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Paleostress analysis of the Groningen gas field, the Netherlands, based on high-resolution 3D seismic data.

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To reconstruct the paleostress tensor from faults, information is required on both the fault orientation and the direction of slip on the fault. Traditionally this data is gathered by direct fault plane measurements in the field, in quarries or in mines, which leads to a relative under representation of areas where rocks from the time of interest are not outcropping (e.g. sedimentary basins).

We propose a workflow based on high-quality 3D seismic data that approximates slip-vector orientations by 3D structural balancing. Fault orientations and associated slip vectors are then used to establish paleostress tensors.

The studied area extends over ca. 750 square kilometers in the NW of the Dutch Groningen high. Here, 13 horizons and 55 normal faults were interpreted between Tertiary and Top Rotliegend stratigraphic levels. Special attention was given to the detailed interpretation of kinematic indicators such as en-echelon fault assemblages, fault grooves, fault splays and fault bifurcations. For this dataset the use of fault shape and horizon cutoffs was selected as a kinematic indicator. In a following work step, all interpreted horizons and faults were balanced for slip-vector approximation. Numerical Dynamic Analysis was subsequently applied for a calculation of paleostress tensors for 1) the Tertiary Lower to Middle North Sea interval, 2) the Upper Cretaceous Chalk interval and 3) the Top Rotliegend horizon.

First results from the NW Groningen area show a clear correspondence with known data for the three time periods under review. The paleostress data calculated for the Tertiary and Cretaceous units correspond well with published paleostress estimates from Southern Germany, France and Great Britain. However, whilst the orientation

of the maximum horizontal compressive stress in this study and previous works are near identical, a difference is observed in the orientation of the principle stresses. This difference might result from the position of the study area on a structural high, dominated by normal faulting, while in other areas inversion was observed. The orientation of the stress tensor in the Top Rotliegend horizon shows excellent correspondence with published data of the Triassic stress field.

This study indicates the potential of the above method as a tool for paleostress reconstruction where classic paleostress reconstructions are not possible. However, the scale of this study compared to the scale of other paleostress studies, the validity of the basic assumptions in paleostress inversion and the identification of unambiguous fault-slip indicators from seismic data require further study. Extension of the approach to different regions in the Netherlands will increase the understanding of basin evolution, halokinesis and tectonic inversion in the Dutch part of the Central European Basin.