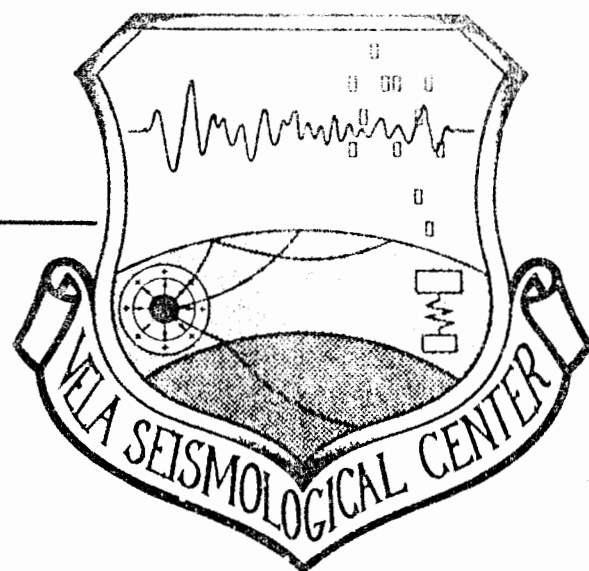


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RESULTS OF THE SDCS (SPECIAL
DATA COLLECTION SYSTEM)
ATTENUATION EXPERIMENT



Z.A. Der, T.W. McElfresh, and A. O'Donnell

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30 OCT 1981

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ABSTRACT

Investigation of teleseismic arrivals at test sites in the western United States (WUS), a site on the Canadian shield and two sites in the northeastern United States revealed marked differences in mantle attenuation among these sites. All sites in the WUS show high attenuation in the underlying mantle, the sites in the northeastern U.S. appear to be intermediate between the WUS and the shield sites. This pattern fits well into the results of broader regional studies of amplitude anomalies, and spectral variations in both P and S waves.

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INTRODUCTION

The SDCS attenuation experiment was motivated by indications of differences in the m_b - M_s relationship for explosions at NTS relative to explosions at USSR test sites. These differences can be explained by anomalously high attenuation in the mantle under the various test sites in the Western United States as opposed to a high Q mantle under shield areas of the USSR. This report consists of three parts and summarizes all of the results of the project to date.

The first part discusses the analysis of data from the SDCS station network. This data base is also supplemented by the analysis of some LRSM data in order to extend the areal coverage and to compensate for the fact that only one SDCS station was located on a shield.

The second part consists of a detailed discussion of the results of the SDCS experiment in the framework of research conducted on attenuation by us and others. This section outlines regional variations of Q_α and Q_β under the United States and puts limits on the absolute and relative variations of these quantities. The need for a frequency dependence of Q is also discussed. Since no comparable study of short-period attenuation has been undertaken in the past and since short-period data are influenced by many extraneous factors not related to mantle Q , a methodology had to be created to reduce the effects of these extraneous factors and to choose parameters less sensitive to them and more diagnostic of mantle Q . The data are interpreted in the following framework:

- a) Due to the well-documented focusing effects of small scale inhomogeneities in the crust and the uncertainties in the estimation of crustal amplification, short-period body wave amplitude anomalies are likely to be biased and are not reliable indicators of mantle Q .
- b) While short-period body wave spectral shapes (especially falloff rates at high frequencies) are extremely sensitive to small variations of mantle Q , they are considerably less affected by other factors.

- c) To measure mantle attenuation a combined interpretation of P and S wave amplitude and spectral data is necessary, with more weight being given to spectral measurements.

The third part of this report contains our arguments for using the methods outlined above. We feel that justifying the methodology within the main body of the report would continually divert the reader's attention to side issues; therefore, we have reserved a separate part of the report to demonstrate the validity of points a-c above and to discuss several other factors that need to be addressed to overcome possible objections. This is an essential part of the report and could be read first. Part III consists of Sections A-F, each of which is referred to in the main part of the text.

In this report we describe attenuation in terms of the quantity $t^* = \int \frac{dt}{Q}$, where Q is the quality factor along a certain seismic ray path and t is the travel time. t^* is naturally a path-dependent quantity since it is a function of the Q variation in the Earth which in turn is a function of depth and region. It is probably also frequency dependent. t^* appears to be the most convenient parameter for characterizing attenuation because for distances greater than 25 degrees it changes little with epicentral distance. Thus, it can be used as a single (although frequency dependent) parameter to characterize regional differences for various types of paths described in terms of upper mantle structures under the source and receiver. For distances less than 20 to 25 degrees, t^* increases with epicentral distance due to the fact that the body waves progressively penetrate the low-velocity - low- Q layer (LVZ) in the upper mantle as the distance increases. The contributions from the LVZ (which is coincident with the low Q layer) dominate the integral and thus t^* becomes a property that depends almost entirely on the types of upper mantle structures the ray path crosses. Thus:

$$t^* \approx \int_D \frac{dt}{Q} + \int_U \frac{dt}{Q} + t_r^* \quad (1)$$

where D is the integral along the downgoing leg of the ray path through the LVZ and U is the upgoing part. t_r^* is the contribution from the rest of the path through the crust and the lower mantle. It is relatively small because the crust and lower mantle are high- Q regions.

Alternate representations of attenuation are less convenient. For instance, if the apparent Q is used it has to be specified as a function of travel time and other parameters. It should be understood therefore that t^* in this report always refers to values measured at teleseismic distances unless it is clearly associated with near distances.

Throughout this report the mean amplitude, travel time, t^* and dominant period differences between stations are not considered significant unless they exceed the 95% statistical confidence levels. The confidence level of some of the data is higher than 99%. This kind of stability is not often found in geophysical literature, and the existence of interstation differentials in the quantities measured can hardly be questioned in such cases.

Details of the experiment that are not essential to the main conclusions of the report are presented in appendices at the end.

PART 1

DATA ANALYSIS FROM SDCS AND SELECTED LRSM STATIONS

The basic theory of the SDCS experiment is that by measuring relative amplitudes and spectral ratios for common events between stations one can infer the degree of anelastic attenuation under each station. The design of the experiment by DARPA is based on an implicit assumption of a degree of seismic reciprocity.

Seismic reciprocity is a general law stated by Knopoff and Gangi (1959), Hudson (1969), and others and is valid for arbitrary inhomogeneous linearly elastic media. This law expresses the interchangeability of source force systems and combinations of receiver displacement parameters. For example, one can state the interchangeability of dilatational force and displacement systems (Hudson, 1969; Knopoff, 1979). Reciprocity requires that the sources and receivers when interchanged occupy exactly the same positions in space. This condition is not satisfied in a strict sense for the SDCS experiment at the NTS sites. This is because, for the m_b -yield application, the sources are at the explosion sites and the receivers are mostly WWSSN and LRSM stations scattered world-wide, whereas for the reciprocal problem, the receivers are close to the explosion site (but not at the same depth) and the sources are located at the seismic belts of the earth. Thus from basic physical grounds alone one cannot expect reciprocity to be exactly valid for the NTS experiment.

The Special Data Collection System network consisted of a variable number of portable seismic stations deployed across the United States and Canada. It is essentially an extension of the LRSM (Long Range Seismic Measurement) network with more up-to-date digital recording systems, although at some sites analog recording was still used. Between 1976 and 1979, these portable stations were deployed at various nuclear test sites in the western United States and at the sites RKON (Red Lake, Ontario), IFME (Island Falls, Maine), and HNME (Houlton, Maine) in order to measure the differences in anelastic attenuation in the mantle under each site. The sites are marked on the map in Figure 1, and relevant site data are tabulated in Table I.

The instrument responses of the short-period systems were identical at all sites except HNME. This makes it impossible to directly compare dominant signal periods and trace amplitudes at this station with the rest of the

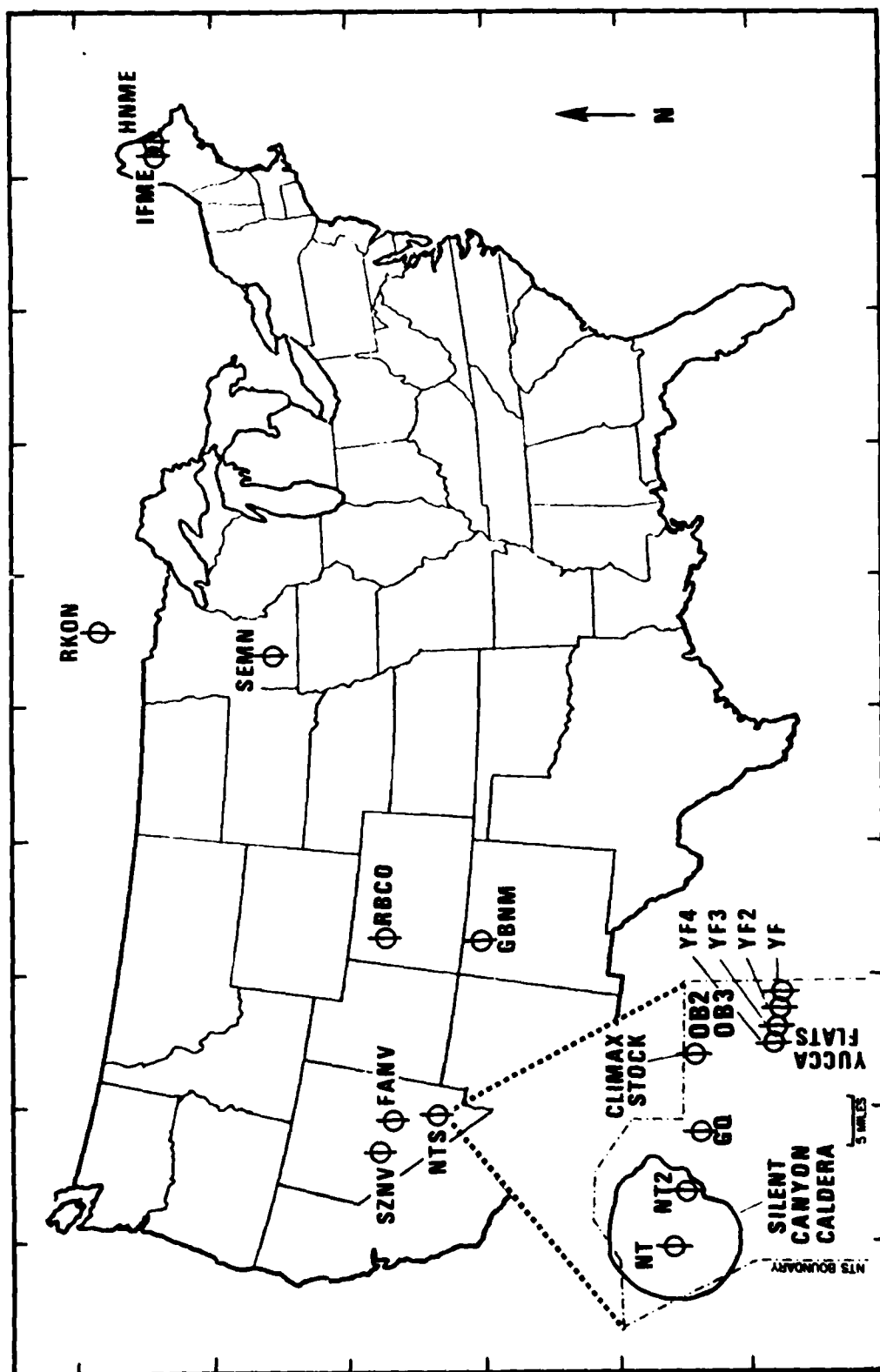


Figure 1 Locations of the SDCS and LRSM stations analyzed in detail in Part I of this report.

TABLE I

Description of SDCS and LRSM stations discussed in Part I of this report

STA	LOCATION	OPERATING PERIOD	SP COMPONENTS*	MODE	CRUST MATERIAL	N LAT	W LONG	ELEVATION M
FANV	FAULTLESS SITE, NEV	6/77-9/77	Z, N, E	ANALOG	ALLUVIUM + TUFF	38.64	116.22	1920
GRNM	GASBUGGY SITE, NM	5/77-8/78	Z, N, E	ANALOG	SEDIMENTS, IGNEOUS DIKES	36.69	107.23	2164
GQNV	GOLD MEADOWS, NTS	10/77-12/77	Z, N, E	ANALOG	GRANITE	37.23	116.21	2057
HNME	HOULTON, ME	2/75-3/76	Z, N, E	DIGITAL	SLATE	46.16	67.99	213
HNME	HOULTON, ME	4/76-8/78	Z, N, E	ANALOG	SLATE	46.16	67.99	213
IFME	ISLAND FALLS, ME	11/77-8/78	Z, N, E	ANALOG	GRANITE	46.03	68.20	232
NTNV	PAHUTE MESA, NTS	8/76-3/77	Z, N, E	DIGITAL	LOW VELOCITY VOLCANICS	31.28	116.42	1987
NT2NV	PAHUTE MESA, NTS	8/76-3/77	Z, N, E	DIGITAL	LOW VELOCITY VOLCANICS	37.25	116.30	2185
OB2NV	CLIMAX STOCK, NTS	8/76-2/78	Z, N, E	DIGITAL	GRANITE	37.23	116.06	1542
OB3NV	CLIMAX STOCK, NTS	4/77-2/78	Z ONLY	DIGITAL	GRANITE	37.23	116.05	1609
RBCO	RIO BLANCO SITE, COLO	12/77-1/79	Z, N, E	DIGITAL	ALLUVIUM + SEDIMENTS	39.81	108.36	1996
RKON	RED LAKE, ONTARIO	3/75-3/78	Z, RNTS, T _{NTS}	DIGITAL	GRANITE	50.84	93.67	365
SENV	SLEEPY EYE, MINN	1/62-6/63	Z, R ₇₃ , T ₁₆₃	ANALOG	GRANITE	44.41	94.67	244
SZNV	SHOAL SITE, NTS	1/63-2/63	Z, R ₃₁₉ , T ₄₉	ANALOG	GRANITE	39.20	118.38	1606
YFNV	YUCCA FLATS, NTS	4/77-9/77	Z, N, E	DIGITAL	ALLUVIUM	37.07	116.00	1271
YF2NV	YUCCA FLATS, NTS	4/77-9/77	Z ONLY	DIGITAL	ALLUVIUM	37.07	116.01	1260
YF3NV	YUCCA FLATS, NTS	4/77-9/77	Z ONLY	DIGITAL	ALLUVIUM	37.07	116.02	1254
YF4NV	YUCCA FLATS, NTS	4/77-9/77	Z, N, E	DIGITAL	ALLUVIUM	37.08	116.04	1244

* SUBSCRIPTS INDICATE ORIENTATION OF R, T COMPONENTS; NTS INDICATES ORIENTATION TOWARD THE NEVADA TEST SITE.

stations. The instrument responses of several kinds of systems discussed in this report are shown in Figure 2.

The approach taken for event selection was to measure events on the first published lists, which were the bulletins of the Hagfors Observatory, that of the French national network or the PDE lists of the USGS. Locations were double checked with later, more accurate event lists. These preliminary locations were sufficient for the purpose of relative magnitude measurements.

Results of Amplitude Studies

During the course of the SDCS experiment the amplitudes and periods of more than 600 events were measured for the purpose of computing interstation m_b differentials. The events were all in the range $25^\circ < \Delta < 85^\circ$ from the stations to ensure traversal of the upper mantle by most of the P wavetrain. A complete listing of the events is shown in Appendix A.

Since the SDCS experiment was designed to resolve problems arising from a study of $M_s - m_b$, it was necessary to compute the conventional m_b using the maximum amplitude in the first 3 seconds of each signal. The writers are of the opinion, in agreement with Butler (1979), that the amplitude of the first cycle or "b" phase is more meaningful; nevertheless, we shall show that our results agree extremely well with those obtained from "b" phase measurements. Following Cleary (1967) and Butler (1979) we have also compiled differentials of trace amplitudes corrected for distance, and we have abandoned the computation of the uncorrected magnitude m'_a used in previous reports because we feel that it is less meaningful than the trace amplitudes (see section B of Part 3).

Histograms of the m_b and trace differentials are shown in Figures 3 and 4 for the station pair RKON and OB2NV, two stations of great diagnostic value since both of these are located on granite and, presumably, are free of large crustal amplification effects. These figures show the extremely large scatter in the amplitude and magnitude differentials characteristic of short-period data. This is not surprising in view of the comments in section D of Part 3 of this report. A noteworthy data point, the Novaya Zemlya nuclear explosion of 02 OCT 76 (marked as N.Z.), is on the flanks of the distributions in spite of the fact that the source is axisymmetric.

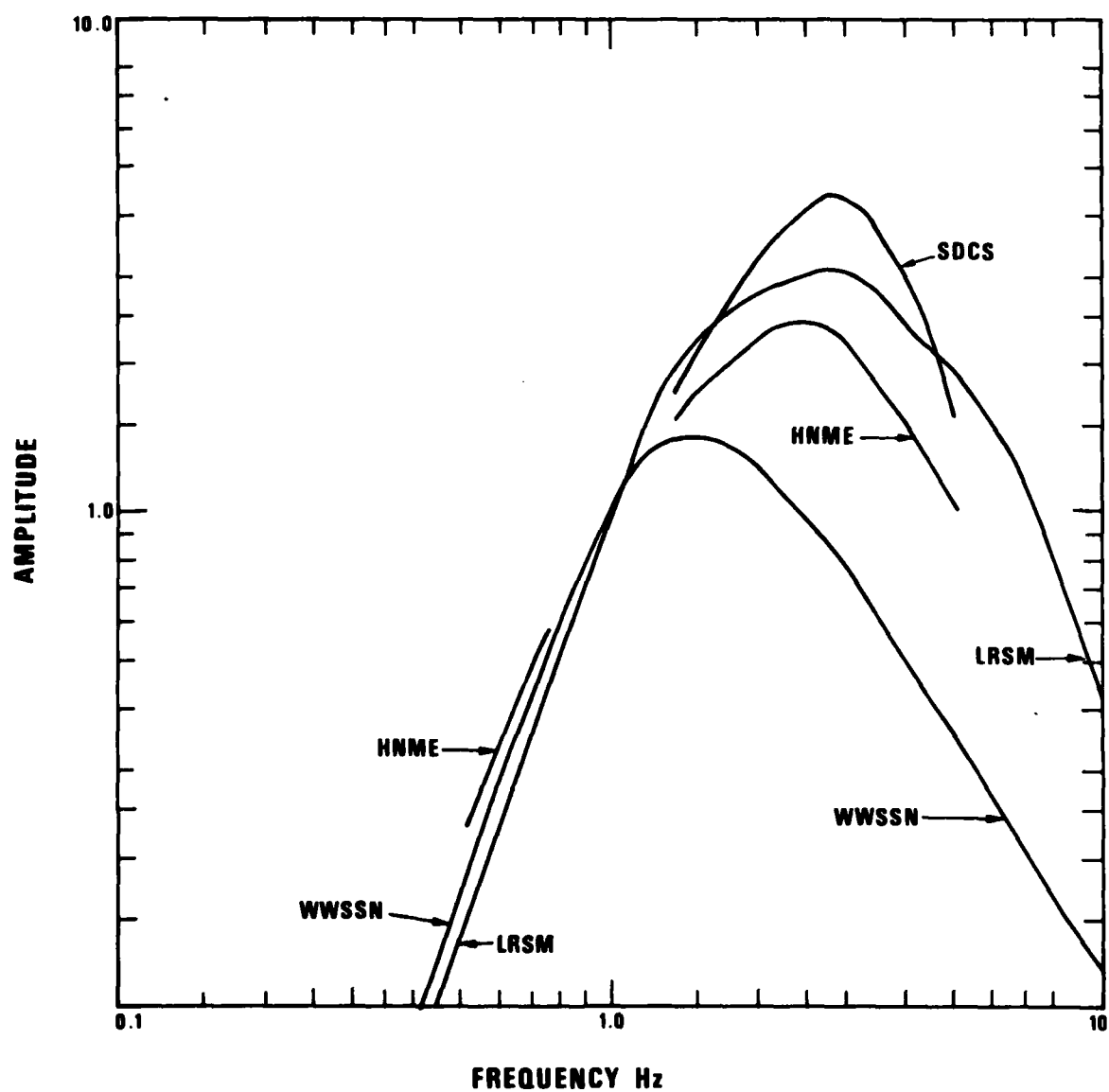


Figure 2 Response curves of the LRSN, SDCS, WWSSN and HNME stations.

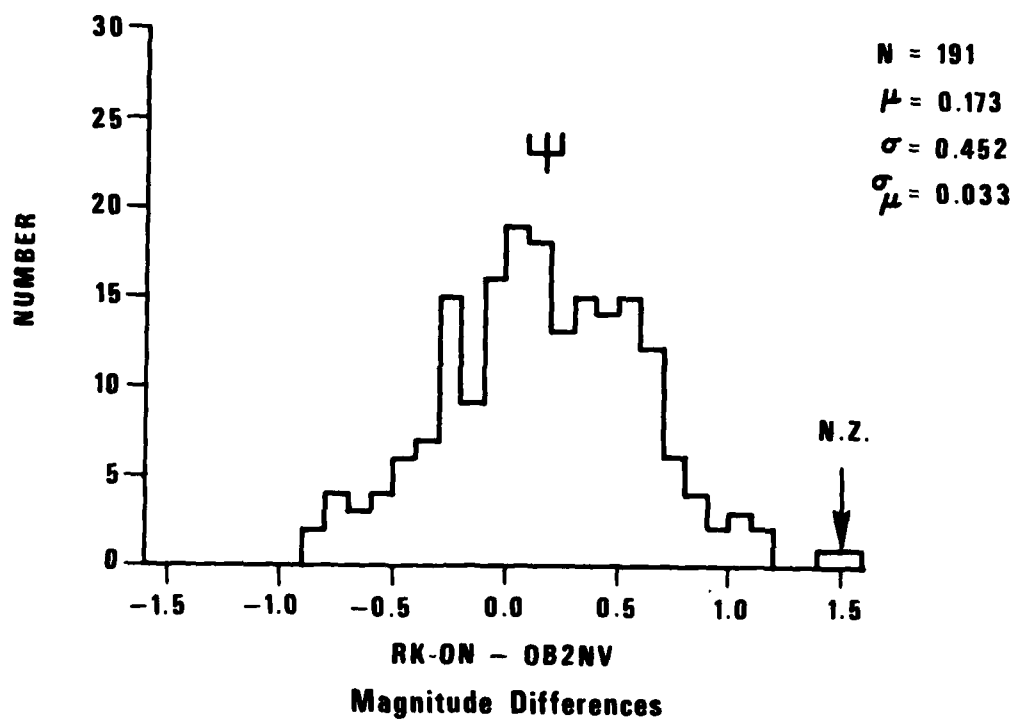
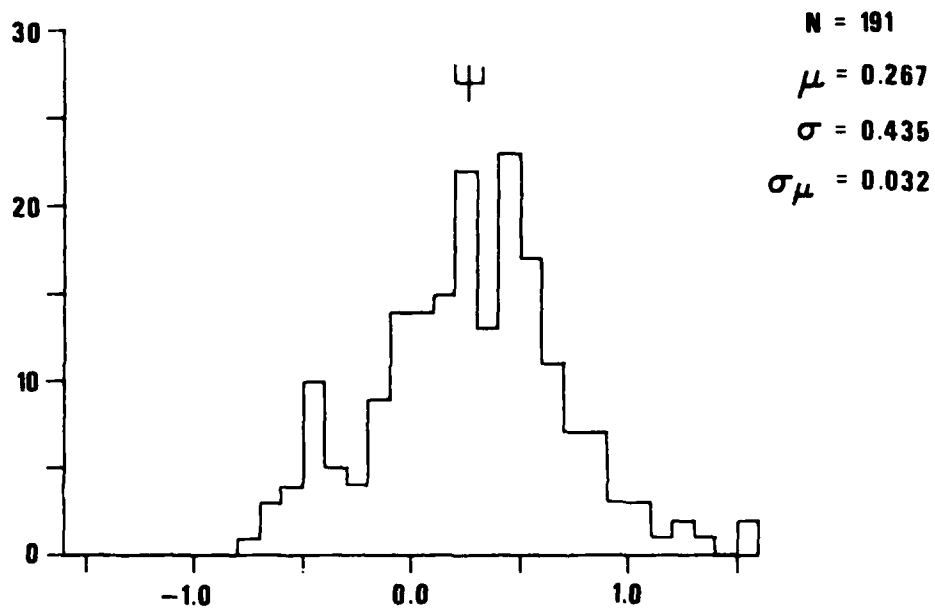


Figure 3 Histogram of m_b differentials between RKON and OB2NV. The mean m_b differential is $0.173 \pm .066$ (95% confidence) magnitude units. The point N.Z. marks a data point from Novaya Zemlya.



RK-ON - OB2NV

$\Delta(\log_{10} A_{tr})$

Figure 4 Histogram of P wave trace amplitude differentials between RKON and OB2NV using ten base logarithms of amplitudes as units. The differential is $0.267 \pm .064$ (95% confidence) showing that the RKON/OB2NV amplitude ratio is about 1.85.

Histograms of the magnitude and trace amplitude differentials for the rest the station pairs are collected in Appendices B and C of this report.

Consider now the standard deviation $\sigma_{\Delta m_b}$ of relative magnitude differentials as a function of the distance between station pairs. Figure 5 is a plot of $\sigma_{\Delta m_b}$ versus $\log \Delta^\circ$. A linear empirical relationship appears to exist. The causes of the linear increase in $\sigma_{\Delta m_b}$ are: 1) decreasing signal similarity for the P waveforms as the distance increases so that m_b cannot be consistently picked at similar portions of the P wavetrain, 2) source radiation patterns that cause systematic variations of amplitudes, and 3) increasing effects of focusing and defocusing. In order to take into account the effect of signal coherence evidenced by the $\sigma_{\Delta m_b} - \Delta^\circ$ relationship, we make use of a least squares technique which also allows us to incorporate all of our measurements into the determination of magnitude differentials across the SDCS network. For a given event we write the magnitude differentials between pairs of stations i and j in the form

$$\Delta m_b^i - \Delta m_b^j = k_{\Delta m_b^{ij}} + \epsilon_{ij}(\Delta_{ij}^\circ) \quad (1)$$

where Δm_b^i is the station term (bias) of station i, $k_{\Delta m_b^{ij}}$ is the observed magnitude differential between station i and j for event k and $\epsilon_{ij}(\Delta_{ij}^\circ)$ is an error term dependent upon the distance Δ_{ij}° between the stations. The expected value of this error term

$$E\{\epsilon_{ij}^2(\Delta^\circ)\} = \sigma_{\Delta m_b}^2(\Delta_{ij}^\circ) \quad (2)$$

can be read from the regression line in Figure 5 as a function of distance.

Because taking differences in all possible combinations is redundant, a hierarchy of stations was assigned as follows: OB2NV, OB3NV, YFNV, YF4NV, YF2NV, YF3NV, NTV, NT2NV, FANV, GBNM, RKON, HNME, and we used the leftmost available station bias term as the reference (positive) term in equation (1). This hierarchy was selected to optimize the distance distribution so that most of the distances used, and consequently the values of $\sigma_{\Delta m_b}$, are as small as possible. Thus OB2NV, at the center of the NTS cluster and located between GBNM and FANV, is the prime candidate for the most commonly used reference station, while RKON and HNME are outliers and rank low.

This least squares procedure causes only minor changes in the relative

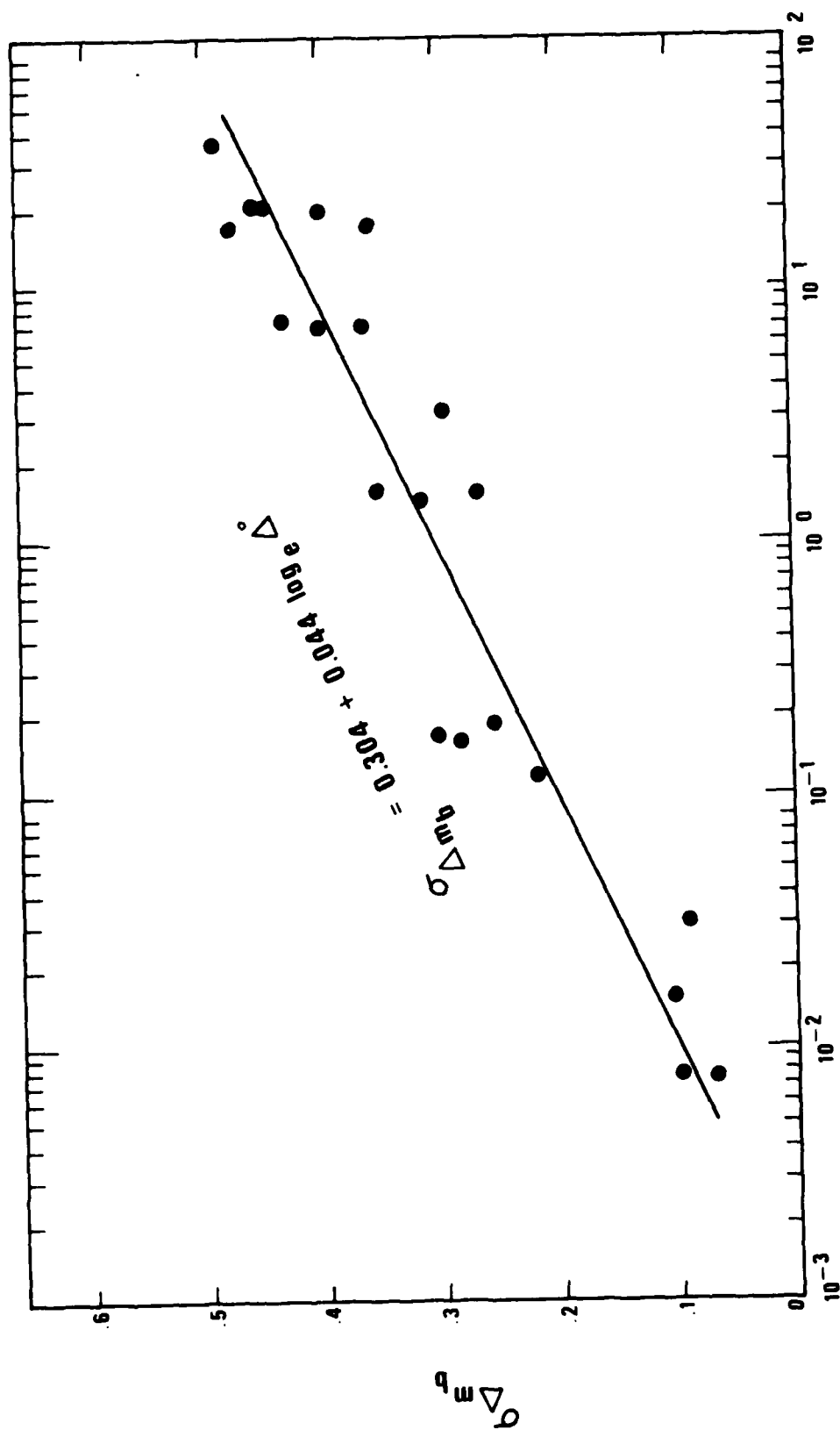


Figure 5 Standard deviation of relative m_b differentials vs. interstation distance. The increase reflects increasing variability of m_b readings for more distant station pairs.

m_b and trace amplitude differentials compared to those directly computed from data and given in the histograms in Appendices B and C. The means of the differentials relative to OB2NV of m_b and trace amplitudes are listed in Table II and also shown with their 95% confidence limits in Figures 6 and 7. The most prominent features of these figures are the high amplitudes of m_b values at the stations on Yucca Flats (YF's) and on Pahute Mesa (NT's). The low amplitude of the station IFME in Maine is another feature of Figure 6.

In order to correct for the effect of the crust on these m_b and trace amplitudes we compared changes in synthetic P pulse amplitudes. Pulse shapes for a 50 kt explosion as modeled by von Seggern and Blandford (1972) were computed after passing them through layered halfspace models using the standard Haskell algorithm. Table III lists the model parameters used in the calculations. We attenuated each pulse with a multiplicative spectral factor $\exp(-\pi f t^*)$, where t^* was chosen to be 0.45, a typical value for the WUS. By removing most of the high frequencies, the attenuation factor makes the pulse more rounded. This pulse has a spectrum which, in spectral content, well represents the average teleseismic P-wave arrivals. It is peaked at 1 Hz and falls off at a rate of somewhat more than ω^{-2} at high frequencies. To reduce variations caused by changes in the angle of incidence, we computed the synthetics for three angles (20°, 25°, and 30° measured from the vertical) and then averaged the relative amplification factors between stations obtained for these three angles.

The Yucca Flats sites rest on thick unconsolidated sediments and tuff that cause considerable signal amplification (Houser, 1968; Fernald et al, 1968; Healy, 1968; Ramspott and Howard, 1975; Hays and Murphy, 1971). The FAULTLESS site (FANV) is also located over alluvium and tuff, but according to test site information, the alluvium is more consolidated at this site (McKeown and Dickey, 1969) (Lt. Col. Bulin of ARPA also provided us with data relevant to the FANV site). Alluvium and a thick sedimentary carbonaceous-shale sequence also underlay the GASBUGGY site (GBNM) (Thornbrough, 1971). In all of these cases the part of the structure that primarily determines crustal amplification was found to be near the surface. Consequently, the structures were modeled only down to the basement (Der et al,

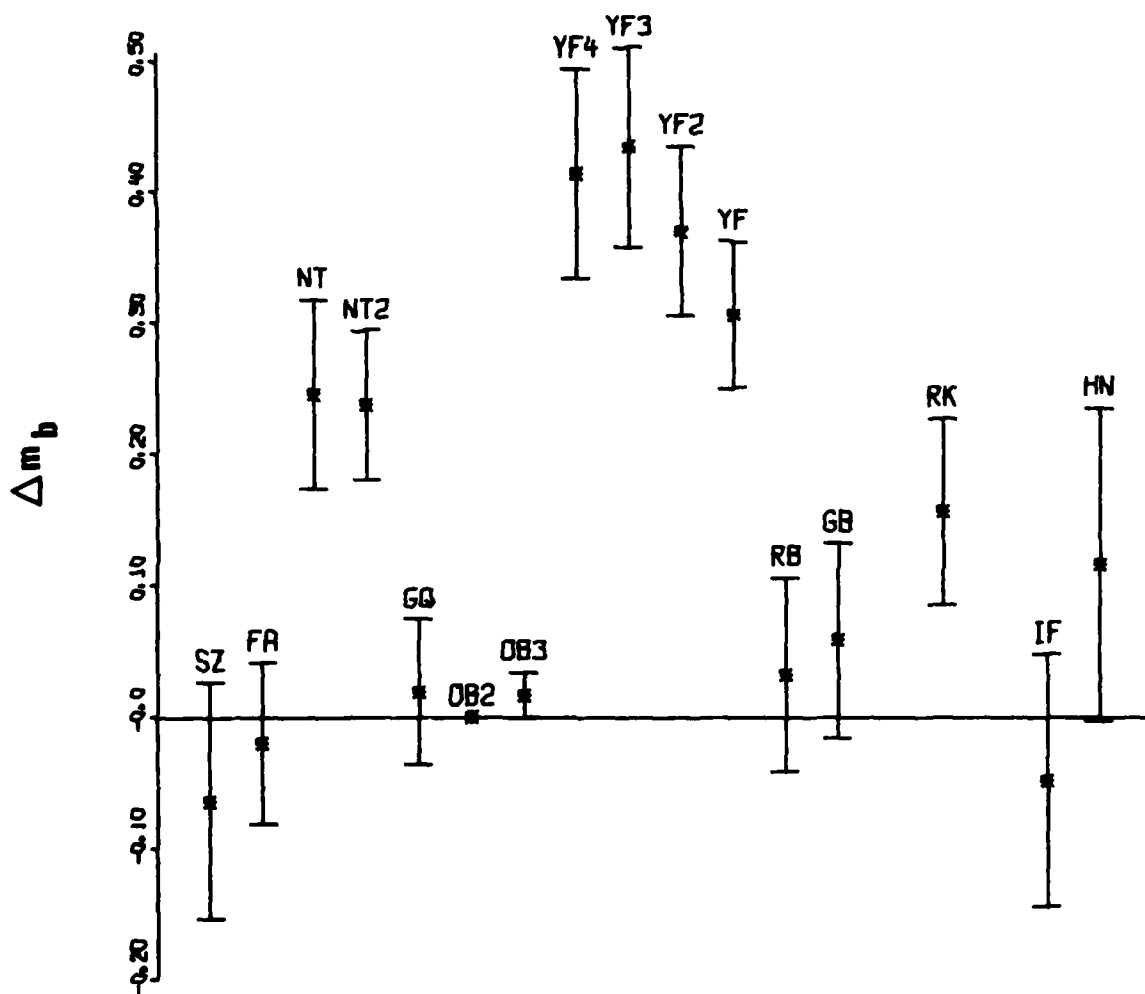


Figure 6 Magnitude bias terms at the various SDCS stations with respect to OB2NV. 95% confidence limits are shown by bars. No corrections for crustal amplification are included.

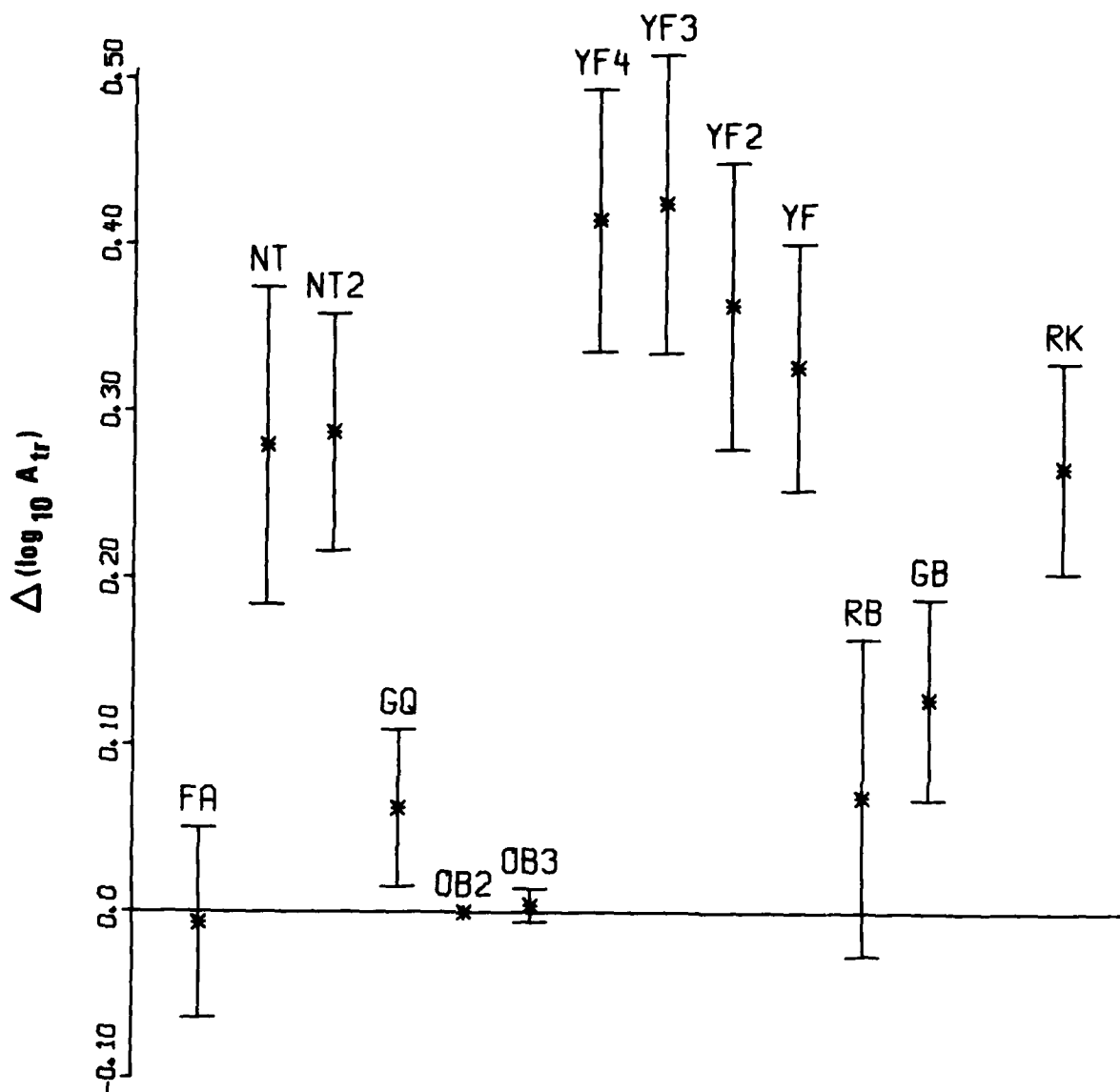


Figure 7 Trace amplitude differentials (expressed in $\log_{10}$ units) relative to OB2NV. No crustal corrections are applied.

TABLE II

Summary of relative magnitudes (Δm_b), trace amplitudes (ΔA_{tr}), crust-corrected values (Δm_b^{corr} , ΔA_{tr}^{corr}), dominant periods (ΔT), and attenuation (Δt^*) with respect to the reference station OB2NV located on the Climax Stock at NTS.

STA	Δm_b	ΔA_{tr}	ΔT	CRUST CORR	Δm_b^{corr}	ΔA_{tr}^{corr}	Δt^*
HNME *	0.116 $\pm$ 0.119	N/A	N/A	0.0	0.116	N/A	-0.098 $\pm$ 0.030
SEMN *	0.156 $\pm$ 0.071	0.267 $\pm$ 0.063	-0.192 $\pm$ 0.038	0.0	0.156	0.267 $\pm$ 0.063	-0.200 $\pm$ 0.031
RKON *	0.306 $\pm$ 0.056	0.327 $\pm$ 0.074	-0.051 $\pm$ 0.071	0.300 [†]	0.006	0.027 $\pm$ 0.074	-0.040 $\pm$ 0.050
YF *	0.370 $\pm$ 0.065	0.364 $\pm$ 0.086	-0.011 $\pm$ 0.067	0.330 [†]	0.040	0.034 $\pm$ 0.086	0.014 $\pm$ 0.055
YF2 *	0.434 $\pm$ 0.076	0.425 $\pm$ 0.090	0.032 $\pm$ 0.074	0.300 [†]	0.134	0.125 $\pm$ 0.090	-0.016 $\pm$ 0.063
YF3 *	0.413 $\pm$ 0.080	0.415 $\pm$ 0.079	-0.013 $\pm$ 0.073	0.310 [†]	0.103	0.105 $\pm$ 0.079	0.006 $\pm$ 0.062
FA *	-0.020 $\pm$ 0.061	-0.007 $\pm$ 0.057	-0.020 $\pm$ 0.068	0.268	-0.288	-0.275 $\pm$ 0.057	-0.036 $\pm$ 0.052
GB *	0.058 $\pm$ 0.074	0.128 $\pm$ 0.060	-0.068 $\pm$ 0.052	0.310	-0.252	-0.182 $\pm$ 0.060	0.013 $\pm$ 0.050
NT *	0.246 $\pm$ 0.072	0.279 $\pm$ 0.095	-0.100 $\pm$ 0.060	0.216	0.030	0.063 $\pm$ 0.095	-0.079 $\pm$ 0.052
NT2 *	0.237 $\pm$ 0.057	0.287 $\pm$ 0.071	-0.100 $\pm$ 0.050	0.210	0.027	0.077 $\pm$ 0.071	-0.059 $\pm$ 0.050
OB3 *	0.016 $\pm$ 0.018	0.004 $\pm$ 0.010	0.007 $\pm$ 0.027	0.0	0.016	0.004 $\pm$ 0.010	-0.036 $\pm$ 0.019
SZ *	-0.064 $\pm$ 0.090	N/A	N/A	0.0	-0.064	N/A	-0.030 $\pm$ 0.091
GQ	0.019 $\pm$ 0.055	0.062 $\pm$ 0.047	-0.086 $\pm$ 0.050	0.0	0.019	0.062 $\pm$ 0.047	-0.052 $\pm$ 0.042
IF	-0.048 $\pm$ 0.096	N/A	N/A	0.0	-0.048	N/A	-0.112 $\pm$ 0.040
RB	0.032 $\pm$ 0.074	0.069 $\pm$ 0.095	-0.014 $\pm$ 0.078	0.134	-0.102	-0.065 $\pm$ 0.095	0.035 $\pm$ 0.035

* Δm_b Adjusted by least squares technique over these stations

[†] Average of finite difference and Haskell results

TABLE III

Crustal models used for estimating crustal amplifications
at the SDCS stations

	d(km)	α (km/sec)	β (km/sec)	ρ (g/cm ²)
FA-NV	0.44	2.50	1.06	2.30
	1.00	3.00	1.60	2.30
	1.00	3.50	1.73	2.30
	1.525	4.00	2.20	2.50
	∞	5.70	3.29	2.70
GB-NM	0.700	2.00	1.06	2.00
	0.150	3.25	1.63	2.00
	0.200	3.45	1.73	2.00
	0.120	3.90	2.16	2.28
	0.600	4.40	2.48	2.49
	0.625	4.80	2.73	2.55
	∞	5.70	3.29	2.70
GQ-NV	2.0	6.10	3.60	2.70
	∞	6.10	3.60	2.70
HN-ME	10.0	5.90	3.36	2.70
	∞	6.35	3.62	2.72
IF-ME	2.0	6.10	3.60	2.70
	∞	6.10	3.60	2.70
NT-NV	1.0	3.00	1.80	2.00
	4.0	3.60	2.00	2.20
	5.0	5.70	3.36	2.70
	∞	6.10	3.60	2.80
NT2NV	1.0	2.86	1.75	2.00
	4.0	3.60	2.00	2.20
	5.0	5.70	3.36	2.70
	∞	6.10	3.60	2.80
OB2NV	10.0	5.70	3.36	2.70
	∞	6.10	3.60	2.80
OB3NV	10.0	5.70	3.36	2.70
	∞	6.10	3.60	2.80
RB-CO	1.0	3.80	2.10	2.30
	∞	6.10	3.60	2.70
RK-ON	6.0	5.64	3.47	2.70
	∞	6.15	3.64	2.80
SZ-NV	2.0	6.10	3.60	2.70
	∞	6.10	3.60	2.70
YF-NV	0.18	1.30	0.659	1.75
	0.55	2.00	1.07	1.196
	∞	5.70	3.36	2.70
YF2NV	0.24	1.30	0.659	1.75
	0.58	2.00	1.07	1.196
	∞	5.70	3.36	2.70
YF3NV	0.29	1.30	0.659	1.75
	0.61	2.00	1.07	1.196
	∞	5.70	3.36	2.70
YF4NV	0.29	1.30	0.659	1.75
	0.70	2.00	1.07	1.196
	∞	5.70	3.36	2.70

1977), which was assumed to have the same elastic properties as the granite stock at OB2NV (which was modeled by a simple homogeneous halfspace). This similarity makes the pulse sizes of the computed synthetic records comparable with correction for halfspace properties below the layered stack.

Finite difference methods were also used to estimate crustal amplification at the four stations on Yucca Flats (the method is described in the paper by Kelly et al, 1976). We attempted to model Yucca Flats with a structure derived from Hays and Murphy (1971), utilizing Ramspott's and Howard's (1975) and Fernald et al's (1968) velocity and structural data. The results of both methods are shown in Table IV. Both the Haskell matrix and the finite difference methods suggest considerable amplification at Yucca Flats, and the two methods yield about the same result.

Plots of m_b differentials relative to OB2NV corrected for crustal effects, Figure 8, show major changes compared to the uncorrected data of Figure 6. The differences between OB2NV and the Yucca Flats (YF) and Pahute Mesa (NT) stations are drastically reduced with the exception of YF3 and YF4 to a level below significance. The m_b values for FANV, RBCO and GBNV are reduced below the level of OB2NV. The thin ($h < 50$ m) weathered layer at HNME does not justify any crustal correction relative to IFME since, in our experience, such thin layers do not amplify teleseismic waves. However, any such correction could move HNME to slightly lower m_b values. The relative positions of RKON and OB2NV, the two key stations on granite, are unchanged, and the differential in m_b , 0.17 m.u., is statistically significant - at higher than the 99% confidence level.

The crust-corrected trace amplitudes expressed in base 10 log units behave similarly as shown in Figure 9. The crustal corrections for trace amplitudes are the same as for m_b since there is no apparent change in period in the synthetic calculations. The OB2NV-RKON differential of 0.267 is highly significant statistically and is in excellent agreement with the results of Butler (1979).

TABLE IV

Results of finite difference and Haskell algorithm calculations of crustal response at Yucca Flats

<u>Stations</u>	<u>Magnitude Differential Relative to OB2NV</u>		
	<u>Observed</u>	<u>Layered (Haskell)</u>	<u>FINITE DIFFERENCE 1 Hz</u>
YF	0.306	0.34	0.26
YF2	0.370	0.34	0.32
YF3	0.434	0.32	0.27
YF4	0.413	0.32	0.30

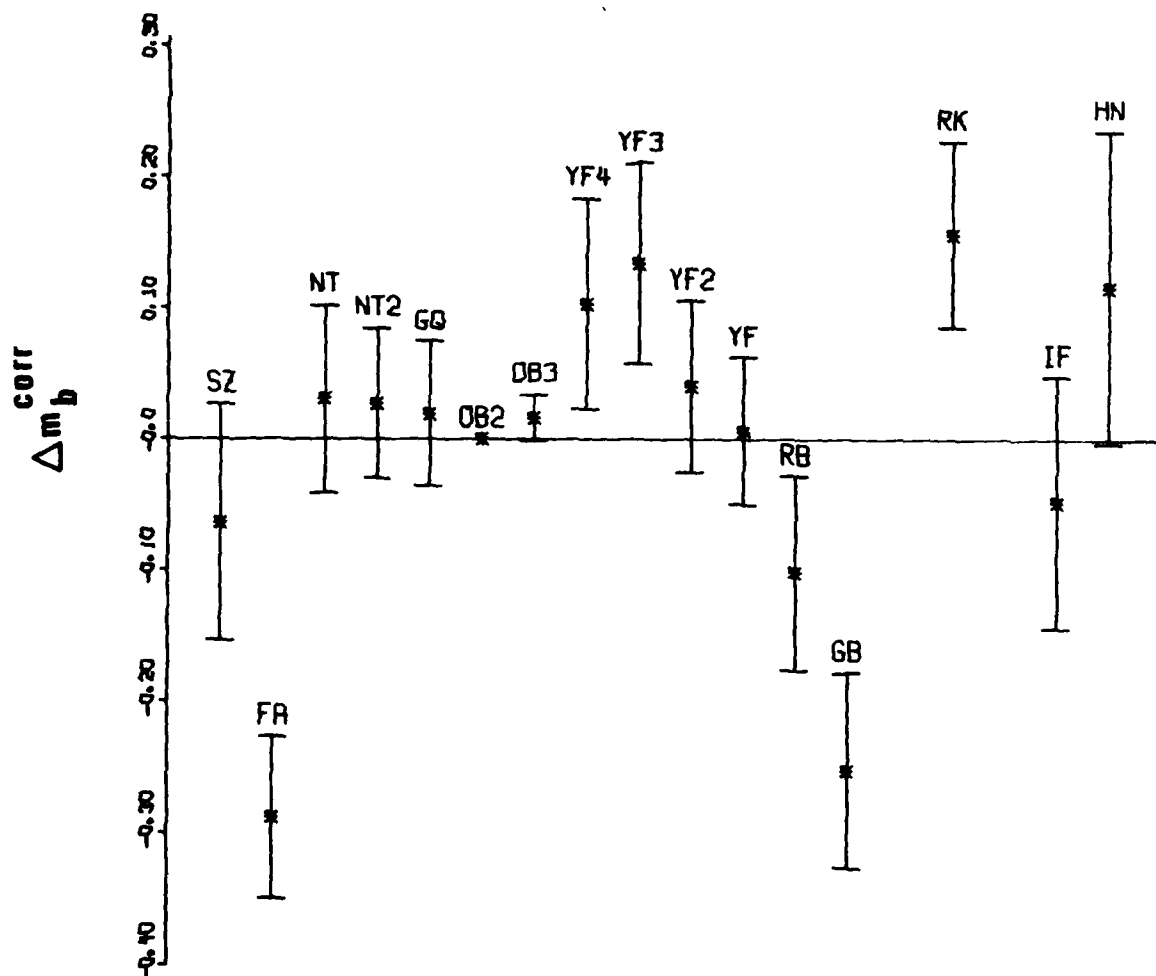


Figure 8 Magnitude bias terms relative to OB2NV with crustal corrections. The m_b levels at Yucca Flats and Pahute Mesa (NTNV and NT2NV) are greatly reduced.

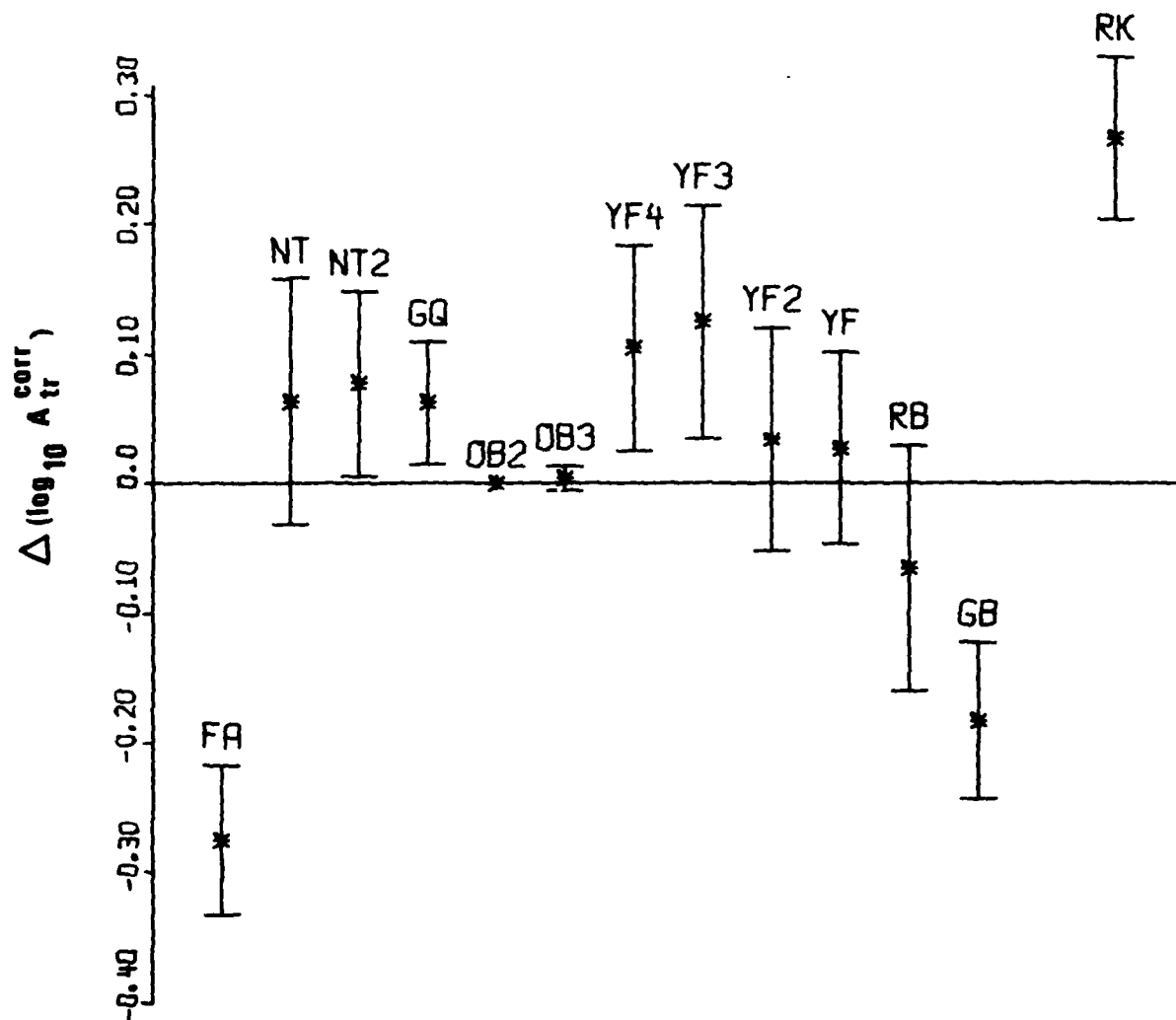


Figure 9 Trace amplitude levels relative to OB2NV ($\log_{10}$ units) with crustal corrections applied.

Possible Bias Effects in m_b Due To Variable Thresholds, Noise Level and Source Region

Since relative and absolute amplitude measurements can be biased by threshold and source region effects (von Seggern and Blandford, 1972; Ringdal, 1976), we have tested our data to determine the extent of any possible bias. The criteria we have used for amplitude measurement require that S/N be greater than 3. Thus, event pairs were eliminated when one of the stations, e.g. station A, has $S/N < 3$. Because this condition could result from low signal at station A relative to station B, the average amplitude at A could be overestimated relative to B at low magnitudes. Only if the great majority of all readings are considerably above the 3:1 S/N level can such bias in the average be ruled out. To test for this bias, we plotted the differentials of m_b for selected stations pairs against the average m_b for the same two stations. Pronounced trends in plots such as these would indicate biases in the procedures used for determining Δm_b . A slight change of Δm_b with increasing magnitude might also suggest a shift of corner frequency of seismic sources of lower frequencies. This shift would be more visible at a high Q than at a low Q station. Absence of a clear trend indicates that bias in Δm_b from variable noise levels is not significant.

Figures 10 through 16 show such plots for a selected set of key station pairs. None of these plots, including the critical pair RKON-OB2NV, suggest a clear trend. Therefore, bias effects from our procedure are probably negligible. Note that the noise level is approximately 0.3 m. u. higher at RKON than at OB2NV. However, the raw amplitudes on the film (magnitude at 1 Hz, not amplitude corrected at T or at A/T) also average 0.3 m. u. at RKON. Thus, the average expected S/N is the same, and no bias would be expected.

To test for the effect of source region biases on the measured relative m_b , we divided the RKON-OB2NV interstation differentials into four groups marked with different symbols as follows:

Symbol

- | | | |
|---|------------------------------------|-------------------------|
| A | $(\Delta m_b - \mu) < -\sigma$ | high amplitude at OB2NV |
| B | $-\sigma < (\Delta m_b - \mu) < 0$ | |
| C | $0 < (\Delta m_b - \mu) < +\sigma$ | |
| D | $(\Delta m_b - \mu) > +\sigma$ | low amplitude at OB2NV |

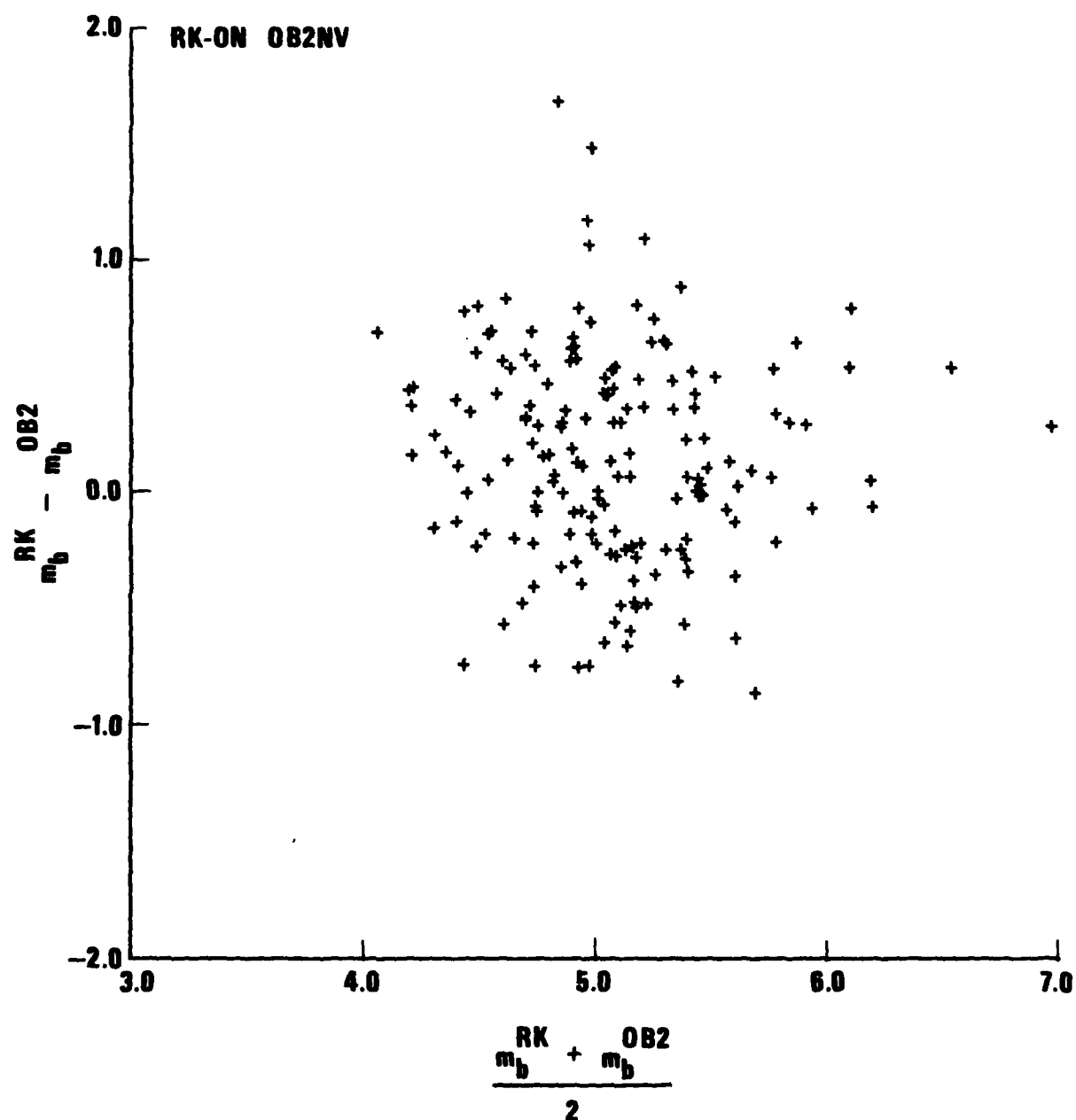


Figure 10 Interstation m_b differentials plotted against the two-station average m_b for station pair RKON - OB2NV. The absence of any clear increasing or decreasing trend indicates that magnitude threshold biases are not present (see text).

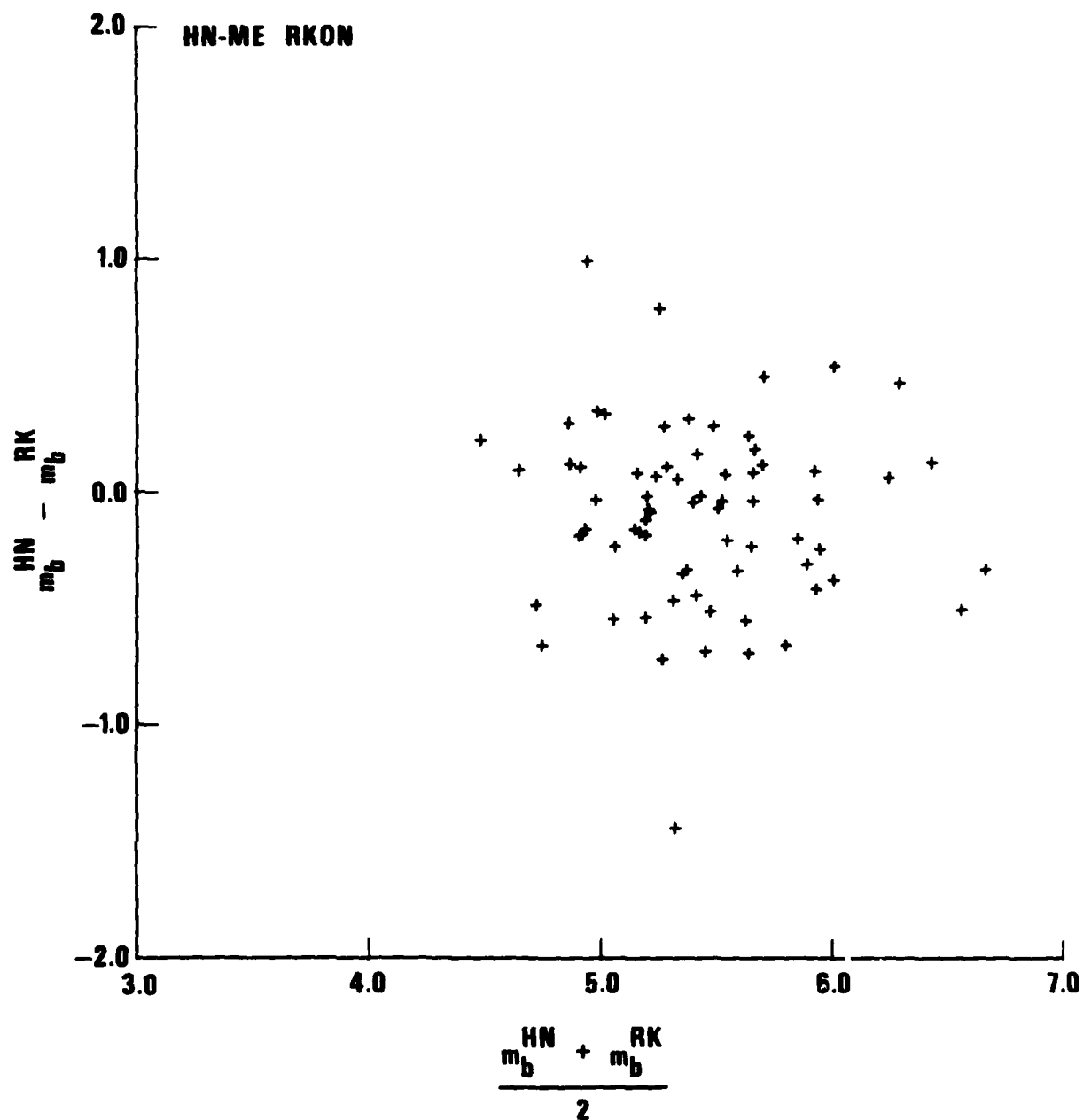


Figure 11 Interstation m_b differentials plotted against the two-station average m_b for the station pair HNME - RKON. The absence of any clear increasing or decreasing trend indicates that magnitude threshold biases are not present (see text).

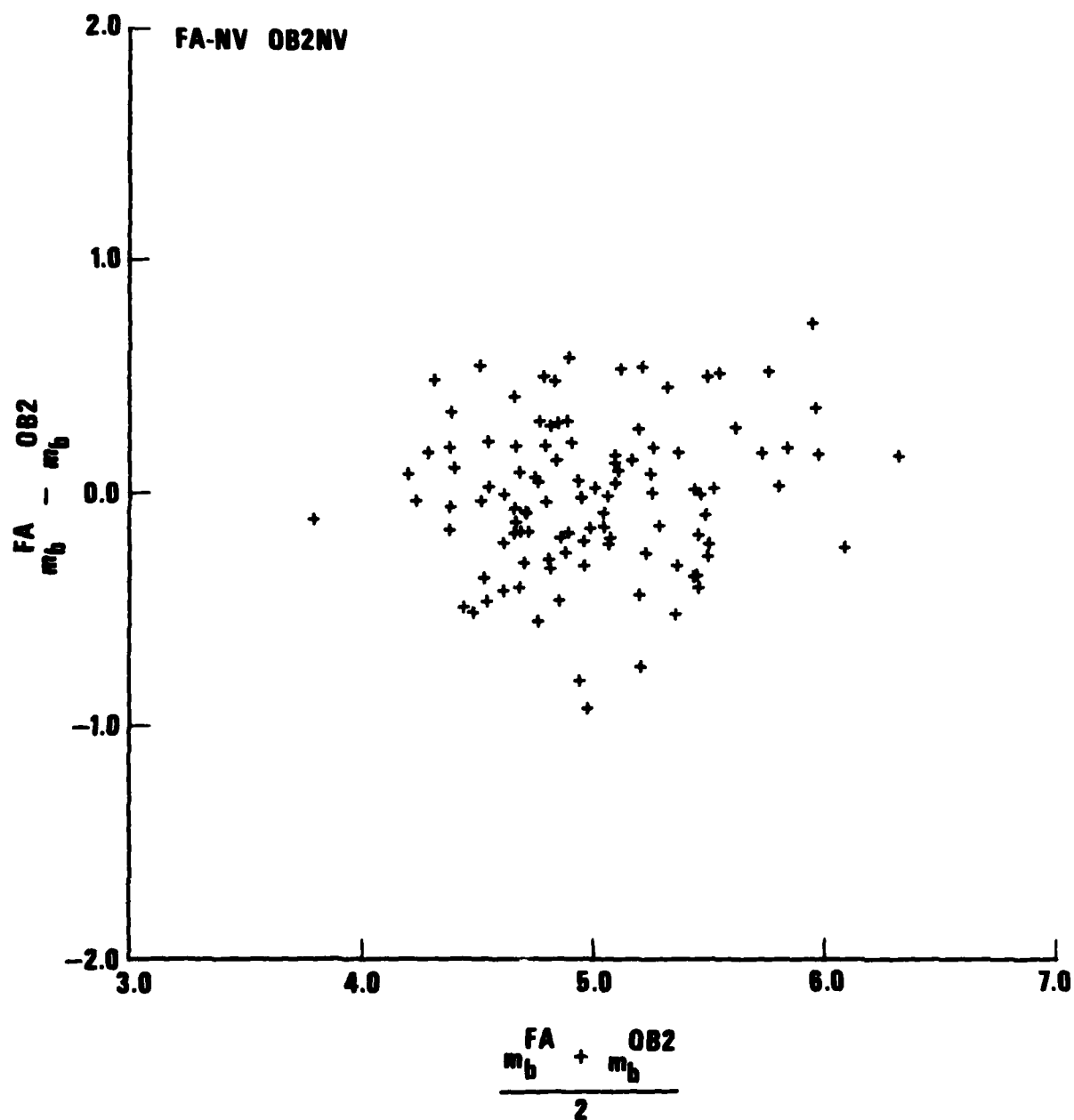


Figure 12 Interstation m_b differentials plotted against the two-station average m_b for the station pair FANV - OB2NV. The absence of any clear increasing or decreasing trend indicates that magnitude threshold biases are not present (see text).

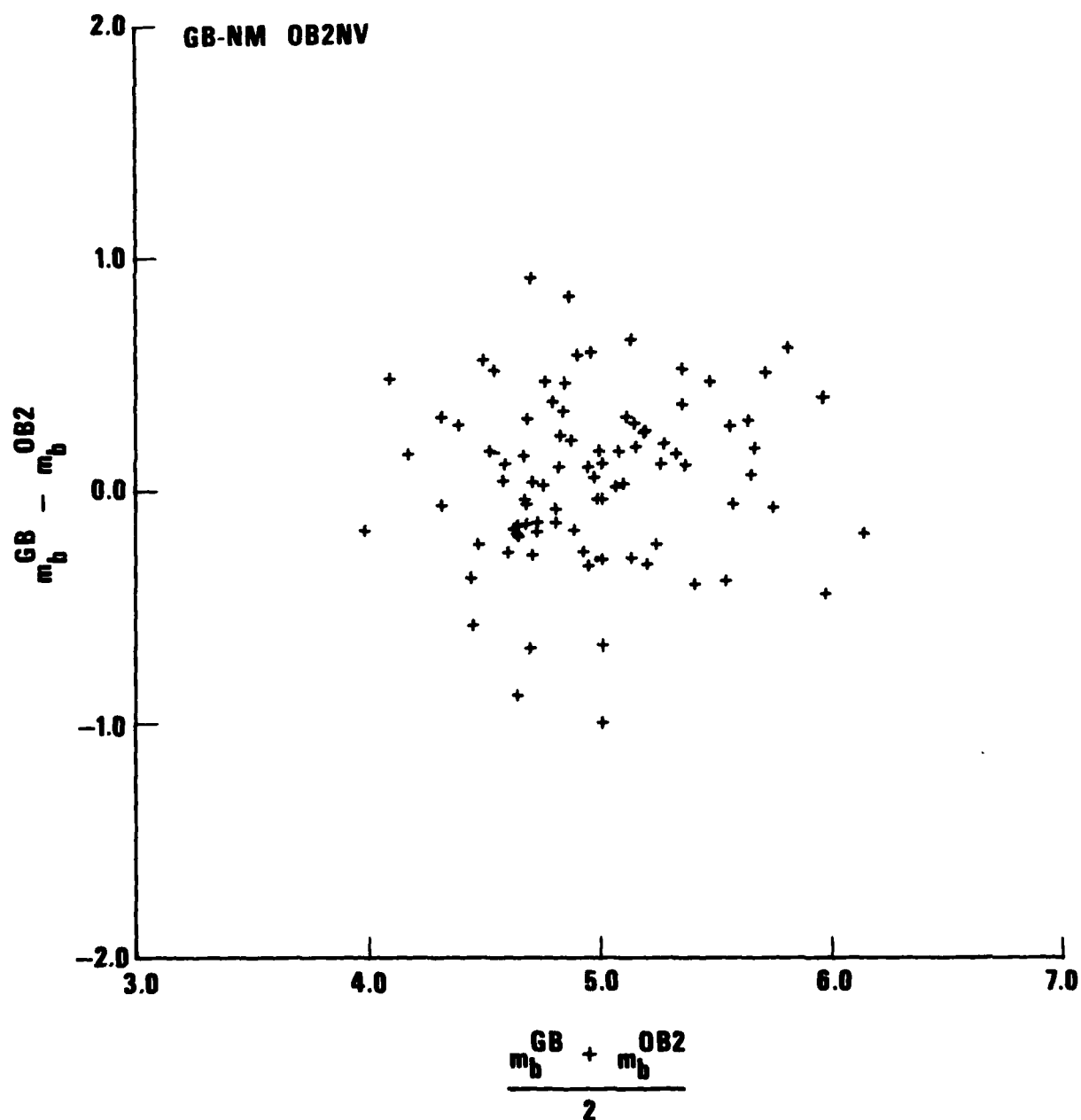


Figure 13 Interstation m_b differentials plotted against the two-station average m_b for the station pair GBNM - OB2NV. The absence of any clear increasing or decreasing trend indicates that magnitude threshold biases are not present (see text).

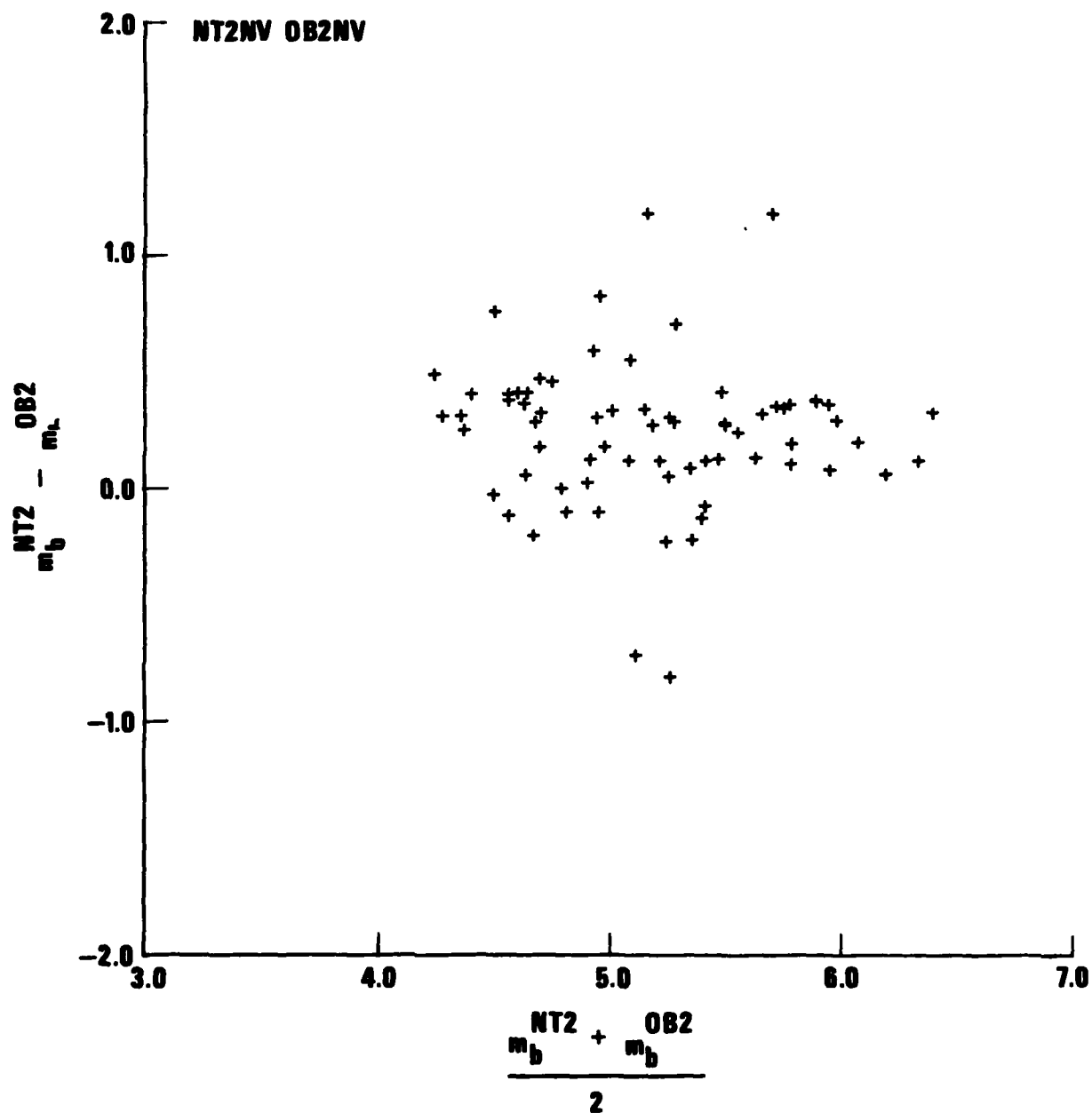


Figure 14 Interstation m_b differentials plotted against the two-station average m_b for the station pair NT2NV - OB2NV. The absence of any clear increasing or decreasing trend indicates that magnitude threshold biases are not present (see text).

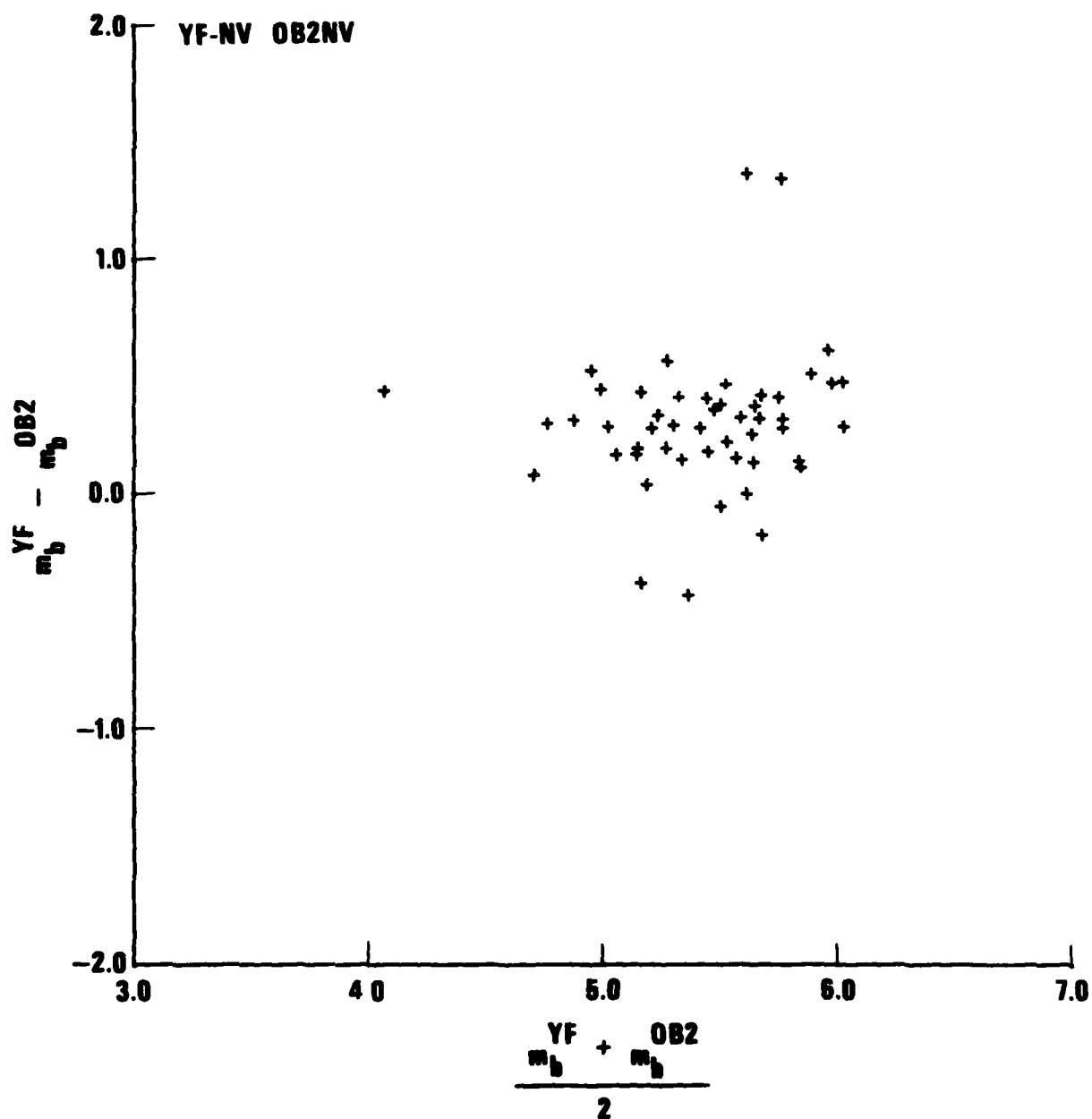


Figure 15 Interstation m_b differentials plotted against the two-station average m_b for the station pair YFNV - OB2NV. The absence of any clear increasing or decreasing trend indicates that magnitude threshold biases are not present (see text).

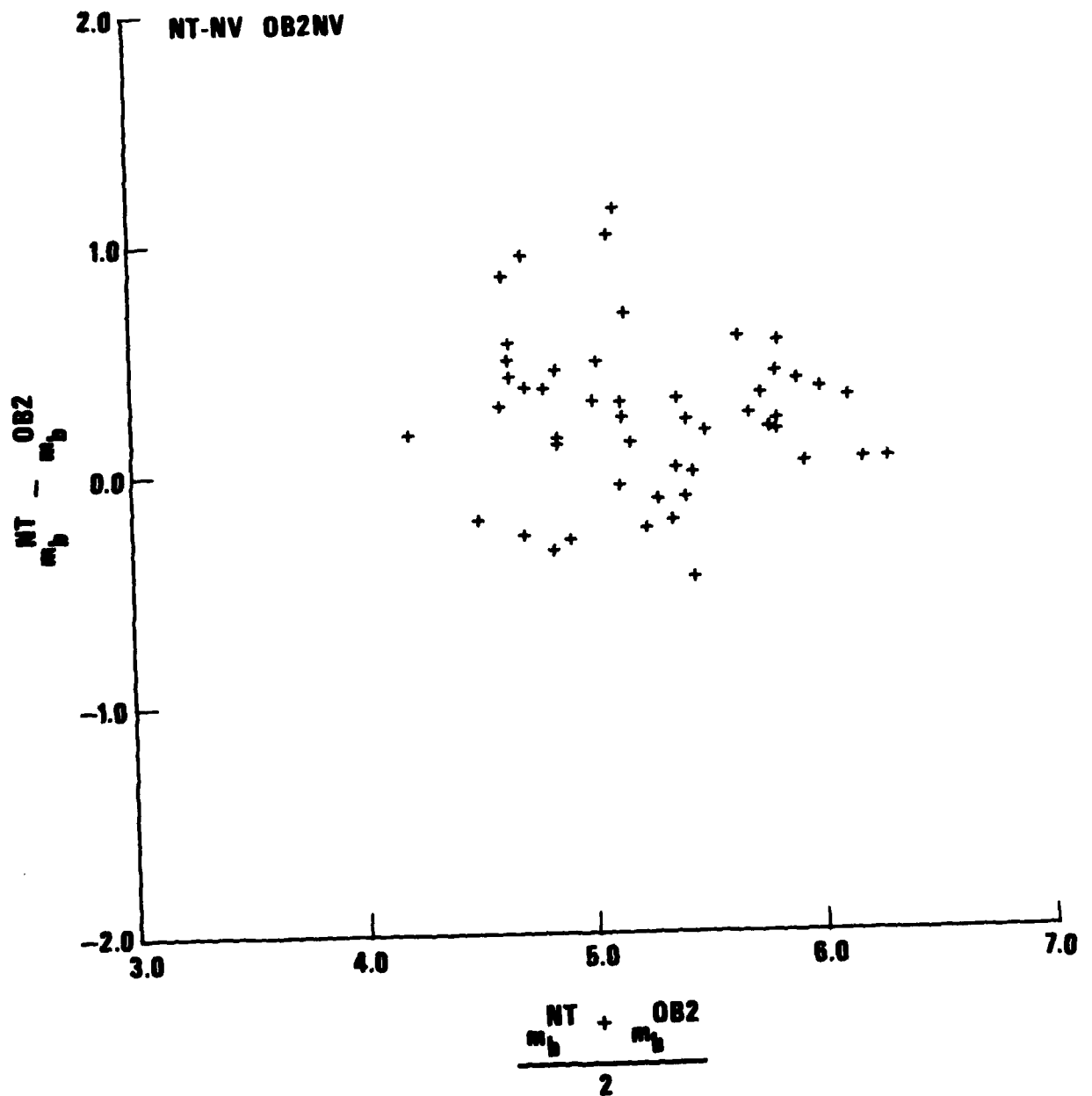


Figure 16 Interstation m_b differentials plotted against the two-station average m_b for the station pair NTN - OB2NV. The absence of any clear increasing or decreasing trend indicates that magnitude threshold biases are not present (see text).

and plotted these symbols against azimuth and distance to OB2NV. Any regional bias such as a consistent orientation of fault planes would cause similar symbols to cluster in some regions. No such clustering is discernible on the diagram shown in Figure 17, and therefore there are no indications of source related biases.

Elimination of source region bias does not mean that near-station azimuthally dependent focusing on small scale crustal inhomogeneities is not present in the data. Such biases cannot at present be removed from these data sets since most of the events occur in belts of seismicity, and thus the azimuth-distance distribution of events is uneven.

Anelastic Attenuation as the Cause of the RKON-OB2NV Magnitude Differential

Having demonstrated the existence of magnitude differentials at the various SDCS stations, we turn now to their cause. In our opinion, anelastic attenuation is responsible for most if not all of the observed differentials. However, since station amplitude or magnitude anomalies are subjected to biases by such factors as crustal inhomogeneities, it is important to find diagnostics that indicate that the magnitude differentials are indeed due to anelastic attenuation.

Concentrating on the critical RKON-OB2NV pair (often used in key arguments in this report), strong support for anelastic attenuation can be found by the simple technique of subdividing the event population at RKON into high frequency (broad band) signals and low frequency (narrow band) signals based on the dominant period. The two populations are identified as $T \leq \bar{T}$ and $T > \bar{T}$, where $\bar{T}$ is the average period for the station for all events. These populations should behave as predicted in the discussion in section B of Part III of this report. This appears to be the case. As shown in Figure 18, the histogram of base 10 logarithms of trace amplitude differentials corrected for distance shows that the differential in trace amplitude is greater for the population $T \leq \bar{T}$, which agrees with the hypothesis that high frequency events undergo greater attenuation. Histograms of $\Delta m'_a$ (magnitudes computed without dividing by the period) show reduced differentials for both populations, and at the same time the difference in the means of the two populations also decreases. This is due to the over-correction associated with the assumption of a monochromatic signal (see section B). Finally, the last line of

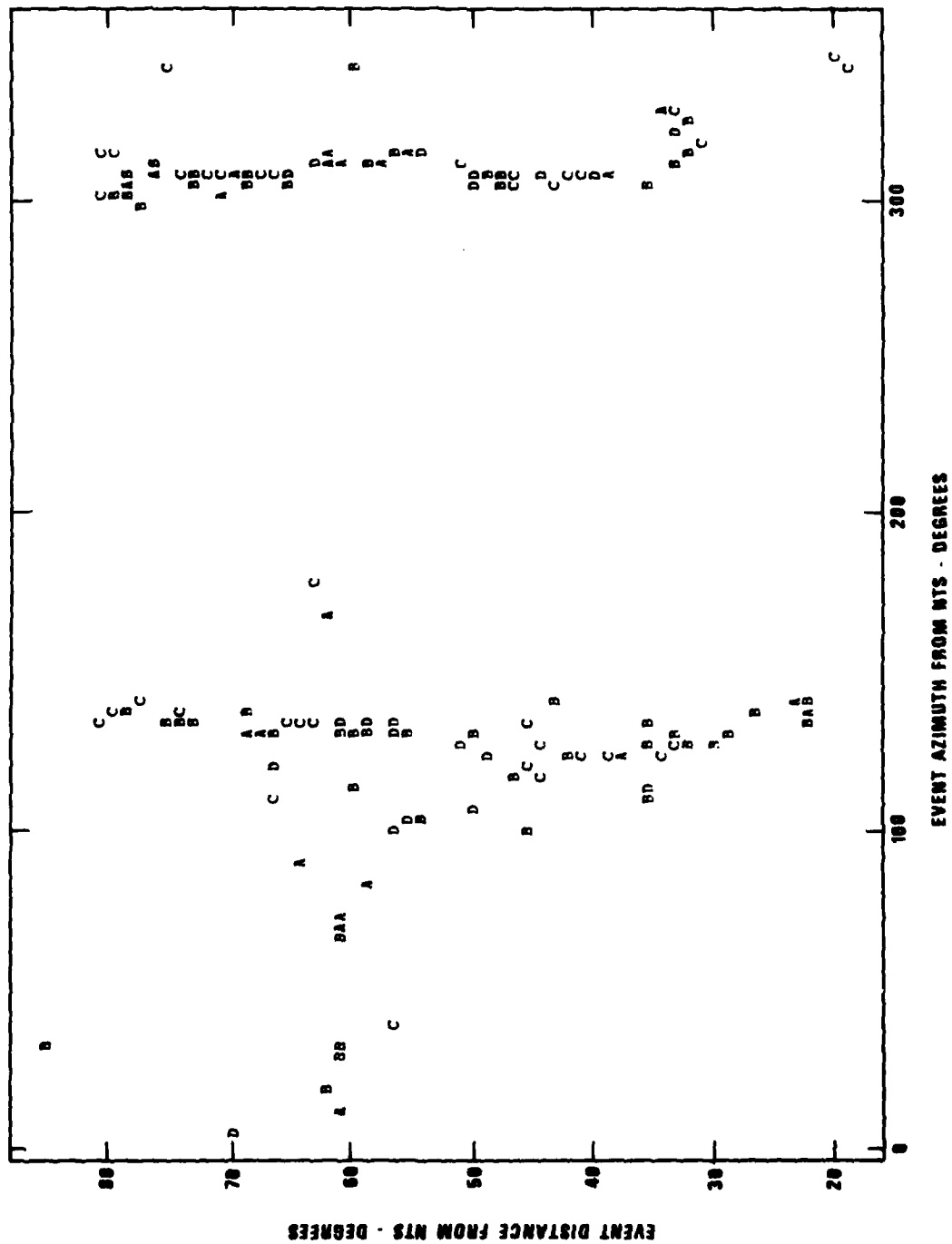


Figure 17 Plot of magnitudes of interstation m_b differentials for the RKON-OB2NV pair against distance and azimuth of OB2NV. The absence of any clear clustering of symbols in any region indicates that there are no source region biasing effects due to dominant source orientations (see text).

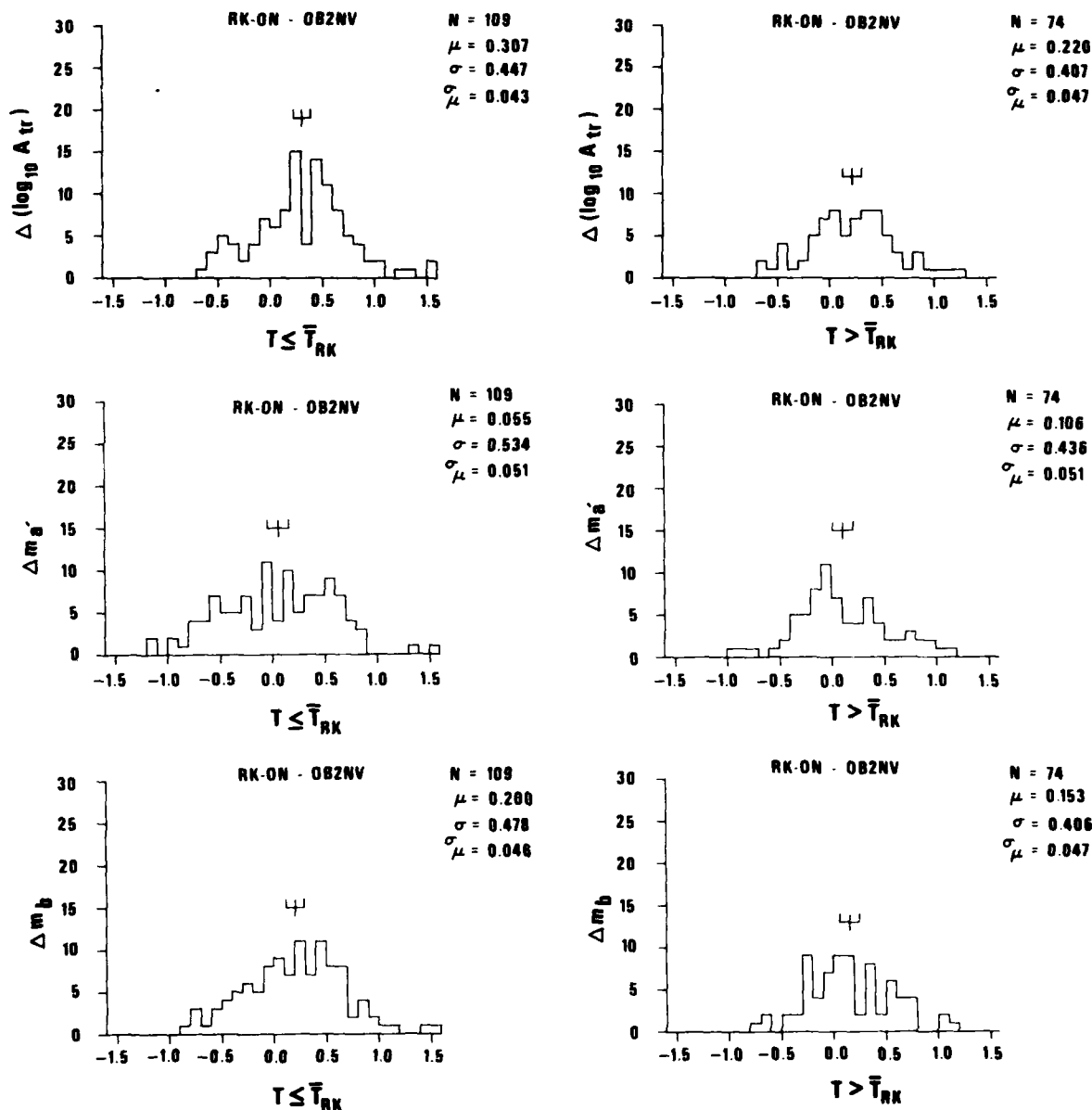


Figure 18 Subdivision of the event population into wide band and narrow band signal populations shows that a) the RKON-OB2NV trace amplitude differential is less for narrow band longer period signals (top row), b) the differential is reduced in m'_a , trace amplitude divided by the instrument magnification at the dominant period measured. This reduction is greater for wide band signals (middle row) and c) division by period T causes the increase of m_b differential relative to that of m'_a , and the increase is greater for wide band signals. This behavior is diagnostic of attenuation as a cause for the RKON-OB2NV magnitude differential (see text and section B of Part III).

Figure 18 shows the m_b computed by dividing by the period. This tends to restore the regional differential since the period is shorter at RKON than at OB2NV. The period differential is also greater for the population $T \leq \bar{T}$ as predicted in section B and judging by the increase of Δm_b versus $\Delta m'_a$.

This behavior is quite consistent with the interpretation of the OB2NV-RKON magnitude differential as an attenuation effect, and it effectively rules out many other interpretations such as accidental local focusing. One feature of this reasoning is that it is based entirely on time domain measurements and should suit those who dislike spectral arguments.

SPECTRAL ANALYSIS

Relative t^* values (Δt^*) for the SDCS stations have been computed by the spectral ratio method. Because computing spectral ratios for all possible pairs of stations is redundant, we computed ratios for station pairs directly connected by lines in Figure 19. Differentials in t^* and their standard deviations ($\sigma_{\Delta t^*}$) for other station pairs can be derived easily from these results. This approach takes advantage of the fact that for closely located station pairs, $\sigma_{\Delta t^*}$ has smaller variance than for distant pairs of stations. (This will be discussed in more detail later.) Thus, for example, determining Δt^* for the RKON-OB2NV and OB2NV-YFNV pairs is more reliable than determining Δt^* directly from the few events common to RKON and YFNV alone. This approach is also the most practical because during the project's two phases many events for the RKON-OB2NV pair were available to reduce the variance of their mean Δt^* , while only a few events were sufficient to define Δt^* for the OB2NV-YFNV pair to the same accuracy.

The histograms of the measured Δt^* are given in Appendix D. In addition to those involving the new stations of Phase III, updated versions of histograms for the OB2NV-RKON and HNME-RKON pairs are presented. In all cases, an accuracy ($2\sigma_{\Delta t^*}$) of ~ 0.05 sec was the goal.

The easiest way to discuss the Δt^* values is to compare them to a common standard station. Figure 20 summarizes the results using OB2NV as the standard. As mentioned above, some of these Δt^* mean values and their standard deviations were derived indirectly. This figure also includes some relative t^* data at SZNV (SHOAL site, on granite) and SEMN with the assumption that t^* at SEMN is the same as at RKON. This can be justified easily by S wave data shown later in this report. Figure 20 shows that all WUS stations have essentially the same t^* as OB2NV except stations NTNV and NT2NV, which have slightly lower t^* than OB2NV. On the other hand, the RKON-OB2NV differential in t^* is about 0.2 sec and highly significant statistically. The HNME-OB2NV differential is less (0.1 sec), but it is also significant at the 95% confidence level. This lower value indicates some attenuation under the northeastern U.S., a possibility suggested by Solomon

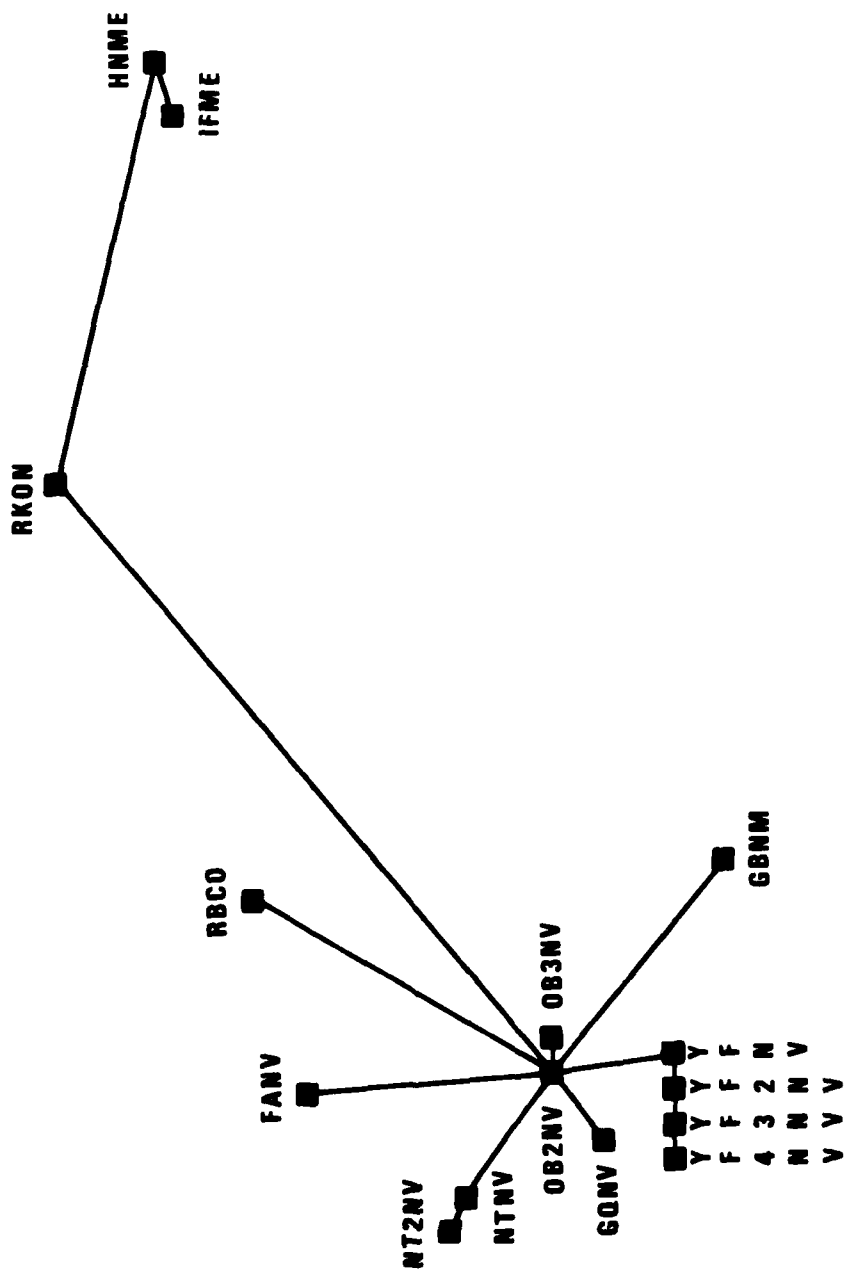


Figure 19 Hierarchy of station pairs selected for spectral ratio computation.

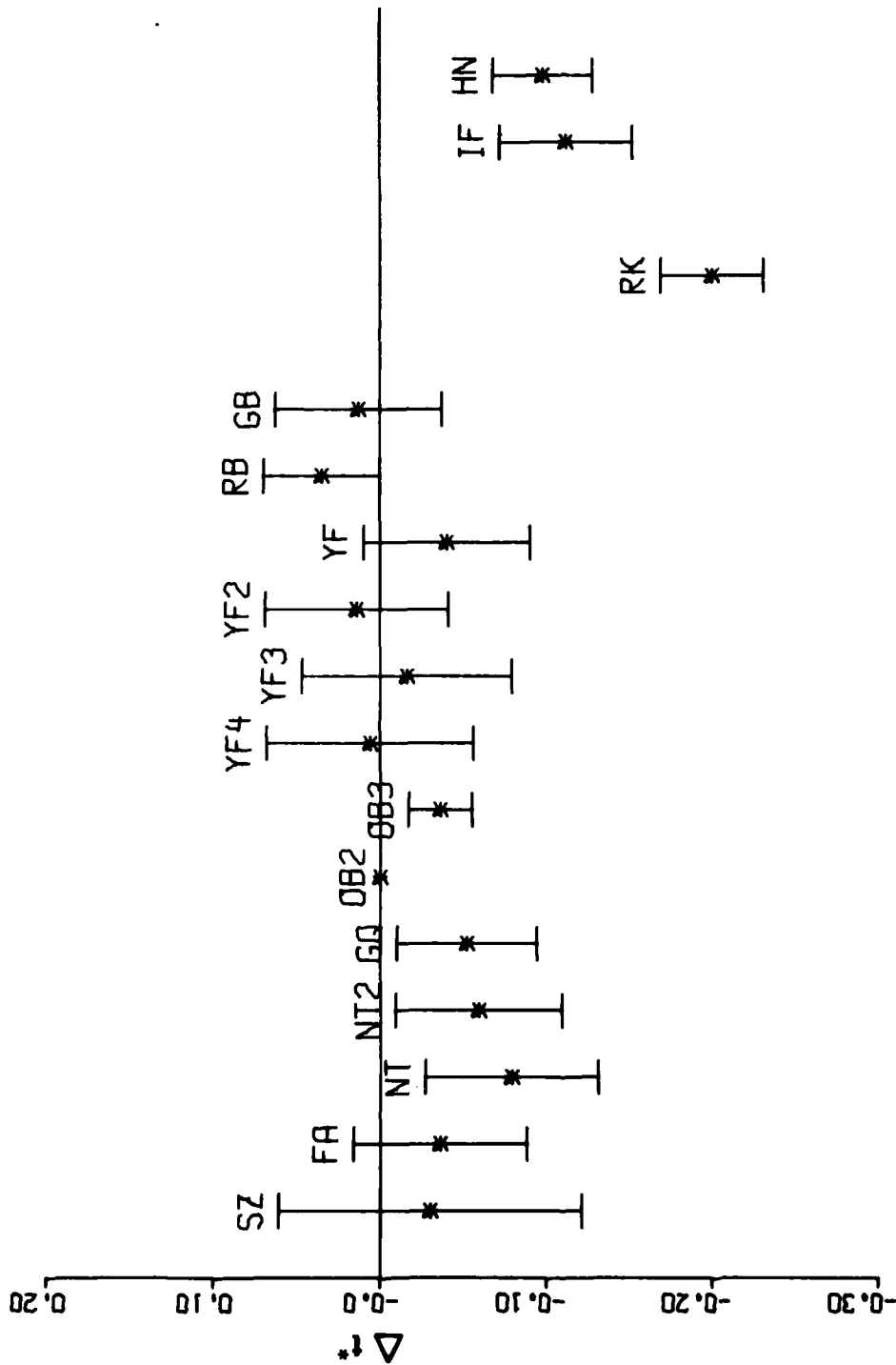


Figure 20 Δt^* values of selected SDCS and LRSM stations relative to that of OB2NV. RKON on a shield has the lowest t^* , while the WUS stations have the largest. 95% confidence limits are indicated by bars.

and Toksöz (1970) and Der et al (1975). The t^* at IFME is comparable to that at HNME.

There was some difficulty with the Yucca Flat stations in reliably determining t^* . This difficulty resulted from high unstationary noise levels due to drilling. As a result, the standard procedure for estimating noise in the signal window (taking spectra of time windows prior to the arrival of the P wave) failed repeatedly. Many of the spectral ratios supposedly show points with high S/N (around 4 Hz) that disagree with the trend at lower frequencies. This can be attributed to nonstationary noise rather than to real signal energy at 4 Hz, which should be far beyond the corner frequency expected for most events. Moreover, crustal response calculations rule out major enhancements of high frequency energy. Thus, the reader should assign less weight to the t^* determination at YF stations.

Returning to Figure 20 the OB2NV-OB3NV differential, although small, is significant statistically. t_p^* for stations NTV, NT2NV and GQNV appears to be smaller than that at OB2NV and Yucca Flats although significantly higher than that of RKON. A high-Q high-velocity plug may be present under Pahute Mesa as suggested by Spence (1974), and this could also affect measurements at nearby GQNV. The high frequency content of L_g is also visibly enhanced at Pahute Mesa (Barker et al, 1980). Since L_g propagates entirely in the crust, this may indicate that the apparently low t^* at NTV and NT2NV could be no more than a local crustal resonance effect. We have no preferred interpretation of this.

As shown in Figure 21, the dominant periods of P waves behave similarly to the Δt_p^* values of Figure 20. ΔT is smaller at NTV, NT2NV, and GQNV than at OB2NV and the Yucca Flats stations. Moreover, all of the WUS stations have ΔT values significantly higher than that of RKON. Periods at HNME are not comparable to those of other SDCS stations due to the difference in instrumentation at HNME. Histograms of ΔT for the rest of the SDCS Network are compiled in Appendix E.

As mentioned earlier, the standard deviation of relative t^* values also depends upon mutual distance between stations in a manner similar to that shown by the magnitude residuals. A plot of $\sigma_{\Delta t^*}$ versus Δ° is shown in Figure 22. Note that the numerical values of $\sigma_{\Delta t^*}$ are smaller and increase

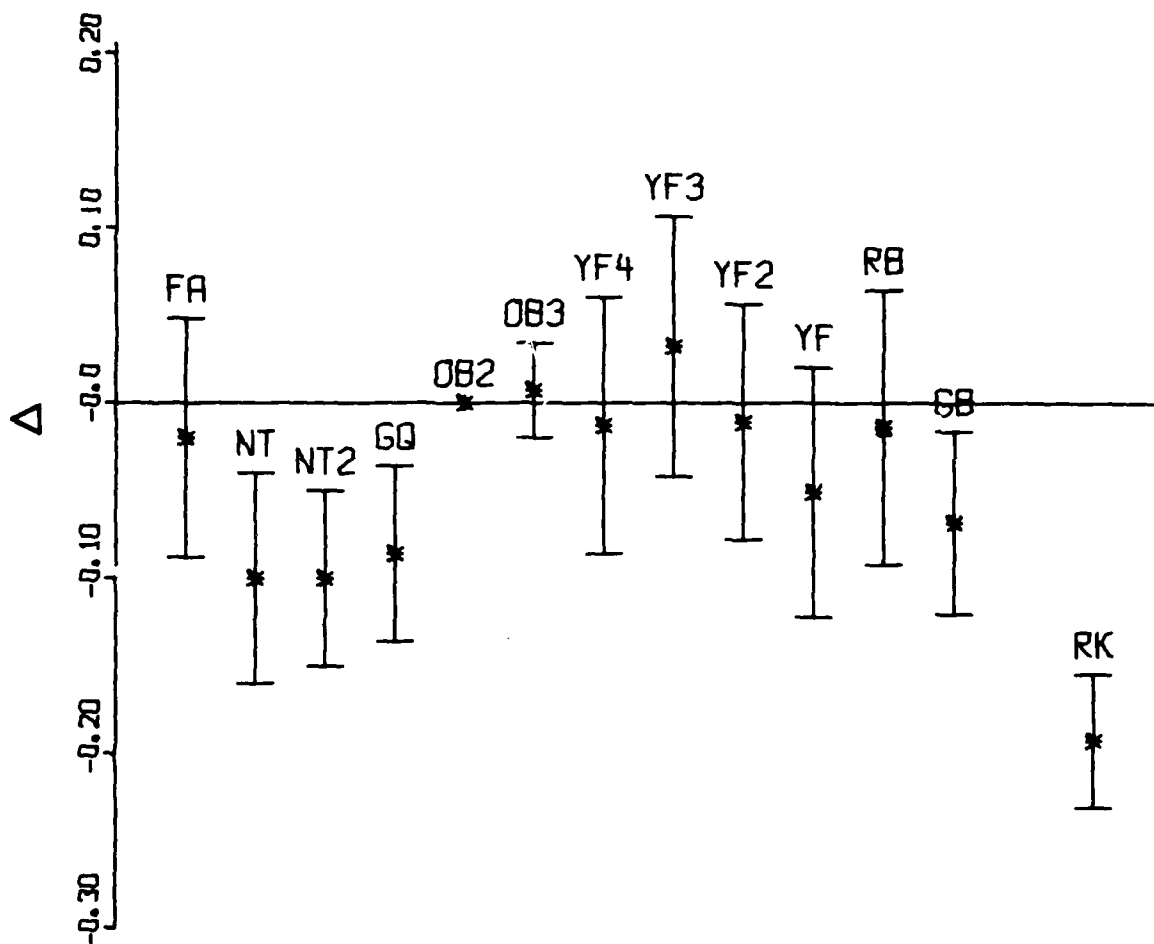


Figure 21 Differentials in dominant period T relative to OB2NV. 95% confidence limits are indicated by bars. RKON has the shortest dominant period. HNME is omitted because its instrument response is different from that of the other stations. No direct comparison of IFME with the rest of the stations was possible.

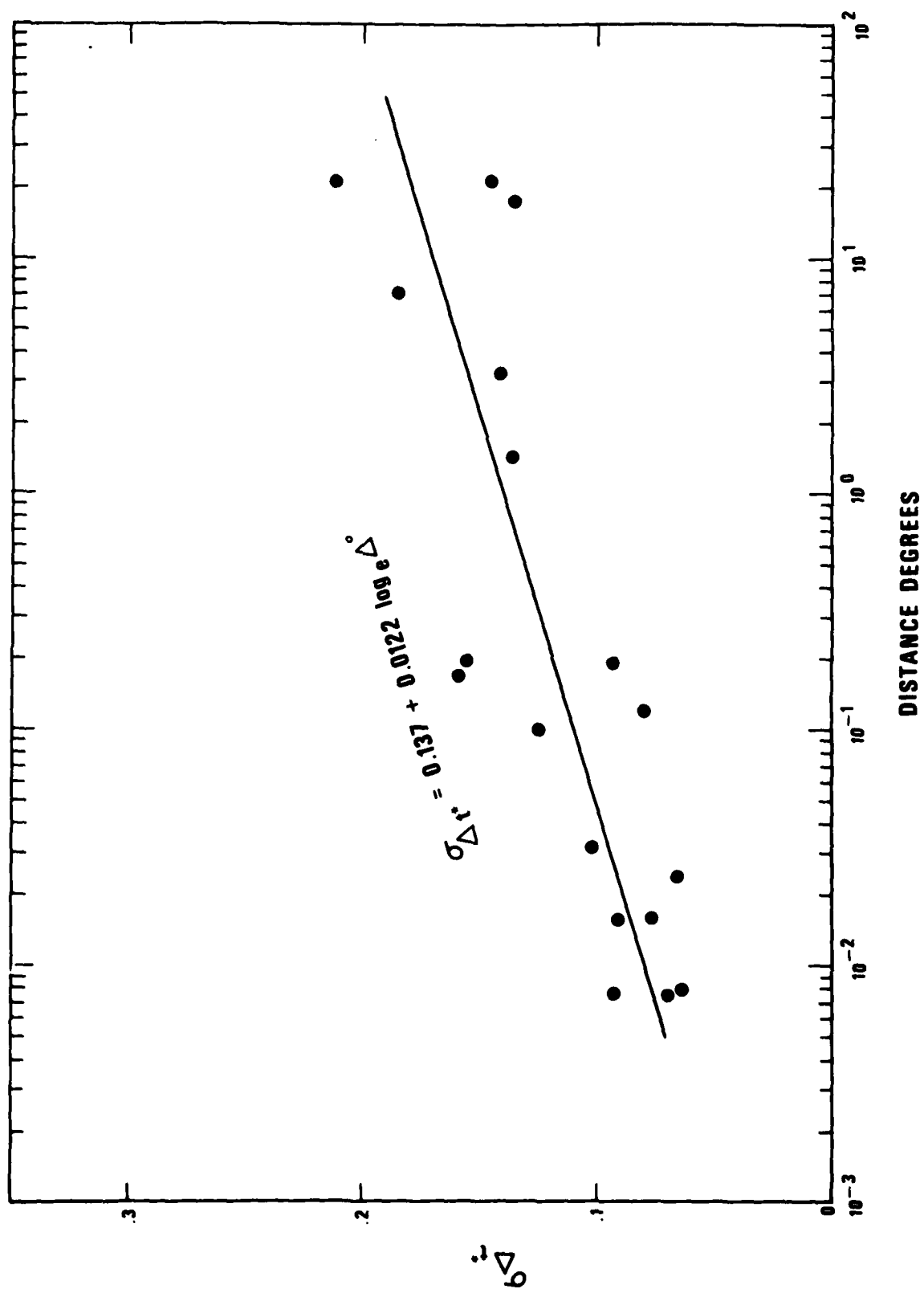


Figure 22 Standard deviation of relative t^* differentials vs. interstation distance.

more slowly with distance than $\sigma_{\Delta m_b}$. Because absolute numerical values of Δm_b and Δt^* are both of the order of a few tenths in magnitude units and seconds, respectively, fewer measurements are needed to establish Δt^* between stations than to determine magnitude residuals. This result is in agreement with experience at seismic arrays and shows that Δt^* is numerically a more stable quantity than Δm_b in terms of multipathing and other disturbances (Der et al, 1977).

Narrow Band Determination of t^* Differential for RKON and OB2NV

In order to see whether the Δt^* value we computed depends excessively on the low level high frequency end of the spectrum (3 to 4 Hz), we recomputed the relative t^* between RKON and OB2NV using spectral slope fits in the narrower 0.5 to 2 Hz band. A strong frequency dependent variation in the relative t^* differential between OB2NV and RKON would result in a drastically different t^* differential for this narrower band. Figure 23 shows that this is not the case--the relative t^* differential $0.24 \pm .06$ sec is not significantly different from the wider band value of $0.20 \pm .03$ sec. This demonstrates that our results do not depend on low level high frequency energy, the existence of which is questioned by some researchers. This statement is also supported by the fact that time domain measurements that depend primarily on the 1 to 2 Hz band are also indicative of t^* , variation between RKON and OB2NV. The above result also rules out a rapid change with frequency in the interstation t^* differential above 1 Hz.

Testing for some Biases in Relative t^*_p Measurements

To see whether any source region bias is apparent in the measured relative t^* , we separated the RKON-OB2NV Δt^* values into four groups designated by different symbols as follows:

Symbol

- A $(\Delta t^* - \mu) < -\sigma$
- B $-\sigma < (\Delta t^* - \mu) < 0$
- C $0 < (\Delta t^* - \mu) < +\sigma$
- D $(\Delta t^* - \mu) > +\sigma$

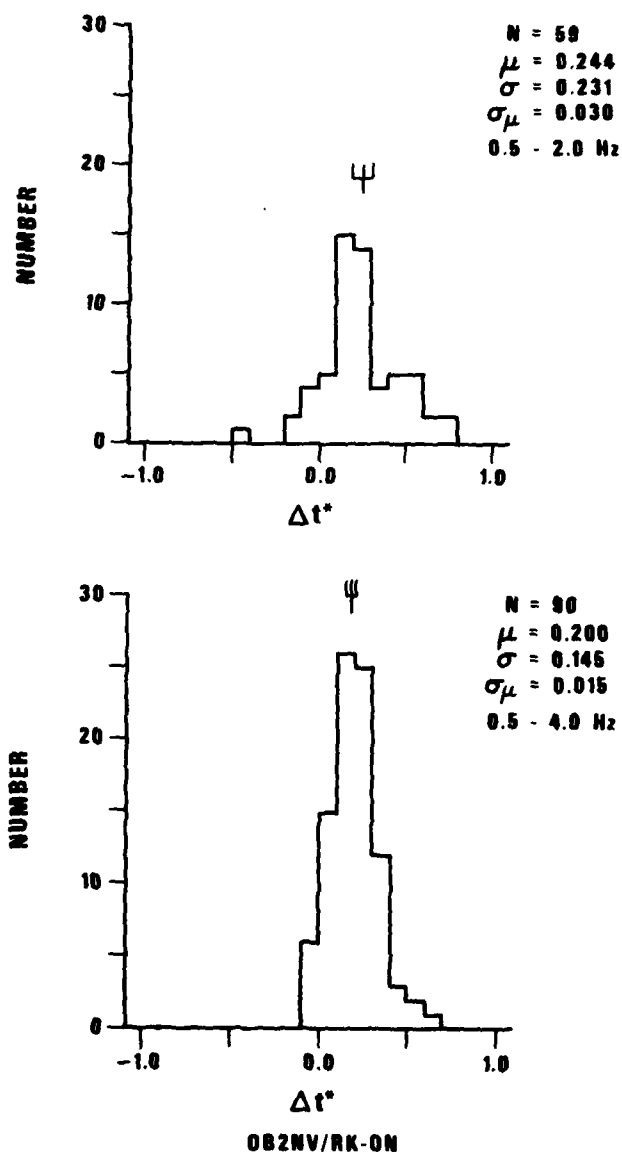


Figure 23 Histograms of OB2NV-RKON t^* differentials computed in the 0.5 to 2.0 Hz and the 0.5 to 4.0 Hz bands. The fact that the narrow-band average differential is about the same as that computed in the 0.5 to 4.0 Hz range (0.244 versus 0.200) rules out rapid change of relative t^* with frequency in this range, and shows that our t^* results do not depend critically on low level high frequency energy. Note that the scatter in these t^* histograms is small compared to that in Figures 3 and 4 for m_b and trace amplitudes, demonstrating the greater consistency of spectral measurements.

and plotted these symbols against azimuth and distance to OB2NV in Figure 24. This subdivision assigns the letter D to the largest t^* difference and A to the least. The resulting pattern shows no convincing evidence of regional biases. Such biases could in theory be due to directionality of finite sources that would result in consistent regional patterns of Δt^* if the fault planes were oriented in any consistent manner relative to the station pair studied. The lack of any such bias effect is not surprising since, although the geographical distribution of sources used is clearly non-random, the orientation of the trends of seismic belts, island arcs and the like relative to the OB2NV-RKON station pairs varies enough to eliminate such bias even if the source mechanism of all events were the same. But the fact is that sources in the seismic belt include a variety of mechanisms, and this further reduces chances for finding overall, consistent source related biases in the determination of Δt^* from averages of many events.

To demonstrate further that Δt^* behaves consistently, consider the recordings of a Novaya Zemlya explosion in Figure 25. On the left is the recording at OB2NV and on the right at RKON. This source is supposedly symmetrical azimuthally, but the trace amplitudes differ by a factor of 30, a dramatic illustration of the instability of amplitude measurements. The filtered traces shown below demonstrate that the P wave is richer in high frequencies at RKON than at OB2NV. The S/N ratio is high for this event. This figure also demonstrates that the concept of "transparency" used in time domain work is not a physically meaningful one. OB2NV was regarded as a "transparent" station in much of the time domain work of Butler et al (1979) and it is clearly not in this case. The waveform of P is quite complex. Experience at seismic arrays indicates that "transparency" is a function of near receiver focusing and thus varies with the azimuth of the events observed.

Studies of S Waves at SDCS Stations

Although the prime emphasis in this project was on P wave amplitude residuals and spectra, a limited search was made for short-period S waves recorded in the SDCS data base. The S wave data thus found is limited, and the S/N ratio of these signals is generally not good. In Figures 26 through

31 we show a few examples of short-period S waves and the spectral ratios computed from them. Due to the poor S/N ratios of these signals most of the spectral ratios are based over a frequency range of only 0.75 Hz. Nevertheless, the available data indicate that RKON is richer in high frequency content, and GBNM appears to have t_s^* values comparable to OB2NV. Due to the sparse data and the emphasis on m_b , S wave amplitude residuals were not studied at SDCS stations.

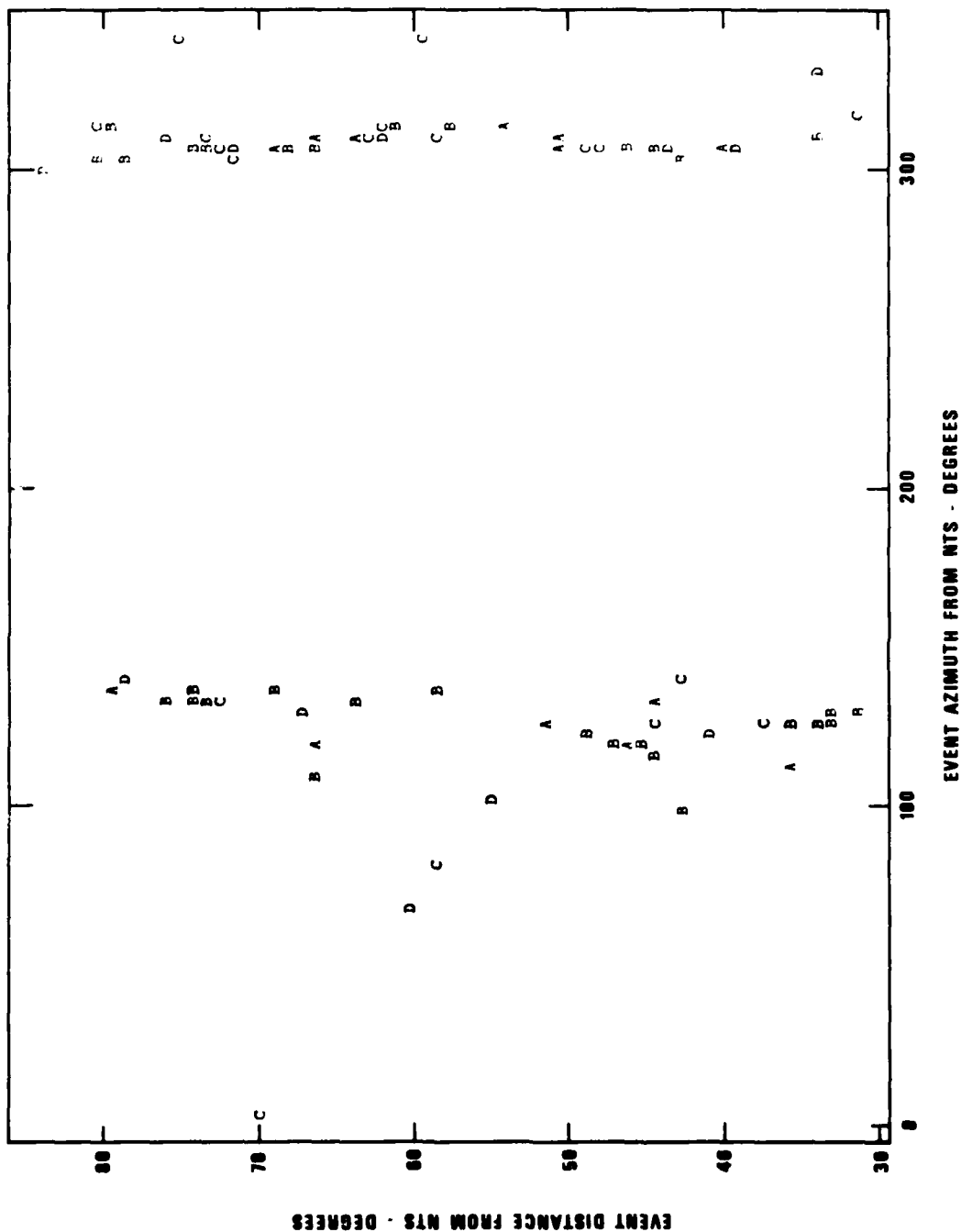
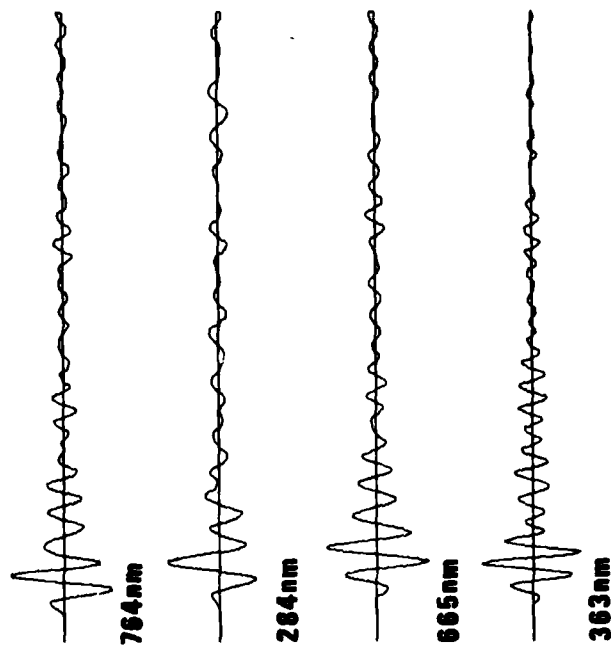
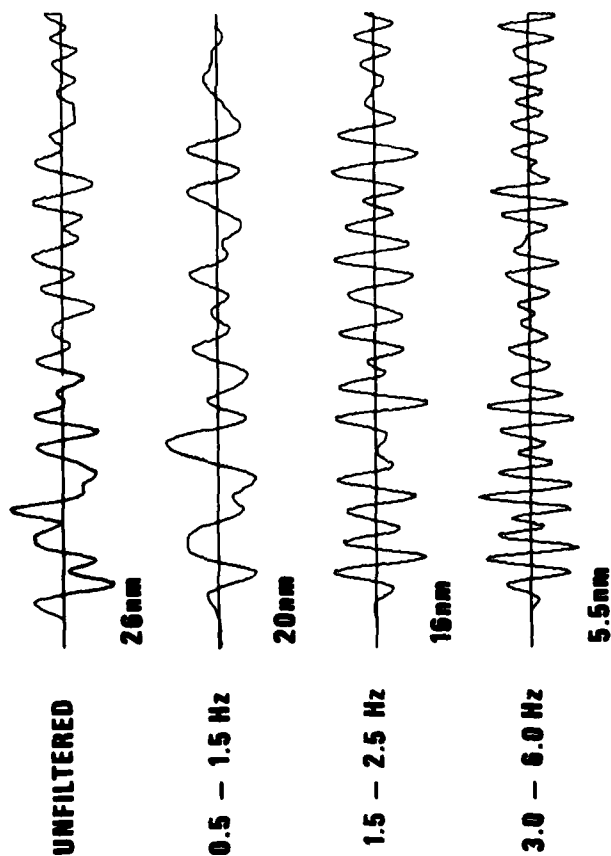


Figure 24 Magnitudes of t^* differentials for the OB2NV/RKON station pair plotted against distance and azimuth to OB2NV. The absence of clear clustering of symbols shown rules out any dominance of a preferred fault directivity in any region (see text).

RKON



OB2NV



0 1 2 3 4 5 SECONDS

Figure 25 Comparison of signals from a Novaya Zemlya shot recorded at OB2NV and RKON.

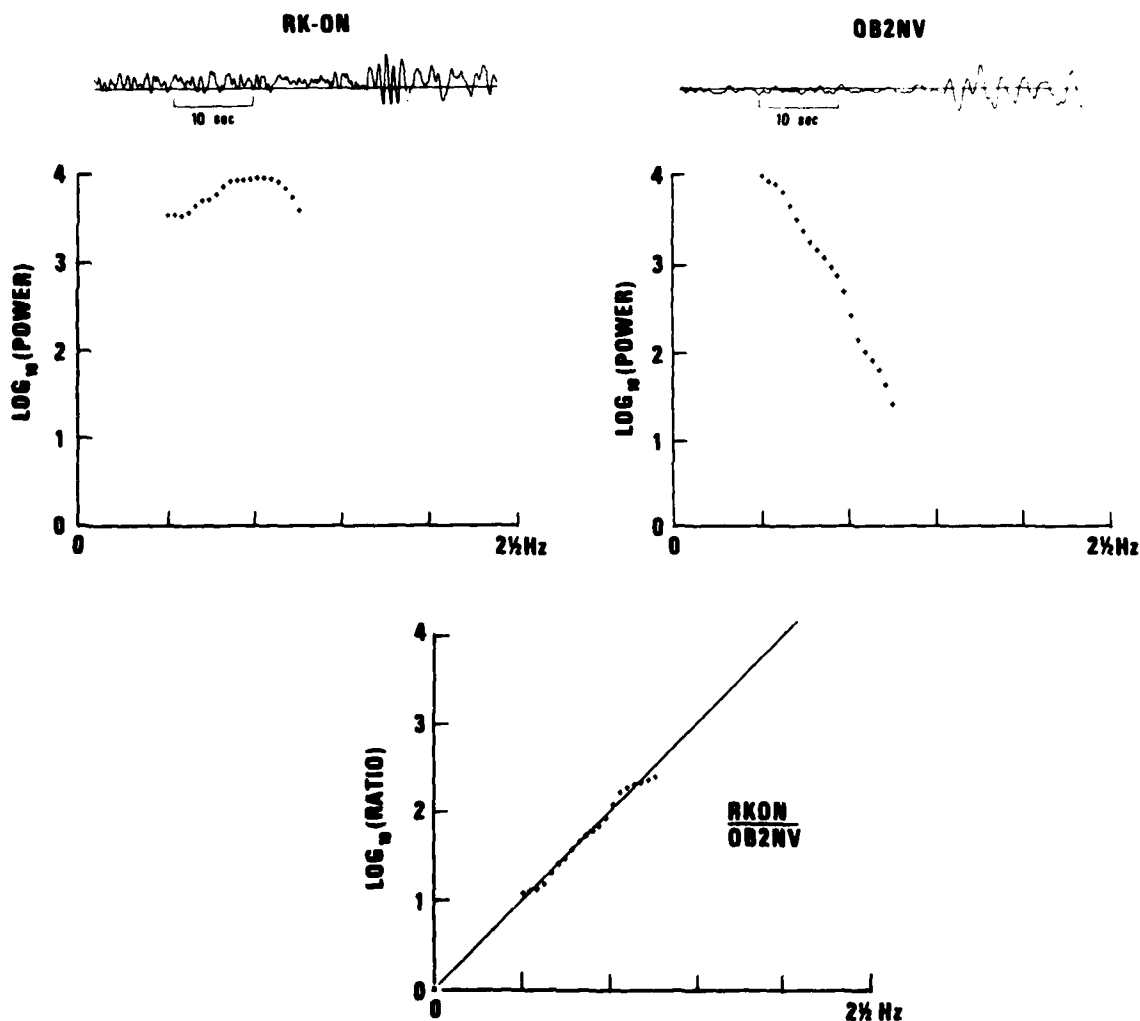


Figure 26 S wave spectra and spectral ratio for the station pair
RKON - OB2NV (radial component), 4 September 1977
23:20:48.0, Aleutian Islands.

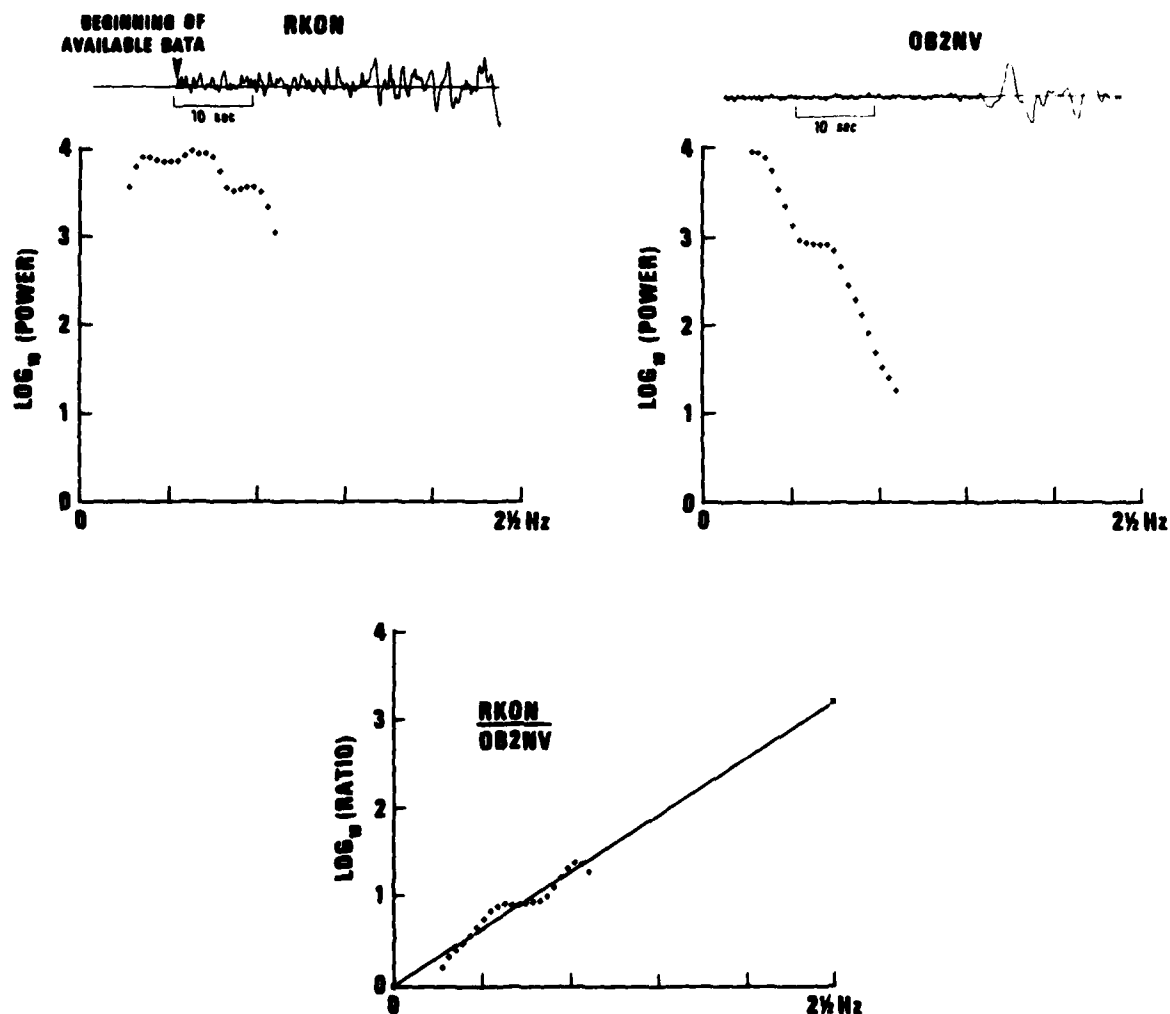


Figure 27 S wave spectra and spectral ratio for the station pair
RKON - OB2NV (transverse component), 4 September 1977
15:40:59.7, Aleutian Islands.

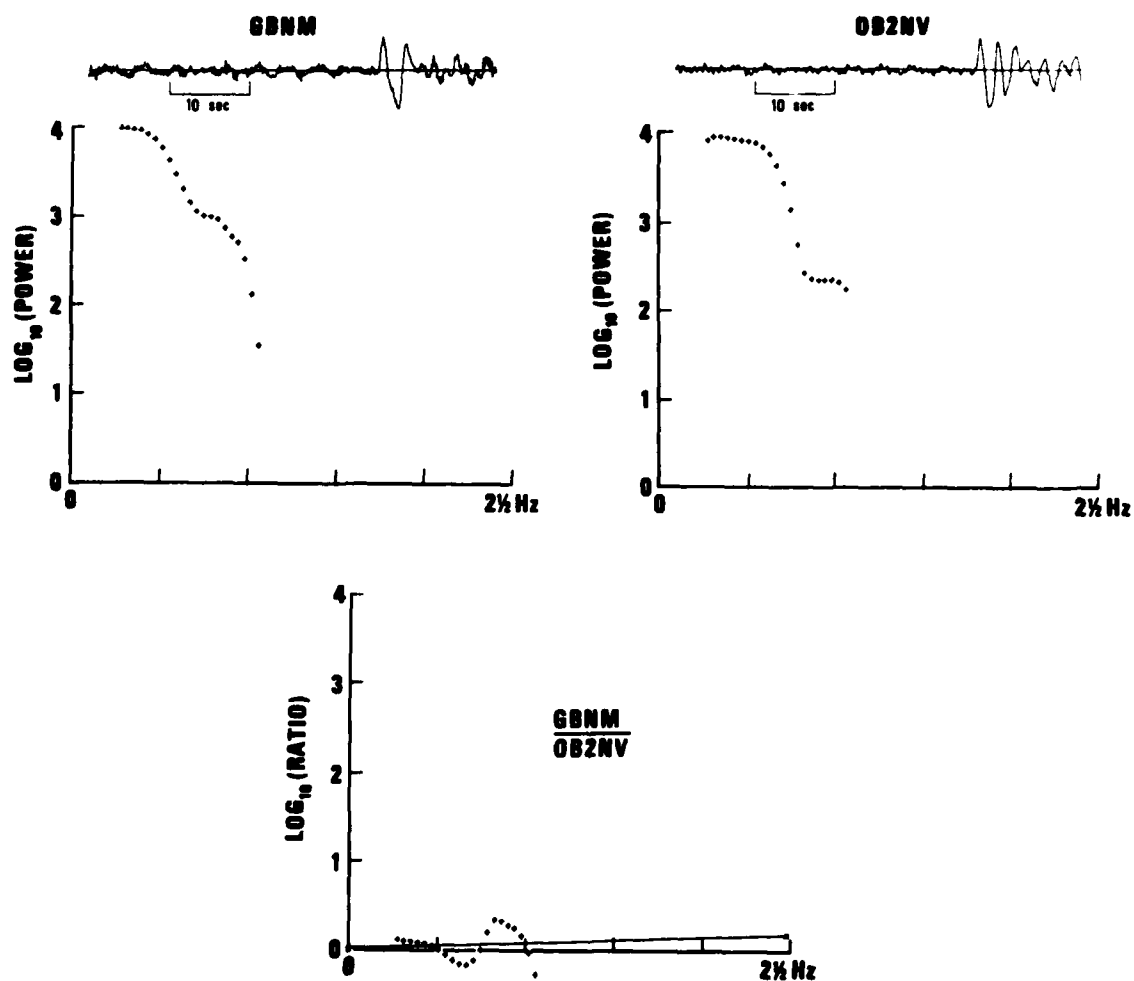


Figure 28 S wave spectra and spectral ratio for the station pair
GBNM - OB2NV (transverse component), 19 June 1977
11:47:22.3, Kurile Islands.

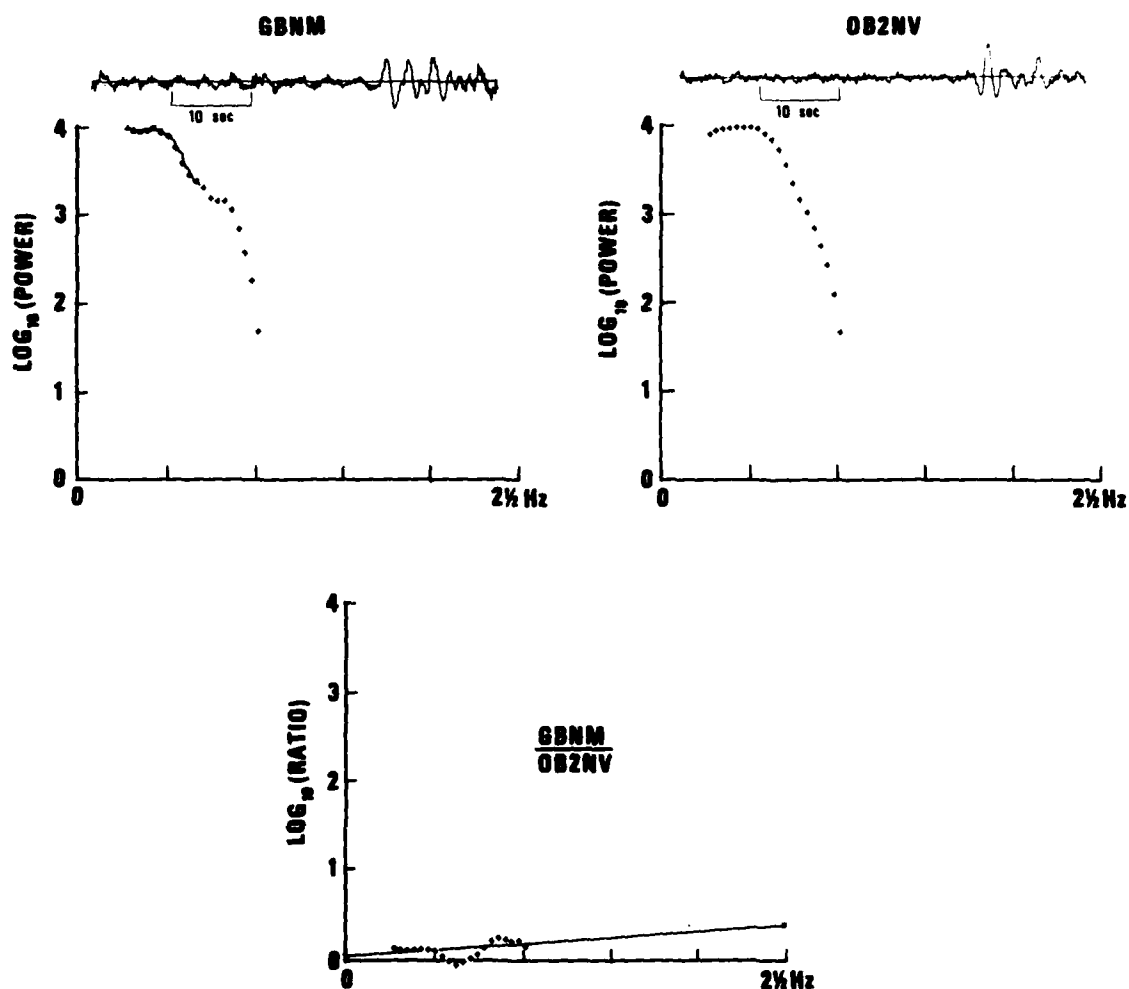


Figure 29 S wave spectra and spectral ratio for the station pair
GBNM - OB2NV (radial component), 19 June 1977
11:47:22.3, Kurile Islands.

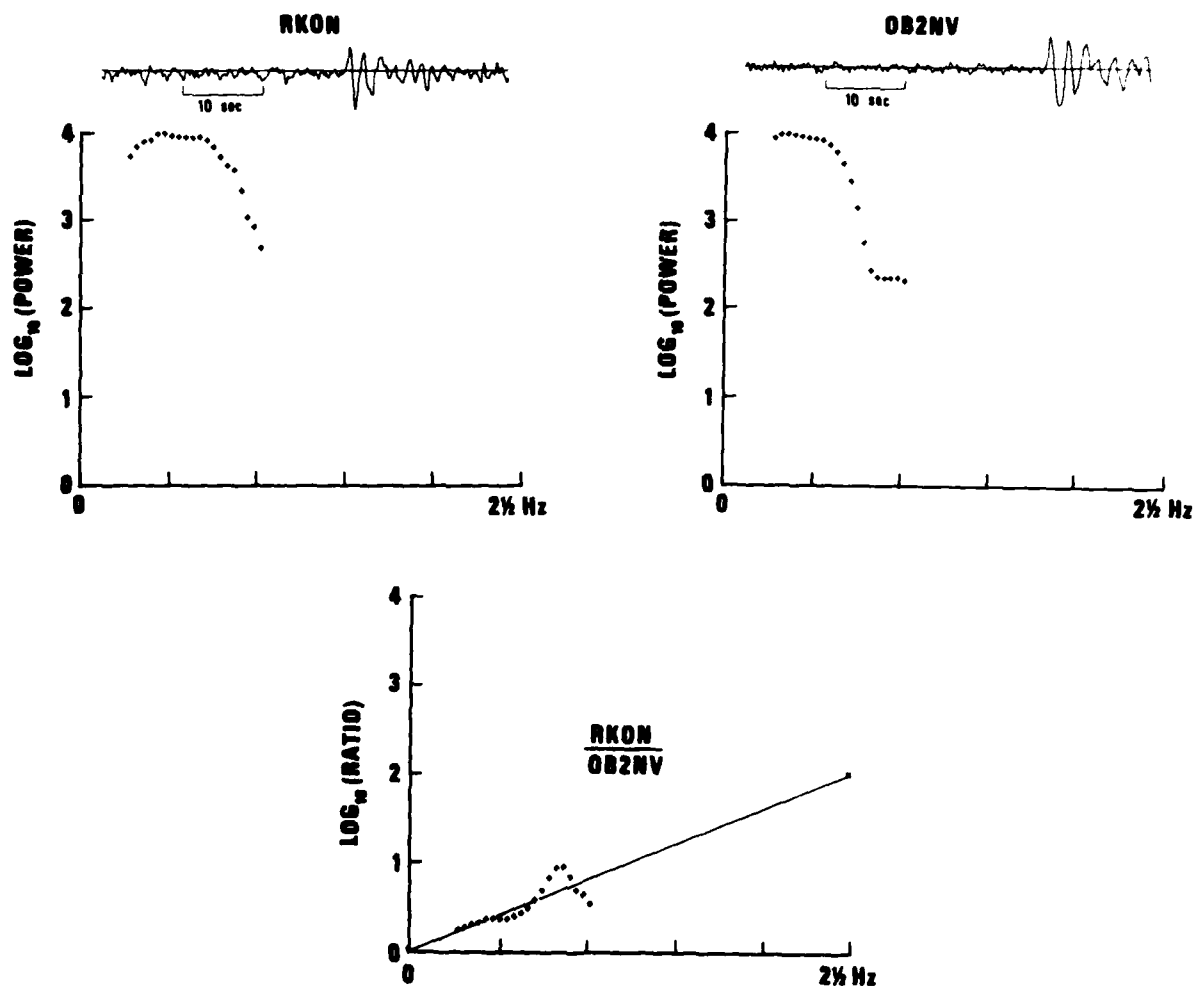


Figure 30 S wave spectra and spectral ratio for the station pair
RKON - OB2NV (transverse component), 19 June 1977
11:47:22.3, Kurile Islands.

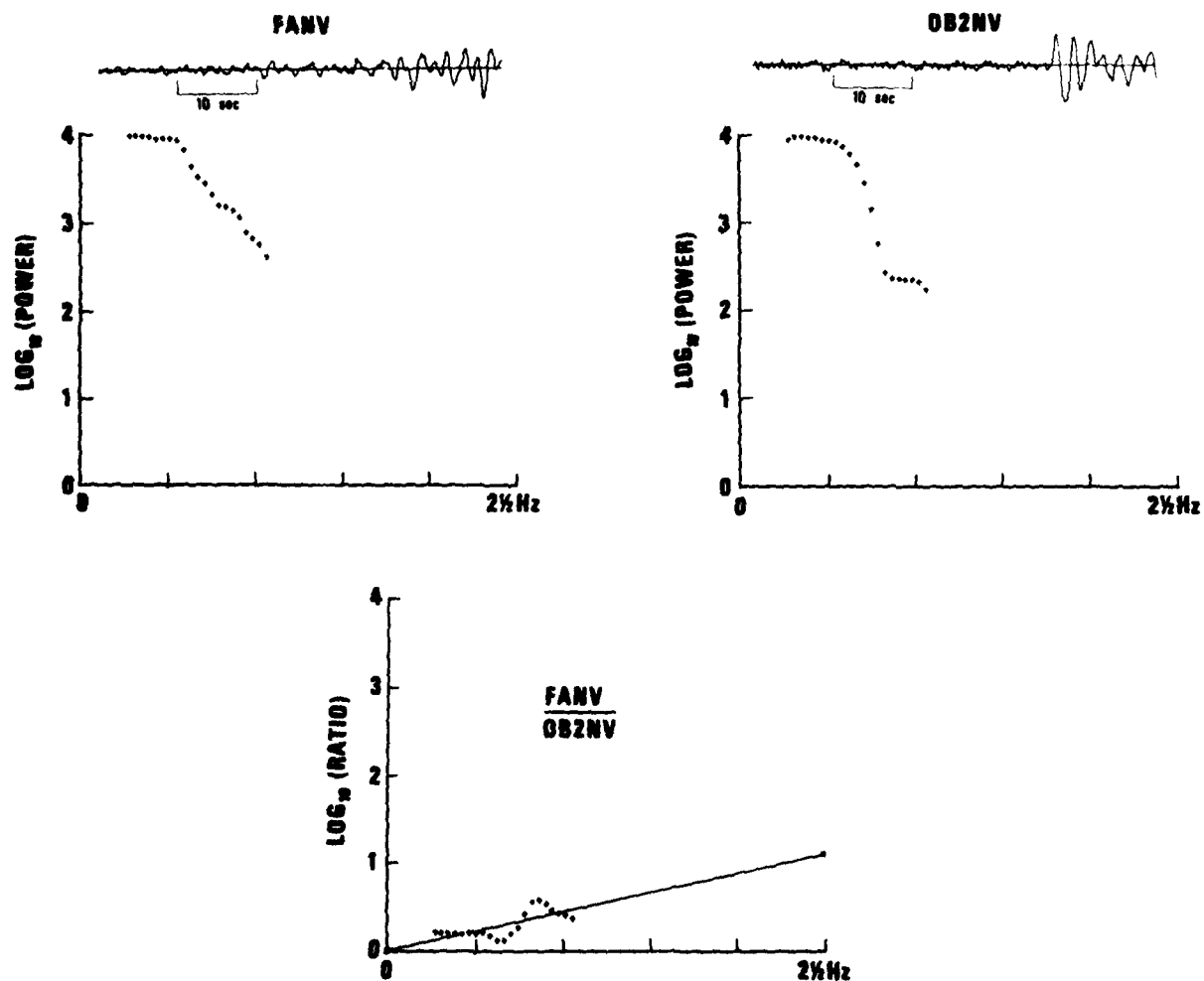


Figure 31 S wave spectra and spectral ratio for the station pair FANV - OB2NV (transverse component), 19 June 1977 11:47:22.0, Kurile Islands.

TRAVEL TIME RESIDUALS

Since P wave travel time residuals constitute an additional parameter that characterizes the physical state of the mantle under a given station, we have computed relative travel time residuals for all SDCS stations with sufficient data base. Late arrivals are commonly associated with high upper mantle attenuation and the presence of a low velocity layer in the upper mantle. Worldwide observations support the correlation of travel time residuals with highly attenuative properties and other diagnostic geophysical measurements such as S wave delays, heat flow, and electrical conductivity. In view of this fact, it is important to measure the relative travel time residuals among the SDCS stations in order to further evaluate the condition of the upper mantle under each station. Travel times for P waves were routinely compiled throughout the SDCS project, but it is only recently that we have accumulated sufficient data to compute travel time residuals.

The stations of prime interest are OB2NV, RKON and IFME, all of which are located on granite, though great distances apart. Determination of relative residuals between the members of this group is complicated by large scatter in the results of the computation. Generally speaking, the greater the distance between stations the greater the scatter. Thus, the problem is less serious for the group of stations located throughout the WUS (OB2NV, FANV, GBNM) since the relative distances are less. Finally, the stations at NTS constitute a tightly spaced group for which the measurement of relative residuals constitutes no difficulty.

In all travel time studies one also has to deal with some measurements which are grossly in error. This did not prove to be extremely difficult. In most cases, as a large number of readings was compiled, we found a tight group resembling a normal distribution with some very obvious outliers. We followed the standard statistical practice of computing the standard deviation σ for the tight group and omitting all points removed by more than 3σ from this group. The mean travel time residuals were then computed from the purged data set. Histograms of travel time differences for various station pairs are given in Appendix F. The differentials and their 95% confidence limites are tabulated in Table V.

TABLE V

Travel time residuals for selected SDCS stations relative to OB2NV

<u>STATION</u>	<u>ΔT</u>	<u>ΔT^{corr}</u>
FANV	0.03 ± 0.16	-0.52
GENM	-0.05 ± 0.25	-0.49
HNME	-1.28 ± 0.63	-1.04
NTNV	0.43 ± 0.23	-0.23
RKON	-1.89 ± 0.29	-1.68
YFNV	0.61 ± 0.22	0.37

As mentioned above, the standard deviations of travel time differentials have a distance dependence similar to those of the magnitude and t^* differentials. This is shown in Figure 32. The physical causes for this phenomenon are the increasing effect of mislocation of events with distance and the increasing probability of misreading the first arrivals due to the decreasing visual similarity of the signals.

Table V also shows the residuals corrected for elevation and local geology and adjusted relative to OB2NV (OB2NV is assumed to be zero). The table shows that all WUS stations are late relative to RKON, which agrees with results obtained by other workers (Sengupta and Julian, 1976). Stations in the northeastern United States, HNME and IFME, are later than RKON but not by as much as the WUS stations. This picture is in perfect agreement with other studies and also conforms to our evaluation of relative t^* differentials, assuming that LVZ is associated with low Q .

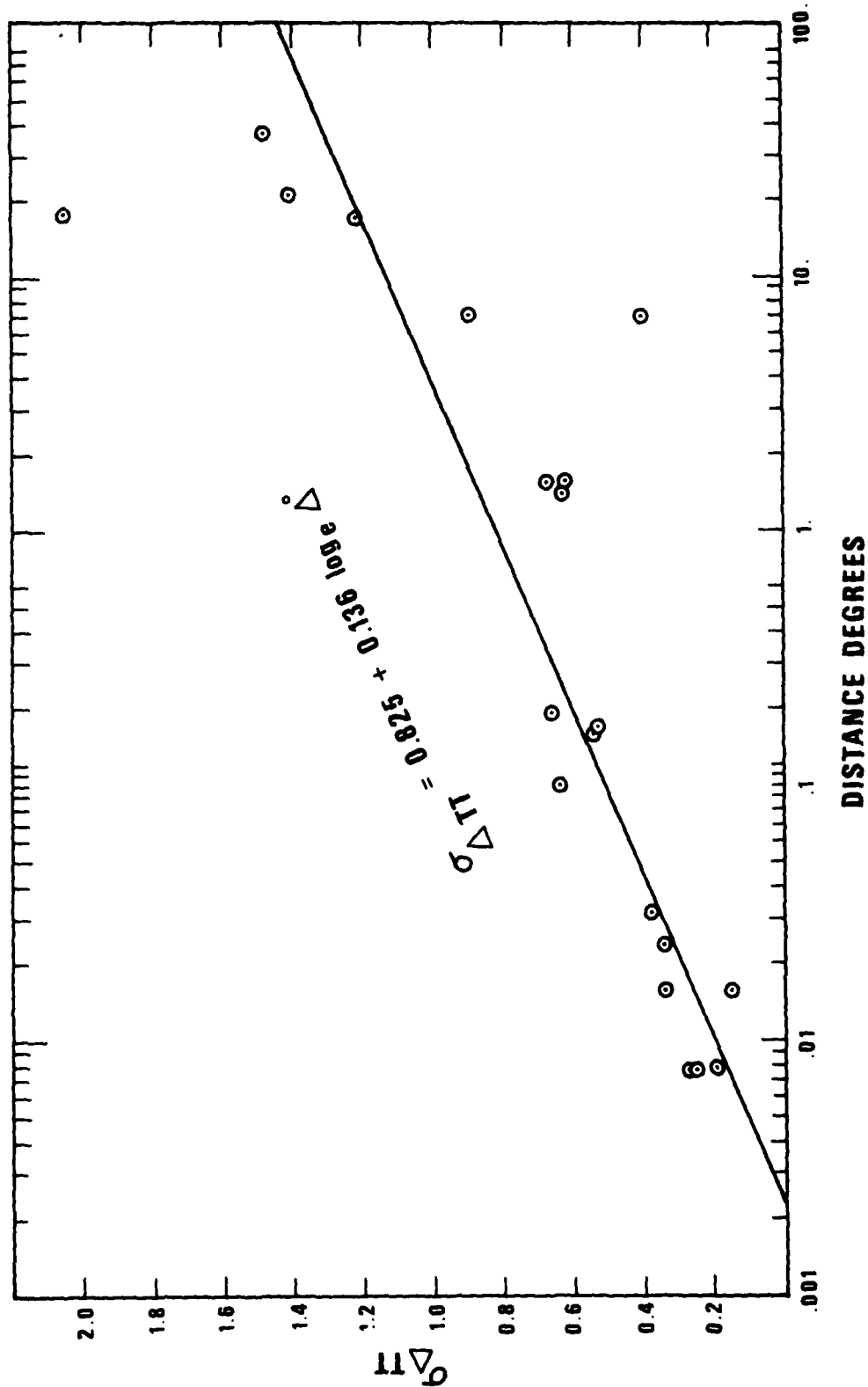


Figure 32 Standard deviation of relative travel time difference as a function of interstation distance.

SUMMARY

Numerical values of the most relevant diagnostic parameters obtained in the data analysis are summarized in Table II. The data indicate that after crustal corrections are made, P wave amplitudes tend to be lower at the WUS test sites than at RKON. The NEUS stations, HNME and IFME, appear to be intermediate in amplitude between the two groups, but large scatter in the data does not permit the determination of a significant m_b difference between these stations and either OB2NV or RKON. Crustal corrections leave large differences between the stations in m_b or trace amplitudes which are unexplained in terms of t^* or known structures and are presumably caused by local focusing effects.

Spectral measurements indicate a significant loss of high frequency content at all WUS test sites relative to RKON. The NEUS stations, HNME and IFME, occupy an intermediate position in frequency content. The t^* determined from spectral ratios shows a good qualitative agreement with the dominant periods measured by analysts.

Travel time residuals shown in Table V indicate that after local crustal and elevation corrections, P waves arrive late at all WUS test sites relative to RKON. The NEUS stations, HNME and IFME, again appear to be intermediate in their relationship.

The significance of these results will be discussed in the next part of this report in the broader context of related work by SDAC and other researchers.

PART 2
EVALUATION OF THE RESULTS OF THE SDCS PROJECT IN THE CONTEXT OF RELATED WORK
BY SDAC AND OTHER RESEARCHERS

The first part of this report presented the results of data analysis from the SDCS and a few LRSM stations. The areal coverage of this station set is limited; only one of the stations, RKON, is located on a shield. Thus it is extremely important to show that RKON is not in any way anomalous lest our conclusion concerning the other shield regions be seriously in error. The station in Maine should also be tested in the same context. Since there have been other studies of amplitude and magnitude anomalies of teleseismic P waves, our results must be interpreted in the framework provided by these. For example, some recent broad regional studies of P wave anomalies were interpreted in a manner that seemed to be in conflict with our conclusions. We shall show that no real conflict exists if some errors and unintentional misrepresentations are corrected. We also include here some results of our own spectral and amplitude studies of P and S waves. In addition, we shall outline regional variations of Q_α under the contiguous United States. In the last part of this section we shall put some limits on the absolute values of t_p^* and t_s^* and discuss possible forms of frequency dependence of t^* for two types of paths.

Discussion of the Results of the SDCS Experiment in the Context of Amplitude and Spectral Studies of Short-Period P and S Waves

Although we pointed out in the previous part of this report that the SDCS data can be interpreted in terms of decreased Q_β in the upper mantle, there is still a need to integrate these results into a framework of other regional studies to confirm our interpretation. Any lateral decrease of Q_β in the mantle would cause the following suite of phenomena all of which have to be present:

- a) Decrease of P wave amplitudes resulting in a magnitude anomaly for P waves.
- b) Decrease of high frequency content in P waves.
- c) A regional anomaly for S wave amplitudes. The effect should be greater than that for P waves.
- d) High frequency content of S waves should decrease at a greater degree than that for P waves since $t_s^* \sim 4t_p^*$.

We shall discuss manifestations of these phenomena and show that all of these are present in much of the western United States.

P-Wave Amplitude Anomalies

It would be expected that in the regions underlain by a low Q mantle the P-wave amplitudes from observed teleseisms would be reduced. This has been confirmed in several studies of magnitude variations across the U.S. (Evernden and Clark, 1970; Cleary, 1967; North, 1977; Booth et al, 1974). The various studies all show a negative bias in amplitudes in most of the WUS relative to the EUS as a whole. The methods of data selection and amplitude measurement methods vary, and the reported bias values for common stations in many cases also differ considerably.

Figure 33 shows the regional pattern obtained by Booth et al (1974). This map shows strong negative magnitude residuals in the southwestern United States and positive residuals in the north central section of the country. A study of these residuals (Der et al, 1979) showed that crustal amplification alone cannot explain this pattern, and that even after correcting for crustal effects, a 0.33 m.u. EUS-WUS regional bias remains. Figure 34 from this study shows that magnitude residuals plotted against logarithms Δm_b^c of multiplicative crustal amplification factors A_c tend to cluster around two regression lines for the WUS and EUS populations respectively. Therefore, a multiple regression using both the crustal amplification factor A_c and t_p^* is necessary to reduce the variance. The regression on the set of stations gave for an assumed EUS-WUS t^* difference

$$\Delta m_b \sim (1.35 \pm 0.32) \Delta t^*$$

at the 95% confidence level.

This coefficient is of the same order as

$$\pi f / \ln 10 = 1.36 \text{ (for } f = 1 \text{ Hz)}$$

which would be the multiplicative coefficient between t^* and the 10 base logarithms of amplitudes for an attenuated 1 Hz wave. This equation shows that average regional variations of amplitudes in short-period P and t^* are closely tied together and cannot be specified independently.

Consider now some results of a study by Butler and Ruff (1980) in the same context. Figures 35 to 39 show logarithmic plots of P wave amplitudes

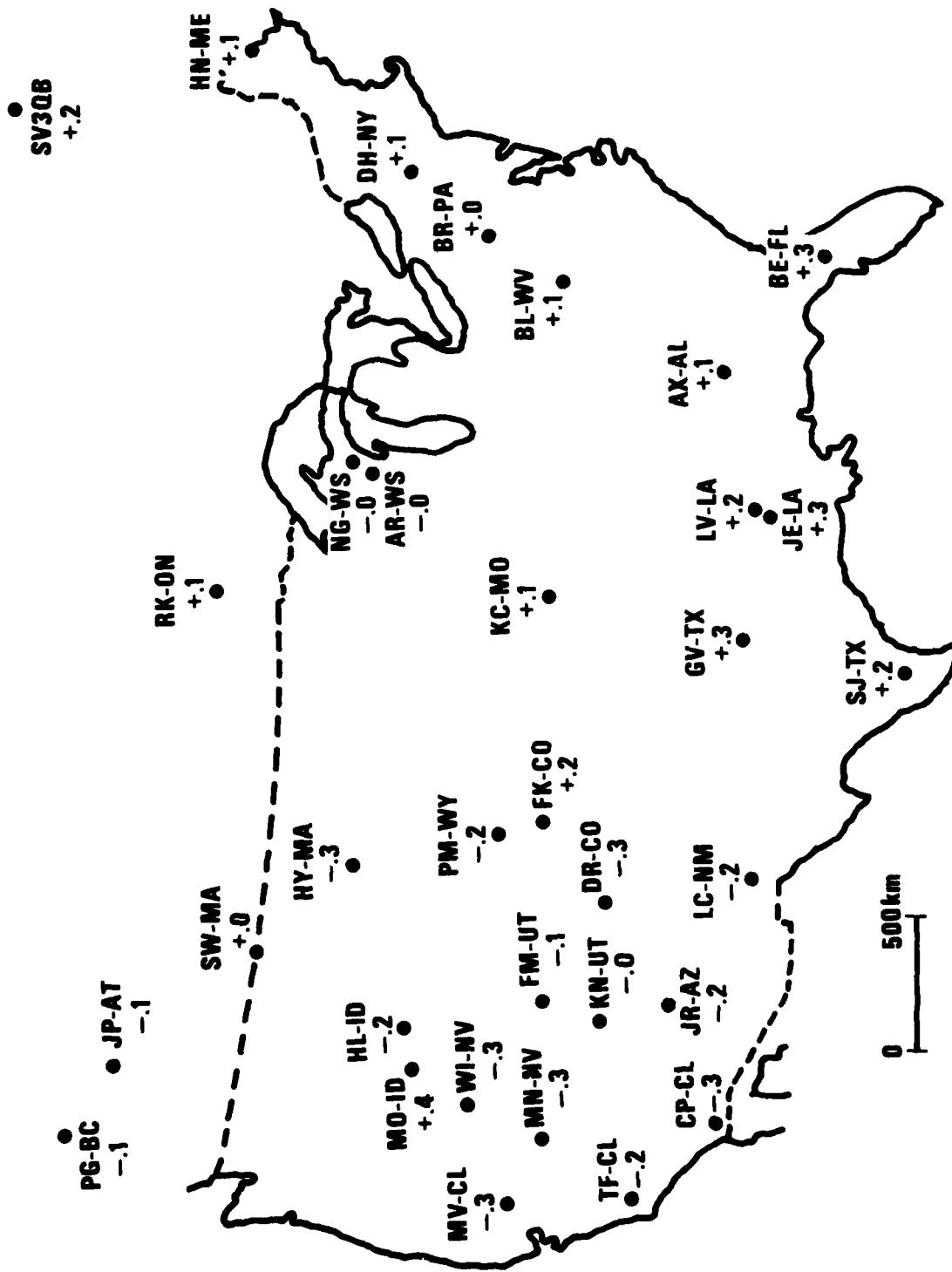


Figure 33 Magnitude residuals for LRS stations (after Booth et al, 1974).

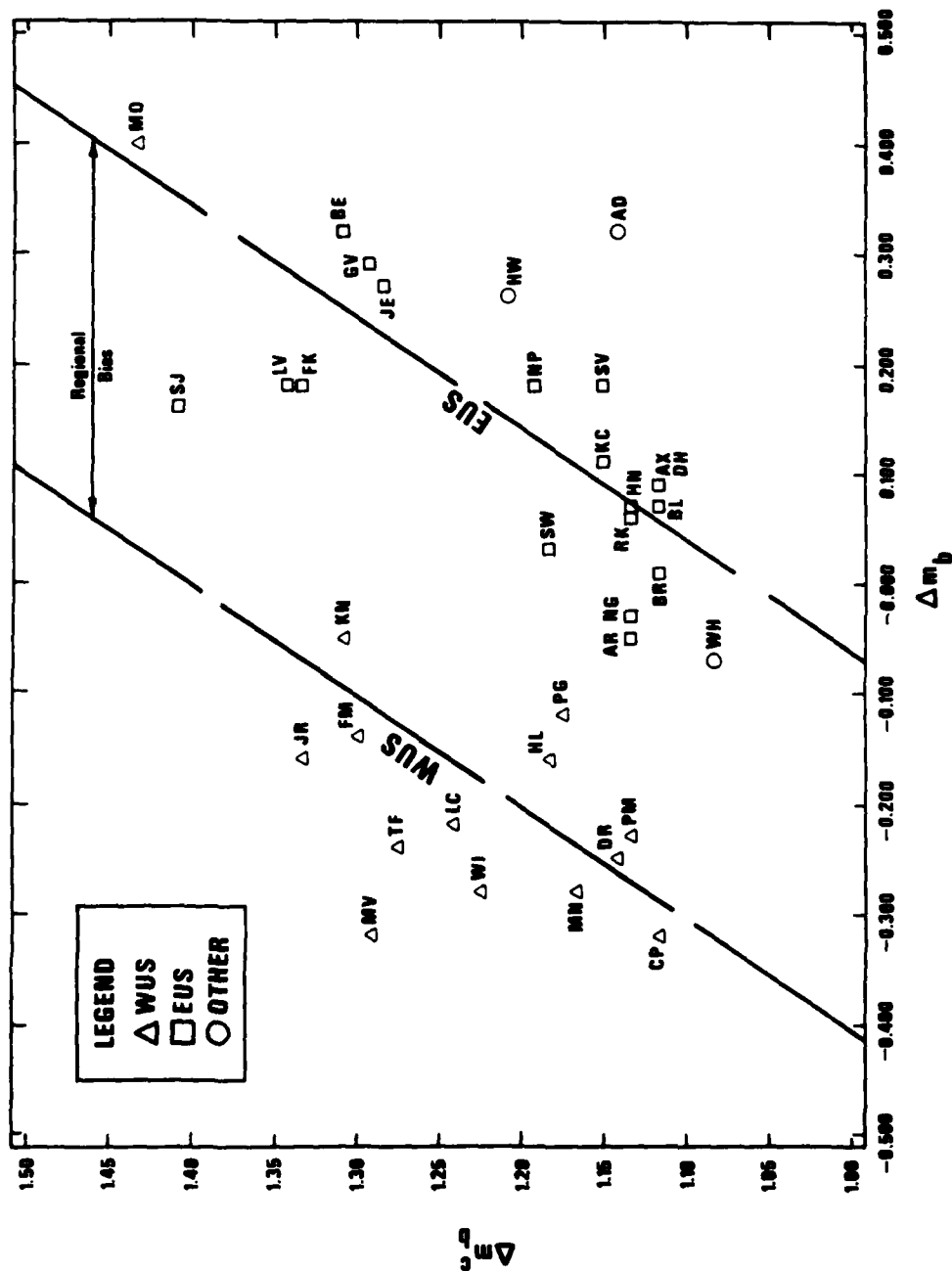


Figure 34 Magnitude residuals for Booth et al (1974) plotted against the logarithms of crustal amplification factor A. The data points tend to cluster around two regression lines, one for the EUS, the other for the WUS.

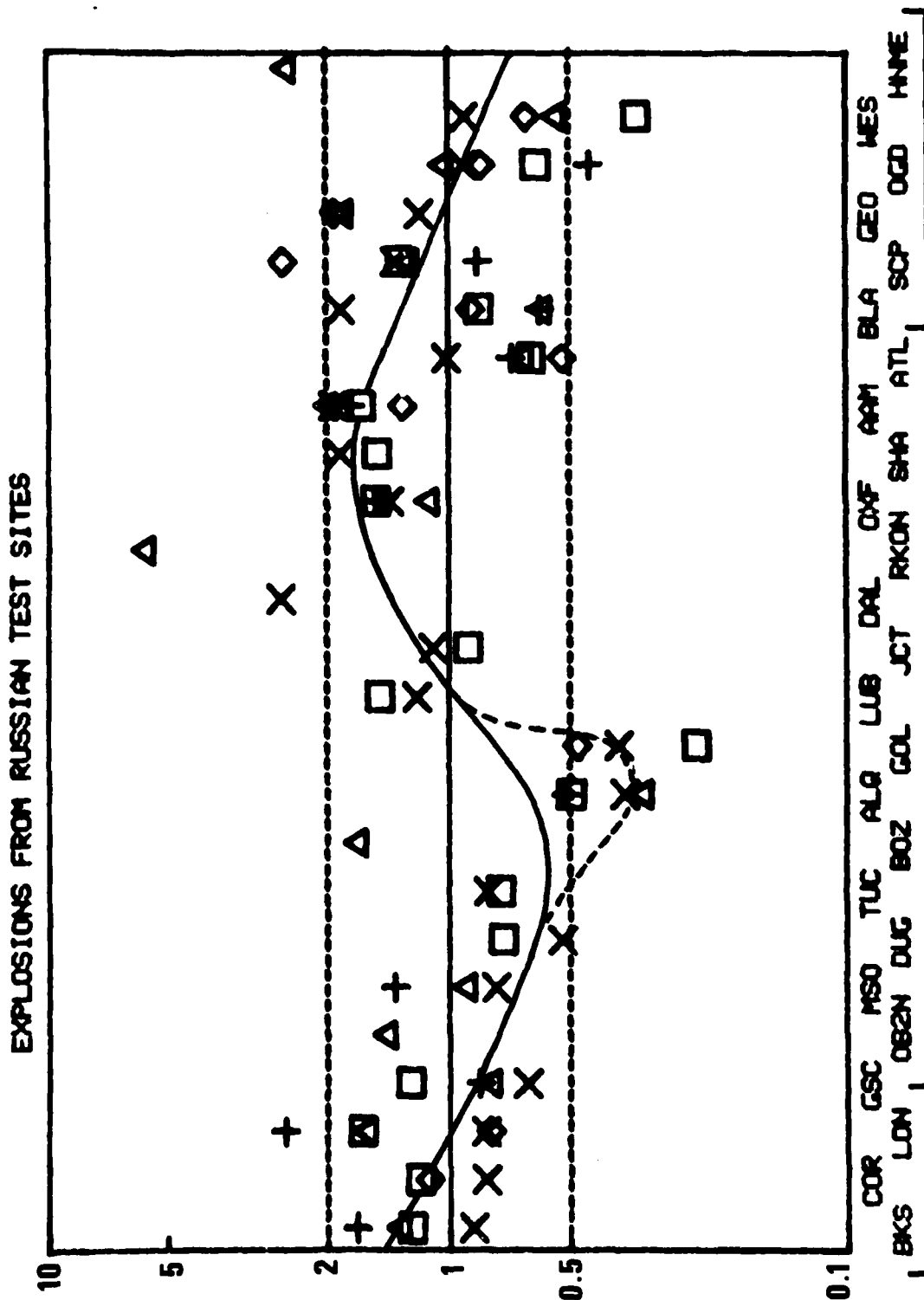


Figure 35 Logarithms of P wave trace amplitudes of WWSN and SDCS stations (after Butler et al (1980)). Common shapes of the anomaly pattern are sketched for these stations (see text). NEUS stations and some Pacific coastal stations are given disproportional weight in these plots. The data shown are from events at Russian test sites.

EARTHQUAKES IN KURILE IS., JAPAN, BONIN IS., & NORTHWEST

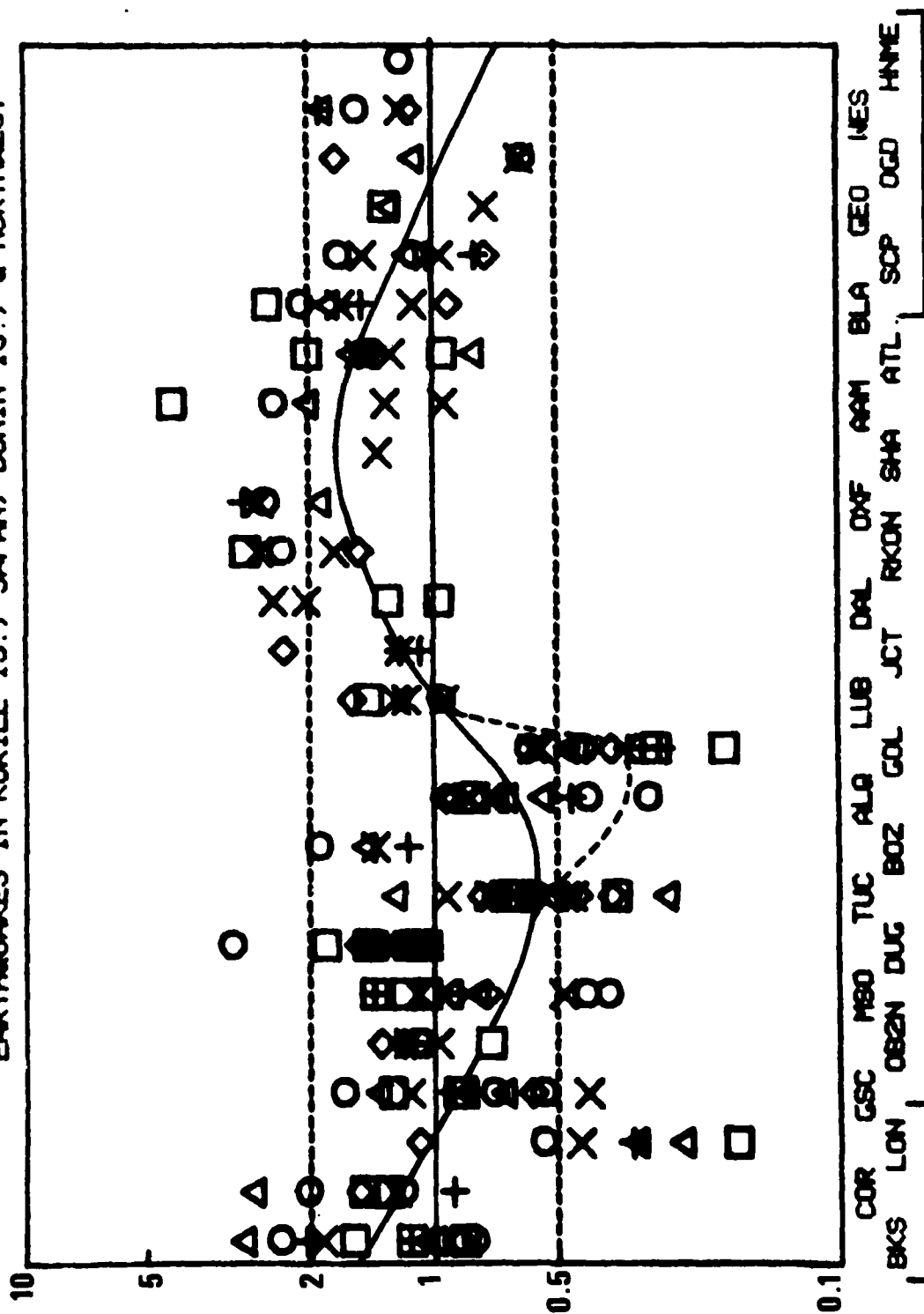


Figure 36 Logarithms of P wave trace amplitudes for WSSN and SDCS stations (after Butler et al, (1980)). Common shapes of the anomaly patterns are sketched for these stations (see text). NEUS stations and some Pacific coastal stations are given disproportional weight in these plots. The data shown are from Kurile Islands, Japan, Bonin Islands and other northwestern events.

EARTHQUAKES TO THE NORTH-WEST AZIMUTH

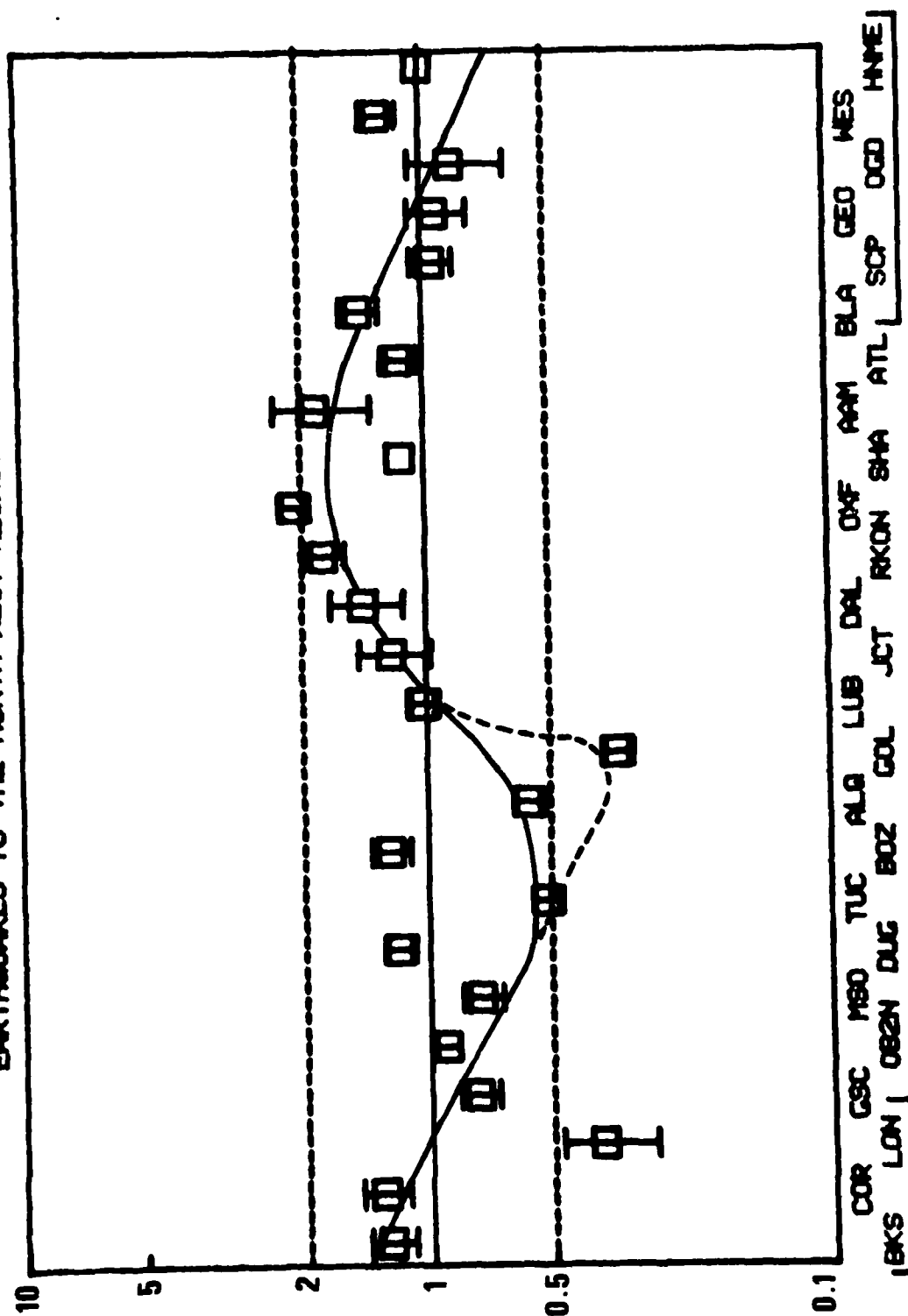


Figure 37 Logarithms of P wave trace amplitudes for WSSN and SDCS stations (after Butler et al, (1980)). Common shapes of the anomaly pattern are sketched for these stations (see text). NEUS stations and some Pacific coastal stations are given disproportional weight in these plots. The data shown are from earthquakes along the northwest azimuth.

SOUTH AMERICAN EARTHQUAKES

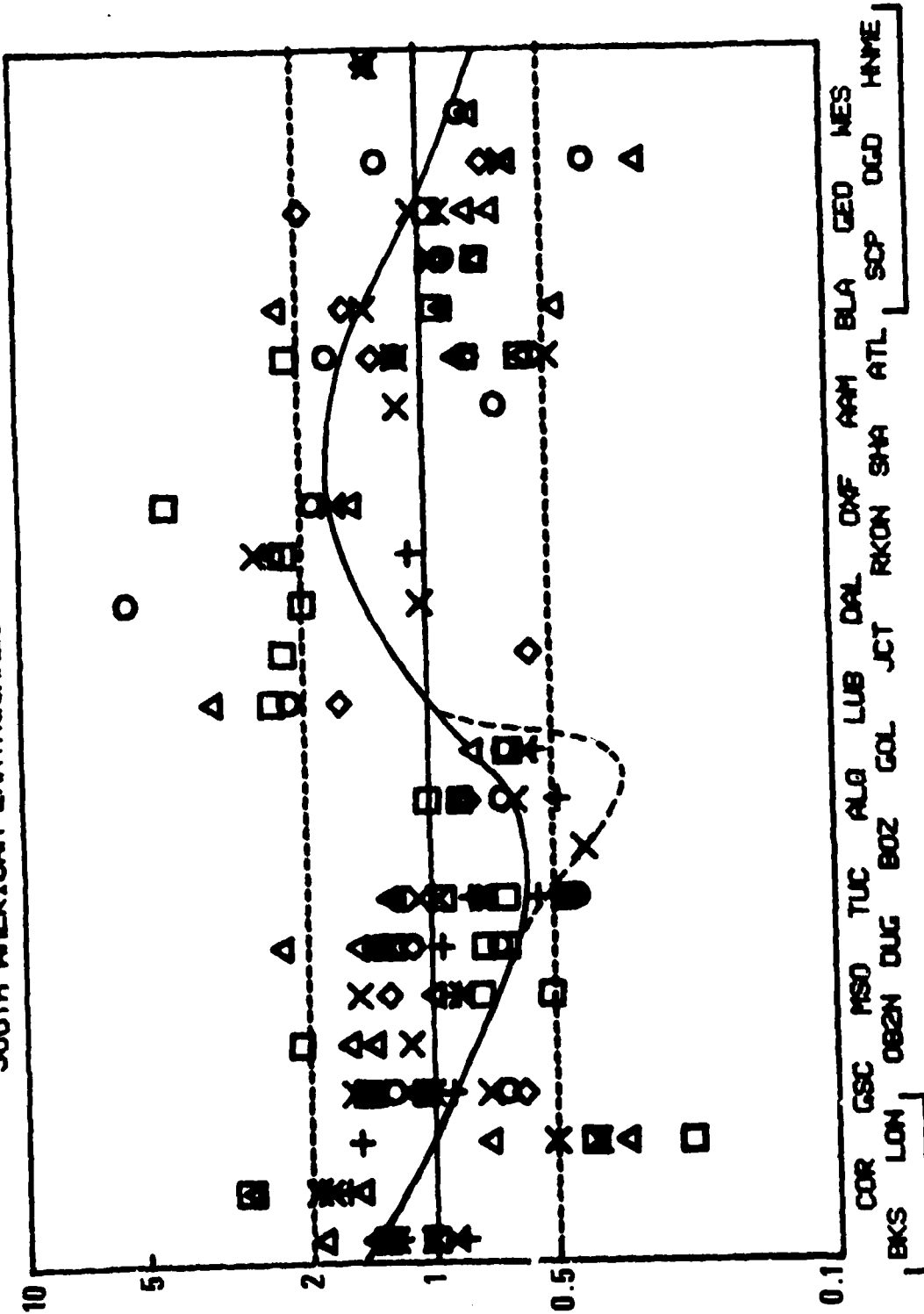


Figure 38 Logarithms of P wave trace amplitudes for WSSN and SDCS stations (after Butler et al, 1980)). Common shapes of the anomaly pattern are sketched for these stations (see text). NEUS stations and some Pacific coastal stations are given disproportional weight in these plots. The data shown are from South American earthquakes.

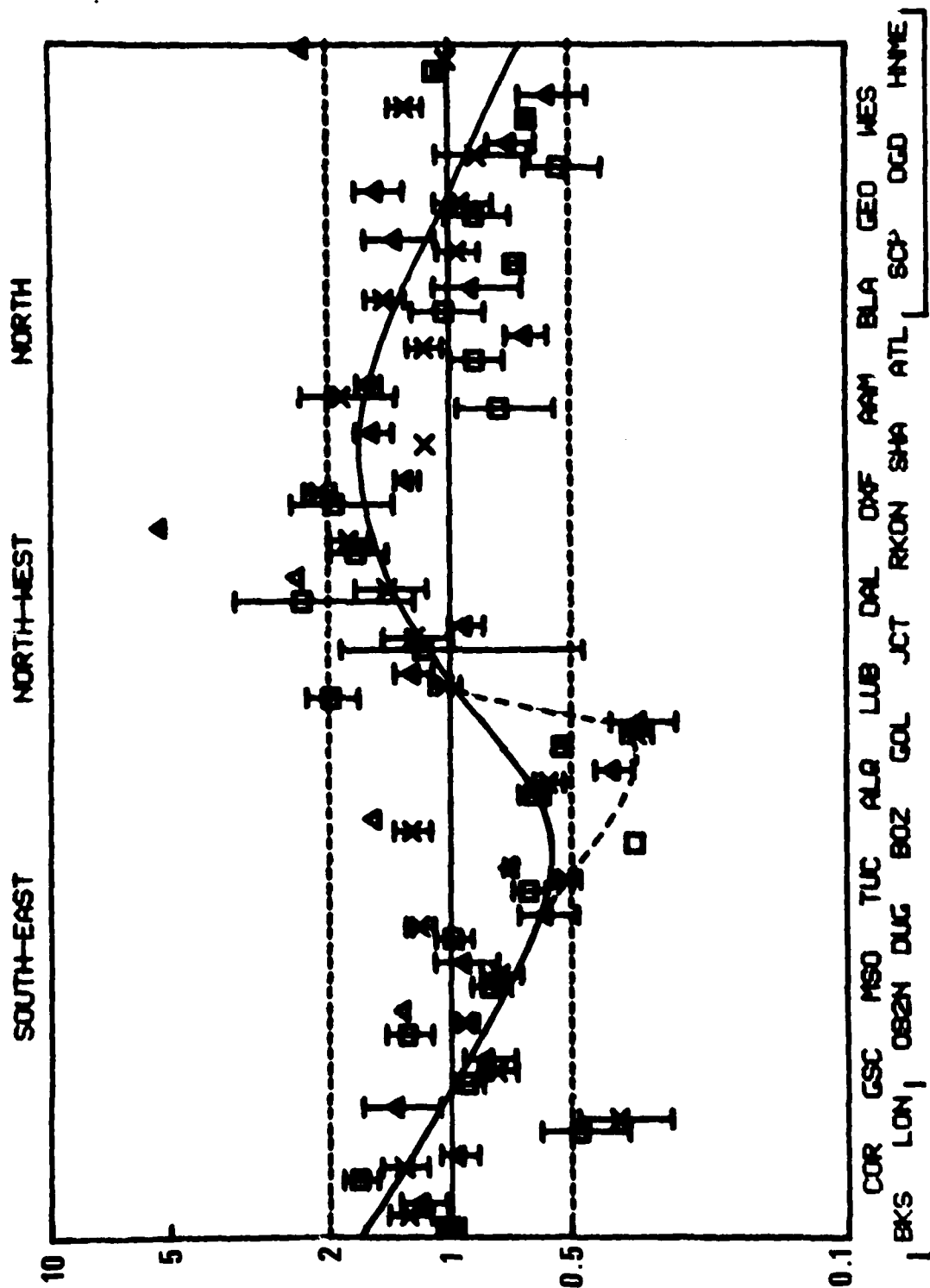


Figure 39 Logarithms of P wave trace amplitudes for WSSN and SDCS stations (after Butler et al, (1980)). Common shapes of the anomaly pattern are sketched for these stations (see text). NEUS stations and some Pacific coastal stations are given disproportional weight in these plots. The data shown are from all events from the SE, NW, and N azimuths.

as E-W cross sections of sorts across the United States. These represent amplitude patterns for Russian test sites, earthquakes from the Kuriles, all earthquakes for the NW azimuth, South American earthquakes, and the sum of all of the data. For convenience of presentation they spaced the stations equally on the plots, a practice that gives an enhanced visual weight to some groups of stations that is out of proportion to the small areas they occupy (ie, the BLA-SCP-GEO-OGD-WES-HNME group and the BKS-COR-LON group). We shall refer to this fact later. Inspecting these figures in succession one can see a common pattern (sketched in freehand with a solid line) that is clearly associated with the crust-mantle structure under the United States. The wide variations from azimuth to azimuth and source region to source region are not surprising in view of the focusing phenomena described in Section D of the last part of this report. There is an indication of another detail, a low amplitude region along the Rocky Mountain front (dashed line).

Another curious feature of Figures 35 to 39 is that on most of these plots the SDCS stations OB2NV, RKON and HNME are high in amplitude relative to their surroundings. This arouses the suspicion that in Butler's work, when data from the two networks, SDCS and WWSSN, were assembled together, the mean m_b levels of the two networks were not adjusted properly. To investigate this we attempted to tie OB2NV in with this pattern by computing the magnitude differential at the common station OB2NV and station ANMO (ALQ). Readings of trace amplitude differentials at corresponding portions of the P wavetrain for 72 events resulted in the histogram of $\log_{10}$ (Amplitude) shown in Figure 40. The mean differential $-0.15 \pm .058$ (95% confidence) indicates that the relative positions of WWSSN and SDCS stations in the study of Butler et al (1979) are not correct since Butler's differential between OB2NV and ALQ is much larger; it is outside the confidence limits indicated. This confirms our suspicion. Within each network, the relative differences in m_b levels are, however, correct in Butler's study and for the SDCS network his results agree well with ours.

Figure 35 to 39 were interpreted by Butler et al (1979) as showing that no average EUS-WUS regional difference in amplitudes exists, and the visual impression from these figures appears to confirm this if one averages the levels in the WUS and EUS in their graphs. However, if one considers the relative areas covered by the stations in the northeastern United States,

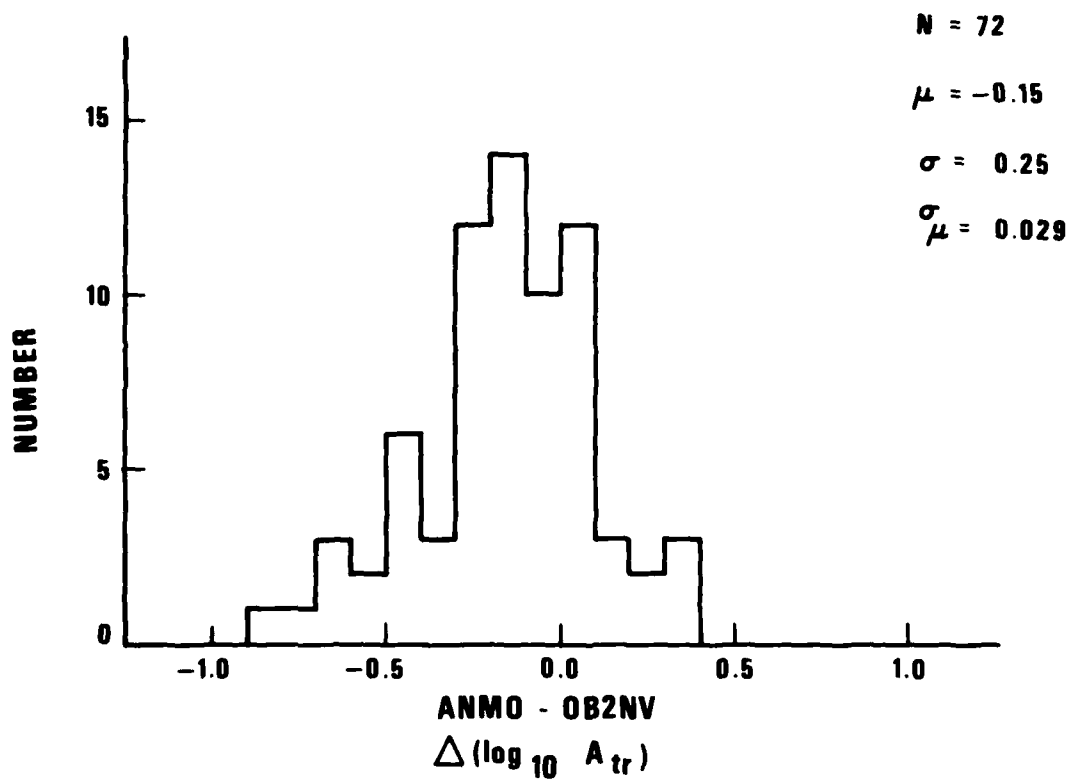


Figure 40 Histogram of trace amplitude differentials of P waves at OB2NV and ALQ (ANMO). This differential is significantly different from the value given by Butler et al, (1980).

about 1/20 of the total area, the visual weight given to the stations in the NEUS in Butler's figures (where they are evenly spaced) is excessive. Therefore these figures are highly deceptive. If one takes averages weighted with respect to the areas covered, the conclusion of many researchers that the EUS as a whole has larger m_b or amplitude levels than the WUS still stands.

P Wave Spectral Anomalies

Due to the sensitivity of high frequency body waves to variations of t_p^* , spectral slopes are strong diagnostics of regional variations of attenuation. While body wave magnitude measurements involve mostly 1 Hz energy, spectra of P waves often show significant energy up to 4 Hz that is considerably more sensitive to variations of Q than 1 Hz energy. This fact, together with the greater stability of spectral slopes with respect to lateral inhomogeneities, makes spectral measurements extremely important in evaluating mantle Q under any location.

Spectral measurements can be used in various ways to estimate t_p^* in the earth. Spectral ratios of the observed P spectra to the estimated source spectrum can be used to estimate the absolute value of t_p^* . In most cases, absolute strengths of sources are not well known for either earthquakes or explosions; however, the slopes of source spectra are well enough specified to put reasonable limits on t_p^* . For explosions, near source measurements are often available to estimate the source spectrum from a reduced displacement potential. In the absence of near source data it appears that source models such as those of von Seggern and Blandford (1972) or Mueller and Murphy (1971) describe explosion spectra with sufficient accuracy to permit the computation of t_p^* to within 0.1 second. For earthquake observations, basic physical arguments require that the spectra fall off beyond a specific (although ill defined) corner frequency at rates of ω^{-2} or ω^{-3} , a condition that immediately puts limits on the possible range of absolute t_p^* .

In addition to estimating absolute t_p^* , spectral ratios of body waves observed at various stations for common events can be used to determine regional variations of anelastic attenuation. The ideal sources for such studies are nuclear explosions because, except for possible strain release, they are non-directional sources essentially radiating the same spectrum in all directions.

In our previous papers (Der and McElfresh, 1976, 1977) we compiled t^* estimates for a group of paths crossing the mantle under the United States, mostly for nuclear explosions. Paths not crossing the mantle under the WUS were associated with signals of significant energy in the 3 to 4 Hz range. Paths crossing the mantle under the WUS showed a great reduction of the high frequency content. The t^* for shield paths was found to be around 0.2 sec while for paths crossing the upper mantle under the WUS the t^* was between 0.4 and 0.5 sec. None of our data showed t^* equal or larger than 1 sec, although it is possible that some paths from the WUS to other tectonic regions might have $t_p^* \sim 1$ sec. Spectral ratios computed at the SDCS stations also fall into the pattern outlined above. All WUS test sites show relatively high t_p^* compared to RKON, while the stations in the northeastern U.S. are intermediate with regard to t_p^* , a position that correlates with the regional amplitude patterns.

S Wave Amplitude Anomalies

An additional measure of regional attenuation is provided by amplitude anomalies of short-period S waves. Short-period S waves are commonly not observed for shallow focus events, but are fairly common for deep earthquakes. This fact by itself puts some limitation on the values of t_s^* that we shall discuss later.

If regional P magnitude anomaly patterns are caused by variations of Q, then regional amplitude anomaly patterns of S should resemble those of P. This appears to be the case. In Figure 41 we show average SH trace amplitude residual terms expressed in units of $\log_{10}(\text{Amplitude})$ from the seven deep earthquakes listed in Table VI. The amplitudes were corrected for SH radiation pattern using the double couple representation of the sources. Data points close to nodal lines and requiring a large correction were omitted to avoid overcorrections due to uncertainties in source orientation. The average event magnitude was used for normalizing the amplitudes for each event. The SH residuals clearly show patterns similar to those for the P waves in Figure 33 (Booth et al, 1974). Furthermore, as Figure 42 shows, correction for crustal amplification effects on SH using flat layered models of crust under LRSM stations does not remove the anomalies. The approach used is identical to that presented by Der et al (1979). The scatter

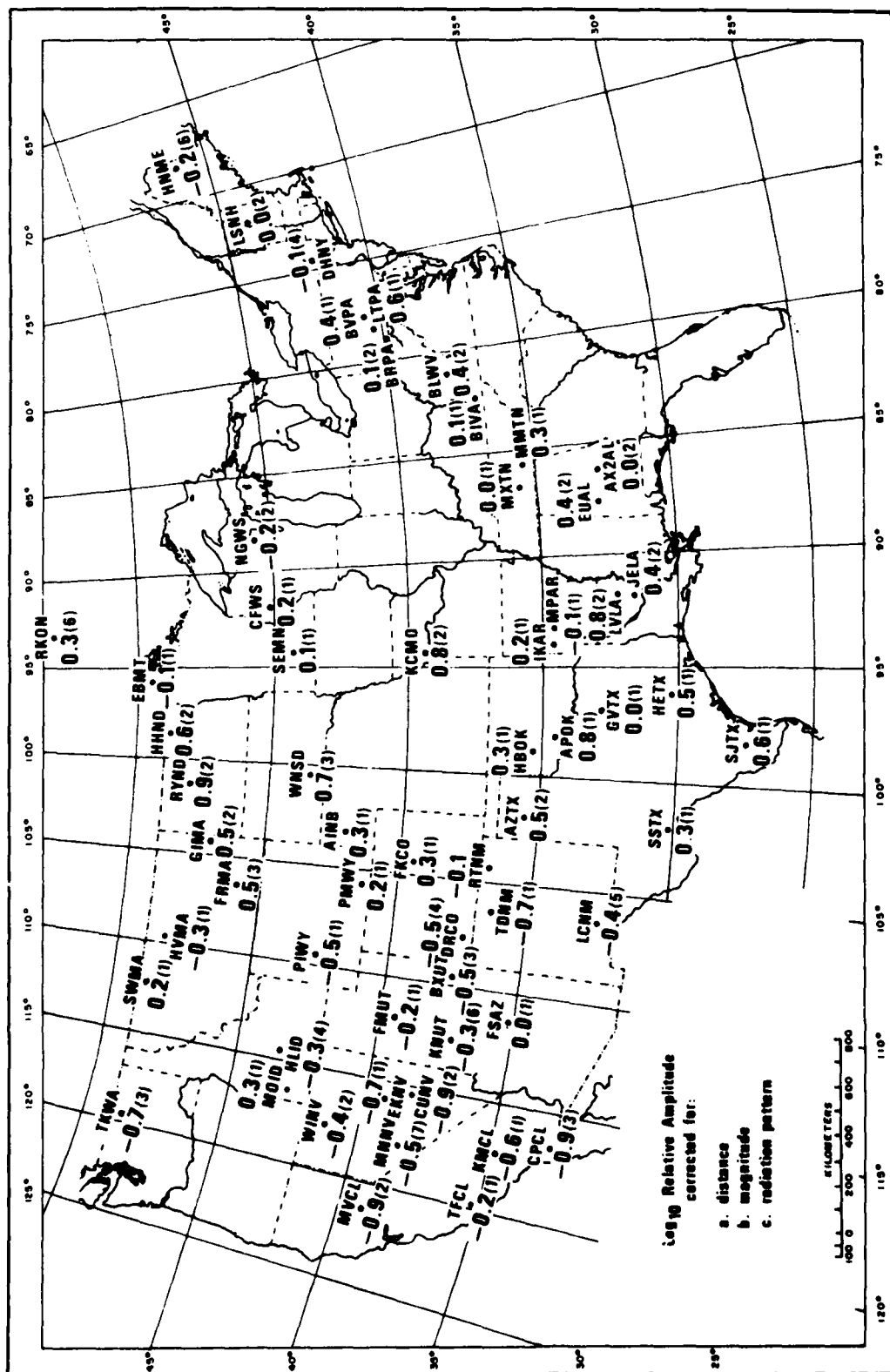


Figure 41 Short-period SH wave amplitude anomalies corrected for double couple radiation patterns and adjusted for relative magnitudes and distances for seven deep earthquakes listed in Table VI. The anomalies are given in units of ten base logarithms of amplitude. Large negative anomalies occur in the southwestern United States.

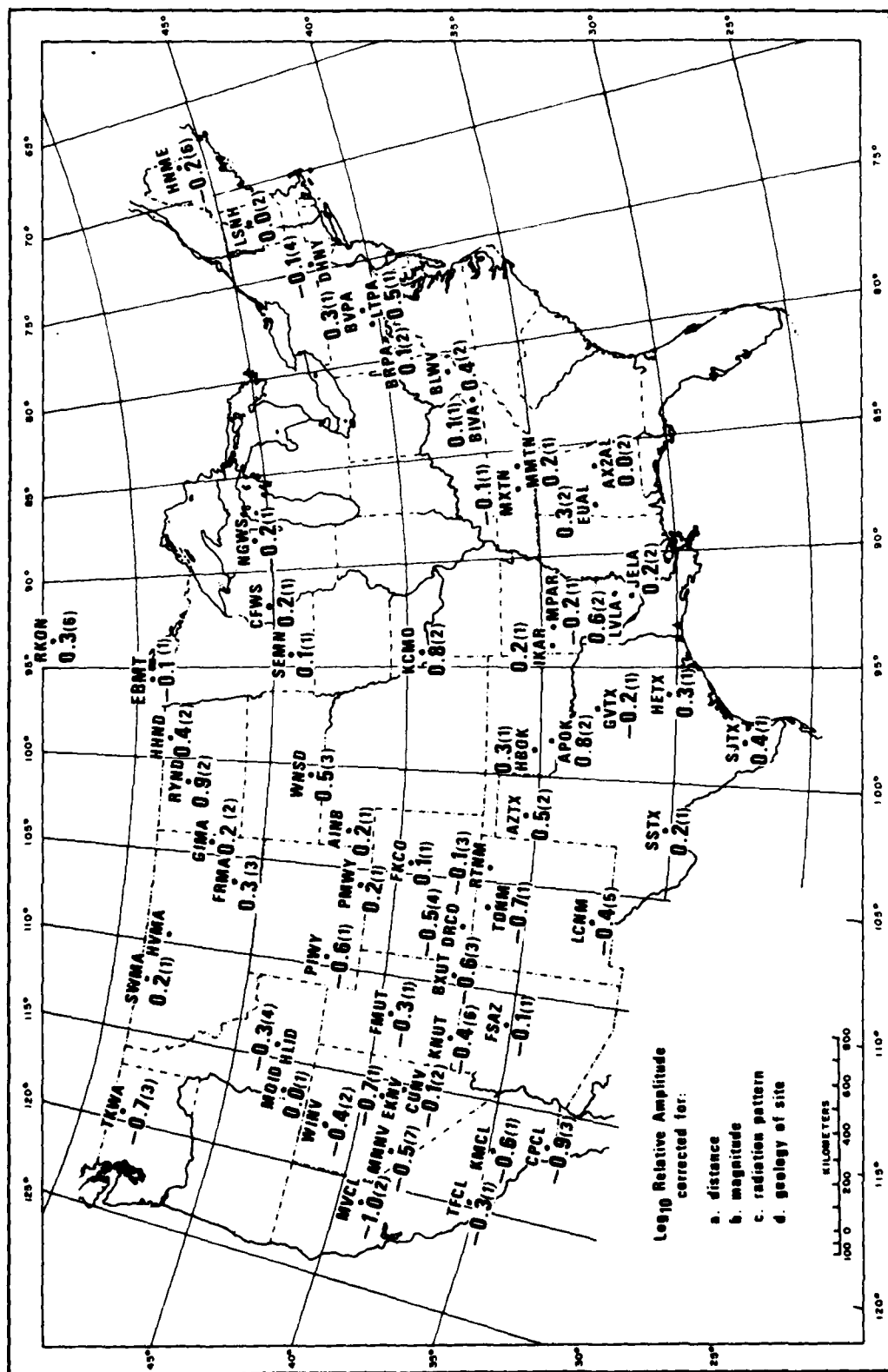


Figure 42 Short-period SH wave amplitude anomalies corrected for radiation patterns and adjusted for relative magnitudes, distance and estimated crustal amplification. Large negative values occur in the southwestern United States indicating the diminution of amplitudes in this region by anelastic attenuation.

TABLE VI
Seven deep earthquakes used for Figures 41 and 42

DATE	ORIGIN TIME	LOCATION	DEPTH (km)	LATITUDE	LONGITUDE	m_b	FOCAL MECHANISM		
							RAKE	DIP	STRIKE
08 DEC 62	21:27:18.0	NE ARGENTINA	620	27.0S	63.0W	7.0	241.21	85.02	164.75
09 NOV 63	21:15:30.0	WESTERN BRAZIL	600	9.0S	71.5W	7.0	258.10	66.89	104.01
10 NOV 63	01:00:38.8	PERU-BRAZIL BORDER	600	9.2S	71.4W	5.6	259.92	61.47	126.60
18 MAR 64	04:37:26.9	NW OF KURILES	438	52.5N	153.6E	5.6	270.00	85.00	50.00
22 AUG 66	14:21:14.0	SEA OF OKHOTSK	653	50.3N	147.7E	5.1	270.00	90.00	20.00
22 NOV 66	06:29:53.1	SEA OF OKHOTSK	469	48.0N	146.8E	5.7	90.00	55.00	190.00
12 OCT 67	12:53:46.9	NW OF KURILES	483	52.2N	152.5E	5.5	298.71	79.16	43.10

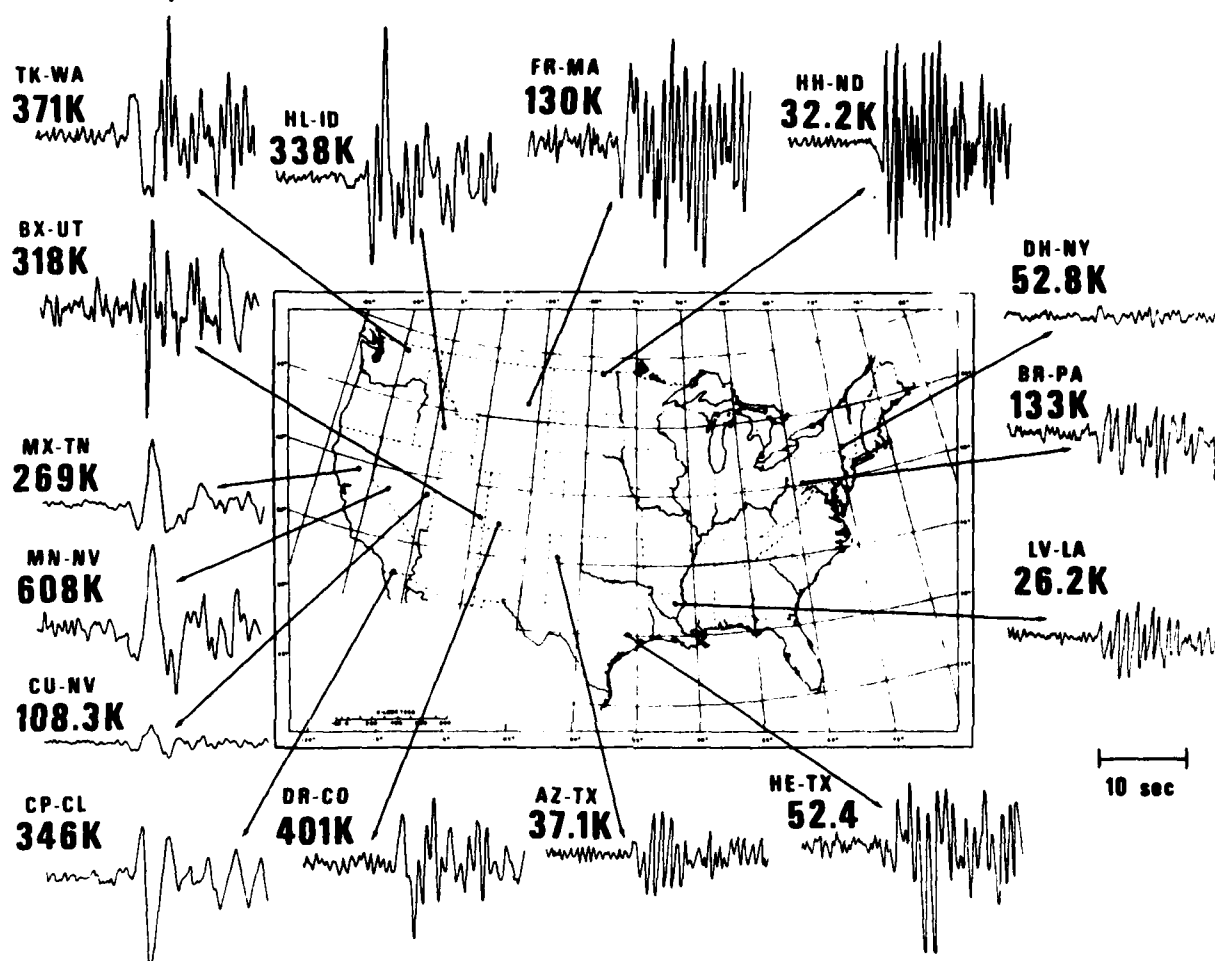
is still quite large, a fact that is not surprising since S waves are also subjected to the same lateral inhomogeneity effects as P waves, but the pattern is clear nonetheless. Unfortunately, short-period S waves are not sufficiently abundant to achieve the same accuracy in the estimation of station terms, but most of the negative residuals, especially the large ones, are in the western United States.

S Wave Spectral Measurements

According to most evidence, $t_s^* \sim 4 t_p^*$ appears to be valid for regional as well as teleseismic changes in t^* (Solomon and Toksöz, 1970; Der et al, 1980). Consequently, spectral changes in S should be quite noticeable from region to region. This appears to be true also. In Figures 43 to 49 we show tracings of short-period S waves at various LRSM stations across the U.S. Pointers show the location of the recording LRSM station on the map, and the instrument gains are given above each trace. Since one of the perpendicular horizontal components of the LRSM stations is oriented towards NTS, the tracings were done on the component closest to the transverse direction (SH) to the event. Although a few of these components may be misoriented by as much as 45° , the figures show a clear tendency for the stations in the southwestern U.S. to have lower amplitudes and lower frequencies. These are typical examples of this phenomenon and are not accidents of fault plane orientation and directivity. All broad band S waves (sometimes containing significant signal energy up to 2.5 Hz) show this phenomenon regardless of fault plane orientation. These events, not previously analyzed in our recent study (Der et al, 1980), demonstrate that visible regional differences in the frequency content of S waves are the rule and there is nothing exceptional about the data presented by Der et al (1980). We have inspected S waves from large numbers of deep events all showing similar variation.

Differential attenuation manifests itself in various ways in the time domain. Wide band signals with considerable high frequency content undergo a significant lengthening of dominant periods by the preferential reduction of the high frequency end of the spectrum. Narrow band signals containing less high frequency show little change in waveform. For both types of signals the overall trace amplitude is reduced, and this reduction is greater for the

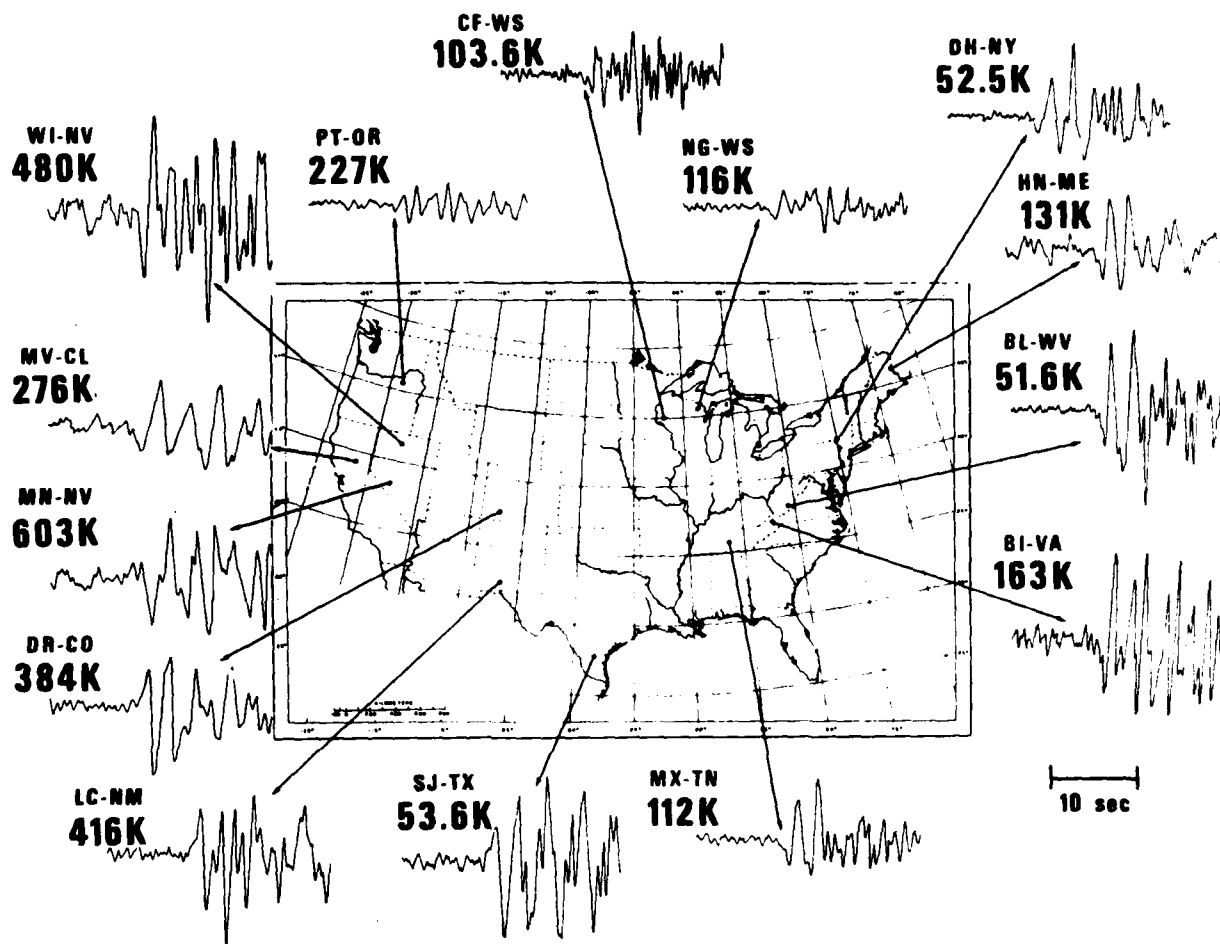
**PERU-BRAZIL BORDER 09.25 71.5°W
10 NOV 63 OT = 01:00:38.8**



Short period SH

Figure 43 Tracings of short-period SH phases at LRSM stations across the United States. Depending on the frequency content of the signals, the time domain manifestations of anelastic attenuation vary, but the overwhelming majority of the signals show a diminution of amplitudes and the decrease of high frequency content in most of the WUS with especially severe effects in the southwestern United States. No corrections for radiation patterns were made in these figures. Instrument gains are shown on each trace.

ARGENTINA 27°S 63°W
08 DEC 62 OT = 21:27:18.0



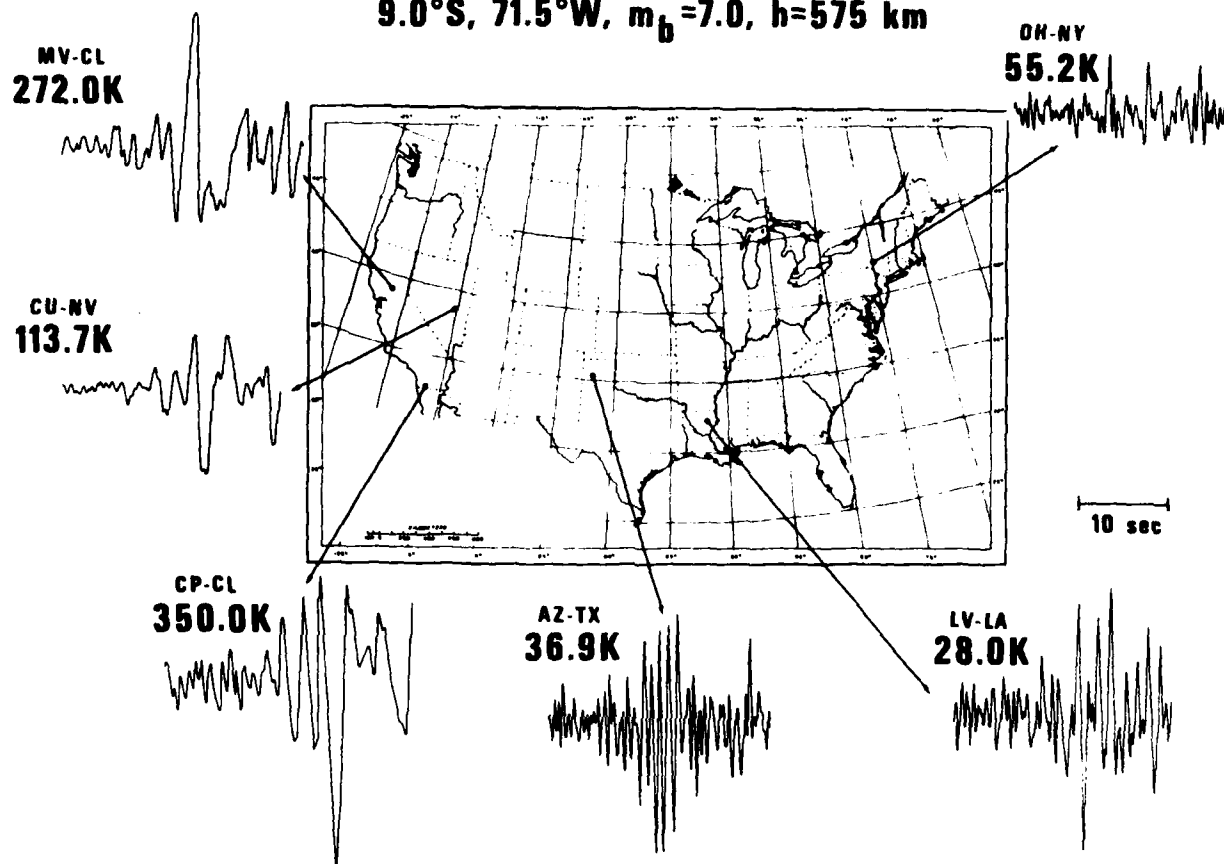
Short period SH

Figure 44 Tracings of short-period SH phases at LRSM stations across the United States. Depending on the frequency content of the signals, the time domain manifestations of anelastic attenuation vary, but the overwhelming majority of the signals show a diminution of amplitudes and the decrease of high frequency content in most of the WUS with especially severe effects in the southwestern United States. No corrections for radiation patterns were made in these figures. Instrument gains are shown on each trace.

WESTERN BRAZIL 09 NOV 63

T = 21:15:30.0

9.0°S, 71.5°W, $m_b=7.0$, $h=575$ km



Short period SH

Figure 45 Tracings of short-period SH phases at LRSM stations across the United States. Depending on the frequency content of the signals, the time domain manifestations of anelastic attenuation vary, but the overwhelming majority of the signals show a diminution of amplitudes and the decrease of high frequency content in most of the WUS with especially severe effects in the southwestern United States. No corrections for radiation patterns were made in these figures. Instrument gains are shown on each trace.

**PERU-BRAZIL BORDER REGION 9.1°S 71.4°W
03 NOV 65 OT = 01:39:03.1**

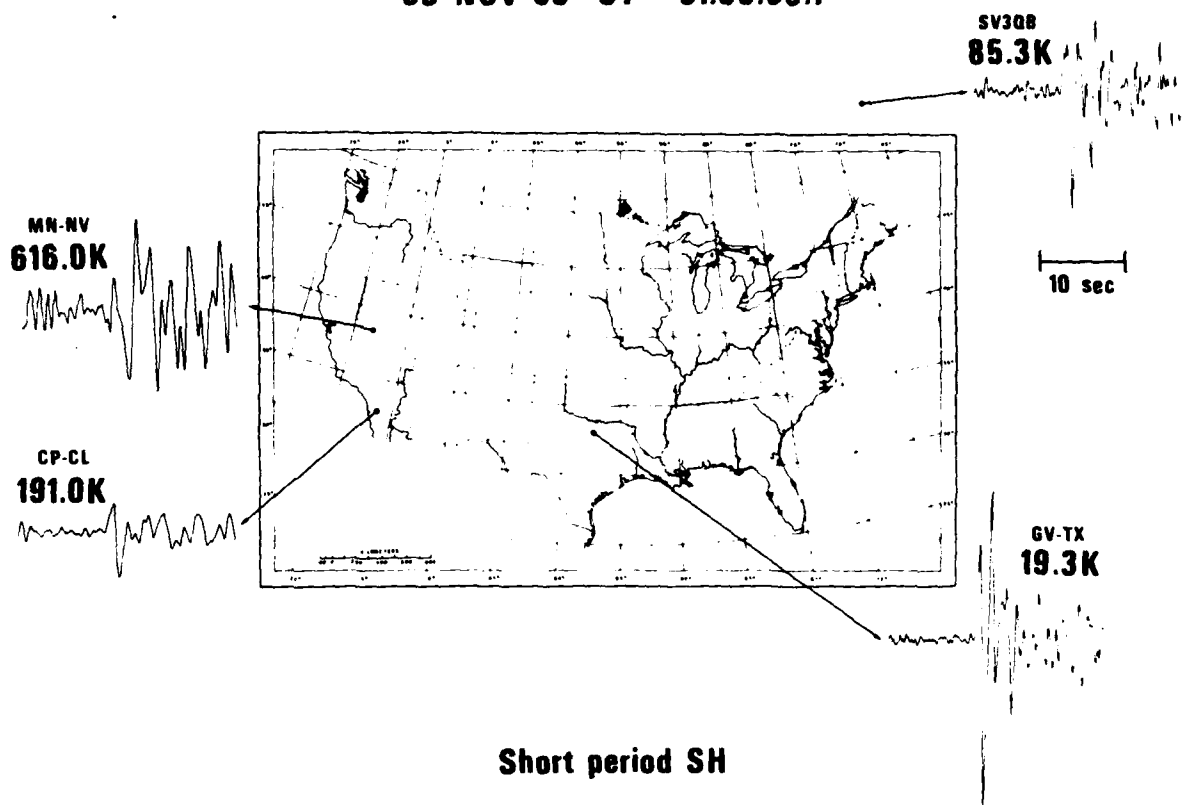
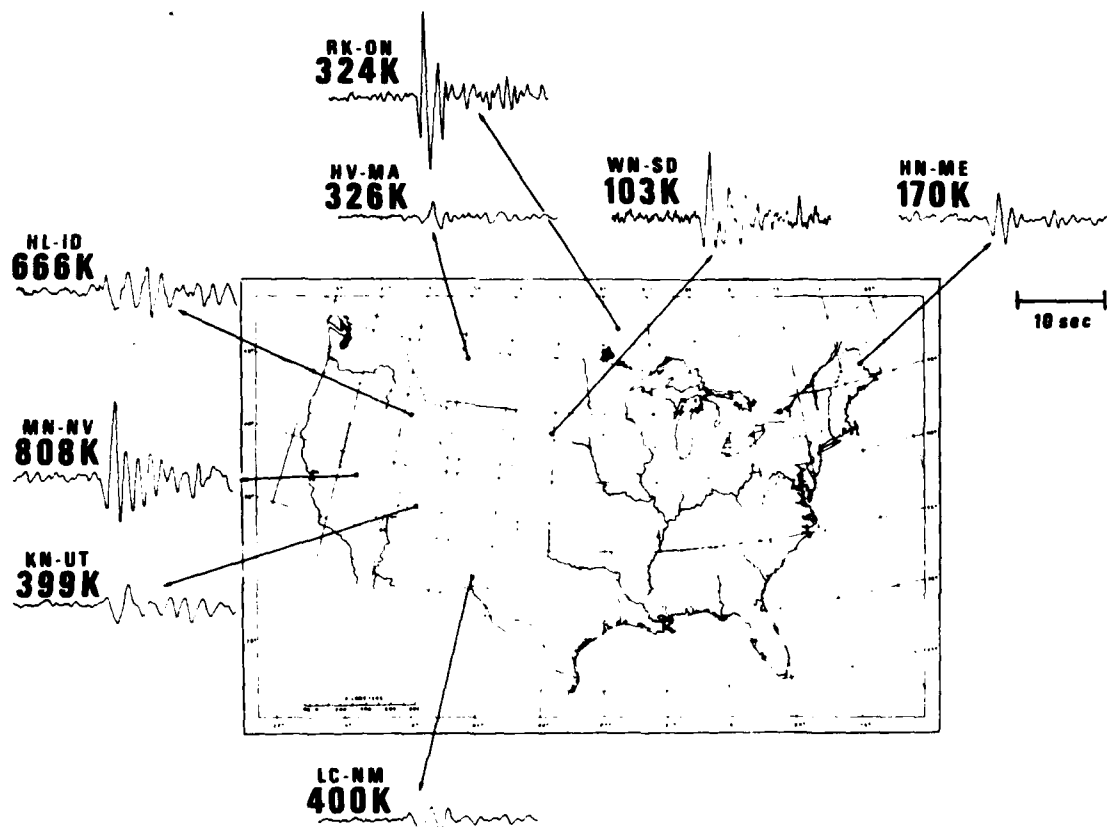


Figure 46 Tracings of short-period SH phases at LRSM stations across the United States. Depending on the frequency content of the signals, the time domain manifestations of anelastic attenuation vary, but the overwhelming majority of the signals show a diminution of amplitudes and the decrease of high frequency content in most of the WUS with especially severe effects in the southwestern United States. No corrections for radiation patterns were made in these figures. Instruments gains are shown on each trace.

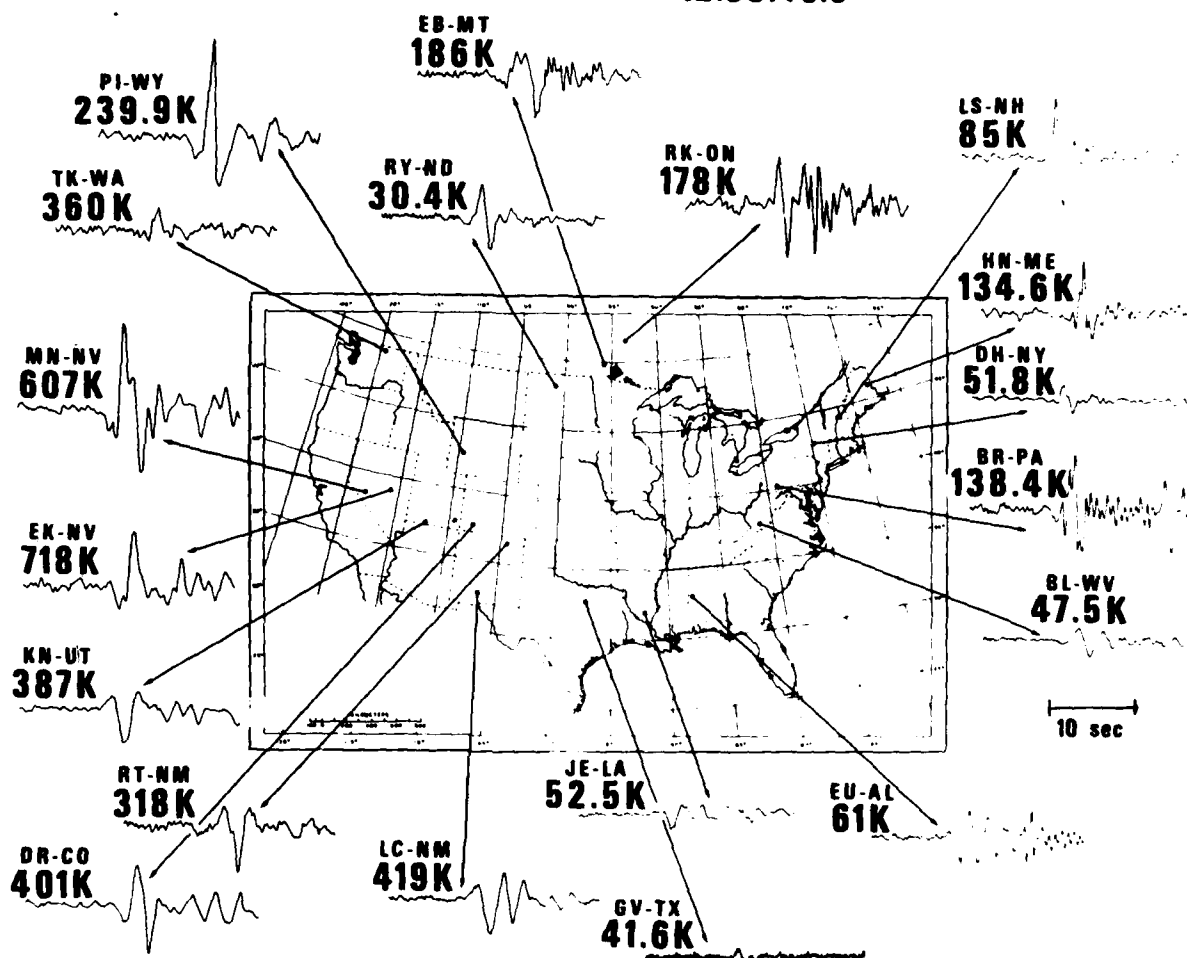
NW of KURILES 52.65°N 153.6°E
18 MAR 64 OT = 04:37:26.9 OT



Short period SH

Figure 47 Tracings of short-period SH phases at LRSM stations across the United States. Depending on the frequency content of the signals, the time domain manifestations of anelastic attenuation vary, but the overwhelming majority of the signals show a diminution of amplitudes and the decrease of high frequency content in most of the WUS with especially severe effects in the southwestern United States. No corrections for radiation patterns were made in these figures. Instrument gains are shown on each trace.

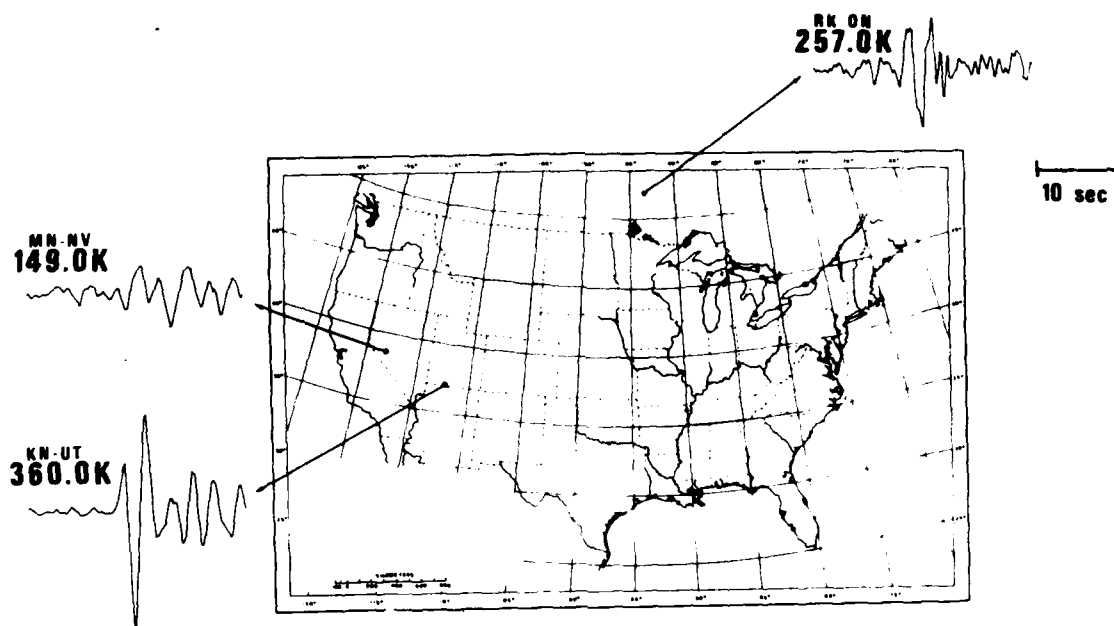
NW of KURILE ISLANDS 522°N 152.5E
12 OCT 1967 OT = 12:53:46.9



Short period SH

Figure 48 Tracings of short-period SH phases at LRSM stations across the United States. Depending on the frequency content of the signals, the time domain manifestations of anelastic attenuation vary, but the overwhelming majority of the signals show a diminution of amplitudes and the decrease of high frequency content in most of the WUS with especially severe effects in the southwestern United States. No corrections for radiation patterns were made in these figures. Instrument gains are shown on each trace.

SANTIAGO DEL ERSTERO, ARGENTINA 27.4°S 63.3°W
17 JAN 67 OT = 01:07:54.3



Short period SH

Figure 49 Tracings of short-period SH phases at LRSM stations across the United States. Depending on the frequency content of the signals, the time domain manifestations of anelastic attenuation vary, but the overwhelming majority of the signals show a diminution of amplitudes and the decrease of high frequency content in most of the WUS with especially severe effects in the southwestern United States. No corrections for radiation patterns were made in these figures. Instrument gains are shown on each trace.

wide band signals (Der and McElfresh, 1980). The above-mentioned tracings show examples of both types of behavior. The nature of signals can be easily judged by their appearance at the high Q shield sites. WWSSN records show similar variations, but the high frequency content riding over lower frequency waves is suppressed somewhat relative to those shown due to the different instrument response.

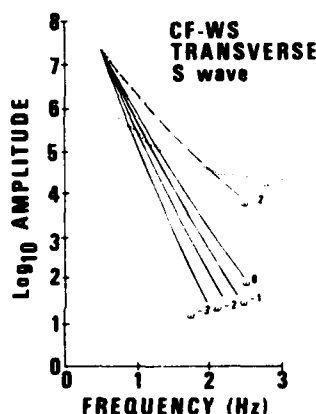
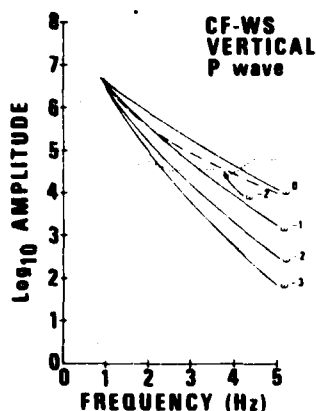
The differential in SH wave trace amplitudes reflects the regional Q differential to a lesser extent than would the amplitude at the dominant frequencies of the signals in the low Q regions. Many S signals in the north central U.S. have dominant frequencies at slightly less than 1 Hz; such frequencies appear to be completely absent in the southeastern U.S. The Q differential can effectively be measured only in the frequency domain, of course.

In a previous study (Der et al, 1980) we have shown that the regional averages of t_s^* differentials are 3 to 4 times larger than the average t_p^* differentials.

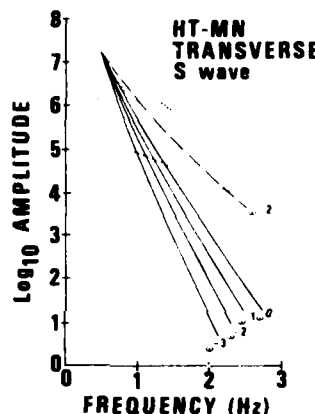
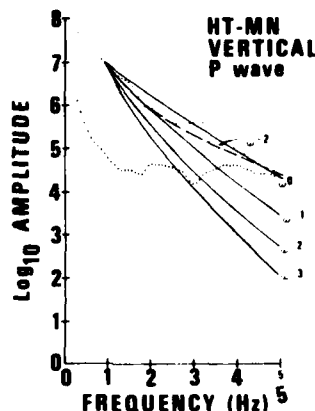
Outlining the Regional Variations of Q Under the United States

In spite of the many uncertainties with regard to source spectra, source mechanism, absolute source strengths and the precise determination of Q in the Earth, reasonable limits on the values of Q can be established in the short-period band by utilizing the great sensitivity of high frequency energy to Q. Consider the consequences of $t_p^* \sim 1$ sec and $t_s^* \sim 4$ sec, values widely used in long-period simulations and also claimed to be valid in the short-period band. Figure 50 shows spectra of P and S waves from some deep events observed in the north central United States. If one generously allows for the source depth by halving the t^* values to $t_p^* \sim 0.5$ and $t_s^* \sim 2$ sec and plots the expected spectral falloff rates of ω^0 , ω_p^{-1} , ω^{-2} , and ω_s^{-3} in the source spectra (solid lines), there is a sizable discrepancy at the high frequency end in each case. This discrepancy is especially obvious in the S waves where it amounts to more than two orders of magnitude. Furthermore, for S waves it is clearly prevalent even in the vicinity of 1 Hz. The observed spectra in all cases are incompatible with $t_p^* \sim 0.5$ and $t_s^* \sim 2$ and require considerably lower values for these quantities.

SANTIAGO DEL ESTERO, ARGENTINA
08 DEC 62 21:27:18.0
2.7°S, 63.0°W $m_b=7.0$ $h=620$ km



ARGENTINA
29 SEP 62 15:17:47.7
2.7°S, 63.6°W $m_b=6.5$ $h=575$ km



WESTERN BRAZIL
28 NOV 64 16:41:33.4
7.7°S, 71.6°W $m_b=5.6$ $h=626$ km

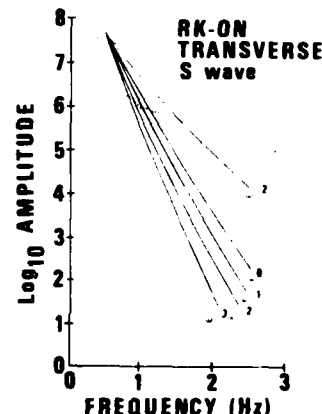
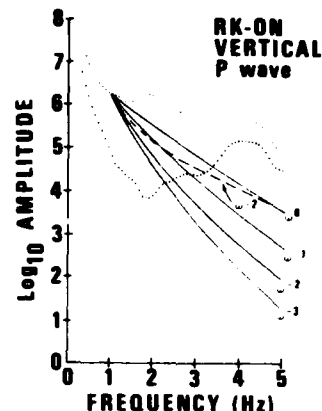


Figure 50 Spectra of signal and noise (upper and lower dotted lines) of selected P and S waves from deep earthquakes observed in the north-central U. S. The spectra were corrected for instrument response. The falloff rates of theoretical spectra (solid lines) (assuming various falloff rates for the source spectrum with $t^* = .5$ and $t^* = 2$, and also allowing for the source depth) lead to discrepancies of several orders of magnitude. These values of t^* , commonly used in time domain work, are therefore unacceptable. The values of $t^* = 0.2$ and $t^* = 0.8$ (dashed lines) with an ω^{-2} falloff in the assumed source spectra fit better, but even these values may be too high.

We estimate from a larger data set that $t_p^* < 0.2$ and $t_s^* < 0.8$ sec is needed to satisfy these data. This is illustrated by the dashed lines in Figure 50 assuming a falloff rate of ω^{-2} , which is the most likely value for large events such as these. This implies that $t_p^* \leq 0.2$ and $t_s^* \leq 0.8$ for deep events and that for shallow events in this type of upper mantle (shield) at both ends of the paths, $t_p^* \leq 0.4$ and $t_s^* \leq 1.6$. This result, together with the long-period result of $t_p^* \sim 1$ and $t_s^* \sim 4$ along similar paths by other workers, implies that t^* is frequency dependent. We must point out, however, that most results in the long-period band are not applicable to shields, and the possibility remains that t^* is low but not dependent on frequency for shields.

Consider again an additional constraint that limits the regional variation of t_p^* —the size of P wave magnitude anomalies. Since these are of the order of 0.3 magnitude units, the corresponding t^* variation must be of the order of 0.2 sec (Der et al, 1979). This is the same result that one arrives at by using spectral ratios (Der and McElfresh, 1977; this report). This implies $t_p^* \sim 0.6$ for paths crossing the mantle under the western United States and terminating in a shield type of structure at the other end. Values such as $t_p^* = 1.3$ (Hadley, 1979) are therefore too high and cannot be accepted in the short-period band.

As far as measured relative regional variations of short-period t_s^* in the U.S. are concerned, these are of the order of 0.8 or maybe somewhat less. The existing constraints are not too tight on these (Der et al, 1980).

t_s^* must also satisfy another condition imposed by observations, namely that for shallow earthquakes short-period S is usually not seen. This condition is quite unspecific since it is not clear how the amplitude of S compares to that of P in the short-period band at the source. Assuming the S amplitude to be five times that of the P (double corner), one gets the result that for $t_s^* = 2$ sec, S will have 5% of the amplitude of P at 1 Hz. A slightly higher $t_s^* \sim 2.4$, corresponding to tectonic-to-shield type paths and the known phenomenon of corner frequency shift of S to lower frequencies, can easily account for the observed disappearance of S into the P coda. Therefore our values appear to satisfy this condition without the need for $t_s^* \sim 4$, a high value commonly claimed by some researchers.

It is conceivable that one could occasionally observe a t_s^* considerably larger than what we consider representative from deep events. For example, a body wave could encounter pockets of attenuating material close to the source (Sacks and Okada, 1974). Such observations, however, cannot be considered representative for the mantle under the north central United States, a common medium for all arrivals observed in this region. Observations of high frequency S wave energy from deep events would be unlikely if any observed low Q is attributed to the mantle under the observing station, unless we presuppose lateral Q variations of extremely small scale. This is because the raypaths sample a relatively small region under the station.

All of the data presented here appear to be compatible with an apparent t_p^* of 0.1 to 0.2 second for shield to shield type paths and 0.4 to 0.5 sec along paths from a shield to the WUS. The data are also compatible with the measurements for explosions listed by us (Der and McElfresh, 1977) and the relative t_s^* measurements from deep events (Der et al, 1980).

Correlation with Travel Time Delays and the Extent of the Mantle Low Velocity Layer

It is not necessary for travel time delays to correlate with regional variations of Q since seismic wave velocities are also dependent on chemical composition. Nevertheless, the correlation between the regional variations of Q outlined above and travel time delays reported by Sengupta and Julian (1976) is extremely good. The major features of their results, shown in Figure 51, include large delays in the Basin and Range and SWUS in general, early arrivals in the shield, and slightly late arrivals along the Atlantic seaboard and in New England. The late P arrivals in New England have since been studied in more detail (Taylor and Toksöz, 1979). The P wave travel times at OB2NV are 1.7 sec late relative to RKON after elevation correction, and because of this NTS fits well into the regional pattern presented by Sengupta and Julian. The same observation can be made with regard to the S wave delays in North America as compiled recently by Wickens and Buchbinder (1980). The larger S delays in the southwestern corner of the United States appear to coincide in area with the most severe attenuation of S waves apparent in our Figures 43 to 49. There are also indications that the

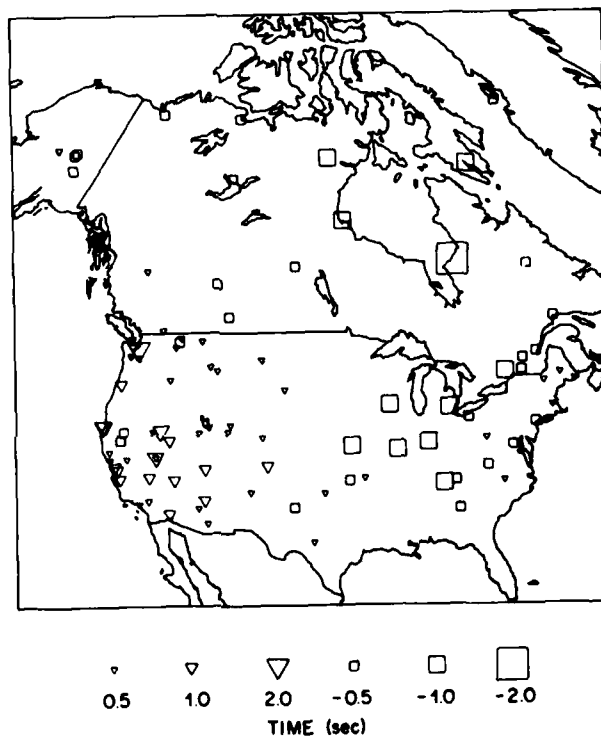


Figure 51 Travel time delays for P waves from deep events across the United States (after Sengupta and Julian, 1976).

relationship between P and S delays is different in the EUS versus the WUS (Romanowitz and Cara, 1980), indicating that the travel time delay pattern cannot be associated with changes in thickness of simple low velocity layers without changes in velocity contrast. Low velocities in the upper mantle also manifest themselves in the diminution of phase velocities of surface waves with significant particle motion in the mantle. There appears to be a correlation between low surface wave Q and low phase velocities worldwide (Lee and Solomon, 1979; Nakanishi, 1979). The low Q-low mantle velocity regions are also characterized by negative m_b residuals (North, 1977). Low mantle velocities and low Q thus appear to be areally correlated worldwide.

Frequency Dependence and Worldwide Implications

Strictly speaking, frequency dependence of Q can only be established if attenuation is measured in a wide frequency band using short- and long-period instruments over the same paths. Consideration of frequency dependence introduces a large number of additional parameters into studies of attenuation. It is possible that the form of frequency dependence changes from region to region, and the depth distribution of Q may be different at various frequencies (Solomon, 1972; Lundquist, 1979). These uncertainties can be resolved only by further detailed studies. A large number of reported t^* determinations within the U.S. in the long-period band were obtained by time domain methods, but these cannot be accepted as valid until the controversies surrounding them are resolved. We have shown above that in the short-period band values of $t^* \approx 1$, as often obtained by time domain techniques, are unacceptable.

In the following we shall outline possible frequency dependence of t_p^* using three assumptions. The first assumption is that the Q and velocity structures are basically identical for all shields, so that absolute attenuation measurements in other shield regions can be applied to the north central U.S. The second assumption is that $t_s^* \approx 4t_p^*$. This assumption is supported by most of the data in the literature, and the slight modification due to losses in compression proposed by Sailor and Dziewonski (1978) does not affect the following argument. The third assumption is that most of the losses in the mantle occur in the upper 200 km and that the contribution of any low Q region at the core mantle boundary is relatively small. All of these assumptions agree well with the findings of research to date.

We now proceed to describe attenuation in terms of t_p^* as a function of frequency along two types of teleseismic paths. The first type of path crosses a shield-stable platform type structure at both the downgoing and upgoing legs of the path. We call these paths "shield paths" in the following discussion. The second type crosses a WUS (tectonic) type of mantle on either leg of the path. We term these paths "shield-to-tectonic". In the previous section we put several bounds on the possible values of t_p^* and t_s^* in the short-period band within the U.S. These are:

- . t_p^* is of the order of 0.1 to 0.2 sec for shield paths in the 0.5 to 4 Hz range (from spectral measurements).
- . $t_s^* \sim 2$ for shield paths around 1 Hz.
- . The t_p^* differential between shield and shield-to-tectonic paths is of the order of 0.2 sec.

These constraints are supported by short-period t_p^* measurements from other regions. Spectral measurements of short-period P waves having shield type paths from Asia to NORSAR imply $t_p^* \sim 0.1$ (Nojonen, 1975, Ringdal, 1976; Filson and Frasier, 1972). The spectral differences between WUS and central Asia earthquakes and explosions at NORSAR imply a t_p^* differential of the order of 0.2. Spectra of teleseismic P waves for a wide variety of paths observed on shields contain significant high-frequency energy in the 3 to 4 Hz range, essentially ruling out any constant $t_p^* \sim 1$ for most such paths.

Having put limits on t_p^* and t_s^* within the short-period band, we can proceed now to review the evidence in the long-period band. The studies by Solomon and Toksöz (1970) and Solomon (1972) give a regional t_p^* differential of $\Delta t_p^* \sim 0.5$ sec or more in the two types of paths. The studies of Lee and Solomon (1975 and 1979) result in Q_β structures that imply a long-period t_p^* differential of only 0.25. Ray tracing through the Q models given would yield t_p^* of the order of 0.6 to 1.7 in the eastern U.S. (EUS) and close to unity for an EUS-WUS path. This by itself would imply frequency dependence of Q, but the absolute Q values in these models are rather uncertain due to the inherent difficulties of measuring Q of surface waves over short paths. In any case, these studies indicate that the upper mantle Q also varies regionally in the long-period band. Therefore, the fitting of absorption band models that do not allow for this by shifting the high-frequency limit

only (Lay and Helmberger, 1980) unnecessarily constrains the results. The work of Nakanishi (1979) provides further indications that the upper mantle Q measured in the 150 to 300 sec period range is high under shields. It appears from his work that, on the average, anelastic losses under shields are less than those associated with model MM8 of Anderson et al (1965). At teleseismic distances model MM8 gives a t_p^* of the order of 0.6 to 0.8 sec; thus those values should be considered as upper limits of t_p^* for a long-period band also.

The ideal measurement of Q_β under shields would be provided by multiple ScS phases. Unfortunately, there are no studies of ScS that could be clearly associated with purely shield type paths (and none under the eastern United States). Nevertheless, the average Q_β ScS values for the whole mantle of 600 by Kovach and Anderson (1964) and 580 by Sato and Espinosa (1967) may be indicative of Q values in regions above the downgoing slab in South America that may have Q characteristics similar to shields (Sacks and Okada, 1974). These Q values are considerably higher than those obtained from multiple ScS studies elsewhere (Sipkin and Jordan, 1980), but the corresponding t_p^* at teleseismic distances in such structures would still be 0.4 to 0.5 sec, twice the apparent t^* from spectral ratios in the short-period band. Thus even these high Q values imply some weak frequency dependence of Q for shield type of paths. If the average Q under shields turns out to be lower, as suggested by the average mantle Q_{ScS} of 225 for continents (Sipkin and Jordan, 1980), the frequency dependence would, of course, be stronger.

The above constraints allow one to draw the preliminary sketch shown in Figure 52 of frequency dependence of t_p^* for the two types of paths discussed above. The most natural assumption is a smooth variation that appears to be supported by indications of smooth changes in both the short- and long-period bands (Archambeau et al, 1969; Sato and Espinosa, 1967; Brune, 1977; Yoshida and Tjusiura, 1975). Such a gradual change does not greatly bias any relative or absolute t^* measurements from spectral ratios although to allow for such bias the curves are drawn higher than the t^* determined from spectral ratios assuming a constant Q . Details of the regional and frequency dependence of Q under the United States must still be worked out.

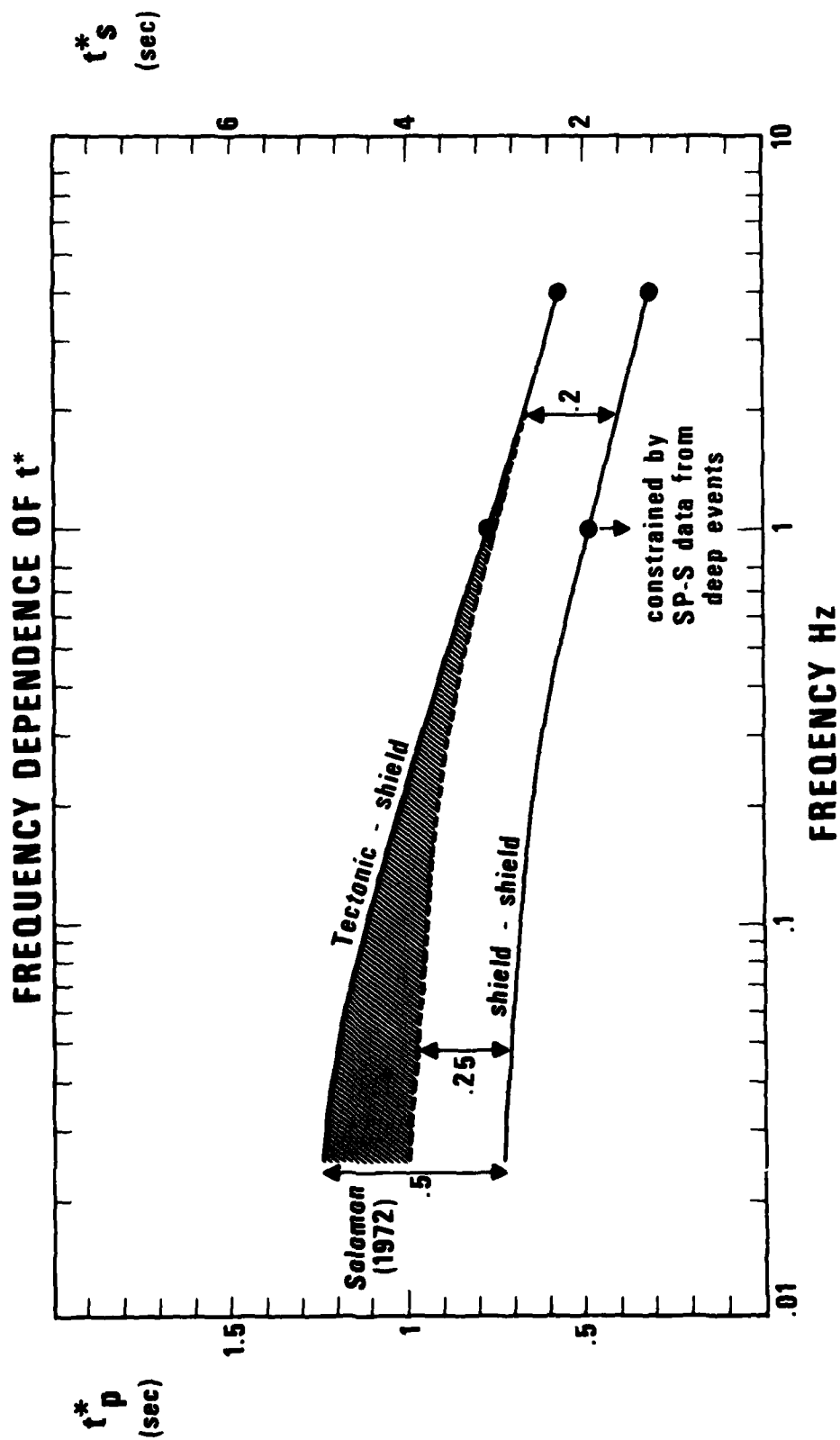


Figure 52 Proposed variation of t_p^* and t_s^* with frequency for purely shield type of paths (lower curve) and for a mixed WUS-shield path.

We now discuss briefly some worldwide measurements of Q in the context of frequency dependence and regional variations. Worldwide measurements of Q_{ScS} and mantle waves (Sipkin and Jordan, 1979, 1980; Nakanishi, 1979) show that the regional variation of Q in the long-period band is similar to that observed in the short-period band (Barazangi et al, 1975; Oliver and Isacks, 1967; Solomon, 1972). Attenuation is extremely high behind island arcs in certain areas, under mid-ocean ridges and in tectonic regions. It is low under shields and old ocean basins. This appears to be true throughout the 0.003 to 4 Hz band. In most regions of the Earth, attenuation measurements in the long-period band indicate Q values that would give $t_p^* \sim 1$ and $t_s^* \sim 4$. Most Q models derived from free oscillation data also imply $t_p^* \sim 1$ and $t_s^* \sim 4$ (Anderson and Hart, 1977). On the other hand, observations of high frequency energy in the 3 to 5 Hz range are quite common over a wide variety of teleseismic paths (Asada and Takano, 1963; Takano, 1971; Felix et al, 1971; Noponen, 1975) providing the observations were made using instrumentation peaked at high frequencies and having suitable recording systems. A large number of worldwide Q_p estimates are given by Rivers and Der (1980) indicating $t_p^* \sim 0.5$ for most of the paths studied. Reports of similar observations in the literature are too numerous to quote them all. There is thus a clear conflict between short- and long-period Q measurements that apparently can be resolved only by assuming a frequency dependent Q that doubles within the range of 0.01 to 2 Hz.

CONCLUSIONS

- Large scale regional amplitude anomalies exist for teleseismic P and S waves in the United States. The regional distribution of P and S wave amplitude anomalies is essentially identical, but the range of variation is greater for S waves. The amplitude patterns cannot be explained by crustal amplification, and corrections for crustal amplification leave a pattern of high amplitudes in the north central United States and low amplitudes in the western United States--especially in the southwestern part of the country. The northeastern United States is characterized by moderately depressed amplitude levels.
- The regional amplitude anomalies correlate with spectral changes in both P and S waves; low amplitudes are accompanied by losses in high frequency energy. These spectral changes are quite dramatic in S waves from deep events observed across the United States. The regional variation of teleseismic t^* across the United States is of the order of 0.2 seconds for P and about three to four times that for S.
- The existence of these anomalies confirms the hypothesis that the causes of these variations are lateral changes in Q_β in the mantle under the United States.
- The data presented indicate that mantle attenuation is greatest under the southwestern United States, including the Basin and Range province, and it is the least in the shield region of the north central United States. As a whole, the western United States mantle is more attenuating than the mantle under the eastern United States. The northeastern United States appears to be characterized by mantle attenuation greater than that of the shield region but less than that of the Basin and Range province. The SDCS results fit well into the regional pattern outlined.
- The regional variations in Q correlate well with travel-time residuals and variations in the upper mantle LVZ that are derived from surface wave studies that indicate that the LVZ is also a low Q region.
- The amount of high frequency energy in short-period teleseismic P and S waves in the U.S. and worldwide is incompatible with the values of $t_p^* \sim 1$ sec

and $t_s^* \sim 4$ sec derived from long-period attenuation studies and commonly used in synthetic simulations. This appears to indicate that Q is frequency dependent and doubles in value somewhere in the range of 0.01 to 2 Hz.

PART 3

BASIC QUESTIONS RELATED TO THE ANALYSIS OF SHORT-PERIOD DATA AND THE MEASUREMENT OF ATTENUATION IN THE 0.5 TO 5 HZ BAND

Interpretation of short-period data and the determination of Q from such data presents special problems that are of no concern in the long-period band. In the short-period band the scale of inhomogeneities in the crust and the surface topography become comparable to the wavelength, and that introduces complications due to focusing of seismic energy, crustal amplifications of signals and scattering. In addition, the frequency content of signals becomes a critical and sensitive determinant of Q at high frequencies. The tools seismologists use in analyzing signals are the measurement of wave amplitudes and spectra and the matching of waveforms. In the following sections we shall evaluate the relative effects that various factors have on these signal characteristics. We shall discuss the effects of Q on amplitude and spectral measurements and critically evaluate time domain methods of waveform matching. We shall also estimate the possible effects of instrument nonlinearity on Q measurements. As dictated by the diversity of subjects, this part of the report consists of separate sections discussing the above topics. These are referred to when appropriate in the previous parts of this report.

Section A: The Effect of t^* on the Absolute Level of Spectra in the Short-Period Band

For a constant t^* the effect of attenuation is described by the formula

$$A \sim \exp(-\pi f t^*) \quad (1)$$

where A is the wave amplitude, f is frequency and $t^* = T/Q_{av}$. T is travel time and Q_{av} is the average quality factor. Let us examine this function for some values of t_p^* and t_s^* frequently mentioned in the literature. Figure 53 shows a plot of equation (1) for various t_p^* . As the figure shows, $t_p^* = 1$ implies that 4 Hz amplitudes are reduced by a factor of more than 10^4 relative to those at 1 Hz. Thus the assumption of $t_p^* = 1$ rules out the observation of 4 Hz energy in P waves for all practical recording systems presently in use since lower frequencies would saturate the system before 4 Hz energy would be observable.

Now let us consider the consequences of various constant t_s^* on the spectra of S waves, as shown in Figure 54. The factor of 4 increase of t_s^* relative to t_p^* essentially shifts the frequency axis by the same factor to the range around 1 Hz. This effect is even more severe than the value $t_s^* = 3$ sec claimed for deep earthquakes by Burdick (1978) and, in spite of the counterbalancing effect of most short-period instrument responses, effectively rules out any observation of 1 to 2 Hz energy in S waves from deep events.

It appears, however, that 4 Hz energy is routinely observable from P waves even at low Q sites such as OB2NV. This is demonstrated in Figure 55, where we show five typical spectra from this site. Furthermore, 1 to 2 Hz energy is often observed in S waves from deep earthquakes as shown in Figure 50 of part 2 of this report. Observational evidence, therefore, precludes the general use of such high values as $t_p^* \sim 1$ and $t_s^* \sim 4$ since, as we have shown above, such values would depress the higher frequencies by many orders of magnitude and thus render them unobservable.

In view of the fact that spectra of short-period body waves are extremely sensitive to even small variations of Q , we must conclude that studies claiming these high values are incorrect. We shall show in section C that distortion of the shape of the spectra, especially the falloff rate toward high frequencies, is also primarily determined by t^* .

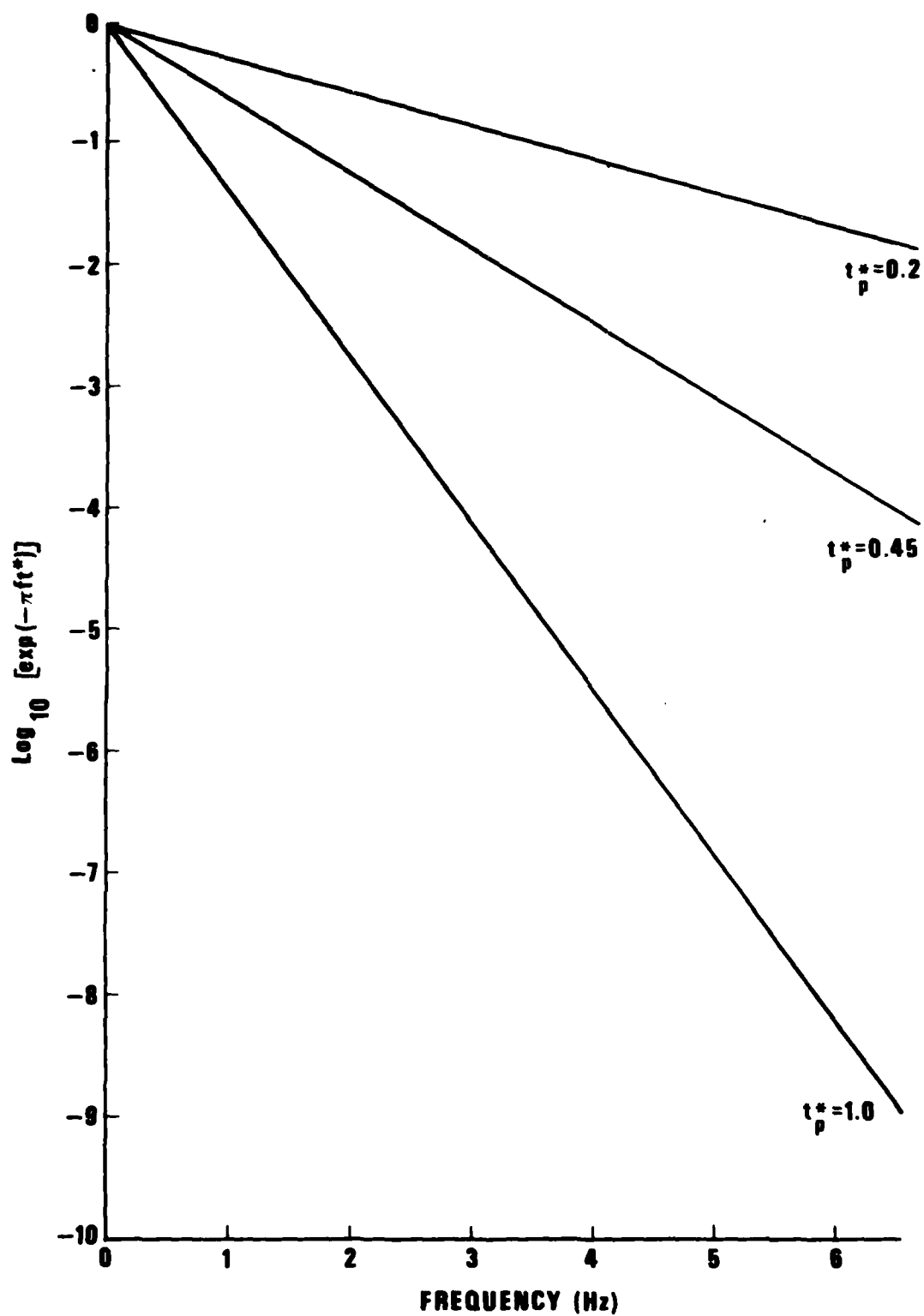


Figure 53 Diminution of P wave amplitudes as a function of frequency for various values of t_p^* .

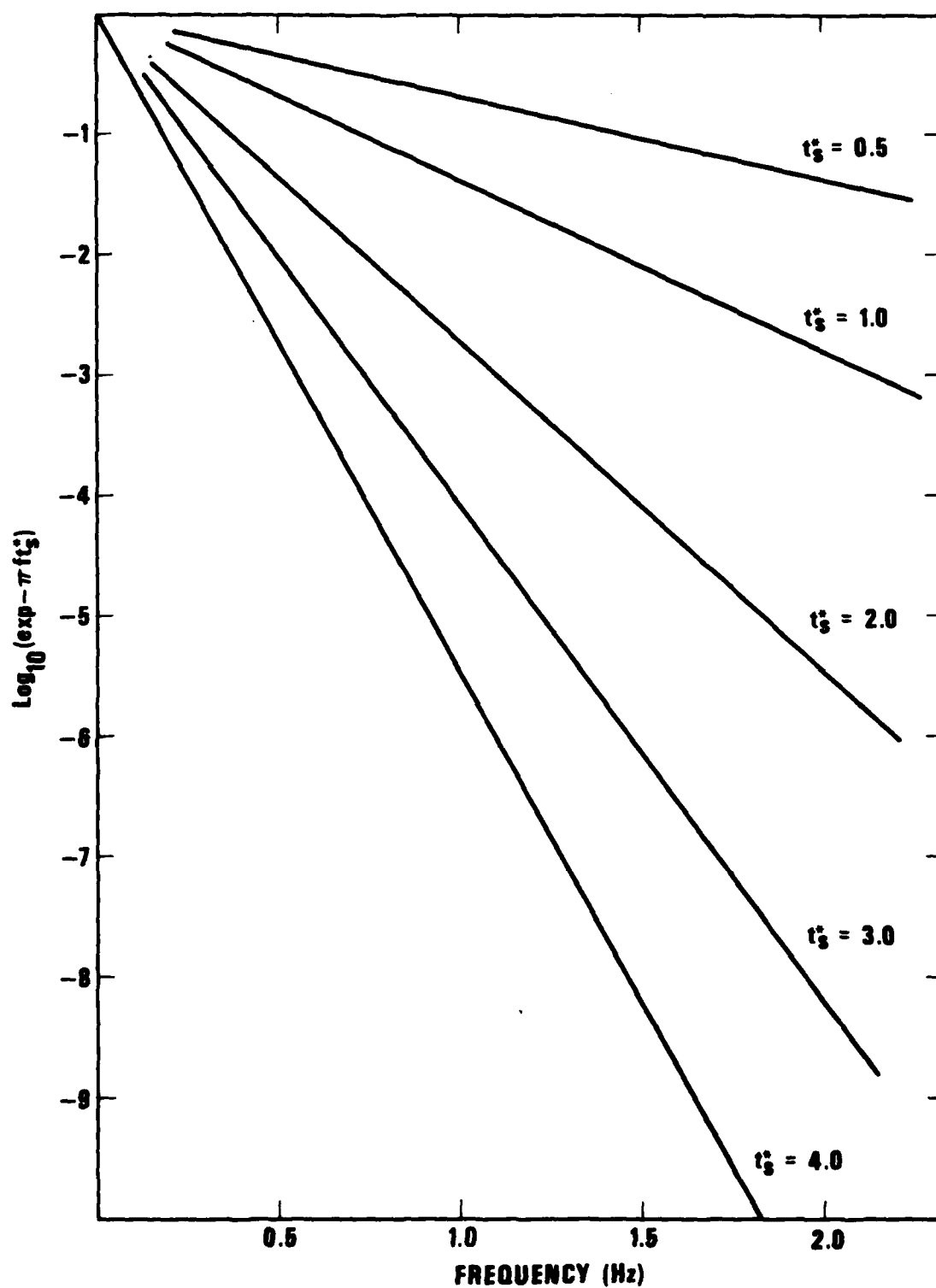


Figure 54 Diminution of S wave amplitudes as a function of frequency for various values of t_s^* .

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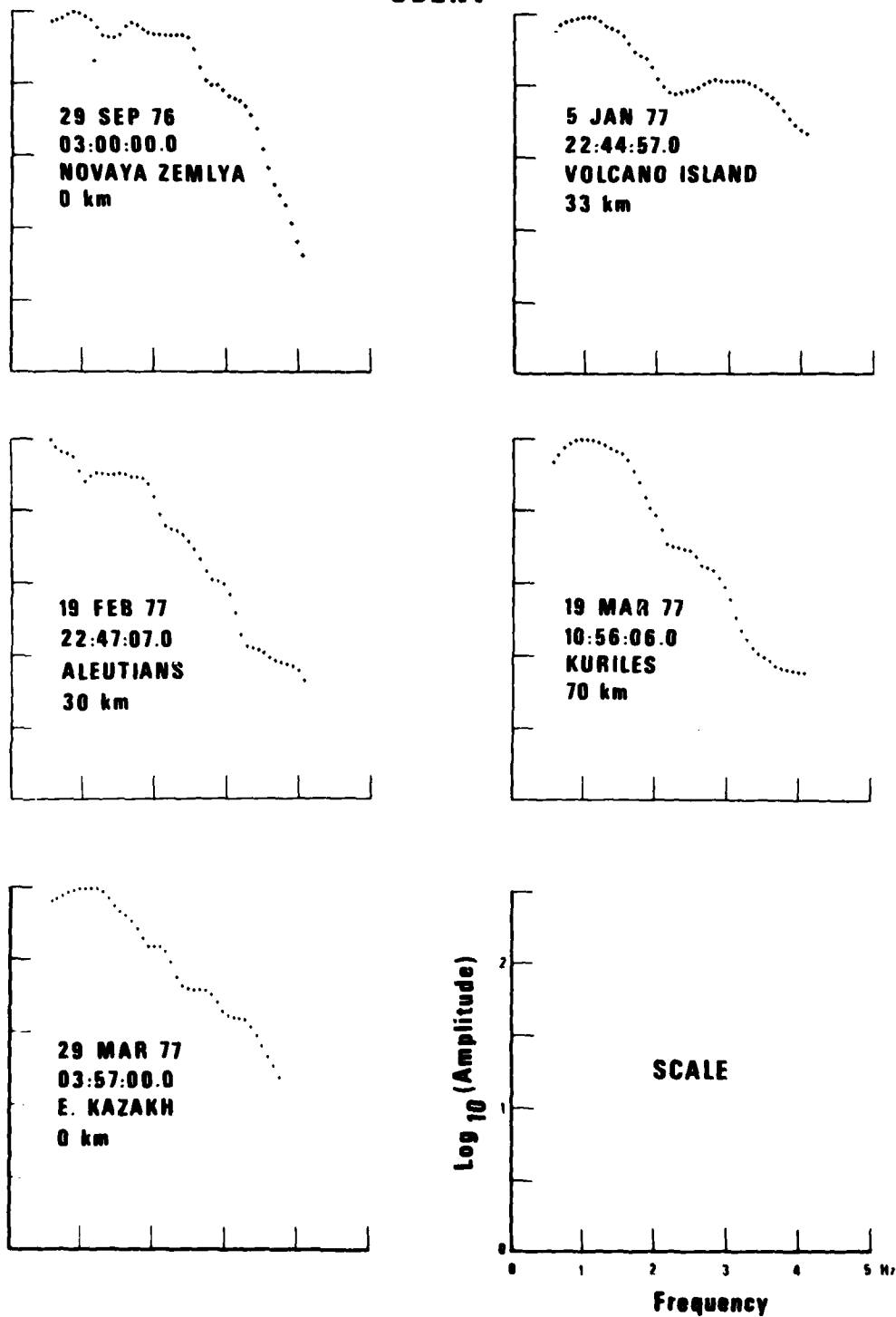


Figure 55 P wave spectra at OB2NV showing significant signal energy at 4 Hz. (All these spectra have a minimum of 3:1 ratio of signal to noise power.)

Section B: Time Domain Manifestations of Varying t_p^* and Their Biasing
Effect on the Computation of m_b

The first order visible effects of t^* in the time domain are changes in the amplitudes and dominant periods of the body waves affected. These changes can be seen to various degrees, depending on the spectral characteristics of the seismic sources. Figure 56 illustrates this. This figure shows a wide band (left) and a narrow band (right) signal causally filtered by various t^* . The narrow band signal, typical of large events used in time domain simulations, is quite insensitive to t_p^* . Note that its waveshape and dominant period change little. The wide band signal, on the other hand, shows a drastic change in general appearance with increasing t_p^* , and the dominant period changes from 0.5 sec to 1.8 sec. The maximum trace amplitude changes by a factor of ten for the wide band signal and by a factor of five for the narrow band signal over the entire range of 0.8 sec in t^* . Thus the effect of t^* on two time domain representations can be visually quite different, and not all signals will show a major change in dominant period.

When a change of period does occur it will introduce a paradox if m_b is computed from such signals using the standard formula

$$m_b = \log_{10} \frac{A_{tr}}{m(T) \cdot T} + B(\Delta^\circ)$$

where A_{tr} is the trace amplitude, $m(T)$ is the magnification of the instrument at the dominant measured period T , and B is a distance-dependent correction factor. For example, if m_b is computed for the wideband signals associated with $t_p^* = 0$ and $t_p^* = 0.6$ at the left of Figure 56, one obtains the result that m_b is larger for $t_p^* = 0.6$. This is the reverse of what one would expect on physical grounds for high frequency signals. The cause of this is the period dependent instrument (LRSM in this case) factor $m(T)$ that overcorrects due to the implicit assumption that the time domain amplitude measurement is associated with a single frequency. This paradox affects the body wave magnitude and amplitude results whenever the standard m_b procedure is adhered to. For moderate changes of t^* the actual reversal of m_b values does not occur, but for wide band signals the m_b procedure tends to de-emphasize the attenuation effect. These considerations caused us to abandon the measure

$$m'_a = \log_{10} \frac{A}{m(T)} + B(\Delta^\circ)$$

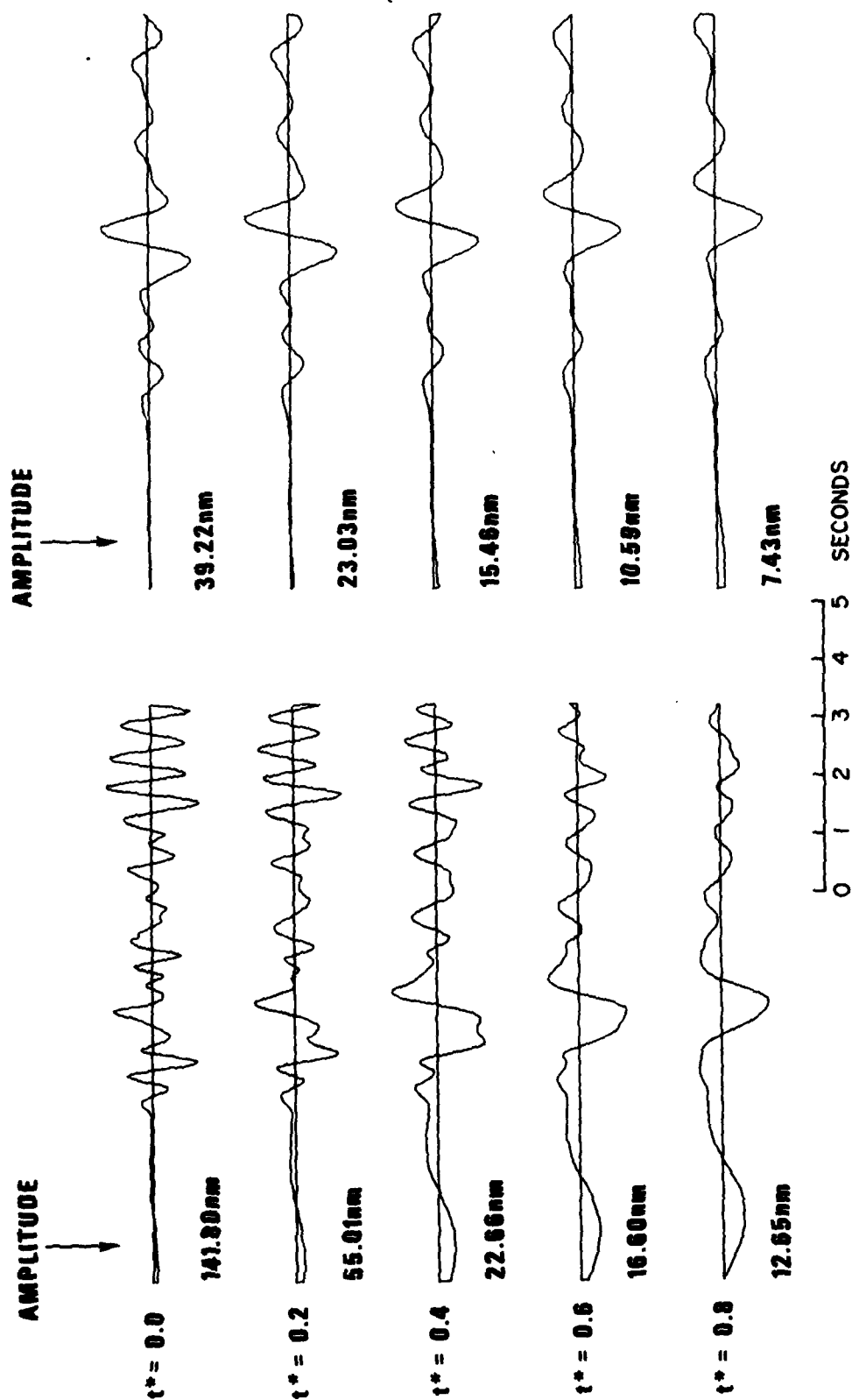


Figure 56 Different manifestations of the same t^* on wide band and narrow band signals in the time domain. The wide band signal shows more change in amplitude and dominant period (left) than the narrow band, low frequency signal (right).

used in our previous reports and to substitute trace amplitudes A_{tr} in our discussions.

That this effect is not a hypothetical presupposition but actually does occur is shown in Figure 18 of Part I and the accompanying discussion (page 42 of this report). The fact that the effect of attenuation on m_b critically depends on source spectra makes a search for more meaningful spectral measures of body wave energy necessary.

These remarks were made in order to point out how deceptive purely time domain observations and simulations can be. These problems do not exist, on the other hand, if comparisons are made in the spectral domain. The advent of high quality recording stations with large dynamic ranges makes purely time domain comparisons obsolete, since spectral calculations are more sensitive and reliable indicators of variations of t^* with frequency and geographical region. Time domain comparisons fail to utilize the broad band information available in signals recorded with systems of high dynamic range.

Section C: Various Effects on Body Wave Spectral Shapes (Excluding Attenuation)

Taking ratios of observed body wave spectra at various sites in order to measure relative attenuation and taking ratios of observed spectra to model source spectra in order to obtain values of t^* are widely used methods in seismology. These techniques utilize the slope of the spectra by fitting straight lines to spectral ratios on a semilogarithmic plot, discarding the absolute amplitude, the high variability of which is unrelated to anelastic attenuation (see Section D of this report). In this section, we shall list and evaluate various effects not related to t^* that might seriously bias the results of such studies. We do not claim that these effects on rare occasions cannot be important, but we merely wish to consider their relative importance compared to t^* . In Section A, we demonstrated the drastic effect of t^* on body wave spectra. In the following, we shall demonstrate that the effect of other factors is much smaller.

The most prominent crustal perturbation of spectral slopes at the source is the effect of surface reflections. Compared to these, the internal reverberations have a small effect (Fuchs, 1966). For earthquakes, this includes the phases pP and sP , the relative amplitudes of which depend on the surface reflection coefficients and the orientation of the source mechanisms. For explosions, the pP and any possible spall phase can affect the spectrum. However, pP and the corresponding clear spectral nulls are mostly absent in the observed seismograms, indicating that either the effective surface reflection coefficient is small (due to either scattering or nonplanar surfaces) or that multipathing effects obscure the surface reflections. In any case, the P wave spectra may be affected by the surface reflections.

It must be pointed out that synthetic results based on elastic flat layer models are often demonstrably not valid. Such calculations generally predict a large free surface reflection. In contrast, the actual data for most explosions do not show such large secondary arrivals, and the spectral minima (nulls) to be expected are weak or not detectable (Der and McElfresh, 1976). It appears that the effective reflection coefficient of the free surface is much less than unity at most places. The physical reasons for

this are that the free surface is not flat and that there exist inhomogeneities close to the source that distort the waveforms. The reduction of effective surface reflection coefficient means that the nulls in the spectra disappear, and the effect on the t^* measurements becomes negligible. Furthermore, in the few cases when these nulls are apparent in the data, it is easy to correct the spectra for pP interference and eliminate this factor. For earthquakes, pP and sP both occur with amplitudes varying relative to direct P. In such situations clear spectral nulls usually do not appear. The variants of such simulations may include the spall phase or a pP with the spectra modified by near-surface layers. In any case, none of these models can consistently mimic the effect of anelastic attenuation that consistently suppresses the high frequency end of the spectrum.

Another possible effect on spectra and waveforms is that of multipathing and focusing. Studies of seismic arrivals at arrays reveal that secondary arrivals of energy delayed in time and (often) deflected in the direction of arrival are present in most teleseismic body waves (Mack, 1969). Some of these can be deterministically modeled by an uneven Moho or deep structures in the mantle (Berteussen et al, 1975; Capon, 1974; Capon and Berteussen, 1974; Christofferson, 1975; Dahle, 1975; Dahle et al, 1975; Haddon and Husebye, 1978; Hadley, 1979; Chang and von Seggern, 1980 and many others) or by the theory of waves in homogeneous random media. The effect of identical multipath arrivals with random amplitudes at random times is to introduce fluctuations in the body wave spectra, but it cannot introduce a consistent decrease of amplitudes with frequency similar to the factor $\exp(-\pi f t^*)$.

To assess the effect of such random variations we computed spectral ratios between individual sensor pairs belonging to various subarrays at NORSAR for ten events. Since we do not believe that t^* actually changes across the array, the observed fluctuations in the slopes of the spectral ratios between 0.5 to 4 Hz must reflect the random effect due to multipathing. Figure 57 shows the histogram of slopes of spectral ratios expressed in terms of apparent t^* . The standard deviation of this population is 0.06 sec, showing that the spectral ratios are quite stable and the scatter is quite small. Using the empirical formula $\Delta m_b \approx 1.35 \Delta t^*$ (Der et al, 1979), this would translate into $\Delta m_b \sim 0.08$. The actual variation of

RELATIVE t^* MEASUREMENTS ACROSS NORSAR

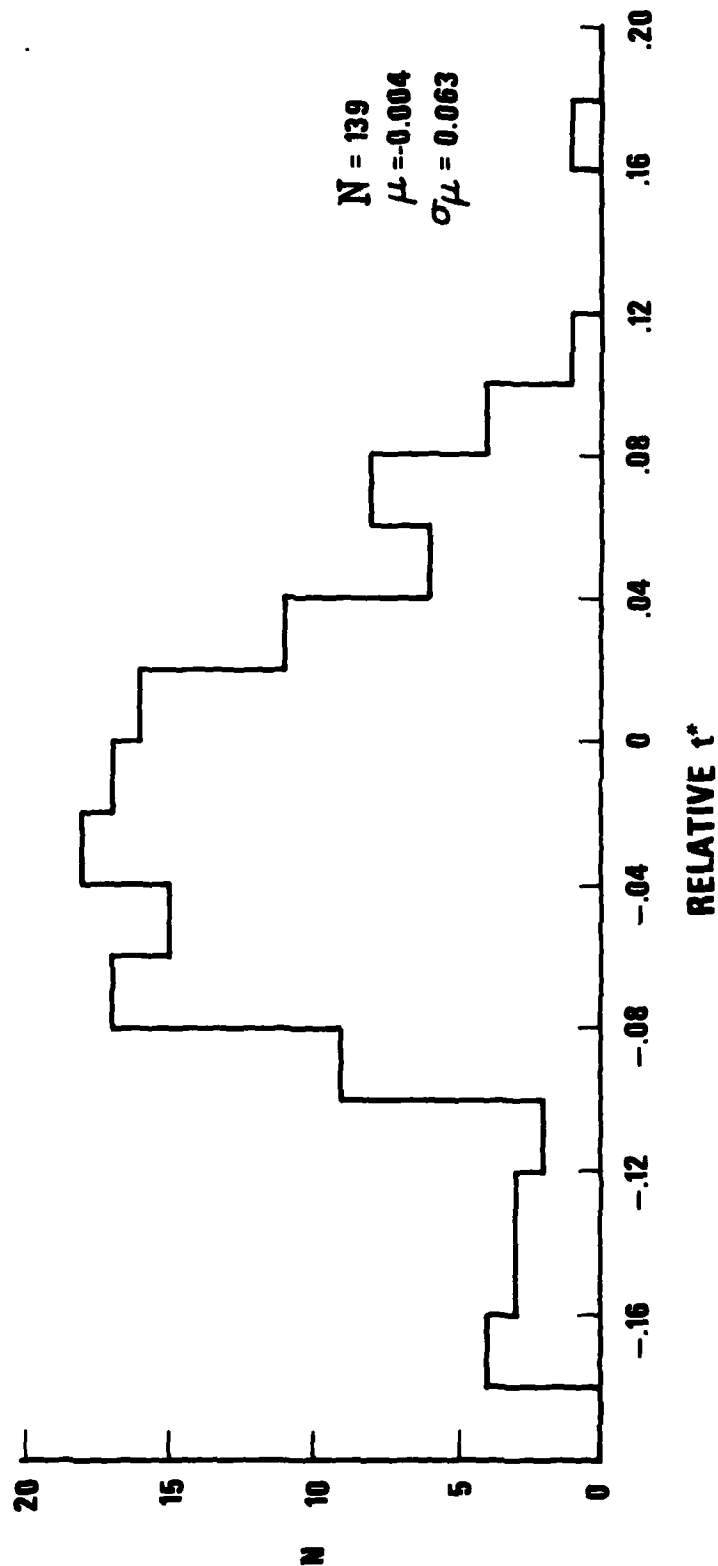


Figure 57 Relative t^* between subarrays at NORSAR for ten tele-seismic events. The histogram shows that the scatter of Δt^* compared to that of amplitudes is small ($\sigma = 0.06$ sec). This illustrates the relative stability of spectral measurements.

Δm_b measured directly is about 0.4 magnitude units at NORSAR. This demonstrates that spectral slopes are more stable than signal amplitudes. Large variations of amplitudes across LASA were also reported by Chang and von Seggern (1980). These are generally distance and azimuth dependent.

The receiver crust is another factor to consider when evaluating studies that involve spectral ratios. The effect of the receiver crust manifests itself in the increase of the peak amplitude of the signal and the prolongation of wavetrains (ringing) at sites with thick low-velocity sedimentary cover. In the frequency domain, the slopes of amplitude responses of most crustal models are flat when fitted with least squares lines over the 0.5 to 4.0 Hz range. Over shorter frequency ranges these slopes will be greater. In general the presence of the receiver crust does not seriously affect the spectral ratios.

A few remarks need to be made about detailed slopes of crustal responses. In computing synthetic seismograms, specific crustal structures are routinely used to model the crustal reverberations in detail in the time domain. This, on the surface, conveys an impression of precision. Experience with short-period spectral work indicates, however, that the details of such calculations both in the time and frequency domains cannot be trusted. An indication of this is that for short-period waves Phinney's (1964) radial to vertical spectral ratio method never worked, the probable reason being that at most places the near-surface geology is horizontally heterogeneous giving different spectral ratios in various directions. The dominant effect of the crust is associated with acoustic impedance changes due to variations in the near-surface materials (Der et al, 1979) that causes considerable changes in the amplitude levels while leaving the gross spectral slopes unaffected.

Another objection often voiced against spectral calculations is that scattered high frequency energy in the coda can significantly bias the t^* measurements. First of all, it must be pointed out that while scattering near the receiver may apparently enhance high frequencies by some mechanism such as P conversion to Rayleigh waves, such scattering cannot generate high frequency energy. Any such signal energy observed must have come from the source. The simplest test to assess the relative contribution of the P-wave coda to the high frequency part of the spectra is band pass filtering

of P-wavetrains. Figures 58 to 60 show some examples of this. In filtering these traces, a set of causal band pass filters with a flat response in the band indicated on the figures and a 24 dB/octave falloff outside the band were used. Algorithms for causal digital filtering are described in many textbooks (Oppenheim and Schaffer 1975 for example). In most of the cases shown, the envelopes of the wavetrains are essentially similar in all bands. This indicates that our use of a 9-second signal window is not only representative of the signal spectra, but it also has the beneficial effect that the spectra are more stable than those computed from shorter windows. Any enhancement of high frequency energy in the coda is not comparable in effect to that of even small changes of t^* . Thus, the claim that the scattering effect is significant has no basis in fact.

Finally, an effect that can significantly alter both the observed relative amplitudes and the spectra is directionality of earthquake sources. Although considerable work has been done in the long-period band to model such effects, and fair success has been achieved in modeling waveforms, not all of the problems have been solved to date. Modeling of unequal P and S corner frequencies is still deficient (Molnar et al, 1973; Hanks, 1980), and source time functions are over-simplified. In the short-period band, simulation of waveforms is largely unsuccessful for earthquakes and doubtful for explosions. It is likely that short-period radiation patterns are extremely complex for large and moderate sized earthquakes. While at long-periods, with wavelengths comparable to the fault length, an earthquake may resemble a double couple source with some directionality component added, this is much less likely to be true in the short-period band where the details of source motion in space and time play a more significant role. We conclude that modeling of large earthquakes in the 0.5 to 5 Hz frequency range is beyond the state-of-the-art since no one has done it successfully. In the absence of modeling capability one has to rely on averaging over many events to reduce the source directionality effects in order to estimate path characteristics. Fortunately, all seismic regions contain enough variability in source mechanisms to make this possible.

We tabulate the main conclusions of this section in Table VII.

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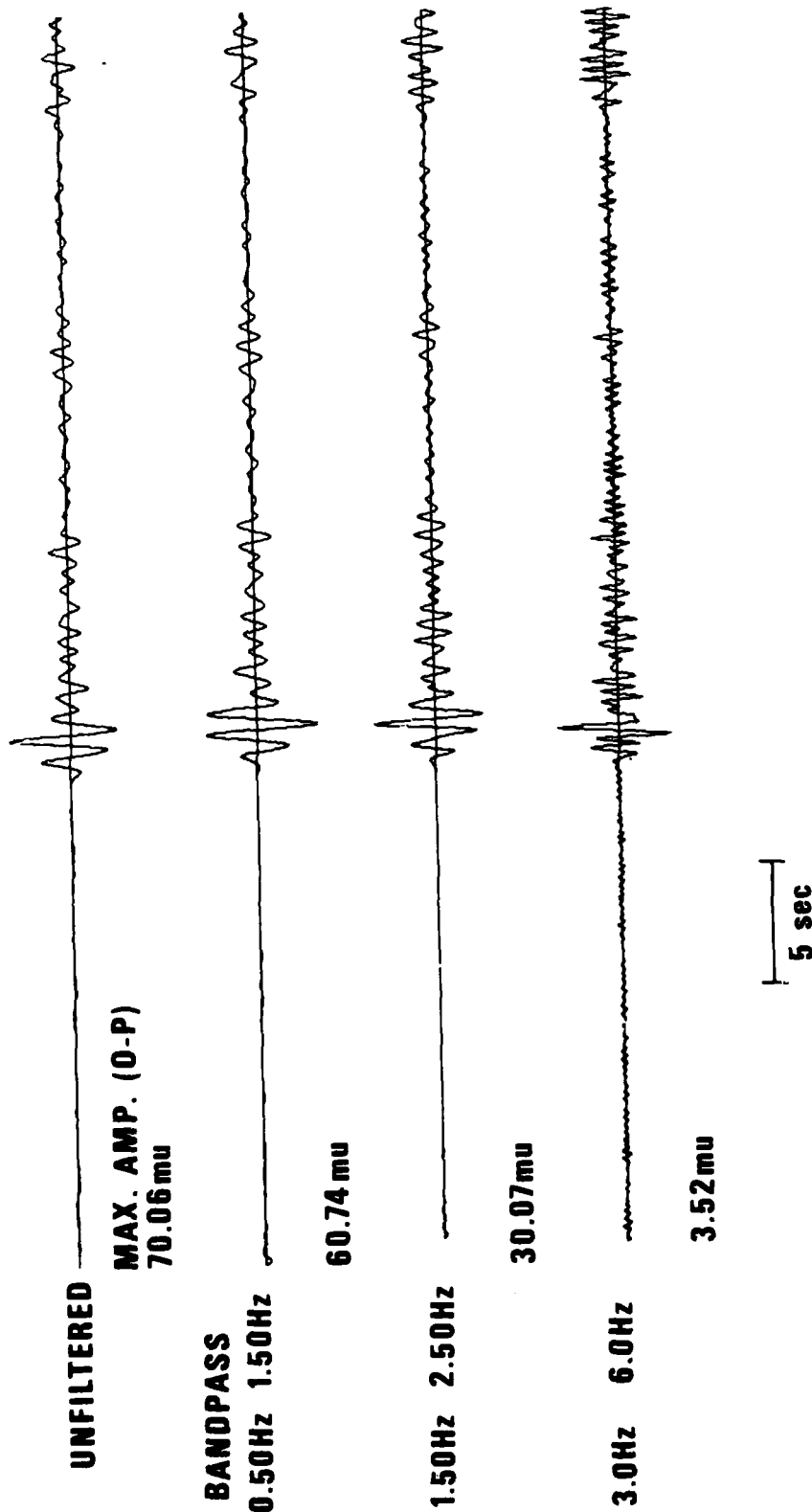


Figure 58 Band pass filtered P wave seismograms at the NTS station OB2NV. The figures show that the frequency content in P waves does not change much in the first 10 sec of the signal. Therefore taking spectra of the first 9 sec of P does not introduce a significant bias in t^* relative to that computed from shorter windows.

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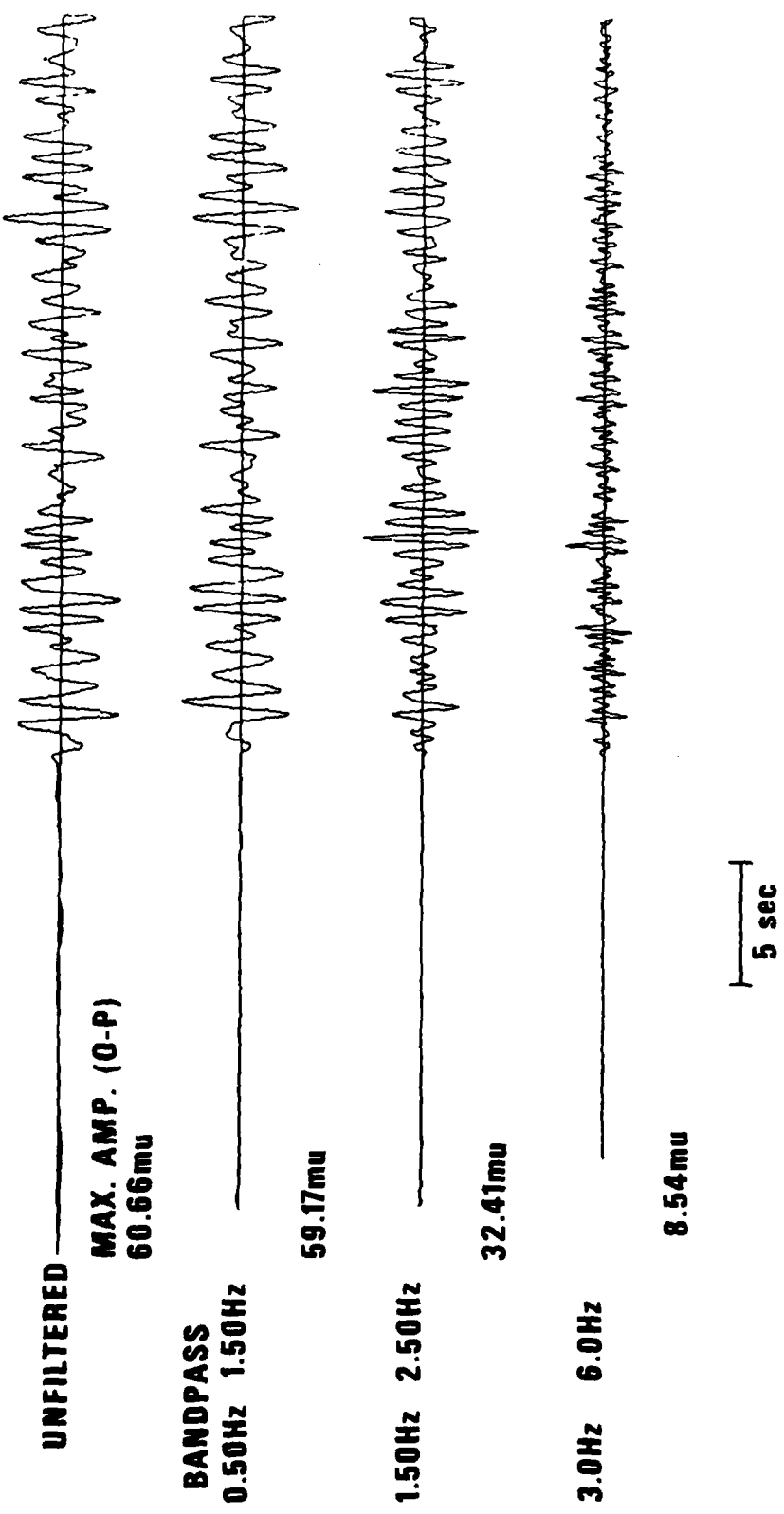


Figure 59 Band pass filtered P wave seismograms at the NTS station OB2NV. The figures show that the frequency content in P waves does not change much in the first 10 sec of the signal. Therefore taking spectra of the first 9 sec of P does not introduce a significant bias in the relative to that computed from shorter windows.

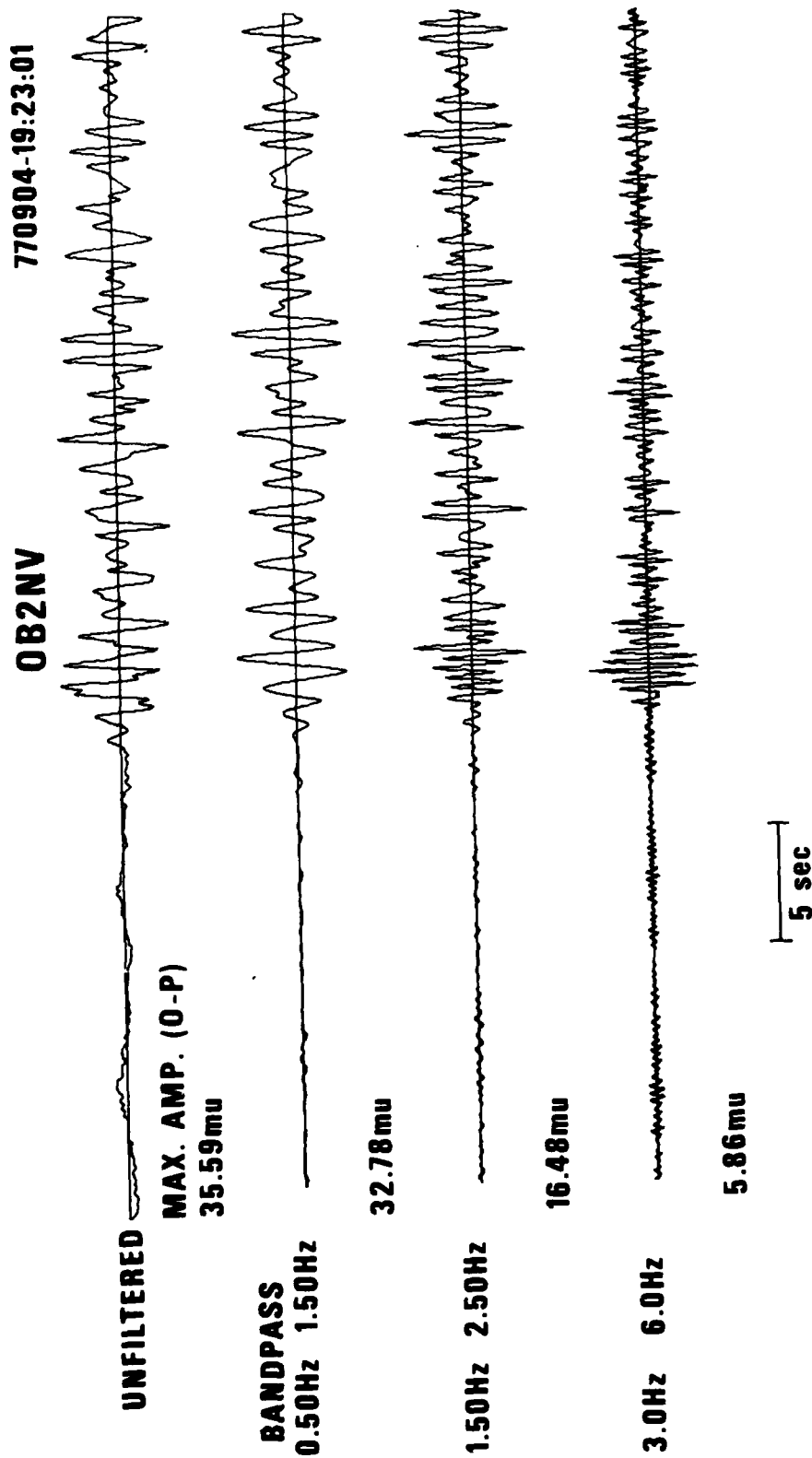


Figure 60 Band pass filtered P wave seismograms at the NTS station OB2NV. The figures show that the frequency content in P waves does not change much in the first 10 sec of the signal. Therefore taking spectra of the first 9 sec of P does not introduce a significant bias in t^* relative to that computed from shorter windows.

TABLE VII

The Effect of Various Factors on Spectral Slopes
(falloff rates with frequency disregarding absolute amplitudes)

<u>Factor</u>	<u>Properties</u>	<u>Relative Importance</u>
Anelastic attenuation	Causes a falloff of spectra $\exp(-\pi f t^*)$ with frequency	First order large effect (several orders of magnitude at high frequency end of spectrum)
Crustal amplification	Distorts spectrum	Rarely it can cause an error in t^* up to .1 sec on sediments, negligible at most hard rock sites
Surface reflections (pP, sP, etc)	Introduce nulls in the spectra	If detectable it can be easily corrected for. Negligible in comparison to t^* effect if surface reflection coefficient is considerably less than unity
Scattering	May enhance high frequencies	Negligible in comparison to t^*
Multipathing	Changes spectral slope	Negligible in most cases (Wald's theorem)
Source directivity	Changes spectra with azimuth,. Poorly understood in the short-period band.	Can be large for earthquakes, can be averaged but with large sets of events, negligible for pure explosions
Near surface or receiver focusing	May change spectrum	Probably negligible (It cannot suppress or enhance high frequencies similarly to t^*)

Section D: Perturbing Effects Influencing Body Wave Amplitudes (Excluding Attenuation)

Some discussion of amplitudes was presented in the previous section where perturbations of the spectra were compared to those of the signal amplitudes as a result of various extraneous factors. In this section, we shall discuss these factors in more detail and at the same time critically examine the proposition that averaged P-wave amplitude levels at any location can be used as the sole measure of attenuation in the mantle underlying that location.

We have examined the effect of varying constant t^* on amplitude, and it appears that the measured amplitude differential due to t^* variations is dependent on the source spectrum. It is larger for high frequency signals and smaller for low frequency signals. This in itself makes it difficult to relate t^* directly to amplitude residuals, although it can be done either empirically (Der et al, 1979) or by synthetic simulation.

The effect of the source crust can be reliably modeled if the source is known to be linear elastic and if the crust is a laterally homogeneous flat layered medium. In most cases, neither criterion is satisfied. The effect of an unknown effective surface reflection coefficient on the time domain amplitudes can be quite severe, and small variations in the reflection coefficient and the source depth can cause large changes in amplitude. This can be avoided by picking amplitudes prior to the arrival of surface reflections.

The receiver crust has a large effect on amplitudes. At sites located on thick unconsolidated sediments the body wave amplitudes can be several times larger than at sites on solid rock, and this amplification is more severe for S waves. The regional geology under the average seismic station is usually not known well enough to model such effects with sufficient accuracy, although crustal corrections computed by flat layered models achieved a statistically significant reduction of variance in average amplitude measurements for a larger set of stations (Der et al, 1979). This does not mean, however, that corrections computed for individual stations are accurate. This is not surprising since, even if the site is carefully surveyed with refraction profiles or borehole measurements, the shear velocity-depth distribution is usually unknown.

Let us consider now the effect of randomness of the media around the sources and receivers. Lateral horizontal inhomogeneities around sources appear to be the cause of broad regional systematic variations of amplitude that can be associated with the source locations. The existence of such effects has been verified by several studies (Hadley, 1979; Butler, 1979), and this implies that in order to measure t^* on amplitudes this random effect must be removed by averaging measurements from many source regions.

The effects of inhomogeneities close to the receiver are also well documented. These effects, well known to researchers involved with analysis of array data, manifest themselves as large azimuthally dependent relative amplitude variations between even closely situated sites. The relative amplitude patterns are repeatable for groups even at similar azimuths and distances, and even the intersite modifications of waveforms are repeatable and describable in terms of transfer functions (Filson and Frasier, 1972; Chang and von Seggern, 1980; Butler and Ruff, 1980; Lay et al, 1979). These phenomena were recognized early in array work and have been analyzed extensively using various models (Berteussen et al, 1975; Capon, 1974; Capon and Berteussen, 1974; Christofferson, 1975; Dahle, 1975; Dahle et al, 1975; Haddon and Husebye, 1978; Chang and von Seggern, 1980 and many others).

The existence of focusing phenomena is also consistent with the picture of the crust provided by the COCORP studies (Schilt et al, 1978), which clearly demonstrate the widespread occurrence of lateral inhomogeneities in the crust. It is not unusual for sensors spaced only a few km apart to show fairly large amplitude ratios. This hardly comes as a surprise since the geology is complex enough at most locations and such effects due to focusing and defocusing of seismic waves are to be expected. It was found by Chang and von Seggern (1980) that at NORSAR such anomalies tend to average out to zero if amplitude measurements at a large range of distances and azimuths are taken. However, this cannot be done at most stations that operate for limited lengths of time due to the non-random geographical distribution of sources. This means that such effects cannot always be removed. Besides, there is no guarantee that the average of such site anomalies approaches zero in all cases, even if equal weights are given to a wide range of azimuths and distances.

The expected consequence of the near source and receiver inhomogeneities is that magnitude levels, even at closely spaced stations, may exhibit differences that cannot be explained and that P-wave magnitude anomalies at individual stations cannot be used by themselves to determine the degree of attenuation in the mantle under any location. The attached Table VIII summarizes the effect of various factors influencing trace amplitudes. Most of these are of the first order.

TABLE VIII

The Effect of Various Factors on Absolute Signal Amplitudes

<u>Factor</u>	<u>Properties</u>	<u>Relative Importance</u>
Anelastic Attenuation	Changes signal amplitudes	First order, but less for low frequency ($f < 1$ Hz) signals
Crustal Amplification	Amplifies signals	Large, comparable in size to that of t^* variations to be expected. Can be estimated to some degree
Surface Reflections	Change amplitude	Can be estimated but time domain estimation is nonunique
Scattering	Unknown	Unknown
Multipathing	Unknown	Unknown, can be large
Source Directionality	Unknown	Few demonstrated examples in the short-period band, no adequate methods exist to estimate its importance in the short-period band. Can be removed by averaging over many events
Near Source or Receiver Focusing	Changes signal amplitudes	Larger than that of t^* variations in question. Great obstacle to estimation of yields. Absolute level of change cannot be established at most locations

Section E: A Critique of Time Domain Methods

A large number of papers in recent literature employ time domain matching of synthetic waveforms with observed waveforms, during which attenuation (t^*) is estimated in a deterministic multiparametric scheme. The common approach begins with the source by computing some fault model or an RDP, then continues the computation of the waveforms through deterministic models of the crust, upper mantle, receiver crust and instrument response. Several free parameters, including t^* , are adjusted in the process to obtain the "best" visual fit in the time domain. Those values thus obtained are assumed to constitute a valid description of the source and path properties.

This method achieved fair-to-good success in modeling seismograms in the long-period band; consequently, researchers were emboldened to apply the technique to short-period data. Unfortunately, the methodology as applied thus far has so many flaws that most of the results should be declared invalid in the short-period band and doubtful in the long-period band. We summarize some general criticisms below (more specific objections are given elsewhere in this report):

1. The quality of the matching of two time domain waveforms in the short-period band primarily depends on the low frequency end of the spectrum for large events, thus ignoring the high frequencies. Waveforms for such events are extremely insensitive to t^* (Der and McElfresh, 1980) and cannot reliably measure variations in t^* of the order of a few tenths of a second (See Figure 56).
2. The practitioners of this method create the overall impression that the mantle, crust and source parameters are well known and precisely controlled in their simulations. We submit that this is not the case. Short-period data are characterized by large spatial fluctuations in waveshapes, amplitudes and spectra brought about by small scale inhomogeneities in the earth. Simple parameterization cannot adequately describe these fluctuations.
3. The high variability and scatter inherent in short-period data requires statistical techniques for the extraction of meaningful information. In particular, analysis of variance of the parameters in the problem, such as t^* in our case, should be considered. In much of the synthetic work no

statistical evaluation of the stability of results is given, and the data sets fitted in the short-period band are often unreasonably small.

4. There is a tendency to extrapolate successful theoretical models to the short-period band or to use theoretically defined but restrictive models for simulating the data. The validity of each type of theoretical model should be independently demonstrated using carefully chosen data sets. Only models that have clearly been validated should be used in fitting parameters. Unfortunately, this is frequently not the case. For example, the Haskell type of propagating fault model that cannot adequately simulate the frequently observed inequality of P and S corner frequencies is used uncritically in many simulations (Molnar et al, 1969; Hanks, 1980). Another example: fitting Minster's absorption band model to data (Lay and Helmberger, 1980) unnecessarily restricts the class of obtainable solutions.

5. As far as attenuation studies are concerned, a considerable amount of detail in time domain modeling is irrelevant. Since we are interested primarily in the spectral content of the source versus that of the observed waveform, details of time domain waveforms depending mostly on phase properties of spectra are of no interest. Simple limiting arguments with regard to spectra are sufficient to put reasonable bounds on attenuation.

6. Time domain methods often end up with the same $t_p^* \sim 1$ and $t_s^* \sim 4$ in the long-period band for travel paths involving a variety of upper mantle structures. This conflicts with the observed regional variations of surface wave attenuation (Nakanishi, 1979; Mills, 1978; Lee and Solomon, 1979). It also appears that if one considers only the attenuation results obtained by not using the time domain methodology, these correlate well with the regional patterns of surface wave and short-period body wave attenuation in the studies just quoted. It seems, therefore, that results of time domain studies with regard to attenuation do not make sense in the broad geophysical context, which indicates that the methodology is not suitable for measuring attenuation.

7. In the short-period band, the t_p^* obtained by time domain methods is often demonstrably wrong (pages 105 to 107 of this report). Furthermore, t^* reported by various authors for similar paths using the time domain methods

differ greatly. For teleseismic paths to NTS, Burdick and Helberger (1979), Hadley (1979), and Helberger (1973) use t_p^* values of 1.0, 1.3 and 0.7 respectively. Besides the fact that two of these values are clearly impossible (pages 93 and 108 of this report), the range of variation is such that, if true, they would imply an m_b variation of about 0.67. Since the regional magnitude variations we are attempting to explain are of the order of 0.2 to 0.3, such instability in the results cannot be tolerated, and time domain methods as practiced today thus have no place in magnitude-yield studies. We must point out that spectral methods yield short-period t^* that are repeatable and quite close in value, as reported by several authors quoted in the literature and in this report.

8. A variant of time domain waveform matching is the use of synthetics in both the short- and long-period bands (Burdick, 1978; Hadley, 1979). This is, in effect, a variation of the spectral ratio method. Although this approach has a potential for usefulness, no conclusive results have been produced thus far that can be applied to the short-period band. Burdick's results for short-period S are outside the frequency range of interest (the dominant frequency of these short-period S waves is 0.25 Hz). Hadley's result of $t_p^* \sim 1.3$ is not unique. Der and Blandford (1979) showed that plausible modifications to more reasonable values of insufficiently constrained parameters in Hadley's simulations can reduce t^* to 0.6. It appears again that the time domain amplitudes in these simulations are too sensitive to the various unconstrained factors.

Summarizing this section, it appears that although time domain methods have contributed a great deal to our knowledge of earth structure and, to a lesser degree, of source mechanisms, they are not suitable for studying attenuation unless radical changes are made in the methodology. For the reasons listed above and in the discussions elsewhere in this report, we shall disregard all results with respect to attenuation produced by such methods.

Section F: The Possibility of Generation of High Frequencies in the Recorded Signal by Instrument Nonlinearity

In a recent paper Sacks (1980) suggested that the high frequency energy observed in short-period seismograms may not be actual signal energy but rather an artifact caused by nonlinear distortion in the system when a high amplitude but low frequency P or S wave excites it. This, if true for the LRSM, SDCS, or LASA-NORSAR systems, would be quite serious, especially with regard to attenuation studies. Although it seems implausible that work over the course of 20 years has overlooked such an effect, and although recording non-linearities are routinely recognized and avoided, we have re-examined this question and concluded that with such instrumentation there is no serious possibility of such effects.

We have analyzed some constant amplitude harmonic (constant current, equivalent to constant ground acceleration) calibration signals that were routinely run for the LRSM system at high equivalent ground motion amplitude levels. These high levels resulted in the FM analog high-gain recording system being close to the nonlinear (clipping) levels. The selected station was MNNV for 31 August 1963. We computed amplitude spectra on the calibrations as well as on the preceding noise background. Some examples of these are shown in Figures 61 to 64. The calibration frequencies range from 0.33 to 5.0 Hz. These calibrations were run routinely on the last day of each month at every LRSM station, and the resulting system response was plotted in the logs. The signal spectra all show clear peaks at the center frequency of the calibrations, and the calibration spectra quickly descend to noise level. Side lobes above noise level are visible only for 1.0 and 1.5 Hz. These signals are less than a factor of two below the visible FM clipping levels. In fact, the 1.0 and 1.5 Hz spectra had to be computed from the radial channels because the vertical channels (for these frequencies only) did clip. Inspection of the film, however, shows no clipping. This proves that the clipping is in the FM system and not in the instrument. Clipping of this sort is routinely recognized, and the standard procedure in these cases is to use the low gain recording channels.

Another approach to the question of non-linearity is to observe signals having equal levels of 1 Hz but different levels of 5 Hz energy. Such observations would seem to rule out the possibility that the 5 Hz energy was

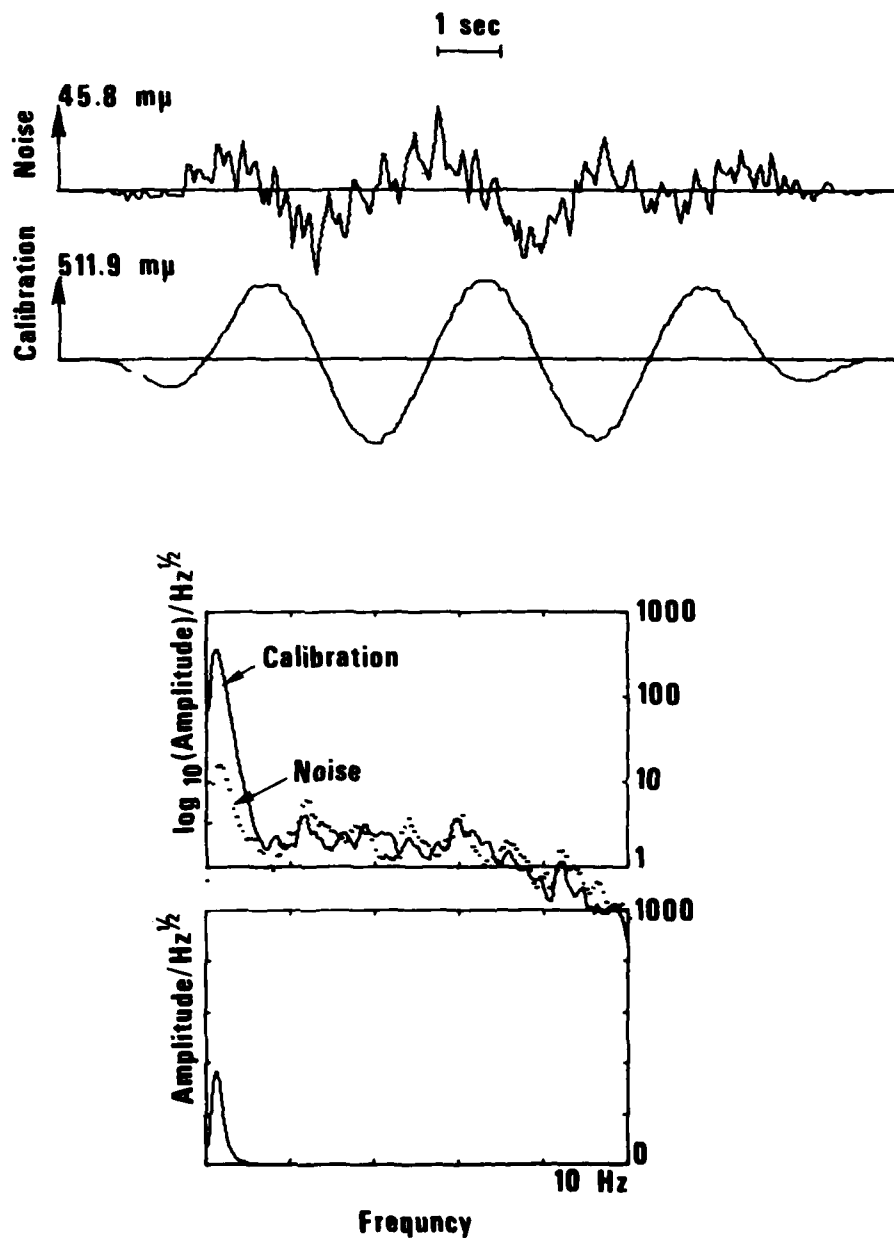


Figure 61 Spectra of steady state calibration signals at LRSM stations. The spectra are dominated by the frequency of the input signal with only minor contamination by harmonics presumably generated by nonlinearity.

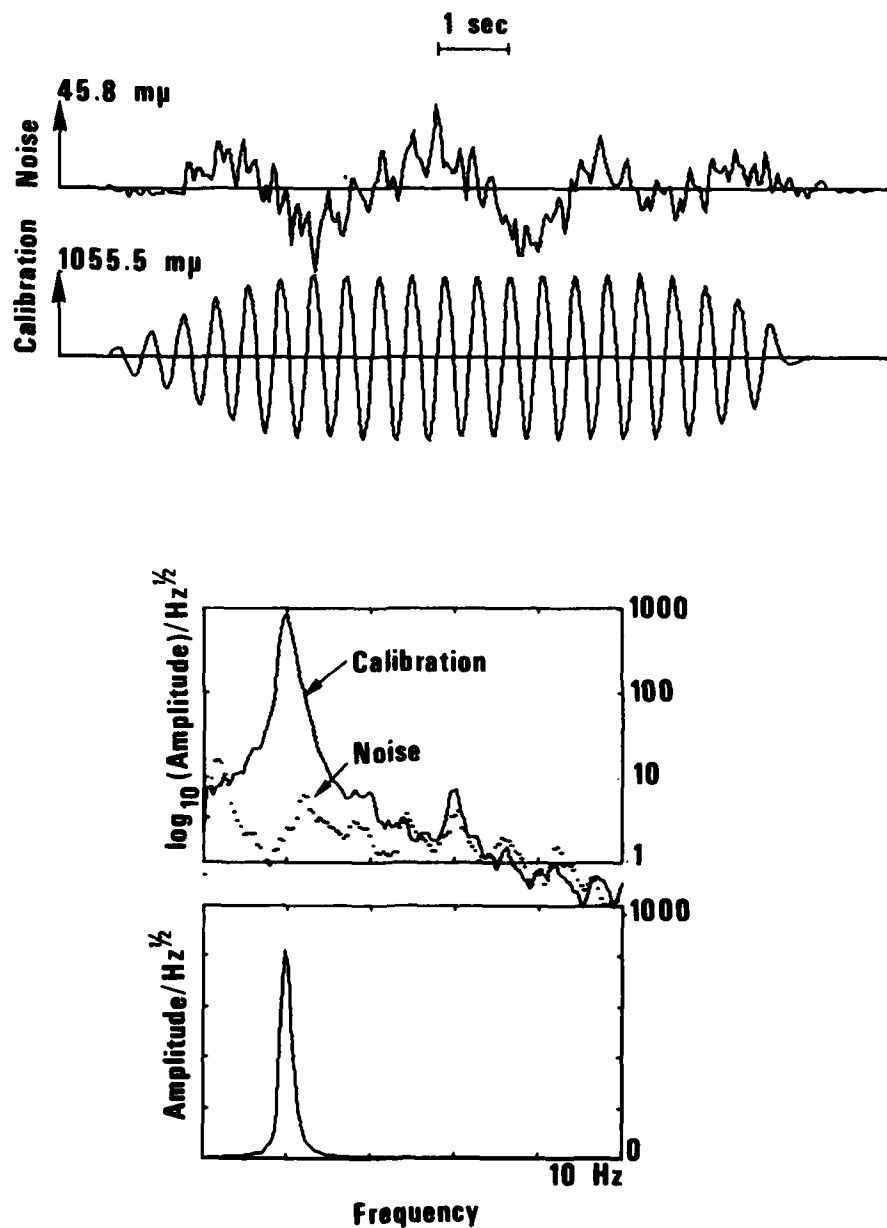


Figure 62 Spectra of steady state calibration signals at LRSM stations. The spectra are dominated by the frequency of the input signal with only minor contamination by harmonics presumably generated by nonlinearity.

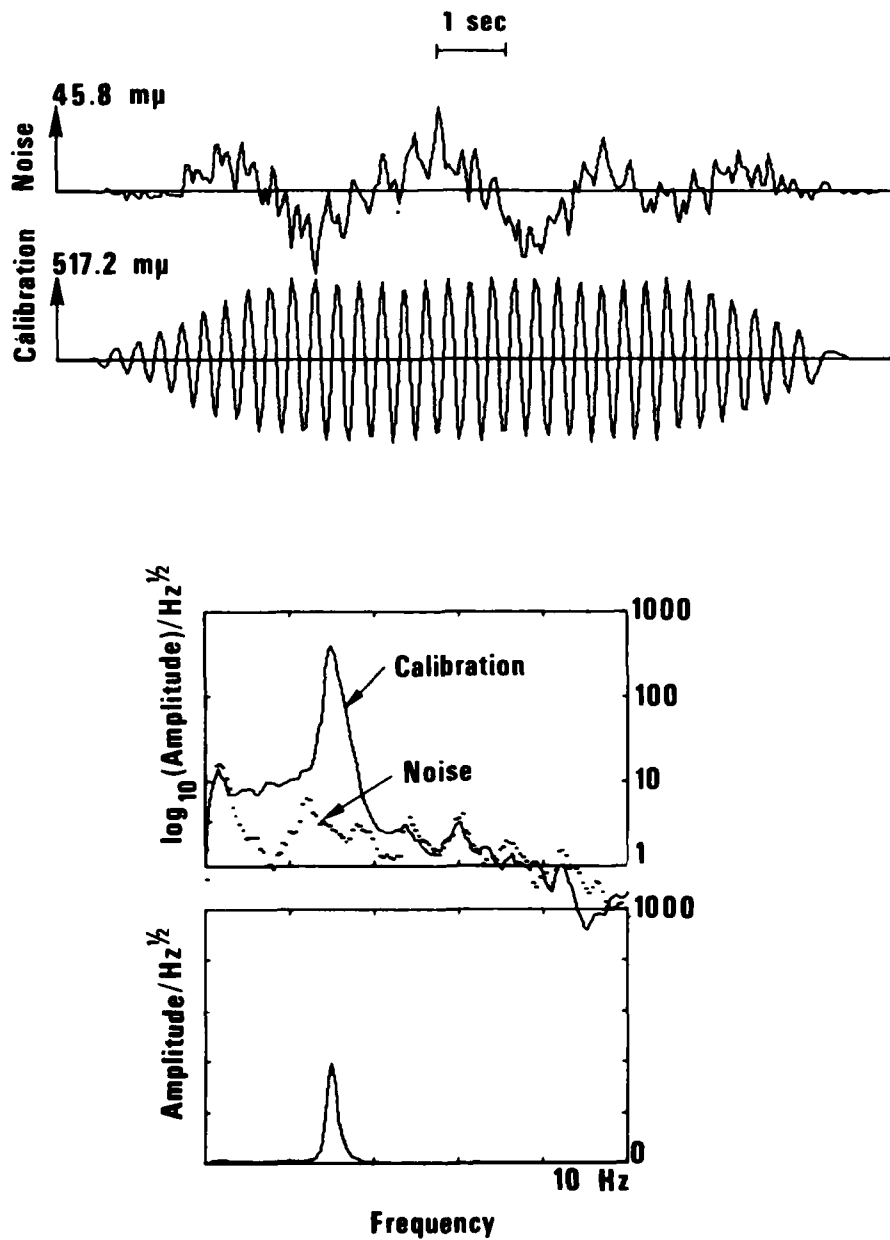


Figure 63 Spectra of steady state calibration signals at LRSM stations. The spectra are dominated by the frequency of the input signal with only minor contamination by harmonics presumably generated by nonlinearity.

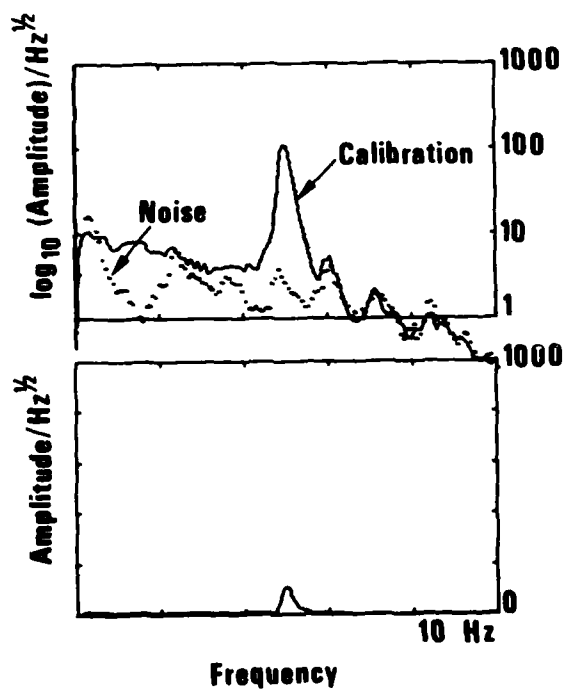
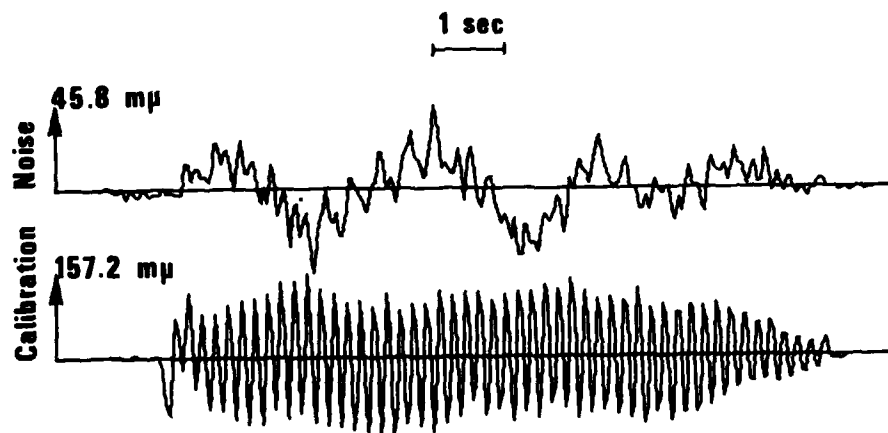


Figure 64 Spectra of steady state calibration signals at LRSM stations. The spectra are dominated by the frequency of the input signal with only minor contamination by harmonics presumably generated by nonlinearity.

created by the 1 Hz energy. Figures 65 and 66 are two events as recorded at the center element of the C3 subarray of NORSAR. These signals show no indication of clipping or nonlinear distortion. Low t^* values are based on spectra such as that seen in Figure 65. The spectra as seen through the system response are nearly flat so that a small non-linear side lobe cannot account for the high frequency energy. Compare Figures 65 and 66 which have about equal 1 Hz levels but which differ at 5 Hz by a factor of about 30 in amplitude. These differences in spectra cannot be associated with non-linearity.

Additional evidence is offered by close-in observations of NTs explosions with the same instrumentation. Figure 67 shows recordings at KNUT and MNV, at distances of about 200 and 300 km from explosions of 1100 kt (BENHAM) down to perhaps less than 1 kt (BUTEO). Note that the smaller BUTEO event has the higher frequency and the recorded amplitude for BUTEO is equivalent to a large-magnitude earthquake teleseismically, while the BENHAM amplitude through the system response is 100 times larger. Figure 68 shows the raw unsmoothed spectra. For BUTEO the spectrum is nearly flat. We see directly that in BENHAM as compared to BUTEO the high frequencies are dramatically absent above 3 Hz. Also, for frequencies below about 7 Hz the amplitude spectra are down only about 30 dB even for BENHAM. In Figure 69 we show the spectral ratio of these two events. Note that it is in excellent agreement with cube root scaling theory, ranging from a ratio of over 1000 at low frequencies to a ratio of about 10 at 5 Hz. For these events the FM systems do not clip because resistors are added in the circuit as necessary to keep the voltage in range. This does show that the basic seismometer system must be linear to much higher amplitude levels than those encountered in teleseismic practice.

Many of our arguments are also based on short-period S waves, such as those shown in Figures 43-49 of the first section of this report. First of all, the most severe clipping could not cause a change in the dominant periods of the signals unless the nonlinearity is clearly seen (by reversing the peaks). Even this becomes impossible if one considers the instrument gains in these figures, if the S amplitudes are equal everywhere as some claim. The instruments with the highest gains, thus having the highest

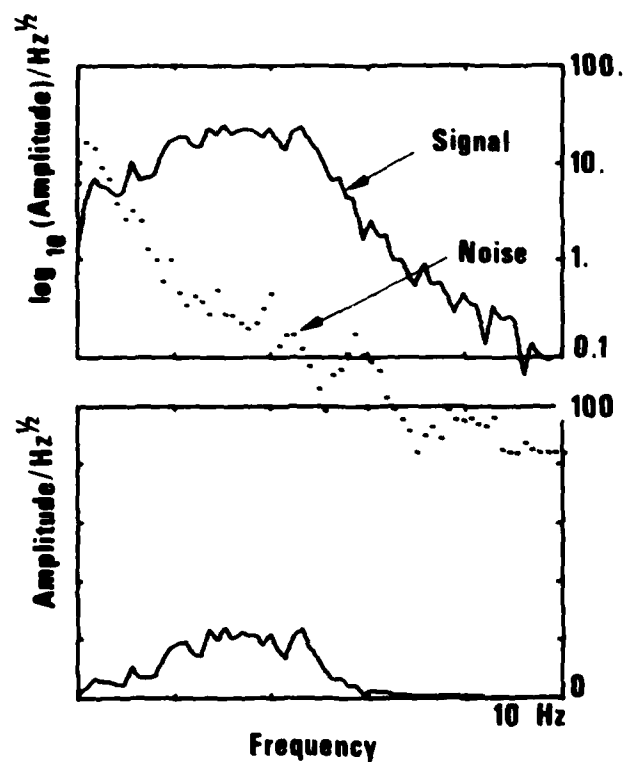
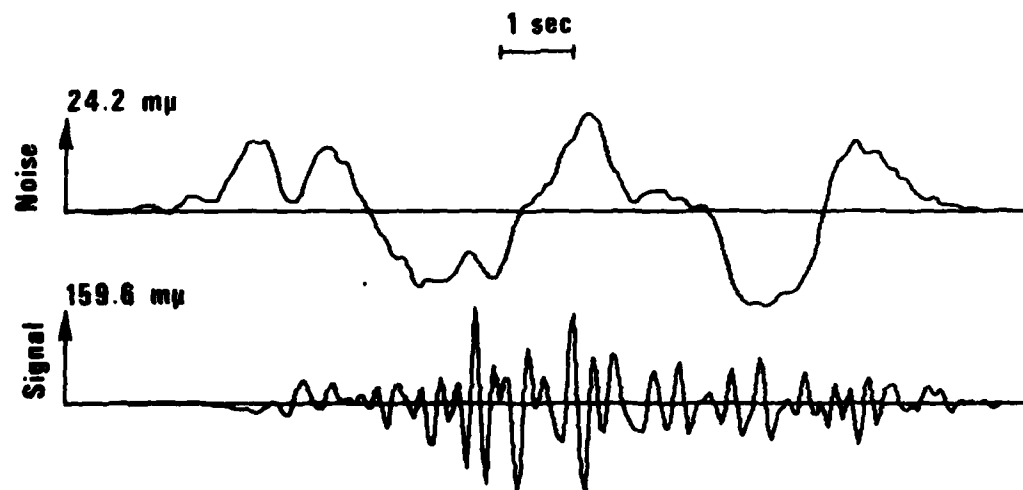


Figure 65,66 Spectra of two events at the C3 subarray of NORSAR. For the same amplitude level at 1 Hz, the level at 5 Hz differs considerably. If nonlinearity were the source of 5 Hz energy for the various events these levels should be the same.

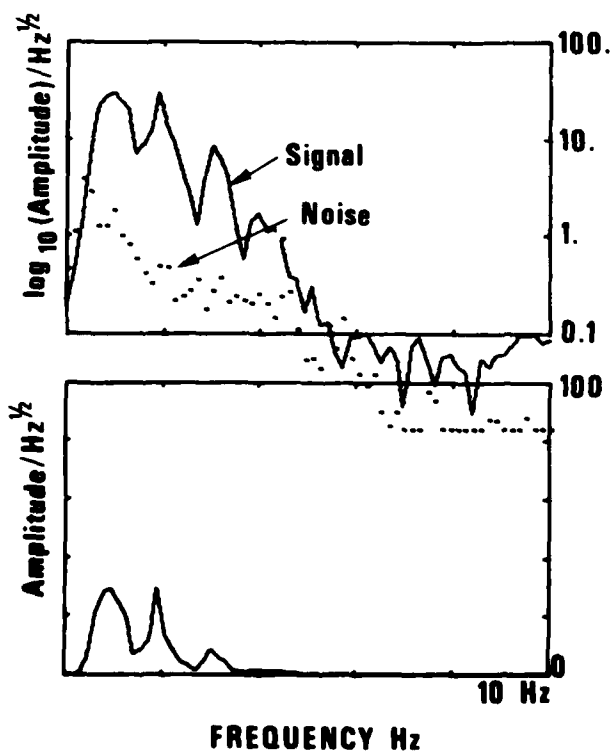
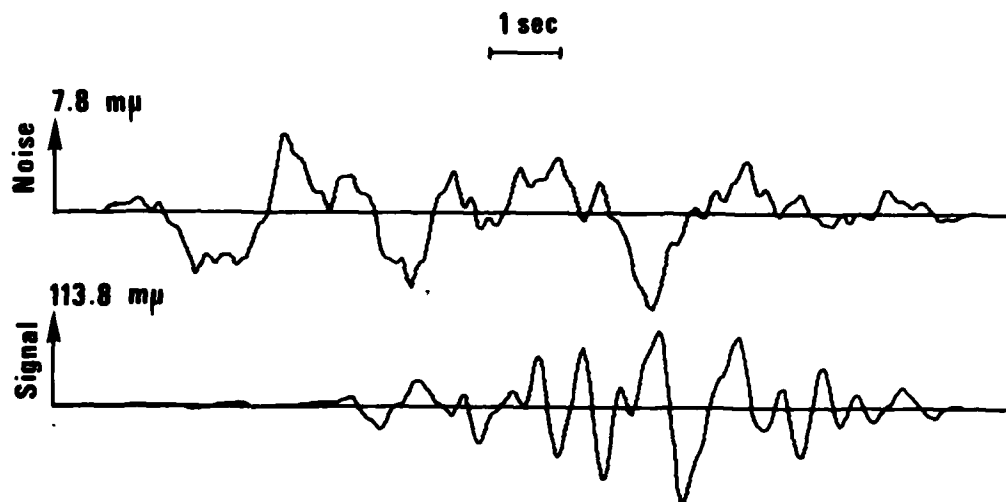


Figure 65,66 Spectra of two events at the C3 subarray of NORSAR. For the same amplitude level at 1 Hz, the level at 5 Hz differs considerably. If nonlinearity were the source of 5 Hz energy for the various events these levels should be the same.

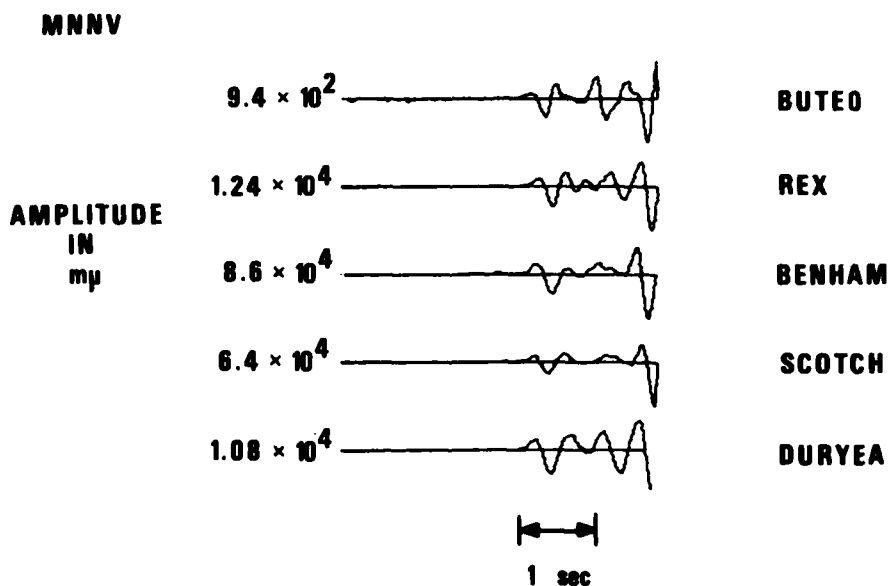
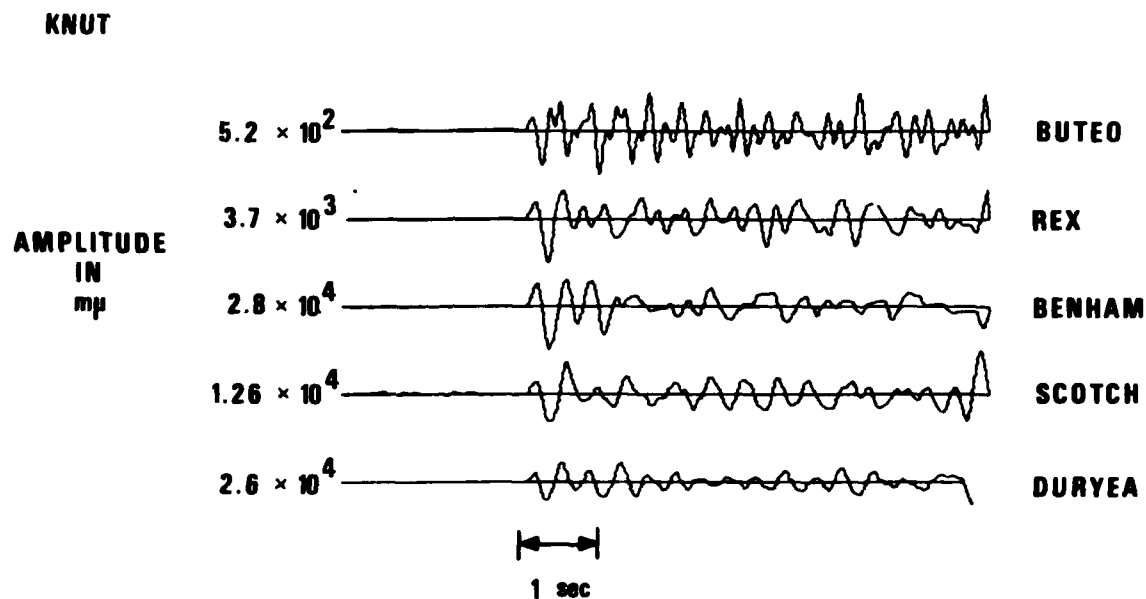


Figure 67 NTS explosions recorded at KNUT and MNNV.

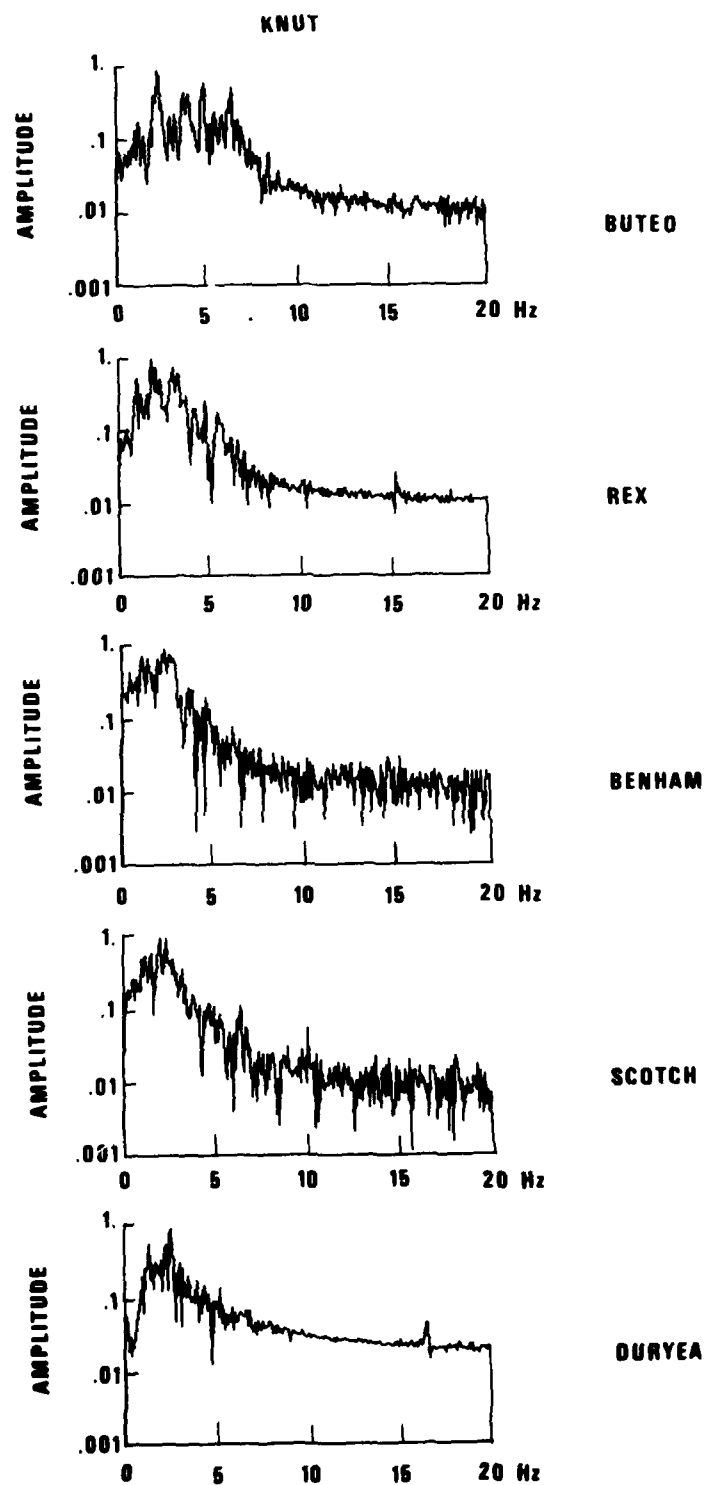


Figure 68 Log amplitude spectra at KNUT for the time windows shown in Figure 67 for BUTEO, REX, BENHAM, SCOTCH, and DURYEA.

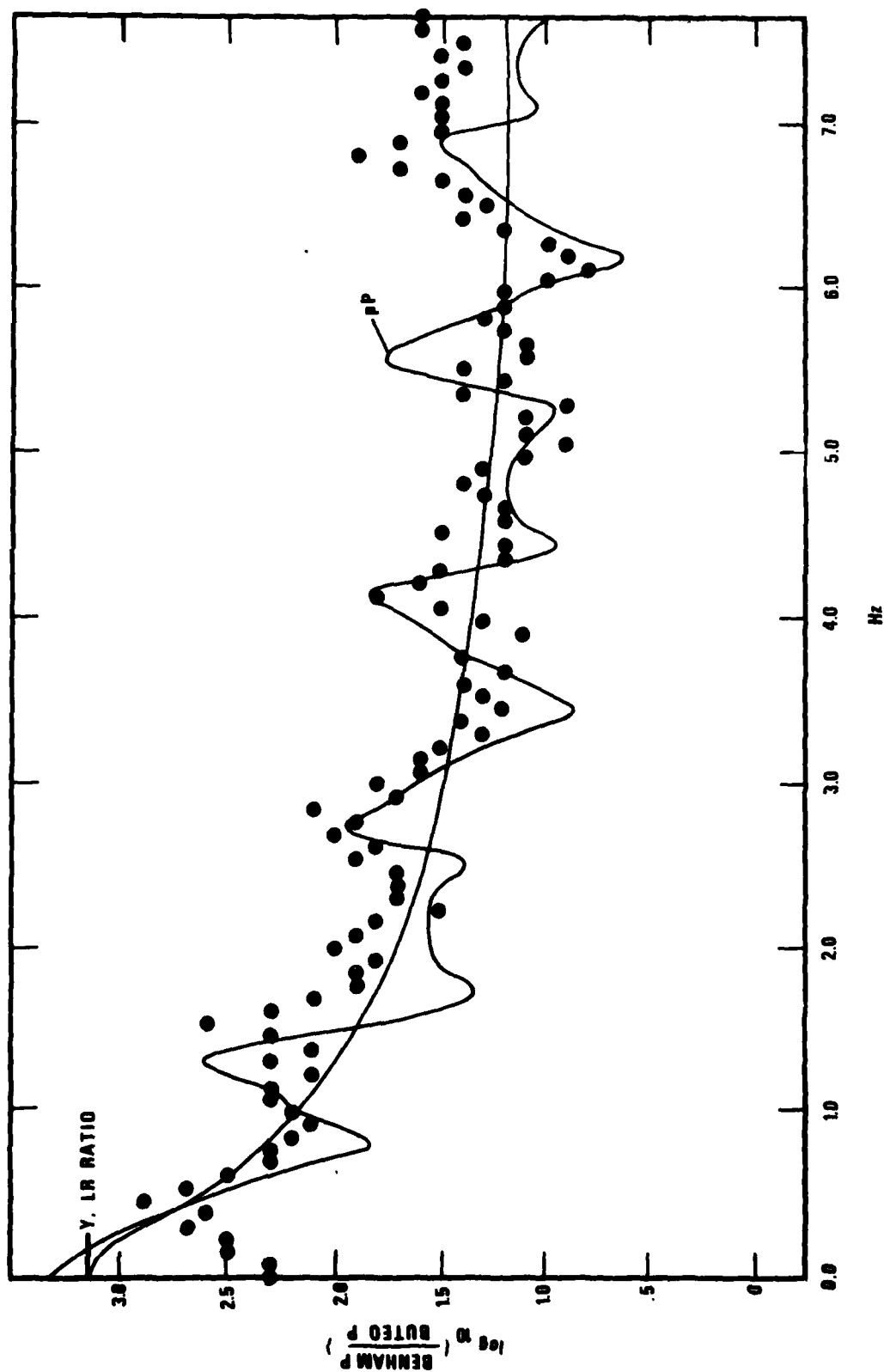


Figure 69 Dots give the observed spectral ratio BENHAM/BUTEO. The theoretical spectral ratios appropriate to the tuff model, $B=0$, $k=12$ have been superimposed, with and without the effects of pP included.

potential to generate extraneous high frequencies by nonlinearity, should show the shortest S wave periods and the greatest high frequency content. However, in reality the reverse is true. Due to the offsetting inequalities of S wave amplitudes and gains the signals are recorded at roughly the same recording levels on the magnetic tape, and no clipping is detectable.

Since the mechanical system of seismograms is highly linear, most non-linearity comes from the FM tape. (As noted, the calibration signals did not clip on the film that bypassed the FM recording.) Both high gain (in the SWUS) and low gain (in the EUS) should have about the same amount of distortion, yet the frequency contents are visibly unequal.

Additional data is available from the tests performed in the manufacturing plant. As an example, we choose the model 4681 seismograph consisting of the "small Benioff" vertical seismometer and a phototube amplifier. This system was widely used in the LRSM program. Figure 70 from TR-63-55 illustrates the linearity of the recorded amplitude versus input shake table displacement at 1 Hz. The small deviations seen could as well be due to inaccuracies in the shake table driving motors as to the seismometer. This shake table is still in use in Garland. The largest signals were nearly 10 cm peak-to-peak on the graphic display, and no other frequencies were visible even though a 2 mm ripple could have been seen. This places the non-linearity at 700 microns more than 34 dB down. 700 microns is, of course, much larger than any teleseismic signal. Figure 71 shows a complete frequency response for this instrument on a shake table. Between the plotted points there is not much room for a spurious resonance. Other raw data plots of phase and amplitude response from shake tables in TR-59-14 have about two times as many points and still show no resonances. The responses are generally taken at an input displacement of 9.2 microns which is much larger at these frequencies than most teleseismic signals.

We have also examined the develocorder recordings of single TFO elements of an 03 September 1967 event off the coast of Peru. This is shown in Figure 72. The large LR waves with periods of 14 seconds as seen on the short-period instrument arrive around 21:42 and are on scale, with an amplitude of 15 cm peak-to-peak on the viewer. There is also visible 3 to 5 Hz energy from local sources of noise with amplitudes of 1 mm peak-to-peak.

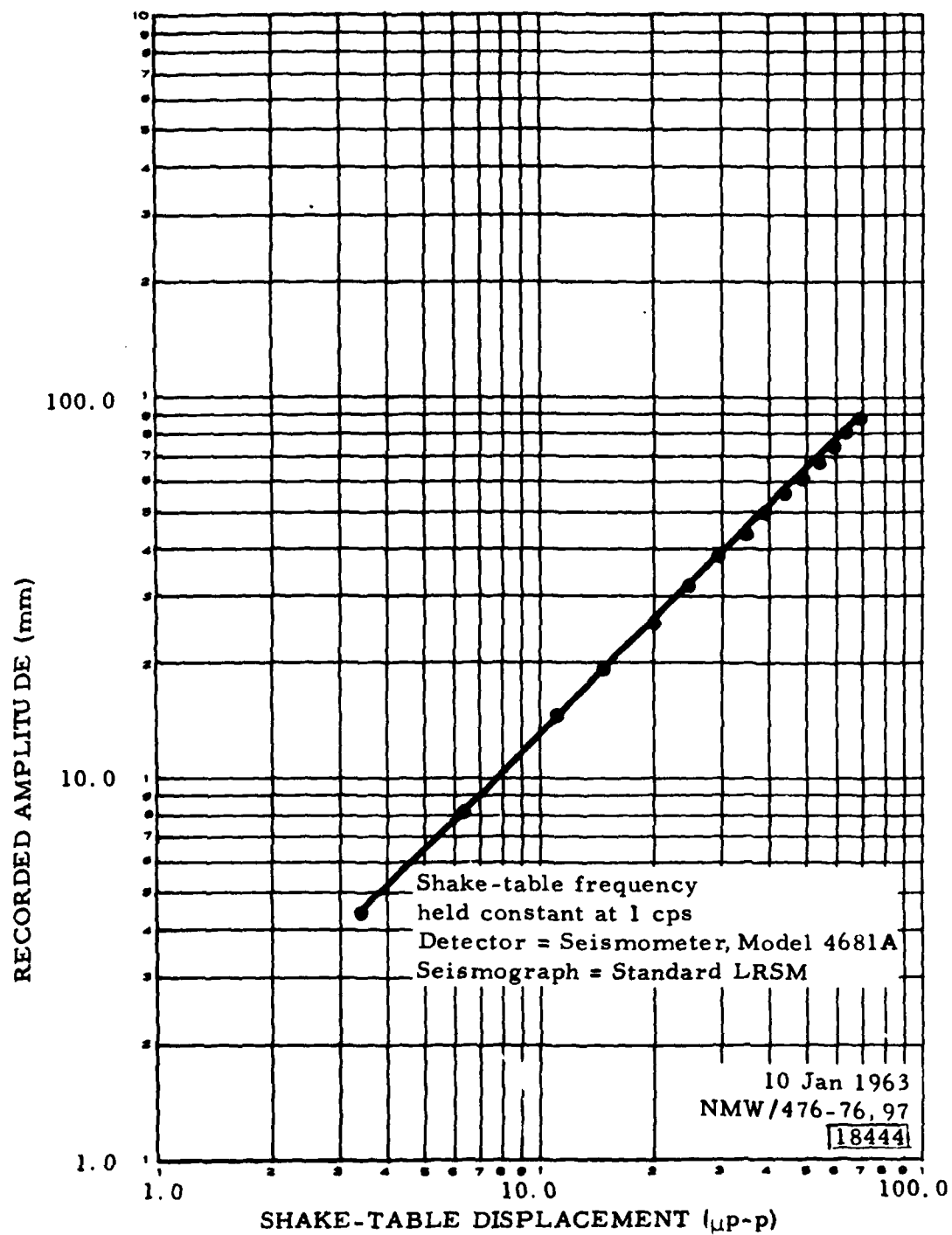


Figure 70 Shake table test results on a "small Benioff" short-period instrument.

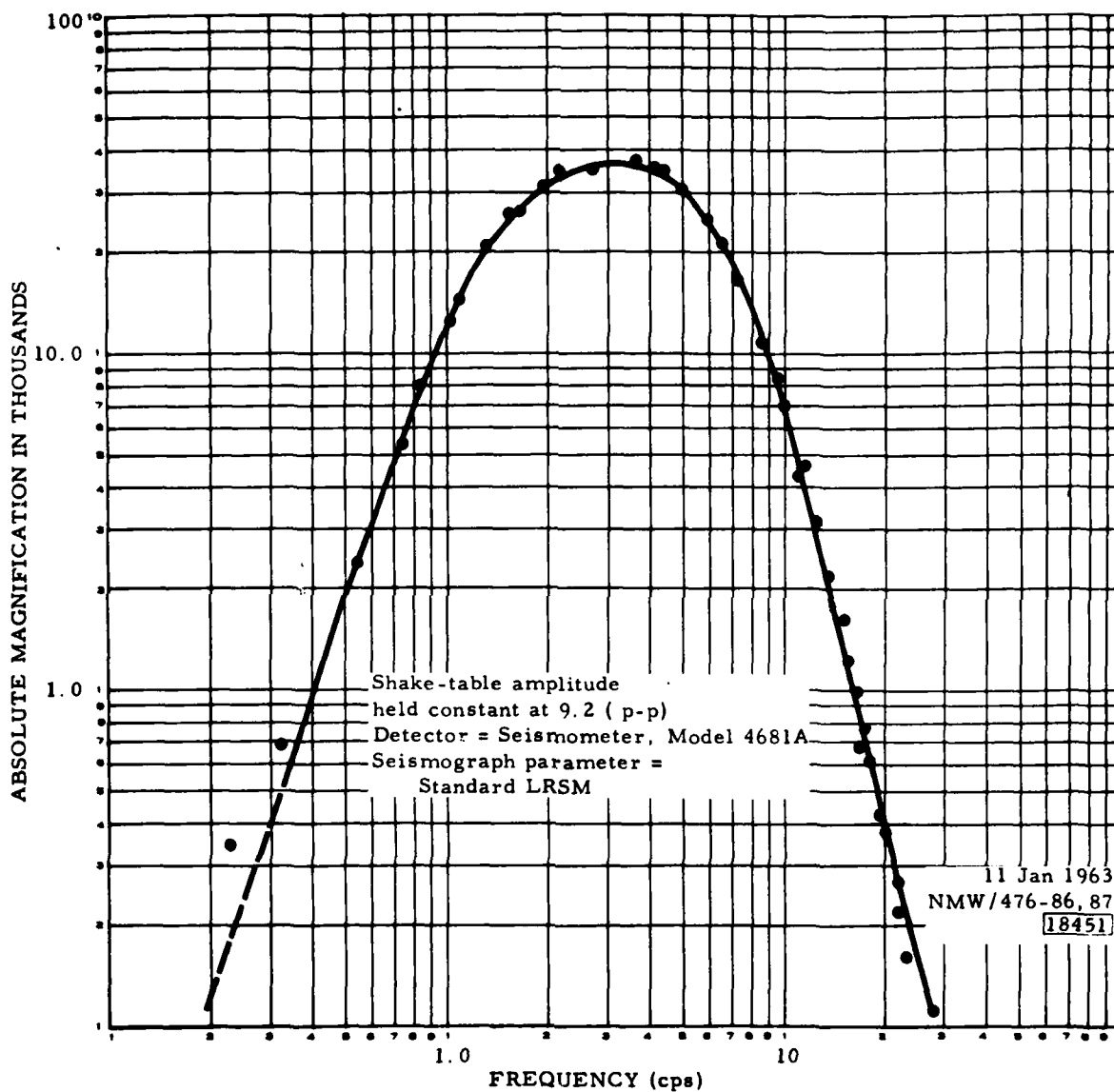


Figure 71 Complete steady state shake table test of the "small Benioff" instrument.

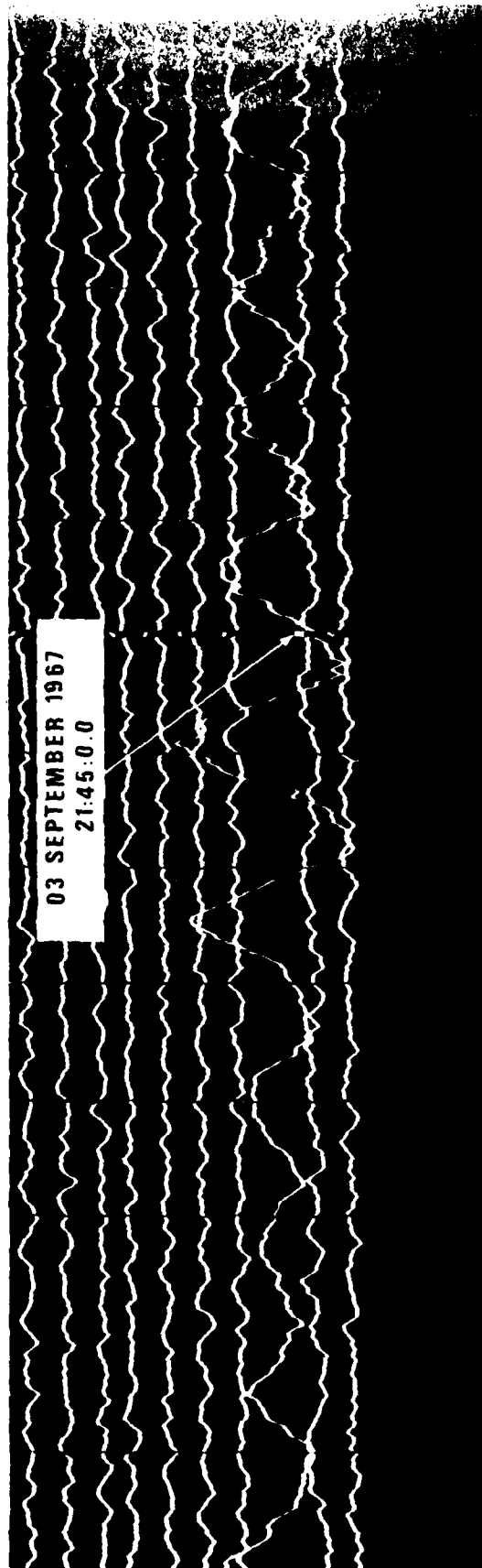


Figure 72 Long-period Rayleigh waves as seen through the short-period instrument at TFO. In spite of the high amplitude of the wave exciting the instrument no increase in the high frequency content of the seismogram is seen, and the frequency of the input wave dominates.

This same energy is visible before the arrival of P. In this case, there is no apparent non-linearity of the seismograph system to a level of 44 dB. In terms of non-linearity with respect to ground displacement, taking account of the differing magnifications at 14 seconds and 3 Hz, the linearity is on the order of $44 + 80 = 124$ dB. In this case, the LR also includes a non-vertical component of motion that eliminates the possibility of cross talk between components. By analogy, the short-period ($f \sim 1$ Hz) oscillations in the S waves shown in Figure 72 cannot be caused by, say, a huge 0.1 Hz S wave exciting the seismometer. Such a signal would still be dominantly 0.1 Hz in frequency as seen through the short-period instruments.

Further arguments showing that nonlinearity is not an admissible explanation for low t^* and that high frequencies are an integral part of a real signal can be summarized as follows:

- a) The high frequency content of short-period signals recorded on identical systems varies with geological-geophysical setting.
- b) High frequency signals show other meaningful geophysical detail such as surface reflections of pP, sP and travel time triplications.
- c) The high frequency content of P and S waves differs for comparable long or intermediate frequency amplitudes.
- d) The high frequency content of signals in identical geophysical station settings is of the same order of magnitude regardless of component, make and construction of the instruments and systems, including hydrophones.

In summary, while we do not disagree with Sacks that nonlinearity can, and actually does, introduce harmonics at levels far below that of the predominant signal, we must conclude that in our analyses such effects do not play a significant role.

IMPLICATIONS OF THE FINDINGS OF THIS REPORT TO YIELD ESTIMATION

There is some confusion about the interpretation of the results of the SDCS experiment and the significance of the "discrepancy" between the m_b bias estimates derived from amplitude measurements and spectral differences. There also appears to be a strong feeling, shared by some, that the m_b bias derived from amplitudes is the true measure of bias due to attenuation because of "reciprocity". We feel that a few clarifying remarks are necessary. Beginning with the reciprocity theorem as it is stated in textbooks, we can say that, if we have a dilatational source and a dilatation measuring device, then in any anisotropic, inhomogeneous medium with arbitrary geometry, we can interchange the source and the receiver and obtain exactly the same seismogram, if the source is represented by the same force system and has the same time function. This is clearly not a practical situation, and we shall now explore by more practical examples how this reciprocity breaks down as we move away from the above mentioned situation. Let us assume two granite bodies in two regions and explode, underground, two nuclear devices of the same yield at the same depth (but not at the same time). We then record the seismic waves at the surface near the explosion sites with a vertical seismograph. Although the strict mathematical reciprocity has already broken down, we can still expect to see very similar seismograms since, assuming that the source media are similar, the source time functions are the same and the near source and receiver focusing effects are still approximately reciprocal. If we assume now that one of the sites has a different source medium, we cannot expect to see the same seismogram, because nuclear devices of the same yield do not give the same equivalent elastic source strength and time function in different source media. The amplitudes and the waveforms at the two sites will not be the same. Now if the events are moved away from the recording sites by only a few tens of kilometers, the near source focusing effects will be different, and even if the devices are exploded in the same media, the seismograms can be quite different in amplitude. (The seismograms may not differ in waveform, since near source focusing probably does not affect them as much.) The next step is to move the sites far away from the explosions. Even in identical source media and with identical yields, there can be quite large differences in waveforms and

amplitudes, because both near receiver and source focusing effects will be quite different. If, as in the SDCS experiment, we use sources of uneven azimuthal distribution, as we were forced to do because of the given limitations of global seismicity to determine differences in m_b level, a "discrepancy" between the measured t^* and m_b residuals is not surprising but to be expected, because near receiver focusing, which is azimuthally dependent, cannot be averaged out entirely with the available data. (We must note that with certain types of inhomogeneities that consistently focus or defocus teleseismic arrivals, there is no guarantee that even azimuthal weighting would help.) The only way the measured m_b would be a valid measure of "bias" including the Q and focusing effects is if we had a measured source located where the observing stations are located. Therefore, the claim that "reciprocity" requires that the m_b bias measured be the true measure of anelastic losses is fallacious, because stations are not located near the event epicenters.

The relative m_b levels and their confidence limits resulting from this experiment mean relatively little for individual stations. They are probably biased by focusing and, if we had events with more even azimuthal distribution (which would have required many years to accumulate), the results could have been quite different and the mean m_b residuals could even be outside the confidence limits given in this report. Some examples of these anomalies, are the .15 m_b difference between HNME and IFME (which cannot be adequately explained by near surface geology), and the differences between the FANV-GBNM pair and the rest of the WUS stations, although the t^* are similar within both groups. Focusing provides a likely explanation for these differences and the references in this report demonstrate that this phenomenon is real and widespread and affects seismic waves in all areas of the world. Common sense dictates, therefore, that while we should not disregard amplitude data, we should interpret it with caution, and rely more on spectral data to determine anelastic losses. Anomalies of m_b are more meaningful if regional averages which can be interpreted in terms of Q are taken (Der et al., 1979; Lay and Helmberger, 1980).

After establishing what the SDCS m_b does not mean, let us discuss what was actually measured. Since spectra are less affected by focusing and other

site effects, we claim that the contribution of Q to the decrease of signal amplitudes from NTS was measured by estimating differences in t^* relative to a shield area. Although, according to the best evidence, the Soviet test sites appear to be on shields or stable platforms, the findings of this report do not bear on whether RKON or HNME is a better analog to Kazakh or Novaya Zemlya. Such decisions should be based on facts involving seismic waves originating from those areas. At the SDAC and at large arrays, many years of work on short-period body wave spectra support the idea that the mantle under shield areas is less attenuating than the mantle under tectonic regions. Nevertheless, considerably more work is needed to test the validity, with respect to mantle attenuation, of possible analogs around the world.

The measured m_b residuals in the SDCS experiment are in rough agreement with the t^* , but no exact agreement with the available data can be expected, since even the time domain features agree with the interpretation in terms of Q . We assume that the available data was sufficient to average out most, but not all of the focusing effects. This is reassuring, since it would be quite disturbing if the relative signs of the m_b and t^* residuals were not consistent with the Q interpretation. Additional S wave information and broad regional studies mentioned in this report also confirm that the Q effects are indeed real.

Although body wave amplitude measurements by themselves are not suitable to measure attenuation for yield estimation, one must ultimately use wave amplitudes for estimating yields. First of all, one should make distinction between the t^* effect and the effects of crustal structure, both near receiver and near source focusing. The m_b bias due to attenuation alone in upper mantle under NTS appears to be in the 0.20 to 0.27 magnitude unit range, if one uses the empirical formula $\Delta m_b \sim 1.35 \Delta t^*$ for the NTS stations. This is slightly higher than the actually measured m_b differentials. The formula can also be justified on the basis of synthetic studies of pulses from nuclear explosions. Figure 73 shows that a line with a slope of 1.35 fits curves derived from synthetics of m_b versus t^* quite well. This figure also shows that in the 10 kt to 100 kt range some of the effects on m_b due to varying periods discussed in Section B are not important, although they did affect the earthquakes used for measuring Δm_b . For estimating yields throughout the world, upper mantle Q should be thoroughly mapped under the source regions of interest and under the stations used for determining the

yields. Crustal effects under these stations should also be estimated and corrections for these effects should be made.

Effects due to near-source focusing can be determined only for very small source regions for explosions with known yields. In the absence of such information, averages of m_b for a large range of epicentral distances and azimuths will probably eliminate such effects. In general, near-receiver focusing cannot be eliminated unless all receiving stations have many sensors, thus enabling one to outline the causative structures and to derive deterministic formulas for corrections. Since the requirement for the elimination of near-source focusing also demands a large range of azimuths and distances for stations around the source, this calls for many large arrays. We do not consider this a very practical or economical alternative, and one is again reduced to using network averages of m_b .

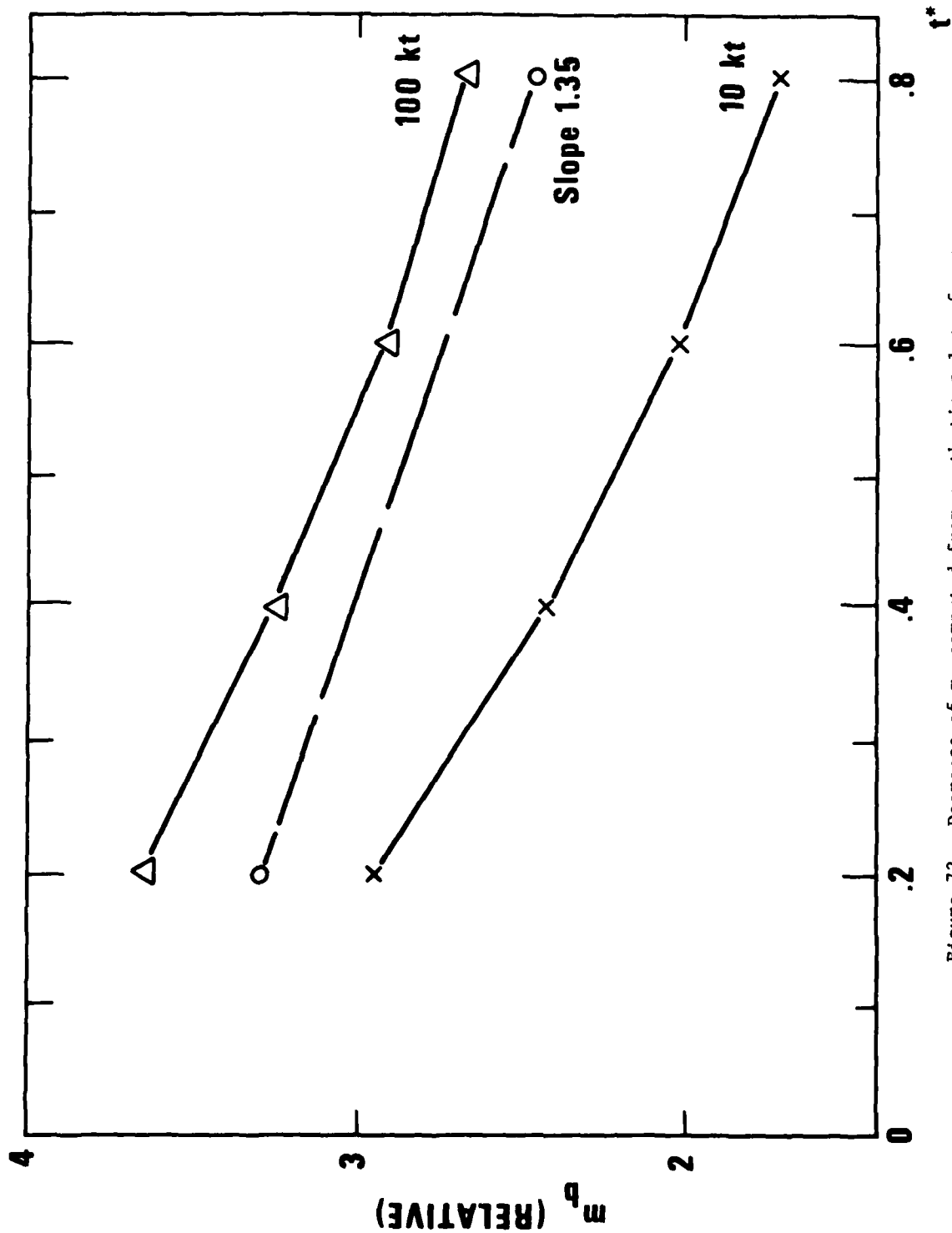


Figure 73 Decrease of m_b computed from synthetic pulses for a 10 kt and a 100 kt nuclear explosion due to increasing t^* . The empirical relationship $\Delta m_b \sim 1.35 \Delta t^*$ is sketched in for comparison. The overall slopes of the three curves are similar.

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APPENDIX A

List of Events Used in the SDCS Project Along With
Amplitudes, Dominant Periods and Distances

14 SEP 76 15 46 5.2 5.06 0 3 EASTER IS.
26.4S 113.2W

0.0
HN-ME 34.4 74.0 .83 -3
HR-CN 35.6 251.6 .76 -3
CB2NV 36.3 42.7 .94 -3

15 SEP 76 15 20.0 5.84 0 4 AUSTRIA
46.2N 13.3E

0.0
HN-ME 32.6 70.0 .81 -3
HR-CN 34.4 48.2 .49 -3
CB2NV 35.1 56.7 1.09 -3

NI2NV 35.1 142.7 1.23 -3
15 SEP 76 21 13.4 5.30 C 4 AUSTRIA
46.2N 13.2E

0.0
HN-ME 33.5 62.8 .78 -3
HR-CN 34.3 100.6 .54 -3
CB2NV 35.0 40.3 1.19 -3

NI2NV 35.0 102.1 .91 -3
29 SEP 76 00 00.0 0.00 1 5 A. Z.
73.5N 53.7E

0.0
HN-ME 34.7 192.4 .85 -3
HR-CN 35.4 153.3 .44 -3
CB2NV 36.1 39.1 .84 -3

NI2NV 36.7 45.5 .53 -3
NI2NV 36.7 71.8 .48 -3
19 SEP 76 23 31.1 5.27 C 5 S. PANAMA
7.2N 82.4W

0.0
HN-ME 40.5 95.2 .71 -3
HR-CN 44.7 262.7 1.01 -3
CB2NV 44.0 180.0 1.45 -3

NI2NV 44.0 477.3 1.03 -3
NI2NV 44.0 449.2 .96 -3
19 SEP 76 57 53.1 5.41 0 5 MEXICO
17.9N 100.6W

0.0
HN-ME 39.0 80.2 .78 -3
HR-CN 39.4 39.4 .61 -3
CB2NV 39.0 320.4 .86 -3

NI2NV 39.0 383.4 .66 -3
NI2NV 39.3 308.4 .73 -3
23 SEP 76 20 17.6 5.12 0 4 EL SALVADOR
13.2N 85.5W

0.0
HN-ME 37.5 134.5 1.3 10 27 35.3
HR-CN 37.5 353.3 0.7 10 27 33.5
CB2NV 37.5 62.2 1.04 10 27 0.3

NI2NV 37.5 157.3 0.85 10 27 2.1
06 SEP 76 56 23.2 4.57 C 3 ATLANTIC
53.1N 32.1W

0.0
HN-ME 34.6 138.5 .70 10 1 45.0
HR-CN 34.6 65.4 .75 10 3 13.1
CB2NV 34.6 17.9 1.06 -3

05 SEP 76 11 27.0 5.04 C 3 MEXICO
19.5N 101.1W

0.0
HN-ME 38.6 49.5 1.00 20 13 53.7
HR-CN 38.9 45.3 .80 20 13 0.3
CB2NV 39.0 80.5 .96 -3

05 SEP 76 11 43.6 5.17 C 3 MEXICO
13.7N 100.7W

0.0
HN-ME 38.5 106.8 .96 20 19 7.9
HR-CN 38.7 67.6 1.00 20 13 13.8
CB2NV 39.0 1052.0 1.14 20 16 51.0

09SEP76	CS	27	46.0	5.05	C	3	SVALBARD
77.6N	8.0E						
0.0							
RR-CN	42.2	153.7	1.13	9	3	41.8	
CB2NV	42.1	25.8	.54	9	3	48.5	
NI1-NV	60.0	35.1	.71	9	3	57.1	
29SEP76	CS	52	33.0	5.08	O	4	CUBA
19.3N	80.6W						
0.0							
RR-CN	32.1	135.3	.70	3	5	10.6	
CB2NV	32.6	120.1	.86	3	5	33.5	
NI1-NV	32.6	171.6	.61	3	5	35.8	
NI2NV	32.6	237.1	.86	3	5	35.7	
25SEP76	CS	47	20.6	5.13	O	4	EASTER IS.
26.4S	115.0W						
0.0							
RR-CN	76.5	147.2	.85	21	5	25.1	
CB2NV	63.6	32.6	1.28	21	5	32.8	
NI1-NV	63.6	18.8	1.50	21	5	53.7	
NI2NV	63.6	69.3	.94	21	5	53.8	
26SEP76	CS	35	49.3	4.55	O	3	BAIKAL
51.1N	157.2E						
0.0							
RR-CN	61.7	17.7	.63	6	46	3.8	
CB2NV	60.0	3.8	.80	6	46	57.9	
NI1-NV	60.0	28.3	.56	6	46	57.7	
26SEP76	CS	13	36.1	4.63	O	4	ARGENTINA
23.1S	64.6W						
0.0							
RR-CN	83.0	46.1	.70	7	25	59.3	
CB2NV	81.2	29.4	.67	7	25	31.9	
NI1-NV	31.4	15.0	.67	7	25	53.3	
NI2NV	31.4	63.6	.61	7	25	32.6	
30SEP76	CS	04	10.9	5.21	C	5	CHILE - ARG. BORDER
24.2S	68.2W						
0.0							
RR-CN	70.3	43.4	1.30	3	15	23.1	
CB2NV	76.3	171.5	1.10	3	16	10.4	
NI1-NV	76.1	198.9	1.10	3	16	1.4	
NI2NV	76.4	583.3	.80	3	16	2.9	
25SEP76	CS	40	47.0	4.52	O	4	EASTER IS.
24.6S	106.8W						
0.0							
RR-CN	76.3	40.3	.70	10	52	44.2	
CB2NV	62.4	103.0	1.00	10	51	9.6	
NI1-NV	62.5	40.1	.90	10	51	12.0	
NI2NV	62.5	24.3	.60	10	51	10.6	
22SEP76	CS	07	1.3	5.30	O	2	CHINA
39.9N	106.5E						
0.0							
RR-CN	93.8	19.5	.90	20	20	20.7	
CB2NV	93.6	11.5	.60	20	20	17.6	
22SEP76	CS	30	30.8	4.76	C	5	ALEUTIANS
51.6N	175.9W						
0.0							
RR-CN	64.3	45.8	.60	2	41	0.9	
CB2NV	48.6	211.0	.40	2	39	7.0	
NI1-NV	43.7	18.1	.80	2	38	29.4	
NI2NV	43.5	80.0	.60	2	38	30.9	
22SEP76	CS	20	27.6	5.03	O	4	VOLCANO IS.
23.3N	142.1E						
110.0							
RR-CN	51.1	249.0	.80	3	33	13.8	
CB2NV	54.9	235.1	.60	3	32	50.3	
NI1-NV	54.6	505.6	.60	3	32	49.5	
NI2NV	54.7	569.6	.50	3	32	50.0	

04CCIT76	06	59	19.5	4.62	0	4	C. MEXICO
20. N	99. W						
0.0							
HK-ONV	30.1		35.1	1.80	7	5	34.2
CB2NV	22.1		42.7	1.50	7	4	20.3
NI1NV	22.1		140.4	1.10	7	4	23.2
NI2NV	22.1		105.7	1.00	7	4	22.2
04CCIT76	23	36	06.0	5.17	0	5	E. UADORA
0.2S	77.5W						
0.0							
HK-HE	42.1		73.0	1.50	23	44	45.8
HK-CN	42.1		36.3	1.70	23	45	21.9
CB2NV	11.6		11.6	1.10	23	45	12.7
NI1NV	11.9		51.1	1.40	23	45	15.6
NI2NV	11.8		42.9	1.50	23	45	14.5
07CCIT76	22	01	12.5	4.60	0	4	E. UADORA
0.8S	10.3W						
0.0							
HK-CN	52.5		21.9	.80	22	10	23.7
CB2NV	50.4		22.6	.50	22	10	5.2
NI1NV	50.6		230.2	.30	22	10	8.6
NI2NV	50.5		110.6	.30	22	10	7.0
09CCIT76	09	22	46.6	4.55	0	5	KORLANDORSKY IS.
55.1N	164.3E						
0.0							
HK-HE	69.6		22.2	.70	9	33	57.2
HK-CN	55.9		25.5	.70	9	32	26.3
CB2NV	44.1		98.0	.80	9	32	18.3
NI1NV	44.1		61.0	.60	9	32	17.3
NI2NV	44.4		58.1	.70	9	32	17.8
08CCIT76	09	22	56.3	4.53	0	5	KORLANDORSKY IS.
55.1N	164.1E						
0.0							
HK-HE	65.6		36.0	.50	9	34	7.5
HK-CN	65.0		25.8	.70	9	32	36.6
CB2NV	44.8		102.0	.90	9	32	29.0
NI1NV	44.8		87.0	.80	9	32	29.1
NI2NV	44.5		75.4	.70	9	32	28.7
08CCIT76	14	38	27.9	4.78	0	4	KURILES
43.8N	155.7E						
0.0							
HK-HE	76.8		44.4	.70	14	50	21.6
HK-CN	61.1		23.3	.60	14	49	53.3
CB2NV	61.4		8.7	.90	14	48	46.0
NI1NV	61.2		26.2	.60	14	48	45.5
23CCIT76	03	03	00.0	5.20	1	4	B. KAZ
50.0N	79.0E						
0.0							
HK-HE	75.9		241.4	.80	5	15	10.3
HK-CN	75.5		448.5	.50	5	15	5.4
NI1NV	51.9		109.6	.70	5	15	10.8
NI2NV	51.5		78.5	.90	5	16	11.0
09CCIT76	12	31	06.6	4.97	0	5	COSTA RICA
10.7N	85.8W						
0.0							
HK-HE	36.5		71.6	1.00	12	38	32.4
HK-CN	40.6		40.5	.80	12	38	45.9
CB2NV	37.9		106.7	1.20	12	38	27.6
NI1NV	38.2		424.8	1.20	12	38	30.2
NI2NV	38.1		239.3	1.10	12	38	29.1
09CCIT76	02	52	24.3	4.47	0	4	KURILES
45.1N	153.1E						
0.0							
HK-HE	81.1		9.2	.70	3	4	43.8
HK-CN	67.9		23.0	.70	3	3	23.3
CB2NV	64.5		37.2	.90	3	3	5.9
NI2NV	64.7		52.0	.70	3	3	5.3

09CCT76	16 02	26.9	4.54	0 5	J. COLUMBIA
9.4N	77.5W				
C.O					
HR-CNV	37.7	35.8	.70	16	5 54.0
HR-CNV	43.6	31.8	.70	16	10 34.8
CB2NV	44.5	9.6	.80	16	10 43.6
NI2NV	44.8	73.0	.60	16	10 45.5
NI2NV	44.7	25.1	.70	16	10 45.6
09CCT76	19 41	27.1	4.31	0 2	S. PERU
15.2S	71.6W				
C.O					
HR-CNV	68.6	21.8	.50	19	52 30.6
CB2NV	67.0	18.2	.60	19	52 22.7
09CCT76	21 10	24.1	4.53	C 2	P3RU COAST
10.3S	79.5W				
C.O					
HR-CNV	62.3	28.7	.70	21	20 45.5
CB2NV	62.6	6.7	.70	21	20 23.4
09CCT76	23 48	9.0	4.39	0 3	C. AMEB. COAST
10.3N	91.0W				
C.O					
HR-CNV	40.9	15.7	.70	23	55 40.3
CB2NV	35.4	7.0	.80	23	55 17.8
NI2NV	35.6	13.6	.60	23	55 19.9
10CCT76	22 58	56.6	4.91	C 4	KURILES
45.4N	151.0E				
C.O					
HR-CNV	82.2	57.1	.90	3	11 19.2
HR-CNV	68.7	37.5	1.00	3	9 59.8
CB2NV	66.3	14.4	1.00	3	9 47.3
NI2NV	66.1	18.6	.50	3	9 46.6
10CCT76	16 19	20.8	4.46	C 3	ECUADOR
0.4S	78.2W				
C.O					
HR-CNV	52.9	38.1	.70	5	28 35.8
CB2NV	51.4	5.4	1.10	6	26 25.9
NI2NV	51.5	19.4	.60	6	26 29.0
10CCT76	14 32	04.9	4.59	0 3	KURILES
45.2N	147.7E				
C.O					
HR-CNV	71.9	19.2	.50	14	43 30.8
CB2NV	65.4	11.4	.90	14	43 9.7
NI2NV	65.3	15.6	.50	14	43 9.4
06CCT76	12 12	36.0	5.8	C 3	ECUADOR
0.6S	78.7W				
C.O					
HR-CNV	47.7	212.2	2.0	9	21 13.5
HR-CNV	53.0	131.2	1.3	9	21 51.9
NI2NV	51.4	226.1	1.2	9	21 44.5
12CCT76	14 24	52.1	4.56	0 4	S. HONSHU, JAPAN
31.2N	141.5E				
C.O					
HR-CNV	64.6	17.6	0.6	4	37 26.2
CB2NV	60.4	38.2	0.9	4	37 5.2
NI2NV	60.1	42.1	1.4	4	37 5.3
NI2NV	60.2	87.5	0.9	4	37 5.1
12CCT76	23 49	24.3	4.41	C 3	CS1 COLUMBIA
2.8N	77.5W				
C.O					
HR-CNV	44.1	17.9	0.6	23	57 33.5
HR-CNV	45.5	64.0	0.6	23	57 16.4
CB2NV	45.3	11.0	0.7	23	57 15.9
13CCT76	17 35	45.1	4.68	0 2	W3N22UBLA
10.5N	62.2W				
C.O					
HR-CNV	47.6	58.6	0.6	17	44 22.8
CB2NV	55.1	15.2	0.8	17	45 20.6

21CCT76	4	24	16.0	4.62	C	5	N. CHILE
22.1S	70.0W						
C.O							
EN-ME	66.2		21.0	0.7	4	35	17.0
ER-CN	75.6		36.2	0.6	4	38	1.6
CB2NV	73.9		23.8	1.0	4	35	50.9
NT1-NV	73.6		68.0	0.8	4	35	52.5
NT12NV	73.6		39.9	1.0	4	35	52.1
21CCT76	15	13	22.8	4.92	O	3	ALBUTIAN
52.3N	169.3W						
E.O							
ER-CN	44.6		16.8	0.4	15	21	31.3
CE2NV	39.6		62.0	0.7	15	20	50.4
NT12NV	39.6		69.0	1.0	15	20	48.1
22CCT76	4	4	22.6	4.64	C	5	CSI OF NICARAGUA
12.1N	87.6W						
70.0							
EN-ME	37.5		32.2	0.9	4	11	34.1
ER-CN	35.1		70.7	0.6	4	11	39.1
CB2NV	35.6		18.1	0.6	4	11	16.0
NT1-NV	36.1		36.0	0.6	4	11	19.3
NT12NV	36.1		49.9	0.7	4	11	17.8
22CCT76	5	53	50.9	4.57	O	4	EL SALVADOR
13.2N	88.2W						
79.0							
ER-CN	37.5		54.6	0.7	5	0	59.5
CE2NV	34.6		13.1	0.8	6	0	32.5
NT1-NV	34.6		43.0	0.7	6	0	35.2
NT12NV	34.7		44.3	0.5	6	0	33.9
22CCT76	18	35	23.9	5.26	C	3	KODIAR REG
56.1N	155.3W						
C.O							
ER-CN	34.6		113.7	0.5	16	42	16.5
CB2NV	31.2		80.1	1.3	19	41	45.4
NT12NV	31.0		192.3	1.2	13	41	44.7
24CCT76	17	19	55.5	4.60	O	2	CBM. ALASKA
63.1N	145.1W						
70.0							
ER-ME	46.4		33.9	0.8	17	28	14.2
CB2NV	32.4		30.5	0.8	17	28	19.3
26CCT76	55	55	56.4	5.34	C	5	KJILE IS
45.1N	150.8E						
130.0							
ER-ME	61.6		89.6	0.6	6	12	0.6
ER-CN	66.3		105.3	0.8	6	10	43.3
CB2NV	66.1		27.6	0.5	6	10	30.5
NT1-NV	65.6		270.1	0.6	6	10	23.2
NT12NV	65.3		385.0	0.6	6	10	29.8
28CCT76	9	55	21.3	4.55	O	2	9330
14.6S	73.7W						
C.O							
ER-CN	67.6		26.7	0.7	10	10	19.1
CB2NV	65.4		9.7	0.7	10	10	6.8
28CCT76	19	23	2.7	4.9	C	3	KJILE IS
47.1N	151.1E						
C.O							
ER-ME	80.9		126.4	0.7	19	35	18.9
CB2NV	78.4		22.5	0.9	19	33	49.2
NT12NV	78.1		25.9	0.8	19	33	48.5
12CCT76	14	47	32.7	5.39	C	3	BAPPIN BAY
72.0N	70.1W						
89.0							
ER-ME	26.1		171.6	0.7	14	52	58.3
NT1-NV	41.8		181.1	0.7	14	55	15.1
NT12NV	41.6		138.1	0.6	14	55	15.1
15CCT76	14	14	26.6	4.6	C	2	KJILES
45.1N	146.1E						
C.O							
ER-ME	63.0		43.1	0.5	14	26	30.5
NT12NV	67.8		35.1	0.6	14	25	3.6

17	NCV76	5	33	35.5	5.5	0	2	KURILES
51	N156	E						
100	O							
BR	-ME	75.6		408.9	0.7	5	45	10.7
NI	2NV	60.5		424.2	0.7	5	43	36.3
22	ECV76	20	9	2.7	4.5	0	2	VENEZUELA
7	N	72.2	W					
0	O							
BR	-CN	47.2		120.5	0.5	23	17	33.5
NI	2NV	55.2		35.2	0.4	23	18	0.5
26	NCV76	23	43	12.6	4.8	0	4	PERU-ECUADOR BDR
2	S	77.2	W					
0	O							
BR	-ME	45.2		41.7	0.8	23	52	3.3
NI	2NV	55.2		80.0	0.5	23	52	43.3
NI	2NV	54.1		269.9	0.6	23	52	36.7
NI	2NV	54.0		175.3	0.8	23	52	37.2
1	ECV76	14	15	33.2	5.0	C	3	COSTA RICA
10	N	65.2	W					
0	O							
BR	-ME	39.0		213.1	1.3	14	23	2.5
BR	-CN	41.6		83.7	1.1	14	23	21.4
NI	2NV	39.5		320.8	1.0	14	23	7.6
1	ECV76	17	44	33.8	4.5	C	2	CST OF CENT. AMER.
12	N	90.2	W					
0	O							
BR	-CN	38.7		46.5	0.7	17	31	54.9
NI	2NV	34.4		129.7	0.6	17	31	25.5
3	ECV76	5	27	34.4	4.9	0	2	CHILE-BOLIVIA
21	S	63.2	W					
79	O							
BR	-CN	74.7		145.2	0.7	5	39	2.7
NI	2NV	73.1		216.5	1.0	5	39	56.5
3	ECV76	23	10	23.1	4.6	C	2	N. CHILE
22	S	63.2	W					
0	O							
BR	-CN	76.5		80.0	0.8	23	22	12.1
NI	2NV	75.1		60.1	0.7	23	22	4.4
30	NCV76	0	40	57.0	6.3	C	3	CHILE-BOLIVIA
21	S	65.2	W					
63	O							
BR	-ME	66.6		1102.7	0.6	3	51	39.4
BR	-CN	74.5		4001.4	0.6	C	52	25.3
NI	2NV	72.9		1804.5	1.0	0	52	19.4
4	ECV76	5	6	29.7	4.7	C	4	N. CHILE
21	S	69.2	W					
0	O							
BR	-CN	74.5		58.5	0.51	3	13	8.1
CB	2NV	72.9		62.0	0.8	3	13	0.9
NI	2NV	73.1		104.7	0.8	5	18	2.4
NI	2NV	73.0		75.2	0.8	5	13	1.9
4	ECV76	12	32	35.4	5.2	C	4	N. CHILE
20	S	69.2	W					
103	O							
BR	-ME	66.6		80.7	1.3	12	43	12.3
BR	-CN	74.5		94.1	0.6	12	44	0.1
NI	2NV	72.9		454.2	0.8	12	43	54.3
NI	2NV	72.8		333.4	0.9	12	43	54.0
5	ECV76	22	1	22.1	4.84	C	2	BONN IS.
23	N	140.2	E					
39	O							
BR	-CN	61.6		182.4	0.6	22	13	23.9
NI	2NV	63.1		296.7	0.7	22	13	7.7
6	ECV76	19	46	2.4	4.9	0	2	EASTER IS.
34	S	112.2	W					
0	O							
BR	-CN	55.5		62.6	1.0	13	56	45.5
NI	2NV	71.8		46.8	0.9	13	57	26.3

7	DEC	76	9	36	41.4	4.7	C	3	S.	HCNSHU
34										
36										
HR	-CN				25.1	0.8		3	48	34.
NI	-NV				163.4	1.0		3	48	21.2
NI	-NV				387.4	0.8		3	48	21.6
9	DEC	76	4	24	6.4	4.3	0	2	EL	SALVADOR
14										
14										
FR	-CN				270.3	0.7		4	31	17.6
NI	-NV				28.1	0.7		4	30	37.3
9	DEC	76	9	58	19.7	4.5	C	3	OFF	CSI OREGON
4										
4										
EN	-ME				149.7	0.8		3	58	51.2
FR	-CN				124.3	0.6		5	56	23.2
NI	-NV				201.9	1.3		5	54	3.0
9	DEC	76	15	37	41.0	4.9	0	3	KJ	ILES
44										
44										
HR	-ME				53.2	0.5		15	50	2.7
FR	-CN				111.0	0.6		15	48	43.8
NI	-NV				81.4	0.5		15	48	36.0
20	CCT	76	8	0	0.0	0.00	1	5	M.	N.Z.
73										
73										
HR	-ME				59.5	0.7		3	9	23.2
FR	-CN				256.1	0.4		8	5	25.8
CB	-NV				5.1	0.6		8	11	9.3
NI	-NV				58.0	0.4		8	11	9.5
NI	-NV				11.9	0.5		8	11	9.7
19	DEC	76	14	37	30.0	0.00	0	2	KJ	ILES
45										
45										
FR	-CN				41.8	0.7		14	48	41.7
NI	-NV				68.1	0.6		14	48	28.0
20	DEC	76	10	18	58.0	0.00	0	3	COLUMBIA	
7										
7										
HR	-ME				169.4	1.4		10	25	21.5
FR	-CN				228.1	1.3		10	26	43.1
NI	-NV				147.1	0.9		10	26	32.6
15	DEC	76	12	26	4.0	0.00	0	3	JAPAN	
30										
30										
FR	-CN				17.9	0.7		12	39	7.0
NI	-NV				37.9	1.0		12	38	56.4
NI	-NV				32.7	1.1		12	38	56.8
20	DEC	76	20	33	50.0	0.00	0	5	BR.	COLUMBIA
55										
55										
FR	-ME				1160.9	1.25		20	40	43.2
FR	-CN				3078.0	1.3		20	38	9.6
OB	-NV				948.7	1.3		20	36	41.9
NI	-NV				1333.5	1.4		20	36	39.0
NI	-NV				1094.8	1.8		20	36	40.8
20	DEC	76	21	22	25.0	0.00	C	5	BR.	COLUMBIA
56										
56										
FR	-ME				63.0	1.0		21	23	10.0
FR	-CN				395.4	0.9		21	26	31.5
CB	-NV				79.1	1.3		21	25	4.8
NI	-NV				271.7	1.2		21	25	3.4
NI	-NV				142.3	1.4		21	25	3.5
22	DEC	76	1	1	42.0	0.00	C	4	VOLCANO	IS.
24										
24										
FR	-CN				360.6	1.0		1	14	39.2
CE	-NV				242.1	1.1		1	14	7.5
NI	-NV				377.5	1.1		1	13	55.6
NI	-NV				590.1	1.0		1	14	7.1

13	EC76	23	1	28.0	0.00	0	2	N. PACIFIC
32	N145	E						
	C.O							
BR-CN	52.4			63.7	0.6	23	14	2.3
NI-NV	77.3			111.3	0.6	23	13	39.3
14	EC76	16	6	56.0	0.00	C	3	JAPAN
31	N130	E						
	C.O							
BR-CN	85.5			220.0	0.8	15	19	49.8
NI-NV	87.7			472.0	1.6	16	19	39.4
NI-NV	87.6			423.9	1.5	16	19	39.5
27	EC76	18	8	8.0	0.00	0	3	JAPAN
42	N145	E						
	C.O							
BR-CN	74.			34.4	0.6	18	19	47.6
CB2NV	55.5			19.0	0.6	18	15	36.7
NI-NV	56.			28.8	0.6	18	19	36.2
30	EC76	3	57	0.	0.00	1	3	E. KAZ
50	N75	E						
	C.O							
BR-CN	75.2			38.6	0.6	4	9	6.7
CB2NV	52.0			14.6	0.8	4	10	14.0
NI-NV	51.8			17.4	0.5	4	10	12.0
31	EC76	9	16	37.	0.00	0	5	JAPAN
40	N145	E						
	C.O							
BR-CN	66.5			53.0	1.0	9	29	43.0
CB2NV	75.7			45.9	0.7	9	26	34.1
NI-NV	72.9			25.1	1.0	9	28	25.5
NI-NV	72.6			17.0	0.6	9	28	24.5
NI-NV	72.7			27.1	0.7	9	28	25.1
1	JAN77	11	33	42.4	5.13	0	4	JAPAN
30	6N137	2E						
43	3.0							
BR-CN	67.6			139.3	0.8	11	45	38.0
CB2NV	63.4			44.7	0.8	11	44	22.7
NI-NV	63.2			127.9	0.8	11	45	21.8
NI-NV	63.3			199.0	0.7	11	45	22.4
7	EC76	4	57	0.0	0.00	1	4	E. KAZAKH
50	N75	E						
	C.O							
BR-CN	75.5			267.9	0.9	5	5	10.7
BR-CN	75.2			582.8	0.4	5	5	5.9
NI-NV	51.9			100.0	0.8	5	10	11.6
NI-NV	51.9			116.6	0.7	5	10	11.4
5	JAN77	10	37	33.6	4.76	C	4	VOLCANIC IS.
2	5N142	5E						
	C.O							
BR-CN	66.5			31.4	0.8	10	50	17.9
CB2NV	64.5			5.9	1.0	10	49	49.3
NI-NV	64.0			12.5	0.7	10	49	49.5
NI-NV	64.1			22.9	1.3	10	49	49.0
5	JAN77	42	44	57.0	5.5	C	4	VOLCANIC IS.
23	3N143	6E						
	C.O							
BR-CN	66.7			157.9	0.9	22	57	59.4
CB2NV	64.6			135.9	0.7	22	57	27.6
NI-NV	64.6			181.7	0.9	22	57	27.0
NI-NV	64.4			263.4	0.9	22	57	27.3
6	JAN77	7	55	55.5	5.24	C	5	MOBILES
49	3N155	4E						
	C.O							
BR-CN	76.2			75.6	0.8	8	7	52.0
BR-CN	64.2			76.8	0.6	8	6	29.0
CB2NV	61.1			47.3	1.2	8	6	16.1
NI-NV	61.1			50.2	0.8	8	6	15.7
NI-NV	61.4			59.7	0.8	8	6	15.2

6 JAN 77	16	2	3.6	5.36	C	4	ANDREANOF IS.
51.3N	175.4W						
C.O							
RR-CN	49.7	212.6	0.5	16	10	43.0	
CB2-NV	44.4	36.1	0.8	16	10	10.3	
NI1-NV	44.4	65.4	0.7	16	10	18.8	
NI2-NV	44.3	27.8	0.7	16	10	7.6	
22 SEP 76	C	16	9.3	6.05	0	5	KJRIIE IS.
44.5N	149.1E						
HM-ME	83.3	675.	0.7	3	28	30.7	
RR-CN	70.0	1898.2	1.1	0	27	14.8	
CB2-NV	67.4	650.3	0.9	0	27	1.5	
NI1-NV	67.4	798.0	0.78	0	27	0.7	
NI2-NV	67.4	1036.5	0.7	0	27	0.9	
17 JAN 77	6	23	42.6	5.32	0	4	ECNIE IS.
26.7N	142.6E						
RR-CN	85.6	71.8	1.0	6	36	24.2	
CB2-NV	81.6	47.2	1.1	6	35	37.1	
NI1-NV	81.4	64.3	1.1	6	35	56.2	
NI2-NV	81.5	96.4	1.1	6	35	56.5	
17 JAN 77	9	42	22.5	4.68	0	4	S. OF ALASKA
53.6N	158.7W						
C.C							
RR-CN	36.1	49.4	0.6	9	49	46.7	
CB2-NV	31.6	29.9	0.8	9	49	3.8	
NI1-NV	31.4	39.6	0.8	9	49	2.2	
NI2-NV	31.5	33.6	0.7	9	49	2.8	
24 JAN 77	6	11	30.0	4.86	0	5	KJRIIE IS
45.5N	150.9E						
HM-ME	75.6	48.1	0.7	6	23	42.1	
RR-CN	66.4	67.1	0.7	6	22	24.3	
CB2-NV	64.5	15.9	0.9	6	22	9.8	
NI1-NV	64.3	13.4	0.6	6	21	57.3	
NI2-NV	64.4	22.6	0.7	6	22	7.2	
3 FEB 77	21	30	53.0	0.00	0	4	RUSSIA-CHINA BDR
43.5N	150.9E						
C.O							
RR-ME	55.4	57.8	0.5	21	43	53.4	
RR-CN	55.7	290.4	0.4	21	42	53.3	
CB2-NV	55.6	52.1	0.5	21	43	3.1	
NI1-NV	55.7	261.0	0.5	21	43	4.5	
16 FEB 77	C	31	29.	0.00	0	3	N. ATLANTIC
24.5N	48.6E						
C.O							
RR-CN	44.1	42.3	0.7	0	39	27.3	
CB2-NV	55.6	43.4	1.0	0	41	3.7	
NI1-NV	55.6	101.3	0.8	0	41	5.4	
13 FEB 77	5	51	11.	0.00	C	4	KAMCHATKA
52.5N	160.9E						
C.O							
RR-ME	71.5	120.4	0.6	5	2	55.4	
RR-CN	71.9	139.4	0.6	5	1	30.2	
CB2-NV	71.1	81.3	0.7	5	1	24.8	
NI1-NV	71.9	187.6	0.8	5	1	24.3	
16 FEB 77	0	50	18.0	0.00	0	3	ATLANTIC OCEAN
32.2N	25.0E						
C.O							
RR-ME	76.	34.5	0.7	0	56	53.3	
RR-CN	73.3	85.9	0.9	0	59	8.9	
NI1-NV	72.4	16.4	0.7	1	1	11.8	
16 FEB 77	1	5	48.	0.00	0	2	PACIFIC OCEAN
33.5N	150.9E						
C.O							
RR-CN	75.1	20.5	0.5	12	33	57.4	
NI1-NV	70.6	13.4	0.4	12	39	53.2	

17	EE	77	13	32	7.0	0.00	C	3	KOBANDORFSKI
56	C	0							
RR	-CNV	54.6			94.6	1.0	13	41	52.7
OB	2NV	7.1			7.1	1.2	13	41	55.6
NT	2NV	31.9			31.9	0.8	13	41	55.1
18	EE	77	40	51	26.0	0.00	C	4	JAPAN
34	C	0							
RR	-HE	55.0			66.9	1.2	21	4	57.8
RR	-CNV	416.4			416.4	0.8	21	3	53.5
OB	2NV	425.3			425.3	1.0	21	3	35.8
NT	2NV	903.8			903.8	1.0	21	3	35.4
19	EE	77	4	1	58.0	0.00	C	3	PACIFIC OCEAN
31	C	0							
RR	-CNV	21.0			21.0	0.8	4	14	47.6
OB	2NV	24.1			24.1	1.2	4	14	29.3
NT	2NV	494.0			494.0	1.0	4	14	29.2
19	EE	77	5	51	1.0	0.00	C	3	KACHAIKA
51	C	0							
RR	-CNV	28.7			28.7	0.6	6	1	18.1
CE	2NV	93.0			93.0	0.8	6	1	8.2
NT	2NV	23.1			23.1	0.6	6	1	8.0
19	EE	77	22	33	55.0	0.00	C	4	ALEUTIANS
53	C	0							
RR	-HE	66.0			700.1	0.9	22	45	7.4
RR	-CNV	557.1			557.1	0.6	22	43	29.7
OB	2NV	232.6			232.6	1.0	22	42	21.3
NT	2NV	533.0			533.0	1.0	22	42	11.0
19	EE	77	22	47	7.0	0.00	C	3	ALEUTIANS
49	C	0							
RR	-CNV	91.6			91.6	0.6	22	57	6.3
OB	2NV	21.1			21.1	0.5	22	56	47.3
NT	2NV	48.5			48.5	0.7	22	58	46.6
20	EE	77	7	2	0.0	0.00	C	2	KODIAK IS. REG.
56	C	0							
RR	-CNV	12.4			12.4	0.7	7	9	3.6
CE	2NV	5.6			5.6	0.8	7	8	41.9
20	EE	77	8	0	36.0	0.00	C	3	ALEUTIANS
51	C	0							
RR	-CNV	192.0			192.0	0.7	3	10	24.7
OB	2NV	6.4			6.4	0.5	3	10	5.6
NT	2NV	16.2			16.2	0.7	3	10	4.5
19	EE	77	22	46	44.0	0.00	C	5	BRAZIL
8	C	0							
RR	-HE	54.3			160.5	1.3	22	56	1.0
RR	-CNV	290.7			290.7	1.0	22	56	44.6
OB	2NV	70.0			70.0	1.0	22	56	33.8
NT	2NV	163.3			163.3	1.3	22	56	35.3
19	EE	77	14	27	5.0	0.00	C	3	M.E. CHINA BDR
42	C	0							
RR	-HE	930.1			930.1	0.7	14	40	2.0
RR	-CNV	374.3			374.3	0.8	14	39	7.6
OB	2NV	887.5			887.5	0.8	14	39	12.0
12	EE	77	2	58	55.0	0.00	C	4	M. ATLANTIC RIDGE
32	C	0							
RR	-CNV	115.0			115.0	1.0	3	6	12.2
OB	2NV	177.9			177.9	1.2	3	6	6.2
NT	2NV	294.7			294.7	0.8	3	6	9.1
NT	2NV	236.0			236.0	1.1	3	6	7.6

13	NAE77	4	55	55.0	0.00	C	5	BRAZIL
2	C.O	56.5						
HN	-CNV	49.0		56.3	1.1		4	55.1
OB	2-NV	60.9		113.6	0.7		4	44.6
BT	-NV	66.4		144.2	0.6		4	38.6
NI	2-NV	66.7		220.1	0.6		4	40.3
NI	2-NV	66.6		183.6	0.8		4	39.9
13	NAE77	21	15	17.0	0.00	C	5	VENEZUELA
1	C.O	64.5						
HN	-CNV	45.3		57.7	0.9		21	23
OB	2-NV	60.9		113.6	0.8		21	24
BT	-NV	60.0		152.3	0.8		21	24
NI	2-NV	60.0		314.1	1.0		21	24
NI	2-NV	60.0		300.2	0.9		21	24
15	NAE77	21	28	9.0	0.00	C	4	COSTA RICA
5	C.O	63.5						
HN	-CNV	42.7		180.9	0.7		21	36
OB	2-NV	47.1		255.9	0.7		21	34
BT	-NV	41.1		272.5	0.7		21	35
NI	2-NV	41.1		200.2	0.7		21	34
16	NAE77	6	22	19.0	0.00	C	4	ALASKA PEN.
56	C.O	155.5						
HN	-CNV	45.7		16.5	0.7		6	30
OB	2-NV	45.0		13.4	0.8		6	30
BT	-NV	45.0		38.5	0.7		6	30
NI	2-NV	45.9		31.4	0.8		6	30
19	NAE77	10	56	6.0	0.00	C	5	ARJILES
43	C.O	149.5						
HN	-CNV	65.0		434.7	0.7		11	8
OB	2-NV	71.5		524.0	0.7		11	7
BT	-NV	65.0		351.9	0.8		11	7
NI	2-NV	65.0		392.4	0.8		11	7
NI	2-NV	65.6		498.4	0.6		11	7
44	NAE77	19	21	40.0	0.00	C	4	ROMANIA
44	C.O	26.5						
HN	-CNV	71.7		1055.9	0.6		19	32
OB	2-NV	51.8		117.3	0.7		19	34
BT	-NV	51.9		229.9	0.7		19	34
NI	2-NV	51.9		239.3	0.8		19	34
7	NAE77	0	29	11.0	0.00	C	4	N.E. CHINA
43	C.O	114.5						
HN	-CNV	83.1		51.3	0.3		0	41
OB	2-NV	83.6		7.7	0.7		0	41
BT	-NV	83.6		39.0	0.5		0	41
NI	2-NV	83.6		53.8	1.2		0	41
7	NAE77	5	11	55.0	0.00	C	4	N. PACIFIC
39	C.O	145.5						
HN	-CNV	74.7		73.5	0.6		9	23
OB	2-NV	70.9		137.3	0.6		9	23
BT	-NV	70.6		220.5	0.7		9	23
NI	2-NV	70.7		202.7	0.5		9	23
21	NAE77	4	36	38.0	0.00	C	4	VOLCANO IS.
23	C.O	145.5						
HN	-CNV	50.5		9.1	0.7		4	43
OB	2-NV	54.4		22.3	1.0		4	48
BT	-NV	54.1		13.8	0.8		4	43
NI	2-NV	54.2		41.6	1.0		4	48

21HAB77	6 58	18.0	0.00	0 4	MARIANA IS.
21. N141. E					
C.O					
BR-CN	53.6	6.9	0.6	7 11	23.9
CB2NV	87.1	29.3	1.0	7 10	37.6
NT-NV	86.6	32.7	0.8	7 10	36.5
NI2NV	86.5	65.4	0.8	7 10	37.0
23HAB77	2 11	25.0	0.00	0 4	CST. VENEZUELA
11. N 65. W					
C.O					
BR-CN	44.7	2174.6	0.5	2 15	31.5
CB2NV	45.6	274.5	0.6	2 15	50.6
NT-NV	45.9	665.9	0.7	2 15	53.1
NI2NV	49.6	676.5	0.6	2 15	52.4
23HAB77	3 46	10.0	0.00	0 4	HOKKAIDO
45. N145. E					
C.O					
BR-CN	71.6	21.7	0.7	3 57	24.5
CB2NV	70.1	12.7	0.8	3 57	12.0
NT-NV	65.8	31.2	0.7	3 57	23.0
NI2NV	65.5	12.7	0.5	3 57	11.7
26HAB77	4 36	10.0	0.00	0 4	FOX IS.
52. N168. W					
C.O					
BR-CN	44.3	167.5	0.9	4 44	22.3
CB2NV	38.6	195.9	1.0	4 43	40.9
NT-NV	36.6	239.0	1.1	4 43	39.3
NI2NV	38.7	216.7	1.1	4 43	39.9
29HAB77	3 57	0.0	0.00	1 3	B. KAZAKH
50. N 78. E					
C.O					
BR-CN	76.5	76.4	0.4	4 9	6.5
CB2NV	51.9	33.7	0.7	4 10	13.1
NT-NV	51.8	45.6	0.6	4 10	13.7
5APR77	7 34	58.1	0.00	0 2	S. PEEU
15. S 70. W					
C.O					
BR-CN	65.1	24.0	0.6	7 45	52.4
CB2NV	67.8	64.1	0.8	7 45	44.1
5APR77	7 35	49.5	0.00	0 2	KAMCHATKA
54.3N161.5E					
C.O					
BR-CN	57.6	11.0	0.7	7 49	39.6
CB2NV	67.6	5.5	0.6	7 49	26.1
9APR77	17 16	5.5	0.00	0 2	ARGENTINA
27.9S 67.0W					
C.O					
BR-CN	62.0	26.2	0.61	17 23	3.3
CB2NV	75.6	9.5	0.75	17 27	53.1
10APR77	8 31	24.6	0.00	0 3	CUBILES
44.6N147.2E					
C.O					
BR-CN	71.2	98.0	0.54	8 42	44.1
CB2NV	69.1	135.8	0.91	8 42	32.0
YE-NV	65.0	445.4	0.8	8 43	1.9
10APR77	18 45	18.1	0.00	0 2	KAMCHATKA
52.6N158.8E					
C.O					
BR-CN	60.1	12.7	0.5	18 55	11.9
CB2NV	58.6	5.7	0.42	13 55	3.3
12APR77	3 54	41.7	0.00	0 2	KONANDCRSKY
56. N164. E					
C.O					
BR-CN	55.5	25.7	0.6	4 4	18.0
YE-NV	52.0	54.3	0.6	4 4	13.6
13APR77	18 20	38.3	0.00	0 2	HAT IS.
51.5N179.6W					
C.O					
BR-CN	50.7	47.2	0.6	18 25	39.4
CB2NV	46.1	95.3	0.8	13 29	5.1

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30	EE	77	20	31	58.0	0.00	0	2	PERU		
14.9	S	75.3	W								
ER	-CN	67.6			49.9	0.7	20	42	44.9		
CB	2NV	64.6			28.7	0.5	20	42	23.7		
30	EE	77	21	49	45.5	0.00	0	3	ALBERTIANS		
52.1	N	173.4	W								
36.0	C										
ER	-HE	63.2			41.0	0.7	22	0	7.5		
ER	-CN	43.2			87.2	0.4	21	58	13.3		
CB	2NV	42.2			56.2	0.65	21	37	27.6		
13	AY	77	22	5	8.0	0.00	0	2	PERU		
6.1	S	77.0	W								
12.0	C										
ER	-CN	56.7			188.0	0.63	0	16	50.5		
CB	2NV	56.6			42.2	0.7	0	13	37.9		
5	AY	77	22	14	35.7	0.00	0	2	HOKKAIDO		
4.1	N	142.3	W								
2.0	C										
ER	-CN	75.3			59.6	0.72	22	26	11.8	38.4	0.5
ER	-HE	63.0			38.7	0.8	22	27	13.7		
6	AY	77	23	53	37.5	0.00	0	4	KURILES		
4.2	N	152.0	W								
70.0	C										
CB	2NV	65.4			47.3	0.6	4	4	13.6	43.1	1.0
ER	-CN	67.6			163.5	0.9	4	4	28.2	89.0	0.7
ER	-HE	60.0			78.5	0.8	4	5	46.8		
1	AY	77	24		141.7	0.8	4	4	14.4		
6	AY	77	24	52	36.7	0.00	0	2	PERU COAST		
15.6	S	74.7	W								
15.0	C										
CB	2NV	65.6			17.0	1.0	13	3	21.9	9.3	1.0
ER	-CN	66.5			38.4	0.8	13	3	37.9		
6	AY	77	20	31	56.7	0.00	0	2	CHINA. AMER. COAST		
11.9	N	88.3	W								
11.0	C										
ER	-CN	39.2			51.1	0.7	20	39	24.1	45.5	0.7
CB	2NV	35.5			44.4	0.4	20	33	55.6	25.7	0.55
7	AY	77	22	13	29.9	0.00	0	2	JAN MAYEN IS.		
71.8	N	1.3	W								
71.0	C										
ER	-CN	43.2			76.7	1.2	2	21	32.3	14.8	1.1
CB	2NV	61.9			69.7	0.9	2	23	51.7	26.0	0.75
5	AY	77	12	19	16.1	0.00	0	2	N. CHILE		
21.9	S	69.1	W								
120.0	C										
CB	2NV	73.6			36.5	1.0	12	30	38.6	31.8	0.8
ER	-CN	75.5			23.8	0.84	12	30	46.9	23.8	0.84
9	AY	77	15	2	49.0	0.00	0	2	E. CHINA SEA		
27.2	N	126.8	W								
13.0	C										
CB	2NV	52.6			27.0	1.4	15	15	47.4	16.0	0.85
ER	-CN	54.2			58.7	0.67	15	15	52.6	33.0	0.65
10	AY	77	6	49	27.8	0.00	0	2	PERU-BRAZIL BDR		
6.1	S	74.6	W								
6.0	C										
ER	-CN	61.1			10.0	0.5	6	55	42.4	10.0	0.5
CB	2NV	59.5			7.2	0.6	6	59	35.7	2.9	0.5
12	AY	77	21	37	32.3	0.00	0	3	KURILES		
50.1	N	154.9	W								
100.0	C										
ER	-CN	63.4			229.0	0.6	21	47	52.4	214.0	0.6
CB	2NV	61.8			57.0	0.99	21	47	41.6	30.0	0.7
ER	-HE	76.0			263.0	0.89	21	49	14.2		
12	AY	77	11	17	52.1	0.00	0	2	N.E. CHINA		
39.4	N	117.6	W								
39.0	C										
CB	2NV	86.8			21.7	0.7	11	30	50.2		
ER	-CN	85.6			50.5	0.59	11	30	32.0		

13 MAY 77	3	2	38.2	0.00	0	2	MEXICO-GUATEMALA BR		
15 JUN 77	91.5								
22 MAY 77	34.9		18.2	0.75	3	3		11.9	0.8
09 JUN 77	30.3		21.4	0.9	3	8			
13 MAY 77	13.35		14.4	0.00	0	2	W. PERO		
12 JUN 77	77.0								
12 JUN 77	56.1		31.1	0.6	13	45		17.9	1.4
02 JUN 77	56.1		14.5	1.05	13	44		10.7	1.2
14 MAY 77	43.9	4	43.9	0.00	0	3	ECUADOR COAST		
11 JUN 77	55.1								
03 JUN 77	45.6		45.6	1.6	6	13		4.2	1.36
01 JUN 77	45.6		43.0	1.8	6	12		9.4	1.3
01 JUN 77	45.6		48.4	1.8	6	12			
20 JUL 77	16.48	48	57.6	0.00	0	2	CENT. AMER. CST.		
11 JUN 77	83.4								
01 JUN 77	45.6		21.1	1.7	16	57			
01 JUN 77	39.4		30.6	1.5	16	56			
01 JUL 77	17.16	16	57.1	0.00	0	2	BERMUDIC IS.		
15 JUN 77	179.9								
01 JUN 77	53.1		62.2	0.6	17	25			
01 JUN 77	97.4		15.6	2.0	17	30			
01 JUL 77	13.45	45	1.3	0.00	0	4	ALASKA PEN.		
04 JUN 77	162.4								
01 JUN 77	55.3		55.3	0.91	13	51		28.4	0.92
01 JUN 77	49.2		49.2	0.94	13	51			
01 JUN 77	34.7		21.0	0.8	13	51			
01 JUN 77	41.2		12.0	0.7	13	52			
24 JUL 77	68.6	44	53.3	0.00	0	4	VENEZUELA CST.		
11 JUN 77	68.6								
01 JUN 77	49.3		9.7	0.66	5	53		8.2	0.7
01 JUN 77	49.3		9.9	0.65	5	53			
01 JUN 77	49.3		7.9	0.8	5	53			
01 JUN 77	42.6		27.0	0.7	5	52			
01 JUL 77	173.6	23	18.2	0.00	0	7	TONGA IS.		
01 JUN 77	173.6								
24 JUN 77	75.2		200.5	1.22	6	34			
01 JUN 77	95.2		46.9	1.5	6	6		46.9	1.7
01 JUN 77	244.1		72.9	1.35	6	4			
01 JUN 77	72.9		72.9	1.8	6	4		25.6	1.7
01 JUN 77	74.4		74.4	1.8	6	4			
01 JUN 77	125.0		125.0	2.3	6	4			
01 JUN 77	81.2		128.2	1.8	6	35			
24 JUL 77	16.15	15	50.1	0.00	0	4	ATLANTIC		
17 JUN 77	46.1								
01 JUN 77	63.6		7.6	1.3	16	30		6.7	1.1
01 JUN 77	63.6		8.0	1.3	16	30			
01 JUN 77	63.6		5.9	0.5	16	30			
01 JUN 77	63.6		11.4	0.8	16	35			
01 JUL 77	142.9	5	55.3	0.00	0	3	SAKHALIN IS.		
01 JUN 77	142.9								
01 JUN 77	67.6		10.0	1.3	3	16		5.0	0.8
01 JUN 77	67.6		11.0	1.8	3	16			
01 JUN 77	74.2		9.0	1.2	3	17			
01 JUL 77	12.55	55	45.4	0.00	0	4	FIGI IS		
01 JUN 77	178.9								
01 JUN 77	61.6		21.5	0.8	13	11		14.3	0.8
01 JUN 77	61.6		20.4	0.8	13	11			
01 JUN 77	61.6		5.5	0.7	13	11			
01 JUN 77	61.6		6.0	1.4	13	11			

25 JUL 77	17 5	3.1	0.00	0	2	P3RU	
11.7S	15.1W						
C.O.							
FA-NV	63.3	13.1	1.3	17	13	35.5	
GE-NM	67.7	11.4	1.0	17	14	50.7	
26 JUL 77	4 25	23.0	0.00	0	4	JAFAN	
33.8N	141.1E						
14.2S							
CB2NV	75.4	43.4	0.88	4	36	53.1	41.0 0.78
CE3NV	75.4	46.1	0.66	4	36	53.2	
FA-NV	74.4	21.4	0.9	4	36	47.5	
GE-NM	81.1	39.8	0.8	4	37	24.0	
26 JUL 77	7 43	5.8	0.00	0	4	CHILE-ARGENTINA BDR	
31.1S	70.2W						
12.5S							
CE2NV	80.6	21.7	0.81	7	55	5.3	18.5 0.84
CE3NV	80.6	19.9	0.8	7	55	5.4	
FA-NV	81.8	26.2	0.7	7	55	11.5	
GE-NM	76.1	26.3	0.9	7	54	33.5	
26 JUL 77	10 28	0.0	0.00	0	4	SAMOA IS	
15.9S	171.9W						
43.0C							
CB2NV	75.4	16.6	1.08	10	39	39.2	14.0 0.9
CB3NV	75.4	13.9	0.92	10	39	39.2	
FA-NV	76.1	27.6	0.7	10	39	43.3	
GE-NM	91.1	10.0	1.2	10	40	11.0	
26 JUL 77	16 55	59.9	0.00	0	4	SIBERIA	
69.4N	90.4E						
C.O.							
CB2NV	71.6	20.9	0.96	17	11	23.2	15.5 0.72
CE3NV	71.6	29.5	0.78	17	11	23.1	
FA-NV	70.2	22.8	1.0	17	11	13.0	
GE-NM	73.1	35.3	0.7	17	11	31.7	
27 JUL 77	2 55	4.4	0.00	0	4	TONGA IS.	
16.8S	173.5W						
C.O.							
CB2NV	76.4	25.0	1.0	3	6	54.8	22.6 1.0
CE3NV	76.4	24.3	1.1	3	6	54.8	
FA-NV	77.1	26.0	1.0	3	6	59.5	
GE-NM	82.2	30.4	1.1	3	7	23.0	
29 JUL 77	9 50	29.0	0.00	0	2	PACIFIC OCEAN	
1.5N	107.0W						
C.O.							
FA-NV	36.1	12.0	1.0	5	57	47.0	
GE-NM	38.2	12.9	0.8	9	56	33.5	
29 JUL 77	16 51	10.6	0.00	0	4	TONGA IS.	
13.2S	175.2W						
14.5S							
CB2NV	75.2	35.0	0.8	17	2	59.6	29.1 0.8
CE3NV	75.2	34.1	0.72	17	2	58.6	
FA-NV	75.9	24.0	0.7	17	3	2.0	
GE-NM	85.0	19.1	1.1	17	3	28.3	
30 JUL 77	1 56	59.9	0.00	1	2	B. KAZAKH	
49.7N	76.2E						
C.O.							
FA-NV	50.7	12.0	0.7	2	10	6.5	
GE-NM	53.5	19.6	0.8	2	10	19.0	
30 JUL 77	22	16.3	0.00	0	4	N. PERU	
5.6S	77.3W						
C.O.							
CE2NV	56.0	12.6	1.1	5	11	55.9	10.8 1.26
CE3NV	56.0	13.1	1.12	5	11	56.1	
FA-NV	57.0	18.4	1.3	5	12	3.5	
GE-NM	50.7	50.0	0.8	5	11	16.0	
30 JUL 77	45	49.1	0.00	0	4	CHILE COAST	
30.6S	71.4W						
C.O.							
CB2NV	75.6	38.6	1.05	5	51	52.3	30.7 1.15
CE3NV	75.6	41.4	1.05	5	51	51.9	
FA-NV	75.6	28.8	0.8	5	51	39.0	
GE-NM	75.2	54.2	1.0	5	51	26.0	

30 JUL 77	7	56	36.4	0.00	0	4	BL	SALVADOR		
13 JUN 77	2	58	5.5							
GE - NV										
CB - NV			14.0	0.81	8	3			9.8	0.85
CE - NV			13.6	0.71	8	3				
GE - NV			25.2	0.7	6	3				
CB - NV			31.8	0.8	8	2				
CE - NV			33.3	0.00	0	2				
31 JUL 77	41							FIGI IS.		
19 JUN 77	176	2								
GE - NV			11.5	1.7	2	54				
CB - NV			10.8	1.1	2	54				
CE - NV			47.9	0.00	0	2				
31 JUL 77	10							NEW ZEALAND		
15 JUN 77	168	1								
GE - NV			8.5	1.7	22	23				
CB - NV			27.1	0.6	22	23				
CE - NV			58.4	0.00	0	4				
25 MAY 77	09							FIJI IS.		
17 JUN 77	178	6								
GE - NV			10.0	1.0	12	21				
CB - NV			361.0	1.0	12	21				
CE - NV			163.0	1.2	12	21			128.0	1.0
GE - NV			177.0	1.2	12	21				
CB - NV			00.4	0.00	1	7				
CE - NV								B. KAZAKH		
29 MAY 77	57									
49 JUN 77	76	5								
GE - NV			9.5	0.7	3	10			62	
CB - NV			189.0	1.0	03	10				
CE - NV			218.0	1.0	03	10				
GE - NV			46.0	0.5	03	10			446.0	.55
CB - NV			95.9	0.9	03	10			50.0	.96
CE - NV			93.7	0.8	03	10				
GE - NV			204.3	1.0	03	10				
CB - NV			01.7	0.00	0	4				
CE - NV								COAST N. PAKISTAN		
23 JUN 77	64	6								
GE - NV			843.0	0.4	02	39				
CB - NV			836.0	0.4	02	39				
CE - NV			60.1	0.6	02	39			9.2	.45
GE - NV			60.5	0.7	02	39				
CB - NV			33.1	0.00	0	4				
CE - NV								ICELAND		
02 JUN 77	14	55								
6 JUN 77	19	1								
GE - NV			8.0	1.3	15	3			94	
CB - NV			35.9	1.4	15	3			23.5	1.3
CE - NV			22.7	1.6	15	3				
GE - NV			22.1	0.6	15	3				
CB - NV			36.1	0.00	0	8				
CE - NV								CHILE-BOLIVIA BORDER		
02 JUN 77	50									
20 JUN 77	58	6								
GE - NV			11.0	0.9	17	1			94	
CB - NV			168.5	1.0	17	01				
CE - NV			126.0	1.0	17	01				
GE - NV			169.0	1.0	17	01				
CB - NV			121.3	1.0	17	01				
CE - NV			122.0	0.9	17	01			44.0	1.0
GE - NV			120.0	0.8	17	01			57.6	0.9
CB - NV			99.0	1.0	17	01				
CE - NV			06.8	0.00	0	10				
02 JUN 77	46							NEAR COAST N. CHILE		
20 JUN 77	70	5								
GE - NV			9.0	0.5	2	57			48	
CB - NV			15.0	1.5	2	57			99	
CE - NV			126.0	1.0	02	22				
GE - NV			132.0	1.1	02	22				
CB - NV			110.0	1.2	02	22				
CE - NV			129.0	1.2	02	22				
GE - NV			131.6	1.5	02	22				
CB - NV			93.0	2.3	02	22				
CE - NV			68.0	1.6	02	22				
GE - NV			66.5	1.5	02	22				

05 JUN 77	06 41	17.9	0.00	C 9	HOKKAIDO, JAPAN		
42.4N	142.8E						
FA-NV	71.6	9.0	0.5	6	32	43.3	550
GE-NV	76.4	43.0	1.0	6	33	22.0	1042
YE-NV	77.0	75.0	0.7	06	22	50.0	
YE-NV	77.0	60.0	0.6	06	22	51.0	
YE-NV	77.0	61.0	0.6	06	22	50.0	
YE-NV	77.0	60.0	0.7	06	22	50.0	
HR-CN	74.6	22.5	0.6	06	22	56.7	22.0 :6
CB2-NV	72.9	20.0	0.7	06	22	49.9	15.6 :7
CB3-NV	72.9	20.6	0.7	06	22	49.9	
05 JUN 77	15 15	13.0	0.00	C 8	GBR BRITAIN		
04.6S	152.2E						
FA-NV	54.1	5.5	1.0	15	32	18.0	47
GE-NV	101.2	8.0	0.8	15	32	51.0	99
YE-NV	54.4	20.0	0.9	15	32	19.0	
YE-NV	54.4	61.0	0.8	15	32	19.1	
YE-NV	54.4	308.0	0.8	15	32	19.1	
HR-CN	125.5	43.0	1.1	15	32	00.0	
CB2-NV	94.1	133.0	0.9	15	32	18.1	78.0 1.0
CB3-NV	94.1	123.0	0.9	15	32	18.2	
03 JUN 77	13 25	16.0	0.00	C 9	CHL-BOLIVIA BORDER		
22.5S	67.3W						
FA-NV	76.1	16.0	1.3	13	36	48.5	35
GE-NV	65.6	35.0	1.3	13	36	11.3	99
YE-NV	74.4	30.0	1.0	13	36	42.3	
YE-NV	74.4	37.0	1.1	13	36	42.5	
HR-CN	66.1	80.1	1.2	13	36	01.2	
CB2-NV	74.4	244.0	1.2	13	36	42.5	196.0 1.2
CB3-NV	74.4	408.0	1.4	13	36	42.3	
09 JUN 77	14 25	49.0	0.00	C 7	JAR E COAST HONSHU		
33.5N	141.5E						
FA-NV	75.0	10.5	1.5	14	37	22.5	35
GE-NV	76.1	40.0	1.3	14	37	29.1	
YE-NV	76.1	45.0	1.2	14	37	29.0	
YE-NV	76.0	164.0	1.1	14	37	26.2	84.0 1.1
CB2-NV	76.0	150.0	1.2	14	37	28.2	
CB3-NV	76.1	449.0	1.1	14	37	29.0	
17 JUN 77	14 29	22.3	0.00	C 6	FJI ISLANDS		
19.7S	179.2W						
FA-NV	82.9	36.0	0.8	2	40	27.0	65
YE-NV	82.2	828.0	0.9	02	40	23.4	
YE-NV	82.2	651.0	1.0	02	40	23.3	
YE-NV	82.2	773.0	1.1	02	40	23.4	
YE-NV	82.2	723.0	1.2	02	40	23.4	
CB2-NV	82.2	382.0	0.9	02	40	23.3	
17 JUN 77	14 45	11.5	0.00	C 5	MAR ISLANDS		
19.1N	145.6E						
FA-NV	84.1	14.0	0.6	14	57	31.6	65
YE-NV	84.0	493.0	1.3	14	57	35.4	
YE-NV	84.0	549.0	1.1	14	57	35.4	
CB2-NV	84.0	204.0	0.9	14	57	34.6	127.0 0.75
CB3-NV	84.0	213.0	1.0	14	57	34.6	
14 JUL 77	07 15	35.0	0.00	C 5	ICELAND		
64.7N	017.1E						
FA-NV	55.4	12.5	2.0	7	23	33.0	420
GE-NV	57.0	31.0	1.3	7	23	24.6	781
CB2-NV	60.4	7.4	1.3	07	23	45.9	
HR-CN	40.2	18.3	0.9	07	23	13.5	3.4 0.8
CB3-NV	60.4	7.5	1.2	07	25	45.9	14.7 0.7

21 JUL 77	01	39.3	0.00	C	4	NEW H2ERIDES IS.	
19 JUL 77	16	54.0	1.0	07	13	54.7	
19 JUL 77	16	20.0	1.0	07	13	54.4	16.5 0.85
19 JUL 77	16	21.0	1.0	07	13	54.5	
19 JUL 77	16	50.0	1.0	07	13	54.7	
24 JUL 77	55	38.9	0.00	0	8	MARIANA ISLANDS	
19 JUL 77	14	405.0	0.65	20	31	32.1	
19 JUL 77	14	565.0	0.8	20	31	32.0	
19 JUL 77	14	15.0	1.0	20	31	34.2	9.0 0.6
19 JUL 77	14	329.3	0.7	20	31	31.3	47.1 0.87
19 JUL 77	14	461.0	0.7	20	31	32.0	
19 JUL 77	14	552.0	0.7	20	31	32.2	
19 JUL 77	14	116.1	0.6	20	31	23.0	
19 JUL 77	14	141.0	1.0	20	31	2.0	
21 JUL 77	51	37.7	0.00	C	9	CARIBBEAN SEA	
19 JUL 77	16	74.0	0.95	04	33	33.3	
19 JUL 77	16	63.8	0.8	04	33	33.7	
19 JUL 77	16	39.0	1.4	04	33	25.1	52.6 0.9
19 JUL 77	16	39.8	0.95	04	33	40.0	
19 JUL 77	16	40.0	0.9	04	33	40.0	
19 JUL 77	16	92.7	1.2	04	33	39.5	
19 JUL 77	16	67.0	1.1	04	33	33.3	
19 JUL 77	16	20.7	0.3	04	33	46.0	
19 JUL 77	16	13.0	1.3	04	33	42.7	
21 JUL 77	16	58.8	0.00	C	4	MARIANA ISLANDS	
19 JUL 77	14	276.9	0.5	17	29	11.6	
19 JUL 77	14	413.9	0.7	17	29	11.4	
19 JUL 77	14	323.0	0.7	17	29	11.4	
19 JUL 77	14	369.0	0.6	17	29	11.5	
21 JUL 77	15	47.3	0.00	C	9	SOLICOM ISLANDS	
19 JUL 77	15	465.0	1.0	11	29	04.6	
19 JUL 77	15	577.6	1.1	11	29	4.5	
19 JUL 77	15	177.0	1.5	11	29	00.0	5.6 0.9
19 JUL 77	15	177.0	1.4	11	29	53.0	
19 JUL 77	15	424.0	1.1	11	29	47.6	
19 JUL 77	15	646.0	1.1	11	29	04.6	
19 JUL 77	15	600.0	1.0	11	29	4.5	
19 JUL 77	15	287.8	1.5	11	29	1.0	
19 JUL 77	15	16.4	1.5	11	29	35.0	
31 JUL 77	20	02.8	0.00	C	7	OFF COI C. AMERICA	
19 JUL 77	16	27.0	1.3	10	27	8.6	1042
19 JUL 77	16	43.9	1.3	10	27	53.5	
19 JUL 77	16	51.5	1.3	10	27	52.3	
19 JUL 77	16	46.9	1.3	10	27	53.7	
19 JUL 77	16	43.8	1.4	10	27	53.0	
19 JUL 77	16	18.7	1.4	10	27	54.1	
19 JUL 77	16	19.0	1.4	10	27	54.3	
31 JUL 77	16	05.1	0.00	C	9	R/K IS. ALEUTIANS	
19 JUL 77	16	10.0	1.0	15	24	21.0	62
19 JUL 77	16	51.9	0.6	15	24	38.5	
19 JUL 77	16	52.9	0.5	15	24	38.3	
19 JUL 77	16	65.9	0.8	15	24	37.6	
19 JUL 77	16	59.0	0.9	15	24	37.6	
19 JUL 77	16	29.0	1.0	15	24	36.1	
19 JUL 77	16	25.4	1.0	15	24	36.0	
19 JUL 77	16	270.0	1.0	15	24	15.6	
19 JUL 77	16	68.0	1.1	15	24	13.3	

28 JAN 77	04 24	26.0	0.00	0 2	BONIN ISLANDS		
29.0N 139.0E							
CB2 NV	87.8	21.6	0.5	04	37	16.8	
CB2 NV	83.6	39.5	0.7	04	36	58.7	
15 JUL 77	06 16	30.5	0.00	0 3	RAI IS.	ALEUTIANS	
51.5N 178.0E							
54.0N							
CB2 NV	47.5	8.7	0.6	06	25	02.4	
CB2 NV	51.8	42.0	0.5	06	25	33.0	
CB3 NV	47.5	8.5	0.8	06	25	02.4	
4 JUN 77	15 0	38.8	0.00	0 4	LAKE	BAIKAL REG.	
56.3N 111.5E							
56.5N							
CB2 NV	78.1	8.4	1.1	15	12	32.4	5.1 .8
CB3 NV	78.1	9.2	1.2	15	12	32.4	
FA-NV	76.8	6.0	1.3	15	12	24.5	550
GE-NM	65.9	60.0	0.8	15	12	49.0	1042
4 JUN 77	18 54	20.7	0.00	0 2	LEEWARD IS.		
13.2N 164.0W							
13.0N							
FA-NV	49.5	16.0	0.7	19	3	14.3	550
GE-NM	42.1	32.0	1.0	19	2	13.0	1042
5 JUN 77	38 38	3.5	0.00	0 4	ARGENTINA		
23.0S 66.6W							
23.0S							
CB2 NV	76.7	35.4	1.0	6	49	29.5	29.9 .9
CB3 NV	76.7	32.6	1.06	6	49	29.5	
FA-NV	77.8	43.5	0.7	6	49	35.5	550
GE-NM	71.6	9.0	0.8	6	48	59.3	99
5 JUN 77	22 23	39.0	0.00	0 3	N. ATLANTIC RIDGE		
13.4N 44.7W							
13.0N							
CB2 NV	67.2	8.5	1.3	22	34	36.1	6.1 1.1
FA-NV	67.3	7.5	0.7	22	34	36.3	550
GE-NM	60.1	30.0	1.0	22	33	40.7	1094
6 JUN 77	6 38	43.1	0.00	0 4	DOMINICAN REP.		
19.4N 65.5W							
19.0N							
FA-NV	44.6	33.0	1.0	6	46	57.0	550
GE-NM	37.2	26.0	0.7	6	45	55.0	1094
CB2 NV	44.1	33.1	1.0	6	46	53.4	2.0 0.5
CB3 NV	44.1	31.0	1.2	6	46	53.4	2.0 0.5
7 JUN 77	13 31	25.4	0.00	0 4	ARGENTINA		
29.8S 67.8W							
29.0S							
FA-NV	82.0	38.0	1.0	13	43	32.0	430
GE-NM	76.1	12.0	1.0	13	43	0.7	99
CB2 NV	80.8	39.4	1.1	13	43	26.2	4.4 0.8
CB3 NV	80.8	46.3	1.0	13	43	26.3	
8 JUN 77	1 44	39.0	0.00	0 2	N. PERU COAST		
5.1S 78.9W							
5.0S							
FA-NV	55.0	5.5	0.7	1	54	40.0	440
GE-NM	52.9	18.0	1.1	1	53	54.3	1094
9 JUN 77	14 5	43.7	0.00	0 2	FIDJI IS.		
21.9S 177.1W							
21.0S							
FA-NV	83.1	4.0	0.8	14	17	41.5	35
GE-NM	88.1	22.0	1.0	14	18	6.3	1094
23 JUL 77	2 51	47.4	0.00	0 2	MEXICO		
14.5N 56.9W							
14.0N							
FA-NV	25.5	4.4	1.3	2	57	47.5	
GE-NM	24.0	51.3	0.7	2	56	54.7	
1 JUN 77	8 57	28.0	0.00	0 3	TONGA IS.		
21.1S 174.2W							
21.0S							
GE-NM	56.2	36.0	1.6	9	10	7.3	1042
CB2 NV	75.5	23.7	1.04	9	5	37.8	3.5 .85
CB3 NV	75.9	26.2	1.16	9	5	37.9	

1 JUN 77	12 54	53.5	0.00	0 4	TURKEY		
35.3	31.4						
GBR	NV	57.5	40.0	0.8	13	3	19.0 1042
GBR	NV	100.0	7.3	0.76	13	3	32.8 5.3 .76
GBR	NV	100.0	6.7	0.88	13	3	32.7
GBR	NV	100.0	121.3	0.7	13	3	55.7 91.6 .8
11 JUN 77	20 33	28.4	0.00	0 3	N. ATLANTIC RIDGE		
33.0	39.0						
GBR	NV	60.5	15.4	1.5	20	43	45.1 9.3 1.3
GBR	NV	60.5	12.9	1.7	20	43	45.1
GBR	NV	42.6	20.8	1.6	20	41	27.6 16.9 1.4
12 JUN 77	6 48	5.1	0.00	0 7	JAPAN		
43.0	142.0						
GBR	NV	71.8	35.0	0.8	8	9	3.0 500
GBR	NV	71.8	86.0	0.8	8	9	41.3 573
GBR	NV	71.8	181.0	0.81	8	9	10.9
GBR	NV	71.8	208.0	0.83	8	9	10.9
GBR	NV	71.8	64.4	0.85	8	9	9.4 41.2 0.88
GBR	NV	71.8	58.0	0.85	8	9	9.5
GBR	NV	71.8	60.5	0.86	8	9	17.6 55.0 0.7
12 JUN 77	12 C	28.3	0.00	0 4	GULF OF MEX.		
22.0	88.0						
GBR	NV	29.0	18.0	1.0	12	6	14.0 500
GBR	NV	29.0	12.0	0.9	12	6	18.0 573
GBR	NV	29.0	8.3	0.66	12	6	5.0 7.1 0.64
GBR	NV	29.0	9.0	0.6	12	6	5.0
12 JUN 77	16 16	45.8	0.00	0 3	N. FEBRIDES		
15.0	169.4						
GBR	NV	50.0	15.0	1.0	12	29	42.5 500
GBR	NV	50.0	24.6	0.76	12	29	40.3
GBR	NV	50.0	24.7	0.53	12	29	40.3
12 JUN 77	28	32.2	0.00	0 5	CAN. AMER. CST.		
15.0	90.0						
GBR	NV	34.0	36.0	1.0	5	35	12.8 410
GBR	NV	34.0	5.5	0.7	5	35	16.6 57
GBR	NV	34.0	13.8	1.4	5	35	3.6
GBR	NV	34.0	14.4	1.4	5	35	3.6
GBR	NV	34.0	51.7	0.8	5	35	40.0 30.1 0.8
12 JUN 77	2 2	13.4	0.00	0 5	N. CHILE CST.		
10.0	70.0						
GBR	NV	34.0	4.0	0.8	8	13	43.5 30
GBR	NV	34.0	5.5	0.7	8	13	6.3 57
GBR	NV	34.0	19.1	0.9	8	13	37.1
GBR	NV	34.0	21.4	1.16	8	13	37.1
GBR	NV	34.0	43.9	0.85	8	13	46.6 33.1 0.89
12 JUN 77	8 8	44.3	0.00	0 6	TONGA IS.		
10.0	174.0						
GBR	NV	76.0	11.0	2.0	10	21	47.0 30
GBR	NV	76.0	85.0	1.3	10	21	14.3 573
GBR	NV	76.0	91.0	1.23	10	20	43.8
GBR	NV	76.0	99.0	1.2	10	20	43.7
GBR	NV	76.0	43.0	1.5	10	20	42.9
GBR	NV	76.0	46.0	1.5	10	20	43.0
13 JUN 77	15 12	52.4	0.00	0 4	KIDIAK IS.		
15.0	15.0						
GBR	NV	31.2	16.0	0.9	15	19	8.9 410
GBR	NV	31.2	48.0	0.7	15	19	2.0 573
GBR	NV	31.2	8.4	0.9	15	19	19.0
GBR	NV	31.2	7.2	0.8	15	19	18.0 6.9 0.75

19 JUN 77	17	5	21.6	0.00	C 4	MEXICO		
14.9N	53.3W							
FA-NV	31.1		23.5	0.8	17	11	41.5	398
GE-NV	19.0		0.8	17	10	47.7	83	
CB2-NV	0.1		9.4	0.9	17	11	31.8	
CB3-NV	0.1		8.8	1.1	17	11	31.7	
19 JUN 77	18	17	37.6	0.00	O 5	N. ATLANTIC RIDGE		
15.5N	46.7W							
FA-NV	34.5		26.5	0.7	18	23	16.0	398
GE-NV	31.1		38.0	1.5	19	27	28.3	885
CB2-NV	64.4		24.2	1.45	18	26	16.5	
CB3-NV	1.1		35.0	1.0	18	26	43.6	
20 JUN 77	16	41	13.9	0.00	C 3	UNITED IS.		
53.9N	164.4W							
FA-NV	35.5		45.0	0.7	0	48	14.0	425
CB2-NV	36.5		39.0	0.9	0	48	23.0	
CB3-NV	36.9		36.9	0.9	0	48	22.9	26.8 0.85
20 JUN 77	30		54.4	0.00	O 3	N. CHILE		
23.9S	65.4W							
FA-NV	16.3		13.0	0.6	6	42	36.0	425
CB2-NV	16.3		3.0	0.88	6	42	29.7	
CB3-NV	16.3		9.7	0.96	6	42	23.4	7.3 0.7
14 MAY 77	58		51.8	0.00	O 3	ECUADOR CST.		
1.8N	85.4W							
FA-NV	49.5		30.0	0.89	7	7	38.5	9.5 .9
CB2-NV	49.5		11.8	0.8	7	7	7.5	4.3 .9
CB3-NV	49.5		11.1	0.9	7	7	7.5	
15 MAY 77	21		4.1	0.00	O 4	RUJILES		
49.9N	152.6W							
FA-NV	44.5		159.2	0.8	0	1	16.5	128.5 .8
CB2-NV	44.5		33.6	0.8	0	1	7.8	9.0 .7
CB3-NV	44.5		39.1	0.9	0	1	7.8	
15 MAY 77	50		44.1	0.00	C 3	PAK IS.		
52.5N	168.2W							
FA-NV	44.1		32.3	0.5	15	23	54.4	27.5 .8
CB2-NV	44.1		56.1	1.32	15	23	12.8	36.2 1.14
CB3-NV	44.1		54.7	1.25	15	23	12.8	
21 JUN 77	58		22.3	0.00	C 5	TONGA IS.		
15.5S	174.6W							
FA-NV	26.5		6.8	0.8	9	9	42.3	65
FA-NV	26.5		31.1	0.97	9	9	38.5	
FA-NV	26.5		102.0	0.97	9	9	38.5	
CB2-NV	26.5		276.0	0.85	9	9	38.5	210.0 0.8
CB3-NV	26.5		19.0	0.95	9	9	38.5	
21 JUN 77	11		30.2	0.00	O 6	JAPAN		
35.4N	140.4W							
FA-NV	71.6		24.0	1.5	7	23	23.5	425
FA-NV	71.6		44.9	0.75	7	23	29.3	
FA-NV	71.6		52.9	0.75	7	23	29.6	
CB2-NV	71.6		102.0	0.78	7	23	28.6	67.0 1.1
CB3-NV	71.6		160.0	0.8	7	23	28.5	
FA-NV	71.6		21.5	1.10	7	23	43.0	19.9 1.34
22 JUN 77	50		31.2	0.00	O 6	KAMCHATKA		
53.7N	160.7W							
FA-NV	56.0		47.0	1.3	9	0	7.3	425
FA-NV	56.0		99.3	0.95	9	0	16.3	
FA-NV	56.0		113.7	1.06	9	0	16.2	
CB2-NV	56.0		75.7	1.23	9	0	14.2	21.2 1.24
CB3-NV	56.0		135.5	1.26	9	0	14.1	
FA-NV	56.0		67.5	0.74	9	0	23.0	60.1 0.89

13JUL77	6	35	35.7	0.00	0	3	CHILE-ARGENTINA BDR		
29.1S	65.7W								
104.0									
CB2NV	75.3		22.4	1.1	6	47	30.3		15.4 1.0
CB3NV	75.3		19.5	1.1	6	47	30.3		
BR-CN	82.7		30.6	1.0	6	47	45.5		24.8 0.84
15JUL77	7.9N	4	8.9	0.00	0	2	N. COLUMBIA		
72.1W									
0.0									
CB2NV	45.4		9.6	0.64	13	13	0.2		8.4 0.65
CB3NV	49.4		7.9	0.6	13	13	0.3		
10JUL77	13.4	24	21.1	0.00	0	4	ALASKA PEN.		
161.9W									
0.0									
CB2NV	55.5		134.1	1.3	13	31	19.4		111.6 1.1
CB3NV	55.5		129.0	1.4	13	31	19.3		
BR-CN	55.5		220.0	1.1	13	31	55.6		84.6 1.2
BR-ME	55.5		84.6	1.2	13	31	58.9		
20JUL77	10.1N	36	28.0	0.00	0	8	AJDREANOF IS.		
178.0W									
0.0									
FA-NV	44.3		8.5	0.6	10	44	20.0	410	
GE-NM	51.1		54.0	0.7	10	45	12.6	905	
YF4NV	45.5		38.8	0.7	10	44	29.3		
YF5NV	45.5		38.1	0.9	10	44	29.3		
YF6NV	45.5		30.1	0.8	10	44	29.3		
YF7NV	45.5		39.6	0.8	10	44	29.2		
CE2NV	45.5		9.9	0.9	10	44	28.0		7.0 0.8
CE3NV	45.5		15.7	0.5	10	44	27.8		
21JUL77	15.2N	19	59.2	0.00	0	4	ALASKA PEN.		
157.9W									
0.0									
FA-NV	33.5		20.7	0.6	2	26	7.0		
GE-NM	33.5		9.0	1.0	2	27	21.6	73	
CB2NV	33.5		16.0	0.9	2	26	36.6		13.1 1.0
CE3NV	33.5		20.6	0.9	2	26	36.7		
10JUN77	0.0	41	8.4	0.00	0	2	N.E. CHINA		
118.1E									
0.0									
FA-NV	67.3		6.0	1.5	0	53	44.0	500	
GE-NM	55.0		17.5	0.8	0	54	13.3	1094	
10JUN77	22.9S	35	18.6	0.00	0	2	SUMATRA		
101.5E									
0.0									
FA-NV	130.4		17.0	0.5	2	54	25.0	500	
GE-NM	137.1		29.0	0.8	2	54	38.3	1094	
15JUN77	8.6N	5	33.5	0.00	0	2	MEXICO CST		
103.7W									
0.0									
FA-NV	32.1		14.0	1.8	3	12	1.3	410	
GE-NM	26.3		22.0	1.0	3	11	26.6	573	
14JUN77	12.1S	52	37.4	0.00	0	2	ARGENTINA		
66.0W									
0.0									
FA-NV	75.0		24.5	0.5	13	4	31.2	410	
GE-NM	72.8		27.0	0.7	12	52	37.4	885	
15JUN77	13.1N	18	6.9	0.00	0	4	CENT. PACIFIC		
95.2E									
0.0									
FA-NV	36.5		50.0	0.7	13	25	32.7	410	
GE-NM	22.4		13.0	1.0	13	24	36.3	83	
CB2NV	18.6		13.0	1.0	13	25	23.0		
CE3NV	18.6		14.0	0.9	13	25	23.1		
17JUN77	15.0N	26	30.3	0.00	0	4	S. ALASKA		
61.5W									
0.0									
FA-NV	1.0		12.0	0.5	8	32	42.5	398	
GE-NM	6.5		29.0	0.8	8	33	30.3	885	
CB2NV	2.5		9.1	0.78	8	32	53.3		4.1 0.45
CE3NV	2.5		9.3	0.72	8	32	53.5		

13JUN77	10	23	56.0	0.00	0	4	JAPAN		
42.1N	142.0E								
FA-NV	74.4		14.0	0.8	10	35	26.0	398	
GE-NM	74.4		28.0	0.8	10	35	3.7	885	
CB-NV	74.4		11.3	0.9	10	35	1.8		9.3 0.8
CE-NV	74.4		10.4	0.9	10	35	31.8		
19JUN77	16	45	41.8	0.00	0	5	CHILE-BOLIVIA	BDR	
21.0S	66.7W								
FA-NV	74.4		32.0	1.0	17	1	6.3	65	
GE-NM	74.4		23.0	1.1	17	0	28.3	83	
CB-NV	74.4		14.0	1.1	17	0	55.7		
CE-NV	74.4		578.0	1.1	17	0	59.7		
19JUN77	20	56	42.9	0.00	0	4	MEXICO-GUATEMALA		
15.7N	93.0W								
FA-NV	30.7		7.0	1.1	21	2	44.0	65	
GE-NM	30.7		19.0	1.1	21	1	50.0	83	
CB-NV	30.7		35.0	1.64	21	2	34.7		30.8 1.3
CE-NV	30.7		36.0	1.6	21	2	34.8		
19JUN77	7	22	17.4	0.00	0	2	SAMOA IS. REGION		
13.5S	174.0W								
FA-NV	74.4		4.2	0.7	7	33	57.4	65	
GE-NM	74.4		26.0	1.5	7	34	26.0	885	
19JUN77	8	26	34.9	0.00	0	2	WINDWARD IS.		
11.1N	62.1W								
FA-NV	55.3		9.5	0.7	8	35	43.5	398	
GE-NM	55.3		14.0	0.8	8	34	49.3	885	
19JUN77	11	47	22.3	0.00	0	5	MIRIERS		
41.2N	151.0E								
FA-NV	64.4		10.0	1.0	11	53	46.0	65	
GE-NM	64.4		21.0	0.6	11	53	27.6	83	
CB-NV	64.4		100.0	1.4	11	53	52.9		43.0 1.2
CE-NV	64.4		36.0	1.2	11	53	52.9		
19JUN77	10	39	39.0	0.00	0	2	MEXICO-GUATEMALA		
15.2N	52.6E								
FA-NV	31.2		15.0	0.8	3	16	56.0	425	
GE-NM	31.2		30.0	1.0	3	16	3.0	985	
1AUG77	0	47	15.9	0.00	0	3	N. COLOMBIA		
7.1N	72.7W								
BR-CN	47.1		57.0	0.53	0	55	48.9		39.0 0.5
FA-NV	47.1		11.0	0.8	0	56	13.5	687	
GE-NM	47.1		17.0	0.7	0	55	18.5	1042	
1AUG77	16	30	37.7	0.00	0	4	CHILE-BOLIVIA	BDR.	
21.8S	68.6W								
FA-NV	74.4		28.0	1.1	16	41	57.9		21.0 0.9
GE-NM	74.4		32.0	1.05	16	41	57.8		
CB-NV	74.4		42.0	0.7	16	42	4.3	688	
CE-NV	74.4		10.0	0.7	16	41	26.7	68	
1AUG77	19	12	20.7	0.00	0	4	FIJI IS.		
19.3S	178.4W								
FA-NV	61.4		194.0	0.85	19	23	16.2		
GE-NM	61.4		226.0	0.76	19	23	16.3		
CB-NV	61.4		272.0	0.75	19	23	16.2		
CE-NV	61.4		262.0	0.7	19	23	16.3		
1AUG77	22	6.4	0.00	0	2	ANDREANO? IS.			
51.4N	175.4W								
FA-NV	64.4		72.0	0.95	2	32	39.0		
GE-NM	64.4		112.0	0.92	2	30	47.2		

68	UG77	5	26	43.2	0.00	0	2	TONGA REG.		
22	OS17	5	EW							
CB	33	81.6		44.0	0.94	5	39	2.7	35.5	0.92
CB	33	81.6		41.8	1.1	5	33	2.7		
68	UG77	52		46.5	0.00	0	8	TONGA IS.		
19	SS17	4	W							
FA	1	78.7		36.0	0.7	12	4	49.7	500	
FA	1	78.7		70.5	1.3	12	5	16.5	1146	
FA	1	78.7		46.7	1.15	12	4	45.9		
FA	1	78.7		49.5	1.22	12	4	45.8		
FA	1	78.7		73.4	1.27	12	4	45.8		
FA	1	78.7		54.6	1.32	12	4	45.7		
CB	33	78.7		34.2	1.06	12	4	45.6	23.	1.04
CB	33	78.7		32.3	1.19	12	4	45.5		
68	UG77	8		2.6	0.00	0	10	PANAMA-COSTA RICA		
9	GN82	7	W							
FA	1	42.2		17.0	1.1	7	16	0.5	47	
FA	1	42.2		11.5	1.5	7	15	13.5	729	
FA	1	42.2		176.8	1.58	7	15	54.8		
FA	1	42.2		209.2	1.47	7	15	54.7		
FA	1	42.2		184.0	1.5	7	15	54.5		
FA	1	42.2		204.0	1.5	7	15	54.5		
FA	1	42.2		91.5	1.6	7	15	52.8	12.5	1.8
FA	1	42.2		93.0	1.7	7	15	52.9		
FA	1	42.2		708.0	0.9	7	16	3.1		
FA	1	42.2		34.2	0.8	7	13	36.4		
68	UG77	46		31.0	0.00	0	2	TONGA IS.		
22	SS17	4	W							
CB	33	81.1		7.4	1.4	16	55	41.4		
CB	33	81.1		8.0	1.4	16	55	41.4		
68	UG77	50		57.5	0.00	0	2	CST OF MEXICO		
14	GN58	7	W							
FA	1	28.7		9.5	0.8	1	55	45.3	688	
FA	1	28.7		3.0	1.3	1	55	55.3	68	
68	UG77	26		55.0	0.00	0	9	ANDREANCF IS.		
12	GN17	2	W							
FA	1	42.2		7.5	0.8	23	34	42.5	47	
FA	1	42.2		32.5	0.3	23	34	34.3	73	
FA	1	42.2		215.0	0.66	23	34	51.8		
FA	1	42.2		185.0	0.76	23	34	51.8		
FA	1	42.2		176.0	0.64	23	34	51.8		
FA	1	42.2		178.0	0.75	23	34	51.7		
FA	1	42.2		115.0	0.36	23	34	50.6	85.0	0.86
FA	1	42.2		110.0	0.55	23	34	50.6		
FA	1	42.2		83.8	0.56	23	34	50.6	40.5	0.79
68	UG77	0		6.3	0.00	0	6	CST OF COLUMBIA		
17	GN77	7	W							
FA	1	46.5		35.0	1.0	7	8	37.2	500	
FA	1	46.5		41.0	0.9	7	7	40.6	1146	
FA	1	46.5		14.0	0.95	7	8	30.1	12.3	1.00
FA	1	46.5		14.1	1.1	7	8	30.0	16.8	1.03
FA	1	46.5		101.8	1.05	7	7	40.8		
FA	1	46.5		59.5	0.9	7	8	24.6	16.8	1.03
68	UG77	5		39.7	0.00	0	4	FITI IS.		
17	GN77	15	W							
FA	1	80.8		60.0	0.7	15	17	4.5	500	
FA	1	80.8		46.0	0.9	15	17	30.1	1146	
FA	1	80.8		50.0	1.15	15	17	1.4	40.2	0.96
FA	1	80.8		56.0	1.1	15	17	1.5		
68	UG77	20		53.7	0.00	0	2	FITI REG.		
21	GN77	22	W							
FA	1	84.2		22.4	0.58	22	32	41.4		
FA	1	84.2		22.8	0.64	22	32	41.3		

SAIG77	1	38	12.7	0.00	C 6	N. ATLANTIC RIDGE		
30.6N	41.5W							
FA-NV	60.3	12.0	1.3	1	48	25.3	500	
GE-NM	60.3	18.5	1.5	1	47	41.2	938	
CB2-NV	60.3	23.5	1.28	1	46	28.2		14.0 .74
CE-NV	60.3	17.0	1.36	1	48	28.2		
BN-NV	45.1	17.6	0.75	1	46	15.3		
BM-NV	45.1	29.7	0.94	1	43	44.2		
10AUG77	36	1.9	0.00	0	4	KJDIAR IS.		
56.3N	152.6E							
FA-NV	29.8	26.5	2.0	9	42	6.0	500	
GE-NM	29.8	30.0	1.1	9	42	59.7	417	
CB2-NV	29.8	21.0	1.7	9	42	15.3		
CE-NV	29.8	21.0	1.74	5	42	15.2		
10JUN77	32	12.0	0.00	C 2	PERU COAST			
14.5S	75.0W							
FA-NV	65.6	11.0	0.8	15	42	58.0	425	
GE-NM	65.6	19.0	1.0	15	42	16.3	833	
CB2-NV	65.6	13.6	0.00	C 2	KANCHATKA CST			
10JUN77	19							
13.9N	163.5E							
FA-NV	54.4	79.0	0.8	20	28	44.8	440	
GE-NM	54.4	15.0	0.7	20	29	30.5	73	
CB2-NV	54.4	18.5	0.00	0	2	ECUADOR		
1.4S	16.7W							
FA-NV	54.4	41.0	1.4	19	6	45.0	429	
GE-NM	54.4	52.0	0.8	19	6	55.7	854	
CB2-NV	54.4	25.3	0.00	0	2	CHILE-BOLIVIA BDR		
22JUN77	52							
22.1N	66.1W							
FA-NV	75.1	9.0	0.7	1	3	53.0	70	
GE-NM	75.1	45.0	0.7	1	3	15.7	854	
CB2-NV	75.1	34.9	0.00	0	2	N. ATLANTIC RIDGE		
22JUN77	38							
22.3N	45.2E							
FA-NV	61.7	66.5	1.8	15	46	57.3	429	
GE-NM	61.7	7.0	1.5	15	45	8.0	73	
CB2-NV	61.7	12.9	0.00	0	3	N. ATLANTIC RIDGE		
22JUN77	18							
22.7N	45.2E							
FA-NV	61.5	10.5	1.8	16	28	33.3	70	
GE-NM	61.5	15.0	1.4	16	27	46.0	73	
CB2-NV	61.5	15.3	1.6	16	28	34.6		23.0 1.1
29JUN77	19	34.7	0.00	0	3	N. ATLANTIC RIDGE		
22.6N	45.2W							
FA-NV	61.8	8.0	2.7	19	28	53.5	70	
GE-NM	61.8	18.0	1.8	19	28	6.0	68	
CB2-NV	61.8	158.0	1.7	19	28	54.6		19.0 1.6
29JUN77	6	41.3	0.00	0	2	CHIAPAS MEXICO		
12.0N	95.9W							
FA-NV	32.2	14.0	0.7	4	13	25.7	429	
GE-NM	32.2	24.0	1.1	4	12	30.0	833	
CB2-NV	32.2	15.4	0.00	C 3	ANDREANOF IS.			
23JUN77	47							
51.6N	176.1E							
FA-NV	43.0	29.0	1.3	8	55	11.5	429	
GE-NM	43.0	10.0	0.3	8	56	4.7	68	
CB2-NV	43.0	26.0	1.0	8	55	19.8		
10JUN77	45	55.4	0.00	0	5	N. CHILE		
19.2S	65.5E							
FA-NV	72.5	25.0	1.2	2	57	21.7	70	
GE-NM	72.5	10.0	0.7	2	56	42.7	73	
CB2-NV	72.5	188.0	0.8	2	57	15.4		108.0 1.0
17JUN77	45	337.0	1.2	2	57	14.6		
17.0N	71.1E							
FA-NV	71.1	413.0	1.2	2	57	14.5		

30 JUN 77	E 51	24.7	0.00	C 4	TONGA IS.	
15.2S	174.6W					
C.O						
FA-NV	76.6	5.0	1.0	9	3	14.8 70
GE-NM	81.9	65.0	1.2	9	3	43.0 833
CB2-NV	76.6	29.0	1.0	9	3	11.1
CB3-NV	76.6	26.0	1.1	9	3	11.1
30 JUN 77	11 13	36.9	0.00	0 2	N. CHILE	
27.2S	69.5W					
42.0						
FA-NV	75.0	42.0	1.0	11	25	37.3 462
GE-NM	73.1	30.0	0.8	11	25	3.7 833
1 JUL 77	12 7	8.2	0.00	0 2	TONGA IS.	
17.1S	174.1W					
C.O						
FA-NV	77.7	4.5	0.8	12	18	59.9 70
GE-NM	82.8	5.0	0.9	12	19	27.7 73
2 JUL 77	9 5	2.0	0.00	0 2	N. CHILE CST	
25.9S	71.0W					
C.O						
FA-NV	77.1	13.5	0.7	5	20	59.0 70
GE-NM	71.3	8.0	1.2	5	20	23.7 52
2 JUL 77	15 50	46.9	0.00	0 4	KAMCHATKA CST	
53.0N	160.2E					
57.0						
FA-NV	56.5	43.0	1.1	16	0	26.0 462
GE-NM	62.5	14.0	1.0	16	1	5.0 52
CB2-NV	57.6	29.0	1.2	16	0	32.5
CB3-NV	57.6	26.0	1.3	16	0	33.0
3 JUL 77	12 55	39.9	0.00	0 2	FOX IS.	
52.4N	167.5W					
11.0						
FA-NV	37.5	24.0	0.9	13	2	55.4 435
GE-NM	44.3	15.0	0.9	13	3	31.0 52
3 JUL 77	17 25	46.9	0.00	0 2	FOX IS.	
52.6N	167.5W					
0.0						
FA-NV	37.5	22.0	0.6	17	37	3.3 435
GE-NM	44.3	10.0	0.9	17	37	58.0 52
4 JUL 77	2 7	41.0	0.00	0 2	N. ATLANTIC	
57.6N	32.9W					
C.O						
FA-NV	54.8	7.0	0.8	2	17	12.3 425
GE-NM	51.6	19.0	1.3	2	16	48.0 573
5 JUL 77	1 13	14.7	0.00	0 2	KURILES	
50.7N	156.8E					
C.O						
FA-NV	55.4	9.5	0.5	1	23	19.7 425
GE-NM	65.8	28.0	0.7	1	24	3.0 573
6 JUL 77	4 42	21.1	0.00	0 2	S. PANAMA	
5.4N	82.4W					
0.0						
FA-NV	45.2	10.0	2.0	4	50	39.6 35
GE-NM	38.7	43.5	1.5	4	49	46.9 78
6 JUL 77	10 2	52.9	0.00	0 2	ARGENTINA	
27.5S	67.3E					
18C.O						
FA-NV	80.1	19.2	0.8	10	14	47.0 125
GE-NM	74.7	53.5	0.8	10	14	13.5 833
7 JUL 77	22 55	59.1	0.00	0 2	TRANCTU ARCH	
22.0S	139.2E					
C.O						
FA-NV	64.3	27.0	0.7	23	10	34.5 425
GE-NM	66.0	46.5	1.2	23	10	46.4 843
7 JUL 77	5 57	32.3	0.00	0 2	TONGA IS.	
16.3S	174.6W					
C.O						
FA-NV	77.5	11.0	0.9	10	9	17.3 440
GE-NM	82.7	24.5	0.8	10	9	45.4 843

7 JUL 77	15	3	37.1	0.00	0	2	EASTER ISLAND		
35.0S	107.6W								
FA-NV	74.1		14.0	0.9	15	15	11.2	440	
GE-NM	46.5		18.0	2.0	15	14	57.0	843	
9 JUL 77	3		55.5	0.00	0	2	MEXICO		
16.9N	35.1W								
102.0									
FA-NV	28.5		5.0	1.1	7	9	42.0	440	
GE-NM	23.5		13.5	0.7	7	6	47.3	68	
11 JUL 77	38		32.1	0.00	0	2	RAT IS.		
51.2N	176.2E								
3.0									
FA-NV	47.7		19.0	1.2	9	47	11.2	440	
GE-NM	54.4		33.0	1.3	9	48	2.3	865	
11 JUL 77	35		49.6	0.00	0	2	KURILES		
47.9N	155.6E								
7.0									
FA-NV	61.2		11.0	1.1	12	45	57.5	440	
GE-NM	67.8		35.0	1.3	12	46	41.1	865	
11 JUL 77	57		19.0	0.00	0	2	CENT. ALASKA		
64.8N	146.7W								
3.0									
FA-NV	31.6		9.0	1.0	16	3	43.6	440	
GE-NM	36.8		10.0	1.0	16	4	26.5	68	
16 JUL 77	39		54.9	0.00	0	2	ARGENTINA		
23.8S	66.7W								
111.0									
FA-NV	77.7		31.8	1.0	12	51	43.0		
GE-NM	71.5		5.5	1.0	12	51	4.3	68	
3 AUG 77	25		21.5	0.00	0	2	PANAMA-COLUMBIA BDR		
6.4N	77.5E								
154.0									
FA-NV	46.0		15.5	1.0	2	33	29.7	500	
GE-NM	39.1		5.0	0.8	2	32	33.7	83	
3 AUG 77	5		36.6	0.00	0	2	KURILES		
49.9N	150.5E								
55.0									
FA-NV	61.0		7.0	0.7	12	15	41.3	44	
GE-NM	67.5		25.0	0.7	12	16	23.5	83	
4 AUG 77	20		50.5	0.00	0	2	CENT. AMERICA CST		
11.8N	88.6W								
10.0									
FA-NV	36.4		8.0	1.1	13	27	59.7	44	
GE-NM	30.0		24.0	1.3	13	27	2.7	78	
9 AUG 77	15		34.6	0.00	0	2	S. PERU		
15.4S	72.4W								
3.0									
FA-NV	67.6		6.0	1.1	12	33	34.4	500	
GE-NM	61.6		22.5	1.0	12	29	53.5	938	
11 JUN 77	45		21.1	0.00	0	3	FUJI IS.		
16.2S	178.5W								
3.0									
FA-NV	75.9		21.0	0.7	11	57	32.0	500	
CB2NV	75.3		15.3	1.1	11	57	29.0		10.0 0.8
CE3NV	75.3		14.0	1.2	11	57	29.1		
17 JUN 77	54		28.4	0.00	0	3	COSTA RICA		
10.7N	85.3W								
3.0									
GE-NM	32.7		5.0	0.7	23	1	3.7	83	
CB2NV	38.0		36.0	0.7	23	1	51.8		6.4 0.6
CB3NV	38.5		38.5	0.7	23	1	51.9		
18 JUN 77	4		2.2	0.00	0	5	FUJI IS.		
20.2S	177.8W								
3.0									
FA-NV	62.3		37.5	0.7	10	15	32.8	65	
YE-NV	61.6		196.0	0.9	10	15	29.3		
YE-NV	61.6		261.0	0.8	10	15	29.3		
CE2NV	61.7		146.0	0.75	10	15	29.2		109.0 0.75
CE3NV	61.7		149.0	0.7	10	15	29.2		

26JUN77	55	26.2	0.00	0	2	FIGI IS.		
17.8S	178.4W							
FA-NV	81.0	11.0	0.8	6	11	40.3	75	
CB2NV	80.4	67.0	0.85	6	11	33.1		52.0 0.8
26JUN77	10 15	48.9	0.00	0	3	FAHANA IS.		
21.1N	89.7W							
FA-NV	43.4	43.0	1.0	10	23	52.6	440	
CB2NV	43.1	31.0	1.0	10	23	49.7		24.0 1.0
YF-NV	43.0	119.0	0.85	10	23	43.5		
13AUG77	13 13	35.1	0.00	0	6	KURILES		
44.3N	147.5E							
FA-NV	67.4	18.5	0.9	3	24	27.4	456	
GE-NV	74.1	7.0	1.0	3	25	7.9	42	
CB2NV	68.7	37.0	0.95	3	24	33.7		28.4 0.8
CF3NV	68.7	33.3	0.95	3	24	33.7		
FR-CN	70.9	41.7	0.86	3	24	45.3		4.0 0.36
FR-CN	84.1	24.1	0.74	3	25	53.7		
13AUG77	7 57	44.9	0.00	0	5	CEN1. CHILE CST		
28.3S	71.5W							
FA-NV	78.5	15.0	1.0	8	9	36.0	456	
GE-NV	78.1	31.0	1.1	8	9	3.0	521	
CB2NV	77.7	12.2	0.85	8	9	29.9		12.1 0.85
CF3NV	77.7	14.7	0.7	8	9	30.0		
FR-CN	81.5	30.8	0.67	8	9	41.8		22.5 0.58
13AUG77	19 33	11.7	0.00	0	5	JAPAN		
43.2N	145.4E							
FA-NV	65.8	10.0	0.7	19	44	17.0	456	
GE-NV	76.4	5.0	0.9	19	44	55.9	68	
CB2NV	70.8	22.7	0.83	19	44	23.3		19.5 0.76
CB3NV	70.8	21.4	0.88	19	44	23.3		
FR-CN	72.5	49.7	0.64	19	44	34.1		39.4 0.81
14AUG77	4 22	51.9	0.00	0	5	VENEZUELA CST		
10.9N	82.6W							
FA-NV	55.0	16.0	1.0	4	32	13.0	456	
GE-NV	47.4	4.5	0.7	4	31	19.2	68	
CB2NV	44.5	23.7	0.89	4	32	10.4		4.6 0.83
CF3NV	44.5	19.8	1.0	4	32	11.1		
FR-CN	47.1	32.5	0.48	4	31	11.7		7.3 0.66
14AUG77	10 58	9.5	0.00	0	5	N. CHILE CST		
19.8S	73.6W							
FA-NV	70.8	41.0	1.0	11	3	30.0	456	
GE-NV	64.6	6.0	1.1	11	8	51.3	68	
CB2NV	65.6	45.9	0.88	11	9	23.5		39.5 0.88
CB3NV	65.6	42.5	0.91	11	9	23.5		
FR-CN	72.8	28.7	0.8	11	9	35.0		21.4 0.83
14AUG77	11 30	33.5	0.00	0	4	N. PERU CST		
6.2S	80.3W							
FA-NV	51.5	14.0	0.8	11	39	37.0	885	
CB2NV	46.4	3.9	1.0	11	40	12.1		3.3 1.3
CB3NV	46.4	3.9	1.0	11	40	12.3		
FR-CN	40.2	22.8	0.9	11	40	35.2		17.4 0.88
14AUG77	23 45	15.7	0.00	0	6	SEA OF JAPAN		
41.8N	138.6E							
FA-NV	75.8	135.0	1.1	0	1	1.4		
YF3NV	75.8	160.0	1.25	0	1	1.3		
YF4NV	75.8	104.0	1.1	0	1	1.4		
YF2NV	75.8	122.0	1.15	0	1	1.3		
CB2NV	75.8	139.0	1.2	0	1	59.5		108.0 1.0
FR-CN	76.8	40.0	0.56	0	1	4.0		7.0 0.55

15 AUG 77	C 24	30.9	0.00	0	2	ANDREANCF IS.	
51.5N 175.6W							
FA-NV	41.6	7.0	0.7	0	32	29.3	456
GE-NM	49.6	33.5	1.1	0	33	21.6	833
15 AUG 77	41	9.3	0.00	C 7		FIGI IS.	
22.9S 176.7E							
FA-NV	3.1	47.0	1.7	5	33	35.3	456
GE-NM	3.1	66.3	1.63	5	33	31.4	
CB2-NV	3.1	84.0	1.5	5	33	31.2	
CB3-NV	3.1	76.0	1.4	5	33	31.3	
CB4-NV	3.1	83.0	1.4	5	33	31.5	
CB5-NV	3.1	38.2	1.1	5	33	31.3	
CB6-NV	3.1	41.1	1.2	5	33	31.3	
15 AUG 77	54	5.4	0.00	0	5	CAN1. AMERICA	28.0 1.3
12.9N 110.0W							
FA-NV	4.1	12.5	0.8	6	0	53.8	456
GE-NM	4.1	22.5	0.7	5	59	57.9	833
CB2-NV	4.1	10.4	0.83	6	0	44.7	
CB3-NV	4.1	10.0	0.86	6	0	44.8	
CB4-NV	4.1	22.5	0.72	6	1	20.9	
15 AUG 77	43	52.5	0.00	C 2		PERU ECUADOR BDR	8.3 0.9
4.3S 80.6E							
FA-NV	4.1	11.0	2.0	16	59	1.5	519
GE-NM	4.1	53.0	1.0	16	58	15.3	864
16 AUG 77	47	14.5	0.00	0	2	TONGA IS.	
17.6S 170.3E							
FA-NV	5.6	37.0	1.3	4	59	4.0	519
GE-NM	5.6	60.0	1.0	4	59	31.7	864
20 AUG 77	46	11.4	0.00	0	2	CARIBBEAN SEA	
16.7N 86.7W							
FA-NV	3.6	8.0	1.5	2	52	56.8	94
GE-NM	3.6	5.0	1.0	2	51	56.7	781
20 AUG 77	51	51.4	0.00	C 2		CARIBBEAN SEA	
16.4N 86.6E							
FA-NV	3.1	37.0	1.0	3	58	38.0	94
GE-NM	3.1	9.0	0.7	3	57	37.3	781
20 AUG 77	24	24.4	0.00	0	2	ARGENTINA	
28.8S 66.4E							
FA-NV	5.5	9.0	1.5	18	36	26.3	94
GE-NM	5.5	9.0	1.3	18	35	54.0	78
20 AUG 77	C	0.6	0.00	0	6	CAN1. SIBERIA	
64.1N 55.8E							
FA-NV	3.4	31.0	1.0	22	11	35.3	950
GE-NM	3.4	16.0	0.66	22	11	57.0	78
CB2-NV	3.4	29.0	0.65	22	11	43.8	
CB3-NV	3.4	31.0	0.75	22	11	43.8	
CB4-NV	3.4	78.0	0.65	22	11	10.9	
CB5-NV	3.4	57.0	0.67	22	10	39.2	
21 AUG 77	15	28.4	0.00	C 2		TONGA IS	17.0 0.6
26.5S 175.5W							
FA-NV	4.5	13.0	1.0	3	27	46.4	
OB2-NV	4.5	12.0	1.1	3	27	46.4	
OB3-NV	4.5	30.1	0.00	0	2	SANOA IS	9.9 1.2
21 AUG 77	44						
14.7S 173.3W							
FA-NV	5.4	5.0	0.8	4	56	14.3	106
GB-NM	5.4	3.5	1.4	4	56	45.0	78

21 AUG 77	5 15	39.2	0.00	0 8	HONSHU CST		
141.1							
GE-1-NV		19.0	0.7	5 32	4.7	78	
GE-1-NV		136.0	1.3	5 31	33.9		
GE-1-NV		180.0	1.26	5 31	33.9		
GE-1-NV		171.0	1.24	5 31	33.9		
GE-1-NV		175.0	1.35	5 31	33.9		
GE-1-NV		65.0	1.2	5 31	32.7		29.0 1.14
GE-1-NV		60.0	1.2	5 31	32.6		
GE-1-NV		44.0	1.0	5 31	46.0		35.0 1.2
21 AUG 77	5 15	41.7	0.00	0 9	GUATEMALA CST		
141.1							
GE-1-NV		24.0	1.0	11 40	28.2	106	
GE-1-NV		7.0	1.1	11 39	32.7	73	
GE-1-NV		106.0	1.2	11 40	19.2		
GE-1-NV		140.0	1.25	11 40	19.3		
GE-1-NV		142.0	1.3	11 40	19.6		
GE-1-NV		137.0	1.25	11 40	19.4		
GE-1-NV		63.4	1.11	11 40	19.6		54.5 1.25
GE-1-NV		61.0	1.1	11 40	19.6		
GE-1-NV		83.0	0.75	11 40	53.5		7.6 0.5
21 AUG 77	5 12	55.6	0.00	0 8	CHILE BOLIVIA EDR		
141.1							
GE-1-NV		11.0	0.8	3 24	21.0	106	
GE-1-NV		5.5	0.8	3 23	46.1	68	
GE-1-NV		96.0	0.93	3 24	17.0		
GE-1-NV		93.0	1.0	3 24	16.9		
GE-1-NV		120.0	0.83	3 24	17.1		
GE-1-NV		64.0	0.95	3 24	17.6		
GE-1-NV		64.0	0.9	3 24	17.7		
GE-1-NV		113.0	0.7	3 24	24.4		35.0 1.0
21 AUG 77	5 15	30.7	0.00	0 2	FIGI IS		
141.1							
GE-1-NV		21.0	1.6	7 47	31.8	531	
GE-1-NV		5.0	1.3	7 48	0.7	67	
21 AUG 77	5 16	40.2	0.00	0 2	ARGENTINA		
141.1							
GE-1-NV		13.0	0.7	17 6	12.5	531	
GE-1-NV		53.5	1.0	17 5	36.8	1645	
21 AUG 77	5 16	0.8	0.00	0 10	RAI IS		
141.1							
GE-1-NV		36.0	1.0	7 24	25.7	531	
GE-1-NV		4.5	1.0	7 25	16.5	73	
GE-1-NV		121.0	0.75	7 24	35.6		
GE-1-NV		148.0	0.8	7 24	35.5		
GE-1-NV		168.0	0.78	7 24	35.6		
GE-1-NV		164.0	0.7	7 24	35.5		
GE-1-NV		75.0	0.85	7 24	34.1		8.0 0.8
GE-1-NV		75.0	0.8	7 24	34.1		
GE-1-NV		258.0	0.7	7 25	3.8		120.0 0.9
GE-1-NV		52.0	0.7	7 26	47.0		
21 AUG 77	5 14	26.6	0.00	0 2	CHILE CST		
141.1							
GE-1-NV		20.0	1.0	3 6	29.2	544	
GE-1-NV		32.0	0.8	3 5	56.0	937	
21 AUG 77	5 15	56.7	0.00	0 7	PANAMA		
141.1							
GE-1-NV		45.0	1.0	15 49	15.0	688	
GE-1-NV		69.0	1.0	15 46	23.0	937	
GE-1-NV		63.0	1.1	15 45	6.8		
GE-1-NV		59.0	1.05	15 49	6.7		
GE-1-NV		21.0	1.1	15 49	7.0		19.0 1.0
GE-1-NV		21.0	1.1	15 49	7.0		
GE-1-NV		27.0	0.85	15 49	23.0		12.0 0.75

[illegible]

3 SEP 77	11 56	17.7	0.00	C 8	TONGA IS		
1 SEP 77	11 56	17.7	0.00	C 8	TONGA IS		
PA - NV	4.5	2.0	12	3	4.3	50	
GE - NV	12.0	1.3	12	3	3.7	57	
VE - NV	107.0	1.3	12	3	0.1		
VE - NV	101.0	1.3	12	3	0.3		
VE - NV	89.0	1.3	12	3	0.3		
VE - NV	100.0	1.3	12	3	0.3		
VE - NV	46.0	1.1	12	3	0.1		
VE - NV	48.0	1.1	12	3	0.1		
VE - NV	57.0	0.00	0 2	VENEZUELA			37.0 1.4
1 SEP 77	11 56	17.7	0.00	C 8	TONGA IS		
PA - NV	13.0	0.8	15	34	51.3	675	
GE - NV	29.0	1.0	15	33	56.9	729	
VE - NV	45.7	0.00	0 2	DOMINICAN REP.			
1 SEP 77	11 56	17.7	0.00	C 8	TONGA IS		
PA - NV	13.0	0.8	15	41	48.6	675	
GE - NV	29.0	1.0	15	40	49.0	729	
VE - NV	53.7	0.00	0 10	HAT IS			
1 SEP 77	11 56	17.7	0.00	C 8	TONGA IS		
PA - NV	9.5	0.5	15	49	22.4	50	
GE - NV	35.0	1.3	15	49	13.7	57	
VE - NV	260.0	1.0	15	49	32.4		
VE - NV	260.0	1.0	15	49	32.5		
VE - NV	251.0	0.9	15	49	32.1		
VE - NV	339.0	1.0	15	49	32.0		
VE - NV	110.0	1.0	15	49	30.2		20.0 1.1
VE - NV	148.0	0.8	15	49	30.3		
VE - NV	179.0	0.8	15	49	3.0		18.0 0.8
VE - NV	143.0	1.15	15	49	49.2		
VE - NV	47.5	0.00	C 8	HCM SBU			
1 SEP 77	11 56	17.7	0.00	C 8	TONGA IS		
PA - NV	7.0	1.0	16	51	53.7	50	
GE - NV	325.0	1.25	16	51	0.1		
VE - NV	42.0	1.1	16	51	0.0		
VE - NV	18.0	1.0	16	51	59.0		
VE - NV	221.0	1.2	16	51	0.0		
VE - NV	122.0	1.15	16	51	8.1		27.0 1.1
VE - NV	99.0	1.0	16	51	15.0		
VE - NV	37.0	0.00	0 9	HAT IS.			21.0 1.1
1 SEP 77	11 56	17.7	0.00	C 8	TONGA IS		
PA - NV	18.0	0.7	17	18	57.5	50	
GE - NV	826.0	0.9	17	19	13.4		
VE - NV	977.0	1.1	17	19	13.3		
VE - NV	628.0	1.2	17	19	13.0		
VE - NV	745.0	1.15	17	19	13.0		
VE - NV	50.0	0.7	17	19	5.2		38.0 1.3
VE - NV	77.0	0.7	17	19	5.2		
VE - NV	123.0	0.6	17	19	36.3		62.0 0.6
VE - NV	80.0	1.15	17	21	23.9		
VE - NV	50.5	0.00	0 9	HAT IS			
1 SEP 77	11 56	17.7	0.00	C 8	TONGA IS		
PA - NV	17.0	0.8	17	33	15.0	50	
GE - NV	985.0	1.1	17	33	28.0		
VE - NV	1044.0	1.2	17	33	28.0		
VE - NV	913.0	1.1	17	33	28.0		
VE - NV	1159.0	1.1	17	33	28.0		
VE - NV	63.0	0.7	17	33	22.1		16.0 0.8
VE - NV	195.0	0.6	17	33	22.1		
VE - NV	195.0	0.5	17	33	44.5		65.0 0.6
VE - NV	130.0	1.5	17	33	40.1		

45	FE	77	18	0	11.2	0.00	0	8	BAT	IS	
51	ON	17	6	3							
3	C										
FA	-NV	46	4		30.0	1.0	18	8	37.0	544	
FA	-NV	47	4		103.0	0.83	18	8	47.0		
FA	-NV	47	4		120.0	0.85	18	8	47.0		
OB	-NV	47	4		34.0	1.0	18	8	44.7	7.0	0.65
OB	-NV	47	4		32.0	1.1	18	8	44.7		
YF	-NV	47	4		118.0	0.75	18	8	47.0		
YF	-NV	47	4		94.0	0.7	18	8	47.0		
HR	-CM	51	5		92.0	0.5	18	9	17.1	22.0	0.6
45	SEP	77	17	38	21.6	0.00	0	2	BAT	IS	
51	IN	17	7	6							
13	C										
FA	-NV	46	6		11.5	1.1	17	46	52.3	50	
GE	-NM	53	6		31.5	1.2	17	47	44.2	57	
45	SEP	77	18	25	55.1	0.00	0	10	BAT	IS	
51	IN	17	7	9							
13	C										
FA	-NV	46	6		3.0	1.2	18	34	18.0	50	
GE	-NM	53	6		30.0	1.1	18	35	9.5	57	
YF	-NV	47	6		287.0	1.0	18	34	27.4		
YF	-NV	47	6		115.0	1.3	18	34	27.4		
CE	-NV	47	6		103.0	1.1	18	34	25.7	32.0	1.1
CE	-NV	47	6		98.0	1.1	18	34	25.7		
YF	-NV	47	6		326.0	1.2	18	34	27.4		
YF	-NV	47	6		384.0	1.25	18	34	27.3		
HR	-CM	67	7		146.0	0.5	18	34	57.2	13.0	0.5
HR	-CM	67	7		34.0	0.5	18	36	43.3		
45	SEP	77	18	38	28.4	0.00	0	2	BAT	IS	
51	IN	17	8	3							
66	C										
FA	-NV	46	4		31.0	1.1	18	46	50.0	544	
GE	-NM	53	1		12.0	1.3	18	47	41.1	57	
45	SEP	77	19	23	1.1	0.00	0	9	BAT	IS	
51	ON	17	7	7							
26	C										
FA	-NV	46	6		5.5	1.3	19	31	30.0	50	
GE	-NM	53	1		17.0	1.1	19	32	21.7	57	
YF	-NV	47	6		170.0	1.0	19	31	39.8		
YF	-NV	47	6		231.0	1.1	19	31	39.7		
YF	-NV	47	6		244.0	0.9	19	31	39.9		
YF	-NV	47	6		218.0	1.0	19	31	39.9		
CE	-NV	47	6		59.0	1.2	19	31	37.5	12.0	0.9
CE	-NV	47	6		57.0	1.3	19	31	37.5		
HR	-CM	53	2		66.0	0.4	19	32	9.1	16.0	0.4
45	SEP	77	22	18	35.3	0.00	0	2	BAT	IS	
51	ON	17	6	4							
8	C										
FA	-NV	47	4		5.5	0.7	22	27	5.2	544	
GE	-NM	54	1		15.0	0.8	22	27	58.0	729	
45	SEP	77	23	20	48.0	0.00	0	9	BAT	IS	
51	ON	17	8	5							
14	C										
FA	-NV	46	3		16.5	1.8	23	29	11.1	50	
YF	-NV	47	4		430.0	1.4	23	29	19.6		
YF	-NV	47	4		386.0	1.5	23	29	19.8		
YF	-NV	47	4		352.0	1.3	23	29	19.7		
YF	-NV	47	4		411.0	1.3	23	29	19.7		
CE	-NV	47	4		128.0	1.6	23	29	10.6	117.0	1.6
CE	-NV	47	4		130.0	1.6	23	29	19.4		
HR	-CM	55	1		255.0	0.5	23	31	50.8	84.0	0.9
HR	-CM	67	7		113.0	1.2	23	31	35.8		
45	SEP	77	23	58	6.2	0.00	0	2	BAT	IS	
50	ON	17	7	7							
6	C										
FA	-NV	46	5		25.0	1.2	1	6	40.3	544	
GE	-NM	55	6		7.5	1.1	1	7	32.5	68	

51	SEP	77	12	52	14.9	0.00	C	9	RAT	IS		
51	SEP	77	177.6									
51	SEP	77	46.8		13.6	1.3	13	0	36.5	544		
51	SEP	77	46.8		64.5	1.0	13	1	28.5	833		
51	SEP	77	46.8		50.0	1.1	13	0	45.4			
51	SEP	77	46.8		49.0	1.1	13	0	45.4			
51	SEP	77	46.8		40.0	1.0	13	0	45.6			
51	SEP	77	46.8		49.0	1.0	13	0	45.7			
51	SEP	77	46.8		17.0	1.1	13	0	44.4		13.0	1.1
51	SEP	77	46.8		17.0	1.1	13	0	44.2			
51	SEP	77	46.8		12.0	0.6	13	1	16.5		11.0	0.6
51	SEP	77	178.6	31	6.2	0.00	C	2	RAT	IS		
51	SEP	77	46.8		5.0	0.5	22	39	25.8	544		
51	SEP	77	46.8		3.0	0.8	22	40	20.5	68		
51	SEP	77	178.6	48	31.0	0.00	C	2	ADREANO	IS		
51	SEP	77	178.6									
51	SEP	77	46.8		8.0	0.5	6	56	37.0	513		
51	SEP	77	46.8		21.0	1.0	6	57	29.0	833		
51	SEP	77	46.8	36	8.8	0.00	C	5	S. PERU			
51	SEP	77	178.6									
51	SEP	77	46.8		12.0	0.7	6	47	21.8	525		
51	SEP	77	46.8		18.5	0.8	6	46	41.1	729		
51	SEP	77	46.8		53.0	0.8	6	47	14.7		47.0	0.8
51	SEP	77	46.8		55.0	0.7	6	47	14.7			
51	SEP	77	46.8		15.0	0.5	6	47	22.9			
51	SEP	77	46.8	3	53.8	0.00	C	5	MONA	PASSAGE		
51	SEP	77	178.6									
51	SEP	77	46.8		22.0	0.8	8	12	5.3	525		
51	SEP	77	46.8		13.5	0.7	8	11	4.8	729		
51	SEP	77	46.8		82.0	0.8	8	12	1.4		74.0	0.8
51	SEP	77	46.8		71.0	1.0	8	12	1.6			
51	SEP	77	46.8		39.0	0.8	8	11	23.5		28.0	0.8
51	SEP	77	46.8	35	6.2	0.00	C	6	RUSSIA-CHINA	BDR		
51	SEP	77	178.6									
51	SEP	77	46.8		10.5	0.7	2	46	6.5	53		
51	SEP	77	46.8		19.0	1.0	2	46	40.7	63		
51	SEP	77	46.8		125.0	0.9	2	46	14.4		72.0	0.9
51	SEP	77	46.8		111.0	0.9	2	46	14.3			
51	SEP	77	46.8		360.0	0.6	2	46	8.7		315.0	0.6
51	SEP	77	46.8		101.0	0.9	2	47	4.0			
51	SEP	77	46.8	58	50.6	0.00	C	3	S. ALASKA			
51	SEP	77	178.6									
51	SEP	77	46.8		11.3	0.7	16	5	11.4	544		
51	SEP	77	46.8		24.0	0.9	16	5	23.0			
51	SEP	77	46.8		25.0	0.8	16	5	23.9			
51	SEP	77	46.8	17	59.2	0.00	C	4	RAT	IS		
51	SEP	77	178.6									
51	SEP	77	46.8		36.0	0.8	21	26	20.3	544		
51	SEP	77	46.8		44.0	0.86	21	26	28.2		24.0	0.8
51	SEP	77	46.8		41.0	0.8	21	26	28.0			
51	SEP	77	46.8		38.7	0.55	21	27	0.7		23.8	0.64
51	SEP	77	46.8	39	5.6	0.00	C	5	PERU	CST.		
51	SEP	77	178.6									
51	SEP	77	46.8		5.0	0.8	4	49	40.5	53		
51	SEP	77	46.8		4.5	1.0	4	48	59.3	72		
51	SEP	77	46.8		33.0	0.9	4	49	33.2			
51	SEP	77	46.8		39.0	1.1	4	49	33.4			
51	SEP	77	46.8		77.5	0.8	4	49	50.4		67.2	0.9

10	SE	77	5	24	2.2	0.00	0	2	TONGA IS		
15	9S	174	1								
FA	-NV	77	2		13.0	0.8	9	35	59.6	544	
GE	-NM	82	4		17.5	1.1	9	36	26.3	1042	
10	SE	77	10	21	9.1	0.00	C	9	GUATEMALA		
14	1N	91	5								
FA	-NV	77	2		22.0	1.1	10	27	40.6	53	
GE	-NM	82	4		269.0	1.3	10	27	30.6		
10	SE	77	10		14.0	1.2	10	27	33.5		
14	1N	91	5		228.0	1.3	10	27	30.3		
FA	-NV	77	2		277.0	1.2	10	27	30.4		
GE	-NM	82	4		100.0	1.2	10	27	31.2		
10	SE	77	10		98.0	1.2	10	27	31.3		
14	1N	91	5		495.0	1.0	10	28	22.1		
FA	-NV	77	2		166.0	0.84	10	28	11.5		
GE	-NM	82	4								
10	SE	77	10	0	0.5	0.00	0	2	LAKE EAIKAL REG	22.6	0.94
14	1N	92	1								
FA	-NV	77	2		8.0	1.0	16	11	59.4	544	
GE	-NM	82	4		32.0	0.8	16	12	23.1	72	
10	SE	77	10	56	28.3	0.00	C	2	MEXICO		
14	1N	92	1								
FA	-NV	77	2		10.0	0.8	17	2	2.0	544	
GE	-NM	82	4		7.0	1.0	17	2	6.7	72	
10	SE	77	10	6	4.7	0.00	0	2	SAMOA IS		
14	1N	92	1								
FA	-NV	77	2		38.0	2.0	14	19	50.0	531	
GE	-NM	82	4		11.0	1.3	14	20	18.1	78	
10	SE	77	10	12	33.1	0.00	C	2	SAHOA IS		
14	1N	92	1								
FA	-NV	77	2		40.0	2.0	14	24	15.3	531	
GE	-NM	82	4		8.8	1.7	14	24	43.5	78	
10	SE	77	10	19	24.1	0.00	0	2	CRETE		
14	1N	92	1								
FA	-NV	77	2		66.4	170.0	1.25	23	30	11.7	
GE	-NM	82	4		224.0	0.9	23	31	19.6		
10	SE	77	10	48	45.3	0.00	C	3	KJRILES	18.0	0.5
14	1N	92	1								
FA	-NV	77	2		9.3	1.0	16	56	56.6	531	
GE	-NM	82	4		57.0	1.0	16	59	4.3		
10	SE	77	10		27.0	0.9	16	55	16.2	52.0	1.0
14	1N	92	1		45.4	0.00	0	2	VIRGIN IS	17.0	0.75
FA	-NV	77	2								
GE	-NM	82	4		12.0	0.7	23	26	31.1	544	
10	SE	77	10	16	23.5	1.0	23	25	32.6	990	
14	1N	92	1		52.7	0.00	C	4	E. SEA OF JAPAN		
FA	-NV	77	2		18.0	1.7	23	28	31.5	544	
GE	-NM	82	4		71.5	1.1	23	25	8.5	990	
10	SE	77	10		27.0	1.2	23	26	37.3		
14	1N	92	1		39.0	1.0	23	28	41.4	16.0	1.1
FA	-NV	77	2		49.3	0.00	C	6	TONGA IS	35.0	0.9
GE	-NM	82	4								
10	SE	77	10		11.0	2.0	0	33	37.0	50	
14	1N	92	1		25.0	1.8	0	34	36.5	73	
FA	-NV	77	2		111.0	1.6	0	33	33.4		
GE	-NM	82	4		155.2	1.56	0	33	33.4		
10	SE	77	10		145.0	1.56	0	33	34.1		
14	1N	92	1		66.0	1.8	0	33	32.7	13.0	0.9

15	FA-1	172.5	33	8.6	0.00	0	2	SAMOA IS.		
15	GE-1	172.5	55	8.0	0.7	3	44	55.1	544	
15	CB-1	172.5	55	20.5	1.1	3	45	25.0	990	
15	FA-1	172.5	55	42.0	0.00	0	2	SAMOA IS		
15	GE-1	172.5	55	4.0	1.5	4	11	28.5	50	
15	CB-1	172.5	55	87.0	1.2	4	11	58.6	990	
15	FA-1	172.5	55	32.3	0.00	0	4	JAPAN		
15	GE-1	172.5	55	13.0	0.7	5	6	52.2	544	
15	CB-1	172.5	55	48.0	0.8	5	6	30.8	990	
15	FA-1	172.5	55	16.0	0.8	5	6	57.7		9.0 0.7
15	CB-1	172.5	55	13.0	0.65	5	6	6.7		10.0 0.95
15	FA-1	172.5	36	7.7	0.00	0	3	CHILE-ARGENTINA BDR		
15	GE-1	172.5	36	3.2	0.8	5	47	36.3	50	
15	CB-1	172.5	36	5.0	1.0	5	47	30.5	73	
15	FA-1	172.5	36	31.0	1.0	5	47	30.5		26.0 0.85
15	CB-1	172.5	36	34.7	0.00	0	4	HAT IS		
15	FA-1	172.5	46	10.5	1.0	14	47	7.1	544	
15	GE-1	172.5	46	33.5	0.7	14	47	59.3	990	
15	CB-1	172.5	46	12.0	1.1	14	47	14.8		9.5 0.5
15	FA-1	172.5	46	34.0	0.4	14	47	46.1		
15	CB-1	172.5	46	7.3	0.00	0	2	AUSTRIA		
15	FA-1	172.5	46	44.0	0.8	0	0	39.2	550	
15	GE-1	172.5	46	58.0	1.3	0	0	26.5	833	
15	CB-1	172.5	46	53.1	0.00	0	6	EUROPE IS.		
15	FA-1	172.5	46	16.5	1.3	10	59	17.7	513	
15	GE-1	172.5	46	112.0	0.9	10	59	22.8		
15	CB-1	172.5	46	100.0	0.9	10	59	22.6		
15	FA-1	172.5	46	97.0	0.9	10	59	22.5		
15	GE-1	172.5	46	62.0	0.9	10	59	21.9		40.0 0.85
15	CB-1	172.5	46	103.0	0.9	10	59	21.9		
15	FA-1	172.5	28	48.4	0.00	0	4	ALBERTIANS		
15	GE-1	172.5	28	6.5	0.7	16	36	39.4	44	
15	CB-1	172.5	28	63.0	0.9	16	36	47.1		52.0 0.8
15	FA-1	172.5	44	104.0	0.85	16	36	47.1		
15	GE-1	172.5	44	47.0	1.0	16	36	31.7		
15	CB-1	172.5	44	7.5	0.00	0	8	EL SALVADOR		
15	FA-1	172.5	44	11.0	0.8	5	50	48.0	44	
15	GE-1	172.5	44	8.5	0.9	5	50	51.3	73	
15	CB-1	172.5	44	138.0	1.0	5	50	38.3		
15	FA-1	172.5	44	132.0	1.0	5	50	38.0		
15	GE-1	172.5	44	150.0	1.0	5	50	38.0		
15	CB-1	172.5	44	67.0	1.0	5	50	38.4		37.0 1.2
15	FA-1	172.5	21	284.0	0.7	5	50	11.5		172.0 0.8
15	GE-1	172.5	21	23.4	0.00	0	2	CHILE CST		
15	CB-1	172.5	21	6.5	1.4	18	33	32.0	44	
15	FA-1	172.5	12	14.5	1.3	18	33	0.0	73	
15	GE-1	172.5	12	31.0	0.00	0	2	E. SEA CF JAPAN		
15	CB-1	172.5	12	12.5	1.7	3	23	59.5	488	
15	FA-1	172.5	12	13.0	1.0	3	24	33.2	990	

21	EE	77	16	5	5.0	0.00	C	2	VENEZUELA	CST		
9	CM	62	CM									
GA	-NV	56	7		15.0	1.5	16	14	46.3	488		
GE	-NV	45	3		28.5	1.3	16	13	51.8	990		
15	EE	77	17	35	24.0	0.00	0	2	B. CST	KAMCHATKA		
14	ON	161	CE									
GA	-NV	56	7		36.0	1.8	17	49	4.3	488		
GE	-NV	45	3		10.5	1.5	17	49	48.5	78		
15	EE	77	11	47	4.0	0.00	0	2	ALASKA	FEN.		
14	ON	161	CE									
GA	-NV	56	7		7.5	0.8	11	53	46.3	531		
GE	-NV	45	3		15.5	0.8	11	54	43.1	885		
15	EE	77	11	3	54.2	5.50	0	5	FEBO			
14	ON	161	CE									
1	EE	77	11		34.0	0.8	3	13	51.5	24		
GC	-NV	56	7		16.5	1.3	13	13	13.8	26		
GC	-NV	56	7		341.0	1.0	13	13	51.0			
CH	-NV	56	7		396.0	1.0	14	14	0.7			
CH	-NV	56	7		117.0	1.4	13	13	16.5			
15	EE	77	11	27	36.4	0.00	0	5	CHILE	CST	231.0	1.1
14	ON	161	CE								109.0	0.5
GC	-NV	56	7		16.0	1.0	2	39	40.1	175		
GC	-NV	56	7		7.5	1.0	2	39	14.5	313		
CH	-NV	56	7		15.0	1.0	2	39	39.5		9.0	0.7
CH	-NV	56	7		14.0	1.0	2	39	39.9		20.0	1.0
15	EE	77	11	9	14.7	0.00	C	3	5	TCNGA	IS.	
25	6S	115	CE									
GC	-NV	56	7		16.0	1.3	21	21	45.3	238		
CH	-NV	56	7		3.0	1.2	21	21	46.2			
CH	-NV	56	7		7.0	1.4	21	21	46.2			
15	EE	77	11	21	31.9	0.00	C	3	FLGT	REGION		
17	7S	178	CM									
42	0. C											
GC	-NV	56	7		28.0	0.8	21	22	58.0	238		
CH	-NV	56	7		16.0	1.0	21	22	55.5		12.0	0.7
CH	-NV	56	7		15.0	1.0	21	22	55.4		13.0	0.9
15	EE	77	11	3	37.2	0.00	0	3	5	IONGA	IS	
26	5S	174	CM									
GC	-NV	56	7		20.5	1.0	2	16	9.3	238		
CH	-NV	56	7		13.0	1.2	2	16	9.7		11.0	1.1
CH	-NV	56	7		12.0	1.1	2	16	10.0			
15	EE	77	11	53	46.4	0.00	0	3	5	HOMSHU		
31	OM	140	CE									
GC	-NV	56	7		3.8	1.0	12	6	4.2	25		
CH	-NV	56	7		28.0	1.1	12	6	4.7		16.0	1.0
CH	-NV	56	7		28.0	1.15	12	6	4.8			
15	EE	77	11	16	30.0	0.00	0	5	PERU	CST		
14	ON	161	CE									
GC	-NV	56	7		18.5	0.8	23	26	41.0	175		
CH	-NV	56	7		14.5	0.9	23	26	42.7	313		
CH	-NV	56	7		19.0	0.8	23	26	40.5		10.0	0.9
CH	-NV	56	7		17.0	0.85	23	26	40.5		83.0	0.85
15	EE	77	11	34	31.5	0.00	C	5	MEXICO	CST		
15	EE	77	11	34	31.5	0.00	C	5	MEXICO	CST		
GC	-NV	56	7		27.0	1.2	7	40	10.1	200		
CH	-NV	56	7		16.5	1.3	7	40	26.3	448		
CH	-NV	56	7		74.0	1.26	7	40	9.3		17.7	1.1
CH	-NV	56	7		77.0	1.25	7	40	9.2		39.0	1.1
CH	-NV	56	7		61.0	1.0	7	41	26.0			

16	CCT	77	1	59	33.7	0.00	C	4	KUBILES		
47	C	153	8								
GC	-1	63	1		14.0	2.7	2	10	9.7	200	
GC	-1	63	1		14.0	1.0	2	10	43.6	448	
CB	2	63	1		29.0	2.4	2	13	9.6		6.0 1.8
CB	3	63	1		31.0	2.5	2	10	9.7		
16	CCT	77	25		43.0	0.00	C	5	S. ALASKA		
59	C	152	8								
GC	-1	63	1		5.0	0.8	4	32	4.2	200	
GC	-1	63	1		15.5	0.8	4	32	44.3	448	
CB	2	63	1		17.3	1.15	4	32	4.5		10.3 1.13
CB	3	63	1		17.3	1.0	4	32	4.6		
CB	3	63	1		30.0	0.75	4	32	13.6		
21	CCT	77	6		2.9	0.00	0	3	FIGI IS		
18	C	179	2								
GC	-1	81	5		22.5	1.3	12	18	19.5	470	
GC	-1	81	5		24.7	1.43	12	18	19.4		11.9 1.10
CB	2	81	5		25.2	1.38	12	18	19.3		
25	CCT	77	41		6.4	0.00	C	4	N CHILE CST		
20	C	12	7								
GC	-1	70	4		16.5	0.6	10	32	11.3	500	
GC	-1	70	4		33.0	1.0	10	32	45.5	417	
CB	2	70	4		33.3	0.9	10	32	15.7		7.0 0.8
CB	3	70	4		33.2	1.0	10	32	15.8		
30	CCT	77	1		50.8	0.00	0	4	GUATEMALA CST		
13	C	50	8								
GC	-1	22	1		14.0	2.5	0	8	25.2	500	
GC	-1	22	1		4.0	1.1	0	8	39.2	31	
CB	2	22	1		15.0	1.8	0	8	25.6		12.0 1.6
CB	3	22	1		15.0	1.8	0	8	25.6		
30	CCT	77	4		3.3	0.00	C	3	FIGI IS		
21	C	178	5								
GC	-1	82	1		5.5	0.7	1	16	29.5	40	
GC	-1	82	1		4.0	0.7	1	16	29.8		44.0 0.65
CB	2	82	1		59.0	0.6	1	16	29.8		
40	CCT	77	45		11.0	0.00	C	4	WINDWARD IS.		
12	C	59	5								
GC	-1	49	1		8.0	1.3	13	33	34.5	417	
CB	2	49	1		11.0	0.7	13	33	25.0		4.6 0.9
CB	3	49	1		9.0	0.8	13	33	25.0		
CB	3	49	1		40.0	0.7	13	33	28.7		
40	CCT	77	35		6.0	0.00	0	4	H. CST. HONSHU		
38	C	158	5								
GC	-1	76	1		8.0	1.3	15	51	25.8	36	
GC	-1	76	1		103.0	1.1	15	50	54.2		76.0 1.2
CB	2	76	1		99.0	1.2	15	50	54.3		
CB	3	76	1		41.0	1.5	15	51	7.1		35.0 1.2
51	CCT	77	19		18.2	0.00	C	3	ANDREA CFP IS.		
51	C	175	6								
GC	-1	46	1		21.0	0.8	21	27	28.1		18.0 1.0
CB	2	46	1		21.0	0.8	21	27	28.2		
CB	3	46	1		37.0	0.45	21	27	59.4		32.0 0.5
16	CCT	77	0		44.8	0.00	C	4	MEXICO CST.		
16	C	53	1								
GC	-1	23	5		2.5	0.7	6	5	43.5	31	
GC	-1	23	5		8.7	1.16	6	6	32.3		
CB	2	23	5		9.6	1.14	6	6	32.4		
CB	3	23	5		15.0	0.55	6	7	21.9		9.0 0.4

21	CCI	77	19	5	41.0	0.00	C	4	FOX IS.		
53	CCI	170	CH								
G	CCI	40	C		18.5	0.9	19	17	25.3	35	
G	CCI	40	C		24.5	1.0	19	18	12.1	31	
G	CCI	40	C		199.0	1.0	19	17	14.2		134.0 1.1
G	CCI	40	C		180.0	1.1	19	17	14.1		
UN	CCI	77	1	45	11.0	0.00	0	3	HONGSHU	CST.	
UN	CCI	177	CH								
G	CCI	82	1		33.0	1.1	1	57	13.6	450	
G	CCI	82	1		27.0	1.0	1	57	26.2		23.3 0.95
G	CCI	82	1		26.0	1.0	1	57	26.2		
24	CCI	77	57		5.0	0.00	0	4	N. ATLANTIC		
44	CCI	19	CH								
G	CCI	66	6		26.0	1.0	6	8	23.8	450	
G	CCI	66	6		78.5	1.0	6	7	49.5	427	
G	CCI	66	6		21.0	1.1	6	7	11.2		15.7 0.9
G	CCI	66	6		19.0	1.1	6	7	11.0		
UN	CCI	77	5		12.0	0.00	0	4	ALASKA	PENN.	
UN	CCI	177	CH								
G	CCI	33	7		33.0	0.9	7	16	22.5	450	
G	CCI	33	7		4.5	0.8	7	17	6.5	31	
G	CCI	33	7		29.0	0.85	7	15	53.7		
G	CCI	33	7		27.0	0.85	7	15	53.6		
44	CCI	77	38		15.6	0.00	0	3	JAPAN		
44	CCI	177	CH								
G	CCI	75	21		25.0	1.2	21	56	3.3	417	
G	CCI	75	21		13.0	0.7	21	49	30.5		
G	CCI	75	21		13.0	0.7	21	49	30.5		
55	CCI	77	54		22.8	0.00	0	3	R. RUSSIA		
55	CCI	177	CH								
G	CCI	71	4		8.0	0.9	4	5	46.7		6.5 0.9
G	CCI	71	4		8.0	0.9	4	5	46.7		
G	CCI	71	4		9.5	0.8	4	5	46.5	500	
1	CCI	77	19		23.9	0.00	0	3	KONGA IS.		
1	CCI	177	CH								
G	CCI	81	1		33.5	2.5	1	31	42.3	396	
G	CCI	81	1		19.0	1.7	1	31	8.7		15.0 1.7
G	CCI	81	1		20.0	1.8	1	31	8.8		
10	CCI	77	51		31.8	0.00	0	3	COSTA RICA		
10	CCI	177	CH								
G	CCI	32	5		25.5	0.7	5	56	1.7	396	
G	CCI	32	5		37.0	1.1	5	56	50.7		26.0 0.95
G	CCI	32	5		35.0	1.05	5	56	51.0		
10	CCI	77	47		52.0	0.00	0	4	REBU		
10	CCI	177	CH								
G	CCI	65	14		6.5	0.8	14	57	31.5	31	
G	CCI	65	14		72.0	1.45	14	57	8.3		62.0 1.2
G	CCI	65	14		94.0	1.2	14	57	8.5		
22	CCI	77	35		58.7	0.00	0	3	FIJI IS.		138.0 1.0
22	CCI	177	CH								
G	CCI	81	23		4.0	1.3	23	48	18.4	74	
G	CCI	81	23		23.0	1.2	23	48	18.9		
G	CCI	81	23		25.0	1.2	23	48	19.0		
53	CCI	77	53		4.3	5.60	0	4	ANDREANOF IS.		
53	CCI	177	CH								
G	CCI	49	10		7.0	1.0	10	1	46.6	31	
G	CCI	49	10		104.0	0.75	10	1	1.3		29.0 1.4
G	CCI	49	10		525.0	0.45	10	1	36.5		15.0 0.5
G	CCI	49	10		149.0	0.8	10	3	30.1		

41	NOV 77	10	2	9.5	5.00	0	4	ANDREANOF IS.		
51	DEC 77	175								
61	JAN 78									
71	FEB 78	49		32.5	1.3	10	10	53.3	396	
81	MAR 78	49		30.0	0.83	10	10	7.5		26.0 1.0
91	APR 78	49		196.0	0.5	10	10	45.0		177.0 0.5
101	MAY 78	49		69.0	0.9	10	12	37.6		
111	JUN 78	77	45	33.7	0.00	C	4	GUATEMALA CST.		
121	JUL 78	50								
131	AUG 78									
141	SEP 78	3		5.5	1.0	12	5	12.5	70	
151	OCT 78	3		50.5	1.0	12	5	24.5	396	
161	NOV 78	3		38.0	1.1	12	5	11.4		13.0 1.0
171	DEC 78	3		278.0	0.35	12	5	46.7		26.0 0.4
181	JAN 79	77	7	51.5	0.00	C	2	ANDREANOF IS.		
191	FEB 79	175								
201	MAR 79									
211	APR 79	41		36.0	1.2	18	16	20.8	396	
221	MAY 79	43		35.0	1.1	18	15	35.5		
231	JUN 79	77	44	9.2	0.00	C	3	ANDREANOF IS.		
241	JUL 79	175								
251	AUG 79									
261	SEP 79	43		10.0	0.6	14	5	6.3	74	
271	OCT 79	43		46.4	1.0	14	5	7.0		7.0 0.6
281	NOV 79	48		485.0	0.5	14	5	44.6		23.0 0.8
291	DEC 79	77	39	35.3	5.50	C	5	KAMCHATKA		
301	JAN 80	175								
311	FEB 80									
321	MAR 80	57		14.0	1.3	2	45	22.3	78	
331	APR 80	57		12.0	0.8	2	49	58.5	31	
341	MAY 80	57		107.0	1.3	2	49	22.1		23.0 1.1
351	JUN 80	57		182.0	0.8	2	45	30.0		76.0 0.8
361	JUL 80	57		84.0	0.9	2	5	56.5		
371	AUG 80	77	59	8.3	0.00	C	4	KURILES		
381	SEP 80	175								
391	OCT 80									
401	NOV 80	6		21.0	1.3	15	5	35.8	480	
411	DEC 80	6		42.0	1.3	15	10	16.0	396	
421	JAN 81	6		24.0	1.3	15	9	39.5		17.0 1.1
431	FEB 81	77	14	21.0	1.3	15	9	39.9		
441	MAR 81	175		41.5	0.00	C	3	KURILES		
451	APR 81									
461	MAY 81	6		19.0	1.1	21	25	37.0	365	
471	JUN 81	6		9.0	0.95	21	24	49.1		
481	JUL 81	6		8.0	0.9	21	24	49.0		
491	AUG 81	77	25	24.9	0.00	C	4	COSTA RICA		
501	SEP 81	175								
511	OCT 81									
521	NOV 81	3		15.5	0.5	4	3	4.8	417	
531	DEC 81	3		13.0	0.9	4	3	53.3		8.0 0.9
541	JAN 82	3		14.0	0.8	4	3	53.3		
551	FEB 82	3		25.0	0.5	4	3	5.0		20.0 1.2
561	MAR 82	77	16	44.0	0.00	C	5	KURILES		
571	APR 82	175								
581	MAY 82									
591	JUN 82	6		26.5	0.7	3	27	44.0	450	
601	JUL 82	6		30.0	0.7	3	27	18.7	417	
611	AUG 82	6		24.0	0.79	3	27	44.3		16.7 0.79
621	SEP 82	6		23.8	0.67	3	27	44.3		
631	OCT 82	77	50	26.0	0.6	3	27	57.3		
641	NOV 82	175		9.6	0.00	C	3	CHILE		
651	DEC 82									
661	JAN 83									
671	FEB 83	7		10.0	0.8	14	1	46.7	450	
681	MAR 83	7		14.0	0.85	14	1	46.2		12.7 0.8
691	APR 83	7		13.0	0.9	14	1	46.2		
701	MAY 83	77	4	46.3	0.00	C	3	FIJI REGION		
711	JUN 83	175								
721	JUL 83									
731	AUG 83	61		17.0	0.8	19	16	14.0	39	
741	SEP 83	61		156.0	0.9	19	16	14.3		131.0 0.9
751	OCT 83	61		143.0	0.8	19	16	14.4		

13	HC	77	42	56.6	5.10	C 5	N. PERU		
26	GC	73							
OB	HC	73		60.0	1.1	8	51	46.3	417
CE	HC	73		79.0	0.85	8	51	22.4	65.0 0.9
CE	HC	73		75.0	0.9	8	51	22.4	
HC	HC	73		104.0	0.8	8	51	37.7	85.0 0.9
HC	HC	73		83.0	1.1	8	51	55.9	
14	HC	77	25	5.5	4.50	0 5	FOR IS.		
52	GC	77							
94	GC	77							
GE	HC	77		5.5	0.7	19	37	23.0	36
CE	HC	77		26.0	0.9	19	37	36.9	13.0 0.7
CE	HC	77		40.0	0.8	19	37	36.9	
HC	HC	77		87.4	0.75	19	37	16.2	66.0 1.0
HC	HC	77		95.0	1.3	19	37	13.1	
16	HC	77	30	55.3	0.00	0 3	N. CHIEF CST		
24	GC	77							
GE	HC	77		35.5	0.9	19	42	2.8	395
CE	HC	77		21.1	0.9	19	42	33.4	
CE	HC	77		21.0	0.95	19	42	33.4	
16	HC	77	36	17.6	0.00	C 4	HOKKAIDO JAPAN REG		
42	GC	77							
GE	HC	77		33.5	0.8	19	43	15.3	417
CE	HC	77		21.0	0.9	19	43	43.2	20.0 1.1
CE	HC	77		20.0	0.9	19	43	43.2	
HC	HC	77		71.0	0.8	19	43	51.2	13.0 0.4
17	HC	77	20	34.1	0.00	C 4	S. HCN SHU		
33	GC	77							
GC	HC	77		27.0	1.3	17	32	31.3	78
GC	HC	77		270.0	1.1	17	32	32.1	222.0 1.1
CE	HC	77		243.0	1.1	17	32	32.1	
HC	HC	77		236.0	1.3	17	32	46.0	208.0 1.0
20	HC	77	53	45.6	0.00	C 5	CBN1. ALASKA		
62	GC	77							
GE	HC	77		20.0	0.9	19	0	26.7	470
GC	HC	77		48.0	1.1	19	0	2.8	417
CE	HC	77		37.0	0.9	19	0	27.0	26.0 0.9
CE	HC	77		32.0	1.0	19	0	27.1	
HC	HC	77		37.0	0.4	19	0	20.0	75.0 0.5
24	GC	77	9	28.7	0.00	0 4	E. SEA OF JAPAN		
24	GC	77							
GC	HC	77		21.7	1.0	2	20	43.8	470
GC	HC	77		44.5	1.0	2	21	14.3	417
CE	HC	77		23.0	1.1	2	20	44.2	17.0 1.0
CE	HC	77		74.0	1.1	2	20	44.2	
11	HC	77	29	16.0	0.00	C 4	ANDREANOF IS.		
22	GC	77							
GC	HC	77		35.5	0.6	21	34	53.1	470
GC	HC	77		49.0	0.9	21	34	37.5	417
CE	HC	77		21.0	0.8	21	34	37.7	16.0 0.8
CE	HC	77		22.0	0.85	21	34	37.7	
22	HC	77	39	15.5	0.00	C 2	FUJI REGION		
19	GC	77							
OB	HC	77		20.0	1.1	8	51	33.3	
GC	HC	77		18.2	1.0	8	51	32.2	470
11	HC	77	6	32.0	0.00	0 2	ARGENTINA		
11	GC	77							
GC	HC	77		15.0	0.8	10	18	55.0	
GC	HC	77		15.2	0.7	10	18	55.2	470

23 NOV 77	10	10	15.0	0.00	0	2	ARGENTINA		
31.75	67.78								
CE	82.4		14.0	0.9	10	22	36.2	13.0	0.9
UN	82.4		15.0	0.8	10	22	38.5	470	
23 NOV 77	10	35	19.2	0.00	0	2	ARGENTINA		
31.15	69.68								
CE	81.6		9.8	1.0	10	17	41.7		
UN	81.6		9.0	1.1	10	17	42.0	470	
23 NOV 77	11	8	41.1	0.00	0	2	ARGENTINA		
31.05	67.68								
CE	81.5		47.0	1.1	11	21	0.7	13.0	0.8
UN	82.0		44.0	0.8	11	21	0.3	470	
23 NOV 77	11	44	18.6	0.00	0	2	ARGENTINA		
31.15	67.58								
CE	82.3		15.0	0.9	11	56	39.6		
UN	82.4		17.8	0.9	11	56	40.0	470	
23 NOV 77	11	46	55.1	0.00	0	2	ARGENTINA		
31.15	67.78								
CE	82.3		23.3	0.9	11	59	16.1	22.0	0.8
UN	82.4		21.3	0.7	11	59	16.3	470	
23 NOV 77	11	58	44.5	0.00	0	2	ARGENTINA		
31.15	67.48								
CE	81.5		131.0	1.3	12	10	28.1	9.0	0.6
UN	81.6		10.2	1.1	12	10	28.3	35	
23 NOV 77	13	5	0.2	0.00	0	2	ARGENTINA		
31.15	67.78								
CE	81.5		96.0	1.3	13	17	20.7	48.0	1.4
UN	82.0		60.0	1.1	13	17	21.2	470	
23 NOV 77	13	38	46.7	0.00	0	2	ARGENTINA		
31.15	66.08								
CE	81.9		15.0	1.1	13	51	7.4	8.0	0.8
UN	82.0		15.0	0.8	13	51	7.8	470	
23 NOV 77	16	36	1.2	0.00	0	2	ARGENTINA		
31.15	68.28								
CE	81.5		101.0	1.1	16	48	22.5	85.0	1.2
UN	82.0		8.5	0.9	16	48	23.0	35	
23 NOV 77	16	52	3.0	0.00	0	2	ARGENTINA		
31.15	67.68								
CE	82.3		35.0	1.0	22	4	20.4	30.0	1.1
UN	82.4		34.5	0.8	22	4	21.0	470	
23 NOV 77	27		34.7	0.00	0	2	ARGENTINA		
31.15	67.78								
CE	82.5		38.0	1.2	23	39	57.0	28.0	1.2
UN	82.6		31.0	1.0	23	39	57.3	470	
23 NOV 77	1	57	28.0	0.00	0	2	ARGENTINA		
31.15	67.68								
CE	82.5		75.0	1.5	2	5	51.3	41.0	1.3
UN	82.5		54.0	1.1	2	5	51.8	470	
23 NOV 77	15		3.5	0.00	0	2	ARGENTINA		
31.15	67.78								
CE	82.1		38.0	1.1	2	27	25.6	7.0	1.1
UN	82.1		35.5	0.8	2	27	26.7	470	
23 NOV 77	17	0	1.3	0.00	0	2	TUANOTO ARCH		
31.15	139.08								
CE	82.6		145.0	1.0	17	10	27.7	88.0	1.0
UN	82.6		17.1	0.8	17	10	27.3	35	

24 KC 77	17	56	40.9	0.00	C 2	CHILE-BOLIVIA		
21.25	67.7							
CB 2-NV	74.1		80.0	1.0	18	8	19.3	69.0 1.0
CB 2-NV	74.1		64.3	1.0	18	8	19.7	470
UN 4-NOV 77	18	20	12.3	0.00	C 2	ARGENTINA		
32.15	68.2							
CB 2-NV	62.4		71.0	1.0	18	32	34.8	
CB 2-NV	62.4		65.2	0.8	18	32	35.2	470
UN 4-NOV 77	18	42	38.6	0.00	C 2	ARGENTINA		
41.35	67.5							
CE 2-NV	62.2		79.0	1.3	16	55	59.6	30.0 1.2
CE 2-NV	62.2		5.8	1.1	18	55	59.6	35
UN 6-NOV 77	13	52	46.5	0.00	C 2	ARGENTINA		
31.25	67.4							
150.0								
CB 2-NV	62.1		16.0	1.2	14	4	48.7	11.0 0.9
CB 2-NV	62.1		12.0	1.1	14	4	49.0	520
UN 7-NOV 77	6	36	1.7	0.00	C 2	KURILES		
46.2	153.1							
CB 2-NV	64.6		31.0	1.1	8	46	41.7	10.0 1.0
CB 2-NV	64.6		25.9	1.5	8	46	41.1	520
UN 7-NOV 77	8		2.3	0.00	C 2	ARGENTINA		
31.55	69.7							
CE 2-NV	61.2		16.0	0.9	9	20	21.8	
CE 2-NV	61.2		19.0	1.0	9	20	21.5	520
UN 7-NOV 77	10	15	19.7	0.00	C 2	FIJI REGION		
23.25	178.1							
CB 2-NV	64.0		14.0	1.1	10	31	49.3	
CB 2-NV	64.0		13.8	1.0	10	31	48.7	520
UN 7-NOV 77	10	46	42.5	0.00	C 2	ALBERTIANS		
31.4	166.2							
CB 2-NV	62.7		106.0	1.0	10	54	0.0	86.0 1.0
CB 2-NV	62.7		8.0	0.8	10	54	59.2	40
UN 7-NOV 77	12	40	20.0	0.00	C 2	FIJI REGION		
19.85	178.4							
CE 2-NV	61.6		112.3	0.9	12	51	38.0	24.2 0.65
CE 2-NV	61.6		11.7	0.8	12	51	38.8	40
UN 7-NOV 77	15	5	9.1	5.20	C 4	ALASKA PENN		
15.5	178.4							
CE 2-NV	63.1		70.5	0.71	15	11	34.3	50.7 0.83
CE 2-NV	63.1		48.0	0.7	15	11	33.7	520
UN 7-NOV 77	15	17	25.4	0.00	C 2	ARGENTINA		
31.15	67.7							
CB 2-NV	61.5		75.5	1.22	0	29	41.9	58.7 1.04
CB 2-NV	61.5		6.8	1.0	0	29	42.4	40
UN 7-NOV 77	19		38.6	0.00	C 2	ARGENTINA		
11.35	67.5							
CB 2-NV	62.4		65.0	0.7	4	31	53.2	38.3 0.62
CB 2-NV	62.4		6.0	1.1	4	31	55.3	40
UN 7-NOV 77	6	31	36.9	0.00	C 2	ARGENTINA		
11.5	67.4							
CB 2-NV	62.1		107.0	1.4	6	43	50.7	26.0 0.9
CB 2-NV	62.1		3.3	1.0	6	43	50.8	40
UN 7-NOV 77	18	40	21.0	0.00	C 2	ARGENTINA		
11.5	65.5							
CB 2-NV	61.6		89.0	1.0	18	52	26.2	79.0 1.0
CB 2-NV	61.6		7.3	0.8	18	52	26.4	40

21	77	12	57	15.4	5.70	0	6	8.	CS1.	KAMCHATKA
5	155.8									
1	77	12		15.0	0.8	13	9	4.0		65
1	62.6			12.0	0.7	13	7	42.1		31
1	44.0			1.5		13	7	5.8		
1	156.0			0.8		13	6	41.9		
1	6.0			0.7		13	6	42.0		21
1	125.0			0.9		13	6	15.1		
77	12	23		56.9	0.00	0	3		COSTA RICA CST.	
6	4.4									
1	22.5			14.0	1.1	12	29	0.0		64
1	34.8			15.0	1.1	12	30	46.5		385
1	40.5			49.2	1.74	12	31	36.4		
77	11	39		4.7	0.00	0	3		SEA OF OKHOTSK	
4	146.6									
1	66.0			24.0	0.5	11	50	54.3		64
1	71.1			3.5	0.7	11	49	45.0		31
1	62.6			0.73		11	49	13.0		
77	0	32		17.7	0.00	0	4		CHILE ARGENTINA BDR	
3	65.1									
1	64.2			47.5	1.0	0	42	51.0		64
1	78.5			3.5	1.0	0	44	5.0		8
1	60.0			12.4	0.8	0	44	33.3		38
1	137.6			1.1		0	44	32.9		
77	1	14		15.7	0.00	0	5		N. ATLANTIC OCEAN	
17	55.0									
1	34.4			26.0	1.5	1	21	3.3		36
1	44.0			1.1		1	23	11.8		5
1	93.0			0.9		1	24	4.0		
1	162.0			2.1		1	20	32.6		
1	50.0			1.2		1	20	33.0		350
77	10	6		21.2	0.00	0	5		ARGENTINA	
3	61.4									
1	66.1			13.5	1.0	10	17	4.0		36
1	71.7			61.0	1.3	10	13	15.8		417
1	71.4			47.0	1.2	10	18	40.7		
1	71.6			64.5	1.0	10	13	14.7		
1	71.6			21.0	0.6	10	18	15.1		350
77	6	55		52.8	0.00	0	2		JAPAN	
4	147.6									
1	71.2			13.0	1.2	9	7	16.0		109
1	71.5			43.0	1.0	9	7	33.0		391
77	6	50		40.6	0.00	0	4		KUWAIT IS.	
4	152.5									
1	62.6			5.5	1.0	9	2	49.2		4
1	71.6			60.0	0.8	9	2	28.3		45
1	71.6			349.0	1.2	9	2	29.2		
1	63.7			105.4	1.1	9	2	57.0		
77	47			36.7	0.00	0	2		ARGENTINA	
3	68.1									
1	60.4			8.4	1.3	3	59	43.5		47
1	71.3			10.0	1.3	3	59	30.0		31
77	57			46.8	0.00	0	2		MEXICO CST.	
10	106.9									
1	25.0			34.0	1.3	3	3	49.0		563
1	25.5			32.0	1.1	3	3	20.7		360
77	25			25.6	0.00	0	2		ARGENTINA	
3	67.7									
1	60.2			27.0	1.3	2	37	37.5		563
3	77.1			27.5	1.4	2	37	21.1		375

23 DEC 77	11 15	45.0	0.00	C 2	NORWEGIAN SEA	
72.3	0.1					
BE-CC	57.6	29.0	1.2	11 25	37.4	531
BE-CC	60.2	13.0	1.7	11 25	55.7	375
24 DEC 77	19	1.1	0.00	C 2	ARGENTINA	
23.0	66.6					
BE-CC	73.9	32.0	1.1	5 30	38.6	531
BE-CC	77.1	44.5	1.1	5 30	21.3	375
BE-CC	143.2	2	13.0	0.00	C 2	JAPAN
BE-CC	77.6	3.0	1.0	21 14	7.0	40
BE-CC	60.2	9.0	1.1	21 14	21.5	31
BE-CC	77.1	54.0	0.00	C 2	S. ALASKA	
60.2	153.7					
BE-CC	45.2	100.0	0.7	15 18	24.5	
BE-CC	45.2	26.0	0.5	15 18	24.7	170
BE-CC	77.1	11.9	0.00	C 2	S. ITALY	
40.0	15.5					
BE-CC	58.4	840.0	0.9	17 44	37.4	
BE-CC	58.4	9.0	0.7	17 44	38.5	10
BE-CC	77.1	21.8	0.00	C 2	BBHO	
14.7	71.6					
BE-CC	60.9	340.0	1.75	8 3	18.8	
BE-CC	60.9	250.0	1.3	8 3	17.0	
10 JAN 78	50	19.5	5.70	C 3	RUHLE IS.	
46.2	152.3					
BE-CC	60.6	199.0	0.81	1 2	25.6	
BE-CC	60.6	5.0	0.7	1 2	25.6	18
BE-CC	60.6	98.5	1.1	1 1	6.2	
13 JAN 78	3	5.0	5.80	C 3	RUHLE IS.	
44.6	145.6					
BE-CC	83.3	289.0	0.97	20 15	27.7	
BE-CC	83.3	7.5	0.9	20 15	26.0	54
BE-CC	70.0	397.6	0.9	20 14	11.0	
17 JAN 78	33	15.3	5.70	C 3	ARGENTINA	
31.2	67.6					
BE-CC	77.2	113.0	0.96	11 45	7.7	
BE-CC	77.2	11.0	0.9	11 45	6.7	112
BE-CC	64.5	175.0	0.9	11 45	48.3	
20 JAN 78	42	56.9	0.00	C 2	CHIE-ARGENTINA BDR	
34.0	70.5					
BE-CC	60.5	221.0	1.38	4 54	54.7	
BE-CC	60.5	29.0	1.2	4 54	54.0	112
24 JAN 78	54	22.9	5.80	C 3	RUHLE IS.	
44.6	145.7					
BE-CC	60.4	156.0	1.04	6 6	46.8	
BE-CC	60.4	35.0	0.8	6 6	47.0	105
BE-CC	60.4	283.0	0.9	6 6	30.3	
24 JAN 78	18	17.4	5.70	C 3	ARGENTINA	
31.7	68.9					
BE-CC	77.2	136.0	0.95	13 30	12.3	
BE-CC	77.2	15.0	1.1	13 30	11.7	100
BE-CC	64.7	456.0	0.7	13 30	50.8	
24 JAN 78	45	59.7	0.00	C 2	ARGENTINA	
27.7	66.5					
BE-CC	73.7	63.4	1.07	17 57	11.6	
BE-CC	73.7	3.0	1.0	17 57	10.7	100

25 JAN 78	21 51	27.7	5.20	0 3	B. CS1.	KAMCHATKA	
53 JAN 78	15 52						
HE-CC-CH		72.2	83.7	1.33	22 2	55.0	
HE-CC-CH		72.2	17.0	1.2	22 2	55.0	110
HE-CC-CH		55.4	105.9	0.9	22 0	29.2	
30 JAN 78	78 0	18.1	4.90	0 5	B. CS1.	KAMCHATKA	
53 JAN 78	15 52						
HE-CC-CH		72.2	68.9	0.97	5 11	45.3	
HE-CC-CH		72.2	3.0	1.0	11 11	45.3	110
HE-CC-CH		60.1	13.0	1.5	10 10	28.8	
HE-CC-CH		55.4	15.0	1.1	10 10	48.8	227
HE-CC-CH		50.7	50.7	1.0	10 10	18.6	
28 JAN 78	77 32	41.7	0.00	0 2	ICELAND		
64 JAN 78	17 46						
HE-CC-CH		55.4	93.9	1.03	20 42	36.7	
HE-CC-CH		55.4	63.5	1.0	20 42	30.4	396
3 JAN 78	78 57	35.1	0.00	0 3	ANDREANCF IS.		
51 JAN 78	17 46						
HE-CC-CH		46.5	184.9	0.87	21 6	15.6	
HE-CC-CH		46.5	16.0	1.1	21 6	21.2	80
HE-CC-CH		51.1	55.0	1.0	21 6	40.7	438
3 JAN 78	78 10	0.8	0.00	0 3	ARGENTINA		
31 JAN 78	66 08						
HE-CC-CH		80.3	41.6	1.45	1 22	14.2	
HE-CC-CH		80.3	20.0	2.0	1 22	45.6	80
HE-CC-CH		77.3	55.0	1.1	1 21	55.3	438
4 JAN 78	78 57	19.0	0.00	0 2	JAPAN		
42 JAN 78	142 22						
HE-CC-CH		75.7	75.2	0.91	1 5	2.5	
HE-CC-CH		75.7	5.1	1.2	1 5	20.3	36
4 JAN 78	78 52	17.1	0.00	0 3	COSIA BICA		
3 JAN 78	64 48						
HE-CC-CH		31.4	18.0	1.3	22 59	22.0	
HE-CC-CH		31.4	31.0	2.0	22 59	6.3	36
HE-CC-CH		31.4	18.0	1.6	22 59	57.3	438
25 JAN 78	78 23	16.5	0.00	0 3	S. PACIFIC		
22 JAN 78	127 16						
HE-CC-CH		64.2	174.0	1.4	3 33	51.3	
HE-CC-CH		64.2	50.0	1.5	3 33	51.2	200
HE-CC-CH		61.6	6.0	1.2	3 33	33.3	31
28 JAN 78	77 5	37.3	0.00	0 2	MEXICO		
16 JAN 78	95 68						
HE-CC-CH		26.1	28.0	1.2	22 11	13.7	
HE-CC-CH		26.1	6.9	0.7	22 10	45.3	17
23 JAN 78	78 38	7.3	0.00	0 2	KAMCHATKA		
54 JAN 78	15 50						
HE-CC-CH		60.1	26.0	1.4	22 46	15.2	
HE-CC-CH		60.1	24.0	0.8	22 46	34.8	227
29 JAN 78	78 5	5.8	0.00	0 2	KJBIL3 IS.		
45 JAN 78	149 18						
HE-CC-CH		65.9	120.0	1.1	2 15	53.3	
HE-CC-CH		65.9	3.0	0.9	2 16	16.3	17
29 JAN 78	78 32	32.8	0.00	0 2	B. CS1.	KAMCHATKA	
14 JAN 78	15 56						
HE-CC-CH		55.5	13.0	1.3	2 42	22.9	
HE-CC-CH		62.4	17.9	1.0	2 42	43.0	227

29 JAN 78	18 10	3.6	0.00	0 2	S. OF PANAMA	
4.4M	78.6M					
BE-CC	44.4	79.0	0.9	18 13	16.6	
GE-CC	41.6	3.4	0.9	18 17	54.4	17
30 JAN 78	3	44.5	0.00	0 2	CST. OF PERU	
11.0S	80.1M					
BE-CC	57.2	23.0	1.0	7 13	32.2	
GE-CC	54.1	14.0	1.2	7 13	10.2	227
1 FEB 78	14 58	43.7	0.00	0 2	KURILE IS.	
48.9M	153.7M					
15.1C						
BE-CC	65.6	74.0	1.2	15 9	17.9	
GE-CC	68.4	47.5	1.0	15 9	35.8	227
2 FEB 78	51	38.2	0.00	0 2	N.W. OF KURILE IS.	
47.6M	146.6M					
44.0C						
BE-CC	70.1	14.0	0.8	7 2	8.6	
GE-CC	73.0	13.3	0.7	7 2	25.5	227
3 FEB 78	1	57.9	0.00	0 2	KURILE IS.	
44.4M	145.9M					
4.0C						
BE-CC	63.4	75.0	1.0	8 14	27.8	
IF-CC	63.5	11.0	1.0	8 14	27.7	91
13 FEB 78	2	54.2	5.20	0 3	E CST KAMCHATKA	
56.3M	162.6M					
68.0C						
BE-CC	65.1	43.0	0.8	13 13	52.2	
IF-CC	65.2	5.0	0.8	13 14	3.7	26
RR-CC	66.4	110.0	1.0	13 12	23.1	
16 FEB 78	47	33.1	0.00	0 2	E CST COLUMBIA	
55.5M	77.6M					
7.1C						
BE-CC	41.5	118.0	1.0	3 55	11.3	
IF-CC	41.4	9.0	0.7	3 55	10.3	42
17 FEB 78	43	31.0	0.00	0 2	CENT. CHILE CST	
28.9M	72.4M					
40.0C						
BE-CC	76.4	105.0	1.4	6 55	16.3	
GE-CC	73.3	28.2	1.1	6 54	56.9	188
22 FEB 78	7	37.1	5.80	0 3	GUATEMALA	
14.4M	51.2M					
70.0C						
BE-CC	77.2	1314.6	1.23	6 14	47.8	
IF-CC	77.0	14.0	1.0	6 14	40.6	4
RR-CC	76.0	763.0	0.7	6 14	33.1	
26 FEB 78	5	42.2	5.40	0 5	KURILE IS.	
49.2M	155.5M					
7.0C						
BE-CC	77.4	59.0	1.1	0 17	39.2	
IF-CC	77.5	10.0	1.0	0 17	39.2	91
GE-CC	74.5	43.0	1.1	0 16	21.2	
RR-CC	73.5	19.8	1.1	0 16	39.5	208
26 FEB 78	16	52.6	5.80	0 3	EASTER IS. REG.	
26.5M	113.6M					
18.0C						
BE-CC	63.6	153.4	1.47	9 29	20.3	
IF-CC	63.4	25.3	1.1	9 29	19.2	91
RR-CC	76.6	234.0	1.3	9 28	55.6	
14 FEB 78	35	7.0	5.40	0 3	GUATEMALA	
14.2M	51.2M					
70.0C						
BE-CC	77.4	231.1	1.51	17 42	13.9	
IF-CC	77.2	6.6	0.8	17 42	12.5	7
RR-CC	76.2	263.0	0.8	17 42	05.4	
7 FEB 78	45	37.4	4.80	0 3	N. COLUMBIA	
6.9M	13.0M					
1.0C						
BE-CC	79.5	104.0	0.9	11 52	53.1	
IF-CC	79.3	19.0	0.9	11 52	52.0	62
RR-CC	76.7	261.0	0.6	11 53	53.3	

7HAB78	22	33	44.0	0.00	0	2	CRETE	
34.50	25.2E							
HM-MEE	67.9		67.2	0.59	22	44	45.4	
IF-MEE	68.1		24.0	0.6	22	44	46.2	62
19HAB78	1	39	19.2	5.90	C	3	ABXICO	
17.00	99.7W							
64.C								
HM-MEE	39.2		347.0	1.6	1	46	41.5	
IF-MEE	39.2		7.0	1.3	1	46	40.0	10
FK-ON	33.8		184.0	1.1	1	45	55.9	
22HAB78	50		34.9	0.00	0	2	KOBILE IS.	
43.80	148.9E							
47.C								
HM-MEE	84.3		218.0	2.5	1	3	2.6	
IF-MEE	84.3		27.0	1.7	1	3	2.5	109
22HAB78	1	34	30.6	0.00	0	2	KOBILE IS.	
44.00	148.9E							
4.C								
HM-MEE	84.1		162.4	1.3	21	47	3.9	
IF-MEE	84.1		20.0	0.8	21	47	4.8	114
23HAB78	31		3.8	6.10	C	3	KURILE IS.	
44.30	148.7E							
36.C								
HM-MEE	83.9		334.6	1.3	0	43	30.6	
IF-MEE	83.9		4.5	0.8	0	43	30.0	10
FK-CN	71.2		533.0	1.0	0	42	14.9	
23HAB78	1	49	38.6	5.60	C	3	KOBILE IS.	
43.90	148.9E							
54.C								
HM-MEE	84.2		81.2	1.41	2	2	5.1	
IF-MEE	84.2		14.0	0.7	2	2	6.5	114
FK-ON	71.2		52.3	0.9	2	00	49.1	
26HAB78	3	56	59.7	5.60	C	3	E. KAZAKH	
49.70	18.1E							
5.C								
HM-MEE	75.7		59.8	0.9	4	5	10.4	
IF-MEE	75.9		9.0	0.8	4	9	11.0	95
FK-CN	60.0		120.0	0.8	4	9	6.6	
26HAB78	1	5	0.7	5.40	C	3	E CSI KAMCHATKA	
43.40	162.9E							
53.C								
HM-MEE	71.4		162.4	0.97	21	16	17.8	
IF-MEE	71.4		35.0	0.8	21	16	18.2	95
FK-CN	58.2		150.3	1.0	21	44	48.0	
23HAB78	17		2.0	5.80	C	3	KOBILE IS.	
40.80	150.8E							
5.C								
HM-MEE	78.0		236.8	1.3	20	25	1.8	
IF-MEE	78.0		50.0	1.2	20	29	3.0	103
FK-CN	65.0		225.0	1.2	20	27	39.4	
19HAB78	13		11.0	0.00	C	3	W. CHILE RISE	
38.20	53.5E							
5.C								
HM-MEE	75.1		86.8	1.75	9	25	17.3	
IF-MEE	65.4		4.5	1.0	9	24	19.0	36
FK-CN	75.9		14.0	2.0	9	24	57.5	188
19HAB78	27		35.5	4.60	0	5	N. COLUMBIA	
6.90	72.5W							
172.C								
HM-MEE	45.7		70.8	0.67	6	35	39.3	
IF-MEE	28.8		8.0	0.8	6	35	18.0	36
FK-CN	43.2		22.1	1.0	6	35	19.5	198
HM-MEE	39.8		38.8	0.7	6	34	49.8	
FK-CN	46.8		319.0	0.5	6	35	50.0	
19HAB78	14	49	42.3	0.00	C	3	KOBILE IS.	
48.90	15.4.9E							
5.C								
HM-MEE	64.9		36.3	0.87	15	C	24.1	
IF-MEE	61.5		4.0	0.9	15	C	2.5	36
FK-CN	67.8		21.0	0.7	15	C	42.2	198

204	AB	7E	3	59	8.7	0.00	C	2	S. ALASKA	
60.4	AN	1E	3	74						
164	C									
FE	-CC		34.6		67.2	0.45		4	5	41.5
GE	-NH		17.6		19.0	0.6		4	6	7.0
204	AB	7E	19		29.4	0.00	0	2	CAFAN	188
42.4	AN	142.7E								
66.0	C									
FE	-CC		75.6		56.4	0.92		7	31	8.6
GE	-NH		76.5		17.0	0.6		7	31	23.3
204	AB	7E	42		46.0	0.00	0	3	MID-ATLANTIC RIDGE	188
1.0	ON	25.6E								
12.0	C									
FE	-CC		60.6		55.7	1.50		15	55	0.0
GE	-NH		75.3		9.0	1.2		15	55	19.7
204	AB	7E	9		43.1	0.00	C	3	MID-ATLANTIC RIDGE	188
42.4	AN	142.7E								
66.0	C									
FE	-CC		60.6		102.3	2.06		18	21	57.1
GE	-NH		75.6		7.5	1.0		18	21	16.3
204	AB	7E	13		33.8	0.00	C	2	KURILE IS.	188
42.4	AN	142.7E								
66.0	C									
FE	-CC		71.2		13.0	1.1		1	24	49.9
GE	-NH		74.0		13.0	1.2		1	25	5.0
204	AB	7E	9		0.3	0.00	C	3	KURILE IS.	188
42.4	AN	142.7E								
66.0	C									
FE	-CC		71.2		100.5	1.09		22	20	15.0
GE	-NH		71.9		12.0	1.3		22	21	45.5
204	AB	7E	55		15.8	0.00	C	2	KURILE IS.	188
42.4	AN	142.7E								
66.0	C									
FE	-CC		71.1		55.0	1.0		17	6	30.0
GE	-NH		73.9		24.0	1.4		17	6	45.6
204	AB	7E	52		17.2	0.00	C	2	KURILE IS.	198
42.4	AN	142.7E								
66.0	C									
FE	-CC		71.6		49.0	1.1		0	3	34.0
GE	-NH		74.4		19.0	1.0		0	3	30.0
204	AB	7E	0		16.5	0.00	C	2	KURILE IS.	188
42.4	AN	142.7E								
66.0	C									
FE	-CC		70.4		35.0	1.1		6	11	31.0
GE	-NH		75.2		18.0	1.5		6	11	46.9
204	AB	7E	9		56.6	0.00	C	2	KURILE IS.	188
42.4	AN	142.7E								
66.0	C									
FE	-CC		70.4		14.0	1.0		7	21	11.1
GE	-NH		75.2		11.0	1.0		7	21	27.2
204	AB	7E	1		42.1	0.00	C	2	KURILE IS.	188
42.4	AN	142.7E								
66.0	C									
FE	-CC		70.7		32.0	0.9		11	13	0.0
GE	-NH		73.4		14.0	1.0		11	13	15.7
204	AB	7E	27		5.3	0.00	0	2	N. CHILE	188
42.4	AN	142.7E								
66.0	C									
FE	-CC		70.6		30.0	1.5		17	38	9.4
GE	-NH		75.7		12.0	1.3		17	37	50.0
204	AB	7E	39		13.0	0.00	C	2	KURILE IS.	198
42.4	AN	142.7E								
66.0	C									
FE	-CC		70.5		31.0	0.9		17	50	28.1
GE	-NH		75.7		18.0	1.6		17	50	43.6

26YAB	7E	19	57	24.5	0.00	0	2	MEXICO
18.6N	99.8W							
5E.C								
FE-CC	22.4			101.0	1.0	20	2	20.7
GE-NM	15.2			21.0	1.8	20	1	46.0
4APR	7E	19	33	50.2	0.00	0	2	ARGENTINA
31.3S	66.3W							
C.O								
HN-ME	77.3			115.6	0.99	19	45	46.8
IF-ME	77.3			4.0	0.7	19	45	46.0
4APR	7E	21	11	44.3	0.00	0	2	N. OF PANAMA
10.2N	77.9W							
37.0								
EN-ME	36.8			436.3	1.30	21	18	50.7
IF-ME	36.8			20.0	1.1	21	18	49.5
7APR	7E	7	44	58.3	0.00	0	2	KURILE IS.
44.4N	148.4E							
5C.C								
HN-ME	83.6			273.2	1.00	7	57	22.1
IF-ME	83.6			19.0	0.7	7	57	22.3
11APR	7E	15	30	0.5	0.00	1	2	S. NEVADA
37.2N	116.2W							
C.O								
EN-ME	36.4			322.0	1.3	15	37	9.2
IF-ME	36.4			55.0	1.0	15	37	8.4
11APR	7E	17	44	59.9	0.00	0	2	CALIF-NEV BDR
36.9N	116.2W							
C.O								
EN-ME	36.5			359.0	1.2	17	52	9.7
IF-ME	36.5			26.0	1.0	17	52	8.6
12APR	7E	1	22	13.1	0.00	0	2	KURILE IS.
44.1N	148.1E							
6C.C								
HN-ME	64.3			66.0	0.8	1	34	51.0
IF-ME	64.3			7.0	0.7	1	34	51.3
12APR	7E	3	42	4.2	0.00	0	2	KODIAK IS. REG.
56.3N	152.6W							
0.C								
HN-ME	50.4			137.0	1.2	3	51	4.1
IF-ME	50.4			12.0	1.0	3	51	4.1
12APR	7E	16	51	10.6	0.00	0	2	NICARAGUA CST.
12.8N	87.6W							
7C.C								
HN-ME	37.0			80.0	1.2	16	56	17.2
IF-ME	37.0			10.0	1.0	16	56	15.6
13APR	7E	6	0	39.4	0.00	0	2	N. ATLANTIC OCEAN
57.1N	36.7W							
27.C								
HN-ME	22.2			300.0	1.3	6	5	32.4
IF-ME	22.2			31.0	0.9	6	5	34.5
15APR	7E	17	18	36.2	0.00	0	2	GUATEMALA
14.2N	91.2W							
65.0								
HN-ME	37.2			120.0	1.0	17	25	44.4
IF-ME	37.2			52.0	0.9	17	25	42.7
20APR	7E	22	19	28.2	0.00	0	2	KURILE IS.
46.9N	151.7E							
72.C								
HN-ME	60.8			80.0	0.8	22	31	34.5
IF-ME	60.8			20.0	0.6	22	31	34.3
24APR	7E	4	28	49.3	0.00	0	2	ANDREANCF IS.
51.1N	176.1E							
6C.C								
HN-ME	64.5			91.0	0.8	4	39	19.9
IF-ME	64.5			11.0	0.7	4	39	19.7
23APR	7E	4	28	36.2	0.00	0	2	N. COLUMBIA CST
12.2N	72.5W							
2C.C								
HN-ME	34.0			123.0	1.1	4	35	17.2
IF-ME	34.0			9.0	0.8	4	35	15.9

1977	DEC	77	12	35	44.7	0.00	0	2	DOMINICAN REP.
1978	JAN	78	12	35	65.8				
1978	JAN	78	12	35	21.2	36.0	1.0	12	40 24.0 64
1978	JAN	78	12	35	11.5	1.1	12	42 45.0 385	
1978	JAN	78	12	35	29.1	0.00	0	2	C. CHILE CST.
1978	JAN	78	12	35	71.2				
1978	JAN	78	12	35	64.6	3.0	1.0	15	54 5.1 8
1978	JAN	78	12	35	60.0	1.5	15	55 19.1 385	
1978	JAN	78	12	35	4.9	0.00	0	2	ARGENTINA
1978	JAN	78	12	35	68.0				
1978	JAN	78	12	35	65.5	11.0	1.0	17	15 49.0 8
1978	JAN	78	12	35	5.5	1.1	17	17 0.5 8	
1978	JAN	78	12	35	45.8	0.00	0	2	ARGENTINA
1978	JAN	78	12	35	67.6				
1978	JAN	78	12	35	65.7	19.5	0.7	3	33 24.2 42
1978	JAN	78	12	35	45.5	1.3	3	34 36.5 448	
1978	JAN	78	12	35	12.3	0.00	0	2	VENEZUELA
1978	JAN	78	12	35	65.7				
1978	JAN	78	12	35	28.4	66.0	1.0	16	28 4.6 31
1978	JAN	78	12	35	40.4	2.0	0.8	16	30 14.5 7
1978	JAN	78	12	35	6.0	0.00	0	2	ARGENTINA
1978	JAN	78	12	35	68.9				
1978	JAN	78	12	35	65.1	12.0	1.2	11	1 38.5 80
1978	JAN	78	12	35	30.0	1.8	11	2 1.3 438	
1978	JAN	78	12	35	42.5	0.00	0	2	CHILE-ARGENTINA EDR
1978	JAN	78	12	35	71.0				
1978	JAN	78	12	35	71.3	17.0	1.1	8	36 46.6 80
1978	JAN	78	12	35	56.0	1.0	8	39 46.9 438	
1978	JAN	78	12	35	1.3	0.00	0	2	ARGENTINA
1978	JAN	78	12	35	67.6				
1978	JAN	78	12	35	65.6	13.0	1.2	6	41 44.6 80
1978	JAN	78	12	35	21.0	1.2	6	42 57.4 438	
1978	JAN	78	12	35	56.1	0.00	0	2	NE CCASI HCNSHU
1978	JAN	78	12	35	142.6				
1978	JAN	78	12	35	61.5	44.0	1.0	-3	
1978	JAN	78	12	35	24.0	1.0	23	42 23.6 158	
1978	JAN	78	12	35	57.1	0.00	0	2	HOKKAIDO, JAPAN
1978	JAN	78	12	35	142.6				
1978	JAN	78	12	35	26.3	21.0	0.6	-3	
1978	JAN	78	12	35	6.0	1.5	6	31 52.3 158	
1978	JAN	78	12	35	58.3	0.00	0	3	KURILE ISLANDS
1978	JAN	78	12	35	145.4				
1978	JAN	78	12	35	70.6	26.0	0.7	-3	
1978	JAN	78	12	35	21.0	0.7	07	56 25.6 158	
1978	JAN	78	12	35	17.3	0.6	07	57 22.1	
1978	JAN	78	12	35	53.0	0.00	0	2	KURILE ISLANDS
1978	JAN	78	12	35	149.4				
1978	JAN	78	12	35	70.7	46.0	0.9	-3	
1978	JAN	78	12	35	11.0	0.6	08	41 27.5 158	
1978	JAN	78	12	35	04.2	0.00	0	3	KURILE ISL REG
1978	JAN	78	12	35	152.6				
1978	JAN	78	12	35	132.0	1.3	-3		
1978	JAN	78	12	35	7.0	1.1	03	49 07.6 16	
1978	JAN	78	12	35	35.0	0.6	03	51 04.1	
1978	JAN	78	12	35	39.4	0.00	0	3	N ATL OCEAN
1978	JAN	78	12	35	66.7				
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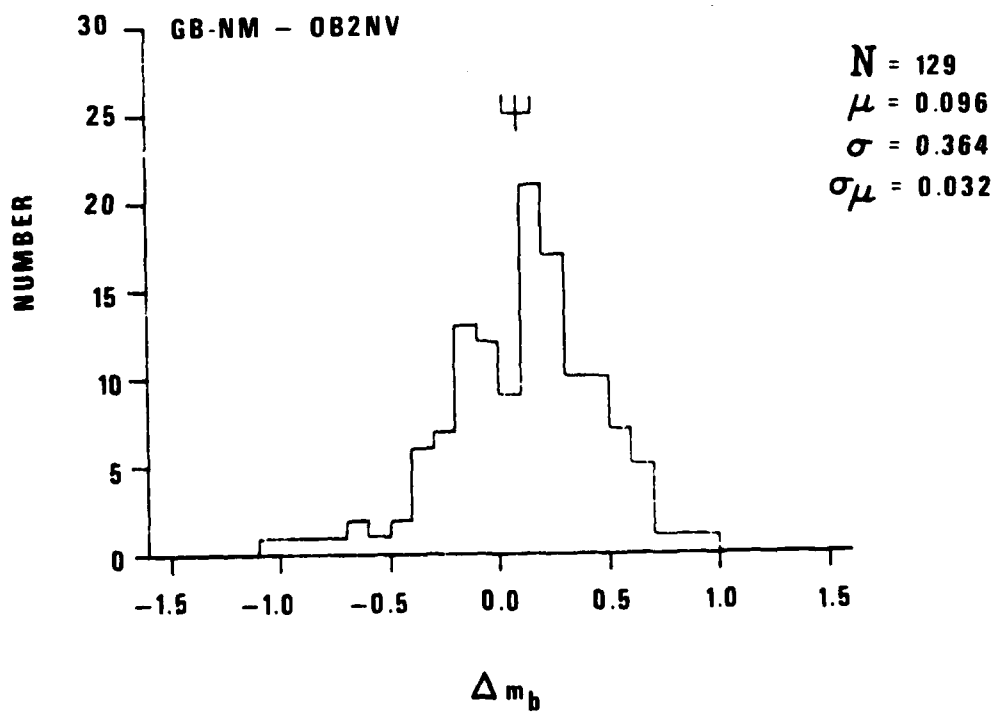
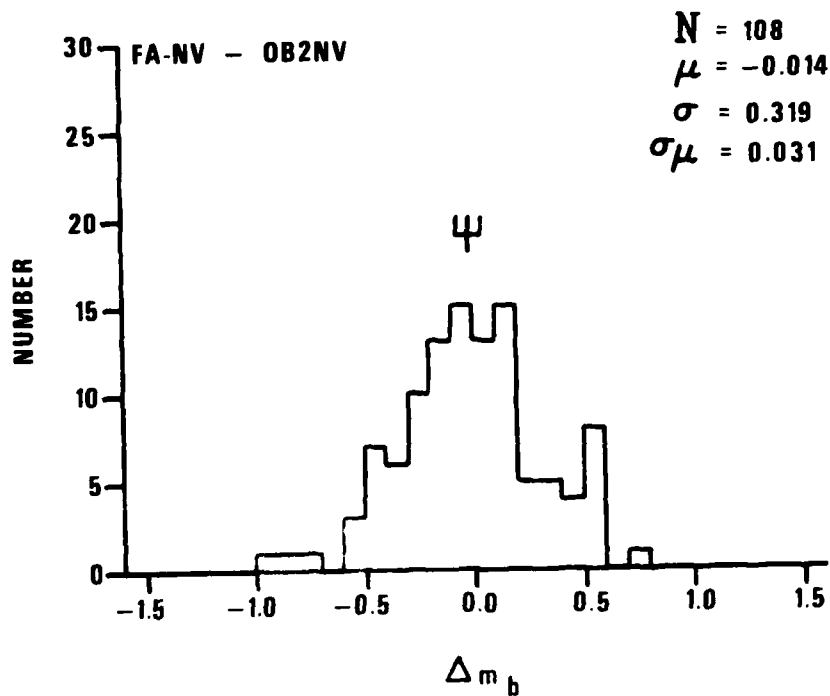
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53.6N	183.8W						
FE-CC							
GE-NM	33.3		43.0	1.2	-3		
03APR78	03	06	48.1	0.00	C	2	S OF PANAMA
53.6N	183.8W						
FE-CC							
GE-NM	45.4		29.0	0.9	-3		
03APR78	07	51	30.8	0.00	C	2	E COAST HONSHU
53.6N	144.4E						
FE-CC							
GE-NM	72.7		43.0	1.4	-3		
03APR78	11	28	23.4	0.00	C	2	S PACIFIC OCEAN
53.6N	131.1E						
FE-CC							
GE-NM	72.0		41.0	1.9	-3		
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53.6N	77.9W						
FE-CC							
GE-NM	40.1		290.0	1.0	-3		
19APR78	04	01	41.1	0.00	C	2	KURILE ISLANDS
44.4N	149.1E						
FE-CC							
GE-NM	70.8		13.0	1.0	-3		
19APR78	07	32	53.5	0.00	C	2	S OF HONSHU
30.8N	141.8E						
FE-CC							
GE-NM	64.0		26.0	1.0	-3		
20APR78	22	19	28.2	0.00	C	3	KURILE ISLANDS
46.8N	151.6E						
FE-CC							
GE-NM	68.0		140.0	1.0	-3		
23APR78	23	40	01.3	0.00	C	2	OAXALA, MEXICO
16.9N	97.9W						
FE-CC							
GE-NM	24.6		139.0	1.0	-3		
24APR78	04	28	49.3	0.00	C	3	ANDREANOFF ISL
51.5N	176.1W						
FE-CC							
GE-NM	47.0		60.0	1.00	-3		
26APR78	03	28	19.3	0.00	C	2	GJEREEEC MEX. COAST
16.5N	99.0W						
FE-CC							
GE-NM	24.7		66.0	1.0	-3		
26APR78	21	01	05.3	0.00	C	2	NICARAGUAN COAST
12.0N	86.5W						
FE-CC							
GE-NM	33.8		55.0	1.2	-3		
27APR78	01	41	15.5	0.00	C	2	KJDIAR ISL REG
56.6N	152.7W						
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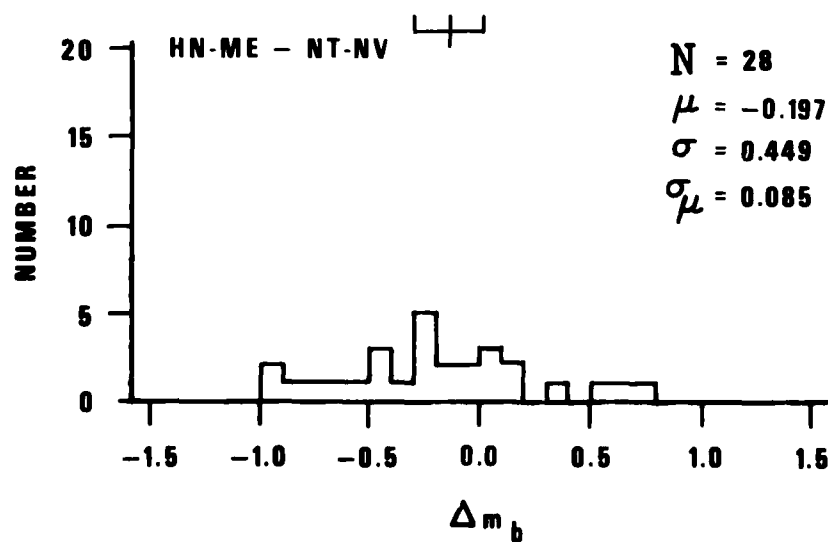
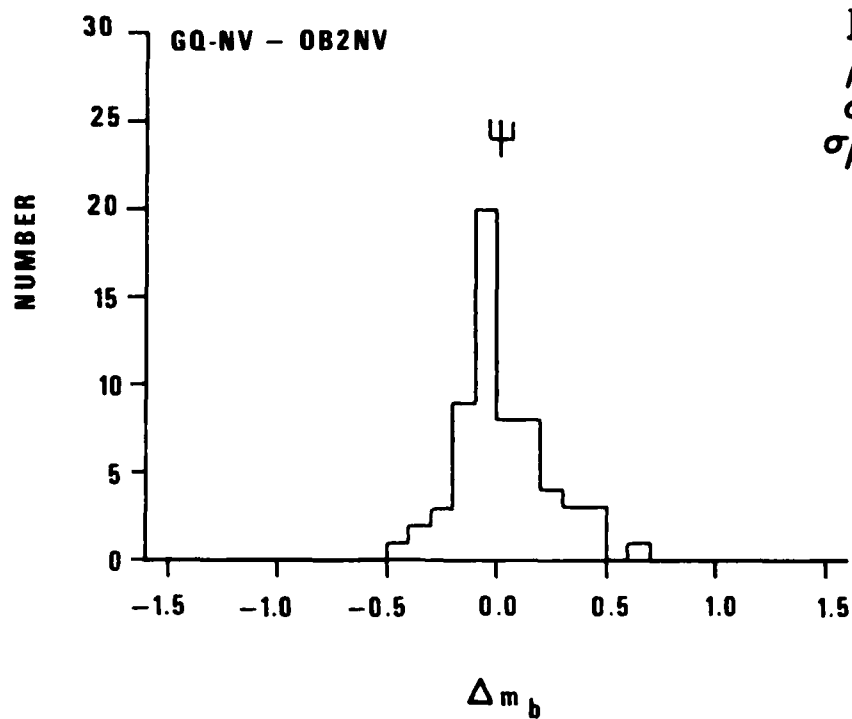
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12	CO								
88	CO				30.0	1.6	-9		
88	CO				3.0	0.7	04	36	33.7 10
88	CO				77.0	0.7	04	35	17.2
63	CO	7E	05	32	48.5	5.10	0	2	C ALASKA
127	CO								
88	CO				31.0	0.8	05	41	07.2
88	CO				36.0	0.5	05	41	07.6 182
63	CO	7E	07	31	06.0	5.10	0	2	KAMCHATKA
127	CO								
88	CO				13.0	0.6	07	42	31.1
88	CO				10.0	0.6	07	42	33.0 182
11	CO	7E	00	23	38.0	5.70	0	2	ALCREANCY IS
11	CO								
88	CO				234.0	1.1	03	34	29.8
88	CO				43.0	0.6	03	34	29.4 182
11	CO	7E	23	18	37.6	5.00	0	2	COAST CHIAPAS, MEX
11	CO								
88	CO				69.0	1.1	23	25	39.3
88	CO				13.0	0.7	23	24	27.1 182
14	CO	7E	08	32	20.2	4.90	0	2	33X/GUATMLA BDR
14	CO								
88	CO				73.0	0.9	03	39	15.6
88	CO				29.0	0.6	08	39	15.5 182
2	CO	7E	13	10	33.1	5.50	0	2	PERUVIAN COAST
12	CO								
88	CO				237.0	1.5	13	20	13.7
88	CO				5.0	0.6	13	20	13.0 16
11	CO	7E	01	07	26.1	5.70	0	2	NICARAGUAN COAST
11	CO								
88	CO				752.0	1.6	01	14	30.6
88	CO				26.0	1.1	01	14	30.0 16
02	CO	7E	20	41	45.7	5.00	0	2	VANCOUVER IS.
50	CO								
88	CO				112.0	1.2	20	49	10.5
88	CO				18.0	1.2	20	49	09.7 173
06	CO	7E	03	58	33.9	5.50	0	2	E. COAST KAMCHATKA
51	CO								
88	CO				156.0	1.3	04	10	10.7
88	CO				4.0	1.1	04	10	10.6 18
03	CO	7E	07	35	00.9	5.20	0	2	ESBU-BGAZ BRDR
11	CO								
88	CO				34.0	0.8	07	44	08.6
88	CO				21.0	0.7	07	44	08.6 173
05	CO	7E	18	04	26.7	5.30	0	2	CHIEF-REG BRDR
25	CO								
88	CO				59.0	0.8	13	15	57.3
88	CO				14.0	0.8	13	15	56.0 173
11	CO	7E	02	57	00.1	5.90	0	2	KAZANK SSR
49	CO								
88	CO				93.0	0.8	03	09	11.0
88	CO				4.0	0.9	03	09	11.3 173
13	CO	7E	08	18	29.6	5.60	0	2	S OF PANAMA
13	CO								
88	CO				13.0	0.5	03	26	20.9
88	CO				7.5	0.7	03	26	18.0 173

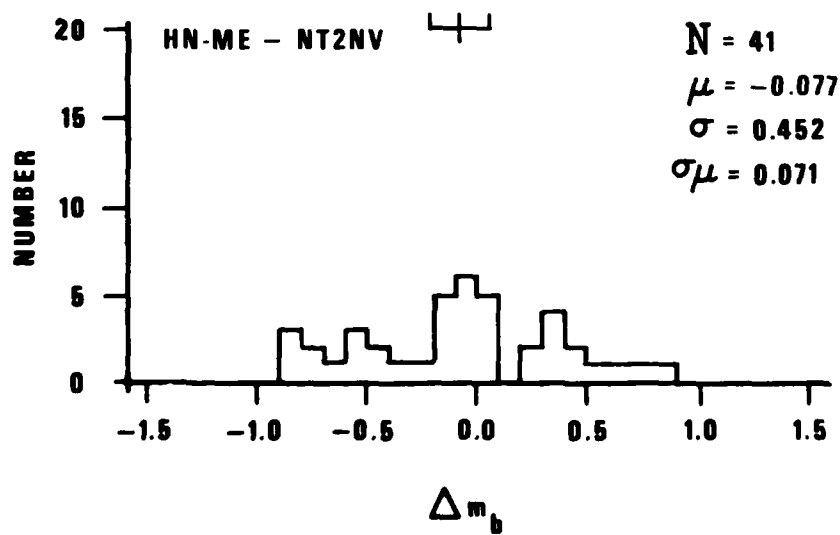
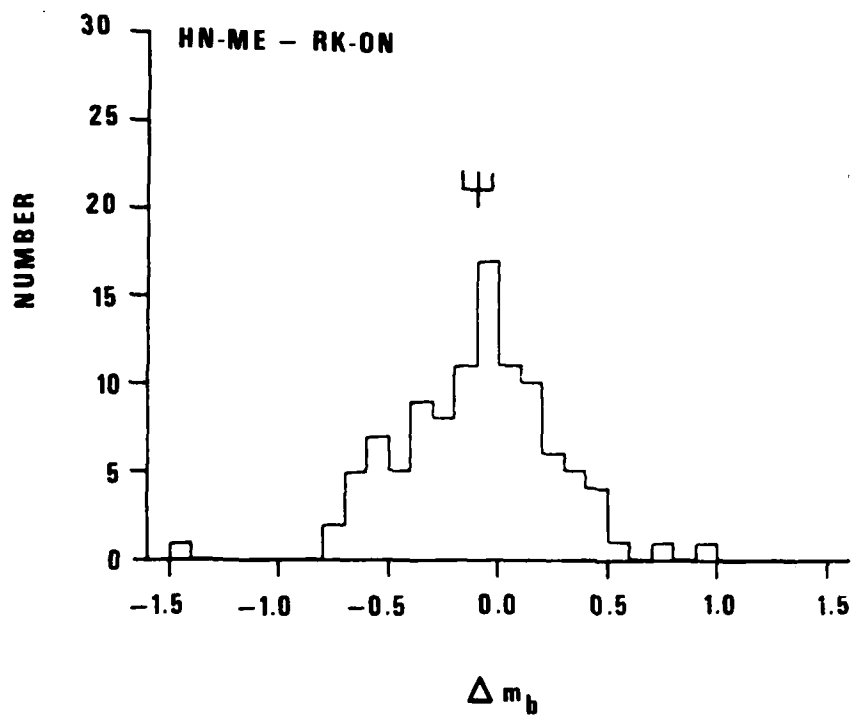
15 JUN 78	C9 28	59.3	5.40	C 2	KURILE IS	
44.5	ON 149.1E					
HA-ME		24.0	48.0	0.8	C9 41	23.8
HA-ME		24.1	28.0	0.6	C9 41	23.0
19 JUN 78	10 31	06.2	5.30	C 2	GREECE	173
40.7N	23.2E					
OC.0						
HA-ME		62.7	25.0	1.3	10 41	33.2
HA-ME		62.5	15.0	1.2	10 41	35.0
20 JUN 78	20 03	23.6	6.20	0 2	GREECE	190
40.3N	20.3E					
OC.0						
HA-ME		62.7	28.0	0.6	20 13	50.4
HA-ME		62.5	3.0	0.8	20 13	52.0
01 JAN 78	22 52	17.1	5.20	C 2	COSTA RICA	18
09.1N	84.4W					
CS.0						
HA-ME		39.4	53.8	1.0	22 39	39.0
HA-ME		42.0	103.0	0.9	23 00	01.4
06 JAN 79	07 08	46.2	5.00	0 2	ANDREANOF	
51.7N	176.1E					
CS.0						
HA-ME		64.4	50.9	1.1	07 19	14.8
HA-ME		45.1	123.3	0.6	07 17	25.8
01 FEB 78	23 36	50.2	5.60	C 2	KURILES	
45.2N	120.1E					
CC.0						
HA-ME		65.7	96.0	1.0	23 49	12.5
HA-ME		65.3	126.0	1.0	23 47	55.6
23 FEB 78	16 55	59.9	5.60	1 2	NEVADA	
36.9N	115.9W					
CC.0						
HA-ME		36.4	248.0	1.5	17 07	68.3
HA-ME		20.9	144.0	1.5	17 34	45.3
19 MAR 78	03 46	59.8	0.00	1 2	KAMCHATKA	
43.3N	77.8E					
CC.0						
HA-ME		75.5	44.5	0.9	03 59	68.9
HA-ME		75.7	35.6	0.6	03 59	05.1

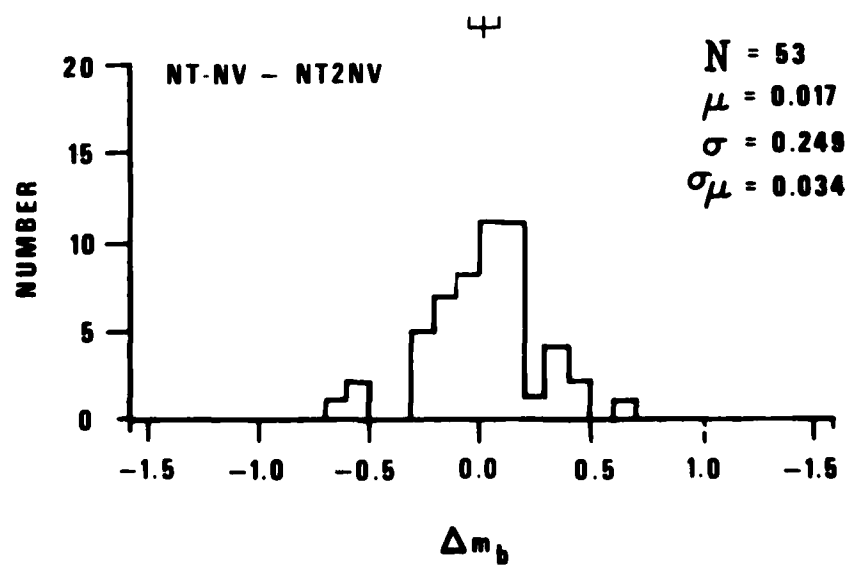
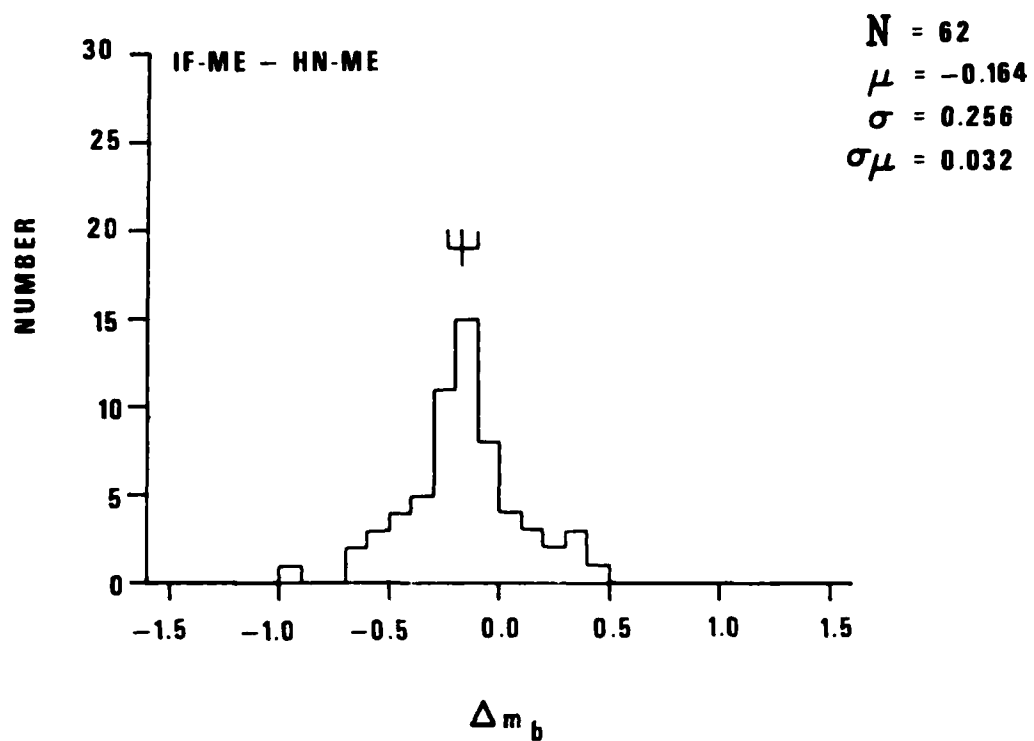
APPENDIX B

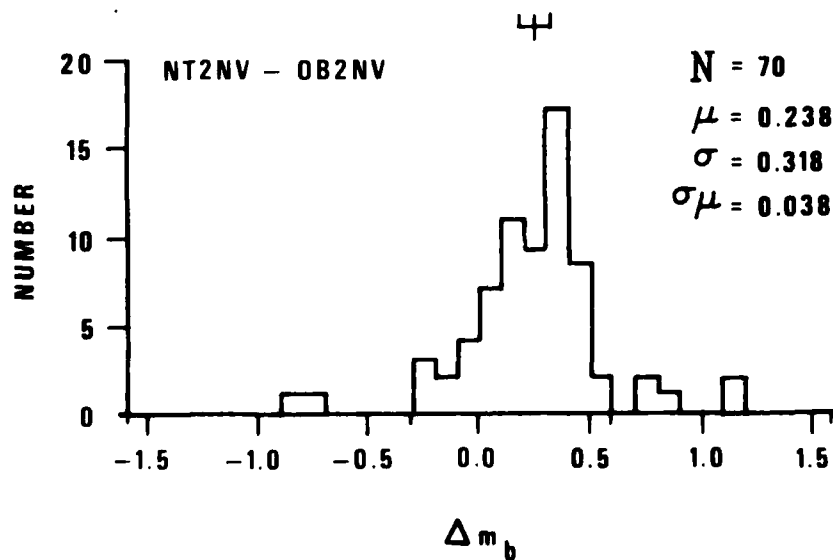
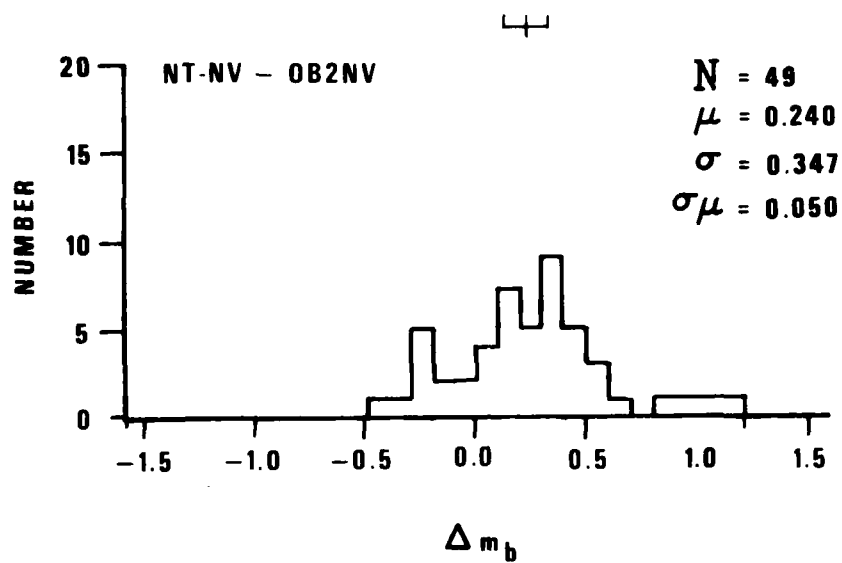
Histograms of Magnitude Differentials Δm_b for Various
Pairs of SDCS Stations

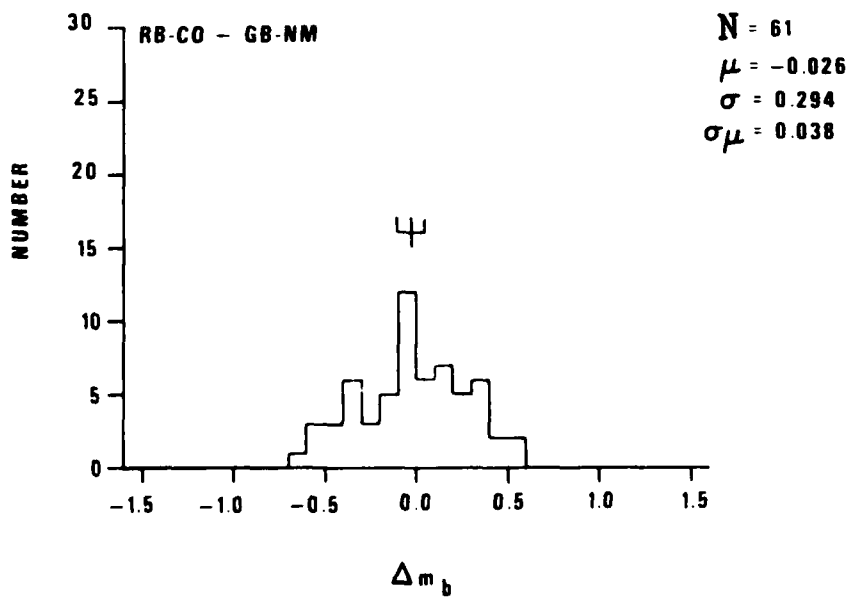
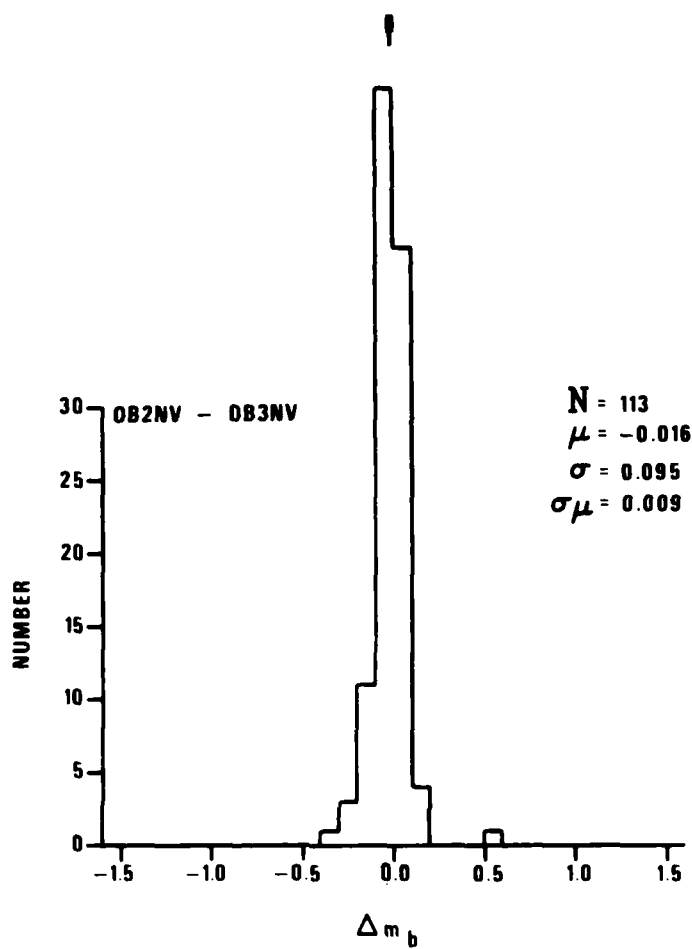


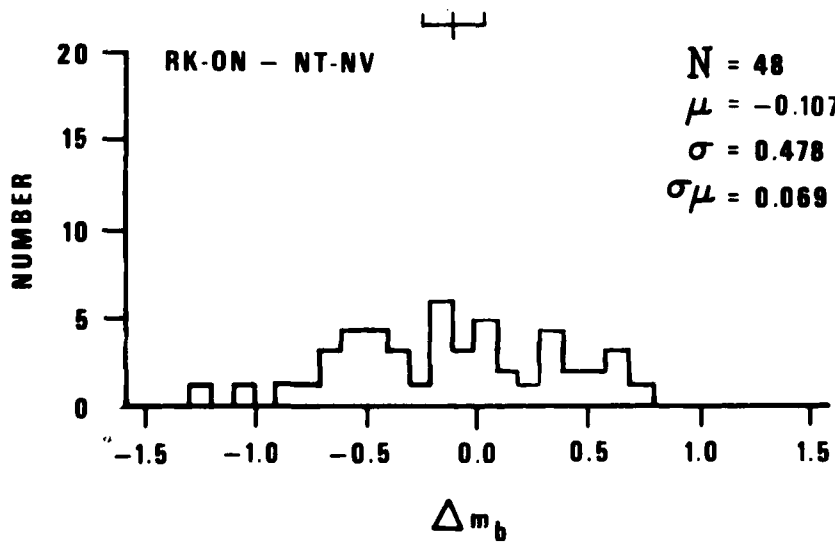
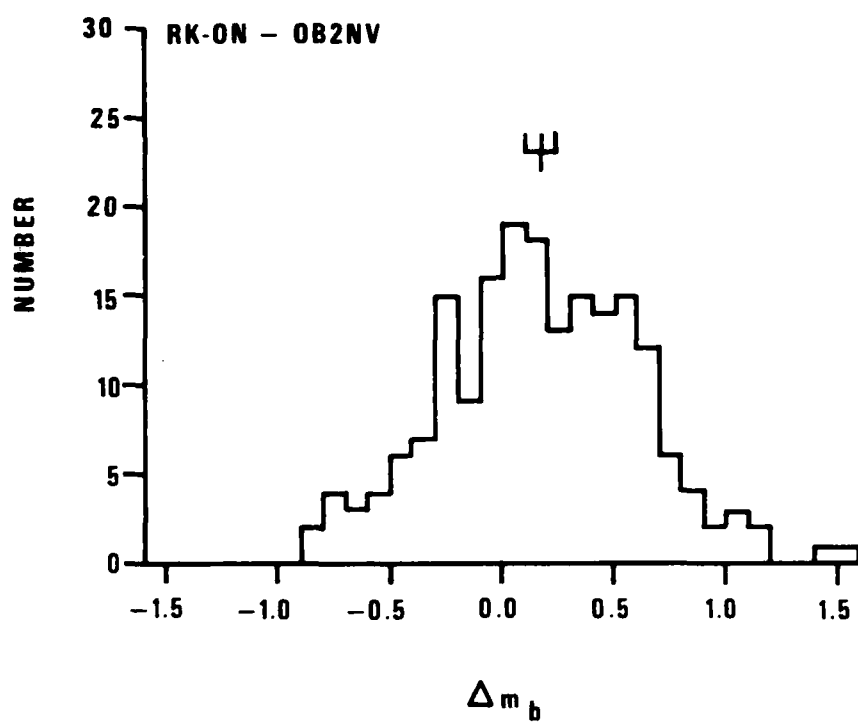


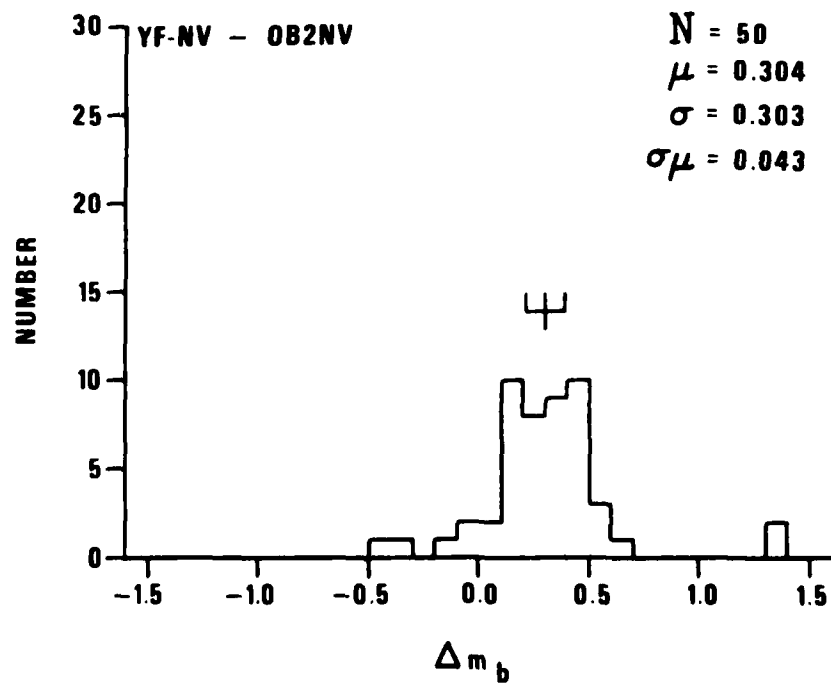
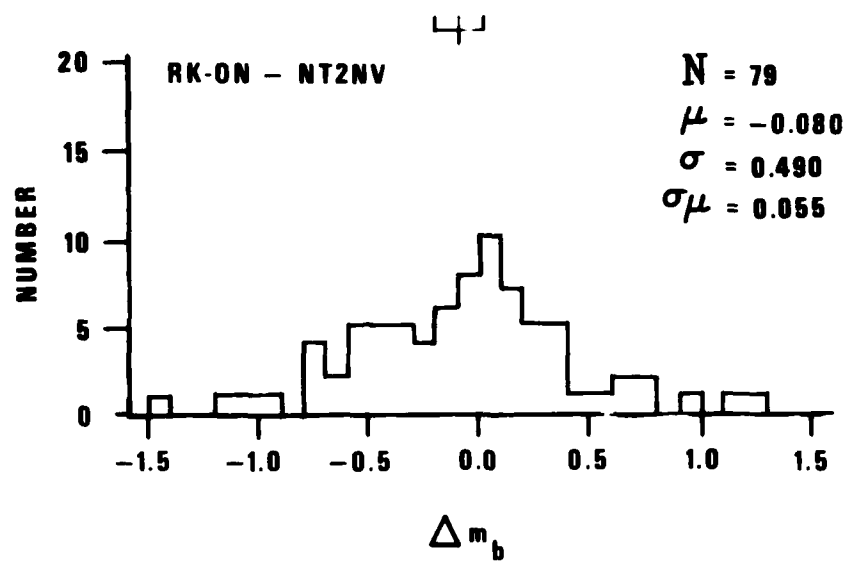


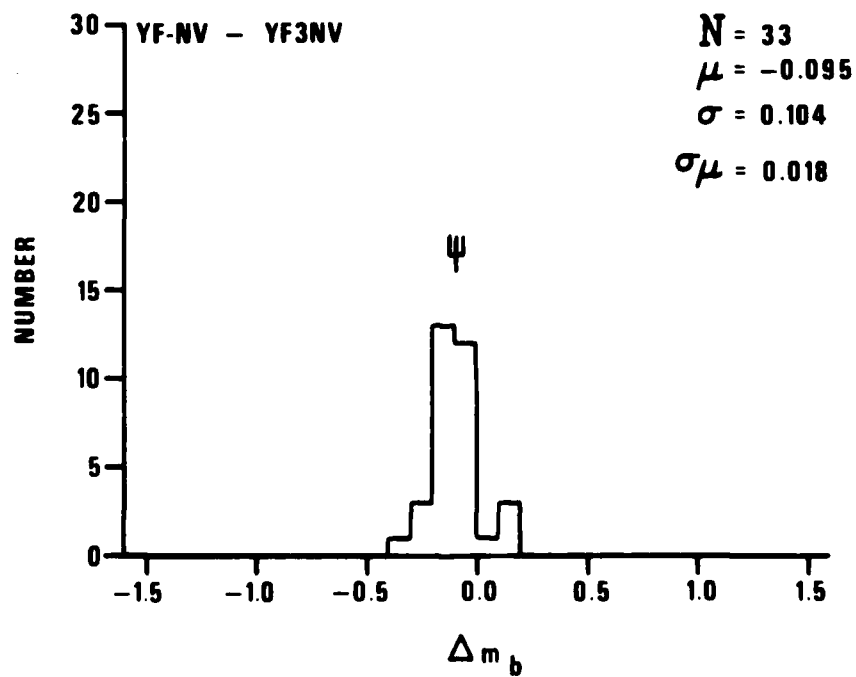
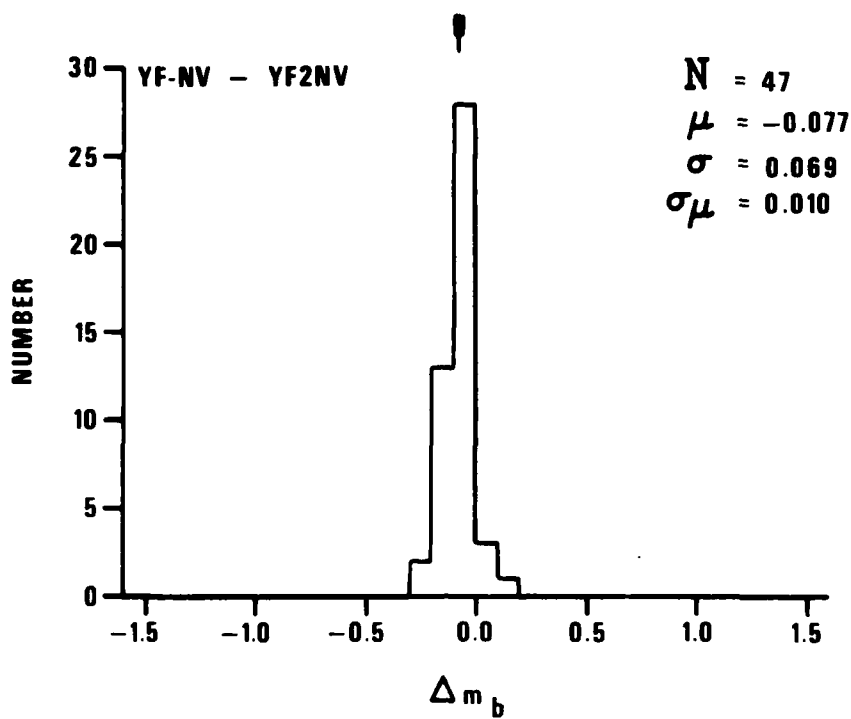


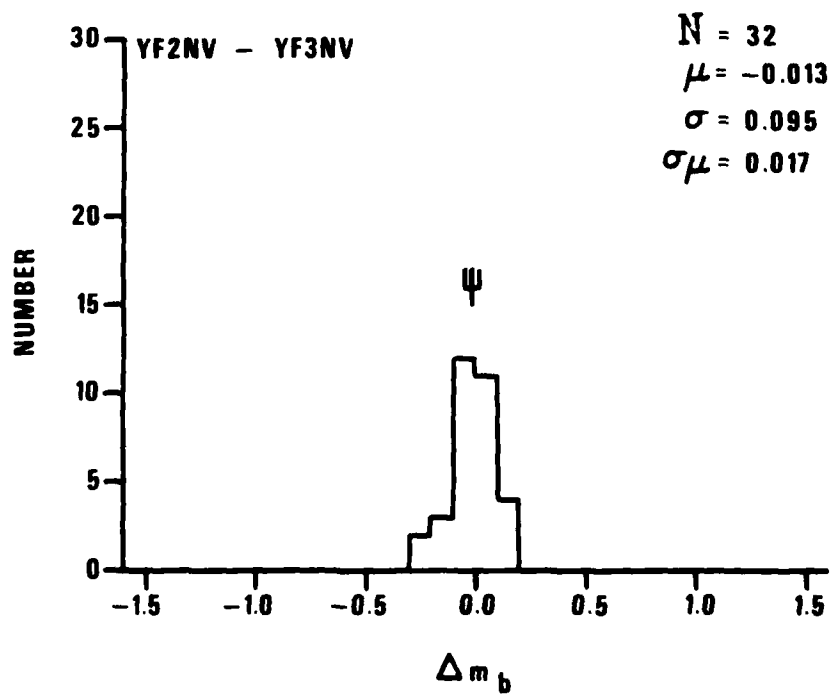
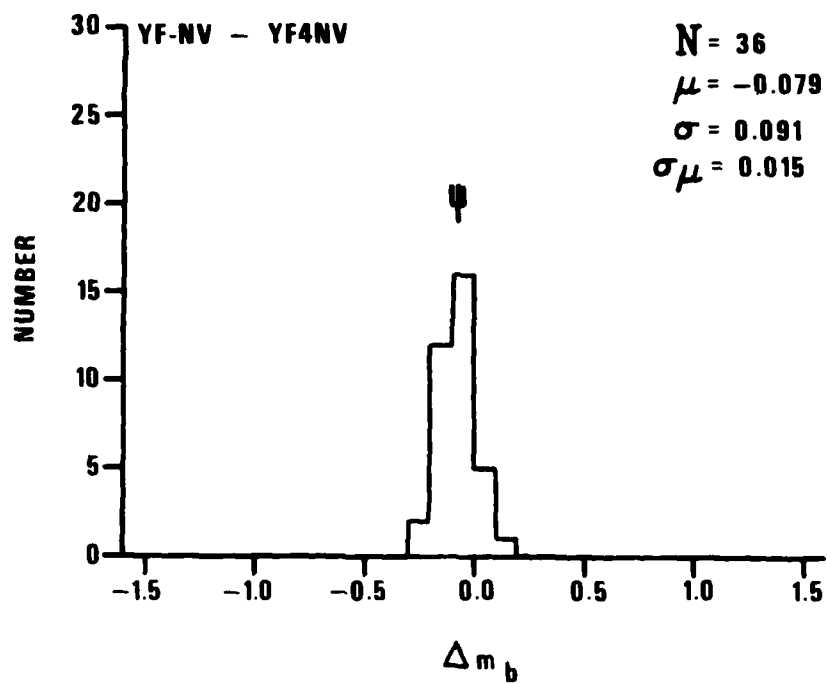


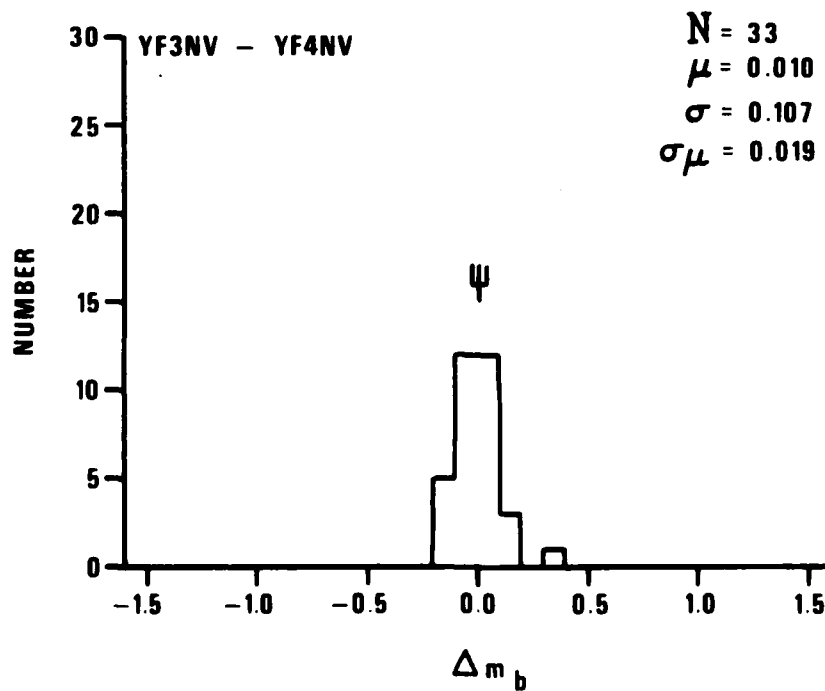
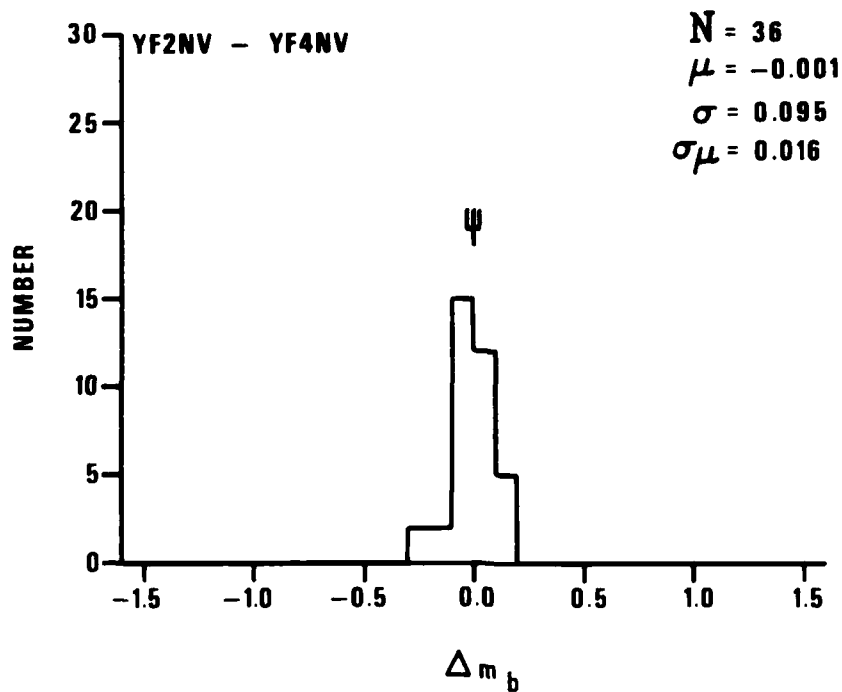






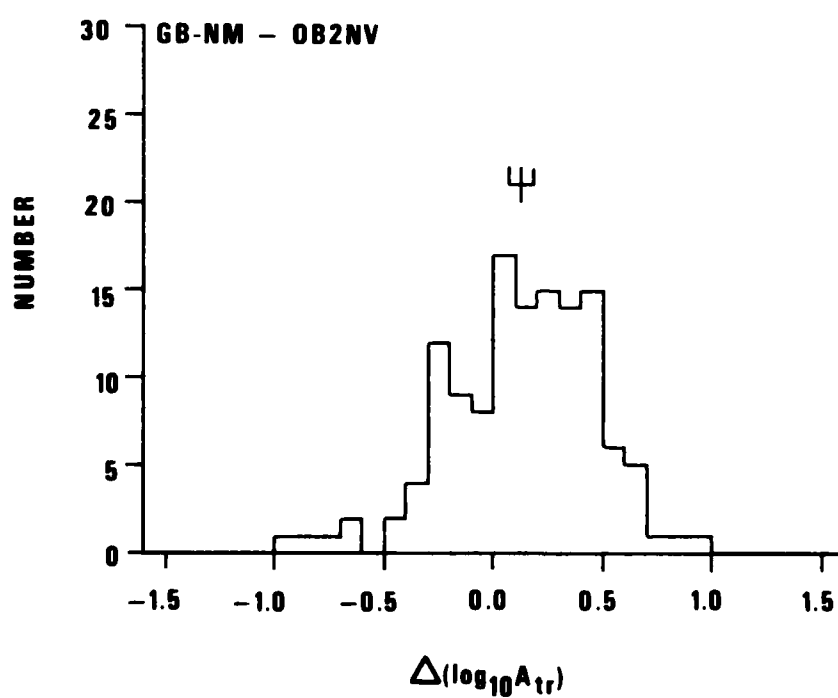
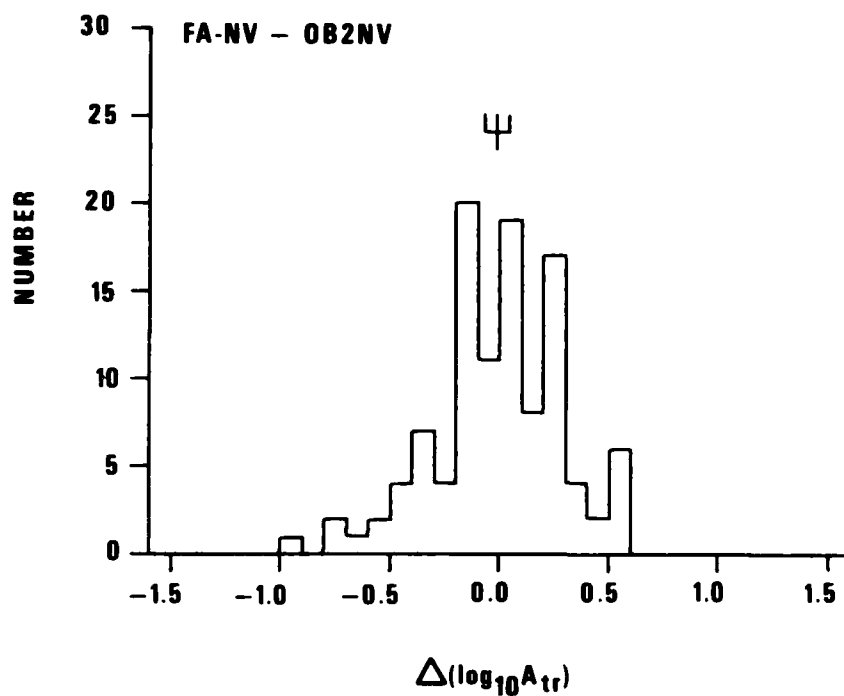


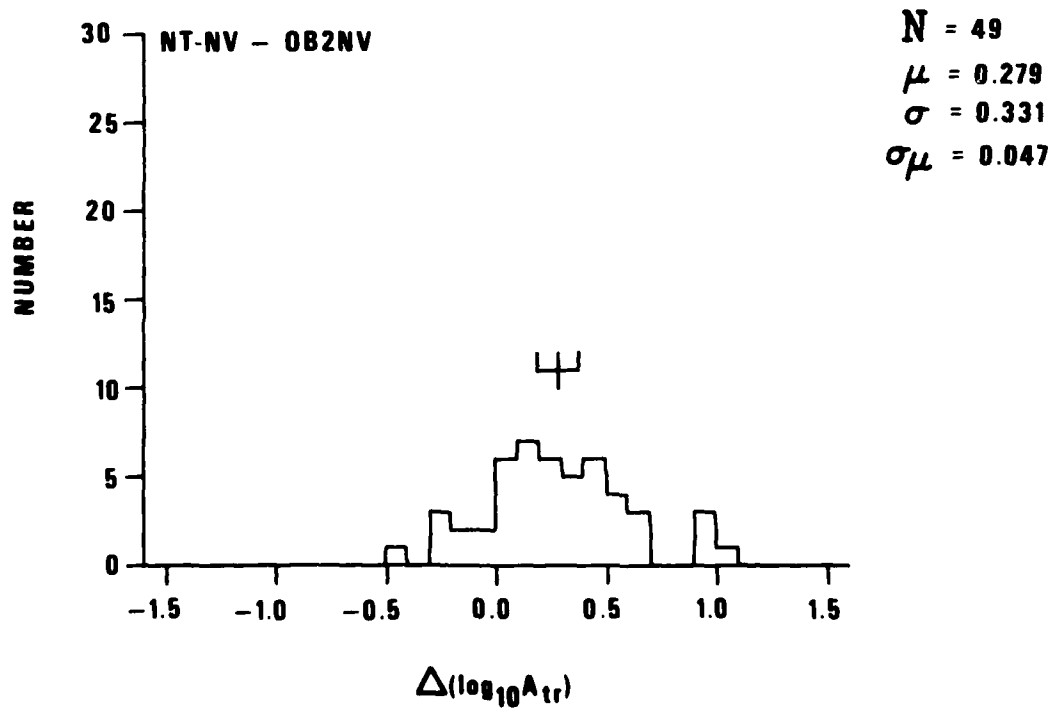
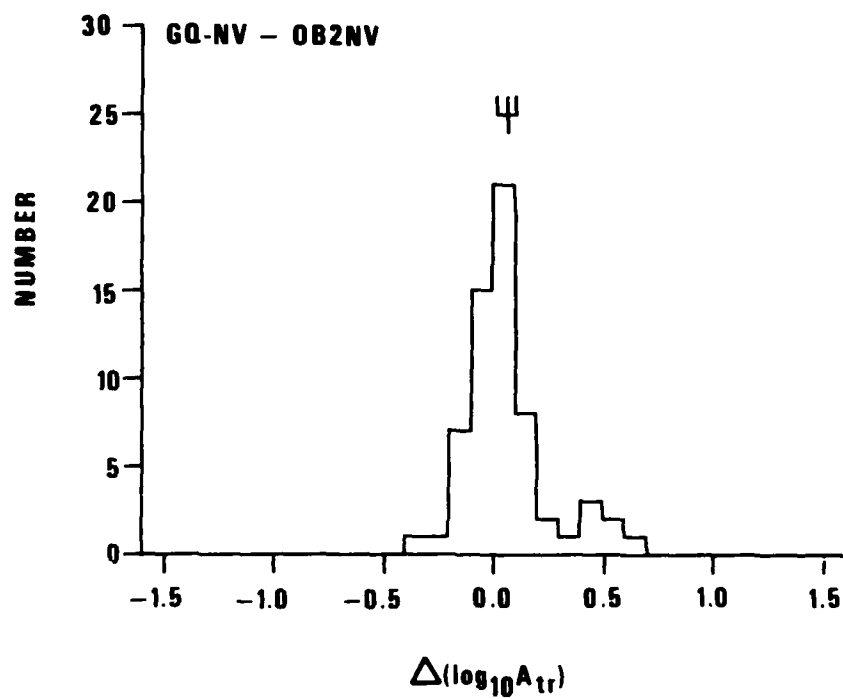


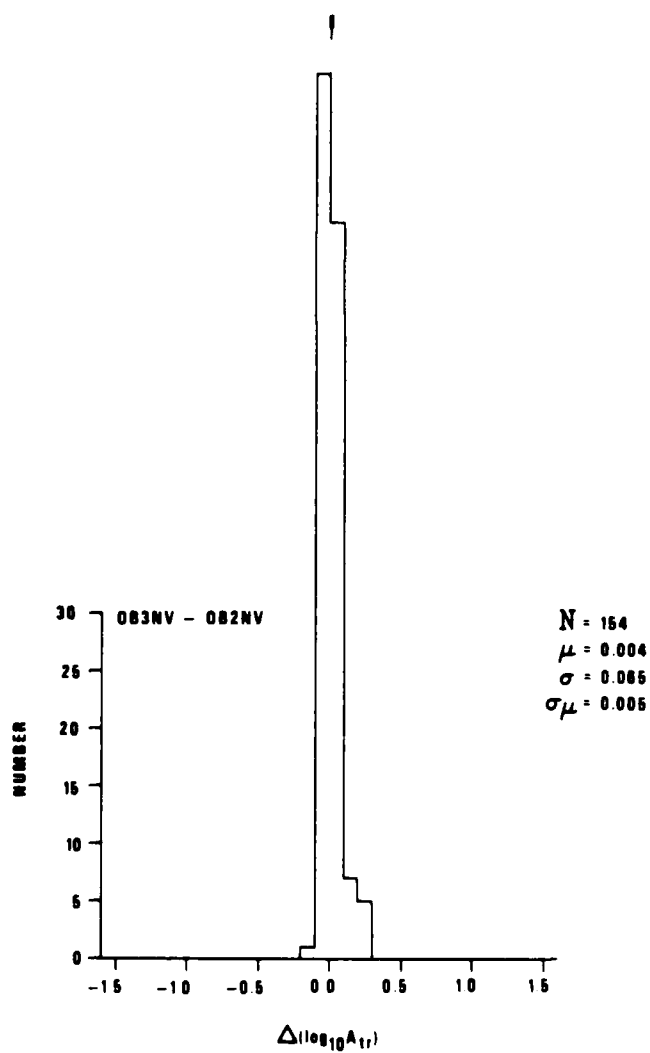
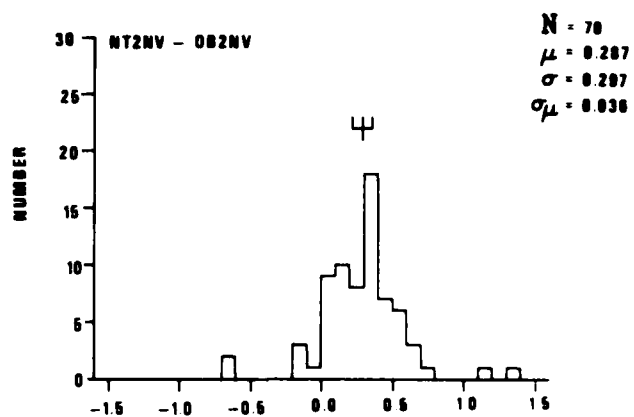


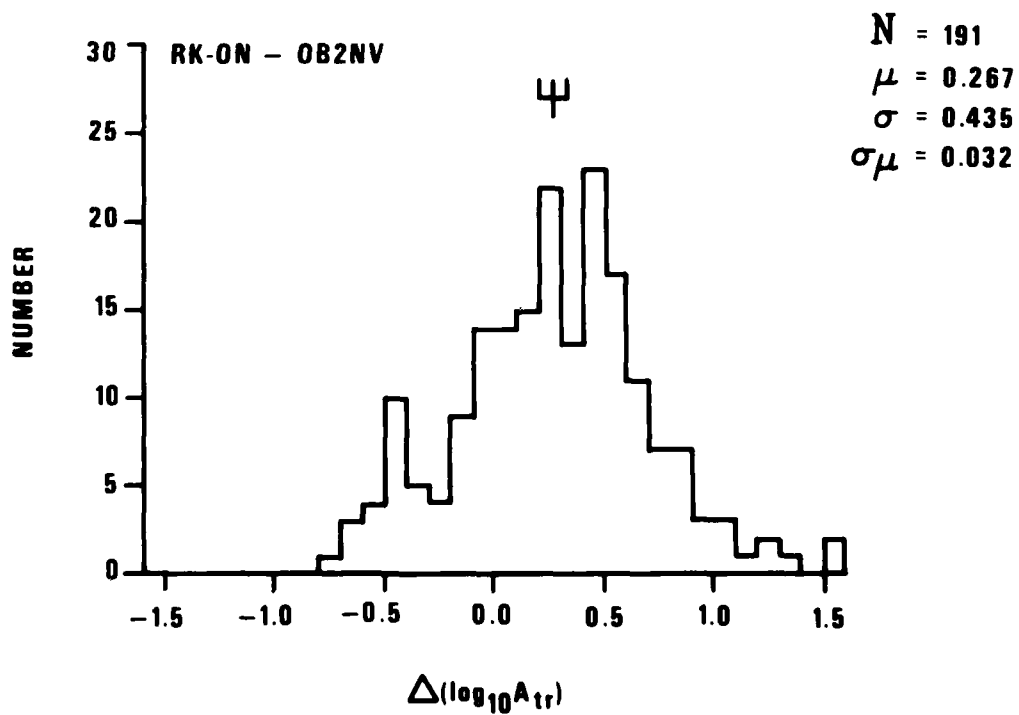
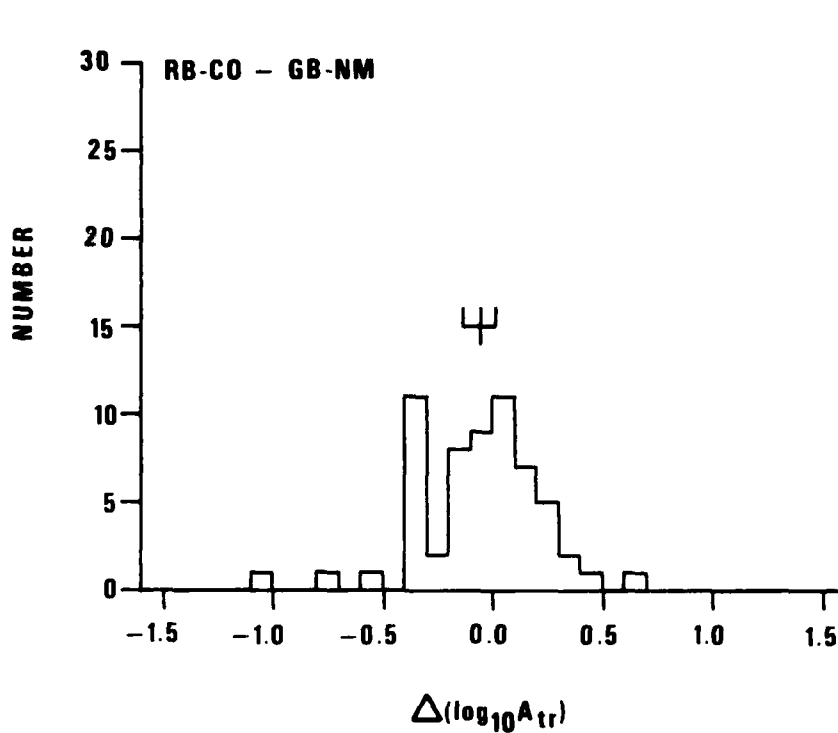
APPENDIX C

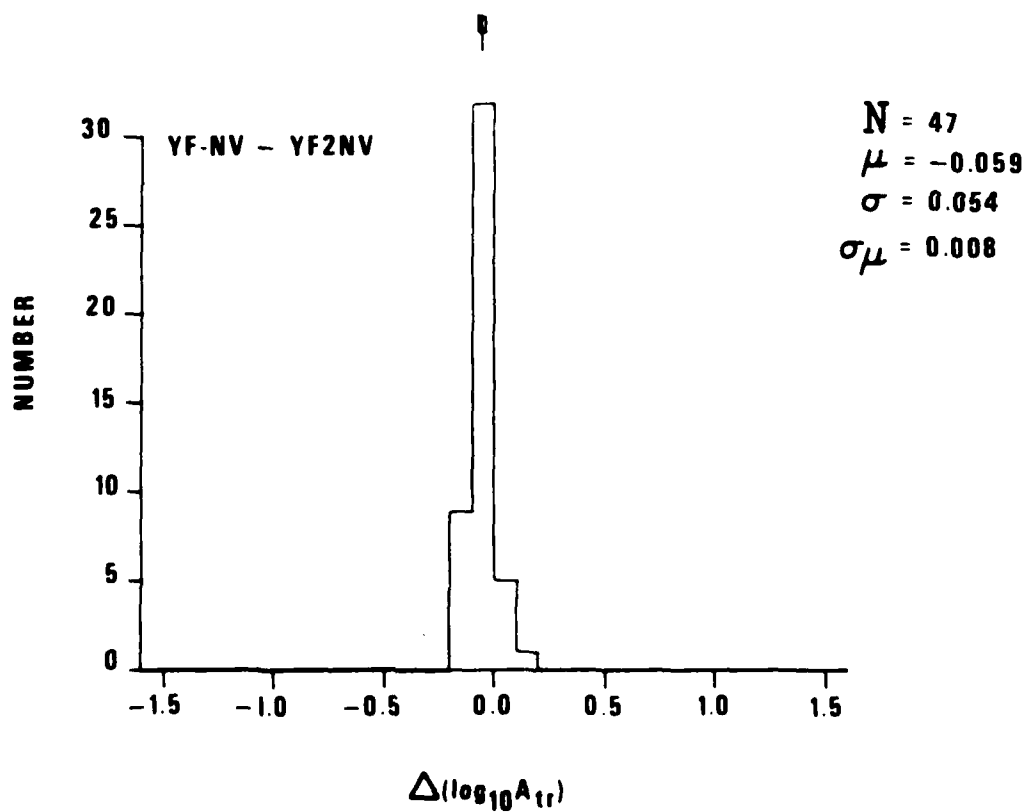
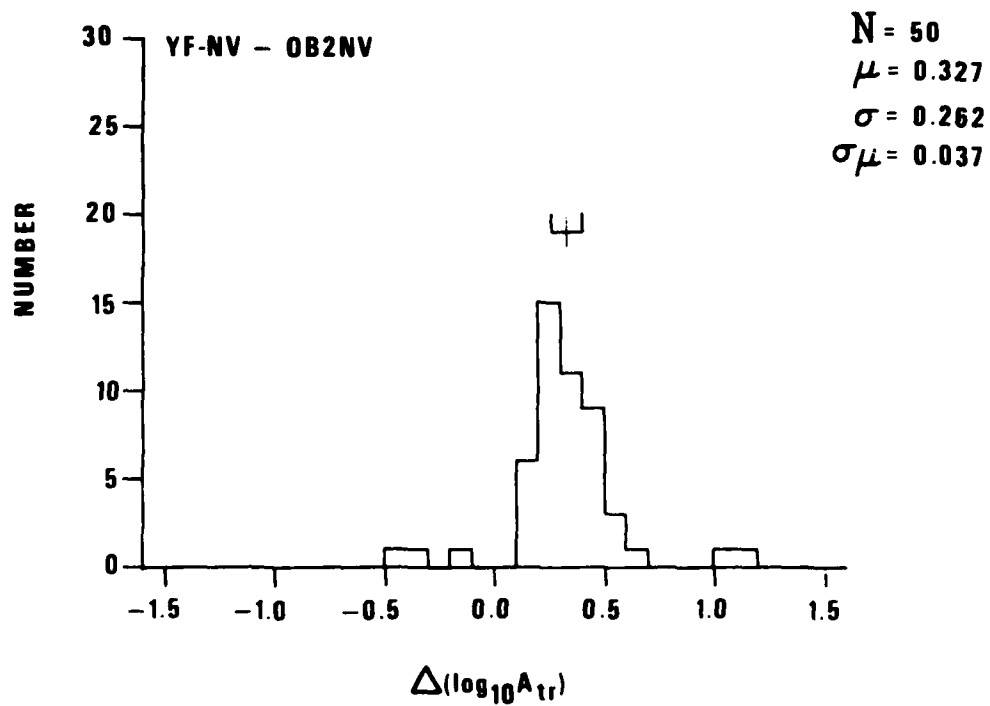
Histograms of Trace Amplitude Differentials ΔA_{tr} for
Various Pairs of SDCS Stations

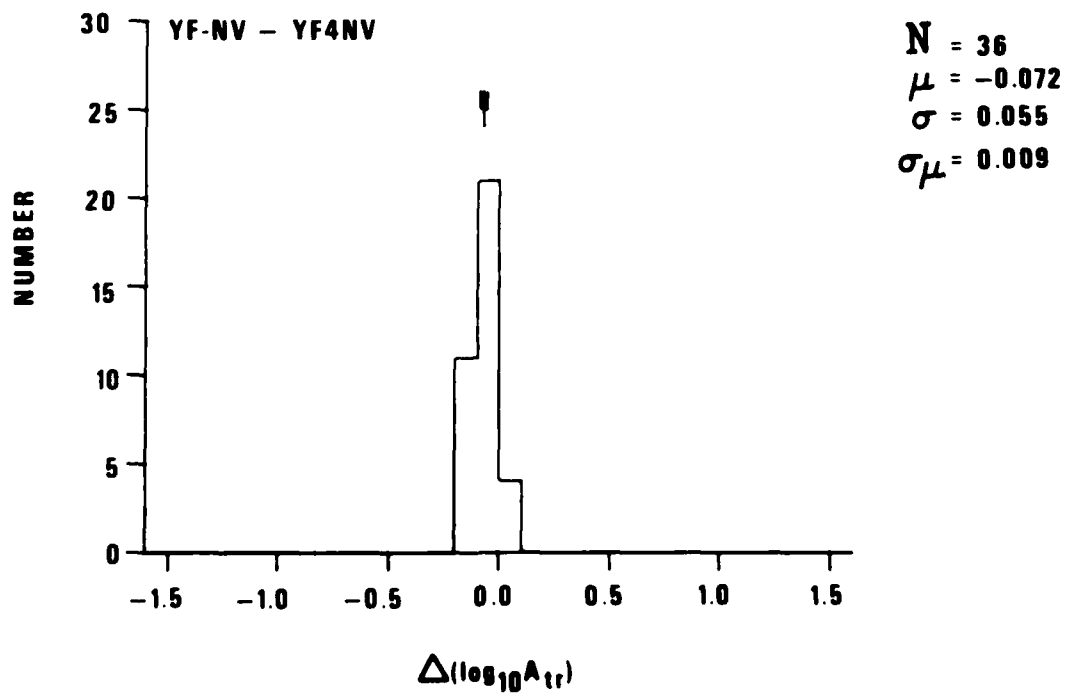
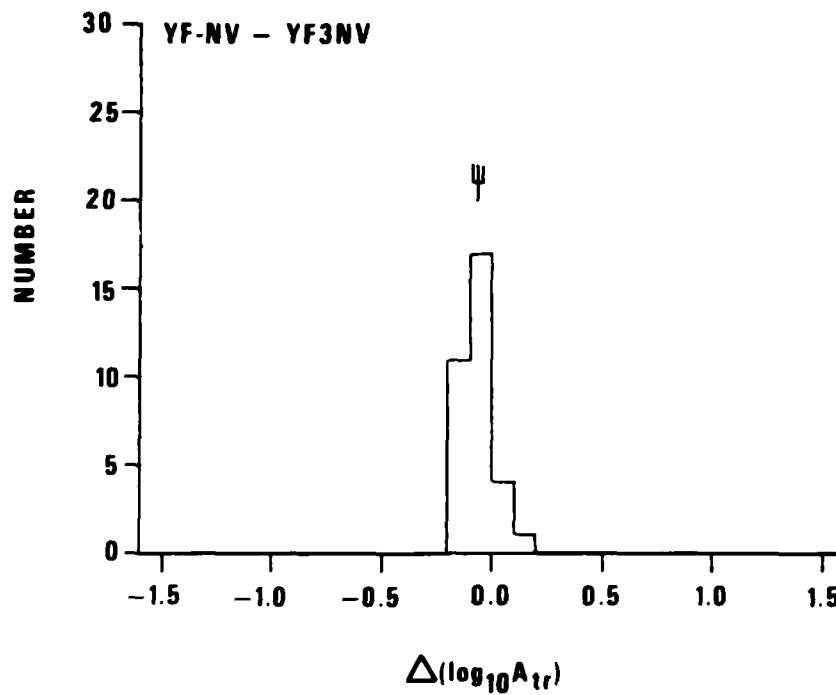


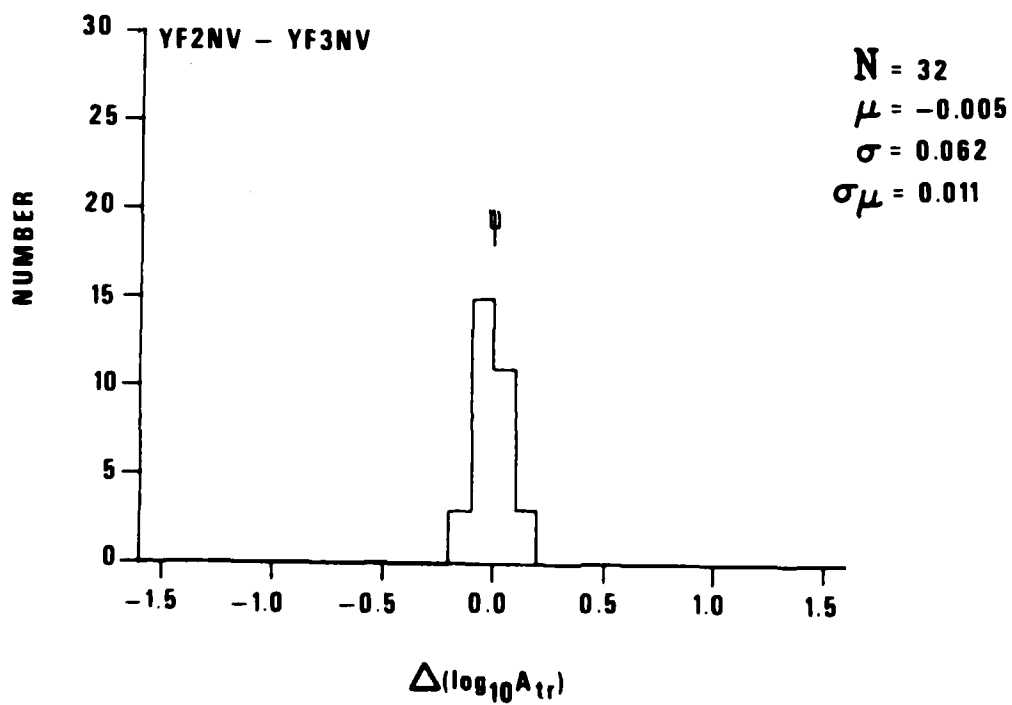
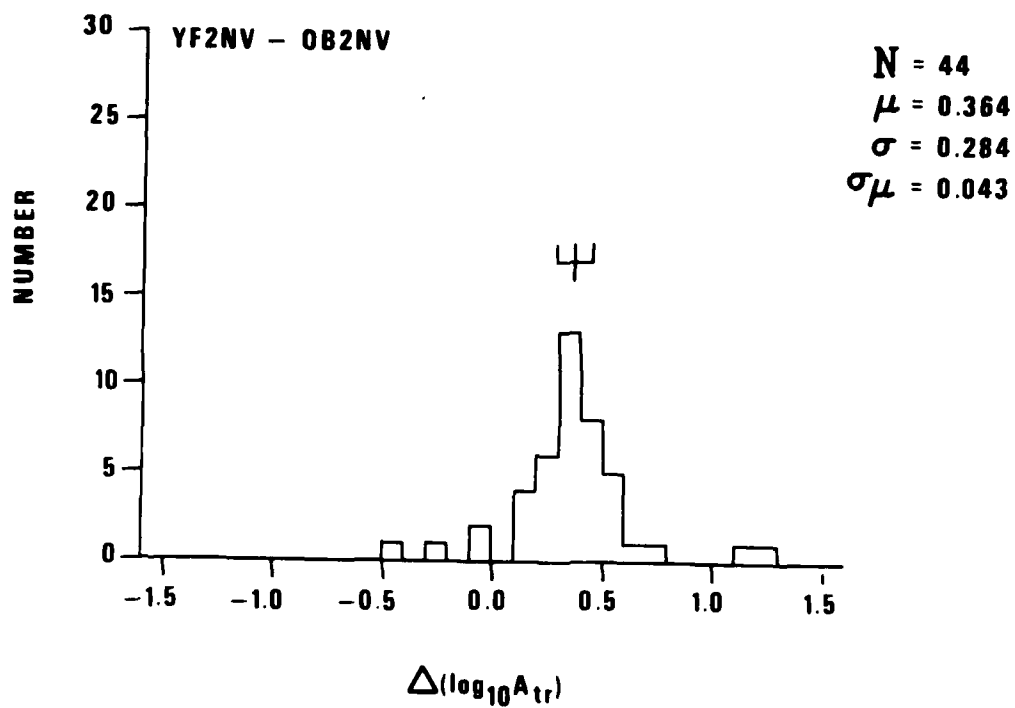


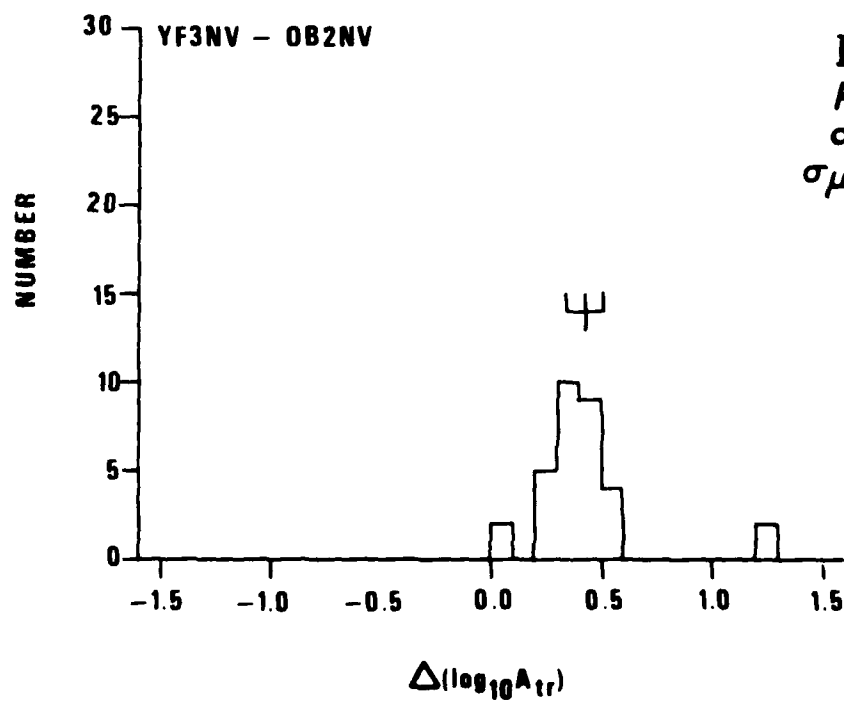
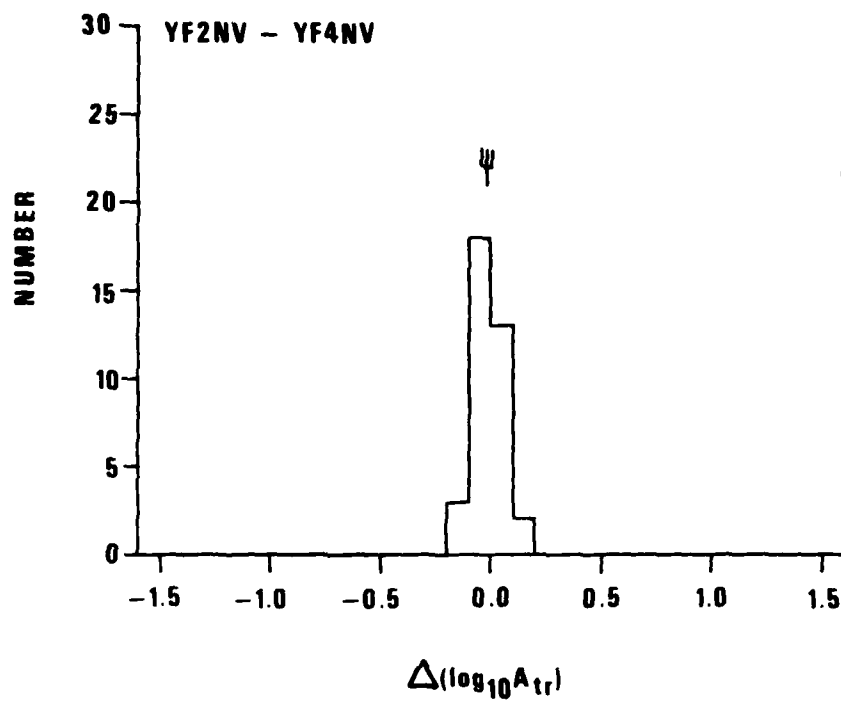


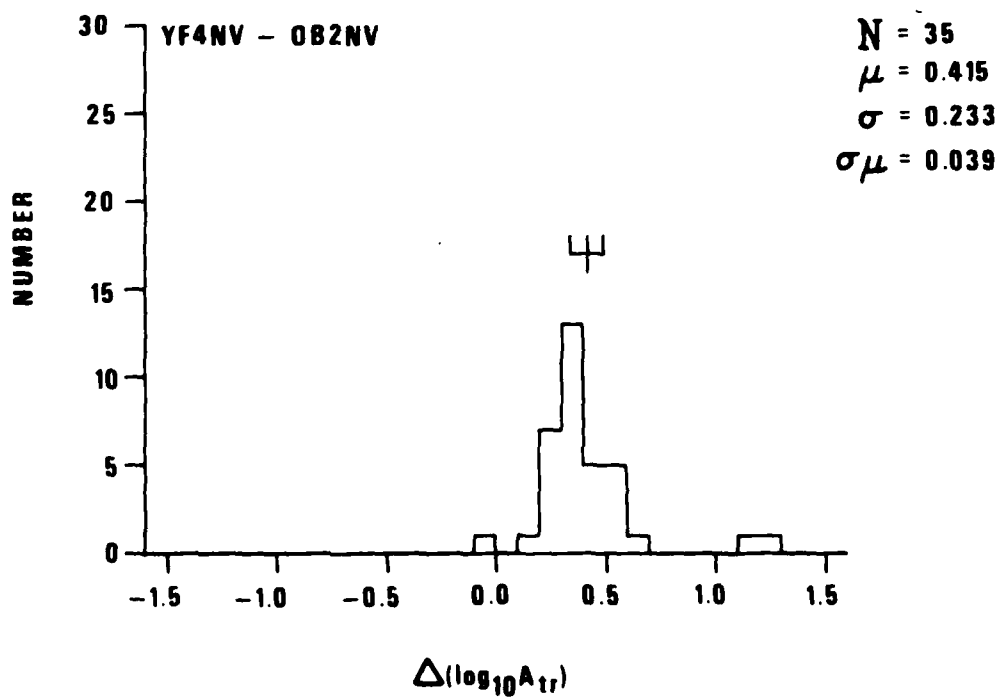
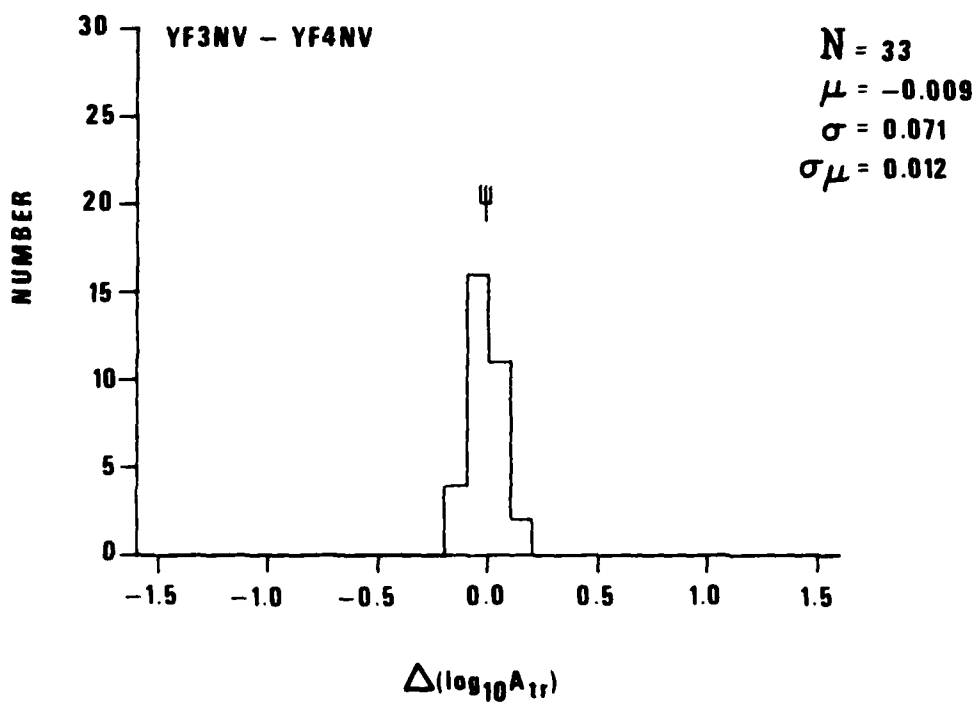




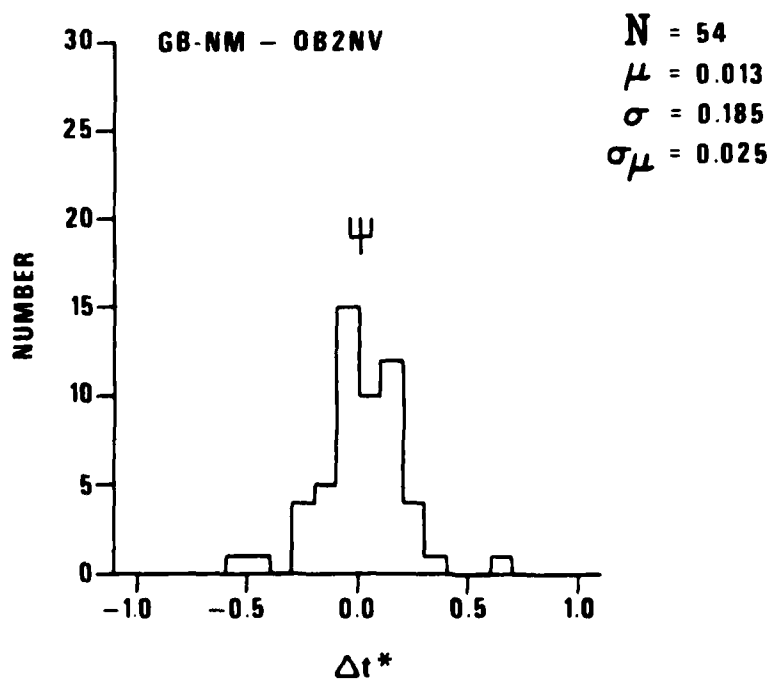
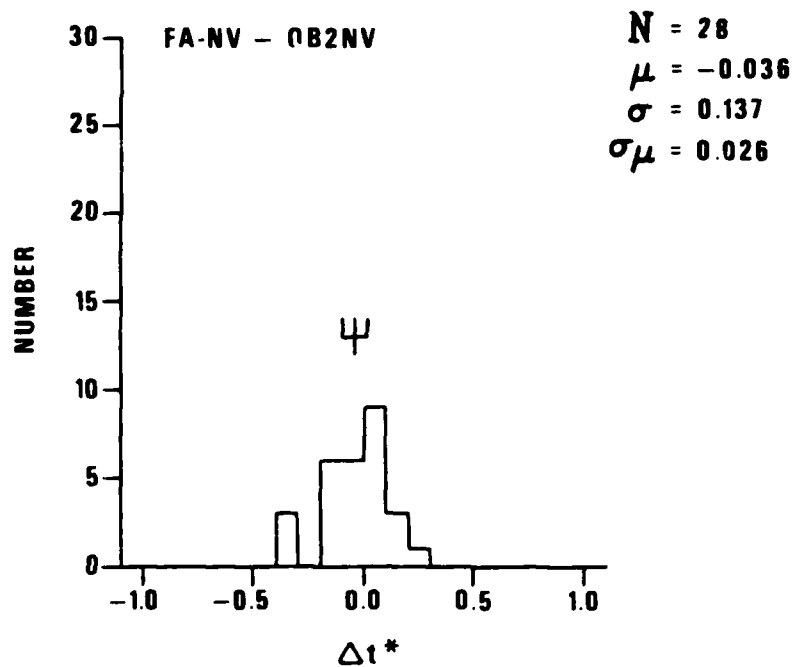


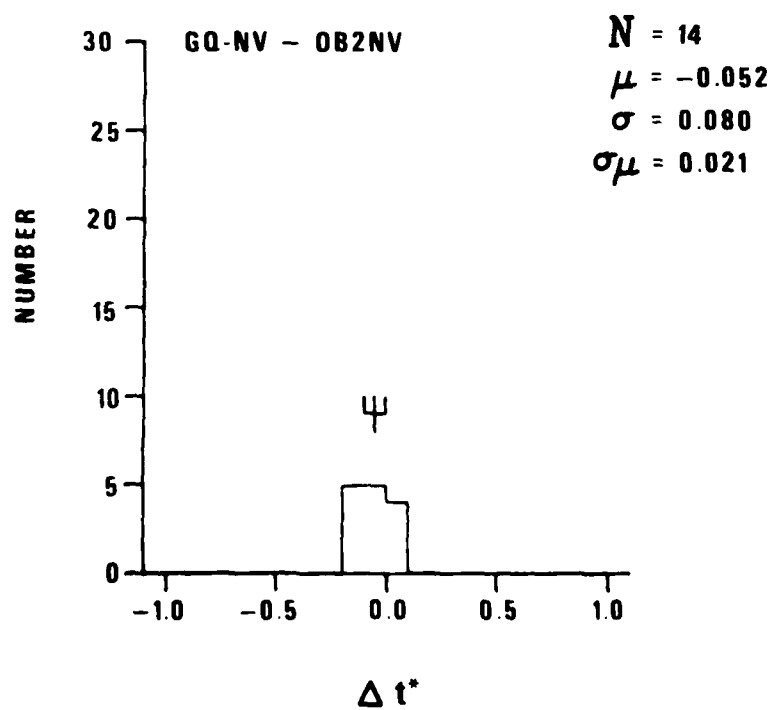
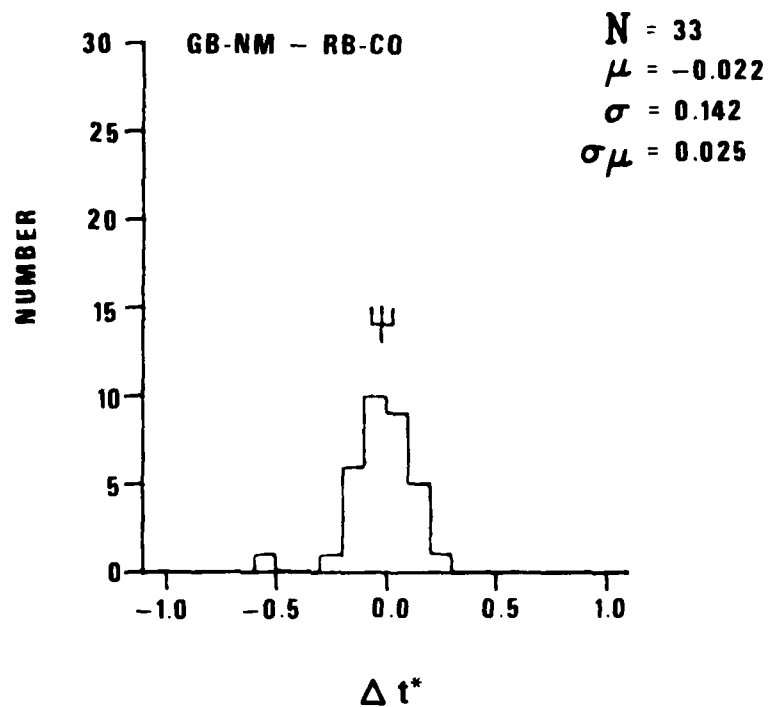


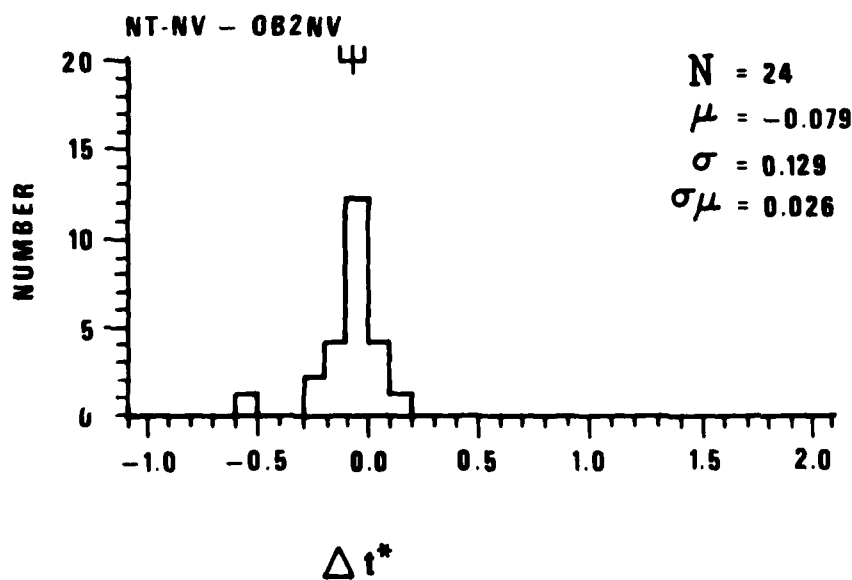
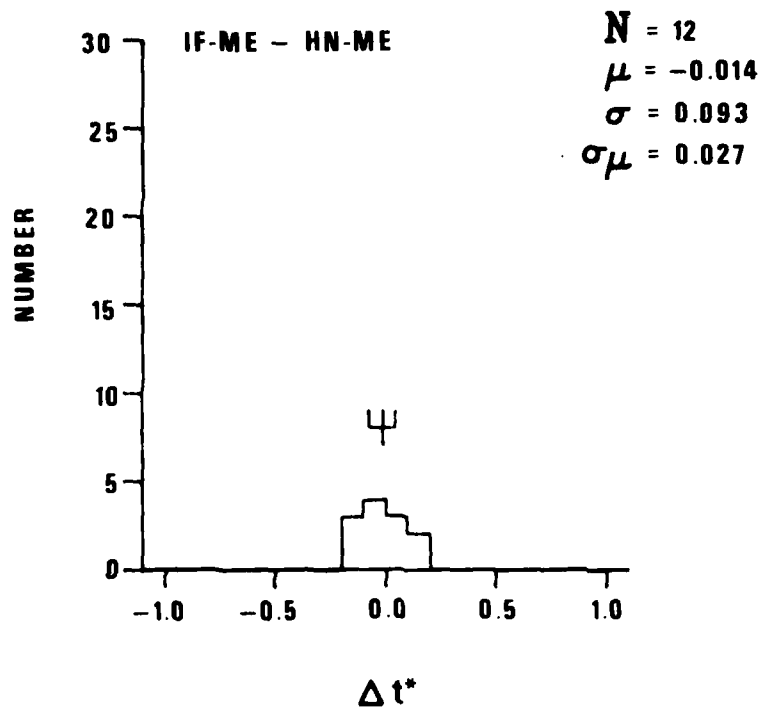


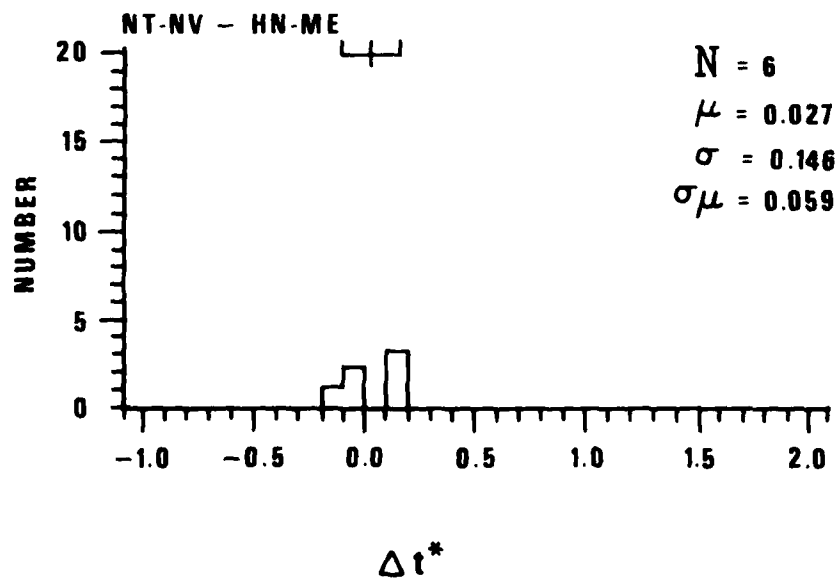
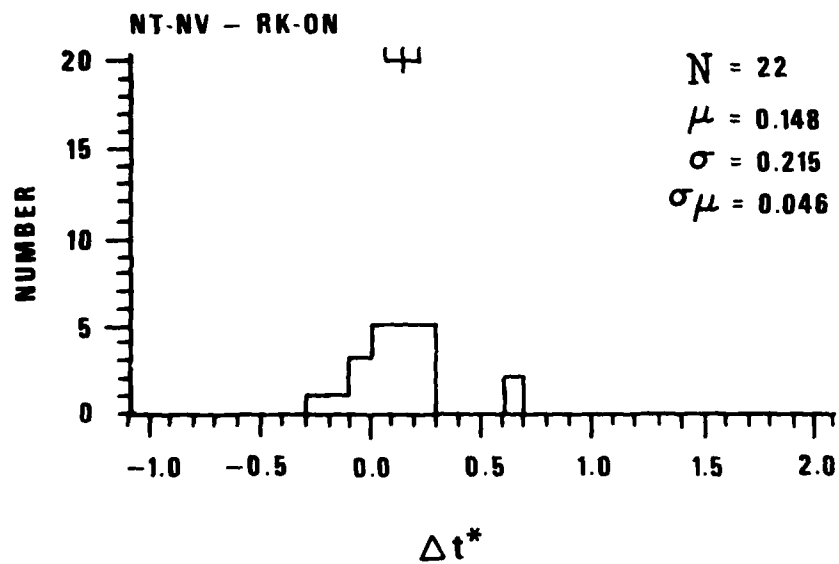


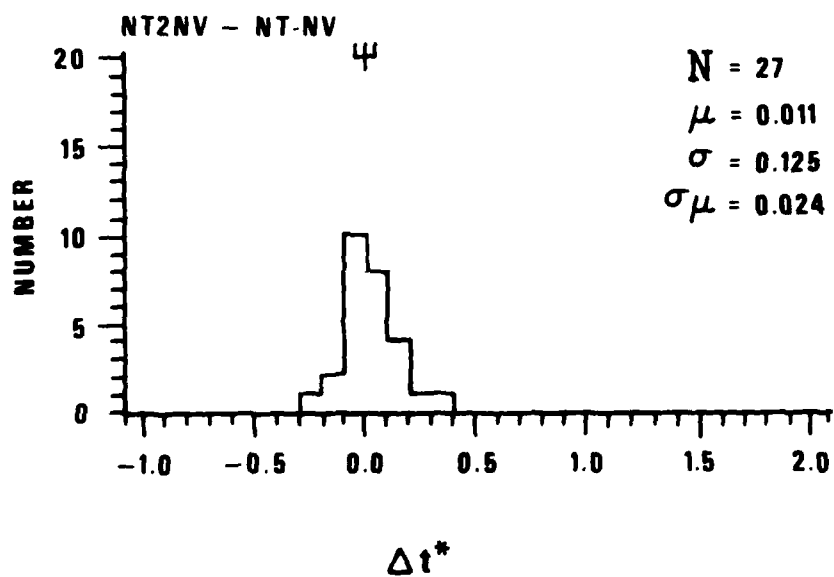
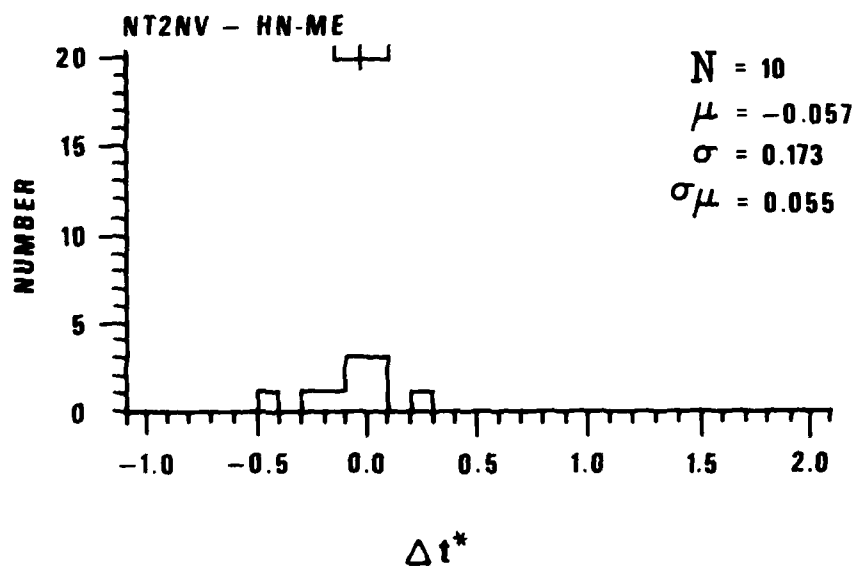
APPENDIX D
Histograms of Differentials Δt^* for Various Pairs of
SDCS Stations

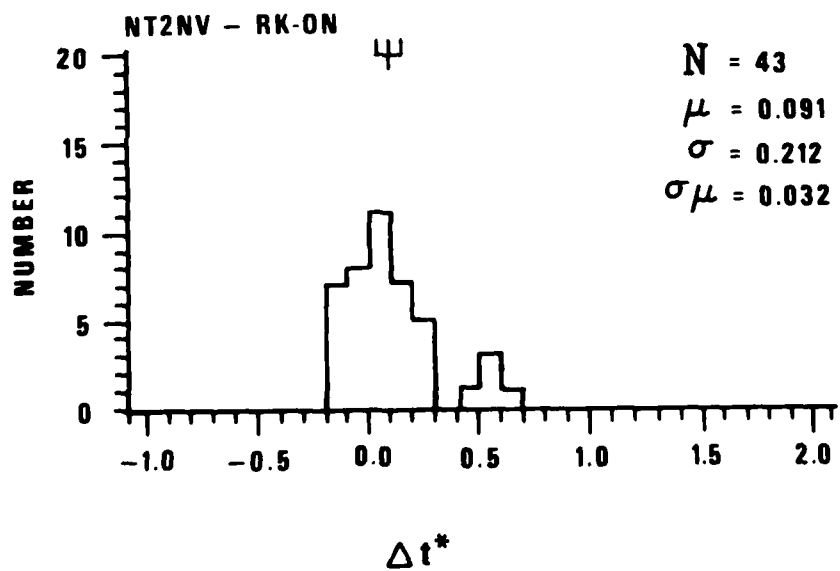
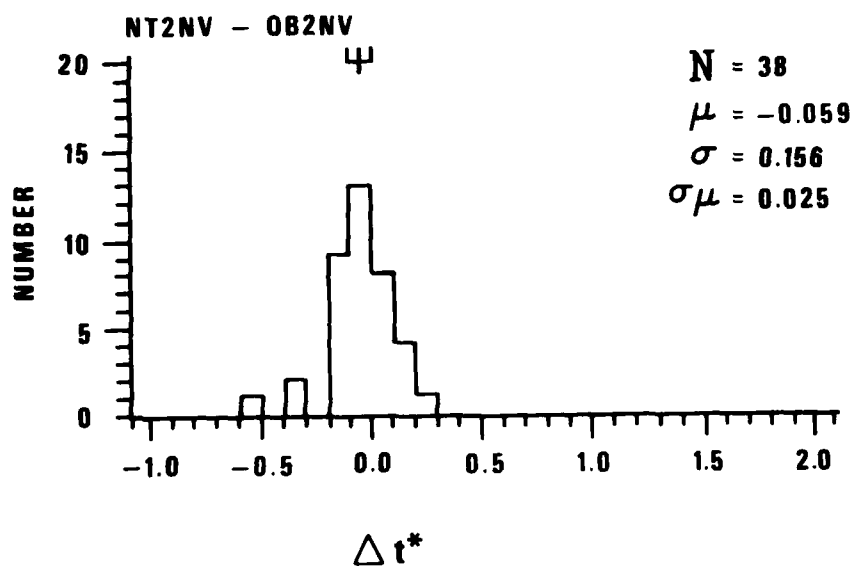


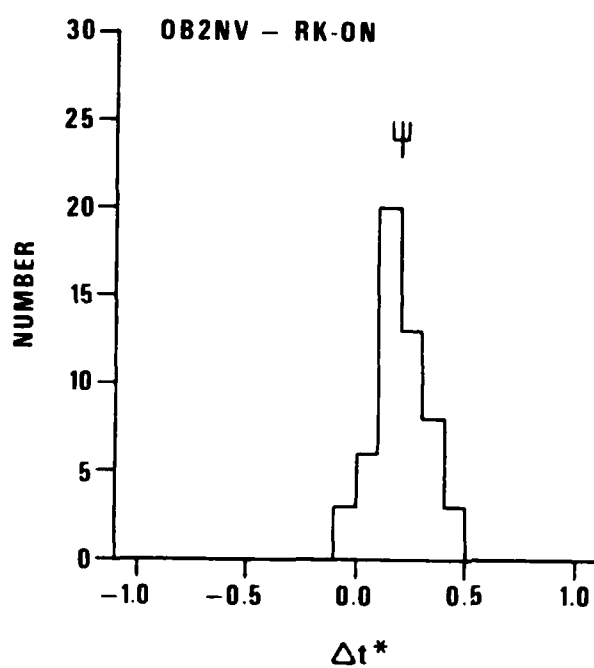




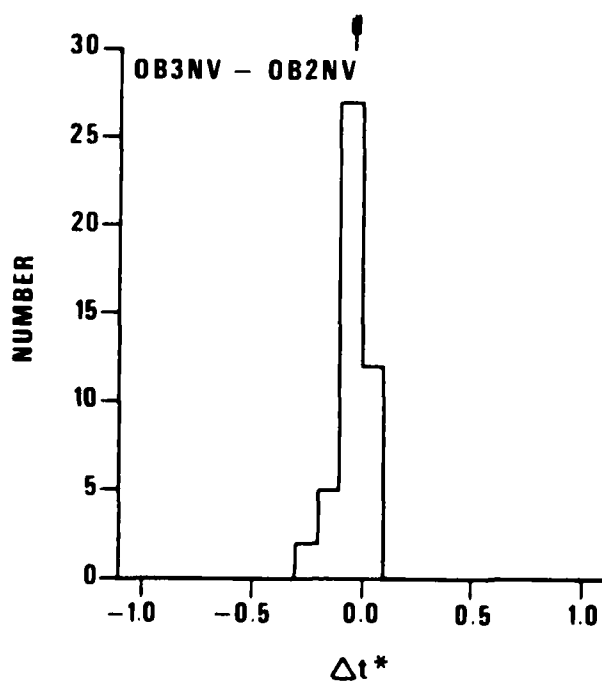




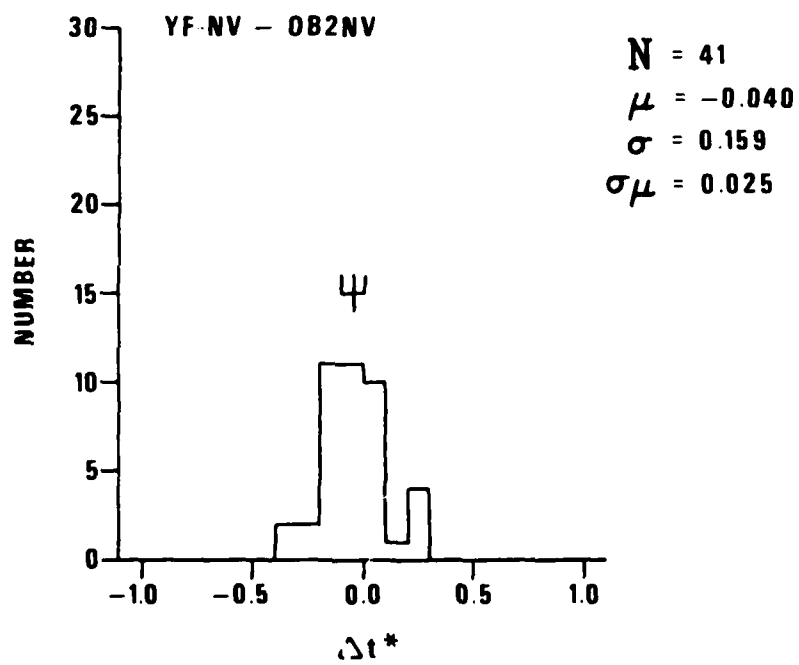
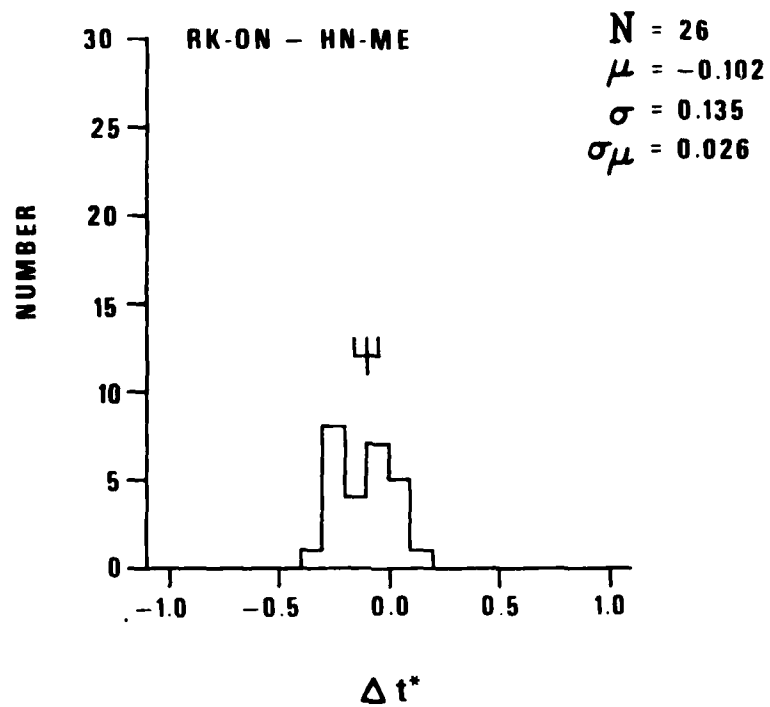


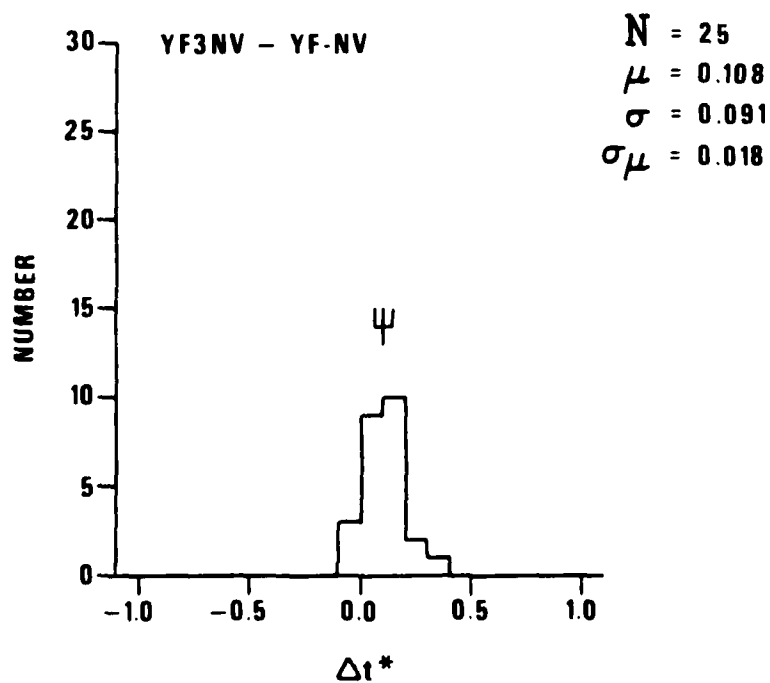
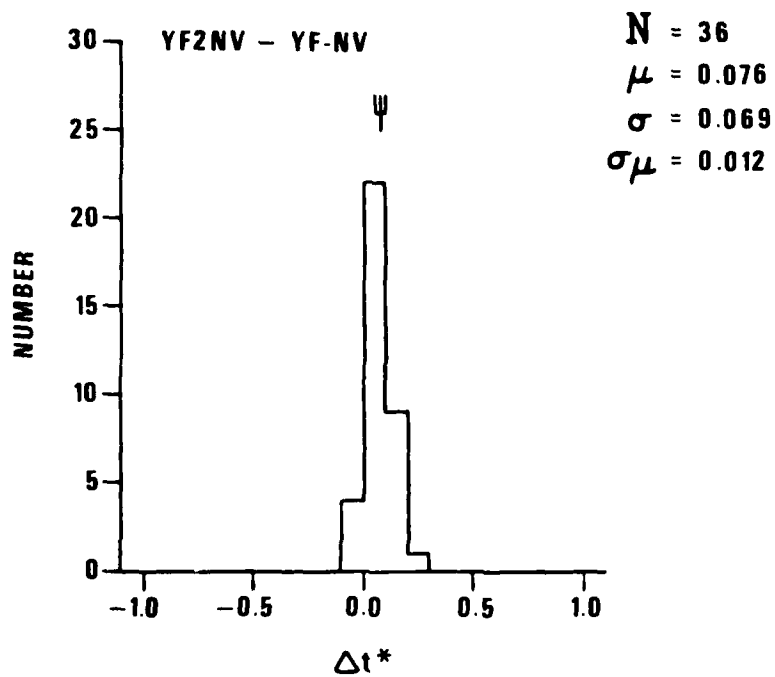


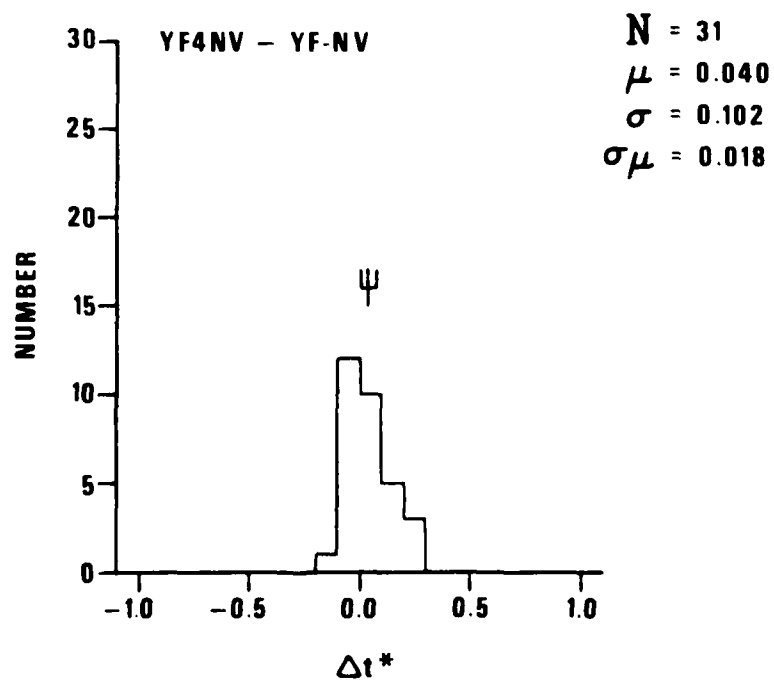
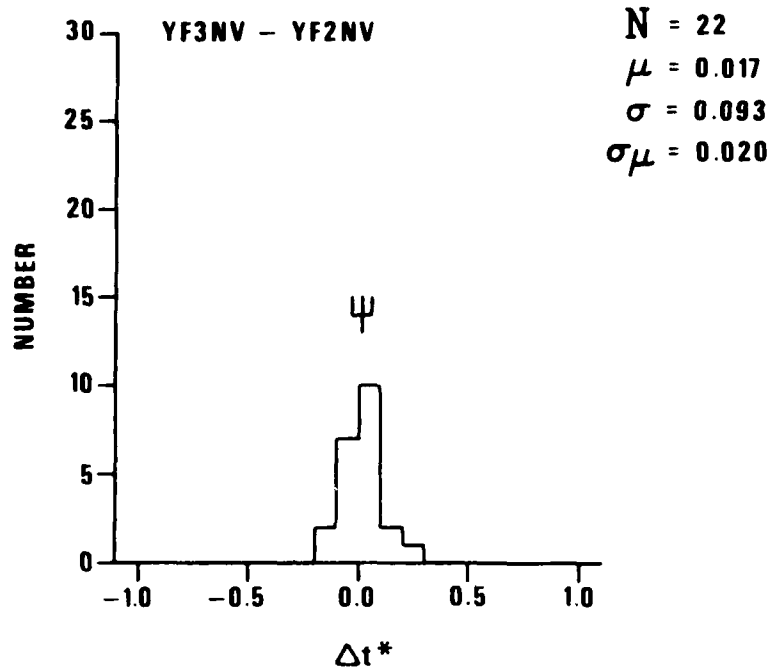
$N = 53$
 $\mu = 0.203$
 $\sigma = 0.130$
 $\sigma_{\mu} = 0.018$

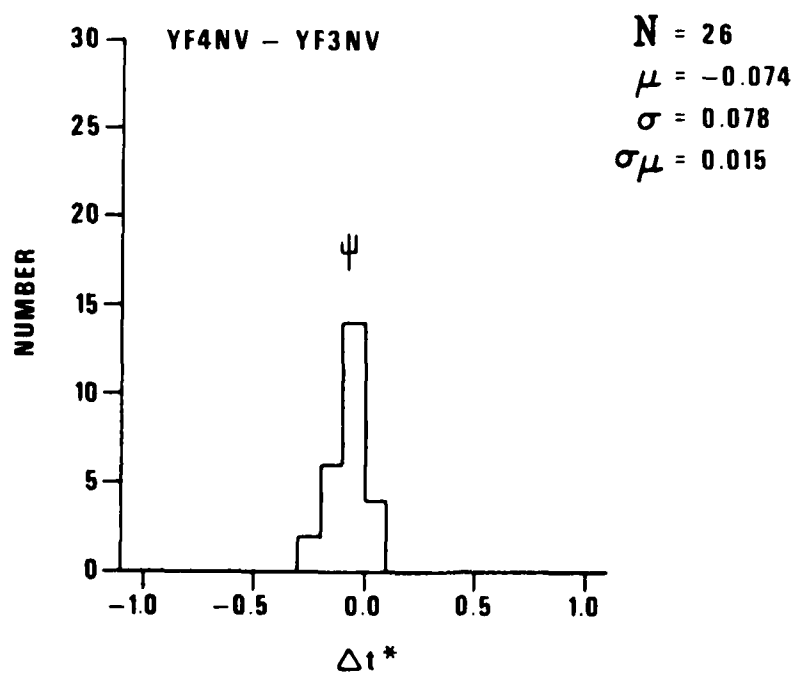
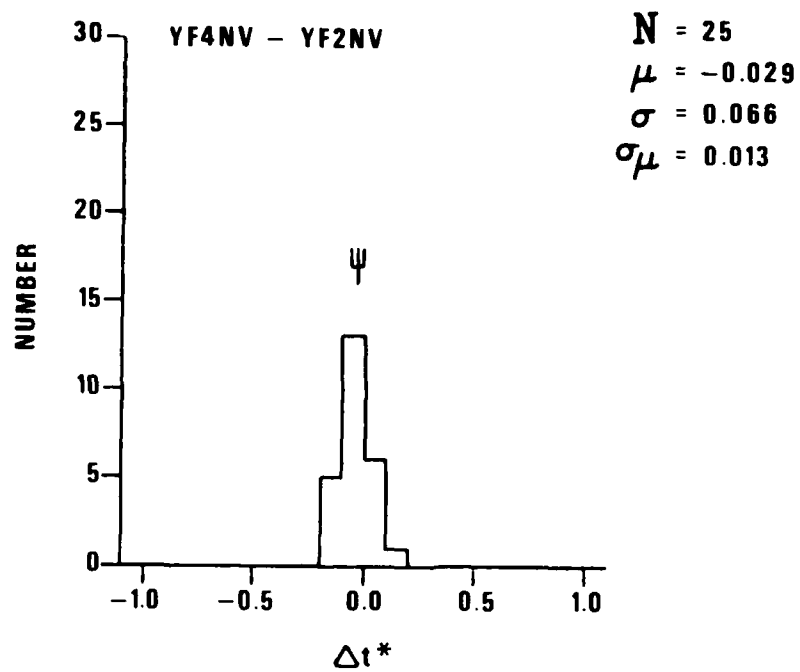


$N = 46$
 $\mu = -0.036$
 $\sigma = 0.065$
 $\sigma_{\mu} = 0.010$



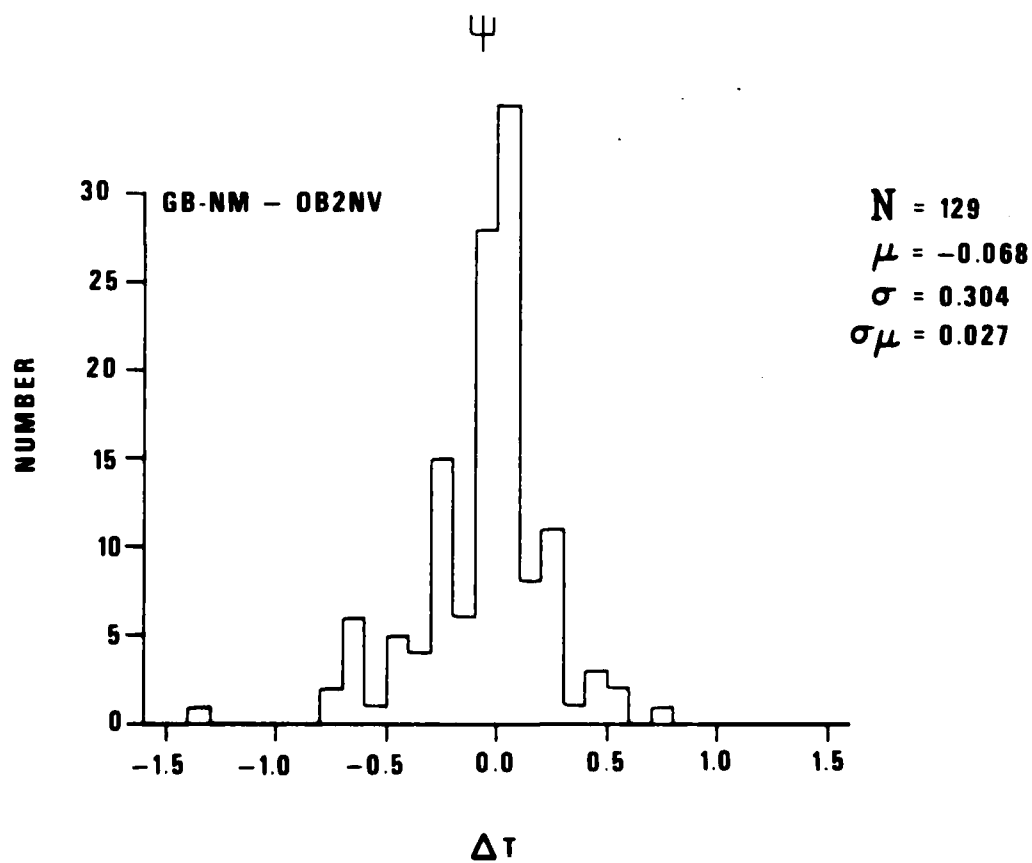
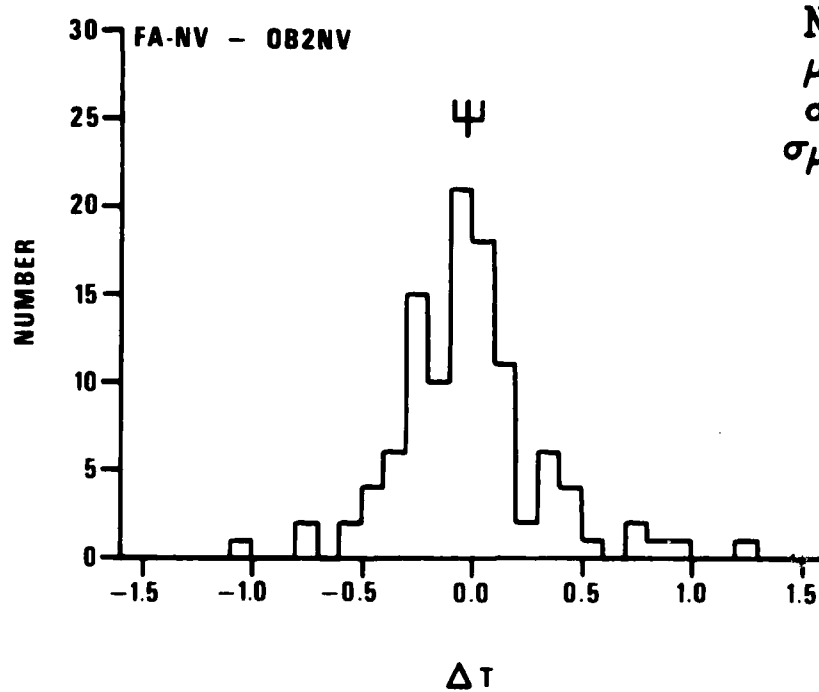


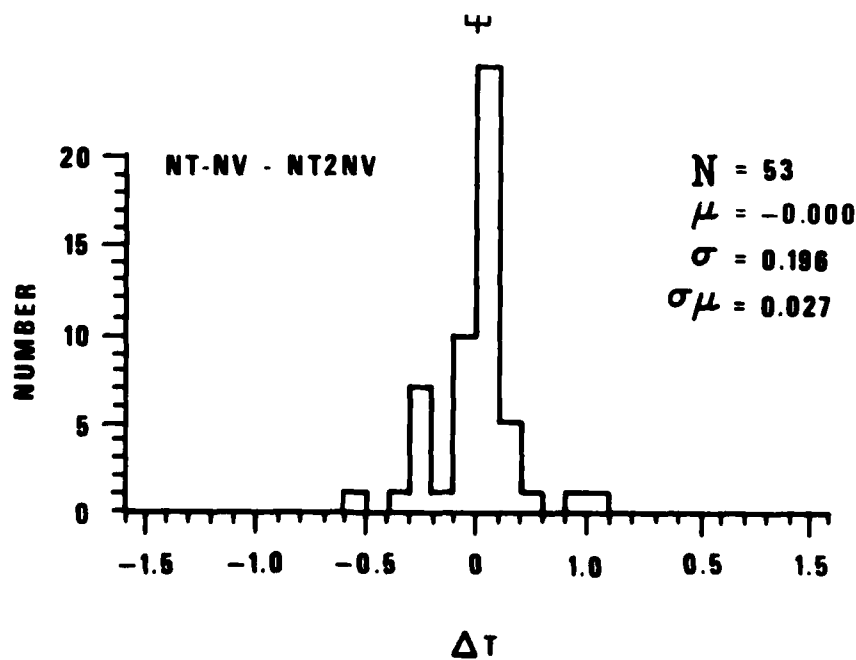
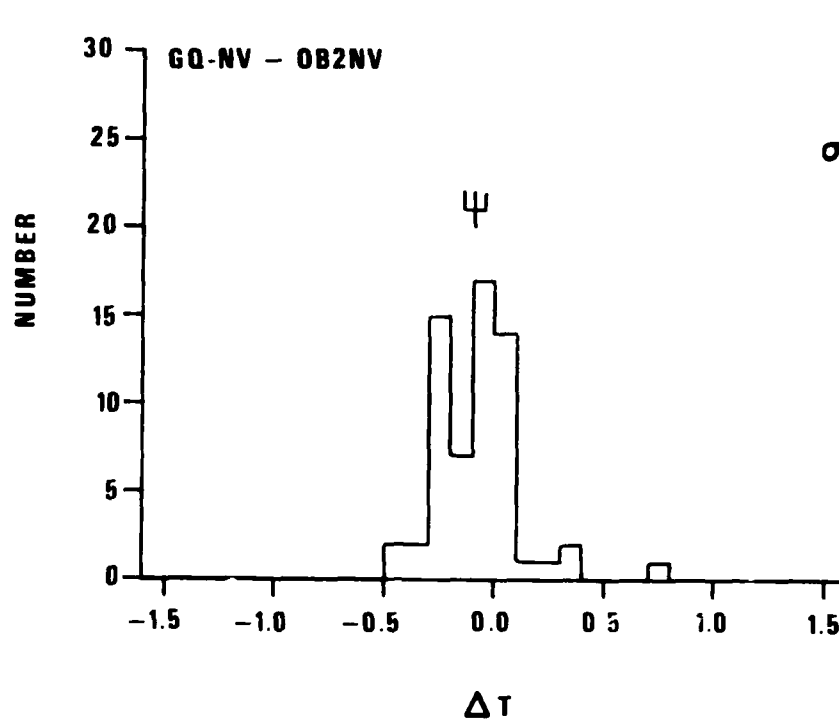


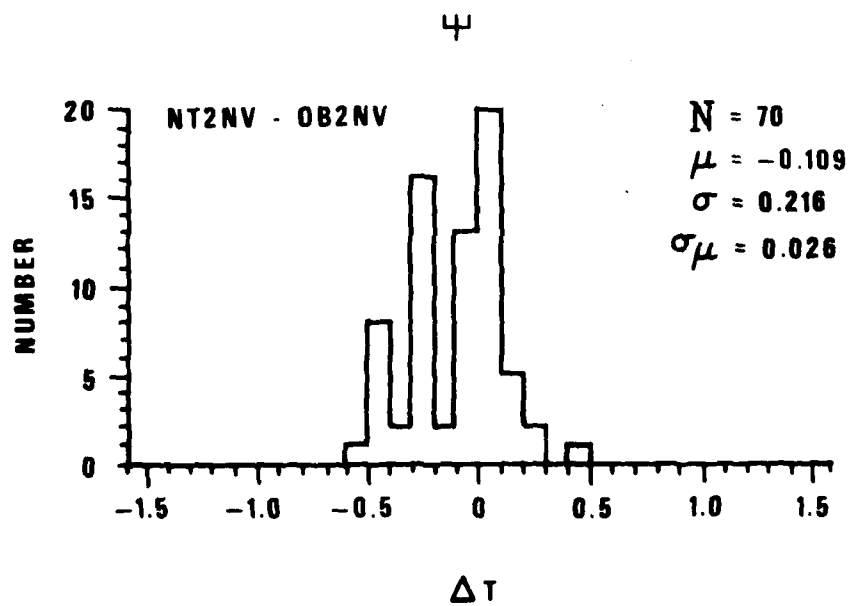
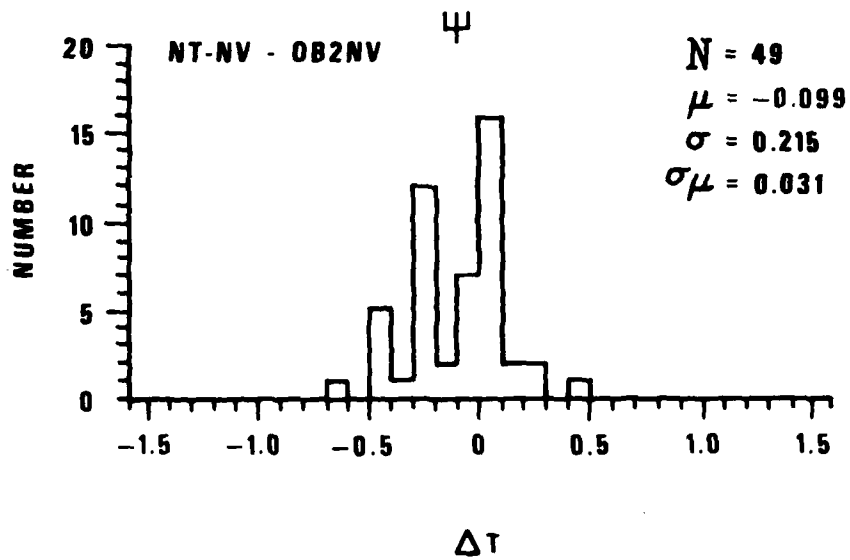


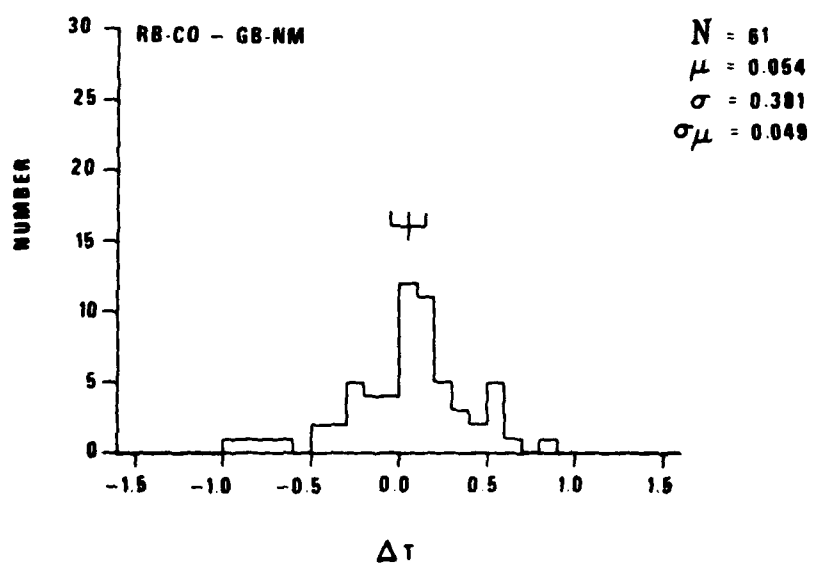
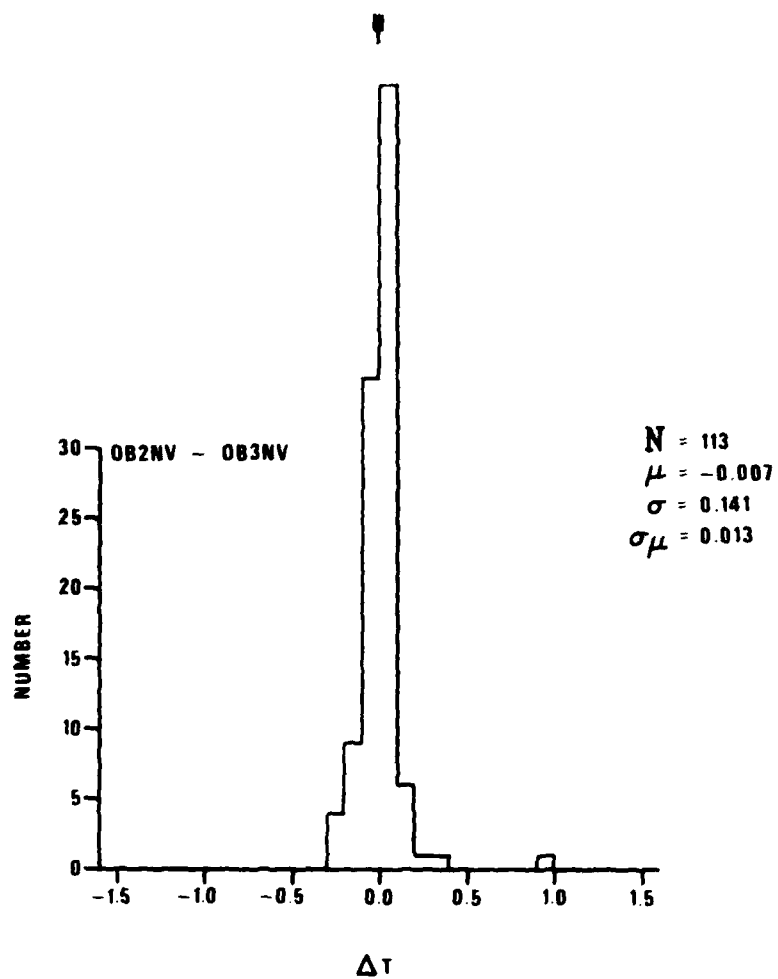
APPENDIX E

Histograms of Dominant Period Differentials ΔT for
Various Pairs of SDCS Stations

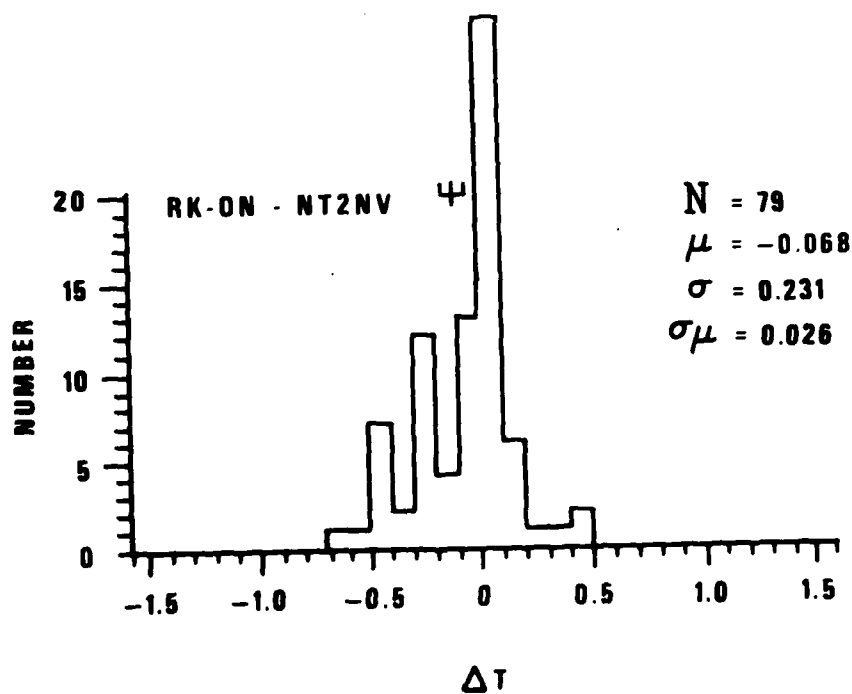
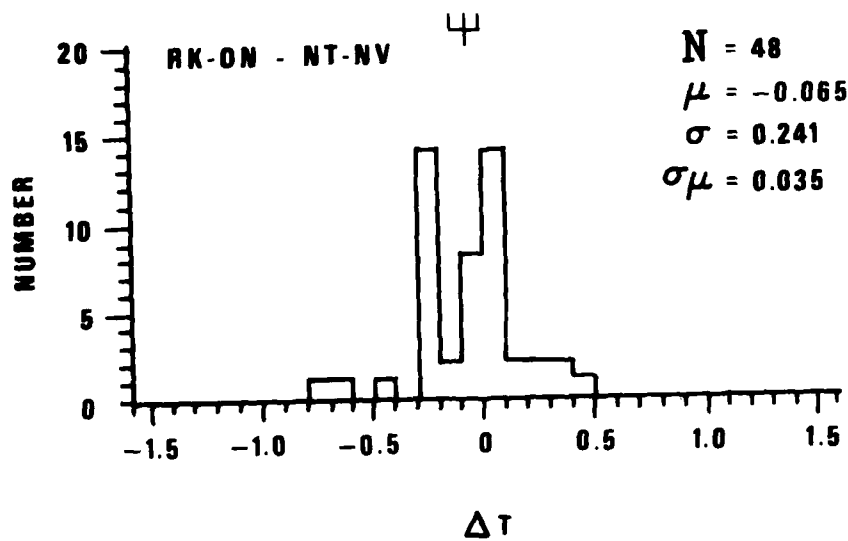


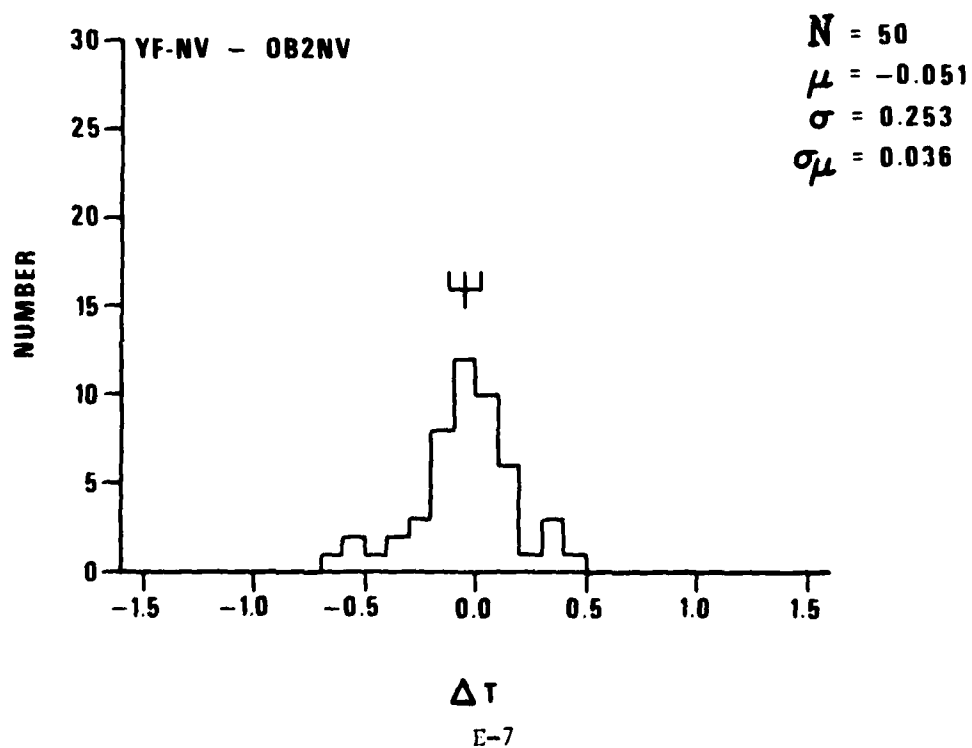
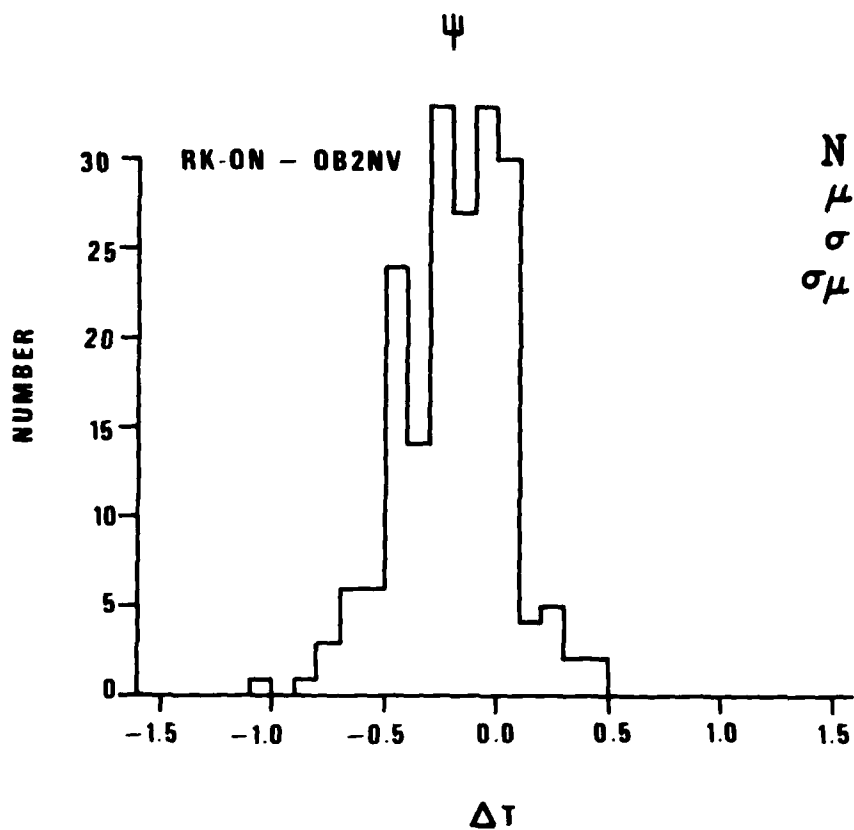


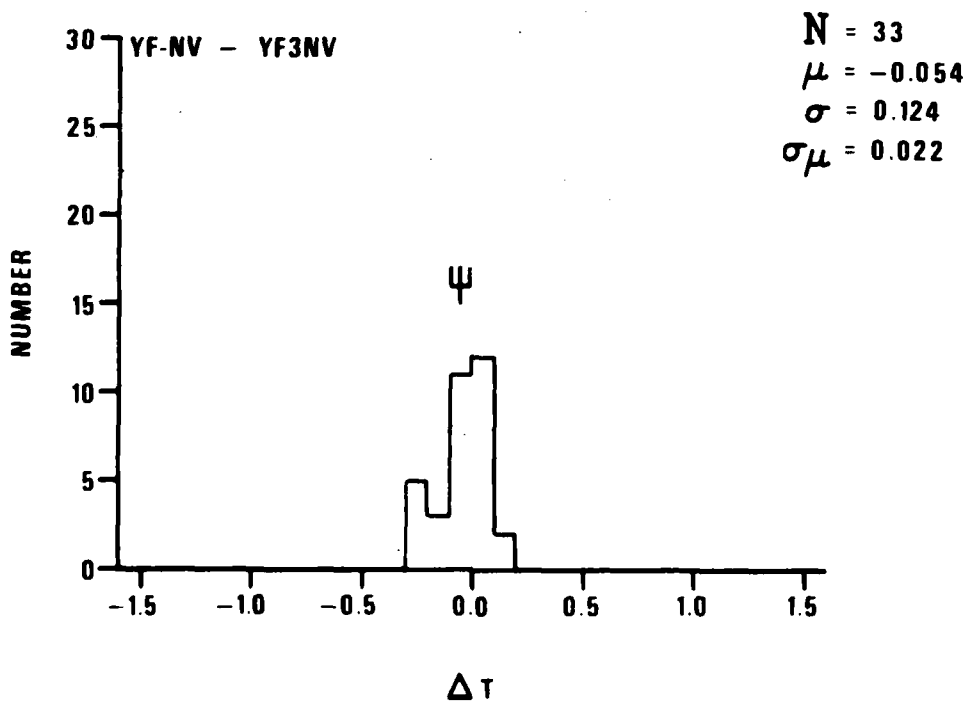
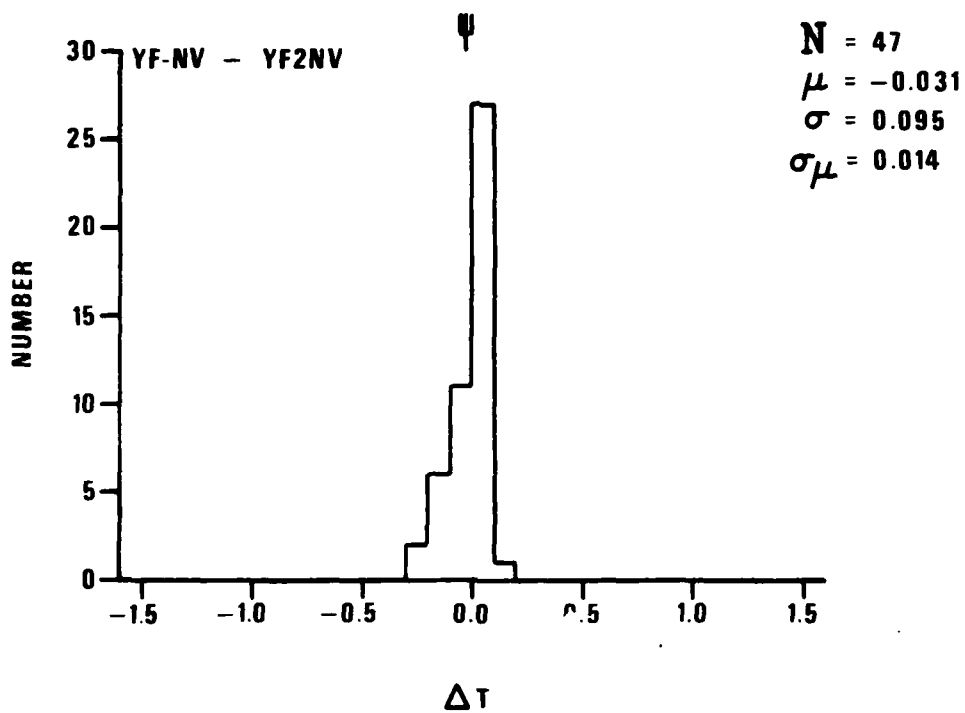


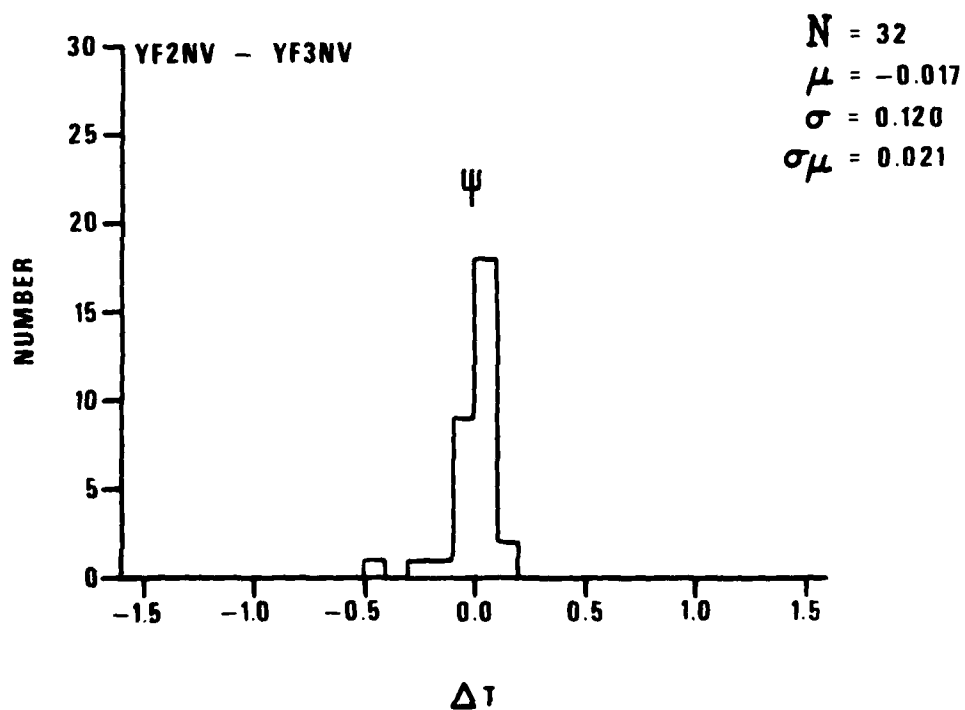
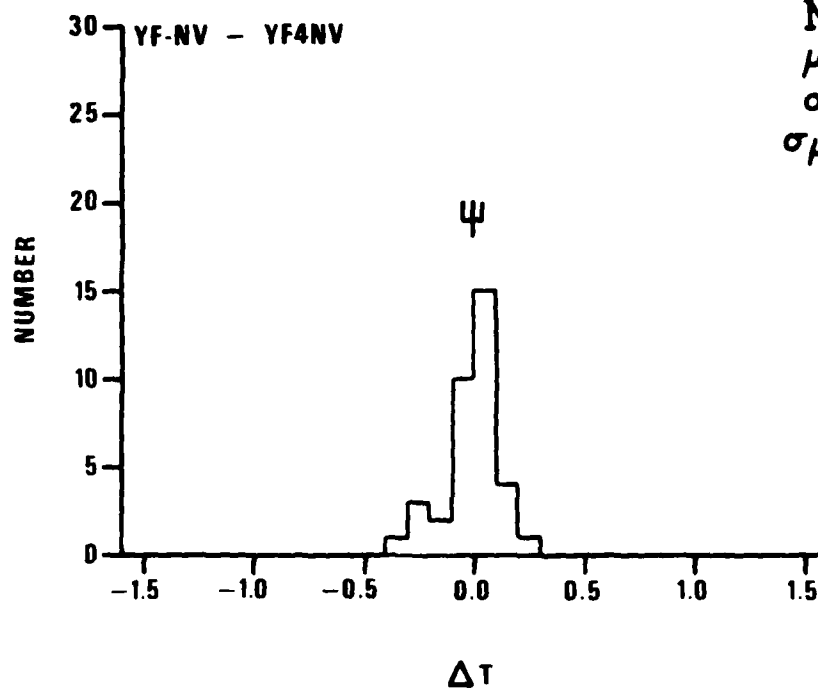


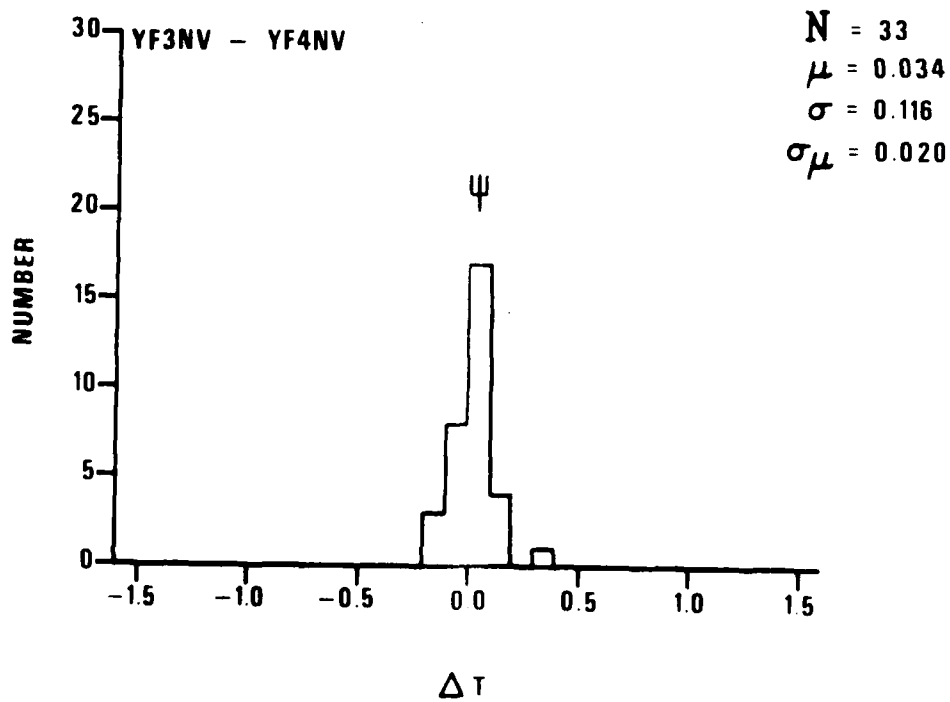
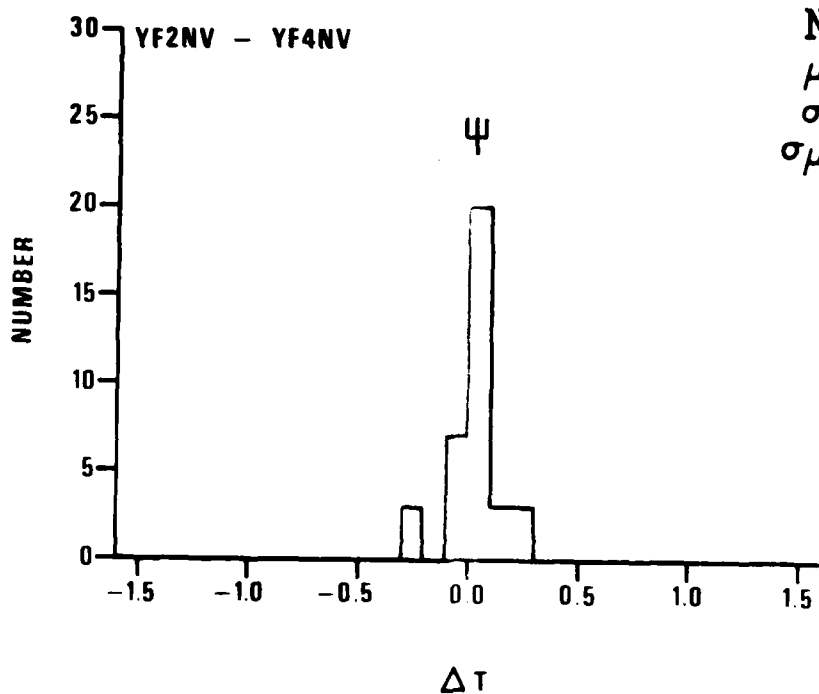
E-5





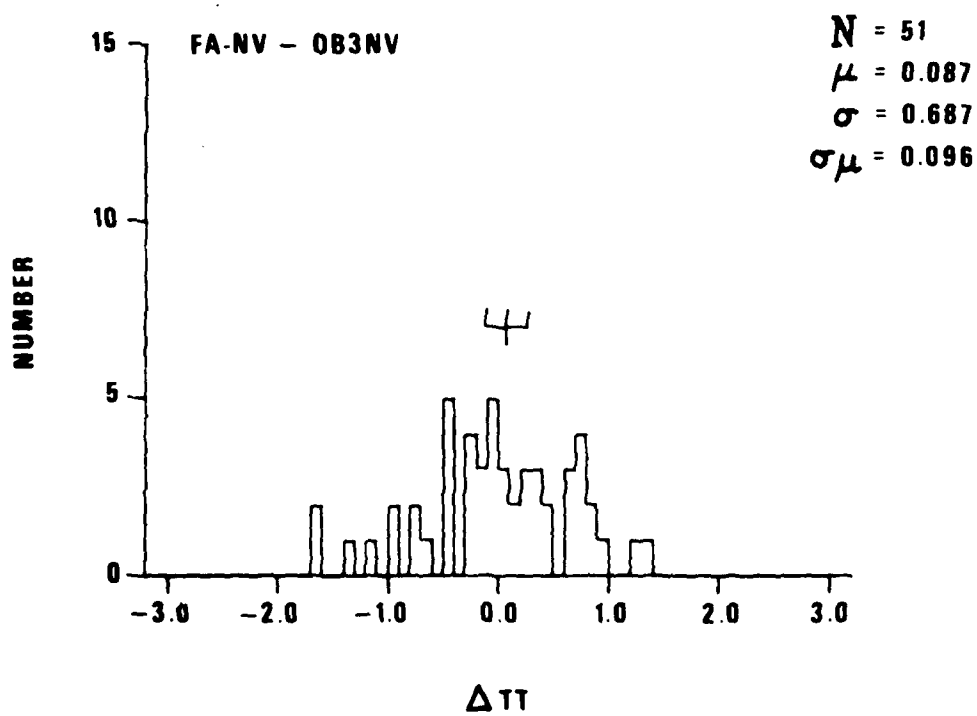
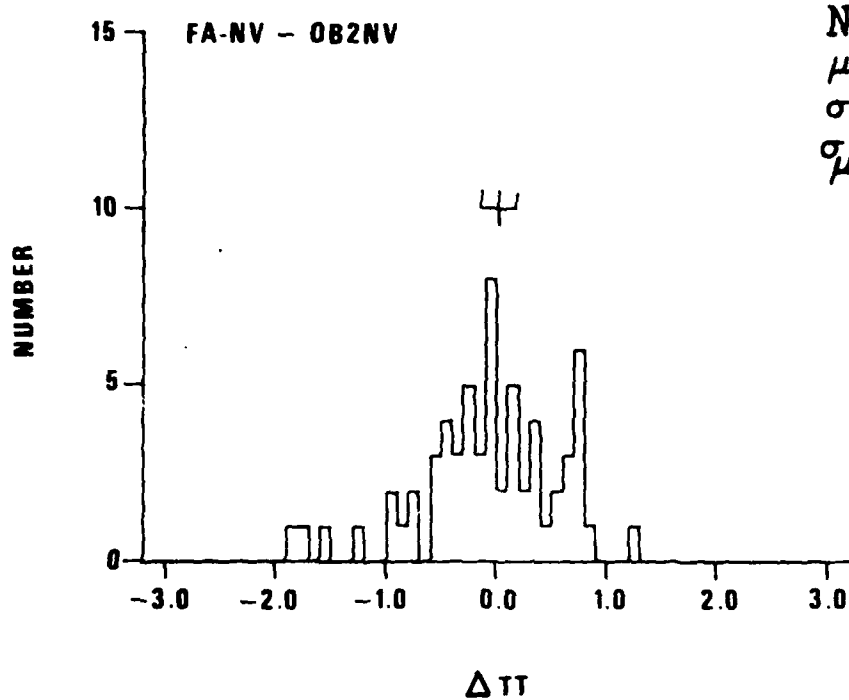


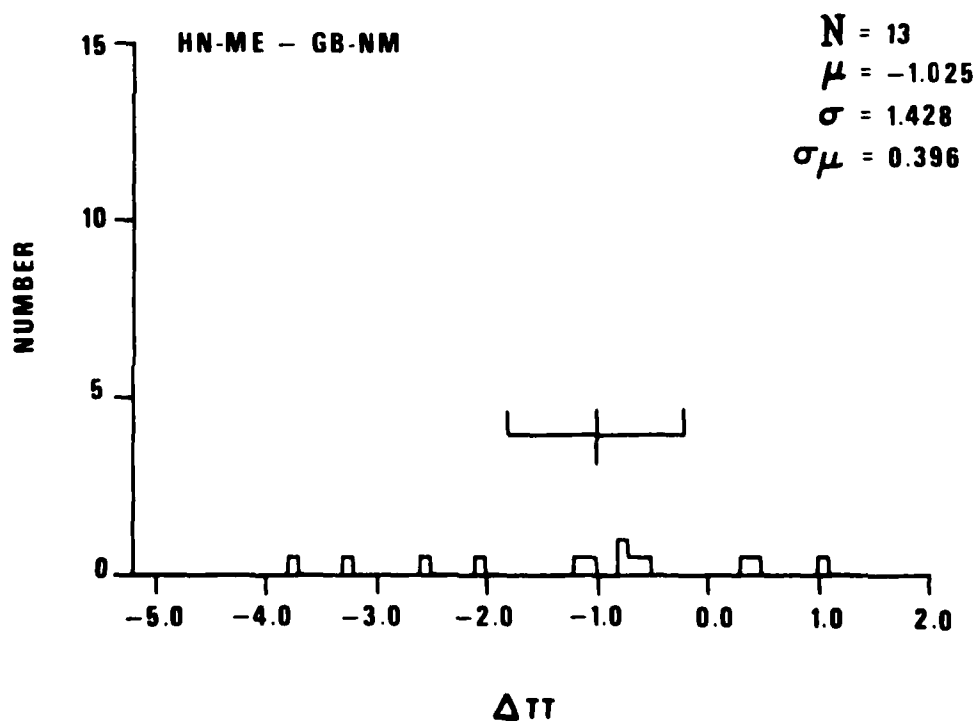
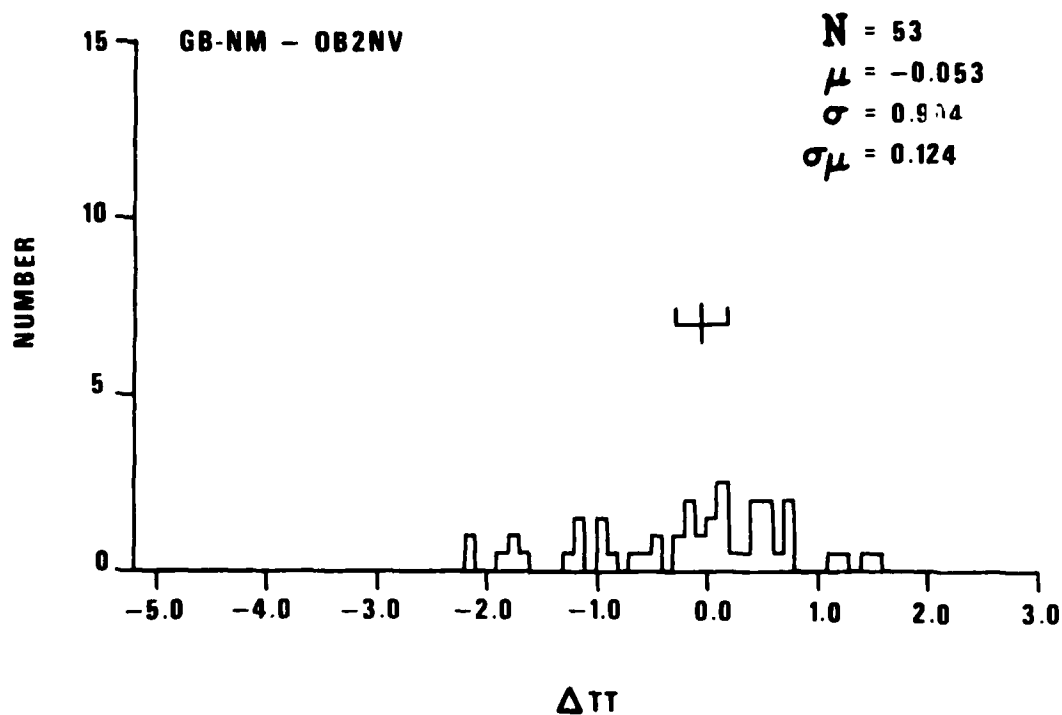


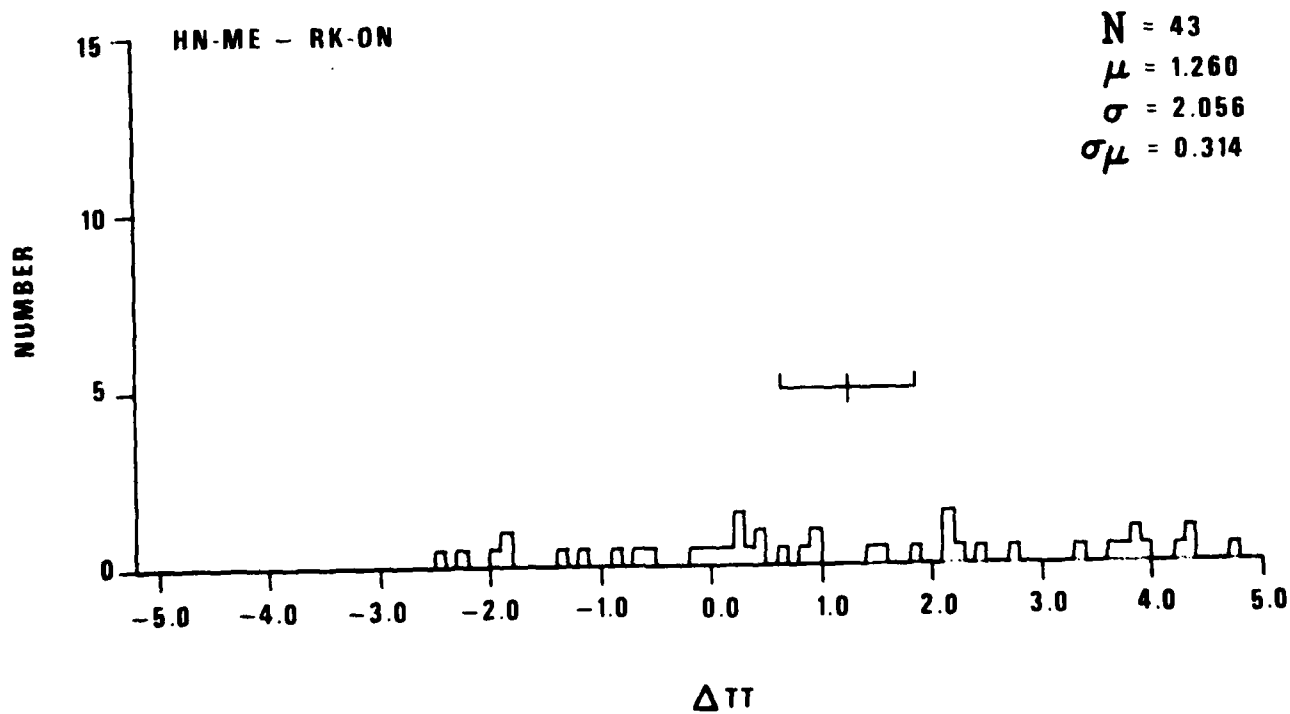
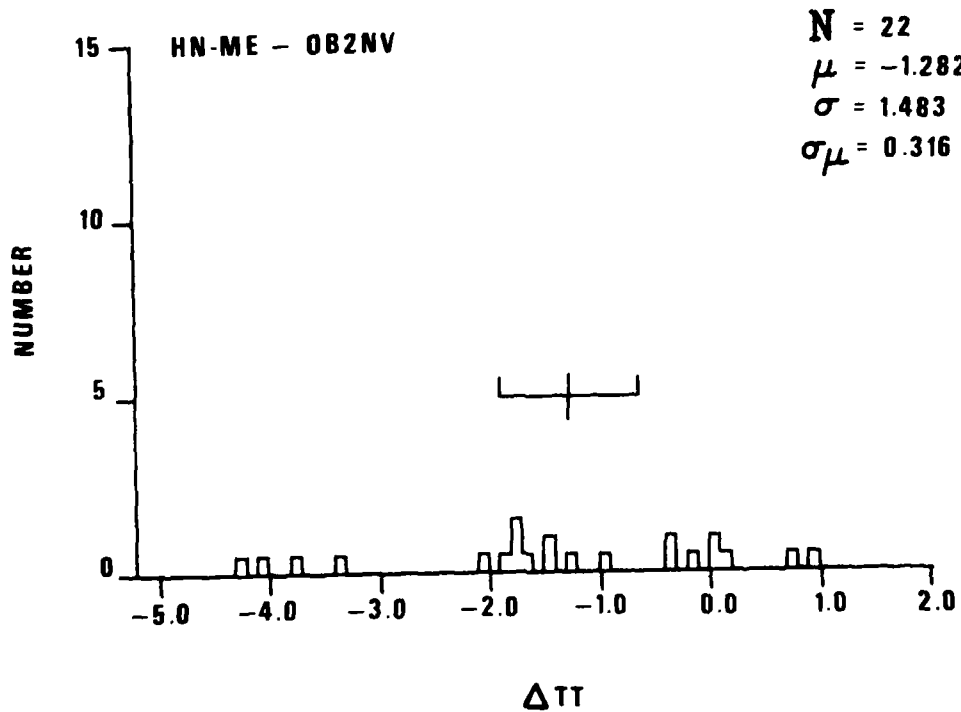


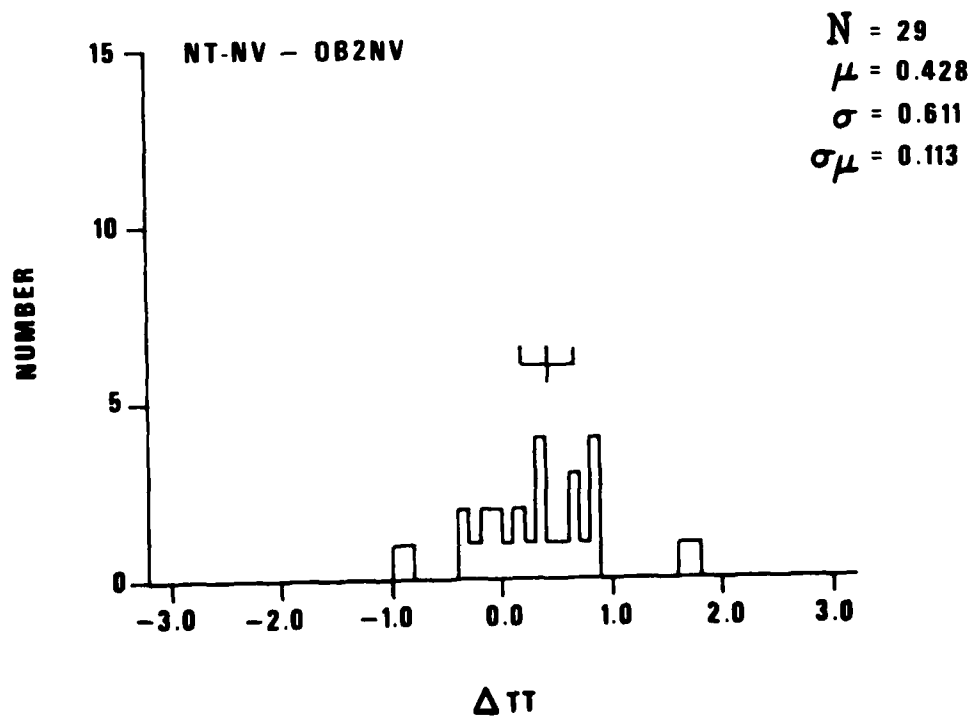
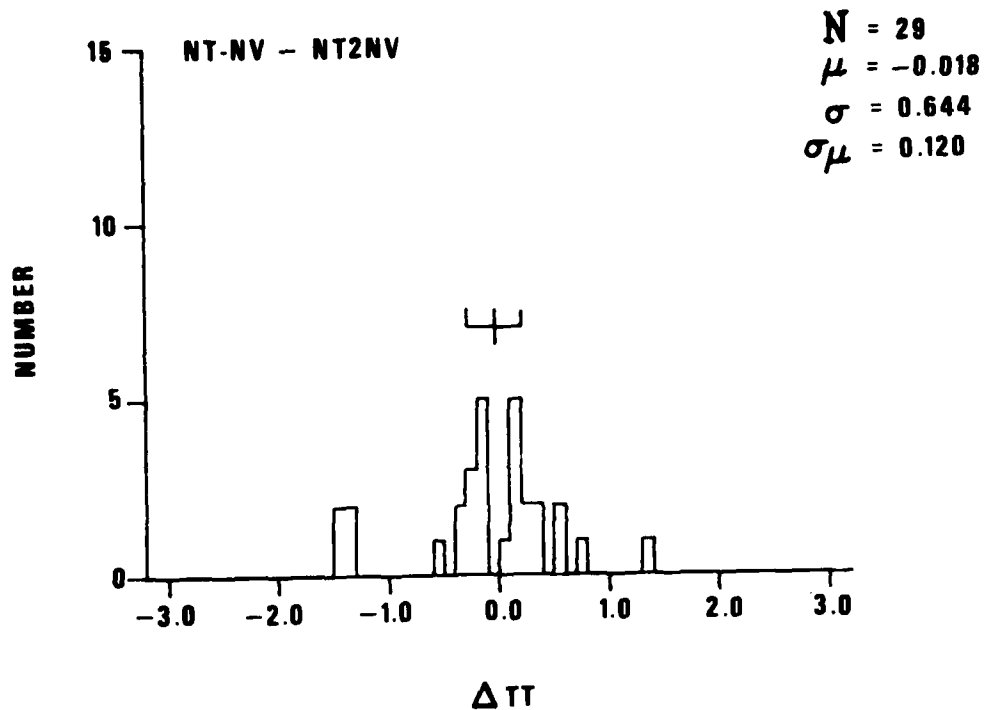
APPENDIX F

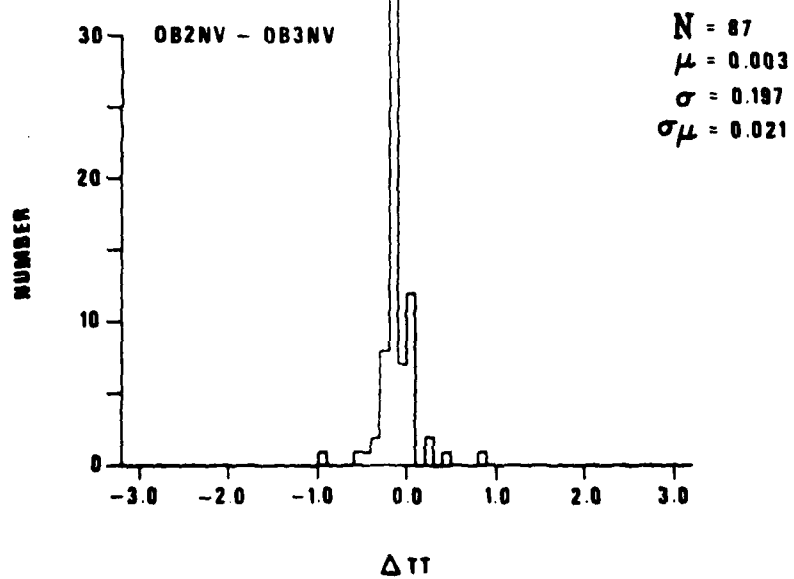
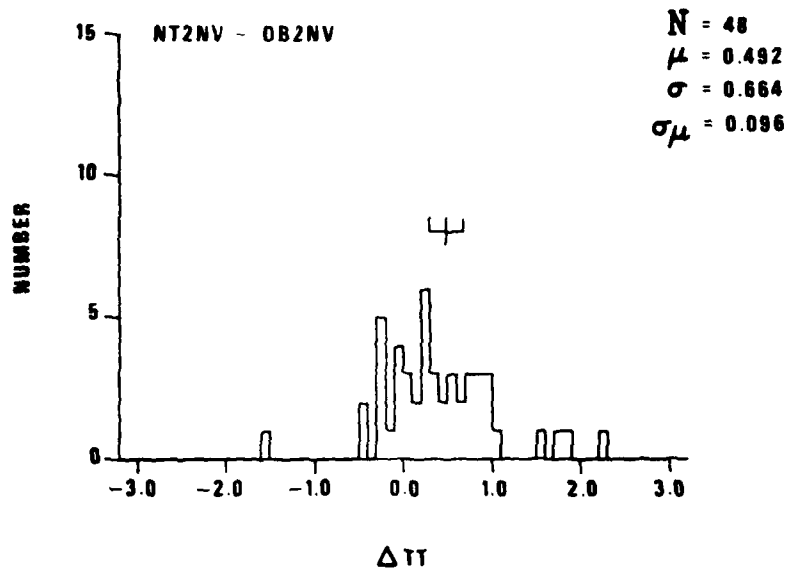
Histograms of Travel Time Differentials for Various
Pairs of SDCS Stations

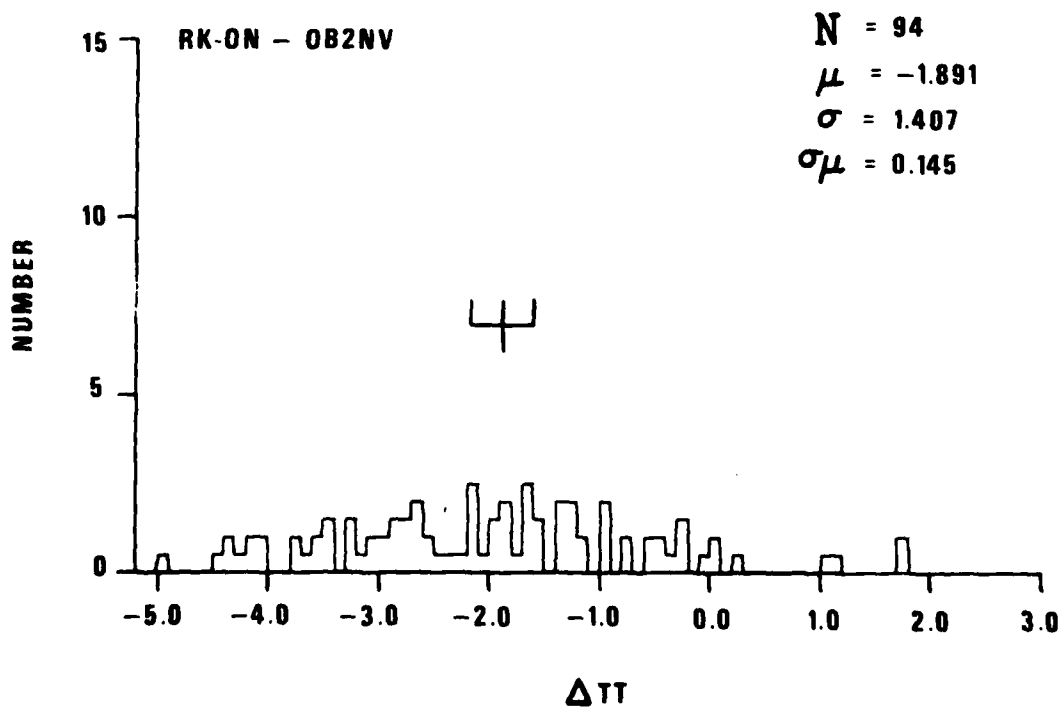
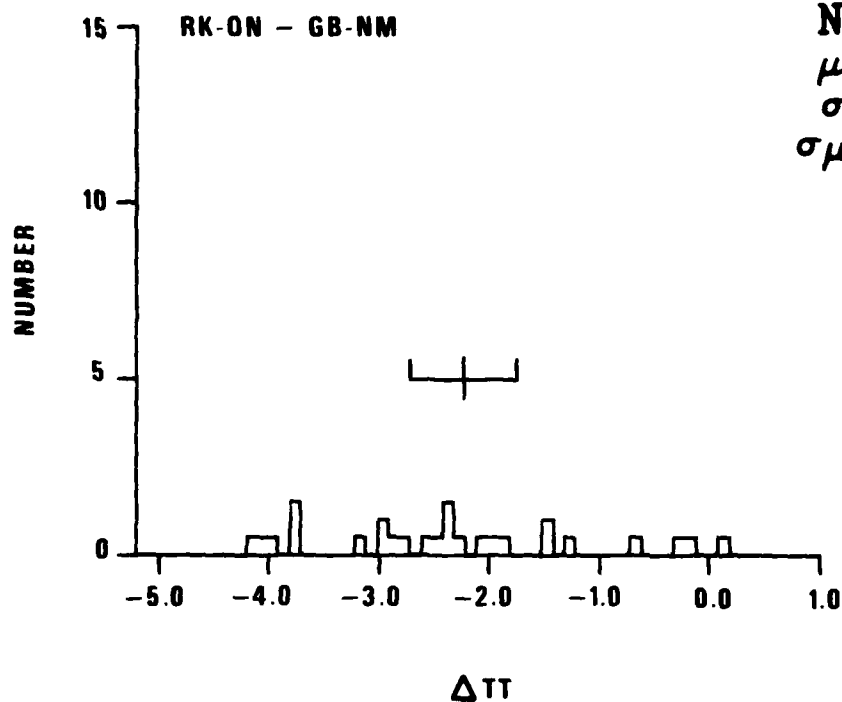


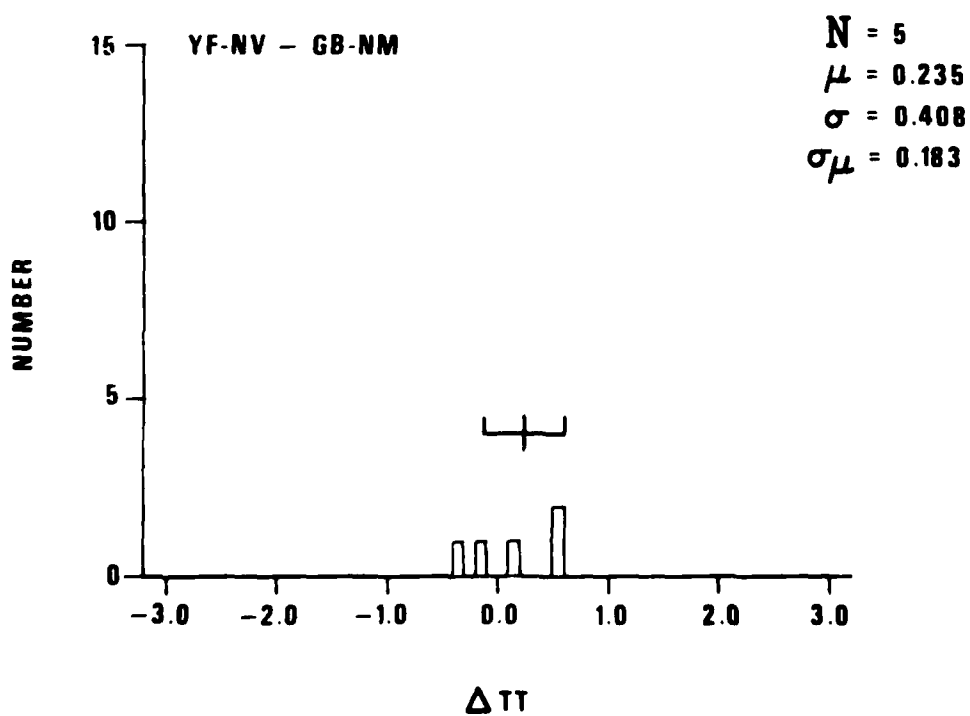
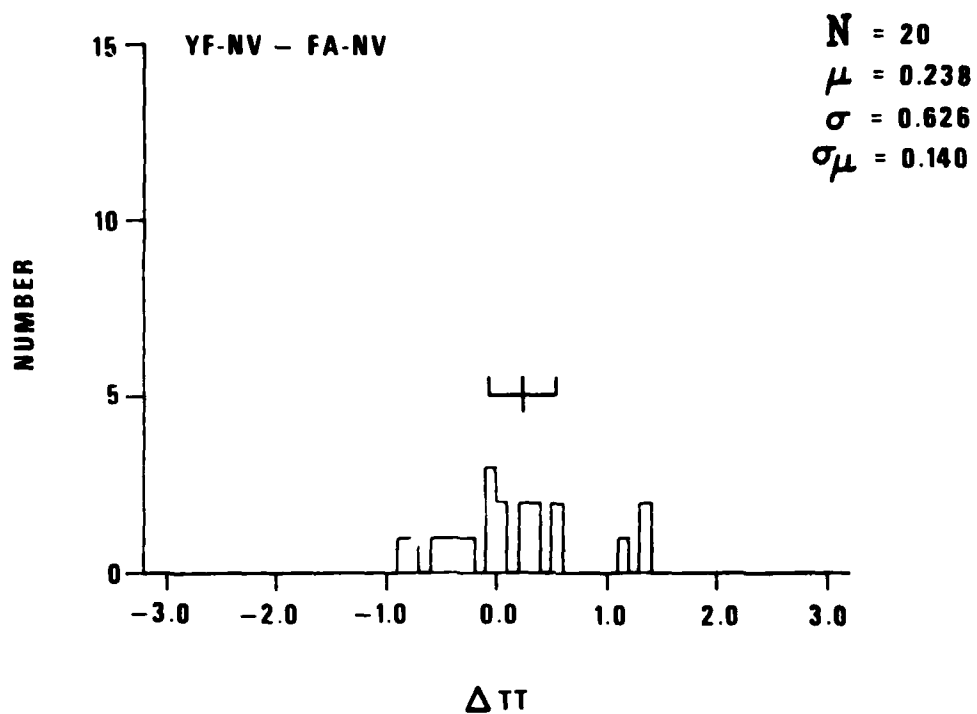


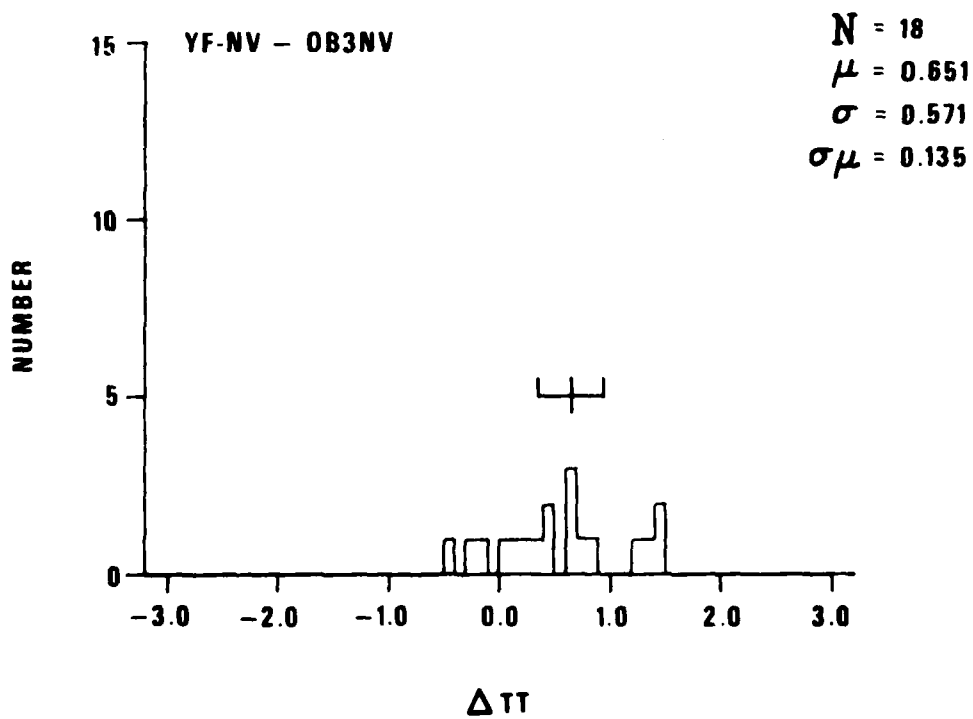
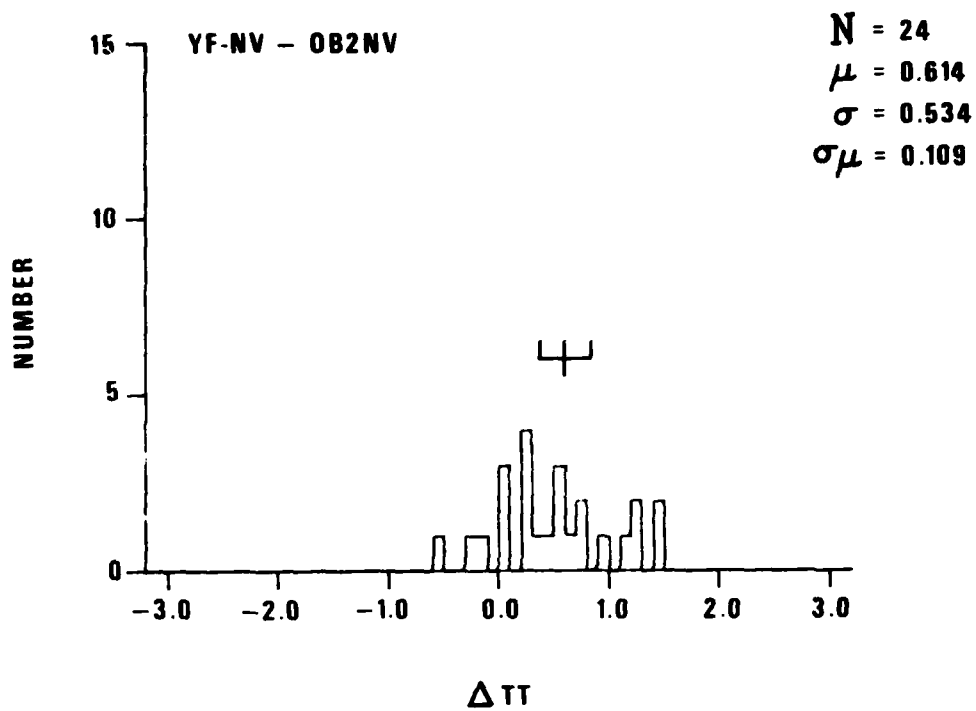


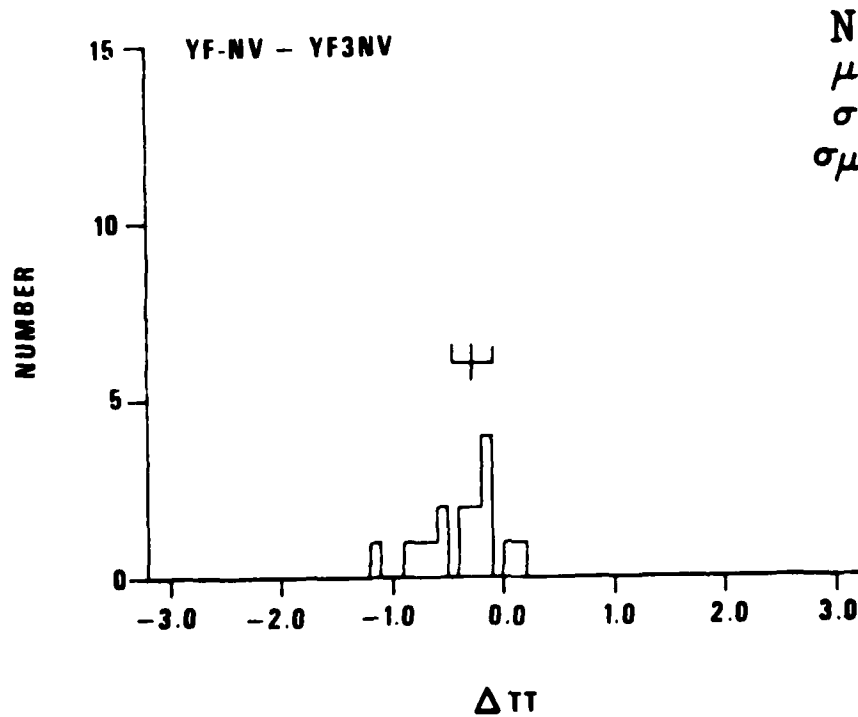
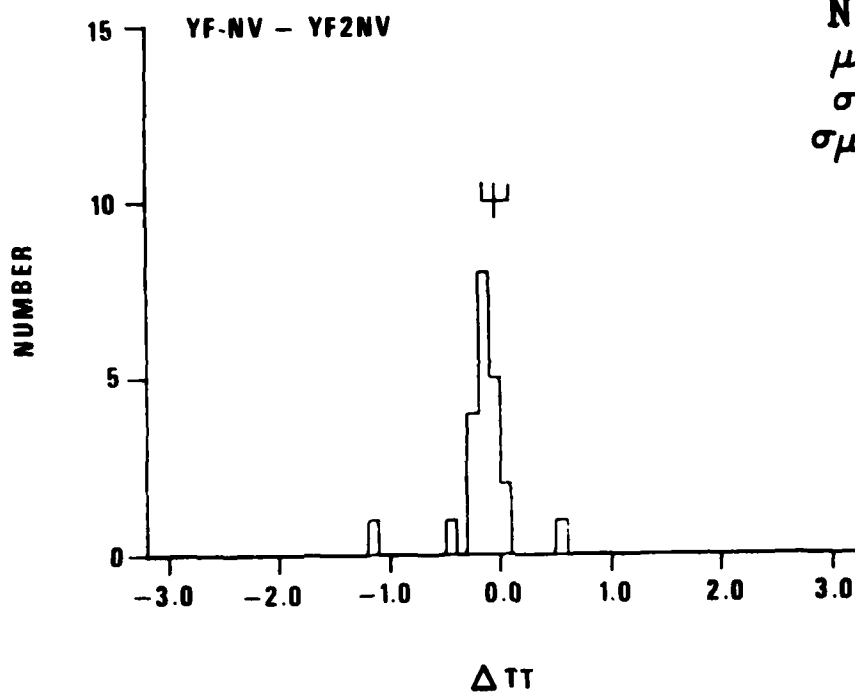


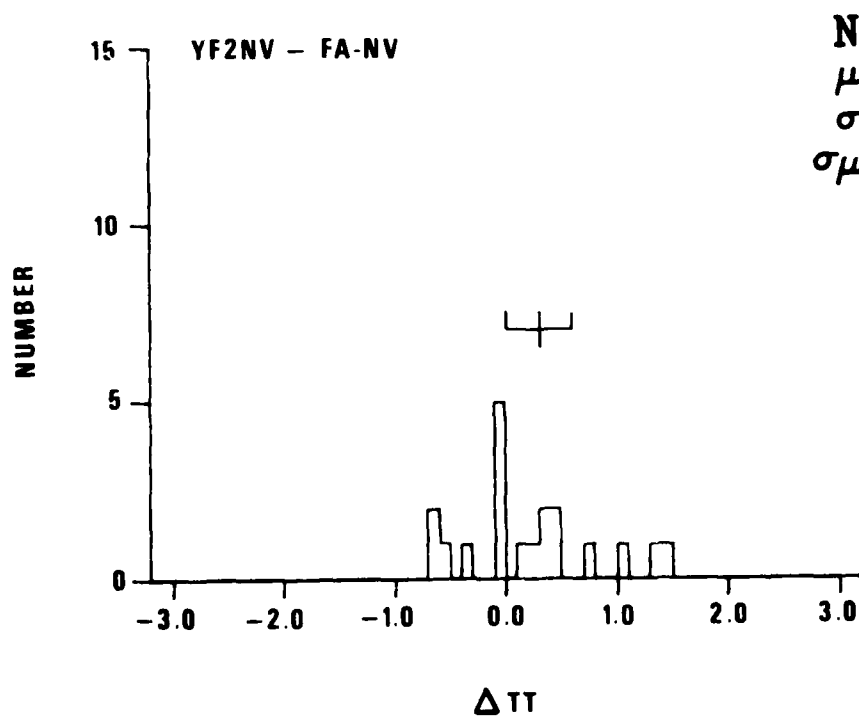
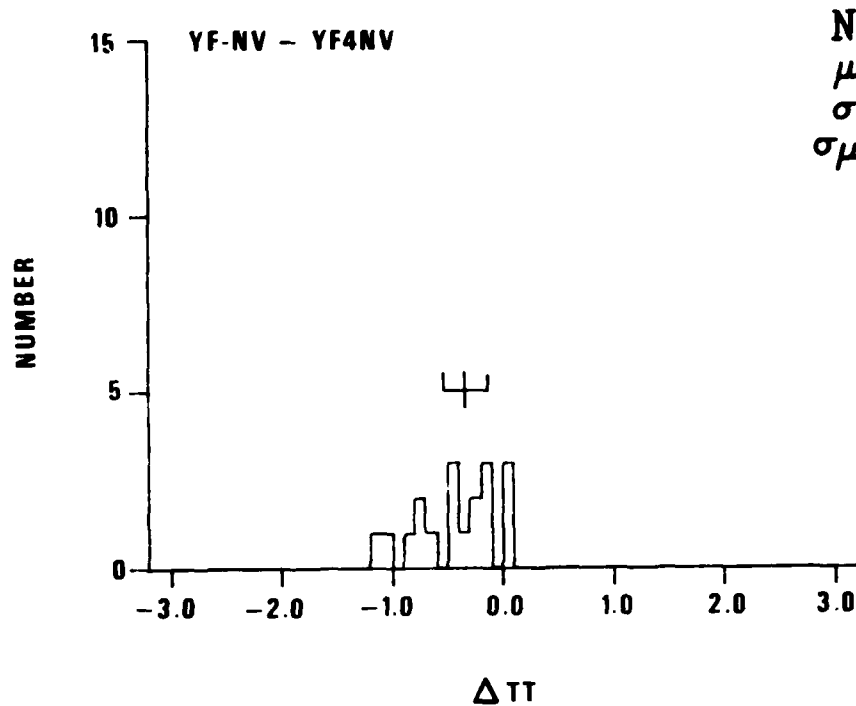


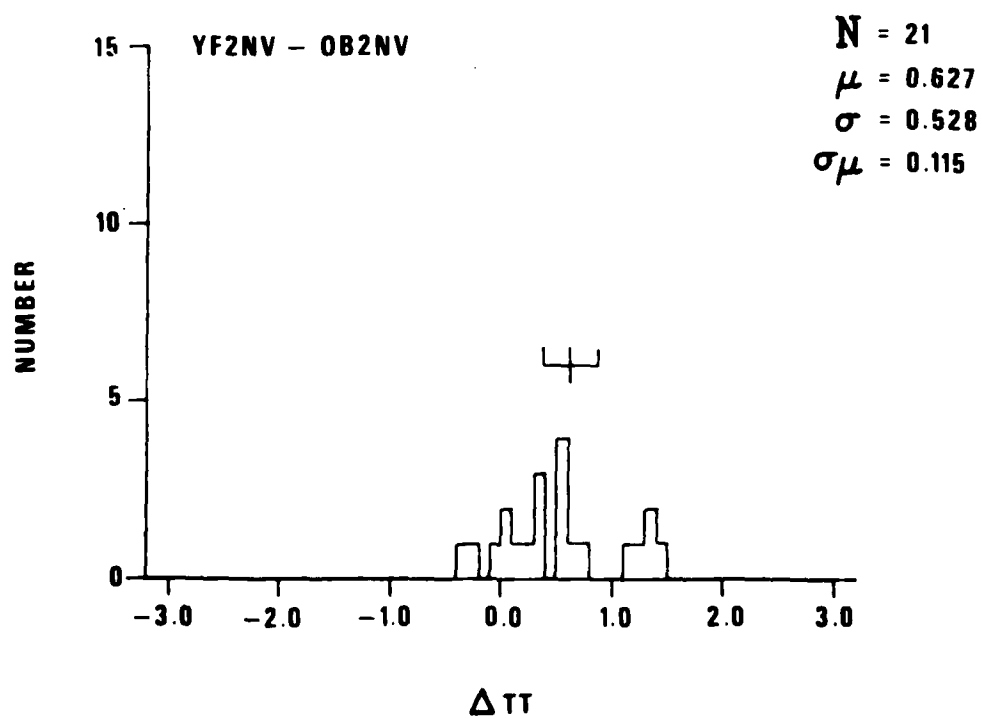
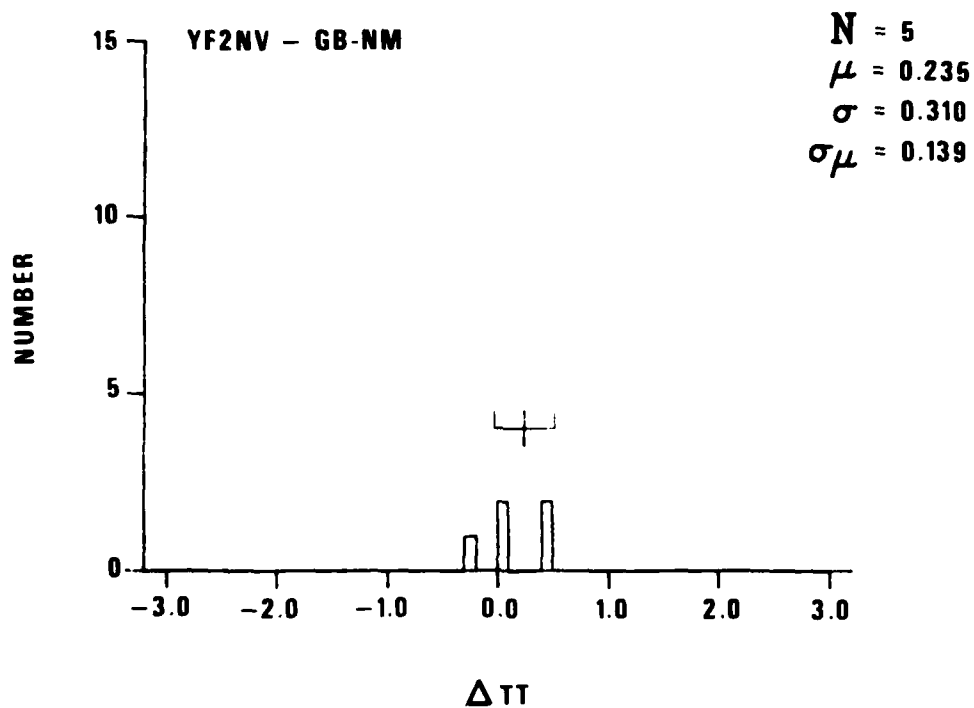


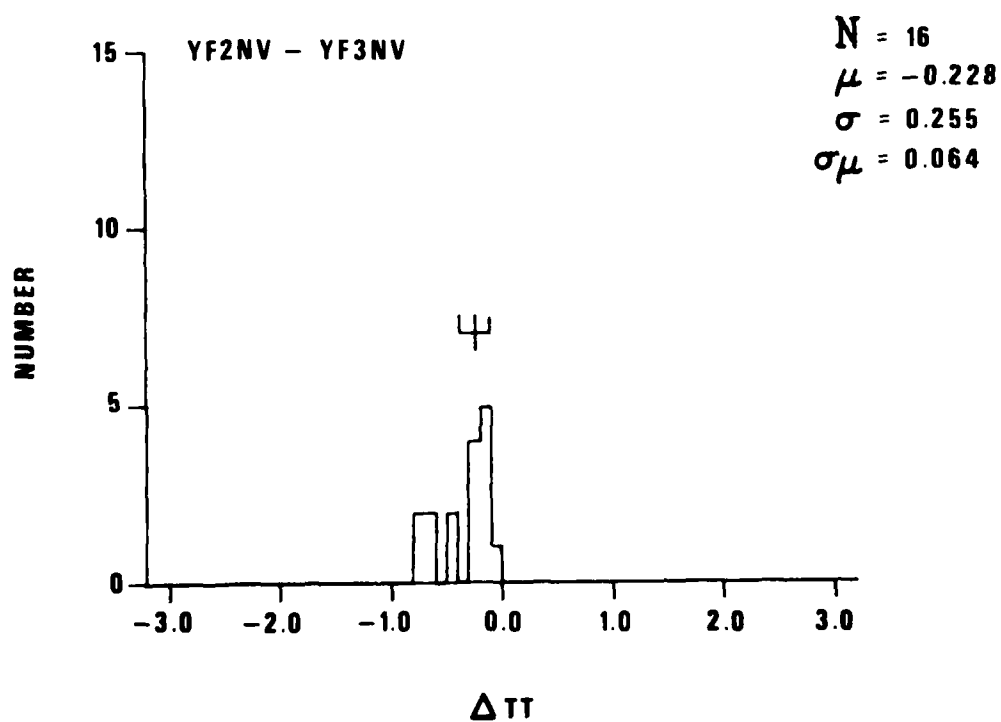
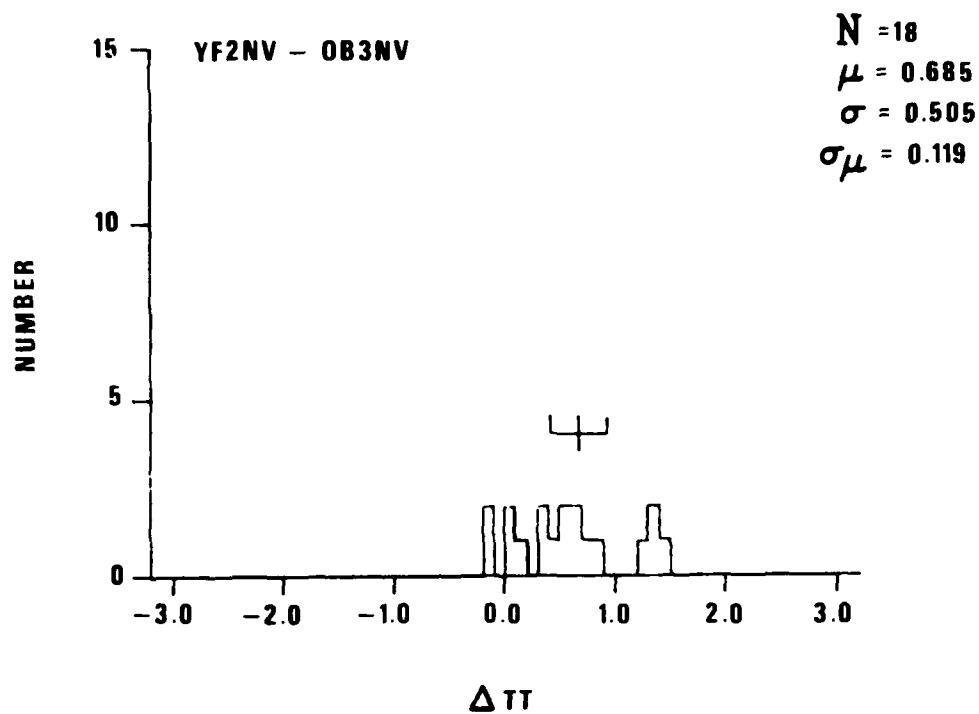


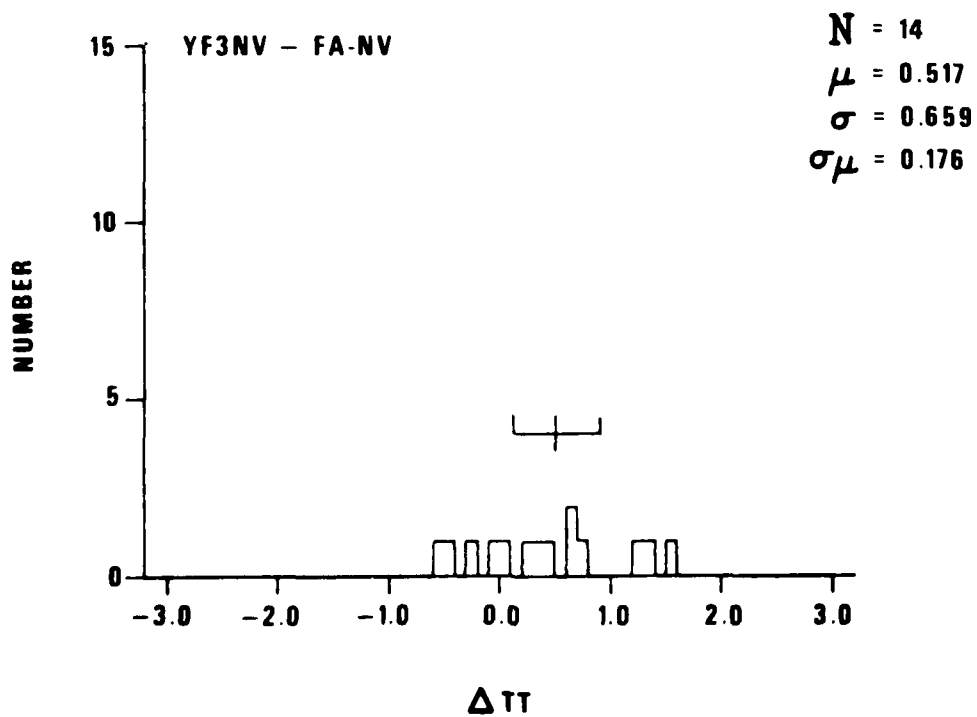
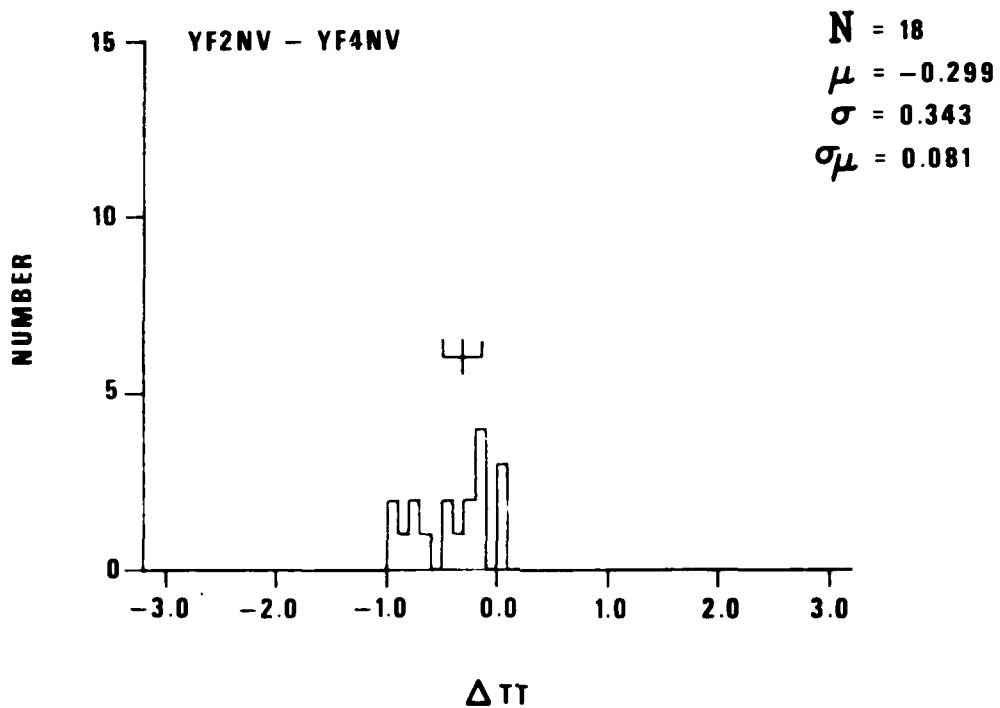


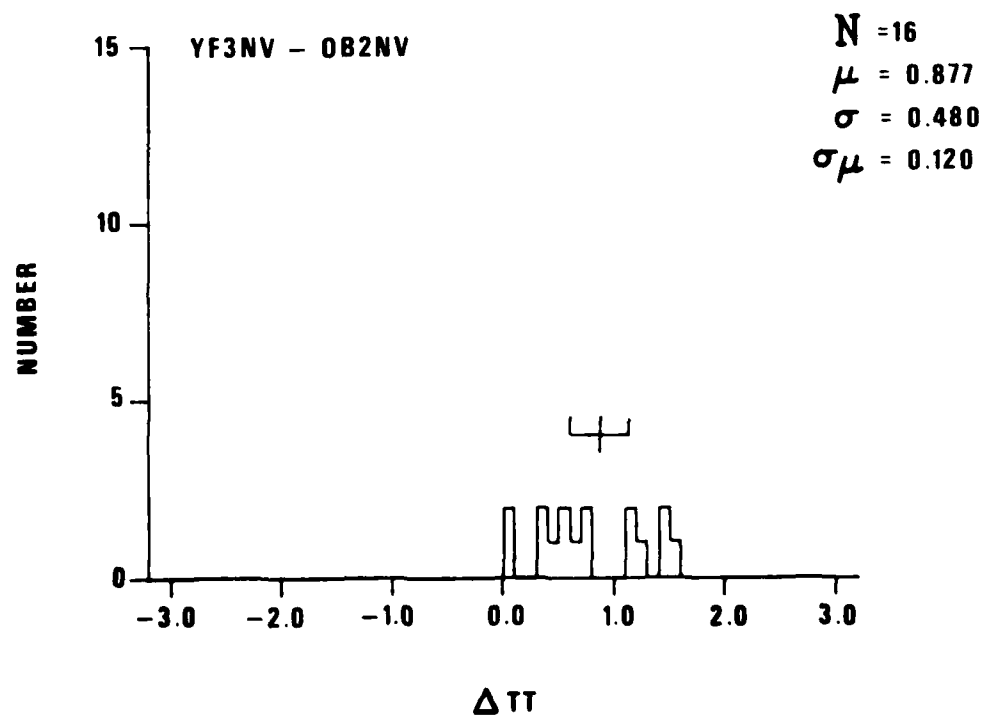
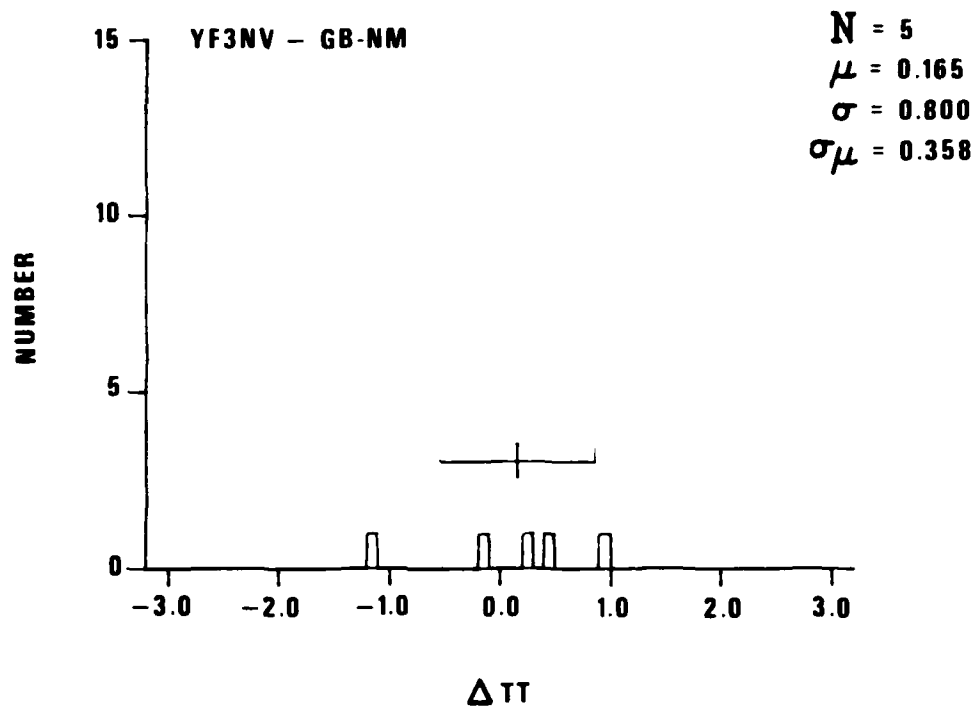


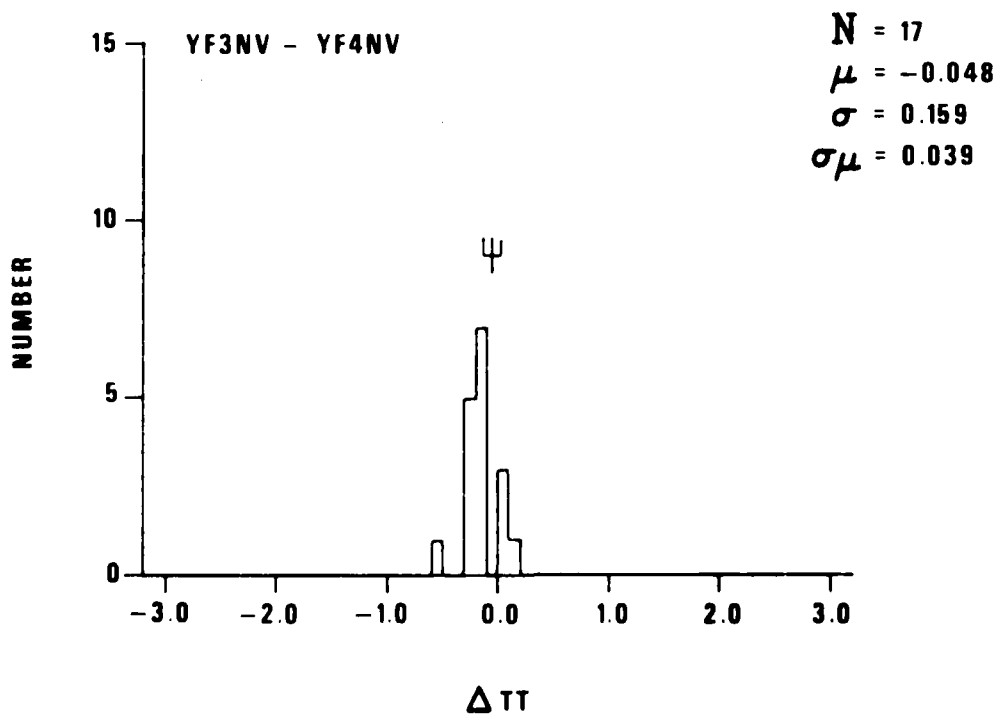
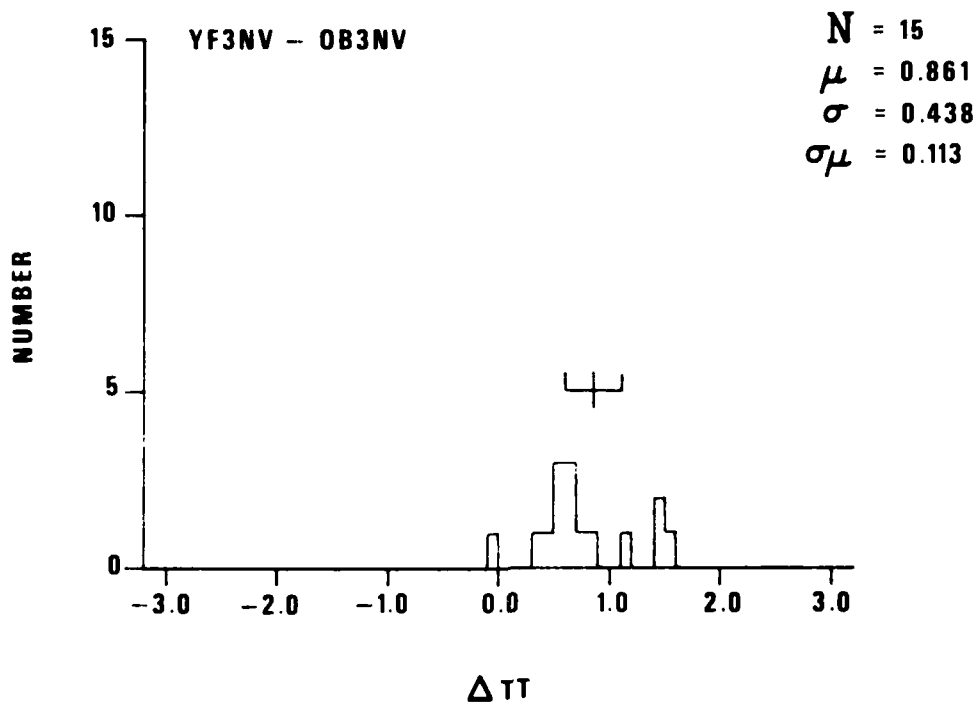


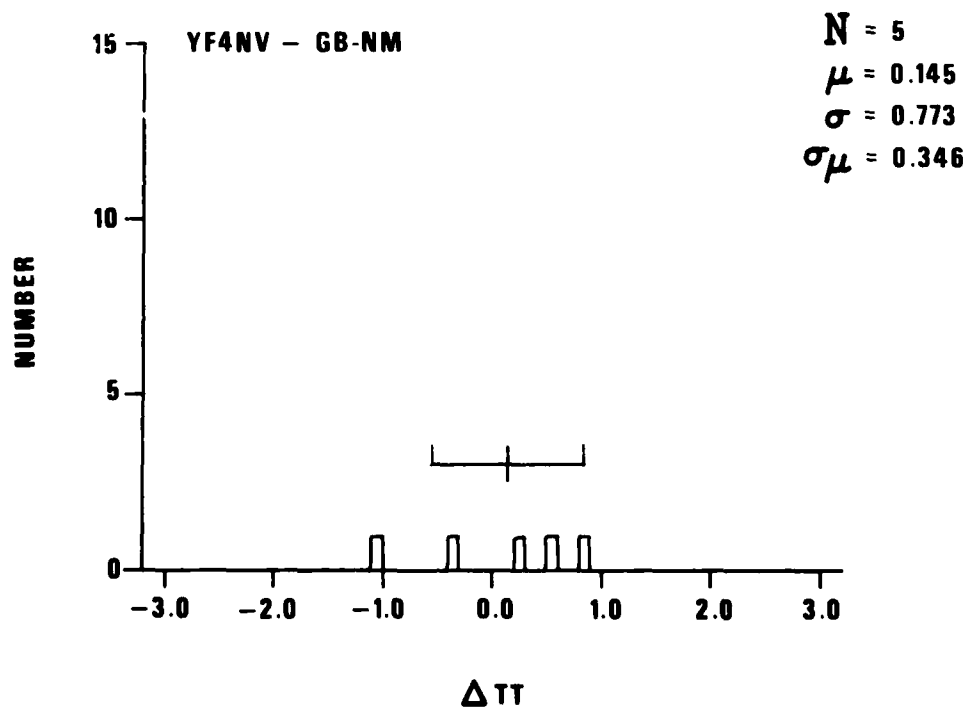
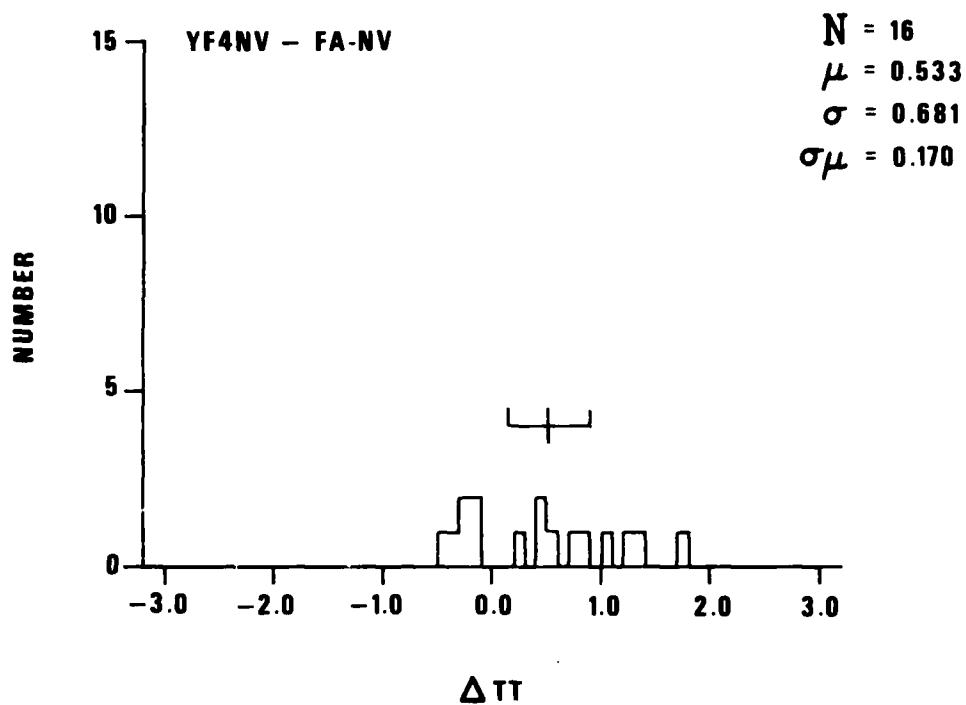


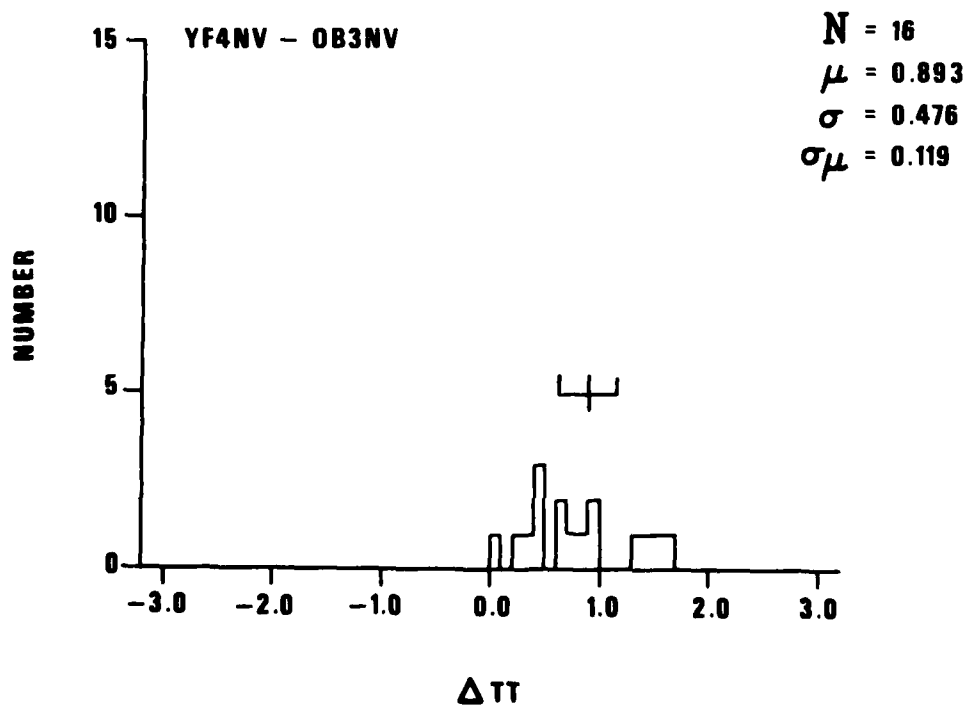
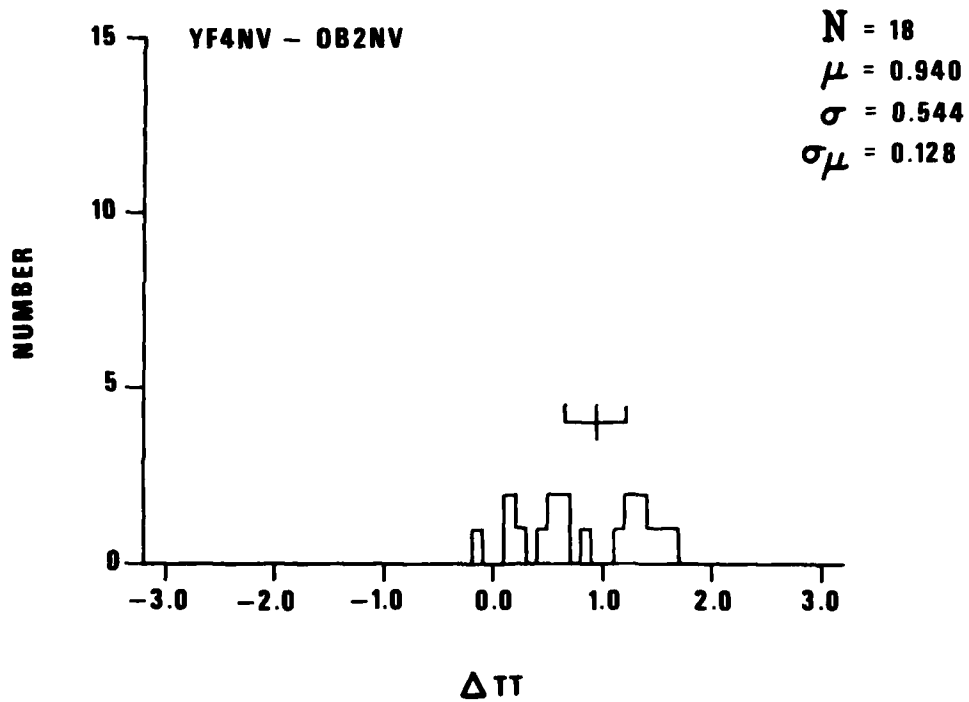












SUPPLEMENTARY

INFORMATION

MEMORANDUM

TO: All Recipients of VSC-TR-81-14

FROM: Z. A. Der and T. W. McElfresh

DATE: 26 October 1982

SUBJECT: Explanation of amplitude data in VSC-TR-81-14

The raw station data presented in Appendix A of the final SDCS report (VSC-TR-81-14) has the format:

STA	Δ	A	T	Arrival			GAIN	A_b	T_b
				H	M	S			
IF-ME	77.2	11.0	0.9	11	45	6.7	112		

where

- STA = station name
- Δ = station to event distance (deg)
- A = maximum signal amplitude* (first three cycles)
- T = dominant period of corresponding cycle (sec)
- H = hour
- M = minute
- S = second

} Arrival Time

- GAIN = gain factor (see below)
- A_b = b-phase amplitude, if measured
- T_b = b-phase period, if measured

*Attention is called to the Amplitude and GAIN columns. If no gain factor is given, then the amplitude A is understood to be in units of nanometers. This is the case for those stations having digital recording equipment.

If a gain factor is listed for a station, then the amplitude A is in millimeters as measured directly from the film viewer. In this case, the amplitude in nanometers can be computed using the equation:

$$A_{nm} = 500 A_{mm} / \text{GAIN}$$

This conversion was applied by the computer program that produced the histograms of magnitude differentials Δm_b and trace amplitude differentials ΔA_{tr} shown in Appendices B and C. Thus the histograms and results of the report are valid as stated.

The few repeated events in Appendix A are due to the arrival and processing of various subsets of the data at different times. This also accounts for the events not being listed chronologically.

The authors regret any confusion that this may have caused our readers. We are planning to re-issue the data shown in Appendix A in a unified format in the near future.

ZAD-TWM/paw