NORSAR ROYAL NORWEGIAN COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

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SEMIANNUAL TECHNICAL SUMMARY
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VI. SUMMARY OF TECHNICAL REPORTS/PAPERS PREPARED

VI.1 Example of a seismic absorption band at high frequencies

There is growing evidence that, in most regions of the earth, seismic absorption in terms of $Q^{-1}(\omega)$ forms a band centered at relatively low frequencies, i.e., the high-frequency cut-off of this absorption band is in the range of short-period body waves (0.2-1.0 Hz) (Doornbos, 1983). One should nevertheless consider the possibility that the absorption band is at higher frequencies in those regions which are known to be highly absorptive, or 'low-Q' (e.g., Anderson and Given, 1982). Examples of such regions are thought to be the upper mantle low-velocity zone, the region near the base of the mantle (the D" layer) and the region near the top of the inner core. Observational verification is usually difficult, but the relative amplitudes and waveforms of some short-period core phases provide an interesting case. Short-period NORSAR records show a characteristic change of the PKIKP waveform passing through the inner core, as compared to PKP_{BC} bottoming above. One can attribute this change to the effect of absorption in the inner core, provided adequate care is taken to avoid frequency-dependent elastic effects, to avoid source effects and to eliminate receiver structure effects. We have used full NORSAR array beams to eliminate near-receiver effects, and this limits our analysis to events between 1971-1976, when the array still had its full size. Fig. VI.1.1 shows PKIKP and PKP_{BC} from three such events in the distnce range 147-151°. The two phases are characteristically different, but they should have a similar waveform apart from absorption effects. By verifying that the Hilbert transform of PKP_{BC} is similar to the PKP_{AB} waveform, it can be concluded that the anomalous waveshape is in PKIKP. To investigate this effect we convolved PKP_{BC} with an absorption band operator characterizing transmission through the inner core; we also corrected the amplitude ratio due to purely elastic effects. The required inner core absorption band turns out to be on the high-frequency side of the data. Absorption bands encompassing the data (a 'constant Q' model) or on the low-frequency side of it (the more usual absorption band) are unsuccessful. Fig. VI.1.2.a-c illustrate the effect of typical examples of such absorption bands. The conclusion is that for absorption in the inner core, the low-frequency cut-off of the band $(2\pi\tau_2)^{-1}$ is above 2 Hz, and minimum Q_α in the center of the band is likely to be below 100. The intrinsic dissipation can be in shear and/or in bulk. Recently proposed bulk dissipation mechanisms where the governing equations are diffusive (Loper and Fearn, 1983) have consequences for the high-frequency side of the absorption band. However, with the relative position of the inner core absorption band as inferred here, the differences are unlikely to be observable.

D.J. Doornbos

References

Anderson, D.L. and J.W. Given, 1982: Absorption band Q model for the earth, J. Geophys. Res. 87, 3893-3904.

Doornbos, D.J., 1983: Observable effects of the seismic absorption band in the earth, Geophys. J. R. Astr. Soc., in press.

Loper, D.E. and D.R. Fearn, 1983: A seismic model of a partially molten inner core, J. Geophys. Res.

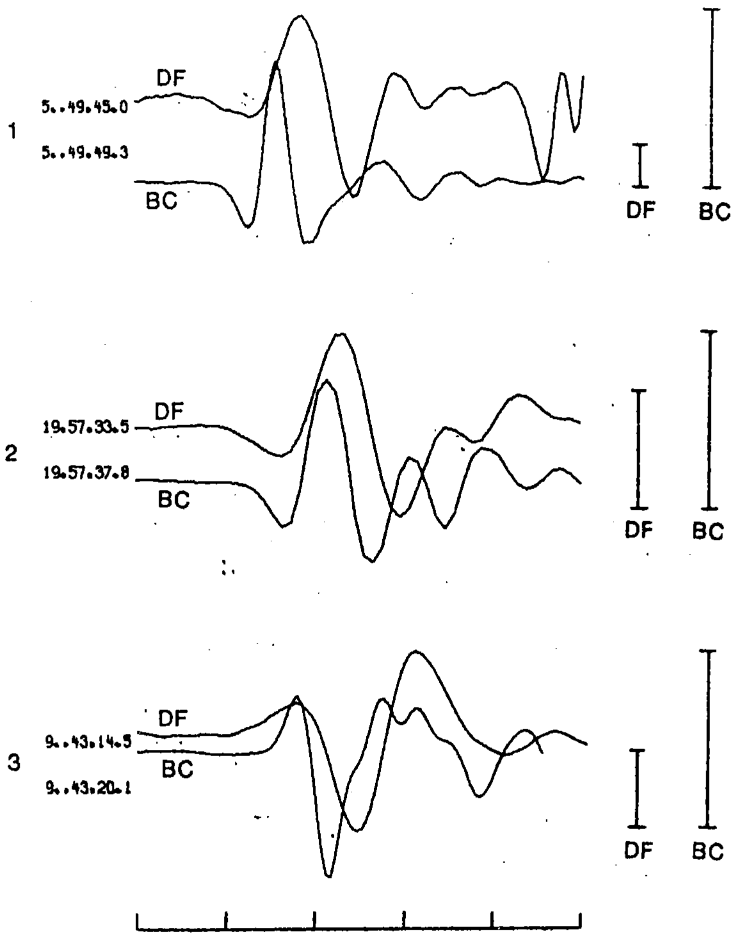

Fig. VI.1.1 NORSAR array beams with PKIKP(DF) and PKP(BC) from three events in the distance range 147-151°. Relative times adjusted to the first peak or trough. Record length is 5 seconds. The relative amplitude scaling is indicated to the right.

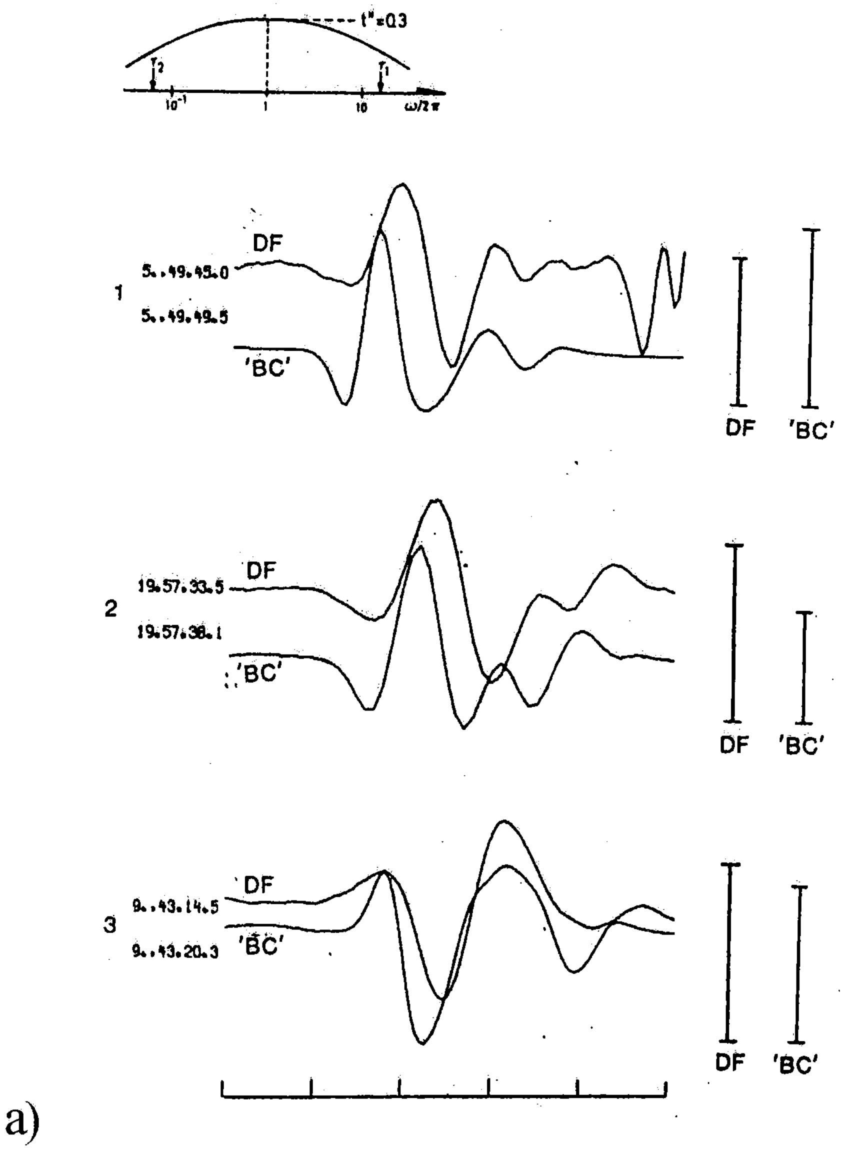

Fig. VI.1.2 Observed PKIKP(DF) compared with synthetic derived from PKP(BC) by correcting for relative path effects, including absorption in the inner core. Other details as in Fig. VI.1.1. Inner core absorption bands are specified by: (a) $t_m^*=0.3$ s, $(2\pi\tau_2)^{-1}=0.0625$ Hz, $(2\pi\tau_1)^{-1}=16$ Hz; (b) $t_m^*=1.0$ s, $(2\pi\tau_2)^{-1}=0.002$ Hz, $(2\pi\tau_1)^{-1}=0.5$ Hz; (c) $t_m^*=1.4$ s, $(2\pi\tau_2)^{-1}=4$ Hz, $(2\pi\tau_1)^{-1}=40$ Hz.

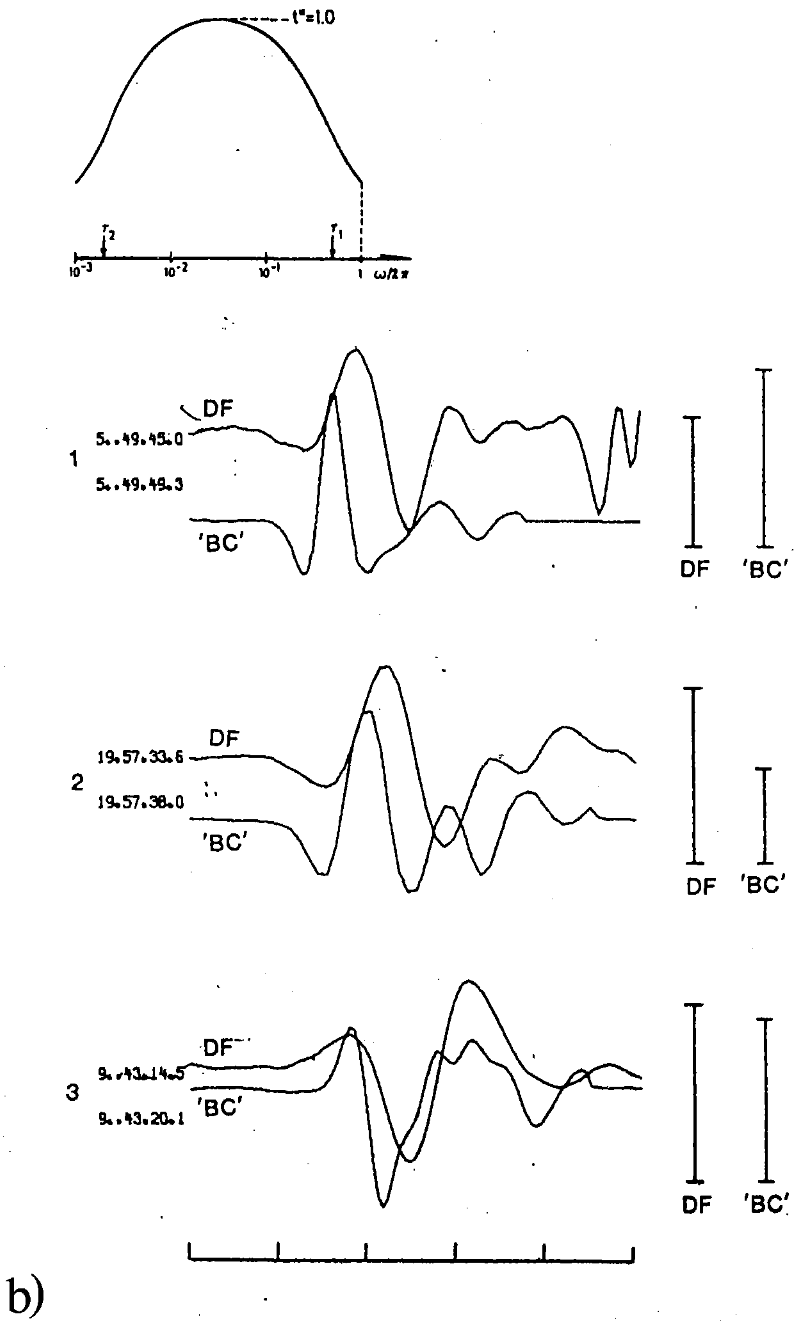
t*=1.0
T2
T1
10^-3
10^-2
10^-1
1
ω/2π
1
DF
5..49.45.0
5..49.49.3
'BC'
DF
'BC'
2
DF
19.57.33.6
19.57.38.0
'BC'
DF
'BC'
3
DF
9..43.14.5
9..43.20.1
'BC'
DF
'BC'
b)

Fig. VI.1.2

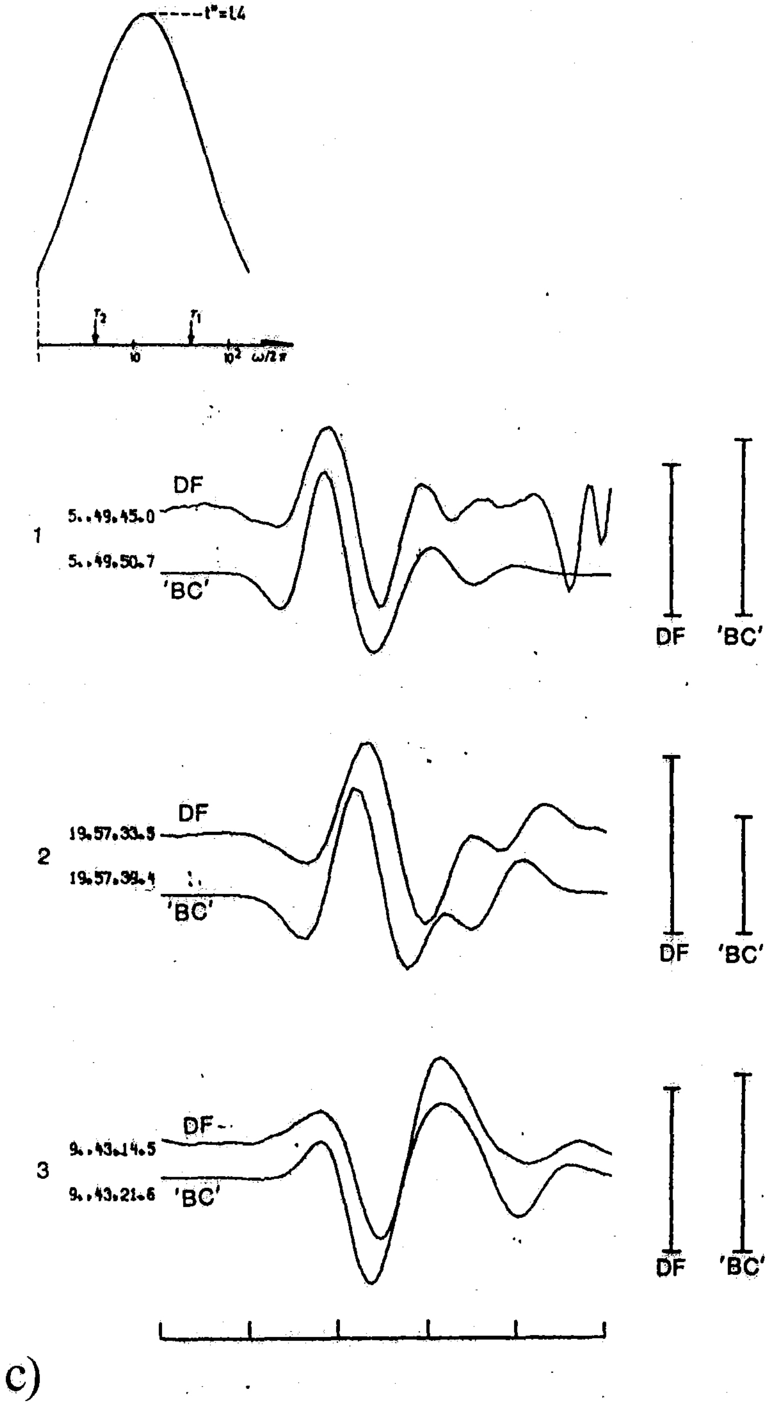
t* = 1.4
T2
T1
1
10
10²
ω/2π
DF
5..49.45.0
1
5..49.50.7
'BC'
DF
'BC'
DF
19.57.33.5
2
19.57.39.4
'BC'
DF
'BC'
DF
9..43.14.5
3
9..43.21.6
'BC'
DF
'BC'
c)

Fig. VI.1.2