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UNIVERSAL DISPERSION TABLES
1. LOVE WAVES ACROSS OCEANS AND CONTINENTS ON A SPHERICAL EARTH

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ABSTRACT

The variational approach to surface wave dispersion problems has been largely replaced by the powerful method of Haskell which is exact and particularly convenient for use on digital computers. This paper shows how the two methods may be combined to yield dispersion curves which can be used to interpret data from any layered structure.

A set of graphs and tables is presented which can be used to calculate the dispersion of Love waves in the period range of 4 to 1000 seconds over any spherical earth model. In addition, it is possible to determine by inspection which portion of the earth is contributing to a set of observed dispersion data thereby facilitating the design of an appropriate earth model. These tables can be used to determine how much freedom can be taken with proposed models without violating dispersion data. Application to the inverse problem is immediate.

Introduction

The calculation of the dispersion relationships for surface waves travelling over realistic spherical earth models is a fundamental seismological problem, arising both in earth structure and in source mechanism studies. It is a routine matter now, for those having access to high speed computers, to calculate the dispersion appropriate for any mode of propagation in a given radially symmetric earth model. Fairly complete fundamental mode solutions have been published for the standard earth models of Gutenberg, Jeffreys, Lehmann, Bullen and Bullard, and minor variations of these velocity and density structures. Comparison of these theoretical calculations with long period observational data show that the Gutenberg or Lehmann velocity structures and the Bullen A density structures provide better agreement than the alternatives, but none of the standard earth models is completely satisfactory. Because of the large number of parameters involved in defining a realistic earth model and the complicated way in which they enter into the dispersion relations, it is difficult to determine which parameters must be changed in order to achieve better agreement between the theory and the data. Even in crustal studies where the total thickness of the earth's crust is the only quantity of interst, good agreement between observed dispersion and a curve from a set of standard curves where only the total crustal thickness is varied is seldom obtained. This indicates that the velocity-density structure of the standard model must also be varied. Published dispersion curves or families of dispersion curves do not permit the estimation of the effect of these variations. A large volume of dispersion curve families would be required to extend the standard curve matching method to include the effects of crustal and mantle layering and different crustal velocity-density structures.

The trial and error method of modifying a test structure and recomputing dispersion is a slowly converging process without clear-cut guide lines as to the necessary modifications. Even with a high-speed digital computer the calculations are so tedious that only the most tentative efforts have been made to modify a trial struc-

ture until there is good agreement between theory and data, thereby taking full advantage of the surface wave information. Even in the few cases where good agreement has been obtained between a theoretical dispersion curve and observed dispersion data, it has not been possible to make any statements concerning the possibility of other structures fitting equally well. It is not usually clear which features of the proposed model are necessary and which may be modified without violating the data. It is particularly difficult for other earth scientists to assess the relative merits of various competing earth models.

The present series of papers was motivated by the above considerations but have been expanded to allow groups without access to electronic computers to conveniently compute dispersion for complicated structures by hand or with a desk calculator.

A method is developed here which is a modification of Jeffreys' (1961) suggested use of Rayleigh's principle. Haskell's matrix method is used to calculate the period relationship (phase velocity vs. period) and the eigenfunctions for a layered medium. The eigenfunction is considered invariant for small changes in the physical parameters in the calculation of variational partial derivatives. The result is a series of tables and graphs which show the effect of every parameter in the waveguide at all periods. This information, along with the theoretical dispersion results for the trial model, permits the rapid calculation of the dispersion for any other model by hand or with a desk calculator.

This initial paper presents results pertinent for fundamental Love wave phase velocity calculations in the period range 4 to 1000 seconds. Later papers will deal with Rayleigh waves, higher modes and free oscillations. The tables presented here can also be used to compute Love wave attenuation simply by allowing the parameter perturbations to become complex.

Theory

Although the variational method has been used to calculate approximately the steady state response of a radially or vertically inhomogeneous waveguide, the method finds its proper role as a corrective scheme to investigate the effect of small changes in the waveguide. It should be pointed out that even though the differences among the various proposed earth models are physically significant, they are mathematically small, and the restriction to "small changes" is not severe.

The analysis follows that of Jeffreys (1961) generalized to multi-layered media. The following analysis also holds for a spherical body with the change of variables given in Anderson and Toksöz (1963). If the horizontal transverse displacement for a wave travelling in the x-direction is

$$v(z) \cos (\omega t - kx) \tag{1}$$

the average values of the kinetic energy, T, and the elastic potential energy, V, are

$$4T = \int \rho\omega^2 v^2 \, dz, \qquad 4V = \int \mu(k^2 v^2 + v'^2) \, dz \tag{2}$$

where the integration extends over the entire depth of the waveguide and the prime denotes differentiation with respect to the depth variable z.

Since the kinetic energy and the potential energy, averaged over a cycle, are equal

$$\omega^2 I_0 = k^2 I_1 + I_2 \tag{3}$$

where

$$\begin{aligned} I_0 &= \int \rho v^2 \, dz \\ I_1 &= \int \mu v^2 \, dz \\ I_2 &= \int \mu v'^2 \, dz \end{aligned} \tag{4}$$

The dispersion relation $\omega = \omega(k)$ for the structure being studied can be obtained by a variety of techniques including numerical integration of the equations of motion, a variational technique or the Thomson-Haskell matrix method. The latter is particularly convenient for use on computers and has the additional advantage, for the problem at hand, of yielding closed form expressions for the above integrals. The theory of the matrix method applied to a variety of surface wave problems is treated by Haskell (1953), Anderson (1961), Anderson (1962), Harkrider and Anderson (1962), Gilbert and MacDonald (1960) and Anderson and Toksöz (1963). It need not be discussed further here. The other methods can also be used as a basis for the sort of calculations presented here, but they would have the disadvantages inherent in any completely numerical method.

Once having the dispersion relation and the eigenfunctions we wish to investigate the change in phase velocity at a given period corresponding to a given change in a physical parameter. If we vary μ, keeping ω and ρ fixed, we have, to first order,

$$\frac{\delta c}{\delta \mu} = \left(ck^2 \frac{\delta I_1}{\delta \mu} + c \frac{\delta I_2}{\delta \mu} \right) \Big/ (2 I_1 k^2) \tag{5}$$

Similarly, if we vary ρ, keeping ω and μ constant

$$\frac{\delta c}{\delta \rho} = \left(-c^3 \frac{\delta I_0}{\delta \rho} \right) \Big/ 2 I_1 \tag{6}$$

In a layered structure of n homogeneous layers

$$\begin{aligned} I_0 &= \sum_{m=1}^{n} \int_{h_m}^{h_{m+1}} \rho_m v^2 \, dz = \sum_{m=1}^{n} I_{0_m} \\ I_1 &= \sum_{m=1}^{n} \int_{h_m}^{h_{m+1}} \mu_m v^2 \, dz = \sum_{m=1}^{n} I_{1_m} \\ I_2 &= \sum_{m=1}^{n} \int_{h_m}^{h_{m+1}} \mu_m v'^2 \, dz = \sum_{m=1}^{n} I_{2_m} \end{aligned} \tag{7}$$

By Rayleigh's Principle, for a perturbation of parameters only in the mth layer

$$\begin{aligned} \delta I_0 &= \delta I_{0_m} = \int_{h_m}^{h_{m+1}} \delta\rho_m v^2 \, dz \\ \delta I_1 &= \delta I_{1_m} = \int_{h_m}^{h_{m+1}} \delta\mu_m v^2 \, dz \\ \delta I_2 &= \delta I_{2_m} = \int_{h_m}^{h_{m+1}} \delta\mu_m v'^2 \, dz \end{aligned} \tag{8}$$

Because of the linearization the total effect on phase velocity is

$$dc = \sum_{m=1}^{n} \left(\frac{\delta c}{\delta \mu}\right)_m d\mu_m + \sum_{m=1}^{n} \left(\frac{\delta c}{\delta \rho}\right)_m d\rho_m \tag{9}$$

The unperturbed layers, of course, do not contribute to the summation.

In the Haskell formulation of the surface wave problem the motion-stress vector in the mth layer, $\mathfrak{D}_m(z)$, can be written

$$\mathfrak{D}_m(z) = B_m \mathfrak{D}_m(z_m) \tag{10}$$

Where m is the layer index and the depth corresponding to $z = z_m$ is the top of the mth layer. With the convention

$$\mathfrak{D}_m(z) = (\dot{v}/c, p_{zy})$$

it follows that

$$\dot{v}(z)/c = B_{11}\dot{v}(z_m)/c + B_{12}p_{yz}(z_m) \tag{11}$$

where

$$\begin{aligned} B_{11} &= \cos kr_{\beta_m} d_m \\ B_{12} &= i(\mu_m r_{\beta_m})^{-1} \sin kr_{\beta_m} d_m \\ d_m &= h_{m+1} - h_m \\ r_{\beta_m} &= (c^2/\beta_m^2 - 1)^{1/2} \end{aligned} \tag{12}$$

The energy integrals can now be calculated exactly

$$\begin{aligned} I_{0_m} = -\frac{1}{k^2}\Bigg[\left(\frac{\dot{v}}{c}\right)_m^2 \left(\frac{h_m}{2} + \frac{\sin 2Q}{4kr_{\beta_m}}\right) - \left(\frac{\dot{v}}{c}\right)_m (p_{yz})_m \mu_m^{-1} r_{\beta_m}^{-2} \left(\frac{1 - \cos 2Q}{2k}\right) \\ + (p_{yz})^2_m \mu_m^{-2} r_{\beta_m}^{-2} \left(\frac{h_m}{2} - \frac{\sin 2Q}{4kr_{\beta_m}}\right)\Bigg] \end{aligned} \tag{13}$$

$$I_{1_m} = \frac{\mu_m}{\rho_m} I_{0_m} \tag{14}$$

$$\begin{aligned} I_{2_m} = &- \left(\frac{\dot{v}}{c}\right)^2 \mu_m r_{\beta_m}^2 \left[\frac{h_m}{2} - \frac{\sin 2Q}{4kr_{\beta_m}}\right] \\ &- \left(\frac{\dot{v}}{c}\right)_m (p_{yz})_m \left[\frac{1 - \cos 2Q}{2k}\right] - (p_{yz})_m^2 \mu_m^{-1} \left[\frac{h_m}{2} + \frac{\sin 2Q}{4kr_{\beta_m}}\right] \end{aligned} \tag{15}$$

where $Q = kr_{\beta_m} d_m$.

The *earth stretching* transformations of Anderson and Toksöz (1963) were used in the calculation of I_0, I_1, and I_2, these integrals now representing good approximations for the spherical earth problem.

The effect of other parameters in the system can easily be investigated from the above equations. For example, the following relations are useful

$$\left(\rho \frac{\delta c}{\delta \rho}\right)_\beta = \left(\rho \frac{\delta c}{\delta \rho}\right)_\mu + \left(\mu \frac{\delta c}{\delta \mu}\right)_\rho \tag{16}$$

$$\left(h \frac{\delta c}{\delta h}\right)_{\rho,\mu,\beta} \approx \left(\rho \frac{\delta c}{\delta \rho}\right)_\beta \tag{17}$$

$$\left(\beta \frac{\delta c}{\delta \beta}\right)_\rho \approx 2 \left(\mu \frac{\delta c}{\delta \mu}\right)_\rho \tag{18}$$

where h is a layer thickness and the subscripts are quantities being held constant.

Use of Tables and Curves

The calculation of dispersion over any spherical, layered earth model involves the use of two tables. The first gives the layer parameters for the trial model and the second gives the partial derivatives of phase velocity with respect to these layer parameters at various periods. Complete tables are presented here for two trial earth models—one oceanic and one continental. A series of partial derivative graphs are presented for several models to illustrate their behavior. In addition to the partial derivative tables, a set of tables is given which indicates the effect of a 10% change in the parameter. The numbers in the partial derivative tables are, in fact, derived from these latter tables.

Table 1 gives the layer index, layer thickness, and depth, shear velocity, density and rigidity for each layer in a model designated Gutenberg-Birch II. This is a continental type model with a density distribution that is closely related to the velocity distribution. Table 2 gives the corresponding values for a model designated CIT13F. This is a model that was designed in the course of a study of the oceanic mantle and gives a good fit to oceanic Love wave data. These models are the trial structures upon which the basic partial derivative tables are based. Tables 1 and 2 also tabulate modifications of these models in which the crust and upper mantle are split into finer layers for detailed studies of this region using shorter period Love

TABLE 1

LAYER INDEX (M), LAYER THICKNESS (D), SHEAR VELOCITY (BETA), DENSITY (RHO) AND RIGIDITY (N) FOR GUTENBERG BIRCH II CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II CONTINENTAL

M	D (km)	DEPTH (km)	BETA (km/sec)	RHO (g/cm^3)	N ($10^{10} dy/cm^2$)
1	19.0	9.50	3.550	2.750	34.65
2	2.0	20.00	3.800	2.900	41.87
3	2.0	22.00	3.800	2.900	41.87
4	2.0	24.00	3.800	2.900	41.87
5	2.0	26.00	3.800	2.900	41.87
6	6.0	30.00	3.800	2.900	41.87
7	5.0	35.50	3.800	2.900	41.87
8	7.0	41.50	4.587	3.560	74.90
9	5.0	47.50	4.560	3.543	73.67
10	5.0	52.50	4.543	3.530	72.85
11	5.0	57.50	4.520	3.515	71.81
12	5.0	62.50	4.505	3.504	71.11
13	5.0	67.50	4.487	3.500	70.46
14	5.0	72.50	4.475	3.494	69.96
15	5.0	77.50	4.460	3.490	69.42
16	10.0	85.00	4.440	3.488	68.76
17	20.0	100.00	4.420	3.495	68.27
18	20.0	120.00	4.400	3.513	68.01
19	20.0	140.00	4.390	3.528	67.99
20	20.0	160.00	4.400	3.546	68.65
21	20.0	180.00	4.420	3.564	69.62
22	20.0	200.00	4.450	3.582	70.93
23	20.0	220.00	4.480	3.606	72.37
24	20.0	240.00	4.520	3.628	74.12
25	20.0	260.00	4.570	3.652	76.27
26	20.0	280.00	4.610	3.676	78.12
27	35.0	307.50	4.660	3.700	80.34
28	50.0	350.00	4.810	3.773	87.29
29	50.0	400.00	4.950	3.848	94.28
30	50.0	450.00	5.090	3.924	101.66
31	50.0	500.00	5.220	3.996	108.88
32	50.0	550.00	5.360	4.071	116.95
33	75.0	612.50	5.500	4.147	125.44
34	100.0	700.00	5.770	4.301	143.19
35	100.0	800.00	6.040	4.422	161.32
36	100.0	900.00	6.300	4.543	180.31
37	150.0	1025.00	6.350	4.573	184.39
38	200.0	1200.00	6.500	4.694	198.32
39	200.0	1400.00	6.600	4.769	207.73
40	200.0	1600.00	6.750	4.845	220.75
41	200.0	1800.00	6.850	4.920	230.85
42	200.0	2000.00	6.950	4.996	241.31
43	200.0	2200.00	7.000	5.056	247.74
44	200.0	2400.00	7.100	5.116	257.89
45	200.0	2600.00	7.200	5.192	269.15
46	200.0	2800.00	7.250	5.267	276.84
47	200.0	3000.00	7.200	5.267	273.04
48	20.0	3110.00	7.200	5.252	272.26

GUTENBERG BIRCH II LAMINATED CRUST

M	D (km)	DEPTH (km)	BETA (km/sec)	RHO (g/cm^3)	N ($10^{10} dy/cm^2$)
1	0.5	0.25	3.550	2.750	34.65
2	0.5	0.75	3.550	2.750	34.65
3	1.0	1.50	3.550	2.750	34.65
4	1.0	2.50	3.550	2.750	34.65
5	1.0	3.50	3.550	2.750	34.65
6	1.0	4.50	3.550	2.750	34.65
7	2.0	6.00	3.550	2.750	34.65
8	2.0	8.00	3.550	2.750	34.65
9	5.0	11.50	3.550	2.750	34.65
10	5.0	16.50	3.550	2.750	34.65
11	5.0	21.50	3.800	2.900	41.87
12	5.0	26.50	3.800	2.900	41.87
13	5.0	31.50	3.800	2.900	41.87
14	4.0	36.00	3.800	2.900	41.87
15	2.0	39.00	4.587	3.560	74.90
16	5.0	42.50	4.587	3.560	74.90
17	5.0	47.50	4.560	3.543	73.67
18	5.0	52.50	4.543	3.530	72.85
19	5.0	57.50	4.520	3.515	71.81
20	5.0	62.50	4.505	3.504	71.11
21	5.0	67.50	4.487	3.500	70.46
22	5.0	72.50	4.475	3.494	69.96
23	5.0	77.50	4.460	3.490	69.42
24	10.0	85.00	4.440	3.488	68.76
25	10.0	95.00	4.420	3.495	68.27
26	10.0	105.00	4.420	3.495	68.27
27	20.0	120.00	4.400	3.513	68.01
28	20.0	140.00	4.390	3.528	67.99
29	20.0	160.00	4.400	3.546	68.65
30	20.0	180.00	4.420	3.564	69.62
31	20.0	200.00	4.450	3.582	70.93
32	20.0	220.00	4.480	3.606	72.37
33	20.0	240.00	4.520	3.628	74.12
34	20.0	260.00	4.570	3.652	76.27
35	20.0	280.00	4.610	3.676	78.12
36	35.0	307.50	4.660	3.700	80.34
37	50.0	350.00	4.810	3.773	87.29
38	50.0	400.00	4.950	3.848	94.28
39	50.0	450.00	5.090	3.924	101.66
40	50.0	500.00	5.220	3.996	108.88
41	50.0	550.00	5.360	4.071	116.95
42	75.0	612.50	5.500	4.147	125.44
43	100.0	700.00	5.770	4.301	143.19
44	100.0	800.00	6.040	4.422	161.32
45	100.0	900.00	6.300	4.543	180.31
46	200.0	1050.00	6.350	4.573	184.39

TABLE 2

LAYER INDEX (M), LAYER THICKNESS (D), SHEAR VELOCITY (BETA), DENSITY (RHO) AND RIGIDITY (N) FOR CIT13F OCEANIC EARTH MODEL

CIT13F OCEANIC

M	D (km)	DEPTH (km)	BETA (km/sec)	RHO (g/cm^3)	N (10^{10}dy/cm^2)
1	0.5	0.25	0.800	1.900	1.21
2	2.0	1.50	2.800	2.540	21.06
3	5.0	5.00	3.700	2.900	39.70
4	9.0	12.00	4.600	3.320	70.25
5	5.0	19.00	4.600	3.325	70.35
6	5.0	24.00	4.560	3.330	69.24
7	10.0	31.50	4.460	3.335	66.33
8	20.0	46.50	4.400	3.350	64.85
9	20.0	66.50	4.400	3.375	65.34
10	20.0	86.50	4.400	3.390	65.63
11	20.0	106.50	4.400	3.410	66.01
12	20.0	126.50	4.400	3.425	66.30
13	20.0	146.50	4.440	3.440	67.81
14	20.0	166.50	4.480	3.460	69.44
15	20.0	186.50	4.510	3.475	70.68
16	20.0	206.50	4.540	3.490	71.93
17	20.0	226.50	4.540	3.510	72.34
18	20.0	246.50	4.540	3.525	72.65
19	20.0	266.50	4.560	3.540	73.60
20	20.0	286.50	4.560	3.560	74.02
21	20.0	306.50	4.560	3.570	74.23
22	20.0	326.50	4.580	3.590	75.30
23	20.0	346.50	4.580	3.605	75.61
24	40.0	376.50	4.580	3.630	76.14
25	50.0	421.50	4.620	3.690	78.76
26	10.0	451.50	4.670	3.775	82.32
27	100.0	506.50	5.500	4.020	121.60
28	100.0	606.50	5.620	4.225	133.44
29	100.0	706.50	5.890	4.400	152.64
30	100.0	806.50	6.000	4.560	164.16
31	100.0	906.50	6.200	4.630	177.97
32	200.0	1056.50	6.410	4.740	194.75
33	200.0	1256.50	6.550	4.850	208.07
34	200.0	1456.50	6.690	4.960	221.99
35	200.0	1656.50	6.780	5.070	233.05
36	150.0	1831.50	6.850	5.150	241.65
37	100.0	1956.50	6.900	5.208	247.95
38	100.0	2056.50	6.950	5.270	254.55
39	100.0	2156.50	7.000	5.320	260.67
40	100.0	2256.50	7.050	5.370	266.90
41	100.0	2356.50	7.100	5.420	273.22
42	100.0	2456.50	7.140	5.470	278.85
43	100.0	2556.50	7.190	5.520	285.36
44	100.0	2656.50	7.230	5.560	290.63
45	154.0	2783.50	7.280	5.610	297.32
46	100.0	2910.50	7.300	5.660	301.62

CIT13F OCEANIC LAMINATED CRUST

M	D (km)	DEPTH (km)	BETA (km/sec)	RHO (g/cm^3)	N (10^{10}dy/cm^2)
1	0.1	0.05	0.800	1.900	1.21
2	0.2	0.20	0.800	1.900	1.21
3	0.2	0.40	0.800	1.900	1.21
4	0.5	0.75	2.800	2.540	21.06
5	0.5	1.25	2.800	2.540	21.06
6	1.0	2.00	2.800	2.540	21.06
7	1.0	3.00	3.700	2.900	39.70
8	2.0	4.50	3.700	2.900	39.70
9	2.0	6.50	3.700	2.900	39.70
10	2.0	8.50	4.600	3.320	70.25
11	2.0	10.50	4.600	3.320	70.25
12	2.0	12.50	4.600	3.320	70.25
13	2.0	14.50	4.600	3.320	70.25
14	1.0	16.00	4.600	3.320	70.25
15	5.0	19.00	4.600	3.325	70.35
16	5.0	24.00	4.560	3.330	69.24
17	5.0	29.00	4.460	3.335	66.33
18	5.0	34.00	4.460	3.335	66.33
19	5.0	39.00	4.400	3.350	64.85
20	5.0	44.00	4.400	3.350	64.85
21	5.0	49.00	4.400	3.350	64.85
22	5.0	54.00	4.400	3.350	64.85
23	10.0	61.50	4.400	3.375	65.34
24	10.0	71.50	4.400	3.375	65.34
25	10.0	81.50	4.400	3.390	65.63
26	10.0	91.50	4.400	3.390	65.63
27	20.0	106.50	4.400	3.410	66.01
28	20.0	126.50	4.400	3.425	66.30
29	20.0	146.50	4.440	3.440	67.81
30	20.0	166.50	4.480	3.460	69.44
31	20.0	186.50	4.510	3.475	70.68
32	20.0	206.50	4.540	3.490	71.93
33	20.0	226.50	4.540	3.510	72.34
34	20.0	246.50	4.540	3.525	72.65
35	20.0	266.50	4.560	3.540	73.60
36	20.0	286.50	4.560	3.560	74.02
37	20.0	306.50	4.560	3.570	74.23
38	20.0	326.50	4.580	3.590	75.30
39	20.0	346.50	4.580	3.605	75.61
40	40.0	376.50	4.580	3.630	76.14
41	50.0	421.50	4.620	3.690	78.76
42	10.0	451.50	4.670	3.775	82.32
43	100.0	506.50	5.500	4.020	121.60
44	100.0	606.50	5.620	4.225	133.44
45	100.0	706.50	5.890	4.400	152.64
46	200.0	856.50	6.000	4.560	164.16

waves. Any given crustal and upper mantle structure can be achieved by perturbing the density and rigidity in the upper layers. Table 3 gives the layer parameters for a model patterned after the Gutenberg IV model of MacDonald and Ness (1961). This model has a Bullen A type density distribution. The Jeffreys-Bullen model is also tabulated in table 3.

Table 4 presents the complete dispersion and partial derivative results for the Gutenberg-Birch II model. If the parameters in the layers are changed in order to approximate another continental type structure the phase velocity at the indicated period is changed by an amount Δc, where

$$\Delta c = \sum_{M=1}^{N} \text{DCDRHO}\ (M)\cdot\Delta\rho + \sum_{M=1}^{N} \text{DCDMU}\ (M)\cdot\Delta\mu \tag{19}$$

In this case $N = 46$ is the total number of layers used to approximate the mantle but the summation need only extend over the perturbed layers. DCDRHO and DCDMU are computerese for $\delta c/\delta\rho$ and $\delta c/\delta\mu$.

Table 5 gives the effect of a ten-percent change in the parameters for this model and in this case

$$\Delta c = 10\sum_{M=1}^{N} [(\text{DC/DRHO}\ (M))\cdot(\Delta\rho/\rho)] + 10\sum_{M=1}^{N} [(\text{DC/DMU}\ (M))\cdot(\Delta\mu/\mu)] \tag{20}$$

or

$$\Delta c = 21\sum_{M=1}^{N} [\text{DC/DMU}\ (M)]\cdot\Delta\beta/\beta$$

$$+ 10\sum_{M=1}^{N} [\text{DC/DMU}\ (M) + \text{DC/DRHO}\ (M)]\cdot\Delta\rho/\rho \tag{21}$$

When only the shear velocity is being perturbed the second summation in the last expression does not contribute. DC/DMU and DC/DRHO are, respectively, $(\rho\delta c/\delta\rho)_\mu/10$ and $(\mu\delta c/\delta\mu)_\rho/10$.

Tables 6 and 7 give the corresponding results for the CIT13F model. As much as possible a new mantle structure should be designed in the framework of the layering given. When this is too restrictive tables 8 through 11 allow finer adjustments to be made in the near surface structure in order to satisfy short period ($<$200 second) data. Still finer adjustments may be made by splitting the layers again and apportioning the partial derivatives appropriately.

Accuracy of the Method

The partial derivatives have been tested for a variety of cases, and tables similar to the ones presented here have been in routine use for about 14 months at Caltech. The tables are believed to be error free and very accurate in spite of the various approximations that have been used in their calculation. Each user, however, should convince himself of the reliability and extent of applicability of the tables for his own

TABLE 3

LAYER PARAMETERS FOR THE JEFFREYS-BULLEN AND GUTENBERG IV CONTINENTAL EARTH MODELS

JEFFREYS-BULLEN

M	D (km)	DEPTH (km)	BETA (km/sec)	RHO (g/cm^3)	N ($10^{10} dy/cm^2$)
1	15	7.5	3.360	2.650	29.91
2	18	24.0	3.740	2.870	40.14
3	17	41.5	4.360	3.330	63.30
4	25	62.5	4.390	3.350	64.56
5	35	92.5	4.440	3.370	66.43
6	40	130.0	4.490	3.410	68.74
7	50	175.0	4.560	3.450	71.73
8	50	225.0	4.640	3.490	75.13
9	50	275.0	4.720	3.530	78.64
10	50	325.0	4.800	3.570	82.25
11	63	381.5	4.900	3.615	86.79
12	37	431.5	5.040	3.700	93.98
13	100	500.0	5.310	3.890	109.68
14	100	600.0	5.660	4.125	132.14
15	100	700.0	5.930	4.320	151.91
16	100	800.0	6.130	4.490	168.72
17	150	925.0	6.290	4.620	182.78
18	200	1100.0	6.440	4.739	196.54
19	400	1400.0	6.620	4.915	215.39
20	400	1800.0	6.830	5.135	239.54
21	400	2200.0	7.020	5.340	263.15
22	400	2600.0	7.210	5.540	287.99

GUTENBERG IV

M	D (km)	DEPTH (km)	BETA (km/sec)	RHO (g/cm^3)	N ($10^{10} dy/cm^2$)
1	21	10.5	3.55	2.738	34.50
2	10	26.0	3.80	3.000	43.31
3	20	41.0	4.65	3.321	71.80
4	10	56.0	4.60	3.370	71.30
5	10	66.0	4.57	3.352	70.00
6	10	76.0	4.51	3.358	68.30
7	10	86.0	4.46	3.368	66.99
8	10	96.0	4.41	3.378	65.69
9	20	111.0	4.37	3.388	64.70
10	30	136.0	4.35	3.409	64.50
11	20	161.0	4.36	3.430	65.20
12	30	186.0	4.38	3.461	66.39
13	20	211.0	4.42	3.481	68.00
14	30	236.0	4.46	3.500	69.62
15	50	276.0	4.52	3.524	71.99
16	50	326.0	4.66	3.592	78.00
17	50	376.0	4.82	3.650	84.79
18	50	426.0	5.00	3.696	92.40
19	50	476.0	5.14	3.820	100.92
20	100	551.0	5.38	4.010	116.06
21	100	651.0	5.69	4.140	134.03
22	100	751.0	5.96	4.390	155.93
23	100	851.0	6.15	4.550	172.09
24	100	951.0	6.24	4.620	179.89
25	200	1101.0	6.34	4.730	190.12
26	200	1301.0	6.47	4.850	203.02
27	200	1501.0	6.61	4.970	217.14
28	200	1701.0	6.72	5.050	228.04
29	200	1901.0	6.81	5.200	241.15
30	100	2051.0	6.88	5.302	250.96
31	100	2151.0	6.88	5.302	250.96
32	200	2301.0	6.94	5.439	261.96
33	200	2501.0	7.06	5.497	273.99
34	200	2701.0	7.14	5.590	284.97
35	100	2851.0	7.11	5.697	287.99
36	100	2951.0	7.11	5.700	288.14

TABLE 4a

PERIOD (T), PHASE VELOCITY (c) AND VARIATIONAL PARTIAL DERIVATIVES FOR GUTENBERG BIRCH II CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II CONTINENTAL

PSEUDO SPHERICAL CALCULATION

T(SECS)	1079.48	951.57	861.17	788.74	727.21	673.12
C(K/SEC)	6.720	6.620	6.520	6.420	6.320	6.220

M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.02256	0.00052	-0.02542	0.00060	-0.02783	0.00067	-0.03004	0.00074	-0.03214	0.00082	-0.03420	0.00090
2	-0.00235	0.00005	-0.00265	0.00006	-0.00290	0.00007	-0.00313	0.00008	-0.00335	0.00009	-0.00356	0.00009
3	-0.00235	0.00005	-0.00265	0.00006	-0.00290	0.00007	-0.00312	0.00008	-0.00334	0.00009	-0.00356	0.00009
4	-0.00235	0.00005	-0.00264	0.00006	-0.00289	0.00007	-0.00312	0.00008	-0.00334	0.00009	-0.00355	0.00009
5	-0.00234	0.00005	-0.00264	0.00006	-0.00289	0.00007	-0.00312	0.00008	-0.00333	0.00009	-0.00354	0.00009
6	-0.00701	0.00016	-0.00789	0.00019	-0.00864	0.00021	-0.00932	0.00023	-0.00997	0.00026	-0.01060	0.00028
7	-0.00582	0.00014	-0.00655	0.00016	-0.00717	0.00017	-0.00773	0.00019	-0.00827	0.00021	-0.00879	0.00023
8	-0.00811	0.00019	-0.00913	0.00022	-0.00999	0.00024	-0.01078	0.00027	-0.01152	0.00030	-0.01225	0.00033
9	-0.00577	0.00013	-0.00649	0.00015	-0.00710	0.00017	-0.00766	0.00019	-0.00819	0.00021	-0.00870	0.00023
10	-0.00575	0.00013	-0.00647	0.00015	-0.00707	0.00017	-0.00763	0.00019	-0.00815	0.00021	-0.00867	0.00023
11	-0.00572	0.00013	-0.00644	0.00015	-0.00705	0.00017	-0.00760	0.00019	-0.00812	0.00021	-0.00863	0.00023
12	-0.00570	0.00013	-0.00642	0.00015	-0.00702	0.00017	-0.00757	0.00019	-0.00809	0.00021	-0.00859	0.00023
13	-0.00568	0.00013	-0.00639	0.00015	-0.00699	0.00017	-0.00753	0.00019	-0.00805	0.00021	-0.00855	0.00023
14	-0.00566	0.00013	-0.00637	0.00015	-0.00696	0.00017	-0.00750	0.00019	-0.00801	0.00021	-0.00851	0.00023
15	-0.00564	0.00013	-0.00634	0.00015	-0.00693	0.00017	-0.00747	0.00019	-0.00798	0.00021	-0.00847	0.00023
16	-0.01122	0.00027	-0.01261	0.00031	-0.01378	0.00034	-0.01484	0.00038	-0.01585	0.00042	-0.01682	0.00046
17	-0.02219	0.00053	-0.02493	0.00061	-0.02722	0.00069	-0.02930	0.00076	-0.03127	0.00084	-0.03317	0.00091
18	-0.02181	0.00053	-0.02447	0.00061	-0.02669	0.00068	-0.02871	0.00075	-0.03060	0.00083	-0.03242	0.00091
19	-0.02141	0.00052	-0.02400	0.00060	-0.02614	0.00068	-0.02807	0.00075	-0.02988	0.00082	-0.03162	0.00090
20	-0.02101	0.00052	-0.02350	0.00060	-0.02556	0.00067	-0.02742	0.00075	-0.02914	0.00082	-0.03078	0.00089
21	-0.02059	0.00052	-0.02299	0.00060	-0.02497	0.00067	-0.02673	0.00074	-0.02836	0.00081	-0.02990	0.00088
22	-0.02016	0.00051	-0.02247	0.00059	-0.02436	0.00066	-0.02603	0.00073	-0.02756	0.00080	-0.02899	0.00087
23	-0.01973	0.00051	-0.02194	0.00059	-0.02373	0.00066	-0.02531	0.00072	-0.02674	0.00079	-0.02807	0.00086
24	-0.01929	0.00051	-0.02140	0.00058	-0.02310	0.00065	-0.02458	0.00072	-0.02591	0.00078	-0.02713	0.00085
25	-0.01885	0.00050	-0.02086	0.00057	-0.02246	0.00064	-0.02384	0.00071	-0.02507	0.00077	-0.02618	0.00083
26	-0.01841	0.00050	-0.02032	0.00057	-0.02182	0.00063	-0.02310	0.00070	-0.02423	0.00076	-0.02523	0.00082
27	-0.03124	0.00086	-0.03434	0.00098	-0.03675	0.00109	-0.03877	0.00120	-0.04050	0.00130	-0.04200	0.00140
28	-0.04241	0.00119	-0.04633	0.00135	-0.04929	0.00150	-0.05167	0.00163	-0.05364	0.00176	-0.05526	0.00189
29	-0.03971	0.00114	-0.04303	0.00129	-0.04542	0.00142	-0.04725	0.00154	-0.04865	0.00165	-0.04968	0.00176
30	-0.03709	0.00109	-0.03984	0.00123	-0.04171	0.00134	-0.04303	0.00144	-0.04391	0.00153	-0.04443	0.00162
31	-0.03457	0.00104	-0.03680	0.00116	-0.03818	0.00126	-0.03904	0.00134	-0.03948	0.00142	-0.03955	0.00148
32	-0.03216	0.00099	-0.03390	0.00109	-0.03486	0.00117	-0.03532	0.00124	-0.03537	0.00130	-0.03506	0.00135
33	-0.04428	0.00140	-0.04612	0.00152	-0.04689	0.00162	-0.04695	0.00170	-0.04645	0.00175	-0.04546	0.00179
34	-0.05211	0.00168	-0.05334	0.00180	-0.05334	0.00188	-0.05252	0.00194	-0.05105	0.00197	-0.04902	0.00197
35	-0.04471	0.00149	-0.04482	0.00156	-0.04394	0.00159	-0.04240	0.00161	-0.04034	0.00160	-0.03786	0.00156
36	-0.03828	0.00131	-0.03758	0.00134	-0.03612	0.00134	-0.03415	0.00132	-0.03180	0.00128	-0.02916	0.00123
37	-0.04787	0.00172	-0.04583	0.00172	-0.04302	0.00168	-0.03972	0.00162	-0.03607	0.00153	-0.03220	0.00142
38	-0.04852	0.00185	-0.04474	0.00178	-0.04053	0.00168	-0.03609	0.00155	-0.03156	0.00141	-0.02707	0.00126
39	-0.03401	0.00140	-0.02986	0.00128	-0.02583	0.00116	-0.02195	0.00102	-0.01828	0.00089	-0.01489	0.00075
40	-0.02324	0.00103	-0.01934	0.00090	-0.01591	0.00077	-0.01285	0.00064	-0.01015	0.00053	-0.00781	0.00042
41	-0.01553	0.00075	-0.01220	0.00061	-0.00951	0.00049	-0.00727	0.00039	-0.00542	0.00031	-0.00393	0.00023
42	-0.01014	0.00053	-0.00749	0.00041	-0.00550	0.00031	-0.00397	0.00023	-0.00278	0.00017	-0.00189	0.00012
43	-0.00649	0.00037	-0.00448	0.00026	-0.00310	0.00019	-0.00209	0.00013	-0.00138	0.00009	-0.00087	0.00006
44	-0.00406	0.00025	-0.00262	0.00017	-0.00169	0.00011	-0.00107	0.00007	-0.00065	0.00005	-0.00038	0.00003
45	-0.00252	0.00017	-0.00151	0.00010	-0.00091	0.00007	-0.00053	0.00004	-0.00030	0.00002	-0.00016	0.00001
46	-0.00157	0.00012	-0.00088	0.00007	-0.00049	0.00004	-0.00027	0.00002	-0.00014	0.00001	-0.00007	0.00001
47	-0.00100	0.00008	-0.00053	0.00004	-0.00028	0.00002	-0.00015	0.00001	-0.00007	0.00001	-0.00003	0.00000
48	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 4b

PERIOD (T), PHASE VELOCITY (c) AND VARIATIONAL PARTIAL DERIVATIVES FOR GUTENBERG BIRCH II CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II

T(SECS)	624.48		580.00		538.79		500.19		463.71		428.91	
C(K/SEC)	6.120		6.020		5.920		5.820		5.720		5.620	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.03621	0.00098	-0.03820	0.00107	-0.04019	0.00116	-0.04217	0.00126	-0.04414	0.00136	-0.04613	0.00147
2	-0.00377	0.00010	-0.00398	0.00011	-0.00418	0.00012	-0.00439	0.00013	-0.00459	0.00014	-0.00480	0.00015
3	-0.00376	0.00010	-0.00397	0.00011	-0.00418	0.00012	-0.00438	0.00013	-0.00458	0.00014	-0.00479	0.00015
4	-0.00376	0.00010	-0.00396	0.00011	-0.00417	0.00012	-0.00437	0.00013	-0.00457	0.00014	-0.00478	0.00015
5	-0.00375	0.00010	-0.00396	0.00011	-0.00416	0.00012	-0.00436	0.00013	-0.00457	0.00014	-0.00477	0.00015
6	-0.01122	0.00031	-0.01184	0.00033	-0.01244	0.00036	-0.01305	0.00039	-0.01365	0.00043	-0.01425	0.00046
7	-0.00930	0.00026	-0.00981	0.00028	-0.01031	0.00030	-0.01081	0.00033	-0.01130	0.00036	-0.01180	0.00038
8	-0.01296	0.00036	-0.01366	0.00039	-0.01436	0.00042	-0.01505	0.00045	-0.01573	0.00049	-0.01641	0.00053
9	-0.00921	0.00025	-0.00970	0.00028	-0.01020	0.00030	-0.01068	0.00032	-0.01117	0.00035	-0.01164	0.00038
10	-0.00917	0.00025	-0.00966	0.00027	-0.01015	0.00030	-0.01063	0.00032	-0.01111	0.00035	-0.01158	0.00038
11	-0.00912	0.00025	-0.00961	0.00027	-0.01010	0.00030	-0.01058	0.00032	-0.01105	0.00035	-0.01152	0.00038
12	-0.00908	0.00025	-0.00957	0.00027	-0.01005	0.00030	-0.01052	0.00032	-0.01099	0.00035	-0.01145	0.00038
13	-0.00904	0.00025	-0.00952	0.00027	-0.00999	0.00030	-0.01046	0.00032	-0.01092	0.00035	-0.01138	0.00037
14	-0.00899	0.00025	-0.00947	0.00027	-0.00994	0.00030	-0.01040	0.00032	-0.01086	0.00035	-0.01131	0.00037
15	-0.00895	0.00025	-0.00942	0.00027	-0.00988	0.00030	-0.01034	0.00032	-0.01079	0.00035	-0.01123	0.00037
16	-0.01777	0.00050	-0.01870	0.00054	-0.01961	0.00059	-0.02051	0.00064	-0.02139	0.00069	-0.02226	0.00074
17	-0.03501	0.00100	-0.03681	0.00108	-0.03857	0.00117	-0.04029	0.00127	-0.04197	0.00137	-0.04361	0.00147
18	-0.03417	0.00099	-0.03587	0.00107	-0.03754	0.00116	-0.03914	0.00125	-0.04070	0.00135	-0.04220	0.00145
19	-0.03327	0.00098	-0.03488	0.00106	-0.03643	0.00115	-0.03791	0.00124	-0.03934	0.00133	-0.04069	0.00143
20	-0.03233	0.00097	-0.03382	0.00105	-0.03525	0.00113	-0.03661	0.00122	-0.03788	0.00131	-0.03908	0.00140
21	-0.03135	0.00096	-0.03272	0.00104	-0.03403	0.00112	-0.03524	0.00120	-0.03637	0.00128	-0.03739	0.00137
22	-0.03033	0.00095	-0.03159	0.00102	-0.03276	0.00110	-0.03383	0.00118	-0.03480	0.00126	-0.03565	0.00134
23	-0.02929	0.00093	-0.03042	0.00101	-0.03146	0.00108	-0.03239	0.00115	-0.03320	0.00123	-0.03388	0.00130
24	-0.02823	0.00092	-0.02924	0.00099	-0.03014	0.00105	-0.03092	0.00112	-0.03158	0.00119	-0.03209	0.00126
25	-0.02717	0.00090	-0.02805	0.00096	-0.02882	0.00103	-0.02946	0.00109	-0.02996	0.00115	-0.03031	0.00121
26	-0.02610	0.00088	-0.02686	0.00094	-0.02750	0.00100	-0.02800	0.00106	-0.02835	0.00112	-0.02854	0.00117
27	-0.04327	0.00150	-0.04432	0.00160	-0.04514	0.00169	-0.04571	0.00178	-0.04600	0.00187	-0.04598	0.00194
28	-0.05652	0.00201	-0.05744	0.00213	-0.05801	0.00224	-0.05818	0.00234	-0.05794	0.00242	-0.05724	0.00249
29	-0.05034	0.00186	-0.05064	0.00194	-0.05057	0.00202	-0.05011	0.00209	-0.04923	0.00214	-0.04790	0.00217
30	-0.04456	0.00169	-0.04435	0.00176	-0.04376	0.00181	-0.04279	0.00184	-0.04143	0.00186	-0.03965	0.00186
31	-0.03925	0.00154	-0.03861	0.00158	-0.03761	0.00160	-0.03626	0.00161	-0.03456	0.00160	-0.03251	0.00158
32	-0.03441	0.00138	-0.03343	0.00140	-0.03214	0.00141	-0.03053	0.00139	-0.02862	0.00137	-0.02642	0.00132
33	-0.04399	0.00181	-0.04209	0.00181	-0.03979	0.00179	-0.03710	0.00175	-0.03407	0.00168	-0.03073	0.00158
34	-0.04647	0.00195	-0.04348	0.00191	-0.04010	0.00184	-0.03638	0.00174	-0.03240	0.00162	-0.02823	0.00148
35	-0.03501	0.00151	-0.03188	0.00144	-0.02852	0.00134	-0.02502	0.00123	-0.02146	0.00110	-0.01791	0.00096
36	-0.02630	0.00116	-0.02330	0.00107	-0.02022	0.00097	-0.01715	0.00086	-0.01415	0.00074	-0.01131	0.00062
37	-0.02821	0.00130	-0.02420	0.00116	-0.02028	0.00102	-0.01654	0.00086	-0.01306	0.00071	-0.00993	0.00056
38	-0.02270	0.00110	-0.01857	0.00094	-0.01477	0.00078	-0.01136	0.00062	-0.00841	0.00048	-0.00594	0.00035
39	-0.01180	0.00062	-0.00908	0.00049	-0.00675	0.00038	-0.00482	0.00028	-0.00328	0.00020	-0.00210	0.00013
40	-0.00583	0.00033	-0.00420	0.00025	-0.00290	0.00018	-0.00191	0.00012	-0.00119	0.00008	-0.00069	0.00005
41	-0.00275	0.00017	-0.00184	0.00012	-0.00118	0.00008	-0.00071	0.00005	-0.00040	0.00003	-0.00021	0.00002
42	-0.00123	0.00008	-0.00077	0.00005	-0.00045	0.00003	-0.00025	0.00002	-0.00013	0.00001	-0.00006	0.00000
43	-0.00053	0.00004	-0.00030	0.00002	-0.00016	0.00001	-0.00008	0.00001	-0.00004	0.00000	-0.00002	0.00000
44	-0.00021	0.00002	-0.00011	0.00001	-0.00005	0.00000	-0.00002	0.00000	-0.00001	0.00000	-0.00000	0.00000
45	-0.00008	0.00001	-0.00004	0.00000	-0.00002	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000
46	-0.00003	0.00000	-0.00001	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
47	-0.00001	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
48	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 4c

PERIOD (T), PHASE VELOCITY (c) AND VARIATIONAL PARTIAL DERIVATIVES FOR GUTENBERG BIRCH II CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II CONTINENTAL

PSEUDO SPHERICAL CALCULATION

T(SECS)	422.12		388.89		356.64		325.10		294.04		263.25	
C(K/SEC)	5.600		5.500		5.400		5.300		5.200		5.100	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.04652	0.00150	-0.04852	0.00162	-0.05057	0.00175	-0.05271	0.00189	-0.05501	0.00205	-0.05758	0.00223
2	-0.00484	0.00016	-0.00504	0.00017	-0.00525	0.00018	-0.00547	0.00020	-0.00571	0.00021	-0.00597	0.00023
3	-0.00483	0.00016	-0.00503	0.00017	-0.00524	0.00018	-0.00546	0.00020	-0.00569	0.00021	-0.00595	0.00023
4	-0.00482	0.00016	-0.00502	0.00017	-0.00523	0.00018	-0.00545	0.00020	-0.00568	0.00021	-0.00593	0.00023
5	-0.00481	0.00016	-0.00501	0.00017	-0.00522	0.00018	-0.00543	0.00020	-0.00566	0.00021	-0.00591	0.00023
6	-0.01437	0.00047	-0.01497	0.00051	-0.01558	0.00055	-0.01622	0.00059	-0.01689	0.00064	-0.01763	0.00069
7	-0.01189	0.00039	-0.01239	0.00042	-0.01289	0.00045	-0.01340	0.00049	-0.01394	0.00053	-0.01454	0.00058
8	-0.01655	0.00054	-0.01722	0.00058	-0.01791	0.00063	-0.01861	0.00068	-0.01935	0.00073	-0.02016	0.00079
9	-0.01174	0.00038	-0.01222	0.00041	-0.01270	0.00045	-0.01319	0.00048	-0.01370	0.00052	-0.01426	0.00056
10	-0.01168	0.00038	-0.01215	0.00041	-0.01262	0.00044	-0.01310	0.00048	-0.01361	0.00052	-0.01415	0.00056
11	-0.01161	0.00038	-0.01207	0.00041	-0.01254	0.00044	-0.01301	0.00048	-0.01350	0.00052	-0.01404	0.00056
12	-0.01154	0.00038	-0.01200	0.00041	-0.01245	0.00044	-0.01292	0.00048	-0.01340	0.00051	-0.01392	0.00055
13	-0.01147	0.00038	-0.01192	0.00041	-0.01237	0.00044	-0.01282	0.00047	-0.01329	0.00051	-0.01379	0.00055
14	-0.01140	0.00038	-0.01184	0.00041	-0.01228	0.00044	-0.01272	0.00047	-0.01318	0.00051	-0.01366	0.00055
15	-0.01132	0.00038	-0.01175	0.00041	-0.01219	0.00044	-0.01262	0.00047	-0.01306	0.00051	-0.01353	0.00054
16	-0.02243	0.00075	-0.02327	0.00081	-0.02410	0.00087	-0.02493	0.00093	-0.02578	0.00100	-0.02666	0.00108
17	-0.04393	0.00149	-0.04551	0.00160	-0.04706	0.00172	-0.04858	0.00184	-0.05009	0.00197	-0.05165	0.00212
18	-0.04249	0.00147	-0.04392	0.00158	-0.04528	0.00169	-0.04659	0.00180	-0.04786	0.00192	-0.04910	0.00205
19	-0.04095	0.00145	-0.04220	0.00155	-0.04336	0.00165	-0.04445	0.00175	-0.04545	0.00186	-0.04637	0.00198
20	-0.03930	0.00142	-0.04037	0.00151	-0.04133	0.00161	-0.04218	0.00170	-0.04289	0.00180	-0.04348	0.00190
21	-0.03758	0.00139	-0.03846	0.00147	-0.03921	0.00156	-0.03981	0.00164	-0.04025	0.00173	-0.04050	0.00181
22	-0.03581	0.00135	-0.03649	0.00143	-0.03702	0.00151	-0.03739	0.00158	-0.03755	0.00165	-0.03749	0.00171
23	-0.03400	0.00131	-0.03449	0.00138	-0.03481	0.00145	-0.03494	0.00151	-0.03484	0.00157	-0.03448	0.00162
24	-0.03217	0.00127	-0.03248	0.00133	-0.03260	0.00139	-0.03250	0.00144	-0.03216	0.00148	-0.03152	0.00151
25	-0.03035	0.00122	-0.03048	0.00128	-0.03041	0.00133	-0.03011	0.00136	-0.02954	0.00139	-0.02865	0.00141
26	-0.02856	0.00118	-0.02852	0.00122	-0.02826	0.00126	-0.02777	0.00129	-0.02700	0.00130	-0.02590	0.00130
27	-0.04594	0.00195	-0.04550	0.00201	-0.04468	0.00206	-0.04343	0.00208	-0.04169	0.00208	-0.03937	0.00204
28	-0.05705	0.00250	-0.05575	0.00255	-0.05390	0.00256	-0.05145	0.00255	-0.04832	0.00249	-0.04445	0.00238
29	-0.04758	0.00217	-0.04568	0.00217	-0.04328	0.00214	-0.04034	0.00208	-0.03683	0.00198	-0.03273	0.00183
30	-0.03925	0.00186	-0.03697	0.00182	-0.03426	0.00176	-0.03112	0.00167	-0.02756	0.00154	-0.02359	0.00137
31	-0.03205	0.00157	-0.02958	0.00151	-0.02678	0.00142	-0.02366	0.00131	-0.02028	0.00117	-0.01667	0.00101
32	-0.02595	0.00130	-0.02343	0.00123	-0.02069	0.00113	-0.01776	0.00102	-0.01469	0.00088	-0.01158	0.00072
33	-0.03003	0.00156	-0.02639	0.00143	-0.02258	0.00128	-0.01868	0.00111	-0.01480	0.00091	-0.01107	0.00071
34	-0.02738	0.00145	-0.02311	0.00128	-0.01887	0.00109	-0.01479	0.00089	-0.01098	0.00069	-0.00758	0.00050
35	-0.01721	0.00093	-0.01382	0.00078	-0.01064	0.00063	-0.00778	0.00048	-0.00532	0.00034	-0.00332	0.00022
36	-0.01077	0.00059	-0.00821	0.00047	-0.00595	0.00036	-0.00405	0.00025	-0.00254	0.00017	-0.00143	0.00010
37	-0.00936	0.00054	-0.00673	0.00040	-0.00456	0.00028	-0.00286	0.00019	-0.00163	0.00011	-0.00081	0.00006
38	-0.00550	0.00033	-0.00363	0.00022	-0.00222	0.00014	-0.00124	0.00008	-0.00061	0.00004	-0.00026	0.00002
39	-0.00191	0.00012	-0.00112	0.00007	-0.00060	0.00004	-0.00029	0.00002	-0.00012	0.00001	-0.00004	0.00000
40	-0.00061	0.00004	-0.00032	0.00002	-0.00015	0.00001	-0.00006	0.00000	-0.00002	0.00000	-0.00001	0.00000
41	-0.00018	0.00001	-0.00008	0.00001	-0.00003	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000
42	-0.00005	0.00000	-0.00002	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
43	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
44	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
45	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
46	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
47	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
48	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 4d

PERIOD (T), PHASE VELOCITY (c) AND VARIATIONAL PARTIAL DERIVATIVES FOR GUTENBERG BIRCH II CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II

T(SECS)	232.54		201.79		170.93		140.07		109.70		81.33	
C(K/SEC)	5.000		4.900		4.800		4.700		4.600		4.500	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.06062	0.00244	-0.06445	0.00270	-0.06965	0.00305	-0.07737	0.00354	-0.09027	0.00432	-0.11513	0.00578
2	-0.00627	0.00025	-0.00665	0.00028	-0.00717	0.00032	-0.00792	0.00037	-0.00914	0.00044	-0.01143	0.00058
3	-0.00625	0.00025	-0.00663	0.00028	-0.00713	0.00032	-0.00787	0.00036	-0.00907	0.00044	-0.01127	0.00058
4	-0.00623	0.00025	-0.00660	0.00028	-0.00710	0.00032	-0.00782	0.00036	-0.00898	0.00044	-0.01110	0.00058
5	-0.00621	0.00025	-0.00658	0.00028	-0.00706	0.00031	-0.00777	0.00036	-0.00890	0.00044	-0.01093	0.00057
6	-0.01849	0.00076	-0.01956	0.00084	-0.02096	0.00094	-0.02297	0.00108	-0.02614	0.00130	-0.03168	0.00168
7	-0.01523	0.00063	-0.01607	0.00069	-0.01716	0.00078	-0.01870	0.00089	-0.02106	0.00106	-0.02498	0.00135
8	-0.02108	0.00086	-0.02220	0.00095	-0.02364	0.00105	-0.02563	0.00119	-0.02858	0.00140	-0.03323	0.00171
9	-0.01490	0.00061	-0.01567	0.00067	-0.01664	0.00074	-0.01797	0.00084	-0.01989	0.00097	-0.02279	0.00118
10	-0.01477	0.00061	-0.01551	0.00067	-0.01644	0.00074	-0.01769	0.00083	-0.01946	0.00096	-0.02202	0.00114
11	-0.01463	0.00060	-0.01534	0.00066	-0.01623	0.00073	-0.01741	0.00082	-0.01904	0.00094	-0.02127	0.00111
12	-0.01449	0.00060	-0.01517	0.00066	-0.01602	0.00072	-0.01712	0.00081	-0.01860	0.00092	-0.02054	0.00107
13	-0.01435	0.00060	-0.01500	0.00065	-0.01580	0.00071	-0.01682	0.00080	-0.01817	0.00090	-0.01982	0.00103
14	-0.01420	0.00059	-0.01482	0.00064	-0.01557	0.00071	-0.01652	0.00078	-0.01774	0.00088	-0.01911	0.00100
15	-0.01404	0.00059	-0.01463	0.00064	-0.01534	0.00070	-0.01622	0.00077	-0.01730	0.00086	-0.01841	0.00097
16	-0.02762	0.00116	-0.02871	0.00126	-0.02999	0.00137	-0.03153	0.00151	-0.03331	0.00167	-0.03471	0.00183
17	-0.05329	0.00227	-0.05509	0.00245	-0.05710	0.00265	-0.05932	0.00287	-0.06144	0.00312	-0.06187	0.00330
18	-0.05035	0.00219	-0.05162	0.00234	-0.05289	0.00250	-0.05400	0.00266	-0.05434	0.00281	-0.05193	0.00282
19	-0.04720	0.00210	-0.04794	0.00222	-0.04848	0.00234	-0.04854	0.00244	-0.04733	0.00249	-0.04277	0.00237
20	-0.04391	0.00199	-0.04412	0.00209	-0.04395	0.00217	-0.04306	0.00222	-0.04056	0.00218	-0.03450	0.00195
21	-0.04053	0.00188	-0.04023	0.00195	-0.03943	0.00199	-0.03771	0.00198	-0.03419	0.00188	-0.02724	0.00157
22	-0.03713	0.00177	-0.03637	0.00180	-0.03500	0.00181	-0.03260	0.00176	-0.02835	0.00160	-0.02105	0.00124
23	-0.03377	0.00165	-0.03260	0.00166	-0.03076	0.00163	-0.02783	0.00154	-0.02313	0.00133	-0.01592	0.00096
24	-0.03050	0.00152	-0.02899	0.00151	-0.02676	0.00145	-0.02347	0.00133	-0.01858	0.00110	-0.01179	0.00073
25	-0.02737	0.00140	-0.02558	0.00136	-0.02307	0.00128	-0.01957	0.00113	-0.01471	0.00089	-0.00856	0.00054
26	-0.02441	0.00128	-0.02240	0.00122	-0.01972	0.00112	-0.01614	0.00096	-0.01148	0.00071	-0.00610	0.00039
27	-0.03637	0.00197	-0.03253	0.00183	-0.02765	0.00162	-0.02152	0.00132	-0.01417	0.00091	-0.00664	0.00044
28	-0.03973	0.00222	-0.03404	0.00198	-0.02728	0.00165	-0.01951	0.00123	-0.01128	0.00074	-0.00428	0.00029
29	-0.02800	0.00163	-0.02267	0.00138	-0.01681	0.00106	-0.01075	0.00071	-0.00522	0.00036	-0.00149	0.00011
30	-0.01926	0.00117	-0.01466	0.00093	-0.01000	0.00066	-0.00566	0.00039	-0.00228	0.00016	-0.00048	0.00004
31	-0.01294	0.00081	-0.00923	0.00060	-0.00576	0.00039	-0.00287	0.00020	-0.00095	0.00007	-0.00014	0.00001
32	-0.00852	0.00055	-0.00567	0.00038	-0.00322	0.00023	-0.00140	0.00010	-0.00037	0.00003	-0.00004	0.00000
33	-0.00763	0.00051	-0.00466	0.00033	-0.00236	0.00017	-0.00087	0.00007	-0.00018	0.00001	-0.00001	0.00000
34	-0.00473	0.00032	-0.00254	0.00018	-0.00108	0.00008	-0.00031	0.00002	-0.00005	0.00000	-0.00000	0.00000
35	-0.00182	0.00013	-0.00083	0.00006	-0.00028	0.00002	-0.00006	0.00000	-0.00001	0.00000	-0.00000	0.00000
36	-0.00068	0.00005	-0.00026	0.00002	-0.00007	0.00001	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000
37	-0.00034	0.00002	-0.00011	0.00001	-0.00002	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
38	-0.00009	0.00001	-0.00002	0.00000	-0.00000	0.00000	-0.00000	0.00000				
39	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000				
40	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000				
41	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000				

TABLE 5a

PHASE VELOCITY PERTURBATIONS (IN KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY (DC/DRHO) AND RIGIDITY (DC/DMU) FOR GUTENBERG-BIRCH II CONTINENTAL EARTH MODEL

VARIATIONS FOR 10 0/0 CHANGE IN PARAMETER
GUTENBERG BIRCH II CONTINENTAL

PSEUDO SPHERICAL CALCULATION

T(SECS)	1079.48		951.57		861.17		788.74		727.21		673.12	
C(K/SEC)	6.720		6.620		6.520		6.420		6.320		6.220	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00620	0.00179	-0.00699	0.00207	-0.00765	0.00232	-0.00826	0.00258	-0.00884	0.00284	-0.00940	0.00311
2	-0.00068	0.00023	-0.00077	0.00026	-0.00084	0.00029	-0.00091	0.00033	-0.00097	0.00036	-0.00103	0.00039
3	-0.00068	0.00023	-0.00077	0.00026	-0.00084	0.00029	-0.00091	0.00033	-0.00097	0.00036	-0.00103	0.00039
4	-0.00068	0.00023	-0.00077	0.00026	-0.00084	0.00029	-0.00090	0.00033	-0.00097	0.00036	-0.00103	0.00039
5	-0.00068	0.00023	-0.00076	0.00026	-0.00084	0.00029	-0.00090	0.00033	-0.00097	0.00036	-0.00103	0.00039
6	-0.00203	0.00068	-0.00229	0.00078	-0.00251	0.00088	-0.00270	0.00098	-0.00289	0.00107	-0.00308	0.00118
7	-0.00169	0.00057	-0.00190	0.00065	-0.00208	0.00073	-0.00224	0.00081	-0.00240	0.00089	-0.00255	0.00098
8	-0.00289	0.00141	-0.00325	0.00162	-0.00356	0.00182	-0.00384	0.00202	-0.00410	0.00223	-0.00436	0.00244
9	-0.00204	0.00099	-0.00230	0.00114	-0.00252	0.00128	-0.00271	0.00142	-0.00290	0.00156	-0.00308	0.00171
10	-0.00203	0.00098	-0.00228	0.00112	-0.00250	0.00126	-0.00269	0.00140	-0.00288	0.00154	-0.00306	0.00169
11	-0.00201	0.00096	-0.00226	0.00111	-0.00248	0.00124	-0.00267	0.00138	-0.00285	0.00152	-0.00303	0.00166
12	-0.00200	0.00095	-0.00225	0.00109	-0.00246	0.00123	-0.00265	0.00136	-0.00283	0.00150	-0.00301	0.00164
13	-0.00199	0.00094	-0.00224	0.00108	-0.00245	0.00122	-0.00264	0.00135	-0.00282	0.00148	-0.00299	0.00162
14	-0.00198	0.00093	-0.00222	0.00107	-0.00243	0.00121	-0.00262	0.00134	-0.00280	0.00147	-0.00297	0.00161
15	-0.00197	0.00092	-0.00221	0.00106	-0.00242	0.00119	-0.00261	0.00132	-0.00278	0.00146	-0.00296	0.00159
16	-0.00391	0.00183	-0.00440	0.00210	-0.00481	0.00236	-0.00518	0.00262	-0.00553	0.00288	-0.00587	0.00315
17	-0.00776	0.00362	-0.00871	0.00417	-0.00951	0.00468	-0.01024	0.00519	-0.01093	0.00570	-0.01159	0.00624
18	-0.00766	0.00359	-0.00860	0.00413	-0.00938	0.00463	-0.01008	0.00513	-0.01075	0.00564	-0.01139	0.00617
19	-0.00756	0.00357	-0.00847	0.00411	-0.00922	0.00461	-0.00990	0.00510	-0.01054	0.00561	-0.01115	0.00613
20	-0.00745	0.00358	-0.00833	0.00412	-0.00907	0.00462	-0.00972	0.00512	-0.01033	0.00562	-0.01091	0.00613
21	-0.00734	0.00361	-0.00819	0.00415	-0.00890	0.00465	-0.00953	0.00515	-0.01011	0.00565	-0.01066	0.00616
22	-0.00722	0.00365	-0.00805	0.00420	-0.00872	0.00470	-0.00932	0.00520	-0.00987	0.00569	-0.01039	0.00620
23	-0.00711	0.00370	-0.00791	0.00425	-0.00856	0.00475	-0.00913	0.00525	-0.00964	0.00574	-0.01012	0.00624
24	-0.00700	0.00375	-0.00777	0.00431	-0.00838	0.00482	-0.00892	0.00531	-0.00940	0.00580	-0.00984	0.00630
25	-0.00688	0.00382	-0.00762	0.00438	-0.00820	0.00489	-0.00871	0.00539	-0.00916	0.00588	-0.00956	0.00637
26	-0.00677	0.00388	-0.00747	0.00444	-0.00802	0.00495	-0.00849	0.00544	-0.00891	0.00592	-0.00927	0.00640
27	-0.01156	0.00689	-0.01271	0.00788	-0.01360	0.00876	-0.01434	0.00960	-0.01498	0.01043	-0.01554	0.01125
28	-0.01600	0.01038	-0.01748	0.01181	-0.01860	0.01307	-0.01950	0.01425	-0.02024	0.01540	-0.02085	0.01650
29	-0.01528	0.01078	-0.01656	0.01218	-0.01748	0.01340	-0.01818	0.01452	-0.01872	0.01557	-0.01912	0.01657
30	-0.01455	0.01112	-0.01563	0.01247	-0.01637	0.01362	-0.01688	0.01466	-0.01723	0.01560	-0.01743	0.01646
31	-0.01382	0.01135	-0.01470	0.01264	-0.01526	0.01370	-0.01560	0.01462	-0.01578	0.01543	-0.01580	0.01614
32	-0.01309	0.01158	-0.01380	0.01277	-0.01419	0.01372	-0.01438	0.01452	-0.01440	0.01519	-0.01427	0.01573
33	-0.01836	0.01752	-0.01913	0.01911	-0.01945	0.02033	-0.01947	0.02128	-0.01926	0.02200	-0.01885	0.02250
34	-0.02241	0.02408	-0.02294	0.02578	-0.02294	0.02695	-0.02259	0.02772	-0.02196	0.02814	-0.02108	0.02823
35	-0.01977	0.02398	-0.01982	0.02512	-0.01943	0.02572	-0.01875	0.02591	-0.01784	0.02574	-0.01674	0.02522
36	-0.01739	0.02357	-0.01707	0.02414	-0.01641	0.02419	-0.01551	0.02385	-0.01445	0.02315	-0.01325	0.02214
37	-0.02189	0.03167	-0.02096	0.03165	-0.01967	0.03098	-0.01816	0.02981	-0.01649	0.02821	-0.01473	0.02625
38	-0.02277	0.03667	-0.02100	0.03525	-0.01902	0.03326	-0.01694	0.03083	-0.01481	0.02806	-0.01270	0.02504
39	-0.01622	0.02912	-0.01424	0.02666	-0.01232	0.02402	-0.01047	0.02125	-0.00872	0.01841	-0.00710	0.01559
40	-0.01126	0.02280	-0.00937	0.01978	-0.00771	0.01693	-0.00623	0.01423	-0.00492	0.01168	-0.00378	0.00934
41	-0.00764	0.01723	-0.00600	0.01409	-0.00468	0.01143	-0.00358	0.00908	-0.00267	0.00704	-0.00193	0.00530
42	-0.00507	0.01273	-0.00374	0.00978	-0.00275	0.00747	-0.00198	0.00560	-0.00139	0.00408	-0.00094	0.00287
43	-0.00328	0.00908	-0.00227	0.00652	-0.00156	0.00468	-0.00106	0.00329	-0.00070	0.00224	-0.00044	0.00147
44	-0.00208	0.00644	-0.00134	0.00430	-0.00086	0.00288	-0.00055	0.00189	-0.00033	0.00120	-0.00020	0.00073
45	-0.00131	0.00455	-0.00079	0.00282	-0.00047	0.00176	-0.00028	0.00107	-0.00016	0.00063	-0.00008	0.00035
46	-0.00083	0.00320	-0.00046	0.00185	-0.00026	0.00107	-0.00014	0.00060	-0.00007	0.00033	-0.00004	0.00017
47	-0.00053	0.00223	-0.00028	0.00122	-0.00015	0.00067	-0.00008	0.00035	-0.00004	0.00018	-0.00002	0.00008
48	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 5b

PHASE VELOCITY PERTURBATIONS (IN KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY (DC/DRHO) AND RIGIDITY (DC/DMU) FOR GUTENBERG-BIRCH II CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II

T(SECS)	624.48		580.00		538.79		500.19		463.71		428.91	
C(K/SEC)	6.120		6.020		5.920		5.820		5.720		5.620	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00996	0.00340	-0.01051	0.00370	-0.01105	0.00402	-0.01160	0.00436	-0.01214	0.00472	-0.01269	0.00510
2	-0.00109	0.00043	-0.00115	0.00047	-0.00121	0.00051	-0.00127	0.00055	-0.00133	0.00060	-0.00139	0.00065
3	-0.00109	0.00043	-0.00115	0.00047	-0.00121	0.00051	-0.00127	0.00055	-0.00133	0.00060	-0.00139	0.00064
4	-0.00109	0.00043	-0.00115	0.00047	-0.00121	0.00051	-0.00127	0.00055	-0.00133	0.00060	-0.00139	0.00064
5	-0.00109	0.00043	-0.00115	0.00047	-0.00121	0.00051	-0.00127	0.00055	-0.00132	0.00060	-0.00138	0.00064
6	-0.00325	0.00129	-0.00343	0.00140	-0.00361	0.00152	-0.00378	0.00165	-0.00396	0.00179	-0.00413	0.00193
7	-0.00270	0.00107	-0.00284	0.00117	-0.00299	0.00127	-0.00313	0.00137	-0.00328	0.00149	-0.00342	0.00161
8	-0.00461	0.00266	-0.00486	0.00289	-0.00511	0.00314	-0.00536	0.00340	-0.00560	0.00368	-0.00584	0.00398
9	-0.00326	0.00186	-0.00344	0.00203	-0.00361	0.00220	-0.00378	0.00238	-0.00396	0.00258	-0.00413	0.00279
10	-0.00324	0.00184	-0.00341	0.00200	-0.00358	0.00217	-0.00375	0.00235	-0.00392	0.00254	-0.00409	0.00275
11	-0.00321	0.00181	-0.00338	0.00197	-0.00355	0.00214	-0.00372	0.00231	-0.00388	0.00250	-0.00405	0.00270
12	-0.00318	0.00179	-0.00335	0.00195	-0.00352	0.00211	-0.00369	0.00229	-0.00385	0.00247	-0.00401	0.00267
13	-0.00316	0.00177	-0.00333	0.00193	-0.00350	0.00209	-0.00366	0.00226	-0.00382	0.00244	-0.00398	0.00264
14	-0.00314	0.00176	-0.00331	0.00191	-0.00347	0.00207	-0.00363	0.00224	-0.00379	0.00242	-0.00395	0.00261
15	-0.00312	0.00174	-0.00329	0.00189	-0.00345	0.00205	-0.00361	0.00222	-0.00377	0.00240	-0.00392	0.00258
16	-0.00620	0.00344	-0.00652	0.00374	-0.00684	0.00405	-0.00715	0.00438	-0.00746	0.00473	-0.00776	0.00510
17	-0.01223	0.00680	-0.01286	0.00739	-0.01348	0.00800	-0.01408	0.00865	-0.01467	0.00933	-0.01524	0.01004
18	-0.01200	0.00672	-0.01260	0.00729	-0.01319	0.00789	-0.01375	0.00852	-0.01430	0.00917	-0.01483	0.00986
19	-0.01174	0.00666	-0.01230	0.00722	-0.01285	0.00781	-0.01338	0.00841	-0.01388	0.00904	-0.01435	0.00970
20	-0.01146	0.00666	-0.01199	0.00721	-0.01250	0.00778	-0.01298	0.00837	-0.01343	0.00898	-0.01386	0.00961
21	-0.01117	0.00668	-0.01166	0.00722	-0.01213	0.00778	-0.01256	0.00835	-0.01296	0.00894	-0.01333	0.00953
22	-0.01086	0.00672	-0.01131	0.00725	-0.01173	0.00780	-0.01212	0.00835	-0.01247	0.00891	-0.01277	0.00947
23	-0.01056	0.00675	-0.01097	0.00728	-0.01134	0.00780	-0.01168	0.00834	-0.01197	0.00887	-0.01222	0.00940
24	-0.01024	0.00680	-0.01061	0.00731	-0.01094	0.00782	-0.01122	0.00833	-0.01146	0.00883	-0.01164	0.00932
25	-0.00992	0.00686	-0.01024	0.00735	-0.01053	0.00785	-0.01076	0.00833	-0.01094	0.00880	-0.01107	0.00925
26	-0.00959	0.00688	-0.00987	0.00736	-0.01011	0.00783	-0.01029	0.00828	-0.01042	0.00872	-0.01049	0.00913
27	-0.01601	0.01205	-0.01640	0.01283	-0.01670	0.01359	-0.01691	0.01432	-0.01702	0.01499	-0.01701	0.01559
28	-0.02132	0.01757	-0.02167	0.01858	-0.02189	0.01953	-0.02195	0.02039	-0.02186	0.02114	-0.02160	0.02174
29	-0.01937	0.01749	-0.01949	0.01834	-0.01946	0.01908	-0.01928	0.01970	-0.01894	0.02016	-0.01843	0.02044
30	-0.01749	0.01722	-0.01740	0.01787	-0.01717	0.01839	-0.01679	0.01875	-0.01626	0.01893	-0.01556	0.01890
31	-0.01568	0.01672	-0.01543	0.01717	-0.01503	0.01746	-0.01449	0.01757	-0.01381	0.01748	-0.01299	0.01715
32	-0.01401	0.01612	-0.01361	0.01637	-0.01308	0.01643	-0.01243	0.01630	-0.01165	0.01596	-0.01076	0.01539
33	-0.01824	0.02276	-0.01746	0.02276	-0.01650	0.02249	-0.01539	0.02192	-0.01413	0.02104	-0.01274	0.01983
34	-0.01999	0.02796	-0.01870	0.02733	-0.01725	0.02634	-0.01565	0.02497	-0.01393	0.02325	-0.01214	0.02117
35	-0.01548	0.02435	-0.01410	0.02316	-0.01261	0.02166	-0.01106	0.01985	-0.00949	0.01780	-0.00792	0.01553
36	-0.01195	0.02083	-0.01058	0.01925	-0.00919	0.01744	-0.00779	0.01544	-0.00643	0.01331	-0.00514	0.01111
37	-0.01290	0.02397	-0.01107	0.02144	-0.00927	0.01873	-0.00756	0.01592	-0.00597	0.01311	-0.00454	0.01040
38	-0.01066	0.02185	-0.00872	0.01860	-0.00693	0.01538	-0.00533	0.01231	-0.00395	0.00947	-0.00279	0.00696
39	-0.00563	0.01285	-0.00433	0.01028	-0.00322	0.00794	-0.00230	0.00589	-0.00156	0.00416	-0.00100	0.00277
40	-0.00282	0.00724	-0.00203	0.00542	-0.00141	0.00389	-0.00092	0.00266	-0.00057	0.00171	-0.00033	0.00103
41	-0.00135	0.00385	-0.00091	0.00268	-0.00058	0.00178	-0.00035	0.00111	-0.00020	0.00065	-0.00010	0.00035
42	-0.00062	0.00195	-0.00038	0.00126	-0.00023	0.00077	-0.00012	0.00044	-0.00006	0.00023	-0.00003	0.00011
43	-0.00027	0.00093	-0.00015	0.00055	-0.00008	0.00031	-0.00004	0.00016	-0.00002	0.00008	-0.00001	0.00003
44	-0.00011	0.00042	-0.00006	0.00023	-0.00003	0.00012	-0.00001	0.00005	-0.00001	0.00002	-0.00000	0.00001
45	-0.00004	0.00019	-0.00002	0.00009	-0.00001	0.00004	-0.00000	0.00002	-0.00000	0.00001	-0.00000	0.00000
46	-0.00002	0.00008	-0.00001	0.00004	-0.00000	0.00001	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000
47	-0.00001	0.00004	-0.00000	0.00002	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
48	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 5c

PHASE VELOCITY PERTURBATIONS (IN KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY (DC/DRHO) AND RIGIDITY (DC/DMU) FOR GUTENBERG-BIRCH II CONTINENTAL EARTH MODEL

VARIATIONS FOR 10 0/0 CHANGE IN PARAMETER
GUTENBERG BIRCH II CONTINENTAL

PSEUDO SPHERICAL CALCULATION

T(SECS)	422.12		388.89		356.64		325.10		294.04		263.25	
C(K/SEC)	5.600		5.500		5.400		5.300		5.200		5.100	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.01279	0.00518	-0.01334	0.00560	-0.01391	0.00606	-0.01450	0.00655	-0.01513	0.00710	-0.01584	0.00773
2	-0.00140	0.00066	-0.00146	0.00071	-0.00152	0.00076	-0.00159	0.00083	-0.00165	0.00090	-0.00173	0.00097
3	-0.00140	0.00065	-0.00146	0.00071	-0.00152	0.00076	-0.00158	0.00083	-0.00165	0.00090	-0.00173	0.00097
4	-0.00140	0.00065	-0.00146	0.00071	-0.00152	0.00076	-0.00158	0.00083	-0.00165	0.00089	-0.00172	0.00097
5	-0.00139	0.00065	-0.00145	0.00071	-0.00151	0.00076	-0.00158	0.00083	-0.00164	0.00089	-0.00171	0.00097
6	-0.00417	0.00196	-0.00434	0.00212	-0.00452	0.00229	-0.00470	0.00247	-0.00490	0.00268	-0.00511	0.00291
7	-0.00345	0.00163	-0.00359	0.00176	-0.00374	0.00190	-0.00389	0.00206	-0.00404	0.00223	-0.00422	0.00242
8	-0.00589	0.00404	-0.00613	0.00436	-0.00638	0.00470	-0.00663	0.00507	-0.00689	0.00548	-0.00718	0.00593
9	-0.00416	0.00283	-0.00433	0.00305	-0.00450	0.00329	-0.00467	0.00355	-0.00486	0.00383	-0.00505	0.00414
10	-0.00412	0.00279	-0.00429	0.00301	-0.00445	0.00324	-0.00463	0.00349	-0.00480	0.00377	-0.00500	0.00408
11	-0.00408	0.00274	-0.00424	0.00296	-0.00441	0.00318	-0.00457	0.00343	-0.00475	0.00370	-0.00493	0.00400
12	-0.00404	0.00271	-0.00420	0.00292	-0.00436	0.00314	-0.00453	0.00338	-0.00469	0.00365	-0.00488	0.00394
13	-0.00401	0.00268	-0.00417	0.00288	-0.00433	0.00310	-0.00449	0.00334	-0.00465	0.00360	-0.00483	0.00388
14	-0.00398	0.00265	-0.00414	0.00285	-0.00429	0.00307	-0.00444	0.00330	-0.00460	0.00355	-0.00477	0.00383
15	-0.00395	0.00262	-0.00410	0.00282	-0.00425	0.00303	-0.00440	0.00326	-0.00456	0.00351	-0.00472	0.00378
16	-0.00782	0.00517	-0.00812	0.00556	-0.00841	0.00598	-0.00870	0.00642	-0.00899	0.00690	-0.00930	0.00742
17	-0.01535	0.01019	-0.01591	0.01094	-0.01645	0.01174	-0.01698	0.01258	-0.01751	0.01348	-0.01805	0.01446
18	-0.01493	0.01000	-0.01543	0.01072	-0.01591	0.01146	-0.01637	0.01225	-0.01681	0.01307	-0.01725	0.01395
19	-0.01445	0.00983	-0.01489	0.01051	-0.01530	0.01121	-0.01568	0.01193	-0.01603	0.01268	-0.01636	0.01345
20	-0.01394	0.00973	-0.01431	0.01037	-0.01466	0.01103	-0.01496	0.01169	-0.01521	0.01235	-0.01542	0.01302
21	-0.01339	0.00965	-0.01371	0.01025	-0.01397	0.01085	-0.01419	0.01145	-0.01434	0.01203	-0.01444	0.01259
22	-0.01283	0.00959	-0.01307	0.01014	-0.01326	0.01069	-0.01339	0.01122	-0.01345	0.01171	-0.01343	0.01216
23	-0.01226	0.00950	-0.01244	0.01001	-0.01255	0.01050	-0.01260	0.01095	-0.01256	0.01136	-0.01243	0.01169
24	-0.01167	0.00942	-0.01178	0.00988	-0.01183	0.01031	-0.01179	0.01068	-0.01167	0.01099	-0.01143	0.01121
25	-0.01109	0.00934	-0.01113	0.00975	-0.01111	0.01011	-0.01100	0.01041	-0.01079	0.01062	-0.01046	0.01072
26	-0.01050	0.00920	-0.01048	0.00956	-0.01039	0.00985	-0.01021	0.01007	-0.00993	0.01018	-0.00952	0.01017
27	-0.01700	0.01570	-0.01684	0.01618	-0.01653	0.01653	-0.01607	0.01672	-0.01542	0.01671	-0.01457	0.01643
28	-0.02152	0.02184	-0.02103	0.02222	-0.02034	0.02237	-0.01941	0.02223	-0.01823	0.02173	-0.01677	0.02082
29	-0.01831	0.02047	-0.01758	0.02048	-0.01665	0.02021	-0.01552	0.01963	-0.01417	0.01867	-0.01259	0.01728
30	-0.01540	0.01886	-0.01451	0.01852	-0.01344	0.01790	-0.01221	0.01695	-0.01081	0.01564	-0.00926	0.01395
31	-0.01281	0.01706	-0.01182	0.01643	-0.01070	0.01551	-0.00946	0.01430	-0.00810	0.01278	-0.00666	0.01095
32	-0.01056	0.01525	-0.00954	0.01438	-0.00842	0.01325	-0.00723	0.01187	-0.00598	0.01025	-0.00471	0.00843
33	-0.01245	0.01955	-0.01094	0.01795	-0.00936	0.01605	-0.00775	0.01387	-0.00614	0.01147	-0.00459	0.00894
34	-0.01178	0.02072	-0.00994	0.01827	-0.00812	0.01559	-0.00636	0.01276	-0.00472	0.00989	-0.00326	0.00712
35	-0.00761	0.01506	-0.00611	0.01264	-0.00471	0.01018	-0.00344	0.00778	-0.00235	0.00556	-0.00147	0.00362
36	-0.00489	0.01067	-0.00373	0.00850	-0.00270	0.00644	-0.00184	0.00458	-0.00115	0.00300	-0.00065	0.00176
37	-0.00428	0.00987	-0.00308	0.00740	-0.00208	0.00522	-0.00131	0.00342	-0.00075	0.00203	-0.00037	0.00105
38	-0.00258	0.00650	-0.00170	0.00445	-0.00104	0.00283	-0.00058	0.00164	-0.00029	0.00084	-0.00012	0.00037
39	-0.00091	0.00253	-0.00054	0.00155	-0.00029	0.00086	-0.00014	0.00043	-0.00006	0.00018	-0.00002	0.00006
40	-0.00030	0.00092	-0.00015	0.00050	-0.00007	0.00024	-0.00003	0.00010	-0.00001	0.00003	-0.00000	0.00001
41	-0.00009	0.00031	-0.00004	0.00015	-0.00002	0.00006	-0.00001	0.00002	-0.00000	0.00001	-0.00000	0.00000
42	-0.00002	0.00009	-0.00001	0.00004	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
43	-0.00001	0.00003	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
44	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
45	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
46	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
47	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00001
48	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 5d

PHASE VELOCITY PERTURBATIONS (IN KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY (DC/DRHO) AND RIGIDITY (DC/DMU) FOR GUTENBERG-BIRCH II CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II

T(SECS)	232.54		201.79		170.93		140.07		109.70		81.33	
C(K/SEC)	5.000		4.900		4.800		4.700		4.600		4.500	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.01667	0.00846	-0.01772	0.00937	-0.01915	0.01056	-0.02128	0.01225	-0.02482	0.01496	-0.03166	0.02002
2	-0.00182	0.00107	-0.00193	0.00118	-0.00208	0.00133	-0.00230	0.00153	-0.00265	0.00186	-0.00331	0.00245
3	-0.00181	0.00107	-0.00192	0.00118	-0.00207	0.00132	-0.00228	0.00153	-0.00263	0.00185	-0.00327	0.00243
4	-0.00181	0.00106	-0.00191	0.00118	-0.00206	0.00132	-0.00227	0.00152	-0.00261	0.00184	-0.00322	0.00241
5	-0.00180	0.00106	-0.00191	0.00117	-0.00205	0.00132	-0.00225	0.00152	-0.00258	0.00183	-0.00317	0.00239
6	-0.00536	0.00318	-0.00567	0.00351	-0.00608	0.00394	-0.00666	0.00452	-0.00758	0.00543	-0.00919	0.00703
7	-0.00442	0.00264	-0.00466	0.00291	-0.00498	0.00325	-0.00542	0.00373	-0.00611	0.00445	-0.00724	0.00567
8	-0.00751	0.00646	-0.00790	0.00709	-0.00842	0.00788	-0.00912	0.00894	-0.01017	0.01045	-0.01183	0.01283
	-0.00528	0.00451	-0.00555	0.00494	-0.00590	0.00548	-0.00637	0.00618	-0.00705	0.00718	-0.00807	0.00868
10	-0.00521	0.00443	-0.00547	0.00485	-0.00580	0.00536	-0.00624	0.00604	-0.00687	0.00697	-0.00777	0.00831
11	-0.00514	0.00434	-0.00539	0.00474	-0.00571	0.00524	-0.00612	0.00587	-0.00669	0.00673	-0.00748	0.00794
12	-0.00508	0.00427	-0.00532	0.00466	-0.00561	0.00513	-0.00600	0.00574	-0.00652	0.00654	-0.00720	0.00761
13	-0.00502	0.00420	-0.00525	0.00458	-0.00553	0.00503	-0.00589	0.00560	-0.00636	0.00635	-0.00694	0.00729
14	-0.00496	0.00415	-0.00518	0.00451	-0.00544	0.00494	-0.00577	0.00548	-0.00620	0.00617	-0.00668	0.00700
15	-0.00490	0.00408	-0.00511	0.00443	-0.00535	0.00485	-0.00566	0.00536	-0.00604	0.00599	-0.00642	0.00672
16	-0.00963	0.00800	-0.01001	0.00867	-0.01046	0.00945	-0.01100	0.01038	-0.01162	0.01149	-0.01211	0.01261
17	-0.01862	0.01553	-0.01925	0.01672	-0.01996	0.01808	-0.02073	0.01963	-0.02147	0.02129	-0.02162	0.02255
18	-0.01769	0.01489	-0.01813	0.01590	-0.01858	0.01699	-0.01897	0.01812	-0.01909	0.01908	-0.01824	0.01916
19	-0.01665	0.01425	-0.01691	0.01507	-0.01710	0.01589	-0.01712	0.01661	-0.01670	0.01695	-0.01509	0.01608
20	-0.01557	0.01368	-0.01564	0.01432	-0.01559	0.01487	-0.01527	0.01521	-0.01438	0.01498	-0.01223	0.01337
21	-0.01444	0.01311	-0.01434	0.01356	-0.01405	0.01385	-0.01344	0.01382	-0.01218	0.01310	-0.00971	0.01095
22	-0.01330	0.01253	-0.01303	0.01279	-0.01254	0.01282	-0.01168	0.01246	-0.01015	0.01132	-0.00754	0.00881
23	-0.01218	0.01192	-0.01176	0.01198	-0.01109	0.01178	-0.01004	0.01112	-0.00834	0.00965	-0.00574	0.00696
24	-0.01107	0.01129	-0.01052	0.01117	-0.00971	0.01075	-0.00851	0.00983	-0.00674	0.00813	-0.00428	0.00540
25	-0.01000	0.01066	-0.00934	0.01038	-0.00843	0.00976	-0.00715	0.00863	-0.00537	0.00677	-0.00313	0.00413
26	-0.00897	0.00998	-0.00823	0.00954	-0.00725	0.00875	-0.00593	0.00747	-0.00422	0.00555	-0.00224	0.00308
27	-0.01346	0.01580	-0.01204	0.01472	-0.01023	0.01304	-0.00796	0.01058	-0.00524	0.00727	-0.00246	0.00356
28	-0.01499	0.01938	-0.01284	0.01729	-0.01029	0.01444	-0.00736	0.01076	-0.00426	0.00649	-0.00161	0.00257
29	-0.01078	0.01540	-0.00872	0.01298	-0.00647	0.01003	-0.00414	0.00668	-0.00201	0.00338	-0.00057	0.00101
30	-0.00756	0.01186	-0.00575	0.00941	-0.00392	0.00668	-0.00222	0.00394	-0.00090	0.00165	-0.00019	0.00036
31	-0.00517	0.00886	-0.00369	0.00658	-0.00230	0.00428	-0.00115	0.00222	-0.00038	0.00076	-0.00006	0.00012
32	-0.00347	0.00647	-0.00231	0.00448	-0.00131	0.00265	-0.00057	0.00120	-0.00015	0.00033	-0.00002	0.00004
33	-0.00316	0.00642	-0.00193	0.00408	-0.00098	0.00215	-0.00036	0.00082	-0.00008	0.00018	-0.00001	0.00001
34	-0.00203	0.00463	-0.00109	0.00259	-0.00047	0.00114	-0.00013	0.00034	-0.00002	0.00005	-0.00000	0.00000
35	-0.00081	0.00207	-0.00037	0.00098	-0.00012	0.00035	-0.00003	0.00007	-0.00000	0.00001	-0.00000	0.00000
36	-0.00031	0.00088	-0.00012	0.00035	-0.00003	0.00010						
37	-0.00015	0.00045	-0.00005	0.00015	-0.00001	0.00003						
38	-0.00004	0.00013	-0.00001	0.00003	-0.00000	0.00000						
39	-0.00000	0.00002	-0.00000	0.00000	-0.00000	0.00000						
40	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000						
41	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000						

TABLE 6a

PERIOD (T), PHASE VELOCITY (c) AND VARIATIONAL PARTIAL DERIVATIVES FOR CIT13F OCEANIC EARTH MODEL

CIT13F OCEANIC

PSEUDO SPHERICAL CALCULATION

T(SECS)	1009.06	899.29	818.64	753.04	696.84	647.11
C(K/SEC)	6.720	6.620	6.520	6.420	6.320	6.220

M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.00063	0.00001	-0.00071	0.00002	-0.00078	0.00002	-0.00084	0.00002	-0.00090	0.00002	-0.00095	0.00002
2	-0.00254	0.00006	-0.00284	0.00007	-0.00311	0.00007	-0.00335	0.00008	-0.00358	0.00009	-0.00381	0.00010
3	-0.00633	0.00014	-0.00709	0.00017	-0.00775	0.00019	-0.00836	0.00021	-0.00894	0.00023	-0.00951	0.00025
4	-0.01134	0.00026	-0.01271	0.00030	-0.01389	0.00033	-0.01499	0.00037	-0.01603	0.00041	-0.01704	0.00045
5	-0.00627	0.00014	-0.00702	0.00016	-0.00768	0.00019	-0.00828	0.00021	-0.00886	0.00023	-0.00941	0.00025
6	-0.00625	0.00014	-0.00700	0.00016	-0.00765	0.00018	-0.00825	0.00020	-0.00882	0.00023	-0.00938	0.00025
7	-0.01244	0.00029	-0.01393	0.00033	-0.01523	0.00037	-0.01643	0.00041	-0.01756	0.00045	-0.01867	0.00049
8	-0.02465	0.00057	-0.02760	0.00066	-0.03016	0.00074	-0.03252	0.00082	-0.03476	0.00090	-0.03694	0.00098
9	-0.02428	0.00057	-0.02716	0.00065	-0.02967	0.00073	-0.03198	0.00081	-0.03416	0.00089	-0.03627	0.00098
10	-0.02389	0.00057	-0.02670	0.00065	-0.02914	0.00073	-0.03139	0.00081	-0.03350	0.00089	-0.03555	0.00097
11	-0.02348	0.00056	-0.02622	0.00064	-0.02859	0.00072	-0.03076	0.00080	-0.03280	0.00088	-0.03477	0.00096
12	-0.02305	0.00056	-0.02571	0.00064	-0.02800	0.00072	-0.03009	0.00080	-0.03205	0.00087	-0.03393	0.00096
13	-0.02261	0.00056	-0.02518	0.00064	-0.02739	0.00071	-0.02939	0.00079	-0.03126	0.00087	-0.03305	0.00095
14	-0.02216	0.00055	-0.02464	0.00063	-0.02676	0.00071	-0.02867	0.00078	-0.03045	0.00086	-0.03213	0.00094
15	-0.02170	0.00055	-0.02408	0.00063	-0.02611	0.00070	-0.02793	0.00078	-0.02960	0.00085	-0.03118	0.00093
16	-0.02122	0.00054	-0.02351	0.00062	-0.02544	0.00070	-0.02716	0.00077	-0.02874	0.00084	-0.03021	0.00091
17	-0.02074	0.00054	-0.02293	0.00062	-0.02476	0.00069	-0.02638	0.00076	-0.02785	0.00083	-0.02921	0.00090
18	-0.02026	0.00054	-0.02234	0.00061	-0.02406	0.00068	-0.02558	0.00075	-0.02694	0.00082	-0.02818	0.00089
19	-0.01976	0.00053	-0.02173	0.00061	-0.02335	0.00068	-0.02476	0.00074	-0.02601	0.00081	-0.02714	0.00088
20	-0.01926	0.00053	-0.02112	0.00060	-0.02264	0.00067	-0.02394	0.00074	-0.02507	0.00080	-0.02609	0.00087
21	-0.01875	0.00052	-0.02050	0.00060	-0.02191	0.00066	-0.02310	0.00073	-0.02412	0.00079	-0.02502	0.00085
22	-0.01824	0.00052	-0.01987	0.00059	-0.02117	0.00065	-0.02225	0.00072	-0.02316	0.00078	-0.02394	0.00084
23	-0.01772	0.00051	-0.01924	0.00058	-0.02043	0.00065	-0.02140	0.00071	-0.02220	0.00077	-0.02286	0.00082
24	-0.03403	0.00102	-0.03675	0.00115	-0.03881	0.00128	-0.04044	0.00139	-0.04172	0.00150	-0.04270	0.00161
25	-0.03969	0.00124	-0.04247	0.00140	-0.04445	0.00154	-0.04589	0.00167	-0.04688	0.00179	-0.04751	0.00190
26	-0.00748	0.00024	-0.00794	0.00027	-0.00825	0.00029	-0.00845	0.00032	-0.00856	0.00034	-0.00860	0.00036
27	-0.07050	0.00210	-0.07421	0.00231	-0.07645	0.00248	-0.07766	0.00263	-0.07802	0.00276	-0.07765	0.00286
28	-0.06076	0.00190	-0.06277	0.00205	-0.06351	0.00216	-0.06334	0.00225	-0.06241	0.00232	-0.06085	0.00236
29	-0.05203	0.00167	-0.05269	0.00177	-0.05231	0.00184	-0.05115	0.00187	-0.04938	0.00189	-0.04709	0.00188
30	-0.04435	0.00148	-0.04402	0.00154	-0.04284	0.00157	-0.04106	0.00157	-0.03880	0.00155	-0.03617	0.00150
31	-0.03759	0.00130	-0.03651	0.00132	-0.03481	0.00132	-0.03266	0.00129	-0.03019	0.00124	-0.02749	0.00118
32	-0.06046	0.00219	-0.05705	0.00215	-0.05289	0.00208	-0.04824	0.00198	-0.04329	0.00185	-0.03819	0.00170
33	-0.04237	0.00165	-0.03817	0.00155	-0.03384	0.00144	-0.02950	0.00130	-0.02524	0.00116	-0.02117	0.00101
34	-0.02898	0.00122	-0.02482	0.00109	-0.02096	0.00096	-0.01739	0.00083	-0.01414	0.00070	-0.01123	0.00058
35	-0.01939	0.00088	-0.01573	0.00074	-0.01260	0.00062	-0.00992	0.00051	-0.00763	0.00041	-0.00571	0.00032
36	-0.00974	0.00047	-0.00747	0.00038	-0.00567	0.00030	-0.00423	0.00023	-0.00307	0.00018	-0.00217	0.00013
37	-0.00476	0.00024	-0.00350	0.00019	-0.00255	0.00014	-0.00182	0.00011	-0.00126	0.00008	-0.00085	0.00005
38	-0.00379	0.00020	-0.00270	0.00015	-0.00190	0.00011	-0.00131	0.00008	-0.00088	0.00006	-0.00057	0.00004
39	-0.00301	0.00017	-0.00207	0.00012	-0.00141	0.00008	-0.00094	0.00006	-0.00061	0.00004	-0.00038	0.00003
40	-0.00239	0.00014	-0.00159	0.00009	-0.00105	0.00007	-0.00068	0.00004	-0.00042	0.00003	-0.00025	0.00002
41	-0.00189	0.00011	-0.00122	0.00008	-0.00078	0.00005	-0.00048	0.00003	-0.00029	0.00002	-0.00017	0.00001
42	-0.00151	0.00009	-0.00094	0.00006	-0.00058	0.00004	-0.00035	0.00002	-0.00020	0.00001	-0.00011	0.00001
43	-0.00120	0.00008	-0.00073	0.00005	-0.00044	0.00003	-0.00025	0.00002	-0.00014	0.00001	-0.00008	0.00001
44	-0.00097	0.00007	-0.00057	0.00004	-0.00033	0.00002	-0.00019	0.00001	-0.00010	0.00001	-0.00005	0.00000
45	-0.00120	0.00009	-0.00070	0.00005	-0.00040	0.00003	-0.00022	0.00002	-0.00012	0.00001	-0.00006	0.00000
46	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 6b

PERIOD (T), PHASE VELOCITY (c) AND VARIATIONAL PARTIAL DERIVATIVES FOR CIT13F OCEANIC EARTH MODEL

CIT 13F OCEANIC

T(SECS)	602.14		560.79		522.28		486.02		451.55		418.48	
C(K/SEC)	6.120		6.020		5.920		5.820		5.720		5.620	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.00101	0.00003	-0.00106	0.00003	-0.00111	0.00003	-0.00117	0.00003	-0.00122	0.00004	-0.00126	0.00004
2	-0.00403	0.00011	-0.00424	0.00012	-0.00445	0.00013	-0.00466	0.00014	-0.00486	0.00015	-0.00505	0.00016
3	-0.01005	0.00027	-0.01059	0.00029	-0.01111	0.00032	-0.01162	0.00035	-0.01212	0.00037	-0.01260	0.00040
4	-0.01802	0.00049	-0.01898	0.00053	-0.01991	0.00057	-0.02083	0.00062	-0.02172	0.00067	-0.02258	0.00072
5	-0.00996	0.00027	-0.01048	0.00029	-0.01100	0.00032	-0.01151	0.00034	-0.01200	0.00037	-0.01247	0.00040
6	-0.00992	0.00027	-0.01044	0.00029	-0.01096	0.00032	-0.01146	0.00034	-0.01195	0.00037	-0.01242	0.00040
7	-0.01974	0.00054	-0.02078	0.00058	-0.02180	0.00063	-0.02280	0.00068	-0.02377	0.00074	-0.02470	0.00079
8	-0.03905	0.00107	-0.04109	0.00117	-0.04309	0.00126	-0.04504	0.00136	-0.04693	0.00147	-0.04875	0.00158
9	-0.03832	0.00106	-0.04030	0.00116	-0.04223	0.00125	-0.04411	0.00135	-0.04592	0.00146	-0.04765	0.00156
10	-0.03752	0.00106	-0.03942	0.00115	-0.04127	0.00124	-0.04306	0.00134	-0.04478	0.00144	-0.04641	0.00155
11	-0.03665	0.00105	-0.03847	0.00114	-0.04022	0.00123	-0.04191	0.00132	-0.04351	0.00142	-0.04503	0.00152
12	-0.03572	0.00104	-0.03744	0.00113	-0.03908	0.00122	-0.04066	0.00131	-0.04214	0.00140	-0.04352	0.00150
13	-0.03474	0.00103	-0.03635	0.00111	-0.03788	0.00120	-0.03933	0.00129	-0.04068	0.00138	-0.04191	0.00147
14	-0.03372	0.00102	-0.03521	0.00110	-0.03662	0.00118	-0.03794	0.00127	-0.03915	0.00135	-0.04023	0.00144
15	-0.03266	0.00100	-0.03403	0.00108	-0.03531	0.00116	-0.03650	0.00124	-0.03756	0.00132	-0.03848	0.00141
16	-0.03157	0.00099	-0.03282	0.00106	-0.03397	0.00114	-0.03502	0.00122	-0.03593	0.00129	-0.03670	0.00137
17	-0.03045	0.00097	-0.03158	0.00105	-0.03260	0.00112	-0.03350	0.00119	-0.03427	0.00126	-0.03487	0.00133
18	-0.02931	0.00096	-0.03031	0.00103	-0.03119	0.00110	-0.03195	0.00117	-0.03256	0.00123	-0.03301	0.00130
19	-0.02814	0.00094	-0.02902	0.00101	-0.02976	0.00107	-0.03038	0.00114	-0.03084	0.00120	-0.03114	0.00125
20	-0.02696	0.00093	-0.02771	0.00099	-0.02832	0.00105	-0.02880	0.00111	-0.02911	0.00116	-0.02925	0.00121
21	-0.02577	0.00091	-0.02639	0.00097	-0.02686	0.00103	-0.02720	0.00108	-0.02737	0.00113	-0.02736	0.00117
22	-0.02457	0.00089	-0.02506	0.00095	-0.02540	0.00100	-0.02561	0.00105	-0.02564	0.00109	-0.02549	0.00112
23	-0.02337	0.00088	-0.02373	0.00093	-0.02395	0.00097	-0.02402	0.00102	-0.02392	0.00105	-0.02364	0.00108
24	-0.04339	0.00170	-0.04377	0.00179	-0.04385	0.00188	-0.04363	0.00195	-0.04308	0.00200	-0.04216	0.00204
25	-0.04775	0.00200	-0.04760	0.00209	-0.04709	0.00217	-0.04620	0.00223	-0.04491	0.00226	-0.04321	0.00228
26	-0.00857	0.00037	-0.00846	0.00039	-0.00828	0.00040	-0.00802	0.00041	-0.00769	0.00041	-0.00729	0.00041
27	-0.07654	0.00294	-0.07471	0.00300	-0.07220	0.00302	-0.06904	0.00302	-0.06522	0.00297	-0.06076	0.00289
28	-0.05865	0.00237	-0.05587	0.00236	-0.05256	0.00232	-0.04878	0.00225	-0.04457	0.00215	-0.03998	0.00201
29	-0.04432	0.00184	-0.04113	0.00179	-0.03761	0.00171	-0.03381	0.00160	-0.02980	0.00147	-0.02568	0.00133
30	-0.03322	0.00144	-0.03002	0.00136	-0.02664	0.00126	-0.02318	0.00115	-0.01969	0.00102	-0.01627	0.00088
31	-0.02460	0.00110	-0.02161	0.00101	-0.01860	0.00091	-0.01563	0.00080	-0.01278	0.00068	-0.01010	0.00056
32	-0.03304	0.00153	-0.02798	0.00135	-0.02312	0.00116	-0.01858	0.00097	-0.01444	0.00078	-0.01079	0.00061
33	-0.01735	0.00086	-0.01384	0.00072	-0.01071	0.00058	-0.00800	0.00045	-0.00573	0.00033	-0.00390	0.00024
34	-0.00868	0.00046	-0.00649	0.00036	-0.00468	0.00027	-0.00324	0.00019	-0.00212	0.00013	-0.00131	0.00008
35	-0.00415	0.00024	-0.00290	0.00017	-0.00194	0.00012	-0.00123	0.00008	-0.00074	0.00005	-0.00041	0.00003
36	-0.00147	0.00009	-0.00096	0.00006	-0.00060	0.00004	-0.00035	0.00002	-0.00019	0.00001	-0.00009	0.00001
37	-0.00055	0.00004	-0.00034	0.00002	-0.00020	0.00001	-0.00011	0.00001	-0.00005	0.00000	-0.00002	0.00000
38	-0.00035	0.00002	-0.00021	0.00001	-0.00012	0.00001	-0.00006	0.00000	-0.00003	0.00000	-0.00001	0.00000
39	-0.00023	0.00002	-0.00013	0.00001	-0.00007	0.00001	-0.00003	0.00000	-0.00002	0.00000	-0.00001	0.00000
40	-0.00014	0.00001	-0.00008	0.00001	-0.00004	0.00000	-0.00002	0.00000	-0.00001	0.00000	-0.00000	0.00000
41	-0.00009	0.00001	-0.00005	0.00000	-0.00002	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000
42	-0.00006	0.00000	-0.00003	0.00000	-0.00001	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000
43	-0.00004	0.00000	-0.00002	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
44	-0.00003	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
45	-0.00003	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
46	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 6c

PERIOD (T), PHASE VELOCITY (c) AND VARIATIONAL PARTIAL DERIVATIVES FOR CIT13F OCEANIC EARTH MODEL

CIT13F OCEANIC

PSEUDO SPHERICAL CALCULATION

T(SECS)	412.00		380.15		348.98		318.19		287.45		256.41	
C(K/SEC)	5.600		5.500		5.400		5.300		5.200		5.100	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.00127	0.00004	-0.00132	0.00004	-0.00136	0.00005	-0.00141	0.00005	-0.00145	0.00005	-0.00150	0.00006
2	-0.00509	0.00016	-0.00528	0.00017	-0.00545	0.00019	-0.00563	0.00020	-0.00580	0.00022	-0.00598	0.00023
3	-0.01270	0.00041	-0.01316	0.00044	-0.01361	0.00047	-0.01404	0.00050	-0.01447	0.00054	-0.01491	0.00058
4	-0.02275	0.00073	-0.02358	0.00078	-0.02438	0.00084	-0.02515	0.00090	-0.02592	0.00096	-0.02670	0.00103
5	-0.01256	0.00040	-0.01302	0.00043	-0.01346	0.00047	-0.01388	0.00050	-0.01430	0.00053	-0.01473	0.00057
6	-0.01251	0.00040	-0.01297	0.00043	-0.01340	0.00046	-0.01382	0.00050	-0.01424	0.00053	-0.01466	0.00057
7	-0.02488	0.00081	-0.02578	0.00087	-0.02663	0.00093	-0.02746	0.00099	-0.02828	0.00106	-0.02911	0.00113
8	-0.04911	0.00160	-0.05084	0.00172	-0.05250	0.00184	-0.05410	0.00197	-0.05565	0.00210	-0.05722	0.00225
9	-0.04799	0.00159	-0.04963	0.00170	-0.05119	0.00182	-0.05267	0.00194	-0.05410	0.00207	-0.05550	0.00221
10	-0.04672	0.00157	-0.04825	0.00168	-0.04968	0.00179	-0.05102	0.00191	-0.05228	0.00203	-0.05350	0.00216
11	-0.04532	0.00155	-0.04671	0.00165	-0.04800	0.00176	-0.04917	0.00187	-0.05025	0.00198	-0.05123	0.00210
12	-0.04378	0.00152	-0.04503	0.00162	-0.04615	0.00172	-0.04714	0.00182	-0.04800	0.00193	-0.04874	0.00203
13	-0.04214	0.00149	-0.04323	0.00159	-0.04417	0.00168	-0.04497	0.00177	-0.04560	0.00187	-0.04607	0.00196
14	-0.04043	0.00146	-0.04135	0.00155	-0.04211	0.00163	-0.04270	0.00171	-0.04311	0.00180	-0.04331	0.00187
15	-0.03865	0.00142	-0.03940	0.00150	-0.03998	0.00158	-0.04036	0.00165	-0.04054	0.00172	-0.04049	0.00178
16	-0.03683	0.00138	-0.03741	0.00146	-0.03780	0.00153	-0.03799	0.00159	-0.03795	0.00164	-0.03764	0.00169
17	-0.03497	0.00135	-0.03538	0.00141	-0.03559	0.00147	-0.03558	0.00152	-0.03533	0.00157	-0.03480	0.00160
18	-0.03308	0.00131	-0.03332	0.00136	-0.03335	0.00142	-0.03316	0.00146	-0.03271	0.00149	-0.03196	0.00151
19	-0.03117	0.00126	-0.03125	0.00131	-0.03111	0.00135	-0.03074	0.00139	-0.03010	0.00140	-0.02916	0.00141
20	-0.02926	0.00122	-0.02917	0.00126	-0.02887	0.00129	-0.02834	0.00132	-0.02754	0.00132	-0.02643	0.00131
21	-0.02734	0.00118	-0.02711	0.00121	-0.02666	0.00124	-0.02597	0.00125	-0.02502	0.00124	-0.02377	0.00122
22	-0.02544	0.00113	-0.02506	0.00116	-0.02447	0.00117	-0.02365	0.00117	-0.02258	0.00116	-0.02121	0.00112
23	-0.02356	0.00109	-0.02306	0.00110	-0.02234	0.00111	-0.02141	0.00110	-0.02022	0.00108	-0.01877	0.00103
24	-0.04194	0.00205	-0.04059	0.00206	-0.03885	0.00205	-0.03669	0.00201	-0.03410	0.00194	-0.03102	0.00182
25	-0.04282	0.00228	-0.04062	0.00226	-0.03801	0.00221	-0.03497	0.00212	-0.03151	0.00199	-0.02762	0.00181
26	-0.00720	0.00041	-0.00671	0.00040	-0.00615	0.00038	-0.00552	0.00036	-0.00483	0.00033	-0.00409	0.00029
27	-0.05979	0.00287	-0.05463	0.00274	-0.04894	0.00256	-0.04279	0.00234	-0.03626	0.00207	-0.02946	0.00175
28	-0.03903	0.00198	-0.03412	0.00181	-0.02903	0.00161	-0.02388	0.00138	-0.01879	0.00113	-0.01393	0.00088
29	-0.02485	0.00129	-0.02071	0.00113	-0.01667	0.00095	-0.01283	0.00076	-0.00933	0.00058	-0.00626	0.00040
30	-0.01561	0.00085	-0.01238	0.00070	-0.00941	0.00056	-0.00677	0.00042	-0.00453	0.00029	-0.00274	0.00018
31	-0.00960	0.00054	-0.00723	0.00042	-0.00517	0.00032	-0.00346	0.00022	-0.00212	0.00014	-0.00115	0.00008
32	-0.01013	0.00058	-0.00714	0.00042	-0.00473	0.00029	-0.00289	0.00019	-0.00159	0.00011	-0.00075	0.00005
33	-0.00359	0.00022	-0.00227	0.00014	-0.00132	0.00009	-0.00069	0.00005	-0.00032	0.00002	-0.00012	0.00001
34	-0.00118	0.00008	-0.00066	0.00004	-0.00034	0.00002	-0.00015	0.00001	-0.00006	0.00000	-0.00002	0.00000
35	-0.00036	0.00003	-0.00018	0.00001	-0.00008	0.00001	-0.00003	0.00000	-0.00001	0.00000	-0.00000	0.00000
36	-0.00008	0.00001	-0.00004	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
37	-0.00002	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
38	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
39	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
40	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
41	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
42	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
43	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
44	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
45	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
46	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 6d

PERIOD (T), PHASE VELOCITY (c) AND VARIATIONAL PARTIAL DERIVATIVES FOR CIT13F OCEANIC EARTH MODEL

CIT 13F OCEANIC

T(SECS)	224.67		191.71		156.82		119.10		78.14		38.58	
C(K/SEC)	5.000		4.900		4.800		4.700		4.600		4.500	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.00155	0.00006	-0.00161	0.00007	-0.00170	0.00007	-0.00186	0.00009	-0.00227	0.00011	-0.00368	0.00020
2	-0.00618	0.00025	-0.00642	0.00027	-0.00678	0.00029	-0.00743	0.00034	-0.00905	0.00043	-0.01454	0.00072
3	-0.01540	0.00062	-0.01601	0.00067	-0.01688	0.00074	-0.01849	0.00084	-0.02243	0.00107	-0.03536	0.00177
4	-0.02756	0.00111	-0.02862	0.00120	-0.03016	0.00132	-0.03294	0.00150	-0.03968	0.00189	-0.06017	0.00300
5	-0.01520	0.00061	-0.01578	0.00066	-0.01661	0.00073	-0.01810	0.00083	-0.02168	0.00103	-0.03192	0.00159
6	-0.01512	0.00061	-0.01569	0.00066	-0.01650	0.00072	-0.01796	0.00082	-0.02143	0.00102	-0.03099	0.00155
7	-0.03001	0.00122	-0.03111	0.00131	-0.03268	0.00144	-0.03549	0.00163	-0.04209	0.00202	-0.05941	0.00298
8	-0.05891	0.00241	-0.06094	0.00259	-0.06383	0.00283	-0.06892	0.00318	-0.08057	0.00389	-0.10787	0.00545
9	-0.05699	0.00236	-0.05874	0.00253	-0.06118	0.00274	-0.06537	0.00305	-0.07452	0.00364	-0.09135	0.00467
10	-0.05474	0.00229	-0.05614	0.00245	-0.05803	0.00263	-0.06117	0.00290	-0.06749	0.00334	-0.07414	0.00384
11	-0.05218	0.00222	-0.05320	0.00235	-0.05447	0.00251	-0.05646	0.00271	-0.05983	0.00300	-0.05753	0.00303
12	-0.04938	0.00214	-0.04996	0.00225	-0.05059	0.00237	-0.05138	0.00251	-0.05186	0.00265	-0.04248	0.00228
13	-0.04638	0.00204	-0.04653	0.00213	-0.04650	0.00222	-0.04612	0.00229	-0.04398	0.00228	-0.02974	0.00163
14	-0.04329	0.00194	-0.04301	0.00200	-0.04236	0.00205	-0.04093	0.00206	-0.03663	0.00193	-0.01993	0.00111
15	-0.04016	0.00183	-0.03948	0.00187	-0.03828	0.00188	-0.03595	0.00184	-0.03007	0.00161	-0.01291	0.00073
16	-0.03702	0.00172	-0.03599	0.00174	-0.03431	0.00172	-0.03127	0.00162	-0.02437	0.00132	-0.00815	0.00047
17	-0.03392	0.00161	-0.03257	0.00160	-0.03050	0.00155	-0.02695	0.00142	-0.01952	0.00107	-0.00525	0.00029
18	-0.03084	0.00150	-0.02924	0.00147	-0.02686	0.00140	-0.02298	0.00124	-0.01543	0.00086	-0.00307	0.00018
19	-0.02785	0.00139	-0.02603	0.00134	-0.02344	0.00125	-0.01937	0.00106	-0.01203	0.00068	-0.00182	0.00011
20	-0.02495	0.00128	-0.02297	0.00121	-0.02024	0.00110	-0.01614	0.00090	-0.00926	0.00053	-0.00106	0.00006
21	-0.02216	0.00117	-0.02007	0.00109	-0.01728	0.00097	-0.01327	0.00076	-0.00701	0.00041	-0.00061	0.00004
22	-0.01950	0.00106	-0.01735	0.00097	-0.01457	0.00084	-0.01074	0.00063	-0.00521	0.00031	-0.00034	0.00002
23	-0.01700	0.00096	-0.01483	0.00086	-0.01212	0.00072	-0.00856	0.00052	-0.00380	0.00023	-0.00019	0.00001
24	-0.02742	0.00166	-0.02318	0.00144	-0.01813	0.00115	-0.01196	0.00077	-0.00465	0.00030	-0.00016	0.00001
25	-0.02329	0.00158	-0.01853	0.00130	-0.01331	0.00096	-0.00768	0.00056	-0.00233	0.00017	-0.00004	
26	-0.00329	0.00025	-0.00246	0.00019	-0.00161	0.00013	-0.00080	0.00007	-0.00018	0.00002		
27	-0.02255	0.00140	-0.01574	0.00102	-0.00934	0.00063	-0.00395	0.00027	-0.00065	0.00005		
28	-0.00946	0.00062	-0.00560	0.00038	-0.00260	0.00018	-0.00072	0.00005	-0.00005			
29	-0.00373	0.00025	-0.00185	0.00013	-0.00066	0.00005	-0.00012	0.00001	-0.00000			
30	-0.00143	0.00010	-0.00059	0.00004	-0.00016	0.00001	-0.00002	0.00000				
31	-0.00052	0.00004	-0.00018	0.00001	-0.00004	0.00000	-0.00000	0.00000				
32	-0.00029	0.00002	-0.00008	0.00001	-0.00001	0.00000	-0.00000					
33	-0.00003	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000					
34	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000						
35	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000						

TABLE 7a

PHASE VELOCITY PERTURBATIONS (IN KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY (DC/DRHO) AND RIGIDITY (DC/DMU) FOR CITI13F OCEANIC EARTH MODEL

VARIATIONS FOR 10 O/O CHANGE IN PARAMETER
CITI13F OCEANIC

PSEUDO SPHERICAL CALCULATION

T(SECS)	1009.06		899.29		818.64		753.04		696.84		647.11	
C(K/SEC)	6.720		6.620		6.520		6.420		6.320		6.220	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00012	0.00000	-0.00013	0.00000	-0.00015	0.00000	-0.00016	0.00000	-0.00017	0.00000	-0.00018	0.00000
2	-0.00064	0.00012	-0.00072	0.00014	-0.00079	0.00016	-0.00085	0.00017	-0.00091	0.00019	-0.00097	0.00021
3	-0.00183	0.00057	-0.00206	0.00066	-0.00225	0.00074	-0.00242	0.00082	-0.00259	0.00090	-0.00276	0.00099
4	-0.00377	0.00182	-0.00422	0.00209	-0.00461	0.00235	-0.00498	0.00260	-0.00532	0.00286	-0.00566	0.00314
5	-0.00208	0.00101	-0.00233	0.00116	-0.00255	0.00130	-0.00275	0.00144	-0.00294	0.00159	-0.00313	0.00174
6	-0.00208	0.00099	-0.00233	0.00114	-0.00255	0.00128	-0.00275	0.00142	-0.00294	0.00156	-0.00312	0.00171
7	-0.00415	0.00190	-0.00465	0.00218	-0.00508	0.00245	-0.00548	0.00271	-0.00586	0.00299	-0.00623	0.00327
8	-0.00826	0.00371	-0.00925	0.00425	-0.01010	0.00477	-0.01090	0.00529	-0.01165	0.00582	-0.01237	0.00638
9	-0.00819	0.00371	-0.00917	0.00426	-0.01001	0.00478	-0.01079	0.00530	-0.01153	0.00583	-0.01224	0.00638
10	-0.00810	0.00371	-0.00905	0.00425	-0.00988	0.00477	-0.01064	0.00529	-0.01136	0.00582	-0.01205	0.00637
11	-0.00801	0.00371	-0.00894	0.00426	-0.00975	0.00477	-0.01049	0.00529	-0.01118	0.00581	-0.01185	0.00636
12	-0.00789	0.00371	-0.00881	0.00425	-0.00959	0.00477	-0.01031	0.00528	-0.01098	0.00580	-0.01162	0.00634
13	-0.00778	0.00377	-0.00866	0.00432	-0.00942	0.00484	-0.01011	0.00536	-0.01075	0.00588	-0.01137	0.00642
14	-0.00767	0.00383	-0.00853	0.00439	-0.00926	0.00491	-0.00992	0.00544	-0.01053	0.00596	-0.01112	0.00650
15	-0.00754	0.00387	-0.00837	0.00443	-0.00907	0.00496	-0.00970	0.00548	-0.01029	0.00601	-0.01084	0.00654
16	-0.00741	0.00391	-0.00821	0.00447	-0.00888	0.00500	-0.00948	0.00552	-0.01003	0.00604	-0.01054	0.00657
17	-0.00728	0.00391	-0.00805	0.00446	-0.00869	0.00499	-0.00926	0.00550	-0.00977	0.00601	-0.01025	0.00653
18	-0.00714	0.00390	-0.00787	0.00445	-0.00848	0.00497	-0.00902	0.00547	-0.00950	0.00597	-0.00993	0.00648
19	-0.00699	0.00391	-0.00769	0.00447	-0.00827	0.00498	-0.00877	0.00548	-0.00921	0.00597	-0.00961	0.00646
20	-0.00686	0.00391	-0.00752	0.00445	-0.00806	0.00496	-0.00852	0.00545	-0.00893	0.00593	-0.00929	0.00640
21	-0.00669	0.00389	-0.00732	0.00443	-0.00782	0.00493	-0.00825	0.00540	-0.00861	0.00587	-0.00893	0.00633
22	-0.00655	0.00390	-0.00713	0.00444	-0.00760	0.00493	-0.00799	0.00540	-0.00832	0.00585	-0.00859	0.00630
23	-0.00639	0.00389	-0.00694	0.00442	-0.00737	0.00490	-0.00771	0.00535	-0.00800	0.00579	-0.00824	0.00622
24	-0.01235	0.00775	-0.01334	0.00878	-0.01409	0.00972	-0.01468	0.01060	-0.01514	0.01143	-0.01550	0.01223
25	-0.01465	0.00974	-0.01567	0.01100	-0.01640	0.01211	-0.01693	0.01314	-0.01730	0.01409	-0.01753	0.01497
26	-0.00282	0.00197	-0.00300	0.00221	-0.00311	0.00242	-0.00319	0.00261	-0.00323	0.00279	-0.00325	0.00295
27	-0.02834	0.02559	-0.02983	0.02811	-0.03073	0.03021	-0.03122	0.03200	-0.03136	0.03353	-0.03121	0.03480
28	-0.02567	0.02530	-0.02652	0.02733	-0.02683	0.02889	-0.02676	0.03008	-0.02637	0.03094	-0.02571	0.03149
29	-0.02289	0.02555	-0.02318	0.02704	-0.02301	0.02802	-0.02251	0.02860	-0.02173	0.02881	-0.02072	0.02867
30	-0.02023	0.02436	-0.02007	0.02528	-0.01953	0.02569	-0.01872	0.02571	-0.01769	0.02537	-0.01650	0.02468
31	-0.01740	0.02316	-0.01691	0.02352	-0.01612	0.02342	-0.01512	0.02294	-0.01398	0.02213	-0.01273	0.02102
32	-0.02866	0.04260	-0.02704	0.04193	-0.02507	0.04051	-0.02287	0.03849	-0.02052	0.03596	-0.01810	0.03303
33	-0.02055	0.03440	-0.01851	0.03233	-0.01641	0.02987	-0.01431	0.02711	-0.01224	0.02415	-0.01027	0.02108
34	-0.01438	0.02702	-0.01231	0.02413	-0.01040	0.02123	-0.00863	0.01834	-0.00701	0.01551	-0.00557	0.01281
35	-0.00983	0.02046	-0.00797	0.01730	-0.00639	0.01444	-0.00503	0.01182	-0.00387	0.00946	-0.00290	0.00736
36	-0.00501	0.01145	-0.00385	0.00916	-0.00292	0.00725	-0.00218	0.00563	-0.00158	0.00426	-0.00112	0.00312
37	-0.00248	0.00606	-0.00182	0.00464	-0.00133	0.00353	-0.00095	0.00263	-0.00066	0.00190	-0.00044	0.00133
38	-0.00200	0.00514	-0.00142	0.00381	-0.00100	0.00280	-0.00069	0.00202	-0.00046	0.00141	-0.00030	0.00095
39	-0.00160	0.00434	-0.00110	0.00311	-0.00075	0.00221	-0.00050	0.00154	-0.00033	0.00104	-0.00020	0.00068
40	-0.00128	0.00366	-0.00085	0.00253	-0.00056	0.00174	-0.00036	0.00117	-0.00023	0.00076	-0.00014	0.00048
41	-0.00103	0.00309	-0.00066	0.00206	-0.00042	0.00137	-0.00026	0.00089	-0.00016	0.00056	-0.00009	0.00033
42	-0.00082	0.00261	-0.00051	0.00168	-0.00032	0.00108	-0.00019	0.00067	-0.00011	0.00041	-0.00006	0.00023
43	-0.00066	0.00222	-0.00040	0.00139	-0.00024	0.00086	-0.00014	0.00052	-0.00008	0.00030	-0.00004	0.00017
44	-0.00054	0.00191	-0.00032	0.00116	-0.00019	0.00070	-0.00011	0.00041	-0.00006	0.00023	-0.00003	0.00012
45	-0.00067	0.00257	-0.00039	0.00153	-0.00022	0.00090	-0.00012	0.00051	-0.00006	0.00028	-0.00003	0.00014
46	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 7b

PHASE VELOCITY PERTURBATIONS (IN KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY (DC/DRHO) AND RIGIDITY (DC/DMU) FOR CIT13F OCEANIC EARTH MODEL

CIT 13F OCEANIC

T(SECS)	602.14		560.79		522.28		486.02		451.55		418.48	
C(K/SEC)	6.120		6.020		5.920		5.820		5.720		5.620	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00019	0.00000	-0.00020	0.00000	-0.00021	0.00000	-0.00022	0.00000	-0.00023	0.00000	-0.00024	0.00000
2	-0.00102	0.00023	-0.00108	0.00025	-0.00113	0.00027	-0.00118	0.00029	-0.00123	0.00031	-0.00128	0.00034
3	-0.00292	0.00108	-0.00307	0.00117	-0.00322	0.00127	-0.00337	0.00137	-0.00352	0.00148	-0.00365	0.00159
4	-0.00598	0.00342	-0.00630	0.00372	-0.00661	0.00403	-0.00692	0.00436	-0.00721	0.00470	-0.00750	0.00506
5	-0.00331	0.00190	-0.00349	0.00206	-0.00366	0.00224	-0.00383	0.00242	-0.00399	0.00261	-0.00415	0.00281
6	-0.00330	0.00187	-0.00348	0.00203	-0.00365	0.00220	-0.00382	0.00238	-0.00398	0.00256	-0.00414	0.00276
7	-0.00658	0.00357	-0.00693	0.00388	-0.00727	0.00420	-0.00760	0.00454	-0.00793	0.00490	-0.00824	0.00527
8	-0.01308	0.00696	-0.01376	0.00756	-0.01443	0.00819	-0.01509	0.00885	-0.01572	0.00954	-0.01633	0.01025
9	-0.01293	0.00696	-0.01360	0.00755	-0.01425	0.00818	-0.01489	0.00883	-0.01550	0.00952	-0.01608	0.01022
10	-0.01272	0.00694	-0.01336	0.00753	-0.01399	0.00814	-0.01460	0.00879	-0.01518	0.00945	-0.01573	0.01015
11	-0.01250	0.00692	-0.01312	0.00751	-0.01371	0.00811	-0.01429	0.00874	-0.01484	0.00939	-0.01535	0.01007
12	-0.01224	0.00689	-0.01282	0.00747	-0.01339	0.00806	-0.01393	0.00868	-0.01443	0.00931	-0.01491	0.00995
13	-0.01195	0.00698	-0.01250	0.00755	-0.01303	0.00813	-0.01353	0.00874	-0.01399	0.00936	-0.01442	0.00999
14	-0.01167	0.00706	-0.01218	0.00762	-0.01267	0.00820	-0.01313	0.00880	-0.01354	0.00940	-0.01392	0.01000
15	-0.01135	0.00709	-0.01183	0.00764	-0.01227	0.00821	-0.01268	0.00879	-0.01305	0.00936	-0.01337	0.00994
16	-0.01102	0.00711	-0.01145	0.00765	-0.01186	0.00820	-0.01222	0.00876	-0.01254	0.00931	-0.01281	0.00985
17	-0.01069	0.00705	-0.01108	0.00758	-0.01144	0.00810	-0.01176	0.00863	-0.01203	0.00914	-0.01224	0.00964
18	-0.01033	0.00698	-0.01068	0.00748	-0.01099	0.00798	-0.01126	0.00848	-0.01148	0.00896	-0.01164	0.00941
19	-0.00996	0.00695	-0.01027	0.00743	-0.01054	0.00791	-0.01075	0.00837	-0.01092	0.00881	-0.01102	0.00923
20	-0.00960	0.00687	-0.00986	0.00733	-0.01008	0.00778	-0.01025	0.00821	-0.01036	0.00861	-0.01041	0.00897
21	-0.00920	0.00678	-0.00942	0.00721	-0.00959	0.00763	-0.00971	0.00802	-0.00977	0.00838	-0.00977	0.00870
22	-0.00882	0.00673	-0.00900	0.00714	-0.00912	0.00752	-0.00919	0.00788	-0.00920	0.00820	-0.00915	0.00847
23	-0.00842	0.00662	-0.00856	0.00701	-0.00863	0.00736	-0.00866	0.00769	-0.00862	0.00796	-0.00852	0.00818
24	-0.01575	0.01297	-0.01589	0.01366	-0.01592	0.01428	-0.01584	0.01482	-0.01564	0.01525	-0.01531	0.01554
25	-0.01762	0.01578	-0.01757	0.01648	-0.01738	0.01708	-0.01705	0.01754	-0.01657	0.01784	-0.01594	0.01795
26	-0.00323	0.00309	-0.00319	0.00320	-0.00312	0.00329	-0.00303	0.00335	-0.00290	0.00338	-0.00275	0.00336
27	-0.03077	0.03578	-0.03003	0.03644	-0.02902	0.03674	-0.02775	0.03667	-0.02622	0.03615	-0.02442	0.03516
28	-0.02478	0.03169	-0.02360	0.03152	-0.02221	0.03097	-0.02061	0.03002	-0.01883	0.02864	-0.01689	0.02684
29	-0.01950	0.02816	-0.01810	0.02728	-0.01655	0.02604	-0.01488	0.02444	-0.01311	0.02250	-0.01130	0.02025
30	-0.01515	0.02367	-0.01369	0.02232	-0.01215	0.02069	-0.01057	0.01880	-0.00898	0.01668	-0.00742	0.01440
31	-0.01139	0.01964	-0.01001	0.01801	-0.00861	0.01618	-0.00724	0.01420	-0.00592	0.01212	-0.00468	0.01001
32	-0.01566	0.02976	-0.01326	0.02623	-0.01096	0.02256	-0.00881	0.01887	-0.00685	0.01527	-0.00512	0.01187
33	-0.00841	0.01797	-0.00671	0.01491	-0.00519	0.01200	-0.00388	0.00932	-0.00278	0.00694	-0.00189	0.00491
34	-0.00430	0.01029	-0.00322	0.00800	-0.00232	0.00600	-0.00161	0.00430	-0.00105	0.00293	-0.00065	0.00188
35	-0.00210	0.00555	-0.00147	0.00403	-0.00098	0.00280	-0.00063	0.00185	-0.00037	0.00115	-0.00021	0.00066
36	-0.00076	0.00221	-0.00049	0.00150	-0.00031	0.00096	-0.00018	0.00059	-0.00010	0.00033	-0.00005	0.00017
37	-0.00029	0.00090	-0.00018	0.00058	-0.00010	0.00035	-0.00006	0.00020	-0.00003	0.00010	-0.00001	0.00005
38	-0.00019	0.00062	-0.00011	0.00038	-0.00006	0.00022	-0.00003	0.00012	-0.00002	0.00006	-0.00001	0.00003
39	-0.00012	0.00042	-0.00007	0.00025	-0.00004	0.00014	-0.00002	0.00007	-0.00001	0.00003	-0.00000	0.00001
40	-0.00008	0.00028	-0.00004	0.00016	-0.00002	0.00008	-0.00001	0.00004	-0.00000	0.00002	-0.00000	0.00001
41	-0.00005	0.00019	-0.00003	0.00010	-0.00001	0.00005	-0.00001	0.00002	-0.00000	0.00001	-0.00000	0.00000
42	-0.00003	0.00013	-0.00002	0.00007	-0.00001	0.00003	-0.00000	0.00001	-0.00000	0.00001	-0.00000	0.00000
43	-0.00002	0.00009	-0.00001	0.00004	-0.00000	0.00002	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000
44	-0.00001	0.00006	-0.00001	0.00003	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
45	-0.00001	0.00007	-0.00001	0.00003	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
46	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 7c

PHASE VELOCITY PERTURBATIONS (IN KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY (DC/DRHO) AND RIGIDITY (DC/DMU) FOR CIT13F OCEANIC EARTH MODEL

VARIATIONS FOR 10 0/0 CHANGE IN PARAMETER
CIT13F OCEANIC

PSEUDO SPHERICAL CALCULATION

T(SECS)	412.00		380.15		348.98		318.19		287.45		256.41	
C(K/SEC)	5.600		5.500		5.400		5.300		5.200		5.100	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00024	0.00000	-0.00025	0.00001	-0.00026	0.00001	-0.00027	0.00001	-0.00028	0.00001	-0.00028	0.00001
2	-0.00129	0.00034	-0.00134	0.00037	-0.00139	0.00040	-0.00143	0.00042	-0.00147	0.00045	-0.00152	0.00049
3	-0.00368	0.00162	-0.00382	0.00174	-0.00395	0.00186	-0.00407	0.00199	-0.00420	0.00213	-0.00433	0.00228
4	-0.00755	0.00514	-0.00783	0.00551	-0.00809	0.00591	-0.00835	0.00633	-0.00860	0.00677	-0.00886	0.00725
5	-0.00418	0.00285	-0.00433	0.00306	-0.00447	0.00328	-0.00462	0.00351	-0.00476	0.00375	-0.00490	0.00402
6	-0.00417	0.00280	-0.00432	0.00300	-0.00446	0.00322	-0.00460	0.00344	-0.00474	0.00368	-0.00488	0.00394
7	-0.00830	0.00535	-0.00860	0.00574	-0.00888	0.00615	-0.00916	0.00658	-0.00943	0.00703	-0.00971	0.00753
8	-0.01645	0.01040	-0.01703	0.01116	-0.01759	0.01195	-0.01812	0.01277	-0.01864	0.01364	-0.01917	0.01458
9	-0.01620	0.01037	-0.01675	0.01111	-0.01728	0.01188	-0.01778	0.01268	-0.01826	0.01352	-0.01873	0.01442
10	-0.01584	0.01029	-0.01636	0.01101	-0.01684	0.01175	-0.01730	0.01252	-0.01772	0.01332	-0.01814	0.01415
11	-0.01545	0.01020	-0.01593	0.01090	-0.01637	0.01161	-0.01677	0.01234	-0.01713	0.01308	-0.01747	0.01385
12	-0.01500	0.01009	-0.01542	0.01075	-0.01581	0.01142	-0.01615	0.01210	-0.01644	0.01278	-0.01669	0.01348
13	-0.01450	0.01011	-0.01487	0.01075	-0.01520	0.01139	-0.01547	0.01202	-0.01569	0.01265	-0.01585	0.01326
14	-0.01399	0.01012	-0.01431	0.01073	-0.01457	0.01133	-0.01477	0.01191	-0.01491	0.01247	-0.01498	0.01300
15	-0.01343	0.01005	-0.01369	0.01062	-0.01389	0.01117	-0.01403	0.01169	-0.01409	0.01217	-0.01407	0.01261
16	-0.01285	0.00996	-0.01306	0.01048	-0.01319	0.01097	-0.01326	0.01143	-0.01324	0.01183	-0.01314	0.01216
17	-0.01228	0.00974	-0.01242	0.01021	-0.01249	0.01064	-0.01249	0.01102	-0.01240	0.01134	-0.01221	0.01156
18	-0.01166	0.00950	-0.01175	0.00991	-0.01176	0.01028	-0.01169	0.01059	-0.01153	0.01081	-0.01127	0.01094
19	-0.01104	0.00930	-0.01106	0.00966	-0.01101	0.00997	-0.01088	0.01020	-0.01066	0.01034	-0.01032	0.01036
20	-0.01042	0.00904	-0.01039	0.00935	-0.01028	0.00958	-0.01009	0.00974	-0.00980	0.00979	-0.00941	0.00972
21	-0.00976	0.00875	-0.00968	0.00900	-0.00952	0.00917	-0.00927	0.00925	-0.00893	0.00922	-0.00849	0.00905
22	-0.00913	0.00852	-0.00900	0.00871	-0.00879	0.00881	-0.00849	0.00882	-0.00811	0.00872	-0.00761	0.00846
23	-0.00849	0.00821	-0.00831	0.00835	-0.00805	0.00839	-0.00772	0.00833	-0.00729	0.00815	-0.00677	0.00781
24	-0.01522	0.01559	-0.01473	0.01569	-0.01410	0.01561	-0.01332	0.01530	-0.01238	0.01473	-0.01126	0.01386
25	-0.01580	0.01794	-0.01499	0.01779	-0.01403	0.01737	-0.01290	0.01667	-0.01163	0.01564	-0.01019	0.01424
26	-0.00272	0.00335	-0.00253	0.00328	-0.00232	0.00316	-0.00208	0.00298	-0.00182	0.00273	-0.00154	0.00242
27	-0.02404	0.03490	-0.02196	0.03329	-0.01967	0.03113	-0.01720	0.02841	-0.01458	0.02512	-0.01184	0.02130
28	-0.01649	0.02643	-0.01441	0.02413	-0.01226	0.02144	-0.01009	0.01841	-0.00794	0.01513	-0.00588	0.01169
29	-0.01093	0.01976	-0.00911	0.01720	-0.00733	0.01446	-0.00565	0.01163	-0.00410	0.00882	-0.00275	0.00617
30	-0.00712	0.01393	-0.00565	0.01154	-0.00429	0.00916	-0.00309	0.00688	-0.00206	0.00480	-0.00125	0.00303
31	-0.00444	0.00959	-0.00335	0.00755	-0.00239	0.00564	-0.00160	0.00394	-0.00098	0.00252	-0.00053	0.00142
32	-0.00480	0.01123	-0.00338	0.00824	-0.00224	0.00567	-0.00137	0.00360	-0.00075	0.00206	-0.00036	0.00101
33	-0.00174	0.00455	-0.00110	0.00299	-0.00064	0.00181	-0.00034	0.00098	-0.00015	0.00046	-0.00006	0.00018
34	-0.00058	0.00170	-0.00033	0.00099	-0.00017	0.00052	-0.00007	0.00024	-0.00003	0.00009	-0.00001	0.00003
35	-0.00018	0.00058	-0.00009	0.00030	-0.00004	0.00014	-0.00001	0.00005	-0.00000	0.00002	-0.00000	0.00000
36	-0.00004	0.00015	-0.00002	0.00007	-0.00001	0.00003	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000
37	-0.00001	0.00004	-0.00000	0.00002	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
38	-0.00001	0.00002	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
39	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
40	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
41	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
42	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
43	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
44	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
45	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
46	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

TABLE 7d

PHASE VELOCITY PERTURBATIONS (IN KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY (DC/DRHO) AND RIGIDITY (DC/DMU) FOR CIT13F OCEANIC EARTH MODEL

CIT 13F OCEANIC

T(SECS)	224.67		191.71		156.82		119.10		78.14		38.58	
C(K/SEC)	5.000		4.900		4.800		4.700		4.600		4.500	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00029	0.00001	-0.00031	0.00001	-0.00032	0.00001	-0.00035	0.00001	-0.00043	0.00001	-0.00070	0.00002
2	-0.00157	0.00052	-0.00163	0.00056	-0.00172	0.00062	-0.00189	0.00071	-0.00230	0.00090	-0.00369	0.00153
3	-0.00447	0.00245	-0.00464	0.00265	-0.00490	0.00292	-0.00536	0.00333	-0.00651	0.00423	-0.01025	0.00704
4	-0.00915	0.00779	-0.00950	0.00842	-0.01001	0.00924	-0.01094	0.01053	-0.01318	0.01326	-0.01998	0.02111
5	-0.00505	0.00431	-0.00525	0.00466	-0.00552	0.00511	-0.00602	0.00581	-0.00721	0.00727	-0.01061	0.01122
6	-0.00504	0.00423	-0.00522	0.00457	-0.00549	0.00501	-0.00598	0.00568	-0.00713	0.00708	-0.01032	0.01073
7	-0.01001	0.00807	-0.01037	0.00871	-0.01090	0.00953	-0.01184	0.01080	-0.01404	0.01337	-0.01981	0.01976
8	-0.01973	0.01561	-0.02042	0.01681	-0.02138	0.01834	-0.02309	0.02065	-0.02699	0.02521	-0.03614	0.03535
9	-0.01923	0.01539	-0.01982	0.01651	-0.02065	0.01791	-0.02206	0.01996	-0.02515	0.02377	-0.03083	0.03052
10	-0.01856	0.01505	-0.01903	0.01606	-0.01967	0.01729	-0.02074	0.01900	-0.02288	0.02191	-0.02513	0.02523
11	-0.01779	0.01466	-0.01814	0.01555	-0.01858	0.01657	-0.01925	0.01790	-0.02040	0.01983	-0.01962	0.02001
12	-0.01691	0.01418	-0.01711	0.01492	-0.01733	0.01572	-0.01760	0.01664	-0.01776	0.01756	-0.01455	0.01513
13	-0.01596	0.01387	-0.01601	0.01445	-0.01600	0.01502	-0.01587	0.01552	-0.01513	0.01549	-0.01023	0.01104
14	-0.01498	0.01349	-0.01488	0.01391	-0.01466	0.01424	-0.01416	0.01433	-0.01267	0.01341	-0.00690	0.00771
15	-0.01395	0.01297	-0.01372	0.01323	-0.01330	0.01332	-0.01249	0.01300	-0.01045	0.01137	-0.00449	0.00516
16	-0.01292	0.01240	-0.01256	0.01249	-0.01197	0.01235	-0.01091	0.01169	-0.00850	0.00950	-0.00285	0.00336
17	-0.01190	0.01167	-0.01143	0.01160	-0.01071	0.01125	-0.00946	0.01030	-0.00685	0.00776	-0.00177	0.00212
18	-0.01087	0.01092	-0.01031	0.01070	-0.00947	0.01016	-0.00810	0.00898	-0.00544	0.00626	-0.00108	0.00131
19	-0.00986	0.01023	-0.00921	0.00987	-0.00830	0.00917	-0.00686	0.00781	-0.00426	0.00502	-0.00065	0.00080
20	-0.00888	0.00947	-0.00818	0.00899	-0.00721	0.00816	-0.00575	0.00668	-0.00330	0.00395	-0.00038	0.00047
21	-0.00791	0.00871	-0.00717	0.00812	-0.00617	0.00718	-0.00474	0.00565	-0.00250	0.00305	-0.00022	0.00028
22	-0.00700	0.00802	-0.00623	0.00734	-0.00523	0.00632	-0.00386	0.00475	-0.00187	0.00235	-0.00012	0.00016
23	-0.00613	0.00729	-0.00535	0.00654	-0.00437	0.00547	-0.00308	0.00392	-0.00137	0.00176	-0.00007	0.00009
24	-0.00995	0.01263	-0.00841	0.01097	-0.00658	0.00876	-0.00434	0.00584	-0.00169	0.00227	-0.00006	0.00008
25	-0.00860	0.01245	-0.00684	0.01022	-0.00491	0.00752	-0.00283	0.00440	-0.00086	0.00132	-0.00002	0.00002
26	-0.00124	0.00205	-0.00093	0.00160	-0.00061	0.00110	-0.00030	0.00057	-0.00007	0.00013	-0.00000	0.00000
27	-0.00907	0.01699	-0.00633	0.01235	-0.00376	0.00761	-0.00159	0.00332	-0.00026	0.00056	-0.00000	0.00000
28	-0.00400	0.00828	-0.00237	0.00510	-0.00110	0.00245	-0.00031	0.00070	-0.00002	0.00005		
29	-0.00164	0.00384	-0.00081	0.00198	-0.00029	0.00073	-0.00005	0.00013	-0.00000	0.00000		
30	-0.00065	0.00164	-0.00027	0.00070	-0.00007	0.00020	-0.00001	0.00002				
31	-0.00024	0.00067	-0.00008	0.00024	-0.00002	0.00005	-0.00000	0.00000				
32	-0.00014	0.00040	-0.00004	0.00011	-0.00001	0.00002						
33	-0.00002	0.00005	-0.00000	0.00001	-0.00000	0.00000						
34	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000						
35	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000						

TABLE 8a

VARIATIONAL PARTIAL DERIVATIVES FOR GUTENBERG BIRCH II LAMINATED CRUST AND UPPER MANTLE CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II LAMINATED CRUST AND UPPER MANTLE

T(SECS)	84.00		78.73		73.70		68.94		64.49		60.37	
C(K/SEC)	4.510		4.490		4.470		4.450		4.430		4.410	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.00301	0.00015	-0.00321	0.00016	-0.00344	0.00017	-0.00370	0.00019	-0.00401	0.00020	-0.00437	0.00022
2	-0.00301	0.00015	-0.00321	0.00016	-0.00344	0.00017	-0.00370	0.00019	-0.00401	0.00020	-0.00436	0.00022
3	-0.00602	0.00030	-0.00641	0.00032	-0.00687	0.00034	-0.00740	0.00037	-0.00802	0.00041	-0.00872	0.00045
4	-0.00601	0.00030	-0.00640	0.00032	-0.00686	0.00034	-0.00739	0.00037	-0.00800	0.00041	-0.00870	0.00045
5	-0.00600	0.00030	-0.00639	0.00032	-0.00684	0.00034	-0.00737	0.00037	-0.00798	0.00041	-0.00868	0.00045
6	-0.00599	0.00030	-0.00637	0.00032	-0.00683	0.00034	-0.00735	0.00037	-0.00796	0.00041	-0.00866	0.00045
7	-0.01193	0.00059	-0.01270	0.00063	-0.01360	0.00068	-0.01464	0.00074	-0.01584	0.00081	-0.01722	0.00089
8	-0.01186	0.00059	-0.01262	0.00063	-0.01350	0.00068	-0.01452	0.00074	-0.01570	0.00081	-0.01705	0.00089
9	-0.02925	0.00146	-0.03107	0.00157	-0.03319	0.00170	-0.03564	0.00184	-0.03845	0.00201	-0.04165	0.00220
10	-0.02847	0.00145	-0.03016	0.00155	-0.03210	0.00167	-0.03434	0.00181	-0.03689	0.00197	-0.03976	0.00215
11	-0.02755	0.00141	-0.02908	0.00150	-0.03083	0.00162	-0.03282	0.00174	-0.03507	0.00189	-0.03757	0.00205
12	-0.02657	0.00138	-0.02793	0.00147	-0.02947	0.00157	-0.03120	0.00169	-0.03313	0.00182	-0.03526	0.00197
13	-0.02546	0.00135	-0.02663	0.00143	-0.02794	0.00152	-0.02939	0.00163	-0.03098	0.00175	-0.03269	0.00188
14	-0.01949	0.00105	-0.02028	0.00111	-0.02115	0.00118	-0.02209	0.00126	-0.02311	0.00134	-0.02417	0.00144
15	-0.00948	0.00049	-0.00983	0.00051	-0.01021	0.00054	-0.01062	0.00056	-0.01105	0.00060	-0.01149	0.00063
16	-0.02318	0.00119	-0.02398	0.00124	-0.02484	0.00130	-0.02575	0.00137	-0.02669	0.00144	-0.02764	0.00151
17	-0.02245	0.00115	-0.02314	0.00120	-0.02387	0.00126	-0.02463	0.00131	-0.02539	0.00137	-0.02613	0.00143
18	-0.02174	0.00112	-0.02233	0.00116	-0.02294	0.00121	-0.02355	0.00126	-0.02415	0.00131	-0.02470	0.00135
19	-0.02103	0.00109	-0.02153	0.00112	-0.02203	0.00116	-0.02251	0.00121	-0.02296	0.00124	-0.02335	0.00128
20	-0.02034	0.00105	-0.02075	0.00109	-0.02114	0.00112	-0.02151	0.00115	-0.02182	0.00119	-0.02206	0.00121

T(SECS)	56.60		53.17		50.07		47.28		44.78		42.52	
C(K/SEC)	4.390		4.370		4.350		4.330		4.310		4.290	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.00476	0.00025	-0.00521	0.00027	-0.00569	0.00030	-0.00621	0.00033	-0.00677	0.00036	-0.00734	0.00040
2	-0.00476	0.00025	-0.00520	0.00027	-0.00569	0.00030	-0.00621	0.00033	-0.00676	0.00036	-0.00734	0.00040
3	-0.00951	0.00049	-0.01040	0.00055	-0.01137	0.00060	-0.01241	0.00066	-0.01351	0.00073	-0.01465	0.00080
4	-0.00950	0.00049	-0.01038	0.00054	-0.01134	0.00060	-0.01238	0.00066	-0.01347	0.00073	-0.01461	0.00080
5	-0.00947	0.00049	-0.01035	0.00054	-0.01130	0.00060	-0.01233	0.00066	-0.01342	0.00073	-0.01455	0.00079
6	-0.00944	0.00049	-0.01031	0.00054	-0.01126	0.00060	-0.01228	0.00066	-0.01336	0.00072	-0.01448	0.00079
7	-0.01876	0.00098	-0.02048	0.00108	-0.02235	0.00119	-0.02436	0.00131	-0.02648	0.00144	-0.02869	0.00158
8	-0.01856	0.00098	-0.02024	0.00108	-0.02206	0.00118	-0.02402	0.00130	-0.02608	0.00143	-0.02821	0.00156
9	-0.04523	0.00241	-0.04918	0.00265	-0.05346	0.00292	-0.05803	0.00320	-0.06281	0.00351	-0.06774	0.00382
10	-0.04296	0.00236	-0.04644	0.00258	-0.05019	0.00283	-0.05414	0.00309	-0.05822	0.00337	-0.06239	0.00366
11	-0.04032	0.00223	-0.04329	0.00243	-0.04643	0.00264	-0.04968	0.00287	-0.05299	0.00311	-0.05630	0.00335
12	-0.03755	0.00213	-0.03999	0.00231	-0.04251	0.00250	-0.04508	0.00270	-0.04763	0.00290	-0.05011	0.00310
13	-0.03450	0.00203	-0.03638	0.00218	-0.03827	0.00234	-0.04012	0.00251	-0.04190	0.00267	-0.04354	0.00284
14	-0.02526	0.00154	-0.02634	0.00164	-0.02739	0.00175	-0.02837	0.00186	-0.02924	0.00197	-0.02998	0.00207
15	-0.01193	0.00066	-0.01236	0.00070	-0.01275	0.00073	-0.01310	0.00076	-0.01338	0.00079	-0.01360	0.00082
16	-0.02856	0.00158	-0.02942	0.00166	-0.03018	0.00173	-0.03081	0.00179	-0.03127	0.00185	-0.03155	0.00189
17	-0.02681	0.00149	-0.02741	0.00155	-0.02789	0.00160	-0.02822	0.00164	-0.02837	0.00168	-0.02833	0.00170
18	-0.02518	0.00140	-0.02555	0.00144	-0.02578	0.00148	-0.02585	0.00150	-0.02575	0.00152	-0.02546	0.00153
19	-0.02364	0.00132	-0.02381	0.00135	-0.02383	0.00137	-0.02369	0.00138	-0.02338	0.00138	-0.02289	0.00138
20	-0.02218	0.00124	-0.02218	0.00126	-0.02202	0.00127	-0.02171	0.00127	-0.02122	0.00126	-0.02058	0.00124

TABLE 8b

VARIATIONAL PARTIAL DERIVATIVES FOR GUTENBERG BIRCH II LAMINATED CRUST AND UPPER MANTLE CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II LAMINATED CRUST AND UPPER MANTLE

T(SECS)	40.47		38.62		36.92		35.36		33.91		32.57	
C(K/SEC)	4.270		4.250		4.230		4.210		4.190		4.170	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.00793	0.00044	-0.00853	0.00047	-0.00914	0.00051	-0.00974	0.00055	-0.01033	0.00059	-0.01091	0.00063
2	-0.00793	0.00043	-0.00853	0.00047	-0.00913	0.00051	-0.00973	0.00055	-0.01032	0.00059	-0.01090	0.00063
3	-0.01583	0.00087	-0.01703	0.00094	-0.01823	0.00102	-0.01943	0.00110	-0.02060	0.00117	-0.02176	0.00125
4	-0.01578	0.00087	-0.01697	0.00094	-0.01817	0.00102	-0.01936	0.00110	-0.02053	0.00117	-0.02168	0.00125
5	-0.01572	0.00087	-0.01690	0.00094	-0.01808	0.00102	-0.01926	0.00109	-0.02042	0.00117	-0.02156	0.00125
6	-0.01563	0.00086	-0.01680	0.00094	-0.01797	0.00101	-0.01914	0.00109	-0.02028	0.00116	-0.02140	0.00124
7	-0.03095	0.00172	-0.03324	0.00186	-0.03553	0.00201	-0.03780	0.00216	-0.04003	0.00231	-0.04222	0.00246
8	-0.03040	0.00170	-0.03260	0.00184	-0.03481	0.00199	-0.03699	0.00213	-0.03912	0.00228	-0.04120	0.00242
9	-0.07275	0.00415	-0.07778	0.00449	-0.08277	0.00483	-0.08767	0.00517	-0.09243	0.00551	-0.09703	0.00585
10	-0.06656	0.00396	-0.07068	0.00426	-0.07471	0.00456	-0.07859	0.00486	-0.08229	0.00516	-0.08580	0.00544
11	-0.05955	0.00359	-0.06269	0.00384	-0.06568	0.00407	-0.06847	0.00431	-0.07105	0.00453	-0.07341	0.00474
12	-0.05247	0.00330	-0.05468	0.00350	-0.05669	0.00369	-0.05849	0.00387	-0.06006	0.00403	-0.06138	0.00418
13	-0.04503	0.00300	-0.04632	0.00315	-0.04740	0.00329	-0.04826	0.00341	-0.04889	0.00352	-0.04928	0.00362
14	-0.03056	0.00217	-0.03099	0.00226	-0.03124	0.00234	-0.03132	0.00240	-0.03123	0.00246	-0.03097	0.00250
15	-0.01373	0.00084	-0.01378	0.00086	-0.01375	0.00087	-0.01364	0.00088	-0.01345	0.00088	-0.01318	0.00088
16	-0.03162	0.00193	-0.03150	0.00195	-0.03118	0.00197	-0.03067	0.00197	-0.02998	0.00196	-0.02914	0.00193
17	-0.02811	0.00172	-0.02769	0.00172	-0.02710	0.00171	-0.02634	0.00169	-0.02543	0.00166	-0.02440	0.00162
18	-0.02500	0.00153	-0.02436	0.00151	-0.02357	0.00149	-0.02264	0.00145	-0.02159	0.00141	-0.02045	0.00136

T(SECS)	31.31		30.12		28.99		27.91		26.88		25.89	
C(K/SEC)	4.150		4.130		4.110		4.090		4.070		4.050	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.01147	0.00067	-0.01202	0.00070	-0.01255	0.00074	-0.01306	0.00078	-0.01355	0.00082	-0.01402	0.00085
2	-0.01146	0.00067	-0.01201	0.00070	-0.01254	0.00074	-0.01305	0.00078	-0.01354	0.00082	-0.01400	0.00085
3	-0.02289	0.00133	-0.02398	0.00141	-0.02503	0.00148	-0.02604	0.00156	-0.02701	0.00163	-0.02794	0.00171
4	-0.02279	0.00133	-0.02388	0.00140	-0.02492	0.00148	-0.02592	0.00155	-0.02689	0.00163	-0.02781	0.00170
5	-0.02266	0.00132	-0.02373	0.00140	-0.02476	0.00147	-0.02575	0.00155	-0.02670	0.00162	-0.02761	0.00169
6	-0.02249	0.00132	-0.02355	0.00139	-0.02456	0.00147	-0.02553	0.00154	-0.02646	0.00161	-0.02735	0.00168
7	-0.04433	0.00261	-0.04638	0.00276	-0.04834	0.00290	-0.05022	0.00304	-0.05201	0.00318	-0.05371	0.00332
8	-0.04321	0.00257	-0.04515	0.00271	-0.04700	0.00285	-0.04876	0.00299	-0.05044	0.00312	-0.05202	0.00325
9	-0.10143	0.00618	-0.10563	0.00650	-0.10960	0.00681	-0.11334	0.00712	-0.11684	0.00741	-0.12010	0.00770
10	-0.08907	0.00572	-0.09211	0.00598	-0.09490	0.00624	-0.09744	0.00647	-0.09973	0.00670	-0.10176	0.00691
11	-0.07551	0.00494	-0.07736	0.00512	-0.07895	0.00529	-0.08029	0.00545	-0.08137	0.00558	-0.08221	0.00571
12	-0.06246	0.00432	-0.06329	0.00444	-0.06388	0.00454	-0.06423	0.00463	-0.06435	0.00470	-0.06425	0.00475
13	-0.04945	0.00370	-0.04940	0.00376	-0.04915	0.00381	-0.04869	0.00383	-0.04805	0.00384	-0.04724	0.00384
14	-0.03057	0.00253	-0.03002	0.00254	-0.02935	0.00254	-0.02856	0.00253	-0.02766	0.00251	-0.02667	0.00247
15	-0.01286	0.00087	-0.01247	0.00086	-0.01203	0.00084	-0.01155	0.00082	-0.01103	0.00080	-0.01048	0.00077
16	-0.02815	0.00190	-0.02705	0.00186	-0.02584	0.00180	-0.02455	0.00174	-0.02319	0.00168	-0.02178	0.00160
17	-0.02326	0.00157	-0.02204	0.00151	-0.02075	0.00145	-0.01942	0.00138	-0.01805	0.00130	-0.01668	0.00123

TABLE 8c

VARIATIONAL PARTIAL DERIVATIVES FOR GUTENBERG BIRCH II LAMINATED CRUST AND UPPER MANTLE CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II LAMINATED CRUST AND UPPER MANTLE

PSEUDO SPHERICAL CALCULATION

T(SECS)	23.53		21.30		19.14		17.00		14.83		12.56	
C(K/SEC)	4.000		3.950		3.900		3.850		3.800		3.750	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.01509	0.00094	-0.01605	0.00103	-0.01691	0.00111	-0.01772	0.00120	-0.01852	0.00128	-0.01944	0.00138
2	-0.01508	0.00094	-0.01604	0.00103	-0.01690	0.00111	-0.01770	0.00119	-0.01850	0.00128	-0.01941	0.00138
3	-0.03009	0.00188	-0.03199	0.00205	-0.03369	0.00222	-0.03528	0.00238	-0.03687	0.00256	-0.03867	0.00275
4	-0.02992	0.00188	-0.03180	0.00204	-0.03348	0.00221	-0.03503	0.00237	-0.03658	0.00254	-0.03832	0.00273
5	-0.02969	0.00187	-0.03153	0.00203	-0.03316	0.00219	-0.03467	0.00235	-0.03616	0.00252	-0.03783	0.00270
6	-0.02938	0.00185	-0.03117	0.00201	-0.03275	0.00217	-0.03420	0.00232	-0.03561	0.00248	-0.03718	0.00266
7	-0.05760	0.00365	-0.06097	0.00396	-0.06392	0.00426	-0.06658	0.00455	-0.06911	0.00484	-0.07187	0.00517
8	-0.05559	0.00356	-0.05863	0.00385	-0.06122	0.00412	-0.06347	0.00438	-0.06553	0.00463	-0.06765	0.00490
9	-0.12722	0.00836	-0.13294	0.00895	-0.13739	0.00948	-0.14076	0.00995	-0.14325	0.01036	-0.14514	0.01075
10	-0.10575	0.00737	-0.10825	0.00774	-0.10932	0.00801	-0.10904	0.00817	-0.10738	0.00823	-0.10415	0.00815
11	-0.08322	0.00594	-0.08277	0.00606	-0.08093	0.00607	-0.07770	0.00596	-0.07296	0.00572	-0.06633	0.00531
12	-0.06306	0.00480	-0.06067	0.00474	-0.05715	0.00457	-0.05257	0.00429	-0.04685	0.00390	-0.03976	0.00335
13	-0.04453	0.00375	-0.04099	0.00356	-0.03678	0.00329	-0.03200	0.00292	-0.02670	0.00248	-0.02085	0.00195
14	-0.02388	0.00233	-0.02077	0.00213	-0.01746	0.00187	-0.01408	0.00157	-0.01072	0.00123	-0.00746	0.00088
15	-0.00901	0.00069	-0.00748	0.00060	-0.00595	0.00050						
16	-0.01815	0.00139	-0.01453	0.00116	-0.01107	0.00092						
17	-0.01328	0.00102	-0.01007	0.00080	-0.00719	0.00060						
18	-0.00973	0.00074	-0.00699	0.00056	-0.00469	0.00039						
19	-0.00714	0.00055	-0.00487	0.00039	-0.00306	0.00025						
20	-0.00524	0.00040	-0.00339	0.00027	-0.00200	0.00017						
21	-0.00385	0.00029	-0.00236	0.00019	-0.00131	0.00011						
22	-0.00284	0.00022	-0.00165	0.00013	-0.00086	0.00007						
23	-0.00209	0.00016	-0.00115	0.00009	-0.00056	0.00005						
24	-0.00268	0.00021	-0.00138	0.00011	-0.00062	0.00005						
25	-0.00145	0.00011	-0.00067	0.00005	-0.00027	0.00002						
26	-0.00078	0.00006	-0.00033	0.00003	-0.00011	0.00001						
27	-0.00066	0.00005	-0.00024	0.00002	-0.00007	0.00001						
28	-0.00019	0.00001	-0.00006	0.00000	-0.00001	0.00000						
29	-0.00005	0.00000	-0.00001	0.00000	-0.00000	0.00000						
30	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000						
31	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000						

T(SECS)	10.15		7.50		4.52	
C(K/SEC)	3.700		3.650		3.600	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.02067	0.00151	-0.02269	0.00170	-0.02648	0.00204
2	-0.02064	0.00151	-0.02264	0.00170	-0.02641	0.00204
3	-0.04108	0.00300	-0.04503	0.00338	-0.05242	0.00405
4	-0.04066	0.00298	-0.04447	0.00334	-0.05151	0.00398
5	-0.04005	0.00294	-0.04364	0.00329	-0.05020	0.00388
6	-0.03925	0.00288	-0.04257	0.00321	-0.04850	0.00376
7	-0.07543	0.00556	-0.08103	0.00613	-0.09053	0.00703
8	-0.07027	0.00522	-0.07417	0.00565	-0.08001	0.00624
9	-0.14672	0.01112	-0.14795	0.01146	-0.14543	0.01150
10	-0.09864	0.00789	-0.08874	0.00725	-0.06791	0.00565
11	-0.05685	0.00465	-0.04235	0.00354	-0.01978	0.00171
12	-0.03077	0.00262	-0.01899	0.00163	-0.00527	0.00046
13	-0.01437	0.00135	-0.00732	0.00068	-0.00125	0.00011

TABLE 9a

PHASE VELOCITY PERTURBATIONS (KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY AND RIGIDITY FOR GUTENBERG BIRCH II LAMINATED CRUST AND UPPER MANTLE CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II LAMINATED CRUST AND UPPER MANTLE

T(SECS)	84.00		78.73		73.70		68.94		64.49		60.37	
C(K/SEC)	4.510		4.490		4.470		4.450		4.430		4.410	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00083	0.00051	-0.00088	0.00055	-0.00095	0.00060	-0.00102	0.00065	-0.00110	0.00071	-0.00120	0.00078
2	-0.00083	0.00051	-0.00088	0.00055	-0.00094	0.00060	-0.00102	0.00065	-0.00110	0.00071	-0.00120	0.00078
3	-0.00165	0.00103	-0.00176	0.00110	-0.00189	0.00119	-0.00204	0.00130	-0.00220	0.00142	-0.00240	0.00156
4	-0.00165	0.00103	-0.00176	0.00110	-0.00189	0.00119	-0.00203	0.00130	-0.00220	0.00142	-0.00239	0.00155
5	-0.00165	0.00102	-0.00176	0.00110	-0.00188	0.00119	-0.00203	0.00129	-0.00220	0.00141	-0.00239	0.00155
6	-0.00165	0.00102	-0.00175	0.00110	-0.00188	0.00119	-0.00202	0.00129	-0.00219	0.00141	-0.00238	0.00155
7	-0.00328	0.00204	-0.00349	0.00220	-0.00374	0.00237	-0.00403	0.00258	-0.00436	0.00282	-0.00473	0.00309
8	-0.00326	0.00204	-0.00347	0.00219	-0.00371	0.00237	-0.00399	0.00257	-0.00432	0.00281	-0.00469	0.00308
9	-0.00804	0.00507	-0.00855	0.00544	-0.00913	0.00588	-0.00980	0.00638	-0.01057	0.00696	-0.01145	0.00762
10	-0.00783	0.00502	-0.00829	0.00538	-0.00883	0.00579	-0.00944	0.00628	-0.01014	0.00683	-0.01094	0.00746
11	-0.00799	0.00590	-0.00843	0.00630	-0.00894	0.00676	-0.00952	0.00729	-0.01017	0.00790	-0.01090	0.00858
12	-0.00771	0.00578	-0.00810	0.00615	-0.00855	0.00659	-0.00905	0.00708	-0.00961	0.00763	-0.01022	0.00825
13	-0.00738	0.00564	-0.00772	0.00599	-0.00810	0.00638	-0.00852	0.00683	-0.00898	0.00733	-0.00948	0.00788
14	-0.00565	0.00440	-0.00588	0.00466	-0.00613	0.00495	-0.00641	0.00527	-0.00670	0.00563	-0.00701	0.00602
15	-0.00337	0.00364	-0.00350	0.00382	-0.00363	0.00401	-0.00378	0.00423	-0.00393	0.00446	-0.00409	0.00471
16	-0.00825	0.00890	-0.00854	0.00932	-0.00884	0.00977	-0.00917	0.01026	-0.00950	0.01078	-0.00984	0.01132
17	-0.00796	0.00850	-0.00820	0.00887	-0.00846	0.00926	-0.00873	0.00967	-0.00900	0.01010	-0.00926	0.01054
18	-0.00767	0.00816	-0.00788	0.00848	-0.00810	0.00881	-0.00831	0.00916	-0.00852	0.00952	-0.00872	0.00987
19	-0.00739	0.00780	-0.00757	0.00808	-0.00774	0.00836	-0.00791	0.00865	-0.00807	0.00894	-0.00821	0.00921
20	-0.00713	0.00749	-0.00727	0.00773	-0.00741	0.00797	-0.00754	0.00821	-0.00765	0.00843	-0.00773	0.00864

T(SECS)	56.60		53.17		50.07		47.28		44.78		42.52	
C(K/SEC)	4.390		4.370		4.350		4.330		4.310		4.290	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00131	0.00086	-0.00143	0.00095	-0.00157	0.00104	-0.00171	0.00115	-0.00186	0.00126	-0.00202	0.00138
2	-0.00131	0.00086	-0.00143	0.00094	-0.00156	0.00104	-0.00171	0.00115	-0.00186	0.00126	-0.00202	0.00138
3	-0.00262	0.00171	-0.00286	0.00189	-0.00313	0.00208	-0.00341	0.00230	-0.00371	0.00252	-0.00403	0.00276
4	-0.00261	0.00171	-0.00285	0.00189	-0.00312	0.00208	-0.00340	0.00229	-0.00370	0.00252	-0.00402	0.00276
5	-0.00260	0.00171	-0.00285	0.00188	-0.00311	0.00208	-0.00339	0.00229	-0.00369	0.00251	-0.00400	0.00275
6	-0.00260	0.00171	-0.00283	0.00188	-0.00310	0.00207	-0.00338	0.00228	-0.00367	0.00251	-0.00398	0.00275
7	-0.00516	0.00340	-0.00563	0.00375	-0.00615	0.00413	-0.00670	0.00455	-0.00728	0.00499	-0.00789	0.00546
8	-0.00510	0.00339	-0.00556	0.00373	-0.00607	0.00411	-0.00660	0.00452	-0.00717	0.00495	-0.00776	0.00541
9	-0.01244	0.00836	-0.01352	0.00920	-0.01470	0.01011	-0.01596	0.01110	-0.01727	0.01215	-0.01863	0.01325
10	-0.01181	0.00817	-0.01277	0.00895	-0.01380	0.00981	-0.01489	0.01072	-0.01601	0.01169	-0.01716	0.01270
11	-0.01169	0.00934	-0.01255	0.01017	-0.01346	0.01107	-0.01441	0.01202	-0.01537	0.01301	-0.01633	0.01402
12	-0.01089	0.00893	-0.01160	0.00968	-0.01233	0.01047	-0.01307	0.01129	-0.01381	0.01214	-0.01453	0.01299
13	-0.01001	0.00849	-0.01055	0.00913	-0.01110	0.00980	-0.01164	0.01050	-0.01215	0.01120	-0.01263	0.01188
14	-0.00732	0.00644	-0.00764	0.00688	-0.00794	0.00734	-0.00823	0.00780	-0.00848	0.00825	-0.00869	0.00869
15	-0.00425	0.00496	-0.00440	0.00521	-0.00454	0.00547	-0.00466	0.00571	-0.00476	0.00593	-0.00484	0.00612
16	-0.01017	0.01186	-0.01047	0.01241	-0.01074	0.01292	-0.01097	0.01340	-0.01113	0.01382	-0.01123	0.01418
17	-0.00950	0.01097	-0.00971	0.01138	-0.00988	0.01176	-0.01000	0.01208	-0.01005	0.01234	-0.01004	0.01253
18	-0.00889	0.01020	-0.00902	0.01050	-0.00910	0.01076	-0.00913	0.01096	-0.00909	0.01109	-0.00899	0.01114
19	-0.00831	0.00946	-0.00837	0.00966	-0.00838	0.00982	-0.00833	0.00991	-0.00822	0.00993	-0.00805	0.00988
20	-0.00777	0.00881	-0.00777	0.00893	-0.00772	0.00900	-0.00761	0.00901	-0.00744	0.00894	-0.00721	0.00881

TABLE 9b

PHASE VELOCITY PERTURBATIONS (KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY AND RIGIDITY FOR GUTENBERG BIRCH II LAMINATED CRUST AND UPPER MANTLE CONTINENTAL EARTH MODEL

GUTENBERG BIRCH II LAMINATED CRUST AND UPPER MANTLE

T(SECS)	40.47		38.62		36.92		35.36		33.91		32.57	
C(K/SEC)	4.270		4.250		4.230		4.210		4.190		4.170	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00218	0.00151	-0.00235	0.00164	-0.00251	0.00177	-0.00268	0.00190	-0.00284	0.00204	-0.00300	0.00217
2	-0.00218	0.00151	-0.00234	0.00164	-0.00251	0.00177	-0.00268	0.00190	-0.00284	0.00204	-0.00300	0.00217
3	-0.00435	0.00301	-0.00468	0.00327	-0.00501	0.00353	-0.00534	0.00380	-0.00567	0.00407	-0.00598	0.00434
4	-0.00434	0.00301	-0.00467	0.00327	-0.00500	0.00353	-0.00532	0.00379	-0.00564	0.00406	-0.00596	0.00433
5	-0.00432	0.00300	-0.00465	0.00326	-0.00497	0.00352	-0.00530	0.00378	-0.00562	0.00405	-0.00593	0.00432
6	-0.00430	0.00299	-0.00462	0.00325	-0.00494	0.00351	-0.00526	0.00377	-0.00558	0.00403	-0.00589	0.00430
7	-0.00851	0.00595	-0.00914	0.00645	-0.00977	0.00697	-0.01040	0.00749	-0.01101	0.00801	-0.01161	0.00853
8	-0.00836	0.00589	-0.00897	0.00639	-0.00957	0.00689	-0.01017	0.00739	-0.01076	0.00790	-0.01133	0.00840
9	-0.02001	0.01439	-0.02139	0.01556	-0.02276	0.01674	-0.02411	0.01792	-0.02542	0.01910	-0.02668	0.02026
10	-0.01830	0.01373	-0.01944	0.01478	-0.02054	0.01582	-0.02161	0.01686	-0.02263	0.01787	-0.02359	0.01886
11	-0.01727	0.01505	-0.01818	0.01606	-0.01905	0.01706	-0.01986	0.01803	-0.02061	0.01896	-0.02129	0.01985
12	-0.01522	0.01383	-0.01586	0.01465	-0.01644	0.01544	-0.01696	0.01619	-0.01742	0.01688	-0.01780	0.01752
13	-0.01306	0.01255	-0.01343	0.01318	-0.01375	0.01376	-0.01400	0.01429	-0.01418	0.01475	-0.01429	0.01515
14	-0.00886	0.00909	-0.00899	0.00946	-0.00906	0.00979	-0.00908	0.01007	-0.00906	0.01029	-0.00898	0.01047
15	-0.00489	0.00629	-0.00491	0.00642	-0.00489	0.00651	-0.00485	0.00657	-0.00479	0.00659	-0.00469	0.00658
16	-0.01126	0.01445	-0.01121	0.01464	-0.01110	0.01473	-0.01092	0.01474	-0.01067	0.01466	-0.01037	0.01449
17	-0.00996	0.01264	-0.00981	0.01266	-0.00960	0.01260	-0.00933	0.01245	-0.00901	0.01223	-0.00864	0.01193
18	-0.00882	0.01111	-0.00860	0.01101	-0.00832	0.01083	-0.00799	0.01058	-0.00762	0.01026	-0.00722	0.00988
19	-0.00782	0.00976	-0.00754	0.00956	-0.00721	0.00930	-0.00685	0.00898	-0.00645	0.00860	-0.00603	0.00818
20	-0.00694	0.00861	-0.00662	0.00834	-0.00626	0.00802	-0.00587	0.00765	-0.00547	0.00724	-0.00505	0.00680

T(SECS)	31.31		30.12		28.99		27.91		26.88		25.89	
C(K/SEC)	4.150		4.130		4.110		4.090		4.070		4.050	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00315	0.00231	-0.00331	0.00244	-0.00345	0.00258	-0.00359	0.00271	-0.00373	0.00283	-0.00385	0.00296
2	-0.00315	0.00231	-0.00330	0.00244	-0.00345	0.00257	-0.00359	0.00270	-0.00372	0.00283	-0.00385	0.00296
3	-0.00629	0.00461	-0.00659	0.00488	-0.00688	0.00514	-0.00716	0.00540	-0.00743	0.00566	-0.00768	0.00591
4	-0.00627	0.00460	-0.00657	0.00486	-0.00685	0.00513	-0.00713	0.00539	-0.00739	0.00564	-0.00765	0.00589
5	-0.00623	0.00458	-0.00653	0.00485	-0.00681	0.00511	-0.00708	0.00536	-0.00734	0.00562	-0.00759	0.00586
6	-0.00619	0.00456	-0.00648	0.00482	-0.00675	0.00508	-0.00702	0.00533	-0.00728	0.00558	-0.00752	0.00583
7	-0.01219	0.00904	-0.01275	0.00955	-0.01329	0.01005	-0.01381	0.01055	-0.01430	0.01103	-0.01477	0.01151
8	-0.01188	0.00890	-0.01242	0.00939	-0.01292	0.00987	-0.01341	0.01035	-0.01387	0.01081	-0.01431	0.01126
9	-0.02789	0.02141	-0.02905	0.02253	-0.03014	0.02362	-0.03117	0.02467	-0.03213	0.02570	-0.03303	0.02668
10	-0.02449	0.01982	-0.02533	0.02073	-0.02610	0.02161	-0.02680	0.02244	-0.02743	0.02322	-0.02798	0.02395
11	-0.02190	0.02068	-0.02243	0.02145	-0.02290	0.02216	-0.02328	0.02281	-0.02360	0.02338	-0.02384	0.02389
12	-0.01811	0.01808	-0.01836	0.01859	-0.01853	0.01902	-0.01863	0.01938	-0.01866	0.01967	-0.01863	0.01988
13	-0.01434	0.01549	-0.01433	0.01575	-0.01425	0.01594	-0.01412	0.01605	-0.01393	0.01610	-0.01370	0.01607
14	-0.00886	0.01058	-0.00871	0.01065	-0.00851	0.01065	-0.00828	0.01060	-0.00802	0.01050	-0.00774	0.01035
15	-0.00458	0.00652	-0.00444	0.00644	-0.00428	0.00632	-0.00411	0.00617	-0.00393	0.00599	-0.00373	0.00579
16	-0.01002	0.01424	-0.00963	0.01391	-0.00920	0.01352	-0.00874	0.01306	-0.00826	0.01255	-0.00775	0.01199
17	-0.00824	0.01157	-0.00781	0.01115	-0.00735	0.01067	-0.00688	0.01016	-0.00640	0.00961	-0.00591	0.00903
18	-0.00679	0.00946	-0.00635	0.00899	-0.00589	0.00848	-0.00543	0.00795	-0.00497	0.00740	-0.00451	0.00684
19	-0.00560	0.00772	-0.00516	0.00724	-0.00472	0.00673	-0.00429	0.00622	-0.00386	0.00570	-0.00345	0.00518
20	-0.00463	0.00634	-0.00421	0.00586	-0.00379	0.00537	-0.00339	0.00489	-0.00301	0.00441	-0.00264	0.00394

TABLE 9c

Phase Velocity Perturbations (km/sec) Resulting from a 10% Change in Density and Rigidity for Gutenberg Birch II Laminated Crust and Upper Mantle Continental Earth Model

VARIATIONS FOR 10 0/0 CHANGE IN PARAMETER
GUTENBERG BIRCH II LAMINATED CRUST AND UPPER MANTLE

PSEUDO SPHERICAL CALCULATION

T(SECS)	23.53		21.30		19.14		17.00		14.83		12.56	
C(K/SEC)	4.000		3.950		3.900		3.850		3.800		3.750	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00415	0.00327	-0.00441	0.00357	-0.00465	0.00385	-0.00487	0.00414	-0.00509	0.00445	-0.00534	0.00479
2	-0.00415	0.00327	-0.00441	0.00356	-0.00465	0.00385	-0.00487	0.00414	-0.00509	0.00444	-0.00534	0.00479
3	-0.00827	0.00652	-0.00880	0.00711	-0.00927	0.00769	-0.00970	0.00826	-0.01014	0.00886	-0.01063	0.00954
4	-0.00823	0.00650	-0.00874	0.00708	-0.00921	0.00765	-0.00963	0.00821	-0.01006	0.00880	-0.01054	0.00947
5	-0.00816	0.00646	-0.00867	0.00704	-0.00912	0.00759	-0.00953	0.00814	-0.00994	0.00872	-0.01040	0.00936
6	-0.00808	0.00642	-0.00857	0.00698	-0.00901	0.00752	-0.00940	0.00805	-0.00979	0.00861	-0.01023	0.00922
7	-0.01584	0.01265	-0.01677	0.01373	-0.01758	0.01476	-0.01831	0.01576	-0.01901	0.01678	-0.01976	0.01790
8	-0.01529	0.01233	-0.01612	0.01333	-0.01684	0.01427	-0.01745	0.01517	-0.01802	0.01605	-0.01860	0.01699
9	-0.03499	0.02898	-0.03656	0.03103	-0.03778	0.03285	-0.03871	0.03447	-0.03939	0.03591	-0.03991	0.03724
10	-0.02908	0.02555	-0.02977	0.02682	-0.03006	0.02774	-0.02999	0.02832	-0.02953	0.02851	-0.02864	0.02826
11	-0.02413	0.02486	-0.02400	0.02537	-0.02347	0.02542	-0.02253	0.02497	-0.02116	0.02397	-0.01924	0.02225
12	-0.01829	0.02010	-0.01759	0.01985	-0.01657	0.01915	-0.01524	0.01798	-0.01359	0.01631	-0.01153	0.01404
13	-0.01291	0.01570	-0.01189	0.01492	-0.01067	0.01376	-0.00928	0.01224	-0.00774	0.01038	-0.00605	0.00818
14	-0.00693	0.00977	-0.00602	0.00891	-0.00506	0.00783	-0.00408	0.00657	-0.00311	0.00517	-0.00216	0.00368
15	-0.00321	0.00520	-0.00266	0.00450	-0.00212	0.00374	-0.00160	0.00294	-0.00111	0.00214	-0.00069	0.00137
16	-0.00646	0.01043	-0.00517	0.00870	-0.00394	0.00691	-0.00281	0.00515	-0.00183	0.00350	-0.00103	0.00205
17	-0.00470	0.00750	-0.00357	0.00593	-0.00255	0.00442	-0.00168	0.00304	-0.00099	0.00186	-0.00048	0.00094
18	-0.00343	0.00542	-0.00247	0.00406	-0.00165	0.00284	-0.00101	0.00180	-0.00053	0.00099	-0.00022	0.00044
19	-0.00251	0.00392	-0.00171	0.00279	-0.00108	0.00183	-0.00060	0.00107	-0.00029	0.00053	-0.00010	0.00020
20	-0.00184	0.00285	-0.00119	0.00192	-0.00070	0.00118	-0.00036	0.00064	-0.00016	0.00029	-0.00005	0.00009
21	-0.00135	0.00208	-0.00083	0.00133	-0.00046	0.00077	-0.00022	0.00038	-0.00009	0.00016	-0.00002	0.00004
22	-0.00099	0.00152	-0.00058	0.00092	-0.00030	0.00050	-0.00013	0.00023	-0.00005	0.00008	-0.00001	0.00002
23	-0.00073	0.00111	-0.00040	0.00064	-0.00020	0.00032	-0.00008	0.00014	-0.00003	0.00005	-0.00001	0.00001
24	-0.00094	0.00141	-0.00048	0.00076	-0.00021							
25	-0.00051	0.00076	-0.00023	0.00037	-0.00009							
26	-0.00027	0.00041	-0.00011	0.00018	-0.00004							
27	-0.00023	0.00035	-0.00008	0.00013	-0.00002							
28	-0.00007	0.00010	-0.00002	0.00003	-0.00000							
29	-0.00002	0.00003	-0.00000	0.00001	-0.00000							
30	-0.00000	0.00001	-0.00000	0.00000	-0.00000							
31	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
32	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
33	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
34	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
35	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
36	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
37	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
38	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
39	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
40	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
41	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
42	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
43	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
44	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
45	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
46	-0.00000	0.00000	-0.00000	0.00000	-0.00000							
47	-0.00000	0.00000	-0.00000	0.00000	-0.00000							

T(SECS)	10.15		7.50		4.52	
C(K/SEC	3.700		3.650		3.600	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00568	0.00523	-0.00624	0.00590	-0.00728	0.00708
2	-0.00567	0.00523	-0.00623	0.00589	-0.00726	0.00707
3	-0.01130	0.01041	-0.01238	0.01172	-0.01442	0.01403
4	-0.01118	0.01031	-0.01223	0.01159	-0.01417	0.01380
5	-0.01101	0.01018	-0.01200	0.01139	-0.01380	0.01346
6	-0.01079	0.00999	-0.01171	0.01113	-0.01334	0.01302
7	-0.02074	0.01928	-0.02228	0.02125	-0.02490	0.02436
8	-0.01932	0.01809	-0.02040	0.01958	-0.02200	0.02163
9	-0.04035	0.03852	-0.04069	0.03973	-0.03999	0.03985
10	-0.02713	0.02733	-0.02440	0.02511	-0.01868	0.01957
11	-0.01649	0.01946	-0.01228	0.01483	-0.00574	0.00715
12	-0.00892	0.01098	-0.00551	0.00684	-0.00153	0.00192
13	-0.00417	0.00563	-0.00212	0.00283	-0.00036	0.00047
14	-0.00127	0.00218	-0.00051	0.00085	-0.00005	0.00008
15	-0.00034	0.00071	-0.00010	0.00021	-0.00001	0.00001
16	-0.00044	0.00091	-0.00010	0.00022	-0.00000	0.00001
17	-0.00016	0.00033	-0.00002	0.00005	-0.00000	0.00000
18	-0.00006	0.00012	-0.00001	0.00001	-0.00000	0.00000
19	-0.00002	0.00005	-0.00000	0.00000	-0.00000	0.00000

particular problem by modifying the trial structures and comparing the "predicted" results with those computed or published elsewhere. All published theoretical Love wave dispersion curves should be reproducible from the tables given here.

TABLE 10a

VARIATIONAL PARTIAL DERIVATIVES FOR CIT13F LAMINATED CRUST AND UPPER MANTLE OCEANIC EARTH MODEL

CIT13F OCEANIC LAMINATED CRUST AND UPPER MANTLE

PSEUDO SPHERICAL CALCULATION

T(SECS)	119.11		98.96		78.15		57.53		38.61		23.42	
C(K/SEC)	4.700		4.650		4.600		4.550		4.500		4.450	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.00037	0.00002	-0.00040	0.00002	-0.00045	0.00002	-0.00055	0.00003	-0.00074	0.00004	-0.00126	0.00006
2	-0.00074	0.00003	-0.00081	0.00004	-0.00091	0.00004	-0.00110	0.00005	-0.00148	0.00008	-0.00251	0.00014
3	-0.00074	0.00003	-0.00080	0.00004	-0.00091	0.00005	-0.00110	0.00006	-0.00147	0.00009	-0.00248	0.00019
4	-0.00186	0.00008	-0.00201	0.00009	-0.00227	0.00011	-0.00273	0.00013	-0.00366	0.00018	-0.00612	0.00031
5	-0.00186	0.00008	-0.00201	0.00009	-0.00227	0.00011	-0.00273	0.00013	-0.00365	0.00018	-0.00608	0.00031
6	-0.00371	0.00017	-0.00401	0.00019	-0.00452	0.00021	-0.00545	0.00026	-0.00725	0.00036	-0.01199	0.00063
7	-0.00371	0.00017	-0.00401	0.00019	-0.00451	0.00021	-0.00543	0.00026	-0.00720	0.00036	-0.01175	0.00060
8	-0.00740	0.00034	-0.00799	0.00037	-0.00899	0.00043	-0.01079	0.00052	-0.01423	0.00071	-0.02284	0.00119
9	-0.00738	0.00034	-0.00796	0.00037	-0.00894	0.00043	-0.01069	0.00052	-0.01396	0.00071	-0.02172	0.00116
10	-0.00736	0.00033	-0.00793	0.00037	-0.00889	0.00042	-0.01059	0.00051	-0.01370	0.00068	-0.02069	0.00107
11	-0.00733	0.00033	-0.00790	0.00037	-0.00885	0.00042	-0.01051	0.00051	-0.01351	0.00067	-0.01996	0.00103
12	-0.00731	0.00033	-0.00787	0.00037	-0.00881	0.00042	-0.01044	0.00051	-0.01333	0.00067	-0.01928	0.00100
13	-0.00729	0.00033	-0.00785	0.00037	-0.00877	0.00042	-0.01036	0.00050	-0.01315	0.00066	-0.01865	0.00096
14	-0.00364	0.00017	-0.00391	0.00018	-0.00437	0.00021	-0.00515	0.00025	-0.00651	0.00033	-0.00910	0.00047
15	-0.01812	0.00083	-0.01947	0.00091	-0.02170	0.00103	-0.02552	0.00124	-0.03197	0.00160	-0.04355	0.00224
16	-0.01798	0.00082	-0.01929	0.00090	-0.02145	0.00102	-0.02510	0.00123	-0.03105	0.00155	-0.04067	0.00209
17	-0.01783	0.00082	-0.01910	0.00089	-0.02119	0.00101	-0.02467	0.00121	-0.03017	0.00151	-0.03819	0.00196
18	-0.01767	0.00081	-0.01890	0.00089	-0.02091	0.00100	-0.02422	0.00119	-0.02929	0.00147	-0.03588	0.00185
19	-0.01749	0.00081	-0.01869	0.00088	-0.02061	0.00099	-0.02375	0.00117	-0.02839	0.00143	-0.03369	0.00174
20	-0.01731	0.00080	-0.01845	0.00087	-0.02029	0.00098	-0.02324	0.00115	-0.02744	0.00138	-0.03152	0.00163
21	-0.01711	0.00079	-0.01820	0.00086	-0.01995	0.00096	-0.02271	0.00112	-0.02645	0.00134	-0.02936	0.00153
22	-0.01689	0.00078	-0.01794	0.00085	-0.01958	0.00095	-0.02214	0.00110	-0.02543	0.00129	-0.02725	0.00142
23	-0.03314	0.00154	-0.03506	0.00167	-0.03805	0.00185	-0.04253	0.00212	-0.04777	0.00244	-0.04848	0.00254
24	-0.03216	0.00151	-0.03384	0.00162	-0.03639	0.00178	-0.04001	0.00201	-0.04347	0.00223	-0.04083	0.00215
25	-0.03111	0.00147	-0.03253	0.00157	-0.03462	0.00171	-0.03737	0.00189	-0.03914	0.00202	-0.03385	0.00179
26	-0.02998	0.00142	-0.03114	0.00151	-0.03277	0.00163	-0.03464	0.00176	-0.03485	0.00181	-0.02760	0.00147
27	-0.05650	0.00271	-0.05800	0.00285	-0.05987	0.00301	-0.06114	0.00314	-0.05758	0.00303	-0.03974	0.00215

T(SECS)	15.56		12.55		11.00		9.98		9.23		8.63	
C(K/SEC)	4.400		4.350		4.300		4.250		4.200		4.150	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.00276	0.00015	-0.00497	0.00027	-0.00730	0.00041	-0.00962	0.00056	-0.01191	0.00072	-0.01419	0.00088
2	-0.00546	0.00037	-0.00978	0.00076	-0.01432	0.00124	-0.01877	0.00178	-0.02315	0.00239	-0.02749	0.00306
3	-0.00530	0.00060	-0.00934	0.00140	-0.01348	0.00245	-0.01745	0.00370	-0.02125	0.00514	-0.02492	0.00677
4	-0.01290	0.00067	-0.02242	0.00121	-0.03194	0.00177	-0.04086	0.00233	-0.04918	0.00288	-0.05699	0.00343
5	-0.01273	0.00068	-0.02197	0.00121	-0.03111	0.00178	-0.03958	0.00234	-0.04740	0.00289	-0.05464	0.00344
6	-0.02467	0.00137	-0.04189	0.00246	-0.05849	0.00360	-0.07347	0.00473	-0.08692	0.00584	-0.09901	0.00692
7	-0.02360	0.00127	-0.03912	0.00219	-0.05351	0.00311	-0.06597	0.00398	-0.07667	0.00478	-0.08582	0.00554
8	-0.04424	0.00245	-0.07087	0.00414	-0.09415	0.00577	-0.11308	0.00724	-0.12822	0.00855	-0.14015	0.00971
9	-0.03948	0.00230	-0.05940	0.00376	-0.07479	0.00509	-0.08557	0.00620	-0.09268	0.00711	-0.09689	0.00784
10	-0.03530	0.00192	-0.04979	0.00286	-0.05918	0.00356	-0.06418	0.00405	-0.06600	0.00435	-0.06554	0.00451
11	-0.03248	0.00176	-0.04360	0.00249	-0.04957	0.00298	-0.05156	0.00324	-0.05091	0.00335	-0.04855	0.00333
12	-0.02996	0.00162	-0.03830	0.00218	-0.04164	0.00249	-0.04152	0.00261	-0.03935	0.00258	-0.03603	0.00247
13	-0.02772	0.00150	-0.03376	0.00192	-0.03510	0.00209	-0.03355	0.00210	-0.03051	0.00200	-0.02681	0.00183
14	-0.01309	0.00071	-0.01538	0.00087	-0.01546	0.00092	-0.01431	0.00089	-0.01261	0.00082	-0.01073	0.00073
15	-0.05902	0.00317	-0.06484	0.00365	-0.06125	0.00361	-0.05345	0.00330	-0.04448	0.00288	-0.03578	0.00242
16	-0.05026	0.00268	-0.04950	0.00276	-0.04208	0.00245	-0.03315	0.00202	-0.02492	0.00159	-0.01810	0.00120
17	-0.04343	0.00232	-0.03863	0.00215	-0.02969	0.00173	-0.02119	0.00129	-0.01443	0.00092	-0.00949	0.00063
18	-0.03770	0.00201	-0.03038	0.00169	-0.02116	0.00123	-0.01369	0.00083	-0.00845	0.00053	-0.00503	0.00033
19	-0.03283	0.00175	-0.02405	0.00134	-0.01522	0.00088	-0.00895	0.00054	-0.00502	0.00032	-0.00271	0.00018
20	-0.02846	0.00153	-0.01896	0.00106	-0.01090	0.00063	-0.00582	0.00035	-0.00297	0.00019	-0.00145	0.00010
21	-0.02456	0.00132	-0.01488	0.00083	-0.00777	0.00045	-0.00377	0.00023	-0.00175	0.00011	-0.00077	0.00005
22	-0.02110	0.00114	-0.01162	0.00065	-0.00551	0.00032	-0.00243	0.00015	-0.00102	0.00007	-0.00041	0.00003
23	-0.03350	0.00181	-0.01610	0.00091	-0.00667	0.00039	-0.00258	0.00016	-0.00095	0.00006	-0.00033	0.00002
24	-0.02412	0.00131	-0.00960	0.00054	-0.00329	0.00019	-0.00105	0.00006	-0.00032	0.00002	-0.00009	0.00001
25	-0.01706	0.00093	-0.00563	0.00032	-0.00159	0.00009	-0.00042	0.00003	-0.00011	0.00001	-0.00003	0.00000
26	-0.01183	0.00065	-0.00324	0.00019	-0.00076	0.00005	-0.00017	0.00001	-0.00003	0.00000	-0.00001	0.00000
27	-0.01351	0.00075	-0.00287	0.00017	-0.00053	0.00003	-0.00009	0.00001	-0.00001	0.00000	-0.00000	0.00000

As an early test of the method the dispersion and partials were computed for a Jeffreys-Bullen type mantle. These results were used to predict the dispersion when the layer parameters were modified in such a way as to approximate a Gutenberg-Bullen type mantle. The actual dispersion for a Gutenberg-Bullen model was then computed. Since the partial derivative tables are routine computer output in the

TABLE 10b

VARIATIONAL PARTIAL DERIVATIVES FOR CIT13F LAMINATED CRUST AND UPPER MANTLE OCEANIC EARTH MODEL

CIT 13F OCEANIC LAMINATED CRUST AND UPPER MANTLE

T(SECS)	8.12		7.68		7.29		6.94		6.62		6.32	
C(K/SEC)	4.100		4.050		4.000		3.950		3.900		3.850	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.01650	0.00106	-0.01885	0.00124	-0.02127	0.00145	-0.02379	0.00167	-0.02644	0.00192	-0.02925	0.00219
2	-0.03183	0.00380	-0.03622	0.00463	-0.04069	0.00557	-0.04529	0.00662	-0.05008	0.00782	-0.05512	0.00919
3	-0.02848	0.00863	-0.03198	0.01073	-0.03543	0.01312	-0.03886	0.01583	-0.04231	0.01894	-0.04579	0.02250
4	-0.06436	0.00398	-0.07135	0.00454	-0.07800	0.00511	-0.08434	0.00569	-0.09041	0.00628	-0.09624	0.00688
5	-0.06138	0.00399	-0.06768	0.00454	-0.07357	0.00509	-0.07908	0.00564	-0.08425	0.00621	-0.08908	0.00678
6	-0.10991	0.00799	-0.11973	0.00905	-0.12853	0.01009	-0.13639	0.01112	-0.14334	0.01214	-0.14942	0.01314
7	-0.09360	0.00624	-0.10016	0.00690	-0.10556	0.00751	-0.10988	0.00807	-0.11317	0.00859	-0.11549	0.00905
8	-0.14931	0.01074	-0.15605	0.01163	-0.16060	0.01239	-0.16317	0.01302	-0.16393	0.01352	-0.16302	0.01389
9	-0.09880	0.00841	-0.09885	0.00882	-0.09735	0.00909	-0.09459	0.00922	-0.09081	0.00923	-0.08620	0.00912
10	-0.06346	0.00455	-0.06023	0.00450	-0.05619	0.00437	-0.05162	0.00419	-0.04676	0.00395	-0.04178	0.00367
11	-0.04512	0.00323	-0.04106	0.00307	-0.03668	0.00286	-0.03222	0.00261	-0.02785	0.00235	-0.02369	0.00208
12	-0.03213	0.00230	-0.02803	0.00209	-0.02397	0.00186	-0.02013	0.00163	-0.01659	0.00140	-0.01343	0.00118
13	-0.02293	0.00164	-0.01917	0.00143	-0.01569	0.00122	-0.01259	0.00102	-0.00990	0.00083	-0.00762	0.00067
14	-0.00889	0.00063	-0.00719	0.00053	-0.00568	0.00044	-0.00440	0.00036	-0.00333	0.00028	-0.00247	0.00022
15	-0.02801	0.00198	-0.02140	0.00158	-0.01597	0.00123	-0.01165	0.00093	-0.00831	0.00069	-0.00578	0.00050
16	-0.01277	0.00089	-0.00877	0.00064	-0.00586	0.00044	-0.00381	0.00030	-0.00241	0.00020	-0.00148	0.00013
17	-0.00605	0.00042	-0.00374	0.00027	-0.00224	0.00017	-0.00130	0.00010	-0.00073	0.00006	-0.00040	0.00003
18	-0.00289	0.00020	-0.00161	0.00012	-0.00087	0.00006	-0.00045	0.00004	-0.00022	0.00002	-0.00011	0.00001
19	-0.00141	0.00010	-0.00071	0.00005	-0.00034	0.00003	-0.00016	0.00001	-0.00007	0.00001	-0.00003	0.00000
20	-0.00068	0.00005	-0.00031	0.00002	-0.00013	0.00001	-0.00006	0.00000	-0.00002	0.00000	-0.00001	0.00000
21	-0.00033	0.00002	-0.00013	0.00001	-0.00005	0.00000	-0.00002	0.00000	-0.00001	0.00000	-0.00000	0.00000
22	-0.00016	0.00001	-0.00006	0.00000	-0.00002	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000
T(SECS)	6.05		5.79		5.54		5.31		5.10		4.89	
C(K/SEC)	3.800		3.750		3.700		3.650		3.600		3.550	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.03228	0.00249	-0.03558	0.00284	-0.03922	0.00324	-0.04328	0.00370	-0.04787	0.00423	-0.05310	0.00486
2	-0.06050	0.01076	-0.06629	0.01258	-0.07262	0.01471	-0.07961	0.01721	-0.08741	0.02018	-0.09621	0.02371
3	-0.04936	0.02661	-0.05305	0.03138	-0.05691	0.03655	-0.06099	0.04350	-0.06535	0.05123	-0.07006	0.06040
4	-0.10187	0.00751	-0.10732	0.00816	-0.11263	0.00884	-0.11783	0.00955	-0.12295	0.01030	-0.12801	0.01109
5	-0.09362	0.00736	-0.09787	0.00795	-0.10187	0.00856	-0.10561	0.00919	-0.10913	0.00983	-0.11240	0.01050
6	-0.15467	0.01413	-0.15911	0.01511	-0.16278	0.01607	-0.16568	0.01702	-0.16783	0.01795	-0.16924	0.01887
7	-0.11687	0.00946	-0.11736	0.00982	-0.11698	0.01013	-0.11578	0.01037	-0.11380	0.01056	-0.11108	0.01068
8	-0.16060	0.01414	-0.15679	0.01425	-0.15174	0.01424	-0.14556	0.01411	-0.13841	0.01386	-0.13044	0.01350
9	-0.08096	0.00891	-0.07523	0.00860	-0.06919	0.00820	-0.06296	0.00773	-0.05667	0.00720	-0.05045	0.00663
10	-0.03683	0.00337	-0.03203	0.00305	-0.02748	0.00272	-0.02325	0.00240	-0.01939	0.00208	-0.01593	0.00178
11	-0.01983	0.00181	-0.01633	0.00156	-0.01323	0.00131	-0.01053	0.00109	-0.00824	0.00088	-0.00633	0.00071
12	-0.01067	0.00098	-0.00832	0.00079	-0.00636	0.00063	-0.00477	0.00049	-0.00350	0.00038	-0.00251	0.00028
13	-0.00575	0.00053	-0.00424	0.00040	-0.00306	0.00030	-0.00216	0.00022	-0.00148	0.00016	-0.00100	0.00011
14	-0.00179	0.00016	-0.00126	0.00012	-0.00087	0.00009	-0.00058	0.00006	-0.00038	0.00004	-0.00024	0.00003
15	-0.00393	0.00036	-0.00260	0.00025	-0.00167	0.00016	-0.00105	0.00011	-0.00063	0.00007	-0.00037	0.00004
16	-0.00088	0.00008	-0.00051	0.00005	-0.00028	0.00003	-0.00015	0.00002	-0.00008	0.00001	-0.00004	0.00000
17	-0.00021	0.00002	-0.00010	0.00001	-0.00005	0.00000	-0.00002	0.00000	-0.00001	0.00000	-0.00000	0.00000
18	-0.00005	0.00000	-0.00000	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
19	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
20	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
T(SECS)	4.70		4.52		4.35		4.20		4.05		3.92	
C(K/SEC)	3.500		3.450		3.400		3.350		3.300		3.250	
M	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU	DCDRHO	DCDMU
1	-0.05908	0.00560	-0.06597	0.00647	-0.07393	0.00752	-0.08305	0.00875	-0.09351	0.01021	-0.10541	0.01193
2	-0.10619	0.02793	-0.11757	0.03298	-0.13058	0.03903	-0.14534	0.04623	-0.16210	0.05476	-0.18099	0.06480
3	-0.07518	0.07130	-0.08077	0.08427	-0.08691	0.09969	-0.09356	0.11788	-0.10080	0.13925	-0.10862	0.16414
4	-0.13301	0.01193	-0.13793	0.01283	-0.14278	0.01378	-0.14742	0.01478	-0.15182	0.01582	-0.15589	0.01691
5	-0.11544	0.01118	-0.11821	0.01189	-0.12071	0.01262	-0.12282	0.01336	-0.12451	0.01410	-0.12574	0.01484
6	-0.16990	0.01976	-0.16980	0.02061	-0.16896	0.02143	-0.16727	0.02219	-0.16477	0.02288	-0.16146	0.02347
7	-0.10765	0.01074	-0.10358	0.01073	-0.09896	0.01065	-0.09379	0.01050	-0.08821	0.01028	-0.08231	0.01000
8	-0.12179	0.01303	-0.11264	0.01246	-0.10318	0.01182	-0.09355	0.01110	-0.08396	0.01033	-0.07458	0.00953
9	-0.04439	0.00603	-0.03860	0.00542	-0.03317	0.00481	-0.02814	0.00421	-0.02358	0.00364	-0.01951	0.00311
10	-0.01290	0.00150	-0.01028	0.00124	-0.00808	0.00102	-0.00624	0.00082	-0.00476	0.00065	-0.00357	0.00051
11	-0.00477	0.00055	-0.00353	0.00043	-0.00256	0.00032	-0.00183	0.00024	-0.00128	0.00017	-0.00088	0.00013
12	-0.00176	0.00020	-0.00121	0.00015	-0.00081	0.00010	-0.00053	0.00007	-0.00034	0.00005	-0.00022	0.00003
13	-0.00065	0.00008	-0.00041	0.00005	-0.00026	0.00003	-0.00016	0.00002	-0.00009	0.00001	-0.00005	0.00001
14	-0.00015	0.00002	-0.00009	0.00001	-0.00005	0.00001	-0.00003	0.00000	-0.00002	0.00000	-0.00001	0.00000
15	-0.00021	0.00002	-0.00012	0.00001	-0.00006	0.00001	-0.00003	0.00000	-0.00002	0.00000	-0.00001	0.00000
16	-0.00002	0.00000	-0.00001	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
17	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

Caltech dispersion programs the new tables were used to predict back to the Jeffreys-Bullen model. The results are shown in fig. 1.

The tables are particularly designed for investigation of the physical properties of the crust and mantle. However, the effect of crustal thickness changes may be

estimated by use of equation 17. Figure 2 shows a rather extreme trial case where another forward-backward experiment has been performed for illustration. In the "forward" case a crustal layer has been decreased in thickness by 50%. In the

TABLE 11a

PHASE VELOCITY PERTURBATIONS (KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY AND RIGIDITY FOR CIT13F LAMINATED CRUST AND UPPER MANTLE OCEANIC EARTH MODEL

VARIATIONS FOR 10 C/O CHANGE IN PARAMETER
CIT13F OCEANIC LAMINATED CRUST AND UPPER MANTLE

PSEUDO SPHERICAL CALCULATION

T(SECS)	119.11		98.96		78.15		57.53		38.61		23.42	
C(K/SEC)	4.700		4.650		4.600		4.550		4.500		4.450	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00007	0.00000	-0.00008	0.00000	-0.00009	0.00000	-0.00010	0.00000	-0.00014	0.00000	-0.00024	0.00001
2	-0.00014	0.00000	-0.00015	0.00000	-0.00017	0.00001	-0.00021	0.00001	-0.00028	0.00001	-0.00048	0.00002
3	-0.00014	0.00000	-0.00015	0.00000	-0.00017	0.00001	-0.00021	0.00001	-0.00028	0.00001	-0.00047	0.00002
4	-0.00047	0.00018	-0.00051	0.00020	-0.00058	0.00023	-0.00069	0.00028	-0.00093	0.00038	-0.00155	0.00065
5	-0.00047	0.00018	-0.00051	0.00020	-0.00058	0.00023	-0.00069	0.00028	-0.00093	0.00038	-0.00154	0.00066
6	-0.00094	0.00036	-0.00102	0.00039	-0.00115	0.00045	-0.00138	0.00056	-0.00184	0.00076	-0.00305	0.00132
7	-0.00108	0.00067	-0.00116	0.00074	-0.00131	0.00085	-0.00157	0.00104	-0.00209	0.00142	-0.00341	0.00240
8	-0.00215	0.00133	-0.00232	0.00147	-0.00261	0.00170	-0.00313	0.00208	-0.00413	0.00283	-0.00662	0.00473
9	-0.00214	0.00133	-0.00231	0.00147	-0.00259	0.00169	-0.00310	0.00207	-0.00405	0.00280	-0.00630	0.00460
10	-0.00244	0.00235	-0.00263	0.00259	-0.00295	0.00297	-0.00352	0.00362	-0.00455	0.00481	-0.00687	0.00752
11	-0.00244	0.00234	-0.00262	0.00258	-0.00294	0.00295	-0.00349	0.00359	-0.00449	0.00474	-0.00663	0.00724
12	-0.00243	0.00234	-0.00261	0.00257	-0.00292	0.00294	-0.00347	0.00357	-0.00442	0.00467	-0.00640	0.00699
13	-0.00242	0.00233	-0.00260	0.00257	-0.00291	0.00293	-0.00344	0.00355	-0.00437	0.00461	-0.00619	0.00676
14	-0.00121	0.00116	-0.00130	0.00128	-0.00145	0.00146	-0.00171	0.00176	-0.00216	0.00228	-0.00302	0.00329
15	-0.00602	0.00581	-0.00647	0.00639	-0.00722	0.00728	-0.00849	0.00875	-0.01063	0.01124	-0.01448	0.01577
16	-0.00599	0.00569	-0.00642	0.00624	-0.00714	0.00709	-0.00836	0.00848	-0.01034	0.01075	-0.01354	0.01448
17	-0.00595	0.00542	-0.00637	0.00593	-0.00707	0.00672	-0.00823	0.00801	-0.01006	0.01002	-0.01274	0.01304
18	-0.00589	0.00538	-0.00630	0.00588	-0.00697	0.00665	-0.00808	0.00788	-0.00977	0.00975	-0.01197	0.01226
19	-0.00586	0.00522	-0.00626	0.00570	-0.00691	0.00643	-0.00796	0.00757	-0.00951	0.00926	-0.01129	0.01129
20	-0.00580	0.00518	-0.00618	0.00564	-0.00680	0.00634	-0.00779	0.00743	-0.00919	0.00898	-0.01056	0.01059
21	-0.00573	0.00513	-0.00610	0.00558	-0.00668	0.00625	-0.00761	0.00728	-0.00886	0.00868	-0.00984	0.00989
22	-0.00566	0.00508	-0.00601	0.00551	-0.00656	0.00616	-0.00742	0.00712	-0.00852	0.00837	-0.00913	0.00921
23	-0.01118	0.01009	-0.01183	0.01090	-0.01284	0.01210	-0.01436	0.01384	-0.01612	0.01591	-0.01636	0.01658
24	-0.01085	0.00985	-0.01142	0.01059	-0.01228	0.01164	-0.01350	0.01310	-0.01467	0.01458	-0.01378	0.01405
25	-0.01055	0.00963	-0.01103	0.01029	-0.01174	0.01120	-0.01267	0.01237	-0.01327	0.01327	-0.01147	0.01178
26	-0.01016	0.00935	-0.01056	0.00992	-0.01111	0.01068	-0.01174	0.01155	-0.01181	0.01191	-0.00936	0.00968
27	-0.01927	0.01792	-0.01978	0.01880	-0.02042	0.01984	-0.02085	0.02075	-0.01963	0.02002	-0.01355	0.01418

T(SECS)	15.56		12.55		11.00		9.98		9.23		8.63	
C(K/SEC)	4.400		4.350		4.300		4.250		4.200		4.150	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00052	0.00002	-0.00094	0.00003	-0.00139	0.00005	-0.00183	0.00007	-0.00226	0.00009	-0.00270	0.00011
2	-0.00104	0.00005	-0.00186	0.00009	-0.00272	0.00015	-0.00357	0.00022	-0.00440	0.00029	-0.00522	0.00037
3	-0.00101	0.00007	-0.00178	0.00017	-0.00256	0.00030	-0.00332	0.00045	-0.00404	0.00062	-0.00473	0.00082
4	-0.00328	0.00142	-0.00569	0.00254	-0.00811	0.00373	-0.01038	0.00490	-0.01249	0.00607	-0.01448	0.00723
5	-0.00323	0.00143	-0.00558	0.00256	-0.00790	0.00375	-0.01005	0.00493	-0.01204	0.00609	-0.01388	0.00725
6	-0.00627	0.00288	-0.01064	0.00518	-0.01486	0.00759	-0.01866	0.00997	-0.02208	0.01230	-0.02515	0.01459
7	-0.00684	0.00503	-0.01134	0.00870	-0.01552	0.01236	-0.01913	0.01579	-0.02223	0.01899	-0.02489	0.02198
8	-0.01283	0.00971	-0.02055	0.01644	-0.02730	0.02292	-0.03279	0.02875	-0.03718	0.03395	-0.04064	0.03856
9	-0.01145	0.00913	-0.01723	0.01495	-0.02169	0.02021	-0.02482	0.02462	-0.02688	0.02824	-0.02810	0.03113
10	-0.01172	0.01350	-0.01653	0.02006	-0.01965	0.02504	-0.02131	0.02842	-0.02191	0.03054	-0.02176	0.03166
11	-0.01078	0.01239	-0.01448	0.01753	-0.01646	0.02092	-0.01712	0.02279	-0.01690	0.02352	-0.01612	0.02343
12	-0.00995	0.01140	-0.01272	0.01535	-0.01383	0.01752	-0.01379	0.01831	-0.01307	0.01814	-0.01196	0.01735
13	-0.00920	0.01052	-0.01121	0.01348	-0.01165	0.01472	-0.01114	0.01474	-0.01013	0.01402	-0.00890	0.01288
14	-0.00435	0.00496	-0.00511	0.00612	-0.00513	0.00646	-0.00475	0.00627	-0.00419	0.00578	-0.00356	0.00514
15	-0.01963	0.02229	-0.02156	0.02568	-0.02036	0.02543	-0.01777	0.02324	-0.01479	0.02023	-0.01190	0.01701
16	-0.01674	0.01857	-0.01648	0.01912	-0.01401	0.01699	-0.01104	0.01399	-0.00830	0.01099	-0.00603	0.00834
17	-0.01448	0.01536	-0.01288	0.01426	-0.00990	0.01145	-0.00707	0.00854	-0.00481	0.00607	-0.00316	0.00417
18	-0.01257	0.01334	-0.01013	0.01119	-0.00706	0.00813	-0.00457	0.00549	-0.00282	0.00354	-0.00168	0.00220
19	-0.01100	0.01138	-0.00806	0.00868	-0.00510	0.00572	-0.00300	0.00351	-0.00168	0.00205	-0.00091	0.00116
20	-0.00953	0.00989	-0.00635	0.00686	-0.00365	0.00411	-0.00195	0.00229	-0.00099	0.00122	-0.00049	0.00062
21	-0.00823	0.00856	-0.00499	0.00540	-0.00260	0.00294	-0.00126	0.00149	-0.00058	0.00072	-0.00026	0.00033
22	-0.00707	0.00738	-0.00389	0.00423	-0.00185	0.00209	-0.00081	0.00096	-0.00034	0.00042	-0.00014	0.00018
23	-0.01131	0.01185	-0.00543	0.00593	-0.00225	0.00256	-0.00087	0.00103	-0.00032	0.00040	-0.00011	0.00015
24	-0.00814	0.00859	-0.00324	0.00356	-0.00111	0.00127	-0.00035	0.00042	-0.00011	0.00013	-0.00003	0.00004
25	-0.00578	0.00614	-0.00191	0.00211	-0.00054	0.00062	-0.00014	0.00017	-0.00004	0.00004	-0.00001	0.00001
26	-0.00401	0.00429	-0.00110	0.00122	-0.00026	0.00030	-0.00006	0.00007	-0.00001	0.00001	-0.00000	0.00000
27	-0.00461	0.00497	-0.00098	0.00110	-0.00018	0.00021	-0.00003	0.00004	-0.00001	0.00001	-0.00000	0.00000

"backward" case the thickness has been increased back to the original value—this corresponding now to a 100% change in thickness. It is more accurate to modify the physical properties in the framework of the standard model layering as also shown in figure 2. This tactic removes the restriction of small changes since the maximum

TABLE 11b

PHASE VELOCITY PERTURBATIONS (KM/SEC) RESULTING FROM A 10% CHANGE IN DENSITY AND RIGIDITY FOR CIT13F LAMINATED CRUST AND UPPER MANTLE OCEANIC EARTH MODEL

CIT 13F OCEANIC LAMINATED CRUST AND UPPER MANTLE

T(SECS)	8.12		7.68		7.29		6.94		6.62		6.32	
C(K/SEC)	4.100		4.050		4.000		3.950		3.900		3.850	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00314	0.00013	-0.00358	0.00015	-0.00404	0.00018	-0.00452	0.00020	-0.00502	0.00023	-0.00556	0.00027
2	-0.00605	0.00046	-0.00688	0.00056	-0.00773	0.00068	-0.00861	0.00081	-0.00952	0.00095	-0.01047	0.00112
3	-0.00541	0.00105	-0.00608	0.00130	-0.00673	0.00160	-0.00738	0.00193	-0.00804	0.00230	-0.00870	0.00274
4	-0.01635	0.00839	-0.01812	0.00957	-0.01981	0.01076	-0.02142	0.01198	-0.02296	0.01322	-0.02444	0.01450
5	-0.01559	0.00840	-0.01719	0.00956	-0.01869	0.01072	-0.02009	0.01189	-0.02140	0.01308	-0.02263	0.01428
6	-0.02792	0.01684	-0.03041	0.01907	-0.03265	0.02126	-0.03464	0.02343	-0.03641	0.02557	-0.03795	0.02768
7	-0.02715	0.02477	-0.02905	0.02738	-0.03061	0.02980	-0.03186	0.03204	-0.03282	0.03409	-0.03349	0.03593
8	-0.04330	0.04262	-0.04526	0.04616	-0.04657	0.04917	-0.04732	0.05168	-0.04754	0.05367	-0.04727	0.05515
9	-0.02865	0.03338	-0.02867	0.03502	-0.02823	0.03609	-0.02743	0.03662	-0.02634	0.03666	-0.02500	0.03623
10	-0.02107	0.03197	-0.02000	0.03162	-0.01865	0.03073	-0.01714	0.02941	-0.01552	0.02773	-0.01387	0.02579
11	-0.01498	0.02271	-0.01363	0.02155	-0.01218	0.02006	-0.01070	0.01835	-0.00925	0.01652	-0.00786	0.01463
12	-0.01067	0.01615	-0.00931	0.01469	-0.00796	0.01310	-0.00668	0.01146	-0.00551	0.00984	-0.00446	0.00829
13	-0.00761	0.01150	-0.00636	0.01003	-0.00521	0.00856	-0.00418	0.00716	-0.00329	0.00586	-0.00253	0.00470
14	-0.00295	0.00444	-0.00239	0.00375	-0.00189	0.00309	-0.00146	0.00250	-0.00111	0.00197	-0.00082	0.00152
15	-0.00931	0.01391	-0.00711	0.01109	-0.00531	0.00864	-0.00388	0.00657	-0.00276	0.00488	-0.00192	0.00354
16	-0.00425	0.00614	-0.00292	0.00440	-0.00195	0.00307	-0.00127	0.00208	-0.00080	0.00137	-0.00049	0.00088
17	-0.00202	0.00277	-0.00125	0.00179	-0.00075	0.00112	-0.00043	0.00068	-0.00024	0.00040	-0.00013	0.00022
18	-0.00096	0.00132	-0.00054	0.00077	-0.00029	0.00043	-0.00015	0.00023	-0.00007	0.00012	-0.00004	0.00006
19	-0.00047	0.00063	-0.00024	0.00033	-0.00011	0.00017	-0.00005	0.00008	-0.00002	0.00004	-0.00001	0.00002

T(SECS)	6.05		5.79		5.54		5.31		5.10		4.89	
C(K/SEC)	3.800		3.750		3.700		3.650		3.600		3.550	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.00613	0.00030	-0.00676	0.00035	-0.00745	0.00039	-0.00822	0.00045	-0.00910	0.00051	-0.01009	0.00059
2	-0.01149	0.00131	-0.01259	0.00153	-0.01380	0.00179	-0.01512	0.00209	-0.01661	0.00245	-0.01828	0.00288
3	-0.00938	0.00324	-0.01008	0.00382	-0.01081	0.00449	-0.01159	0.00529	-0.01242	0.00623	-0.01331	0.00734
4	-0.02587	0.01582	-0.02726	0.01719	-0.02861	0.01862	-0.02993	0.02011	-0.03123	0.02169	-0.03251	0.02337
5	-0.02378	0.01550	-0.02486	0.01675	-0.02588	0.01804	-0.02683	0.01935	-0.02772	0.02071	-0.02855	0.02211
6	-0.03929	0.02977	-0.04041	0.03183	-0.04135	0.03386	-0.04208	0.03586	-0.04263	0.03782	-0.04299	0.03975
7	-0.03389	0.03758	-0.03403	0.03900	-0.03392	0.04021	-0.03358	0.04119	-0.03300	0.04192	-0.03221	0.04240
8	-0.04657	0.05612	-0.04547	0.05658	-0.04400	0.05655	-0.04221	0.05602	-0.04014	0.05503	-0.03783	0.05358
9	-0.02348	0.03537	-0.02182	0.03413	-0.02007	0.03256	-0.01826	0.03069	-0.01643	0.02860	-0.01463	0.02633
10	-0.01223	0.02366	-0.01063	0.02142	-0.00912	0.01912	-0.00772	0.01684	-0.00644	0.01461	-0.00529	0.01250
11	-0.00658	0.01274	-0.00542	0.01092	-0.00439	0.00921	-0.00350	0.00763	-0.00273	0.00621	-0.00210	0.00496
12	-0.00354	0.00686	-0.00276	0.00557	-0.00211	0.00443	-0.00158	0.00346	-0.00116	0.00264	-0.00083	0.00197
13	-0.00191	0.00369	-0.00141	0.00284	-0.00102	0.00213	-0.00072	0.00156	-0.00049	0.00112	-0.00033	0.00078
14	-0.00059	0.00115	-0.00042	0.00084	-0.00029	0.00061	-0.00019	0.00042	-0.00013	0.00029	-0.00008	0.00019
15	-0.00131	0.00251	-0.00086	0.00173	-0.00056	0.00116	-0.00035	0.00075	-0.00021	0.00048	-0.00012	0.00029
16	-0.00029	0.00054	-0.00017	0.00033	-0.00009	0.00019	-0.00005	0.00011	-0.00003	0.00006	-0.00001	0.00003
17	-0.00007	0.00012	-0.00003	0.00006	-0.00002	0.00003	-0.00001	0.00002	-0.00000	0.00001	-0.00000	0.00000
18	-0.00002	0.00003	-0.00001	0.00001	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
19	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

T(SECS)	4.70		4.52		4.35		4.20		4.05		3.92	
C(K/SEC)	3.500		3.450		3.400		3.350		3.300		3.250	
M	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU	DC/DRHO	DC/DMU
1	-0.01123	0.00068	-0.01253	0.00079	-0.01405	0.00091	-0.01578	0.00106	-0.01777	0.00124	-0.02003	0.00145
2	-0.02018	0.00340	-0.02234	0.00401	-0.02481	0.00475	-0.02762	0.00562	-0.03080	0.00666	-0.03439	0.00788
3	-0.01428	0.00867	-0.01535	0.01025	-0.01651	0.01212	-0.01778	0.01433	-0.01915	0.01693	-0.02064	0.01996
4	-0.03378	0.02514	-0.03503	0.02702	-0.03627	0.02903	-0.03744	0.03113	-0.03856	0.03333	-0.03960	0.03563
5	-0.02932	0.02356	-0.03003	0.02505	-0.03066	0.02659	-0.03120	0.02814	-0.03163	0.02970	-0.03194	0.03126
6	-0.04315	0.04162	-0.04313	0.04343	-0.04292	0.04515	-0.04249	0.04675	-0.04185	0.04819	-0.04101	0.04946
7	-0.03122	0.04262	-0.03004	0.04258	-0.02870	0.04228	-0.02720	0.04169	-0.02558	0.04083	-0.02387	0.03972
8	-0.03532	0.05172	-0.03267	0.04948	-0.02992	0.04692	-0.02713	0.04407	-0.02435	0.04102	-0.02163	0.03783
9	-0.01287	0.02395	-0.01119	0.02151	-0.00962	0.01909	-0.00816	0.01672	-0.00684	0.01447	-0.00566	0.01236
10	-0.00428	0.01053	-0.00341	0.00874	-0.00268	0.00715	-0.00207	0.00575	-0.00158	0.00456	-0.00118	0.00357
11	-0.00158	0.00390	-0.00117	0.00300	-0.00085	0.00227	-0.00061	0.00168	-0.00042	0.00123	-0.00029	0.00088
12	-0.00058	0.00144	-0.00040	0.00103	-0.00027	0.00072	-0.00018	0.00049	-0.00011	0.00033	-0.00007	0.00022
13	-0.00022	0.00053	-0.00014	0.00035	-0.00009	0.00023	-0.00005	0.00014	-0.00003	0.00009	-0.00002	0.00005
14	-0.00005	0.00012	-0.00003	0.00008	-0.00002	0.00005	-0.00001	0.00003	-0.00001	0.00002	-0.00000	0.00001
15	-0.00007	0.00017	-0.00004	0.00010	-0.00002	0.00006	-0.00001	0.00003	-0.00001	0.00002	-0.00000	0.00001
16	-0.00001	0.00001	-0.00000	0.00001	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000
17	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000	-0.00000	0.00000

change is from a mantle velocity or density to the corresponding crustal value or vice versa.

PARTIAL DERIVATIVE CURVES

The tables of the preceding section allow for the effects of sphericity and a liquid core and can be used to calculate dispersion over any earth model. When plotted

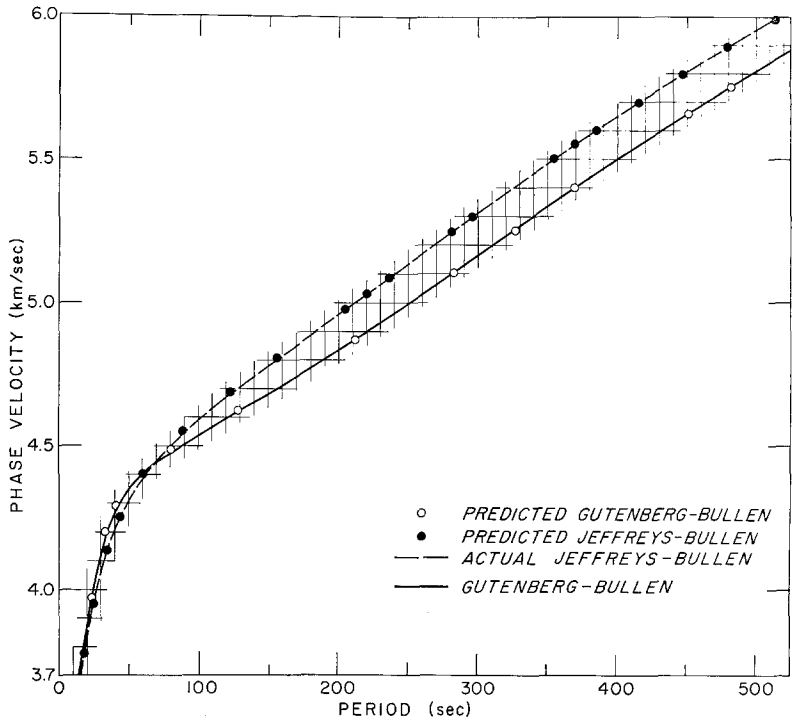

FIG. 1. Results of a numerical experiment in which the known dispersion results and partial derivative tables for a Jeffreys-Bullen type earth model are used to predict dispersion for a model with a Gutenberg-Bullen upper mantle and *vice versa*.

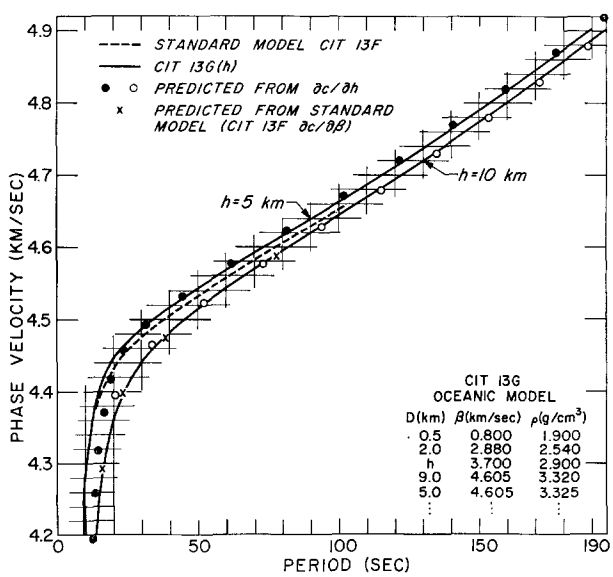

FIG. 2. Results of numerical experiment using equation 17 to predict effect of a change in thickness of a crustal layer compared with results obtained by modifying the shear velocities in the upper 250 km. of the standard model CIT13F so as to correspond to the desired structure.

the resulting partial derivative curves shed considerable light on the meaning and interpretation of dispersion data. The partial derivative curves tend to be bell shaped (on semi-log and log-log graphs) and peak at periods corresponding to horizontal wave lengths of roughly 2 to 6 times the layer depth. The peak, or maximum effect, decreases with increasing depth of the layer for a layer of a given thickness. The near surface layers dominate over quite a wide frequency range and their properties must be well known before any attempt is made to analyze the deeper layers, i.e., structures should be designed from the top down.

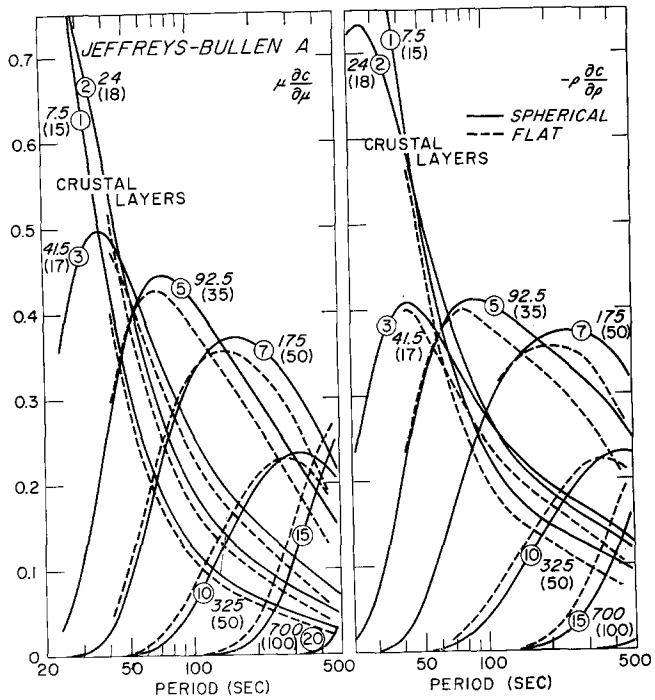

FIG. 3. Phase velocity perturbations (km/sec) for Jeffreys-Bullen A Earth Model. The parameters are layer number (circled), depth to layer midpoint (in km.) and layer thickness (in parentheses). To use, multiply the ordinate by the fractional change of the appropriate variable. Attenuation can be computed by allowing the perturbations to become complex.

These curves may be used to determine which section of the waveguide is contributing to an observed set of dispersion data and which sections are beyond the reach of the observations. They can be used to design a structure which satisfies the data and indicate how much freedom can be taken with the resulting model without violating the data to more than the experimental error.

Figure 3 shows partial derivative curves for the Jeffreys-Bullen Continental Model. In this model the rigidity and density increase monotonically with depth. Since the displacements for such a model die off approximately exponentially with depth, the partial derivative curves are roughly symmetrical on a logarithmic period scale and the peak effect divided by the layer thickness dies off uniformly with layer depth. Also shown are the partial derivatives for the equivalent flat layered model. Note that the effect of sphericity is to shift the curves to longer periods and slightly

reduce the symmetry. These curves may be normalized by dividing by the layer thickness.

Corresponding curves for the Gutenberg IV continental model (MacDonald and Ness, 1961) are shown in figure 4. This model has a velocity reversal in the upper mantle and the possibility exists for efficient channeling of certain periods. This effect shows up in a skewing of the partial derivative curves toward shorter periods.

The oceanic model CIT 9 has a more pronounced low-velocity zone and the skewing in figures 5 and 6 is even more apparent. An additional phenomenon, that of a cut-off period, also shows up now. A low rigidity region partially decouples the crust from the mantle. At periods greater than the decoupling period, which in this

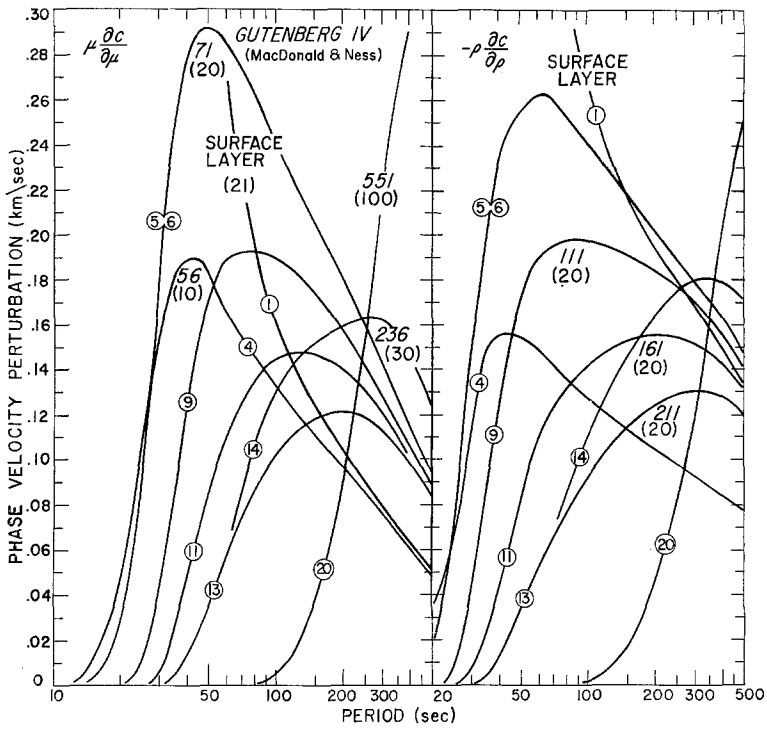

FIG. 4. Phase velocity perturbations (km/sec) for Gutenberg IV Earth Model.

case is about 23 seconds, a large amount of energy is in the low-velocity channel. At shorter periods most of the energy is in the crustal layers. The decoupling phenomenon also manifests itself by nearly vertical portions in the phase and group velocity curves.

Figures 7 and 8 show the partial derivative curves for the standard model designated CIT13F for the period range 10 to 1000 seconds. Note the double logarithmic scale. Figure 9 shows the shear velocity structure of this model and, for comparison, two other proposed oceanic models. The ticks on the ordinate show how this model was split into layers.

These curves all show the equal role played by density and rigidity in the Love wave problem. These are the natural variables in any theoretical discussion. However, the shear velocity and the density are more often the variables of interest in

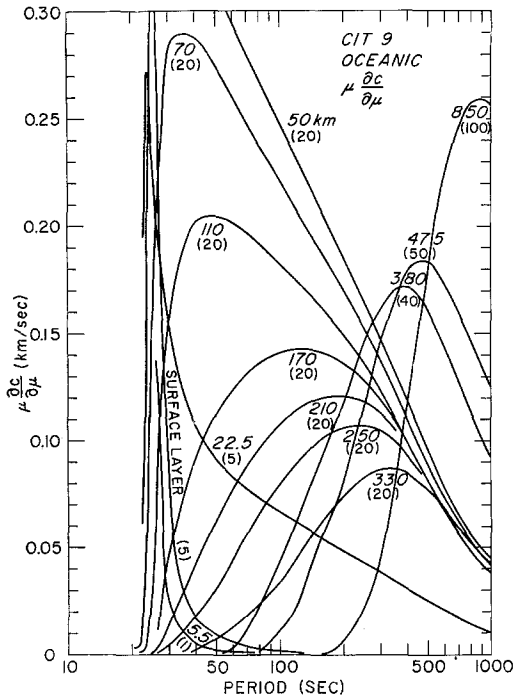

FIG. 5. Phase velocity perturbations due to a change in various layer rigidities (density held constant) for model CIT9.

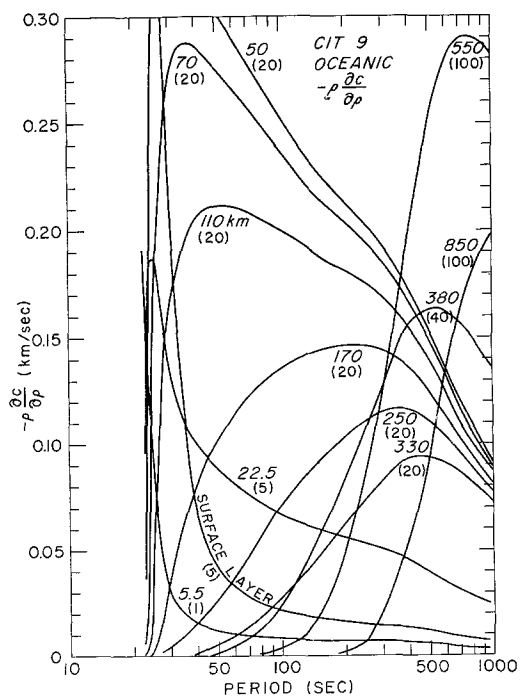

FIG. 6. Phase velocity perturbations due to a change in various layer densities (rigidity held constant) for model CIT9.

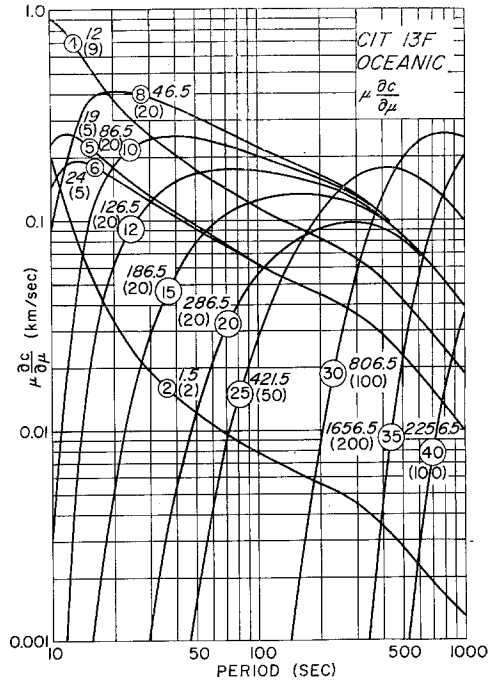

FIG. 7. Phase velocity perturbations corresponding to rigidity changes (density held constant) in various layers of the CIT13F Standard Oceanic Model. To use multiply ordinate by the fractional change in the layer rigidity being modified. The circled numbers are layer designations, italicized numbers are depths to layer midpoints, parenthetical numbers are layer thicknesses.

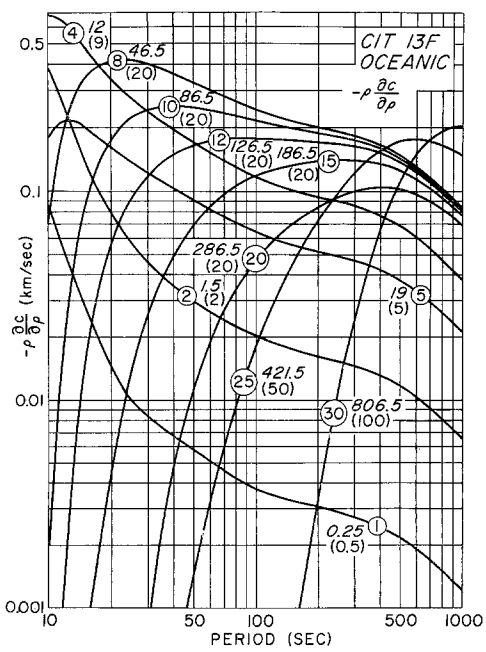

FIG. 8. Phase velocity perturbations corresponding to density changes (rigidity held constant) in various layers of the CIT13F Standard Oceanic Model. See caption of figure 7 for explanation. If the parameter perturbations are imaginery, then the curves are proportional to the resulting Q^{-1}.

the corresponding experimental problem since travel time results provide the starting point for most surface wave interpretations. Figure 10 shows the relative effect of shear velocity perturbations (density held constant) and density perturbations (velocity held constant) and indicates the predominant role played by the shear velocity. It is clear that the reliability of density determinations using Love wave results will be an order of magnitude less than the reliability of the shear velocity determinations. The situation improves, of course, if the shear velocity is known

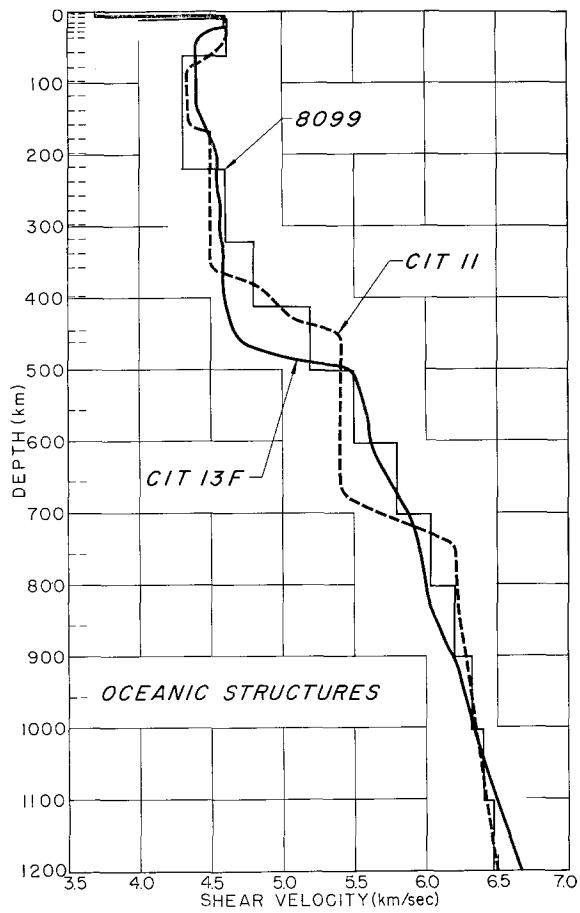

FIG. 9. Shear velocity structures for CIT13F, CIT11 and 8099.

independently. In fact, surface waves and free oscillations promise to be in important additional source of information concerning the density structure in regions of the Earth where the seismic velocities are well known.

The similarity in shape of the partial derivative curves for the various layers suggests that a considerable lack of uniqueness is involved when an attempt is made to find a linear combination of the theoretical perturbation curves that match an observed "discrepancy curve." This question is discussed more rigorously in a forthcoming paper (Archambeau and Anderson, in preparation). Ambiguity can be reduced by using higher mode data as a supplementary constraint. Phase velocity

perturbations for the 2nd Love Mode for the Gutenberg-Birch Continental Model are shown in figure 11. Note the double peaked character of these curves compared with the single peak fundamental mode curves. Of particular interest here is the suggestion that this mode, the so-called *Sa* wave, in the period range of about 15–20 seconds, "sees" the upper mantle from about 80–150 km. more than it sees the crustal layers, making this a particularly powerful phase for the study of the upper mantle.

The direct calculation of group velocity perturbations requires special techniques not covered in this paper. It is easy, however, to devise numerical schemes for determining a group velocity correction from derived phase velocity corrections.

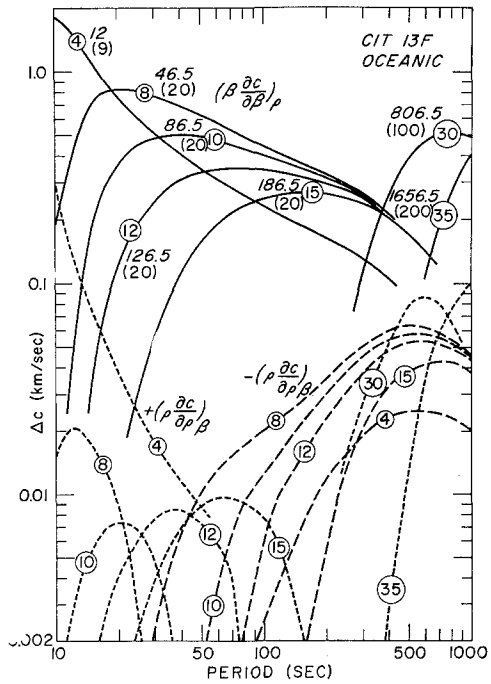

FIG. 10. Phase velocity perturbations for CIT13F Standard Oceanic Model with shear velocity and density as the independent variables.

For example, a two-point difference scheme yields

$$U = U_0(1 + \alpha)$$

where

$$\alpha = (\delta k_{-1} - \delta k_{+1})/(k_{+1} - k_{-1})$$

$$\delta k = -(k\delta c/c)$$

$$k = 2\pi/cT$$

where the δk are those determined at periods adjacent to the period for which group velocity is desired. Tables 12 and 13 provide group velocity information for the standard models.

A later paper will deal with the free oscillation problem. The question in this case is how the period (σ) of a free oscillation of order n is affected by changes in the physical properties. Meanwhile, torsional oscillation data for periods less

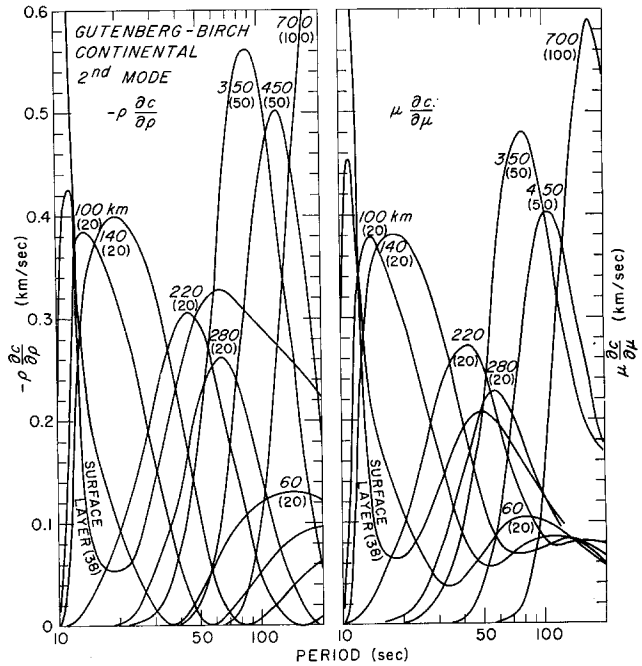

FIG. 11. Phase velocity perturbations for 1st higher Love mode for Gutenberg-Birch Continental Model. Note the "windows" that occur in certain period ranges which allow deeper layers to be seen through the nearer surface layers.

than 1000 seconds may be interpreted by converting it to dispersion data by computing

$$T = 2\pi/\sigma$$

$$c = 2\pi/[(n + \tfrac{1}{2}) \cdot T]$$

and proceeding as in the travelling wave case.

THE INVERSE SURFACE WAVE PROBLEM

The usual method of interpreting surface wave data is by an indirect trial and error procedure. The tables and graphs in this paper can be used as guidelines in a technique of this sort. Dorman and Ewing (1962) systematized the trial and error method by numerically solving a simultaneous set of linear equations relating empirically determined parameter corrections to the discrepancy between the

observed and the numerical trial dispersion data. The tables of theoretical partial derivatives presented in this paper can be used to replace the numerical derivatives in this technique. Preliminary results utilizing this approach were presented at the recent IUGG meeting (Anderson, *et al.* (1963), Archambeau and Anderson (1963)). Alternatively, the closed form expressions for the various partial derivatives can be used to do the same sort of thing completely analytically to avoid the numerical difficulties arising in the attempted inversion of almost singular matrices.

TABLE 12

PERIOD (T), PHASE VELOCITY (c) AND GROUP VELOCITY (U) FOR GUTENBERG BIRCH II CONTINENTAL MODEL

T (secs)	c (km/sec)	U (km/sec)	T (secs)	c (km/sec)	U (km/sec)
1079.48	6.72	6.060	60.37	4.41	4.1240
951.57	6.62	5.783	56.60	4.39	4.0967
861.17	6.52	5.576	53.17	4.37	4.0664
788.74	6.42	5.406	50.07	4.35	4.0339
673.13	6.22	5.131	47.28	4.33	3.9994
580.00	6.02	4.912	44.78	4.31	3.9637
500.19	5.82	4.734	42.52	4.29	3.9273
422.12	5.60	4.5792	40.47	4.27	3.8909
388.89	5.50	4.5220	38.62	4.25	3.8549
356.64	5.40	4.4727	36.92	4.23	3.8198
325.10	5.30	4.4307	35.36	4.21	3.7860
294.04	5.20	4.3955	33.91	4.19	3.7537
263.25	5.10	4.3664	32.57	4.17	3.7231
232.54	5.00	4.3424	31.31	4.15	3.6944
201.79	4.90	4.3222	30.12	4.13	3.6678
170.93	4.80	4.3039	28.99	4.11	3.6431
155.49	4.75	4.2946	27.91	4.09	3.6204
140.07	4.70	4.2847	26.88	4.07	3.5998
124.77	4.65	4.2732	25.89	4.05	3.5812
109.70	4.60	4.2588	24.93	4.03	3.5645
106.74	4.59	4.2554	23.99	4.01	3.5497
100.87	4.57	4.2479	23.53	4.00	3.5430
95.10	4.55	4.2393	21.30	3.95	3.5161
89.47	4.53	4.2293	19.14	3.90	3.4993
84.00	4.51	4.2177	17.00	3.85	3.4916
81.33	4.50	4.2111	14.83	3.80	3.4917
78.73	4.49	4.2041	12.56	3.75	3.4982
73.70	4.47	4.1883	10.15	3.70	3.5089
68.94	4.45	4.1698	7.50	3.65	3.5089
64.49	4.43	4.1484	4.52	3.60	3.5309

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TABLE 13

PERIOD (T), PHASE VELOCITY (c), AND GROUP VELOCITY (U) FOR CIT13F OCEANIC MODEL

T (secs)	c (km/sec)	U (km/sec)
1009.06	6.72	5.96
899.29	6.62	5.71
818.64	6.52	5.52
696.84	6.32	5.216
602.14	6.12	4.978
522.28	5.92	4.787
451.55	5.72	4.635
412.00	5.60	4.561
380.15	5.50	4.509
318.19	5.30	4.433
287.45	5.20	4.4093
256.41	5.10	4.3944
224.67	5.00	4.3886
191.71	4.90	4.3915
156.82	4.80	4.4020
119.10	4.70	4.4162
98.96	4.65	4.4211
78.14	4.60	4.4206
57.53	4.55	4.4109
38.58	4.50	4.3927
23.42	4.45	4.354
15.56	4.40	4.2349
12.55	4.35	4.0593
11.00	4.30	3.889
9.23	4.20	3.605
7.29	4.00	3.2067
6.32	3.85	2.9920
4.05	3.30	2.281

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