

Contents

<i>Preface</i>	<i>page xi</i>
1 Introduction	1
1.1 Early efforts at seismic tomography	2
1.2 Ocean acoustic tomography	3
1.3 Global tomography	3
1.4 Some major discoveries	4
1.5 Helioseismology	7
1.6 Finite-frequency tomography	8
2 Ray theory for seismic waves	10
2.1 The stress tensor	10
2.2 Forces in continuous media	11
2.3 Newton's law and the elastodynamic equations	12
2.4 The acoustic wave equation	15
2.5 The ray approximation	18
2.6 Ray solutions in layered and spherical systems	21
2.7 Geometrical spreading	24
2.8 Rays in an isotropic, elastic Earth	25
2.9 Fermat's Principle	27
2.10 Huygens, Fresnel and Green	29
2.11 Flow: solar p-waves or ocean acoustic waves	33
2.12 Appendix A: Some elements of Fourier analysis	35
3 Ray tracing	39
3.1 The shooting method	39
3.2 Ray bending	42
3.3 Other raytracing algorithms for 3D media	45
3.4 Ray-centred coordinates	47
3.5 Dynamic ray tracing	48

3.6	Ray tracing on the sphere	51
3.7	Computational aspects	52
4	Wave scattering	56
4.1	The acoustic Green's function	58
4.2	An acoustic point scatterer	60
4.3	Green's functions for elastic waves	61
4.4	Green's functions in the ray approximation	65
4.5	The Born approximation	68
4.6	Scattering of a plane wave	70
4.7	The scattering matrix	74
4.8	Appendix B: The impulse response	77
5	Body wave amplitudes: theory	79
5.1	Geometrical spreading	79
5.2	The quality factor Q	81
5.3	The correspondence principle	83
5.4	Attenuating body waves	85
5.5	Scattering	87
6	Travel times: observations	90
6.1	Phase picks	93
6.2	Matched filters	97
6.3	Wavelet estimation	100
6.4	Differential times	103
6.5	Signal and noise	106
6.6	Time–distance analysis in helioseismology	107
7	Travel times: interpretation	113
7.1	The ray theoretical interpretation	113
7.2	Cross-correlation of seismic arrivals	118
7.3	Forward scattering	121
7.4	Finite frequency sensitivity: a simple example	122
7.5	Finite frequency kernels: general	126
7.6	Alternative arrival time measurements	132
7.7	Alternative methods for kernel computation	134
7.8	Computational aspects	135
8	Body wave amplitudes: observation and interpretation	142
8.1	Amplitude observations	143
8.2	t^* observations	146
8.3	Amplitude healing	148
8.4	Boundary topography	149

8.5	Finite-frequency Q tomography	151
9	Normal modes	155
9.1	The discrete spectrum	156
9.2	Rayleigh's Principle	163
9.3	Mode splitting	165
9.4	Observations of mode splits	171
10	Surface wave interpretation: ray theory	175
10.1	The theory of surface waves	177
10.2	Love and Rayleigh waves	180
10.3	Measuring fundamental mode dispersion	184
10.4	Measuring higher mode dispersion	187
10.5	Waveform fitting	189
10.6	Partitioned waveform inversion (PWI)	191
10.7	Appendix C: Asymptotic theory	194
11	Surface waves: finite-frequency theory	203
11.1	Phase and amplitude perturbations	204
11.2	Practical considerations	208
11.3	Phase velocity maps: an incompatibility	212
12	Model parametrization	214
12.1	Global parametrization	215
12.2	Local parametrization	217
12.3	Numerical considerations	223
12.4	Spectral analysis and model correlations	224
13	Common corrections	228
13.1	Ellipticity corrections	228
13.2	Topographic and bathymetric time corrections	232
13.3	Crustal time corrections	235
13.4	Surface wave corrections	237
13.5	Source corrections	238
13.6	Amplitude corrections for body waves	242
13.7	Dispersion corrections	244
13.8	Instrument response	245
13.9	Clock corrections	247
14	Linear inversion	249
14.1	Maximum likelihood estimation and least squares	250
14.2	Alternatives to least squares	254
14.3	Singular value decomposition	255
14.4	Tikhonov regularization	259

14.5	Bayesian inference	260
14.6	Information theory	263
14.7	Numerical considerations	266
14.8	Appendix D: Some concepts of probability theory and statistics	269
15	Resolution and error analysis	271
15.1	Resolution matrix	271
15.2	Backus–Gilbert theory	275
15.3	Sensitivity tests	279
16	Anisotropy	284
16.1	The elasticity tensor	285
16.2	Waves in homogeneous anisotropic media	290
16.3	S-wave splitting	291
16.4	Surface wave anisotropy	296
17	Future directions	301
17.1	Beyond Born	301
17.2	Adjoint methods	302
17.3	Global coverage of seismic sensors	306
17.4	Helioseismology and astroseismology	307
	<i>Bibliography</i>	308
	<i>Index</i>	334