

Using GIS and Satellite Imagery to Locate Hydrocarbons

Jay Rauschkolb

Paper # 868

**Presented at the ESRI International User Conference, San Diego,
California**

July 7 - 10, 2003

ABSTRACT

The purpose of this project is to show it is possible to use remote sensing techniques to detect oil seeps and oil spills and use ArcView to determine the hydrocarbon locations.

Modern remote sensing software was used to process NASA's ASTER Multispectral Images.

The files were loaded with Band 3 (0.76 - 0.86 μm) as Red, Band 2 (0.63 - 0.69 μm) as Green and Band 1 (0.52 - 0.60 μm) as Blue. ASTER's 15 m ground resolution and image enhancement techniques allowed the identification of offshore oil seeps in California and the detection of oil leaking from offshore production platforms in Azerbaijan.

INTRODUCTION

The purpose of this project was to prove that oil spills and natural oil seeps can be detected using remote sensing techniques, and Arc View can be used to determine the location of the hydrocarbons. Most of the data analyzed in this project was from NASA's ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) Multispectral Images. Excellent results were obtained using the ASTER VNIR Data with Band 3 (0.76 – 0.86 μm) as Red, Band 2 (0.63 – 0.69 μm) as Green and Band 1 (0.52 – 0.60 μm) as Blue. Using these bands, the ASTER satellite's ground resolution is 15 m.

The Project

The two areas studied in this project were Azerbaijan because it is known for having abundant oil seeps and possible leaking platforms and Santa Barbara Channel because it has some of the world's most spectacular natural oil seeps.

The author spent about one year in Azerbaijan and was able to visit many of the oil fields studied in this project. He often flew over these oil fields at low altitude and always observed oil leaking from around these platforms. The Caspian Sea and Azerbaijan are very well known for abundant natural oil seeps and leaking oil platforms [Williams, 1998]. The oil fields presented in this paper are located above massive anticlines that contain millions of barrels of oil [George, July 1993]. It is very likely that the platforms were placed directly above known oil seeps, because oil had to be present in the reservoir rocks below these locations. Therefore, the observed oil may originate from natural oil seeps on the seabed.

The Santa Barbara Channel in California was studied because it is considered to be one of the most abundant hydrocarbon seepage areas in the world [Landes, 1973; Wilson et al., 1974; Galloway, 1992; Hovland and Judd, 1992; Hornafius et al., 1999]. The author has spent one and a half years in the Santa Barbara Channel area and most of the time natural oil slicks are present in the water. Oil slicks and sticky oil mousse are usually observed surrounding the kelp beds in the waters off of Coal Oil Point.

The Analysis

The initial part of the project was to determine if the image enhancement techniques built into the remote sensing software was able to reveal the presence of hydrocarbons.

- ENVI's Linear Contrast Stretch, Piecewise Linear Contrast Stretch, Gaussian Contrast Stretch, Histogram Equalization Contrast Stretch, and Square Root Contrast Stretch were tested.
- ER Mapper's Linear Transform, Autoclip Transform, Level Slice Transform, Histogram Equalize Transform, Gaussian Equalize Transform, Logarithmic Transform, Exponent Transform and De Quantized Transform were tested.

The land area of the Apsheron Peninsula in Azerbaijan is large and bright in the images so many of the enhancement techniques produce very nice images of the land.

Unfortunately, the offshore oil fields are surrounded by dark water, so each of the oil fields must be cropped and enhanced individually.

In some cases individual stretches and transforms worked well and at other times a combination of stretches and transforms worked well.

Once the hydrocarbons were detected in the enhanced images, then the full image was loaded into Arc View so the exact location of the hydrocarbons could be determined and marked. If many ASTER Images are used in a project, then they can be loaded in Arc

View as different views and the locations of the hydrocarbons can be compared. When oil slicks that appear to spread out in different directions due to the winds and tides occur in multiple images, then the location that is contained in all of the images is probably the source of the seeps.

For this technique to work and be meaningful, then ground truth is necessary. The analyst must be certain that images of oil slicks are being recorded rather than some other natural phenomena that look similar to oil slicks.

Numerous other ASTER Band combinations and other techniques such as Principal Component and Thermal IR Bands were tested but this study found the ASTER VNIR Bands 1, 2 and 3 with their 15 m resolution seemed to work best.

Conclusions

This project has proven that oil spills and natural oil seeps can be detected by using remote sensing techniques and Arc View can be used to determine and record their locations. Therefore, these same techniques can be used for environmental monitoring studies where oil exploration and development projects are underway, where pipelines traverse great distances underwater and for the detection of naturally occurring oil seeps from hydrocarbon bearing sediments.

Acknowledgements

We want to thank NASA and JPL for allowing the use their ASTER and Landsat Images and VENOCO INC. for allowing the use their map of oil seeps in the Santa Barbara Channel. We would also like to thank Robert Crippen of JPL, Floyd Sabins of Chevron and UCLA, Eric Frost, Jim Hollarn, Robert Mellors, Douglas Stow, John Kaiser and Gia Truong of San Diego State University for their advice and encouragement.

List of Illustrations:

1. Title page
2. Abstract
3. Location Map of Azerbaijan
4. Map of the Apsheron Peninsula in Azerbaijan
5. ASTER Image of the Apsheron Peninsula R3 G2 B1
6. Arc View of the Apsheron Peninsula Project
7. Location of Ostrov Peschanny Oil Field in ASTER Image
8. Ostrov Peschanny Oil Field Not Enhanced
9. Ostrov Peschanny Oil Field Enhanced Image
10. Location of Ostrov Artema Oil Field in ASTER Image

11. Ostrov Artema Oil Field Not Enhanced
12. Ostrov Artema Oil Field Enhanced Image
13. Location of Oil Field N.E. of Sangachaly in ASTER Image
14. Oil Field N.E. of Sangachaly Not Enhanced
15. Oil Field N.E. of Sangachaly Enhanced Image
16. Location of Oil Field at 40 Deg 10' North and 49 Deg 50' East in ASTER Image
17. Oil Field at 40 Deg 10' North and 49 Deg 50' East Not Enhanced
18. Oil Field at 40 Deg 10' North and 49 Deg 50' East Enhanced Image
19. VENOCO's Map of Oil Seeps in the Santa Barbara Channel
20. Cropped Landsat Image of Santa Barbara area
21. Arc View of Santa Barbara Project
22. ASTER Image of Santa Barbara Full Scene
23. Cropped Landsat Image of Coal Oil Point
24. Cropped ASTER Image of Coal Oil Point
25. Enhanced ASTER Image of Coal Oil Point

References

Encarta Virtual Globe 1999, Microsoft Corporation, Redmont, Washington

ENVU USER'S GUIDE V.3, December 1997, Better Solutions Consulting, Lafayette, Colorado, USA

ER Mapper 6.0 User Guide, September 1998, Earth Resources Mapping Pty Ltd, Perth, Western Australia

Galloway, James M., 1992., ["Natural Oil and Gas Seepage in the Coastal Areas of California."](#) MMS Special Information paper.

George, D., Caspian Sea reserves could rival those of Saudi Arabia; Azerbaijan coup slows development pact negotiations; Kazakhstan opens aquatory to foreign involvement, PennWell Publishing Company Offshore, July 1993

Hornafius, J. S., D. Quigley, and B. Luyendyk, The world's most spectacular marine hydrocarbon seeps (Coal Oil Point, Santa Barbara Channel, California): Quantification of emissions, Journal of Geophysical Research, Vol. 104, No. C9, 20,703-20,711, September 1999

Hovland, M., and A. G. Judd, The global production of Methane from shallow submarine sources, Cont. Shelf Res., 12, 1231-1238, 1992.

Landes, K. K., Mother nature as an oil polluter, AAPG Bull., 57, 637-641, 1973

Sabins, F. F., 1987, Remote Sensing Principles and Interpretation, W. H. Freeman and Company, New York

Tactical Pilotage Chart, TPC F-4C, Armenia, Azerbaijan, Georgia, Kazakhstan, Russia, Turkey, Scale 1:500,000

Williams, A., Detecting the sleeping giants of the Caspian - from space, National Remote Sensing Centre U.K., PennWell Publishing Company, July 1998

Wilson, R. D., P. H. Monaghan, A. Osanik, L. C. Price and M. A. Rogers, Natural Marine Oil Seepage, Science. 184, 857-865, 1974.

The Author

Jay Rauschkolb
Remote Sensing Analyst
Operations and Wellsite Geologist
Central Asia Research and
Remediation Exchange (CARRE)
Department of Geological Sciences
San Diego State University
6884 Deep Valley Road
San Diego, CA 92120
Phone/Fax: (619) 286-5007
E-mail: jayrauschkolb@cox.net