Landsat ETM Applications: Identifying Geological and Coastal Landforms, SE Red Sea Coast, Saudi Arabia

O. A. Alharbi[(1)], M.R. Phillips[(1)], A.T. Williams[(1)] and R.A. Bantan[(2)]

Faculty of Applied design and Engineering, Swansea Metropolitan University, Mt Pleasant, Swansea, SA1 6ED, UK.

Marine Geology Department, Faculty of Marine Science, King Abdulaziz University, Jeddah, Saudi Arabia,

PHYSICAL BACKGROUND

The coastal plain on the SE Red Sea coast widens at Jizan (40km) and becomes progressively wider further south in the Yemen.

Ash Shuqayq coastal area is considered a broad, featureless, low relief depositional coastal plain. Along this low-lying coast; sediment cover is thick. An ambiguous terrigenous material is supplied from the adjacent coastal escarpments through many ancient wadis during the flash floods. Therefore, most of the sediments on the shore zone are of terrigenous origin.

METHOD USED

Landsat enhanced thematic mapper (ETM) data: Two Landsat images covering the study area (path 167/row 48 and path 168/row 47) (Fig. 2), acquired, were used to detect geological and geomorphological features. Two different interpretation techniques are used:

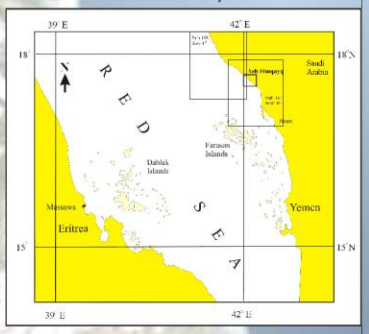
(1) Interpretations of the mosaic unsupervised classification, true colour composite of bands 3, 2 and 1, false colour composite of bands 7, 4 and 1 and 4, 5 and 7 images assigned to red, green and blue (RGB).

(2) of Landsat ETM bands for geological mapping of southwestern Saudi Arabia especially the Ash Shuqayq coastal area, including unsupervised classification; single bands and false colour composite of bands 7, 4 and 1, and 4, 5 and 7 images assigned to red, green and blue (RGB) colours respectively.

Ground truthing

Data was obtained from a number of different sources including, field work for this study, geological maps (Blank, et al., 1986) and Saudi Arabian Ports Authority maps. A Geographic Positions System (GPS model GARMIN 40), was used in the field to locate feature positions on a field map and to facilitate their location in the corresponding remote sensing image(Pandiaraj, et al., 2010).

Location of Red Sea & study area

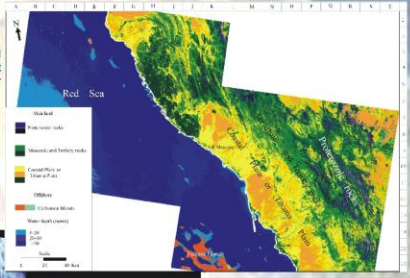


The southwest of Saudi Arabia including the Ash Shuqayq coastal area are referred as Path 167/Row 48 and Path 168/Row 47

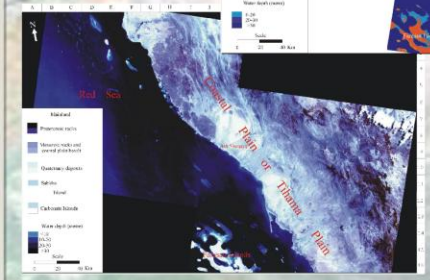
RESULT AND DISCUSSION

Identification of the geological futures, southwest Saudi Arabia: The image show areas of Proterozoic rocks in the east, a north-northwest trending belt of Mesozoic to lower Tertiary rocks in the centre, and a large area of coastal plain (Tihama Plain) of middle Tertiary to Quaternary deposits near the coast.

Identification of bathymetry of the Ash Shuqayq Coastal area: The main factor controlling the amount of reflected energy of wavelength bands 1, 2 and 3, is transparency of the water column and roughness of the surface. The deeper the water, the weaker is the reflected signal (Kowalik et al. 1994). The Landsat image bands 3, 2 and 1 have been prepared to produce a bathymetric map of the Ash Shuqayq coastal area. The maximum mapping depth in this image is about 30 m, which is a limit, imposed by clear water penetration of the visible blue band 1 of Landsat ETM.



Mosaic of Landsat ETM unsupervised classification image, covering southwest of SaudiArabian and adjacent deeper water of the southeast Red Sea.



Mosaic of Landsat ETM true colour image band 3,2 and 1 (RGB), covering southeast of the Red Sea shelf and the coastal plain of the southwest of the SaudiArabia.

Identification of the landforms deduced from the Ash Shuqayq satellite images: Different bands combinations were submitted to an interactive linear stretch. A visual interpretation has been made of images produced from an unsupervised classification), bands 4 (0.76-0.9 µm), 5 (1.55-1.75µm), and 7 (2.08-2.35 µm). Images were assigned to RGB colours. This type of analysis amounts to the detection and subsequent recognition and identification as well as mapping of different geomorphological units.

Seven major geomorphological units have been distinguished and mapped using the Landsat images of the Ash Shuqayq coastal area. These comprise recent sediments of sand dune, sabkhas, sandy beaches, lagoons, wadis, organic carbon and vegetation areas.

Field checking helped in the distinction and subsequent mapping of these units. In general, Ash Shuqayq area is a broad, low relief depositional coastal plain. Along the low-lying coast, sediment cover is generally thick. The morphology of the shoreline includes coastal mountains; sea cliffs especially to the north, while in the middle and south, lagoons, wadi mouths, sand dunes and tidal inlets are common. Aeolian activity together with the wadis contributes most of the terrigenous material to the shore zone.

Sand dunes and Sand flats: This unit is distinguished by its yellow colour in the unsupervised classification image, and light brown due to high reflectance (74%) of band 4, low reflectance (55%) of band 5 and (42%) of band 7.

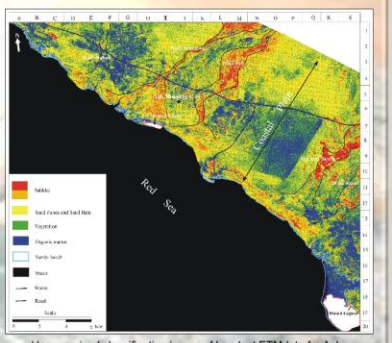
Sandy beach: This unit is distinguished by dark blue in the unsupervised classification image, and brown due to reflectance of 50%, 38% and 22% of bands 4, 5 and 7 respectively. The beach extends from the upper most limit of wave action to the low-tide mark. They are typically composed of sand or pebbles. In general, sand beaches are supplied partly by material eroded from adjacent parts of the coast, partly by fluvial sediment and partly by sand carried shoreward from the sea floor (Bird, 1984).

Sabkhas: Sabkha areas appear grey due to high reflectance (87%) of band 4 and (79%) of band 5 and 7.

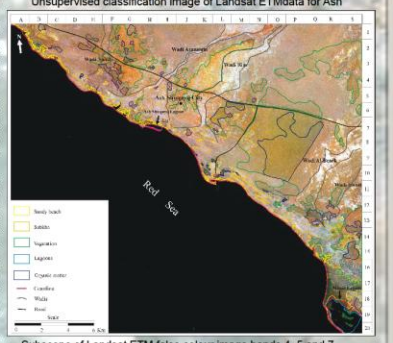
Wadis: This geomorphologic unit is red in the unsupervised classification image and white due to high reflectance of band 4 and 5 (98%), and band 7 (96%). The coastal plain is traversed by five wadis namely from south to north; Itwad, Al Beark, Rim, Aramram and Nahab. These wadies formed during lowered sea levels and are considered as the geomorphological features resulted from the geologic events of the Late Quaternary. In general, the coast shows dominantly terrigenous sediments of gravely sand to muddy sand.

Vegetation: In the supervised classification, this is displayed as orange due to high (88%) reflectance of band 4 and reflectance 55% and 24% of bands 5 and 7 respectively, and distinguished by green in the unsupervised classification image. Vegetated areas occur in several places North of the Ash Shuqayq area, Wadi Nahab is covered by Doum palm (*Hyphaene thebaica*).

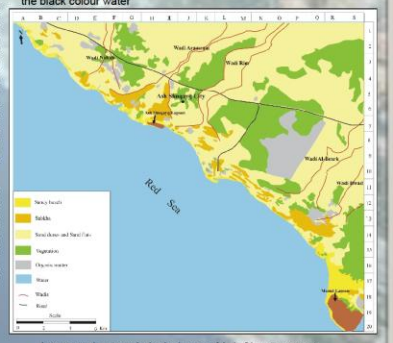
Organic matter: This unit is distinguished by dark blue in the unsupervised classification image, brown to dark brown in the supervised, due to low reflectance of band 4 (60%), band 5 (30%) and absorption of band 7.



Unsupervised classification image of Landsat ETMdata for Ash



Subscene of Landsat ETM false colour image bands 4, 5 and 7 deduced from Figure 9, shows the Ash Shuqayq coastal plain, and the black colour water



Interpreted geomrphological map of Ash Shuqayq coast

Through the processes of weathering, including the effects of climate and plant and animal activity, unconsolidated earth materials develop distinct soil horizons. Organic soils (muck and peat) formed from decomposed plant materials in very wet environment, are typical in shallow lakes or areas with a very high ground water table (Lillesand et al., 2004). The organic matters in the Ash Shuqayq area occur near vegetation areas and could be interpreted as due to plant fragments settling and mixed with sediments.

Lagoons: This unit occurs as a white colour in the unsupervised classification images. Ash Shuqayq lagoons are considered as shallow depressions which retain water even at low tide. Some lagoons occupy mouths of ancient wadis and others developed in tidal regions, which gradually developed into tidal flat environments. A small part of the coastline is developed as a barrier coastline.

CONCLUSIONS: Interpretations of Landsat images of the Ash Shuqayq area together with field study and sample collection help understand how coastal geomorphology, lithology and tectonics influence distribution and transport of nearshore littoral sediments. The Ash Shuqayq coastal area is largely bounded from the north by resistant headlands and long stretches of wide, sand beaches backed by dune fields toward the south with marine limestone platform terraces seaward. Numerous wadis drained this area and contribute to the vast majority of the total input of sediment to the coastal zone.

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