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RUPTURE HISTORY OF THE 1979 IMPERIAL VALLEY EARTHQUAKE ESTIMATED FROM EL CENTRO STRONG-MOTION ACCELEROGRAMS

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SUMMARY

The rupture history of the 1979 Imperial Valley, California earthquake is estimated using the strong-motion accelerograms in El Centro. The arrival times of the distinct phases at the El Centro differential array and at the El Centro array #9 are examined with reference to the source time map by Supdich and Cranswick (1984), and the location and timing of the sources which caused these phases are determined. The result is inconsistent with the rupture propagation with fixed source depth, and suggests the large break at shallow depth and the jump of the rupture.

INTRODUCTION

During the 1979 Imperial Valley earthquake, a considerable number of the strong-motion records were obtained owing to the dense observation network in the Imperial Valley (Ref.1). Using these records, the rupture process of the earthquake, which provides a basis on nature of near-field motion, has been already studied by several investigators (Refs.2,3,4). Although almost the same strong-motion data set was used in these studies, some discrepancies can be found among these studies probably due to complexity of the rupture process. Consequently, the details of the rupture process remain still uncertain.

Spudich and Cranswick (Ref.5) investigated on the rupture propagation of this earthquake by means of the cross-correlation of the records on the El Centro differential array which is a 213-m-long linear array of five accelerometers. They extracted the evidence of the rupture propagation, but could not reveal the rupture history determinately. This is because such records from the linear array are insufficient to determine the rupture history. In this paper, to supplement their study, the accelerograms from the adjacent station in addition to the array are examined to estimate the rupture history of the earthquake.

COMPARISON OF ACCELEROGRAMS AT EL CENTRO ARRAY #9 AND DIFFERENTIAL ARRAY

The El Centro Array #9 (E09) is located only 1.3 kilometer west of the El Centro differential array (EDA), as shown in Fig.1. The location of this station is favorable to the analysis of the rupture history, because EDA is a linear array in a NS direction and a combination of EDA and E09 may be considered as a two-dimensional array. At E09, an old-type C&GS accelerograph

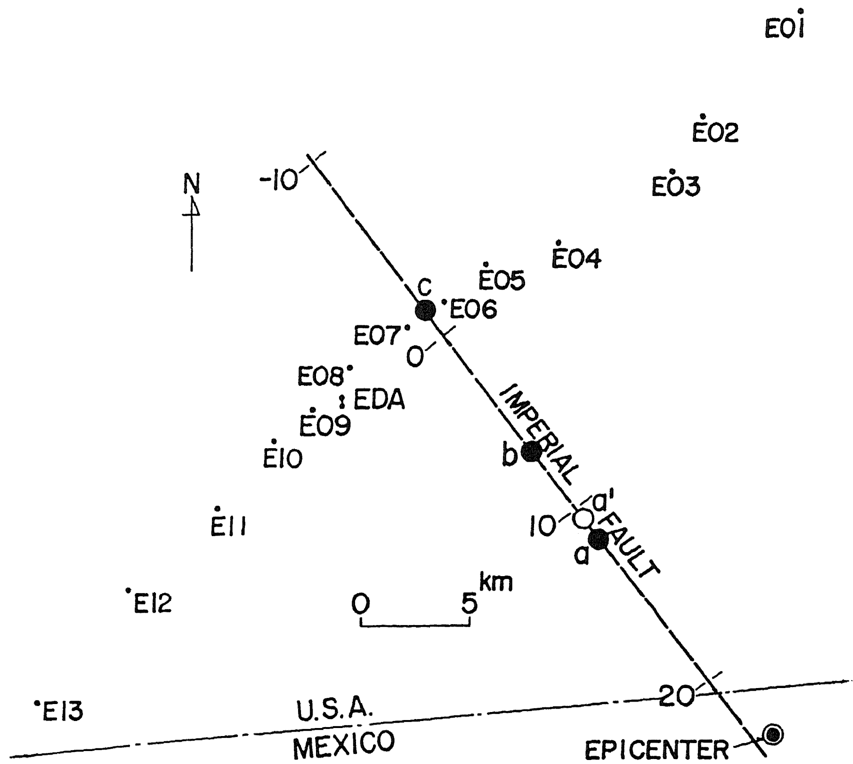

Fig.1 Location of Strong-Motion Stations in the Imperial Valley

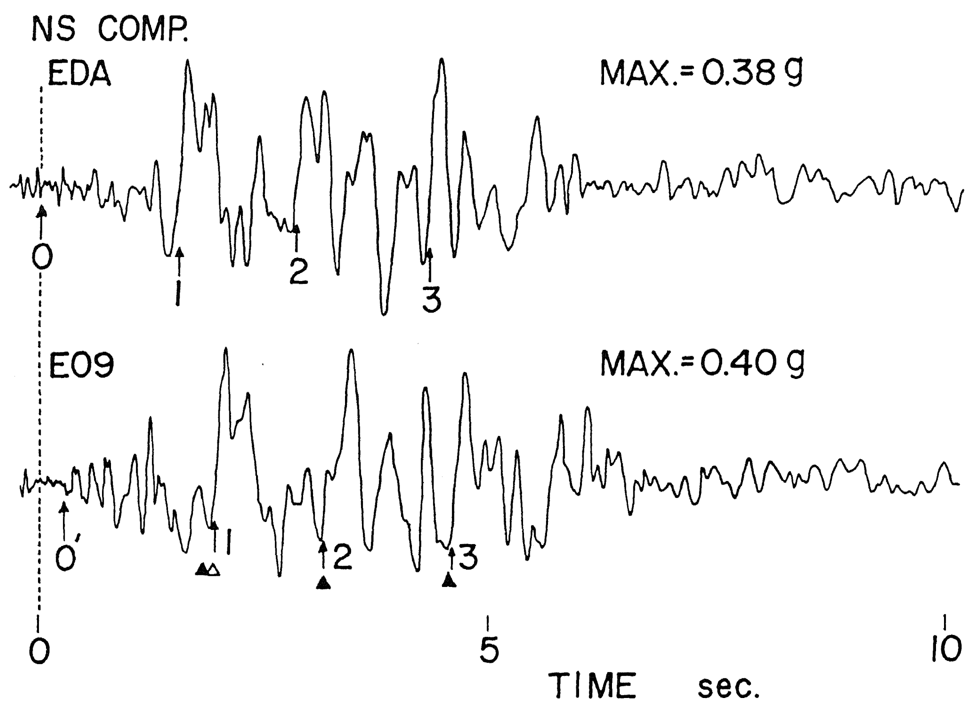

Fig.2 Comparison of Accelerograms (NS Component) at EDA and E09

was installed and recorded the strong motion during the earthquake. This accelerogram, however, has some problems, that is; (1) paper transport delayed *several seconds after the time of triggering*, (2) *irregular paper transport* occurred for a half second at the main part of S-waves, and (3) no absolute time was recorded. Accordingly, this accelerogram was not digitized by U.S.G.S. which is in charge of this station.

Although the quality of this accelerogram may not be excellent, the author has already digitized this accelerogram carefully and made the time-spacing correction for the part of the irregular paper transport (Ref.6). The part of the largest vertical motion is lost due to the delay in the paper transport, and it may be difficult to discuss the correlation of the vertical motion at E09 with that at EDA. As for the horizontal motion, however, the correlation of both records could be investigated, because the paper transport started before the first S-wave arrival. The comparison of NS-component of both records is shown in Fig.2. The waveforms are similar to each other, and several corresponding phases are found as numbered in Fig.2. If the location and timing of the sources which caused these phases are determined, the rupture history can be revealed.

In order to discuss the arrival time of these phases, it is necessary to establish the relative time base of both records. For this purpose, the travel time of S-wave and the first S-wave arrival in the records are used. As shown in Fig.3, the travel time curve is computed for the velocity structure in the Imperial Valley. The velocity structure used is shown in Fig.4. The difference in the travel times from the hypocenter to EDA and to E09 results in 0.26 s. The position of first S-wave arrival in the EDA record has been indicated in Ref.5. This position shown by the phase 0 in Fig.2 is set to 0 s. The position of first arrival in the E09 record can be read at the phase 0' in Fig.2, and this position should be set to 0.26 s that is the difference in the computed travel time.

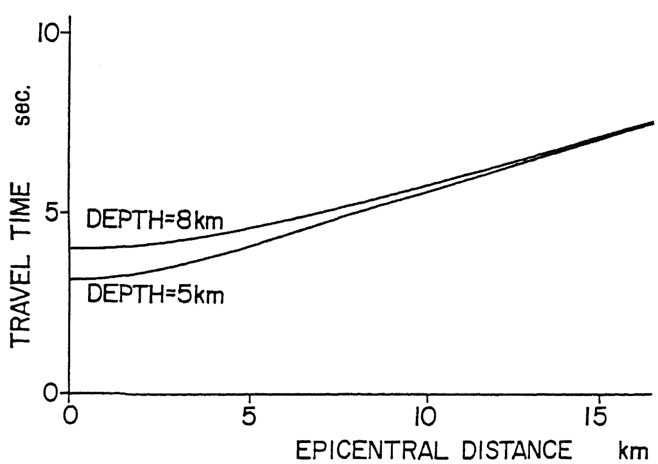

Fig.3 Travel Time Curve of S-wave

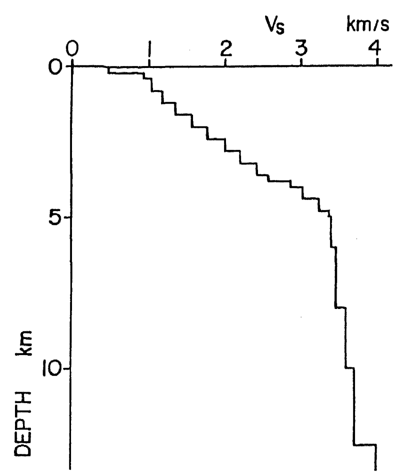

Fig.4 S-Profile in the Imperial Valley

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To determine the location and timing of the source, in addition to the timing of these phases, the source time map derived from EDA array records

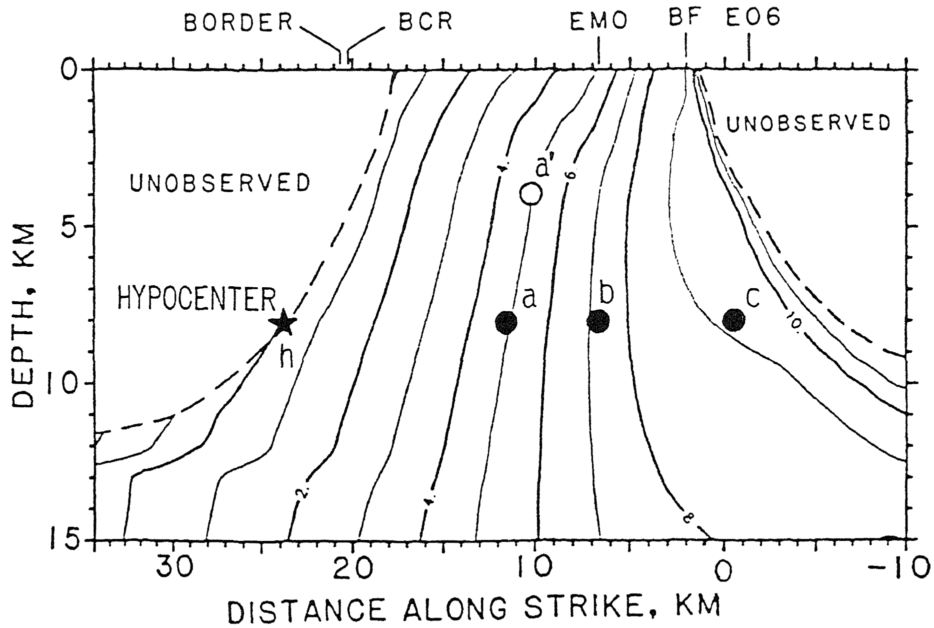

Fig.5 Source Time Map (after Spudich and Cranswick, 1984)

(Ref.5) is used. This map shown in Fig.5 means the allowable combination of location and timing of individual source over the fault plane. Using this map, when the source depth is fixed to be 8 km, the sources of phases 1 to 3 of the EDA record can be located at points a to c, respectively. The location of these points is shown in Figs.1 and 5. The arrival times of S-wave at E09 from these sources are calculated and shown by solid triangles in Fig.2. For the phases 2 and 3, the calculated arrival time agrees well with the observed. For the phase 1, however, the calculated S-wave arrives faster than the observed phase. Consequently, it could be considered that the sources b and c are plausible, but the source a is not acceptable.

The location and timing of the source which satisfy the arrival time of the phase 1 on both records are found from the source time map by a trial-and-error procedure. As the result, the source for the phase 1 can be located 13 km north-west from the epicenter at depth of 4 km, as shown by a' in Figs.1 and 5. The calculated arrival time at E09 from this source is shown by open triangle in Fig.2. This shallow location is not consistent with an interpretation by Spudich and Cranswick (Ref.5) that the rupture propagates at 8 km depth with variable rupture velocity.

If the source a' with shallow depth occurred indeed, the surface-wave should be recognized in the strong-motion records. Fig.6 shows the vertical ground velocities at the El Centro strong-motion stations that are E01 to E13. The location of these stations is shown in Fig.1. It has been already confirmed that the later phases with longer period in these records are due to Rayleigh wave excited in sediments (Ref.7). Considering the radiation pattern of Rayleigh wave by the source a', the Rayleigh wave with larger amplitude must be observed at E03, E10 and E11. Actually, the amplitude of the later phase is larger at E02, E03, E04, E10 and E11, as shown in Fig.6. Therefore, the observed Rayleigh wave in the strong-motion records supports the location of the source a'.

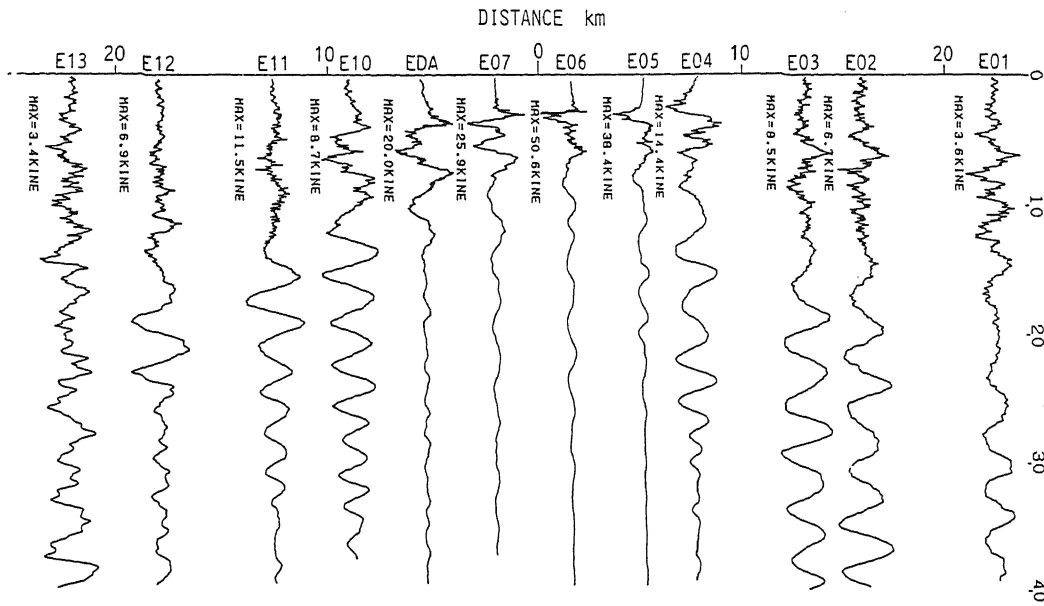

Fig.6 Vertical Ground Velocities at El Centro Strong-Motion Stations

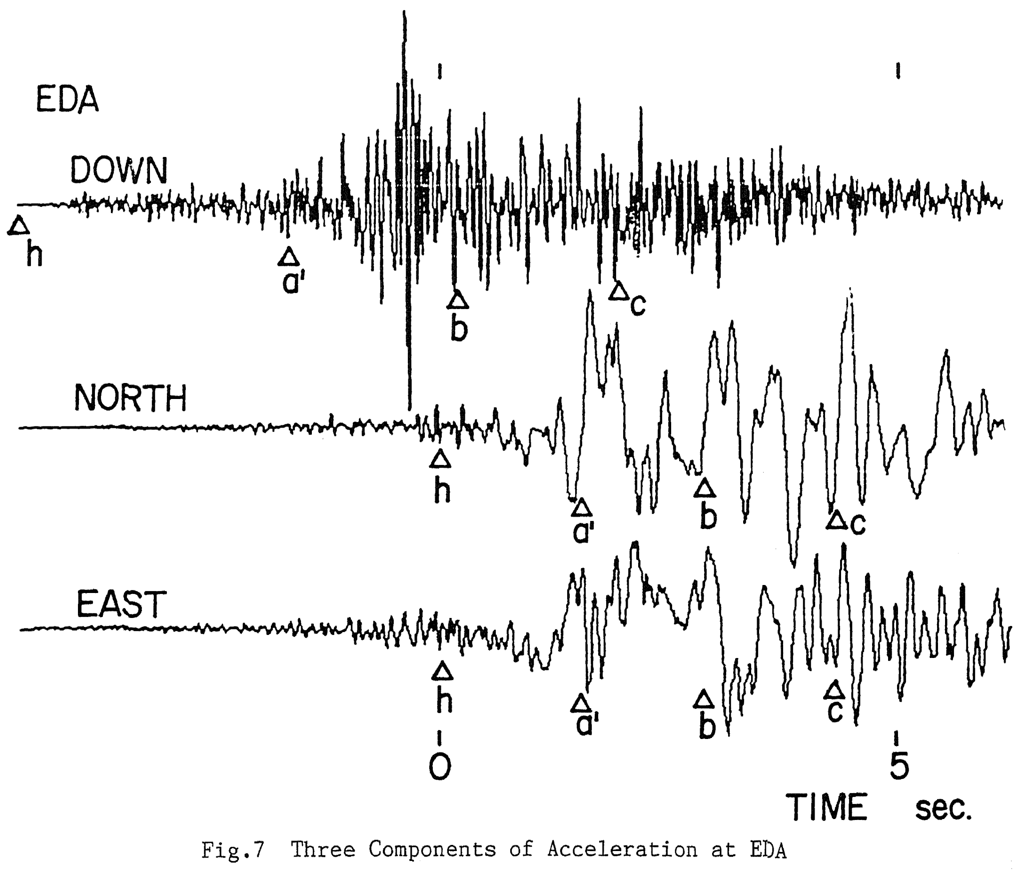

Fig.7 Three Components of Acceleration at EDA

According to the location and timing of the sources a', b and c, it follows that the rupture propagates upward from the hypocenter to the source a' with subshear rupture velocity, and then the rupture jumps down to the source b and propagates to the source c with supershear rupture velocity. The phases in the EDA record which caused by the sources h(hypocenter), a', b and c are indicated in Fig.7. The large amplitude vertical acceleration (LAVA) is recognized between the phase by the source a' and that by the source b. This suggests that LAVA is generated during the jump of the rupture.

CONCLUSIONS

The rupture history of the 1979 Imperial Valley Earthquake is investigated from the El Centro strong-motion accelerograms. The following interpretation on the rupture history of the earthquake may be possible;

(1) The rupture propagates upward from the hypocenter to the source a' at subshear rupture velocity.
(2) Then, the rupture jumps down to 8 km depth, and this jump may cause the large amplitude vertical acceleration.
(3) After the jump, the rupture propagates about 10 km at supershear rupture velocity.

ACKNOWLEDGMENT

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