Abstract

The search for liquid hydrocarbons using visual indicators of surface seepage has a history dating back to the Mesopotamian/Babylonian Civilisations, around 4000BC, when the resource was used for fueling lamps and providing pitch for waterproofing boats. It therefore seems prescient that we have chosen the Zagros Fold & Thrust belt as a natural laboratory to continue the search for expressions of migrating Hydrocarbons. Our research focuses on providing a regional screening tool to assess whether a combination of medium resolution Landsat, ASTER and Hyperion data can be used to discriminate seepage signatures emanating from the foothills and frontal fold-thrust domains of the prolific Zagros Hydrocarbon Province. We would like to illustrate the utility of such a technique by mapping a number of previously field-mapped seepage locations and impregnation types (i.e. oil, gas, bitumen, sulphur spring, gach-e-turush) compiled by BP Geologists in the 50’s and 60’s and since published on readily accessible geological maps. Each location has been mapped geologically – structure and local stratigraphy – at 1:50,000 scale using publicly available and free to acquire Landsat OLI and SRTM data to characterise each locality. Stratigraphic units mapped by BP have been re-mapped at greater scale to provide geological context for our efforts at discriminating the local seepage types. Understanding the local geology will help to understand the migration constraints both structurally and geochemically. We have used a combination of surface seepage indicators that have been widely published since the advent of medium resolution multispectral sensors in the early 90’s and as such, Schumacher’s (1996, and subsequently by many others) paper describes the main types of anomaly that can be expected and detected by remote sensing applications. These relate to spectrally resolving the alteration of clays to Kaolinite, redox-related ferric-ferrous red bed bleaching, and lastly carbonate, gypsum and silica precipitation. We have not considered vegetation anomalies in this location due to the sparse vegetation cover. We have used a range of techniques including atmospherically corrected and orthorectified image processing, ASTER-derived band ratios (from previously published sources), relative absorption depth ratios, focused PCA and multi-temporal image stacking that can then be semiautomated in ArcGIS to provide anomalous spectral signatures relating to the 5 classes of alteration commonly reported, as mentioned above. We then “stack” our results to illustrate how alteration mineral assemblages relate to the different seepage styles mapped on the ground. Spectral Library (primarily USGS) signatures have been used as we have had no access to the field samples. At present, we have not yet used more advanced remote
sensing techniques involving spectral angle mapping, mixture-tuned match filtering/pixel-unmixing or other statistical approaches as we do not have field samples to calibrate to. While we realise the potential limitations of this approach, our initial aim is to provide a rapid and semi-automated hydrocarbon province/domain screening tool that locates likely seepage clusters that warrant further appraisal, using Very High Resolution imagery (such as WV3) combined with targeted field verification and sample collection. Our poster shows our preliminary results and how these might provide a useful regional screening tool, using our semi-automated processing workflow, based on the 10 sites in the Zagros Mountains. The results indicate that the seepage impregnations mapped in the field 70 years ago can be readily recognised on the imagery, but that others have no discernible signature, albeit at the resolution that the data we have used provides. We hope in the near future to augment our results with additional study using more discriminating remote sensing techniques and Hyperion and WV3 data in this region and others where access to ground truthing and sampling allows a more fully inclusive investigation.

References Cited


The Kush Kun structure (Figure 8) lies just to the south of the main boundary fault of the Zagros Mountains, where it is impinged by a splay from the aforementioned boundary faults, for which there is scant record spectrally and a further set, mostly oil, formed in the frontallimb of the structure, for which there are several anomalies picked up by our mapping (Figure 8).

The search for liquid hydrocarbons using visual indicators of surface seepage has a history dating back to the Mesopotamian/Babylonian Civilisations, around 4000 BC, when the resource was used for fuelling lamps and providing pitch for waterproofing boats. It therefore seems prescient for expressions of migrating hydrocarbons to be sought spectrally with the advent of new satellite technologies. These include, for example, the recent release of WorldView-3 from DigitalGlobe, which is able to provide high resolution imagery across the VNIR, SWIR and LWIR regions (Table 1).

Table 1: VNIR and SWIR spectral bands

<table>
<thead>
<tr>
<th>Band</th>
<th>VNIR</th>
<th>SWIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blue</td>
<td>Blue</td>
</tr>
<tr>
<td>2</td>
<td>Green</td>
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<tr>
<td>3</td>
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<td>4</td>
<td>Red</td>
<td>Red</td>
</tr>
<tr>
<td>5</td>
<td>NIR</td>
<td>SWIR</td>
</tr>
</tbody>
</table>

In the case of the Zagros Fold-Thrust Belt, the search for hydrocarbons has focused on spectral anomalies that are characteristics of a petroleum seep, gypsum, jarosite, sulphuric acid, and sulphur. The resulting sulphur produces sulphur streams and in the case of the Zagros Fold-Thrust Belt, we can quantify the presence of hydrocarbon seepage in the form of spectral anomaly generation.

Acknowledgements

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References


Band index generation – concepts

Characteristics – i.e. their particular reflectance or absorption features.