

# **2018 17th International Conference on Ground Penetrating Radar (GPR 2018)**

**Rapperswil, Switzerland  
18 – 21 June 2018**



**IEEE Catalog Number: CFP18E75-POD  
ISBN: 978-1-5386-5778-2**

**Copyright © 2018 by the Institute of Electrical and Electronics Engineers, Inc.  
All Rights Reserved**

*Copyright and Reprint Permissions:* Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854. All rights reserved.

***\*\*\* This is a print representation of what appears in the IEEE Digital Library. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP18E75-POD
ISBN (Print-On-Demand):	978-1-5386-5778-2
ISBN (Online):	978-1-5386-5777-5
ISSN:	2474-3836

**Additional Copies of This Publication Are Available From:**

Curran Associates, Inc  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: (845) 758-0400  
Fax: (845) 758-2633  
E-mail: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

CURRAN ASSOCIATES INC.  
**proceedings**  
.com

# TABLE OF CONTENTS

<b>GPR FULL-WAVEFORM INVERSION, RECENT DEVELOPMENTS, AND FUTURE OPPORTUNITIES .....</b>	<b>1</b>
<i>J. van der Kruk ; T. Liu ; A. Mozaffari ; N. Gueting ; A. Klotzsche ; H. Vereecken ; C. Warren ; A. Giannopoulos</i>	
<b>A HIGH-STABILITY DUAL-CHIP GPR FOR COOPERATIVE TARGET PROBING .....</b>	<b>7</b>
<i>D. Rabus ; F. Minary ; G. Martin ; J.-M. Friedt</i>	
<b>MODELING OF 3D STOCHASTIC FRACTURE MEDIA AND CALCULATION OF GPR RESPONSE.....</b>	<b>13</b>
<i>Jingyi Lin ; Zhaofa Zeng ; Jing Li ; Ling Zhang ; Nan Huaj ; Zhipeng Hu</i>	
<b>NO-CONTACT GPR FOR INVESTIGATING PAINTED WALLS .....</b>	<b>19</b>
<i>Massimiliano Pieraccini ; Lapo Miccinesi</i>	
<b>LUNAR REGOLITH PENETRATING RADAR ON THE LANDER FOR CHANG'E-5 MISSION .....</b>	<b>25</b>
<i>S.X. Shen ; X.L. Hua ; B. Zhou ; Y.X. Li ; W. Lu ; Q. Liu ; Y.C. Ji ; G.Y. Fang ; L. Wang</i>	
<b>RESEARCH ON THE GEOLOGICAL RADAR ANTENNA FOR APPLICATION IN FULL SPACE OF MINE ROADWAY.....</b>	<b>30</b>
<i>Xu Xianlei ; Ma Zheng ; Li Junpeng ; Xie Dongshan</i>	
<b>THE DEVELOPMENT OF MULTI-PASS GPR SYSTEM USING SHORT CHIRP SIGNAL .....</b>	<b>34</b>
<i>Toshimitsu Nozu ; Shigeji Yamada ; Kiyoshi Yoshida ; Toshimune Imai ; Toshihiko Sakagami ; Atsuo Senga</i>	
<b>IRREGULAR CHANGES IN ANTENNA HEIGHT DURING HIGH SPEED SCANNING AS A SOURCE OF ESSENTIAL ERRORS IN MEASURING THE THICKNESS OF ASPHALT .....</b>	<b>41</b>
<i>Alan Frid ; Vladimir Frid</i>	
<b>GPR TOMOGRAPHY IN A WATER SATURATED CONTEXT USING A 13 BOREHOLES CONFIGURATION .....</b>	<b>45</b>
<i>N. Belkowiche ; H. Jourde ; J.P. Rolando ; G. Massonnat ; G. Sénéchal ; D. Rousset</i>	
<b>A M-SEQUENCE UWB RADAR SYSTEM DESIGN AND CONTRAST TEST WITH AN IMPULSE RADAR .....</b>	<b>50</b>
<i>Xin Liu ; Kun Yan ; Zhongcheng Chen ; Cheng Li ; Jingwei Zhang ; Shengbo Ye ; Guangyou Fang</i>	
<b>AN FPGA-BASED FLEXIBLE AND MIMO-CAPABLE GPR SYSTEM .....</b>	<b>54</b>
<i>Arvind Srivastav ; David Ariando ; Soumyajit Mandal</i>	
<b>FIELD EXPERIMENTS USING A PULSE DIRECTIONAL BOREHOLE RADAR SYSTEM WITH A DIPOLE ARRAY ANTENNA .....</b>	<b>60</b>
<i>Satoshi Ebihara ; Yuya Onishi ; Daisuke Katanabe ; Hidehisa Watanabe ; Nobuhiko Shiga ; Kazushige Wada ; Shinsuke Karasawa</i>	
<b>INITIAL LABORATORY FIELD TESTS OF THE ROVER-MOUNTED GPR FOR CHINA'S FIRST MISSION TO MARS.....</b>	<b>66</b>
<i>Bin Zhou ; Yuxi Li ; Dezhi Li ; Wei Lu ; Shaoxiang Shen ; Guang-You Fang ; Yan Su ; Shun Dai</i>	
<b>OPTIMIZATION OF SAMPLING CONVERTER FOR GPR RECEIVER.....</b>	<b>69</b>
<i>V.P. Ruban ; G.P. Pochanin ; O.O. Shuba ; O.G. Pochanin ; O. Ya</i>	
<b>ESTIMATION OF LANE WIDTH FOR OBJECT DETECTION USING IMPULSE GPR WITH “1TX AND 4RX” ANTENNA SYSTEM.....</b>	<b>73</b>
<i>O. Pochanin ; V. Ruban ; T. Ogurtsova ; G. Pochanin ; O. Orlenko ; L. Capineri ; T. Bechtel ; G. Borgioli</i>	
<b>COMPARISON OF GPR AND CAPACITANCE PROBE LABORATORY EXPERIMENTS IN SANDY SOILS.....</b>	<b>78</b>
<i>M. Ercoli ; L. Di Matteo ; C. Pauselli</i>	
<b>AN IMPROVED AIRBORNE VHF RADAR SOUNDER FOR ICE AND DESERT EXPLORATION.....</b>	<b>83</b>
<i>G. Gennarelli ; G. Ludeno ; I. Catapano ; F. Soldovieri ; G. Alberti ; D. Califano ; L. Ciofaniello ; G. Palmese ; C. Papa ; G. Pica ; G. Salzillo ; C. Facchinetti ; F. Longo</i>	
<b>COMPARISON OF PULSED AND STEPPED FREQUENCY CONTINUOUS WAVE (SFCW) GPR SYSTEMS - APPLICATIONS ON REINFORCED CONCRETE AND BRICK/ROCK MASONRIES .....</b>	<b>88</b>
<i>Guido Tronca ; Isaak Tsalicoalou ; Samuel Lehner ; Gianluca Catanzariti</i>	
<b>MINIMUM THRESHOLD FOR THE SAMPLING RATE TO PREVENT AMPLITUDE DISTORTIONS IN ALIASING-FREE GPR SURVEYS .....</b>	<b>94</b>
<i>M. Dossi ; E. Forte ; M. Pipan</i>	
<b>APPLICATION OF THE ATTRIBUTE ANALYSIS FOR INTERPRETATION OF GPR SURVEY DATA .....</b>	<b>100</b>
<i>N. Pudova ; M. Shirobokov ; A. Kuvaldin</i>	
<b>STRUCTURAL PLANES PARAMETERS EXTRACTION METHOD BASED ON BOREHOLE DIGITAL OPTICAL IMAGE AND GPR.....</b>	<b>104</b>
<i>L. Li ; F. Long ; T. Sun ; Z.Q. Han ; X.J. Tang ; W.Z. Ren</i>	
<b>APPLICATION OF SYNCHROQUEEZING SHORT FOURIER TRANSFORM ANALYSIS IN GROUND PENETRATING RADAR THIN LAYER RECOGNITION .....</b>	<b>110</b>
<i>Lihong Qiao ; Yao Qin</i>	
<b>ANALYSIS AND CALIBRATION OF GROUND PENETRATING RADAR SHIELDED ANTENNAS: ANTENNA CALIBRATIONS .....</b>	<b>115</b>
<i>Mezgeen Rasol ; Vega Pérez-Gracia ; Sonia Santos Assunção</i>	
<b>REVERSE TIME MIGRATION OF CROSSWELL GPR DATA BASED ON WAVEFIELD DECOMPOSITION .....</b>	<b>120</b>
<i>Linlin Lei ; Chongmei Zhong ; Li Zhang ; Qingming Zhao ; Huan Yan ; Lei Fu ; Sixin Liu</i>	
<b>A NOVEL INTERFEROMETRY POSITIONING AND TRACKING METHOD WITH SHORT BASELINE FOR UWB THROUGH-THE-WALL RADAR SYSTEM.....</b>	<b>124</b>
<i>Xin Liu ; Jingwei Zhang ; Ruijie Guo ; Guangyao Yang ; Shengbo Ye ; Shiyou Wu ; Guangyou Fang</i>	

<b>STUDY OF OBJECT RECOGNITION WITH GPR BASED ON STFT</b> .....	128
<i>Cheng-Hao Wang ; Xian-Lin Liu</i>	
<b>A MULTI - FREQUENCY GPR DATA FUSION METHOD FOR UNDERGROUND DISEASE DETECTION</b> .....	132
<i>Xu Xianlei ; Li Junpeng ; Ma Zheng</i>	
<b>MIGRATION DECONVOLUTION OF GROUND PENETRATING RADAR (GPR) DATA</b> .....	136
<i>Lei Fu ; Cai Liu ; Sixin Liu ; Zhaofa Zeng ; Hongqing Li ; Linlin Lei</i>	
<b>LUNAR PENETRATING RADAR DATA PROCESSING AND ANALYSIS BASED ON CEEMD</b> .....	140
<i>Zhang Ling ; Zeng Zhaofa ; Li Jing ; Lin Jingyi ; Hu Zhipeng ; Zhang Jianmin</i>	
<b>COMBINATION OF SUPPORT VECTOR MACHINE AND H-ALPHA DECOMPOSITION FOR SUBSURFACE TARGET CLASSIFICATION OF GPR</b> .....	145
<i>Haoqiu Zhou ; Xuan Feng ; Yan Zhang ; Enhedelilai Nilot ; Minghe Zhang ; Zejun Dong ; Jiahui Qi</i>	
<b>STUDY ON POLARIZATION ROTATION OF ELECTROMAGNETIC PLANE WAVE FROM ROUGH SURFACE</b> .....	149
<i>Zejun Dong ; Xuan Feng ; Cai Liu ; Yan Zhang ; Enhedelilai Nilot ; Minghe Zhang ; Haoqiu Zhou</i>	
<b>DRY SNOW PERMITTIVITY EVALUATION FROM DENSITY: A CRITICAL REVIEW</b> .....	153
<i>Federico Di Paolo ; Barbara Cosciotti ; Sebastian E. Lauro ; Elisabetta Mattei ; Elena Pettinelli</i>	
<b>FULL-POLARIMETRIC GPR FOR DETECTING ICE FRACTURES</b> .....	158
<i>Chaopeng Luo ; Xuan Feng ; Cai Liu ; Yan Zhang ; Enhedelilai Nilot ; Minghe Zhang ; Zejun Dong ; Haoqiu Zhou</i>	
<b>UNDERGROUND COMPACTNESS INVERSION ALGORITHM BASED ON HILBERT MARGINAL SPECTRUM</b> .....	162
<i>Qiao Xu ; Yang Feng ; Xu Maoxuan ; Zheng Jing ; Abdukyum Abla</i>	
<b>BOREHOLE RADAR DATA PROCESSING BASED ON EMPIRICAL MODE DECOMPOSITION</b> .....	166
<i>Chunguang Ma ; Qing Zhao ; Jianjian Huo ; Longhao Xie</i>	
<b>ESTIMATING MOISTURE CHANGES IN CONCRETE USING GPR VELOCITY ANALYSIS: POTENTIAL AND LIMITATIONS</b> .....	170
<i>Philipp Koyan ; Jens Tronicke ; Niklas Allroggen ; Andreas Kathage ; Michael Willmes</i>	
<b>TRACING THE LAYER BOUNDARY OF THE ICE SHEET FROM RADIO-ECHO SOUNDING DATA</b> .....	176
<i>S. Wang ; Y. L. Song ; Z. X. Cheng ; Q. Wang ; B. Zhao ; Y. Liu</i>	
<b>A MODIFIED ALGORITHM FOR ACCURATE GPR WAVE VELOCITY ESTIMATION WITH COMMON OFFSET SETTING ANTENNA</b> .....	180
<i>Fei Xie ; Janet Fung-Chu Sham ; Wallace Wai-Lok Lai ; Xavier Dérobert</i>	
<b>RGPR — AN OPEN-SOURCE PACKAGE TO PROCESS AND VISUALIZE GPR DATA</b> .....	186
<i>Emanuel Huber ; Guillaume Hans</i>	
<b>UNDERGROUND COMPACTNESS INVERSION ALGORITHM BASED ON HILBERT MARGINAL SPECTRUM</b> .....	191
<i>Qiao Xu ; Yang Feng ; Zheng Jing</i>	
<b>FULL-POLARIMETRIC GROUND PENETRATING RADAR UNDERGROUND OBJECTS CLASSIFICATION USING RANDOM FOREST</b> .....	195
<i>Minghe Zhang ; Xuan Feng ; Yan Zhang ; Enhedelilai Nilot ; Zejun Dong ; Haoqiu Zhou</i>	
<b>NOISE SUPPRESSION OF GPR DATA USING VARIATIONAL MODE DECOMPOSITION</b> .....	200
<i>Xuebing Zhang ; Xuan Feng ; Enhedelilai Nilot ; Minghe Zhang</i>	
<b>MONITORING SALT TRACER TRANSPORT IN GRANITE ROCK USING GROUND PENETRATING RADAR REFLECTION IMAGING</b> .....	204
<i>P.-L. Giertzuch ; J. Doetsch ; A. Kittilä ; M.R. Jalali ; C. Schmelzbach ; H. Maurer ; A. Shakas</i>	
<b>FREQUENCY DOMAIN REVERSE TIME MIGRATION OF GPR WITH ATTENUATION COMPENSATION</b> .....	210
<i>Hai Liu ; Bangan Xing ; Feng Han ; Feng Zhou</i>	
<b>PONDVIEW: INTUITIVE AND EFFICIENT VISUALIZATION OF 3D GPR DATA</b> .....	214
<i>M. Grasmueck ; D. Viggiano</i>	
<b>DETECTION OF TOP COAL BY CONDUCTIVELY-GUIDED BOREHOLE RADAR WAVES: RESULTS FROM NUMERICAL MODELLING</b> .....	220
<i>Binzhong Zhou ; Reuben Madden</i>	
<b>ELLIPSE-INSCRIBED LINE-ELEMENT MIGRATION, ELM: A NONPARAMETRIC OBJECT-PERIPHERY RECONSTRUCTION METHOD WITH MULTI-STATIC GPR</b> .....	226
<i>Yoshihiko Nomura ; Takumi Narita ; Tokuhiro Sugiura ; Yoshikazu Sudo</i>	
<b>QUANTITATIVE 3-D GPR ANALYSIS TO ESTIMATE THE TOTAL VOLUME AND WATER CONTENT OF A GLACIER</b> .....	230
<i>M. Dossi ; E. Forte ; M. Pipan ; R.R. Colucci</i>	
<b>WEIGHTED-AVERAGING OPERATORS FOR ACCURATE 2.5D FINITE-DIFFERENCE FREQUENCY DOMAIN RADAR WAVES MODELING</b> .....	236
<i>Bernard Doyon ; Bernard Giroux</i>	
<b>CALCULATION OF THE TRANSIENT ELECTRIC FIELD TRANSMITTED IN A LOSSY MEDIUM RADIATED BY AN EQUIVALENT GPR DIPOLE ANTENNA</b> .....	242
<i>Silvestar Šesnić ; Dragan Poljak</i>	
<b>A NOVEL FORWARD MODEL OF GROUND PENETRATING RADAR IN THE FAR FIELD</b> .....	247
<i>J. W. Zhang ; S. B. Ve ; R. J. Guo ; X. F. Liu ; G. Y. Fang</i>	
<b>FULL WAVEFORM INVERSION OF CROSS-HOLE RADAR DATA USING ENVELOPE OBJECTIVE FUNCTION</b> .....	253
<i>Xintong Liu ; Sixin Liu ; Lei Fu</i>	

<b>3D PRE-STACK REVERSE TIME MIGRATION OF GROUND PENETRATING RADAR FOR SUBSURFACE IMAGING</b> .....	258
<i>Minling Wang ; Honghua Wang ; Hai Liu</i>	
<b>DETERMINATION OF COMPLEX PERMITTIVITY BY INVERTING COAXIAL TRANSMISSION LINE DATA USING FDTD</b> .....	262
<i>Kazumori Takahashi ; Markus Loewer ; Jan Igel ; Chisato Konishi</i>	
<b>HIGH-PERFORMANCE NUMERICAL SIMULATION OF RADAR WAVE SCATTERING DUE TO TOPOGRAPHIC ROUGHNESS</b> .....	268
<i>Lanbo Liu ; Guofeng Liu ; Rongyi Qian ; Qinghua Huang ; Zhanhui Li</i>	
<b>NEW IMPROVEMENTS TO THE BOREHOLE RADAR TOMOGRAPHY PACKAGE BH_TOMO</b> .....	272
<i>Bernard Giroux</i>	
<b>ADVANCED THREE-DIMENSIONAL MICROWAVE TOMOGRAPHY FOR THE IMAGING OF BURIED TARGETS</b> .....	278
<i>Davide Comite ; Federica Murgia ; Alessandro Galli ; Ilaria Catapano ; Francesco Soldovieri</i>	
<b>ERROR ESTIMATION OF VELOCITIES DERIVED FROM FDTD SIMULATED MULTI-OFFSET GPR DATA</b> .....	282
<i>Karl-Josef Sandmeier</i>	
<b>A HUYGENS SUBGRIDDING APPROACH FOR EFFICIENT MODELLING OF GROUND PENETRATING RADAR USING THE FINITE-DIFFERENCE TIME-DOMAIN METHOD</b> .....	288
<i>John Hartley ; Antonios Giannopoulos ; Craig Warren</i>	
<b>A MACHINE LEARNING APPROACH FOR SIMULATING GROUND PENETRATING RADAR</b> .....	294
<i>Iraklis Giannakis ; Antonios Giannopoulos ; Craig Warren</i>	
<b>MULTIPARAMETER FULL-WAVEFORM INVERSION OF ON-GROUND GPR USING MEMORYLESS QUASI-NEWTON (MLQN) METHOD</b> .....	298
<i>Enhedelihai Nilot ; Xuan Feng ; Yan Zhang ; Minghe Zhang ; Zejun Dong ; Haoqiu Zhou ; Xuebing Zhang</i>	
<b>THEORY FOR 1D GPR DATA INVERSION FOR A DISSIPATIVE LAYERED MEDIUM</b> .....	302
<i>Bingkun Yang ; Evert Slob</i>	
<b>THEORY FOR 1D FULL WAVEFORM INVERSION OF SURFACE GPR DATA</b> .....	306
<i>Evert Slob</i>	
<b>A NUMERICAL STUDY ON USING GUIDED GPR WAVES ALONG METALLIC CYLINDERS IN BOREHOLES FOR PERMITTIVITY SOUNDING</b> .....	310
<i>Sam Stadler ; Jan Igel</i>	
<b>REAL-TIME DETECTION TECHNOLOGY OF SYNCHRONOUS GROUTING FOR SHIELD TUNNEL AND ANALYSIS OF GROUTING EFFECT</b> .....	316
<i>Xie Xiongyao ; Zeng Li ; Zhou Biao</i>	
<b>APPLICATION OF BOREHOLE RADAR FOR DAM LEAKAGE DETECTION</b> .....	322
<i>Sixin Liu ; Xudong Wang ; Lei Fu ; Bin Wei</i>	
<b>MAPPING COMPLEX GEOLOGY WITH GPR IN A CANADIAN POTASH MINE</b> .....	328
<i>C.W. Funk ; M. van den Bergh</i>	
<b>A CASE STUDY ON DETECTION OF SUBSURFACE CAVITIES OF URBAN ROADS USING GROUND-COUPLED GPR</b> .....	333
<i>Jongeun Baek ; Jin-Sung Yoon ; Chang-Min Lee ; Yeonwoo Choi</i>	
<b>APPLICATION OF GROUND PENETRATING RADAR AND HILBERT TRANSFORMATION HELPS REVEALING ANOMALOUS BODY OF LEAKAGE IN A CONCRETE STRUCTURE; A CASE HISTORY AT HUAI MAE TOR, TAK PROVINCE, THAILAND</b> .....	338
<i>Noppadol Poomvises ; Anchalee Kongsuk ; Prateep Pakdeerod ; Tanapon Suklim</i>	
<b>A REVIEW OF EMPIRICAL METHODS TO ESTIMATE RELATIVE PERMITTIVITY</b> .....	342
<i>A. J. Rubin ; C.L. Ho</i>	
<b>COAL SUBSURFACE MAPPING FOR SELECTIVE MINING</b> .....	348
<i>Andrew D. Strange ; Zak Jecny</i>	
<b>HIGH-RESOLUTION SIMULATION OF POINT BAR STRUCTURES ASSOCIATED WITH PALEOCHANNEL EVOLUTION WITH GPR</b> .....	354
<i>Rongyi Qian ; Lanbo Liu</i>	
<b>A REAL-TIME METHOD FOR LANDMINE DETECTION USING VEHICLE ARRAY GPR</b> .....	358
<i>Xinghua Shi ; Dandan Cheng ; Zhiyan Song ; Chenghao Wang</i>	
<b>TERRAIN ANALYSIS IN EASTERN UKRAINE AND THE DESIGN OF A ROBOTIC PLATFORM CARRYING GPR SENSORS FOR LANDMINE DETECTION</b> .....	364
<i>T. Bechtel ; G. Pochanin ; S. Truskavetsky ; M. Dimitri ; V. Ruban ; O. Orlenko ; T. Byndych ; A. Sherstyuk ; K. Viatkin ; F. Crawford ; P. Falorni ; A. Bulletti ; L. Capineri</i>	
<b>INVESTIGATION OF ICE JAMS USING THE GPR METHOD</b> .....	369
<i>M.P. Fedorov ; L.L. Fedorova ; D.V. Savvin ; T.P. Prudetskaya ; A.V. Omelyanenko</i>	
<b>A COMPARISON OF SOLID AND LOADED BOWTIE ANTENNAS IN GPR FOR THE DETECTION OF BURIED LANDMINES</b> .....	373
<i>Wouter van Verre ; Frank Podd ; Yee M. Tan ; Xianyang Gao ; Anthony J. Peyton</i>	
<b>SIMULATION OF GROUND PENETRATING RADAR FOR ANTI-PERSONNEL LANDMINE DETECTION</b> .....	379
<i>Xianyang Gao ; Frank Podd ; Wouter van Verre ; David J Daniels ; Yee M. Tan ; Anthony J. Peyton</i>	
<b>USING GPR TO DELINEATE THE PORTER'S PASS FAULT AT THE ACHERON ROCK AVALANCHE, NEW ZEALAND</b> .....	385
<i>David C. Nobes ; Harry M. Jol ; Guyon M. Smith ; David H Bell</i>	

<b>DYNAMICS OF THE FOLDS OF THE MCMURDO ICE SHELF, SCOTT BASE, ANTARCTICA</b> .....	389
<i>Emma F. Stubbs ; David C. Nobes</i>	
<b>ESTIMATION OF ANHYDRITE DISTRIBUTION WITH GPR AND ERT IN THE NORTHERN PART OF THE MORSLEBEN SALT STRUCTURE</b> .....	395
<i>V. Gundelach ; M. Furché</i>	
<b>THE STUDY ON THE NEAR SURFACE STRUCTURE IN YINKEN STEPPE DESERT USING GPR METHOD</b> .....	400
<i>Xueyu Zhao ; Ling Zhang ; Zhaofa Zeng ; Quanying Zhang</i>	
<b>STUDY OF PEATLAND INTERNAL STRUCTURE BY THE GROUND PENETRATING RADAR</b> .....	404
<i>Pavel Ryazantsev ; Victor Mironov</i>	
<b>GPR PROFILE OF BEACON VALLEY, DRY VALLEYS, ANTARCTICA: ANALYSIS OF THE GPR RESPONSE FROM ROCKY PERMAFROST</b> .....	408
<i>David C. Nobes ; Ronald S. Sletten ; Michele T. Bannister ; Myfanwy J. Godfrey</i>	
<b>INVESTIGATING KARST CAVE SEDIMENTS OF UNROOFED CAVES WITH GPR, XRF AND XRD</b> .....	413
<i>Teja Čeru ; Matej Dolenc ; Andrej Gosar</i>	
<b>GPR INVESTIGATION OF ICE-FILLED CRACKS IN LOOSE DEPOSITS</b> .....	419
<i>K.O. Sokolov ; N.D. Prudetskii ; L.L. Fedorova ; D.V. Savvin</i>	
<b>CHARACTERIZATION OF SUBSURFACE STRUCTURE IN DIFFERENT LANDFORMS BASED ON GPR PROFILES ALONG THE QINGHAI-TIBET HIGHWAY ON PERMAFROST REGION</b> .....	423
<i>Xinglin Lu ; Ao Song ; Rongyi Qian ; Lanbo Liu</i>	
<b>GPR STUDY OF SAPROPEL DEPOSITS IN KARELIAN SHALLOW WATER AREAS</b> .....	428
<i>Aleksandr Rodionov ; Pavel Ryazantsev</i>	
<b>GROUNDWATER TABLE LEVEL CHANGES BASED ON GROUND PENETRATING RADAR IMAGES: A CASE STUDY</b> .....	431
<i>Sebastian Kowalczyk ; Anna Lejzerowicz ; Beata Kowalczyk</i>	
<b>INTERNAL ARCHITECTURE OF FLUVIAL DEPOSITS AND THE MORPHOLOGY OF THE SELECTED SECTIONS OF NAREW RIVER VALLEY IN WARSAW AREA (CENTRAL POLAND) BASED ON GPR INVESTIGATIONS</b> .....	436
<i>Anna Lejzerowicz</i>	
<b>QUANTIFYING SCOUR DEPTH IN A STRAIGHTENED GRAVEL-BED RIVER WITH GROUND-PENETRATING RADAR</b> .....	442
<i>Emanuel Huber ; Birte Anders ; Peter Huggenberger</i>	
<b>RESEARCH ON THE DIFFERENCE DETECTION METHOD BASED ON GPR DATA</b> .....	447
<i>Xu Xianlei ; Wenru Gao ; Di Zhang ; Yusen Wang</i>	
<b>COMBINING GROUND PENETRATING RADAR AND ELECTRICAL RESISTIVITY TOMOGRAPHY FOR THE STUDY OF HISTORY OF RELIEF DEVELOPMENT IN DNIEPER RIVER VALLEY</b> .....	451
<i>Svetlana Bricheva ; Kirill Efremov</i>	
<b>COMBINED GPR AND SURFACE MAGNETIC RESONANCE INVESTIGATION FOR AQUIFER CHARACTERISATION</b> .....	456
<i>Jan Igel ; Raphael Dlugosch ; Thomas Günther ; Mike Müller-Petke ; Chuandong Jiang ; Julian Helms ; Jörg Lang ; Jutta Winsemann</i>	
<b>ESTIMATION OF PETROPHYSICAL PARAMETERS OF GRANULAR MATERIALS, APPLYING AN AMPLITUDE INVERSION FROM GPR DATA: CASE STUDY IRAPUATO, GTO., MEXICO</b> .....	461
<i>Félix Antonio Centeno Salas ; Dora Carreon Freyre</i>	
<b>DISPLACEMENT FREQUENCY CHARACTERISTICS OF DIRECT TRANSMISSION OF GPR SIGNALS IN BOREHOLE MEASUREMENTS</b> .....	467
<i>Ivan Khristoforov ; Alexander Omelyanenko ; Pavel Omelyanenko ; Pier Paul Overduin</i>	
<b>EXTENDING SURFACE GEOLOGY DATA THROUGH GPR PROSPECTIONS: QUATERNARY FAULTING SIGNATURE FROM THE CAMPOTENESE AREA (CALABRIA-ITALY)</b> .....	471
<i>K. Gafarov ; M. Ercoli ; D. Cirillo ; C. Pauselli ; F. Brozzetti</i>	
<b>DEEP PENETRATION RADAR: HYDROGEOLOGY AND PALEORELIEF OF UNDERLYING MEDIUM</b> .....	477
<i>I. V. Prokopovich ; P. A. Morozov ; A.V. Popov ; V.V. Kopeikin ; A.I. Berkut ; L.M. Krinitsky</i>	
<b>GROUND PENETRATING RADAR FOR DETECTING SUBSURFACE FEATURES OF ACTIVE GAS VENTS — MOFETTES IN SLOVENIA</b> .....	482
<i>Marjana Zajc ; Nina Rman</i>	
<b>FREQUENCY INFLUENCE IN MICROWAVE SUBSURFACE HOLOGRAPHY FOR COMPOSITE MATERIALS TESTING</b> .....	488
<i>Sergey Ivashov ; Andrey Zhuravlev ; Vladimir Razevig ; Margarita Chizh ; Timothy Bechtel ; Lorenzo Capineri ; Binu Thomas</i>	
<b>EFFECT OF SUSPENDED SEDIMENTS ON GROUND PENETRATING RADAR IMAGING OF RIVERBEDS</b> .....	494
<i>David C. Nobes ; Kim A. Hammond ; Kari N. Bassett</i>	
<b>DETECTION OF DIAPHRAGM WALL DEFECTS USING CROSSHOLE GPR</b> .....	500
<i>Hui Qin ; Xiongyao Xie ; Yu Tang ; Zhengzheng Wang</i>	
<b>NONDESTRUCTIVE MOISTURE MAPPING FROM BASEMENT WALLS WITH HIGH-FREQUENCY GPR</b> .....	505
<i>Anja Leppälä ; Rani Hamrouche ; Timo Saarenketo</i>	
<b>FEASIBILITY OF THE USE OF COHERENT DIELECTRIC INTERFACES AS A GPR ANALYSIS METHODOLOGY IN THE CONTEXT OF COASTAL MASONRY: AN EXPERIMENTAL APPROACH</b> .....	510
<i>Cédric Sachet ; Philippe Sentenac ; Donatienne Leparoux ; Philippe Cote ; Christopher Boulay ; Matthieu Molinie</i>	
<b>LABORATORY VALIDATION OF CORROSION-INDUCED DELAMINATION IN CONCRETE BY GROUND PENETRATING RADAR</b> .....	515
<i>Tin Wai Phoebe Wong ; Chi Sun Poon ; Wai Lok Wallace Lai</i>	

<b>A SIMPLIFIED VELOCITY ESTIMATION METHOD FOR MONITORING THE DAMAGED PAVEMENT BY A MULTISTATIC GPR SYSTEM YAKUMO .....</b>	<b>521</b>
<i>Li Yi ; Lilong Zou ; Motoyuki Sato</i>	
<b>A GPR CASE STUDY IN THE LODAN DAM AREA, REMBANG OF CENTRAL JAVA .....</b>	<b>525</b>
<i>Okci Mardoli ; Ivan Ade Soflyan ; Wahyudi W. Parnadi</i>	
<b>GROUND PENETRATING RADAR APPLICATIONS IN MAPPING UNDERGROUND UTILITIES .....</b>	<b>530</b>
<i>Qi Lu ; Cai Liu ; Yan Wang ; Sixin Liu ; Zhaofa Zeng ; Xuan Feng ; Songsheng She</i>	
<b>GMS3 A UNIFIED SYSTEM OF GROUND PENETRATING RADAR AND CAMERA VECTOR FOR EFFICIENT ROAD INFRASTRUCTURE MAINTENANCE .....</b>	<b>534</b>
<i>Jun Shinohara ; Yugo Kato ; Atsushi Okino ; Elvis Anup Shukla ; Tsutomu Baba</i>	
<b>MODELLING THE DIFFUSION OF ELECTROMAGNETIC WAVES IN CONCRETE .....</b>	<b>539</b>
<i>Stephen Razafindratsima ; Mehdi SbartaĀ ; Jean-Paul Balayssac ; Cédric Payan ; Sandrine Rakotonarivo ; Vincent Garnier</i>	
<b>STUDY ON THE LEAKAGE OF THE CLAY DAM USING GROUND PENETRATING RADAR AND ELECTROMAGNETIC METHOD .....</b>	<b>545</b>
<i>Shufan Hu ; Yonghui Zhao ; Tan Qin ; Cong An ; Shuangcheng Ge</i>	
<b>MONITORING OF WATER IMBIBITION OF A PARTICULAR POROUS PAVEMENT STRUCTURE BY IMPULSE AND STEP-FREQUENCY RADAR .....</b>	<b>550</b>
<i>X. Dérobert ; A. Ihamouten ; F. Bosc ; D. Guilbert ; J.N. Gaudin ; S. Todkar ; F. Bernardin ; J.L. Bicard</i>	
<b>NONDESTRUCTIVE INSPECTION OF AN AIRPORT PAVEMENT BY MIMO ARRAY GPR YAKUMO .....</b>	<b>556</b>
<i>LiLong Zou ; Kazutaka Kikuta ; Motoyuki Sato</i>	
<b>USE OF GPR FOR MONITORING EXPANSION MECHANISM OF SUBSURFACE CAVITY .....</b>	<b>562</b>
<i>Yeon Tae Kim ; Ji Young Choi ; Hee Mun Park ; Ki Deok Kim</i>	
<b>ESTIMATING ROCK MOISTURE BASED ON GROUND PENETRATION RADAR SURVEY IN FROZEN AND THAWED STATES .....</b>	<b>566</b>
<i>L. L. Fedorova ; G. A. Kulyandin ; D. V. Savvin</i>	
<b>DEVELOPMENT OF A CHANGE-DETECTION METHOD ON UNDERGROUND AIR VOID IDENTIFICATION BY TIME-LAPSE GPR 3D IMAGING .....</b>	<b>570</b>
<i>Tess Xiang-Huan Luo ; Wallace Wai-Lok Lai ; Ray Kwong-Wai Chang</i>	
<b>GPR DETECTION OF UNDERGROUND VOID BASED ON LOW-RANK AND SPARSE REPRESENTATION .....</b>	<b>576</b>
<i>Li Liu ; Yinping Han ; Jingxia Li ; Hang Xu ; Bingjie Wang</i>	
<b>FEASIBILITY STUDY OF TIME LAPSE GROUND PENETRATING RADAR AS MONITORING MEASURES FOR DEEP EXCAVATION WORKS .....</b>	<b>580</b>
<i>PAK CW Kenneth ; G. Ren ; J. Li ; Wallace Wai-Lok Lai</i>	
<b>FIELD VALIDATION OF WATER PIPE LEAK BY SPATIAL AND TIME-LAPSED MEASUREMENT OF GPR WAVE VELOCITY .....</b>	<b>586</b>
<i>Bella Wei-Yat Cheung ; Wallace Wai-Lok Lai</i>	
<b>USE OF GROUND PENETRATING RADAR MEASUREMENT COMBINED TO RESISTIVITY MEASUREMENT FOR CHARACTERIZATION OF THE CONCRETE MOISTURE .....</b>	<b>592</b>
<i>Malgorzata Katarzyna Wutke</i>	
<b>THE NEED FOR A RELIABLE MAP OF UTILITY NETWORKS FOR PLANNING UNDERGROUND SPACES .....</b>	<b>599</b>
<i>Siow Wei Jaw ; Rob Van Son ; Victor Khoo Hock Soon ; Gerhard Schrotter ; Richard Loo Wei Kiah ; Sandy Teo Shen Ni ; Jingya Yan</i>	
<b>INVESTIGATION OF THE STRUCTURAL SUBSTANCE OF ROADS VIA GEORADAR AND ULTRASOUND .....</b>	<b>605</b>
<i>Guido Kneib ; Dirk Jansen ; Bastian Wacker</i>	
<b>A COMPARATIVE INVESTIGATION OF THE EFFECTS OF CONCRETE SLEEPERS ON THE GPR SIGNAL FOR THE ASSESSMENT OF RAILWAY BALLAST .....</b>	<b>611</b>
<i>L. Bianchini Ciampoli ; S.S. Artagan ; F. Tosti ; V. Gagliardi ; A.M. Alani ; A. Benedetto</i>	
<b>DISTINCTION OF TENDON DUCTS AND REBARS BY GPR REFLECTION SIGNAL PATTERNS .....</b>	<b>617</b>
<i>Govind K. Sharma ; Thomas Kind</i>	
<b>INVESTIGATION OF REINFORCED CONCRETE BRIDGES BY USING A DUAL-POLARIZED HIGH-FREQUENCY GPR .....</b>	<b>621</b>
<i>Davide Pasculli ; Agnese Natali ; Walter Salvatore ; Francesco Morelli ; Davide Morandi</i>	
<b>A GPR-BASED SENSOR TO MEASURE ASPHALT PAVEMENT DENSITY .....</b>	<b>626</b>
<i>Nectaria Diamanti ; J. David Redman ; A. Peter Annan</i>	
<b>HIGH-RESOLUTION HELICOPTER-BORNE GROUND PENETRATING RADAR SURVEY TO DETERMINE GLACIER BASE TOPOGRAPHY AND THE OUTLOOK OF A PROGLACIAL LAKE .....</b>	<b>632</b>
<i>G. J. Church ; A. Bauder ; M. Grab ; S. Hellmann ; H. Maurer</i>	
<b>DEVELOPMENT OF A NOVEL DUAL-POLARIZATION HELICOPTER-BORNE GPR SYSTEM .....</b>	<b>638</b>
<i>L. Langhammer ; L. Rabenstein ; A. Bauder ; L. Schmid ; M. Grab ; P. Schaer ; H.R. Maurer</i>	
<b>ANALYSIS OF GPR FIELD PARAMETERS FOR ROOT MAPPING IN BRAZIL'S CAATINGA ENVIRONMENT .....</b>	<b>643</b>
<i>Emerson R. Almeida ; Jorge L. Porsani ; Adam Booth ; Alexandre T. Brunello ; Tiina Särkinen</i>	
<b>GPR MEASUREMENTS FOR DIAGNOSING TREE TRUNK .....</b>	<b>649</b>
<i>Kazunori Takahashi ; Kunio Aoiike</i>	
<b>ESTIMATING INFILTRATION FRONT DEPTH USING TIME-LAPSE MULTI-OFFSET GATHERS OBTAINED FROM ARRAY ANTENNA GROUND PENETRATING RADAR .....</b>	<b>655</b>
<i>Hirota Saito ; Nobuhito Nagai ; Seiichiro Kuroda ; Jacopo Sala</i>	
<b>MAPPING THE ROOT SYSTEM OF MATURED TREES USING GROUND PENETRATING RADAR .....</b>	<b>660</b>
<i>A.M. Alani ; L. Bianchini Ciampoli ; L. Lantini ; F. Tosti ; A. Benedetto</i>	

<b>ICE VOLUME ESTIMATES OF SWISS GLACIERS USING HELICOPTER-BORNE GPR — AN EXAMPLE FROM THE GLACIER DE LA PLAINE MORTE</b> .....	666
<i>M. Grab ; A. Bauder ; F. Ammann ; L. Langhammer ; S. Hellmann ; G.J. Church ; L. Schmid ; L. Rabenstein ; H.R. Maurer</i>	
<b>SIMULTANEOUS MULTI-CHANNEL GPR MEASUREMENTS FOR SOIL CHARACTERIZATION</b> .....	672
<i>M. S. Kaufmann ; A. Klotzsche ; H. Vereecken ; J. van der Kruk</i>	
<b>GPR INVESTIGATION OF REMAINS OF PILE DWELLINGS IN LAKE ZURICH</b> .....	676
<i>Johannes Hugenschmidt ; Andreas Mäder</i>	
<b>ROMAN ARCHAEOLOGY: THE BENEFIT OF USING GPR INVESTIGATIONS</b> .....	681
<i>P.M. Barone</i>	
<b>GPR SURVEYS AT THE MEDIEVAL CAVE VILLAGE OF CASALROTTO (MOTTOLA, APULIA)</b> .....	686
<i>G. Di Giacomo ; L. De Giorgi ; I. Ditaranto ; I. G. Leucci ; I. Miccoli ; G. Scardozzi</i>	
<b>GPR INVESTIGATIONS AT THE CRYPT OF ST. SEBASTIAN IN STERNATIA (LEECE — SOUTHERN ITALY)</b> .....	691
<i>Lara De Giorgi ; Giovanni Leucci ; Raffaele Persico ; Giovanni Quaral ; Paola Durante ; Sofia Giammaruco</i>	
<b>ARCHAEOLOGICAL GROUND PENETRATING RADAR SURVEYS UNDER VARIABLE SOIL MOISTURE: VISUAL AND NUMERICAL RESULTS</b> .....	694
<i>Isabel Morris ; Branko Glišić ; Andre Gonciar</i>	
<b>GROUND PENETRATING RADAR INVESTIGATION OF AN ANCIENT SPANISH FORTRESS: THE FORT OF SAN DIEGO, ACAPULCO, MEXICO</b> .....	700
<i>J. Ortega-Ramirez ; M. Bano ; L.A. Villa-Alvarado ; R. Junco-Sanchez ; M. Pifia-Cetina ; S. Estrada-Apatiza ; J. C. Vera-Sanchez ; A. Hernández-López</i>	
<b>GPR SURVEYS FOR SOIL AND STRUCTURAL INVESTIGATIONS AT GUBBIO TOWN, ITALY</b> .....	704
<i>Ilaria Catapano ; Giovanni Ludeno ; Francesco Soldovieri ; Francesco Tosti ; Giuseppina Padeletti</i>	
<b>GPR SURVEY OF FORTIFICATION OBJECTS ON MATUA ISLAND</b> .....	711
<i>Igor Prokopovich ; Dmitry Edemsky ; Alexei Popov ; Pavel Morozov</i>	
<b>GEOPHYSICAL SURVEY OF AN ARCHAEOLOGICAL IBERIAN VILLAGE BY MEANS OF GROUND PENETRATING RADAR</b> .....	715
<i>Sónia Santos Assunção ; Viviana Sossa Arancibia ; Vega Pérez Gracia</i>	
<b>EFFECT OF TWO DIFFERENT PROTECTIVE SURFACE MATERIALS ON GROUND PENETRATING RADAR SIGNAL CHARACTERISTICS</b> .....	720
<i>Robert Jacob ; Francesco Berna ; Thomas Urban ; Michael Chazan</i>	
<b>GROUND-PENETRATING RADAR SURVEYS TO INVESTIGATE THE ROMAN COLONY OF LIBARNA - AUGMENTING DRONE AND ELECTRICAL RESISTIVITY DATA</b> .....	724
<i>John H Bradford ; Katherine Huntley ; Hannah Friedman ; Michael Boyles</i>	
<b>GPR (GROUND PENETRATING RADAR) SURVEY AT NOTION (JUNE 2017)</b> .....	729
<i>Firat Yiğit ; Gregory Tucker ; Serkan Özcelik</i>	
<b>HOLOCAUST ARCHAEOLOGY: USING GROUND PENETRATING RADAR TO LOCATE A JEWISH MASS GRAVE IN KAUNAS, LITHUANIA</b> .....	734
<i>Luke T. Burds ; Joseph D. Beck ; Richard J. Mataitis ; Harry M. Jol ; Richard A. Freund ; Alastair F. McClymont ; Paul Bauman</i>	
<b>ANALYSIS OF CORROSION IN HISTORICAL HERITAGE STRUCTURES. THE CASE STUDY OF THE PARK GÜELL IN BARCELONA</b> .....	738
<i>Viviana Sossa Arancibia ; Vega Pérez Gracia ; Sónia Santos Assunção ; Oriol Caselles ; Jaume Clapes ; Ramón González Drigo</i>	
<b>SEARCHING FOR NAZI MASS EXECUTION TRENCHES AT FORT IX (KAUNAS, LITHUANIA)</b> .....	743
<i>Joseph D. Beck ; Luke T. Burds ; Richard J. Mataitis ; Harry M. Jol ; Richard A. Freund ; Alastair F. McClymont ; Paul Bauman</i>	
<b>CONTRIBUTION OF GPR METHOD IN MONITORING AND EVALUATING THE CONSERVATION STATE OF FORTEZZA, RETHYMNO, GREECE</b> .....	747
<i>M. Manataki ; A. Sarris ; D. Oikonomou ; K. Simirdanis ; G. Strapazon ; P. Trapero Fernández</i>	
<b>STUDY OF TOWER STRUCTURE OF THE OCTAGONAL TOWER BASED ON GPR</b> .....	753
<i>L. C. Liu ; Y. Q. Liu ; Z.W. Hu ; R. Y. Qian</i>	
<b>GPR PROSPECTING IN THE CHAPEL OF ARAGON WITHIN THE CO-CATHEDRAL OF ST. JOHN (VALLETTA, MALTA)</b> .....	758
<i>Raffaele Persico ; Sebastiano D'Amico ; Loredana Matera ; Emanuele Colica ; Cynthia De Giorgio ; Adriana Alescio ; Charles Sammut ; Pauline Galea</i>	
<b>IMAGING OF METALLIC FOREIGN BODY IN ORGANISM BY MICROWAVE</b> .....	762
<i>Zhenxing Li ; Chunlin Huang</i>	
<b>DESIGN OF EQUIVALENT SAMPLING METHOD BASED ON VERNIER CALIPER FOR CHANG'E-5 LRPR</b> .....	766
<i>Xiaolei Hua ; Shaoliang Shen ; Bin Zhou ; Guangyou Fang</i>	
<b>SPARSE ARRAY-BASED SYNTHETIC SPECTRUM IMAGING TECHNIQUE</b> .....	770
<i>Hui Wang ; Shiyu Wu ; Ling Huang ; Guangyou Fang ; Xin Liu</i>	
<b>PLANE WAVE ARRIVAL TIME STUDIES WITH A DIPOLE ARRAY ANTENNA IN A BOREHOLE</b> .....	776
<i>Satoshi Ebihara ; Shyuhei Kotani ; Kengo Fujiwara</i>	
<b>DUAL SENSOR “ALLS” FOR HUMANITARIAN DEMINING</b> .....	782
<i>Motoyuki Sato ; Kazutaka Kikuta ; Iakov Chemyak</i>	
<b>WINTER ACCUMULATION MEASUREMENTS ON ALPINE GLACIERS USING GROUND PENETRATING RADAR</b> .....	787
<i>A. Bauder ; G. Mazzone ; C. Berger ; L. Langhammer ; N. Griessinger ; T. Jonas</i>	

**Author Index**