Paleopedology Newsletter

IUSS Commission 1.6
INQUA Focus Group QUASAP

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Paleopedology Newsletter is a joint initiative of the IUSS Commission 1.6–Paleopedology and INQUA Focus Group QUASAP

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Cover photo: The Paleolithic site (MIS 3&2) Kostenki-14 (Markina Gora), Central Russian plain, Voronezh region. Further details: Guidebook for Field Excursions, XIIth International Symposium and Field Seminar on Paleopedology; "Paleosols, pedosediments and landscape morphology as archives of environmental evolution" 10-15 August, 2013, Kursk, Russia.

Contents

Editorial	4
Past Conferences & Meetings	
EGU General Assembly 2019	5-8
International conference ‘Solving the Puzzles from Cryosphere’	9-10
Quaternary Geochronology	10-11
Upcoming Conferences & Meetings	
INQUA 2019	12
XIVth International symposium & field workshop on paleopedology	13-17
16th International Conference on Soil Micromorphology, Poland	18-19
New Publications	
Rodrigues et al. 2019 (Laminar calcretes)	20-21
Menezes et al. 2019 (Ichnology and paleopedology)	22-24
Targulian and Bronnikova 2019 (Soil memory)	24-25
Lucke et al. 2019 (Quaternary International - Special Issue)	25
Invited Contributions	
Jérôme Juilleret (Whole regolith pedology)	26-30
Frank Netterberg (Calcretes)	31-34
Reviving a Landmark Essay (Dan H. Yaalon 1971)	35-46
The Last Page	47

Editorial

The current issue opens with an update regarding past and future activities. Three past conferences are highlighted; EGU General Assembly 2019 (Vienna, Austria), the International conference 'Solving the Puzzles from Cryosphere' held in Pushchino, Russia (report by Maria Bronnikova and Alexey Lupachev), and the Quaternary Geochronology conference which took place in Moscow, Russia (report by Elya Zazovskaya). Amongst the upcoming activities, the XIVth International symposium and field workshop on paleopedology, which is set for August 15-23, 2020, in Altai region, Russia, receives special attention. Other important meetings which are included are the INQUA Conference in Dublin, Ireland (July 25-31), and the 16th International Conference on Soil Micromorphology which will be held in Kraków, Poland, during August 30 to September 3, 2020.

The section of New Publications presents three promising studies: 1) Biotic influence in the genesis of laminar calcretes in Vertisols (Brazil), by Amanda Goulart Rodrigues, 2) Integrating ichnology and paleopedology of alluvial plains (Brazil), by Maurícius Nascimento Menezes, and 3) A new outlook on Soil Memory by Victor Targulian and Maria Bronnikova. Two invited contributions follow the new publications: Whole regolith pedology by Jérôme Juilleret (which is supplemented by a relevant letter of Dan H. Yaalon) and a PhD epilogue on calcretes of South Africa and Namibia, by Frank Netterberg. I thank Jérôme Juilleret and Frank Netterberg for willing to add some of their insights to this Issue. All in all, the variety of included contributions shows that Paleopedology Newsletter is a home for any approach to paleosols and paleoenvironments, be it pedological, sedimentological or geotechnical.

Finally, for the benefit of those who find it hard to locate this out-of-print piece, the June Issue ends with a copy of Yaalon's 1971 seminal paper 'Soil-forming processes in time and space'.

The next issue of the Newsletter is due to December 2019. This is an excellent opportunity to call for contributions: News, meetings, publications, literature comments, thoughts, art and any "paleo-thing" which you might wish to share.

Best wishes,

Danny Itkin
Editor

Past Conferences & Meetings

EGU General Assembly 2019, Vienna, Austria; April 8, 2019

EGU General Assembly 2019 included a session titled 'Pedogenic processes of soils and palaeosols across scales – influence of various factors, including imprints of human activities'. This session was convened by Daniela Sauer together with Anna Schneider, Joscha Becker, Markus Egli and Klaus Kaiser (as co-conveners) and covered 13 oral presentations and 22 posters.

Orals:

Basic research on soil processes may help answering applied research questions; Chairpersons: Markus Egli, Klaus Kaiser, and Stephen Asabere.

- Ground-making research: The first UK arable soil formation rates. Dan Evans, John Quinton, Andrew Tye, Jessica Davies, Simon Mudd, and Angel Rodes.

- Influence of Parent Material Lithology on Dust Accumulation in Alluvial Fan Soils, Mojave Desert, California U.S.A. Eric McDonald and Brad Sion.

- Spatial and temporal dynamics of soil moisture in benchmark soils of the Guinea savannah zone of Ghana - is there an unused potential for food-crop production? Kwabena Abrefa Nketia, Stephen Boahen Asabere, Joscha Becker, Stefan Erasmi, and Daniela Sauer.

- Soil erosion rates' assessment of a forested catchment using $^{239+240}Pu$ and relation to landscape evolution. Francesca Calitri, Markus Egli, and Michael Sommer.

- The effect of particle size on weathering and salt release from coal mine spoils. Mandana Shaygan, Melinda Hilton, Neil McIntyre, and Mansour Edraki.

- Tree species and recovery time drives soil restoration after mining: A chronosequence study. Lingling Shi, Jianchu Xu, and Ostermann Anne.

- Enrichment of heavy metals in surface layers of urban soils. Marco Peli, Stefano Barontini, Benjamin C. Bostick, Roberto G. Lucchini, and Roberto Ranzi.

Soil processes across scales and imprint of human activities;
Chairpersons: Anna Schneider, Joscha Becker, and Daniela Sauer.

- Spatial variability of soil organic carbon at different scales in West Greenland. Philipp Gries, Karsten Schmidt, Thomas Scholten, and Peter Kühn.

- Do tree species affect decadal changes in topsoil pH and C and N stocks?–Resampling of soils in the Danish broadleaved common garden experiment. Christina Steffens, Lars Vesterdal, and Eva-Maria Pfeiffer.

- Functional diversity and dynamics of microbial communities in soil profiles along a 2000-year paddy soil chronosequence. Qingfang Bi, Andreas Richter, Xianyong Lin, and Yong-Guan Zhu.

- Unravelling processes and timescales of tropical pedogenesis using luminescence dating. Tobias Sprafke, Heinz Veit, Christine Thiel, Andre O. Sawakutchi, Felix Lauer, Annette Kadereit, Leonor Rodrigues, Marcia R. Calegari, Beatriz M. Rodrigues, Paul Tchawa, Paul-Desire Ndjigui, Phillipe Tchomga, and Pablo Vidal-Torrado.

- Gaps in the World Reference Base for Soil Resources (WRB) for classifying charcoal hearth soils. Giovanni Mastrolonardo and Giacomo Certini.

- The burnt subsurface of a mega archaeological site in the Jerusalem Highlands, Israel. Oren Ackermann, Joel Roskin, Hamoudi khalaily, Dimirty Yegorov, and Jacob Vardi.

Posters:

Soil processes, soil development and soil patterns across scales;
Chairpersons: Anna Schneider, Klaus Kaiser, and Markus Egli.

- Effects of slope aspect on soil development in the Canadian prairies: a digital approach. Henrik Distel, Florian Hirsch, Thomas Raab, and M. Anne Naeth.

- Dynamics of pedogenic carbonates and their relation to slope aspects in the Rumsey area (Alberta, Canada). Florian Hirsch, Thomas Raab, Henrik Distel, and M. Anne Naeth.

- Contribution of carbonates to soil CO_2 emissions from calcareous soils. Paul Voroney and Ravindra Ramnarine.

- Soil evolution and related erosion rates derived from a carbonate moraine chronosequence of the Swiss Alps. Alessandra Musso, Michael E. Ketterer, and Markus Egli.

- Clay minerals and micromorphological features of soils developed from carbonate-rich slope sediments in the Western Carpathians, South Poland. Joanna Kowalska, Michał Skiba, Tomasz Zaleski, Katarzyna Maj-Szeliga, and Ryszard Mazurek.

- Chemical weathering of volcanic tephra and their impact on pedogenesis in Icelandic soils. Theresa Bonatotzky, Franz Ottner, Egill Erlendsson, and Guðrún Gísladóttir.

- Taxonomic and functional pedodiversity of forest and semidesert zones of the European part of Russia at different hierarchical levels of soil cover formation. Dmitry Golovanov, Maria Konyushkova, Pavel Krasilnikov, Alexey Sorokin, Nelli Agadzhanova, Zarema Gasanova, and Yulia Golovleva.

- Pedogenetic processes in the young soils of Caspian Lowland. Nelli Agadzhanova, Maria Konyushkova, and Pavel Krasilnikov.

- Varnish desert developed on granitic rocks in Sonora, Mexico. Elizabeth Solleiro-Rebolledo, Sergey Sedov, Marina Lebedeva-Verba, Cesar Villalobos, and Rocio Alcantara.

- Leaning Buildings on Alluvial Deposits at Southeastern Region of Mexican Republic. Evaluation and Solution. Oscar Cuanalo.

- Can grain size distribution and soil color be used to determine loess proportions in soils? Fei Yang, Volker Karius, and Daniela Sauer.

- The Ebergoetzen Measurement Site: Linking Biogeochemical Cycles and Soil Development in a Central European Beech Forest. Joscha N. Becker, Harold Hughes, Jürgen Grotheer, Thorsten Zeppenfeld, and Daniela Sauer.

- Microbial mobilization of various P species depends on weathering history of soils. Moritz Köster, Yue Hu, Francisco Nájera, Francisco Matus, Michaela Dippold, and Sandra Spielvogel.

Soils as records of past environments and human activities;
Chairpersons: Anna Schneider, Klaus Kaiser, and Markus Egli.

- Urbanization enhances stocks of P fractions in strongly weathered arable soils of Kumasi (Ghana), West Africa. Stephen Boahen Asabere, Jiangyun Li, Harold James Hughes, and Daniela Sauer.

- Loess-palaeosol sequences along the Rhône Graben (SE France): the potentially missing link between loess archives in central Europe and the Mediterranean region? Nora Pfaffner, Daniela Sauer, Annette Kadereit, Sophie Cornu, Barbara von der Lühe, Pascal Bertran, Mathieu Bosq, and Sebastian Kreutzer.

- Modelling of interglacial paleosol development in the Chinese Loess Plateau. Keerthika Nirmani Ranathunga Arachchige, Peter Finke, and Qiuzhen Yin.

- The traces of past agricultural practices in hilly regions of the Czech Republic. Jitka Elznicova, Johana Vardarman, Iva Machova, Stepanka Tumova, Martin Famera, J. Michael Daniels, and Tomas Matys Grygar.

- Geoecological legacies of pre-industrial charcoal burning – Research questions and approaches. Thomas Raab, Florian Hirsch, Anna Schneider, Alexander Bonhage, and Alexandra Raab.

- Effects of historical charcoal burning on soil landscapes in West Connecticut – Quantifying pyrogenic and organic soil carbon content of Technosols by FTIR analysis. Alexander Bonhage, Larysa Mykhailova, Florian Hirsch, Anna Schneider, Thomas Raab, Thomas Fischer, Alexandra Raab, Sally Donovan, and Will Ouimet.

- Thermal conductivity of charcoal-rich soils – preliminary results from a study on relict charcoal hearth (RCH) sites from Germany and the USA. Sally Donovan, Anna Schneider, Florian Hirsch, Alexander Bonhage, Alexandra Raab, and Thomas Raab.

- The use of LiDAR and remote sensing data in the archaeological topography reconnaissance. Study case Moldavian Plateau Silviu Costel Doru and Mihai Niculita.

- Secondary carbonates (calcretes) in coastal outcrops as archives for paleoenvironmental reconstruction – a case study from Yucatan Peninsula, Mexico. Daisy Valera Fernández, Héctor Cabadas Báez, Elizabeth Solleiro Rebolledo, and Sergey Sedov.

International conference 'Solving the Puzzles from Cryosphere', Pushchino, Russia; April 15-18, 2019

In mid-April 2019, the Institute of Physicochemical and Biological Problems in Soil Science held the International conference 'Solving the Puzzles from Cryosphere'. The event gathered 160 participants from many scientific and educational institutions from 5 countries. The main topics of the conference covered aspects of general, regional and historical geocryology, permafrost hydrology and hydrogeology, geophysical investigations as well as the paleogeographical, microbiological, biotechnological and astrobiological studies in polar regions.

The main subjects dealt with permafrost-affected soils in Arctic and Antarctic regions. The reports of the cryopedological session, which was co-chaired by Alexey Lupachev (IPCBPSS RAS) and Andrei Dolgikh (IG RAS), covered different aspects of genesis, properties and ecological functioning of permafrost-affected soils. Lively illustrated and enriched with data, oral and poster talks provided new information on topics such as permafrost-affected soils as the hydrothermal regime of soils, effects of global and local anthropogenic impacts, influence of freezing-thawing cycles on soil biota and impact of global climate change on cycles of biogenic elements. The geographical coverage of the discussed studies stretched from the oases of Antarctica, to the cryoarid mountainous regions of Central Asia and the cryohydromorphic areas of West Siberia up to the coastal regions of the Arctic Ocean and the glaciers of Svalbard.

A round-table discussion on the issues of the permafrost soils classification included more than 20 researchers. George Matyshak (Lomonosov, Moscow State University) gave a talk on the specifics of frost boiling and cryoturbation in terms of soil classification and discussed the logistic possibilities of the year-round field scientific station in the tundra zone. Svetlana Deneva (IB Komi SC UB RAS) spoke about experiences and issues of the classification and diagnostics of the poorly studied cryogenic marsh soils. Leonid Tsibizov (Trofimuk Institute of Petroleum Geology and Geophysics, SB RAS) shared his experience of running the Samoylov Island multidisciplinary scientific research station.

The session 'Puzzles from the past palaeoocology' (chaired by Dr. Oksana Zanina) was short but impressive. Late Pleistocene paleosols of Quaternary landscape of North Siberia were discussed (Sheinkman, Sedov et al.). Paleocryogenic polygonal relief was described on the Ural Plateau located far beyond cryolithozone (Ryabukha et al.). Other paleocryogenic markers were studied in the northern coastal part of Western Siberia (Pismeniuk et al.), and southwestern Siberia (Larin et al.). Paleoenvironmental data based on analysis of fossil plant and animal remains incorporated in mammoth hair obtained from permafrost were reported (Zanina et al.). An approach to estimate aeolian input in peatlands was demonstrated (Babkin et al.).

The traditional nomination of the most interesting young researchers' oral and poster presentations was awarded during the conference.

Maria Bronnikova, IUSS Paleopedology Commission, Chair
Alexey Lupachev, IUSS Cryosol Working Group, Co-chair

Quaternary Geochronology: Instrumental methods of dating Quaternary sediments, Moscow, Russia; April 24-25, 2019

The all-Russian Scientific Conference (with international participation) 'Quaternary Geochronology: Instrumental methods of dating Quaternary sediments' was held in Moscow in April, 24-25, 2019. This meeting followed the initiative of the Russian Academy of Sciences; Laboratory of Radiocarbon dating & Electronic microscopy of the Institute of Geography, in association with the Geological Institute, the Severtsov Institute of Ecology and Evolution and the Institute of History of Material Culture. The conference was dedicated to the 19th birthday of L.D. Sulergizkii, who was one of the founders of the radiocarbon dating in the former USSR. A key motivation was to revive meetings of the Russian geochronological community. The last geochronological conference of such scale was organized in Russia (USSR) in 1989.

More than 100 people participated the conference, arriving from all across Russia: Moscow, Vladivostok, Yakutsk, Novosibirsk, Tomsk, Tyumen, Irkutsk, Perm, Ekaterinburg, Chelyabinsk, Saint-Petersburg and Ryazan. International colleagues arrived from Poland, Lithuania and Denmark. In total, 62 reports and 48 posters were presented. The conference included 3 thematic sections: Pleistocene geochronology, Holocene geochronology and Methods of geochronology and geochronometry. The main scientific fields were as follows:

- Methodological aspects of radiocarbon dating.
- Application of radiocarbon methods in Earth Sciences and other fields of knowledge.
- The use of cosmogenic nuclides, uranium series and other methods of Quaternary geochronology.
- Dosimetric dating methods.
- Problems of instrumental dating of archeological sites.
- The use of stable isotopes for the reconstruction of Quaternary history.

One highlight of that conference was a round-table titled ‘Archaeological research and geochronology: Love and Hate’, which brought together some lead Russian archaeologists and specialists of instrumental dating methods. Topical problems of dating archaeological objects using instrumental methods were discussed, as well as scientific and ethical problems of interaction of archaeologists and laboratories.

Dr. Elya Zazovskaya
Head
Laboratory of Radiocarbon Dating & Electronic microscopy
Department of Soil Geography & Evolution Institute of Geography
Russian Academy of Science

Upcoming Conferences & Meetings

20th Congress of the International Union for Quaternary Research (INQUA) Dublin, Ireland; July 25-31, 2019

This event will start shortly. You might be interested in the following sessions:

Friday 26th, 14:30-15:15, Posters I, Location: Liffey Hall A & B (Level 1)
https://app.oxfordabstracts.com/events/574/program-app/session/4508

Friday, 26th, 16:45-18:30; Multiproxy studies on continental carbonates: Palaeoclimates and palaeoenvironments Wicklow Hall 2B (Level 2)
https://app.oxfordabstracts.com/events/574/program-app/submission/94221
https://app.oxfordabstracts.com/events/574/program-app/session/4496

Monday, 29th, 14:30-15:15; Terrestrial Processes, Deposits and History: Soil formation - its rates and its use for reconstructing Quaternary landscape evolution; Posters III, Liffey Hall A & B (Level 1)
https://app.oxfordabstracts.com/events/574/program-app/session/5786

Please visit the INQUA 2019 website for the most up-to-date information:

http://www.inqua2019.org/

https://app.oxfordabstracts.com/events/574/program-app/program

INQUA 2019
DUBLIN
IRELAND

Institute for Water and Environmental Problems
the Siberian Branch of the Russian Academy of Sciences

INSTITUTE OF GEOGRAPHY
Russian academy of sciences
founded in 1918

Institute of Geology and Mineralogy
the Siberian Branch of the Russian Academy of Sciences

Institute of Soil Science and Agrochemistry
Siberian Branch of the Russian Academy of Sciences

IUSS Division 1 – Soils in Space and Time
Commission 1.6 – Paleopedology

Dokuchaev Soil Science Society in Russia
Commission on Paleopedology and Subcommission on Micromorphology

XIVth International symposium and field workshop on paleopedology (ISFWP-XIV) Paleosols, pedosediments and landscape morphology as archives of environmental changes Russia, Altai; August 15-23, 2020

Pleistocene and Holocene environmental history; glacial geoforms, dammed lake geoforms and deposits, seismic landslides and more!

This Symposium will include two-day academic sessions in Barnaul (western banks of the Ob River, Altai, Siberia), at the Institute for Water and Environmental Problems, Russian Academy of Sciences, Siberian Branch. The academic part will be followed by a field workshop (4 field working days and 2 travelling days), during which participants will travel across Russian Altai, from northwest to the very southeast and down to the Mongolian border. Explorations of interesting Pleistocene and Holocene soil-sedimentary sequences and specific elements of landscape morphology will be complemented by scenic views of Siberian Chernozemic steppes, high snow-topped mountains and varied landscapes, from mountain tundra and larch taiga to cold and desert steppes.

Locations of academic sessions (Barnaul) and sites of field workshop.

Organizing and program committee;

Chairs: Olga Solomina (Institute of Geography RAS, Moscow, Russia); Alexandr Puzanov (Institute for Water and Environmental Problems SB RAS, Barnaul, Russia).

Co-Chairs: Maria Bronnikova (Institute of Geography RAS, Moscow, Russia & IUSS, Commission 1.6 Paleopedology); Elizabeth Solleiro Rebolledo (National Autonomous University of Mexico (UNAM), Mexico & IUSS, Commission 1.6 Paleopedology).

Secretaries: Yana Kuznyak (Institute for Water and Environmental Problems SB RAS, Barnaul, Russia); Julia Konoplianikova, (Institute of Geography RAS, Moscow, Russia); Julia Karpova (Institute of Geography RAS, Moscow, Russia).

Members of organizing committee: Elia Zazovskaya, Andrey Panin, Alexandra Gol'yeva, Andrey Dolgikh (Institute of Geography RAS, Moscow, Russia); Olga Elchininova, Dmitriy Bezmaternykh, Dmitriy Troshkin, Tamara Rozhdestvenskaya, Sergey Balykin, Ivan Gorbachev, Viktor Kalashnikov (Institute for Water and Environmental Problems SB RAS, Barnaul, Russia); Anna Agatova, Roman Nepop, Valentina Zykina, Vladimir Zykin, Anna Vol'vakh (Institute of Geology and Mineralogy SB RAS, Novosibirsk, Russia); Marina Lebedeva, Irina Kovda (Dokuchaev Soil Science Institute, Moscow, Russia); Maria Dergacheva, Evgeniya Gurkova (Institute of Soil Science SB RAS, Novosibirsk, Russia); Sergey Sedov (National Autonomous University of Mexico (UNAM), Mexico); Tobias Sprafke (Bern University, Switzerland & IUSS, Commission 1.6 Paleopedology); Alexandr Makeev, Galina Samoilova (Moscow State University, Moscow, Russia).

General schedule;

- August 15 - Registration at the conference venue, academic sessions, welcome party.
- August 16- Academic sessions and sightseeing.
- August 17 - Visit to the Middle-Late Pleistocene Loess-paleosol sequence of Krasnogorsky in the north-east of the low mountain area of the Russian Altai, overnight stay in Gorno-Altaisk (the capital of Altai Republic) with a visit to the National Museum of the Republic of Altai.
- August 18 - Scenic journey from Gorno-Altaisk to Aktash to observe paleosols of the South-East Altai. The Chuya Highway (or "Chuysky Trakt") is among the top 5 of the most beautiful roads in the world, according to the National Geographic rating, Seminsky and

Chike-Taman passes, a confluence of Katun and Chuya Rivers, petroglyphs of Kalbak-Tash. Barbeque party on arrival.

- August 19 - Holocene pedosedimentary sequences in the Chuya River valley of the South-East Altai (Baratal, Sukhoi and Kuektanar sections). Surface polygenetic profiles with records of Holocene environmental history: Skeletic Kastanozem Cambic and Skeletic Cambic Calcisol Yermic, South-East Altai. Ice-dammed lakes paleo-shorelines, sediments of outburst floods, Giant gravel dunes in the Kurai basin, and Sukor multievent paleodislocation in the Chuya valley. Archaeological sites associated with various nomadic cultures: burial mounds (kurgans), balbals and stelae, iron smelting furnaces.

- August 20 - Polygenetic Holocene surface Calcisol in Chuya intermountain depression. Redeposited Neogene sediments with Pleistocene pedogenic features at the foot of the Kuray Ridge in the Chuya basin. Landforms and sediments related to major events of regional Pleistocene and Holocene environmental history: giant gravel dunes, Taldura seismically induced landslide, moraines of Chagan-Uzun glacier, Chagan section of Pleistocene glacial and glacio-fluvial deposits, fields of "drop-stones" and the Bigdon Paleolithic site.

- August 21 - Polygenetic Holocene Kastanozem, Late Pleistocene-Holocene pedosedimentary section, Cryic Histosol in Highlands of the Boguty valley. Landforms and sediments associated with the Holocene debris flow activity in the area.

- August 22 - Travel back from Kosh-Agach to Gorno-Altaisk.

- August 23 - Departure from Gorno-Altaisk airport.

Visa requirements;

Participants are strongly advised to check in advance visa requirements in their nearest Russian Embassy or Consulate. Organizers will send an official invitation upon request.

Travelling and tourist service;

There is no regular flight connection between Barnaul, Gorno-Altaisk and most international airports. Participants are recommended to fly via Moscow, but there are some other options that could be discussed at your request. The support of an affiliated tourist agency will be available. For those who fly via Moscow an additional cultural program could be offered.

Important dates;

October-November 2019 - 2nd Circular, registration opens, call for abstracts.

April 1, 2020 - deadline for registration and submission of abstracts. As some of sites along the route are located within a state boarder area, we will need to apply for permission for every participant to enter this area, and the procedure takes time. Therefore, we need to set this early deadline for registration.

Fees;

The preliminary calculated fee for participation in ISWP-XIV is 850 €. It includes flashcards with electronic version of the ISWP-XIV proceedings, and guidebook; printed version of the guidebook and final program, coffee breaks during the academic sessions in Barnaul, guided sightseeing in Barnaul and along the route of the field workshop; transportation, accommodation and all meals during the field workshop. Please note that accommodation, meals and transportation in Barnaul are not included. Low-cost participation in academic sessions only is possible at your request.

Notice of intent;

Dear friends of paleosols, If you intend to participate ISFWP-2020 in Altai, please fill in the form below as your pre-registration and send it by e-mail to the Organizing Committee paleosols2020@gmail.com

It is important to express interest at your earliest convenience due to the limited number of places. We will reserve places for the field workshop for pre-registered participants.

Pre-registration form;

First name:____
Family name:_______________________________________
Middle name:_______________________________________
Affiliation:____
Position:____
Scientific grade:_____________________________________
E-mail:____

This is only a preliminary registration procedure. Please do not forget to register after the second call!

Contacts: Julia Konoplianikova and Julia Karpova (secretaries of the organizing committee). paleosols2020@gmail.com

Old cannel of Chuya River, 1465 m a.s.l.

Chuja River valley, between Kuraj and Chuya basins, Sukhoj brook, 1635 m a.s.l.

Chuya valley, between Kuraj and Chuya basins, Kuyaktanar influx, 1730 m a.s.l.

Small lateral valley in Boguty river valley, 2472 m a.s.l.

Loess-Paleosol Sequence at the Krasnogorskoye Section, the Low-Hill Zone of the Northeastern Altai Mountains, 300 m a.s.l.

Redeposited Neogene sediments with Pleistocene pedogenic features at the foot of Kuray ridge in the Chuya basin, 1780 a.s.l.

16th International Conference on Soil Micromorphology
Kraków 2020

16th International Conference on Soil Micromorphology, Kraków, Poland; August 30-September 3, 2020

This Conference will be hosted by the Jagiellonian University in Kraków; the oldest and one of the leading Polish Universities. Schedule includes scientific sessions and a one-day mid-conference excursion. Pre- and post-conference activities are also planned.

General information;

Venue: Jagiellonian University in Kraków, 3rd Campus, Gronostajowa Str.

General schedule;

Pre-conference;

August 24-30, 2020: Micromorphological course (details will be announced later).

Conference;

- August 30 (Sunday) – registration (afternoon) and ice-breaking party at the Institute of Geography and Spatial Management, Jagiellonian University.
- August 31 (Monday) – registration, opening session, plenary sessions, poster session 1, afternoon: guide visit to Kraków city center (undergrounds beneath the Main Market Square and a walk around the city center).
- September 1 (Tuesday) – Plenary sessions, poster session 2, IUSS Business Meeting, Banquet.

- September 2 (Wednesday) – Mid-conference excursion (selected soils in Kraków and its vicinity).
- September 3 (Thursday) – Plenary sessions, summary and closing ceremony.

Post-conference excursion;

September 4-6, 2020 (Friday to Sunday) – Polish Upland tour with emphasis on micromorphological aspects: Soils developed from loess, gypsum and carbonate rocks; paleosols in loess; fossil Jurassic Podzols; Technosols in metal mining areas.

Important dates;

- July 2019: Second circular.
- September 30, 2019: Early registration opens, call for abstracts.
- February 29, 2020: End of the abstract submission.
- February 29, 2020: Early-bird registration closed.
- March 2020: Acceptance of abstracts.

We look forward to welcoming you in Kraków!

Webpage: http://www.icosm2020.sggw.pl/
Facebook: https://www.facebook.com/16icosm/
Email: icosm2020@sggw.pl
Phone: +48 22 5932612

Contact address: Soil Science Society of Poland (Polskie Towarzystwo Gleboznawcze), UP 130, Warszawa, ul. Szolc-Rogozińskiego 4, skr. poczt. 6

New Publications

Biotic influence in the genesis of laminar calcretes in Vertisols of the Marília Formation (Upper Cretaceous, Brazil)

Amanda Goulart Rodrigues

Laboratory of Sedimentary Geology (Lagesed), Department of Geology, Institute of Geosciences, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil.
rodriguesag.geo@gmail.com

This paper aims to provide a detailed description of laminar calcretes developed in a Vertisol profile of the Marília Formation (Bauru Basin, Upper Cretaceous of Brazil), in order to understand the role of organisms in the genesis and distribution of calcium carbonate in a non-carbonate substrate. The Vertisol profile studied is well-developed and poorly drained, developed on floodplain deposits in the medial part of a distributive fluvial system (Stage 1, Fig. 1). In dry periods, the soil shrank and developed deep cracks, while in wet periods the soil swelled, closing the cracks (Stage 2 of Fig. 1). A stabilization of the geomorphic surface promoted colonization by plants and invertebrate fauna during wet periods (Stage 3, Fig.1). Sparse occurrence of vertical rhizoliths and large amount of horizontal rhizohalos and sheets (or stringers) of calcite suggest that the water table was close to the depositional surface and that root mats lived at or just below it. Alternating availability of water in well-defined seasonality, promoted carbonate accumulation by biotic and abiotic influence, especially with the change of season, from wet to dry. When conditions became drier, roots pumped water from the soil solution, consequently increasing the concentration of ions around the roots, leading to precipitation of calcium carbonate (Stage 4, Fig. 1). The distribution of carbonate in the laminar calcrete followed previous vertic features (wedge-shaped structures and slickensides), plant roots associated with microorganisms (rhizosphere) and invertebrates, as well as water table variations. The biotic mechanisms consisted of intracellular and extracellular root calcification by changes in soil chemistry, creating Microcodium morphologies and rhizoliths, respectively. The role of microorganisms in the decomposition of organic matter (roots and invertebrates), probably led to spherulite genesis. Other subordinate calcite, such as nodules and fracture fillings seems to be related to abiotic influence (evaporation) in their precipitation, since there is no direct relationship with root traces. The proposed model supports the hypothesis that calcification of horizontal root systems is the major contributor to the genesis of ancient laminar calcretes.

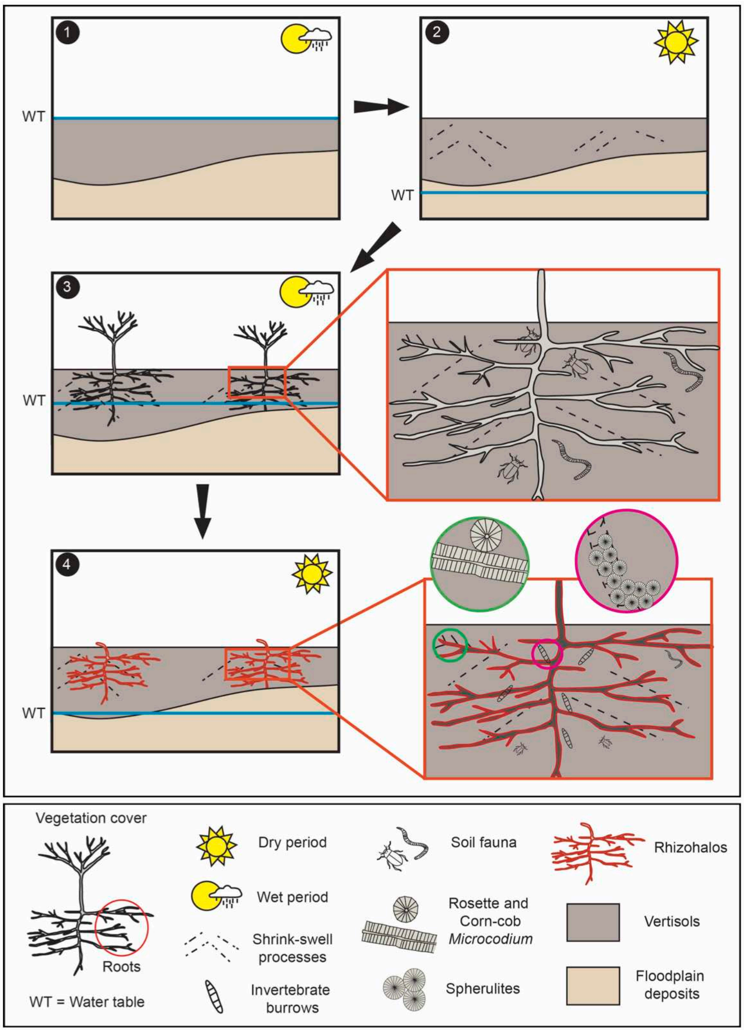

Figure 1 (Figure 13 of Rodrigues et al. 2019). Evolution model for laminar calcretes of the Serra da Galga Member in relation to seasonality, organisms, and water-table variations that govern the carbonate distribution and their genesis. Stage 1: Floodplain deposition and subsequent soil development in wet period. Stage 2: Shrink and swell of soil in dry period, generating slickensides and wedge-shaped peds. Stage 3: Colonization by plants, microorganisms, and invertebrate fauna in the wet period. Stage 4: Decay of roots, Microcodium, spherulite genesis and redoximorphic features development in the dry period.

The above abstract is based on information from Rodrigues et al. (2019). The reader is referred to this paper and the references within it for additional information.

Rodrigues, A.G., Dal' Bó, P.F., Basilici, G., Soares, M.V.T., Menezes, M.N. 2019. Biotic influence in the genesis of laminar calcretes in Vertisols of the Marília Formation (Upper Cretaceous, Brazil). Journal of Sedimentary Research, 2019, v. 89, 440-458.

https://pubs.geoscienceworld.org/sepm/jsedres/article-abstract/89/5/440/570636/biotic-influence-in-the-genesis-of-laminar?redirectedFrom=fulltext

Integrating ichnology and paleopedology in the analysis of Albian alluvial plains of the Parnaíba Basin, Brazil

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In Brazilian continental sedimentary successions, studies integrating ichnology and paleopedology for paleoenvironmental interpretations are still uncommon. Nevertheless, they are crucial for understanding the interactions among sediments, organisms and soil-forming processes. The Albian sediments of the Parnaíba Basin (Itapecuru Formation) were deposited in continental environments. These deposits are composed of very-fine to fine-grained sandstones, interbedded with mudstones and paleosol profiles with well-preserved invertebrate and vertebrate trace fossils and rhizoliths. The alluvial paleosols represent approximately 66% of the exposed sedimentary succession, with well developed greenish-gray to purple horizons characterized by blocky aggregates and widespread redoximorphic features. The paleosols form composite and compound profiles which together with floodplain and crevasse splay deposits form an alluvial depositional environment (Figure 1).

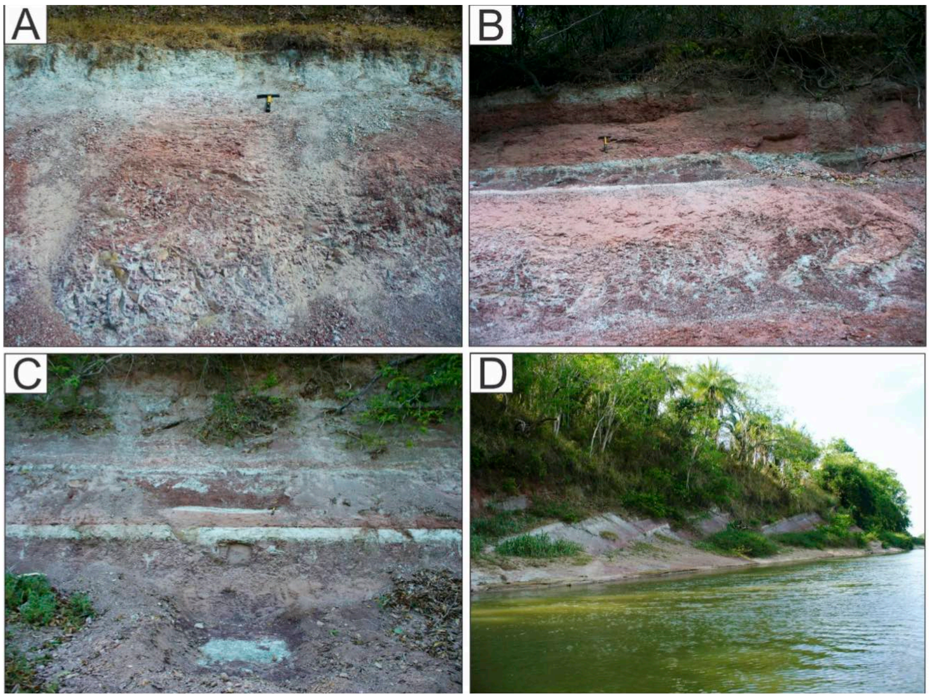

Figure 1 (Figure 2 of Menezes et al. 2019). General view of the studied outcrops: A) Pequi; B) Jundiaí; C) Prata and D) Guanaré localities.

The paleoclimate is interpreted as seasonal, with well defined dry and wet conditions. In the paleosol profiles, five invertebrate ichnogenera, one vertebrate ichnogenus and two types of rhizoliths were recognized and attributed to Scoyenia ichnofacies. The characterization of the ichnofabric revealed three ichnofabrics: ichnofabric I (alluvial paleosols) with bioturbation index ranging from 1 to 4 (5% to 65%) and density of invertebrate burrows and root structures varying from low to high; ichnofabric II and III (crevasse splay) with low to moderate densities and bioturbation index varying from 2 to 4 (10% to 40%) (Figure 2).

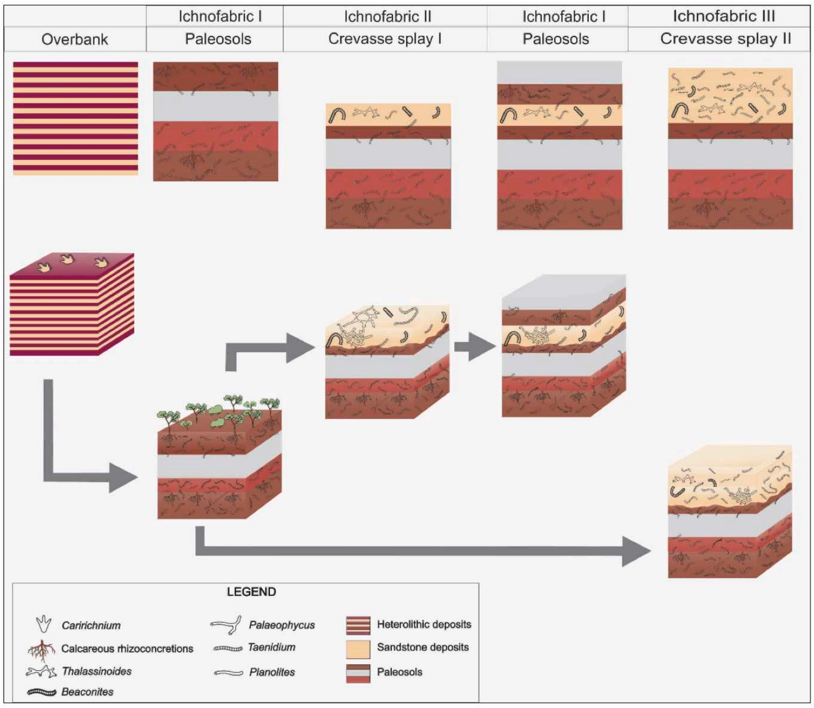

Figure 2 (Figure 8 of Menezes et al. 2019). Schematic reconstruction of the alluvial ichnofabrics of the Itapecuru Formation. Ichnofabric I is characterized by low to high index of bioturbation and occurs in paleosols of the Prata outcrop. Ichnofabric II presents moderate bioturbation index and is part of the crevasse splay deposits of the Pequi outcrop. Ichnofabric III is characterized by low to moderate bioturbation index and occurs in crevasse splay deposits of the Jundiaí outcrop (see Menezes et al. 2019 for outcrop descriptions).

The soil formation occurred over floodplain deposits in periods of landscape stability and conditions of complete or partial saturation in water. The variation in moisture levels was governed by differences in rainfall, river discharge and groundwater fluctuation. Ichnocoenoses in pedogenized sediments of ancient continental environments may indicate fluctuation of the water table, seasonal precipitation indexes, and spatial and temporal variability of the paleohydrological regime for a local or regional area. The water saturation level of Albian paleosols, evidenced by the distribution of redoximorphic features and the variation of ichnofossil types, suggest that the profiles were developed under moderately well drained conditions with short periods of water retention and that the paleoclimate was seasonal and characterized by alternating wet and dry seasons. The alluvial paleoenvironment was characterized by periods of landscape stability in which the pedogenesis exceeded the sedimentation rates.

This article is based on information from Menezes et al. (2019). The reader is referred to this article and the references within it for additional information.

Menezes, M. N., Araújo-Júnior, H. I., Dal' Bó, P.F.F., Medeiros, M. A. A. 2019. Integrating ichnology and paleopedology in the analysis of Albian alluvial plains of the Parnaíba Basin, Brazil, Cretaceous Research 96, 210-226.

https://www.sciencedirect.com/science/article/pii/S0195667118301964

Soil Memory: Theoretical basics of the concept, Its current state, and prospects for development

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This paper overviews the current state of knowledge on the problems of soil memory. A brief review of recent publications concerning soils as information systems, soil behaviour in time and space, and reconstruction of the environment based on soil records is given. Theoretical basics regarding the concept of soil memory as a soil capacity to record the environmental factors and soil forming processes in a set of stable features in the solid phase of the soil body are discussed. Mechanisms of recording, accumulation, and storage of this information, its particular carriers, and methods of their study are considered. Two major models of soil memory and distribution of records in a soil profile in response to evolutionary changes in the environment and soil are suggested. That is in dependence on an increase or a decrease in the pedogenetic potential of climate and biota. A notion of geosystem memory is introduced. The blocks of geosystem memory are discussed in a hierarchy from a subsystem level to a level of particular discrete objects (Fig. 1). Environmental proxy indicators for each block of geosystem memory are listed. Further prospects for the development of the concept of soil memory are seen in widening of a set of methods applied to study the solid-phase soil matrix and in linking the studies of particular components and elements of a soil body with its hierarchical morphogenetic analysis.

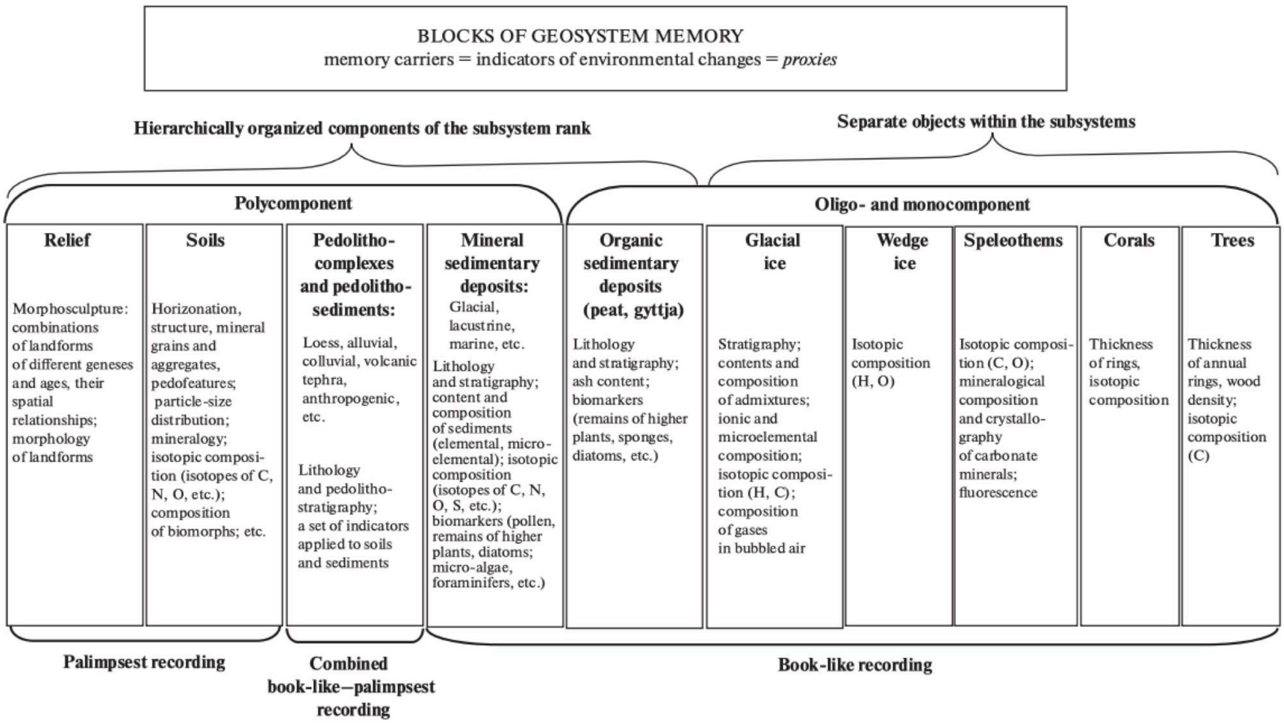

Figure 1 (Figure. 4 of the paper). Major blocks of geosystem memory.

The above abstract is based on information from Targulian and Bronnikova (2019). The reader is referred to this paper and the references within it for additional information.

Targulian, V.O., Bronnikova, M.A., 2019. Soil Memory: Theoretical Basics of the Concept, Its Current State, and Prospects for Development. Eurasian Soil Science, 52(3), pp. 229-243. https://link.springer.com/article/10.1134/S1064229319030116

Landforms, sediments, soils and palaeosols as records of present and former environmental conditions and human-environment interactions

Editors: Bernhard Lucke, Daniela Sauer, Maria Bronnikova, Florian Hirsch, Eric McDonald

Quaternary International, Volume 502, Part B, Pages 179-326 (January 30, 2019)

https://www.sciencedirect.com/journal/quaternary-international/vol/502/part/PB

Invited Contributions

Whole regolith pedology classification in a paleopedological context

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When I was asked to contribute to the newsletter I was surprised and honoured while asked to present the concept of 'Whole Regolith Pedology classification' which I try to revitalize. Actually, in my previous proposal (Juilleret et al., 2016) I did not think about paleosols in specific; it was clear to me that they should be considered as part of the regolith. Regarding which, I will later provide two examples. The proposed diagnostic materials can be used for describing and classifying any outcrop. But first, I will start by presenting the concept:

Already in 1992, a clear interest of classifying regolith materials was expressed during the "Whole–Regolith Pedology" symposium organized by the Soil Science Society of America. Nowadays, in the framework of Critical Zone sciences, it seems essential to revive this concept. In a regolith profile there is no clear separation between the *solum* and *subsolum*, the changes between a pure geological and the soil media are gradual, but for classification purpose we create artificial barrier in the natural soil/ geological continuum. Furthermore, the more geological part of the profiles (C and R layers) are often ignore and badly define in soil classification.

In 1994, Stanley W. Buol proposed to include the geological part of the regolith in a classification system in the framework of Soil Taxonomy (Buol 1994). However, Buol's idea was not embraced and no real effort was made since by other soil scientists. That is somewhat surprising! Although modern soil classification systems focus on diagnostic features, defined by a set of master horizons and (O, A, B and E horizons), early soil classification systems were based on geological substrates rather than on soil properties (Brevik and Miller 2015). The underlying geological materials, or *subsolum*, represented by C and R layers, were considered to have only little influence by pedogenic processes and are commonly disregarded in soil mapping and classification system. Soil scientists tend to consider *subsolum* as "too geologic" and outside their study field, whereas geologist consider this part of the profile as not enough geologic for mapping purposes. Indeed, only the depth of continuous rock (WRB) or lithic contact (Soil Taxonomy) are considered for classification purposes.

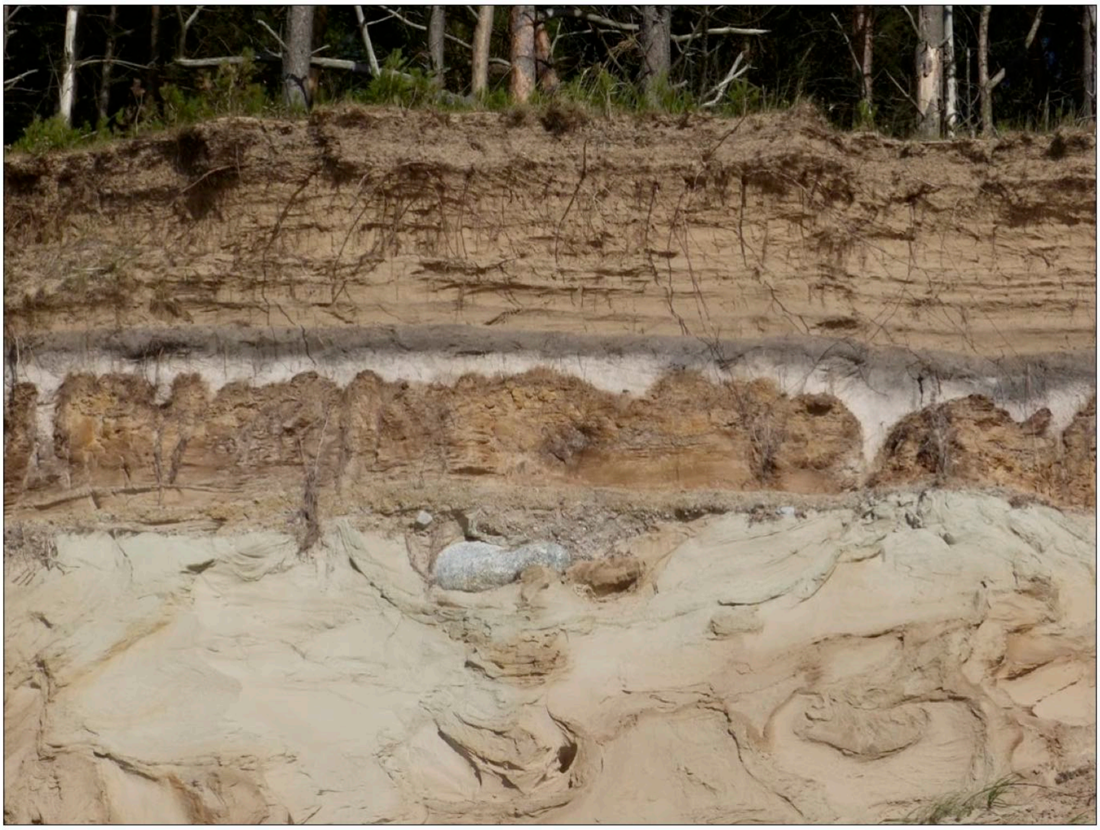
The limited attention given to the C and R layers in the international, most widely used guidelines for soil description (Soil Survey Division Staff 1993; FAO 2006) is reflected in the paucity of categories for qualifying the *subsolum*. This situation is unfortunate as during soil surveys lithogenic features such as weathering status, cleavage, rock structure, rock texture, occurrence of roots and even lithology, could directly be recorded. Such data present useful geological information and therefore could be a direct aid for geological mapping (Juilleret et al. 2012; Brevik and Miller 2015).

Despite the recognised importance of the *subsolum*, procedures for characterising and classifying *subsolum* material have not yet been developed and adopted. In both guideline for soil description (FAO, 2006), Soil Survey Division Staff, 1993). C layers are defines as "little affected by pedogenetic processes and lack properties of "other horizons. This by default "diagnostic" should be changes by clear diagnostic criteria that have to be define.

To fill this gap, Juilleret et al (2016) made a proposal for diagnostic criteria and material which allows the definition of four Subsolum Reference Groups (SRG) respectively named: Regolite Saprolite, Saprock and Bedrock. The proposed system is built in a WRB manner. SRG permit to cover Regolith areas, which are not considered by the WRB system. Indeed, often a WRB soil name is given according to diagnostic horizons observed within the first meter of a soil, whereas the WRB should classify "*any material within 2 m of the Earth's surface*" (IUSS Working Group WRB 2015). This was the original WRB purpose, but for other studies, the concept could include deeper materials. A second level of classification by the use principal qualifiers indicate whether or not an SRG has diagnostic characteristics typical for other SRGs, but which do not meet the thickness requirements of that particular SRG; hence the principal qualifiers allow to convey that the SRG has some intergraded features of another SRG. The supplementary qualifiers provide information relating to morphologic and lithologic properties which are regarded as most relevant for assessing the ecological, hydrological or other environmental functionings of the soil to *subsolum* continuum. The morphologic qualifiers convey information on the nature of the material (texture) and its structural organisation in terms of layering, inclination, degree of cleavage, or nature of the rooting systems.

The SRG system has not yet been tested in paleopedology studies. Among the materials which are considered in paleopedolgy, sediment diagnostics are a key for describing Regolithic material in the *subsolum*. Such diagnostics typically consisting of recent (Quaternary) unconsolidated sediments like alluvium, colluvium, loess or till and can present a stratified structure resulting from progressive accumulation. It often consists of a mixture of fine to coarse material. The consistency of which is generally soft, or at least poorly cemented, and can easily be dug with a spade. Based on the morphogenetic and mechanical similarities of the material, Juilleret et al (2016) also include older unconsolidated, loose deposits such as tertiary marine sand and clay deposits.

Two examples are hereby presented for the use of SRG for classifying a whole regolith with paleosols.



In example 1: although the regolith is deeper than 2 meters (see trees for scale), the SRG can be assessed considering the top of the buried A horizon as a soil surface. The outcrop, located in Jūrkalnes coast in Latvia shows aeolian cover sands (Arenosol) on top of a buried podzol developed from marine terrace, showing glacio-tectonic convolution. The marine terrace consisting of sand deposit is made of Regolithic material diagnostic of the Regolite SRG. The sandy material is expressed by the Arenic qualifier. The fossil glacio-tectonic convolutes are expressed by the Turbic qualifier, and the lithology is expressed by Fluvic qualifier. Combining WRB (IUSS Working Group 2015) and Juilleret et al (2016), the Whole Regolith can be classified as Brunic Arenosol (Aeolic) over Albic Podzol, over Haplic Regolite (Arenic, Relictiturbic) [Fluvic].

Example 2 present a buried paleosol developed from marine terrace in Tanger, Morocco. The paleosol is below a natural pavement made of sandstone clasts, resulting from accumulation of material eroded from the cliff above. The whole Regolith can be classified as Regolite (Skeletic) [Colluvic] above Brunic Arenosol.

Further information regarding the above concept can be found in the following publications:

Juilleret, J., Dondeyne, S., Vancampenhout, K., Deckers, J., Hissler, C., 2016. Mind the gap: a classification system for integrating the subsolum into soil surveys. Geoderma, 264, 332–339.

Juilleret, J., Azevedo AC., Santos, RA., Santos, JCB., Pedron, FA.,Dondeyne, S., 2018“Where Are We with Whole Regolith Pedology?: a Comparative Study from Brazil.” South African Journal of Plant and Soil 35 (4): 251–261.

References:

Brevik EC, Miller BA. 2015. The use of soil surveys to aid in geologic mapping with an emphasis on the Eastern and Midwestern United States. Soil Horizons 56.

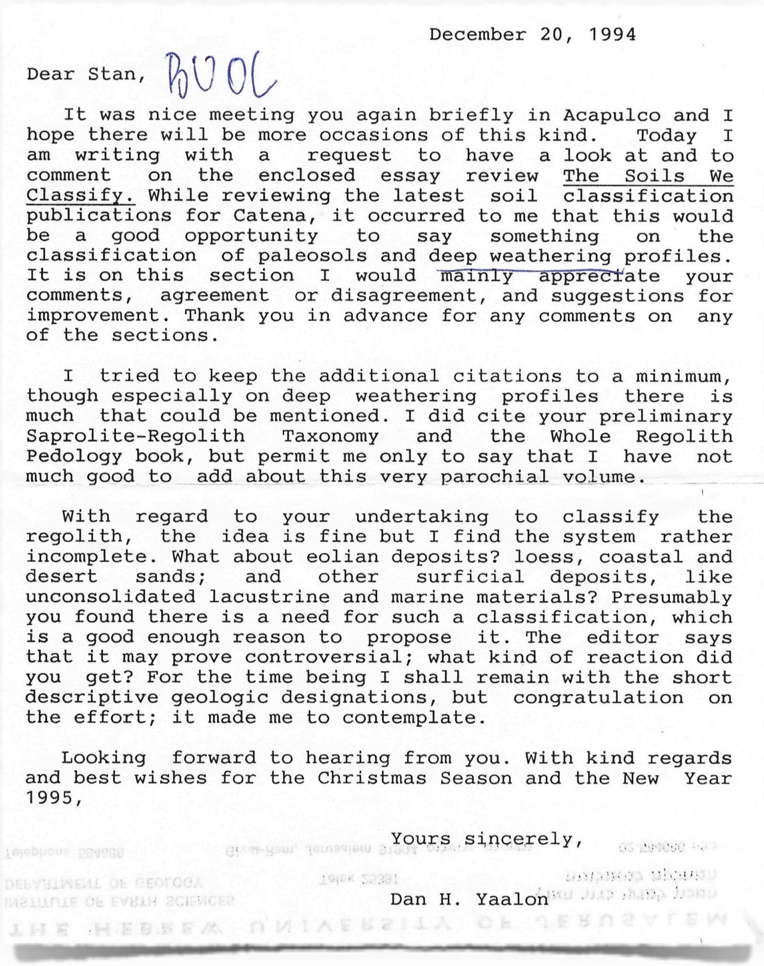
Buol, S.W., 1994. Saprolite-Regolith taxonomy: an approximation. In: Cremeens, D.L., Brown, R.B., Huddleston, J.H. (Eds.), Whole Regolith Pedology: Soil Science Society of America Special Publication Number 34, Madison, pp. 119–132.

FAO, 2006. Guidelines for Soil Description. fourth ed. FAO, Rome, p. 97.

IUSS Working Group WRB. 2015. World reference base for soil resources 2014. International soil classification system for naming soils and creating legends for soil maps: update 2015. World Soil Resources Reports 106. Rome: FAO.

Juilleret, J., Iffly, J.F., Hoffmann, L., Hissler, C., 2012. The potential of soil survey as a tool for surface geological mapping: a case study in a hydrological experimental catchment (Huewelerbach, Grand-Duchy of Luxembourg). Geol. Belg. 15 (1-2), 36–41.

Soil Science Division Staff. 2017. Soil survey manual. C. Ditzler, K. Scheffe, and H.C. Monger (eds.). USDA Handbook 18. Government Printing Office, Washington, D.C.



December 20, 1994

Dear Stan, BUOL

It was nice meeting you again briefly in Acapulco and I hope there will be more occasions of this kind. Today I am writing with a request to have a look at and to comment on the enclosed essay review The Soils We Classify. While reviewing the latest soil classification publications for Catena, it occurred to me that this would be a good opportunity to say something on the classification of paleosols and deep weathering profiles. It is on this section I would mainly appreciate your comments, agreement or disagreement, and suggestions for improvement. Thank you in advance for any comments on any of the sections.

I tried to keep the additional citations to a minimum, though especially on deep weathering profiles there is much that could be mentioned. I did cite your preliminary Saprolite-Regolith Taxonomy and the Whole Regolith Pedology book, but permit me only to say that I have not much good to add about this very parochial volume.

With regard to your undertaking to classify the regolith, the idea is fine but I find the system rather incomplete. What about eolian deposits? loess, coastal and desert sands; and other surficial deposits, like unconsolidated lacustrine and marine materials? Presumably you found there is a need for such a classification, which is a good enough reason to propose it. The editor says that it may prove controversial; what kind of reaction did you get? For the time being I shall remain with the short descriptive geologic designations, but congratulation on the effort; it made me to contemplate.

Looking forward to hearing from you. With kind regards and best wishes for the Christmas Season and the New Year 1995,

Yours sincerely,

Dan H. Yaalon

Copy of Dan H. Yaalon's original letter to Stanley W. Buol (1994).

Epilogue of part of a little-known PhD thesis on the calcretes of South Africa and Namibia

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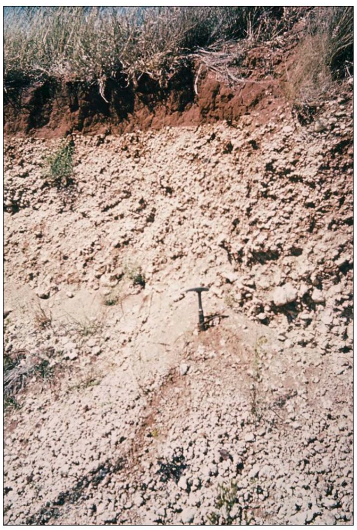
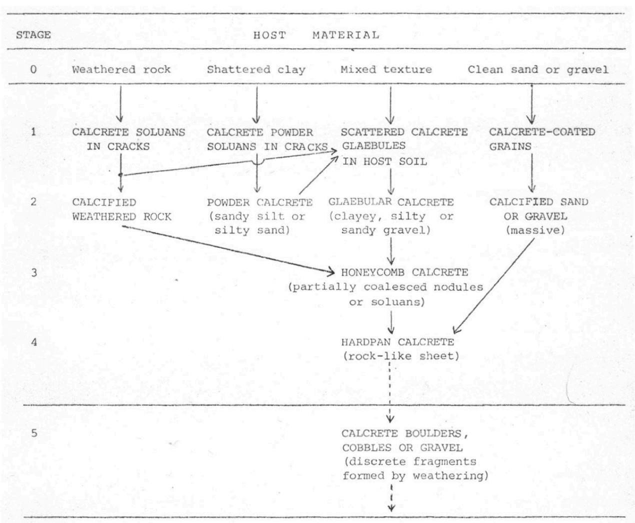
In this article, the term 'calcrete' is preferred as a general term for strongly calcareous, usually cemented soil carbonate horizons. The term 'soil' is used here in its wide engineering sense to mean a horizon which can be excavated without blasting.

Calcretes form in a definite genetic sequence which appears to be modified only by the texture of the host material in which the carbonate crystallizes. In most soils of mixed texture the sequence is one of glaebules (usually nodules) growing larger and more numerous to form a glaebular (nodular) calcrete gravel (Figure 1) which then coalesce to form a honeycomb calcrete. The remaining interstitial host material finally becomes strongly calcified to form a hardpan. This sequence (Figure 2) is modified by the texture of the host material, but hardpan development is the ultimate stage of all calcrete formations. On weathering, hardpan calcretes tend to form boulders. The sequence forms the basis for an easily applied field classification which has both genetic and engineering significance, each variety possessing a significantly different range of engineering properties.





Nodular calcrete gravel (left). Stages in the development and weathering of calcretes (right).

Maps showing the distribution of calcretes in Southern African were prepared from an interpretation of soil maps and the author's own observations, discussed in terms of the five soil-forming factors and shown that climate is (or was) the dominant factor. Well-developed nodular, honeycomb, hardpan and boulder calcretes generally only occur today in areas receiving less than about 550 mm of normal annual rainfall. Good correlations are also afforded by the isolines of Weinert's N=5 value and a Thornthwaite water deficiency of 20 cm. Only calcareous soils with less than 10 % $CaCO_3$ or scattered calcrete nodules are generally found in areas receiving between about 550 mm and about 800 mm/yr of rainfall, where Thornthwaite's water deficiency lies between 20 cm and zero or where Weinert's N-value lies between 5 and 2. Carbonates are generally absent in areas receiving more than about 800 mm/yr of rainfall, in areas enjoying an annual water surplus according to Thornthwaite, or where Weinert's N-value is less than 2. The distribution of calcretes is further affected by the other pedogenic factors, particularly drainage, parent material, and time.

Calcretes are composed chiefly of authigenic calcite and/or dolomite and allogenic quartz, with variable but lesser amounts of clay minerals, opaline silica, soluble salts, felspars, and other allogenic minerals. The typical indurated calcrete is chiefly made up of an authigenic, cryptocrystalline calcite and/or dolomite matrix in which float variable amounts of allogenic quartz grains and which is often veined by coarser calcite. Replacement of quartz and felspars by calcite is common and probably provides the main source of the opaline silica cement which silicifies some calcretes, resulting in Mohs hardnesses of up to 6. No carbonate other than calcite and dolomite and doubtful rare traces of aragonite was detected in the several hundred samples examined petrographically and by powder X-ray diffraction. Palygorskite, smectite and sepiolite were the most commonly encountered clay minerals. The <2 μm fractions of the non-indurated calcretes examined were largely composed of calcite, quartz, clay minerals, and dolomite. Glauconite was identified from calcretes and other soils from the Kalahari Beds in Namibia and may be forming at present in the Etosha Pan.

Chemical analyses compiled mainly from the literature provide a reasonably complete picture of the distribution of the major elements in nodular and hardpan calcretes but information on minor and trace elements and isotopes ratios is scarce. The average hardpan calcrete compares reasonably in major chemical composition with Clarke's average "limestone". Calcretes tend to increase in carbonate content relative to the allogenic component with increasing stage of development.

Most calcretes can be classified into two types according to their origin: pedogenic (formed by the leaching of carbonate from the upper soil horizons and its precipitation below) and non-pedogenic (formed chiefly by the precipitation of carbonate in the unsaturated zone above a shallow perched or permanent water table). Many calcretes are of complex origin, both pedogenic and non-pedogenic processes having acted upon them, and having undergone more than one phase of calcification. Old hardpan and boulder calcretes are often highly brecciated, the result of several phases of calcification, solution, recementation, and expansion during calcification.

The importance of CO_2 loss and transpiration in calcrete formation at all depths is emphasised. Pure evaporation is thought to be of lesser importance.

A new theory of calcrete formation in terms of the effect of variations in matric suction on carbonate solubility is advanced. The theory is supported by field evidence, chemical composition and the abundance of the isotopes ^{13}C and ^{18}O in calcretes.

Calcretes seldom contain any usable fossils and associated stone artefacts and radiometric methods afford the best means of dating. Contrary to the literature, the radiocarbon dating of the carbonate fraction appears most promising. Such dates on ten calcretes (the first from southern Africa) are very compatible with associated fauna and stone artefacts and the proposed sequence of calcrete development.

Rates of calcrete formation varying between about 0.03 and 0.8 mm per year have been calculated from the calcrete ^{14}C dates found in the literature and those mentioned above.

Most calcretes in southern Africa can apparently be classified into the following age groups: Pliocene, Middle/Upper Pleistocene (with Acheulian artefacts), Upper Pleistocene/Holocene (with Middle Stone Age artefacts), and Holocene (with Later Stone Age artefacts, rare cases).

Widespread phases of calcification appear to have occurred during the Pliocene, Middle and Upper Pliocene. Ideal conditions for calcrete formation are probably during waning wet phases rather than during dry phases as is commonly supposed. Most of the calcretes occurring in the general area of southern African receiving less than about 550 mm/yr of rainfall are fossil. Criteria for the recognition of actively forming calcretes are needed.

Methods of locating concealed calcrete deposits for road construction are evaluated, their engineering properties determined and specifications for road construction derived from a back-analysis of some old calcrete roads.

Netterberg, F. (1969). The geology and engineering properties of South African calcretes. CSIR Monograph, Pretoria, Ph.D. thesis, Univ. Witwatersrand, Johannesburg, 4 vols, 75 plates, 106 figs, 172 tables, 12 maps, 1070 pp.

Netterberg, F. (1971). Calcrete in road construction. CSIR Res. Rep. 286, NIRR Bull, 10, Pretoria, 73 pp.

Editorial note;

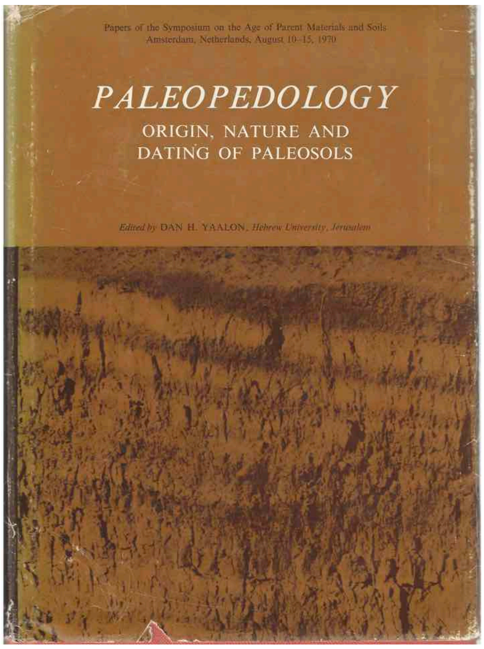
For me, the above contribution of Frank Netterberg bears more than “just” its scientific and historical importance. I’m a great fan of the yet-to-be-fully-understood terrestrial carbonates which are mostly known as ‘calcretes’. What are the pathways which control the genesis of calcrete? What is the environmental significance of calcrete? Why are there more than 50 (mostly local) alternative names to ‘calcrete’ worldwide? And why not even a single name matches the coastal sediment which was coined ‘calcrete’ in 1902 by George W. Lamplugh? Despite decades of study by quite a lot of pedologists and sedimentologists, not many have dedicated their PhD to the subject of calcretes. Amongst which, only a very few have dared taking the challenge of studying the geotechnical properties of this multi-morphological soil/rock. Actually, I’m familiar only with one - that is Frank Netterberg. It is my hope that someone, somewhen, will follow him. A continuance of Netterberg’s work might very well donate a great deal to the global study of calcretes, as well as to terrestrial carbonates as a whole.

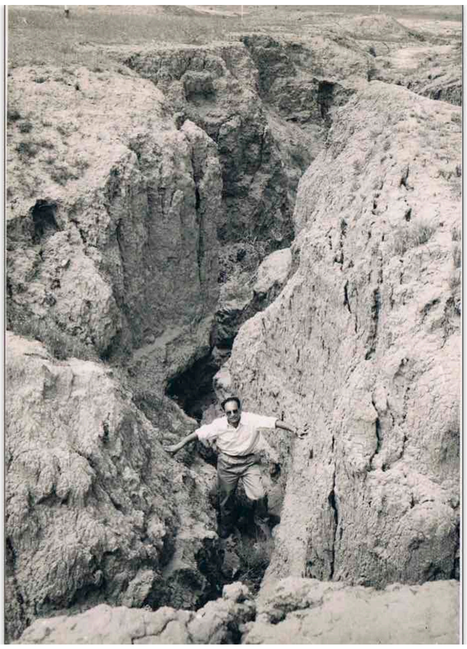
Danny Itkin

Reviving a Landmark Essay

Yaalon, D.H. 1971. Soil-forming processes in time and space, in: Yaalon, D.H. (Ed.), Paleopedology: Origin, Nature and Dating of Paleosols. International Society of Soil Science and Israel Universities Press, Jerusalem, pp. 29–39.

In August 1970, a Symposium on the Age of Parent Materials and Soils was held in Amsterdam, The Netherlands. The Symposium was organized by the International Society of Soil Science (ISSS) and the International Union for Quaternary Research (INQUA), Commission on Paleopedology. Following which, F. A. van Baren, then ISSS Secretary-General, asked Dan H. Yaalon to edit and publish the proceedings of that meeting. A year later came the result with the seminal book of Paleopedology: Origin, Nature and Dating of Paleosols (composed of 29 selected papers from that meeting). The first section of that book includes one of Yaalon's most influential essays: 'Soil-forming processes in time and space'. Unfortunately, this book is long out of print and hardly available. The following copy of Yaalon's paper is hereby provided (see below) for study purposes only (this copy includes some of Yaalon's handwritten notes). Its text and subtext are still as relevant as ever.
(DI)





Paleopedology book cover (left). Dan H. Yaalon in his early career during a field survey in the Negev Desert, Israel (right; photograph courtesy of Uri Yaalon).

SOIL-FORMING PROCESSES IN TIME AND SPACE

D. H. Yaalon

Department of Geology, The Hebrew University, Jerusalem

ABSTRACT

The recognition and persistence of antecedent pedogenic features is related to the nature of the soil-forming processes.

Many features of soil genesis may be interpreted in terms of the steady-state concept of dynamic equilibrium, with balanced inputs and outputs of material and energy. Properties or attributes which relatively rapidly ($< 10^3$ years) approach the steady state are not suitable as indicators of paleopedogenic conditions, except when rapidly fossilized by deep burial. Rapidly adjusting properties usually cannot be identified in relict or exhumed surfaces.

A metastable, near-equilibrium state often exists in the pedon because the terminal steady state was not yet attained due to the slow rate of change, and partly due to the constant (cyclic or intermittent) variations in the driving force of pedogenesis, which lead to the invariable presence of a small lag. Many of the attributes used in paleopedogenic interpretations belong to this group of slowly adjusting features.

Irreversible or self-terminating processes, where the balance of influx and efflux is not maintained, include many weathering processes and mineral transformations which involve loss of material. The stage reached in the transformation or evolutionary sequence is often used for the interpretation of the intensity of the past environment. In another type of self-terminating processes gains exceed losses. Such processes are a common feature of desert and semi-arid soil surfaces, which act as sinks or accumulators of the redistributed material. Calcareous, gypseous or siliceous incrustations, which are usually well preserved both as buried and relict surfaces, rank among the best indicators of paleopedogenic conditions.

INTRODUCTION

A soil-forming process can best be described as a combination of a multitude of individual reactions, taking place in a soil or parent material, acting together or consecutively, and producing a given soil or soil feature. It is a continuous and, usually, slow process. A paleosol is by definition a soil formed in a landscape of the past, i.e., the former soil-forming reaction was either altered as a result of a change in the external environmental conditions or was interrupted by burial. The buried soil only rarely becomes fossilized without undergoing subsequent alteration.

Certain of the soil's acquired properties change rather rapidly in the new environment. Other features persist for an appreciable length of time or can be reconstructed even after some alteration has taken place. On surfaces containing relict soil material, only properties resisting change will bear witness to the former conditions. Awareness of differences in the persistence of the various soil properties and diagnostic features is thus of considerable importance in the interpretation of paleopedogenic conditions.

It is the object of this paper to discuss the relative persistence of the various soil attributes used in identifying and classifying soils, in relation to the soil-forming processes which have produced them. On the basis of the concepts of equilibrium and dynamics, I shall distinguish three groups of processes and derived properties:

1) The reversible, self-regulating processes, which relatively rapidly attain a state of dynamic equilibrium and are therefore also subject to rapid alteration when the environmental conditions change. The products of such processes, e.g., organic material (OM), are thus less useful as criteria for recognising paleopedogenesis as the time interval is extended. They may be the best and in fact the sole evidence in cases where the time lapse is small, e.g., minor accumulation of OM in sequences of ash deposits.

2) The processes and properties in a state of near-equilibrium, or metastability, in which the system, as a result of the slow rate of change, is assumed to be in a steady state or dynamic equilibrium. Because of their relative resistance to change, the soil attributes derived during such processes, e.g. textural B-horizons, are quite commonly used for diagnosing paleopedogenic conditions.

3) The irreversible, self-terminating reactions and derived properties, e.g., various soil crusts, which are usually the best indicators of past processes and conditions. Two types of self-terminating processes can be distinguished, as will be seen below (p. 36).

With regard to the first two groups of processes, the soil is treated as an open system, more or less rapidly adjusting to the change brought about by the external driving force. In the third group, the process itself, even under constant conditions, gradually shapes its own environment.

MODELS OF SOIL DYNAMICS

Many features of soil genesis may be interpreted in terms of the steady-state concept of dynamic equilibrium (Fig. 1). In such a system a state of balance is reached

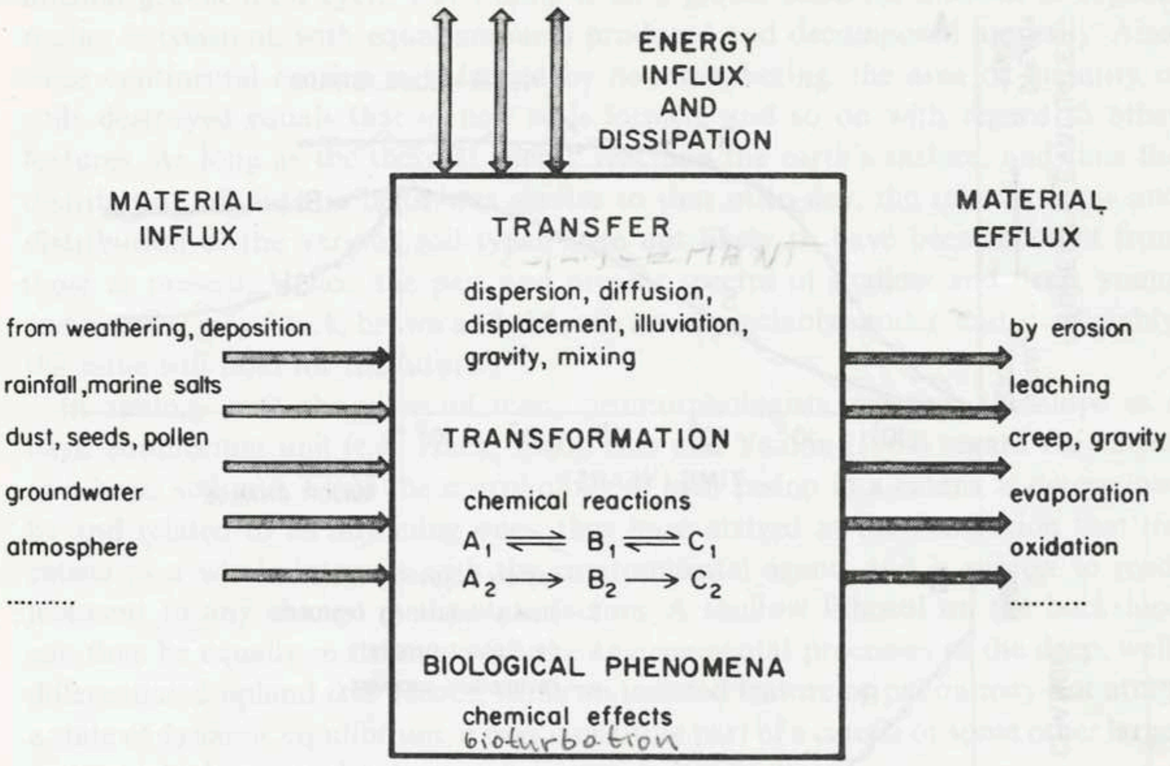


FIG. 1. Schematic diagram of the dynamics of the soil system. When influx equals efflux, the sytem is said to have reached the steady state. Note that transformation includes both reversible and irreversible reactions

and maintained, with balanced inputs and outputs of material and energy. The reactions are by definition reversible and self-regulating. When subject to a change in one of the determinant factors, the system re-establishes a new steady state.

The concept of dynamic equilibrium is embodied in Jenny's (1961) derivation of state factors, which envisages that the soil properties are fully defined by them. Many investigators have also attempted to show that mineralogy, the clay mineral assemblage in particular, is determined by the thermodynamic parameters of phase equilibrium. As ~~steady-state~~ dynamic equilibrium can theoretically be reached from different or opposite directions, this property does not furnish any information on the history of the system, or on the time required to reach the equilibrium condition. However, many soil processes seem to proceed in a definite direction or along a specific genetic pathway, as evidenced by the numerous sequential development or evolution models in the literature. Such testimony was used as the major argument in opposing the concept of dynamic equilibrium (Rode, 1961).

Many properties appear to be at equilibrium mainly because their rate of change is so slow (Fig. 2). While certain rapidly adjusting features of the pedon are reversible and self-regulating, e.g., the mollic horizon, the pedon itself is usually a non-equi-

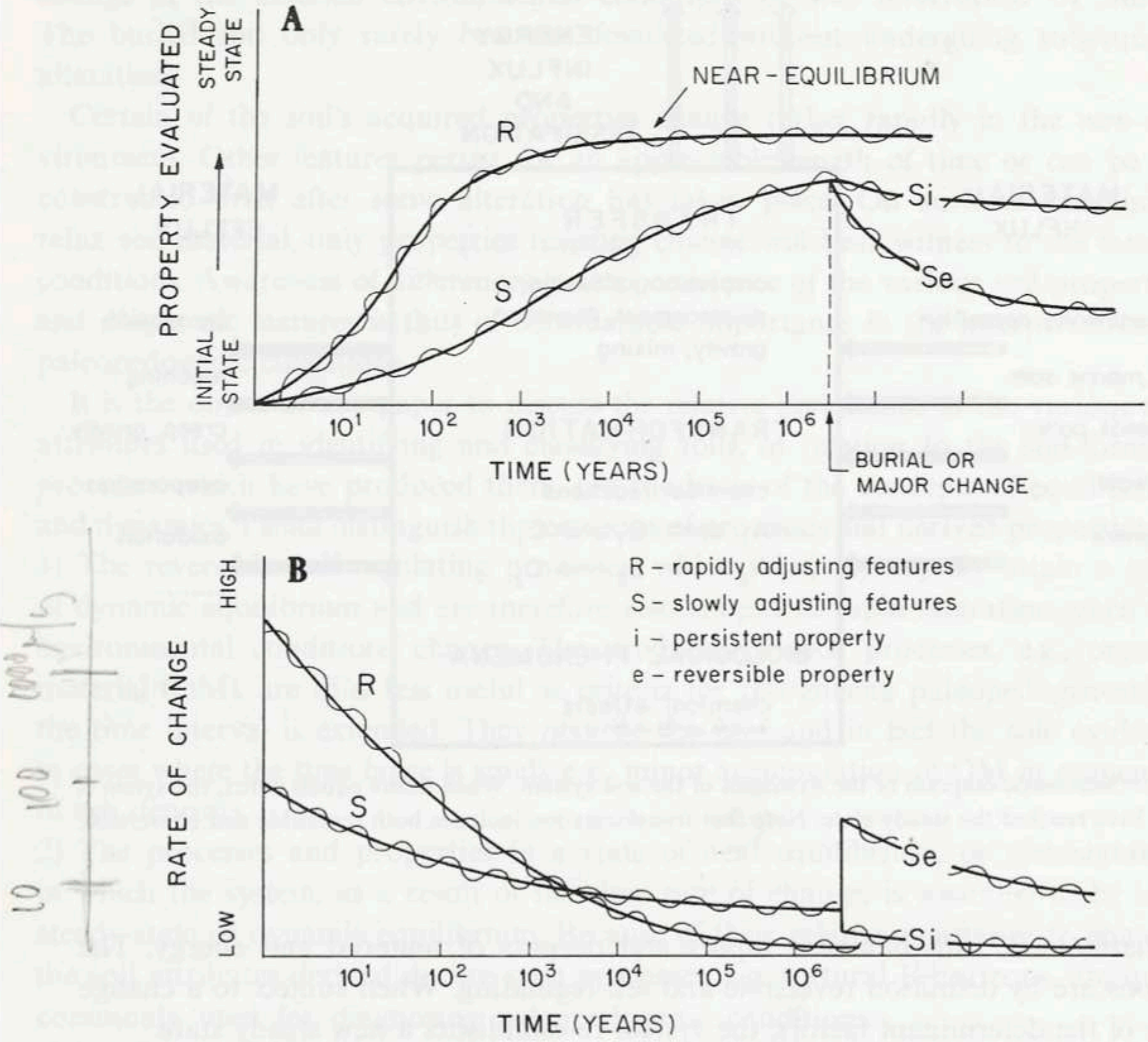


FIG. 2. Schematic diagram showing soil properties approaching the steady state at a rapid or slower rate of change, and indicating possible changes due to subsequent burial or some other major environmental action. Wavy lines indicate effects due to seasonal or other minor fluctuations in the environment. Note that for the relatively slowly adjusting features (S), the rate of change may become low but constant, and can exceed the rate of change of rapidly adjusting properties (R) when these have reached the state of near-equilibrium. If subjected to major change by burial or some other drastic change in the environment, the acquired features will readjust fairly rapidly (S_e) or remain relatively persistent or irreversible (S_i) depending on the nature of the property or feature evaluated

librial system; the inputs are not balanced by outputs and the processes inevitably include irreversible reactions.

The size or dimensions of the system are significant when determining whether the steady-state concept is applicable. A forceful advocate of the concept of dynamic equilibrium is Nikiforoff (1959), who views the soil as part of the global or continental geochemical cycle. For example, on a global scale the amount of organic matter is constant, with equal amounts produced and decomposed annually. Also, since continental erosion is balanced by new weathering, the area or quantity of soils destroyed equals that of new soils formed, and so on with regard to other features. As long as the thermal energy reaching the earth's surface, and thus the distribution of climatic belts, was similar to that of to-day, the relative areas and distribution of the various soil types were not likely to have been different from those at present. Hence, the past and present spectra of shallow and deep, young and mature, grey, black, brown and red soils are appreciably similar, and, predictably, the same will hold for the future.

In analogy with the views of many geomorphologists, who see the slope as a basic equilibrium unit (e.g., Hack, 1960), Dan and Yaalon (1964) regard the catena as a basic soil unit. Since the morphology of each pedon in a catena is determined by and related to its adjoining ones, they have arrived at the conclusion that the catena as a whole interacts with the environmental agents and is subject to readjustment to any change in the state factors. A shallow lithosol on the backslope can thus be equally in balance with the environmental processes as the deep, well-differentiated upland soil. Hence, while an isolated feature or pedon may not attain a state of dynamic equilibrium, it may constitute part of a catena or some other larger system which more closely approximates a steady state.

RELATIVELY RAPIDLY ADJUSTING FEATURES

In this group we include properties which rapidly ($< 10^2$ to 10^3 years) approach dynamic equilibrium with their environment, e.g., the organic matter and nitrogen content, acidity, or certain types of structure. Essentially, all attributes of the soil which show a strong correlation and covariance with the external determinants belong to this category. They comply most closely with the theoretical requirement of *self-regulation* and reversibility.

Features which rapidly adjust to changes in the environmental factors cannot serve as good indicators of paleopedological conditions (Table 1). They certainly cannot be recognized on relict or exhumed surfaces. In buried paleosols they may leave some traces. In New Zealand, and other regions with volcanic ash, buried soils are often recognized on the basis of the darker, humus-coloured bands, which, however, contain only a fraction of the original organic matter.

Not enough is known about the preservation of such transient properties and their subsequent transformation in the subsurface. In Ireland 75% of the organic carbon and nitrogen in a buried soil was depleted over a period of ~ 4,000 years and probably much earlier (Gardiner and Walsh, 1966). It appears that this rapid

TABLE 1.

Soil diagnostic features and horizons grouped according to their mode of origin and relative persistence in paleosols

Altered easily, generally ≤ 10^3 years to reach steady state	Relatively persistent slowly adjusting, generally > 10^3 years to reach steady state	Persistent features **
Properties acquired by reversible, largely self-regulating processes	Mostly steady-state near-equilibrium features or metastable state	Features produced by essentially irreversible, self-terminating processes
Mollic horizon (f)*	Cambic horizon (f)	Oxic horizon (f)
Slickensides (c)	Umbric horizon (f)	Placic horizon (f)
Salic horizon (c)	Spodic horizon (f)	Plinthite (f)
Gypsic horizon (o)	Fragipan (f)	Durinodes (f)
Mottles (c)	Mottles (o)	Petrocalcic horizon (f)
Gilgai features (c)	Argillic horizon (c)	Gypsic crust (f)
Cambic horizon (o)	Natric horizon (o)	Argillic horizon (c)
Spodic horizon (o)	Calcic horizon (f)	Natric horizon (c)
	Gypsic horizon (c)	Albic horizon (o)
	Histic horizon (c)	Fragipan (o)
		Histic horizon (o)
>800μ/y	40-800μ/y	≤40μ/y

* Definitions of horizons and features according to the American classification system. Letters in parenthesis are an attempt to evaluate semi-quantitatively the frequency or persistence of the feature within the group: f—frequently; c—commonly; o—occasionally; r—rarely. Some features are listed in two groups. Most features could be listed in all remaining columns with the connotation (r).

** Subdivision into features with influx exceeding efflux and those with efflux exceeding influx can be made, but was not deemed necessary in the present context, for the evaluation of persistence in paleosols.

transformation is the main reason why so few mollic horizons have been recognized in paleosols. The absence of an A-horizon is quite likely to be as much due to the post-burial destruction of the organic matter as to oft-postulated erosion. Similarly, the acidity or salinity of a buried or relict soil can change without leaving traces of its former conditions.

SLOWLY ADJUSTING FEATURES

Many soil reactions approach the steady state at a very slow rate. While the initial rate of change may be rapid, it gradually becomes asymptotical, and the factor of time thus becomes essentially ineffective. Though no apparent changes are taking place in the system, the terminal steady state has, in most cases, not yet been reached. We shall call this the *near-* or *quasi-equilibrial state*.

Because of the recurrent, cyclic or intermittent variations in the driving forces of pedogenesis (radiation, precipitation, gravity, biologic pressure), a small lag must, theoretically, always exist (Yaalon, 1960). In addition, a system often responds to changes of an external variable only after a threshold value or gradient has been reached. Until then the system will be in a *metastable state*, fairly far removed from the equilibrial state. This resistance to change may be related to what has been termed pedogenic inertia (Bryan and Teakle, 1949), i.e., processes once established, continue despite changes in the environment.

As the most simple example of a lag we can cite the soil temperature wave, both diurnal and annual, which invariably lags behind the atmospheric temperature wave. Thus, the soil is always either being heated or cooled and there is a constant temperature flux. In a similar way other reversible or equilibrial reactions, whether pedoturbation in a vertisol, redox processes in a pseudogley, the formation and destruction of clay coatings in an argillic horizon, or the balance between weathering and erosion on a catenary slope, will be subject to continuous fluxes without attaining the terminal steady state. This is the outcome of the recurrent amplitudinal variations in the driving force.

A large number of diagnostic features and soil properties fall in this category (Table 1) and we shall include in this group all properties which generally approach the steady state rather slowly ($> 10^3$ to 10^4 years).

The slow rate of change of many soil features has furnished the basis for establishing sequences of processes and developments, on which the position of each soil has been ascertained from functional and comparative studies. Though no way has, as yet, been found to establish the properties of the terminal equilibrial state or the possible number of such states, the basic tenets of pedogenesis have in fact evolved from such sequential studies.

The Grey-Brown Podzolic and Red-Yellow Podzolic soils of the eastern United States have both been considered to be near-equilibrium systems, but the possibility that age differences may be the main cause of the difference in their properties has been claimed repeatedly (Cline, 1961; Novak et al., 1970). Since many paleopedogenic interpretations are based on the recognition of such near-equilibrium features in paleosols, their interpretation must obviously be approached with great reservation.

There is an urgent need for studies on the rate of alteration and preservation of pedological features in paleosols. The preservation of many of the diagnostic features listed in Table 1 is no doubt only partial. Diagnosis of antecedent pedogenesis is therefore always subject to uncertainties. Cambic, spodic or umbric horizons have only rarely been reported in paleosols and are possibly only partially preserved.

Fossil argillic, calcic and fragipan horizons have been reported most frequently and thus seem to be less prone to alteration. In Israel pseudogley features appear to be surprisingly well preserved in both relict and buried paleosols, while it is often thought that such mottles are an unstable property. The energy of the active processes (Volobuev, 1964) in the new environment is obviously also of great significance in determining the persistence of the fossil properties.

SELF-TERMINATING PROCESSES

The third group of soil attributes is of a somewhat different character. Internal changes in an open soil system include also *irreversible* reactions. Among these are the transformation of primary minerals and other weathering processes which involve the loss of material. Such processes proceed with time in a definite direction, and they are therefore, in theory, fully characterized by the initial material, process and stage, as for example a weathering sequence.

Of particular interest in this group are the processes in which the response products gradually result in altering the internal environment, e.g., when the leaching and illuviation of clay makes the illuviated horizon less permeable, thus reducing the rate of leaching, which in turn may lead to waterlogging and reducing conditions.

On freely drained sites, the genetic pathway of soils is most commonly visualized as proceeding in the direction of mineral decomposition and the accumulation of residual products comprising the least soluble and least mobile elements. The oxic horizon and plinthite and other "aged" soils represent this state. All less-weathered soils are often pictured as gradually progressing towards it. The good preservation of such terminal soil products on a large scale in Australia and Africa provides excellent support for the extent of this process with time.

In actual fact, in addition to the pronouncedly leaching environment, where the inbalance of influx-efflux is characterized by losses ($I < E$), the desert environment is yet another, and equally extensive, environment where the self-terminating processes are active and observable, but characterized by gains exceeding losses ($I > E$).

The arid and semi-arid soil environment, like any closed basin, acts as a sink for all material released by weathering and introduced from the outside. In such soils or horizons the balance is tipped in favour of influx. The gradual development of desert incrustations, whether gypseous, calcic or siliceous, is an excellent example of such self-terminating processes. The resulting soil features—calcrete, silcrete, etc.—persist for a long time even under changed environmental conditions. Like the plinthite of tropical weathering zones, the calcic, gypsic or petrocalcic horizons are therefore excellent markers and criteria of paleopedological conditions of arid zones.

On a geologic time scale even the closed basin is only a temporary sink, and eventually the accumulation products of the desert region, including the salts, lime and gypsum, will be returned to the overall geochemical cycle of elements. As in the case of plinthite and the other stable attributes of the leaching zone, the return will be due mainly to physical destruction or tectonic events, rather than to active soil processes.

SUMMARY AND CONCLUSIONS

The soil model commonly used at present is a system in which processes of addition, removal, transfer and transformation are active (Simonson, 1959). According to this model, the relative intensity and accentuation of certain of these processes are responsible for the variability of soils from place to place. While explaining admirably the multitude of different soils, the model does not attempt to indicate how the system will develop with time.

It is suggested here that soil-forming processes can be viewed as belonging to one of two large groups, each with two subgroups: 1) those approaching a state of dynamic equilibrium at a) a fast or b) a slower initial rate; and 2) the irreversible or self-terminating processes, where the balance of input and output is not maintained, with c) gains greater than losses ($I > E$) or d) gains less than losses ($I < E$). The two major groups are not mutually exclusive, since the size of the system will often determine whether a certain attribute resulted from one or the other group of processes.

It is suggested that the persistence of various soil features and horizons in paleosols is related to their mode of origin (Table 1).

The irreversible, self-terminating features are resistant and therefore the best indicators of paleopedogenic conditions. Various accumulation crusts of desert and closed-basin origin belong to this group, as do the plinthite, durinodes and oxic horizons exemplifying the weathering residuals in leaching environments.

The processes belonging to the equilibrium group of features have been subdivided into those rapidly reaching equilibrium ($< 10^3$ years) and those attaining steady-state conditions relatively slowly ($> 10^3$ years). The latter include many slowly adjusting properties which are also relatively persistent in paleosols and are thus good diagnostic features of paleopedogenesis. The former include features which are generally poorly preserved under changed conditions, e.g., the mollic horizon, and thus constitute poor criteria for the characterization of paleosols.

As our knowledge of the rate and nature of the various soil-forming processes improves, changes and additions will no doubt be introduced in the suggested grouping.

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DISCUSSION

RUELLAN said that after having worked 10 years in Morocco he came to the same conclusions as YAALON, which he wished to support strongly. In particular, he is in agreement with the conclusion and examples shown regarding carbonate accumulation in the B_{ca} and petrocalcic horizons. In Morocco they are frequently very old but never quite fossil or dead, and no climatic change needs to be invoked. The red B_t and B_{ca} horizons are, however, always a product of a paleoclimate a little more humid (perhaps 100 to 200 mm more) than that of today. RUHE added that the red B_t horizons in New Mexico were engulfed by younger carbonates (dated by ^{14}C) and thus also indicate climatic change.

YAALON said that it was inevitable that over a long period of time the desert surfaces would be subjected to intervals with a higher precipitation. However, he wished to make the point that the red colouring, though not necessarily a red textural B_t horizon, could equally be a product of desert weathering. Each individual case has to be judged and interpreted on the basis of the soils studied, and often no antecedent pedogenesis and climatic change needs to be evoked as, e.g., in the examples cited from Israel or Morocco.

RAAD and also MITCHELL voiced apprehension about the use of the term equilibrium for soils. BAKKER pointed out that in the Netherlands there is evidence that under the present climatic conditions the soils first undergo ripening, then decalcification and also translocation of clay. He thinks that most of the young soils are not in equilibrium with their environment. YAALON suggested that these are good examples of a sequence of processes in an open system approaching the steady state, first rapidly, then more slowly. Ripening is probably difficult to identify in paleosols.

MULCAHY commented that even the formation of such "irreversible" features as iron-stone or plinthite is not quite the end of the story on old landscapes. Plinthite can weather further to iron-oxide-coated quartz grains in a penultimate stage, and to white washed quartz grains in the ultimate, both of which are common in the stable shield areas of Western Australia. YAALON thought that these two stages were essentially due to tectonic disturbances and/or physical change and thus would be part of a new pedogenic cycle with plinthite acting as parent material.

Paleosol's patience