

Fifteen Years of Passive Seismic Listening in Oman: the Good, the Bad and the Ugly

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ABSTRACT

Microseismic (MS) technology is a well established surveillance tool in oil industry. It is based on using surface or downhole arrays of geophones for passive listening to micro-scale earthquakes occurring within and surrounding hydrocarbon reservoirs. Typically, these micro-scale earthquakes are caused by stress changes induced naturally or anthropogenically. In Petroleum Development Oman (PDO), MS monitoring was first introduced in 1999. It has been utilized for two main applications: (1) permanent reservoir surveillance and (2) hydraulic fracture monitoring. In this paper we review the history of permanent MS monitoring in PDO and highlight the success and challenges we experienced in the last fifteen years of monitoring. Permanent MS monitoring in PDO started in 1999 using a shallow network of MS stations deployed close to surface in a giant carbonate field. The project was conducted to understand the origin of tremors felt by staff in the field. The results showed that Microseismicity is localized along the graben faults cutting the field formations. However, the shallow MS network was only able to detect relatively high magnitude events. Few years later, a network of downhole MS monitoring arrays extending up to the depth of the reservoir was deployed to get more insights into the origin of the observed Microseismicity. The results indicated that Microseismicity is caused by the compaction of the soft chalky reservoir due to pressure depletion. This project has proven the MS technology and opened the door wide to extend it to other fields experiencing rock deformation. In some of the projects, MS monitoring is used in conjunction with other surface deformation monitoring tools like GPS, leveling and InSAR satellite imaging. Integration of different data types yields better constrained results.

To date, nine permanent MS projects have been conducted in PDO and some of them still ongoing. Throughout the fifteen years of MS monitoring, PDO has built solid experience on MS deployment, acquisition, processing and interpretation. Leading technologies are used in acquiring and processing the data as to provide near-real time results that can assist in decision making and emergency responses. Future directions will focus on the use of fiber optic cables as a replacement to conventional geophones for MS acquisition. Also, the focus will be on optimizing integration of MS data to better understand reservoir geomechanical behaviors.