ISPRS Journal of Photogrammetry and Remote Sensing 128 (2017) 146–157

Contents lists available at ScienceDirect

ISPRS Journal of Photogrammetry and Remote Sensing

journal homepage: www.elsevier.com/locate/isprsjprs

Hyperspectral remote sensing detection of petroleum hydrocarbons in mixtures with mineral substrates: Implications for onshore exploration and monitoring

Rebecca Del'Papa Moreira Scafutto [a,*], Carlos Roberto de Souza Filho [a], Wilson José de Oliveira [b]

[a] University of Campinas – UNICAMP, Institute of Geosciences, PO Box 6152, 13083-970 Campinas, SP, Brazil
[b] PETROBRÁS – ENG-RLE/PROJEN/EARLR, Av. Henrique Valadares, 28, Centro, 20231-030 Rio de Janeiro, RJ, Brazil

A R T I C L E I N F O

Article history:
Received 27 June 2016
Received in revised form 21 March 2017
Accepted 21 March 2017

Keywords:
Hydrocarbons
Soils
Hyperspectral
Mapping
Onshore

A B S T R A C T

Remote detection and mapping of hydrocarbons (PHCs) *in situ* in continental areas is still an operational challenge due to the small scale of the occurrences and the mix of spectral signatures of PHCs and mineral substrates in imagery pixels. Despite the increasing development of new technologies, the use of hyperspectral remote sensing data as a complementary tool for both oil exploration and environmental monitoring is not standard in the oil industry, despite its potential. The high spectral resolution of hyperspectral images allows the direct identification of PHCs on the surface and provides valuable information regarding the location and spread of oil spills that can assist in containment and cleanup operations. Combining the spectral information with statistical techniques also offers the potential to improve exploration programs focused on the discovery of new exploration fields through the qualitative and quantitative characterization of oil occurrences in onshore areas. In this scenario, the aim of this work was to develop methods that can assist the detection of continental areas affected by natural oil seeps or leaks (crude oils and fuels). A field experiment was designed by impregnating several mineral substrates with crude oils and fuels in varying concentrations. Simultaneous measurements of soil-PHC combinations were taken using both a hand-held spectrometer and an airborne hyperspectral imager. Classification algorithms were used to directly map the PHCs on the surface. Spectral information was submitted to a PLS (partial least square regression) to create a prediction model for the estimation of the concentrations of PHCs in soils. The developed model was able to detect three impregnation levels (low, intermediate, high), predicting values close to the concentrations used in the experiment. Given the quality of the results in controlled experiments, the methods developed in this research show the potential to support the oil industry in the discovery of new oil plays and reservoirs and to define the contamination stage and spread of oil/fuel in areas affected by accidental leaks, improving both exploration and environmental monitoring.

© 2017 International Society for Photogrammetry and Remote Sensing, Inc. (ISPRS). Published by Elsevier B.V. All rights reserved.

Contents

* Corresponding author.
E-mail addresses: rebecca.scafutto@gmail.com (R.D.M. Scafutto), beto@ige.unicamp.br (C.R. de Souza Filho), wilsonjo@petrobras.com.br (W.J. de Oliveira).

http://dx.doi.org/10.1016/j.isprsjprs.2017.03.009
0924-2716/© 2017 International Society for Photogrammetry and Remote Sensing, Inc. (ISPRS). Published by Elsevier B.V. All rights reserved.

1. Introduction

Global economic activities are still strongly related to energy sources, especially with petroleum hydrocarbons (PHCs) and fuels. Innovations in the oil industry have become essential, especially those related to non-conventional exploration methods, to supply future global demands with the discovery of new oil fields. In addition, the prevention and monitoring of environmental impacts caused by oil production and transportation require the continuous development and assessment of new technologies.

The small scale of natural oil occurrences (i.e. seepages) in onshore areas makes the discovery of new exploration fields a challenge. In contrast, small inland oil leaks occur regularly due to damage in oil pipelines and leaking storage tanks (Chakraborty et al., 2012). Apart from the contamination problem itself at isolated sites (e.g., refineries, oils fields), soil and water contaminated by petroleum products can occur in wildlife refuges or natural parks - endangering ecological systems – and at land farms or urban areas, compromising the health of residents and leading to the risk of explosion in worst cases (Fine et al., 1997).

The development of new, effective and environmentally responsible methods for the identification of PHCs in continental areas is currently necessary. The typical procedures to measure PHCs in contaminated soils in the laboratory are highly expensive and, time-consuming; require rigorous field sampling and lack field portability, making wide-scale quantitative assessments challenging (Dent and Young, 1981; Schwartz et al., 2012; Okparanma and Mouazen, 2013).

In this context, remote sensing tools have the potential to foster more efficient prospecting and environmental programs, assisting the discovery of new inland reservoirs and monitoring of oil leaks (e.g. Singh, 1995; Fingas and Brown, 1997; van der Meer et al., 2002; Brekke and Solberg, 2005; Lammoglia and de Souza Filho, 2013; Sanches et al., 2013; Asadzadeh and de Souza Filho, 2016a). Crude oils and petroleum fuels (i.e., diesel and gasoline) have diagnostic absorption doublets at approximately 1725–1760 nm and 2310–2349 nm, respectively (near and shortwave infrared range - NIR-SWIR) (Cloutis, 1989), which are attributed to the primary combinations and overtones of C—H stretching modes of saturated CH_2 and terminal CH_3 or aromatic C—H functional groups (Hunt, 1996).

The identification of characteristic spectral features of PHCs in remote sensing data can provide information about the location and spread of oil spills over large areas (Pabón and de Souza

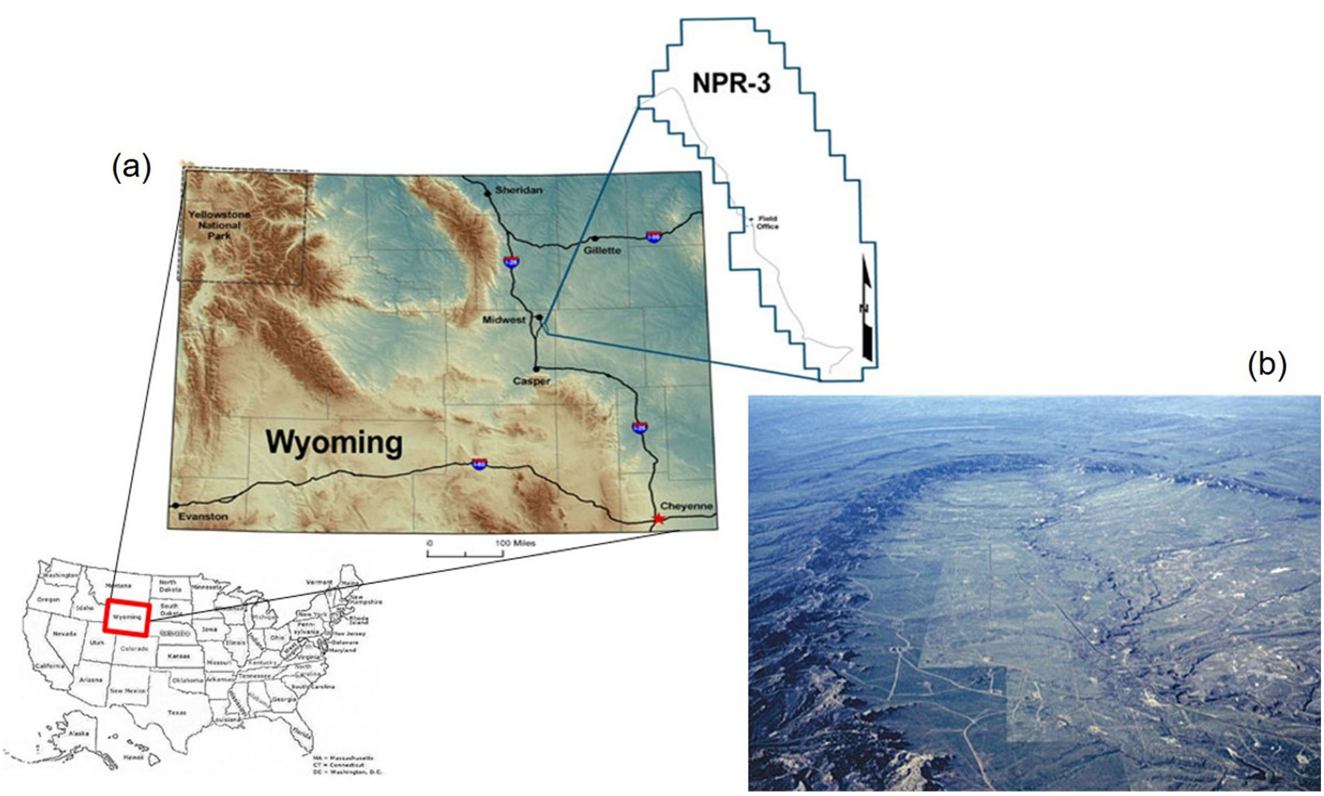

Fig. 1. Rocky Mountain Oilfield Testing Center: (a) locality map of the study area; (b) aerial view of the NPR-3. Source: http://energy.gov.

Download English Version:

https://daneshyari.com/en/article/4972856

Download Persian Version:

https://daneshyari.com/article/4972856

Daneshyari.com