[illegible]D-5 0930h

[illegible]rshock Characteristics and Their Regional Variations in Taiwan

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The frequency-magnitude dependence and temporal behavior of [illegible]ershock sequences in Taiwan, 1964-1988, have been studied us[illegible] data from the Taiwan Telemetered Seismograph Network. Max[illegible] likelihood estimates of the parameters b and p were generally [illegible] by the Gutenberg-Richter relation and the Modified Omori [illegible] Other investigators have found that b values for the population [illegible] shallow earthquakes on land tends to be smaller than for those off[illegible]. We find that while b values for aftershock sequences on land [illegible] from 1.03 to 1.25, the b values of offshore sequences varied [illegible] a much larger range; this may reflect the presence of volcanic [illegible] and tectonic complexity in the offshore region. The p values [illegible] different aftershock sequences varied from 0.21 to 0.89. No corre[illegible] of p with either the b value of the sequence or the mainshock [illegible] was found. We also determined that the length of after[illegible] zone L (in km) increases with time after the mainshock. At [illegible], the best-fitting relation is: $\log L = 0.73 M_L - 3.25$; at 100 [illegible] the relation is: $\log L = 0.25 M_L + 0.24$. The growth in after[illegible] area is more pronounced at smaller magnitudes. The average [illegible] of the aftershocks within 24 hours and/or 100 days for on [illegible] sequences are smaller than those of the offshore sequences. Our [illegible] suggest that seismic hazard studies in Taiwan should account [illegible] variations in aftershock behavior. Further, measurements [illegible] size of the aftershock zone are strongly dependent on the time [illegible] the mainshock.

[illegible]D-6 0945h

[illegible]quakes Northeastern Offshore of Taiwan as Observed by [illegible] Ocean-Bottom Seismograph Network

[illegible] Chen, M Lai and L Wu (All at: Department of Oceanography, [illegible]ional Taiwan Ocean University, Keelung 20224, Taiwan, [illegible]O.C.; e-mail: chenth@vax.oce.ntou.edu.tw)
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[illegible] deployed a network of four ocean-bottom seismograph (OBS) [illegible] offshore of northeastern Taiwan during May of 1994 in a [illegible] study to test feasibility of establishing a larger offshore [illegible] network in the area. Although more than 2500 seismic [illegible] were detected during the four week period, because of the [illegible] of the stations, only 82 events were detected by more than [illegible] stations. They were generally located in two areas: directly [illegible] Hualien on the east coast of Taiwan, including a magnitude [illegible] event on May 24, and along the mid-axis of the Okinawa [illegible] and its extension towards Ilan plane. The OBS data [illegible] improves the hypocenter locations of these offshore [illegible] from those determined by the land station networks of the [illegible] Weather Bureau of Taiwan and Japan Meteorological [illegible] alone.

[illegible] 1030h

[illegible]tation of the Aleutian Main Thrust Zone Derived [illegible] Stress Directions Estimated Based on Fault Plane So[illegible]

[illegible] (Geophysical Inst., UAF, Fairbanks, AK, 99775; ph. 907-474-[illegible] e-mail: hr@fm.gi.alaska.edu); Max Wyss

[illegible] method is used to investigate the stress homogeneity along ma[illegible] boundaries or faults, based on focal mechanism data. The [illegible] of the faults can be estimated without the time- consum[illegible] for stress directions of earthquake focal mechanism data. [illegible] statistical significance of the segment boundaries identified by this [illegible] is tested by the z-test and t-test. We employ this method [illegible] the segmentation of the Aleutian arc by using the main [illegible] and outer rise earthquakes. The earthquake focal mechanisms [illegible] from the Harvard CMT catalog and some papers when avail[illegible]. the data span in time from 1955 to 1993 and in space from [illegible] 145°W. The misfits of individual earthquakes relative to a [illegible] model (the plunges and azimuths of the three principal [illegible] are calculated. The misfit is defined as the smallest rotation [illegible] an axis of any orientation that would bring the direction [illegible] of slip associated with either of the two observed nodal planes [illegible] with the direction and the sense of slip predicted by the [illegible]. The cumulative misfit as a function of earthquake number [illegible] strike of the arc is the tool based on which the segmentation [illegible] of the Aleutians are estimated. Four first- order bound[illegible]. The first one is near 177.5°E which corresponds to the [illegible] projection of the Rat fracture zone. The second is near the [illegible] the Amlia fracture zone intersects the trench. The third [illegible] the eastern end of the 1957 aftershock zone. The last locates [illegible] two major asperities of the 1964 rupture are separated. The [illegible] boundaries are also related to the asperity distributions of the great earthquakes along the Aleutians. The focal mechanism data in the stress-homogeneous segments are then used to invert the principal stress orientations using Gephart's computer codes. The orientations of the principal stresses further demonstrate the validity of our method.

S51D-8 1045h

Slip Distribution of the 1965 Rat Islands Earthquake: A Test of the Asperity Model

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The 4 February 1965 earthquake was the last in a series of great tsunamigenic earthquakes, including the 1957 Aleutian and 1964 Prince William Sound earthquakes, which ruptured almost the entire length of the Alaska-Aleutian Arc. The 1965 Rat Islands earthquake, Mw=8.7, was recorded by the WWSSN, so its source parameters are well known. Several seismological studies have identified areas along the rupture zone on which moment release and, by implication, slip was high. These areas of high slip, or asperities, have been correlated with the tectonic blocks in the western Aleutians.

Our study is a test of the asperity model. We develop a model based on the tectonic structures of the Rat Islands earthquake rupture zone. We invert tsunami waveforms to determine the slip distribution using tide gauge records from Japan, N. America, and the Pacific Islands. Our results show a broad area of moment release in the eastern half of the aftershock zone and a smaller area of high slip in the western half. The eastern slip only generally follows the tectonic structures, while the western slip correlates well with the Near Block where an asperity has been identified. Our results contradict earlier tsunami modelling by Hatori (1981) which shows that rupture extended to the east beyond the aftershock zone. The results from tsunami modeling are only partially consistent with the asperity model derived from seismological data.

S51D-9 1100h

Source Spectral Analysis of Earthquakes Occurred at Southeast of Hokkaido, Japan, Including 1993 Off-Kushiro Earthquake.

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The 1993 Off-Kushiro Earthquake of M=7.8 was one of the largest intermediate depth earthquakes in Japan. Accelerograms with a maximum amplitude of 922 gal was recorded at Kushiro Local Meteorological Observatory, and that of 386 gal was recorded at bedrock stations of CRIEPI in Akkeshi Town, which is located about 40 km east of Kushiro City. These large peaks of observed accelerograms suggest particular source characteristics, especially large stress drop. The source spectrum of the main shock is evaluated from observed horizontal S wave, and the static stress drop and the dynamic stress drop are calculated. The dynamic stress drop of the Off-Kushiro Earthquake shows 2200 bar, and is five times as large as the static stress drop. From the point of view of the scaling low of source spectra, these stressffiΔffiparameters are compared with those of other earthquakes occuerred at Southeast of Hokkaido, Japan, same region as epicenter of the Off-Kushiro Earthquake, and the relationship between stress parameters and magnitude, or source depth are examined. The static stress drops are almost independent of magnitude, while the dynamic stress drops are rather strongly correlated. For some events of M¿5, the ratio of dynamic to static stress drops exceed 1.0 obviously, which show the complexity of source process.

S51D-10 1115h

Seismotectonic of Central Chile Based on Teleseismic and Local Data

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The seismotectonic characteristics of Central Chile are controlled by the subduction of the Nazca plate beneath the South American plate. The geometry of the subducting slab, the associated stress field and the depth of coupling along the plate interface, are determined using reliable hypocenter locations from local and teleseismic data. The available local data were obtained from a permanent seismic network of 14 stations located between 32.5° and 34.5°S operating since 1981, and complemented with data from two field experiments carried out on 1985 (8 stations) and 1986 (14 stations). The teleseismic recorded activity occurred since 1964 (mb≥4.8) was relocated using reported phase readings from the ISC catalog and calibration events recorded by local networks. The focal depth and mechanism of 20 events (mb≥5.5) were constrained using a formal long-period body waves inversion. The subducted Nazca plate shows a relatively steep subduction geometry at 25°S with a dip angle that gradually decreased from ~30° to an almost subhorizontal subduction between 28°S and 33°S, from where the dip angle increases again to ~30° towards the south, in agreement with previous studies. However, these variations in dip are observed mainly at depths greater than 55 km which appears to be the maximum depth of coupling between the downgoing slab and the overriding plate, suggesting an almost constant interplate geometry along the whole zone. The maximum depth of coupling of 55 km, obtained from the deepest thrust events and from the transitional depth of compressional to tensional events, implies a width of the seismogenic contact of about 130 km. Therefore, the different rupture modes of large and great thrust earthquakes observed in Central Chile are probably not related with the geometry of the subduction at the interplate contact.

S51D-11 1130h

The May 10, 1994 Earthquake (mb=5.9): Evidence of Seismic Pre-Slip in the Northern Chile Seismic Gap?

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The Northern Chile region has been considered as a seismic gap where the last great earthquake with destructive tsunami occurred on May 10, 1877 (Mw~8.7). All the teleseismically recorded events (mb≥5.0) occurred between 1962 and 1994 in the northern part of the 1877 rupture area (19°-21°S) were relocated using locally recorded calibration events. In this region, the 1962 (mb=6.1) earthquake is the largest thrust event occurred during the last 32 years. Since this large event until 1987, the seismogenic interplate contact was almost quiet. However, during 1987, a small swarm of reverse faulting events (5.0≤mb≤5.5) was observed at distances of ~50-100 km from the trench. Moreover, on August 8, 1987 it was also observed a normal faulting earthquake (mb=6.4) located beneath the pressumed decoupling zone of the subducting slab. Recently, on May 10, 1994, the interplate contact was again activated by a thrust event (mb=5.9) located at a depth of 58 km, approximately above the 1987 normal faulting earthquake. The focal depth and mechanism of the 1962, 1987, and 1994 earthquakes were constrained by a formal inversion of long-period *P, SV, SH* waveforms recorded at teleseismic distances. Considering that the 1962 thrust earthquake is located in the central part of the interplate contact, the occurrence of the 1987 tensional and 1994 thrust earthquakes, both placed near the coupled-uncoupled transition along the subducting slab, suggests that a seismic pre-slip is taking place in the deepest part of the seismogenic interplate contact in the Northern Chile seismic gap. It is also interesting to point out that the 1994 deep thrust event is located about 100 km inland from the 1987 cluster of compressional lower magnitude events, in approximately the convergence direction between the Nazca and the South American plates, suggesting that also the shallower zone of the interplate contact has been recently activated in the northern part of this seismic gap.

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S51D-12 1145h

Surface-Wave Study of the 22 January 1992 Western Yellow Sea Earthquake

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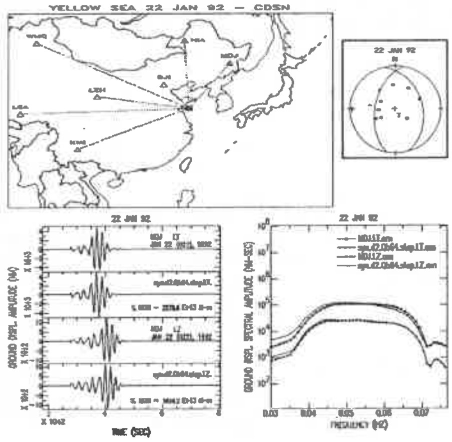
The western Yellow Sea earthquake of 22 January 1992 was reported by the USGS PDE as follows: m_b=5.1, OT=21:41:25.97,LAT=35.351°N, LONG=121.109°E. We present the surface-wave focal mechanism, shear structures, and shear quality factors as obtained by inversions from this event. The average shear crustal and MDJ models (in parentheses) were obtained by inversion from surface-wave group velocities of these stations (using SLU codes). A Poisson's ratio of 0.25 was assumed. Average surface-wave attenuation coefficients in the 10-40 seconds were obtained using the technique of Tsai and Aki (1969) and were then used to invert for shear Q.

Layer Thickness (km)	P (km/sec)	S (km/sec)	Density (g/cm^3)	S Standard Deviation	Q_S^{-1}	Q_S^{-1} Standard Deviation
2.00 (1.00)	2.54 (5.35)	1.47 (3.09)	2.06 (2.57)	0.036 (0.234)	0.155E-01 (0.161E-01)	0.127E-02 (0.955E-03)
7.00 (8.00)	5.98 (5.81)	3.45 (3.35)	2.70 (2.66)	0.017 (0.026)	0.147E-01 (0.156E-01)	0.998E-03 (0.883E-03)
27.00 (20.00)	6.38 (6.27)	3.68 (3.62)	2.81 (2.78)	0.006 (0.008)	0.114E-01 (0.127E-01)	0.651E-03 (0.553E-03)
0.00	7.68 (7.58)	4.31 (4.37)	3.20 (3.17)	0.019 (0.013)	0.552E-02 (0.627E-02)	0.126E-02 (0.908E-03)

Corrected Love-wave and Rayleigh-wave amplitude data from seven CDSN stations were used in focal mechanism search employing the technique of Nguyen and Herrmann (1992, SRL). The result for surface-wave focal mechanism constrained by P-wave first motions is as follows: The source is 2 km deep, with a seismic moment of 4.09E+23 dyne-cm; a nodal plane with a dip of 40°, a slip (rake) of 70°, and a strike of 345°. This source has a predominant dip-slip component for either nodal planes.



S51E MC: 122 Fri 0830h
Observations of Seismic Anisotropy
Presiding: **E Sandvol, New Mexico State; M Savage, Univ of Nevada, Reno**

S51E-1 0830h

Crustal Anisotropy in Northeastern Venezuela: Comparison of Short-Period and Broadband Results

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R M Russo (DTM, Carnegie Institution of Washington, 5241 Broad Branch Rd NW, Washington, DC 20015)

We report preliminary results from an anisotropy study on data gathered in two experiments. A joint IfGHH-INTEVEP-CSIC microearthquake network with short-period seismic stations was deployed for three months (June-August 1990) in northeastern Venezuela and recorded over 300 local and regional earthquakes. All stations were equipped with 3-component 4.5 Hz geophones. The average station spacing was less than 15 km with an array aperture of about 300 km was deployed over an 18 month period (May 1992-September 1993) in northeastern Venezuela and Trinidad. The array was composed of six instruments with approximately 50 km spacing and an array aperture of 450 km. For a comparative analysis of crustal anisotropy between short-period and broadband data we selected two stations of each array with similar locations in two different tectonic settings: a) on the metamorphic tectonized Paria-Trinidad terrane; and b) in the foreland thrust belt of the Serrania del Interior.

We began with the selection of 10 local events whose source-receiver geometries ensured angles of incidence less than 35°, as well as covering similar azimuths for both short-period and broadband sites. The events of the short-period array were low-pass filtered in order to avoid cycle skipping and to allow a complete waveform inversion for shear wave splitting. Our results indicate that the applied inversion method, energy minimization of the smaller eigenvalue of the initial shear wave polarization matrix, works for the evaluation of shear wave splitting on short period records. We find that for the events we have examined so far, delay times between fast and slow split shear waves are small, on the order of .01 to .3 seconds, similar to crustal splitting values worldwide.

S51E-2 0845h

Regional Variation of Teleseismic Shear Wave Splitting Observations in the UK

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We present observations of shear wave splitting recorded by the short-period seismic network in the United Kingdom (UKNET) operated by the British Geological Survey. The network, which extends from the Shetland Islands in the north as far south as the isle of Jersey, spans a range of geographic and tectonic features, which we relate to the observed variation in splitting parameters ϕ and δt, obtained using Silver and Chan's [1991] methodology. Fast polarization directions ϕ sweep from roughly east-west in southern England to northeasterly directions in Scotland. In concert, delay times δt progress northward from values less than 0.75 s to greater than 1 second. The same trend in orientation is not observed in Wales, where ϕ is northwesterly. With that exception, the trend suggests that ϕ follows the pattern of Paleozoic Caledonian and Variscan deformation, whose structures trend nearly east-west in the south of the UK and NNE in the north.

Short-period data is not optimal for splitting studies as evidenced by scatter in the observations and by some sites exhibiting fast polarization directions inconsistent with the hypothesis of a single anisotropic medium with a horizontal axis of symmetry. The short-period results are however consistent with broadband measurements from the GDSN station ESK (Eskdalemuir, Scotland). Short-period network data is therefore suitable for splitting studies when broadband data is unavailable.

S51E-3 0900h

Updated Anisotropy Interpretation for the Uppermost Mantle in Southern Germany

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J Mechie (GeoForschungsZentrum, Potsdam, Germany)
S Sobolev and K Fuchs (Both at: Geophysikalisches Institut, Universität Karlsruhe, Germany)

This paper presents an updated anisotropy interpretation for the uppermost mantle in southern Germany. The dense network of reversed and crossing refraction profiles in this area made it possible to observe almost 900 travel times of the P_n phase which could be effectively used in a time-term analysis to determine horizontal velocity distribution immediately below the Moho. For 12 crossing profiles, amplitude ratios of the P_n phase compared to the dominant crustal phase were utilized to resolve anisotropy (velocity) gradients with depth.

A P-wave anisotropy of 3-4% in a horizontal plane immediately below the Moho at a depth of 30 km increasing up to 10% at a depth of 40 km was determined. For the axis of the highest velocity of about 8.03 km/s at a depth of 30 km a direction of N31°E was obtained. The azimuthal dependence of the observed P_n amplitude is explained by an azimuthal dependent sub-Moho gradient decreasing from 0.06 s^{-1} in the fast direction to 0 s^{-1} in the slow direction of P-wave velocity.

From the seismic results in this study (including the absence of the S_n phase) a petrological model suggesting a change of modal composition and percentage of oriented olivine with depth was derived.

S51E-4 0915h

Determination of Slowness Surfaces in an Anisotropic Formation From Wellbore Seismics

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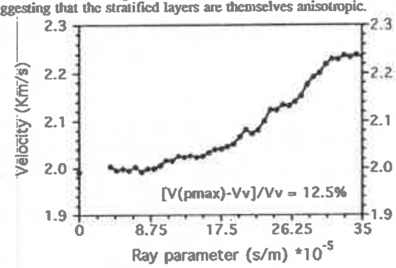
In situ slowness surface curves are obtained from the analysis of a multi-offset and depth wellbore seismic experiment. The downgoing transmitted waves are mapped into the τ-p domain which is a natural domain for slowness surface determination in that the p-axis represents the horizontal component of the slowness and the τ-axis can be converted to its vertical component q. The slowness u defined as the velocity reciprocal (u=1/v) is related to p and q by the relation: $p^2+q^2=u^2$. To determine the slowness surface of a layer between depths z_1 and z_2, two three-component receivers R_1 and R_2 are placed at these depths in a borehole, and sources are activated at the surface at increasing offsets radially from the borehole. The intercept time difference $[\tau_2(p) - \tau_1(p)]$ for the two receivers R_1 and R_2 depends only on the receiver spacing (z_2-z_1) and the vertical component of the slowness: $\tau_2 - \tau_1 = q(z_2 - z_1)$. This equation can be solved for q for each ray parameter p yielding a complete p-q (slowness) curve. A field experiment was conducted over a depth interval from 75 m to 120 m in a sand-shale sequence. The observed slowness curve as converted to v versus p below indicates that the velocity increases with angle of incidence. the observed anisotropy is greater than that expected for a stack of thin isotropic layers suggesting that the stratified layers are themselves anisotropic.



S51E-5 1000h

Azimuthal Anisotropy near the West Coast of America: Surface-wave Modelling and Interpre

Yang Yu, Liqiang Su and Jeffrey Park (Dept. of Geology physics, Yale Univ., P.O. Box 208109, New Haven, 8109)

Lateral variations in azimuthal anisotropy cause Rayleigh- surface wave interactions and lead to anom forms in long-period seismic records. The details of waveforms recorded at a seismic station are determined izontal integral of anisotropic properties along the which complements the vertical integral offered by obs of shear-wave splitting. Waveform anomalies in a singl record, therefore, may contain valuable information abo anisotropy along the source-receiver path, in particula sition of strong gradients that cause Love-to-Rayleigh surface waves. We apply a new interpretive techniqu period surface waves that cross the plate boundaries along coast of North America. Significant waveform anomali ated with Love-to-Rayleigh conversions are consistently at seismic stations in the western United States, indic existence of azimuthal anisotropy in the upper mantle. ments of delay times between QL and Love waves sugg the Love-to-Rayleigh conversion take place near the plate aries. In order to understand better the structures for those data observations, we will model anomalous waveforms with anisotropic earth models using a new inversion technique, based on the great-circle-path tion, that accounts for mixed-type coupling between and Love- surface waves. The technique enables forw verse modelling of surface waves in laterally-varying structure, with an arbitrary fast direction. Observed anomalies are attributed to the strong lateral variation mantle anisotropic structure in the region, which are evid SKS splitting analyses and marine refraction experiments sistent with past and present tectonic features, such as continental boundary, and shear along the Pacific-North plate boundary.

S51E-6 1015h

Anisotropic Tomography using Pn Raypaths the Western United States

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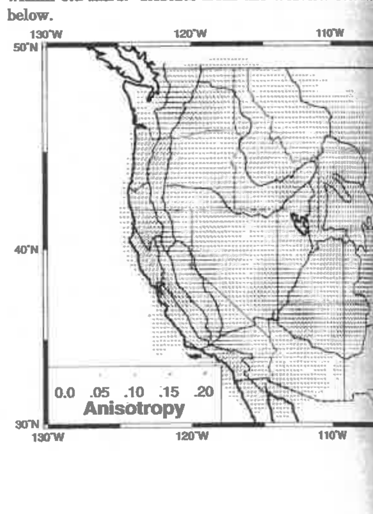
There is little doubt that substantial seismic anisotr ists within the upper mantle; however, anisotropy usually accounted for in most tomography studies. Pn tomography problem is reformulated to include variations in both the magnitude and the directi anisotropy. Both velocity variations and anisotrop tions are smoothed by using Laplacian regulari operators. The amount of regularization not only the trade-off between resolution and variance, but trols the relative amount of the data that is explained velocity variations and the anisotropy variations. gions with poor data coverage, it is not possible to guish between anisotropy and velocity variations; well covered regions, anisotropy variations can be within 0.1 km/s. Results from the western U.S. are below.



S51E-7 1030h

Mapping Seismic States From LI

Eric Sandvol and J Mexico State Un

The current numb anisotropy are insu lationship between last major tectonic the number of mea U.S. The Air Forc gram (LRSM) pres greatly aid in ma muthal anisotropy. wave splitting mea ments in the U.S. patterns of azimu region.

Benioff variable r used at many LRS wave splitting pa records and have f vious results obtai ally, shear-wave recorded at LRSM and Mina, Nevada by analyzing the L ple the number o ments in the U.S. details of mantle d

S51E-8 1045h

Shear-Wave Splitti

M K Savage (Univers 784-4245; e-mail: Campus Box 216, 80309-0216; ph. 30

During 1991 and 199 placed throughout C record earthquakes f upper mantle across seismic shear wave to obtain high-qualit time separation betw tions. The most stri "null" measurements or its orientation is p the direction. Eight had sufficient covera anisotropy in any ori had δt < 0.7s. Most ry, within the Rocky measurements at a la anisotropy should be positive measuremen sistent patterns with portion of the deploy NE-SW to NNE-SSW Rio Grande Rift. In consistent with recer absolute plate motion tation shifts about 60 of the array. In the Colorado Plateau, ϕ SSW and NE-SW ori Colorado Plateau. T ce in this region.

S51E-9 1100h

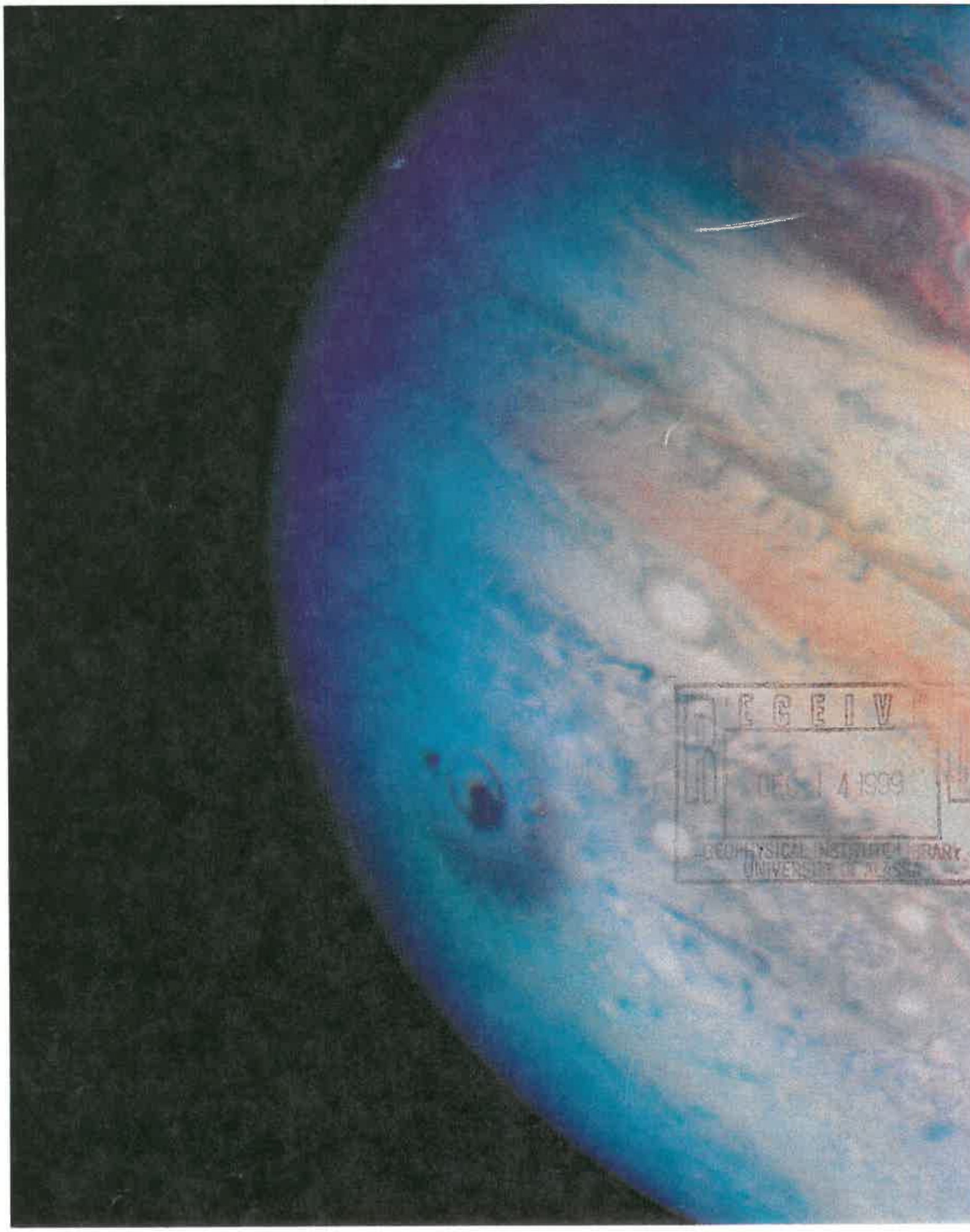
Variations in sh National Seism

M. G. Bostock (De versity of British 822-2082; e-mail:
J. F. Cassidy (Pac Canada, Sidney,

Measurements of SK tions of the Canadi over the period 199 reflect the diversity

1994 FALL MEETING

American Geophysical Union



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