3500
3400
3300
3200
3100
3000
2900
1700
1800
1900
2000
2100
2200
2300
2400
2500


2780: PIPE ORGAN & MONOLITH VENTS
Monolith
Pipe Organ
ALVIN Y
ALVIN X
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
1200
1400
1600
1800
2000
2200
2400
2600
12:27:45
12:26:30
12:25:00
12:23:30
11:56:30
11:55:00
11:53:45
11:52:30
11:51:00
11:47:45
11:44:00
11:42:45
11:41:00
11:37:00
11:35:45
11:30:30
11:29:00
11:27:30
11:26:00
11:24:45
11:23:30
11:22:00
11:19:30
11:14:00
11:12:45
11:11:30
11:10:00
11:06:00
11:04:45
11:03:30
11:02:00
09:27:00
09:25:45


2780: PIPE ORGAN VENT
ALVIN Y
ALVIN X
1450
1425
1400
1375
1350
1325
1300
1300
1325
1350
1375
1400
09:50:00
09:46:00
09:47:30
09:44:45
09:43:30
09:51:30
09:42:00
(2) N1-4
(5) D,M
11:00:45
M40
09:54:00
09:52:45
09:40:45
09:28:45
09:35:00
(4) D
(3) M1-2,G
10:06:45
09:27:00
09:25:45
09:24:30
09:21:45
09:14:45
(1) R


2780: MONOLITH VENT
3590
3585
3580
3575
3570
3565
3560
ALVIN Y
2260
2265
2270
2275
2280
ALVIN X
13:06:45
(8) D,DG
13:20:30
(7) D,DG
M10
(9) G,M
13:25:45
13:52:38
13:56:00
12:32:45


2781: FOUNTAIN & AQUARIUS VENTS
ALVIN Y
ALVIN X
5400
5300
5200
5100
5000
4900
4800
4700
4600
4500
4400
4300
4200
4100
4000
3900
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
Aquarius
Fountain
12:17:30
12:16:00
12:14:45
12:06:00
12:04:45
11:59:30
11:58:00
11:56:45
11:55:30
11:54:00
11:52:45
11:51:30
11:50:00
11:48:45
11:40:45
11:39:30
11:38:00
11:36:45
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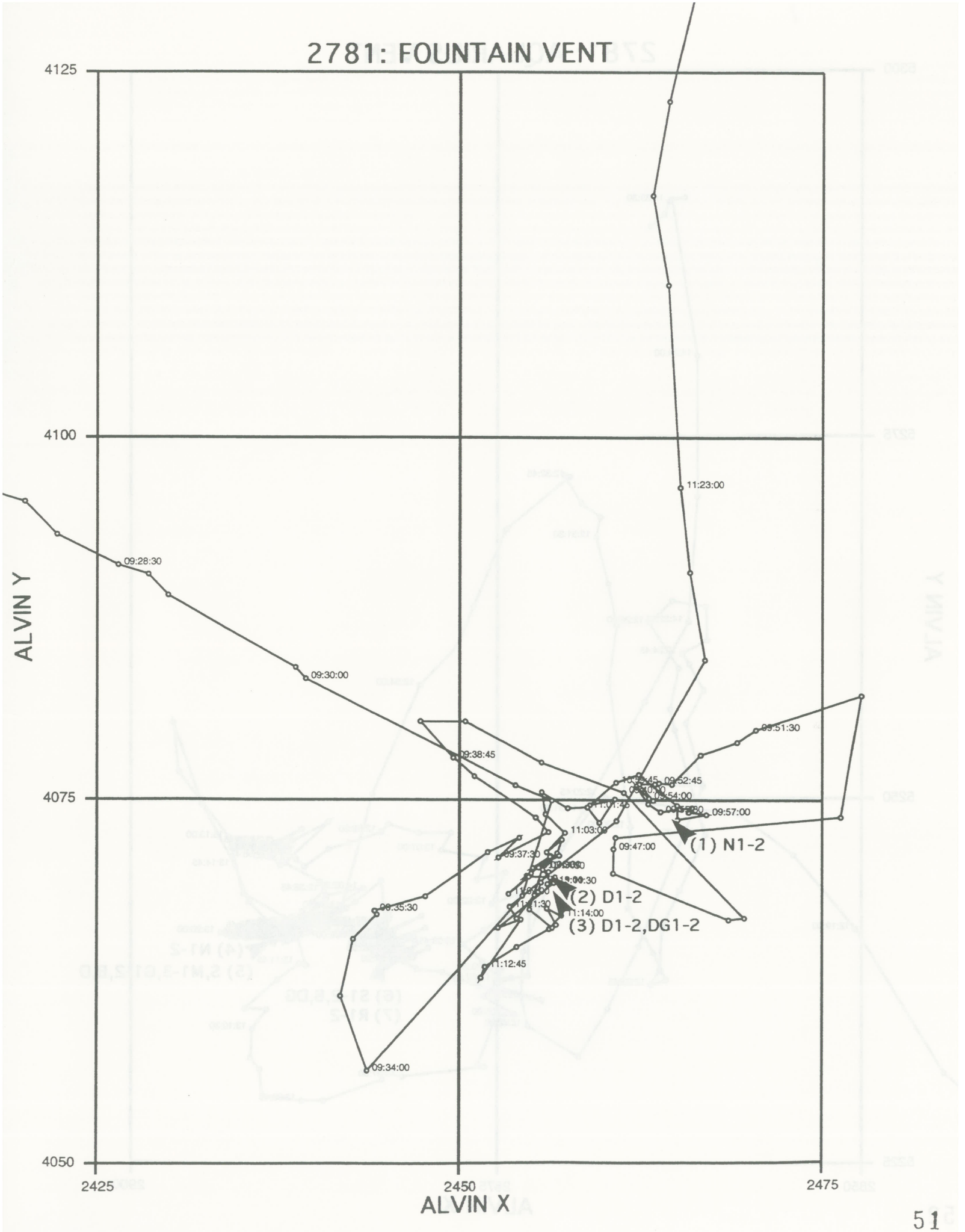
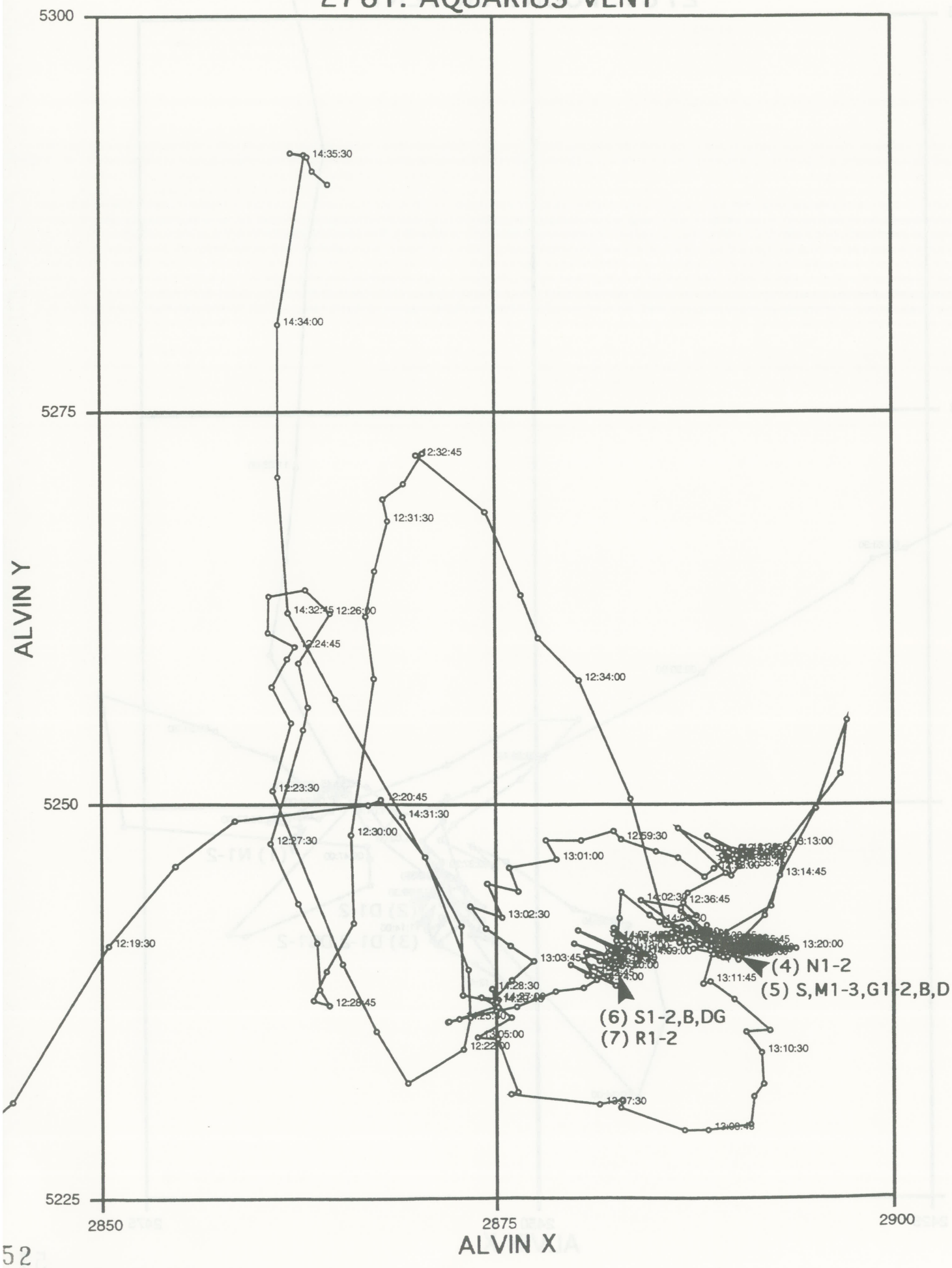
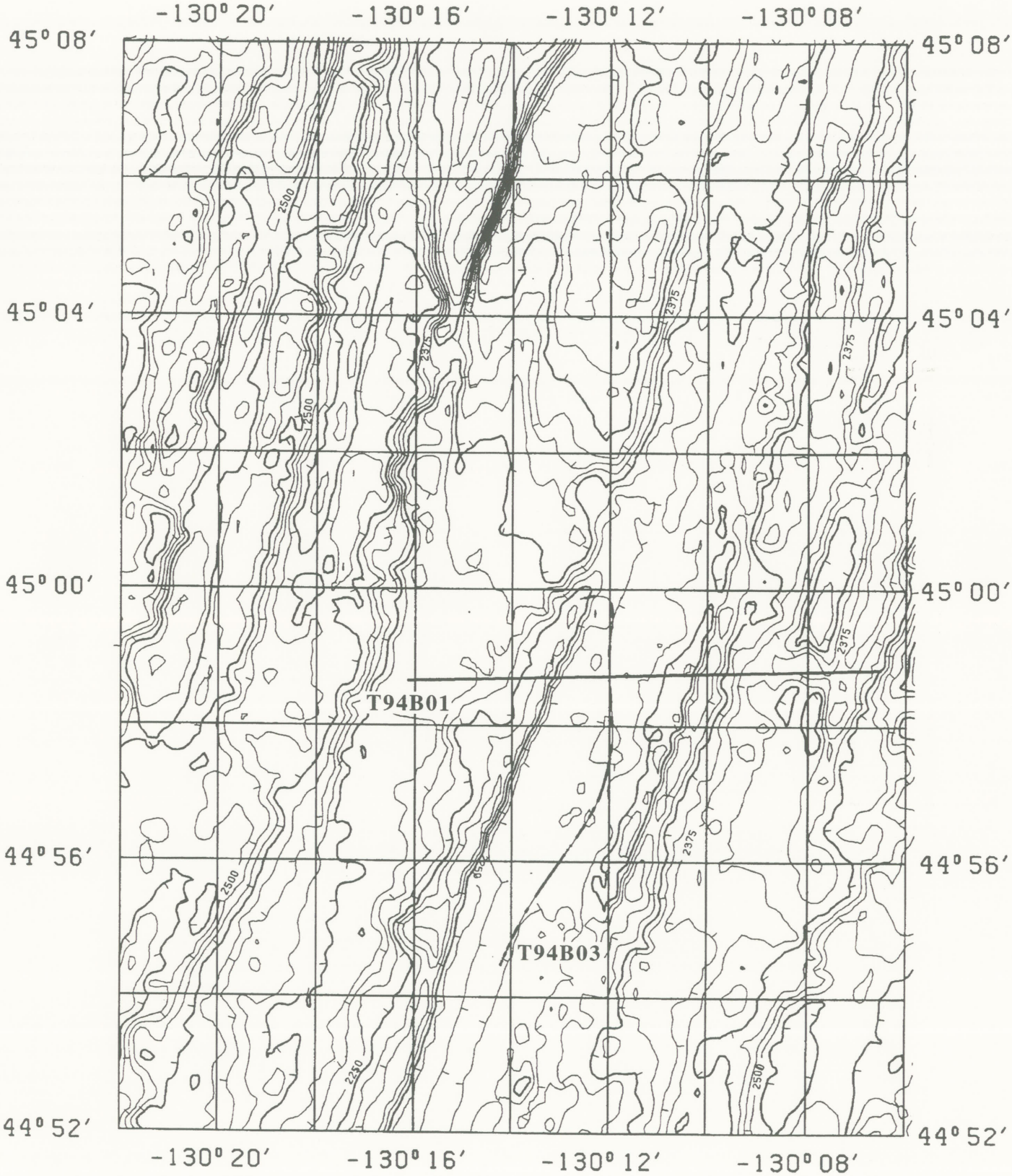
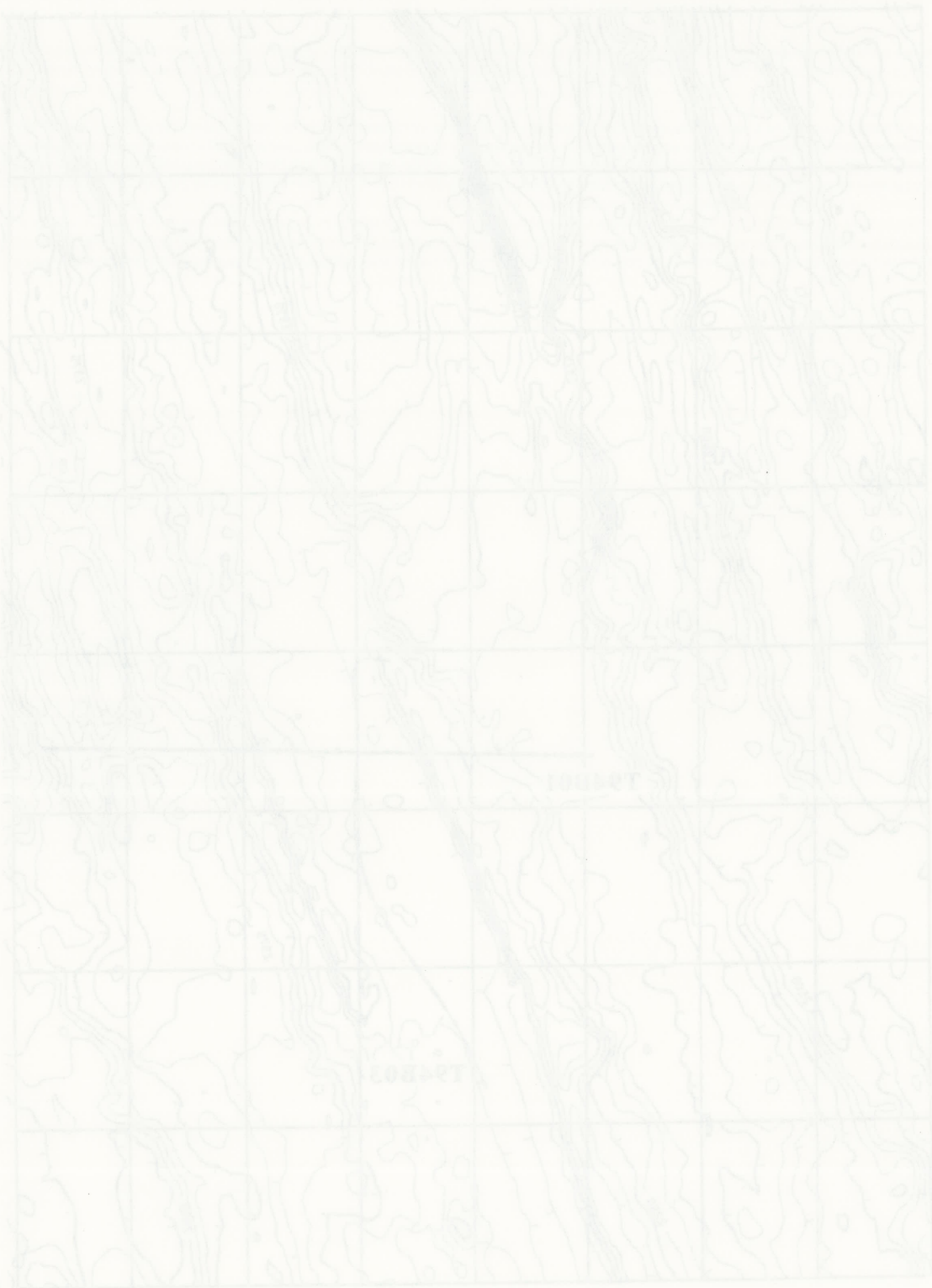
11:24:45
09:34:00


2781: FOUNTAIN VENT
4125
4100
4075
4050
2425
2450
2475
ALVIN Y
ALVIN X
09:28:30
09:30:00
09:34:00
09:35:30
09:37:30
09:38:45
09:47:00
09:51:30
09:52:45
09:54:00
09:57:00
11:03:00
11:12:45
11:14:00
11:23:00
(1) N1-2
(2) D1-2
(3) D1-2,DG1-2


2781: AQUARIUS VENT
5300
5275
5250
5225
2850
2875
2900
ALVIN Y
ALVIN X
14:35:30
14:34:00
12:32:45
12:31:30
14:32:45
12:26:00
12:24:45
12:34:00
12:23:30
12:20:45
14:31:30
12:27:30
12:30:00
12:59:30
13:01:00
13:13:00
13:14:45
14:02:30
12:36:45
13:02:30
12:19:30
13:20:00
13:03:45
(4) N1-2
(5) S,M1-3,G1-2,B,D
13:11:45
12:28:45
(6) S1-2,B,DG
(7) R1-2
13:10:30
13:07:30

# NORTH CLEFT - CTD TOWS





# CLEFT SEGMENT:
# SOUTH CLEFT

# SOUTH CLEFT
# DIVE SUMMARIES

**Video set-up for all dives:**

high 8 mm recorder #1: recorded video from the 3-chip camera, the two Alvin color 1-chip cameras and the black/white down-looking sit camera.

high 8 mm recorder #2: recorded the 3-chip camera exclusively.

*All depths are TOTAL water depth, unless otherwise noted.

## DIVE 2782: Vent 3

June 25, 1994
Pilot: Bob Grieve
Port Observer: Mike Perfit (author of this transcript)
Stbd. Observer: Gary Massoth

Objectives:

1. locate active venting in the cleft around Vent 3
2. Use the SUAVE scanner to measure low-temperature fluids in the cleft from south of Vent 3 to north of Marker "+"
3. Collect rock samples from older flows to west of cleft
4. Document geological relationships between lava types and morphologic features along the cleft from Vent 3 to as far north as the dive would take us
5. Sample basalts along the northerly traverse to get regional geochemical coverage

Dive Summary:

This dive was planned to investigate an area of the southern cleft that had previously been visited twice by the USGS in 1984 and five times in 1987 by the VENTS program. Most of those dives were concentrated within the cleft at specific vents and did not cover much terrain to the north. Video coverage was relatively limited and only a short section of the cleft has been geologically well described. Few basalt samples were previously recovered and none of these were analyzed by previous investigators. The area north of USGS Marker "+" is virtually unexplored and only dredge samples exist from that part of the ridge. Based on sidescan data, the morphology of the cleft seems to change from a single well-defined graben to a wider region comprised of multiple troughs.

The dive started approximately 300 meters west of the cleft in moderately sedimented (30-40% cover) sheet flows. Station 1 (3177x/4986y/2222 m) was very near our drop point and we sampled a piece of "older" ropy sheet flow. We proceeded to the northeast over old sheet flows and came into a region of collapsed lobate flows that appeared to have a greater sediment cover. These gave way to a region of mixed sheets and lobates about 100 m from the cleft. Here we stopped for Station 2 (3452x/5097y/2225 m) to sample a piece of collapsed lobate flow. More and deeper collapse pits became more obvious as we reached the west rim of the cleft. It is relatively narrow here (~50 m) and at least 10 m deep. At Station 3 (3631x/5181y/2229 m), in an area of collapse and pillars just to the east of the eastern wall of the cleft, we sampled a fragment of jumbled sheet flow. We believe this was very close to USGS Marker "3-" although we did not see it.

We turned southwest at this point to head back into the cleft to look for venting along the floor. Within the cleft we observed a great deal of talus cascading down the walls and some hydrothermal sediment mounds that appeared to be associated with some bacterial activity and tubeworms (dead?); some diffuse venting was observed. In places the cleft was very narrow;

slightly wider than a sub-length. The east wall of the cleft appeared to be very abrupt and steep in places, associated with talus and rubble, not volcanic constructional features. After traversing about 200 m south, we turned toward the west wall to head back along the axis to the northeast. Station 4 (3511x/5064y/2239 m) was a piece of jumbled sheet flow that appeared to be from a block along the wall of the cleft. Station 5 was at a low-T hydrothermal mound at about the same latitude as our Station 3 and Marker 3-. The site was characterized by diffuse venting, bacterial mats (or globs?), dead tubeworms and possibly some siliceous deposits. After looking for low-T venting, we decided flow was insufficient to take water samples. We moved 20 to 40 m north to Station 6 (3582x/5216y/2244 m), which was another diffuse venting site where we found a number of small, old-looking, extinct chimneys that looked like the so-called "fairy castle site". A scanner sample was taken here and we noted the presence of clam shells and dead tubeworms.

The dive continued northeastward within the cleft for approximately 350 meters. Much of the west wall was covered with talus and rubble of various sizes ranging from blocks of lava to fine-grained pelagic sediment mixed with glass shards. There were a number of talus/sediment chutes that cut small erosional gullies in the wall. Some small areas of diffuse venting and sediment accumulation were noted along the floor. We encountered Marker + at 11:06 (3719x/5557y) at the base of a hydrothermal sediment mound along the west wall of the cleft. Our x value was very similar to that expected for this marker but our y value was 7 m to the north of that previously determined. We did extensive sampling at this site; Station 7. The site was characterized by a mound of hydrothermal sediment lying along the base of the west wall overlain by extinct sulfide chimneys a up to 4-5 m tall. The chimneys were a few meters east of the uppermost step in the west wall of the cleft. Diffuse water (mostly around 4° C ) was emanating from the area below the chimneys in the sediment which had abundant bacterial "globs". SUAVE scanning was done here and manifold samples were taken in water up to 6.3°C. Above the diffuse venting site, the wall was covered with a crusty sulfide deposit which was difficult to break for sampling and had living and dead tubeworms, snails and limpets(?). A sample of the biology (7B) and the encrusted sulfide (7S-2) were taken from less than a meter above the venting location. The scanner was deployed a second time in 13.4°C diffuse flow. A piece of sulfide from a thin spire on one of the tall extinct chimneys was also sampled (7S-1) as we made a video traverse of the site.

As the dive continued north along the west wall, the cleft seemed to become more volcanic in nature with less talus and more constructional volcanics along the wall. We stopped at Station 8 (3748x/5656y/2252 m) to photo-document and sample (8R) an area where lava had spilled over the wall into the cleft. It was characterized by a small lava mound on the edge of the west wall that had sheets of lava cascading down a steep slope into the cleft where it terminated as a pile of lobate flows. There were a number of features (can be seen on the 3-chip video) that indicated this flow originated on the margins of the cleft and flowed down over preexisting talus to the floor. Some of the drip-like or cuspate features on the wall are difficult to interpret.

Continuing northeast, the cleft appeared to widen somewhat and give way to an area of extensive flat-lying sheet flow. Sample Station 9R (3851x/5880y/2244 m) was taken here about 220 m north of Marker +. This sheet flow has moderate sediment cover, relatively little relief and well-defined linear ropes that primarily are aligned parallel to the direction of the cleft. As we traversed across the flow to the northwest, it became shallower in a series of short steps (each less than 2 m) related to NE-trending fractures. In at least one place the sheet flow seemed to drape over the fault/step rather than being fractured and displaced by it. Total change in elevation from the axis of the cleft to the edge of the sheet flow to the west was about 14 meters. Station 10 (3817x/6127y/2229 m) was in older lobates just west of the sheet flow. We traversed the sheet flow back to the northeast for about 500 m and stopped to sample a jumbled sheet flow at Station 11 (4147x/6566y/2240 m) near the east wall of the cleft which was more well defined than the western wall at this latitude. Mixed sheets and jumbled sheet flows continued to floor the relatively wide and ill-defined cleft for the next 500 m; we noted some areas where there may have been some diffuse hydrothermal flow. The Niskins and a major sampler were taken at Station 12 (4101x/7000y/2239 m) above the sheet flow to get "background" seawater samples. Sample 13R (4218x/7065y/2240 m), a lobate flow, was recovered in the cleft (?) and then Sample 14R

(4645x/7260y/2244 m), an older lobate, was recovered from a few 10's of meters to the east of where the east wall of the cleft was expected to be. We changed heading to drive west for a short time and stopped to sample a piece of lobate collapse at Station 15 (4302x/7355y/2241 m) before ending the dive at around 13:50.

## DIVE 2783: Vent 1; South Cleft

June 26, 1994
PIT: Socrates Carelo
Pilot: Pat Hickey
Port Observer: Dave Butterfield (author of this transcript)

Dive objectives:

The primary purpose of this dive was to conduct sampling operations at the central Vent 1 site and to explore further north, time permitting. A corollary objective was to locate previously deployed markers for co-registration on this year's navigational grid. The sampling was very successful, but there were problems with the sub's computer, and navigation did not work in sub.

Chronology:

On the descent we discovered that the computer was not displaying Depth3 in meters, though Depth1 in psi was displayed. The pilot and co-pilot attempted to correct this, but could not. The ship's 486 computer had to be swapped for the spare computer just before the dive, and there were some parameters missing from the navigation software. Travel times were logged, so navigation could be reconstructed post-dive.

We arrived on the bottom at about 0930 (2732x/2473y), at a depth of 3188 psi or approximately 2232 meters. At 0945 (2709x/2464y) we were in a sparse field of tube worms and clam shells in hydrothermal sediment. We could not tell if any of the clams were alive. We had no appropriate sampling tools, so we did not attempt to sample clams. I took 5 hand-held 35mm shots of this site. We saw Marker circle - here (a bucket lid marker on the seafloor). There were several fish and crabs here. (This clam site was revisited and sampled on a later dive.) We were south of the central high-temperature vent sites indicated by 1984 Markers /O and 1/ on the Vent 1 area map. We drove north, attempting to keep the western Cleft wall to port. My view much of the time was restricted to the top of the Cleft wall. At times during the traverse northward we went up over the wall, then drove back east into the Cleft. The sheet flow where we landed quickly gave way to blocky or jumbled terrain on the Cleft floor. There were many basalt spires with drainback features on them along the western wall. The base of the western wall alternated between talus and what looked like collapsed roof. In places the floor of the Cleft looked like the puzzle pieces of a collapsed lava roof.

There was a ground on the bow camera strobe, so we had to use sub lights for illumination. Later in the dive, the bow cameras also developed a ground problem, and they had to be turned off. Video was good throughout the dive, at times spectacular on the 3-chip camera.

At 10:30 we saw a single chimney with smoker activity. Note that the 3-chip camera time and date registered as 11:06 and 6/25 at 10:33 and 6/26. Pilot reset the 3-chip camera time to match the Alvin time (actually 15 sec behind). Travel times in seconds were 3.091/0.929 for the 11.0/10.5 kHz transponders (2810x/2823y).

We positioned at the chimney to measure temperature and take fluid and sulfide samples. We broke off the top ~80 cm of chimney, and recovered the lower 20 cm in the port aft milk crate. It had a chalcopyrite lining. We took discrete major sample #4 at 10:44, then took discrete major #6 at 10:57. Alvin high-temperature probe gave Tmax = 284°C. Our altitude during sampling at the top of the chimney was 9 m, heading was 227. At 11:07 we took gas-tight sample black 7. Temperature reading at end of sampling was 281°C. We took a temperature measurement in a tube worm colony about 1 m below the smoker, ranged from 12-29°C. Sampled some of the worms

and put in bio box at 11:23. We backed away from the first chimney and drove a short distance roughly north and found a second large chimney with smokers on top and on the sides. We set up for manifold sampling. Took port major with T1=341°C at 11:48. Took port gas-tight with T1= 341.6°C, heading 296, altitude 8 m, depth 2221 m (3184 psi), 2819x/2829y at 11:51. Took the mid-major at 11:53, T1=342°C. Since this was the hottest vent yet seen, we took another major sample (blue, #5), first moving around to the opposite side for better position. Sampler triggered at 12:04 at 2218 m, 2817x/2837y, heading 060. Took hand-held shots of smoker out pilots view-port. Pat says the first chimney we sampled is just to starboard about 10 m away. Another chimney is to port at just a few meters away. We took discrete gas-tight #3, blue, in the 342°C vent. Alvin temperature probe gave 337°C max after sampling. At 12:40 (2817x/2837y/2223 m) we put a small piece of the 340°C chimney in the front port milk crate. It looked like solid chalcopyrite. We also put a larger piece of a lighter-colored, inactive chimney in the front starboard part of basket. I asked Pat to leave the Marker triangle 12 on top of the chimney where it would be visible. First we tripped the orange aft Niskin about 1 mav, then left the marker. We continued to trip the remaining 3 Niskins at approximately 4, 10, and 12 mav, finishing at 13:00.

After the Niskin sampling, we headed north to look for markers and chimneys. We found a rectangular marker at ~ 13:20, and tried to read it. It was covered with slime, and we could not read it even after shaking it off. I thought that perhaps I could make out a circle beneath the coating, and Pat said he could make out "vik" on the side of the marker. We rose up and immediately saw another smoking chimney, but then became lost in a cloud of debris. Our position when we spotted the chimney was 2844x/2878y. Current seemed to be blowing southward. We drove approximately NE and then back SW to find ourselves back at this chimney again at 13:52 (2842x/2879y). The sides of this chimney and the others we sampled had lush communities of tube worms. We measured temperature among the tubeworms at this site, obtaining a maximum of 33.5°C down at the sulfide base of the worms. Smoke was bathing the worms from below. At 13:58 we took discrete major sampler #11 at the base of the tubeworms (recovered sample was brownish "worm water"), heading 106. Moved up slightly and sampled part of a beehive vent, put in starboard aft near bio box. Measured max temperature of 140°C in the beehive diffuse orifice. Took discrete major #9 in this vent at 14:07. Took starboard manifold at 14:15, with T1 at 51°C at start. Temperature rose during bottle filling when pumps were off, probably due to low flow rate at this poorly defined orifice. Took starboard gas-tight at same vent with the same temperature behavior at 14:17. We were out of power and dropped the weights at this site at 14:20.

Although we did not find any legible markers, we believe we sampled the high-temperature chimneys near Markers /O and 1/.

## DIVE 2784: Vent 3

June 27, 1994
Pilot: Matt Heintz
Port Observer: John H. Trefry (author of this transcript)
Starboard Observer: Robert P. Trocine

Objectives:

1. Collect basalt samples from sheet flows to the west of cleft and from non-talus deposits in the cleft.
2. Collect vent fluids and active chimneys from at least two sites along the cleft in the Vent 3 area.
3. Sample a vent plume at depths of 1, 3, 5 and 10 m above a chimney orifice.
4. Survey additional areas along the east and west walls of the cleft for the presence of hydrothermal vents.
5. Collect clam shells if observed.

Dive Summary:

The dive began 0803 on June 27, 1994 and we reached the bottom at 2216 m (x 3429, y 5000) at 0910. We then headed northeast toward the cleft, traveling across a terrain of older sheet flows. At 0916, we collected a sample from a sheet-flow area (sample 1R at x 3441, y 5004, 2228 m). We then continued across the cleft, turned northeast and then northwest and toward our first target in an area previously identified by the U.S.G.S. and sampled by NOAA in 1987 at their Marker 8-. The cleft contained a sizeable covering of hydrothermal sediment and we surveyed the wall on east and west sides of the cleft, identifying chimneys and venting activity on the west side of the cleft. We took up position in a mound/chimney area about 3 m in diameter with some extinct 2 m tall chimneys and at least one, shorter venting chimney (x 3584, y 5219, 2244 m). A sulfide sample was taken (2S) in preparation for fluid sampling at the same location. We did not see Marker 8-. Fluids were collected from the same vent (station 2) with the manifold sampler at decreasing temperatures of 214°C (port major #10), 207°C (port gas-tight) and 197°C (middle major #15). We then collected vent worms from this position and from a slightly shifted position where active, live worms were visible.

Our survey of the Vent 3 field continued along the west wall of the cleft. We tried to stay 5-6 m above the bottom of the cleft and along the wall. Northeast of our station 2 site, we passed through a 200 m long area with a relatively lower abundance of hydrothermal sediment and no observable vent activity. As we neared our second target (U.S.G.S. site +), we again entered an area of more abundant hydrothermal sediment deposits and began more detailed inspection up and down the east and west walls, finally locating a site on the east wall. The first diffuse flows inspected had an ALVIN probe temperature of 48°C and we collected two manifold samples, starboard major #13 and starboard gas-tight (x 3705, y 5562, 2254 m), without the availability of the manifold temperature probes. A slightly more vigorous vent was observed a few meters to the north and we measured temperatures as high as 135°C with the ALVIN probe before taking discrete majors #11 and #4 and gas-tight #7 samples (x 3722, y 5569, 2251 m). The fluid was emanating from beneath a break in the deposit created by the pilot. A piece of basalt was collected from a nearby, apparent talus deposit (5R, x 3711 y 5571). We then proceeded southwest along the west side of the cleft in a continuation of our search for active venting. Along the route, we collected another basalt sample from a large mass in the cleft that appeared not to be part of any talus deposit (6R, x 3593, y 5308, 2232 m). No additional active vents were observed until we returned to our original station 2 location. We set up to sample again at this location but power restrictions constrained what had been a dive with a relatively long bottom time.

We departed from the bottom at about 1436 and surfaced at 1611.

## DIVE 2785: Plume

June 28, 1994
Pilot: Robert Grieve
Port Observer: John Lupton
Starboard Observer: Kevin Roe (author of this transcript)

Objectives:

Water sampling at the Plume Site, to continue time-series, basalt sampling at the northernmost and southernmost part of the dive, and general survey of the cleft north towards Vent 1

Dive Summary:

We commenced the dive at 0755 and reached the bottom at 0902, at coordinates x=1667, y=360. We began driving east. We saw white sediment over lobate flows. Bottom depth at 0907 was 2207 m. By 0912 we saw lava pillows, and by 0914 we were at x=1776, y=309 over layered

basalts. At 0922:37 we were over the west wall at x=1965, y=386 with an altimeter reading of 13 m for the depth of the cleft. At 0926 we reach the bottom of the cleft. At 0930, station 1, we took basalt rock sample 1R1 at x=2021, y=404, bottom depth was 2234 m. We crossed the west wall again at 0936 but returned to the east wall at 0939. At 0943 the east wall had considerable talus at the bottom with only a light dusting of sediment. At 0946, the cleft was noted as only 10 m wide. We bumped into the east wall at 0952. Considerable hydrothermal sediment was noted at 0958.

Our original target, 1X was discovered to be a mistake and switched to target 3 at 0959:30. There were white, filamentous bacterial mats on the east wall as well as brown and blue gray colonies. There was considerable bacterial floc, about the size of golf balls first sinking and then later rising along the east wall. It was discussed whether we could catch this floc in a Niskin. At 1002, station 2 (2239 m), we netted some floc in the sediment net. I don't have a position fix as we were shadowed by the wall. At 1005, I saw tissue paper-like bacterial mats sinking. At 1015, window temperature rose to 2.1°C from 1.6°C further south.

By 1019 the floor of the cleft was totally covered with hydrothermal sediment. At 1023 we noted our first hydrothermal "smoke" as we sunk towards the bottom. Many small spires were noted out of the base of the east wall at 1026, and I took several pictures. The first black smoker I noticed was a little beehive-like structure out the starboard port at 1031. The wine bottle marker of Dive 2118 (Ross and Stakes) was seen at 1037:21 out the starboard port. We then moved in to sample hydrothermal fluid and spires at station 3. At 1051 we took down a spire and put it in the bio box, then waited for the floc to clear. Most of the chimneys in this field were small, dead and covered with hydrothermal oxyhydroxides. The largest of the dead chimneys were approximately 1.5 m. The manifold sampler was in the vent at 1108, maximum temperature during pumping was at first 103-104°C, until the port major was tripped at 1125, at which time, the temperature then rose to 173°C as it was filling (#10, 3M1). The middle major (#15, 3M2) and the port gas-tight (#5, 3G1) were tripped at 1139:45. The steady state temperature was 102°C when pumping but increased to 190°C as the major tripped. The starboard gas tight (#4, 3G2) and the starboard major were tripped at 1146:50. The temperature rose to 232°C during sampling. The Alvin temperature probe was inserted into the same orifice and registered a steady temperature of 247.2°C. At 1154, we moved the Alvin probe to a nearby vent and got a temperature reading of 242°C. Shimmering water was seen flowing below the sub from the starboard port. There were countless soda straw spires seen out the starboard port.

As we prepared to take Niskin samples, still at station #3, it was discovered that the forward two Niskins were already tripped, probably in entering the vent field. At 1211 we tripped the blue Niskin at a total depth of 2240 m, estimated 12 meters above the vent field. The green Niskin was tripped shortly after at approximately 2240 m total depth, 11 m above the vent field. I didn't have good position fixes during the water sampling.

We then commenced a camera transect normal to the ridge for Bob Embley. Our beginning point was at 1220 at x=2221 y=1010 and we finished at 1230 at x=2070, y=1152, then headed back for the cleft crossing lobate flows (1232) and white sponges on the rocks (1233). We crossed over into the cleft at 1237, x=2237, y=1091 and headed northeast along the inside of the cleft. By 1250, we were over hydrothermal sediment, about 50% coverage. A large talus pile was seen at 1251 at the base of the east wall. Four pictures were taken from the starboard port of talus piles at the east wall between 1252 and 1310:43. The last two pictures on the first roll were of hydrothermal sediment in the cleft. Station #4 was the intended northernmost basalt within the cleft, for Mike Perfit, taken at 1308 at x=2465, y=1632, and depth 2243 m. Continuing northeasterly, up the cleft, we got our first look at clam shells in the sediment as previously described at Vent 1. At 1336 we sighted USGS Marker 2/. Three minutes later we had a nice view of ropy flows off the east wall and I took a picture of a sheet flow at 1341. Station #5 at 1343 was a rock sample of this sheet flow at x=2726, y=2421, depth 2228 m. At 1347, I took a picture of clam shells and worms were sighted out the port side. Station #6 at 1349 was a scoop sample of clams and worms at x=2718 y=2465. A drop weight was also sighted in this area. Considerable striations in the sheet flow of the cleft were noted, this time running east to west at 1403. Hydrothermal staining was noted on the rocks at 1408. At 1409, we dropped weights and

began our assent, siting one octopus tentacle, but not enough of the octopus to judge its size, on the way.

## DIVE 2786: Vent 1

June 29, 1994
Pilot: Pat Hickey
Port Observer: Randy Koski
Starboard Observer: Simone Metz (author of this transcript)

Dive Objectives:

1. Photograph each chimney from top to bottom using the 3-chip video.
2. Check temperature of the 284°C chimney identified during Dive 2783.
3. Resample the 342°C chimney identified during Dive 2783.
4. Determine the extent of chimney growth over 3 days following removal of spire tops at the 284°C and 342°C chimneys during Dive 2783.
5. Check temperatures and collect vent fluids from other active chimneys located within the middle of the Vent 1 region.
6. Obtain diffuse vent fluids.
7. Sample the plume of the chimney with exit temperatures of 342°C (identified with Marker triangle #12) at depths of 1, 6 and 15 m above the chimney orifice.
8. Assess the performance of teflon tubing for the collection of high temperature fluids at the 342°C chimney.
9. Collect sulfide samples from active vents.
10. Collect basalt samples from the west and east walls of the Cleft, as well as the center of the Cleft.
11. Photograph the west and east walls of the Cleft using the 3-chip video.

Dive Results:

The dive began at 0749 on June 29, 1994 and we reached bottom at 2215 m (x 2599, y 2812) at 0906. We then headed east toward the Cleft and the site of Vent 1, travelling across a terrain of lobate basalt sheet flow. At 0914, a sample of the lobate basalt sheet flow (1R) was collected (x 2651, y 2809, 2218 m). After recovering the basalt sample, we proceeded east towards the Cleft and the 284°C chimney previously sampled during Dive 2783. Initially, the chimney at x 2824 and y 2830 was photographed from bottom to top using the 3-chip video. Upon completion, we determined that the spire recovered 3 days earlier from the top of the vent chimney had regrown approximately 6 inches. Efforts were made to recover the chimney regrown over the last three days. However, due to the friable nature of the piece only small fragments were recovered. Using the ALVIN probe, the exit temperature of the vent was measured at 283°C, similar to that obtained during Dive 2783.

At approximately 0945, we proceeded due north towards the 342°C chimney identified during Dive 2783 with triangle #12 (x 2825, y 2841). Initially, the chimney was photographed from bottom to top. The chimney is about 9 m high and 2 m wide. In contrast to the 284°C chimney, minimal growth was observed at the point were the spire was removed 3 days prior on Dive 2783. Next, the temperature of the fluid was measured at 334.6°C to 334.8°C using the ALVIN probe. Vent fluids were obtained using both a discrete major (#4, 3D) and a discrete gas tight (#3, 3DG) sample. In addition to the collection of vent fluids, an experiment was carried out at this site to determine whether teflon tubing enclosed in silicon tubing could be used to sample high temperature fluids. High temperature fluids were pumped through this new tubing for 10 minutes. No obvious melting or other deformations were observed in the line. Pumping of the fluid was slow and drew 6 amps on the auxiliary pump.

During the video survey of the chimney at Marker triangle #12, we identified an active

chimney immediately north (x 2825, y 2844, 2221 m) with multiple venting orifices. Further video surveying showed that these two chimneys were joined at the base. The chimney is about 10 m tall and a couple of meters wide. Temperature measurements using the ALVIN probe on an orifice located about 1 m from the top of the chimney showed ~340°C, similar to that obtained for the orifice on the chimney identified by Marker triangle #12. Three vent fluid samples were collected from this orifice, two majors (4M1, 4M2) and one gas tight (4G) sample using the manifold system. Temperatures (T1) from the manifold system during sample collection recorded 338.6°C for the port major (#10), 342.2°C for the gas tight sample and 341.9°C for the middle major (#15). No T2 values are available because the probe was not operational. Next, we moved about 3 to 4 m below this orifice and collected a sulfide spire. Two separate sulfides were recovered. The top part of the spire (4S1) and a bottom section (4S2). Temperatures at this orifice measured 270°C using the ALVIN probe. One discrete major sample (4D1) was collected from this orifice. One additional spire, located about 3 m west of the 342°C spire on this chimney also was sampled. The sulfide spire was collected (4S3) and vent fluids sampled using discrete major #5 (4D2). After completing fluid sampling, we returned to chimney Marker triangle #12 (x 2831, y 2842) to sample the plume. Plume samples were collected at 1m (#5, 3N1), 6 m (#4, 3N2) and 15 m (#3, 3N3) above the vent orifice.

At 1158, we proceeded north at heading 020, to a site previously identified during Dive 2783 containing about 10 chimneys within the middle cleft. Two spires were active. One active chimney (x 2849, y 2883, 2223 m) with an exit temperature of 157°C was sampled for vent fluids with discrete major #9 (5D). The two chimneys were covered with live worms living in diffuse flow at temperatures of 28°C.

At 1220, we headed north. No more chimneys were observed. Along the transit north, a variety of basalt samples were collected. The first basalt sample, from a broken sheet flow on the west side of the cleft (6R, x 2882, y 3051, 2225 m) was collected about 100 m north of the site were the last chimneys were observed. Three additional basalt samples were collected along a west to east transect of the cleft done (using the 3-chip camera) to photograph the relief and nature of the walls of the cleft. On the west wall (x 3000, y 3459, 2221 m), sample 8R was obtained from the top lobate crust. On the east wall (x 3074, y 3464, 2222 m), sample 9R was collected from a lobate sheet flow. Unlike the west wall, the east wall displayed no terraces. The last sample, 10R (x 3082, y 3703, 2222 m), was obtained from the base of the west wall and consisted of sheet flow basalt.

During the north transect, we stopped at an old hydrothermal field (x 3006, y 3349, 2231 m). The area, approximately 50 m wide on the west side of the Cleft, is covered with hydrothermal sediment and bacterial mats. A diffuse vent was observed and sampled with discrete major #6 (7D). Temperature of the diffuse flow was 27°C using the ALVIN probe..

We departed the bottom at about 1400 and surfaced at approximately 1525.

# SOUTH CLEFT DIVE STATIONS: SAMPLES/MARKERS

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alvin Dive 2782: Vent 3, Origin 44° 38.0' / 130° 24.0'** | | | | | | | | | | | |
| ALV2782-1R | 9:22 | 2222 | 3177 | 4986 | 44° 40.692' | 130° 21.598' | | | | basalt | Ropy sheet, older, 30% sediment cover, sample broke into two pieces in basket, sample from area West of cleft |
| ALV2782-2R | 9:41 | 2225 | 3452 | 5097 | 44° 40.752' | 130° 21.390' | | | | basalt | Top of lobate collapse area, older, sample from area West of cleft |
| ALV2782-3R | 9:55 | 2229 | 3631 | 5181 | 44° 40.798' | 130° 21.255' | 3-* | Rectangle | | basalt | Collapse sampled from edge of East side of cleft in an area of pillar and collapsed lobates, *did not actually see marker 3-, but believe we were near it |
| ALV2782-4R | 10:14 | 2239 | 3511 | 5064 | 44° 40.734' | 130° 21.346' | | | 1.91°C | basalt | Sampled from axis of cleft, broke into two or three small pieces |
| ALV2782-6U | 10:39 | 2244 | 3582 | 5216 | 44° 40.816' | 130° 21.292' | | | 2.2°C | SUAVEscan | Fairy Castle site, diffuse flow, clam shells, dead tubeworms and old chimneys |
| ALV2782-7U1 | 11:10 | 2249 | 3718 | 5561 | 44° 41.003' | 130° 21.188' | + | Circle | 5.6°C max | SUAVEscan | Hydrothermal mound, low T vents and extinct chimneys above all along West wall, diffuse venting, bacterial "globs", dead and live tubeworms, snails, limpets (?), marker + is on floor just South of vent along West wall of cleft |
| ALV2782-7M | 11:15 to 11:28 | 2249 | 3718 | 5562 | 44° 41.003' | 130° 21.188' | + | Circle | Alvin 2.12°C, Manifold 6.3°C | manifold: port major | Same spot as above |
| ALV2782-7G | 11:31 | 2249 | 3717 | 5562 | 44° 41.003' | 130° 21.188' | + | Circle | Alvin 5.1°C, Manifold 4.9°C | gas-tight: port | Same spot as above |
| ALV2782-7U2 | 11:33 | 2249 | 3718 | 5562 | 44° 41.003' | 130° 21.189' | + | Circle | 13.4°C | SUAVEscan deployment | Second time scanner was deployed |
| ALV2782-7B | 11:39 | 2238 | 3719 | 5561 | 44° 41.003' | 130° 21.188' | + | Circle | | tubeworms et. al | Sampled next to diffuse flow plus larger tubeworms, taken ~1m above on base of extinct chimney |
| ALV2782-7S1 | ~11:40 | 2249 | 3719 | 5561 | 44° 41.003' | 130° 21.188' | + | Circle | | sulfide | Solid part of West wall, looked like basalt but turned out to be sulfide coating wall next to biology site 7B |
| ALV2782-7S2 | 11:49 | 2250 | 3723 | 5568 | 44° 41.006' | 130° 21.185' | + | Circle | | sulfide | Top spire on extinct sulfide chimney, 10-12 m from floor, chimney edifice is probably 5 m high |
| ALV2782-8R | 12:05 | 2252 | 3748 | 5656 | 44° 41.054' | 130° 21.166' | | | | basalt | Piece of sheet that drapes over the West wall, flows into cleft from above West wall on a small volcanic high |
| ALV2782-9R | 12:24 | 2244 | 3851 | 5880 | 44° 41.174' | 130° 21.088' | | | Alvin 2.07°C | basalt | Piece of flat striated sheet flow, southern extension of large flow to North |
| ALV2782-10R | 12:36 | 2229 | 3817 | 6127 | 44° 41.308' | 130° 21.114' | | | | basalt | Lobate flow from West of cleft, older flows, West of sheets in cleft |
| ALV2782-11R | 12:56 | 2240 | 4147 | 6566 | 44° 41.545' | 130° 20.864' | | | | basalt | Jumbled sheet flow, big ropy in axis |
| ALV2782-12N | 13:18 | 2239 | 4101 | 7000 | 44° 41.781' | 130° 20.900' | | | | Niskin | Blanks for Niskin sample |
| ALV2782-12M | 13:18 | 2239 | 4101 | 7000 | 44° 41.781' | 130° 20.900' | | | | manifold: major | Blanks for major sample |
| ALV2782-13R | 13:23 | 2240 | 4218 | 7065 | 44° 41.815' | 130° 20.810' | | | | basalt | Lobate flow |
| ALV2782-14R | 13:34 | 2244 | 4645 | 7260 | 44° 41.920' | 130° 20.488' | | | | basalt | Older lobate, East side of cleft |
| ALV2782-15R | 13:47 | 2241 | 4302 | 7355 | 44° 41.978' | 130° 20.722' | | | | basalt | Older lobate flow |
| **Alvin Dive 2783: Vent 1, Origin 44° 38.0' / 130° 24.0'** | | | | | | | | | | | |
| ALV2783-1S | 10:38 | 2224 | 2810 | 2823 | 44° 39.524' | 130° 21.875' | | | 284°C | sulfide chimney | Bottom portion of ~1 m tall branch where fluid was subsequently sampled, port milk crate |

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2783-1D1 | 10:43 to 10:46 | 2222 | 2810 | 2823 | 44° 39.524' | 130° 21.875' | | | 284°C | discrete major #4 | Sample of vent fluid from 9 m tall chimney |
| ALV2783-1D2 | 10:57 | 2222 | 2821 | 2821 | 44° 39.523' | 130° 21.867' | | | 284°C | discrete major #6 | Second fluid sample from same 284°C vent |
| ALV2783-1DG | 11:07 | 2222 | 2821 | 2821 | 44° 39.523' | 130° 21.867' | | | 284°C | discrete gas-tight #7 | Temperature probe read 281°C after sampling |
| ALV2783-1B | 11:23 | 2224 | 2810 | 2823 | 44° 39.524' | 130° 21.875' | | | 12-29°C | tevnia tubeworms | Grabbed worms from diffuse venting area ~1-2 m away from 284°C vent, temperature probe placed at base of worms |
| ALV2783-2M1 | 11:48 to 11:54 | 2220 | 2819 | 2829 | 44° 39.527' | 130° 21.868' | 12 | Triangle | 342°C max | manifold: major #10 | Sampled smoker on top of 10 m high chimney with several other smokers lower down, put Marker Triangle #12 on top of chimney |
| ALV2783-2M2 | 11:48 to 11:54 | 2220 | 2819 | 2829 | 44° 39.527' | 130° 21.868' | 12 | Triangle | 342°C max | manifold: major #15 | Sampled smoker on top of 10 m high chimney with several other smokers lower down, put Marker Triangle #12 on top of chimney |
| ALV2783-2G | 11:51 | 2220 | 2819 | 2829 | 44° 39.527' | 130° 21.868' | 12 | Triangle | 342°C max | manifold: starboard gas-tight | ~10-15 m away from 284°C vent |
| ALV2783-2D | 12:00 to 12:08 | 2223 | 2817 | 2837 | 44° 39.532' | 130° 21.870' | 12 | Triangle | 342°C max | discrete major #5 | Same vent as above |
| ALV2783-2DG | 12:23 | 2224 | 2819 | 2829 | 44° 39.527' | 130° 21.868' | 12 | Triangle | 342°C max | discrete gas-tight #3 | Blue sampler, same vent as above |
| ALV2783-2S1 | 12:40 | 2223 | 2817 | 2837 | 44° 39.532' | 130° 21.870' | 12 | Triangle | | sulfide chimney | Broke off small piece of high-temperature chimney where fluids were sampled, chimney started to grow back as we watched, fwd port milk crate |
| ALV2783-2S2 | 12:43 | 2223 | 2817 | 2837 | 44° 39.532' | 130° 21.870' | 12 | Triangle | | sulfide | Piece of light-colored lobe of sulfide, was not actively venting |
| ALV2783-2N1 | ~12:54 | 2224 | 2817 | 2837 | 44° 39.532' | 130° 21.870' | | | | Niskin-5 liter (orange) | Aft Niskin, ~1 m above 342°C vent |
| ALV2783-2N2 | 12:56 | 2222 | 2816 | 2838 | 44° 39.532' | 130° 21.871' | | | | Niskin-5 liter | Second Niskin from front, ~4 m above 342°C vent |
| ALV2783-2N3 | ~12:58 | 2219 | 2813 | 2839 | 44° 39.532' | 130° 21.873' | | | | Niskin-5 liter | Forward Niskin, ~10 m above 342°C vent |
| ALV2783-2N4 | 13:00 | 2222 | 2812 | 2853 | 44° 39.541' | 130° 21.874' | | | | Niskin-5 liter | Second Niskin from aft, ~12 m above 342°C vent |
| ALV2783-3D1 | 13:58 | 2225 | 2842 | 2879 | 44° 39.554' | 130° 21.851' | | | 30°C max | discrete major #11 | Sampled at base of tubeworms |
| ALV2783-3D2 | 14:07 | 2225 | 2842 | 2879 | 44° 39.554' | 130° 21.851' | | | 140°C max | discrete major #9 | |
| ALV2783-3S | 14:05 | 2225 | 2842 | 2879 | 44° 39.554' | 130° 21.851' | | | 140°C max | sulfide chimney | Beehive chimney pieces from vent, stbd aft near bio buck |
| ALV2783-3M | 14:15 | 2225 | 2842 | 2879 | 44° 39.554' | 130° 21.851' | | | T1 51°C, 140°C max | manifold: starboard major #13 | |
| ALV2783-3G | 14:17 | 2225 | 2842 | 2879 | 44° 39.554' | 130° 21.851' | | | T1 51°C, 140°C max | manifold: starboard gas-tight | |

## Alvin Dive 2784: Vent 3, Origin 44° 38.0' / 130° 24.0'

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2784-1R | 9:16 | 2228 | 3441 | 5004 | 44° 40.702' | 130° 21.398' | | | | basalt | About 100 cm^3 piece from sheet flow |
| ALV2784-2S | 10:33 | 2244 | 3584 | 5219 | 44° 40.817' | 130° 21.290' | | | | sulfide | Small pieces from chimney emanating 214°C fluids, very friable, Type III piece |
| ALV2784-2M1 | 10:47 | 2244 | 3583 | 5220 | 44° 40.819' | 130° 21.290' | | | T1 214°C, T2 inoperative | manifold: port major #10 | Vent fluid from Vent 3 area, site on West wall |
| ALV2784-2G | 10:52 | 2245 | 3584 | 5220 | 44° 40.819' | 130° 21.290' | | | T1 207°C, T2 inoperative | manifold: port gas-tight | Vent fluid from Vent 3 area |
| ALV2784-2M2 | 10:55 | 2245 | 3584 | 5221 | 44° 40.819' | 130° 21.290' | | | T1 197°C, T2 inoperative | manifold: middle major #15 | Vent fluid from Vent 3 area |
| ALV2784-2B | 11:05 | 2244 | 3585 | 5219 | 44° 40.819' | 130° 21.290' | | | | tubeworms | Wworms from vent in Vent 3 area, small blackened worms |
| ALV2784-3B | 11:15 | 2245 | 3594 | 5218 | 44° 40.818' | 130° 21.283' | | | | tubeworms | Large stalked, live tubeworms from same mound (further up the mound/chimney structure) |
| ALV2784-4M | 12:41 | 2254 | 3705 | 5562 | 44° 41.003' | 130° 21.196' | | | Alvin 48°C | manifold: starboard major #13 | Fluid from diffuse flow |
| ALV2784-4G | 12:44 | 2254 | 3705 | 5563 | 44° 41.003' | 130° 21.203' | | | Alvin 48°C | manifold: starboard gas-tight | Fluid from diffuse flow |
| ALV2784-4D1 | 13:11 | 2251 | 3722 | 5569 | 44° 41.006' | 130° 21.184' | | | Alvin 135°C | discrete major #11 | Vent fluid from same mound as manifold samples, shift in position to sample |
| ALV2784-4DG | 13:17 | 2250 | 3720 | 5568 | 44° 41.006' | 130° 21.184' | | | Alvin 135°C | discrete gas-tight #7 | Vent fluid from same mound as manifold samples, shift in position to sample |
| ALV2784-4D2 | 13:21 | 2251 | 3724 | 5568 | 44° 41.006' | 130° 21.184' | | | Alvin 135°C | discrete major #4 | From same vent as above |

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2784-5R | 13:47 | 2252 | 3711 | 5571 | 44° 41.008' | 130° 21.194' | | | | basalt | From base of cleft, part of apparent rubble piles, in close proximity to station #4 vent |
| ALV2784-6R | 14:17 | 2232 | 3593 | 5308 | 44° 40.866' | 130° 21.283' | | | | basalt | Piece from lower 5 m of cleft, collected from large pillow, seemed to be part of wall structure |

## Alvin Dive 2785: Plume, Origin 44° 38.0' / 130° 24.0'

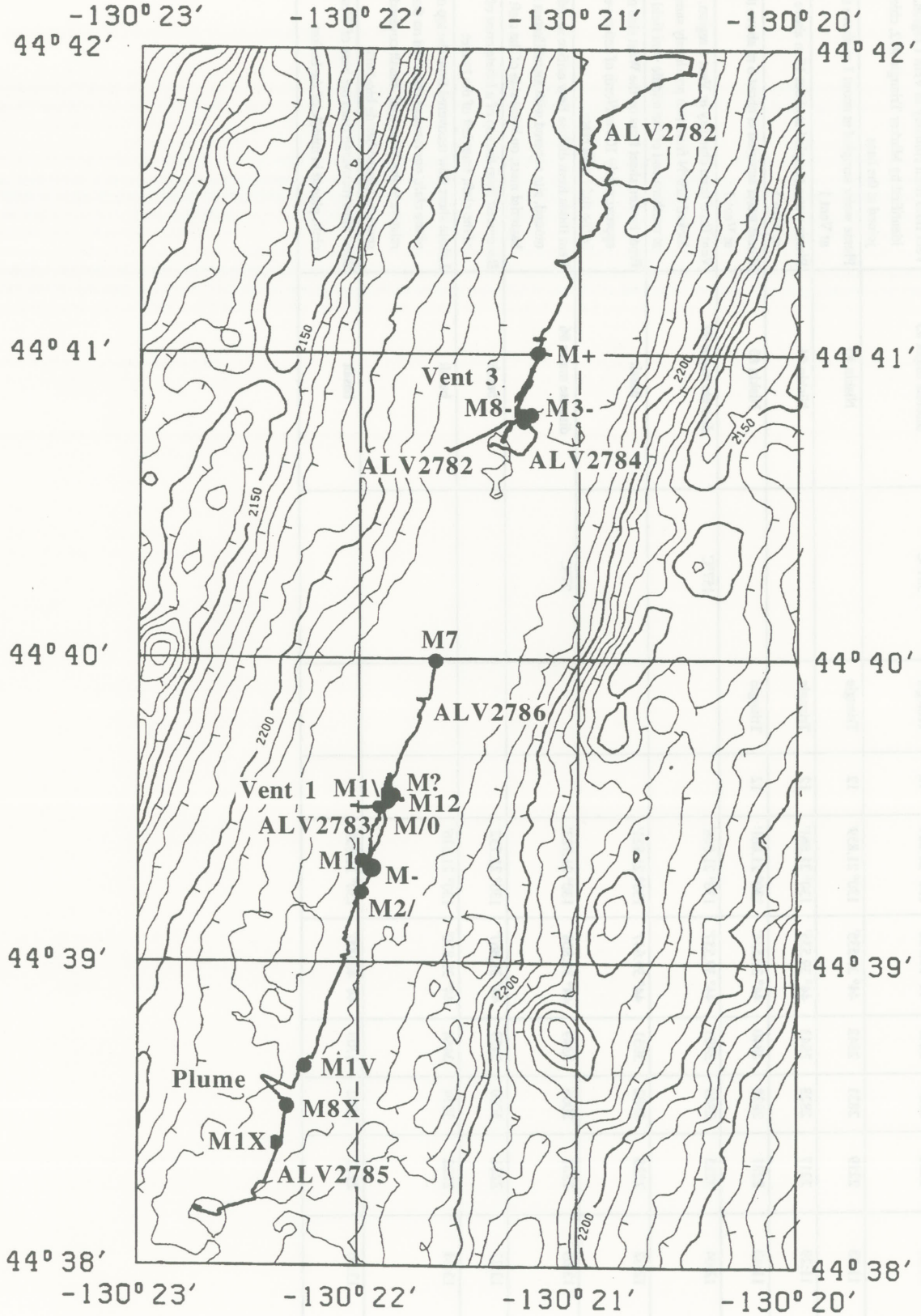
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2785-1R | 9:30 | 2234 | 2021 | 0404 | 44° 38.218' | 130° 22.472' | | | | basalt | Placed in port aft milk crate |
| ALV2785-2B | 10:02 | 2239 | * | * | * | * | | | 1.983°C | brown bacterial floc | No apparent water source |
| ALV2785-3R | 10:51 | 2242 | * | * | * | * | | | | sulfide/anhydrite | Sulfide and anhydrite spire |
| ALV2785-3M1 | 11:25:30 | 2242 | * | * | * | * | | | T1 115-173°C | manifold: port major | |
| ALV2785-3G1 | 11:39:45 | 2242 | * | * | * | * | | | T1 102°C | manifold: port gas-tight | |
| ALV2785-3M2 | 11:39:45 | 2242 | * | * | * | * | | | T1 115-219°C | manifold: middle major | |
| ALV2785-3G2 | 11:46 | 2242 | * | * | * | * | | | T1 118-144°C | manifold: starboard gas-tight | |
| ALV2785-3M3 | 11:46:50 | 2242 | * | * | * | * | | | T1 132-232.5°C | manifold: starboard major | Alvin T° probe in same orifice measured 243-247.2°C |
| ALV2785-3N1 | 12:14 | 2240 | 2252 | 0985 | 44° 38.532' | 130° 22.297' | | | | Niskin (green) | ~11 m above vent |
| ALV2785-3N2 | 12:14 | 2240 | 2252 | 0985 | 44° 38.532' | 130° 22.297' | | | | Niskin (blue) | ~12 m above vent |
| ALV2785-4R | 13:08 | 2243 | 2465 | 1632 | 44° 38.881' | 130° 21.136' | | | | basalt | Piece of sheet flow |
| ALV2785-5R | 13:43:16 | 2228 | 2726 | 2421 | 44° 39.307' | 130° 21.938' | | | | rock | Sheet flow, port forward basket |
| ALV2785-6B | 13:52 | 2229 | 2718 | 2464 | 44° 39.330' | 130° 21.944' | | | | clams and worms | Worms may be dead |

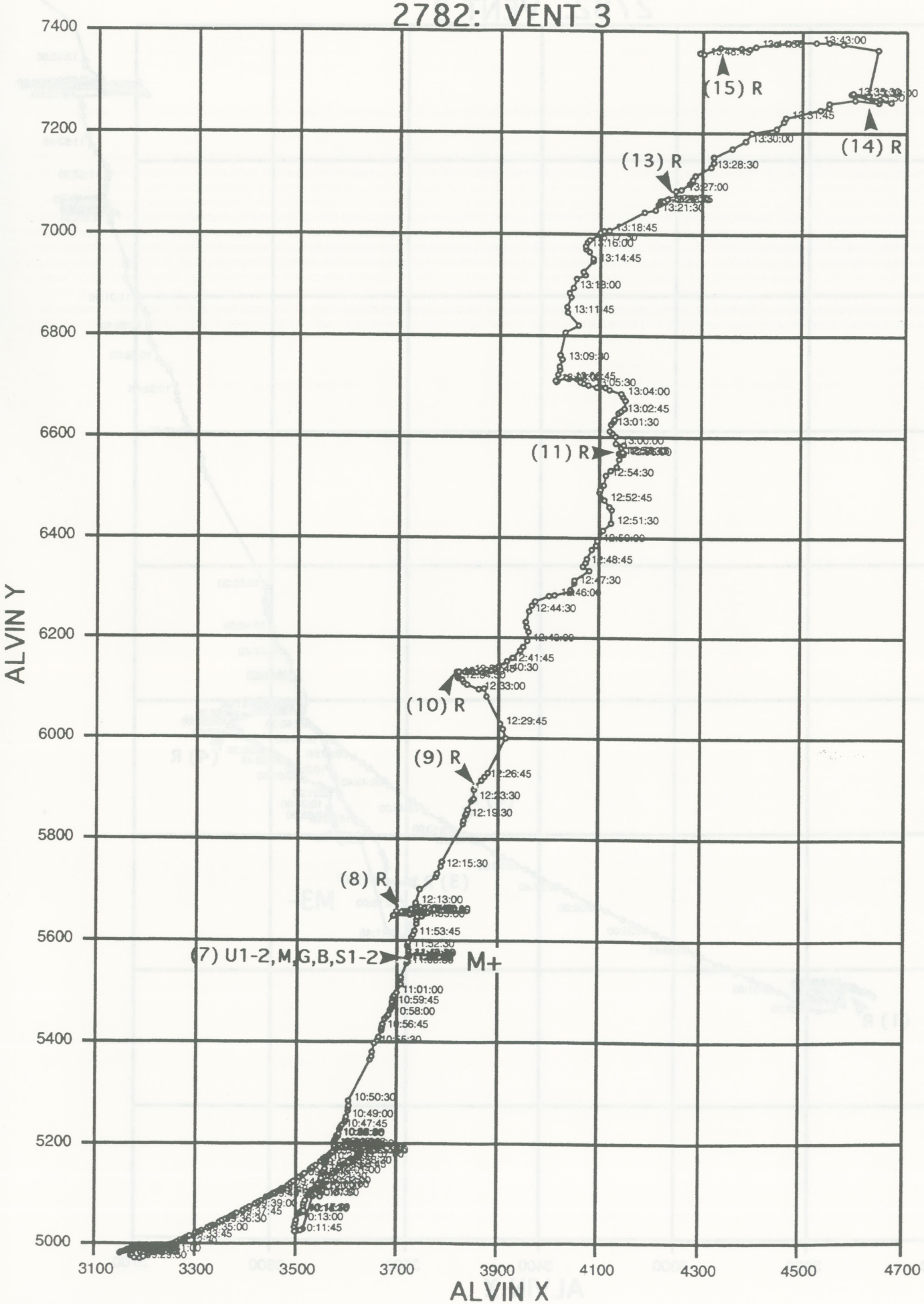
## Alvin Dive 2786: Vent 1, Origin 44° 38.0' / 130° 24.0'

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2786-1R | 9:14 | 2218 | 2650 | 2809 | 44° 39.517' | 130° 21.996' | | | | basalt | Piece recovered from lobate sheet flows to the West of the Cleft Segment, placed in left rear milk crate |
| ALV2786-2S | 9:38:33 | 2223 | 2824 | 2829 | 44° 39.528' | 130° 21.865' | | | 283°C | chimney sulfide | Fragments of chimney sulfide regrown over the last three days following earlier recovery of chimney during ALV2783, placed in left rear milk crate |
| ALV2786-3D | 9:56 | 2222 | 2825 | 2841 | 44° 39.534' | 130° 21.864' | 12 | Triangle | 334.6 to 334.8°C | discrete major #4 | Vent fluid from chimney in Vent 1 region, chimney identified by Marker Triangle #12 |
| ALV2786-3DG | 10:03 | 2223 | 2825 | 2840 | 44° 39.533' | 130° 21.864' | 12 | Triangle | 334.6 to 334.8°C | discrete gas-tight #3 | Vent fluid from chimney in Vent 1 region, chimney identified by Marker Triangle #12 |
| ALV2786-4M1 | 10:29 | 2221 | 2825 | 2844 | 44° 39.536' | 130° 21.864' | 12 | Triangle | T1 338.6°C | manifold: major #10 | T2 not operational, spire is located immediately behind chimney identified by Marker Triangle #12, both are joined at the base |
| ALV2786-4G | 10:31 | 2221 | 2824 | 2844 | 44° 39.535' | 130° 21.865' | 12 | Triangle | T1 342.2°C | manifold: starboard gas-tight | T2 not operational, spire is located immediately behind chimney identified by Marker Triangle #12, both are joined at the base |
| ALV2786-4M2 | 10:33 | 2220 | 2825 | 2844 | 44° 39.536' | 130° 21.864' | 12 | Triangle | T1 341.9°C | manifold: major #15 | T2 not operational, spire is located immediately behind chimney identified by Marker Triangle #12, both are joined at the base |
| ALV2786-4S1 | 10:42:49 | 2222 | 2824 | 2843 | 44° 39.535' | 130° 21.865' | 12 | Triangle | 270°C | chimney sulfide | Spire is located immediately behind chimney identified by Marker Triangle #12, both are joined at the base, top piece of chimney sulfide, placed in back of basket |
| ALV2786-4S2 | 10:43:57 | 2223 | 2823 | 2843 | 44° 39.535' | 130° 21.865' | 12 | Triangle | 270°C | chimney sulfide | Spire is located immediately behind chimney identified by Marker Triangle #12, both are joined at the base, bottom piece of chimney sulfide, placed in rear milk crate, sample orifice located about 3 to 4 m below the top of the chimney |

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2786-4D1 | 10:48 | 2223 | 2823 | 2843 | 44° 39.535' | 130° 21.865' | 12 | Triangle | 270°C | discrete major #11 | Vent fluid from chimney in Vent 1 region, chimney identified by Marker Triangle #12, chimneys are joined at the base |
| ALV2786-4S3 | 11:01 | 2221 | 2824 | 2846 | 44° 39.536' | 130° 21.865' | 12 | Triangle | 331°C | chimney sulfide | Piece of sulfide, placed in between front two baskets, chimney is located behind spire identified by Marker Triangle #12, chimneys are joined at the base |
| ALV2786-4D2 | 11:07 | 2220 | 2824 | 2845 | 44° 39.536' | 130° 21.864' | 12 | Triangle | 331°C | discrete major #5 | Vent fluid from chimney in Vent 1 region, chimney identified by Marker Triangle #12, chimneys are joined at the base |
| ALV2786-3N1 | 11:23 | 2219 | 2831 | 2842 | 44° 39.535' | 130° 21.859' | 12 | Triangle | | Niskin #5 | Plume water sampled at about 1 m above the vent orifice at Vent 1 |
| ALV2786-3N2 | 11:29 | 2217 | 2828 | 2843 | 44° 39.535' | 130° 21.861' | 12 | Triangle | | Niskin #4 | Plume water sampled at about 15 m above the vent orifice at Vent 1 |
| ALV2786-3N3 | 11:40 | 2221 | 2828 | 2840 | 44° 39.534' | 130° 21.861' | 12 | Triangle | | Niskin #3 | Plume water sampled at about 6 m above the vent orifice at Vent 1 |
| ALV2786-5D | 12:04 | 2223 | 2849 | 2883 | 44° 39.557' | 130° 21.846' | | | 157°C | discrete major #9 | Vent fluid from chimney in Vent 1 region, chimney looked 020°N from two previously sampled chimneys at northern end of the middle vent field of Vent 1 |
| ALV2786-6R | 12:32 | 2225 | 2882 | 3051 | 44° 39.647' | 130° 21.821' | | | | basalt | From broken sheet flow on the West side of the cleft, approximately 100 m North of active vent site, placed in the right milk crate |
| ALV2786-7D | 13:05 | 2231 | 3006 | 3349 | 44° 39.808' | 130° 21.727' | | | 27°C | discrete major #6 | Vent fluids from diffuse flow orifice in old hydrothermal mound, site covered with metalliferous sediment and bacterial mats, on West side of the cleft |
| ALV2786-8R | 13:22 | 2221 | 3000 | 3459 | 44° 39.867' | 130° 21.732' | | | | basalt | Recovered from the top of a lobate crust of the West wall of the cleft, front left of the basket |
| ALV2786-9R | 13:34 | 2222 | 3074 | 3464 | 44° 39.870' | 130° 21.676' | | | | basalt | Lobate sheet flow recovered from the top of the East wall of the cleft, nor terraces observed on the East wall relative to the West wall, basalt covered lightly with sponges, placed beside bio-buck |
| ALV2786-10R | 13:50 | 2222 | 3082 | 3703 | 44° 40.000' | 130° 21.669' | | | | basalt | Sheet flow recovered from the base of West wall of the cleft, placed in middle of the basket |

# SOUTH CLEFT - ALVIN




2782: VENT 3
ALVIN Y
ALVIN X
7400
7200
7000
6800
6600
6400
6200
6000
5800
5600
5400
5200
5000
3100
3300
3500
3700
3900
4100
4300
4500
4700
(15) R
(14) R
(13) R
(11) R
(10) R
(9) R
(8) R
(7) U1-2,M,G,B,S1-2
M+
13:43:00
13:30:00
13:28:30
13:27:00
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13:18:45
13:16:00
13:14:45
13:11:45
13:09:30
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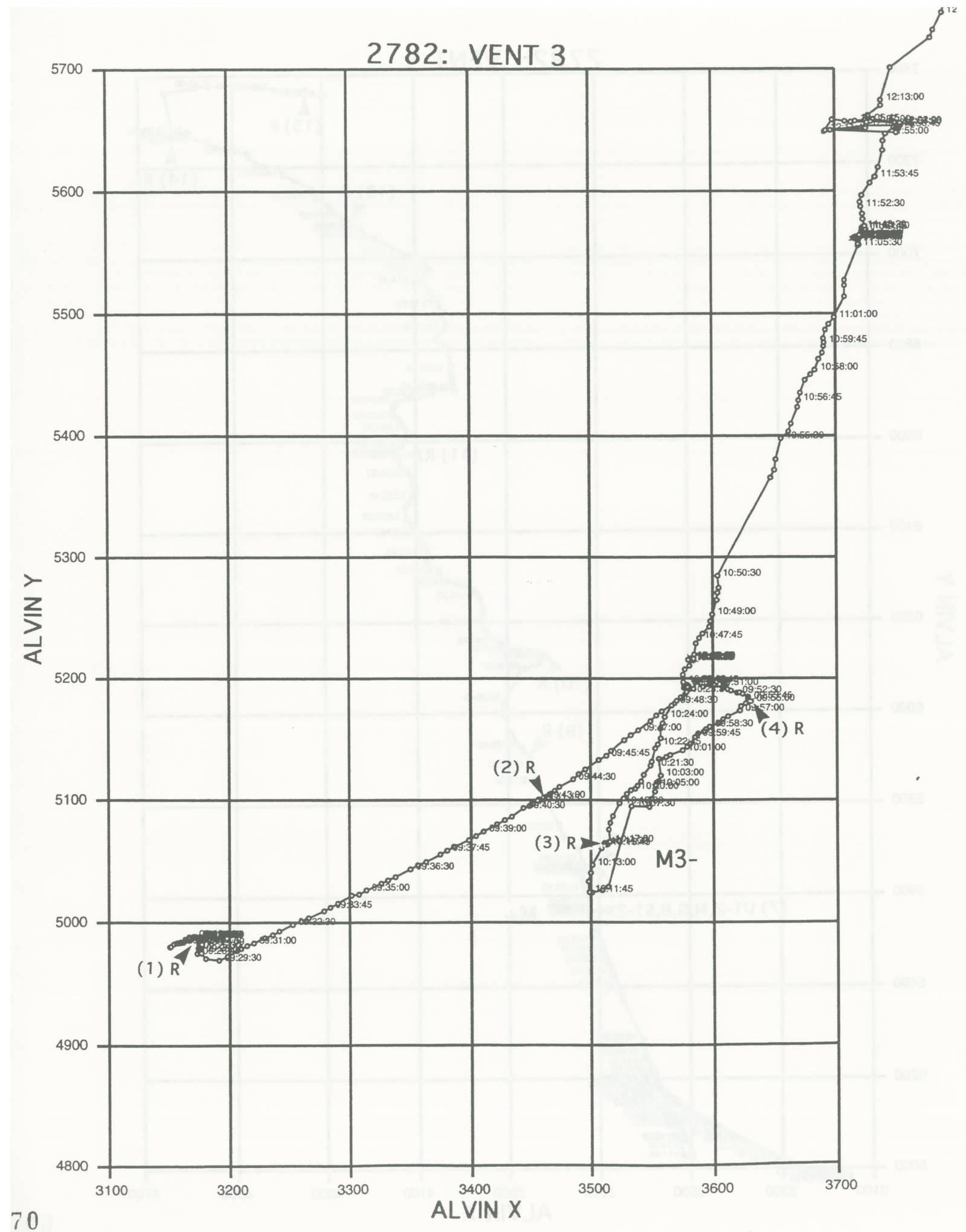
10:11:45


2782: VENT 3
ALVIN Y
ALVIN X
5700
5600
5500
5400
5300
5200
5100
5000
4900
4800
3100
3200
3300
3400
3500
3600
3700
(1) R
(2) R
(3) R
(4) R
M3-
12:13:00
11:53:45
11:52:30
11:01:00
10:59:45
10:58:00
10:56:45
10:50:30
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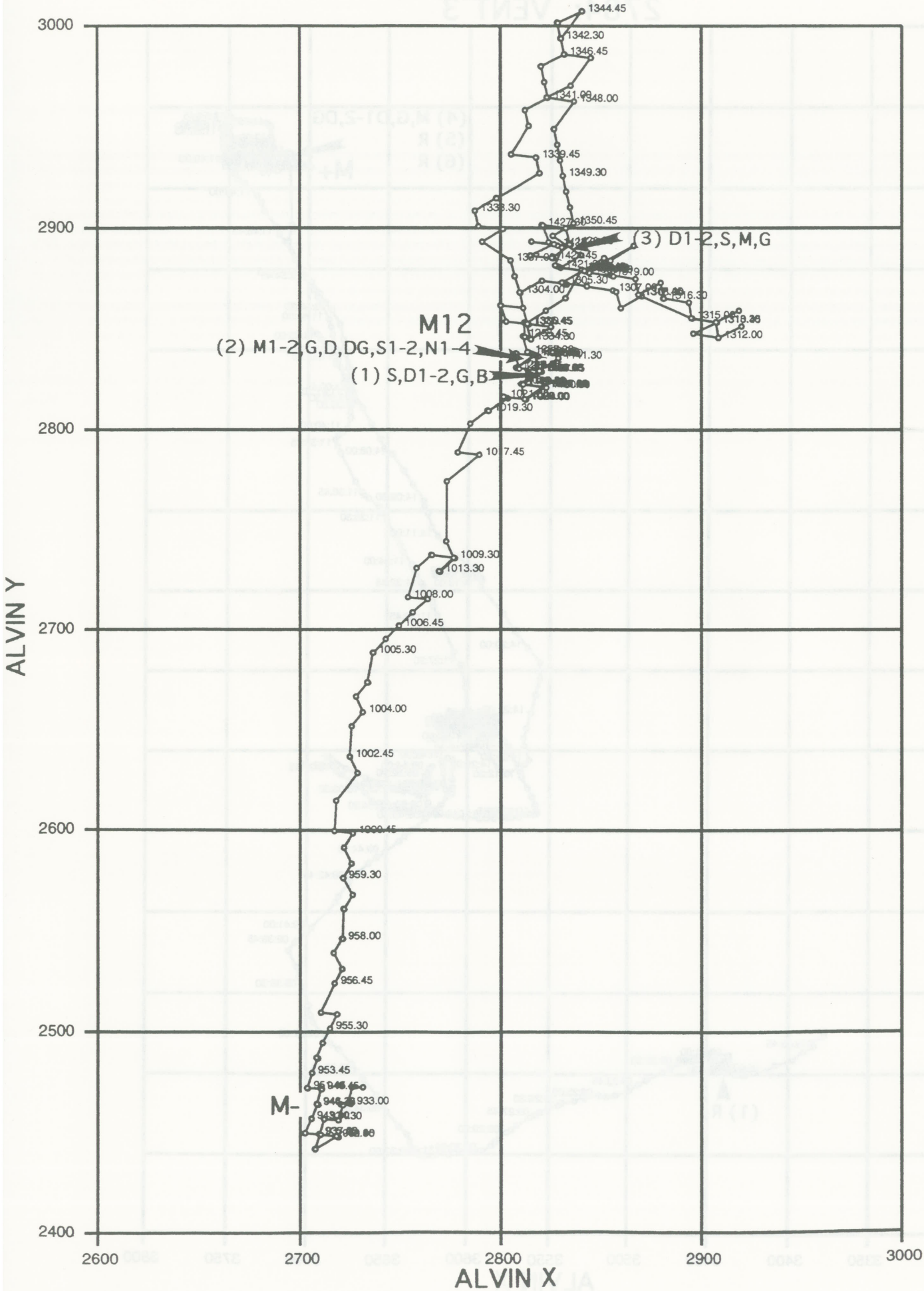
09:29:30


2783: VENT 1
3000
2900
2800
2700
2600
2500
2400
2600
2700
2800
2900
3000
ALVIN Y
ALVIN X
1344.45
1342.30
1346.45
1348.00
1339.45
1349.30
1350.45
(3) D1-2,S,M,G
1304.00
1315.00
1312.00
M12
(2) M1-2,G,D,DG,S1-2,N1-4
(1) S,D1-2,G,B
1019.30
1009.30
1013.30
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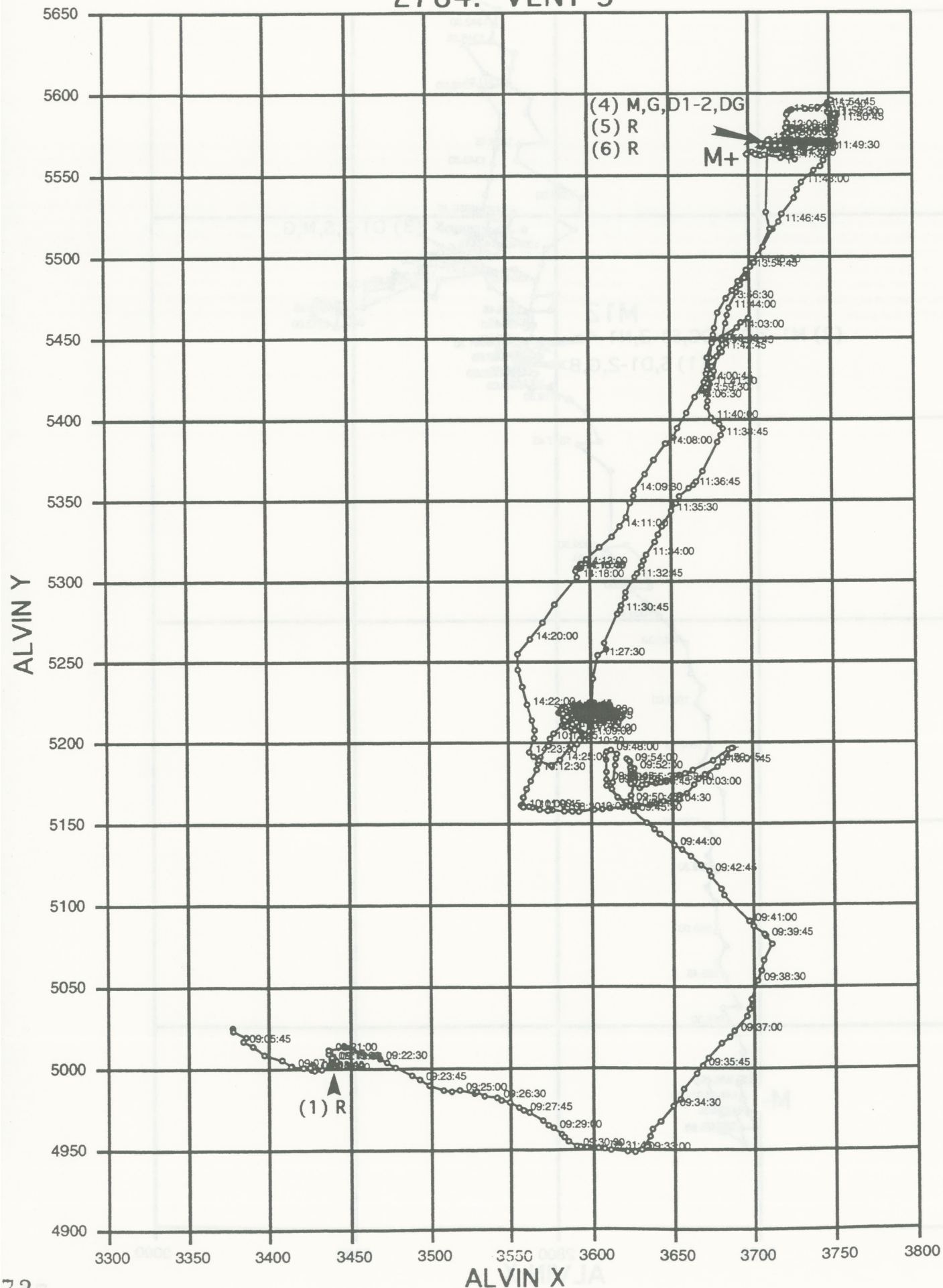
953.45
933.00
M-


2784: VENT 3
(4) M,G,D1-2,DG
(5) R
(6) R
M+
(1) R
ALVIN Y
ALVIN X
5650
5600
5550
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
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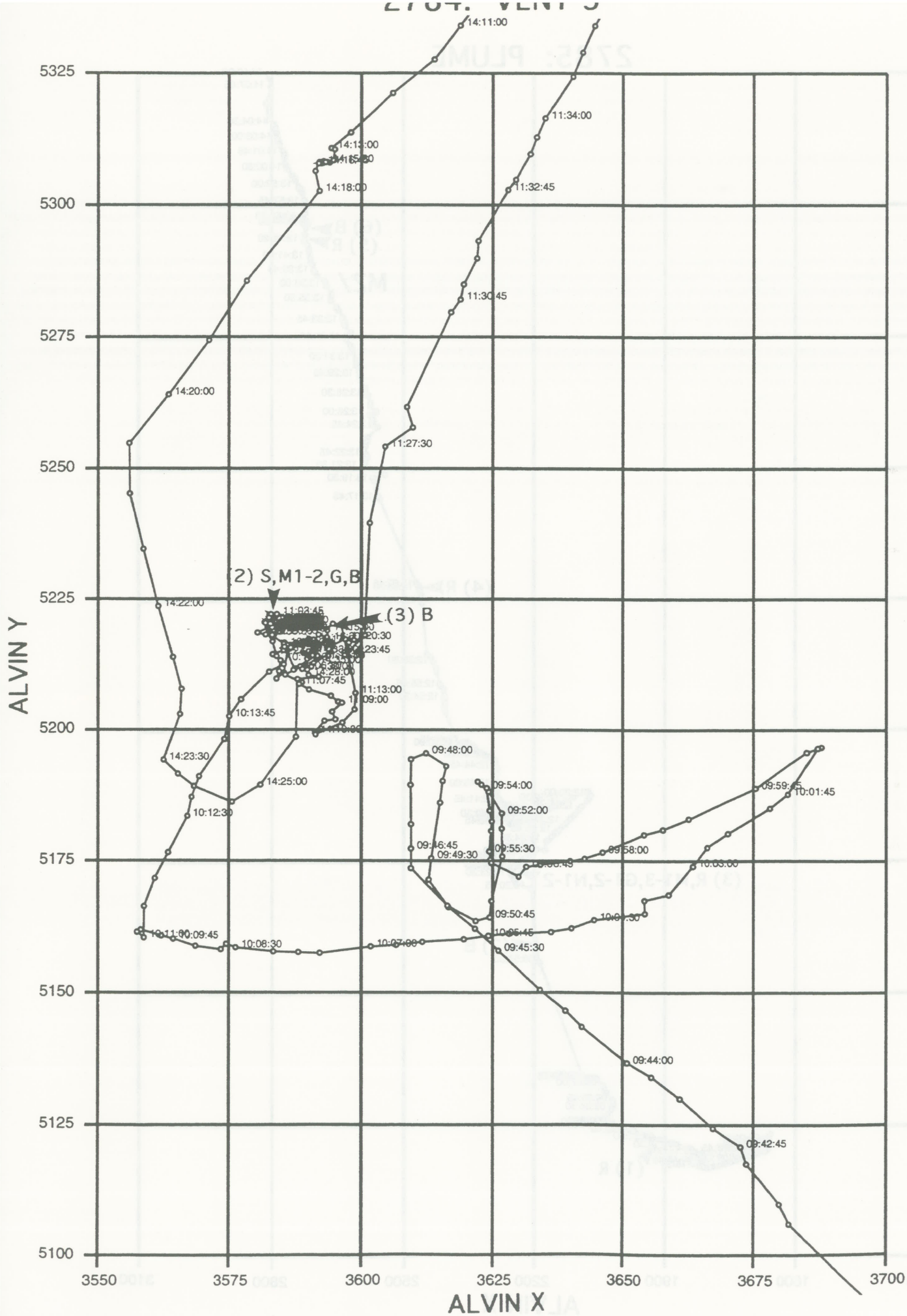
3750
3800



2784: VENT 5
ALVIN Y
ALVIN X
5325
5300
5275
5250
5225
5200
5175
5150
5125
5100
3550
3575
3600
3625
3650
3675
3700
(2) S,M1-2,G,B
(3) B
14:11:00
11:34:00
14:13:00
14:18:00
11:32:45
11:30:45
14:20:00
11:27:30
14:22:00
11:03:45
11:20:30
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11:07:45
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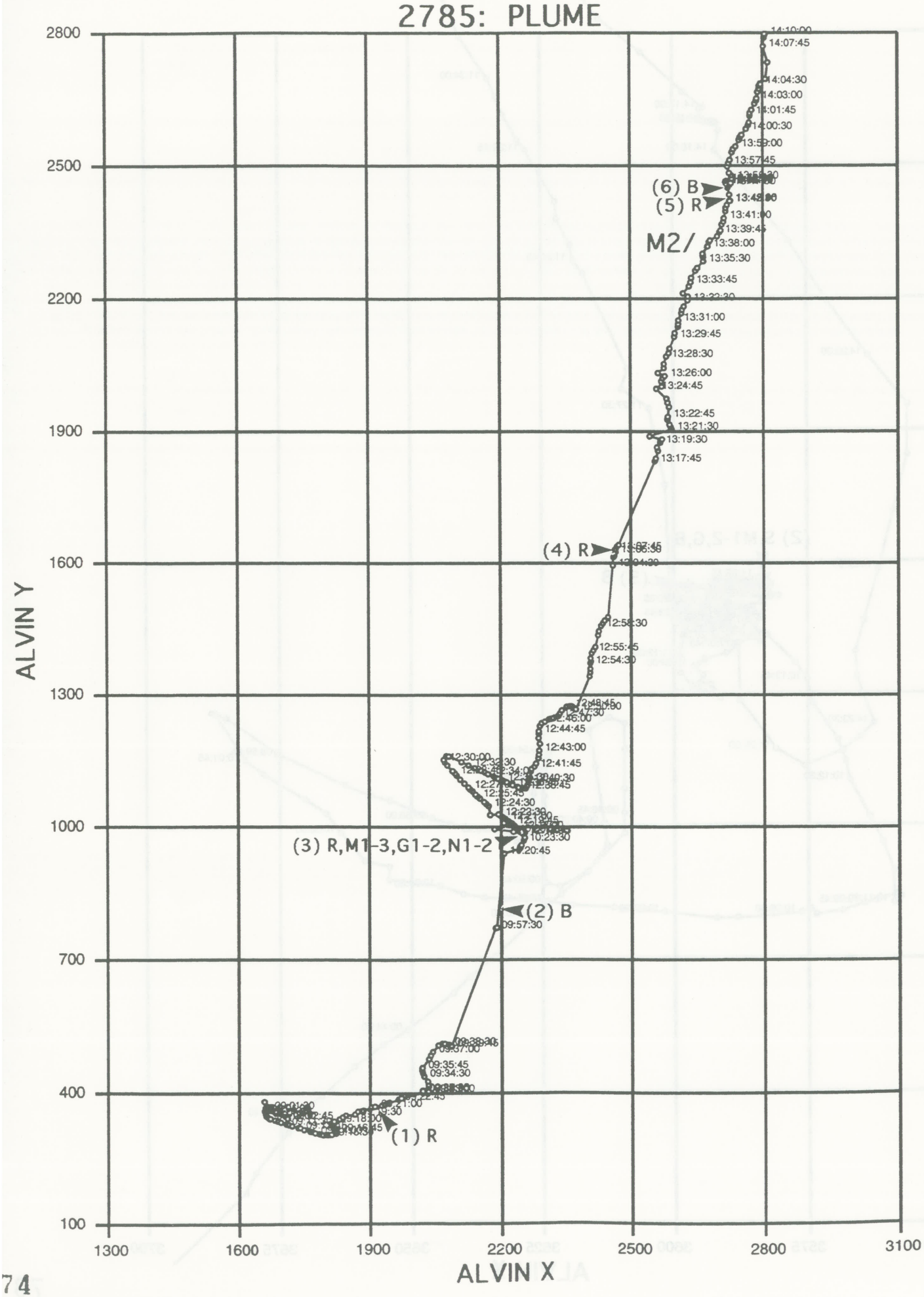
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ALVIN Y
ALVIN X
2800
2500
2200
1900
1600
1300
1000
700
400
100
1300
1600
1900
2200
2500
2800
3100
(6) B
(5) R
M2/
(4) R
(3) R,M1-3,G1-2,N1-2
(2) B
(1) R
14:10:00
14:07:45
14:04:30
14:03:00
14:01:45
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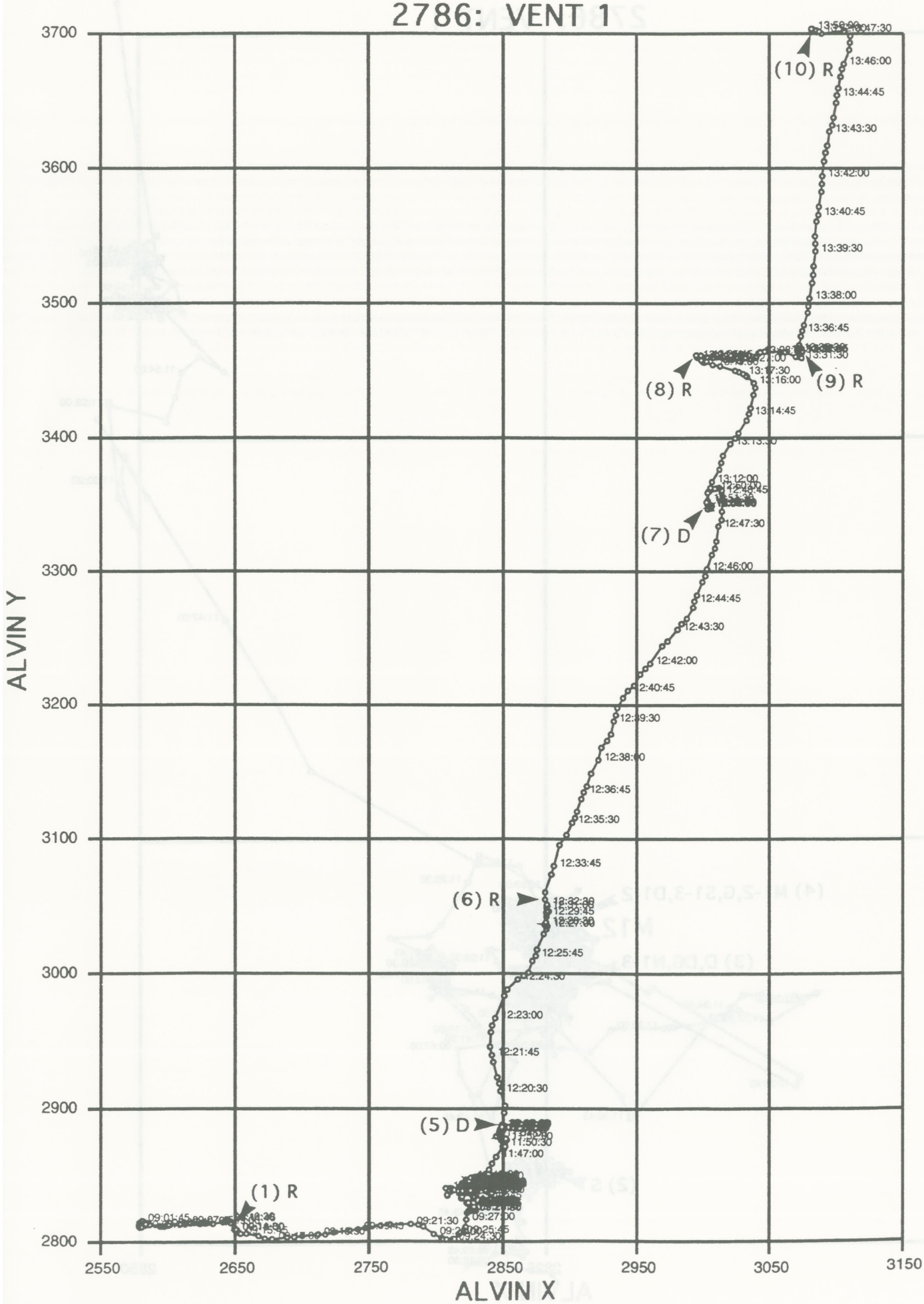
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ALVIN X
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3500
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3300
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2800
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2750
2850
2950
3050
3150
(1) R
(5) D
(6) R
(7) D
(8) R
(9) R
(10) R
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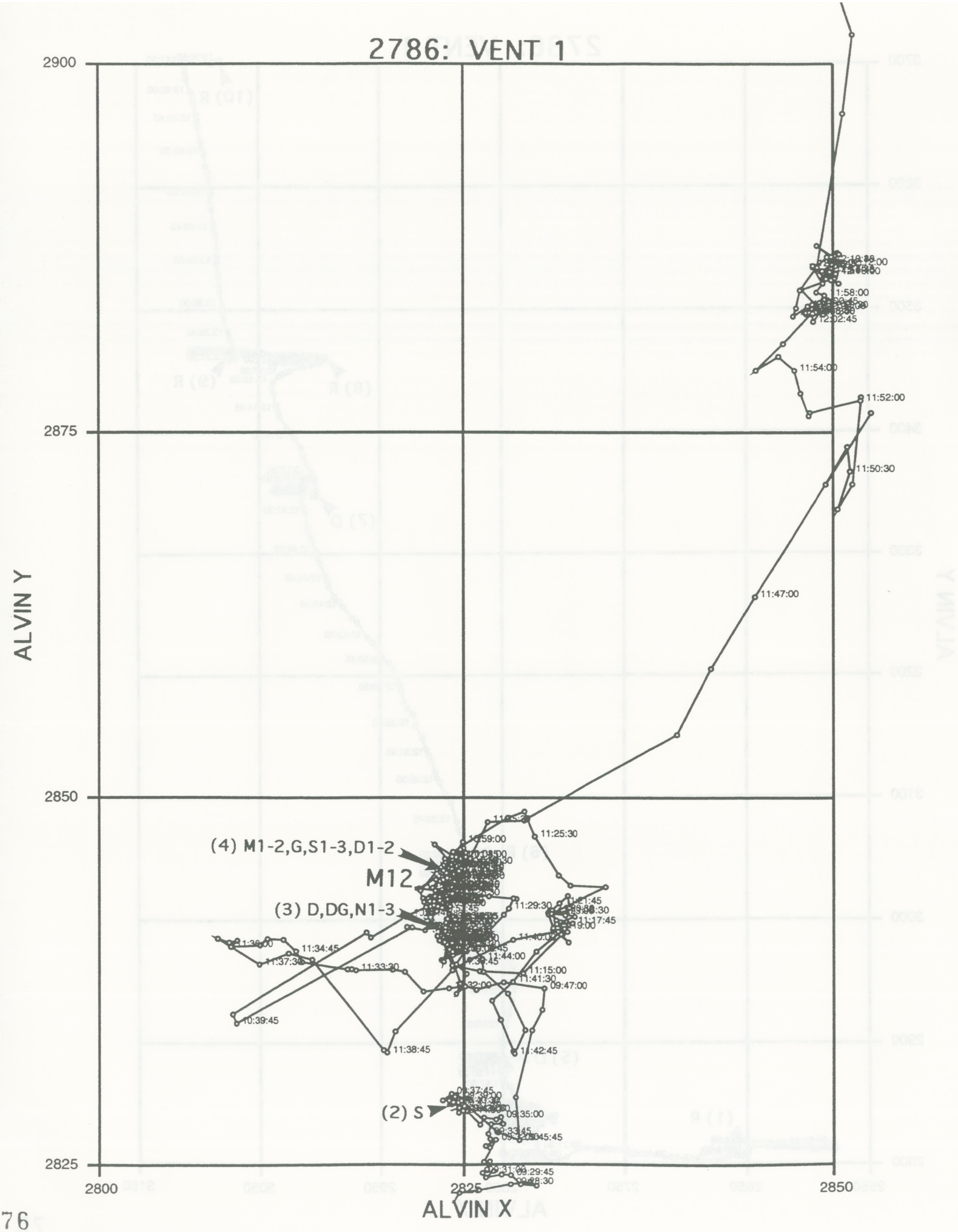
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2850
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M12
(3) D,DG,N1-3
(2) S
11:54:00
11:52:00
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09:47:00
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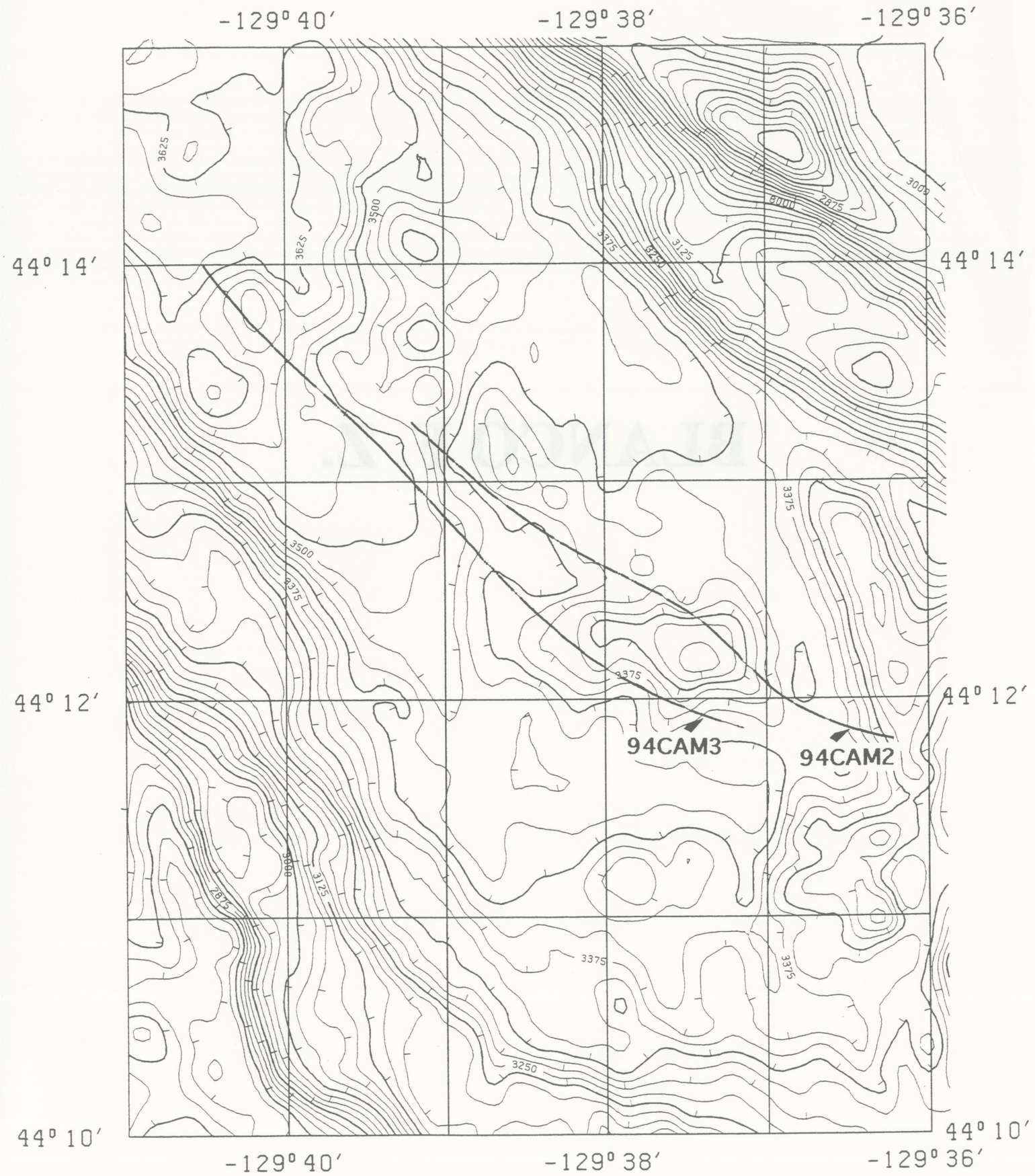
# BLANCO F. Z.

# EAST BLANCO DEPRESSION - CAM TOWS



# COAXIAL SEGMENT

# COAXIAL
# DIVE SUMMARIES

**Video set-up for all dives:**

high 8 mm recorder #1: recorded video from the 3-chip camera, the two Alvin color 1-chip cameras and the black/white down-looking sit camera.

high 8 mm recorder #2: recorded the 3-chip camera exclusively.

*All depths are TOTAL water depth, unless otherwise noted.

## DIVE 2787: Source Site

June 30, 1994
Pilot: Matt Heintz
Port Observer: Bob Embley (author of this transcript)
Stbd. Observer: Jim Holden

Objectives:

The primary goals of the dive were to: (1) complete the basic survey of the Source vent site (which had been discovered on Dive 2681 in October, 1993), (2) take water samples and temperature measurements of the Church Vent (which had been initially sampled in 1993), and of as many new vents as time allowed, (3) recover the University of Washington temperature probe left at the base of Church Vent in 1993.

Dive Synopsis:

One transponder was deployed and surveyed to be used in conjunction with an expendable transponder deployed in October, 1993. Both transponders were deployed on the eastern wall of the axial high of the CoAxial Segment. The initial plan was for ALVIN to drop into the narrow axial valley east and south of the vent (which is located about 25 m up on the western marginal high) and drive NW To locate the vent. After dropping the descent weights and ballasting, Alvin reached the seafloor at 09:18. The seafloor consisted of pillow lavas that had a continuous thin veneer of sediment on them and had sediment pockets that covered about 30-40% of the seafloor. During the traverse upslope to the northwest, it was found that the magnetic and gyro compasses were offset and the course was readjusted to a more northwesterly azimuth. The east-facing slope of the western ridge was primarily constructional in nature. Only one small fissure was observed in the pillow lava slope until a depth of 2070 meters (at 09:31), when the expected larger fissure was reached. Some indications of hydrothermal staining may have been observed in the slope sediments right before reaching the fissure. Since it was known from Dive 2681 that the vent was situated on the eastern rim of the fissure, ALVIN turned to go NE along the fissure. The course along the fissure began at about 345°, but at 09:33 became oriented at about 031°. Some dense colonies of sessile organisms were seen on the fissure wall along this traverse. Beard Vent, which was the southernmost of the two vents discovered in 1993, was encountered at 09:38. Church vent (depth of base about 2058 m) was encountered soon after at 09:42. The temperature probe and Marker 8A was observed at this time, respectively, on the west and north sides of the vent (4384x, 6599y). After Church vent was bypassed to the south; ALVIN turned NW until it reached the fissure, which was then followed to the northeast. A small inactive chimney was observed to starboard at 09:46 and at 09:48, an active vent was observed below in the fissure (with tubeworms). At 09:48:35 (4394x, 6653y) a major, previously unknown, vent was encountered. This vent (that became known as Mongo Vent) consisted of a single chimney composed of (mostly) anhydrite, was about 1-2 m in diameter and about 10 tall. The depth at its base was about 2052 m. An almost clear fluid was vigorously venting from the sides of the chimney within about

3 m of its top. No obvious megafauna was observed on Mongo. This chimney was quite different than Church and Beard vents, which consisted of more consolidated sulfide bases with anhydrite chimneys at the top. Mongo had a surrounding apron of hydrothermal sediment which covered the basalt to a radius of about 2-3 meters. After a video survey of Mongo vent, it was decided to defer sampling it and continue northeast along the fissure to complete the survey of the vent site. A short traverse down slope to the east revealed mostly lobate lava flows and heavier sediment cover near the vents (probably with a significant hydrothermal component). Returning to the eastern lip of the fissure, Alvin continued traversing north. Several small chimneys (probably active) were seen within about 5-10 m north of Mongo Vent, apparently on a small promontory of the fissure's lip. A few minutes later, the last major vent along the fissure was encountered. This area consisted of an extensive colony of the "bottle brush" corals, two small chimneys (anhydrite?) and diffuse venting from a small fissure cutting through the pillow lavas. The fissure may be cutting through a promontory jutting from the eastern side of the larger structure. An attempt was made to continue following the fissure to the northeast, but the structure became complicated, with apparent cross-structures. No more significant signs of venting were observed. At 10:17, ALVIN stopped to take a basalt sample (Station 1R: 4488x; 6829y) before returning to the vent area. At 1032, a NW traverse was begun. After crossing and recrossing a shallow graben, ALVIN headed back towards the vent area at 10:37. Some confusion between the gyro and magnetic headings allowed the main venting area to be overshot to the east. At 10:48, ALVIN headed back to the fissure, reaching it at 10:55 and then descended into the fissure, intending to survey the bottom of it. After trying with great difficulty to maneuver within the fissure, ALVIN rose up and found itself at Church vent. A short traverse to the west and back to Church vent (11:25-11:33) revealed that the main fissure was near the crest of a pillow ridge (no tectonic features were seen to a depth of 2082 on the west side). Arriving back at the bottom of the fissure just west of Church Vent, it was decided to head back to Mongo vent to conduct water sampling. ALVIN ascended from the fissure at Church vent where it was noticed that several smaller active chimneys were lined up in a West-NW azimuth downslope from the main Church vent. Mongo was sighted at 11:41. Marker #1 was deployed at 11:42 on a small basalt mound about 3-5 m south of Mongo Vent (4400x; 6649y). A Titanium major sample (Sample 3D) and a gas-tight (3DG) were taken near the top of the chimney (after knocking a piece of the chimney off) at a temperature of 280°C (4408x; 6659y). The nearly clear vent fluid was flowing out vigorously. ALVIN then proceeded back to Church Vent, where a discrete major, a discrete gas-tight (4D and 4DG), and a sulfide sample were taken at a vent on the northeast side (Sub Hdg.=207°) of the chimney at a temperature of 270°C (4391x; 6622y). Three more water samples were taken on the southeast side of the chimney (Sub Hdg.=028°). After completing the water sampling, ALVIN recovered the U. Washington Temperature Probe and the dive was terminated at 13:50.

## DIVE 2788: Flow Site and CM Mooring

July 1, 1994
Pilot: Bob Grieve
Port Observer: Julia Getsiv (author of this transcript)
Starboard Observer: Laurie Ferioli

Dive Objectives:

1. Find and release the NOAA PMEL's current meter mooring located approximately 1300 m west of the '93 lava flow.
2. Find the three markers (7A, Triangle 0 and 6A) in the central venting area of the '93 lava flow left during the October 1993 AII/Alvin cruise; take temperature measurements and water samples at each site.
3. Make a couple of east-west traverses over the '93 lava flow to better constrain the flow and venting boundaries of the site.
4. Collect an old basalt sample at the mooring site and both an old and new basalt sample at the '93 flow contact.

Dive Summary:

Alvin landed on the bottom at 09:24 (2189x/5811y/2419 m), east of the mooring target, in an area of old, striated pillows and lobes on the order of a few meters across in size. We began exploring the area looking for the mooring release by driving along the seafloor around the estimated mooring location. The terrain was composed primarily of large isolated pillow and lobate structures separated by large flat and heavily sedimented areas. The biota seen included corals, crinoids and fish. At 10:05:36 we started a zig-zag traverse of the area, but still no signs of the mooring. A half hour later top lab suggested that we go up in the water column approximately 50 m (total depth 2396 m) to range on the sonar unit. Using the travel times, the chief pilot Bob Grieve altered his course until the travel times suggested we were nearly on top of the mooring, and should be seeing it in the water column. At 11:08:25 Alvin returned to the seafloor (no navigation fixes), finding the mooring soon after at 11:21:41 (2011x/5596y/2421 m). The mooring was strung out along the seafloor along side a fracture a couple meters wide. Apparently the floats had imploded, though we didn't actually see them, causing the current meter to fall to the seafloor. We first followed the cable southwest (H 210°), searching for the release, but the pilot, recognizing we were following it in the wrong direction, changed course to H 035° at 11:22:35. The end of the mooring was found at 11:27:50, deep in the fissure which was wider at this point, but not wide enough into which Alvin could descend. The walls of the fracture were comprised of truncated pillows and the base rubble and talus. A mooring fix of 2079x 5708y and depth 2423 m were noted before leaving station #1 at 11:30 and heading for the flow site and target #2, Marker 7A.

We headed towards the next target with a heading of 100°, and 1300 m range at 11:30. The total depth of the area was initially 2414 m, but began dropping off at 11:36:02 and reached a maximum of 2430 m at 11:42:11 (2396x, 5692y). The seafloor sloped up ahead of us while we traversed terrain similar to what was initially seen, heavily sedimented and striated large pillows and lobes, with the biota primarily corals and crinoids. At 11:45:05 (2486x/5686y/2418 m) the top of a pillow mound was reached before encountering a steep drop-off. An interesting hollowed out pillow (barrel-shaped) with a crinoid at the opening was seen at the ridge of the mound, not too far from a small fracture. The depth increased from 2416 m (2519x/5683y) at 11:46 to 2453 m (2698x, 5668y) at 11:52:30, while heading 102° and at a range of 680 m from target #2. We traversed another mound approximately four meters tall before dropping off again to a maximum depth of 2462 m. At 12:02:08 (3008x, 5609y) the geology changed from isolated large pillow structures to more densely packed pillows with a medium, rather than heavy, sediment cover. The younger flow formed a small mound which came up 5 m from the west side, and down 16 m on the eastern side. At 12:05:54 (3116x/5581y/2468 m) we were again traversing upslope to the east over densely packed pillows occasionally decorated with small pillow buds. The 1993 lava flow

contact was encountered at 12:13:50 (3329x, 5507y, 2434 m). The new lava had a very light coating of sediment which had accumulated over the past year. Yellow hydrothermal precipitates were also seen in some of the pillow interstices near the contact. The edge of the new flow was primarily small pillows, contrasting with the larger and older pillows on the west side of the contact. Evidence of a post-eruption event, such as white alteration on fractured pillows, was observed while travelling east in search of Marker 7A. The new flow didn't appear to be as glassy as it was in July 1993. The pillows increased in size and became more lobate as we were nearing the ridge of the flow; becoming completely lobate on the flow's ridge, reached at 12:19:24 (3439x/5468y/2397 m). The hydrothermal precipitates also increased towards the center of the flow, completely coating the lobes at 12:19:43 (3444x, 5466y, 2393 m). We crossed the depth of the first target (2399 m) at 12:21:10 and then left the major venting area, still heading east, at 12:21:40. The first shimmering water was seen at 12:21:50 at 3479x 5448y, after we had turned around (H 232°) and entered the major venting area again. The depth however was too shallow for the marker location, so we left that region at 12:25:25, going downhill, and began following the 2399 m depth contour in search of the marker. Drained out pillows and white alteration on fracture surfaces were encountered at 12:26:51 (3444x, 5484y, 2399 m). At 12:30:05, with no marker in site, we began searching for a 038° trending fissure (more evidence of a post-eruptive event) running through the middle and parallel to the long axis of the flow, centered between Marker Triangle 0 and Marker 6A. The fissure was found at 12:41:33 and was ~1-1.5 m wide with a position southeast of the one determined in October 1993. Since we were closer to Triangle 0, we began following the fissure south (H191-210°) towards the new southeast shifted target. The fracture at first became narrower and the floor of the fracture shallower, revealing rubble in the bottom, but at 12:44:48 the fracture got deeper and more narrow again. The fracture split into two at 12:45:16 (3490x/5530y/2410 m) ,with the east fracture being more pronounced. The fracture system ended at 12:45:39, position 3488x, 5523y, 2408 m. The hydrothermal precipitates trail extending out of the fracture led us to the Marker triangle 0 at 12:47:47, new position 3474x, 5472y, 2389 m. The x-coordinate shifted +48 m, and the y-coordinate -65 meters (from the positions determined in the original 1993 Alvin navigation), but the depth stayed the same. A small spot of shimmering water was found at 12:51:04 (3475x/5469y/2389 m) and became the focus of our sampling. A temperature measurement with the Alvin high T° probe measured 9.2°C (compared to 9.0°C measured last October). The port major on the manifold was triggered at 13:07:05 (3471x/5467y), the middle major at 13:09:55 (3471x/5467y) and the port gas-tight at 13:12:22 (3472x/5468y). Noting the shift in the marker position, new estimates for the other two markers were entered into the computer and we headed for the new Marker 7A target at 13:17.

We stayed in the major venting area, following a southwesterly path nearly all the way to Marker 7A, located a minute later at 13:18:17. The new position determined for the marker is 3432x, 5432y, at a depth of 2395 m (shift of +56 for the x-coordinate, -61 for the y-coordinate from the original 1993 Alvin navigation). This site is slightly off the ridge of the flow to the west and is in an area where hydrothermal sediments are observed only in the interstices. Alvin hovered around this area while we searched for shimmering water, but none was found. Since too much sediment had stirred up and no shimmering spots were to attempt a water sample, we left the site at 13:32:42, heading for the new estimate of Marker 6A, the northernmost target.

The major venting area was re-entered at 13:33:38 (3433x, 5430y) and the same 038° trending fissure found at 13:38:12 (3478x, 5516y). We decided to follow the fracture north-northeast for as far as it would go and then maintain that heading towards the new position for Marker 6A. The northern end of the fracture was reached at 13:41:38 (3545x, 5528y) and Marker 6A at 13:48:03. The traverse from 7A to 6A was down slope to a depth of 2424 m, at the northern end of the fracture, and then shoaled to a depth of 2393 m at the marker. A spider crab near a collapse pit was seen near the marker. The new Marker 6A position was determined to be 3582x, 5751y. Again we hovered around the area in search of any shimmering sites, but none were found. A colonizing rack Verena Tunnicliffe had placed next to the marker last October showed no evidence of colonization. The largest collapse region seen during the dive was also found near the marker and could be followed for 1.5 minutes. A basalt sample of the new lobate flow was obtained at 13:56:47 (3579x, 5752y, 2393 m). We then did a SUAVEscan in a pocket filled with

orange bacteria from 14:01:12 to 14:04:27, later revealing some very faint spikes of Fe, Mn and $H_2S$. With very little power left we decided to head west at 14:05:32 to the lava contact and take a sample of old and new basalts before leaving. The depth increased during our traverse from 2394 m to 2454 m, and the major venting area left at 14:06:34, 104 m from the contact. The edge of the lava flow was found at 14:14:58, an old basalt sample taken at 14:16:15 (6R: 3437x, 5738y, 2256 m) and the flow boundary traversed again (3432x, 5746y, 2454 m) to obtain a new basalt sample (7R: 3452x, 5765y,2256 m) before dropping weights.

A note on navigation post-processing: The original 1993 Alvin navigation for this area was replayed by Russ McDuff at the U. of Washington with slightly shifted transponder positions. This replayed navigation corresponded better to that obtained in 1994, decreasing the average offset from 1993 to 1994 (determined from marker positions) to +15 m in x, -9 m in y. Bill Chadwick later applied this average shift to all of the Flow site 1993 Alvin navigation so that it would match the "better" navigation obtained in 1994.

## DIVE 2789: Floc Site

July 2, 1994
PIT: Socrates Carelo
Pilot: Pat Hickey
Observer: Bill Chadwick (author of this transcript)

This was the first of 3 dives to the Floc site, CoAxial segment. The goals of the dive were to 1) drive along the fracture system that had been previously venting warm water as a result of the dike intrusion along the segment last summer and assess the current state of the hydrothermal system; 2) conduct a series of traverses and mapping with the Mesotech sonar to continue our geologic mapping of the area; 3) visit Markers 3A and 11 (previously deployed in October 1993 on dives 2673 and 2676) and pick up a time-lapse camera system at Marker 11.

The dive began east of the fracture system, in a basin southeast of Marker 3A, just south of where dive 2673 left the fracture system to make a traverse to the east. We drove west over an old lava lake area with extensive sheet flows with collapse (~5 m) in its western part. We crossed a narrow linear zone of diffuse venting with bacterial mats and shimmering water on the first traverse to the west. After a broad turn back to the north we crossed the line of venting again, this one more extensive than the first and near where the fissure system intersected the lava lake drain-out area. This is the first place that we saw tubeworms - which is a very significant observation because no macrofauna were observed in October, so this new venting area has been colonized since then. The size and extent of the diffuse vents ranges from small isolated holes between pillows or along cracks to extensive areas of shimmering water, usually coming out of the west floor and wall and rim of the active fissure. All venting areas are surrounded by extensive bacterial mats.

As we continued along the actively venting fissure to the NNE, we began to climb the south slope of a large constructional hill of pillow lavas towards Marker 3A. This part of the fracture system had not been traversed before. We continued to see venting, almost continuously. In some places it was very extensive (over 10s of meters), in others it was more localized. We saw several other locations where tubeworms had colonized vents. They looked healthy, as we could see their red plumes extending above their tubes. The tubeworms were in small clumps of a dozen or less and appeared to be 6" to 12" long. They tended to be down in small holes or pockets between pillows where the warm water was exiting the seafloor.

We arrived at Marker 3A at 10:58 (6461x/6717y) and found venting near the marker, although somewhat diminished from that observed in October. We saw one vent where tubeworms had colonized - and this is a site where they were definitely not observed in October. We sampled water at Marker 3A (1 major and 1 gas-tight, 6465x/6703y/2241 m) and measured a temperature of 7.6°C. The rocks around this site were completely covered with a gelatinous coating of tan colored bacteria, whereas white bacteria occupied the mouths of individual vents.

While sampling water we used the 3-chip camera to zoom-in on the vent orifice (~11:42) and saw another kind of worm living there - this one unknown to us. These worms were very small (a few cm long and a few mm wide), blood red, and pointed at the end, somewhat like an earthworm in shape. The worms were quite animated while being bathed in the diffuse flow.

Next we rose up 25-30 m above the bottom and conducted a Mesotech sonar survey of an area about 300x300 m centered on Marker 3A (12:00-12:40). After the survey we made an E->W traverse on the bottom to Marker 3A. At this point we were running a little low on power, so we made a bee-line for Marker 11 (unfortunately west of the actively venting fracture). We found Marker 11 at 13:20 (6750x/7237y) and could see no active venting near the Marker - certainly the vent that the time-lapse camera and the temperature probe were around was completely dead. This vent had been a vigorous snowblower-type vent in October with large amounts of floc coming out of a hole about a meter in diameter. We only had time to grab the camera and the dropped weights.

In general, the venting in the floc area seemed somewhat diminished, but still quite active. There was not as much floc in the water as was observed in October, the water temperatures appeared to be lower, and no "snowblower" vents were seen like the ones observed then - and the one at Marker 11 was dead.

Nevertheless, the area continues to vent enough to sustain a new colony of vent organism, but it seems likely that the hydrothermal system will continue to cool and contract, so its longevity may be limited.

*July 3, 1994*
*No Dive - Generator Problems*

## Dive 2790: Source Site

July 4, 1994
Pilot: Matt Heintz
Port Observer: John Lupton
Starboard Observer: Hank Chezar (author of this transcript)

The primary goals of this dive were: (1) Complete as many transect lines as possible using the Mesotech Sonar over the Source site (2) Sample fluids in the Beard, Mongo and Twin Spires sites (3) Collect basalt samples at sites other than those previously sampled and (4) collect sulfides where appropriate, particularly at the Beard and Mongo sites.

Dive Summary:

Alvin landed about 300 meters southeast of the start of our Mesotech Survey point. While in viewing range of the seafloor, we traversed along the bottom composed mostly of 20-30% sediment covered pillows and tubes with what looked to be occasional lobate type lava forms. Along this transect we picked up our first basalt sample at 4371x,6333y. Our starting point for our first Mesotech line was 4300x, 6450y. We traversed to the northeast along the fracture at a nominal altitude of 25 m.a.t. at 027° heading for 500 m. The survey showed a fissure more or less trending parallel to our track. The first line ended at 4525x, 6900y, ~500 meters from our starting point. We turned to the northwest, traversed 100 meters, and started our second line at 4425x, 6950y. During this 500 meter traverse we saw none of the fissures noticed on the first line. It showed the slope to be rising to our left fairly consistently along this track. The survey ended at 4200x, 6500y, at which point we transited to the Beard site for water and rock sampling. This site was at 4374x, 6595y, about 400 m from the end of our second Mesotech line. The terrain to Beard was predominantly pillow basalts with a light dusting of sediment and lots of biology covering the rocks. Once at Beard, we sampled. The Alvin probe measured a temperature of

255°C. There we also triggered major #9 (4374x, 6595y), took a biology and sulfide sample, discrete gas-tight #3, and discrete major #15. All sampling was done at an orifice on Beard located about 4 m from the top of the vent. We left Beard at 1141 h and transited through the Church site to Mongo vent. We did not sample at Church. We drove along the lip of a fissure on the way to Mongo. Once there, we found the chimney had collapsed. The Marker was visible at this site. At 1203 h we started sampling at 4408x, 6660y. The manifold temperature probe held steady at 264°C. We triggered the port gas-tight, starboard major, middle major and took an Alvin temperature probe measurement of 284.3°C. Two sulfide samples and all 4 Niskins were take here as well. At 1235 h we left Mongo for the two new sites just to the north ~10-20 m for the Mongo site. We found this new vent at 1242 h in a crevasse with spires about 0.5-0.75 m high. We named it "Twin Spires". We collected a sulfide sample which disintegrated the spire. At 1253 h we took the starboard gas-tight with a T2=223°C, and took the port major (d=2056 m, 4404x, 6701y). At 1255 h the Alvin temperature probe appeared broken due to no readings. We finished sampling by triggering discrete major #14, gas-tight #7 and taking a rock and bottlebrush sample from 1306-1323 h. Power was used up at 1326 h so we ended the dive then. The recorders were shut down at 1328 h.

## Dive 2791: Central & South-Central Floc Vent Region

July 5, 1994
Pilot: Bob Grieve
Port Observer: Jim Holden
Starboard Observer: Gary Massoth (author of this transcript)

Dive Objectives:

1. Determine the thermochemical character of diffuse fluids by *in situ* SUAVE surveys
2. Survey and sample micro- and macro-biological populations at diffuse venting sites
3. Collect discrete chemical samples at diffuse venting sites
4. Establish site for temporal monitoring of biological community and vent fluids where tubeworms have been first observed during this dive series
5. Conduct MesoTech sonar surveys along fissure system near Floc vent

Synopsis:

Marginal sea conditions delayed launch until 0845. Three minutes after splashdown, ALVIN was diving, with first observation of the seafloor made at 0946 (a 58 minute descent). The drop position was over Marker 11 where it was intended that we would use the ALVIN elevator to recover the McDuff *in situ* temperature recorder. Because the high sea state precluded elevator use, we descended on a slant trajectory toward Marker 3A. We landed in the axial fissure 310 m north of Marker 3A bearing 212° to it (6636x, 6986y, 2217 m). We then rose to 25 MAB and conducted a MesoTech survey of the fissure system between the landing site and Marker 3A. We descended slightly west of 3A seeing tubeworms, extensive white mat, and shimmering water and, 32 minutes after landing (1042), Marker 3A. At Station 1 (6448x/6697y,2240 m) ALVIN pointed 062° and sampled port MS (7.3°C) and gas-tight (5.8°C) approximately 2 m from the 3A marker (6454x, 6697y, 2229 m). At the same position SUAVEscan #1 was conducted (8.3°C $T_{max}$, 1103 to 1109 h) with detectable concentrations of $H_2S$, Si, Mn, and Fe and Slurp sampling of worms and mat was accomplished between 1113 and 1118 h. We then descended about 7 m into the fissure directly below Marker 3A where the biological community was sparse relative to that on the adjacent rim, giving a contrasting "brown-out" appearance. The kelp-style bacteria were observed but were brown and hanging down as opposed to white and waving, as observed in October 1993.

Leaving the Marker 3A site we attempted to drive south along the fissure but it closed in forcing us to drive along the western rim where several large and closely spaced "huge diffuse

vents (HDV's)" were seen starting about 40 m south of Marker 3A (6459x, 6635y, 2274 m). South of the HDV's to our southernmost target (Biosite '93, 6338x, 6201y), about 0.5 km along fissure where a small biological community was observed in October 1993, only small patches of white bacterial mat and occasional iron oxyhydroxide colored hydrothermal staining were observed. This transit occurred between 1150 and 1215 and crossed to the east and then back to the west over several parallel fissures which were bordered by collapse pits on the southern end. No venting or macro biological community was observed at the target coordinates.

We then headed north northeast for about 100 m, then northwest for about 75 m, and finally searched in an approximate circular pattern until (1247 h) we intersected what appeared to be the main fissure and the point where Chadwick entered from the west (6350x, 6350y) on dive 2789. From here we continued north along fissure until we observed a large white bacterial mat with on the west wall plus rim and fissure west floor. Here we also observed an abundance of tubeworms that were about 6 inches in length. We chose this site (Station 2) as our diffuse vent "reserve" and attempted to deploy a marker chain with no success due to breakage. We then deployed the triangular shaped, syntactic foam, numeric throughhole-style Marker 2 at 6369x, 6440y, and 2287 m about 4-5 m below the rim of the fissure on the gently sloping talus near the fissure floor. We then conducted SUAVEscans #2-7 (2U1-6) between 1309 and 1339 at locations referenced by clock position relative to ALVIN heading (321°), distance to Marker 2, and biology (#2, 2U1: 6 o'clock, 2-4" from marker, in midst of tube worms at worm plume height, 8.8-9.0°C; #3, 2U2: same worms as #2 but at their bases, 11-11.7°C; #4, 2U3: 6 o'clock, 12-14" from marker, over white bacterial mat, 6-8°C; #5, 2U4: 7 o'clock, 6-8" from flag, at worm plumes, 5.0-6.5°C; #6, 2U5: same worms as #5 but at their bases, 7.0-7.2°C; #7, 2U6: 9 o'clock, 1.5-2.0' from flag on rock in matt, 3.0-3.5°C). Hydrogen sulfide, Si, Mn, and Fe were detected on all of these and subsequent SUAVEscans at concentrations in excess of those measured at the Marker 3A site. We then collected central manifold major 2M (6.0-8.2°C manifold temperature), starboard manifold gas-tight sample 2G, and discrete major 2D (no tape marker) at the site were SUAVEscan #2 was conducted.

We then moved 15 m north but still within the same diffuse vent field to a site similarly at the base of the vertical wall and on the talus slope for our Station 3 site (6368x, 6457y), which was intended for the harvesting of biological specimens (i.e., the "meat market"). We first conducted SUAVEscans #8 and 9, 3U1-2 (1400-1410 h) at the plumes and bases, respectively, of tubeworms which were later harvested for laboratory analysis (#8, 3U1: 6.2-6.7°C; #9, 3U2: 9.6-9.8°C). Between 1412 and 1414 h tubeworms mostly about 6" in length (some as long as 12" by pilot's estimation) were collected from the SUAVEscans #8 and 9 position. We then rose to the west fissure rim above the Marker 2 site and deployed a same-style Marker #6 (6368x, 6469y, 2285 m) on pillow lava at our Station 4 site.

We decided to return to the HDV site (211 m bearing 024°) for additional water and biological sampling. During the transit between 1421 h and 1439 h we maintained an altitude of 25 m and conducted our second MesoTech survey. We chose 6450x, 6652y, 2261 m as our Station 5 site (about 4 m south of Marker 3A). We again approached facing the west wall near the base and settled within reach of tubeworms (the first we observed at HDV), extensive white mat, and shimmering water. We first collected (1439 h) discrete major sample #9, 5D at the base of the tubeworms that were later collected. The forward Niskin was then tripped (1441 h) in shimmering water within 1m of the seafloor. The temperature probe on SUAVE in the ALVIN basket where the Niskins were located read as high as 6°C at this site. The discrete gas-tight sample was then collected (1444 h) from the same site as the #9, 5D. Between 1447 and 1452 h SUAVEscan #10, 5U was conducted at the tips of tube worms (3.5-4.6°C) later collected at 1458. ALVIN was repositioned so the starboard manifold major sample could be collected from this same position (5.0-5.7°C). The tubeworms were collected and then a large chunk of basalt. Ascent weights away occurred at 1500. At 1502 while still visually within plumeborne floc the center Niskin was tripped 36 MAB (2246 m).

## Dive 2792: Flow Site

July 6, 1994
Pilot: Pat Hickey
Port Observer: Mike Perfit
Starboard Observer: Bill Chadwick (author of this transcript)

This dive was at the Flow site, CoAxial segment. The goals of this dive were to 1) drop down near the northern tip of the 1993 lava flow and make several geological traverses and collect a Mesotech survey to help define the structures and eruptive vents there, 2) take a suite of rock samples of the new and surrounding older lavas, 3) traverse east to the flow that had been identified by SeaBeam depth changes as erupted between 1982 and 1991 and make traverses to better define its extent and collect additional rock samples.

We started the dive by landing on the contact between the 93 flow and surrounding lavas, but it turned out to be just a kipuka (a small island of old lavas surrounded by thin new flows). We drove west down to the real contact and sampled both new and old lavas there (station 1, 09:30, 3632x/6086y/2437 m). From here we started the Mesotech survey of a 300x300 m area centered on the tip of the 1993 flow (09:40-11:03). The survey revealed very interesting structures north of the flow. On the center line, it appeared that a well-defined graben was filled by at least one small flow just north of the main 1993 flow. Next we came back down to the bottom to investigate these features. We followed a fissure south, sampled the older lava at station 2 (11:15, 3955x/6406y/2448 m), then realized we were too far east, so we continued further west and encountered 1993 lava in the floor of a graben about 1 m deep. We sampled the new lava here at station 3 (11:27, no nav, 2452 m). We then encountered the west contact of this 1993 lava, but it was not along the west edge of the graben (apparently we had traversed too far south). Navigation was spotty in this area. As we continued south we found the east side of the graben again and followed it until it was buried by the main part of the 1993 flow. From here we drove east to our target on the 1982-91 flow. At 12:09 we reached the western contact of the 1982-91 flow and took a sample (station 4, 2476 m). We continued to traverse east until we got to the top of the flow where we found a "pillow pillar", apparently a small eruptive vent, and sampled (station 5, 12:17, 4177x/6072y/2446 m). We saw extensive deposits from past hydrothermal venting, both on the 1993 flow and on the 1981-92 flow, but saw no active venting the entire dive. From here we drove south along the crest of the 1982-91 flow and found it to be continous, even though the SeaBeam anomalies are small and discontinuous here. The traverse had an up and down profile like a rollercoaster ride, apparently as we crossed from one eruptive center to the next. We stirred up the bottom and used the 2 Niskin bottles to sample the yellow hydrothermal sediment on the 1982-91 flow (station 6, 12:31, 4187x/5916y/2440 m). We took another rock sample of the 1982-91 flow at 12:42 (station 7, 4149x/5633y/2458 m). At 13:07 we encountered older lava (distinctive becase of all the stalked organisms living on it, in contrast to the bare young lavas) and sampled it (station 8, no nav, 2458 m). This was very near where dive 2677 attempted to sample the 1982-91 flow, but ended up sampling older lava. We were in these older lavas for the rest of the dive. Before ending the dive we tripped 2 majors and a gas-tight just for samples of bottom water (3960x/5329y/2458 m).

## DIVE 2793: Floc Site

July 7, 1994
Pilot: Matt Heintz
Port Observer: Bob Embley (author of this transcript)
Stbd. Observer: Mike Devany

Objectives: The primary goals of the dive were to: (1) map and sample vents in the southern portion of the Floc site (~46°18'N); (2) fill in gaps in the Mesotech sonar survey of the fissure system; (3) collect biological samples, and (4) recover the U. Washington temperature probe at the Marker 11 site.

Dive Synopsis: ALVIN descended to the seafloor 100-200 m east of the southern portion of the fissure swarm in which the diffuse venting had been located on previous dives to the north. The first objective was to cross the strike of the fissure swarm to see if any of the fissures were actively venting. ALVIN began a NW course at 09:32 in pillow lavas that had a sediment veneer as well as sediment pockets. After crossing several fissures and a wider one with a downdropped block (small graben?), a fissure which exhibited vivid white staining and orange/yellow staining/coatings was encountered. After taking a stained basalt sample (Station 1R; 6293x, 5789y) at 09:45, an attempt was made to follow the fissure northeast, but its trace was quickly lost. ALVIN then continued on the NW traverse, encountering several more fissures, including two large ones with downdropped blocks. After a course change to 045° at 10:08, ALVIN encountered an area of jumbled sheet flows with extensive pockets of yellow-orange hydrothermal sediments at 10:12 (2275 m). Some shimmering water was being emitted from areas characterized by whitish halos within the hydrothermal sediments. A brownish coating over some of the lavas in the vicinity is probably left from previous venting. A maximum of about 7°C (Station 2; 2273m; 6216x; 6030y) was recorded in one of the white halo areas. Tubeworms, scaleworms, and an unidentified pale-yellow worm were also observed. Since the flow rate was not very vigorous, it was decided to move on. At 10:28 a more active area was encountered characterized by denser suspended matter, floc streams emanating from cracks and holes in the sheet flow, and milky vent fluid. Samples of 5.5-6.2° fluid were taken at 10:32-10:47 (3M1, 3M2, 3G; 2277m; 6222x, 6078y) and Marker 10 was placed near the sample site (4#10 at 2276 m). Small clumps of tubeworms were also observed at the site. Shortly after leaving the vent, the submersible entered a drained out area with short lava spires from which (the top of one) sample 5R was taken at 11:05 in a depth of 2280 m (6217x, 6133y). ALVIN then rose up in the water column to about 25 m altitude and traversed NE along the tectonic trend over the lava lake to a target about 100 SE of Marker 6 (placed during Dive 2791). The Mesotech survey line was completed at 11:26 (6345x, 6398y) and ALVIN returned to the seafloor and began moving northeast along the hydrothermally active fissure which cut through pillow lavas. Signs of venting seen along this traverse were bacterial mats and yellow sediments in the talus below and the west wall of the fissure. Marker 6 was seen at 11:32 and at 11:33, the wall had extensive coatings of bacterial mats. After encountering dense large flocs in the water column at 11:38, another area of extensive bacterial mats, including pervasive "blobby" strands of material was seen on the west wall of the fissure. A slurp of whitish bacterial mat was taken off the wall about 5 m up from the floor of the fissure (Station 6; 2280 m sub depth; 6394x, 6481y). Signs of active venting were seen semi-continuously in the water column and/or NE along the fissure system until the vicinity of Marker 3A, which was spotted at 12:16. North of Marker 3A, yellow coatings/deposits and brown mats were observed in the pillow lavas on and near the fissure(s), but no more signs of active vents were seen. At 12:35, ALVIN rose off the seafloor and began a Mesotech survey line northward to Marker 11. At 13:20, the sub returned to the seafloor and a traverse to the northwest was begun. The temperature probe at the Marker 11 site (a small lava pit a few meters east of the main fissure) was sighted at 13:24. A video survey of the vicinity of Marker 11 revealed that, although venting had ceased at the temperature probe/time lapse camera site (the latter having been recovered on Dive 2789), milky vent fluid was still rising out of the main fissure and from another lava pit a few meters north of the temperature probe site.

Tubeworms were also seen at the active lava pit, which had not been observed at the Marker 11 site in October, 1993. Temperature probing measured a high of about 7.2°C in the pit and samples 7M and 7G were taken at 13:55 (6753x, 7222y at 2239 m). Also, a tubeworm grab was recovered from the edge of the pit (7B). The temperature probe was recovered and the dive ended at 14:21.

## Dive 2794: Flow Site

July 8, 1994
Pilot: Bob Grieve
PIT: Socrates
Port Observer: Mike Perfit (author of this transcript)

Dive Objectives:

1. Look for low-temperature venting along north end of 93 flow
2. Investigate structural and spatial relationships between '93 flow and partially filled fissure just north of the flow, traversed during dive 2792
3. Collect rock samples from flows in the fissure
4. Mesotech the fissure system that extends to the NE from the region previously surveyed on dive 2792.
5. Sample basalts from the most northerly extent of the fissure system covered during the dive to extend geochemical coverage and investigate changes in dike/flow petrology

This dive was planned to investigate the northern most region of the 1993 flow and its extension to the northeast (~ 026°) along a fissure system that extends from beneath the flow and was surveyed with the Mesotech during dive 2792. Although some of the area to the north was traversed during dive 2792, the relationships between the 1993 flow and the fissures was not clear. Based on the Mesotech data, it appears that the fissure has a very varied morphology and in places may be filled with the 1993 flow (or some earlier flow).

The dive started at 09:01, approximately 600 meters south of the main terminus of the 1993 pillow ridge on the east side in older pillow lavas (3887x/6135y). We continued in a NNW direction heading for the contact with the 1993 flow. About 100m north of the drop site (09:20), we encountered the contact between the young and old flows; there was little evidence for any hydrothermal activity or past venting.

Continuing to the NNW, we crossed a deep fissure at 09:34 (3882x/6338y) in the older lavas trending approx. 030° that appeared to have young lava along the floor. Dropping deeper and turning south to investigate, we saw that the young flows emanated from the south and covered over portions of the fissure walls. The east side of the fissure appeared to be higher than the west (which looked constructional) and much of the floor was covered with old-looking sediment covered talus. Continuing SW, the east wall of the fissure was covered by young lava as we approached the main body of the 1993 flow (north end). During the dive it appeared that we may have been in a fissure to the east of the main one seen during dive 2792, but the post-dive navigation suggests we probably traversed the fissure/new flow in the same place during both dives.

After climbing the constructional north end of the 1993 flow, we turned northeast at 10:00 to follow back along the fissure. To the west of the fissure was a region of older constructional pillow ridges. The fissure about 100 m further north contained sediment covered talus and then was buried by a constructional edifice that appeared at first to be made of young pillows. Station #1 was on the west side of this constructional mound. Upon closer inspection, it appears that the pillow lavas are not as young as the 1993 flow but not as old as the main component of pillows that typically comprise the area. Sample 1R (3950x/6554y/2446 m) was taken from these pillows. Continuing northeast, we encountered a narrow fissure at 11:05

(4008x/6560y) trending about 025° that had older looking talus in it. At this time we were approximately at the northernmost point of the 2792 survey so we raised up off of the bottom to start our Mesotech survey. Most of the survey was run between 20 and 30 m from the bottom and at headings between 10° and 30°. We attempted to keep the fissure near the center of the profile but at times it completely disappeared and we wandered off a linear course in an attempt to find it. At first the fissure was deep (~20 m) and had a well-defined graben appearance with a horst in the center. The fissure become poorly defined to the NE, generally less deep and often had multiple (3-5) narrow fissures instead of one main cleft.

About 500 m north of the survey starting point there was no expression of the fissure system, but a small fissure appeared on the east within another 300 m (4270x/7218y). Around this time we were having trouble with our navigation because we were too close to the baseline of the transponders. After switching them, the navigation again began to give us good fixes. We continued to follow this fissure at about 030°-035° and it divided into two to three branches at 11:52 (4392x/7327y) and stepped up on the east.

After surveying for approximately 900 m we dropped to the bottom to see what the fissures looked like and to sample basalt. We landed in old pillows that were cut by several narrow (1-3 m) fissures. At 12:27, one of the fissures became wider (20 m) with a deep cleft along its west wall. Here we found young-looking lavas within the cleft and on a shallow area within the center of the fissure. We stopped to sample young pillow-lobate basalt that looked like the 1993 lavas (Sample 2R, approximated position 4533x/7534y/2461 m). There was a good deal of red-orange staining along the bottom edges of the flows and this was associated with bacterial floc which we slurped with the manifold (Sample 2B). We left Marker 3 (triangle) on top of a small constructional hill in the center of the fissure before we ended the dive.

# COAXIAL DIVE STATIONS: SAMPLES/MARKERS

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Alvin Dive 2787: Source Site, Origin 46° 9.489' / 129° 47.48'** | | | | | | | | | | | |
| ALV2787-1R | 10:24 | 2058 | 4488 | 6829 | 46° 09.404' | 129° 48.524' | | | ~2°C | basalt | Pillow basalt slab removed from a wall of pillows, from the edge of a fracture on the East wall North of the Mongo vent site |
| ALV2787-2#1 | 11:42 | | | | 46° 09.307' | 129° 48.593' | | | | Marker #1 deployment | Deployed marker on a small basalt mound 3-4 m S of Mongo |
| ALV2787-3D | 11:59 | 2053 | 4408 | 6659 | 46° 09.313' | 129° 48.586' | | | 280°C | discrete major #14 | From the top orifice of the Mongo structure, H263° |
| ALV2787-3DG | 12:10 | 2054 | 4408 | 6659 | 46° 09.313' | 129° 48.586' | | | 280°C | discrete gas-tight | From the top orifice of the Mongo structure, H263° |
| ALV2787-4S | 12:35 | 2065 | 4391 | 6622 | 46° 09.292' | 129° 48.599' | | | 270°C | sulfide | An anhydrite-rich sulfide was collected with the arm from the base of the Church Vent, H211° |
| ALV2787-4D | 12:41 | 2065 | 4392 | 6622 | 46° 09.292' | 129° 48.599' | | | 270°C | discrete major #4 | Drawn from the base of the Church Vent, H 205° |
| ALV2787-4DG | 12:50 | 2066 | 4391 | 6621 | 46° 09.292' | 129° 48.599' | | | 270°C | discrete gas-tight | Drawn from the base of the Church Vent, H 205° |
| ALV2787-5M1 | 13:10 | 2070 | 4386 | 6614 | 46° 09.288' | 129° 48.603' | | | 294°C | manifold: port major #1 | Drawn from the base of the Church Vent, H 28° |
| ALV2787-5G | 13:14 | 2070 | 4386 | 6614 | 46° 09.288' | 129° 48.603' | | | 292°C | manifold: port gas-tight | Drawn from the base of the Church Vent, H 28° |
| ALV2787-5M2 | 13:17 | 2070 | 4387 | 6614 | 46° 09.288' | 129° 48.602' | | | 293°C | manifold: middle major #2 | Drawn from the base of the Church Vent, H 28° |
| ALV2787-6T | 13:31 | 2069 | 4393 | 6623 | 46° 09.293' | 129° 48.598' | | | ~2°C | temperature probe | Recover of Russ McDuff's temperature probe deployed on dive ALV2681 in October, 1993, the probe was placed in an orifice at the base of the Church Vent, H266° |
| **Alvin Dive 2788: CM Mooring to Flow Site, Origin 46° 28.493' / 129° 37.516'** | | | | | | | | | | | |
| ALV2788-1 | 11:29 | 2425 | 2078 | 5709 | 46° 31.574' | 129° 35.892' | | | | station | Taking fix for termination of mooring cable into fissure |
| ALV2788-2M1 | 13:07 | 2389 | 3471 | 5467 | 46° 31.444' | 129° 34.804' | 0 | Triangle | Alvin 9.2°C | manifold: port major | Shimmering water, turned on variable pump for about 3 minutes and flushed pump for 30 seconds, pilot reported seeing exhaust |
| ALV2788-2M2 | 13:10 | 2389 | 3471 | 5467 | 46° 31.444' | 129° 34.804' | 0 | Triangle | Alvin 9.2°C | manifold: middle major | Shimmering water, turned on variable pump for about 2 minutes and flushed pump for 30 seconds, pilot reported seeing exhaust |
| ALV2788-2G | 13:12 | 2389 | 3472 | 5468 | 46° 31.444' | 129° 34.803' | 0 | Triangle | Alvin 9.2°C | manifold: port gas-tight | Shimmering water |
| ALV2788-3 | 13:20 | 2396 | 3432 | 5433 | 46° 31.425' | 129° 34.835' | 7A | Square | | station | Located Marker 7A |
| ALV2788-4R | 13:56 | 2394 | 3578 | 5753 | 46° 31.598' | 129° 34.721' | 6A | Square | | basalt | New lava flow (1993), piece from once venting area in the central region of the flow, no shimmering water |
| ALV2788-5U | 14:01 | 2397 | 3590 | 5753 | 46° 31.598' | 129° 34.711' | 6A | Square | | SUAVEscan | Sscanned in lava lobe interstice filled with orange bacterial floc for 3 minutes 15 seconds, near Marker 6A |
| ALV2788-6R | 14:16 | 2456 | 3437 | 5740 | 46° 31.591' | 129° 34.831' | | | | basalt | Old pillow basalt piece from western contact of flow, West of the Marker 6A site |
| ALV2788-7R | 14:21 | 2456 | 3452 | 5765 | 46° 31.604' | 129° 34.819' | | | | basalt | New pillow basalt piece from western contact of flow, West of the Marker 6A site |
| **Alvin Dive 2789: Floc Site, Origin 46° 14.931' / 129° 47.48'** | | | | | | | | | | | |
| ALV2789-1M | 11:39 | 2241 | 6465 | 6703 | 46° 18.558' | 129° 42.428' | 3A | Square | 7.2°C | manifold: port major | H 104° |
| ALV2789-1G | 11:45 | 2240 | 6465 | 6703 | 46° 18.558' | 129° 42.428' | 3A | Square | 7.6°C | manifold: starboard gas-tight | H 104° |
| ALV2789-2 | 13:28 | 2239 | 6756 | 7218 | 46° 18.827' | 129° 42.223' | 11 | Triangle | | recovery | Picked up time-lapse camera, H 286° |
| **Alvin Dive 2790: Source Site, Origin 46° 9.489' / 129° 47.48'** | | | | | | | | | | | |
| ALV2790-1R | 9:24 | 2110 | 4371 | 6333 | 46° 09.137' | 129° 48.615' | | | | basalt | Pillow basalt, ~20% sediment cover on pillow surfaces 100% between pillows |

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2790-2S1 | 11:01 | 2065 | 4374 | 6395 | 46° 09.278' | 129° 48.612' | | | Alvin 255°C | sulfide | Sample placed in middle aft crate |
| ALV2790-2D1 | 11:09 | 2064 | 4374 | 6595 | 46° 09.278' | 129° 48.612' | | | Alvin 255°C | discrete major #9 | Triggered, but sampler moved out of vent while filling, snout loose |
| ALV2790-2B1 | 11:14 | 2064 | 4374 | 6594 | 46° 09.278' | 129° 48.612' | | | | biology | Sample placed in aft bio-buck |
| ALV2790-2S2 | 11:14 | 2064 | 4374 | 6594 | 46° 09.278' | 129° 48.612' | | | | sulfide | Sample placed in aft bio-buck |
| ALV2790-2G | 11:20 | 2064 | 4372 | 6595 | 46° 09.278' | 129° 48.613' | | | | discrete gas-tight #3 | In same orifice as above, sampling close to bottom of vent orifice |
| ALV2790-2D | 11:25 | 2064 | 4374 | 6594 | 46° 09.278' | 129° 48.613' | | | | discrete major #15 | Better sample than discrete major #9 (snout not loose) |
| ALV2790-2B2 | 11:35 | 2062 | 4376 | 6593 | 46° 09.277' | 129° 48.612' | | | | biology | |
| ALV2790-3S1 | 12:03 | 2057 | 4408 | 6660 | 46° 09.313' | 129° 48.586' | | | | sulfide | Mongo vent, H 304°, sample placed in port forward crate |
| ALV2790-3G | 12:07 | 2056 | 4407 | 6660 | 46° 09.313' | 129° 48.587' | | | T2=259-264°C | manifold: port gas-tight | |
| ALV2790-3M | 12:07 | 2056 | 4407 | 6660 | 46° 09.313' | 129° 48.587' | | | T2=235-265°C | manifold: starboard major | |
| ALV2790-3S2 | 12:19 | 2056 | 4408 | 6661 | 46° 09.313' | 129° 48.587' | | | | sulfide | Chalcopyrite on sample, placed in port forward crate |
| ALV2790-3N1 | 12:25 | 2057 | 4412 | 6664 | 46° 09.315' | 129° 48.583' | | | | Niskin | Mongo vent, ~1-3 m above |
| ALV2790-3N2 | 12:34 | 2055 | 4406 | 6655 | 46° 09.310' | 129° 48.588' | | | | Niskin | Mongo vent, ~1 m above |
| ALV2790-3N3 | 12:34 | 2055 | 4406 | 6655 | 46° 09.310' | 129° 48.588' | | | | Niskin | Mongo vent, ~6 m above, learned later this one didn't close |
| ALV2790-3N4 | 12:34 | 2055 | 4406 | 6655 | 46° 09.310' | 129° 48.588' | | | | Niskin | Mongo vent, ~11-12 m above |
| ALV2790-4S | 12:50 | 2060 | 4404 | 6701 | 46° 09.335' | 129° 48.588' | | | | sulfide | Starboard aft crate |
| ALV2790-4G | 12:53 | 2060 | 4404 | 6701 | 46° 09.335' | 129° 48.589' | | | T2=223°C | manifold: starboard gas-tight | |
| ALV2790-4M | 12:53 | 2060 | 4404 | 6701 | 46° 09.335' | 129° 48.589' | | | | manifold: port major | |
| ALV2790-4DM | 13:06 | 2060 | 4404 | 6702 | 46° 09.336' | 129° 48.589' | | | | discrete major #14 | |
| ALV2790-4DG | 13:09 | 2060 | 4404 | 6702 | 46° 09.336' | 129° 48.589' | | | | discrete gas-tight #7 | Not sure if sampler is in vent |
| ALV2790-4R | 13:23 | 2060 | 4403 | 6702 | 46° 09.336' | 129° 48.589' | | | | basalt | Placed in forward bio-buck |
| ALV2790-4B | 13:24 | 2060 | 4405 | 6701 | 46° 09.335' | 129° 48.589' | | | | bottle brush coral | Bottle brush coral, placed in forward bio-buck |

## Alvin Dive 2791: Floc Site, Origin 46° 14.931' / 129° 47.48'

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2791-1M | 10:49 | 2240 | 6448 | 6697 | 46° 18.552' | 129° 42.450' | 3A | Square | 7.1-7.3°C | manifold: port major | Diffuse vent fluid sample drawn from orifice ~2 m south of Marker 3A, the site was covered with a thick older appearing brown and grey mat material |
| ALV2791-1G | 10:56 | 2240 | 6448 | 6697 | 46° 18.552' | 129° 42.450' | 3A | Square | 5.8°C | manifold: port gas-tight | Same as above |
| ALV2791-1U | 11:03 | 2239 | 6460 | 6605 | 46° 18.550' | 129° 42.453' | 3A | Square | 8.3°C max | SUAVEscan | Detectable concentrations of H2S, Si, Mn and Fe |
| ALV2791-1B | 11:18 | 2239 | 6460 | 6605 | 46° 18.550' | 129° 42.453' | 3A | Square | ambient | slup gun | Small red non-alvinellid worms ~3 cm x 0.3 cm and mat material were sampled with the slurp gun off the side of pillow basalt near a diffuse vent orifice 2 m from M3A |
| ALV2791-2#2 | ~13:00 | 2287 | 6369 | 6440 | 46° 18.407' | 129° 42.525' | 2 | Triangle | | deploy Marker #2 | Deployed 4-5m below the rim of the fissure on the gently sloping talus near the fissure floor |
| ALV2791-2U1 | 13:09 to 13:39 | 2288 | 6369 | 6439 | 46° 18.407' | 129° 42.525' | 2 | Triangle | 8.8-9.0°C | SUAVEscan | SUAVEscans at locations referenced by clock position relative to Alvin heading (321°), distance to Marker #2 and biology, here 6 o' clock/2-4"/midst of tubeworms at worm plume height |
| ALV2791-2U2 | 13:09 to 13:39 | 2288 | 6369 | 6439 | 46° 18.407' | 129° 42.525' | 2 | Triangle | 11-11.7°C | SUAVEscan | Same as above but at the base of the tubeworms |
| ALV2791-2U3 | 13:09 to 13:39 | 2288 | 6369 | 6439 | 46° 18.407' | 129° 42.525' | 2 | Triangle | 6-8°C | SUAVEscan | 6 o' clock/12-14"/over white bacterial mat |
| ALV2791-2U4 | 13:09 to 13:39 | 2288 | 6369 | 6439 | 46° 18.407' | 129° 42.525' | 2 | Triangle | 5-6.5°C | SUAVEscan | 7 o' clock/6-8"/at worm plumes |
| ALV2791-2U5 | 13:09 to 13:39 | 2288 | 6369 | 6439 | 46° 18.407' | 129° 42.525' | 2 | Triangle | 7-7.2°C | SUAVEscan | Same as above but at the base of the tubeworms |
| ALV2791-2U6 | 13:09 to 13:39 | 2288 | 6369 | 6439 | 46° 18.407' | 129° 42.525' | 2 | Triangle | 3-3.5°C | SUAVEscan | 9 o' clock/1.5-2"/on rock in mat |

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2791-2M | 13:40 | 2287 | 6370 | 6439 | 46° 18.406' | 129° 42.524' | 2 | Triangle | 8.2°C | manifold: port-middle major | Diffuse vent fluid sample was drawn from an orifice at the base of marker T2, the area was covered almost exclusively with bright white mat material |
| ALV2791-2G | 13:45 | 2287 | 6369 | 6439 | 46° 18.407' | 129° 42.525' | 2 | Triangle | 8.4°C | manifold: starboard gas-tight | Same as above |
| ALV2791-2D | 13:53 | 2288 | 6369 | 6437 | 46° 18.406' | 129° 42.525' | 2 | Triangle | 8.2-8.4°C | discrete major | Same as above |
| ALV2791-3U1 | 14:01 to 14:10 | 2288 | 6368 | 6457 | 46° 18.414' | 129° 42.523' | | | 6.2-6.7°C | SUAVEscan | At plumes of tubeworms, 10 m North of Triangle 2 |
| ALV2791-3U2 | 14:01 to 14:10 | 2288 | 6368 | 6457 | 46° 18.414' | 129° 42.523' | | | 9.6-9.8°C | SUAVEscan | At base of tubeworms, 10 m North of Triangle 2 |
| ALV2791-3B/R | 14:09 | 2288 | 6368 | 6457 | 46° 18.416' | 129° 42.525' | | | 6.7°C tip of worms, 9.8°C base of worms | tubeworm grab with rock | Port manipulator arm grabbed tubeworms and rock from a crevace at the base of the West wall of this fracture, temperatures measured with SUAVE probe, 10 m North of Triangle 2 |
| ALV2791-4#6 | ~14:17 | 2285 | 6368 | 6439 | 46° 18.407' | 129° 42.525' | 6 | Triangle | | deploy Marker #6 | West fissure rim above the Marker #2 site and deployed Marker #6 on pillow lava |
| ALV2791-5D | 14:39 | 2262 | 6450 | 6652 | 46° 18.522' | 129° 42.461' | | | | discrete major #9 | The sample was drawn from a diffuse vent orifice in a region covered predominantly with bright white mat material site ~40 m South of Marker 3A |
| ALV2791-5N1 | 14:41 | 2261 | 6450 | 6652 | 46° 18.522' | 129° 42.461' | | | | Niskin: forward | Drawn ~0.5 m above the diffuse vent field while the sub was resting on the bottom |
| ALV2791-5DG | 14:44 | 2261 | 6450 | 6652 | 46° 18.522' | 129° 42.461' | | | | discrete gas-tight | Same as ALV2791-5D |
| ALV2791-5U | 14:47 to 14:52 | 2261 | 6450 | 6652 | | | | | 3.5-4.6°C | SUAVEscan | At the tips of tubeworms, which were later collected |
| ALV2791-5M | 14:53 | 2261 | 6450 | 6652 | 46° 18.522' | 129° 42.461' | | | | manifold: starboard major | Same as ALV2791-5D |
| ALV2791-5B | 14:56 | 2260 | 6450 | 6652 | 46° 18.522' | 129° 42.461' | | | 3.8°C top of worms 4.4°C base of worms | tubeworm grab | The port arm was used to grab tubeworms from the side of a pillow basalt, the worms were placed in the stbd side of the bio box |
| ALV2791-5R | 14:59 | 2261 | 6450 | 6652 | 46° 18.522' | 129° 42.461' | | | | basalt | Pillow basalt removed from the side of a sloping wall of a fracture midway up the slope from a region of active diffuse flow |
| ALV2791-5N2 | 15:02 | 2246 | 6450 | 6652 | 46° 18.522' | 129° 42.464' | | | ambient | Niskin: middle | The Niskin was tripped as the sub was ascending to the surface, 36 m above region of diffuse venting |

## Alvin Dive 2792: Flow Site, Origin 46° 28.493' / 129° 37.516'

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2792-1R1 | 9:30 | 2437 | 3632 | 6086 | 46° 31.778' | 129° 34.677' | | | | basalt | At contact, West slope of new (1993) flow, piece of older lava |
| ALV2792-1R2 | 9:37 | 2434 | 3632 | 6085 | 46° 31.778' | 129° 34.678' | | | | basalt | Piece of 1993 tabular pillow at contact |
| ALV2792-2R | 11:17 | 2448 | 3955 | 6406 | 46° 31.955' | 129° 34.416' | | | | basalt | Older piece of pillow, from fissure North of new flow |
| ALV2792-3R | 11:24 | 2452 | ~3900 | ~6350 | 46° 31.920' | 129° 34.469' | | | | basalt | Estimated position (no fix), young (1993) flat, smooth pillow in floor of graben |
| ALV2792-4R | 12:06 | 2476 | ~4090 | ~6105 | 46° 31.788' | 129° 34.321' | | | | basalt | Glassy pillow, probably of 82-91 flow |
| ALV2792-5R | 12:17 | 2446 | 4177 | 6072 | 46° 31.772' | 129° 34.247' | | | | basalt | Jumbled flow from top of hornito on top of contructional pillow ridge (probably 82-91 flow) |
| ALV2792-6N1 | 12:28 to 12:32 | 2440 | 4187 | 5916 | 46° 31.694' | 129° 34.240' | | | | Niskin (blue) | On top of pillow ridge (82-91 flow) in area of thick extensive hydrothermal sediment, mixed up sediment then sampled water |
| ALV2792-6N2 | 12:28 to 12:32 | 2440 | 4187 | 5916 | 46° 31.694' | 129° 34.240' | | | | Niskin (green) | On top of pillow ridge (82-91 flow) in area of thick extensive hydrothermal sediment, mixed up sediment then sampled water |

| Name | Time | Total Z | ALV X | ALV Y | Lat | Long | Marker | Type | Temp. | Sample | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2792-7R | 12:51 | 2458 | 4149 | 5633 | 46° 31.534' | 129° 34.270' | | | | basalt | Glassy (82-91 flow), tubular pillow near top of constructional ridge |
| ALV2792-8R | 13:10 | 2458 | ~3965 | ~5300 | 46° 31.354' | 129° 34.418' | | | | basalt | Estimated position (bad fix), older pillows on constructional ridge |
| ALV2792-8M1 | 13:16 | 2458 | 3960 | 5329 | 46° 31.369' | 129° 34.332' | | | | manifold: port major | Fired for background water |
| ALV2792-8M2 | 13:16 | 2458 | 3960 | 5329 | 46° 31.369' | 129° 34.332' | | | | manifold: starboard major | Fired for background water |
| ALV2792-8G | 13:16 | 2458 | 3960 | 5329 | 46° 31.369' | 129° 34.332' | | | | manifold: starboard gas-tight | Fired for background water |

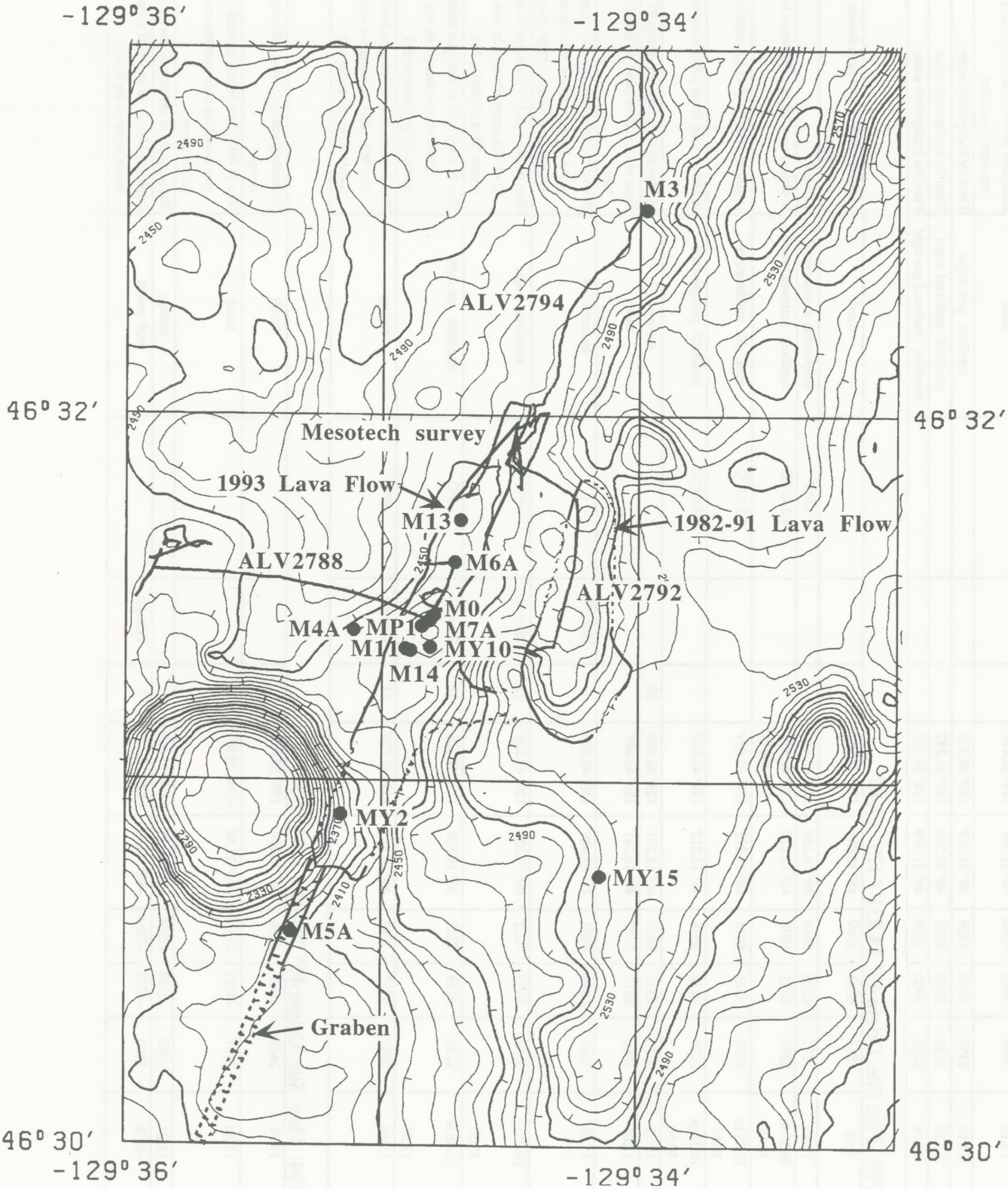
## Alvin Dive 2793: Floc Site, Origin 46° 14.931' / 129° 47.48'

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2793-1R | 9:45 | 2260 | 6293 | 5789 | 46° 18.056' | 129° 42.583' | | | | basalt | Pillow basalt fragment from fissure, characterized by stained rock |
| ALV2793-2 | 10:15 | 2277 | 6216 | 6030 | 46° 18.186' | 129° 42.644' | | | 7.0°C | temperature measurement | On vent |
| ALV2793-3M1 | 10:35 to 10:51 | 2279 | 6222 | 6078 | 46° 18.212' | 129° 42.639' 129° 42.639' | | | 4.5-6.0°C | manifold: starboard major | In diffuse vent, lot of milky water being emitted |
| ALV2793-3M2 | 10:35 to 10:51 | 2279 | 6222 | 6078 | 46° 18.212' | 129° 42.639' | | | 4.5-6.0°C | manifold: middle major | In diffuse vent, lot of milky water being emitted |
| ALV2793-3G | 10:35 to 10:51 | 2279 | 6222 | 6078 | 46° 18.212' | 129° 42.639' | | | 4.5-6.0°C | manifold: port gas-tight | In diffuse vent, lot of milky water being emitted |
| ALV2793-4#10 | 10:52 | 2276 | 6222 | 6079 | 46° 18.221' | 129° 42.638' | 10 | | | deployment | Marker 10 deployed near station #3 in active diffuse vent |
| ALV2793-5R | 11:06 | 2281 | 6217 | 6133 | 46° 18.241' | 129° 42.642' | | | | basalt | Piece of sheet flow taken off lava pillar, South side of lava lake |
| ALV2793-6B | 11:43 | 2288 | 6394 | 6481 | 46° 18.429' | 129° 42.505' | 6 | Triangle | | bacterial mat | Wwhite bacterial mat slurped in using manifold auxilary pump and jar, taken at site venting warm water ~5 m up West wall of fissure, H265°, just North of Marker #6 |
| ALV2793-7M | 13:46 to 13:55 | 2239 | 6753 | 7222 | 46° 18.829' | 129° 42.226' | 11 | Triangle | ~6°C | manifold: major | Near fissure (~2-3 m East) just North of Marker 11 where U of WA temperature probe was deployed (October '93) within 20 m of Marker #11 |
| ALV2793-7G | 13:46 to 13:55 | 2239 | 6753 | 7222 | 46° 18.829' | 129° 42.226' | 11 | Triangle | ~6°C | manifold: gas-tight | Near fissure (~2-3 m East) just North of Marker 11 where U of WA temperature probe was deployed (October '93) within 20 m of Marker #11 |
| ALV2793-7B | 13:59 | 2239 | 6752 | 7222 | 46° 18.829' | 129° 42.226' | 11 | Triangle | ~6°C | biology | Near fissure (~2-3 m East) just North of Marker 11 where U of WA temperature probe was deployed (October '93) within 20 m of Marker #11 |

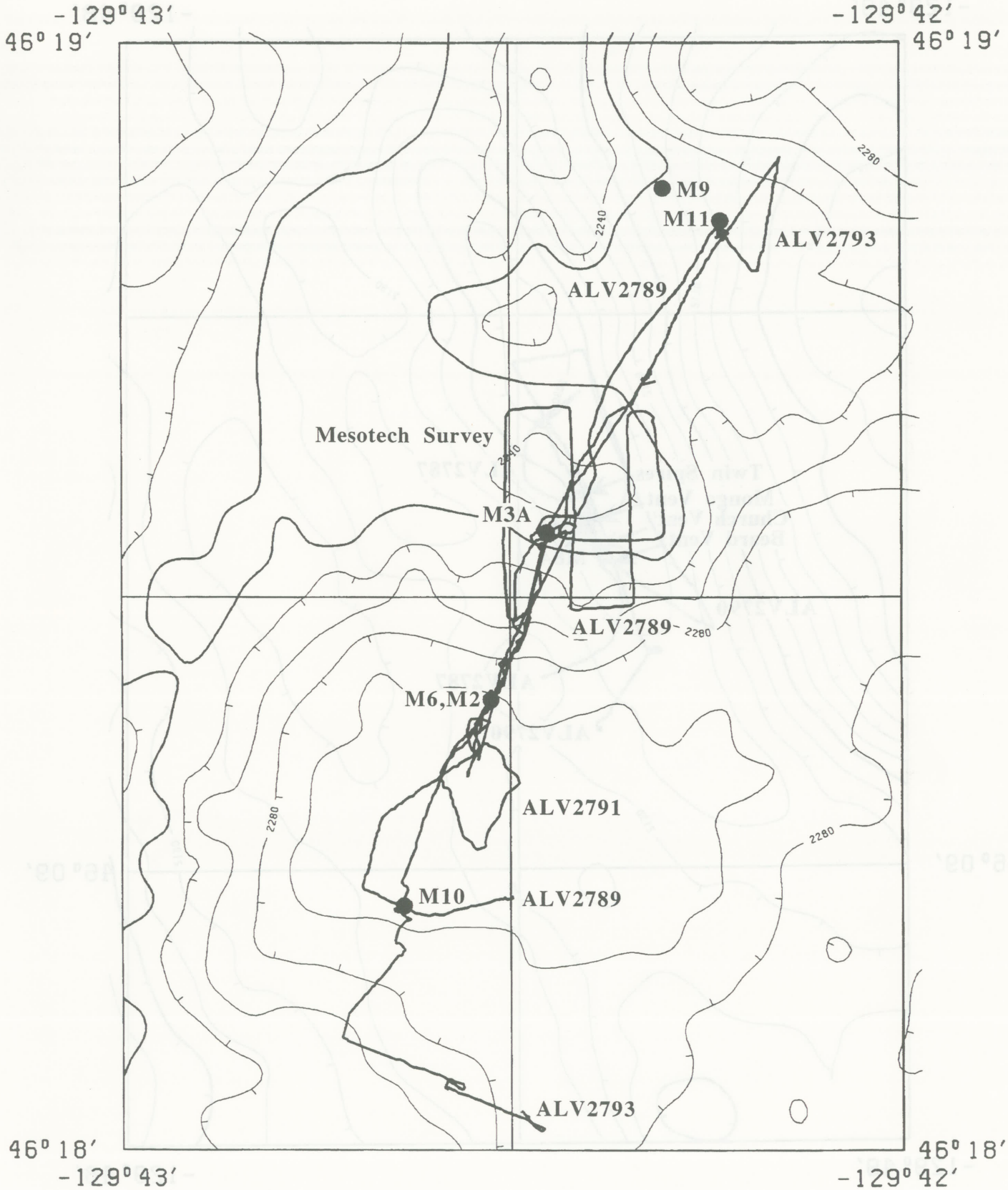
## Alvin Dive 2794: Flow Site, Origin 46° 28.493' / 129° 37.516'

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ALV2794-1R | 10:35 | 2446 | 3959 | 6534 | 46° 32.024' | 129° 34.412' | | | | basalt | Moderately young-looking pillow basalt, with light sed cover |
| ALV2794-2R | 12:20 | 2461 | ~4533 | ~7534 | ~46° 32.56' | ~129° 33.974' | | | | basalt | New (1993?) flow in axis of small (20 m wide) fissure, young-looking with hydrothermal staining along pillow edges |
| ALV2794-2B | 12:27 | 2460 | ~4533 | ~7534 | ~46° 32.56' | ~129° 33.974' | | | | biology | Slurp sample of sed/floc inbetween pillows at station #2 |
| ALV2794-2#3 | ~12:30 | 2460 | ~4533 | ~7534 | ~46° 32.56' | ~129° 33.974' | 3 | Triangle | | deployment | Deployed Marker #3 on top of a small constructional hill in the center of the fissure |

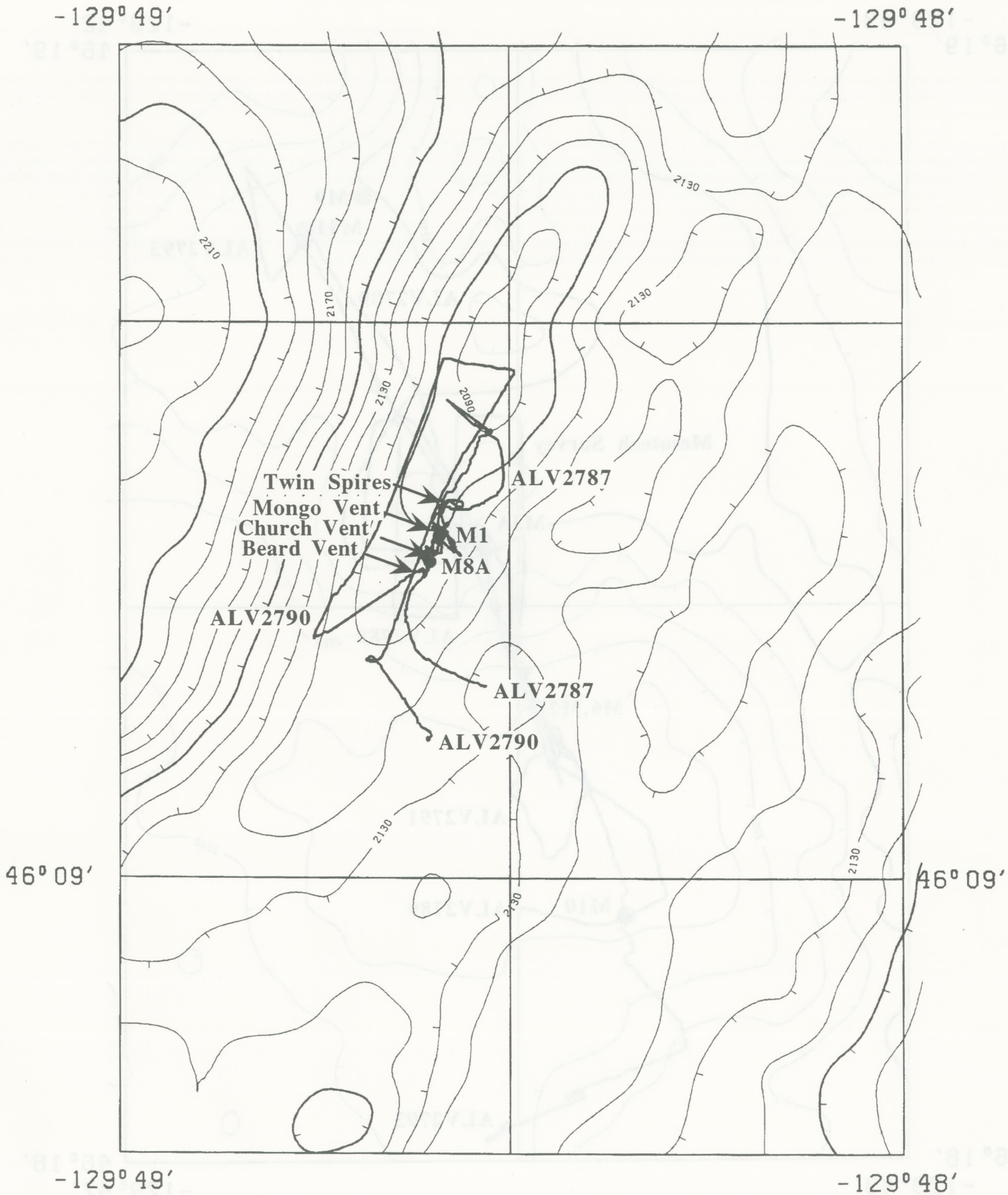
# COAXIAL FLOW SITE - ALVIN

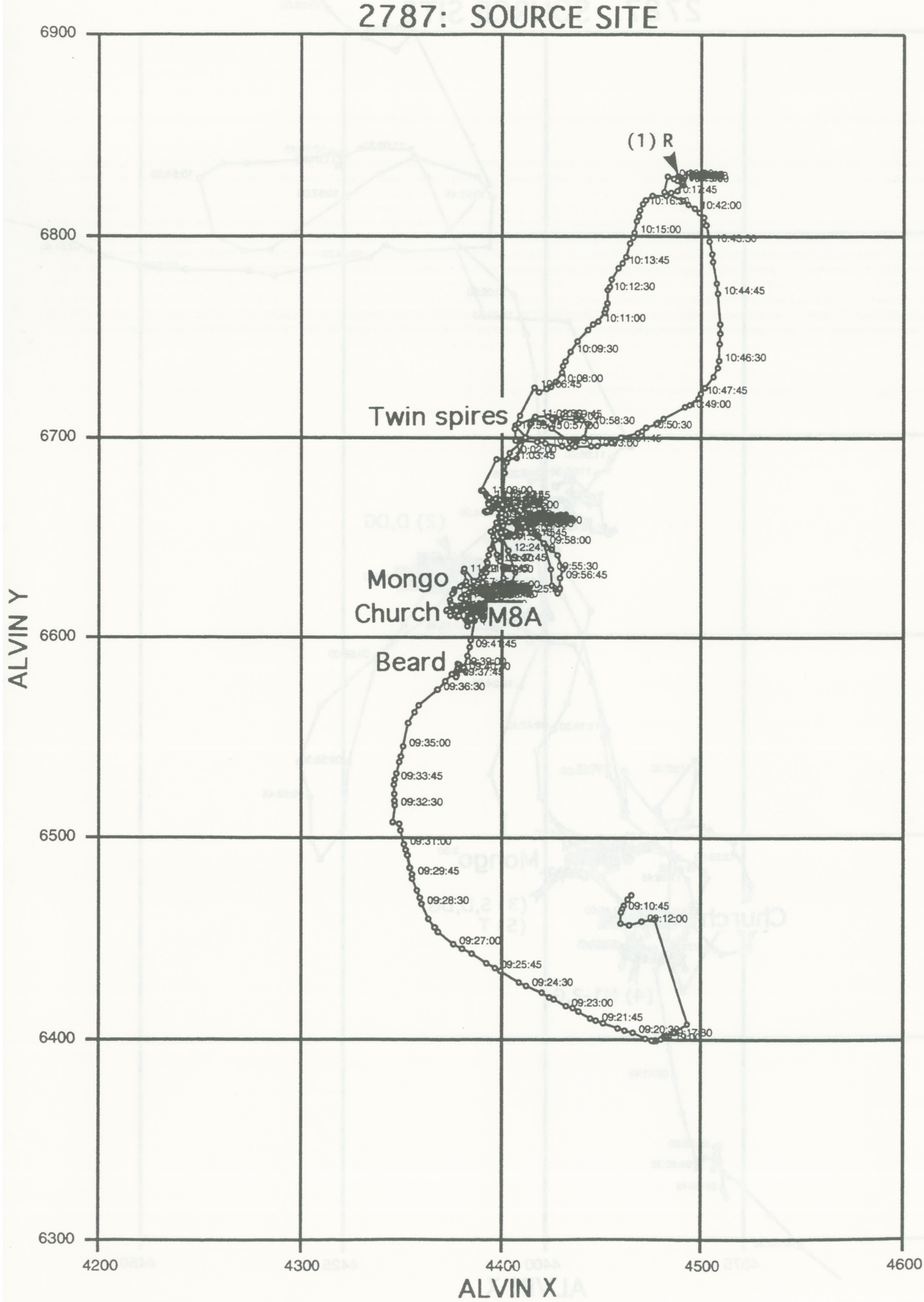


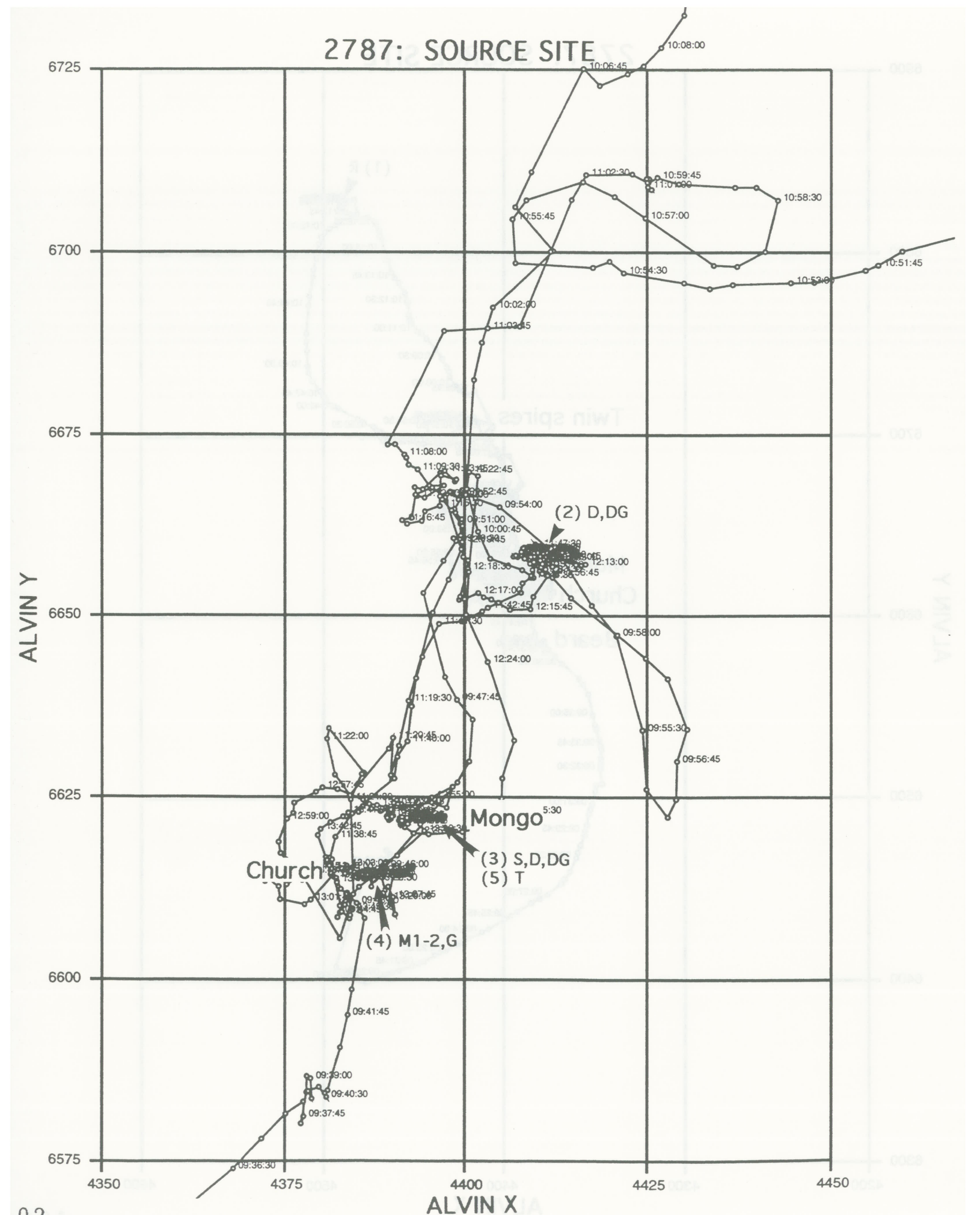
# COAXIAL FLOC SITE - ALVIN



# COAXIAL SOURCE SITE - ALVIN




2787: SOURCE SITE
(1) R
Twin spires
Mongo
Church
M8A
Beard
6900
6800
6700
6600
6500
6400
6300
4200
4300
4400
4500
4600
ALVIN Y
ALVIN X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ALVIN Y
ALVIN X
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6675
6650
6625
6600
6575
4350
4375
4400
4425
4450
10:08:00
10:06:45
11:02:30
10:59:45
10:58:30
10:55:45
10:57:00
10:54:30
10:51:45
10:02:00
11:08:00
09:54:00
(2) D,DG
09:51:00
10:00:45
12:18:30
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12:17:00
12:15:45
09:58:00
12:24:00
11:19:30
09:47:45
09:55:30
09:56:45
11:22:00
12:59:00
11:38:45
Mongo 5:30
(3) S,D,DG
(5) T
Church
(4) M1-2,G
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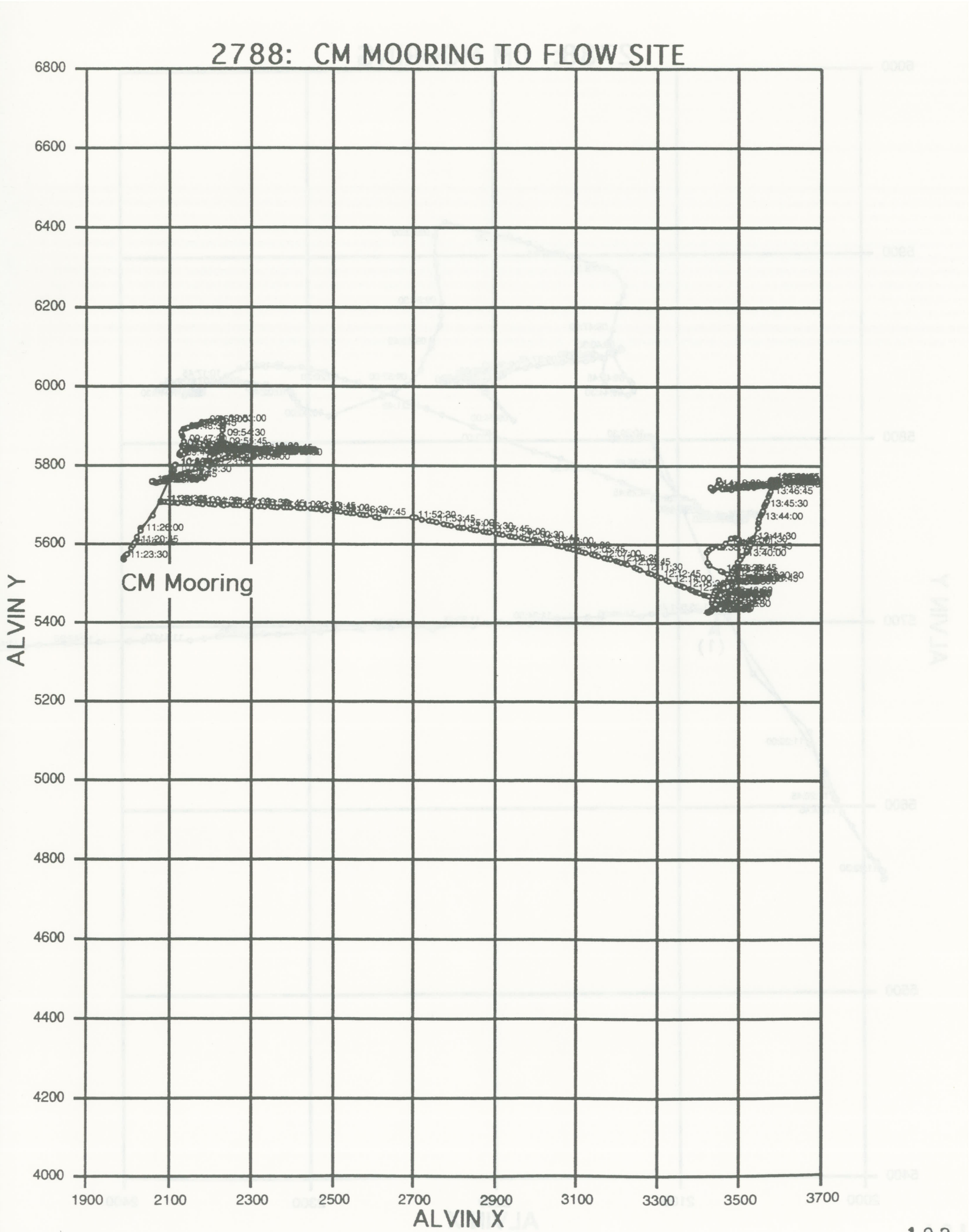
09:39:00
09:40:30
09:37:45
09:36:30

.02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6200
6000
5800
5600
5400
5200
5000
4800
4600
4400
4200
4000
ALVIN Y
1900
2100
2300
2500
2700
2900
3100
3300
3500
3700
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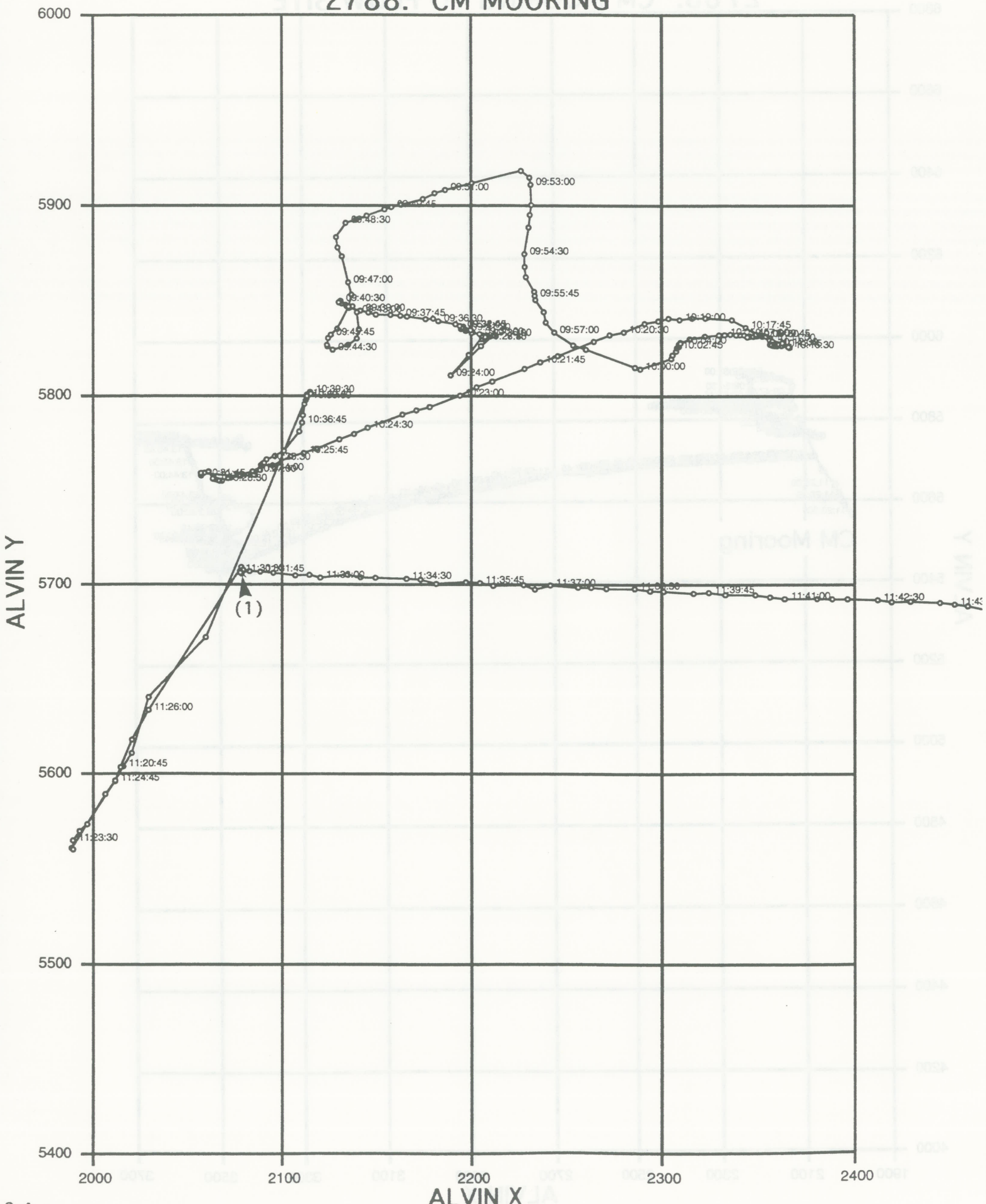
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ALVIN X
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5600
5500
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2100
2200
2300
2400
(1)
09:53:00
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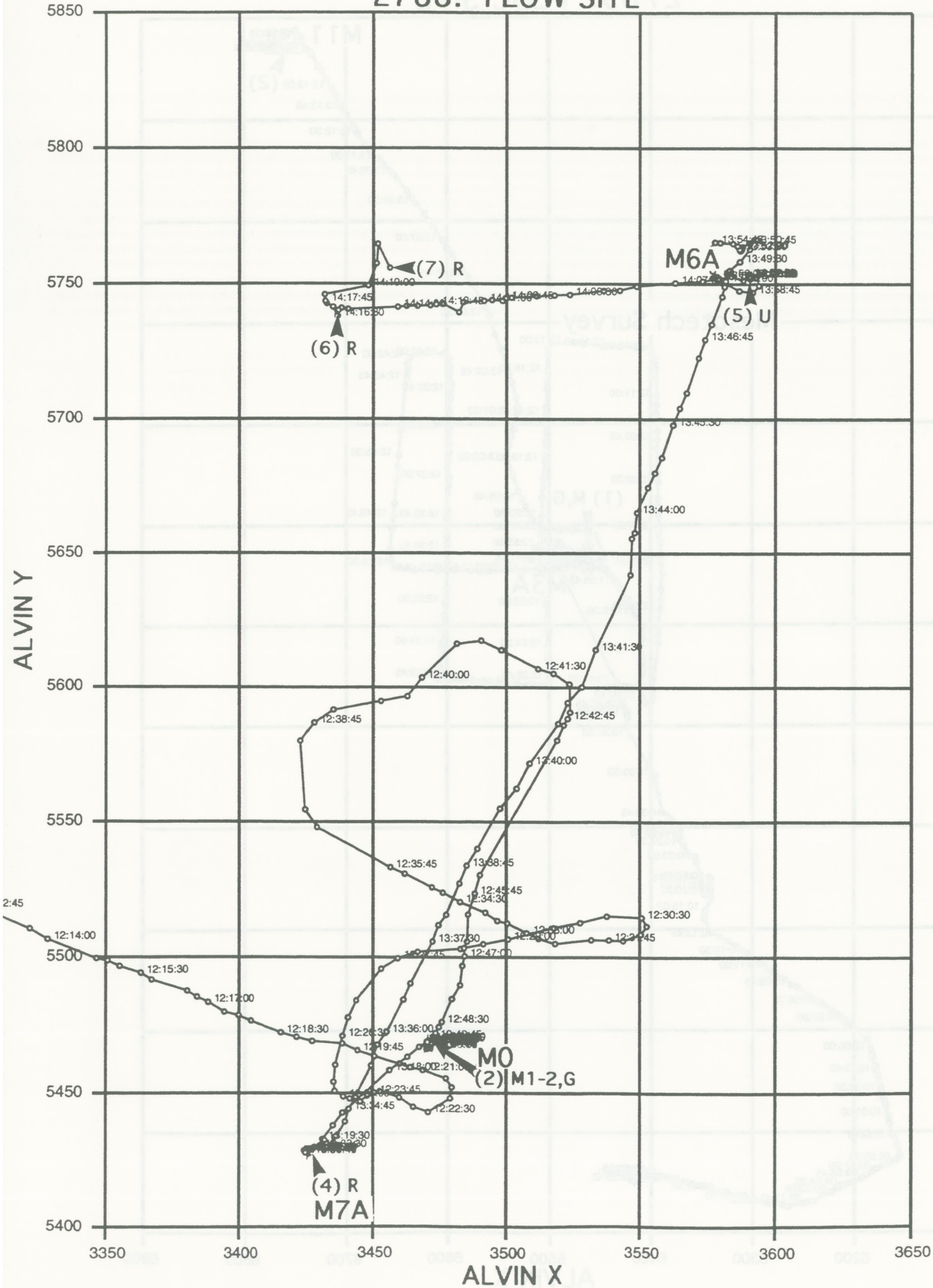
2788: FLOW SITE
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5750
5700
5650
5600
5550
5500
5450
5400
ALVIN Y
3350
3400
3450
3500
3550
3600
3650
ALVIN X
M6A
(7) R
(6) R
(5) U
M0
(2) M1-2,G
(4) R
M7A
14:17:45
14:16:30
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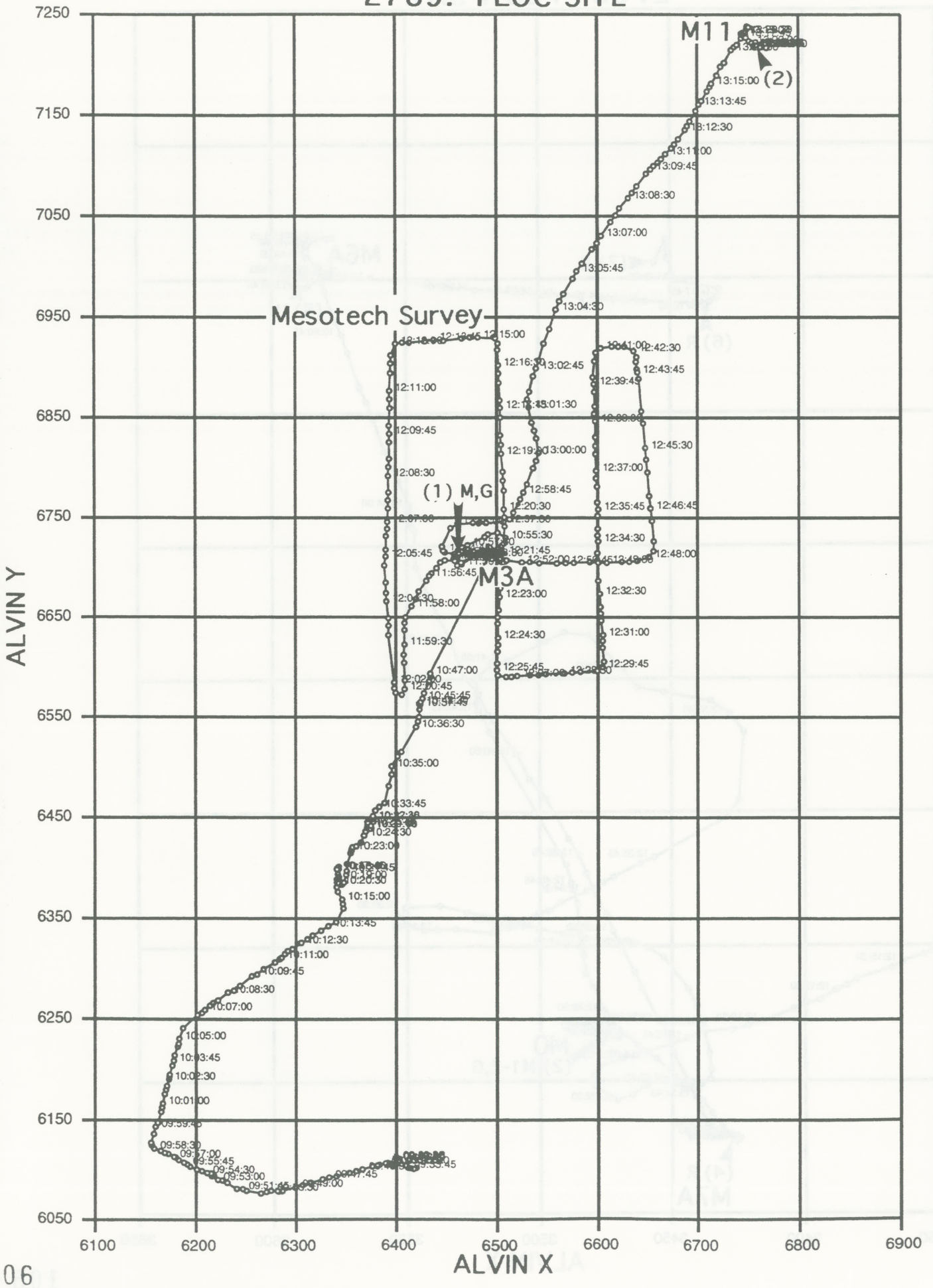
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M11
(2)
Mesotech Survey
(1) M,G
M3A
ALVIN Y
ALVIN X
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7150
7050
6950
6850
6750
6650
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6150
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6700
6800
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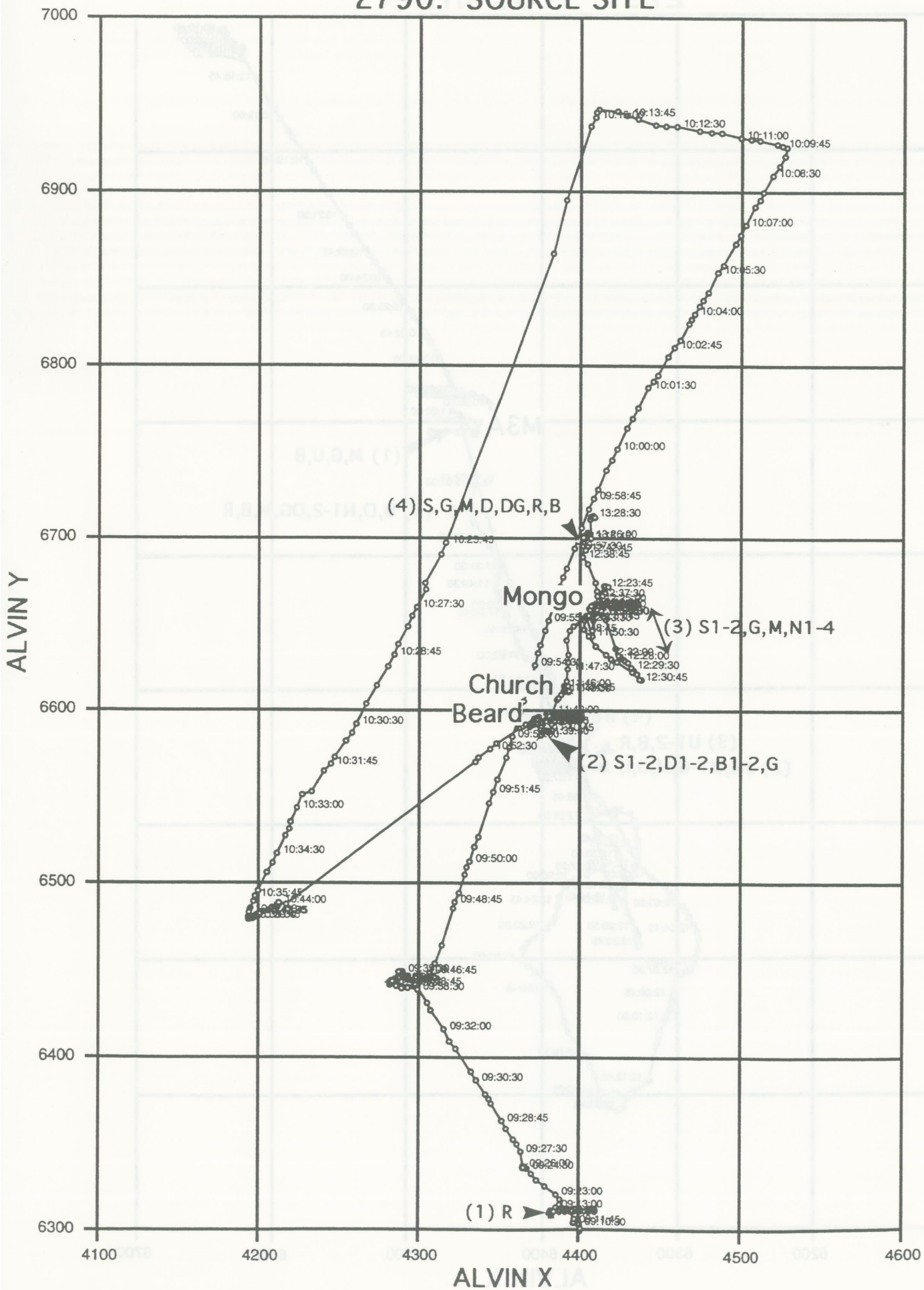
2790: SOURCE SITE
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ALVIN X
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6800
6700
6600
6500
6400
6300
4100
4200
4300
4400
4500
4600
(4) S,G,M,D,DG,R,B
Mongo
(3) S1-2,G,M,N1-4
Church
Beard
(2) S1-2,D1-2,B1-2,G
(1) R
10:13:45
10:12:30
10:11:00
10:09:45
10:08:30
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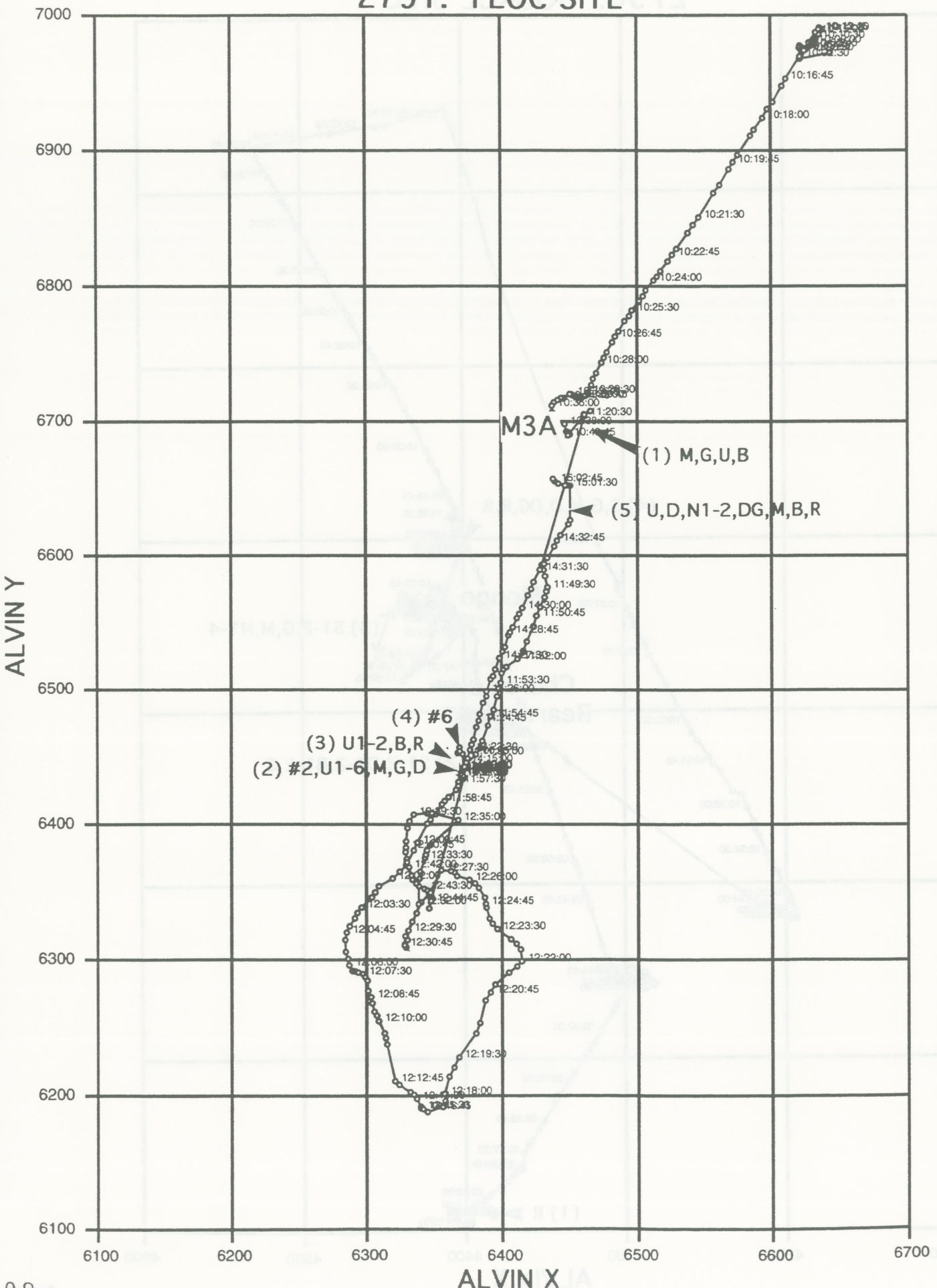
2791: FLOC SITE
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6300
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6100
ALVIN Y
6100
6200
6300
6400
6500
6600
6700
ALVIN X
M3A
(1) M,G,U,B
(5) U,D,N1-2,DG,M,B,R
(4) #6
(3) U1-2,B,R
(2) #2,U1-6,M,G,D
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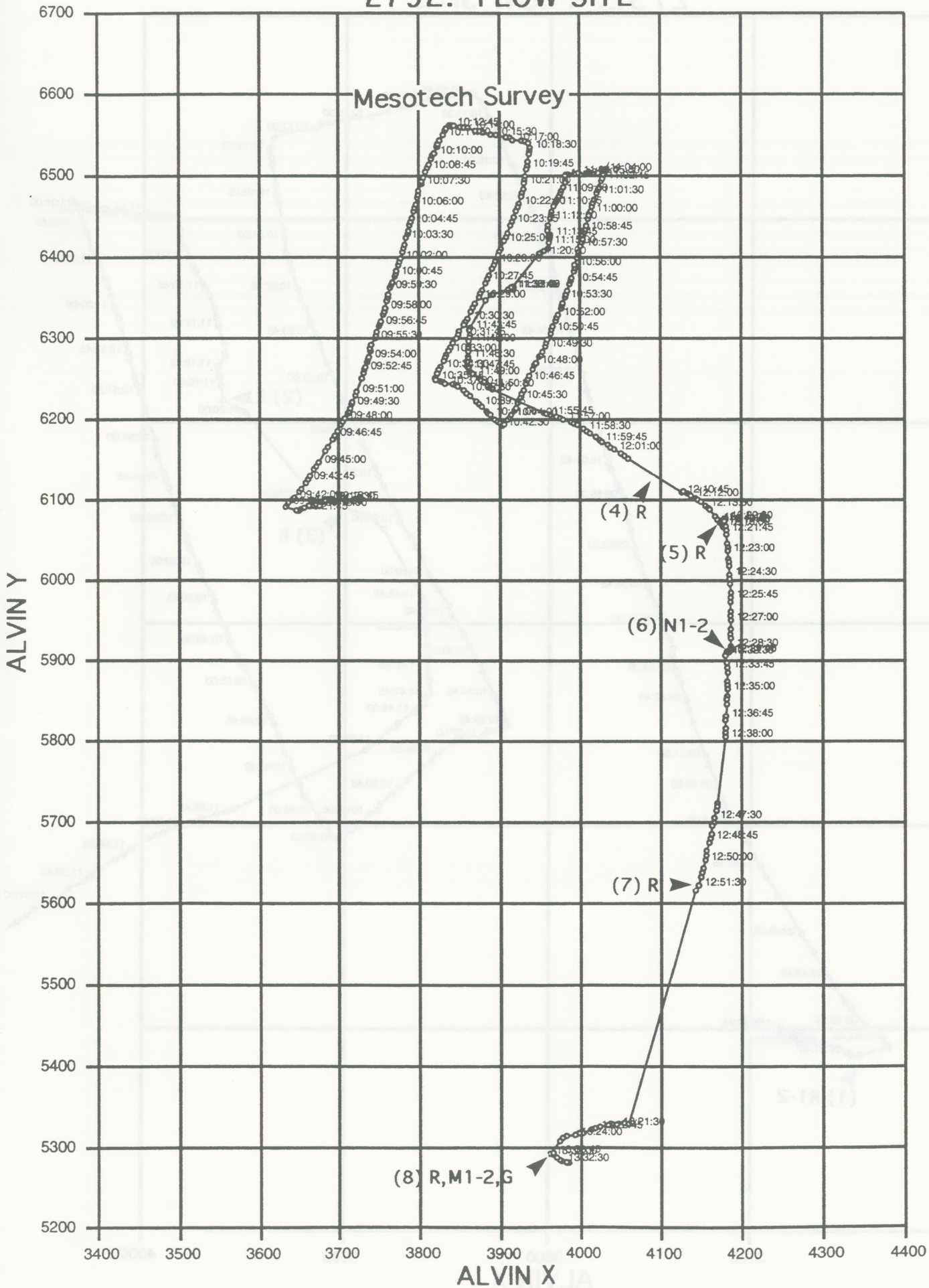
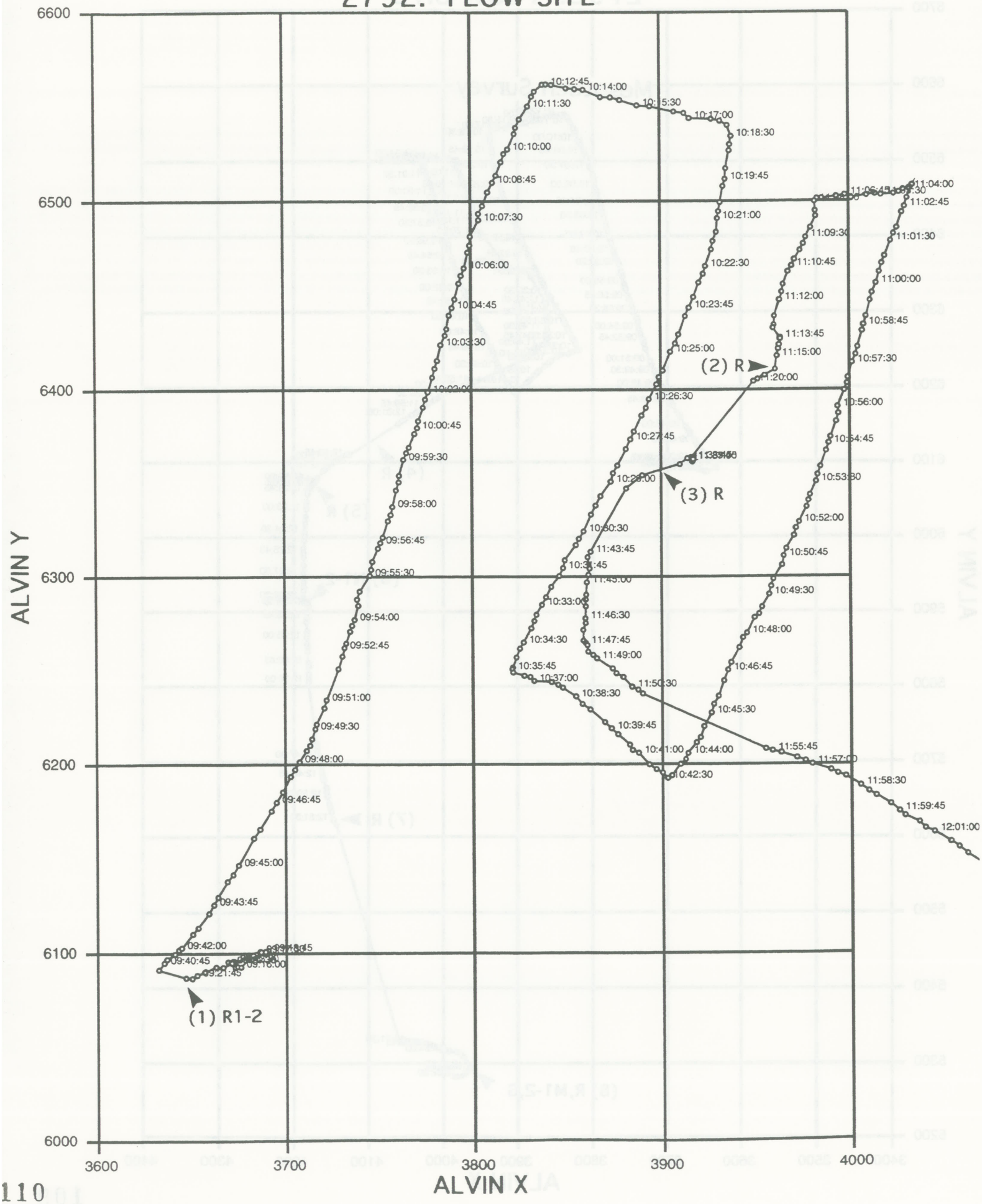
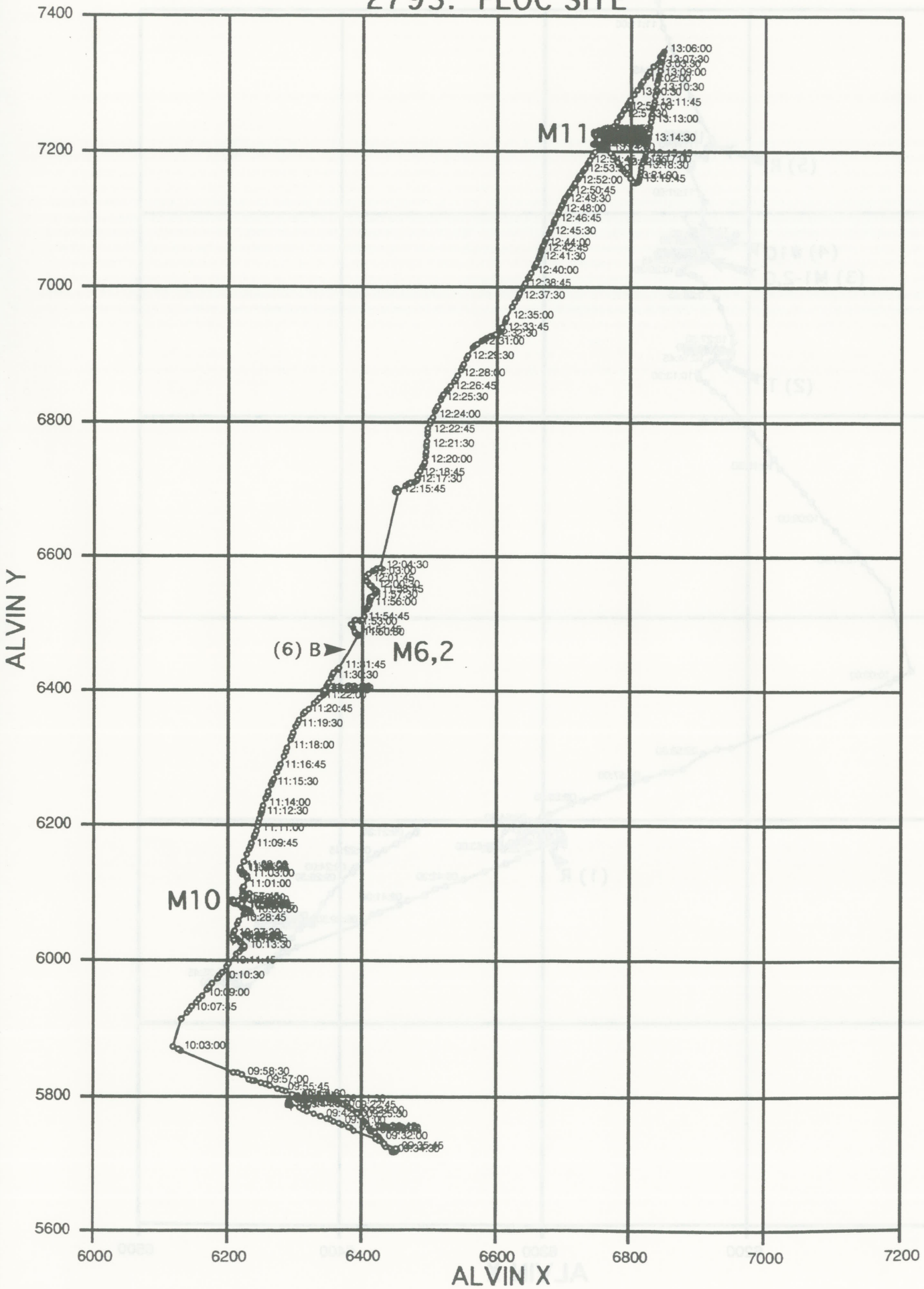
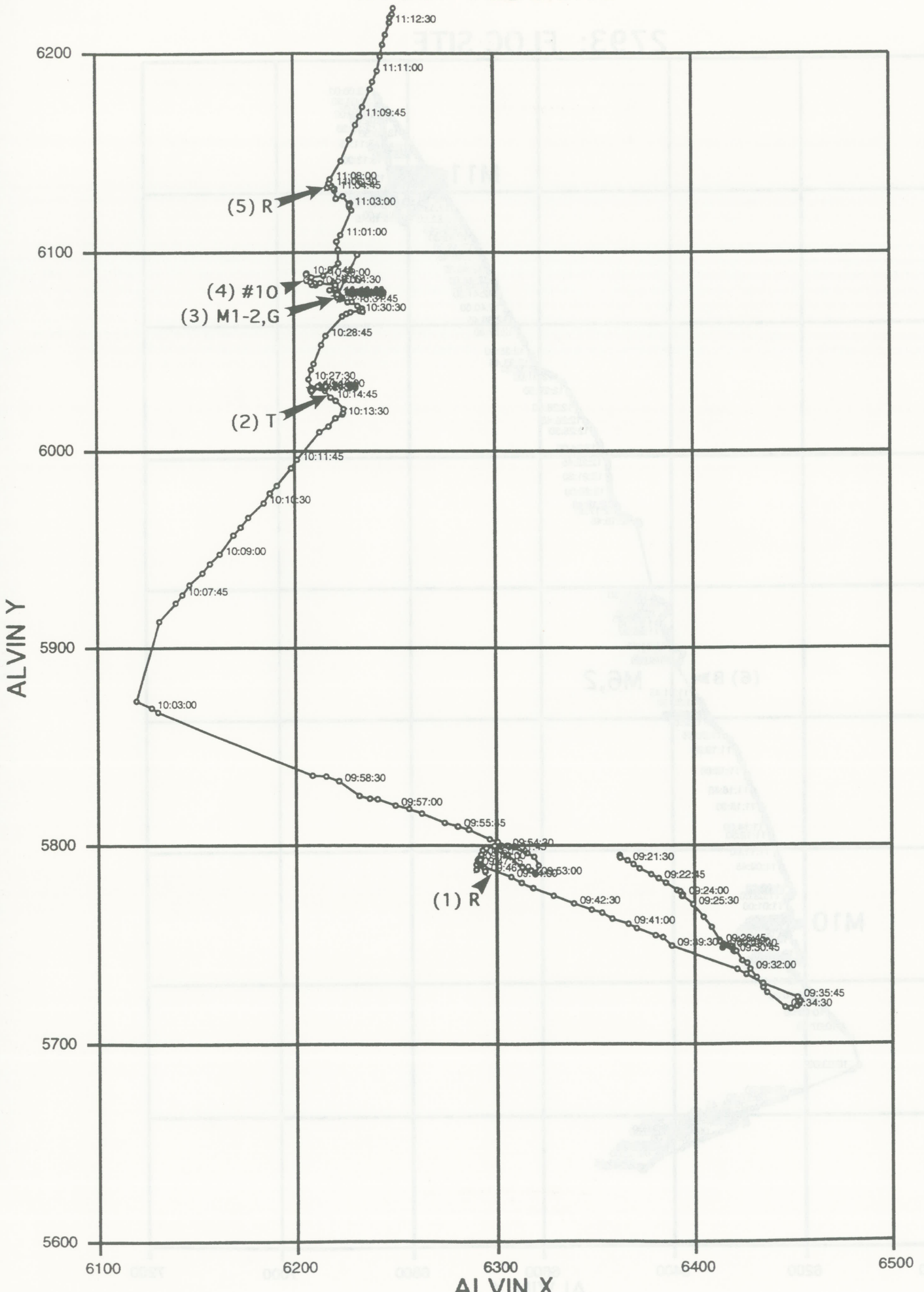
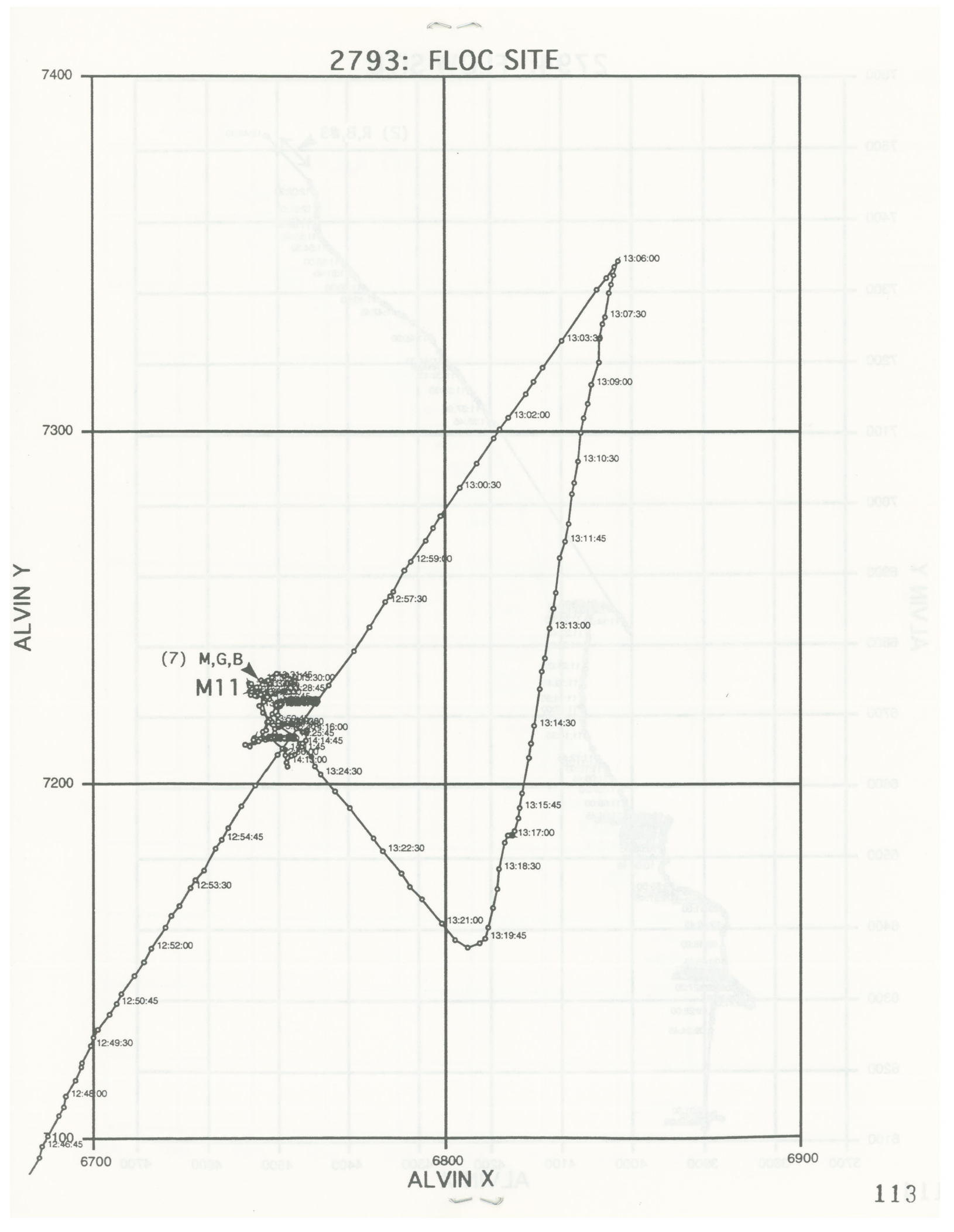
12:18:00


2792: FLOW SITE
Mesotech Survey
(4) R
(5) R
(6) N1-2
(7) R
(8) R,M1-2,G
ALVIN Y
ALVIN X
6700
6600
6500
6400
6300
6200
6100
6000
5900
5800
5700
5600
5500
5400
5300
5200
3400
3500
3600
3700
3800
3900
4000
4100
4200
4300
4400

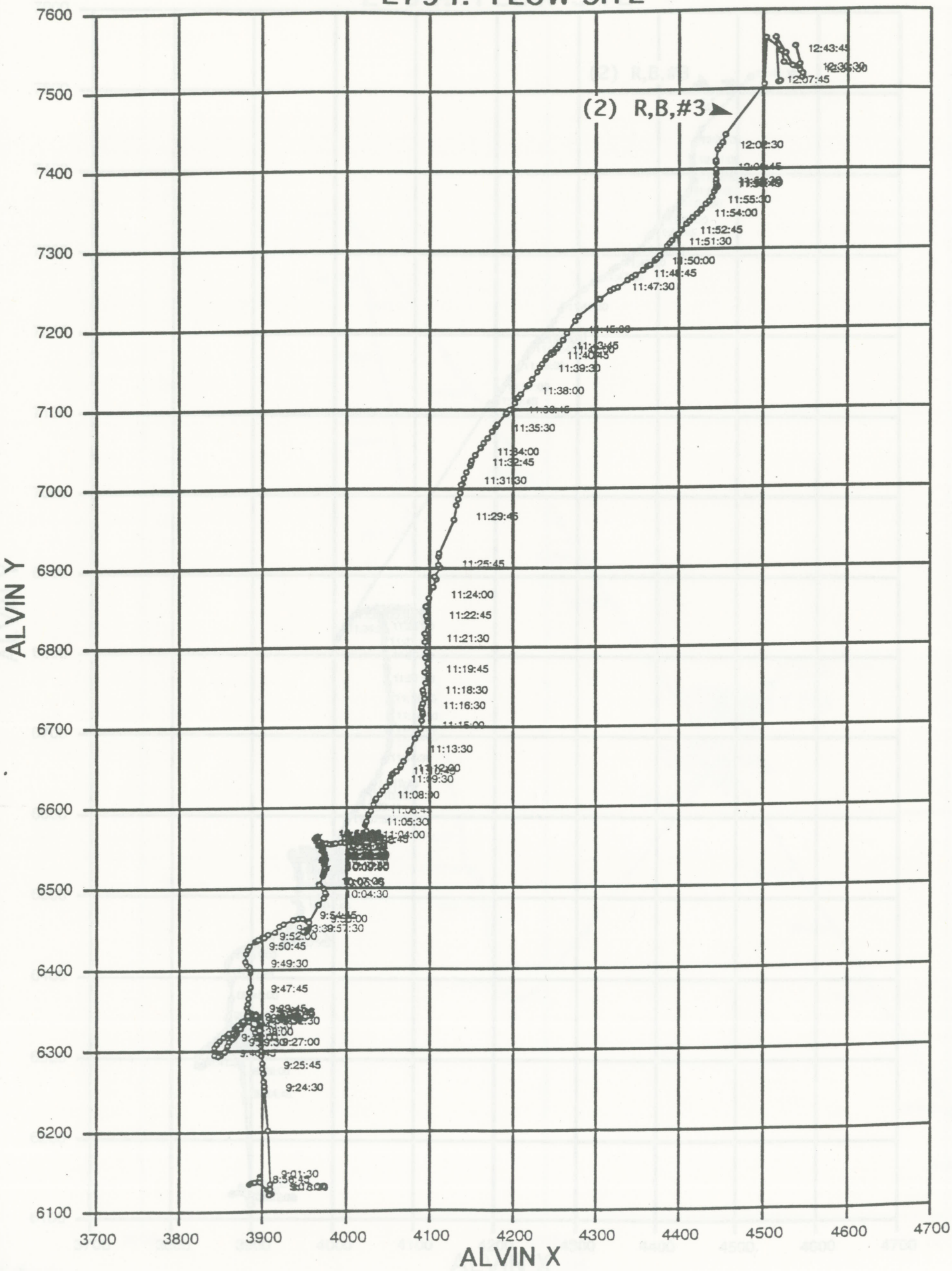

2792: FLOW SITE
ALVIN Y
ALVIN X
6600
6500
6400
6300
6200
6100
6000
3600
3700
3800
3900
4000
(1) R1-2
(2) R
(3) R
09:40:45
09:42:00
09:43:45
09:45:00
09:46:45
09:48:00
09:49:30
09:51:00
09:52:45
09:54:00
09:55:30
09:56:45
09:58:00
09:59:30
10:00:45
10:03:30
10:04:45
10:06:00
10:07:30
10:08:45
10:10:00
10:11:30
10:12:45
10:14:00
10:17:00
10:18:30
10:19:45
10:21:00
10:22:30
10:23:45
10:25:00
10:26:30
10:27:45
10:30:30
10:33:00
10:34:30
10:35:45
10:37:00
10:38:30
10:39:45
10:41:00
10:42:30
10:44:00
10:45:30
10:46:45
10:48:00
10:49:30
10:50:45
10:52:00
10:54:45
10:56:00
10:57:30
10:58:45
11:00:00
11:01:30
11:02:45
11:04:00
11:09:30
11:10:45
11:12:00
11:13:45
11:15:00
11:20:00
11:43:45
11:45:00
11:46:30
11:47:45
11:49:00
11:50:30
11:55:45
11:57:00
11:58:30
11:59:45
12:01:00

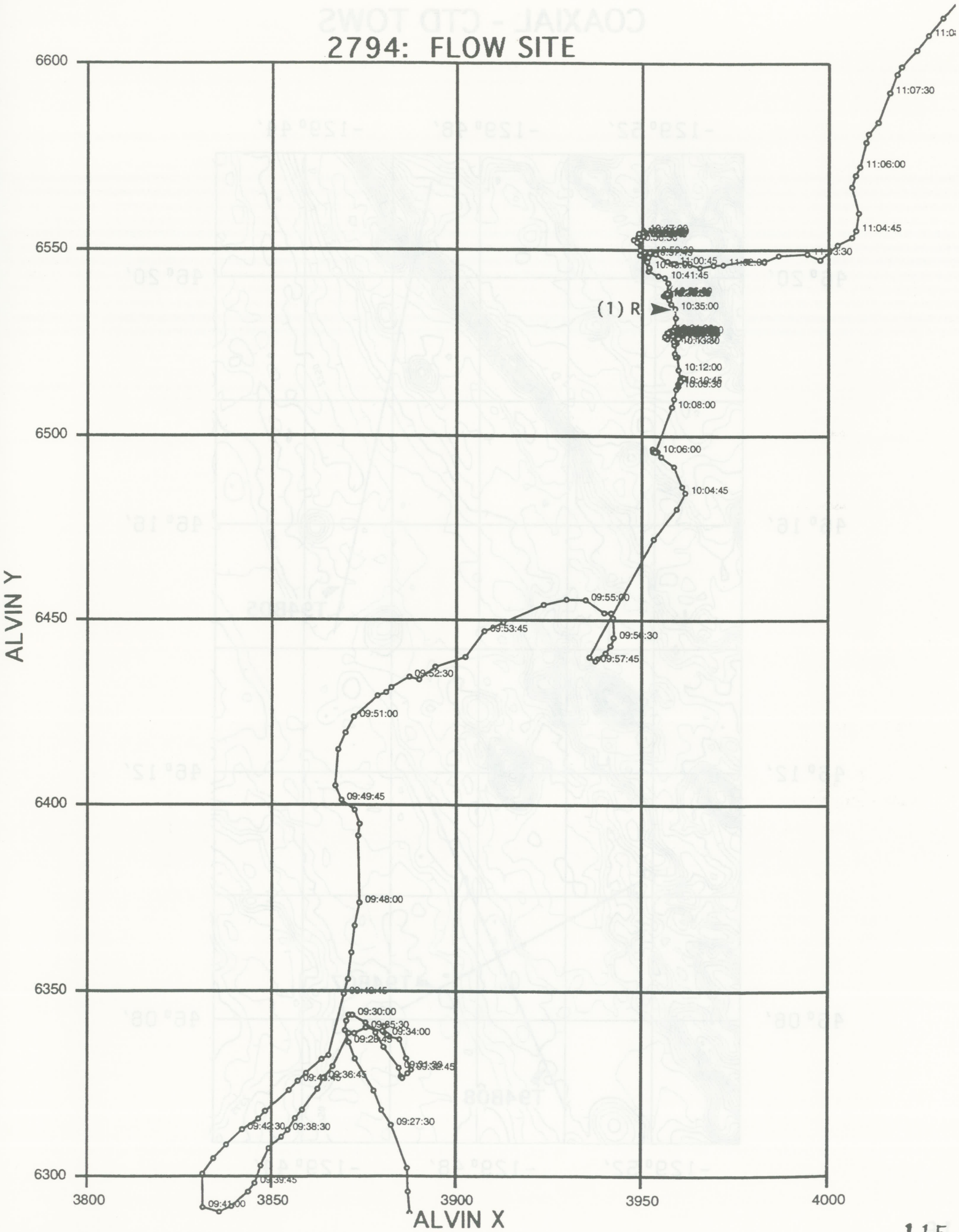

2793: FLOC SITE
ALVIN Y
ALVIN X
7400
7200
7000
6800
6600
6400
6200
6000
5800
5600
6000
6200
6400
6600
6800
7000
7200
M11
(6) B
M6,2
M10


2793: FLOC SITE
11:12:30
11:11:00
11:09:45
11:08:00
11:03:00
11:01:00
(5) R
(4) #10
(3) M1-2,G
10:30:30
10:28:45
10:27:30
10:14:45
10:13:30
(2) T
10:11:45
10:10:30
10:09:00
10:07:45
10:03:00
09:58:30
09:57:00
09:55:45
09:54:30
09:53:00
09:21:30
09:22:45
09:24:00
09:25:30
09:42:30
09:41:00
09:32:00
09:35:45
09:34:30
(1) R
6200
6100
6000
5900
5800
5700
5600
ALVIN Y
6100
6200
6300
6400
6500
ALVIN X

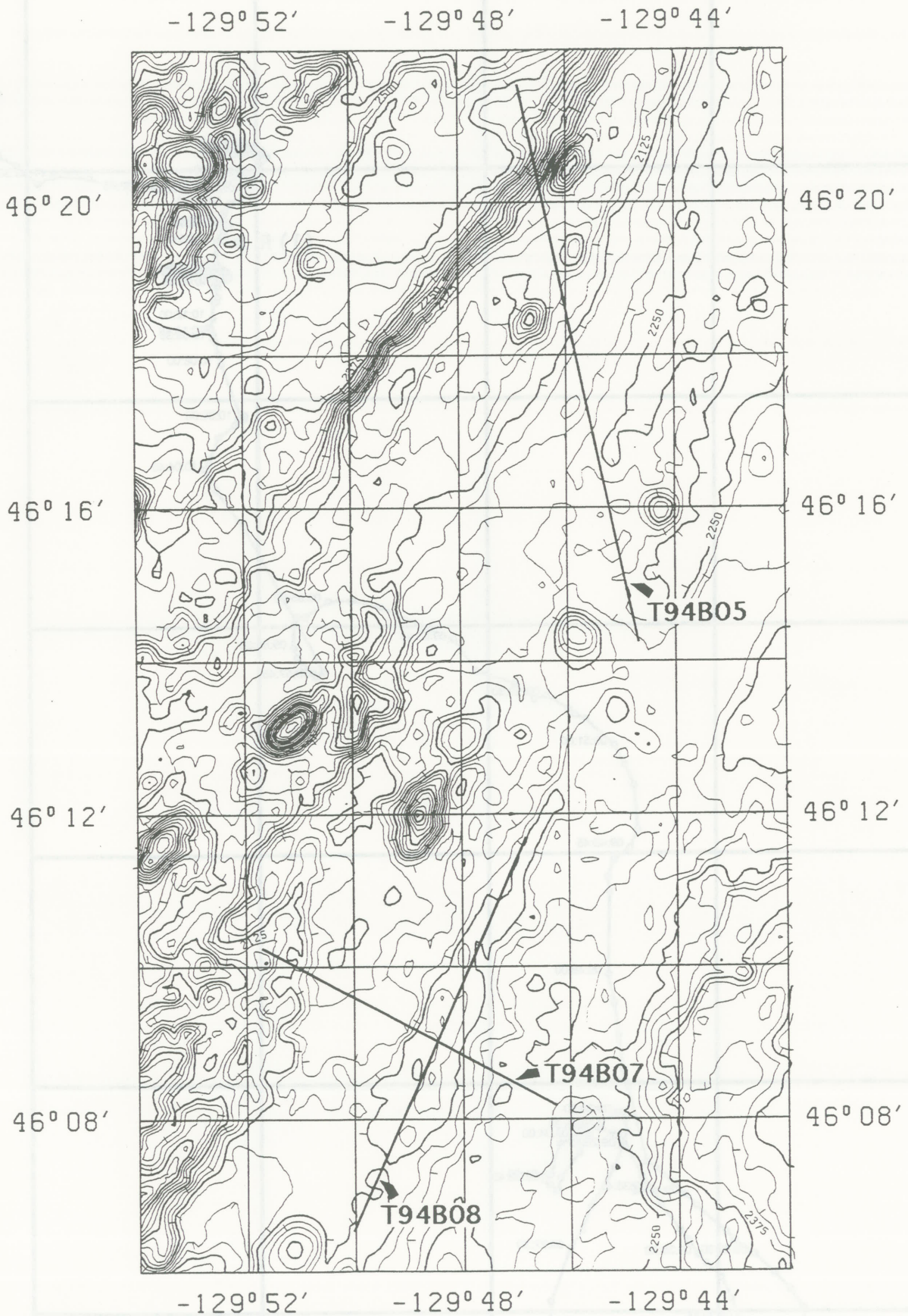

2793: FLOC SITE
7400
7300
7200
7100
6700
6800
6900
ALVIN Y
ALVIN X
(7) M,G,B
M11
13:06:00
13:07:30
13:03:30
13:09:00
13:02:00
13:10:30
13:00:30
13:11:45
12:59:00
12:57:30
13:13:00
13:14:30
13:24:30
13:15:45
13:17:00
12:54:45
13:22:30
13:18:30
12:53:30
13:21:00
13:19:45
12:52:00
12:50:45
12:49:30
12:48:00
12:46:45

# 2794: FLOW SITE

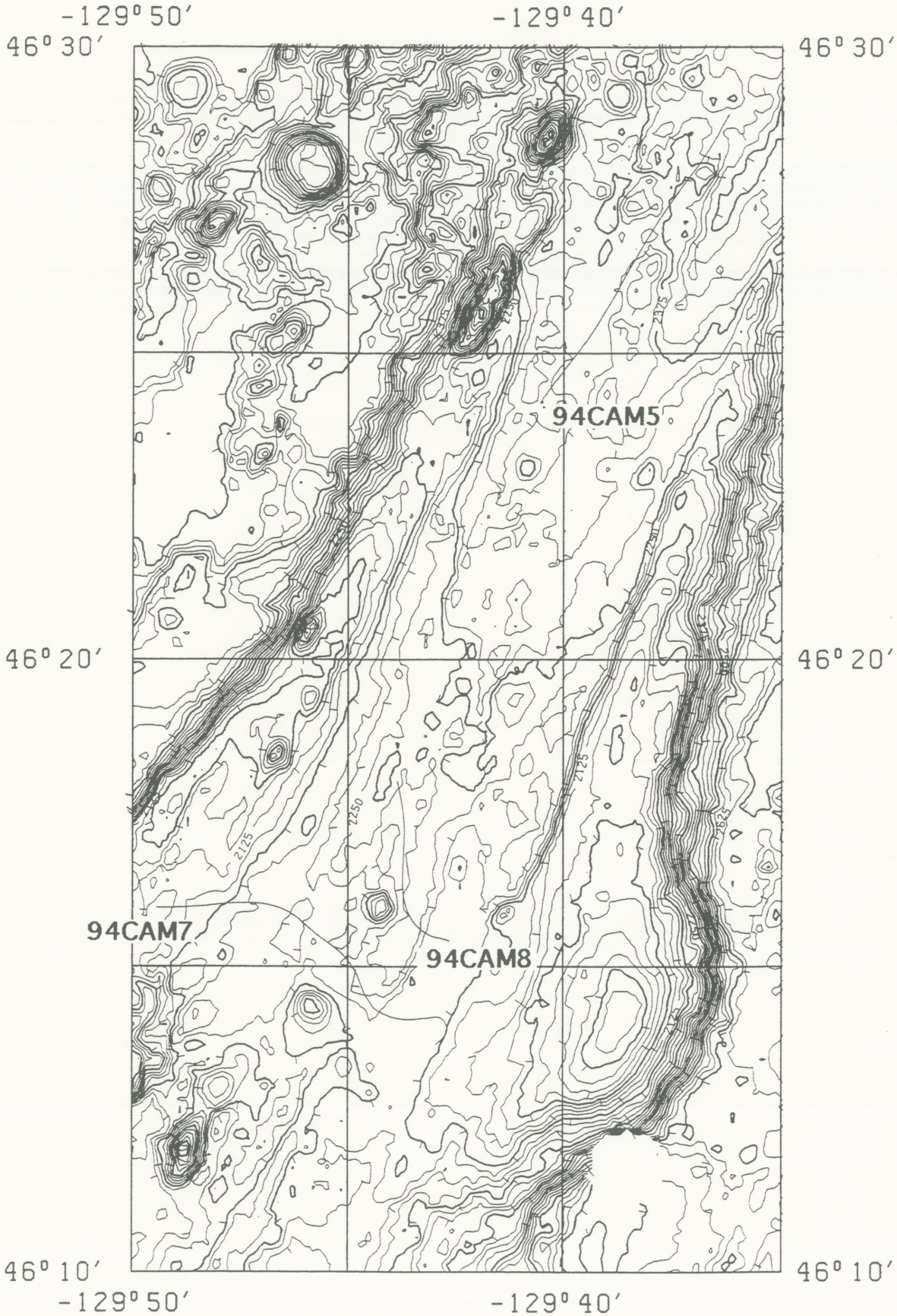


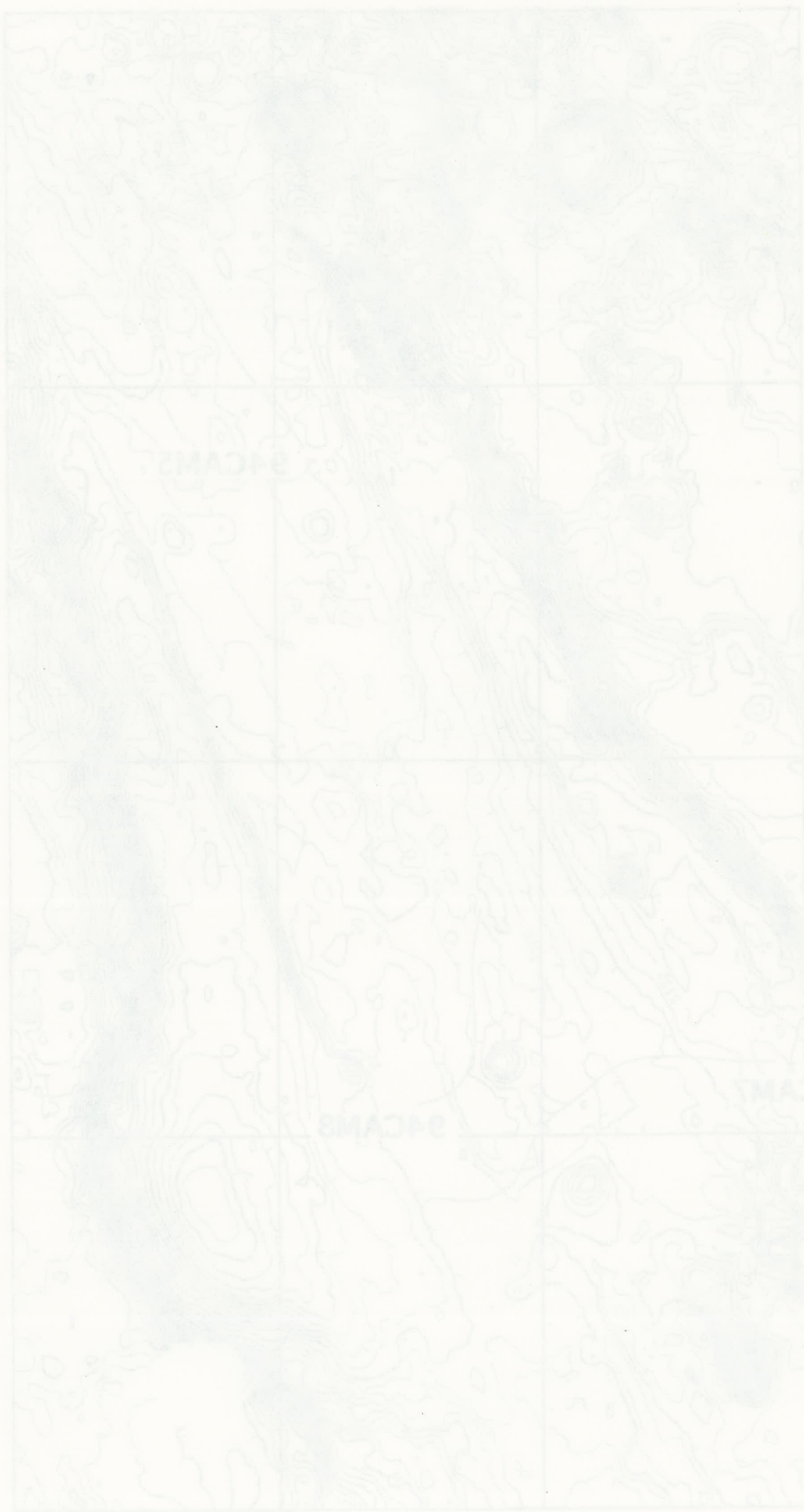

2794: FLOW SITE
6600
6550
6500
6450
6400
6350
6300
3800
3850
3900
3950
4000
ALVIN Y
ALVIN X
(1) R
11:07:30
11:06:00
11:04:45
10:41:45
10:35:00
10:12:00
10:08:00
10:06:00
10:04:45
09:55:00
09:53:45
09:52:30
09:51:00
09:49:45
09:48:00
09:30:00
09:34:00
09:27:30
09:42:30
09:38:30
09:39:45

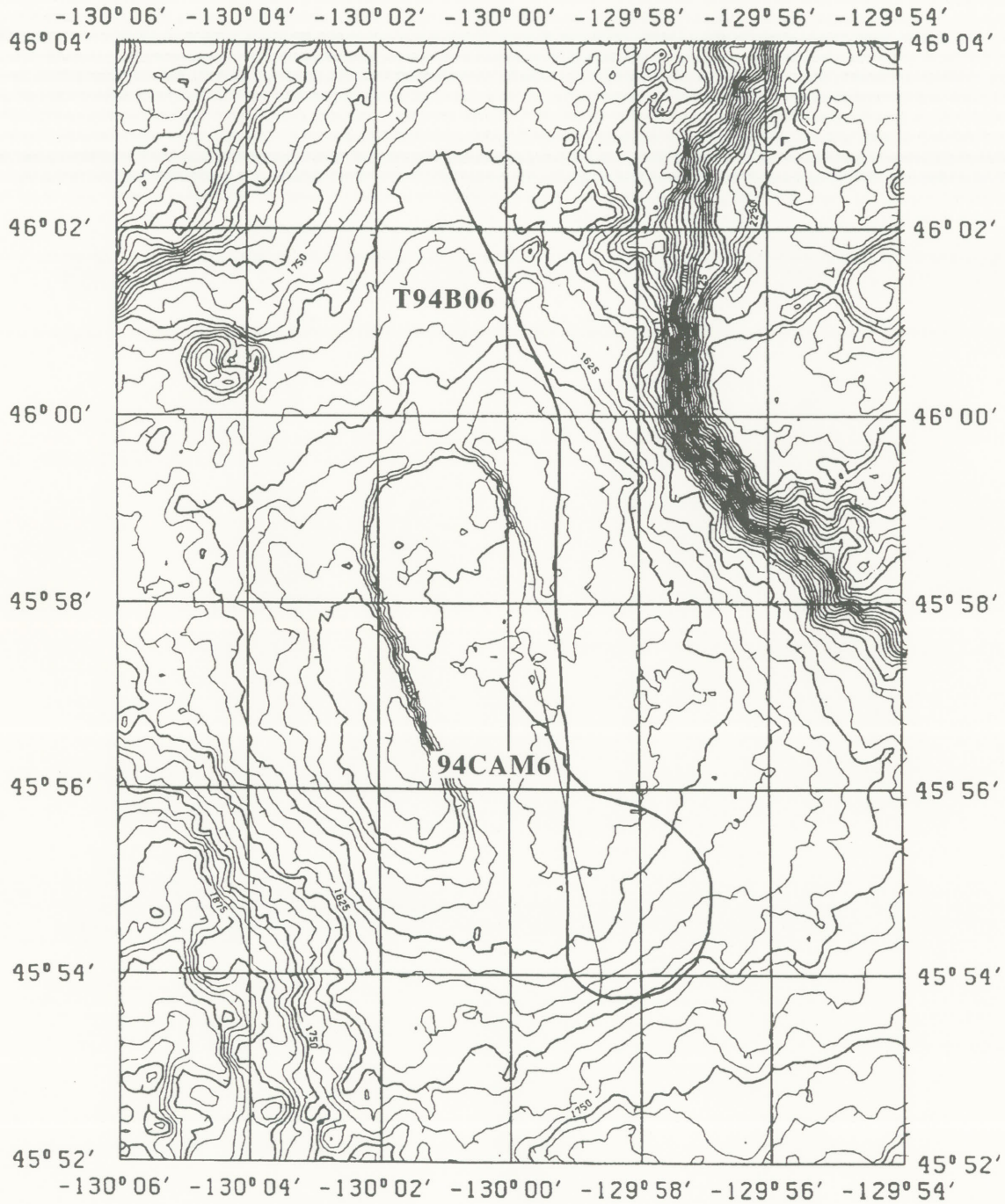
# COAXIAL - CTD TOWS



# COAXIAL - CAM TOWS





# AXIAL VOLCANO

# AXIAL - CTD/CAM TOWS