Azimuthal resisitivity survey - a confirmatory information on the kinematics of near-surface fractures at the Enugu area, Anambra basin, Nigeria

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Abstract

On outcrop scale, the Cretaceous sedimentary rocks of the Anambra basin bears some rarely mentioned and studied deformational structures till date. Extrapolation of the results of orientation of these fractures into the subsurface will enhance the understanding of the permeable zones, fluid migration pattern and therefore increase the success rate in the exploration and exploitation of groundwater and even in the management of the mine drainage problems in the Enugu coalfields. Results of the structural analysis of joints and faults obtained from exposures of the Enugu Shale and Mamu Formations formed the basis for establishing the paleostress direction and stress field rotation within the study area. Two faults occurring at the Enugu Shale exposure near the Onitsha Fly-over gave the impression of conjugate or antithetic fault pattern with one of the faults striking 50^o azimuth and dipping 52^o with a dip direction of 320^o (that is NW) and the other fault striking 315^o and dipping 45^o with a dip direction of 65^o (that is NE). Studied joints gave a NW – SE orientation of the maximum principal stress (σ_1). The joint spacing also ranges from 10 to 100 cm in the Enugu Shale to about 300 cm at the top unit of the Mamu Formation. To further confirm the information furnished by outcrop fracture survey, two Azimuthal Resistivity Surveys (ARS1 and ARS2) were used in characterizing the fracture system within the study area. Azimuthal resistivity survey has an advantage over an outcrop fracture survey in that it is not dependent on small-scale site constraints thereby providing a more representative distribution of fracture directions. Measured apparent resistivities changed with the orientation of the fractures. Graphical interpretation of the ARS data indicates that the dominant fracture strike is oriented in the north-north-west direction at the shallow depths of 7.1, 10.0, 20.0 and 28.3 m. The coefficient of anisotropy, λ ranges from 1.00 to 1.12. Fractures at localities with relatively high values of λ posses relatively high fracture porosity and relatively low specific surface area and thus more likely to be intensely fractured and permeable The fracture porosity estimated from the azimuthal resistivity survey ranged from 0.001 (at the A-spacing of 7.1 m) to 0.03 (at the A-spacing of 20.0 m) for station AR1 and also ranged from virtually no fracture presence (at the A-spacing of 7.1 m) to 0.06 (at the A-spacing of 20.0 m) for station AR2. The fracture porosity from field measurements on outcrops ranged from 0.00054 to 0.00148. This is typical of the fracture porosity estimated at the A-spacing of 7.1 m at the two stations indicating deeper fracturing in the subsurface than in the near-surface. Generally, results from integrated geological and geophysical study indicate a major fracture direction in the north-north-west direction with other minor orientations.

Keywords: azimuthal resistivity survey, outcrop fracture survey, fracture strike, coefficient of anisotropy