

ANALYTICAL GEOCHEMISTRY IN THE SERVICE OF MEDICINE: AN EXPERIMENTAL STUDY OF URINARY STONES FROM NORTHERN GREECE

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Abstract

Knowledge of the precise human biomineral composition may allow physicians to recommend an appropriate prophylactic therapy for the patient and thus prevent or delay the stone recurrence. The present study focuses on the application of complementary analytical techniques to the characterization of human urinary stones. Several gallbladder and renal stone samples were obtained from patients dwelling in areas of northern Greece. A comprehensive analytical study took place, employing the following, common in analytical geochemistry, techniques: Environmental Scanning Electron Microscopy (ESEM) coupled to Energy Dispersive System (EDS), X-Ray Diffraction (XRD), thermogravimetry (TG), μ Raman spectroscopy and Cathodoluminescence (CL). A detailed determination of morphological, micro-structural, molecular, chemical and mineralogical characteristics of the urinary stone samples was achieved. It was evident by our study the application of powerful analytical techniques could substantially help the medical advisors to ascribe a medical treatment of diseases related to stone formation.

Keywords: Human Calculi, ESEM-EDS, Raman, XRD, Cathodoluminescence

Περίληψη

Στην παρούσα μελέτη εφαρμόζονται μέθοδοι της αναλυτικής γεωχημείας στον αναλυτικό χαρακτηρισμό δειγμάτων βιο-ορυκτών, που λήφθηκαν από ασθενείς που διαβιούν στη βόρειο Ελλάδα και πάσχουν από νεφρολιθίαση και χολολιθίαση. Χρησιμοποιήθηκαν οι κάτωθι συνδυασμένες τεχνικές για τον ενδελεχή χαρακτηρισμό των προαναφερθέντων δειγμάτων: Ηλεκτρονική μικροσκοπία σάρωσης συζευγμένη με σύστημα διασποράς ενέργειας (ESEM-EDS), καθοδοφωταύγεια (CL), περιθλασιμετρία Ακτίνων Χ (XRD), Raman φασματοσκοπία και θερμική ανάλυση (TG). Πραγματοποιήθηκε αναλυτικός χαρακτηρισμός των δειγμάτων πέτρας νεφρών και χολής και προσδιορίστηκαν λεπτομερώς τα μορφολογικά, μικρο-δομικά, μοριακά, χημικά και ορυκτολογικά χαρακτηριστικά τους. Έγινε αντιληπτό ότι η χρήση των αναλυτικών αυτών βιο-γεωχημικών μεθόδων μπορεί να συνεισφέρει στην ιατρική επιστήμη, βοηθώντας τους θεράποντες ιατρούς στην αντιμετώπιση των ασθενειών που σχετίζονται με σχηματισμό πέτρας στο ουροποιητικό σύστημα.

Λέξεις κλειδιά: Ηλεκτρονική μικροσκοπία, καθοδοφωταύγεια, περιθλασιμετρία Ακτίνων Χ, Raman φασματοσκοπία, θερμική ανάλυση

1. Introduction

Urinary stones are generally comprised of organic and inorganic compounds (mainly of calcium, phosphate, magnesium salts, oxalate, and uric acid). They occur in varieties of shape, size and crystalline to amorphous structure and range in color from creamy white, yellow, black and brown. There is also variation in the size of stones ranging from few millimeters to 5 cm. The pathogenesis of human stones is complex and is not completely understood.

An elevated number of nephrolithiasis and cholelithiasis (i.e. formation of renal and gallbladder stones respectively) incidents has been observed among patients dwelling in northern Greece, especially within Western Macedonia province (Iordanidis et al, 2010 and 2011). This increasing frequency, related to different epidemiological factors and diseases, prompted us to carry out an analytical investigation on this kind of human stones. Such analytical studies, incorporating both non-destructive and destructive analytical methodologies, have been conducted worldwide, providing significant information on the formation and composition of human calculi and helping the physicians to take prophylactic measures for the patients (Grunhage and Lammert, 2006; Abboud 2008a and 2008b).

In the present study, the application of complementary analytical techniques, such as Environmental Scanning Electron Microscope coupled to Energy Dispersive System (ESEM-EDS), μ Raman spectroscopy, X-Ray Diffraction (XRD), Thermogravimetry (TG) and Cathodoluminescence (CL) is attempted in order to provide a more comprehensive determination of the renal and gallbladder stones.

2. Materials and Methods

Several urinary (renal and gallbladder) samples were supplied by the surgeons of the General Public (Mamatsio) Hospital of Kozani and the Central (Genimatas) Hospital of Thessaloniki, northern Greece. The stones were washed and dried before analysis. Samples were cut and two types of block sections were prepared: polished ones, which were used for the Scanning Electron Microscopy and μ Raman spectroscopy and unpolished ones for the X-Ray Diffraction (XRD) and Cathodoluminescence (CL) analyses. Moreover, a tiny amount of each sample was ground for the thermal analyses.

A Philips QUANTA 200 Environmental Scanning Electron Microscope (ESEM), coupled with an Oxford INCA Energy 200 Energy Dispersive System (EDS) was used for the chemical analyses and the recording of pictures, under back-scattered electron (BSE) mode.

Cathodoluminescence (CL) spectra were collected on polished slabs, at low vacuum mode without coating to keep open way out to the CL emission, using a Gatan MonoCL3 detector with a PA-3 photomultiplier attached to the ESEM.

The Raman spectra of samples were recorded with a Thermo Scientific DXR Raman Microscope with a 780 nm laser beam, which has a point-and-shoot Raman capability of 1- μ m spatial resolution, setting the power value of the sample irradiation at 12 mW. The average spectral resolution in the Raman shift range of 100-3000 cm^{-1} was 5 cm^{-1} .

For the X-ray diffraction (XRD), a Phillips PW1710/00 diffractometer was used with a CuK α radiation source, equipped with a graphite monochromator. The XRD patterns were obtained by step scanning from 2° to 64° (2 θ in steps of 0.020°; 4 s per step) and compared with the XRD card files of the Joint Committee on Powder Diffraction Standards.

Thermogravimetry (TG) analyses were recorded with a thermal analyzer Model 851e Mettler Toledo in N₂ atmosphere. Thermal treatments were performed at a heating rate of 10°C min⁻¹ from room temperature up to 1000°C.

3. Results and Discussion

The macroscopic views of four characteristic gallbladder and one renal calculi, which were analyzed in our study, are shown in Figure 1.

The first gallstone is a 'black pigment' urinary stone with a spherulitic, fragile and porous structure. The ESEM images (Fig.2) reveal a massive appearance with micro nodules. The chemical composition of this gallstone, as revealed by EDS analysis, consists of CaO (44.17 %) and CO₂ (52.15 %), indicating the presence of calcium carbonate minerals. The Raman spectra of two different regions of observation revealed two types of minerals, a calcium carbonate (most favourably ascribed to aragonite) and a bilirubin phase. Finally, the XRD pattern (Fig. 4-1) shows a characteristic hump between 10° and 30° of 2θ angle, ascribed to amorphous organic phases and aragonite mineral, with its characteristic peaks of d-spacing (3.35, 3.27, 1.97 and 1.87 Å).

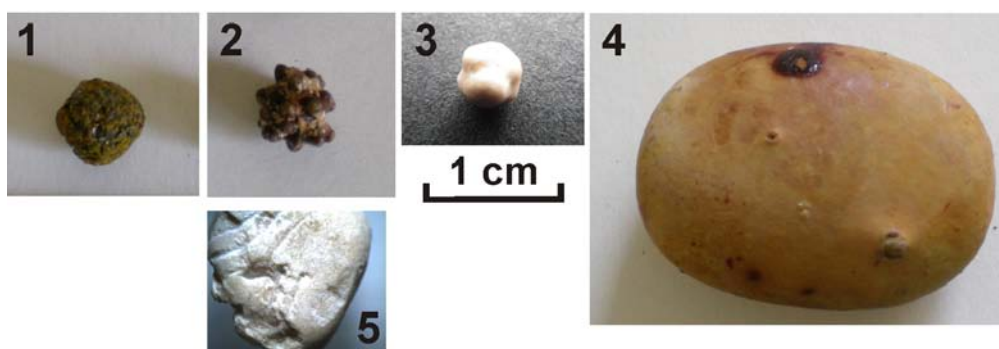


Figure 1 - Macroscopic images of the four gallbladder (No 1 - 4) and one renal (No 5) stones analyzed in this study.

The second sample is an asteroidal assemblage of pale-coloured nodules. The concentric structure is more evident under ESEM observation (Fig. 2). Based on the chemical composition (EDS) of distinct layers within the gallbladder, we can conclude that the inter-bedded layers have a variable composition of calcium carbonate, calcium hydroxyl-apatites and Ca-oxalates. The phosphorous-rich areas are in fact grains intercalated in the concentric matrix. A typical Ca-oxalate mineral (either whewellite [CaC₂O₄.H₂O] or weddellite [CaC₂O₄.2H₂O]) was determined with Raman spectroscopy. The XRD analysis of this sample revealed amorphous organics along with carbonate (characteristic peaks of d-spacing at 5.87, 3.64 and 2.97 Å) and oxalate (peak at 5.19 Å) minerals.

The third sample is a white spherical calculus, with a size of approximately 5 mm and rather dense and hard comparing to the previous ones. The ESEM/EDS analysis inferred a purely organic (CO₂ 100 %) material (Fig. 2). The Raman spectroscopy revealed a very distinct molecule of cholesterol with sharp and clear peaks (Fig. 3). The XRD pattern of the same sample provided information of a mixture of cholesterol crystalline structures (characteristic peaks of d-spacing at 5.21, 4.11 and 4.89 Å) and organic-rich phases, most probably assigned to oxalic acids (peak at 5.56 Å). Precipitation of cholesterol from supersaturated bile leads to the gallstone formation and is related to several different pathways, which in turn include nucleation, crystallization, growth and agglomeration of cholesterol crystals (Jayalakshmi et al., 2009; Athanasiadou et al., 2013).

The fourth gallstone is approximately 3cm long with a pale colour and a pebble-like appearance. An ideal concentric structure is shown in the ESEM image (Fig. 2). Numerous layers are inter-bedded. The growth of the gallbladder calculus occurs around an initially formed nucleus. The EDS analysis determined a gallstone rich in carbon (CO₂ 68.34%) and nitrogen (N₂O₅ 31.44%). The Raman spectra revealed a well-crystallized molecule of uric acid. Uric acid is a heterocyclic compound of carbon, nitrogen, oxygen, and hydrogen with the chemical formula C₅H₄N₄O₃. This

is also confirmed by the XRD analysis (Fig. 4), in which very distinctive peaks of uric acid crystals are revealed (peaks at 6.55, 5.61, 3.85, 3.27, 3.10 and 2.24 Å). Whereas it is usual to have variation in composition from the core to the outer surface of such mixed calculi (Wilson et al., 2010), in our study, several zones throughout the calculus were analyzed by EDS and Raman spectroscopy, indicating a composition of a rather pure uric acid.

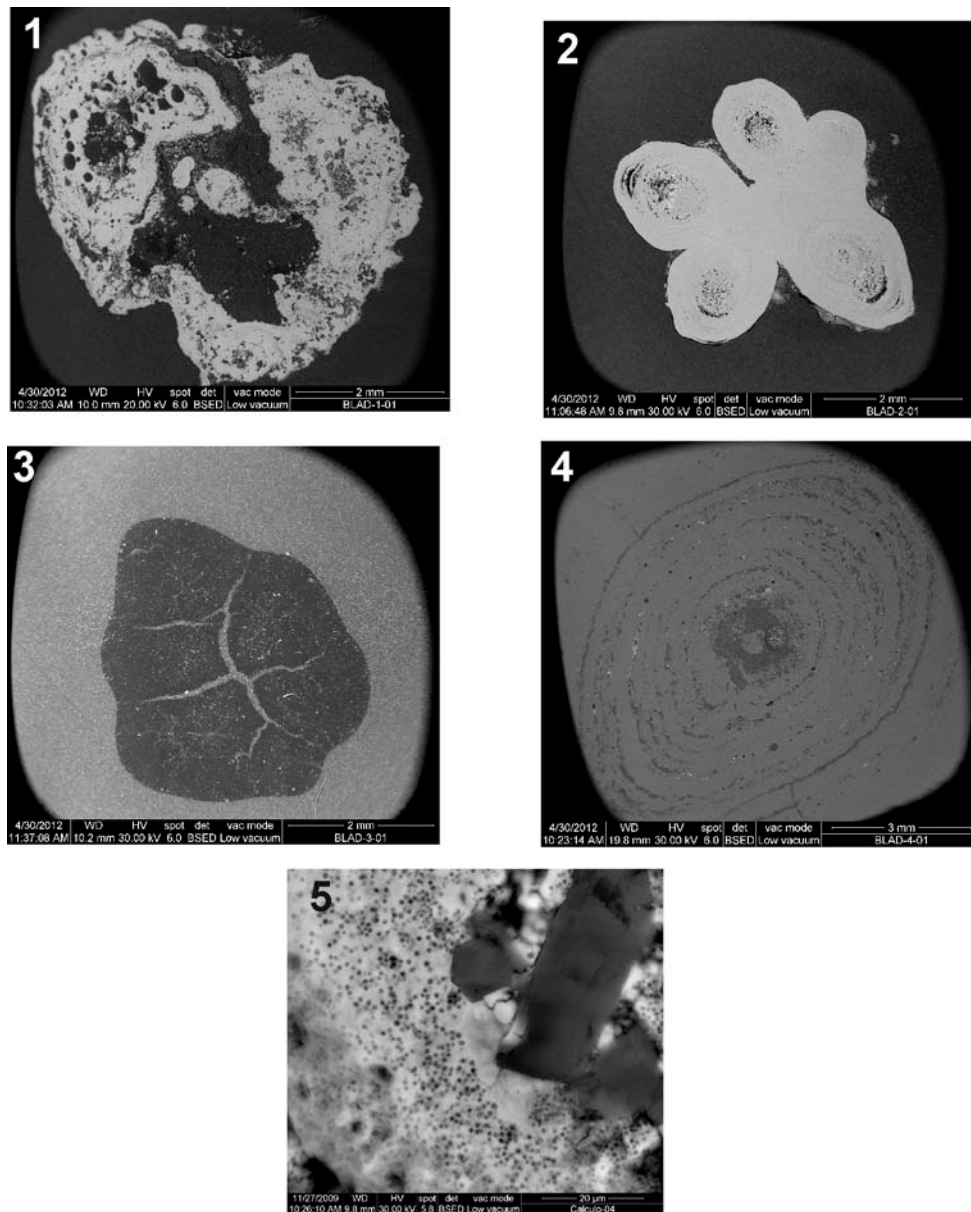


Figure 2 - ESEM images of five urinary stones: (1) calcium-rich gallbladder No1; (2) gallbladder No2, rich in apatites, calcium carbonates and oxalates; (3) the organic-rich gallstone No 3; (4) the amino-acidic gallstone No 4; (5) hexagonal cystine crystals (dark) and microbial remnants (white pores) of the renal stone No5 .

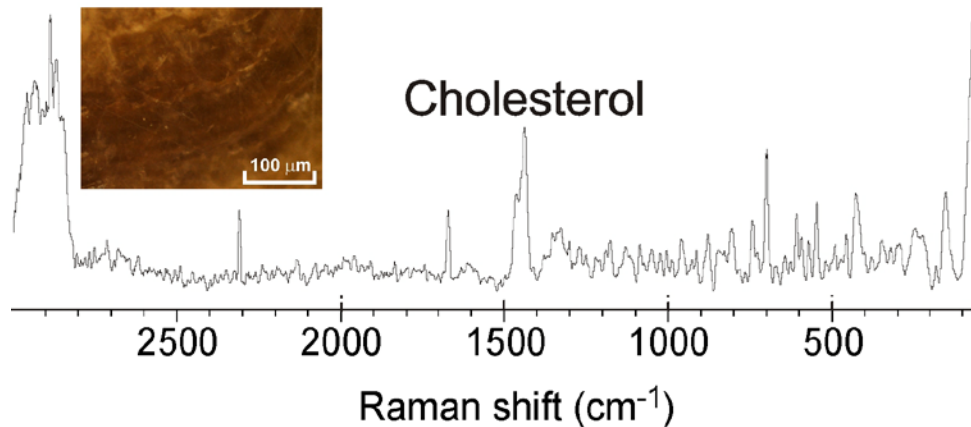


Figure 3 - Raman spectrum and microscopic views using the con-focal Raman microscope of the cholesterol sample No 3.

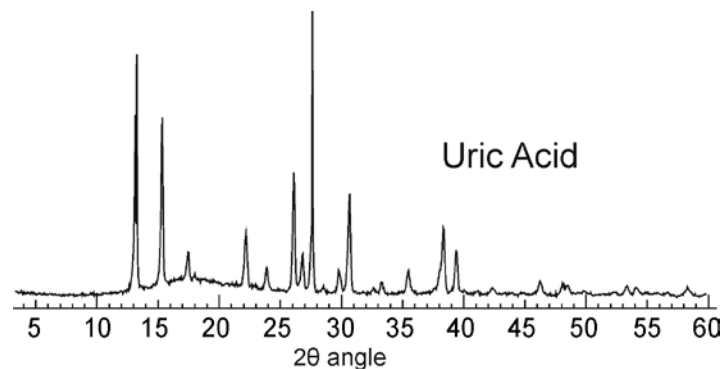


Figure 4 - Characteristic XRD peaks of the Uric Acid crystals of sample No 4.

A characteristic concentric texture is clearly shown for the No5 renal calculus. Using ESEM, thick cystine layers inter-bedded with thin calcium hydroxyl-apatite layers are observed. The elevated concentrations of sulphur are clearly shown under EDS, while calcium and phosphorous prevail within the apatite regions. Characteristic hexagonal cystine crystals are observed under higher magnification (Fig. 2). The mineralogical (XRD) analysis revealed a clear L-cystine structure (the less soluble amino-acid found in the urine) (Fig. 4). The thermal analysis revealed the characteristic endothermic peak at 246 °C found in L-cystine and a high amount of mass loss (90%), as expected for such an organic compound (Fig. 5).

The cathodoluminescence (CL) technique was employed as a complementary method to all the aforementioned techniques (ESEM-EDS, Raman, XRD, TG) to investigate the calculi samples. To our knowledge, there has not been published any CL analytical results on human stones in the global. Thus, it could be regarded as a first attempt to utilize the cathodoluminescence spectroscopy for the analysis of gallbladder calculi. Figure 6 contains characteristic CL spectra of the mineral constituents of the cystine calculus No5. Cathodoluminescence spectra were obtained from several areas of the stone. The chemically pure collagen displays similar and more intense CL plots than hydroxyapatite, thus producing a significant mask of the CL emission, whereas the CL emission peaks at 325 nm (L-cystine-apatite) and 310 nm (Ca-oxalate) could be associated to oxygen hole centre emission defects coupled with C—OH precursor bonds. For the gallbladder stones (No 1-4), in general, two intensive peaks are determined in all the CL spectra, one between

300 and 310 nm, with an intensity varying between 3800 and 8000 a.u., and another rather broad between 600 and 620 nm, with a considerably lower intensity. These analytical data of cathodoluminescence could be regarded as reference for any related future studies, notwithstanding that our CL experiments are launching cathodoluminescence technique as a significant analytical technique for biomaterials characterization.

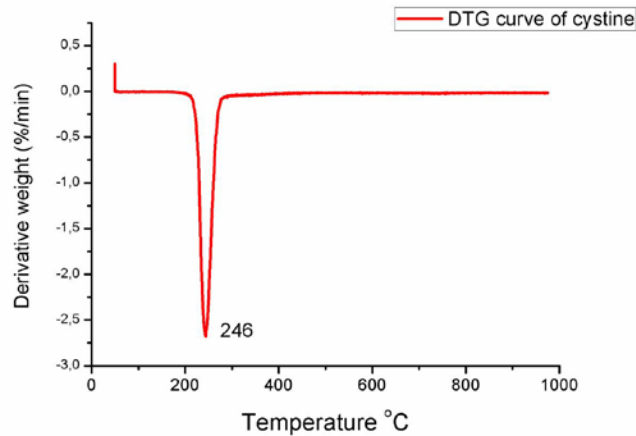


Figure 5 - Derivative Thermogravimetric (DTG) curve of cystine calculus No5.

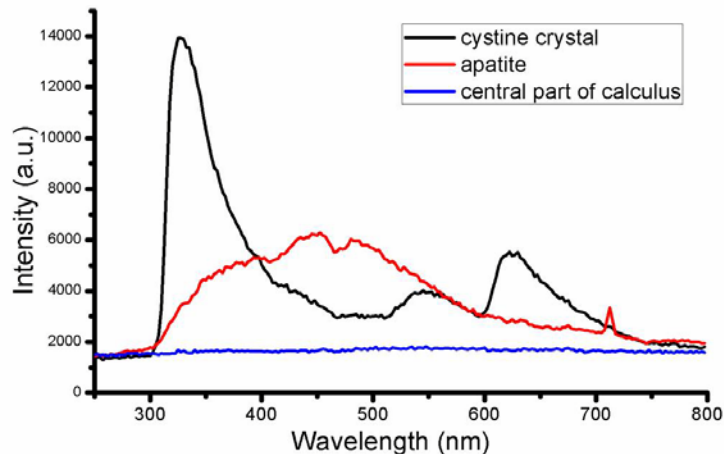


Figure 6 - CL emission spectra of three characteristic areas of cystine calculus No5: central calculi part, apatite mineral and cystine crystal.

In synopsis, the employment of complementary methodologies provided a comprehensive characterization of the human calculi. It is noticeable that certain constituents could not be detected by one single methodology, a fact that clearly demonstrates the significance of using combined techniques such as the electron microscopy imaging and EDS chemical analysis, micro-Raman molecular spectroscopy, X-ray Diffraction for the detection of crystalline phases and the Cathodoluminescence probe for the relationships between defects and emission. Our study proves that the application of powerful analytical techniques could substantially help the medical advisors. In particular, having a thorough micro-chemical and structural analysis of an urinary

stone, the medical treatment of diseases related to stone formation could be better scheduled. Knowledge of the precise bio-mineral composition may allow physicians to recommend an appropriate prophylactic therapy for the patient and thus prevent or delay the cystine stone recurrence.

4. Acknowledgements

The technical staff from the Museo Nacional Ciencias Naturales, CSIC, Madrid (Rafael Gonzalez Martin, Manuel Castillejo, Laura Tormo Cifuentes, Marta Furió Vega, Alberto Jorge García, Cristina Paradela) for their help in conducting the analyses are gratefully acknowledged. We are also indebted to the physicians from the National Hospital of Kozani (Giousef Chisam, Angelopoulos Angelis and Doulgeralis Michael) and Dr. Papadopoulou Lambrini from the School of Geology, Aristotle University of Thessaloniki, for their collaboration.

5. References

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13th International Congress of the Geological Society of Greece
September 5-8 2013, Chania, Crete, Greece

13th International Congress of the Geological Society of Greece

Exploration & Exploitation of Mineral Resources

PROGRAMME

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13th International Congress of the Geological Society of Greece

PROGRAMME

Thursday, September 5, 2013

TECHNICAL UNIVERSITY OF CRETE

19:30 - 21:30 Opening Ceremony, Central Hall,
Building of Sciences, University Campus

Chair: D. Mountrakis, P. Marinos, A. Foskolos, V. Perdikatsis

Opening Lectures (in Greek) by

Em. Professor Elias Mariolakos and

Dr. Ioannis Baziotis

21:30 - 22:30 Ice Breaker

Friday, September 06, 2013

**MEDITERRANEAN AGRONOMIC INSTITUTE OF CHANIA
(MAICH)**

08:00 - 09:00 Registration – Foyer Aristotle Auditorium

	Socrates Amphitheater	Pythagoras Amphitheater	Theophrastus Amphitheater
09:00 -11:00	8 Oral Presentations Mineralogy- Petrology	8 Oral Presentations Remote Sensing/ Seismology I	8 Oral Presentations Sedimentology - Palaeontology
11:00 - 11:30	Coffee Break		
11:30 - 13:30	7 Oral Presentations Environmen- tal Geology	8 Oral Presentations Geophysics	8 Oral Presentations Tectonics
13:30 - 15:00	Lunch Break		
15:00 - 17:30	10 Oral Presentations Eng Geology I	9 Oral Presentations Seismology II	7 Oral Presentations Geochemistry- Ore Geology
17:30 - 18 :00	Coffee Break		
18:00 - 19:30	5 Oral Presentations Eng Geology II	5 Oral Presentations Seismology III	6 Oral Presentations Geodynamics

Poster Thales Hall

09:00 -13:30	Session I
13:30 - 15:00	Lunch Break
15:00 - 19:30	Session II

Saturday, September 07, 2013

**MEDITERRANEAN AGRONOMIC INSTITUTE OF CHANIA
(MAICH)**

9:00 -11:00	Socrates Amphitheater 7 Oral Presentations Industrial Minerals	Aristotle Auditorium 9 Oral Presentations Hydrology - Hydrogeology
11:00 - 11:30	Coffee Break	
11:30 - 13 :30	Socrates Amphitheater 8 Oral Presentations Exploration and Exploitation of Mineral Resources	Aristotle Auditorium 7 Oral Presentations Energy resources
13:30 - 15:00	Lunch Break	
15:00 - 17:00	Aristotle Auditorium Oral Presentations Companies Presentations	
17:00 – 17:30	Aristotle Auditorium Closing remarks	
17:30 - ???	Cretan BBQ	

Poster Thales Hall

09:00 -13:30	Session III
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Sunday, September 08, 2013

07:30- 15:00 Field trip (Optional)

MEDITERRANEAN AGRONOMIC INSTITUTE OF CHANIA (MAICH)**Friday, September 6, 2013**

08:00 - 09:00 Registration – Foyer Aristotle Auditorium

Oral Presentations

09:00 -11:00 Socrates Amphitheater – Mineralogy-Petrology

Chair: Hatzipanagiotou K., Koroneos A.

ID	Title	Authors
69	Geological materials testing and uncertainty calculations: A simple GUM-based algorithm	Dimitrios Xirouchakis & Antonios Bouzinos
135	Petrology and zircon morphology of Syn-tectonic granitoids rocks of Hafafit, South Central Eastern Desert of Egypt	Ismail Thabet, Adamantios Kiliadis, A. Koroneos & S. Kamh
164	Origin of the High-K Tertiary magmatism in Northern Greece: Implications for mantle geochemistry and geotectonic setting	K. Pipera, A. Koroneos, Tr. Soldatos, G. Poli & G. Christofides
190	Evaluation of Cretaceous limestones from the Aitolokarnania province (Western Greece) for their use as road aggregates in terms of their content in swelling clay minerals	Ioannis Mpalatsas, Ioannis Rigopoulos, Basilios Tsikouras & Konstantin Hatzipanagiotou
192	Suitability Assessment of Cretaceous and Eocene carbonate rocks of the Olonos - Pindos Zone (Ileia Prefecture, Western Greece) for industrial applications	Xanthi Tseni, Basilios Tsikouras & Konstantin Hatzipanagiotou
208	Contribution to the evolution of the Perama cave (Ioannina, NW Greece)	Elena Ifandi, Basilios Tsikouras & Konstantin Hatzipanagiotou
209	Petrological implications for the production of methane and hydrogen in hyperalkaline springs from the othrys ophiolite, Greece	B. Tsikouras, G. Etiope, E. Ifandi, S. Kordella, G. Papatheodorou & K. Hatzipanagiotou
292	Thermal behaviour of stevensite at temperatures up to 800°C	George Christidis & Eleni Koutsopoulou

09:00 -11:00 Pythagoras Amphitheater – Remote Sensing/Seismology I

Chair: Parcharidis I., Papadimitriou E.

144	Landslide detection using ALOS optical and radar data. A case study from the prefecture of ILIAS.	Konstantinos Nikolakopoulos, Christos Choussiafis & Vassileia Karathanassi
184	Mapping erosion and deposition changes in the protected wetlands of the Axios River Delta, N. Greece using remote sensing and GIS	Hywel Griffiths, Dionissios Kalivas, George Petropoulos & Paraskevi Dimou
112	Using Remote Sensing Multispectral data and GIS techniques for the Geological Mapping of Halki Island	Konstantinos Nikolakopoulos, Panagiotis Tsombos, Adonis Photiades, Konstantinos Psonis & Alexandra Zervakou
118	Spatial and temporal distribution of rainfall and temperature in Macedonia, Greece, over a thirty year period, using GIS	Georgios Grimpylakos, Theodore Karacostas & Konstantinos Almpnakis
255	Natural and human hazard assessment of the archaeological sites of Paphos area (Cyprus) with the use of Remote Sensing and GIS	Dimitrios Alexakis, Athos Agapiou, Kyriacos Themistocleous, Vasiliki Lysandrou, Apostolos Sarris & Diofantos Hadjimitsis
323	Seismic hazard assessment In the Northern Aegean Sea (Greece) through discrete Semi-Markov modeling	Christina-Elisavet Pertsinidou, Georgios Tsaklidis & Eleftheria Papadimitriou
289	Stochastic analysis of earthquake activity in two seismogenic fault systems in Greece	Charikleia Gkarlaouni, Eleftheria Papadimitriou, Stanislaw Lasocki, Grzegorz Lizurek, Vasileios Karakostas & Adamantios Kiliadis

197	A Markov model for seismic hazard analysis along the Hellenic Subduction Zone (Greece)	Irene Votsi, Georgios Tsaklidis, Nikolaos Limnios, Eleftheria Papadimitriou & Filippos Vallianatos
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09:00 -11:00 Theophrastus Amphitheater – Sedimentology / Paleontology
Chair: Karakitsios V., Pomoni-Papaioannou F.

126	Biostratigraphy and sedimentology of the Ionian Zone Ammonitico Rosso in the Mavron Oros area (NW Epirus, Greece) - Paleogeographic implications	Vasileios Karakitsios & Elissavet Chatzicharalampous
298	Taphonomical observations on the Pygmy Hippopotamus site in Aghia Napa, Cyprus	A. Filippidi, E. Stathopoulou & G. E. Theodorou
284	On some local restricted Maastrichtian environments of the "Hateg Island" (Transylvania, Romania)	Codrea Vlad, Solomon Alexandru, Fărcaș Cristina & Barbu Ovidiu
346	Sedimentation processes and palaeographic evolution of Makrilia Pliocene deposits, SE Crete	L. Moforis, S. Kostopoulou, G. Panagopoulos, I. Pyliotis, M. Triantaphylou, E. Manoutsoglou & A. Zelilidis
309	Biostratigraphical and sedimentological study of an Upper Cretaceous succession in the Sami area (central area of Kefallinia, W. Greece)	E. Zoumpouli, F. Pomoni-Papaioannou, A. Zelilidis & G. Iliopoulos
318	Palaeobotanical study of Polichnitos region, southern part of Lesbos island, Greece (Preliminary results on angiosperm wood)	D. Mantzouka, J. Sakala, Z. Kvaček & V. Karakitsios
79	Carbonate and organic carbon content in the recent sediments of Elefsis bay as indicator of the palaeoenvironment evolution of the system	Alexandros Petropoulos, Afroditi Androni, Tatiana Ntamkarelou & Christos Anagnostou

151	Chemostratigraphy of the Toarcian Oceanic Anoxic Event from the Ionian Zone, Greece	Nefeli Kafousia, Vasileios Karakitsios, Emanuela Mattioli & Hugh C. Jenkyns
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11:00 -11:30 Coffee Break

11:30 -13:30 Socrates Amphitheater – Environmental Geology

Chair: Mitropoulos P., Argyraki A.

214	Geological study for a wetland restoration -The case of the drained Mouria Lake (W Peloponnese)	Adamantia Chatziapostolou, Georgios Siavalas, Stavros Kalaitzidis & Kimon Christanis
40	Geochemical effect of the rock chemistry and the anthropogenic activities on groundwater: the case of NW Euboea, Greece.	Christos Kanellopoulos & Panagiotis Mitropoulos
300	Neutralization of sludge and purification of wastewater from Sindos industrial area of Thessaloniki (Greece) using natural zeolite	A. Filippidis, A. Godelitsas, N. Kantiranis, P.Gamaletsos, E. Tzamos & S. Filippidis
308	Geochemical mapping of the urban soils of Athens, Greece- Preliminary results	Ariadne Argyraki, Efstratios Kelepertzis, George Fligos, Efsthios Athanasiou, Konstantinos Gardiakos & Vivika Kourgia
170	Environmental state of seabed sediments of the broader coastal area of Chios harbour, (Chios island, Aegean Sea)	A. Tsoutsia, V. Kapsimalis, S. Poulos, V. Paraskeyopoulou & E. Dasenakis
168	Investigating the existence of a "palaeo-foreshore zone" at Molos beach (Kefalos Bay, Paros, Greece) in 1884 A.C.	Serafim Poulos, George Ghionis & Stelios Petrakis
25	Hydrothermal methane fluxes from the soil at Lakki plain (Nisyros, Greece)	Walter D'Alessandro, Antonina Lisa Gagliano, Konstantinos Kyriakopoulos & Francesco Parello

11:30 -13:30 Pythagoras Amphitheater – Geophysics

Chair: Vargemezis G., Karmis P.

278	Simulation of ERT surface-to-tunnel measurements	Kleanthis Simyrdanis, Panagiotis Tsourlos, Pantelis Soupios & Grigorios Tsokas
176	Ground Penetrating Radar and Electrical Resistivity Tomography for locating buried building foundations: a case study in the city centre of Thessaloniki, Greece	George Vargemezis, Nectaria Diamanti, Ilias Fikos, Alexandros Stabolidis, Thomas Makedon & Nikolaos Chatzigogos
181	Results for the shallow structure of the broader region of Chania by HVSR measurements of ambient noise and their validation using simulation of ambient noise and independent geological information	Ilias Papadopoulos, Costas Papazachos, Alexandros Savvaidis, Nikos Theodoulidis, Filippos Vallianatos & Panagiotis Tsourlos
46	Hydrogeophysical exploration for estimating groundwater reservoirs areas in Southern Rhodes through ERT (Electrical Resistivity Tomography) method	Petros Karmis, Panagiotis Giannouloupoulos, Filippos Sofos & Ioannis Lappas
312	Resistivity Investigation for Well-Site Definition around Barika Village Southeast of Sulaimany City - Iraqi Kurdistan Region	Ali Ghaib Fadhil, Abdulla Hawre & Anwar Harby
89	Reconstructing Concealed Cultural Remains Through Integrated Geophysical Tomographic Methods	Pantelis Soupios, Nikos Papadopoulos & Apostolos Sarris
162	Late Bronze Age pottery as indicator of the deposition temperatures of the Minoan pyroclastic products, Santorini, Greece	Evdokia Tema, Spyros Pavlides & Despoina Kondopoulou
195	Continuous Magnetotelluric Observations in Western Crete as a tool for the study of the Hellenic Subduction Zone	Despina Kalisperi, John Makris, Iraklis Rigakis, Gerardo Romano & Filippos Vallianatos

11:30 -13:30 Theophrastus Amphitheater – Tectonics

Chair: Kilias A., Pavlidis S.

51	Microstructural finite strain analysis and zircon morphology of the Hafafit granitoids domes South Central Eastern Desert of Egypt	Ismail Thabet, Adamantios Kilias, Antonios Koroneos & Samir kamh
80	Remarks on the Messinian Evaporites of Zakynthos Island (Ionian Sea, Eastern Mediterranean)	Vasileios Karakitsios, Marco Roveri, Stefano Lugli, Vinicio Manzi, Rocco Gennari, Assimina Antonarakou, Maria Triantaphyllou, Konstantina Agiadi & Georgios Kontakiotis
115	Strike slip tectonics and transtensional deformation in the Aegean Region and the Hellenic Arc: Preliminary results	Dimitris Sakellariou, Jean Mascle & Vasilis Lykousis
145	Thrust tectonics in the central part of the External Hellenides, the case of the Gavrovo thrust.	E. Kamberis, S. Sotiropoulos, F. Marnelis & N. Rigakis
146	Clay minerals from the Arkitsa Fault gouge zone, in Central Greece, and implications for fluid flow.	Dimitris Papoulis, Theodora Romiou, Sotirios Kokkalas & Paraskevi Lampropoulou
148	Morphotectonic analysis of Kozani Basin (Western Macedonia, Greece)	Eirini Simou, Vasiliki Karagkouni, George Papantoniou, Dimitrios Papanikolaou & Paraskevi Nomikou
187	Paleoearthquake history on the Spili Fault, Crete, Greece	Vasiliki Mouslopoulou, Daniel Moraetis, Lucilla Benedetti, Valery Guillou & Dionisis Hristopoulos
307	The geotectonic evolution of Olympus Mt. and its mythological analogue	Il. Mariolakos & Emm. Manoutsoglou

13:30 -15:00 Lunch Break

15:00 -17:30 Socrates Amphitheater – Engineering Geology I

Chair: Rozos D., Sabatakakis N.

216	Correlation between mechanical and petrographic parameters of sandstones	Stella Ktena & Nikolaos Sabatakakis
165	Rockfall susceptibility map of Greece	Haris Saroglou
203	Reduction of rockfall risk of the teleferik area of Santorini - Greece	Efthymios Lekkas, Vasiliki Alexoudi & Ioannis Lialiaris
153	Rockfall hazard and risk assessment at road slopes	A. Andrianopoulos, H. Saroglou & G. Tsiambaos
57	Rockfalls: Influence of rock hardness on the trajectory of falling rock blocks	Pavlos Asteriou, Haralambos Saroglou & George Tsiambaos
29	Applying Artificial Neural Networks in Slope Instability related phenomena.	Paraskevas Tsangaratos & Andreas Benardos
155	Investigation and mitigation of a failure at the Taxiarches canal of Mornos Aqueduct	Nikolaos Mourtzas, Antonios Gkiolas, Dimitrios Vakiris & Vasilios Soulis
156	Stabilization of the limestone escarpment of the Skete of Osios Nikanoras under wet conditions due to future filling of the Ilarionas Dam's reservoir	Nikolaos Mourtzas, Antonios Gkiolas & Eleni Kolaiti
259	The engineering geological behaviour of disturbed and weathered gneiss in slopes. The case of the "vertical axis" of Egnatia Motorway, Komotini-Nymfea, Northern Greece	Vassilis Marinos & Andreas Goricki
85	Stability analysis of Construction and Demolition Waste (CDW) deposits in the abandoned quarry of Profitis Ilias, Kozani, Greece	Garyfalia Konstantopoulou & Natalia Spanou

15:00 -17:30 Pythagoras Amphitheater – Seismology II

Chair: Kiratzi A., Voulgaris N.

321	Near-Real-Time Evaluation of the Evolution of a Seismic Excitation: Application to the 2013/01/08 Lemnos Seismic Sequence	E. Teza, E.M. Scordilis, C.B. Papazachos & G.F. Karakaisis
68	Constraints on the Location of the 2008, Mw6.4 Achaia-Ilia Earthquake Fault from Strong Motion Data	Zafeiria Roumelioti, Nikolaos Theodoulidis & Michel Bouchon
157	Improved earthquake location in the area of North Euboean Gulf, after the implementation of a 3D non-linear location method in combination with a 3D velocity model.	Evangelos Mouzakiotis & Vasileios Karastathis
94	Earthquake relocation for Northwestern Greece using 3D crustal model; method comparison and seismotectonic interpretation.	Olga Stavroulopoulou, Efthimios Sokos, Nikos Martakis, & G-Akis Tselentis
320	Local magnitude estimation in Greece, based on recordings of the Hellenic Unified Seismic Network (HUSN)	E.M. Scordilis, D.A. Kementzetzidou & B.C. Papazachos
327	Globally valid relations converting magnitudes of intermediate and deep-focus earthquakes to Mw	A.D. Tsampas, E.M. Scordilis, C.B. Papazachos & G.F. Karakaisis
134	Modeling Seismicity Rate Changes Along The Hellenic Subduction Zone (Greece)	Konstantinos Leptokaropoulos, Eleftheria Papadimitriou, Beata Orlecka-Sikora, Vassilios Karakostas & Filippos Vallianatos
111	Earthquake clusters in NW Peloponnese	M. Mesimeri, E. Papadimitriou, V. Karakostas & G. Tsaklidis

267	Multidimensional earthquake frequency distributions consistent with non-extensive statistical physics: the interdependence of magnitude, interevent time and interevent distance in North California	Andreas Tzani, Filippos Vallianatos & Angeliki Efstathiou
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15:00 -17:30 Theophrastus Amphitheater – Geochemistry / Ore Geology

Chair: Economou M., Kilias S.

272	Pollution assessment of the Drapetsona-Keratsini coastal seabed	Vasilios Kapsimalis, Penelope Talagani, Ioannis Panagiotopoulos, Eleni Kaberi, Grigoris Rousakis, Theodore Kanellopoulos, Stelios Iliakis & Ioannis Hatzianestis
23	Analytical Geochemistry in the service of Medicine: an experimental study of urinary stones from northern Greece	Andreas Iordanidis & Javier Garcia-Guinea
108	Effect of wet milling on the adsorption capacity of a greek natural zeolite used for the removal of heavy metals from solutions	Despoina Katsimicha, Despina Pentari, Olga Pantelaki & Konstantinos Komnitsas
250	Molecular, chemical and morphological evidence for hematite biogenicity at the Quaternary Cape Vani Mn-(Ba-Fe) deposit, Milos, Greece	Stephanos Kilias, Elias Chatzitheodoridis & Ian Lyon
254	Palladium and Platinum in hydrothermal systems: The case of porphyry-Cu systems and sulfides associated with ophiolite complexes	Demetrios Eliopoulos & Maria Economou- Eliopoulos
242	Multistage alteration, mineralization and ore - forming fluid properties at the Viper (Sappes) AU-CU-AG-TE ore body, W. Thrace, Greece	Stephanos Kilias, Jonathan Naden, Manolis Paktsevanoglou, Manolis Giampouras, Alexandra Stavropoulou, Danae Apeiranthiti, Ioannis Mitsis, Theodoros

		Koutles, Costas Michael & Christos Christidis
328	Quantitative determination of mineral matter in lignite by x-ray spectrometry, using the Compton effect	V. Perdikatsis

17:30 -18:00 Coffee Break

18:00 -19:30 Socrates Amphitheater – Engineering Geology II
Chair: Christaras B., Loupasakis C.

343	São Paulo cavern-shaft collapse viewed as a trap-door problem	Georgios Saratsis & Maria Stavropoulou
71	Basin and local scale detection of ground subsidence through Persistent Scatterer Interferometry: the Anthemountas basin (Northern Greece) case study	Federico Raspini, Constantinos Loupasakis, Dimitrios Rozos & Sandro Moretti
240	Preliminary results of investigations of possible ground deformation structures in the early christian basilica, ancient Lechaion harbour, Corinth, Greece	Despina Minos- Minopoulos, Kosmas Pavlopoulos, George Apostolopoulos, Dale Dominey-Howes & Efthimios Lekkas
359	Influence of geological and geotechnical conditions to design a water reservoir in karst area	Emmanouil Steiakakis, Antonios Vafidis, Emmanouil Manoutsoglou and Dionysios Vavadakis
276	Engineering geological and hydrogeological behaviour of recent Neogenic conglomerate deposits in dam foundation. The case of Agiokampos dam in Thessaly, Central Greece	Vassilis Marinos, Serafina Lazaridou, Vassilis Perleros & Konstantina Sotiropoulou

18:00 -19:30 Pythagoras Amphitheater – Seismology III

Chair: Theodoulidis N., Skordilis E.

72	The Web Portal of the EUROSEISTEST Strong Ground Motion Database	Kyriazis Pitilakis, Zafeiria Roumelioti, Maria Manakou, Dimitris Raptakis, Kostas Liakakis, Anastasios Anastasiadis & Dimitrios Pitilakis
78	Characterization of site conditions in Greece for realistic seismic ground motion simulations: pilot application in urban areas	Anastasia Kiratzi, Nikolaos Klimis, Nikolaos Theodoulidis, Vassilis Margaris, Spyros Pavlides, Alexandros Savvaidis, Konstantia Makra, Vassilis Christaras, George Papathannasiou, Alexandros Chatzipetros, Zafeiria Roumelioti, Lia Sapountzi & Theologos Lazaridis
97	Re-examining the stress field of the broader Southern Aegean subduction area using an updated focal mechanism database	Charalampos Kkallas, Costas Papazachos, Manolis Scordilis & Vasilis Margaris
125	Automatic moment tensor determination for the Hellenic Unified Seismic Network	Nikolaos Triantafyllis, Efthimios Sokos & Aristidis Ilias
99	Qualitative precursory pattern before several strong earthquakes in Greece	Ioannis Baskoutas & George Papadopoulos (Popandopoulo)

Chair: Ganas A., Migiros G.

4	Along-strike variations in the Hellenide-Anatolide Orogen: A tale of different lithospheres and consequences	Ring Uwe, Gessner Klaus, Thomson Stuart & Markwitz Vanessa
95	Time series analysis of the NOANET CGPS stations	Konstantinos Chousianitis, Athanasios Ganas, Marios Papanikolaou, Panagiotis Argyrakis, George Drakatos & Konstantinos Makropoulos
213	A re-assessment of the shallow paleomagnetic inclinations of the Western Cyclades, Greece	Kyle Bradley, Emmanuel Vassilakis, Benjamin Weiss & Royden Leigh
231	The 1912 Ganos earthquake: Source constraints using ground motion simulations	Anastasia Kiratzi
334	NOAfaults: A digital database for active faults in Greece	A. Ganas, A. I. Oikonomou & C.Tsimi
230	The 10 June 2012 Mw6.0 earthquake sequence in the easternmost end of the Hellenic Arc	Anastasia Kiratzi, Mustafa Aktar & Nikolaos Svigkas

Thales Hall

09:00 -13:30	Poster Session I
13:30 - 15:00	Lunch Break
15:00 - 19:30	Poster Session II

Poster Session I (09:00 -13:30)

11	CDS correction as a tool for estimating 3D block size distribution	Megi Rusi & Perparim Hoxha
15	Kimmeridgian-Tithonian shallow-water platform clasts from mass flows on top of the Vardar/Axios ophiolites	Georgia Kostaki, Adamantios Kiliass, Hans-Jürgen Gawlick & Felix Schlagintweit
35	Engineering Geological Mapping of the Pallini Urban Area	D. Kotsanis, P. Panagiotopoulos, D. Rozos & C. Loupasakis
47	Changes in flood mortality during the last 50 years in Greece	Michalis Diakakis & Georgios Deligiannakis
73	Paleobathymetry of a Late Pliocene Voutes coast (Heraklion, Crete)	Konstantina Agiadi, Efterpi Koskeridou, Maria Triantaphyllou & Vasileios Karakitsios
75	Amethyst occurrences in Tertiary volcanic rocks of Greece: Mineralogical and genetic implications	Panagiotis Voudouris, Constantinos Mavrogonatos, Marianna Kati, Christos Kanellopoulos, Ioannis Psimis & Evangelia Chlekou
76	A new occurrence of pyrophanite from the amphibolite-hosted skarn in western Kimmeria, Xanthi, northern Greece	Panagiotis Voudouris, Marianna Kati, Christos Kanellopoulos, Constantinos Mavrogonatos, Aikaterini Xinou & Panagiotis Liberopoulos
77	Genesis of alpinotype fissure minerals from Thasos island, northern Greece. Mineralogy, mineral chemistry and crystallizing environment	P. Voudouris, C. Kanellopoulos, C. Mavrogonatos, M. Kati, S. Constantinidou & E. Volioti

100	Flood fatalities in Athens, Greece: 1880-2010	Michalis Diakakis, Katerina-Navsika Katsetsiadou & Aggelos Pallikarakis
110	The influence of rockmass properties at the plastic zone around a circular tunnel	Andreas Antoniou & Ioannis Spyropoulos
114	Mineralogy and chemistry of amphiboles and thermobarometry of Papikion Mt pluton, Rhodope, Northern Greece	Alexandros Drakoulis, Antonios Koroneos, Triantafyllos Soldatos & Lambrini Papadopoulou
120	Comparative geochemistry of three urban streams in Athens: Kifissos-Podoniftis- Pikrodafni	Ariadne Argyraki, Fransesca Paraskos, Margarita Marmara, Kyriaki Papadopoulou & Alexandra Maglaropoulou
130	The application of grain size trend analysis in the fine grained seabed sediment of Alexandroupolis gulf	Aikaterini Karditsa & Serafim Poulos
131	Obtaining information on the Q-structure of the southern Aegean subduction area by spectral slopes from temporary and permanent networks	Chrisanthi Ventouzi, Constantinos Papazachos, Christos Papaioannou & Panagiotis Chatzidimitriou
136	Spatio-temporal earthquake clustering in the western Corinth Gulf	Eleni Karagianni, Paradisopoulou Parthena & Karakostas Vassilios
154	Palaeotectonic environment and landslide phenomena in the area of Malakasa, Greece	Nikolaos Mourtzas & Elias Sotiropoulos
167	An application of GIS analysis on structural data from metamorphic rocks in Santorini island	Antonios Marsellos, David Foster, William S.F. Kidd, Kyoungwon Min, John Garver & Konstantinos Kyriakopoulos

172	Assessment of the Susceptibility of the Coast of Astypalaea Island (S.E. Aegean Sea) to Sea-level Rise	Maria Papoulia, Efthymios Karymbalis, Kalliopi Gaki- Papanastassiou & Hampik Maroukian
173	Coseismic stress distribution along active structures and their influence on time-dependent probability values	Paradisopoulou Parthena, Papadi- mitriou Eleftheria, Mirek Janusz & Karakostas Vassilios
194	Microtremor HVSR study of site effects in the urban area of the town of Mytilene, Lesvos (Greece) - preliminary results	Evangelia Bouranta, Filippos Vallianatos, John N. Hatzopoulos, Ilias Papadopoulos & Petros Gaganis
211	Foraminiferal biostratigraphy and palaeoenvironmental analysis of the basal part of Kalamavka formation (Late Miocene, Ierapetra basin, Eastern Crete)	Hara Drinia, Asimina Antonarakou & Asimina-Markela Louvari
215	Landslide inventory using GISMA techniques	Maria Kordouli, Katerina Kavoura, Konstantinos Nikolakopoulos & Nikolaos Sabatakakis
226	Eastern Mediterranean foraminiferal palaeoecological response to Mid - Late Pliocene climatic regime: a preliminary note	Hara Drinia, Assimina Antonarakou, Spyros Michalakopoulos & Efthymios Tsiolakis
228	Late Quaternary palaeoenvironmental changes in the Aegean Sea: Interrelations and interactions between north and south Aegean Sea	George Kontakiotis, Assimina Antona- rakou & Jan Willem Zachariasse
229	Early-Middle Miocene from Kotaphi Hill section (Nicosia, Cyprus): Biostratigraphy and paleoceanographic implications	Maria Athanasiou, Maria Triantaphyllou, Margarita Dimiza, Alexandra Gogou, Ioanna Bouloubassi, Efthymios Tsiolakis & Georgios Theodorou

244	A non-extensive statistical physics approach to the characterization of the pyroclastic deposits of the Kos volcanic center	Filippos Vallianatos, Giorgos Michas, Giorgos Papadakis, Konstantinos Kyriakopoulos & Vasilis Vasilakopoulos
249	Applicability of the "Lefka Ori" Western Crete region geofactors' interaction matrix (GFIM) as a key to understanding the engineering geological conditions	Aikaterini Pavlaki, Ioannis Meladiotis & Pavlakis Paul
268	Engineering geological conditions of Klokova Mountain, Greece	Haralambos Saroglou & Nikolaos Kazilis
322	Various morphological types of thermogenic travertines in Northern Euboea and Eastern Central Greece	Christos Kanellopoulos
340	Climatic vs tectonic control on the early Late Miocene tectono-stratigraphic deposits of the Pre-Apulian zone, Western Greece	Hara Drinia
344	Molluscan assemblages in a highly variable setting in littoral bottoms of the Lower Pleistocene of Rhodes (Greece)	E. Koskeridou, D. Thivaïou & Ch. Giamali

Poster Session II (15:00 - 19:30)

5	Multi-stage history of compound mantle xenoliths from Western USA: Implications for metasomatic processes in the deep mantle	I. Baziotis, P. D. Asimow, A. Koroneos, G. Poli & T. Ntaflos
13	Morphotectonic analysis of faults in Sperchios basin (Fthiotis, central Greece)	Maria Michail & Alexandros Chatzipetros
21	The Mesohellenic trough and the Thrace basin. Two Tertiary molassic basins in Hellenides: Do they really correlate?	A. Kiliadis, A. Vamvaka, G. Falalakis, A. Sfeikos, E. Papadimitriou, H. Gkarlaouni & V. Karakostas

24	Flood reconstruction using botanical evidence in Rapentosa catchment, in Mararthon, Greece	Michalis Diakakis
26	Producing landslide susceptibility maps by applying expert knowledge in a GIS - based environment	Paraskevas Tsangaratos & Dimitrios Rozos
28	The value of geological data, information and knowledge in producing landslide susceptibility maps.	Paraskevas Tsangaratos & Ioannis Koumantakis
32	Landform classification using GIS techniques. The case of Kimi municipality area, Euboea island, Greece	Ioanna Ilia, Dimitrios Rozos & Ioannis Koumantakis
33	Assessing areas of Slope Instability through a Spatial Decision Support System.	Dimitrios Rozos, Paraskevas Tsangaratos, Constantinos Loupasakis, Ioannis Koumantakis & Konstantinos Markantonis
34	Geoelectric Prospecting in University Campus region for detection of possible geological discontinuities, Rio, Patra, Greece.	Georgios Angelis, Panos Stepha-nopoulos, Stavros Papamarinopoulos
38	Neotectonic analysis, active stress field and active faults; seismic hazard assessment in Western Crete	D. Mountrakis, A. Kilias, Aik. Pavlaki, C. Fassoulas, Efi Thomaidou , C. Papazachos, Ch. Papaioannou, Z. Roumelioti, C. Benetatos & D.Vamvakaris
82	Safety assessment and remedial measures design for an extensive rockfall along the main road to Kimi, East Euboea, Greece	Constantinos Loupasakis, George Lalos & Dimitrios Rozos

133	Rock mass blastability dependence on rock mass quality	Maria Chatziangelou & Basile Christaras
199	Preliminary results on the REE sorption on carbonate rocks	Daniel Moraetis & Vasiliki Mouslopoulou
241	Recent coastline changes of fan deltas in the western Gulf of Corinth, Central Greece	Th Perrou, I. Kaza, V. Efthymiadis, E.Karymbalis & C.Chalkias
245	Geomorphological quantitative analysis of Sperchios river basin area (Central Greece) utilizing geographical information systems	E. Psomiadis, G. Migiros & Antoniou V.
246	A non-extensive approach in investigating Greek seismicity	G. Michas, G. Papadakis & F. Vallianatos
248	The earthquake interevent time distribution along the Hellenic Subduction Zone	G. Papadakis, F. Vallianatos & G. Michas
302	Analysis of relationships among coastal alluvial fans and their contributing catchments in North Evoikos Gulf (Central Greece)	K. Valkanou, E.Karymbalis, D. Papanastassiou, K. Gaki-Papanastassiou & P. Giles
324	Geophysical investigation and its geological interpretation in the frame of an intergrated survey prior to a dam construction in Plati River valley, Rethymno, Greece	George Apostolopoulos, Catherine Pavlaki, Vasilios Perleros & George Amolochitis
326	Geo-characterization of selected areas in Crete [Greece] towards realistic assessment of seismic design actions	A. Vafidis, M. Steiakakis, Z. Agioutantis, A. Savvaidis, B. Margaris, N. Theodoulidis, V. Lekidis, Ch. Karakostas, I. Kalogeras, S. Koutrakis, D. Rozos, C. Loupasakis, Th. Rondoyianni, P. Tsagaratos,

		U. Dikmen, N. Papadopoulos, A. Sarris, P. Souprios, E. Kokkinou, I. Papadopoulos, M. Kouli & F. Vallianatos
329	Coseismic surface displacement variability in relation to lithology	Th. Rondoyanni, E. Lykoudi & E. Kalogeras
330	Environmental magnetism: Application to cave sediments	E. Aidona, S. Pechlivanidou & Ch. Pennos
331	Magnetic susceptibility as a tool for the discrimination of anthropogenic and lithogenic history of topsoils: preliminary results from the broader area of Thessaloniki city	E. Aidona, N. Kazakis, K. Mavroidaki & K. Voudouris
333	Removal of malachite green dye from aqueous solutions by diasporic Greek raw bauxite	I.K. Georgiadis, A. Papadopoulos, A. Filippidis, A. Godelitsas, A. Tsirambides & D. Vogiatzis
335	Occurrence of arsenic in waters and sediments of the Palea Kavala river, NE Macedonia, Northern Greece	K. Giouri, M. Vavelidis & V. Melfos
336	Trace element content and morphological characteristics in microscale of commercially available clays used as cosmetic products	K. Giouri, A. Papadopoulos, A. Bourliva, E. Tzamos, L. Papadopoulou & A. Filippidis
345	Mineralogical and physico-chemical properties of the building materials of Koule castle, Heraklion, Crete	G. Karampatsou, Th. Markopoulos, E. Repouskou & G. Triantafyllou
353	Comparative evaluation of rock-eval and elemental analysis to determine organic carbon content in sediment samples	I. Pylotis, E. Hamilaki, N. Pasadakis & E. Manoutsoglou

357	Rock characterization for the foundation of two water reservoirs using geophysical and borehole data	A. Vafidis, N. Andronikidis, H. Hamdan, G. Kritikakis, N. Economou, G. Panagopoulos, S. Zanettidis, D. Merziotis, S. Pateras, E. Nikoforakis & J.P. Blais
138	Ground deformation measurements over Lake Trichonis based on SAR interferometry (2003-2010)	George Benekos, Issaak Parcharidis, Michael Foumelis & Athanasios Ganas
84	Application of Geostatistical Simulation Models in the Characterization of Complex Geological Structures	Daphne Sideri, Modis Konstantinos & Rozos Dimitrios

Saturday, September 7, 2013

09:00 -11:00 Socrates Amphitheater – Industrial Minerals

Chair: Filippidis A., Stamatakis M.

22	Digital methods for measuring grain size parameters critical to compaction and mechanical properties of aggregate - binder mixtures	Eleutherios Profitis, Dimitrios Kapatos, Elias Chatzitheodoridis, Dimitrios Xirouchakis & Constantinos Loupasakis
180	Aggregate production on the island of Crete: current production conditions and future perspective	Michael Galetakis, Konstantinos Leventakis, George Alevizos, Vagelis Zourbakis & Ioannis Koinakis
52	Correlations between mechanical and geometrical parameters in aggregates: A tool for quality assessment and control.	Dimitrios Xirouchakis

103	The occurrences of Mg-hydroxycarbonates in serpentinites of the western section of the South Aegean Volcanic Arc (West Attica Peninsula-Northeastern Argolis Peninsula), Greece.	Michael Stamatakis & Ioannis Mitsis
90	Synthesis and characterization of four new halloysite-TiO ₂ nanocomposites	Dimitris Papoulis, Sridhar Komarneni, Despoina Toli, Dionisios Panagiotaras & Sarandos Bakalis
152	Development of innovative environmental applications of attapulgitic clay	Vassilis Zotiadis & Ariadne Argyraki
339	Relationship between phosphates mineralogy and mineral processing - The case of Greece	Georgios Anastasakis

09:00 -11:00 Aristotle Auditorium—Hydrology/ Hydrogeology

Chair: Stamatis G., Voudouris K.

6	Spatial - Temporal analysis, variation and distribution of Precipitation in the Water District of Central - Eastern Greece	Ioannis Lappas, Vasilios Tsioumas & Vasilios Zorapas
8	Modeling of rainfall data using stochastic methods (Seasonal ARIMA). Case study of Atalanti meteorological station in Central Eastern Greece	Ioannis Lappas & Ioannis Matiatos
9	Application of the SWAT (Soil and Water Assessment Tool) model in Krathis river basin, North Peloponnissos	Ioannis Lappas & Ioannis Matiatos
158	Delineation of recharge areas of the aquifer systems of Corinthia prefecture by the use of isotopic and other hydrochemical evidence	Andreas Antonakos & Kostas Nikas

224	Hydrogeological regime and groundwater occurrence in the Anthemountas river basin, Northern Greece	Nerantzis Kazakis, Konstantinos Voudouris, Giorgos Vargemezis & Thanasis Pavlou
304	Flood and groundwater management for the mountain plateau of Omalos based on geoinformatics techniques	Nektarios Kourgialas & George Karatzas
20	Analysis of temporal hydrochemical and isotopic variations in spring waters of eastern Peloponnesus (Greece)	Ioannis Matiatos & Apostolos Alexopoulos
19	Multivariate statistical evaluation of groundwater quality characteristics in western Chalkidiki (Greece)	Ioannis Matiatos & Ioannis Lappas
88	Drastic method to map groundwater vulnerability to pollution using nitrate measurements in agricultural areas	Triantafyllia Samara & Gerasimos Yoxas

11:00 -11:30 Coffee Break

11:30 -13:30 Socrates Amphitheater – Exploration and Exploitation of Mineral Resources

Chair: Zelilidis A., Anastasakis G.

349	The tectono-stratigraphic evolution of Eastern Mediterranean with emphasis on Herodotus basin prospectivity for the development of hydrocarbon fields	C. Elia, P. Konstantopoulos, A. Maravelis & A. Zelilidis
351	Depositional environments and hydrocarbon potential of the Miocene deposits of Zakynthos island	Ch. Mpotziolis, S. Kostopoulou, M. Triantaphyllou, A. Maravelis & A. Zelilidis
350	The relation of TOC and CaCO ₃ content in Oligocene shelf deposits on Lemnos island with the depositional conditions	D. Nioti, A. Maravelis, P. Tserolas & A. Zelilidis

64	Use of Mine Planning Software for the Evaluation of Resources and Reserves of a Sedimentary Nickel Deposit	Ioannis Kapageridis, Athanasios Apostolikas, Spyros Pappas & Ioannis Zevgolis
106	Mapping hydrothermal alteration zones from spectral band ratios: a geostatistical approach based on the stable semivariogram model	Georgios Skianis & Aristidis Vaiopoulos
342	The upgrading amenability of the phosphate deposits of Western Greece	O. Pantelaki, G. Bellis & E. Stamboliadis
92	Aggregate Transport and Utilization in Urban Areas: Ecological Footprint and Environmental Impacts	Agioutantis Zacharias, Konstantinos Komnitsas & Andriani Athousaki
332	Marine geology data accessibility in the European Framework: the I.G.M.E. participation in the GEO-SEAS project	Irene Zananiri, Dimitris Mitropoulos, Evangelos Zimianitis, Chryssanthi Ioakim, Vasileios Papadopoulos & George Efthimiou

11:30 -13:30 Aristotle Auditorium – Energy resources

Chair: Hatzigiannis G., Koukouzas N.

196	Dispersed organic matter in bituminous formations of the Ionian Zone (Epirus region, NW Greece) and their hydrocarbon generation potential	Dimitrios Rallakis, George Siavalas, Riza Görkem Oskay, Dimitrios Tsimiklis & Kimon Christanis
124	Geological solutions concluded by petroleum geochemical data in Western Greece	N. Rigakis, V. Karakitsios, F. Marnelis & S. Sotiropoulos
218	The Prospect of Using Greek lignites in an Energy Portfolio related to Power Generation	Cassiani Papanicolaou, John Typou, John Ioakim, Thomas Kotis & Antonios Foscolos

256	Coal deposits of Turkey: properties and importance on energy demand	Rıza Görkem Oskay, Hülya İnaner, Ali İhsan Karayığit & Kimon Christanis
310	Simulation of Underground Coal Gasification process in a Bulgarian Coal field.	N. Koukouzas, I. Katsimpardi & D. Merachev
128	Geothermal Resource Management-A Reservoir Simulation Approach-The Paris Basin Case	Maria Papachristou, Pierre Ungemach & Michael Fytikas
41	The Geothermal occurrence in the Kapistri, Ierapetra area, Crete.	Georgios Chatziyiannis & Theodoros Kavouridis

13:30 -15:00 Lunch Break

15:00 -17:00 Aristotle Auditorium – Companies

Chair: Nikolaou N., Kaplanidis A., Sakelariou D.

	Global sustainability trends in the cement and aggregates industry, the role of the WBCSD/CSI and the leadership of Titan Cement	John Mastoris TITAN
	Integrated geological and quality modeling and mine planning, for the Kassimeya strategic limestone quarry of Alexandria Portland Cement, Egypt	Kostis Dragasakis TITAN
	National reporting codes for the mineral industry: The case of JORC in Australia	Stavros Kalaitzidis Integral Resource Consulting
	Exploring for hydrocarbons in Greece, Hellenic Petroleum Experience	Fivos Simeonidis ΕΛΠΕ
	The non-exclusive 2D seismic project in western offshore Greece for hydrocarbon prospectivity to motivate exploration; Results based on selected fast track data using PGS GeoStreamer GS data.	J. Robinson, A. Angelopoulos, S. Bellas PGS & MEECC

Thales Hall

09:00 -13:30	Poster Session III
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Poster Session III (09:00 -13:30)

17	Assessment of the quality of calcination of marbles from Thassos island using Raman spectroscopy and X - Ray diffraction	George Leontakianakos, Ioannis Baziotis, Eleftherios Profitis, Elias Chatzitheodoridis & Stamatis Tsimas
37	Geomorphological mapping of Messogia plain (East Attica, Greece)	Athanasios Skentos, Nikolaos Liosis & Kosmas Pavlopoulos
53	Spectroscopic and thermal study of bentonites from Milos island, Greece	Anna Bourliva, Kleopas Michailidis, Constantine Sikalidis & Anestis Filippidis
59	Developing an interactive application embodied in the geosciences educational procedure.	Paraskevas Tsangaratos, Maria Perraki & Ioanna Ilia
60	Water resources management in Sperchios river basin, using SWOT analysis	Nikos Stathopoulos, Dimitrios Rozos & Eleni Vasileiou
61	The role of Kefalovruso and Amourio springs in the hydrodynamic regime of Potamia Ellassona basin	Eleni Vasileiou, Ioannis Koumantakis & Nikos Stathopoulos
62	Mineralogical investigation and mineral processing of iron ore from the Skines area (Chania-West Crete)	Dimitrios Trichos, Georgios Alevizos, Antonios Stratakis, Evangelos Petrakis & Michalis Galetakis
63	Pressures in the water environment of Roditsa Area, in Sperchios Delta of Fthiotida Prefecture	Maria Katsifa, Ioannis Koumantakis, Nikos Stathopoulos & Eleni Vasileiou

65	Remote sensing techniques as a tool for detecting water outflows. The case study of Cephalonia Island	Martha Stefouli, Eleni Vasileiou, Eleni Charou, Nikos Stathopoulos, Andreas Perrakis & Paris Giampouras
67	Groundwater quality characteristics of the Anavissos basin	Angelakopoulou Paraskevi, Koumantakis Ioannis, Vasileiou Eleni & Stathopoulos Nikolaos
70	Metamorphic record in metalherzolite pockets within the Virsini metaharzburgite from the Kechros HP metamorphic complex in Eastern Rhodope, Greece	Evipridis Mposkos & Maria Perraki
74	“Extractive industries transparency initiative – EIT” Point of view for exploration the Albanian mining resources	Arbi Shehu & Agim Shehu
113	GIS as an educational tool: Mapping cultural sites in Greek space-time	Apostolia Galani, Giorgos Kritikos, Katerina Theodorakopoulou, Athanasios Skentos & Kosmas Pavlopoulos
147	Development of multi-criteria Decision Support System (DSS) coupled with GIS for identifying optimal locations for Soil Aquifer Treatment (SAT) facilities	Paraskevas Tsangaratos, Theodoros Pizpikis, Eleni Vasileiou, Fotios Pliakas, Christoph Schuth & Andreas Kallioras
200	Theoretical approach of teaching lithosphere in junior high school: a critical review of the content and objectives defined by the curriculum of the ministry of education	George Leontakianakos, Christos Vrachas, Gerasimos Baziotis, Ioannis Baziotis, Georgia Soultati & Georgia Fermeli

202	Is the construction of a sanitary landfill acceptable in a karstic area? The case of the sanitary landfill site in Fokida, central Greece	Georgios Soulios, Christos Mattas, Triantafyllos Kaklis, Michail Sotiriadis, Konstantinos Voudouris & Georgios Dimopoulos
206	Characterization of a new laboratory ceramic product from industrial byproducts as raw materials and caustic magnesia as additive	Vasilios Skliros, Paraskevi, G. Lampropoulou, Basilios Tsikouras, Konstantin Hatzipanagiotou, Angeliki Christogerou & Georgios Angelopoulos
222	Preliminary results of high resolution paleoceanography and paleoclimatology during sapropel S1 deposition (South Limnos basin, North Aegean sea)	S. Kostopoulou, M. B. Triantaphyllou, M. D. Dimiza, A. Gogou, I. Bouloubassi, G. Rousakis, C. Parinos, A. Diamantopoulou, G. Maria & V. Lykousis
227	Utilization trials of lignite solid byproducts of West Macedonia and Peloponnesus Lignite Fired Power Plants for the production of lightweight aggregates	Anagnostopoulos Iason, Lampropoulou Paraskevi, Tzeveleku Theofani, Kastanaki Argyro, Stivanakis Victor & Papama- ntellos Demetrios
234	Source rock potential of the Late Miocene Metochia Formation of Gavdos Island, Greece	Ioannis Pylotis, Avraam Zelilidis, Nikolaos Pasadakis, George Panagopoulos & Emmanouil Manoutsoglou
247	Revealing the geoheritage of eastern Crete through the development of Sitia Geopark	Charalampos Fassoulas, Vaggelis Perakis, Chryssoula Mavrokosta & Spyridon Staridas

293	Groundwater quality of the coastal aquifers in the eastern part of Thermaikos gulf (from Aggelochori to Kallikrateia)	A. Pavlou, G. Soulios, G. Dimopoulos, G. Tsokas, C. Mattas, N. Kazakis & K. Voudouris
295	Environmental assessment of contaminants in the downstream area of a landfill	E. Koutsopoulou, K. Katsanou, D. Papoulis, E. Zagana & P. Tsolis-Katagas
306	Assessment of groundwater pollution in relation to heavy metals of the alluvial aquifer of Thriasion Plain (NW Attica)	D. Kyriazis, E. Zagana, G. Stamatis, F. Filippidis, & E. Psomiades
347	Definition of inferred faults using 3D geological modeling techniques: a case study in Tybaki basin in Crete, Greece	G. Panagopoulos, E. Giannakakos, E. Manoutsoglou, E. Steiakakis, P. Soupios & A. Vafidis
358	The CLEARWATER project: preliminary results from the geophysical survey in Tympaki, Crete, Greece	A. Vafidis, N. Andronikidis, H. Hamdan, G. Kritikakis, N. Economou, G. Panagopoulos, P. Soupios, E. Steiakakis & E. Manoutsoglou
83	Detailed archaeomagnetic study of a ceramic workshop at Kato Achaia: New directional data and archaeomagnetic dating in Greece	Evdokia Tema
81	Morphotectonic analysis in determining the impact of the tectonic activity in the geomorphology of the Heraklion basin (Crete, Greece)	Eleni Kokinou, Hariklia Skilodimou & George Bathrellos
56	Environmental monitoring of soil pollution in urban areas (a case study from Heraklion city (Central Crete, Greece)	Eleni Kokinou, Christina Belonaki, Sakadakis Dimitrios & Sakadaki Katerina

55	Retrieval of Similar Topographic Areas	Eleni Kokinou, Costas Panagiotakis & Theodoros Kinigopoulos
58	A Mineralogical Study of pigments used in two Iakovidis Paintings: verification of artwork authenticity using Raman Micro-Spectroscopy method	Irene Kougemitrou, George Economou, Ioannis Giovannopoulos, Ioannis Baziotis, George Leontakianakos & Vassilis Stathopoulos

17:00 -17:30 Aristotle Auditorium – Closing remarks

17:30 -??? Cretan BBQ

REVIEWERS

Agioutantis Zacharias	Karakostas Vassilis	Psomiadis Emmanouil
Aidona Elina	Karatzas George	Rigakis Nikolaos
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Danelian Taniel	Koukouzas Nikolaos	Soulios George
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Dotsika Elissavet	Kritikakis George	Spanoudakis Nikolaos
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Economou Nikos	Lekkas Efthymios	Stamboliadis Elias
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Godelitsas Athanasios	Mouslopoulou Vasiliki	Tsouchlaraki Androniki
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Kanellopoulos Christos	Perdikatsis Vasilios	Zagana Eleni
Kantiranis Nikolaos	Perraki Maria	Zambetakis-Lekkas
Kaplanidis Andreas	Pomoni Fotini	Zelilidis Avraam
Karakitsios Vasileios	Pomonis Panagiotis	