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VI. SUMMARY OF TECHNICAL REPORTS/PAPERS PREPARED

VI.1 Constrained inversion for sources of finite extent

In the previous Semiannual Summary we reported on the representation of seismic response in terms of 20 source parameters which are related to components of the moment tensors, and which are also related to the parameters of finite fault models. The usual representation in terms of 6 components of the zero degree moment tensor is adequate for point sources at given location. For point sources at unknown location, a 10 parameter representation (including first degree moments) is necessary and adequate, and the location may be determined (Dziewonski et al, 1981). For sufficiently extended sources, the 20 parameter representation (including second degree moments) is necessary; from an investigation of classical Haskell and Savage type of fault models it is estimated that for sources with $M_s>6$, the relative contribution of second degree moments may be of the order of 10% or more, even in long-period seismograms. The representation is adequate as long as source rise time and spatial extent are smaller than seismic wave period and wave length.

Parameters related to second degree moments can be interpreted in terms of source rise time, orientation and spatial extent, and average rupture velocity. Orientation of the source region can also be inferred, in part, from the zero degree moments. Thus, solutions for the different source parameters should be mutually consistent. Furthermore, values for some of the parameters should be positive or, more specifically, be in a range of 'acceptable' values dictated by our conception of the mechanism of faulting. Previously we reported that not all of the above criteria were fulfilled by the results of an inversion of SRO data from a deep event in the Bali Sea. Thus, it appears necessary to impose (generally non-linear) constraints on the solution. We have now obtained the contraints in a linearized form, to be included in the inversion procedure. Moreover, since the constraints are precisely those appearing as a priori assumptions in the conventional methods of source analysis, it is also possible to investigate the impact of these assumptions. Table VI.1.1 and Fig. VI.1.2 summarize a comparison of results of constrained and unconstrained inversion for the Bali Sea event. Case number 1 in this table assumes a point source, and no constraints are necessary. Case number 3 assumes a plane fault, which can be represented by just one double couple. Although the solution for this case seems 'reasonable' (partly because of the constraints so imposed), it should be noted that the RMS error is about the same as for the point source solution, case number 1. Since the latter involves less degrees of freedom, it would be preferred from a statistical point of view. The point source solution does not completely specify a single double couple, hence the corresponding fault is not necessarily plane. This raises a question about the effect of the plane fault assumption in source analysis. Another question concerns the effect of errors (or anomalies) in the data. To investigate these problems we computed synthetic seismograms for the point source solution (displayed in Fig. VI.1.1), and these syntheses formed the basis of a number of inversion experiments, also summarized in Table VI.1.1 and Fig. VI.1.2. From these experiments we conclude that unjustified assumption of a plane fault may lead to overestimate the fault surface area. The same is true if the data are corrupted by errors (or anomalies). The significance of the effect depends on the relative excitation factors of the source parameters. It should be realized that this effect is not a consequence of the moment tensor representation; it is to be expected in any method of source analysis. In the moment tensor formulation however, the plane fault assumption can be avoided.

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References

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Dziewonski, A.M., T.A. Chou and J.H. Woodhouse, 1981: Determination of source mechanism and hypocentral coordinates from waveform data, in 'Identification of Seismic Sources', eds. E.S. Husebye and S. Mykkeltveit, D. Reidel Publ. Co.

Table VI.1.1 Results of inversion with constraints, for Bali Sea event of 1978, June 10. M and N are scalar moments of major and minor double couple, $\Delta(\tau^2)$ is temporal moment of degree two, $\bar{v}$ is average rupture velocity, a^2,b^2,c^2 are eigenvalues of source ellipsoid. Standard deviations in parentheses Fault constraints as discussed in the text, and given explicitly in Doornbos (1982).

Nr	Data	Fault Constrained	M (10^{25} dyne·cm)	N (10^{25} dyne·cm)	$\Delta(\tau^2)$ (s^2)	$\bar{v}$ (km/s)	a^2 (km^2)	b^2 (km^2)	c^2 (km^2)	RMS error
1	Observed	No	1.07 (±0.06)	0.10 (±0.07)	0	0	0	0	0	631
2	Observed	No	1.09 (±0.10)	0.09 (±0.10)	3.23 (±27.14)	45.0 (±75.2)	789.9 (±1120.9)	-3051.9 (±1793.8)	-686.0 (±2489.3)	515
3	Observed	Yes	1.10 (±0.13)	0	0.91 (±1.43)	3.9 (±7.4)	27.6 (±4.7)	1.6 (±4.4)	0	632
4	Synthetic	No	1.07	0.10	0.06	9.9	7.2	-1.2	-1.0	3
5	Synthetic	Yes	1.07	0	0.39	4.4	7.9	2.9	0	59
6	Synthetic*	Yes	1.06	0	0.19	6.9	37.7	4.4	0	56
7	Synthetic**	No	0.93 (±0.05)	0.02 (±0.05)	1.30 (±12.93)	58.7 (±35.8)	1178.8 (±534.2)	-1380.4 (±854.9)	-330.5 (±1186.3)	301
8	Synthetic**	Yes	0.92 (±0.06)	0	1.05 (±0.68)	0.3 (±3.5)	37.1 (±2.2)	0.1 (±2.1)	0	330

* In case number 6, rupture velocity is unconstrained.

** In case number 7 and 8, random errors have been introduced into sythetics.

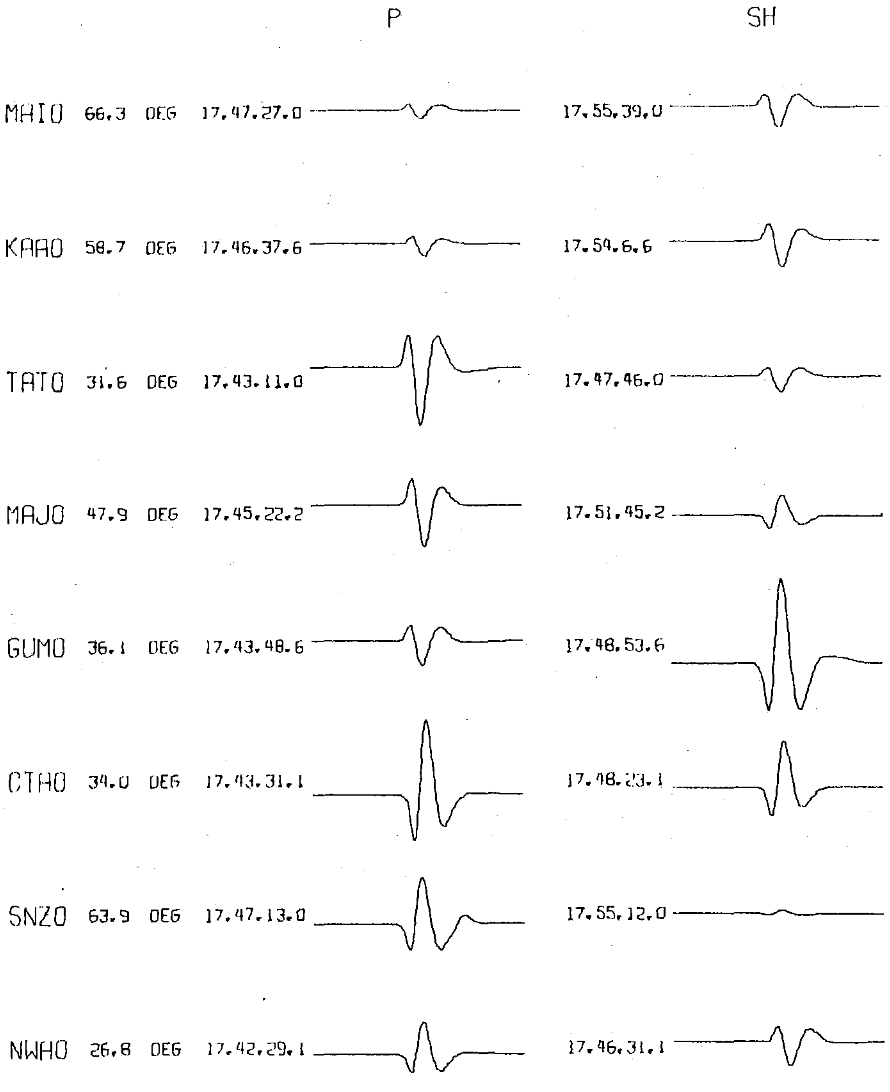

Fig. VI.1.1 Synthetic records with P and SH at SRO and ASRO stations, for a source corresponding to the solution of case number 1 in Table VI.1.1. Record length is 2.5 minutes. Different amplitude scale for different components.

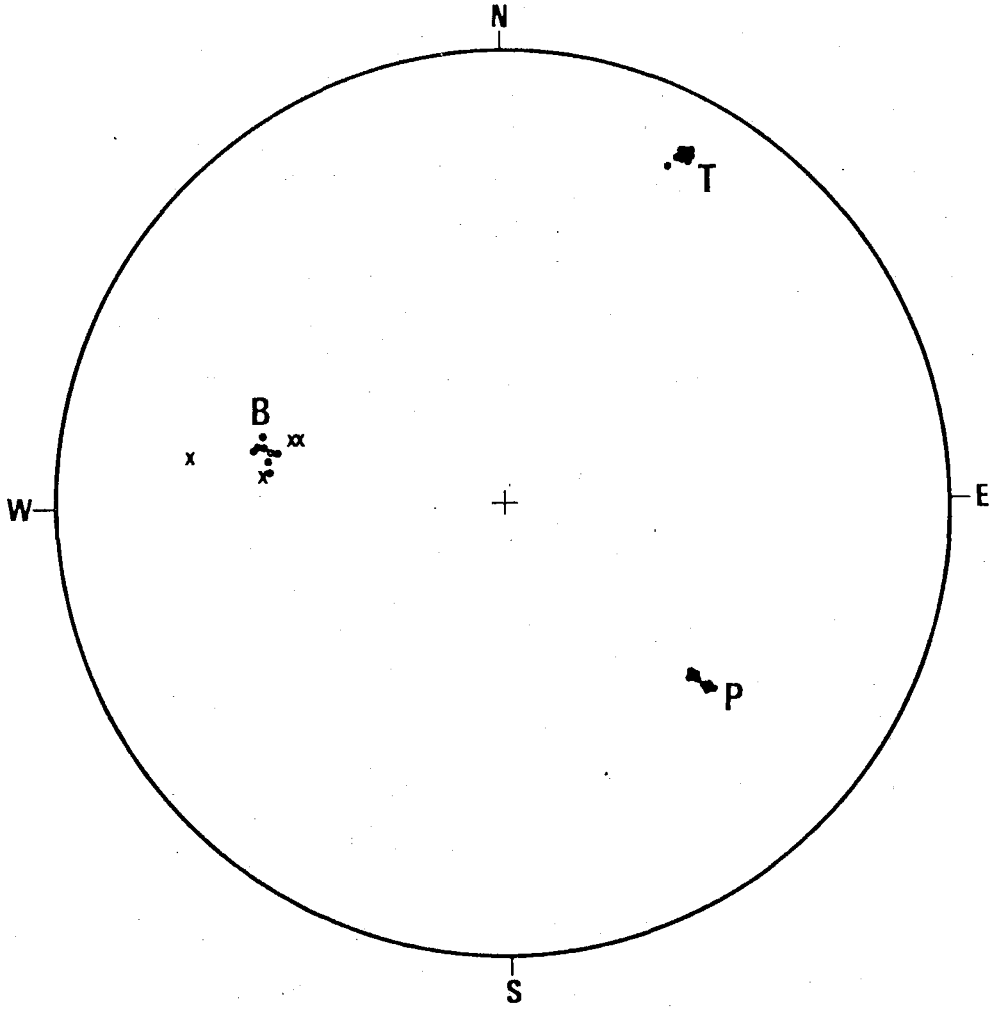

Fig. VI.1.2 Fault plane solutions in equal area projections for the cases in Table VI.1.1. ●: Principal axes of moment tensor of degree zero, x: Major axis of moment tensor of degree two, in cases where fault constraints were imposed.