NIEDERSÄCHSISCHE STAATS- UND
UNIVERSITÄTSBIBLIOTHEK GÖTTINGEN

Werk

Jahr: 1977
Kollektion: fid.geo
Signatur: 8 Z NAT 2148:
Digitalisiert: Niedersächsische Staats- und Universitätsbibliothek Göttingen
Werk Id: PPN1015067948_0043
PURL: http://resolver.sub.uni-goettingen.de/purl?PPN1015067948_0043

LOG Id: LOG_0069
LOG Titel: Abstracts and short communications
LOG Typ: section

Übergeordnetes Werk

Werk Id: PPN1015067948
PURL: http://resolver.sub.uni-goettingen.de/purl?PPN1015067948
OPAC: http://opac.sub.uni-goettingen.de/DB=1/PPN?PPN=1015067948

Terms and Conditions

The Goettingen State and University Library provides access to digitized documents strictly for noncommercial educational, research and private purposes and makes no warranty with regard to their use for other purposes. Some of our collections are protected by copyright. Publication and/or broadcast in any form (including electronic) requires prior written permission from the Goettingen State- and University Library.
Each copy of any part of this document must contain there Terms and Conditions. With the usage of the library's online system to access or download a digitized document you accept the Terms and Conditions.
Reproductions of material on the web site may not be made for or donated to other repositories, nor may be further reproduced without written permission from the Goettingen State- and University Library.

For reproduction requests and permissions, please contact us. If citing materials, please give proper attribution of the source.

Contact

Niedersächsische Staats- und Universitätsbibliothek Göttingen
Georg-August-Universität Göttingen
Platz der Göttinger Sieben 1
37073 Göttingen
Germany
Email: gdz@sub.uni-goettingen.de

J. Geophys. 43, 497–507, 1977

Journal of Geophysics

Abstracts and Short Communications

Phenomenological Representation of Seismic Sources

G. Backus[1] and M. Mulcahy[2]*

[1] Institute of Geophysics and Planetary Physics, University of California,
San Diego, A-025, La Jolla, CA 92093, USA
[2] Department of Geological Sciences, Princeton University, Princeton, NJ 08540, USA

All the usual phenomenological representations of earthquake sources can be obtained from the stress glut, the difference between the elastic model stress tensor field and the true physical stress tensor field. For thermoelastic sources the stress glut is an ordinary function; for faults it is a singular distribution whose support is the fault surface. The equivalent force distribution is the negative divergence of the stress glut. The polynomial moments of the equivalent force and the stress glut are the two types of seismic moment tensors. The force moments are completely determined by the motion and the glut moments are not. If all the force moments are known, the motion is completely determined, and if all the glut moments are known the source is completely determined, along with the force moments and the motion. Contrary to some published work, the seismic moment tensor is not the integral of the stress drop, and the equivalent force is not the negative divergence of the stress drop. The most general point source has as stress glut a finite linear combination of derivatives of delta functions. It can be used to approximate real localized sources. There are point sources which produce no motion. Mechanisms exist by which a real fault may produce a seismic moment tensor with nonzero trace. Real faults probably can be represented as simple surface sources, a generalization of dislocation sources, but less inclusive than De Hoop sources.

References

Backus, G., Mulcahy, M.: Moment tensors and other phenomenological descriptions of seismic sources – I. Continuous displacements. Geophys. J. **46**, 341–361, 1976

Backus, G., Mulcahy, M.: Moment tensors and other phenomenological descriptions of seismic sources – II. Discontinuous displacements. Geophys. J. **47**, 301–329, 1976

---

* *Present address:* Geonomics Inc., 3165 Adeline St., Berkeley, CA 94703, USA

The Influence of the Core and the Oceans on the Chandler Wobble

F.A. Dahlen[1] and M.L. Smith[2]

[1] Department of Geological and Geophysical Sciences, Princeton University,
Princeton, NJ 08540, USA
[2] Cooperative Institute for Research in Environmental Sciences, University of Colorado/NOAA,
Boulder, CO 80302, USA

Elastic-gravitational normal mode theory is used to investigate the dynamical influence of the fluid outer core on the free wobble of a rotating, ellipsoidal Earth model which does not have surficial oceans. A self-consistent equilibrium tidal theory is then employed to determine the passive influence of the associated pole tide on this mode. These calculations yield the observed Chandler

wobble period to within its observational uncertainty; models of the Earth having elastic material properties inferred from high frequency seismological observations appear therefore to predict with good accuracy the response of the real Earth at a period of fourteen months. We find also that more precise measurement of the Chandler wobble period is not likely to constrain strongly the structure of the Earth's fluid core, that estimates of wobble excitation by earthquakes based on a quasi-static calculation of the Earth's response are correctly computed, and that the coupling between wobble and spin induced by the geographically irregular distribution of the oceans is sufficiently slight that it is unlikely ever to be observed.

References

Dahlen, F.A.: The passive influence of the oceans upon the rotation of the Earth. Geophys. J. **46**, 363–406, 1976

Smith, M.L.: Wobble and nutation of the Earth. Geophys. J., 1977 (in press)

The Earth's Core-Mantle Interface Revisited

R. Hide

Geophysical Fluid Dynamics Laboratory, Meteorological Office, Bracknell, Berkshire, England

Determinations of fluctuations in the length of the day have revealed changes due to the transfer of angular momentum between the Earth's "solid" mantle and the overlying atmosphere on time scales upwards of a few weeks, as well as the slower but more pronounced "decade variations" due largely (according to current ideas) to angular momentum transfer between the mantle and the Earth's liquid core. Improvements in techniques for monitoring the Earth's rotation (such as those afforded by recent advances in methods of ranging to artificial satellites and the Moon and of very-long baseline interferometry) should therefore lead to results of interest to meteorologists concerned with planetary-scale motions in the atmosphere and to geophysicists concerned with the magnetohydrodynamics of the core and the origin of the main geomagnetic field. The consideration of the stresses at the Earth's surface and at the core-mantle interface that bring about angular momentum exchange between the solid and fluid parts of the Earth raises a number of basic hydrodynamical questions requiring further experimental and theoretical research. In the case of the core, quantitative difficulties encountered by the suggestion that the stresses are electromagnetic in origin led to the idea of topographic coupling associated with hypothetical undulations of the core-mantle interface.

At a few kilometres in vertical amplitude, such "bumps" would not significantly influence seismic data but they would measurably distort the Earth's gravitational and magnetic fields and might account for a certain correlation between these fields. Indeed, it was as a direct outcome of a test of the "bumps" hypothesis that the correlation between the gravitational and magnetic fields was discovered. Having been introduced originally by the author in an attempt to account for the high variability of the frequency of geomagnetic polarity reversals and certain properties of the geomagnetic secular variation (for references, see Hide, 1977), the hypothesis is now supported by sufficient evidence to justify further work on its various implications for the Earth's internal structure and evolution. It will be particularly important in future work on the interpretation of long wavelength features of the geoid to take into account one direct implication of the aforementioned correlation between the Earth's gravitational and magnetic fields, namely that the broad features of the horizontal pattern of density variations in the mantle are probably characterized by a high degree of vertical coherence—much higher in fact than many workers have evidently been prepared to accept hitherto.

Reference

Hide, R.: Towards a theory of irregular variations in the length of the day and core-mantle coupling. Phil. Trans. Roy. Soc. London **A284**, 547–554, 1977

Seismic Observations of Structure and Physical Properties of the Subcrustal Lithosphere as Evidence for Dynamical Processes in the Upper Mantle

K. Fuchs

Geophysical Institute, University of Karlsruhe, Hertzstr. 16,
D-7500 Karlsruhe, Federal Republic of Germany

Observations of body waves from explosions and earthquakes have revealed recently some unexpected properties of the lower lithosphere: *P*-wave velocities definitely larger than 8.2 km/s and anisotropy with velocities dependent on the azimuth of propagation both under oceans and continents. A model of the subcrustal lithosphere with pieces of laminas of high velocities is proposed to explain the transmission of high-frequency P_n and S_n to teleseismic distances and the tunneling of low-frequency body waves through the subcrustal lithosphere. The preferred orientation of these laminas is probably achieved by the same mechanism which produces the anisotropy.

The observations of high velocities in the lower lithosphere is evidence in itself that anisotropy is present there. Since the direction of maximum velocity correlates in the ocean and on the continent with a number of tectonic features, a causal connection between anisotropy and dynamical processes related to plate motion must be suspected.

References

Fuchs, K., Schulz, K.: Tunneling of low-frequency waves through the subcrustal lithosphere. J. Geophysics **42**, 175–190, 1976

Fuchs, K.: Seismic anisotropy of the subcrustal lithosphere as evidence for dynamical processes in the upper mantle. Geophys. J. **49**, 1977 (in press)

Seismic Anisotropy – a Summary

Stuart Crampin

Institute of Geological Sciences, Murchison House, Edinburgh EH9 3LA, Scotland

The matrix formulation of Crampin (1970), and the decomposition of the elastic tensor into three-by-three sub-matrices (Taylor and Crampin, 1977; Crampin, 1977), permit numerical calculation of both body and surface wave propagation in simple layered anisotropic structures (Keith and Crampin, 1977a, 1977b, 1977c; Crampin and Taylor, 1971; Crampin and King, 1977). The general principles of propagation in anisotropic structures are well understood from these studies, but the effects of the anisotropy on the behaviour of the waves are often subtly different from the corresponding isotropic propagation.

The best known of these differences is that, in the presence of anisotropy, there are azimuthal variations in the velocity of body waves and the dispersion of surface waves. These are difficult to observe in the earth except in particular uniform structures. Such velocity anisotropy in the upper mantle has now been observed many times in refraction experiments at sea, in West Germany (Bamford, 1977), and velocity anisotropy of the dispersion of the Fundamental Rayleigh mode has been observed in the NAZCA plate in the Pacific Ocean (Forsyth, 1975).

Refraction experiments are, perhaps, the most direct way of measuring the variation of velocity within the earth, but they can only give reliable measurements in relatively homogenous areas, and are expensive to perform. It can be shown (Crampin, 1977) that observations of P-wave velocity in a single plane of weakly anisotropic (less than 7% velocity anisotropy) have a relatively simple form:

$$\rho c^2 = A + B\cos 2\theta + C\cos 4\theta,$$

where c is the phase velocity, θ is the azimuth measured from a direction of sagittal symmetry, and A, B, and C are simple linear combinations of the elastic constants. Even when A, B, and C are well determined by the observations, they contain very little information about the elastic constants, or the constituent anisotropic structure (Crampin and Bamford, 1977), but do, of course, identify the symmetry direction.

The most distinctive characteristics, which distinguish propagation in anisotropic material from the corresponding isotropic propagation, are polarization anomalies, where the Rayleigh motion is coupled to the Love, and the P and SV motion is coupled to the SH. The coupling of Rayleigh and Love motion by anisotropy in the upper mantle is most clearly displayed by the Third Generalized mode; the equivalent of the Second Rayleigh mode in an isotropic earth (Crampin, 1975). Such polarizations have been observed along a network of paths covering a large part of Eurasia (Crampin and King, 1977), bounded by the Alpine and Himalayan mountains on land, and the 1000 m depth contour at sea. Such studies are limited by the homogenity of the structure necessary for higher mode propagation, and the difficulty of observing higher modes on conventional photographic seismograms.

Body wave polarization anomalies caused by anisotropy have only recently been recognised and synthesized (Keith and Crampin, 1977c), and have not yet been sought on seismic records. The P, SV, and SH coupling arises because there are 3 body waves propagating in any direction in anisotropic material (a quasi-P wave, and two quasi-shear waves) with orthogonal polarization. The polarizations are fixed by the alignment of the direction of propagation to the symmetry planes of the anisotropic structure, and not by the interface reactions, or the polarization of the incident wave. Synthetic seismograms show that the coupling produces small but significant P→SH and SH→P, and large SV→SH and SH→SV conversions at each isotropic/anisotropic interface, for all directions of propagation except those with sagittal symmetry. Along directions of sagittal symmetry the P and SV waves are decoupled from the SH waves as in isotropic material, although the individual equations of motion may be very much more complicated (Crampin, 1976). The polarization anomalies are very sensitive to the presence of even very weak anisotropy (Crampin, 1977), and it is suggested that analysis of polarization anomalies may be a powerful technique for examining earth structure.

Although the principles of propagation in anisotropic material are understood, the effects of anisotropy are varied and difficult to predict, and numerical calculation is necessary for the description of the behaviour of almost every anomaly. The solution of many problems, that can be solved in isotropic structures, can now be formulated in anisotropic structures, and solved, subject to the need for numerical calculation at an earlier stage in the manipulation. It is unfortunate that the seismologist's usual response is that the earth is largely isotropic, and that anisotropic studies are an unnecessary complication. Many anisotropic problems can now be solved exactly; it is only the effects that are complicated. P-wave arrival times are rather insensitive (except in refraction and reflection experiments) to the velocity variation within the earth, and the presence of an anisotropic layer in the lithosphere (a very plausible concept) may provide a simpler explanation of many arrival time anomalies than previous descriptions requiring scattering, heterogeneous, and discontinuous phenomena.

Acknowledgements. This work was undertaken as part of the research programme of the Institute of Geological Sciences, and is published with the approval of the Director, IGS.

References

Bamford, D.: Pn velocity anisotropy in a continental upper mantle. Geophys. J., in press, 1977

Crampin, S.: The dispersion of surface waves in multilayered anisotropic media. Geophys. J. **21**, 387–402, 1970

Crampin, S.: Distinctive particle motion of surface waves as a diagnostic of anisotropic layering. Geophys. J. **40**, 177–186, 1975

Crampin, S.: A comment on "The early structural evolution and anisotropy of the oceanic upper mantle". Geophys. J. **46**, 193–197, 1976

Crampin, S.: A review of the effects of anisotropic layering on the propagation of seismic waves. Geophys. J., in press, 1977

Crampin, S., Bamford, D.: Inversion of P-wave velocity anisotropy. Geophys. J., in press, 1977

Crampin, S., King, D.W.: Evidence for anisotropy in the upper mantle beneath Eurasia from the polarization of higher mode seismic surface waves. Geophys. J., in press, 1977

Crampin, S., Taylor, D.B.: The propagation of surface waves in anisotropic media. Geophys. J. **25**, 71–87, 1971

Forsyth, D.W.: The early structural evolution and anisotropy of the oceanic upper mantle. Geophys. J. **43**, 103–162, 1975

Keith, C.M., Crampin, S.: Seismic body waves in anisotropic media: reflection and refraction at a plane interface. Geophys. J., in press, 1977a

Keith, C.M., Crampin, S.: Seismic body waves in anisotropic media: propagation through an anisotropic layer. Geophys. J., in press, 1977b

Keith, C.M., Crampin, S.: Seismic body waves in anisotropic media: synthetic seismograms. Geophys. J., in press, 1977c

Taylor, D.B., Crampin, S.: Surface waves in anisotropic media: propagation in a homogeneous halfspace. Phil. Trans. Roy. Soc., submitted 1977

Precise Continuous Monitoring of Seismic Velocity Variations

H. Bungum[1], T. Risbo[2], and E. Hjortenberg[3]

[1] NTNF/NORSAR, P.O. Box 51, N-2007 Kjeller, Norway
[2] University of Copenhagen, Department of Geophysics,
Haraldsgade 6, DK-2200 Copenhagen, Denmark
[3] Geodetic Institute, Department of Seismology,
Gamlehave Allé 22, DK-2920 Charlottenlund, Denmark

Seismic velocities in the siting area of the Norwegian Seismic Array (NORSAR) have been monitored over a time period of one week using a hydroelectric power plant as a continuous wave generator. Propagational phase angle differences have been measured over travel distances ranging from 4.7–13.7 km, and group velocities of the order of 3.5 km/s are derived. This is close to the expected (phase) velocity for S-waves, and the particle motions derived at a distance of 4.7 km correspond also well with those for S-waves. The obtained precisions are 10^{-3} for a time period of about 2h and 10^{-4} when one week of data are used. The phase difference data contain a semidiurnal spectral component with a peak-to-trough amplitude of around 10^{-3}.

Reference

Bungum, H., Risbo, T., Hjortenberg, E.: Precise continuous monitoring of seismic velocity variations. Submitted to J. Geophys. Res., 1976

On the Computation of Theoretical Seismograms for Multimode Surface Waves

G. Calcagnile[1], G.F. Panza[2], F. Schwab[3], and E. Kausel[4]

[1] Istituto di Geodesia e Geofisica, I-70100 Bari, Italy
[2] Istituto di Geodesia e Geofisica, Bari, and Dipartimento di Scienze della Terra,
I-87030 Castiglione Scalo, Italy
[3] Box 131, 308 Westwood Plaza, Los Angeles, CA 90024, USA
[4] Department de Geofisica y Geodesia, Santiago, Chile

It is needlessly expensive to use standard computational techniques, when applying inverse Fourier transformation to construct theoretical seismograms from frequency-domain data for multimode surface waves. Such techniques require the evaluation of dispersion and attenuation information for each mode, at each of a dense set of points which are equally spaced in frequency. These evaluations are by far the most expensive part of the computation of theoretical seismograms for surface waves. By further development of a method proposed by Aki, and departing from the standard, equal-frequency-interval computational techniques, it is possible to decrease the required number of dispersion and attenuation evaluations. With our new method we obtain an increase in computational efficiency of 200% for the fundamental mode and 500% for the higher modes. With the proposed techniques: (a) a quadratic fit to the amplitude spectrum is applied in each frequency interval, (b) a linear or quadratic fit to the phase spectrum is used in each interval, (c) automatic control over the accuracy of the theoretical seismograms is maintained, and (d) with this control feature we can apply the method over as extensive a period range as one desires, irrespective of how rapidly the group velocity varies.

Reference

Calcagnile, G., Panza, G.F., Schwab, F., Kausel, E.: On the computation of theoretical seismograms for multimode surface waves. Geophys. J. **47**, 73–81, 1976

On the Excitation of the Earth's Seismic Normal Modes

N.J. Vlaar

Vening Meinesz Laboratory, Lucas Bolwerk 7, Utrecht, Netherlands

The excitation of the earth's normal modes is formulated as an initial value problem. The static state of the earth, stressed from its hydrostatic reference situation, is considered as the initial state. The initial state is relaxed, at the time of the earthquake, by the removal of the forces maintaining the departure from hydrostatic equilibrium. Expressions are derived for the coefficients giving the relative excitation of the individual modes for the cases where these forces are compensating volume forces or compensating tractions on the faces of a dislocation. It is demonstrated that a point slip dislocation has a body force equivalent in the form of a double couple with a deviatoric moment tensor. However, for a source with volume change no moment tensor equivalent can be found. The volume change, apart from an elastic effect which can be represented by an isotropic moment tensor, has a direct gravitational effect on the excitation. This effect is due to a balanced force field consisting of a point force at the source and a continuous distribution of volume forces throughout the earth. The latter distribution, if not taken into account, may give rise to artificial phases in the frequency spectrum of the normal modes.

Reference

Vlaar, N.J.: On the excitation of the earth's seismic normal modes. Pure and Appl. Geophys. **114**, 863–875, 1976

Seismic Velocities and Density of an Attenuating Earth

R.S. Hart and D.L. Anderson

Seismological Laboratory, California Institute of Technology, Pasadena, CA 91125, USA

The dispersion that accompanies attenuation has been taken into account in many recent body wave studies. In free oscillation and surface wave investigations, however, the effect has been assumed to be of second order and, hence, has been ignored. Liu, Anderson, and Kanamori (1976) have recently re-examined this effect and have shown it to be first order across the seismic band. In order to compare data from different frequency bands, then, a frequency-dependent correction must be applied to the observed phase velocities. The corrected data will then be representative of the elastic properties of the earth at the selected reference frequency. In the case of the free oscillations and long-period surface waves corrected to body wave frequencies (about one cycle/s), this correction factor is of the order of 1%, many times larger than the uncertainty of the raw data.

As a first step in determining the appropriate attenuation corrections, a satisfactory Q model must be developed. We have used free oscillation, surface wave, and body wave observations to obtain a new average Q structure for the earth, designated model SL1. This model includes a low Q zone at both the top and the bottom of the mantle. In these regions, seismic velocities will be frequency dependent. This Q model has been used to correct the observed eigenperiods of the spheroidal and toroidal modes to a reference period of 1 s. The corrected data set was then inverted to obtain the radial variation of density and seismic velocities within the earth. The largest changes from previous gross earth models, obtained through inversion of uncorrected data, occur in the upper mantle and at the very base of the lower mantle. In the upper 700 km of the earth, the inferred compressional and shear velocities increase by about 2% over previous results. The resulting body wave travel-times no longer show the large discrepancies with times predicted by body wave studies. In particular, the shear wave travel-times show only a 1.0 s baseline shift relative to the Jeffreys-Bullen values as compared to the 6–10 s shift of past models. Deep continental-oceanic mantle differences are no longer required to explain this feature.

The fact that seismic velocities depend significantly on frequency considerably complicates efforts to determine the structure and composition of the mantle. A detailed knowledge of the frequency dependence of Q from ultrasonic frequencies to normal mode frequencies as well as the distribution of attenuation with depth is necessary before seismic data can be interpreted with confidence. The development of a Standard Earth is substantially hindered as well. If the Standard Earth is a valid concept, then a standard Q model and reference frequency must also be developed. Work in this area is only just barely beginning. Further, elastic properties at tidal and Chandler periods differ from those at seismic periods and this also restricts the application of a Standard Earth Model.

References

Hart, R.S., Anderson, D.L., Kanamori, H.: The effect of attenuation on gross earth models. J. Geophys. Res., 1977 (in press)

Anderson, D.L., Hart, R.S.: The Q of the earth. Submitted to J. Geophys. Res., 1977

A First-Motion Alternative to Geometrical Ray Theory

C.H. Chapman and S.K. Dey Sarkar

Department of Physics, University of Toronto, Toronto, Ontario M5S 1A7, Canada

In recent years, the direct measurements of the seismic ray parameter and comparisons with synthetic seismograms have improved the interpretations of seismic data. This is particularly true of structure near interfaces in both the crust and deep interior of the earth. Until very recently, however, the computation of synthetic seismograms was too expensive and complicated for routine use. In addition several approximations were necessary in the theory. In this paper the approximations used in generalized ray theory are investigated in more detail and a new approximation is derived.

The generalized ray method is extended to vertically inhomogeneous media without approximation by homogeneous layers (Chapman, 1976a). The response is obtained as an infinite series of depth integrals rather than a summation of many rays. It is shown that this series converges rapidly to geometrical ray theory when the latter is valid. However, it is still expensive to compute the multiple integrals and a simple approximation exists for the infinite series. This we call the *first-motion approximation.*

The first-motion approximation is equivalent to geometrical ray theory but remains valid at caustics and shadows. The same approximation can be derived from generalized ray theory, the WKBJ approximation (Chapman, 1976b) or an intuitive physical argument (disk ray theory). The approximation is sufficiently simple that computations can be performed on a routine basis from the travel-time curve. Comparisons of synthetic seismograms using the first-motion approximation and other methods have been made. The method is sufficiently simple that it can be extended to cases where the WKBJ approximation is invalid, to laterally inhomogeneous and attenuating models and to the inverse problem.

References

Chapman, C.H.: Exact and approximate generalized ray theory in vertically inhomogeneous media. Geophys. J. **46**, 201–233, 1976a

Chapman, C.H.: A first-motion alternative to geometrical ray theory. Geophys. Res. Lett. **3**, 153–156, 1976b

Heterogeneous Velocity Structure at the Base of the Mantle

1. Model

J.A. Snoke and I.S. Sacks

Carnegie Institution of Washington, Department of Terrestrial Magnetism,
5241 Broad Branch Road, N.W., Washington, DC 20015, USA

Using a ray-theory approach, we have modeled regions at the base of the mantle to determine the characteristics of the velocity structure which give rise to observed amplitude variations in PKP arrivals at epicentral distances greater than 158°. Consistent results for the amplitude anomalies over the period range 0.5–10 s were obtained by modeling the lowermost 150 km of the mantle at either the core-entry or core-departure point of the ray as consisting of cells which are 150 km high and 150 km in lateral extent with lateral velocity variations of up to 1.5%. The PKPAB is near-grazing at the mantle-core interface so that a ray traverses a number of cells. Our deterministic model contrasts with Chernov random scattering in allowing for more than a single scattering in the heterogeneous region. Also, the observed frequency dependence of the amplitude anomaly is inconsistent with that predicted by Chernov scattering.

Reference

Snoke, J.A., Sacks, I.S.: A model for laterally heterogeneous velocity structure at the base of the mantle. Carnegie Inst. Wash. Year Book **75**, 233–240, 1976

Heterogeneous Velocity Structure at the Base of the Mantle

2. Observations and Interpretations

I.S. Sacks and J.A. Snoke

Carnegie Institution of Washington, Department of Terrestrial Magnetism,
5241 Broad Branch Road, N.W., Washington, DC 20015, USA

For epicentral distances greater than 158° the core phase PKPAB has near-grazing incidence at the mantle-core boundary and hence is highly sensitive to velocity structure at the base of the mantle, while PKPDF has near-normal incidence and is less sensitive. The amplitude ratio, PKPAB/PKPDF for given earthquake-seismograph pairs is insensitive to source or near station effects. The interpretation ambiguity caused by the two core boundary crossings for each arrival was removed by studying numerous earthquake-seismograph groups which had only one coincident core-mantle crossing region in their paths. Amplitude ratios for regions beneath the East Pacific and West Atlantic, where abundant data are available, show good coherence and indicate large well defined contiguous zones with different local structures. A model (see accompanying paper) which is consistent with the data suggests that in some regions there are small-scale (~150 km) convection cells while other regions may be involved in whole-mantle processes (convection, plumes). Correlations with isostatic anomalies of the gravity field are consistent with this suggestion.

Reference

Sacks, I.S., Beach, L.: Lateral heterogeneities at the base of the mantle—an indication of whole mantle convection. Carnegie Inst. Wash. Year Book **73**, 1020–1032, 1974

Theoretical Seismograms of Core Phases Calculated by a Frequency-Dependent Full Wave Theory, and Their Interpretation

G.L. Choy*

Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964, USA

A frequency-dependent full wave theory is successfully employed to synthesize long period seismograms of the core phases SmKS ($m=1,2, \ldots$) in the distance range 100° to 125°. Body wave displacements are calculated by numerically integrating in the complex ray parameter plane. Langer's method is employed to obtain a uniformly asymptotic approximation to the vertical wave functions. Plane wave reflection and transmission coefficients are adequately corrected for the effect of the curvature at the core-mantle discontinuity by the use of generalized cosines. Results are presented in the time domain, after a numerical Fourier (inverse) transform.

The computed seismograms exhibit many non-ray effects that the SmKS incur upon interacting with the core-mantle boundary. For SKS, the amplitude, group delay and phase delay are very strong functions of frequency at less than 0.5 Hz, both because of the frequency dependence of the reflection/transmission coefficients at the core-mantle boundary, and because of the presence of diffracted energy, called SP(diff)KS, perturbing the waveform. The diffracted energy of the type that perturbs SKS may also interact with shear waves to give rise to a precursor to the body wave ScS, called SP(diff)S. The major complication in synthesizing the portion of the seismogram containing SmKS for $m \geqq 2$ is that the arrival time of each successively higher order reflection is within the waveform of previous lower order reflections. It is found that a summation of body wave displacements from S2KS through S15KS gives an adequate seismogram. Each individual reflection has an amplitude spectrum, group delay and phase delay which are strongly frequency-dependent at less than 0.2 Hz. It is shown that picking conventional arrival times for SmKS, $m \geqq 2$, is nearly impossible. Furthermore, neglecting the frequency dependence of reflection/transmission coefficients can significantly distort the interpretation of amplitude and phase data.

The seismograms generated by this method agree so remarkably well with observed records that the synthetic waveforms provide a powerful test of the validity of particular earth models. In particular, we find that the waveforms of SmKS are exceedingly sensitive to velocity gradients of the upper 200 km of the outer core, and indications are that the velocities in the outer 200 km of the core are higher than that predicted by Hales and Roberts (1971) or earth model 1066B. The pulse widths of SmKS are also used to determine some fault parameters.

Reference

Choy, G.L.: Theoretical seismograms of core phases calculated by a frequency-dependent full wave theory, and their interpretation. Submitted to Geophys. J.R.A.S., 1976

---

* Now with the U. S. Geological Survey, Office of Earthquake Studies, Denver, Colorado 80225, USA

Amplitudes of Long-Period PcP, SKS and SKKS and the Structure at the Base of the Mantle and in the Outer Core

G. Müller[1], R. Kind[1], A. Mula[1], and S. Gregersen[2]

[1] Geophysical Institute, University of Karlsruhe,
Hertzstr. 16, D-7500 Karlsruhe, Federal Republic of Germany
[2] Geodetic Institute, DK-2920 Charlottenlund, Denmark

We have studied the amplitude ratios PcP/P and SKS/SKKS in long-period WWNSS and CSN records of 2 South American and 5 Tonga-Fiji deep-focus earthquakes. These data are compared with theoretical ratios PcP/P and SKS/SKKS, derived from theoretical seismograms for a variety of models of the lowermost mantle, the core-mantle boundary (CMB) and the outer core. The PcP/P data discriminate against models with discrete layers above the CMB and against nonzero S velocities below the CMB. They are reasonably well explained by simple first-order discontinuity models of the CMB. The data may indicate a negative P-velocity gradient above the CMB, but it was not possible to find a satisfactory fit for both PcP/P and the travel times of PcP. The SKS/SKKS ratio is most sensitive with respect to the P-velocity distribution in the outer core down to depths of about 4200 km. Traditional distributions produce ratios which are significantly larger than the observed ratios between 100° and 110°. Agreement of observation and theory is found for a model with increased velocities around 3750 km depth. This model also satisfies the differential travel times of SKS and SKKS, and its SKKKS phase is weak enough to be compatible with the observations. Other models explaining the SKS/SKKS data have not been found. Our model implies pronounced chemical zoning in the outer core.

References

Kind, R., Müller, G.: The structure of the outer core from SKS amplitudes and travel times. Submitted to Bull. Seism. Soc. Am., 1977

Müller, G., Mula, A.H., Gregersen, S.: Amplitudes of long-period PcP and the core-mantle boundary. Phys. Earth Planet. Int. **14**, 30–40, 1977