



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
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Editors

Chengming Ye
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Science Press
Science Press USA Inc.

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

Printed in Beijing

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ISBN 978-1-933100-37-1

4th INTERNATIONAL CONFERENCE ON ENVIRONMENTAL AND ENGINEERING GEOPHYSICS

14–19 June 2010, Chengdu, China

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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.

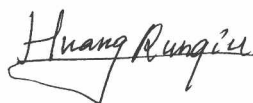
The International Conference on Environmental and Engineering Geophysics receives welcome from the domestic geophysicists and attracts attentions from the international universities and research institutes. After the inaugural (2004) and the 2nd (2006) and 3rd (2008) conferences held in Wuhan, the official 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!



Chair, Organizing Committee of ICEEG 2010

Invited Speakers

<i>Dr. Janet E. Simms, Editor of JEEG, U.S. Army Engineer Research and Development Center, USA</i> Application of magnetic susceptibility for wetlands delineation.....	741
<i>Dr. Alan G. Green, Professor, Institute of Geophysics, Department of Earth Sciences, ETH</i> Seismic reflection images of active faults on New Zealand's South Island.....	2
<i>Dr. Jianghai Xia, Senior Scientist, Kansas Geological Survey, the University of Kansas, USA</i> Estimation of near-surface shear-wave velocity using multichannel analysis of Love waves (MALW)	13
<i>Dr. Yaoguo Li, Associate Professor, Department of Geophysics, Colorado School of Mines, USA</i> Detection of magnetic UXO anomalies in noisy environments	712
<i>Dr. Maik Thomas, Professor, Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences Germany</i> Gravity modelling of the crust and upper mantle for understanding of tectonic processes: a case study for Europe.....	748
<i>Dr. Jan van der Kruk, Professor, The president of NSG, Near-surface Geophysics Section of SEG, Germany</i> High resolution ground penetrating radar imaging and characterization.....	574
<i>Dr. Chih-Ping Lin, Professor, Department of Civil Engineering and Natural Hazard Mitigation Research Center, Taiwan</i> Geotechnical applications and standardization of surface wave method — from engineer's perspective	36
<i>Dr. Torleif Dahlin, Engineering Geology, Lund University, Sweden</i> Γ_0 resistivity monitoring for environmental and engineering applications	312
<i>Dr. Lanbo Liu, Associate Professor, Civil & Environmental Engineering, University of Connecticut, USA</i> Ambient vibration noise as the new source for urban engineering seismology and earthquake engineering: case studies from the metropolitan area of Beijing	25
<i>Dr. Jeffrey G. Paine, Research Scientist, the University of Texas at Austin, Bureau of Economic Geology, USA</i> Assessing collapse risk in evaporite sinkhole-prone areas using gravimetry and radar interferometry	753
<i>Dr. Qiang Xu, Professor, State Key Laboratory of Geohazards Prevention and Geoenvironment Protection, Chengdu University of Technology, Chengdu, Sichuan, China</i> Geo-hazards induced by the Wenchuan Earthquake	936
<i>Dr. John Bradford, Associate Professor, 2nd Vice President, Society of Exploration Geophysicists, Boise State University, USA</i> Locating LNAPL contamination in the field using GPR velocity anomalies: examples from Hill AFB, Utah, USA	566
<i>Dr. Zhi Wang, Professor, Key Laboratory of Earth Exploration and Information Techniques, Chengdu University of Technology, Chengdu, China</i> Structural heterogeneities in the Southeast Tibetan Plateau: Implications for the 2008 M7.9 Wenchuan earthquake generation	53

Contents

Preface	i
Invited Speakers	iii

Volume 1

SECTION 1 SEISMIC TECHNOLOGIES AND APPLICATIONS

Seismic reflection images of active faults on New Zealand's South Island	A.G. Green, F.M. Campbell, A.E. Kaiser, C. Dorn, S. Carpentier, J.A. Doetsch, H. Horstmeyer, D. Nobes, J. Campbell, M. Finnemore, R. Jongens, F. Ghisetti, A.R. Gorman, R.M. Langridge, A.F. McClymont	2
Estimation of near-surface shear-wave velocity using multichannel analysis of Love waves (MALW).....	Jianghai Xia, Richard D. Miller, Recep Cakir, Yinhe Luo, Yixian Xu, Chong Zeng	13
Ambient vibration noise as the new source for urban engineering seismology and earthquake engineering: Case studies from the metropolitan area of Beijing.....	Lanbo Liu, Qifu Chen, Weijun Wang, Cheng Qi, Eric Rohrbach	25
Geotechnical applications and standardization of surface wave method—from engineer's perspective.....	Chih-Ping Lin, Chun-Hung Lin, Tzong-Sheng Chang	36
Structural heterogeneities in the Southeast Tibetan Plateau: implications for the 2008 M7.9 Wenchuan earthquake generation.....	Zhi Wang, Xuben Wang	53
Reverse-time migration velocity modeling for tunnel prediction.....	Xiangbo Gong, Liguang Han, Jianjun Niu, Jihai Gong	58
One new imaging method for near surface seismic survey and application	Hongyan Shen, Qingchun Li	62
Geological structure for disaster prevention investigation employing seismic tomography	Zhixin Zhao, Jiren Xu	69
The updated method in multiple-mode dispersion curves extracting of surface wave	Guangzhou Shao, Qingchun Li, Yongbo Li	72
Modeling of rayleigh-wave propagation in three-dimensional media with topography using staggered-grid finite difference scheme	Limin Wang, Yixian Xu	79
Application study of 3D seismic survey in engineering investigation.....	Zhanjie Shi, Gang Tian, Bangbing Wang, Xiling Yin, Zhihua Wang	85
Shallow SH-wave seismic refraction and reflection methods—site-specific seismic hazards applications..	Yuxia Lu, Edward W. Woolery, Zhenming Wang, Yucheng Shi	90
Study of extracting group velocities of near-surface Rayleigh waves from ambient noise	Wei Chen, Yixian Xu	96
The necessity and application of datum wave field continuation correction	Dingyu Xiong, Chengxiang Wang, Bo Zhao, Baofu Chen, Zhenhua He	102
The research of τ -p transform applied in the tunnel seismic prediction	Zhaoling Wang, Kunquan Tang, Zhengping Liu, Xiaohua Chen, Caibin Yan, Yuanyuan Huang, Zhen Lei	108
Failure mechanism of retaining wall in earthquake and its seismic design measure	Yong Wu, Siming He, Xinpo Li	113
Constrained sparse spike inversion and application.....	Xiangrong Tang, Yuanjun Wang, Jun Wang	120
Insights into coupling mechanisms of multimode surface waves	Xianhai Song, Hanming Gu	126
An analysis of seismic texture attribute based on GLCM.....	Xuefei Chen, Xueben Wang	131
Angle domain method to remove NMO stretch.....	Jianguo Yan, Zhou Zhao, Xuefeng Li, Wen Gu	135
Height and detection of water flowing fractured zone in fully mechanized mining area	Baishan Xu, Qi Li, Zhihong Li, Zhijian Hao1, Guojun Gao	141
A new method of lithological inversion	Gongying Zheng, Qiuling Yang, Xueqiang Zhang	146

Application of steerable pyramid decomposition in minor faults imaging.....	Chun Lin, Xuben Wang, Lihui Liu	151
The testing and analyzing of the vibration data with multi-waves and multi-components excited by dynamic load of construction on loess slopes	Yan Sheng, Zhengping Liu, Guodong Bai, Chengming Gong, Dan Yang, Yuan Lei, Xin Zhang, Yongxiang Zheng	156
An experiment to detect the stratum disturbance range above the metro tunnel caused by its excavation in Chengdu City using rayleigh surface wave method	Li Zhang, Zhengping Liu, Guodong Bai, Yuanyuan Huang, Bin Song, Lang Song, Yongxiang Zheng	162
Application of correlation dimension in seismic data processing	Deqing Zhao, Xuben Wang, Chun Lin	167
The research and application in inversion method of rayleigh surface wave dispersion curves	Jing Li, Min Yan	172
Study on the near-field ground motion of Fukuoka earthquake by the method of computing Green's functions for a layered half-space	Di Wu, Qifeng Luo, Yan Xiong, Ping Tan	179
Research of using SV wave of seismic to detect mined-out area in metallic mines	Baishan Xu, Zhijian Hao, Qi Li	184
Group-velocity dispersion analysis of high-frequency rayleigh waves	Yinhe Luo, Jianghai Xia, Yixian Xu, Chong Zeng	189
TT-transform and its application in surface wave suppression.....	Jianqing Ma, Qingchun Li	195
Random noise decaying of seismic data based on steerable pyramid decomposition	Chun Lin, Xuben Wang, Sibing Liu	200
A method of seismic signal de-noising based on S domain	Huailai Zhou, Yunhua Shi	205
The research of two-component common offset seismic reflected wave exploration in detecting the coal barren zone	Zhijian Hao, Baishan Xu, Qi Li	209
Discussions and improvements on wave-velocity measuring method in seismic safety evaluation.....	Xiliang Liu, Quanzhong Liu, Dong Zhao, Shuangcheng Ge, Haiqing Sun, Gangqun Yu	214
Application of microseismic monitoring technology in hydroelectric project	Yanyan Zou, Chun Sha, Chunan Tang, Nuwen Xu	218
Analysis of dispersion of phase velocities using empirical mode frequency decomposition on SASW.....	Li Jiang, Yixian Xu	225
Two-dimensional numerical simulation and characteristics analysis of seismic wave field based on a tunnel	Jiangping Liu, Niannian Qu, Keming Bu, Cong Zhou	232
Edge-preserving smoothing for seismic image using coherence-enhancing anisotropic diffusion.....	Yanjun Shi, Xuben Wang, Likun Wang	237
The study of using S transform in gyration analysis	Huifeng Li, Qing Wang	241
2D zero-offset common reflection surface stack and its application in engineering seismic prospecting ...	Guohua Liu, Qingchun Li, Xiaoping Tang	250
The application of shallow seismic exploration technology in the mined-out area investigation under the road.....	Hua Zhang, Yuling Gong	255
Study of non-uniform ground motion under complicated ground.....	Hai Su	262
Study on the key technology of probing urban active faults by shallow reflection method with anti-disturbance high resolution.....	Jishun Pan, Zhiquan Huang, Tong Jiang, Zhiquan Lü, Haining Liu, Zhongfu Wang	267
The influence of wavelet delay on the migration imaging accuracy	Wen Tang	275
Theoretical seismograms of rayleigh wave in saturated half space.....	Yu Zhang, Yixian Xu	280
Physical experiments for Rayleigh surface wave field.....	Ziying Xiong, Zhengping Liu, Bin Song, Lang Song	286
Seismic sequence and stratigraphic sequence characteristics in fuqing-pingtian sea area.....	Jiang Xu, Shaohua Zhao	291
Dispersion analysis of Rayleigh waves in viscoelastic media.....	Kai Zhang, Yinhe Luo, Jianghai Xia, Chao Chen	298
Inversion of Rayleigh wave dispersion curves with an artificial neural network		

..... Tianchun Yang, Yanqing Wu, Qiren Wang, Jianping Liao 303

SECTION 2 ELECTRIC / ELECTROMAGNETIC AND SNMR METHODS

Γ_0 resistivity monitoring for environmental and engineering applications.....	Torleif Dahlin	312
Assessment of heterogeneity of an internal structure of an earth-fill embankment with 2-D resistivity survey..	Peangta Satarugsa, Praiswan Uphatum, Manatchanok Buanark, Sakorn Sangchupoo	318
Combined 2D electrical imaging lines into 3D model for detection shallow buried cavities on Kangar, Perlis, Malaysia	Alfouzan F. A., Loke M. H., Hussein A. M., Nawawi M. N. M.	325
Geophysical anomaly by integrated monitoring associated with aftershocks of Wenchuan earthquake of China.....	Xuben Wang, Zhiyong Lü, Qiao Wang, Yun Bai, Xianzhi Zhu, Li Lin	333
Accurate computation of radiomagnetotelluric fields on 3D topography with surface integral equation methods	Zhengyong Ren, Thomas Kalscheuer, Hansruedi Maurer	338
Application of multi-electrodes electrical method to landslide detection in western Hubei	Shengye Zhang, Lixun Chen, Changchun Wang, Yanbin Shi	344
Characterization of carbonate features using electromagnetic multiscale computerized crosshole tomography.....	Hanming Gu, Xianhai Song, Zhe Yan, Riyuan Xia, Shengzhang Zou	349
Parameter improvement of cole-cole model for the large dielectric enhancement of rocks	Miao Luo, Heping Pan	355
1D EM responses of borehole-surface method in frequency-domain.....	Lifeng Mao, Xuben Wang	360
Three dimensional CSMT modeling for complex anomaly bodies	Jifeng Zhang, Jingtian Tang, Xiu Li	365
Application of spatial domain 2D mean filtering on MT static correction	Wenbo Zhang, Guangtao Chen	370
Application of high density electrical method to highway landslide geological survey.....	Keming Bu, Chunmei Zhou	374
The research of SNMR one-dimensional forward excited by finite grounding wire.....	Yuanjie Li, Wei Huang, Zhenyu Li, Shengping Gong	379
Study of capacitive coupling effect and decoupling technology in frequency domain IP.	Guohong Fu	385
Investigation of groundwater pollution at a landfill site using high-density electric resistivity tomography	Shaohong Zhang	391
Research and application of zoom-FFT algorithm on spectrum analysis of long period magnetotelluric ...	Wei Zhang, Xuben Wang, Qingyan Qin, Zhong Li	395
Application of SIRT in Electromagnetic CT.....	Haijun Liu, Zimei Li, Hongxia Yang, Guochuang Hu, Guoming Liu	399
Application of crosshole electromagnetic wave computerized tomography in the investigation of underground caves on residential areas	Xilin Tao, Yanjun Chang, Chanhua Luo, Yongtao, Ze Tao	402
Simulated annealing for vertical magnetic dipole TEM 1D inversion	Jianhui Li, Ziqiang Zhu, Sihong Zeng, Qunyi Liu, Xianqi He, Shiwen Mi	408
A study of integrated geophysical method exploration on landfill leakage detection in Wuhan.....	Hui Liu, Xiangyun Hu, Guiju Wu	412
Calculation and response of SNMR excitation field excited by square coil.....	Yi Yang, Zhenyu Li, Yunhao Guan, Shengping Gong	417
Influence of the source shift in marine controlled-source electromagnetic	Wenbo Zhang, Wenbo Wei, Ming Deng	422
The research on coded signal of UWB search and rescue radar	Zhongming Zhu, Xuben Wang, Jian Yang	426
Theoretical forward and inverse responses of time-dependent landfill leachate plumes to FEM loop-loop configuration.....	Kaiguang Zhu, Jianwen Yang	432
Application of electrical prospecting methods in waste landfill.....	Zimei Li, Haijun Liu, Jin Yang, Lili Wang, Liying Zhao	437
Using high-density resistivity method in the systematic investigation on the water circulatory system of Jiuzhai Valley-Huanglong Core View Area .	Lijuan Chen, Jun Li, Donglang Xu, Xuben Wang	442

The application of CSAMT in prospective evaluation of geothermal resources in Liuzhou, Guangxi, China..... *Jialian Chen, Guoqi Zhu, Jun He, Tongqing Wang* 447

Complex terrain effect and studying on 2.5-D TEM..... *Yun Liu, Xuben Wang* 452

Study of negative polarizability phenomenon due to using induced polarization method in Saline-alkali area *Tianyi Wang, Guohui Liu, Shihui Sun, Meng Wang, Jing Xu* 457

Study on high-frequency MT method in candidate rock geologic structure detection for high level radioactive waste disposal..... *Juzhi Deng, Qingcheng Liu, Yuling Gong, Hua Zhang, Handong Tan* 463

Study of geoelectrical features by using frequency electromagnetic survey at a mining abandoned site *Shaohong Zhang* 468

Study of wavelet de-noising in time-domain airborne electromagnetic data processing..... *Dongwei Lü, Xuben Wang, Bin Chen, Lifeng Mao, Kai Zheng* 473

Survey of the selection moisture forecasting model feature based on support vector machine..... *Zheng Hou, Guohui Liu, Hongwei Song, Tianyi Wang, Ying Yuan* 478

Study on the characteristics of electromagnetic wave field in coal and gas outburst orientation *Jiulong Cheng, Xiaobing Xu, Guoqing Jiang* 483

Application of TEM technology in water abundance detection in coal seam floor..... *Donglin Dong, Cunshe Wang, Wenjie Sun, Zhen Sun* 489

The application of impedance phase in long period magnetotelluric sounding..... *Qingyan Qin, Xuben Wang, Wei Zhang, Zhong Li* 494

3-D terrain effect and numerical modeling on TEM..... *Pinrong Lin, Yun Liu, Jianhua Li* 498

Discussion on artificial neural network technology used to predict the underground water content..... *Hongwei Song, Guohui Liu, Zheng Hou, Tianyi Wang* 503

Capacitively-coupled resistivity methods and its application in near-surface geophysical prospecting..... *Hui Chen, Juzhi Deng, Junjun Hu* 508

Study of the complex resistivity of rocks and ores model using physical simulation..... *Lishan Huang, Shengye Zhang, Rongzhong Jing* 513

The relationship between MRS data in Pearl River Delta of China and water yield *Yao Wang, Zhenyu Li, Wei Huang, Xin Zhou, Shengping Gong* 520

A study on pseudo-abnormality of all-time apparent resistivity for transient electromagnetic method..... *Kai Zheng, Xuben Wang, Songwei Guo, Bin Li* 524

Research on three-dimensional full-space transient electromagnetic modeling for advanced prediction.... *Haiyan Yang, Juzhi Deng, Jianhua Yue* 529

Depth research of magnetic resonance sounding *Yunhao Guan, Zhenyu Li, Zhibao Ni, Yuanjie Li, Yi Yang* 534

The application of integrated geophysical methods in non-destructive archaeological exploration in Jinsha Site..... *Nian Yu, Xuben Wang, Qinglong Hu, Shuquan Gao* 538

2.5-D forward numerical simulation of ip method in time domain under the condition of undulate terrain *Yanbin Shi, Shengye Zhang, Yongliang Meng* 544

Application of mohr circle impedance tensor decomposition to inhibit the distortion caused by shallow inhomogeneity..... *Yanlong Wang, Jiabin Yan, Dawei Fang, Wei Li, Di Wu* 550

Application research of transient electromagnetic method in the underwater-karst detection..... *Jiakun Huang, Juzhi Deng, Qingcheng Liu, Shangping Xie, Hui Chen* 555

Study of negative polarizability phenomenon due to using induced polarization method in saline-alkali area *Tianyi Wang, Guohui Liu, Shihui Sun, Meng Wang, Jing Xu* 560

Volume 2

SECTION 3 GPR APPLICATIONS

Locating LNAPL contamination in the field using GPR velocity anomalies: examples from Hill AFB, Utah, USA *John H. Bradford* 566

High resolution ground penetrating radar imaging and characterization..... *Jan van der Kruk, Giovanni A. Meles, Anja Klotzsche, Rob W. Jacob, Joseph A. Doetsch, Niklas Linde, Hansruedi Maurer, Harry Vereecken, Alan G. Green* 574

Study on signal denoising of ground penetrating radar based on intelligent wavelet transform.....	
..... Guoqing Chen, Guoshao Su, Zhanfeng Fan, Zhiheng Lin, Zhifa Zeng	583
Simulation of GPR in multi-scale heterogeneity medium by overlapping Yee FDTD method.....	
..... Zhaofa Zeng, Jinjie Liu, Fengshan Liu	587
Elimination of direct wave in GPR signal via 2-D physical wavelet frame	
..... Xianxin Shi, Qiufen Yang, Kai Wu	594
A new generation ground penetrating radar with wireless data communication –WGPR system.....	
..... Huaping Wang, Ce Richard Liu, Ren Wei, Guo Chen	600
Design and application of digitized data acquisition system based on LCR-D gravimeter	
..... Panpan Zhang, Bo Shen, Yi Xiao	605
Research and application of explored by ground penetrating radar on the modern spectral technology	
..... Feng Yang, Jing Zhao, Kai Han	611
The application of the improved linear transformation of the finite difference reverse-time migration in the GPR data processing.....	
..... Wenbin Zhou, Deshan Feng, Bin Zhang, Depeng Chen	618
Permittivity measurement for nickel-copper ores by open-ended coaxial probe	
..... Junjun Wu, Sixin Liu, Hang Dong, Lili Zhang	625
Application and research of geologic radar in groundwater disease of tunnel engineering inspection.....	
..... Yu Wang, Minan Tang, Zhenzhong Han, Shengxie Xiao, Yuancai Zhang	631
The study of GPR cross-pole polarization.....	
..... Jing Li, Zhaofa Zeng, Fengshan Liu	637
Detection of periodic motions of visually obscured human beings using UWB radar	
..... Zhaofa Zeng, Jiguang Sun, Yuhong Liu, Tiera Turner, Fang Zeng, Fengshan Liu	642
Instantaneous attributes for characterization of subsurface structures of an active fault by GPR.....	
..... Qi Lu, Zhaofa Zeng, Cai Liu, Xuan Feng, Motoyuki Sato	648
Research on the annular display technology of ground penetrating radar data	
..... Zhixin Liu, Junwen Wu, Yunlei Xu	651
Application research of GPR technology in the governance project of the shaft wall in coal mine	
..... Hua Zhang, Haiyan Yang	656
Radar image characteristics and detection of irrigating pipeline in infield.....	
..... Xianlei Xu, Yanling Zhao, Zhenqi Hu, Junguo Yang, Keke Zhao	661
Application of GPR in evaluation of stability on rocks surrounding hand-dug piles	
..... Minan Tang, Shikun Deng, Xiaohong Hao, Baoling Sun, Jishun Pan, Guangxiang Yuan, Yu Wang	669
Numerical simulations of borehole radar detection for metal ore	
..... Sixin Liu, Junfeng Zhou, Junjun Wu, Zhaofa Zeng	674
The layered media inverse Q filtering algorithm for GPR signals processing based on wavefield downward continuation	
..... Lili Zhang, Sixin Liu, Junjun Wu, Zhixian Zhang	679
Sample analysis and GPR detection for LNAPL contaminated soils.....	
..... Qi Lu, Xuan Feng, Cai Liu, Zhaofa Zeng, Motoyuki Sato	684
Life-detection radar signal processing	
..... Guofang Liu, Zhongming Zhu, Xia Lu	689
Realization of ground-penetrating radar migration imaging in frequency-wavenumber domain.....	
..... Yixiang Luo, Xuben Wang, Liangyi Tang, YiChen, LixiaSong	693
Application of GV3 in tunnel lining detection	
..... Hui Xu, Yanjun Chang, Xilin Tao	700
Application of GPR in the hole survey of the subway project	
..... Chunguan Zhang, Bingqiang Yuan, Liguang Wang, Mingyi Song	707
Design and development of multi-channel penetrating radar system with high-speed sampling	
..... Suping Peng, Fan Cui, Feng Yang, Shuang He	712
Wavelet analysis on the results of compact grouting detected by means of ground penetrating radar	
..... Jun Chen, Yonghui Zhao, Shuangcheng Ge, Guoqian Liang	718
The causes analysis and detection to collapse on civil roads	
..... Chuanlei Wang, Shunfang Xu, Zan Qua, Wei Yang ¹ , Zhixiong Fang	723
Urban underground drainage network investigation of ground penetrating radar.....	
..... Jidong Lü	728

SECTION 4 GRAVITY AND MAGNETIC APPLICATIONS

Detection of magnetic UXO anomalies in noisy environments	734
..... <i>Yaoguo Li, Kristofer Davis, Richard Krahenbuhl, Todd Meglich</i>	
Application of magnetic susceptibility for wetlands delineation.....	741
..... <i>Janet E. Simms, Anthony R. Lobred</i>	
Gravity modelling of the crust and upper mantle for understanding of tectonic processes: a case study for Europe.....	748
..... <i>Mikhail K. Kaban, Magdala Tesauero, Maik Thomas</i>	
Assessing collapse risk in evaporite sinkhole-prone areas using gravimetry and radar interferometry.....	753
..... <i>Jeffrey G. Paine, Sean M. Buckley, Edward W. Collins, Clark R. Wilson</i>	
Gravity and magnetic field feature for archaeology in site of the Emperor Qinshihuang Mausoleum, China.....	764
..... <i>Bingqiang Yuan, Shiyi Liu, Guoming Yu, Mingsheng Yang, Qingbo Duan</i>	
Magnetic properties of the gravel layer in Yichang area and indication for the linking of the three gorges of Yangtze River	770
..... <i>Yufen Zhang, Chang'an Li, Yong Zhang, Ting Li</i>	
Super large-scale magnetic data inversion.....	777
..... <i>Bo Yang, Yixian Xu</i>	
Potential field gradient modulus maxima edge detection based on wavelet transform	783
..... <i>Qinqin Zeng, Tianyou Liu</i>	
Fault determination using one dimensional wavelet analysis.....	787
..... <i>Cooper S. Morris, Tianyou Liu</i>	
Research on the precambrian basement structure of Shanxi fault basin by aeromagnetic data	792
..... <i>Jinlan Liu, Qingchun Li</i>	
The applied research of ground high-precision magnetic survey in intersection-type uranium exploration	797
..... <i>Man Li, Genxian Fang, Zhiyong Zhang, Junchang Cao</i>	
A case study on geophysical techniques for the marine submerged pipeline	802
..... <i>Banglai Lu, Zan Qu, Chao Chen</i>	
The study of 3-D magnetic forward modeling of complex models.....	810
..... <i>Jun Li, Lijuan Cheng, Xuben Wang, Donglang Xu</i>	
Processing of the static data observed by CG-5 gravimeter via Tsoft.....	814
..... <i>Yi Xiao, Bo Shen, Panpan Zhang</i>	
Chaotic particle swarm optimization for geophysical inversion of magnetic data	820
..... <i>Ning Qiu, Qingsheng Liu, Qingli Zeng</i>	
The application of hybrid optimization algorithm in joint inversion of surface and borehole magnetic data	825
..... <i>Dalian Zhang, Tianyou Liu</i>	
Sedimentary provenance studies using magnetic parameters: a case study of Chuan river section at the upper reaches of the Yangtze River	832
..... <i>Yufen Zhang, Lingqin Yan, Chang'an Li, Yong Zhang, Lei Shao</i>	

SECTION 5 SPATIAL INFORMATION TECHNOLOGY

Application of contour strips in protecting water and soil environments... <i>Roy R. Gu, Mahesh Sahu</i>	842
Vegetation spatio-temporal changes and human activities impacts in the Mt. Qomolangma national nature reserve during 2000-2007	849
..... <i>Aike Kan, Xuben Wang, Guoqing Li, Yong Luo, Xu Wu</i>	
Application of remote sensing interpretation in waterlogged area resulted from mining subsidence and water quality monitoring.....	854
..... <i>Wenjie Sun, Qiang Wu, Donglin Dong, Yu Zhang</i>	
The design and research of atmospheric pollution dispersion simulation evaluation information system ..	860
..... <i>Bin Yang, Huixi Xu, Qing Wang</i>	
Zoning of geological disasters risk in the Chengdu earthquake stricken area based on GIS	867
..... <i>Dong Huang, Jianping Qiao, Hongling Tian, Lili Shi</i>	
The research of geo-browser for spatial information applications	873
..... <i>Bin Liu, Fang Miao</i>	
Research on the digital system of archaeological based on GIS.....	881
..... <i>Ligang Cao, Xuben Wang</i>	
The application of CBERS-02B to extract and deduce the linear features	888
..... <i>Qiuling Yang, Fang Miao, Chengming Ye, Jiaguang Li</i>	
Research on geometric rectification of the quickbird satellite image	893
..... <i>Lihong Wan, Yanli Shi</i>	
The ecological security assessment of earthquake-stricken area based on RS and GIS technology—take the city of Dujiangyan as example	898
..... <i>Zhe Li, Zheng-wei He, Ping Sun, Chun Gu</i>	

Application research of hyperspectral-remote-sensing to vegetation coverage rate parameter acquisition	<i>Yaohua Luo, Xianguo Tuo, Jianbo Yang, Zhe Li</i>	905
Fast processing of multi-source remote sensing data and disaster disk assessment technology face to geological disasters research	<i>Dongjian Xue, Zhengwei He, Tao Shu, Xuefeng Zhang, Donghui Zhang</i>	908
The research and application of AHP methods in ecological security monitoring and evaluation for the Tibet Plateau	<i>Xu Wu, Xuben Wang, Aike Kan, Zhiyong Gao, Hanyu Lu</i>	913
The hazard zonation and early warning of the Beijing mountain area debris flow	<i>Jinbao Liu, Zhengwei He, Yingjie Duan</i>	918
The quantitative method of qualitative mining spatial information based on fractal theory	<i>Zhengli Mao, Mingqiang Yang</i>	924

SECTION 6 INTEGRATED GEOPHYSICAL APPLICATIONS

Role of geophysical techniques for carbon capture & storage	<i>Sunjay, Ph. D. Research Scholar</i>	930
Geo-hazards induced by the Wenchuan earthquake	<i>Qiang Xu, Runqiu Huang, Weile Li</i>	936
Crack remote monitor and the application of a landslide in Panzhihua China	<i>Honghui Wang, Xianguo Tuo, Jianbo Yang, Xiaoping Yu, Tianbin Li, Qiang Xu, Dashun Xi</i>	943
Research on optimal design of embedding anti-slide pile by finite element method	<i>Yu Luo, Siming He</i>	948
Application of geophysical methods to the fault detection in Han-Wang, Mianzhu	<i>Xianzhi Zhu, Xuben Wang, Qiao Wang, Shuquan Gao</i>	954
Transient rayleigh surface wave method applied in the non-destructive testing of the quality of cement-soil mixing piles	<i>Jiangping Liu, Yongzai Xi, Niannian Qu, Xiaoliu Wang</i>	959
The application of SMS & web technology in landslide hazard monitoring and forecast system	<i>Jianbo Yang, Xianguo Tuo, Honghui Wang, Zhe Li, Tianbin Li, Qiang Xu</i>	964
Design of self-potential measure system based on acquisition station	<i>Naiquan Sun, Yongmei Yang</i>	969
Experiment analysis and application on nuclear magnetic resonance logging	<i>Huolin Ma, Heping Pan, Zeyu Zhang</i>	974
Key models of landslide risk decision support system of Wanzhou, Chongqing	<i>Hongling Tian, Lili Shi, Zongji Yang</i>	979
The optical grating fiber sensing technology be used in geological hazards monitoring	<i>Xianwei Meng, Qing Zhang, Yanxin Shi, Yongwen Han, Xiaofei Zhang</i>	984
Calculation method of hydrogeological parameters by using logging data	<i>Heping Pan, Yi Wu, Guixin Yang, Shuguang Peng, Weizhen Di</i>	989
Weighted GM (1,1) model in deformation monitoring of applied research	<i>Yuming Wei, Xinghai Dang, Pengyuan Yang, Yuli Yang</i>	995
Construction of mine geological environment monitoring and early warning and forecasting system based on HNGICS-a case study of gold mine at western Henan	<i>Chunmei Zhou, Fusan Guo, Qiaohong Yuan, Deying Li, Xianfu Li</i>	999
Current situation of earthquake preparedness and disaster reduction in China	<i>Li Yu, Yong Guo, Song Gao, Changjiang Lu</i>	1005
Ecological environment sustainable development evaluation for river basins: methodology and modeling	<i>Yan Tang, Aike Kan, Xu Wu, Hanyu Lu</i>	1010
Study on geophysical methods in mine geological environmental assessment	<i>Zhonghong Yu, Chuanlei Wang, Lingqin Yan</i>	1016
The application of seismic geomorphology on interpretation for seismic data	<i>Xuefei Chen, Xueben Wang, Lihui Liu</i>	1021
Necessity and feasibility analysis of the rapid earthquake early warning by mobile	<i>Xiaoling Zhong, Yong Guo</i>	1026
Geological modeling method of three-dimensional surface reconstruction based on two-dimensional outlines	<i>Xingxiang Jian, Yun Liu, Qingyan Qin</i>	1030

Application for prototype basin analysis in the Paleo-tectonic stress fields in Jurassic, western margin Ordos basin	<i>Shujing Sun, Lijun Song, Ni Zhang, Jinghong Li, JingFang</i>	1035
Application for the fission-track thermal evolution history in the formation age of Yaoshan formation, Tan Mountain.....	<i>Lijun Song, Chiyang Liu, Shujing Sun, Bingqiang Yuan, Jinghong Li, Ni Zhang, Guoyu Jiang</i>	1040
Study on mining-induced earthquakes and the disaster model of three coal mines in eastern Pingdingshan district.....	<i>Hongyi Wang, Fuwang Zhang, Zhanfeng Huang</i>	1044
Discussion on the relationship between physiography stage-tectonic rhythm-climate cycle coupling and geological hazard at the Three Gorges area.....	<i>Chang'an Li, Lei Shao, Shengyuan Yuan, Jacques</i>	1050

SECTION 3

GPR APPLICATIONS

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

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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 ($K \sim 81$), whereas common non-aqueous phase liquid (NAPL) contaminants such as light hydrocarbons and chlorinated solvents have very low permittivity ($K \sim 2$) 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