ICEEG 2010 Chengdu China

Proceedings of the 4th International Conference on Environmental and Engineering Geophysics
14-19 June 2010, Chengdu, China

Near-Surface Geophysics and Geohazards

Volume 2

Runqiu Huang
Xuben Wang
Chairs

Xuben Wang
Jianghai Xia
Jianguo Yan
Yixian Xu
Editors

Chengming Ye
Yinhe Luo
Co-Editors

Science Press
Science Press USA Inc.

NEAR-SURFACE GEOPHYSICS AND GEOHAZARDS

Proceedings of the 4th International Conference on Environmental and Engineering Geophysics
14–19 June 2010, Chengdu, China

Volume 2

Runqiu Huang
Xuben Wang
Chairs

Xuben Wang
Jianghai Xia
Jianguo Yan
Yixian Xu
Editors

Chengming Ye
Yinhe Luo
Co-Editors

Science Press
Science Press USA Inc.

NEAR-SURFACE GEOPHYSICS AND GEOHAZARDS

Proceedings of the 4th International Conference on Environmental and Engineering Geophysics
14–19 June 2010, Chengdu, China

Published by Science Press USA Inc.
2031 US Hwy 130, Suite F
Monmouth Junction, NJ 08852
USA

Printed in Beijing

ISBN 978-1-933100-37-1

4th INTERNATIONAL CONFERENCE ON ENVIRONMENTAL AND ENGINEERING GEOPHYSICS

14–19 June 2010, Chengdu, China

Sponsoring Hosts

Chinese Geophysical Society

National Natural Science Foundation of China

China University of Geosciences (CUG)

Chengdu University of Technology (CDUT)

Supporters

Key Lab of Earth Exploration and Information Technology (Chengdu University of Technology), Ministry of Education, China

State Key Lab of Geohazard Prevention and Geoenvironment Protection (Chengdu University of Technology)

Open Laboratory of Engineering Geophysics, Ministry of Land and Resources of the People's Republic of China

Three Gorges Research Center for Geo-hazard, Ministry of Education

Conference Committee

Honorary Chairs:

Guangding Liu Zhenhua He Jingao Zhang

Chairs:

Runqiu Huang Xuben Wang

Co-Chairs:

Jianghai Xia Yaoguo Li Sheng Yu
Yixan Xu

Preface

The 4th International Conference on Environmental and Engineering Geophysics (ICEEG2010) will be held at the Chengdu University of Technology, Chengdu, China from June 14 to June 19, 2010. We publish this important conference document *Near Surface Geophysics and Geohazards—Proceedings of the 4th International Conference on Environmental and Engineering Geophysics* for the general audience of the near-surface geophysics community.

Geohazard is an important issue that our near-surface geophysics community is facing. We all remember that the Wenchuan Ms 8.0 earthquake, which is only 80 km away from Chengdu, caused tremendous damages two years ago. The tragedy made all people, especially, the geophysical workers as we are to face a serious challenge—what we can do in predicting/ preventing, monitoring, and overcoming earthquake and geohazards using geophysical methods. The near-surface geophysics is closely connected to the domestic economy, and even people's daily life, which provides important information for achieving harmony and coordinated development between the human and the nature. This is a challenge but also an opportunity. The ICEEG convention and the publication of "The Proceedings" are precisely for seizing this type of opportunity and meeting this kind of challenge.

"The Proceedings" is a compilation of works of several dozens experts and scholars from the US, Canada, Germany, Australia, France, Switzerland, Sweden, India, South Korea, Thailand, and China, with more than 180 articles contributed for the conference and to conform for the main theme of the conference— "The Near Surface Geophysics and Geohazards", which will be published officially by the Science Press Inc. as references for the attending experts and the scholars from various countries.

The content of "The Proceedings" is extremely broad. It includes not only various near-surface geophysics methods (such as seismic, electrical method and electromagnetic method, 3S technology, potential-field methods, space geophysics, etc.), newly developed theory and technologies in data acquisition, processing, and interpretation, but also the most recent achievements in the domestic economy, such as engineering reconnaissance, environment analysis protection, and remediation, and public safety and assessments of natural resources. "The Proceedings" reflect the recent progress and development in domestic and international engineering and environmental geophysics.

The International Conference on Environmental and Engineering Geophysics receives welcome from the domestic geophysicists and attracts attentions from the international universities and research institutes. After the inaugural (2004) and the 2nd (2006) and 3rd (2008) conferences held in Wuhan, the official journal of the Environmental and Engineering Geophysical Society (EEGS, USA) "FastTimes" and the official journal of the European Association of Geoscientists & Engineers (EAGE) "First Break" published the special articles introducing the conference. Journal of Environmental and Engineering Geophysics, Near Surface Geophysics, and Journal of Earth Science published peer-reviewed papers originally selected from the proceedings of these three conferences in three special issues.

We would like to acknowledge the Chinese Geophysics Society, the Earth Science Branch of the National Natural Science Foundation of China, Chengdu University of Technology (CDUT), and China University of Geosciences (CUG) for their kind support. We would also like to thank all the attending experts and the scholars, particularly those specially invited representatives for their industrious work for the conference and "The Proceedings". Thanks also go to Feng Li and Keli Peng of the Science Press USA Inc. for their special contribution to ensure the publication of "The Proceedings" on time.

We hope "The Proceedings" can provide some useful information for addressing the issues we are facing, bridge the communication of environmental and engineering geophysicists from different nations, promote the development of environmental and engineering geophysics, and contribute to an even small extent for the harmony and coordinated development between the human and the nature.

We wish the 4th International Conference on Environmental and Engineering Geophysics, Chengdu, China a complete success!

Huang Runqiu

Chair, Organizing Committee of ICEEG 2010

Invited Speakers

Contents

Volume 1

SECTION 1 SEISMIC TECHNOLOGIES AND APPLICATIONS

SECTION 2 ELECTRIC / ELECTROMAGNETIC AND SNMR METHODS

Volume 2

SECTION 3 GPR APPLICATIONS

SECTION 4 GRAVITY AND MAGNETIC APPLICATIONS

SECTION 5 SPATIAL INFORMATION TECHNOLOGY

SECTION 6 INTEGRATED GEOPHYSICAL APPLICATIONS

SECTION 3

GPR APPLICATIONS

Locating LNAPL contamination in the field using GPR velocity anomalies: examples from Hill AFB, Utah, USA

John H. Bradford
Boise State University

Abstract

A large scale single offset ground-penetrating radar survey at Hill AFB, Utah, USA, produced a detailed map of the surface of a clay aquitard beneath a NAPL contaminated, unconfined sand and gravel aquifer. Analysis of these data led to identification of several reflectivity and topographic anomalies thought likely to indicate the presence of NAPL. Targeted continuous multi-fold GPR acquisition coupled with reflection tomography and prestack depth migration, showed that these reflectivity anomalies were associated with elevated radar propagation velocity; this response is consistent with NAPL contamination. Subsequent laser induced fluorescence and chemical analysis of borehole samples verified this interpretation.

Introduction

Ground-penetrating radar (GPR) is sensitive to relative dielectric permittivity (K) and effective electric conductivity (σ). The velocity of GPR signal propagation is a function of K, the amplitude of a GPR reflection is dependent on the contrast of K and σ at material boundaries, and attenuation of the signal depends on σ for the material through which the signal is propagating (Davis and Annan, 1989). Water has very high permittivity (K~81), whereas common non-aqueous phase liquid (NAPL) contaminants such as light hydrocarbons and chlorinated solvents have very low permittivity (K~2) and are very poor conductors. Anomalous displacement of water with low permittivity NAPL leads to lower bulk permittivity and conductivity than the surrounding sediments. The amount of the contrast depends on the wetting phase and relative concentrations of water and NAPL. Several modeling and laboratory studies have illustrated that when the organic is the wetting phase, the conductivity and dielectric permittivity drop sharply with very low concentrations of NAPL, whereas the change is more gradual when water is the wetting phase (Endres and Redman, 1996; Santamarina and Fam, 1997). When light hydrocarbons undergo biodegradation, organics acids can be produced that dissolve mineral grains ultimately leading to higher dissolved solid concentration and an increase in electrical conductivity (Atekwana et al., 2004a; Atekwana et al., 2002; Atekwana et al., 2004b). However, field evidence from one site indicates that even when the conductivity increases, the bulk permittivity of the system remains low following what would be predicted for unaltered NAPL (Bradford and Wu, 2007).

The GPR signature associated with the presence of NAPL is manifest in essentially three ways. First, the decrease in dielectric permittivity results in increased EM propagation velocity. Second, the decrease in permittivity can significantly change reflectivity. If the NAPL is in a discreet pool or plume, we expect increased reflectivity or variations in the AVO response associated with the NAPL boundaries. If the NAPL is smeared vertically or has diffuse boundaries, as is the case for residual saturation, we may observe decreased reflectivity in the sediment column due to homogenization of the permittivity profile. This occurs because decreased bulk water content reduces porosity dependence (Olhoeft, 1986). Finally, the conductivity may increase or decrease depending on the state of NAPL degradation.

Here I summarize the results of a comprehensive field study at Hill AFB, Utah, USA designed to locate LNAPL contaminated sediments using continuous multi-offset radar methods. I utilize prestack depth migration velocity analysis to construct detailed EM velocity images, then through comparison with laser induced fluorescence logs (LIF) show zones of anomalously high velocity