DETERMINATION OF EARTHQUAKE FAULT PARAMETERS FROM LONG PERIOD P WAVES

by
Gilbert Arthur Bollinger, B.S.

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Recent theoretical studies predict a "Doppler-type" effect in the time duration of the elastic radiation from propagating sources. When applied to the study of earthquakes, this phenomenon offers the possibility of estimating some of the causal fault parameters. In this investigation the teleseismic long period P wave radiation from four large earthquakes is studied in an effort to detect and analyze any Doppler-type effect present in the waveforms.

Initial observational efforts consisted of referencing the time domain behavior of the long period P waves against their epicenter-to-station azimuths. These studies revealed that, both in time duration and in waveform characteristics, a Doppler-type effect was present. They also showed that this effect was relatively distance-independent. One of the four earthquakes studied, the Alaska aftershock of 02 hours, March 30, 1964, showed the phenomenon especially well. The nodal plane geometry for this shock was unusually symmetrical, that is, one plane was of near vertical orientation and the other was of near horizontal attitude. The P wave periods for this event were observed to be systematically longer in time duration for azimuths perpendicular to the vertical nodal plane than for azimuths parallel to that plane. Study of the P waveforms showed that this temporal extension-constriction effect was uniform throughout the entire wavetrain.

A time-domain mode for the interpretation of these observations was selected. This necessitated extension of the existing theory and the formulation of interpretational procedures. The extension of theory was made by the introduction of the total time of faulting (TT) as the fundamental variable. This variable, TT, was studied theoretically for various fault plane orientations, fracture patterns, and fracture velocities. The results of these studies show that the P pulse lengthens in time duration as the fault length increases and as the fracture velocity decreases. The emitted pulses assume different patterns of temporal behavior for unilateral and bilateral fracture patterns. Finally, the azimuthal variation in pulse time is shown to be greatest in the case of unilateral fracturing. For both unilateral and bilateral rupture this pulse time variation is greater for horizontal faults than for faults of vertical orientation.

Continuing in the time domain, the effect of the mantle path on the P pulses radiated from the faults was implicitly taken into account by postulating several different waveforms as incident at the base of the receiver-crust. The receiver-crust and seismograph effects were explicitly considered by convolving the incident pulses with the impulse response of this crust-seismograph system. The time duration of the resulting synthetic seismograms could then be related to the time duration of the incident pulses. Since these latter time durations are controlled by the causal fault, a relationship between the parameters of the source of the P waves and the observed P waves is established.

The time duration of the first half-cycle of the long period P waves from the previously mentioned four earthquakes were reduced by means of the observed TT relationship of the incident waves. The multiplicity of observing stations over-determines the solution (the fault parameters) and a least squares approach is employed in each case to select the fault length-fracture velocity combination that best satisfies the observational data.

This interpretational procedure yielded the desired fault parameters for the four earthquakes studied. The quantitative results so obtained were found to be in good agreement with the results obtained by other workers employing different analytical techniques.