Geostress Assisted Evolving Permeability Anisotropy and Its Possible Implication in Hydrocarbon Exploration and Exploitation

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The present paper introduces concept of 'geostress assisted evolving permeability anisotropy' with use of stress induced acoustic emission and seismic wave (primary wave) response of rocks under variable stress conditions. The utilized concept may be helpful in identifying the hydrocarbon (petroleum) bearing strata and problems of petroleum migration, damage to petroleum wells caused by the variation in geostress conditions due to tectonic and technogenic activities. The study is based on the assessment of stress-induced evolution of permeability anisotropy with use of relative damage factor (RDF) in similar designed analogous experimental conditions. The sandstone specimens collected form different locations with respect to fault plane from vertical structural litho-succession of Upper Kaimur Group, Vindhyan Supergroup were used for the purpose due to their geomechanically isotropic nature (0.98). The prepared cubical and cylindrical samples of sandstones of dry and saturated with water, kerosene, petrol and diesel were deformed under cyclic stress conditions and incremental stress conditions on servo-controlled Material Testing System (MTS) to quantify the values of geostress and RDF by using acoustic emission analyzer system (MISTRAS-1100) and simple ultrasonic concrete tester.

The results of experimental investigations revel that the values of geostress is lower in locations near the fault planes (10.87 MPa-11.12 MPa). However, the value of geostress is higher away from fault plane (19.24MPa-21.42 MPa). Further, the sandstones located close to fault plane saturated with water, kerosene, petrol and diesel exhibits decreased geostress value such as 5.45MPa, 6.61MPa, 7.42 MPa and 9.01MPa respectively. However, the sandstones far away from fault plane under saturated conditions with water, kerosene, petrol and diesel imparts decreased values of geostress like 20.52MPa, 20.66MPa, 20.75MPa, 21.12MPa respectively. The decreased values of geostress due to saturation are maximum in low stress zones and minimum in high stress zone. The higher values of RDF in rocks of low geostress zone indicate the higher permeability of the in strata in natural condition. In saturated conditions the sandstone having low geostress values shows higher reduction and RDF values In particular the sandstones saturated with water shows higher RDF values in comparison to sandstone saturated with kerosene, petrol and diesel may be due to interaction of water with the matrix of rock resulting into the corrosion of matrix. Similarly the sandstones of lower geostress zone imparts highest RDF in parallel, intermediate in oblique and least in perpendicular direction to stress axis. In incremental stress condition the sandstone of low geostress zone exhibits initial decrease in RDF and reaches constant values. With progress in deformation the values of RDF pronouncedly increase parallel to stress axis in comparison to oblique and perpendicular to stress axis. In the last phase of deformation the values of RDF enhances more in oblique direction in compression to parallel and perpendicular direction to stress axis. The variation in value of RDF suggests the rate of evolution of permeability varies with direction and magnitude of change in stress with geostress condition of basin. The sandstone of lower geostress values saturated with water and hydrocarbons shows further enhancement in evolution rates of permeability evidenced from increase RDF values. Thus both natural and saturated sandstones of different geostress zones deformed under incremental stress condition exhibits highest RDF parallel, higher oblique and least perpendicular to stress axis reveals strong permeability anisotropy. Thus, the evolution of permeability anisotropy is principally dependent on the geostress conditions. Thus, the evolution of permeability anisotropy is considered to be function of

geostress. Therefore, the change in geostress condition of petroleum basins as result of natural disturbances and technogenic application may initiate the evolution of new stress-induced permeable conduits suitable for migration of petroleum from predicted sites and damage to oil and gas well. Hence, the study may prove to be forward step in locating petroleum bearing strata and migration of hydrocarbons and relevant to suggest degree of maintenance damaged well routs for improved recovery and enhanced economy of Petroleum Company.