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A NEW METHOD FOR THE EXTRACTION OF SLIP DIRECTION AND TECTONIC EVOLUTION STUDY THROUGH PALEOSTRESS INVERSION

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The importance of the tectonic evolution in understanding the tectonic changes of the earth's crust is irrefutable and calculating the paleostress and the present day stress through dynamic analysis of faults is necessary in this regard. Several methods based on the inversion of fault slip data (strike, dip, and slip direction) have been proposed. The required data can be obtained both through field observations and also from the focal mechanisms of earthquakes. However, in the meantime, finding a slip direction in comparison to other data is always more challenging, especially if the fault is buried and inactive. Hence, in this study, a method was developed and formulated to calculate the slip direction in these cases. This method employs a 3D modeling software and utilizes the interpreted 3D seismic data. The three-dimensional fault surface is modeled by triangulation, each triangle as a single fault plane has its own unique slip data.

In the estimation of the slip direction, the separation data provided by the inclined shearing algorithm of the commercial restoration software were used. The relation between the slip vector with the pair of separation points is the base of our discussion. The pair of points which had been a part of integrated formation before the faulting are separated after faulting so that they are on different sides of the fault plane. An imaginary line connects them to show the direction of the slip on the fault plane. Therefore, the vector connecting the separation pairs is the slip vector, and its angle with the vector of the strike is the slip angle or rake:

$$\text{Rake} = \pm\varphi = \cos^{-1}\frac{[\cos(90-\theta)].\Delta X+[\sin(90-\theta)].\Delta Y}{\sqrt[2]{\Delta X^2+\Delta Y^2+\Delta Z^2}} \quad (1)$$

The pair of separation points in this algorithm was derived from the intersection of a cut plane (a page always perpendicular to the horizon, with 360 degrees of freedom) with the fault line containing the Allan lines. The fault divides each seamless horizon into two distinct parts, and Allan's lines are obtained from the intersection of the horizons and the fault plane. Therefore, for each faulted horizon, there are two Allan lines on different sides of the fault plane. From each Allan line, a separation point is extracted, and from a series of two Allan lines, one pair of separation points are extracted. By choosing an arbitrary angle for cut-off section and keeping that angle constant and moving the cut-off section along the length of the fault, several separation pairs are obtained. Next, in each trial, we change the cutting angles, so that it will eventually cover all 360 degrees. Finally, we put all the obtained angles (in each triangular surface as a fault plane) along with their respective strikes and dips as input data for the stress inversion. Finally, we compare the outputs and select the best result, by using the inversion parameter, misfit; which is the angular difference between the observed and calculated slip direction in the homogenous stress field, as a quality control tool.

In this study, in one of the southwestern hydrocarbon fields of Iran, the paleostress in different horizons with different geological ages and also present-day stress state was estimated. The tectonic evolution of the study area is determined by showing variations in SHmax directions obtained through the inversion of the fault slip data from 3D seismic interpretation by using two methods of Slip Angle and Instability (Lund-Slonga, 1999). Based on these results, during a comparatively long time from the early Cretaceous to the middle of the lower Tertiary, the direction of the maximum horizontal stress (SHmax) is NW-SE. But the results of the stress inversion official mechanisms (calculated at local and teleseismic distances) shows that the stress orientation has changed from NW-SE (paleostress data) to NE-SW (present state of stress). The comparison of the obtained results with the global stress map also shows the correlation between the obtained maximum horizontal stress with the regional SHmax directions. In conclusion, clockwise rotation in the maximum horizontal stress (SHmax) has taken place in the southwestern Zagros, from the middle of the lower Tertiary up to present time.

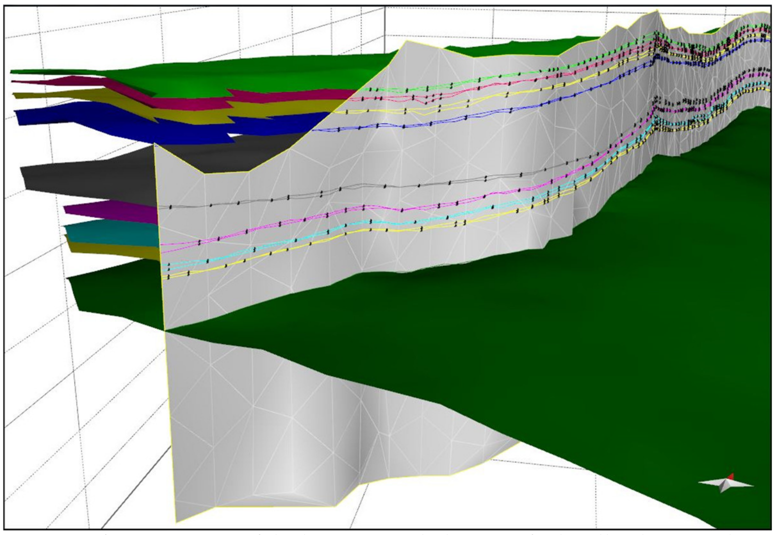

Figure 1. Illustration of intersections of the horizons with the main fault, Allen lines, and separation pairs.

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