A NUMERICAL METHOD FOR FOCAL MECHANISM DETERMINATION USING S WAVE DATA

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The study of focal mechanisms in seismology aims to find what kind of dynamic processes take place at the focus of an earthquake. The analysis of body and surface waves has been used to determine the nature and orientation of the forces acting at the focus of an earthquake. A graphical method based on the analysis of the polarization of the transverse waves has been successfully proposed and extensively used by Stauder (1960, 1962, 1963).

The theoretical displacement field due to various combinations of forces applied at one point in an infinite elastic medium has been developed by Love (1904), Nakano (1923) and Keilis-Borok (1957). These equations have been used in this dissertation to develop a statistical method to determine the orientation of assumed single and double couple sources at the focus of an earthquake from the observation of the polarization angle at N stations.. For a single couple source the method uses a least squares procedure and Lagrange's method of undetermined multipliers to find the orientation of the single couple model best fitting the observed polarization angles. The method thus proposed reduces to finding the eigenvalues and eigenvectors of the matrix formed by the coefficients of the normal equations.

For the double couple source the direction of one of the couples is assumed as known and the orientation of the second couple is calculated from the data at each station. The spread in the orientation of the second couple, given by

$$E = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left\{(\bar{\Theta}_y - \Theta_{y_i})^2 + \left[(\bar{\Phi}_y - \Phi_{y_i})\sin\left(\frac{\bar{\Theta}_y + \Theta_{y_i}}{2}\right)\right]^2\right\}}$$

is minimized with respect to the Θ and Φ coordinates of the orientation of the first couple. The minimum of the function E is found by applying the Newton-Raphson method to finding the roots of the equations

$$\frac{\partial E}{\partial \Theta_x} = 0 \qquad \text{and} \qquad \frac{\partial E}{\partial \Phi_x} = 0 .$$

These two methods have been programmed for an IBM 1620 computer and applied to the determination of the mechanism of 34 earthquakes in the Kamchatka-Kuriles Islands Region, 25 in the Aleutian Islands Region and 6 in Chile-Argentina.

For most of the Kamchatka earthquakes the observed data were found to conform better to a double couple mechanism. The directions of the principal axes of stress for all the earthquakes of this group are very uniform. The axis of tension is in all cases almost vertical. The axis of pressure is almost horizontal and perpendicular to the regional trend of the Kamchatka peninsula and the Kuriles Islands. This orientation of

the regional stresses suggests a thrust fault along the coast line with the continental block moving over the oceanic.

These results show a good agreement with the results found by the application of the graphical method.

For the 25 Aleutian Island earthquakes, only a few of the numerical solutions show a good agreement with the previous graphical solutions (Stauder and Udias, 1963). The lack of agreement in the solutions is due in part to the inclusion of P wave data in the graphical solutions and to the way in which inconsistent readings affect the numerical solutions.

The six earthquakes of Chile-Argentina show an attempt to establish an S wave solution for earthquakes where the available data are necessarily reduced to that obtained from stations covering a small range of azimuths.