

2016 16th International Conference on Ground Penetrating Radar (GPR 2016)

**Hong Kong
13-16 June 2016**



**IEEE Catalog Number: CFP16E75-POD
ISBN: 978-1-5090-5182-3**

**Copyright © 2016 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 publication is a representation of what appears in the IEEE Digital Libraries. Some format issues inherent in the e-media version may also appear in this print version.***

IEEE Catalog Number:	CFP16E75-POD
ISBN (Print-On-Demand):	978-1-5090-5182-3
ISBN (Online):	978-1-5090-5181-6

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
Web: www.proceedings.com

CURRAN ASSOCIATES INC.
proceedings
.com

TABLE OF CONTENTS

MODELING GPR DATA IN THE FOURIER DOMAIN: CHOICE OF THE RADAR SOURCE	1
<i>M. Bano</i>	
GROUND PENETRATING RADAR RESPONSE FROM VOIDS: A DEMONSTRATION USING A SIMPLE MODEL.....	7
<i>D. Nobes</i>	
MULTI-FREQUENCY GPR DATA FUSION.....	13
<i>A. De Coster, S. Lambot</i>	
SUBSURFACE FINE STRUCTURES SURVEY BY GPR B-SCAN IMAGE BASED ON SIGNAL SUBSPACE METHOD	19
<i>T. Sun, Z. Zhang, B. Song, X. Tang, S. Liu</i>	
SNOW COVER EXTRACTION IN MOUNTAIN AREAS USING RADARSAT-2 POLARIMETRIC SAR DATA.....	24
<i>G. He, J. Jiang, Z. Xia, Y. Hao, P. Xiao, X. Feng, Z. Wang</i>	
HIGH RESOLUTION MW HOLOGRAPHIC SYSTEM FOR NDT OF DIELECTRIC MATERIALS AND DETAILS	29
<i>S. Ivashov, A. Zhuravlev, M. Chizh, V. Razevig</i>	
RESEARCH ON MOISTURE CONTENT PREDICTION BY SHORT-TIME ENERGY SPECTRUM.....	34
<i>Q. Xu, Y. Feng, J. Jia</i>	
FLUVIAL ARCHITECTURE OF VISTULA RIVER DEPOSITS IN NATURE RESERVE SWIDERSKIE ISLANDS (WARSAW AREA, CENTRAL POLAND) BASED ON GROUND PENETRATING RADAR (GPR) IMAGES.....	38
<i>A. Lejzerowicz, S. Kowalczyk</i>	
REFLECTION WAVEFORMS OCCURRING IN GPR TREE TRUNK TESTING	44
<i>J. Jezova, S. Lambot</i>	
FDTD SIMULATION OF GPR WITH A REALISTIC MULTI-POLE DEBYE DESCRIPTION OF LOSSY AND DISPERSIVE MEDIA	49
<i>M. Loewer, J. Igel</i>	
COMPARTMENTAL LOW-RANK FILTERING OF RADIO-ECHO SOUNDING DATA	54
<i>Y. Liu, Q. Wang, B. Zhao, X. Liu</i>	
REBAR DETECTION - POD APPROACH TO DETERMINE THE RELIABILITY OF GPR SYSTEMS AND TO QUANTIFY THE INFLUENCE OF DIFFERENT MATERIAL PARAMETERS	59
<i>S. Feistkorn</i>	
A NOVEL ELLIPSE BACK-CAVITY AND SLOT-TUNED BOW-TIE ANTENNA FOR GROUND PENETRATING RADAR.....	65
<i>Y. Wang, D. Yin, J. Liu, T. Kai, Z. Dong, S. Ye, Y. Ji, G. Fang, X. Zhang, X. Zhou, Z. Xue, T. Zhang, C. Wang</i>	
HIGH-RESOLUTION INVESTIGATION OF THE CAPILLARY TRANSITION ZONE AND ITS INFLUENCE ON GPR SIGNATURES.....	69
<i>J. Igel, S. Stadler, T. Gunther</i>	
PREDICTION OF RUTTING EVOLUTION IN FLEXIBLE PAVEMENT LIFE CYCLE AT THE ROAD NETWORK SCALE USING AN AIR-LAUNCHED GROUND-PENETRATING RADAR SYSTEM.....	74
<i>F. Tosti, A. Benedetto, L. Ciampoli, A. Calvi, F. D'Amico</i>	
LABORATORY INVESTIGATIONS FOR THE ELECTROMAGNETIC CHARACTERIZATION OF RAILWAY BALLAST THROUGH GPR.....	81
<i>F. Tosti, A. Benedetto, A. Calvi, L. Ciampoli</i>	
STUDY ON REGOLITH MODELING AND LUNAR PENETRATING RADAR SIMULATION	87
<i>L. Zhang, Z. Zeng, J. Li, J. Lin</i>	
REBAR DIAMETER AND REBAR ORIENTATION USING DIFFERENT ANTENNA POLARIZATIONS.....	92
<i>J. Hugenschmidt, F. Wenk</i>	
INTEGRATED GPR AND PASSIVE SEISMIC INVESTIGATIONS AT CULTURAL HERITAGE SITES: CASE STUDIES IN MALTA.....	97
<i>R. Persico, L. Matera, S. D'Amico, R. Borg, P. Galea</i>	
A SIMULATION-BASED APPROACH FOR RAILWAY APPLICATIONS USING GPR.....	101
<i>A. Benedetto, F. Tosti, L. Ciampoli, L. Pajewski, D. Pirrone, A. Umiliaco, M. Brancadoro</i>	

GROUND PENETRATING RADAR DETECTION AND PARAMETER INVERSION OF METALLIFEROUS VEINS BASED ON STOCHASTIC EFFECTIVE MEDIA MODEL	107
<i>N. Huai, Z. Zeng, J. Li, X. Zhao, C. Liu, F. Liu</i>	
SIMULATION AND PROCESSING OF LPR ONBOARD THE ROVER OF CHANG' E-3 MISSION: BASED ON MULTILAYER LUNAR REGOLITH STRUCTURE STOCHASTIC MEDIA MODEL	113
<i>Y. Hu, Z. Zeng, J. Li, F. Liu</i>	
EVALUATION OF THE ELECTROMAGNETIC PROPERTIES OF NON HOMOGENEOUS CONCRETE BY INVERSION OF GPR MEASUREMENTS	119
<i>M. Albrand, G. Klysz, X. Ferrieres, P. Millot</i>	
DETECTION OF RAILWAY SUBGRADE MOISTURE CONTENT BY GPR	123
<i>J. Cai, S. Liu, L. Fu, Y. Feng</i>	
SOURCE-INDEPENDENT TIME-DOMAIN WAVEFORM INVERSION OF CROSS-HOLE GPR DATA.....	128
<i>X. Meng, S. Liu</i>	
NOISE SUPPRESSING AND DIRECT WAVE REMOVAL IN GPR DATA BASED ON SHEARLET TRANSFORM	132
<i>X. Wang, S. Liu</i>	
DEVELOPING GPR SURVEYS, DATA PROCESSING AND INTERPRETATION TECHNIQUES FOR CRIMINAL GRAVESITES LOCATION.....	137
<i>N. Pudova, U. Urusova, M. Shirobokov, A. Marchkov</i>	
GPR INVESTIGATION AT TWO SITES OF ARCHAEOLOGICAL INTEREST IN VADNAGAR, INDIA	142
<i>M. Thakur, A. Prashant</i>	
CROSSHOLE RADAR FOR UNDERGROUND STRUCTURE DEFECT DETECTION: SYSTEM DESIGN AND MODEL EXPERIMENT.....	148
<i>X. Xie, H. Qin, G. Hong, Y. Chen, K. Zeng</i>	
PASSIVE COOPERATIVE TARGETS FOR SUBSURFACE PHYSICAL AND CHEMICAL MEASUREMENTS	153
<i>J.-M. Friedt</i>	
DETECTION OF HUMAN'S MOTIONS THROUGH A WALL USING UWB RADAR	159
<i>Q. Lu, C. Liu, Z. Zeng, J. Li, X. Zhang</i>	
A NOVEL TWO-DIMENSIONAL MIMO ARRAY TOPOLOGY FOR UWB NEAR-FIELD HIGH-RESOLUTION IMAGING	163
<i>K. Tan, S. Wu, Y. Wang, S. Ye, X. Liu, G. Fang</i>	
DESIGN OF RF TAGS ATTACHING TO BURIED PIPES FOR ENHANCED DETECTION BY GPR	167
<i>W. Zhang, Y. Chang, T. Hao</i>	
SELF-CALIBRATED BOUNDARY DETECTION ALGORITHM FOR HORIZON CONTROL IN LONG-WALL MINING	172
<i>J. Che, C. Chen, L. Stolarczyk</i>	
GPR MONITORING OF CRYOGENIC PROCESSES IN SUBGRADE SOILS	176
<i>L. Fedorova, D. Savvin, M. Fedorov, A. Struchkov</i>	
THE STUDY OF THE ICE CROSSINGS ON THE RIVERS BY THE GROUND-PENETRATING RADAR.....	181
<i>M. Fedorov, L. Fedorova, D. Savvin, A. Kulizhnikov</i>	
EFFICIENT BACK PROJECTION IMAGING APPROACH FOR AIRBORNE GPR USING NUFFT TECHNIQUE.....	187
<i>L. Qu, Y. Yin, Y. Sun, L. Zhang</i>	
NON-DESTRUCTIVE TESTING AT MICROWAVES USING A VECTOR NETWORK ANALYZER AND A TWO-COORDINATE MECHANICAL SCANNER	191
<i>A. Zhuravlev, V. Razevig, M. Chizh, S. Ivashov, A. Bugaev</i>	
DATA ACQUISITION, PROCESSING, AND VISUALIZATION IN MICROWAVE HOLOGRAPHY WITH PROBE TRACKING AND POSITIONING ON VIDEO	196
<i>A. Zhuravlev, V. Razevig, M. Chizh, S. Ivashov, A. Bugaev, A. Kokoshkin, V. Korotkov</i>	
CORRECTION OF GPR WAVE VELOCITY WITH DISTORTED HYPERBOLIC REFLECTION IN UNDERGROUND UTILITY'S GPR SURVEY	201
<i>W. Lai, J. Sham, F. Xie</i>	
USING OF GPR FOR STUDY OF DEPOSITS IN CRYOLITHOZONE.....	205
<i>K. Sokolov, D. Savvin</i>	

AN INVESTIGATION OF RECENT STORM HISTORIES USING GROUND PENETRATING RADAR AT BAY-BAY SPIT, BICOL, CENTRAL PHILIPPINES	209
<i>J. Pile, A. Switzer, L. Soria, F. Siringan, A. Daag</i>	
DEVELOPMENT AND APPLICATION OF A NOVEL COMBINED LOW-FREQUENCY ANTENNA FOR ULTRA-DEEP ADVANCED DETECTION IN MINE	213
<i>X. Xu, S. Peng, Y. Feng, L. Hao</i>	
SOME LIMITS OF THE METHOD OF THE DIFFRACTION HYPERBOLAS AND A PROPOSAL FOR ITS OVERCOMING.....	217
<i>R. Persico, L. Matera, V. Desantis, F. Congedo, S. Lambot, J. Got</i>	
PASSIVE GROUND PENETRATING RADAR USING AM RADIO BROADCASTING SIGNALS.....	222
<i>L. Stolarczyk, G. Stolarczyk, C. Chen, D. Kirk</i>	
GPR SURVEYS AND EXCAVATION GROUND-TRUTHING AT THE SAN TAU BACKBEACH SITE, HONG KONG.....	227
<i>M. Atha, W. Lai, R. Chang</i>	
RANDOM NOISE DE-NOISING AND DIRECT WAVE ELIMINATING IN GROUND PENETRATING RADAR SIGNAL USING SVD METHOD	233
<i>C. Song, Q. Lu, C. Liu, Y. Gao</i>	
STUDYING OF INFLUENCE OF TEMPERATURE OF ROCKS WITH VARYING HUMIDITY ON GPR DATA	238
<i>L. Fedorova, K. Sokolov, D. Savvin, A. Ammosov</i>	
GPR MAPPING OF BEDROCK OF ALLUVIAL GOLD DEPOSITS IN PERMAFROST	242
<i>G. Kulyandin, L. Fedorova, D. Savvin, N. Prudetskii</i>	
A COMPARISON BETWEEN DIFFERENT CENTRAL FREQUENCIES OF INVESTIGATION IN BURIED UTILITY DETECTION THROUGH GPR: A STUDY CASE	246
<i>L. Ciampoli, A. Benedetto, L. Pajewski, A. Alani, F. Tosti</i>	
AUTOMATED REFLECTION PICKING AND INVERSION: APPLICATION TO GROUND AND AIRBORNE GPR SURVEYS.....	250
<i>M. Dossi, E. Forte, M. Pipan, R. Colucci, A. Bortoletto</i>	
A THEORETICAL METHOD TO RELATE THE RELATIVE PERMITTIVITY AND THERMAL CONDUCTIVITY OF SANDS	256
<i>A. Rubin, C. Ho</i>	
PREDICTING GPR PERFORMANCE FOR BURIED VICTIM SEARCH & RESCUE.....	261
<i>N. Diamanti, A. Annan, I. Giannakis</i>	
A STEP TOWARDS QUANTITATIVE TARGET ANALYSIS FOR GPR.....	267
<i>A. Annan, N. Diamanti</i>	
EM CHARACTERIZATION OF CONCRETES FOCUSED ON WATER AND CHLORIDE CONTENTS IN THE FRAME OF MULTI-LINEAR EXPERIMENTAL DESIGNS	272
<i>X. Derobert, G. Villain</i>	
FULL-WAVEFORM INVERSION USING THE STEP FREQUENCY RADAR IN THE GPR BAND TO CHARACTERIZE THE TACK COAT IN HOT-MIX ASPHALT (HMA) LAYERS OF FLEXIBLE PAVEMENTS	277
<i>A. Ihamouten, T. Richard, F. Bosc, N. Boutet, M. Brenugat, X. Derobert, S. Lambot</i>	
SHIFTING ZOOM IN 2D LINEAR INVERSIONS PERFORMED ON GPR DATA GATHERED ALONG AN ELECTRICALLY LARGE INVESTIGATION DOMAIN	283
<i>R. Persico, F. Soldovieri, S. Lambot</i>	
GPR BASED REAL-TIME OBSTACLE DETECTION SYSTEM FOR HORIZONTAL DIRECTIONAL DRILLING.....	287
<i>D. Pasculli, G. Manacorda, D. Morandi, M. Hamers, T. Schauerte, D. Dei, H. Scott, M. Morey</i>	
THE NETTUN PROJECT: DESIGN OF A GPR ANTENNA FOR A TBM.....	293
<i>A. Simi, G. Manacorda</i>	
A NANOSECOND PULSE GENERATOR BASED ON AVALANCHE TRANSISTOR.....	299
<i>K. Zhou, C. Huang, M. Lu</i>	
DEPRESSING THE NOISE EFFECTS SHOWN IN GPR IMAGES BY EMPLOYING THE NON-LOCAL APPROACH	304
<i>H. Chang, Y. Huang, K. Hsu, K. Lee, C. Chiang</i>	
A METHOD OF REMOVING INTERFERENCE FRINGES ON SPHERICAL SUBSURFACE IMAGING WITH CONTINUOUS WAVE PENETRATING RADAR.....	309
<i>M. Li, C. Huang, Y. Su</i>	
FOUNDATION PILE AND CAVITY DETECTION BY THE 3D DIRECTIONAL BOREHOLE RADAR SYSTEM REFLEXTRACKER.....	313
<i>K. Wada, S. Karasawa, K. Kawata, T. Ueki, S. Ebihara</i>	

DESIGN OF HIGH SCANNING RATE FOR ARRAY IMPULSE GROUND PENETRATING RADAR.....	318
<i>Z. Xia, Y. Hao, S. Wu, G. Fang, G. He, J. Jiang, H. Guo, H. Ma, Y. Zhan, X. Liu, H. Yin</i>	
SIMULATION AND MODELING OF RESPONSE OF BURIED PIPES USING FDTD AND RSM	324
<i>A. Hebsur, N. Muniappan, E. Rao, G. Venkatachalam</i>	
MAPPING PALEOCHANNELS IN THE LIBYAN SAHARA WITH GROUND PENETRATING RADAR.....	329
<i>J. Francke</i>	
THE APPLICATION OF LONG-RANGE GPR FOR SEISMIC STATIC CORRECTIONS	334
<i>J. Francke</i>	
A STUDY OF POLARIMETRIC UWB GPR IMAGING FOR UTILITY MAPPING SURVEY APPLICATION	340
<i>D. Marpaung, Y. Lu</i>	
EXPERIMENTS IN SKARN WITH A POLARIZATION-SENSITIVE DIRECTIONAL BOREHOLD RADAR.....	345
<i>S. Ebihara, S. Yamamoto, K. Inada, K. Ishida, A. Kawasaki</i>	
EXPERIMENTS WITH A DIPOLE ARRAY AND LOOP ANTENNA IN A CYLINDRICAL WATER LAYER	351
<i>S. Ebihara, Y. Shimomura, K. Hotta, K. Hosokawa, G. Hoshii</i>	
LANDMINE DETECTION WITH HOLOGRAPHIC RADAR	357
<i>X. Song, Y. Su, C. Huang, M. Lu, S. Zhu</i>	
A NEW USE OF UWB RADAR TO DETECTING VICTIMS AND DISCRIMINATING HUMANS FROM ANIMALS	361
<i>X. Yu, T. Jiao, H. Lv, Y. Zhang, Z. Li, J. Wang</i>	
GPR DETECTION OF SUBSURFACE VOIDS AND ITS VALIDATION BASED ON SIMILARITY PRINCIPLE	366
<i>L. Liu, J. Li, M. Sun, R. Qian, S. Ge</i>	
QUANTIFICATION OF ARCTIC SOIL AND PERMAFROST PROPERTIES USING GROUND PENETRATING RADAR.....	370
<i>B. Dafflon, E. Leger, F. Soom, C. Ulrich, J. Peterson, S. Hubbard</i>	
OPTIMIZATION OF ANTENNA POLARIZATION OF THE MULTISTATIC GPR SYSTEM "YAKUMO"	376
<i>M. Sato, L. Yi, Y. Iitsuka, L. Zou, K. Takahashi</i>	
GPR TOMOGRAPHY BASED ON REGULARIZATION METHOD FOR CONCRETE DEFECT DETECTION	382
<i>S. Hu, Y. Zhao, C. Rao, T. Qin, C. An, S. Ge</i>	
RESEARCH OF FUSION METHOD OF GPR TOMOGRAPHY IMAGES BASED ON WAVELET TRANSFORM	388
<i>C. Du, Q. Zhang, J. Liu, M. Peng</i>	
ELECTROMAGNETIC ENVIRONMENT COMPREHENSION FOR RADAR DETECTION OF VITAL SIGNS AT CHINA NATIONAL TRAINING CENTER FOR EARTHQUAKE SEARCH & RESCUE.....	394
<i>L. Liu, M. Liu, J. Wang</i>	
A VITAL SIGN FEATURE DETECTION AND SEARCH STRATEGY BASED ON MULTIPLE UWB LIFE-DETECTION-RADARS	398
<i>S. Yao, S. Wu, K. Tan, S. Ye, G. Fang</i>	
LONG-TERM MONITORING OF TWO HIGHWAY BRIDGES USING MICROWAVE INTERFEROMETER-CASE STUDIES	404
<i>K. Hsu, C. Cheng, C. Chiang</i>	
METHODOLOGY FOR STUDY OF RIVER CROSSING OF LINEAL ENGINEERING CONSTRUCTIONS BY SUBMERSIBLE GPR	409
<i>I. Khristoforov, P. Omelyanenko, A. Omelyanenko, K. Danilov</i>	
3D GPR IMAGING OF SHALLOW PLASTIC PIPES, TREE ROOTS, AND SMALL OBJECTS	413
<i>M. Grasmueck, A. Novo</i>	
IMAGING LNAPLS CONTAMINATED SOILS BY POLARIMETRIC MIGRATION.....	419
<i>B. Shi, Q. Lu, X. Feng, C. Liu, Y. Yu</i>	
THE DETECTION OF CRACKS IN BLAST-HOLES USING DIRECTIONAL BOREHOLE RADAR.....	424
<i>A. Strange, Z. Jecny</i>	
GPR INVESTIGATION OF “FORTEZZA DA BASSO” (LOWER FORTRESS) IN FLORENCE, ITALY	429
<i>M. Pieraccini, L. Capineri, P. Falorni, D. Devis</i>	

EXPERIMENTAL AND NUMERICAL INVESTIGATIONS FOR GPR EVALUATION OF REINFORCED CONCRETE FOOTBRIDGE	434
<i>J. Lachowicz, M. Rucka</i>	
A COMPARISON OF FINITE-DIFFERENCE, FINITE-INTEGRATION, AND INTEGRAL-EQUATION METHODS IN THE TIME-DOMAIN FOR MODELLING GROUND PENETRATING RADAR ANTENNAS.....	440
<i>C. Warren, L. Pajewski, D. Poljak, A. Ventura, A. Giannopoulos, S. Sesnic</i>	
USING BIDIMENSIONAL EMPIRICAL MODE DECOMPOSITION METHOD TO IDENTIFICATION BURIED OBJECTS FROM GPR B-SCAN IMAGE	445
<i>Y. Qin, L. Qiao, X. Ren, Q. Wang</i>	
INTEGRATED ATTRIBUTE ANALYSIS FOR IMPROVED GPR DATA INTERPRETATION	450
<i>W. Zhao, E. Forte, M. Dossi, M. Pipan</i>	
FRACTURE CHARACTERIZATION WITH GPR: A COMPARATIVE STUDY	455
<i>D. Arosio, J. Deparis, L. Zanzi, S. Garambois</i>	
IMPROVING GPR SIGNAL MODELLING FOR EFFICIENT CHARACTERIZATION OF MULTI-LAYERED MEDIA	461
<i>S. Maiti, S. Patra, A. Bhattacharya</i>	
GROUND-PENETRATING RADAR FINITE-DIFFERENCE REVERSE TIME MIGRATION FROM IRREGULAR SURFACE BY FLATTENING SURFACE TOPOGRAPHY.....	467
<i>X. Lu, R. Qian, L. Liu</i>	
THREE-DIMENSIONAL REVERSE-TIME MIGRATION APPLIED TO A MIMO GPR SYSTEM FOR SUBSURFACE IMAGING.....	472
<i>H. Liu, Y. Zhang, Z. Long, F. Han, Q. Liu</i>	
A MULTIBAND-PASS FILTERING METHOD TO SUPPRESS SLEEPER NOISE IN RAILWAY SUBGRADE VEHICLE-MOUNTED GPR DATA	476
<i>J. Xiao, Y. Wang, L. Liu</i>	
AN APPARATUS FOR COLLECTING UPWARD-LOOKING GPR	481
<i>C. Funk, R. Brehm, A. Errington, K. Backstrom</i>	
SIMULATION OF GPR IN ANISOTROPIC MEDIUM BY FINITE ELEMENT TIME DOMAIN METHOD.....	487
<i>H. Wang, M. Wang, H. Liu</i>	
LOCALIZATION AND BACKSCATTERING DENSITY ESTIMATION FROM GPR DATA WITH NEURAL NETWORK	492
<i>T. Liu, C. Huang, Y. Su, W. Xu</i>	
TOWARDS 3D FULL-WAVEFORM INVERSION OF CROSSHOLD GPR DATA	498
<i>A. Mozaffari, A. Klotzsche, G. He, H. Vereecken, J. Kruk, C. Warren, A. Giannopoulos</i>	
A SURVEY OF ELECTROMAGNETIC CHARACTERISTICS OF SOILS IN THE DONBASS REGION (UKRAINE) FOR EVALUATION OF THE APPLICABILITY OF GPR AND MD FOR LANDMINE DETECTION	502
<i>T. Bechtel, S. Trushkavetsky, L. Capineri, G. Pochanin, N. Simic, K. Viatkin, A. Sherstyuk, T. Byndych, P. Falomi, A. Bulletti, P. Giannelli, V. Ruban, L. Varyanitzia-Roschupkina, M. Bechtel</i>	
THREE DIMENSIONAL SIMULATION OF GPR IN TUNNEL HIDDEN DISEASE BASED ON RSG ALGORITHM	508
<i>X. Yin, B. Zhang</i>	
DATA PROCESSING OF BACKFILL GROUTING DETECTED BY GPR IN SHIELD TUNNEL AND RESEARCH ON EQUIPMENT OF GPR ANTENNA.....	513
<i>X. Xie, Y. Chen, B. Zhou</i>	
MODELING OF STEPPED-FREQUENCY RADAR WAVE PROPAGATION THROUGH PARTIALLY WET LIMESTONE	518
<i>B. Guan, A. Ihamouten, D. Guilbert, F. Bose, X. Derobert, G. Villain, S. Lambot</i>	
3D ROBOTIC IMAGING OF COAL SEAMS USING GROUND PENETRATING RADAR TECHNOLOGY	524
<i>J. Ralston, A. Strange</i>	
EFFECTS OF HOMOGENEOUS/HETEROGENEOUS WATER DISTRIBUTION ON GPR WAVE VELOCITY IN A SOIL'S WETTING AND DRYING PROCESS.....	530
<i>J. Sham, W. Lai, C. Leung</i>	
TIME-FREQUENCY SPECTRAL ANALYSIS OF STEP FREQUENCY CONTINUOUS WAVE AND IMPULSE GROUND PENETRATING RADAR.....	536
<i>P. Wong, W. Lai, M. Sato</i>	
GPR FULL-WAVEFORM INVERSION OF HORIZONTAL ZOP BOREHOLE DATA USING GPRMAX	542
<i>A. Klotzsche, J. Kruk, G. He, H. Vereecken</i>	

A TRAIN-MOUNTED GPR SYSTEM FOR FAST AND EFFICIENT MONITORING OF TUNNEL HEALTH CONDITIONS	547
<i>Y. Zan, G. Su, Z. Li, X. Zhang</i>	
A STUDY OF ANTENNA CONFIGURATION FOR BISTATIC GROUND-PENETRATING RADAR.....	552
<i>W. Kang, C. Kim, J. Kim, S. Park, S. Cho, J. Son, K. Kim</i>	
DATA PROCESSING AND SOME RESULTS OF CHANG'E-5 LRPR GROUND VERIFICATION.....	556
<i>Y. Li, G. Fang, Y. Ji, B. Zhou, S. Shen</i>	
DESIGN OF AN ARRAY ANTENNA SYSTEM FOR CHANG'E-5 LRPR.....	560
<i>W. Lu, Y. Ji, B. Zhou, G. Fang</i>	
THE SUBSURFACE PENETRATING RADAR ON THE ROVER OF CHINA'S MARS 2020 MISSION	564
<i>B. Zhou, S. Shen, Y. Ji, W. Lu, F. Zhang, G. Fang, Y. Su, S. Dai</i>	
GPR INSPECTION OF ASPHALT PAVEMENT USING AN OFF-GROUND ANTENNA ARRAY.....	568
<i>Z. Long, Y. Zhang, H. Liu, J. Wu, W. Ouyang, Y. Xia, Q. Liu</i>	
ELECTROMAGNETIC MARCHENKO EQUATIONS FOR A DISSIPATIVE HETEROGENEOUS MEDIUM.....	572
<i>E. Slob, L. Zhang</i>	
ELECTROMAGNETIC MARCHENKO IMAGING IN 1D.....	576
<i>L. Zhang, E. Slob</i>	
THE ANALYSIS OF FREQUENCY SHIFT OF THE NONMETALLIC PIPELINE'S GPR SIGNAL	580
<i>X. Liao, T. Hong, D. Liu, M. Yang, X. Liao, G. Cao</i>	
Author Index	