

# PRIORITIES IN DESIGNING EARTH OBSERVATION SATELLITES FOR TURKEY'S NATURAL RESOURCES POTENTIAL AND DISASTER MITIGATION

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### ABSTRACT:

Earth observation phenomena include monitoring of disasters originated from tectonic movements. Detecting land cover and climatic changes, the studies of atmosphere, biodiversity, oceans, ecosystems and land management processes are the other important application areas of earth science and environmental earth observation programs.

Nowadays, remote sensing satellites are also vital important determining ore mineral zones. Natural resources which are also hosted oil/gas occurrences and water are exposed to surface of the Earth due to harsh climatic conditions and remarkably tectonic movements. These internal and external processes shaping the landforms of Earth have been active since hundreds of millions years geologically. Turkey falls in an important location geographically for such studies since its location on Alpine-Himalayan orogenic belt and geologic evolution for hundreds of millions years.

On the other hand, many countries are aware of requirements of gradually increased alternative energy sources like hydrogen. As is well known, boron minerals can be used as an energy carrier and stored sun energy easily. Turkey has an approximately 63 % of total world boron reserve in Western Anatolia. Multi and hyperspectral imaging methods detect these mineral occurrences with the aid of narrow and contiguous band wavelengths of electromagnetic spectrum. Furthermore, geothermal features which can be monitored using thermal sensors mounted on satellites should also be taken into consideration in Turkey's remote sensing policy. Western Anatolia and Thrace regions include these important natural resources along active fault structures such as Gediz and Menderes grabens. On the other hand, stereoscopic viewing capability of backward and nadir telescopes similar to ASTER passive sensor can produce digital elevation models allowing to expose these important economic and structural zones considerably.

Designing small satellite and/or spectral ranges of passive sensors according to Turkey's priority is a vital issue. One of the most important priorities of Turkey's remote sensing policy should be the monitoring of tectonic movements driven by African and Eurasian plates caused huge amount of loss of life and property. With launching BILSAT satellite in 2002, initial attempt in earth observational effort has been completed successfully. But usefulness and evaluation of Turkey's natural source potential which may be determined by remote sensing efforts should also be taken into consideration.

## 1. INTRODUCTION

Remote sensing is a science and method integrated terrestrial/extraterrestrial features and objects with space technology. In earth sciences, we can see extraordinary synoptic view capabilities and talented applications of this method with great admiration since 1972. In this respect, earth observation phenomena will be indispensable science and technology in future related earth science applications.

## 2. NEOTECTONIC FEATURES OF TURKEY

As is well known, territories of Turkey are located on Alpine-Himalayan orogenic belt (Figure 1) and amalgamated continental fragments which were represented various part of different continental crusts such as African and Eurasian plates. Remnants of Palaeo and Neotethyan oceans also played important roles in the geological evolution of Turkey, are observed clearly northern and southern parts of the country in an approximately E-W trends (Şengör and Yılmaz, 1981). This complex geological background is brought together with some advantages and disadvantages. Economically, it is a fact that Turkey has important natural resources some of which are exposed on surface. On the other hand, the country is also under threat because of potential earthquake hazard among active North and East Anatolian Fault Zones and Aegean graben-horst systems.

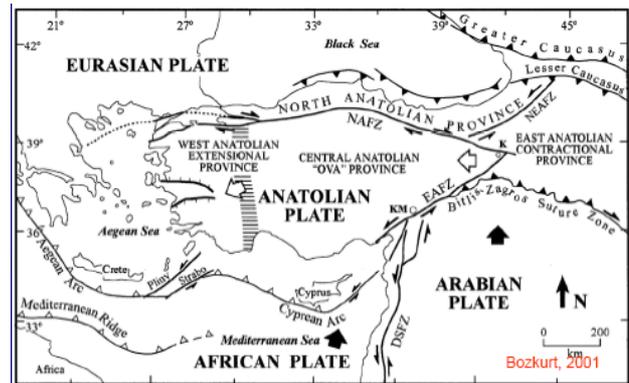


Figure 1: Neotectonic map of Turkey (Bozkurt et. al., 2001)

Climatic conditions and vegetation covers of Turkey especially in central, eastern and south eastern Anatolian regions provide reliable and wealthy interpretations about determining alteration zones related ore minerals and exposing hazardous lineament zones. Exposing these alteration zones form fundamental exploration studies and can indicate possible richness in mineral deposits. Digital image processing methods comprising mainly spatial, spectral enhancements and merging procedures provide remarkable contributions to these exploration studies.

On the other hand, stereoscopic images derived from backward and nadir views of optical imagery are used to

produce digital elevation models (DEM). Actually, these non-analogue data type constitute main map components topographically.

### 3. CHOOSING APPROPRIATE SPECTRAL BANDS

Visible and infrared regions should be also considered designing new optical and hyperspectral sensors. These regions contribute to differentiate describing earth objects such as vegetation and water in considerable amount. As seen in Figure 2, photoelectronic devices such as lead sulphide and silicone can perceive specific electromagnetic regions between visible and infrared regions properly.

Radiation-sensitive detectors span the spectrum from ultraviolet through to the region where energy emitted by the Earth reaches a peak (Figure 2), although no single detector covers the whole range (Drury, 2001). Remote sensors should not be limited with artificial satellites. Aircrafts carrying different kinds of sensors such as panchromatic, multi and/or hyperspectral types should be taken into consideration definitely.

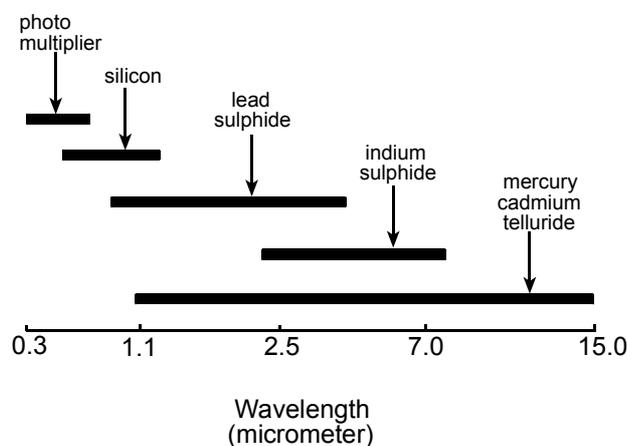


Figure 2: Photoelectronic detectors cover the whole of the useful range of visible and infrared wavelengths (Drury, 2001)

It may even be essential that the most important Earth observational satellite designing program requires electromagnetic band intervals fitting requests and needs. Simultaneously, it should be noted that atmospheric windows which allow electromagnetic radiation emanated from the sun.

### 4. HYPERSPECTRAL IMAGING

As a developing country, Turkey needs a great deal of energy sources. Therefore, it should be taken into consideration small satellites which can be carried hyperspectral sensors. These types of sensors can record a number of narrow and contiguous band intervals rather than multispectral sensors. Imaging spectrometer concept also called the hyperspectral imaging is the last step of terrestrial remote sensing phenomena. Hyper means excessive and spectral also describe a spectrum (Figure 3). These kinds of images contain extreme information about all objects and superior to panchromatic and multispectral images. But, disadvantages of this system have low signal/noise ratio and presentation difficulty. Narrow and adjacent band intervals of imaging spectrometer systems such as AVIRIS and SFSI provide superiority according to broaden and intermittent band design of multispectral sensors.

As is well known, boron minerals are valuable industrial raw materials. Main boron minerals as ulexite, colemanite and tincal crop out in widely regions in Western Anatolia/Turkey.

Unfortunately, multispectral systems could not catch these boron minerals properly because of non-existence continuous band intervals. Choosing appropriate earth remote sensing sensors are also vital important issue for managing monetary sources wisely. It should be considered as Turkey's extremely important needs in terms of natural resources.

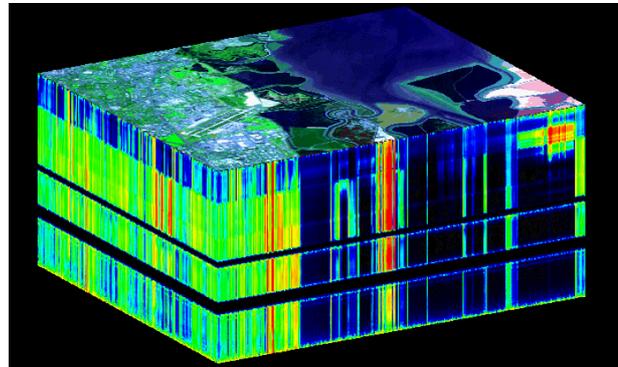


Figure 3 : Hyperspectral cube model for understanding imaging spectrometer concept.

Several works agree that Turkey has approximately 70 % of world boron reserves and deposits in Bigadiç, Sultançayır (Balıkesir), Kestelek (Bursa), Emet (Kütahya) and Kırka (Eskişehir) regions in western Anatolia. These boron minerals can be exposed with the aid of imaging spectrometers instead of routine multispectral sensors such as Landsat TM and ASTER (Figure 4 and 5). From this point of view, small satellites carrying with hyperspectral imaging sensors should be considered that future planning strategy to reveal worthy raw materials such as boron and its compounds for Turkey's need. However, clay and sulphate minerals can be powerful indicators of alteration zones. These types of minerals can be established with the aid of imaging spectrometers. Traditional multispectral sensors can help only reflectance values. Whereas, alteration minerals are detected by hyperspectral sensors.

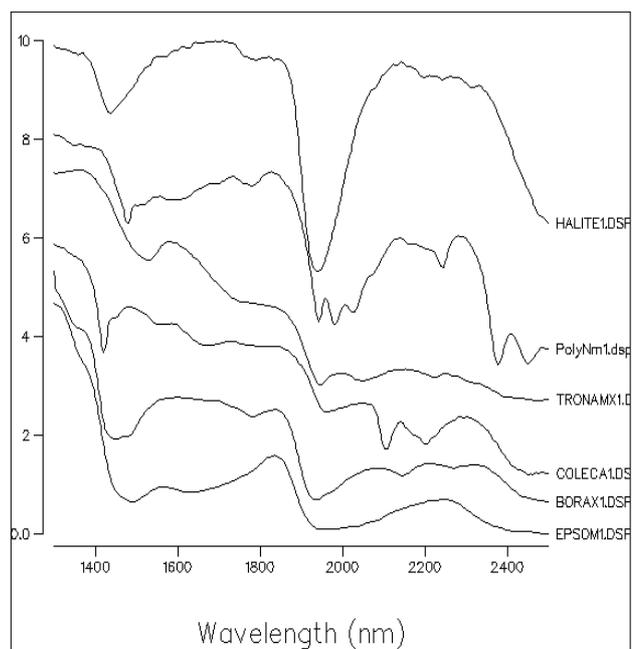


Figure 4: Spectral curves and absorption intervals of some boron and evaporite minerals

On the other hand, hydrocarbon seeps can be detected using remote sensors. It is a fact that well-known and observing hydrocarbon seepages on surface, especially in southeastern Anatolia should be evaluated with these types of sensors and high resolution images carefully. Additionally, oil seepages that can be indicators of possible oil migrations changes surface mineralogy. Using hyperspectral sensors, these mineralogical differences can also be determined.

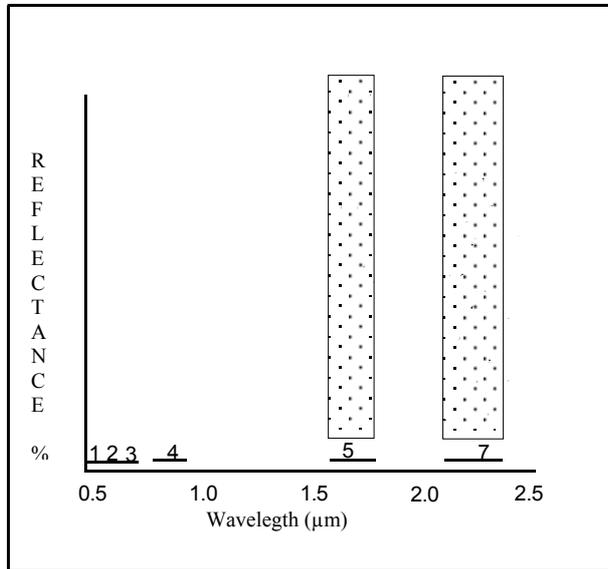


Figure 5: Electromagnetic band intervals of Landsat TM systems.

## 5. TOPOGRAPHIC MAPPING

Continental collision is a complex process which is often accompanied by crustal thickening and compression followed by extensional regime, syn-orogenic magmatism, and exhumation of high-pressure crustal rocks. Turkey is essentially an orogenic collage and are formed various continental fragments. These giant masses are formed from great tectonic movements such as closing oceans and continental collision. It is possibly to describe that the neotectonism is all tectonic events starting from last tectonic regime changes which were realized in any tectonic place. This period differs from one place to another. Neotectonic period has started approximately since Late Miocene (11 Ma) in Turkey. North and East Anatolian fault zones are major well-known active strike-slip zones and are giant products of neotectonic activity in Turkey.

### 5.1. Radar Interferometry

Radar interferometry can help as an active remote sensing method determining movement direction and amount of slip of moving continental crust. This approach gives valuable foresights to authorized decision-makers preventing and mitigation loss of life and properties. These kinds of studies were realized by several works in Turkey (Çakır et. al., 2003; Çakır, 2005).

On the other hand, morphotectonic structures which can be exposed easily with the aid of microwave region of electromagnetic waves. Active or passive structural lineaments such as faults and systematic joints are also very important geological features. They represent also alteration and fault zones. Active faults, especially strike-slip fault zones such as North Anatolian and San Andreas Fault Zones to be caused of

great loss of life and properties because of their lateral displacements rather than perpendicular type.

It should be taken into consideration ground truth campaigns to verify remote sensing studies. These types of studies give valuable contributions to determine remarkable geomorphologic features such as mainly fault lineaments, escarpments, volcanic cones and coastal features. Geological events cause differences in elevated areas. Surface features of these geologic structures can be understood somewhat with the aid of different remote sensing and interpretation methods. But geophysical methods such as seismic and magnetic studies ensure to find these continuations in underground. Various data merging techniques which were combined from different digital or analogue data sources can help to decide final assessments.

Disasters are not limited with sudden movements of Earth's crust. Occurring motions in offshore also sourced tectonically can be caused another types of catastrophic events such as tsunamis, landslides and etc. Turkey has approximately ?? km coastal regions. Especially, southern Aegean and Mediterranean coasts are prone to tsunami disaster due to interaction with African and Anatolian platelets along Hellenic and Cyprus subduction zones (Figure 6). As seen in figure, these zones are parallel to the Anatolian coast and therefore coasts under threat tsunamis.

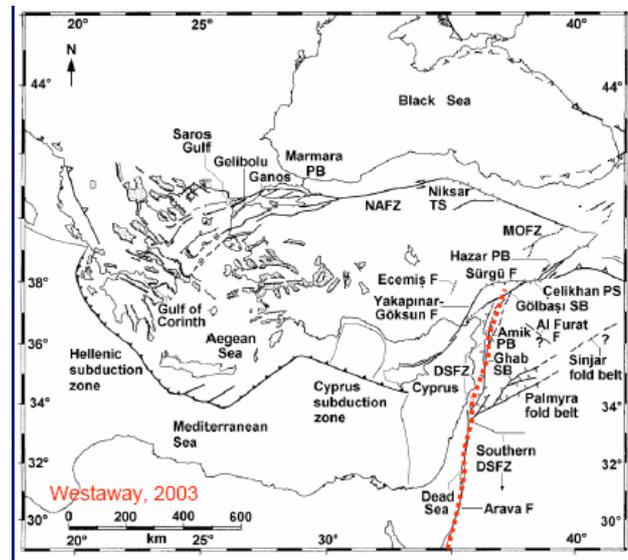


Figure 6 : Hellenic and Cyprus subduction zones parallel to the Mediterranean and southern Aegean Sea (Westaway 2003).

## Conclusions

Small satellites have better temporal resolution rather than old-fashioned large satellites. This advantage can bring to up in new frontiers change detection studies and gives healthy assessments about pre and post disaster inspections.

Designing small satellites especially which can help to bring up targeting topographic differences and natural source potential of this country should be priorities of Turkey. Satellites carrying hyperspectral sensors which can be identified individual minerals such as natural boron minerals or hydrocarbon seepages are encouraged intentionally.

Instruments detecting thermal features emitted from Earth crust should be also considered in Turkey's remote sensing policy. Turkey has great geothermal potential areas located mainly in Western Anatolia and Thrace regions. Kızıldere (Denizli), Germencik (Aydın) regions are some of considerable examples.

On the other hand, Turkey is surrounded by Aegean, Black and Mediterranean Seas. Oil spill problems leave bad impacts in terms of environmental pollution. Radar and high resolution optical imagery data has great advantages identifying these kinds of occurrences.

#### References

Drury, S., 2001, *Image Interpretation in Geology*, Blackwell Science, Nelson Thorne, UK, pp. 290

Cakir, Z., A. Barka, J-B. de Chabaliere, R. Armijo, B. Meyer, 2003, Kinematics of the November 12, 1999 (Mw=7.2) Düzce earthquake deduced from SAR interferometry, *Turkish Journal of Earth Sciences*, 12, 105-118.

Cakir, Z., A. M. Akoglu, S. Belabbes, S. Ergintav, M. Meghraoui, 2005, Creeping along the Ismetpasa section of the North Anatolian Fault (Western Turkey): Rate and extent from InSAR, *Earth and Plan. Sci. Lett.* 238, 225-234.

Sengor, A.M.C. and Yilmaz, Y. (1981) Tethyan evolution of Turkey: a plate-tectonic approach. *Tectonophysics*, 75, pp. 181-241.