

14th International  
Working Meeting  
on Soil  
Micromorphology

8-14 July 2012 Lleida-Spain

## PROGRAMME



Sociedad Española de la  
Ciencia del Suelo



International Union of Soil Sciences

## 14<sup>th</sup> International Working Meeting on Soil Micromorphology – Lleida 2012

### Organizing Committee:

Chair: Rosa M. Poch

Vice-chair: Martine Gerard

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# PROGRAMME

## Sunday 8<sup>th</sup> July

10:00 Optional touristic tour by bus in Barcelona. Price: 24 €. Meeting point: Bus stop of "Bus Turístic", Red Line (Línia Vermella) at Plaça Catalunya, in front of "El Corte Inglés" (East side of the square)

12:00 Free time. Possibility to visit the FC Barcelona Museum and Stadium at the Camp Nou, taking bus n. 54 from Gran Via-Pau Claris (300 m from Plaça Catalunya). Reservations and tickets:  
<http://www.fcbarcelona.com/camp-nou/camp-nou-experience/detail/card/prices-for-camp-nou-experience>

17:30 Registration of participants at *Institut d'Estudis Catalans*. Carrer del Carme 47; 08001 Barcelona.  
(<http://www.iec.cat>)

18:00-19:00 Opening session

Prof. Dr. Salvador Giner  
Chair of the *Institut d'Estudis Catalans* (IEC)

Prof. Dr. Josep M Vives  
Chair of the *Institució Catalana d'Estudis Agraris* (ICEA-IEC)

Prof. Dr. Jaume Porta  
Chair, Spanish Society of Soil Science

Prof. Dr. Rosa M Poch  
Chair, Organising Committee 14<sup>th</sup> IWMSM

Prof. Dr. Karl Stahr  
Chair, Scientific Committee 14<sup>th</sup> IWMSM

- Welcome speeches by Salvador Giner, Jaume Porta and Rosa M Poch
- Presentation of the *Institut d'Estudis Catalans*
- Plenary paper:

*"The 'fabric' of soil micromorphological research in the 20th century - A bibliometric analysis"*,  
by Em. Prof. Dr. Georges Stoops. Universiteit Gent (Belgium).

19:00-20:00 Reception

20:00 Bus to Lleida (for those who attend the scientific sessions Monday and Tuesday). Arrival in Lleida at 22:00 (approx.). The bus will drop the participants at the hotels.

Monday 9<sup>th</sup> July

Auditori Centre de Cultures i Cooperació Transfronterera, Campus de Cappont, C. Jaume II, 67 bis, Lleida

9:00-9:15	Reception
9:15-9:20	Welcome and practical information
9:20-9:25	Presentation by conveners: Karl Stahr, Albert Solé-Benet <i>Session II. Interpreting soil quality, interactions between organisms and minerals, and agro-environment sustainability.</i>
9:25-9:50-9:55	2.1.K <b>Olga Khokhlova</b> <i>Micromorphological evidences of carbonate accumulation in agrogenic soils in the Central Russian forest-steppe</i>
9:55-10:10-10:15	2.1.O <b>Iñigo Virto</b> , Oihane Fernández-Ugalde, Pierre Barré, María José Imaz, Alberto Enrique, Paloma Bescansa, Rosa M. Poch <i>Influence of the soil mineral composition on short-term aggregation in semi-arid Mediterranean soils as observed in aggregate thin sections.</i>
10:15-10:30-10:35	2.2.O <b>Victor Belobrov</b> , Marina Lebedeva (Verba), Mikhail Lebedev, Alexander Kulenkamp, Vasiliy Deryugin, Igor Zamotaev <i>Micromorphological properties of soils under vineyard</i>
10:35-10:50-10:55	2.3.O <b>Selma Simões De Castro</b> , Adriana Aparecida Silva, Geórgia Ribeiro Silveira De Sant'Ana, Richard John Heck <i>Changes in a dystroferic Red Latosol, cultivated with sugar cane in southern Cerrado, Brazil: Part 1 - macro and microstructural changes.</i>
10:55-11:00	Closing remarks / global discussion
11:00-11:30	Tea/coffee break
11:30-11:35	Presentation by conveners: Maja Kooistra, Iñigo Virto <i>Session II. Interpreting soil quality, interactions between organisms and minerals, and agro-environment sustainability.</i>
11:35-12:00-12:05	2.2.K <b>Curtis Monger</b> , Yanhua Feng, Farhad Khormali <i>Soil carbonate: how biological and how important for carbon sequestration?</i>
12:05-12:20-12:25	2.4.O <b>Héctor J. M. Morrás</b> , Beatriz Bonel, Patricia Fernández, Filipe B. Kraemer, Carina Álvarez <i>Topsoil microstructural models in no-till Pampean Mollisols of Argentina. Morphology and development.</i>
12:25-12:40-12:45	2.6.O <b>Farhad Khormali</b> , Curtis Monger, Yanhua Feng <i>Experimental micromorphological evidence for calcite biomineralization along an ecological gradient in Southern New Mexico State, USA</i>
12:45-13:00-13:05	2.5.O <b>Joselito Arocena</b> <i>Evolution of potassium, magnesium and iron contents during biotite alterations in rhizosphere soils of <i>Glomus</i>-inoculated crops</i>
13:05-13:10	Closing remarks / global discussion
13:10-13:30	<u>In Memoriam Prof. Ulrick Babel</u> By <b>Prof. Karl Stahr</b>

13:30-15:00	Lunch break
15:00-16:00	Poster sessions with short (5') explanations. Conveners: Fabio Terribile, Przemyslaw Mroczek
16:00-16:05	Presentation by conveners: Farhad Khormali, Thilo Eickhorst <i>Session III. Soils in extreme environments and under extreme events; micromorphological methods and analyses</i>
16:05-16:30-16:35	3.1.K <b>Marie-Agnès Courty</b> , Roland. Benoit, Sylvie Bonnamy, Michel M. Vaillant <i>Unusual soil microfacies with exceptional debris assemblage tracing cosmic events.</i>
16:35-17:00-17:05	3.2.K <b>Irina Kovda</b> , Marina Lebedeva <i>Morphological and micromorphological identification of soil forming processes in clayey cryogenic soil, Trans-Baikal region, Russia</i>
17:05-17:20-17:25	3.1.O Hannes Schmidt, <b>Thilo Eickhorst</b> , Rolf Tippkoetter <i>Comparative micromorphological and biogeochemical investigations of the soil-root interface in paddy soils</i>
17:25-17:40-17:45	3.2.O Giacomo Mele, Marcella Matrecano, <b>Fabio Terribile</b> , Julie Dee Bell <i>Pore characterization of oil sands by X-ray Micro-CT and 3D image analysis</i>
17:45-18:00-18:05	3.3. O <b>Maria Bronnikova</b> , Il'ya Shorkunov, Irina Turova, Vasilij Shishkov <i>Layered coatings of soils in extreme cryo-arid conditions as a compartment of soil memory</i>
18:05-18:10	Closing remarks / global discussion

The last 5' of every Oral Communication will be devoted to open discussion.

## Tuesday 10<sup>th</sup> July

9:00-9:05	Presentation by conveners: Irina Kovda, Octavio Artieda <i>Session I. Soil genesis and mineral weathering</i>
9:05-9:30-9:35	1.1.K <b>Nicolas Fedoroff</b> , Marie-Agnès Courty <i>Textural features and microfacies expressing temporary and permanent soil water saturation</i>
9:35-9:50-9:55	1.12.O <b>Héctor Cabadas</b> , Elizabeth Solleiro, Sergey Sedov, Birgit Terhorst, Teresa Pi, Federico Landa, Bodo Damm, Christina Wiesbeck <i>Micromorphology of calcretes in the northeast coast of Yucatan Peninsula: an evidence of soil development in karstic geosystems</i>
9:55-10:10-10:15	1.6.O <b>Daniela Sauer</b> , Isabelle Schüllli-Maurer, Ragnhild Sperstad, Rolf Sørensen, Karl Stahr <i>Processes of Albeluvisol formation in two soil chronosequences in S Norway</i>
10:15-10:30-10:35	1.1.O <b>Wojciech Szymanski</b> , Volodymir A. Nikorych <i>Similarity of micromorphological properties of the fragipan horizon in Albeluvisols of the Carpathian Foothills in Poland and the Precarpathian in the Ukraine</i>
10:35-10:50-10:55	1.8.O <b>Peter Kühn</b> , Dana Pietsch <i>Response of pedogenesis to Holocene climate change in south-western Arabia</i>
10:55-11:00	Closing remarks / global discussion

11:00-11:30	Tea/coffee break
11:30-11:35	Presentation by conveners: Curtis Monger, Dian Fiantis <i>Session I. Soil genesis and mineral weathering</i>
11:35-12:00-12:05	1.2.K <b>Rosa M Poch, Iolanda Simó, Jaume Boixadera</b> <i>Benchmark soils on fluvial and fluvio-glacial formations of the upper-Segre valley</i>
12:05-12:20-12:25	1.3.O <b>Georges Stoops</b> <i>Soil development and evolution on Isla Santa Cruz (the Galápagos Islands). A micromorphological approach</i>
12:25-12:40-12:45	1.7.O <b>Michal Jankowski, Piotr Kittel</b> <i>Evidences of soil-forming processes in red coloured Ochre soils (Rubric Arenosols) at the Szykielew archaeological site, Central Poland</i>
12:45-13:00-13:05	1.4.O <b>Marina Lebedeva (Verba), Vasilii Shishkov, Mikhail Lebedev</b> <i>Fabric of topsoil horizons in arid soils of Central Asia</i>
13:05-13:20-13:25	1.2.O <b>Maria Gerasimova, Natalia Chizhikova, Ilya Gurov</b> <i>Zheltozems of Russia: micromorphology, clay minerals, and genetic problems</i>
13:25-13:30	Closing remarks / global discussion
13:30-15:00	Lunch break
15:00-16:00	Poster sessions with short (5') explanations. Conveners: Joselito Arocena, Rafael Rodríguez
16:00-16:05	Presentation by conveners: Georges Stoops, Martine Gerard <i>Session I. Soil genesis and mineral weathering</i>
16:05-16:30-16:35	1.3.K <b>Łukasz Uzarowicz</b> <i>SEM-EDS studies of iron sulfide weathering in technogenic soils (Technosols) developed on mine spoils</i>
16:35-16:50-16:55	1.9.O <b>Martine Gerard</b> <i>Intrabasaltic palaeosols and sediments in continental flood basalt traps: recording weathering</i>
16:55-17:10-17:15	1.10.O <b>Zeng-Yei Hseu, Yoshiyuki Iizuka</b> <i>Chromite weathering as being a source of Cr in paddy soils on serpentinites</i>
17:15-17:30-17:35	1.11.O <b>Dian Fiantis, Malik Nelson, Jusop Shamshuddin, Siti Zauyah, Georges Stoops, Eric Van Ranst</b> <i>Micromorphology and submicroscopy of reconstructed tephra layer of Mt. Talang, Sumatra, Indonesia</i>
17:35-17:50-17:55	1.5.O <b>Rafael Rodríguez Ochoa, José Ramón Olarieta, Carmen Castañeda</b> <i>Micromorphology of salt accumulations in soils of North Monegros, Spain: optical microscopy and SEM</i>
17:55-18:00	Closing remarks / global discussion

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For the participants to the microscope workshops in Barcelona: 18:30 Bus to Lleida

### Wednesday 11<sup>th</sup> July

- 8:30 Depart from the main entrance of the conference hall (Lleida)
- 8:30-9:00 Bus from Lleida to Arbeca
- 9:00-11:00 Visit to Els Vilars d'Arbeca (Iberian Fortress)
- Excursion Guides: Emili Junyent, Ares Vidal, Joan López, J Carles Balasch, Rosa M Poch
- 11:00-11:30 Bus from Arbeca to Les Borges Blanques
- 11:30-13:00 Visit to the Olive Oil Museum
- 13:00-14:30 Lunch in Les Borges Blanques
- 14:30-15:15 Bus to El Soleràs: Bench Terraces of Les Garrigues.
- Excursion Guides: Jaume Boixadera, J Carles Balasch, Rosa M Poch. Convener: Àngel Faz
- 15:15-15:45 Bench Terraces or Les Garrigues – 1<sup>st</sup> stop
- 15:45-16:05 bus
- 16:05-16:45 Bench Terraces or Les Garrigues – 2nd stop
- 16:45-17:00 bus
- 17:00-17:40 Bench Terraces or Les Garrigues – 3<sup>rd</sup> stop
- 17:40-18:30 Back to Lleida.

### Thursday 12<sup>th</sup> July

9:00-9:05	Presentation by conveners: Héctor Morrás, Peter Kühn <i>Session IV. Micromorphology for paleopedology, sediments and loess-paleosol sequences</i>
9:05-9:30-9:35	4.2.K <b>Roger Langohr</b> , Vera Marcelino, Johan Yans, Laurent Bock, Patrick Engels <i>Micromorphological characterization of clay migration features and their relation to soil structure in a 3 m deep plateau soil at Transinne, Belgian Ardennes</i>
9:35-9:50-9:55	4.1.O <b>Elvira Roquero</b> , Pablo G. Silva, Cari Zazo, Jose L. Goy, Francisco Borja <i>Micromorphological features of soils developed in fluvio-marine sediments during the Last Interglacial in the Gulf of Cadiz (Atlantic South Spain)</i>
9:55-10:10-10:15	4.2.O <b>Tobias Sprafke</b> , Birgit Terhorst <i>Micromorphological investigation of the polygenetic paleosol development in the classic loess outcrop of Paudorf (Lower Austria)</i>
10:15-10:30-10:35	4.3.O <b>Seema Singh</b> , B. Parkash, A. K. Awasthi <i>Micromorphology as a tool in evaluating basin depositional environment</i>
10:35-10:50-10:55	4.6.O <b>Ana M. Alonso-Zarza</b> , J. Genise, A. Meléndez, M. Verde <i>A comparison between calcretes and insect traces micromorphology. Examples from the Canary Islands</i>
10:55-11:00	Closing remarks / global discussion
11:00-11:30	Tea/coffee break Group photo

11:30-11:35	<p>Presentation by conveners: Daniela Sauer, Sergey Sedov</p> <p><i>Session IV. Micromorphology for paleopedology, sediments and loess-paleosol sequences</i></p>
11:35-12:00-12:05	<p>4.1.K</p> <p><b>Fabio Scarciglia</b>, Veronica Zumpano, Roberto Sulpizio, Fabio Terribile  <i>Late Pleistocene-Holocene paleoclimatic changes in the Vesuvius volcano area, southern Italy: a micromorphological study of volcanic soils and primary tephra</i></p>
12:05-12:20-12:25	<p>4.5.O</p> <p><b>Héctor José María Morrás</b>, Lucas M. Moretti  <i>Controversy on the origin of the ferrallitic pedological mantle in Misiones. Micromorphological evidences of autochthony.</i></p>
12:25-12:40-12:45	<p>4.4.O</p> <p><b>Peter Kühn</b>, Andrej Sinitisn, Sergey Lisistyn, Dana Pietsch, Sergey Sedov  <i>Micromorphogenesis of MIS2-3 paleosols in Kostienki 14 and Borshchevo 5</i></p>
12:45-13:00-13:05	<p>4.7.O</p> <p>Claudio Zucca, Stefano Andreucci , İhsan Akşit, Y.K. Koca, Sameh Shaddad, Salvatore Madrau, Vincenzo Pascucci, Franco Previtali, <b>Selim Kapur</b>  <i>Genesis and palaeoenvironmental implications of upper Pleistocene palaeosols on the NW Sardinian coast.</i></p>
13:05-13:20-13:25	<p>4.8.O</p> <p>Clara Martí, <b>David Badia</b>, Rosa M. Poch, M.Teresa Garcia  <i>Genesis and characterization of a recarbonated argic palaeosol in Monegros Desert (NE Spain)</i></p>
13:25-13:30	Closing remarks / global discussion
13:30-15:00	Lunch break / Poster time
15:00-15:05	<p>Presentation by conveners: Marie-Agnès Courty, Luca Trombino</p> <p><i>Session V. Site-formation processes in archaeology and cultural landscapes, archaeometry and geoarchaeology</i></p>
15:05-15:30-15:35	<p>5.3.K</p> <p><b>Richard Macphail</b>, F. Berna, J. Crowther, J. Linderholm  <i>Integrated microstratigraphic investigations and the potential of coastal archaeological soils and sediments to record past land use and cultural activities in Norway and the UK.</i></p>
15:35-15:50-15:55	<p>5.7.O</p> <p><b>Carolina Mallol</b>, C. Hernández  <i>Experimental Data on Flat Combustion Structures</i></p>
15:55-16:10-16:15	<p>5.2.O</p> <p><b>Hendrik J. Bruins</b>, Antoine G. Jongmans  <i>Micromorphology of ancient agricultural Terraces in the Negev Desert, Horvat Haluqim (Israel)</i></p>
16:15-16:30-16:35	<p>5.9.O</p> <p><b>Marie-Agnès Courty</b>  <i>Ancestral processing of exceptional organo-mineral materials: microfacies and multi-analytical study</i></p>
16:35-16:50-16:55	<p>5.4.O</p> <p><b>Ivano Rellini</b>, Marco Firpo, Gabriele Martino, Giovanni Boschian, Julien Riel-Salvatore, Roberto Maggi  <i>Climate and environmental changes recognized by micromorphology in Paleolithic deposits at Arene Candide (Liguria, Italy).</i></p>
16:55-17:00	Closing remarks / global discussion
17:00-17:30	Coffee/tea break / Poster time
17:30-18:30	<b>Business Meeting, Commission 1.1. Soil Morphology and Micromorphology</b>



18:30-19:00	Depart from the conference building to the Seu Vella
19:00-20:15	Guided visit to La Seu Vella
20:30-21:30	Meeting dinner
21:30	Concert
23:00	Back to the hotels

The last 5' of every Oral Communication will be devoted to open discussion.

### Friday 13<sup>th</sup> July

9:00-9:05	Presentation by conveners: Richard MacPhail, M Mercè Bergadà <i>Session V. Site-formation processes in archaeology and cultural landscapes, archaeometry and geoarchaeology</i>
9:05-9:30-9:35	5.1.K <b>Jan van Mourik, B. Jansen</b> <i>The added value of biomarker analysis in paleopedology</i>
9:35-9:50-9:55	5.5.O <b>Alexandra Golyeva, Veronica Murashova</b> <i>On the experience of using biomorphic analysis for archaeological interpretation: the example of the floodplain part of Gnezdovo archaeological complex</i>
9:55-10:10-10:15	5.6.O <b>Martin Kehl, Peter Fischer, Renate Gerlach</b> <i>Solifluction deposits, reworked loess, colluvia and archaeological features at the Early Neolithic site of Düren-Arnoldsweiler, Lower Rhine area, Germany – a micromorphological approach</i>
10:15-10:30-10:35	5.12.O <b>Stephania Ern, Luca Trombino, Cristina Cattaneo</b> <i>Micromorphological aspects of forensic geoarchaeology: ultramicroscopic characterization of phosphatic impregnations on soil particles in experimental burials - preliminary results.</i>
10:35-10:50-10:55	5.8.O <b>M. Lourdes González-Arqueros, Lorenzo Vázquez-Selem, Jorge E. Gama-Castro, Emily Mcclung De Tapia</b> <i>Dynamics of erosion and sedimentation in the Valley of Teotihuacan (central Mexico): insights from pedostratigraphy</i>
10:55-11:00	Closing remarks / global discussion
11:00-11:30	Tea/coffee break / Poster time
11:30-11:35	Presentation by conveners: Selim Kapur, Nicolas Fedoroff <i>Session V. Site-formation processes in archaeology and cultural landscapes, archaeometry and geoarchaeology</i>
11:35-12:00-12:05	5.2.K <b>Sergey Sedov, Serafín Sánchez, Elizabeth Solleiro, Alexandra Golyeva</b> <i>Polygenetic soils and pedosediments of Teotihuacan (Mexico): micromorphological effects of landscape evolution and human impact during pre-hispanic occupation.</i>
12:05-12:20-12:25	5.10.O <b>Selim Kapur, Erhan Akça, Mahmut Dingil</b> <i>Micromorphological Characteristics of the Tell Kurdu Archaeological Excavation Site, S. Anatolia</i>
12:25-12:40-12:45	5.3.O <b>Carlos E.R. Schaefer, Kleberston Worsley Souza, Guilherme Resende Correa</b> <i>Micromorphological studies of archaeo-anthrosols from the Amazon floodplain (Amazonian Dark Earths) and shell middens from the Brazilian coast (Sambaquis)</i>

12:45-13:00-13:05	5.11.O <b>Héctor Cabadas</b> , Sergey Sedov, Socorro Jiménez, Becket Lailson, Iliana Ancona, Alan E. Méndez, Lizeth Hernández <i>Petrography analysis in Maya ceramics of Mexico: a micromorphology proxy</i>
13:05-13:20-13:25	5.1.O <b>Marta Mateu</b> , Mercè Bergadà, D. Garcia i Rubert <i>Different techniques on the earth construction at the protohistoric site of Sant Jaume (Alcanar, Tarragona, Spain): construction elements and furniture elements</i>
13:25-13:30	Closing remarks / global discussion
13:30-14:00	Closing session and farewell <b>Jaume Porta</b> Chair – Spanish Society of Soil Science

The last 5' of every Oral Communication will be devoted to open discussion.

## POSTERS

### Session I. Soil genesis and mineral weathering

1.1.P	Octavio Artieda, Rafael Rodríguez-Ochoa, Juan Herrero	<i>Calcite pseudomorphs after lenticular gypsum crystals in Aridisols of the central Ebro Valley, Spain</i>
1.2.P	Javier M. Aznar, Rosa M. Poch, David Badia	<i>Micromorphological features and physical properties of gypseous soils in the Middle Ebro Basin.</i>
1.3.P	Carmen Castañeda, R. Romeo-Gamarra, R. Rodríguez-Ochoa	<i>Soil macro and microfeatures at the southern margin of the saline Gallocanta Lake (NE Spain)</i>
1.4.P	Shih-Hao Jien, Yoshiyuki Iizuka, Zueng-Sang Chen	<i>The formation of different kinds of ferromanganiferous nodules in plinthitic soils</i>
1.5.P	Rafael Rodríguez-Ochoa, Asier Santana, José Ramón Olarieta	<i>Relictic Periglacial Soils in the Middle Ebro Valley (Spain): Macromorphology and Micromorphology</i>
1.6.P	Juan Carlos Loaiza, Alba Bustamante, Rosa M Poch	<i>Periglacial features in the Santa Rosa de Osos high plateau deposits.</i>
1.7.P	Hakime Abbaslou, Ali Abtahi, Francisco José Martín Peinado	<i>Micromorphology of arid soils developed on evaporites (Hormozgan Province, southern Iran)</i>
1.8.P	Tatiana Tursina	<i>Micropedology or micromorphology?</i>
1.9.P	Shahram Manafi	<i>Micromorphic evidences of climate change in some arid and semi arid soils in the west of Urmia Lake, Western Azerbaijan, Iran.</i>
1.10.P	Shahram Manafi, Rosa M Poch	<i>Micromorphic pedofeatures related to pedogenic calcium carbonate in some arid and semiarid soils in the west of Urmia Lake, Iran</i>
1.11.P	Martine Gerard, A Kanzari, T Poquet	<i>Weathering of Granitic Waste Rock Piles of former U-mines in the Limousin (France)</i>
1.12.P	Fabio Scarciglia, Donatella Barca	<i>A novel method for assessing heavy metal distribution in soils coupling laser ablation(LA)-ICP-MS in thin sections with traditional micromorphological and geochemical approaches</i>
1.13.P	Roger Langohr, Vera Marcelino	<i>Origin of the calcium carbonate of the bog marl deposit of the Moervaart Depression in the cover sand area of NW Belgium. Micromorphological evidences of decarbonation and clay migration under a permanent groundwater table in sand ridges</i>
1.14.P	Alireza Raheb, Ahmad Heidari	<i>Using micromorphological and chemical approaches for determination of different forms of iron in some paddy soils</i>

**Genesis and characterization of a recarbonated argic palaeosol in Monegros Desert (NE Spain).**

Clara MARTÍ<sup>1</sup>, David BADIA<sup>1</sup>, Rosa M. POCH<sup>2</sup> and M. Teresa GARCIA-GONZÁLEZ<sup>3</sup>

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**1. Introduction**

The study of paleofeatures in paleosols is a tool in the reconstruction of paleoenvironmental conditions (Hamer et al. 2007). In semi-arid climates, many aspects of soil formation are related to the accumulation of secondary calcium carbonate (Badia et al. 2009, Nettleton et al. 1991), even clay illuviation as a washing process after decarbonation (Gómez-Miguel 2005). The objectives of this study were: 1) to document the mineralogical, morphological and micromorphological properties on a polycyclic soil under currently semi-arid climate of Monegros desert, and 2) to relate soil features, mainly related to calcification, to environmental changes during the late Quaternary.

**2. Materials and methods**

**2.1. Soil morphology and sampling**

The studied pedon developed on calcareous sediments deposited by Alcanadre River during the late Pleistocene on the highest fluvial terrace in the area (Badia et al. 2010). The soil has been classified as Calcic Petrocalcid (SSS 2010) and Petric Calcisol (IUSS 2007) under a thermic-aridic soil climate regime. The 6-m deep pedon was divided into twelve genetic horizons, with several lithological discontinuities and had the following sequence: Ah-Bkm1-Bkm2-2Bkc-2Btkc-2Btk-3BC-4Ckc-4C-5C-6C-7C (Fig. 1).

The current elevated position of the pedon in the landscape, with relief inversion, has allowed preservation of a thickness of this magnitude. The pedon was described in the field according to FAO procedures (FAO 2006), where morphological data were recorded for each horizon. Bulk horizon samples were collected, and air-dried, crushed and sieved to 2 mm to remove coarse fragments. These bulk samples were used for physical, chemical and mineralogical characterization. In addition, oriented clod samples were extracted for thin section preparation. Peds were air dried before being heated to 90°C, impregnated under vacuum with epoxy resin, mounted on glass slides and ground to 30 µm. Thin sections were examined and photographed using a petrographic microscope under both plane- and cross-polarized light.

**2.2. Chemical and physical properties**

Particle size distribution was determined using the pipette method, after the removal of organic matter using H<sub>2</sub>O<sub>2</sub> and with Na-hexametaphosphate used as a dispersing agent (Gee and Bauder 1986). Soil pH (1:2.5 ratio in H<sub>2</sub>O) was determined using a glass electrode (McLean 1982). Total carbonate content was measured volumetrically (with a calcimeter) after treatment with 6N hydrochloric acid (Nelson 1982). The electrolytic conductivity (EC) and the Sodium Adsorption Rate (SAR) were measured in the paste saturated extract (Rhoades 1982).

**2.3. Mineralogical characterization**

The mineralogical composition of the clay fraction (≤ 2 µm) of selected horizons, 2Bkc, 2Btk and 4Ckc, was identified by X-ray powder diffraction (XRD) on a Philips X'Pert diffractometer with graphite-monochromated Cu Kα radiation. XRD patterns were obtained from each sample using: a) random powder mounts, and the following oriented aggregates; b) air dried, c) ethylene glycol-solvated, d) heated at 300 °C and e) 550 °C for 3 h. Semi-quantitative estimates of quartz, goethite and total phyllosilicates were obtained from the random powder patterns, integrating the area of the maxima diffraction at 0.424, 0.416 and 0.444 nm, respectively, and using the mineral intensity factors reported by Schultz (1964). Approximate abundances of illite, smectite and chlorite were obtained in a similar way, using the oriented aggregate patterns

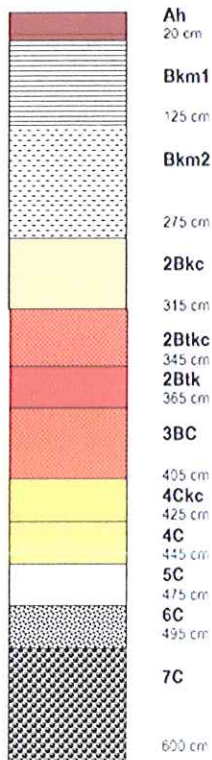


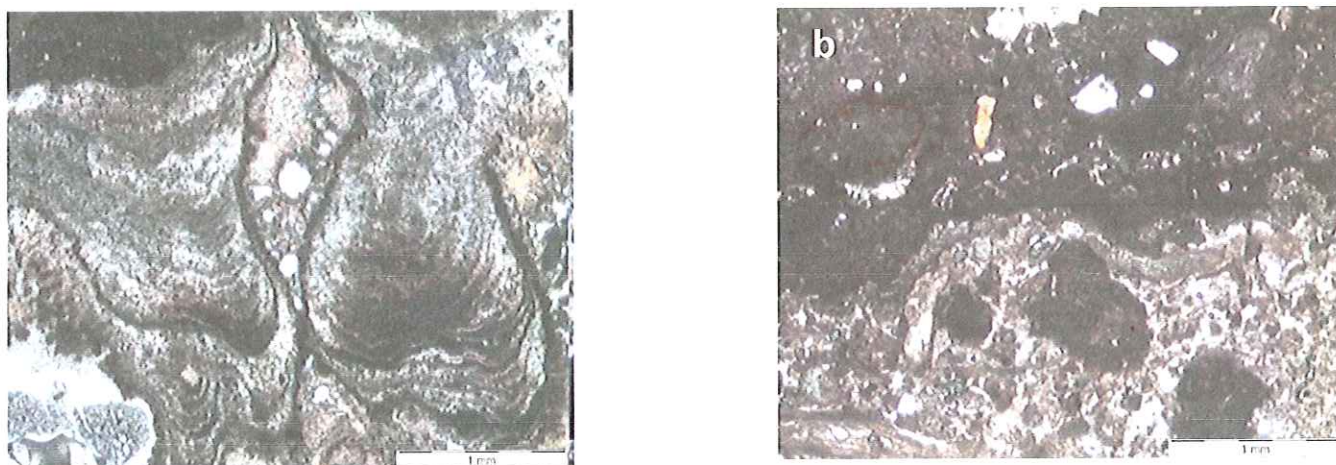
Figure 1. Scheme of the profile

(peak areas at 9.98 nm for illite, 1.65 nm for smectite in ethylene glycol-solvated aggregate and 1.42 nm in 550°C heated oriented aggregate).

### 3. Results and discussion

The bottom part of the profile is composed of layers of sand and silt with gravels of the paleo-Alcanadre river, older than 780 Ma according to paleomagnetic analysis (Lewis et al. 2009). The soil profile is highly calcareous throughout with an average of >40% CaCO<sub>3</sub>, increasing near the soil surface in the form of petrocalcic horizons. All horizons exhibit a homogeneous yellowish brown (10YR 7/4-8/4) colour but tend to be locally reddish as a result of the increase in clay content. The profile can be divided into three types of horizons, based on their texture and calcium carbonate accumulation forms.

Petrocalcic horizons (Bkm) are formed near the top of the profile. They have an average thickness of 250 cm and can be divided into two horizons. The Bkm1 horizon (105 cm thick, with the highest carbonate content) has a massive-laminar structure and it is extremely hard, while Bkm2 horizon (150 cm) presents a nodular structure and is not as hard as the overlying horizon. Micromorphological analyses of the laminar petrocalcic horizon reveal a variety of features such as embedded spherical peds in a gently undulating band matrix of micrite and sparite that sometimes form pendants under the gravels (Fig. 2a). The underlying petrocalcic horizon show a spaced framework of orthic micrite nodules packed between relatively pure micritic laminar bands (Fig. 2b).



**Figure 2.** Thin-section micrographs of (a) laminar petrocalcic (Bkm<sub>1</sub>) horizon and (b) petrocalcic (Bkm<sub>2</sub>) horizon in plane-polarized light

Underlying those petrocalcic horizons, calcic horizons commonly occur with calcite accumulations as nodules and soft concretions (Bkc). Micromorphologically they correspond to coatings, infillings and orthic nodules that indicate an in-situ calcite accumulation process. The precipitation of microcrystalline calcite is also seen filling old channels. Under this horizon, two horizons show evidence of a strong clay illuviation, absent in the overlying horizons. The first one is 30 cm thick, has 28% clay, a light orange colour and a medium subangular blocky structure (2Btkc). The second one has a similar clay content (31.5%), and a moderate fine prismatic structure (2Btk). Both horizons are recarbonated, as shown by the presence of calcite nodules and pseudomycelia.

Two kinds of clay pedofeatures can be distinguished: interbedded microlaminated clay pockets (Fig. 3a), sometimes fragmented and distorted by nodules of micrite (Fig. 3b) and clay coatings along vertical cracks and around calcite channel infillings.

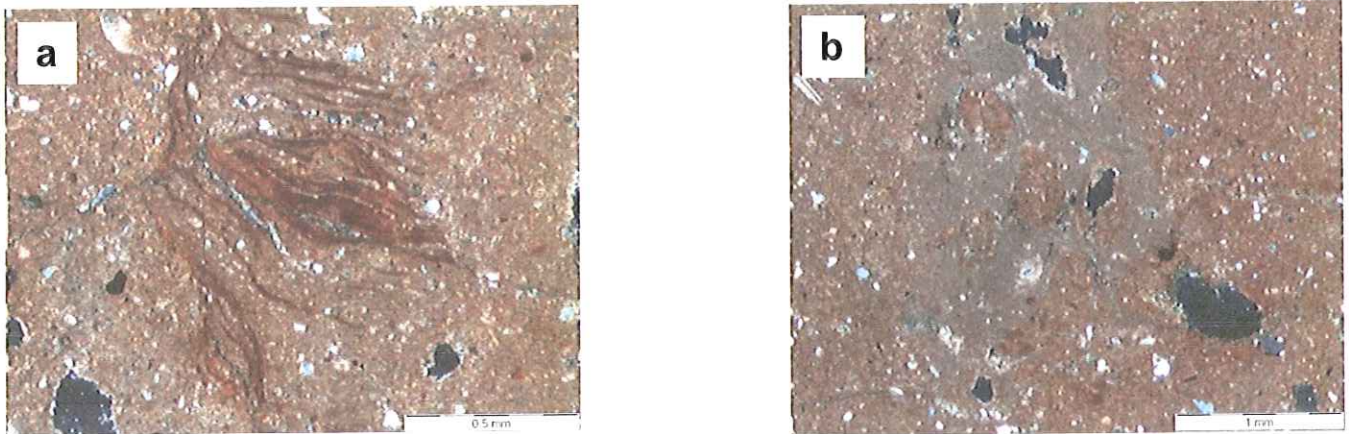


Figure 3. Thin-section micrographs of (a) the argillic horizon (Btk) interbedded microlaminated clay pockets, and (b) nodule of impregnative micritic calcite superimposed in a clay-rich area in cross-polarized light, at 345 cm depth.

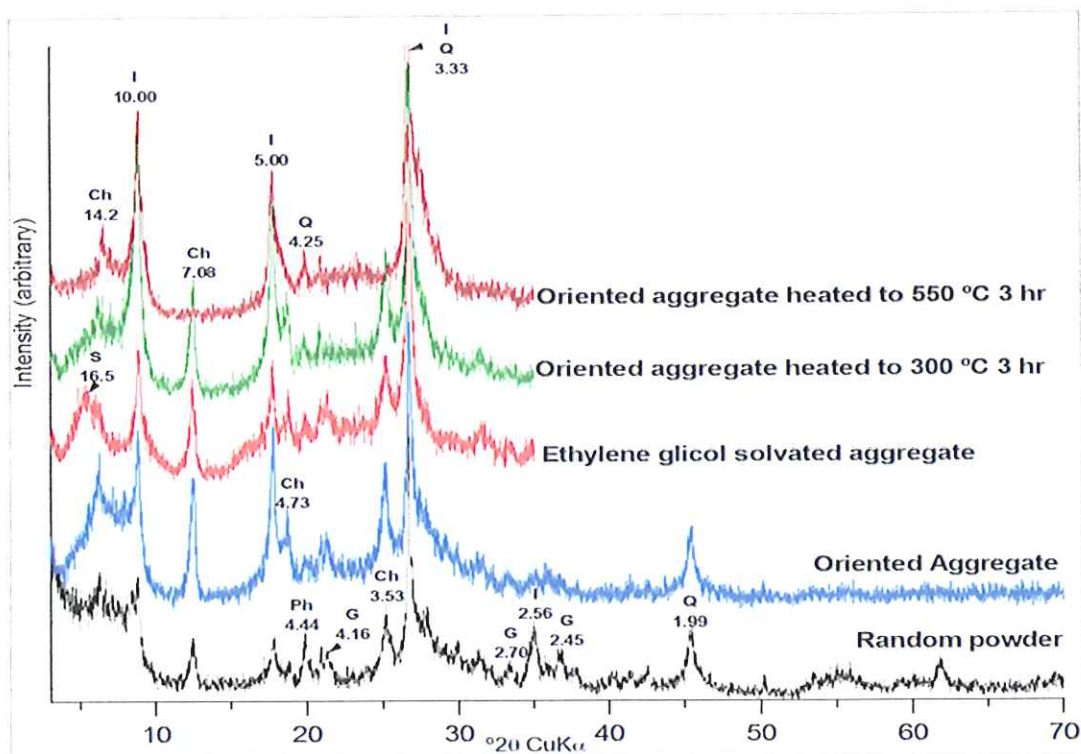


Figure 4. Diffraction patterns from the 2Bkc horizon.

The mineralogical composition of the clay fraction below petrocalcic horizons is very similar. Dioctahedral mica illite is the major phyllosilicate (average content of 59%), while the smectite and chlorite contents are around 11 and 8%, respectively. Goethite has also been detected in all samples and, as it occurs with the other minerals, its content is fairly uniform (average of 6%). Fig. 4 shows, as an example, the X-ray diffraction data of the  $\leq 2 \mu\text{m}$  fraction of the 2Bkc horizon.

The high carbonate content throughout the profile might inhibit current clay translocation – given a wet enough moisture regime – because it would cause flocculation. Consequently the formation of argillic horizons are most likely to be a paleofeature related to a less arid climate than present. This implies that the high carbonate content and crystallitic b-fabric of the profile are the result of later recarbonation. This hypothesis is supported by the fact that nodules appear as dense micritic impregnations superimposed on the textural pedofeatures. Whilst sodium may have played an important role in clay

dispersion, given the current SAR is about 8, the EC is also very high, which means that clay would in any case be flocculated by the high ionic strength. Calcite depletion can be also noticed at 275-345 cm depth (Bkc horizon) as subhorizontal areas not associated with current or past pores. They can be better interpreted as original, non-recalcified zones that formed as the result of a more recent decalcification process.

A common feature from 315 cm to 425 cm depth is the presence of Fe/Mn accumulations which occur in volume percentages varying from about 10% at 315 cm depth to 5% at 425 cm. However, a sudden increase (reaching 40%) can be seen at 345 cm depth, and diminishing in the underlying horizons. Micromorphologically two types of manganese and iron accumulation were distinguished: hypo- and quasi-coatings related to pore channels; and dendritic aggregate nodules within the peds. These morphologies indicate moderate to strong redox conditions, which agrees with the textural pedofeatures as microlaminated pockets that would correspond with clay intercalations formed in waterlogged conditions as explained by Fedoroff et al. (2010).

#### 4. Conclusions

Calcic and argillic horizons are found at different soil depths. The argillic horizon development was formed or readily followed by strong reducing conditions, which agrees with the abundance of smectites and Fe and Mn pedofeatures. The alternative processes described, (petro)calcification and clay illuviation, suggest the existence of paleoenvironments with fluctuating paleohydrological conditions ranging from semi-arid to humid continental conditions. The development of thick petrocalcic horizons in the upper part of the profile, indicates that semi-arid conditions and geomorphologic stability were sustained for long periods in the recent past.

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# CERTIFICATE

The oral communication:

**“GENESIS AND CHARACTERIZATION OF A RECARBONATED ARGIC PALAEO SOL IN MONEGROS DESERT (NE SPAIN)”**

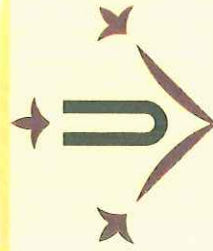
by

**CLARA MARTÍ, DAVID BADIA, ROSA M. POCH, M. TERESA GARCIA**

has been presented at the:

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