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Fault plane solutions of the earthquakes (1.8≤ M_L ≤ 3.5) in the Himachal Himalaya, India

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ABSTRACT

It is widely acknowledged that even when earthquakes occur inside a specific confined area, there can be significant variations in the focal mechanism solutions. Several earthquakes have been detected by broadband seismometers coupled with a digital recorder (Centaur) at six stations in the Himachal Himalaya during 2018-2019. Therefore, we addressed an approach for identifying the orientation of fault planes in the studied area. In this paper, we retrieved the fault plane solutions of 25 earthquakes using a double couple fault plane method, based on P-wave polarity readings and amplitude ratio with the help of the Seisan program. Earthquakes exhibit diverse fault plane solutions. From a total of 25 earthquakes, 3 show normal faulting, 19 show reverse faulting, and 3 show strike-slip mechanism. This is because rupture lengths for local events (M < 3.5) are typically in the range of a few hundred meters to a kilometer, and events may occur on faults with varying orientations. The maximum concentration of thrust faults is consistent with the trend of the Himalayan collisional zone and the location of major faults. Except for some showing a dip greater than 60°, earthquakes with precisely measured depths characterise a zone from 0.1~25 km with an average dip of about 44.6°. All focal mechanisms of events that are available within this zone, indicate a steeper dip. An earthquake that occurred near the Sundarnagar fault, shows a strike-slip mechanism. Based on this interpretation, there may be a genetic relationship between the Himalayan block above the MBT and a transverse structural feature in the underthrusting Indian plate (Sundarnagar fault). Earthquakes reveal a trend of directions concerning the T-axis and P-axis with all types of fault plane solutions.

Keywords: Earthquake, Fault plane solution, Geology and tectonics, Underthrusting, Himachal Himalaya region.

INTRODUCTION

The nature of the instantaneous faulting or earthquake process is one of the most substantial and engaging issues in seismology. The triggering mechanism and the natural mechanism of elastic strain concentration are the fundamentals of earthquake kinematics. Conventionally, the term "fault plane solution" (FPS) relates to the fault orientation, the patterns of stress release, and displacement direction, as well as the dynamic mechanism of seismic wave propagation. The FPS explains the pattern and geometry of faulting following an earthquake. The fault geometry affects the radiated amplitudes in various azimuthal directions, therefore, the FPS is derived from the polarity of the first motion or the amplitude of seismic waves. There is a persuasive explanation that the progressive stresses caused by plate movements, affect specific regions of the Earth's crust and the upper mantle. When stressed rocks suddenly fracture, strain and stress are released simultaneously, which produce seismic waves or earthquake waves. Abrupt fractures typically happen at weak spots in the stressed rocks. The blocks that move in opposite directions due to shear motion on either side of the fault plane, or fracture plane, are referred to as fractures. Since shear motions do not entail a volume change, they can happen anywhere in the brittle region of the Earth's outermost layers, even at significant depths in the upper mantle in some circumstances, where the pressure is quite high. These findings demonstrate that several events with various focal mechanism solution orientations can take place even within a very small region with a few kilometers in dimension. Teleseismic observations from the global network in the 1960s provided sufficient data to determine focal mechanisms for strong and medium-sized earthquakes that were successfully used to formulate the general theory of plate tectonics (Isacks et al., 1968). During the last 15 years, the availability of dense portable networks has permitted the field study of regional micro-seismicity, aftershocks of large earthquakes, swarms, and volcanic events. The methods used for global studies were transferred to local problems without basic modifications. Nevertheless, even in the case of a large number of seismic stations, it is difficult to set up a local network surrounding the focal sphere satisfactorily.

The tangential traction at the interface between two bodies can be inferred from their relative motion. It would be feasible to draw conclusions about the regional stress field if the tangential traction in a given area could be recognised on a variety of planes. A sudden physical change of the ground during an earthquake, releases the accumulated elastic energy. The two blocks of a fault move in opposition to one another, which results in first P motion with distinct polarities in various directions. It would be easy to identify the orientation of the two planes if the measurements from numerous equally dispersed stations around the epicenter were available by partitioning the area into four quadrants with different polarities. However, there is no way to differentiate between the fault plane and the auxiliary plane without additional information. The double-couple source method relies on this inherent ambiguity. To identify the fault plane, there are a few different approaches. A surface break on a fault caused by an earthquake must match one of the planes in the mechanism solution for the displacement and fault plane that were observed. Different approaches must be used because the majority of earthquakes do not coincide with a surface break