ASTER multispectral thermal data and finding water

Conference or Workshop Item

How to cite:

Drury, S.A. and Andrews Deller, M.E. (2004). ASTER multispectral thermal data and finding water. In: United Nations International Workshop on the Use of Space Technology for Disaster Management, 18-22 Oct 2004, Munich, Germany.

Link(s) to article on publisher's website:
http://www.zki.caf.dlr.de/events/2004/unoosa_workshop/unoosa_workshop_2004_en.html

ASTER Multispectral Thermal Data and Finding Water

S.A. Drury and M.E. Andrews Deller (Open University, UK)
s.a.drury@open.ac.uk m.e.andrews@open.ac.uk

Almost every emergency from which refugees flee results in their immediate need for clean drinking water. Wells rather than surface supplies are the safest source.

The most productive sources of groundwater are sediments composed mainly of quartz and feldspars, or carbonates, which have high permeability and high yields. Sediments containing high proportions of fines (clay, mica, silt) are poor aquifers with low permeability and yields. Advance knowledge of the most promising aquifers in disaster-prone areas helps in the search for emergency water supplies, should disaster strike. Equally, if not more important, it helps assure clean supplies during normal times

Large areas that are threatened by natural and socio-economic hazards, and those associated with conflict require a rapid and simple means of outlining potential groundwater supplies. Thermally emitted Earth observation data offer a very useful reconnaissance tool.

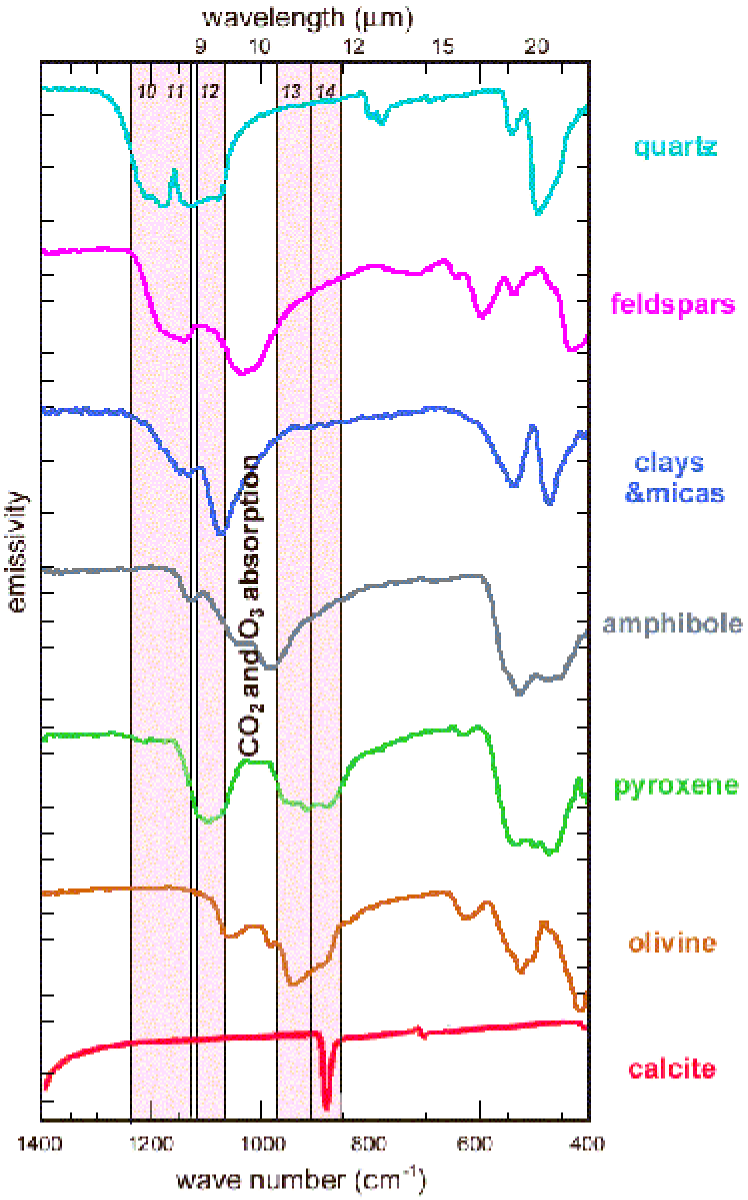

Figure 1 Thermal emissivity spectra of common rock-forming minerals

The spectra in Figure 1 imply that images whose red, green and blue components use ASTER bands 14, 12 and 10 effectively highlight surface soils and rocks that contain abundant quartz and feldspar in red hues compared with all other common minerals, that appear in other hues. Carbonates (e.g. calcite) from which limestones are formed should show as cyan (blue-green).

Alluvial and colluvial aquifers, and dam sites

Unconsolidated aquifers - alluvium and colluvium (hill-slope sediments) - are the easiest in which wells can be sunk. However, in areas with steep slopes or those subject to flash floods, unconsolidated sediments may contain a lot of fines that clog the pores between larger grains, so reducing well yields, compared with well-sorted sediments.

In many areas, water supplies from surface dams rapidly dwindle because the reservoirs become silted up. Sedimentation, however, can offer an opportunity for sub-surface water storage that, unlike reservoirs, is protected from evaporation. If the fill contains abundant fines, that sediment gives low yields if wells are sunk above dams after they no longer give useful surface supplies

By checking the geology of drainage catchment basins it is possible to predict the quality of the sediments carried by rivers and flash floods, either to form natural alluvium or the fill that accumulates above dams. Areas underlain by granites and gneisses yield abundant quartz + feldspar. When deposited as alluvium, colluvium or behind dams, soft sediments in such catchments have good water potential. Areas underlain by clay-rich sedimentary rocks, basalts and schists yield a high proportion of fines. Unconsolidated sediments in catchments dominated by such rocks have poor water potential. Figure 2 shows an example of an ASTER multispectral thermal image that highlights catchments in which quartz and feldspar probably dominate the sedimentary material being transported.

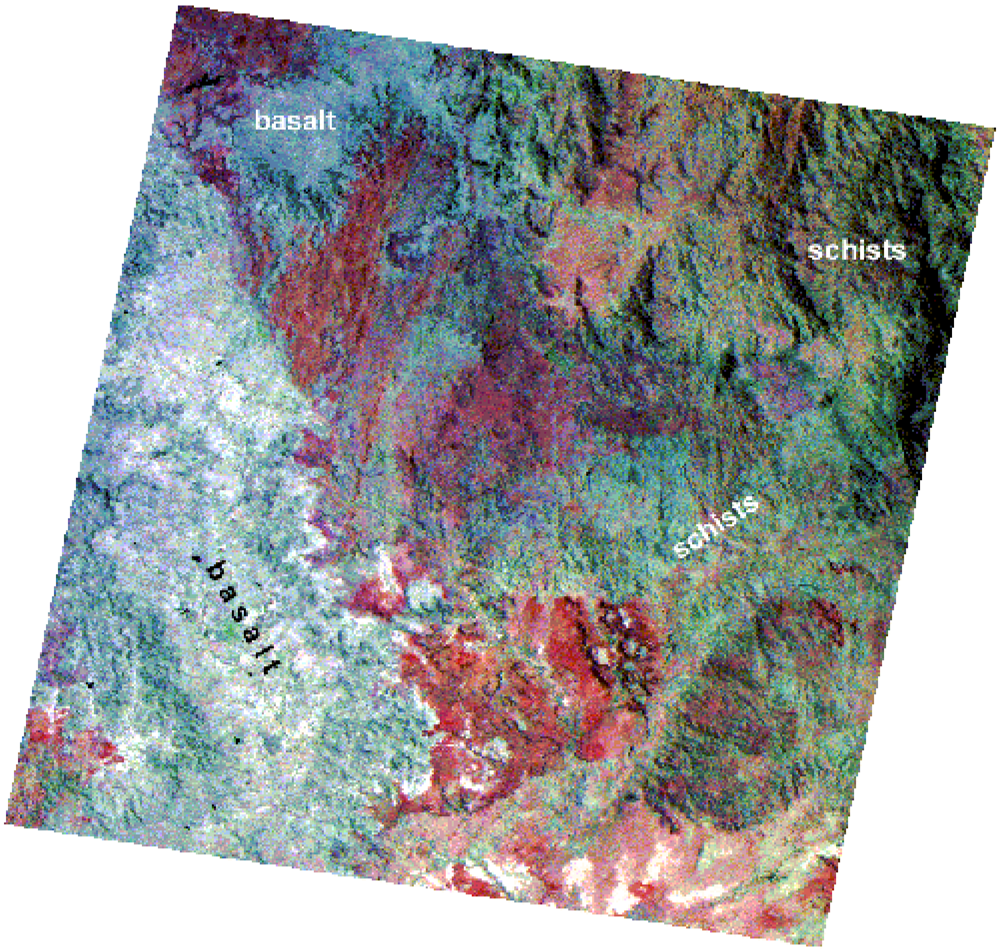

Figure 2 ASTER thermal image showing the geology of different catchments

Figure 3 adds a cautionary note. An area of coastal alluvium shows red on and ASTER thermal image, indicating high quartz and feldspar content. However, the same area imaged by ASTER's detectors that cover reflected visible to short-wave infrared radiation indicates that much of this alluvium also contains high proportions of fine-grained mica and clays (bluish), and mica-like chlorite (red, orange and magenta). Only the yellowish areas are likely to be alluvium composed almost entirely of quartz and feldspar, and therefore the better aquifers.

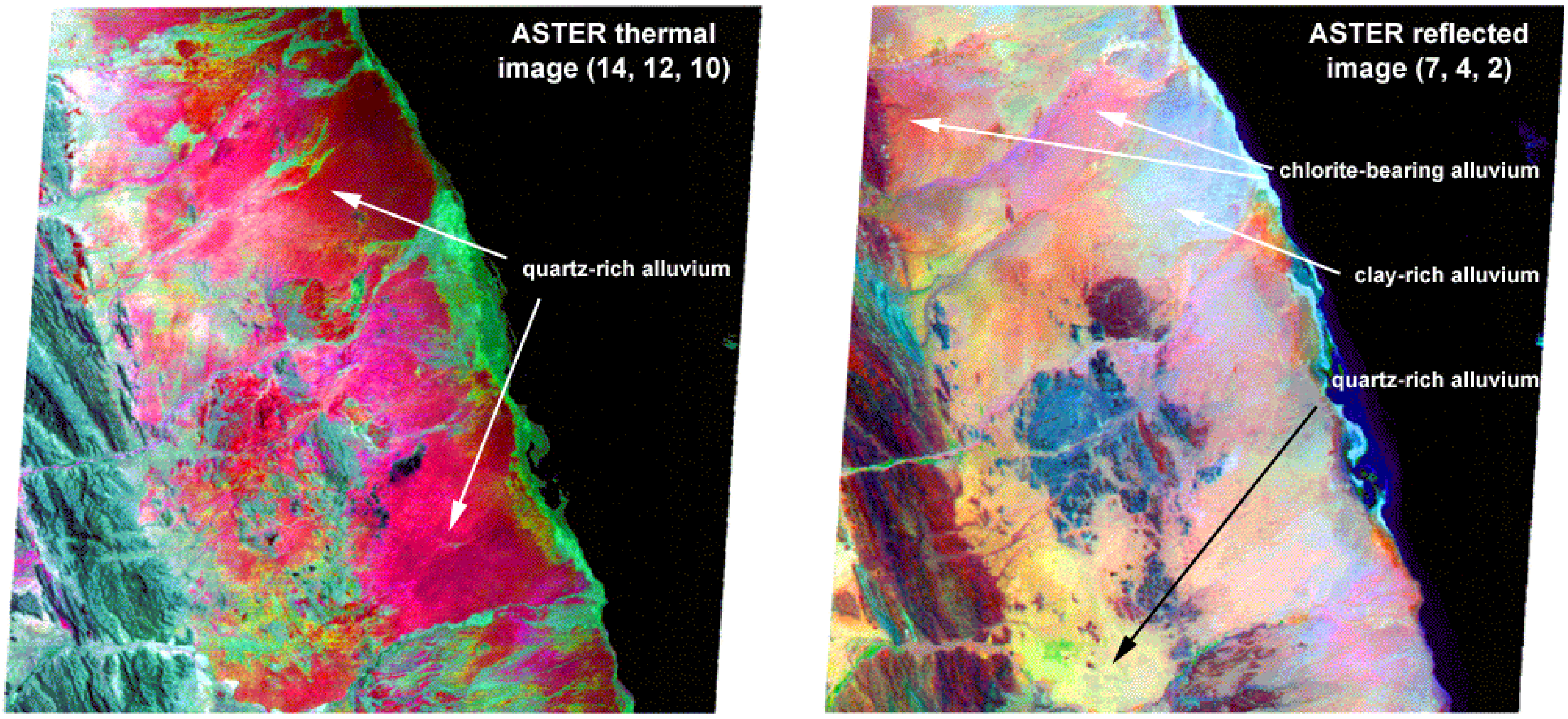

Figure 3 Comparison of ASTER thermal and reflected images

Stratiform aquifers

Consolidated sedimentary and volcanic rocks that have been laid down in beds or flows are those most widely used for large groundwater supplies Aquifers in stratiform sequences often alternate with rocks that hinder the movement of water, leading to conditions where groundwater accumulates in zones of saturated aquifers,

Stratiform sequences continue over large areas below ground level, especially when the layers have been tilted. Because layers generally remain the same thickness, large, hidden groundwater sources can be predicted at depth,

Assessing stratiform aquifers employs similar ideas to those for unconsolidated sediments. Quartz- and carbonate-rich sedimentary rocks form the most important groundwater sources. Because they are often fractured or full of cavities, and have porous weathered tops, lavas are useful aquifers.

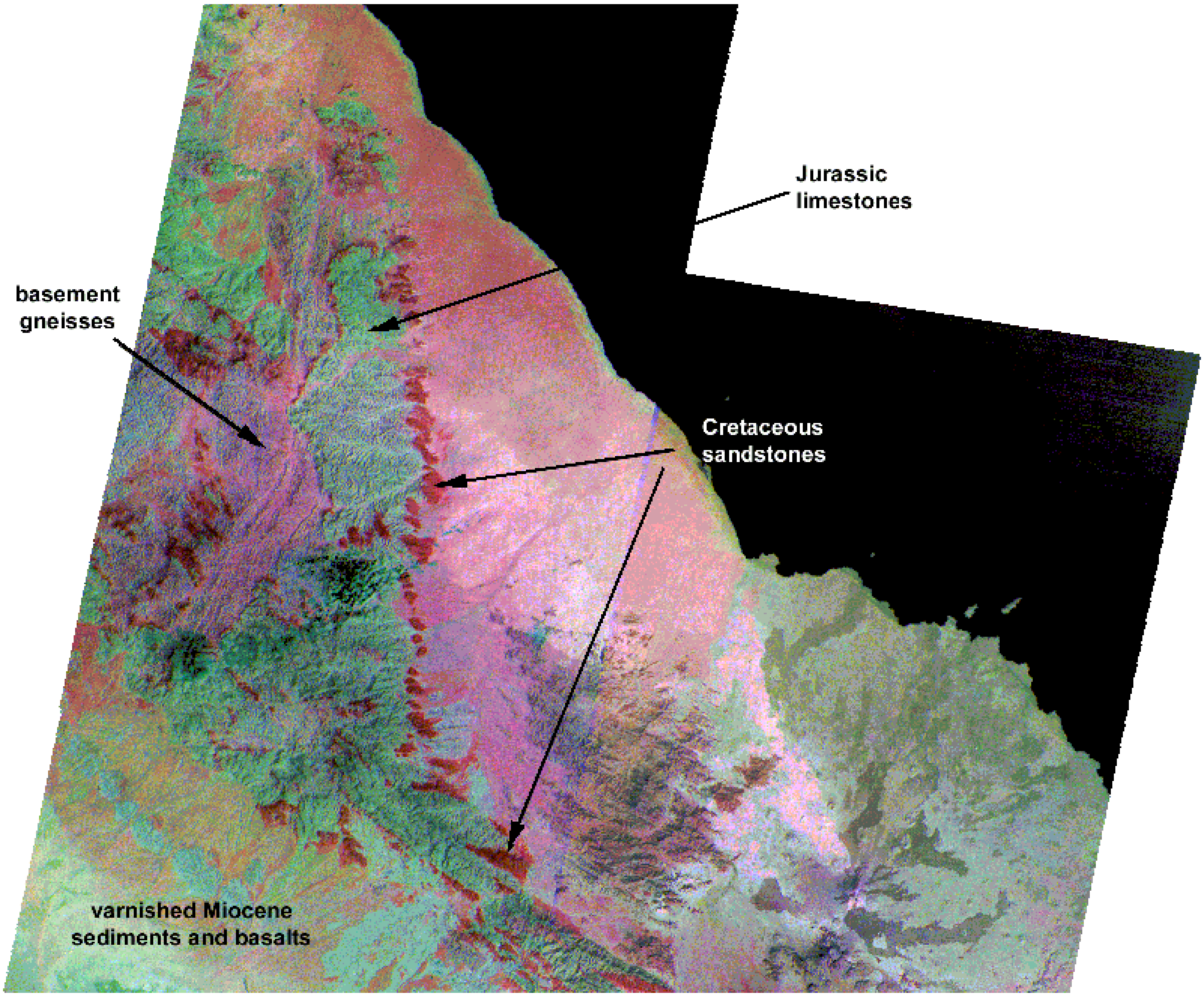

Figure 4 Mosaic of five ASTER thermal images of part of Danakil, Eritrea.

Figure 4 shows how ASTER thermal images can discriminate quartz- and carbonate-rich stratiform aquifers.

Areas of crystalline rocks

Areas underlain by crystalline igneous and metamorphic rocks offer little in the way of large aquifers, because the rocks contain no pore spaces. Fracture zones in such areas are sometimes sources of groundwater, because they are full of shattered rock. Locating the fractures themselves requires better resolution images than ASTER thermal. However, fractured crystalline rocks that are rich in quartz and feldspar have more open pore spaces than those that contain abundant micas, chlorite or amphiboles. Such sheet and chain silicates react with circulating water to form clays that clog the secondary porosity. Crystalline marbles are particularly interesting as groundwater sources in basement areas. Where they are highly fractured, cracks in them are widened by solution to produce excellent aquifers.

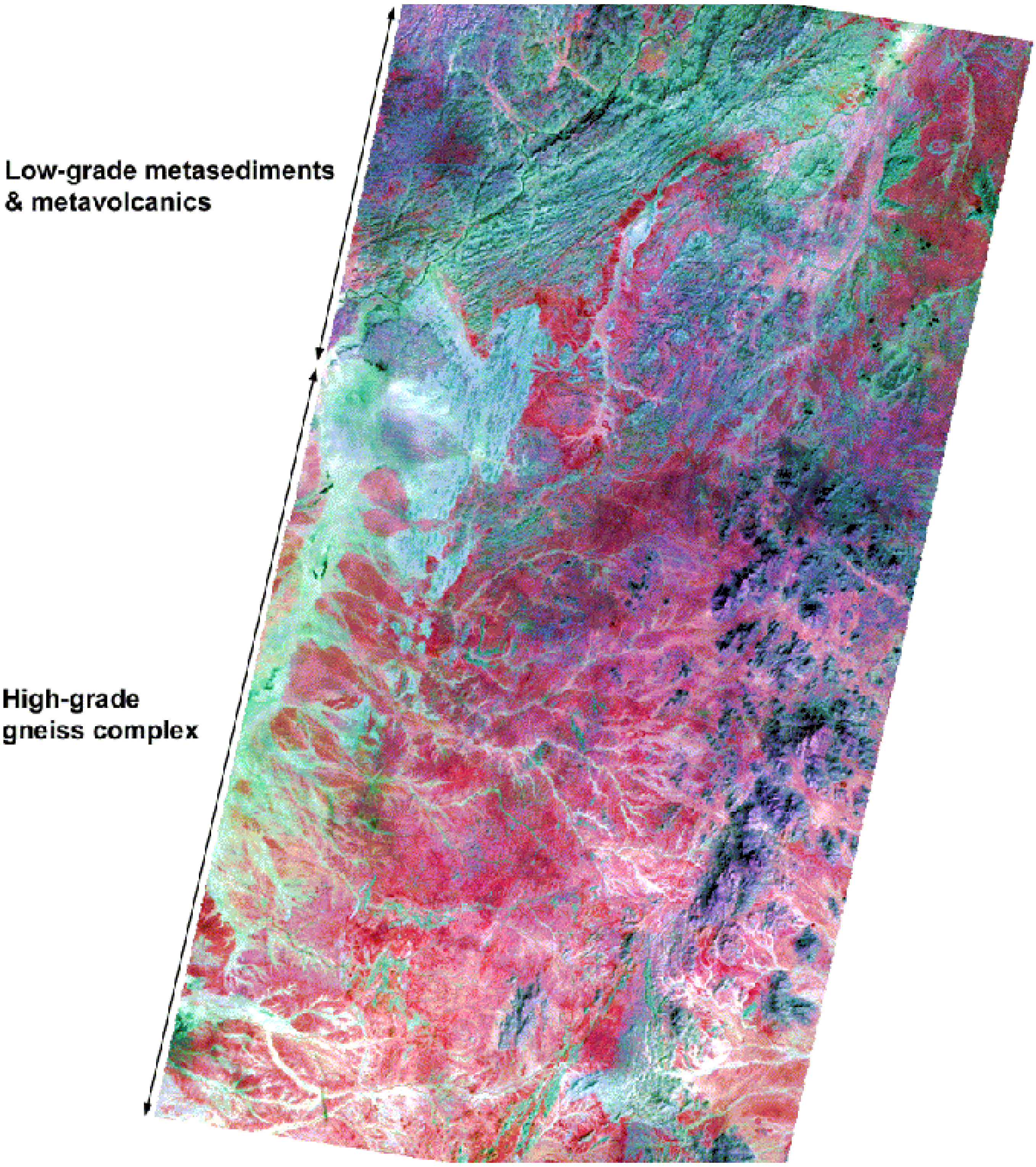

Figure 5 Mosaic of three ASTER thermal images of the Sudan-Eritrea border

Figure 5 shows how ASTER thermal images discriminate quartz-rich crystalline rocks and alluvium derived from them (reds) from those rich in micas and chlorite (greens and blues) in an area of basement.

Conclusions and future possibilities

ASTER multispectral thermal images are easily interpreted in the context of potential supplies of groundwater Having only moderate resolution (90 metres) which limits the detail that can be seen, files of thermal data for 70 x 70 km scenes are much smaller than those of higher resolution ASTER, Landsat and other data. Very large areas can be covered by mosaics of ASTER thermal data, without file sizes becoming unmanageable.

Unlike images from other parts of the electromagnetic spectrum, vegetation cover does not interfere with geological interpretation, unless it is very dense. In areas ranging from very arid to humid savannah, ASTER thermal data form a useful tool for rapid reconnaissance of groundwater potential at regional scales. They open up the possibility for creating groundwater assessment maps that cover vast areas of Africa, thereby laying a basis for rapid response to displacement of people by disaster or conflict, as well as helping supply high quality drinking water to established communities.