REMOTE SENSING-BASED DETECTION OF OIL SHOWS AND MICROSEEPAGE-INDUCED ALTERATIONS: CASE STUDIES FROM BRAZIL AND IRAN

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ABSTRACT: Hydrocarbons (HC) commonly migrate from reservoir to the surface in either pervasive gaseous form, known as microseepage, or as fluids through narrow fractures known as macroseepage. The former, which is widespread over many charged traps, is typically associated with an array of diagenetic physio-chemical and mineralogical transformations in the soils and sediments, whereas the latter is manifested by local accumulation of liquid or solid petroleum. Typically, seepages demonstrate a working petroleum system in a sedimentary basin. Occasionally, however, it can be used as a tool for basin screening and target evaluation. Accordingly, the detection of micro-, and macroseeps has a high priority in oil and gas exploration. From a remote sensing perspective, a macroseep can be directly targeted using HC's spectral signatures centered at 2300 and 1700 nm wavelengths, whereas a microseepage is only detectable indirectly by its surficial mineralogical footprints. In this approach, the depletion, enrichment, or species transformation in iron oxides/oxyhydroxides, clays, carbonates, and sulphates are spectrally characterized by the means of their diagnostic absorption features in the visible and near-infrared (VNIR) or the short-wave infrared (SWIR) ranges.

Simulated WorldView-3 (WV-3) satellite data showed potential for direct HC detection. Here, we present results achieved from real datasets acquired over a test site located near the town of Anhembi, Brazil. This area represents an exhumed HC reservoir of bitumen (tar) accumulations in the early Triassic sandstones of the Pirambóia formation. The tar-sands were characterized in the imagery by absorption features in 1700 (band 12) and 2200 nm (band 14) wavelengths related to bitumen and montmorillonite, respectively. However, the shape of the absorption, including the shoulders, were highly variable between the rock exposures. By using a match filtering technique, the distribution of tar-sands were mapped and latter verified during fieldwork. This experiment revealed that where tar-sands occupy at least half of the areal extend of a pixel (equivalent to ≈ 25 m^2 at 7.5 m resolution), it can be unambiguously detected by the WV-3 sensor.

In the second study conducted over the Alborz oil field near the city of Qom in Iran, we used Sentinel-2 and ASTER satellite data to map the secondary alterations in Miocene red-beds consisting of sandstone, siltstone, marl, and conglomerates. The ASTER data was able to map the distribution of clays (montmorillonite and palygorskite) and to some extent carbonates (calcite and ankerite) and Sentinel-2 was superior in delineating ferric minerals including hematite, goethite and/or ferrihydrite over the oil field.

This study demonstrates that common satellite sensors (e.g. Sentinel-2 or ASTER) provide sufficient spatial and spectral resolution to map the widespread microseepage-induced alterations, whereas for direct detection of oil shows and analogous macroseepages with discrete outcrops, a system similar or superior to WV-3, with high spatial and spectral resolution, is required.

KEYWORDS: SEEPAGE, HYDROCARBON EXPLORAION, REMOTE SENSING