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Conference presentation / Izlaganje na skupu

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Download date / Datum preuzimanja: **2024-11-25**



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# Glauconite formation in a palaeosol as an indicator of the incipient sea-level rise: case study of the Zlatni rt, Istria, Croatia

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This work has been fully supported by Croatian Science Foundation under the project IP-2019-04-8054 – WianLab (Western Istrian Anticline as an Ideal Natural Laboratory for the Study of the Regional Unconformities in Carbonate Rocks).



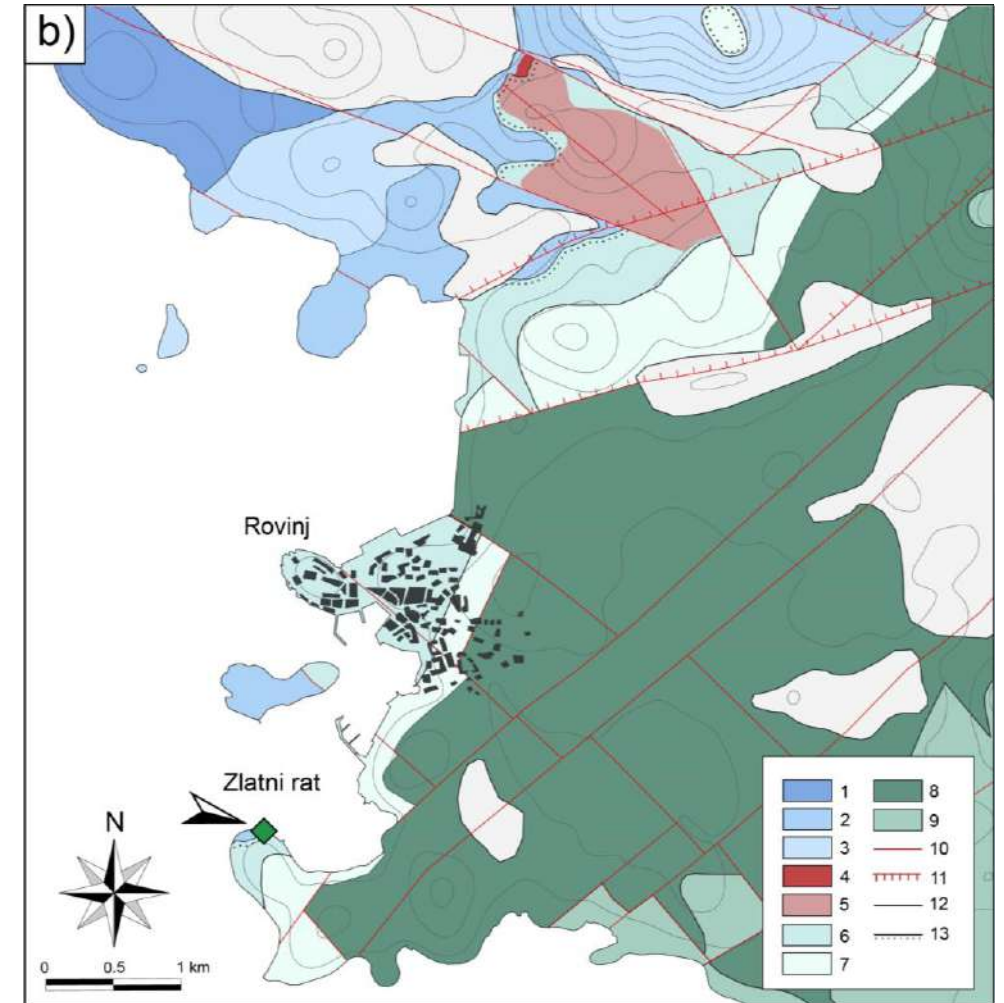


# Introduction

- Glauconite forms through potassium uptake by neoformed iron-rich smectite in semi-confined micromilleus of faecal pellets and carbonate bioclasts
- Usually forms below 15°C on the shelf, between 150 and 300 m
- It can also form in other environments: slope, abyssal plain, lagoons as well as in lacustrine and even in pedogenic environments
- One such example is the Upper Jurassic Paleosol from the Zlatni rt locality

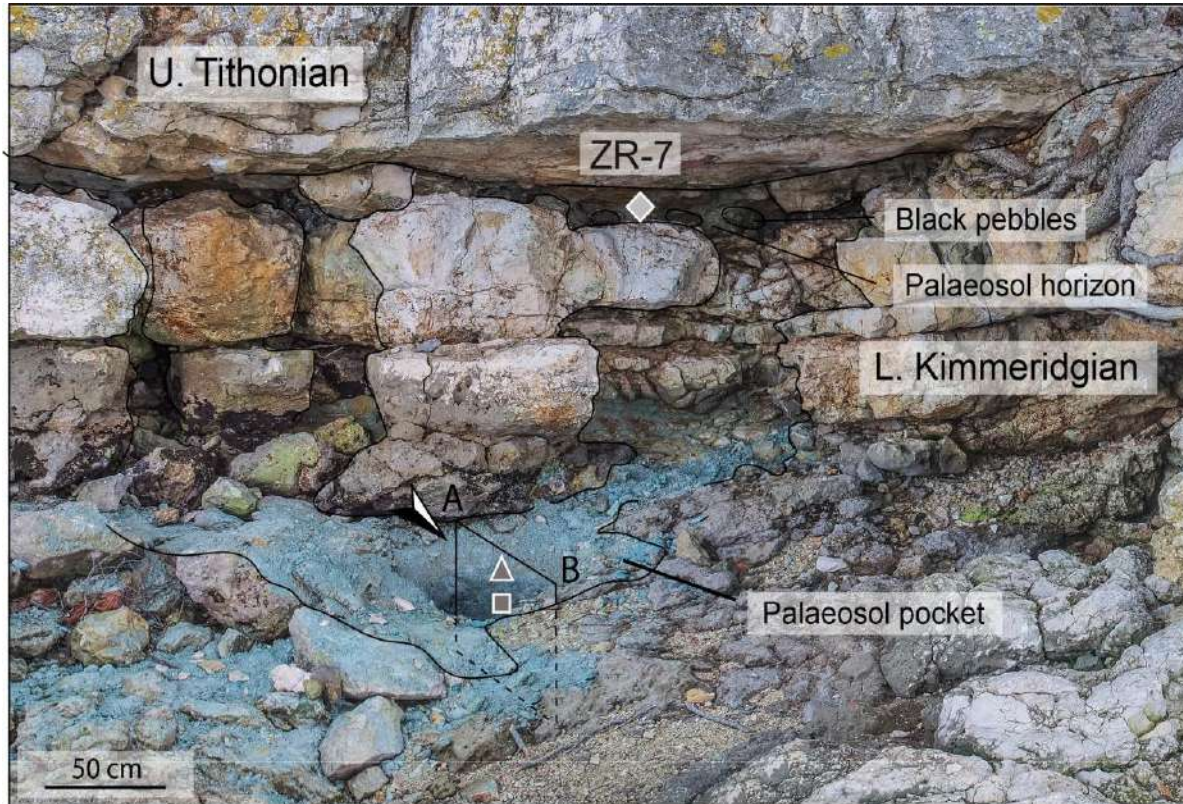
# Geological setting

- Zlatni rt palaeosol formed during an emersion phase in the Northern (Istrian) part of the Adriatic carbonate platform, which lasted between the early Kimmeridgian and late Tithonian
- It separates the first, and the second mega-sequence in the succession of the Western Istrian anticline
- Bedrock: Oxfordian to early Kimmeridgian Muča unit
- Cover: upper Tithonian Kirmenjak unit

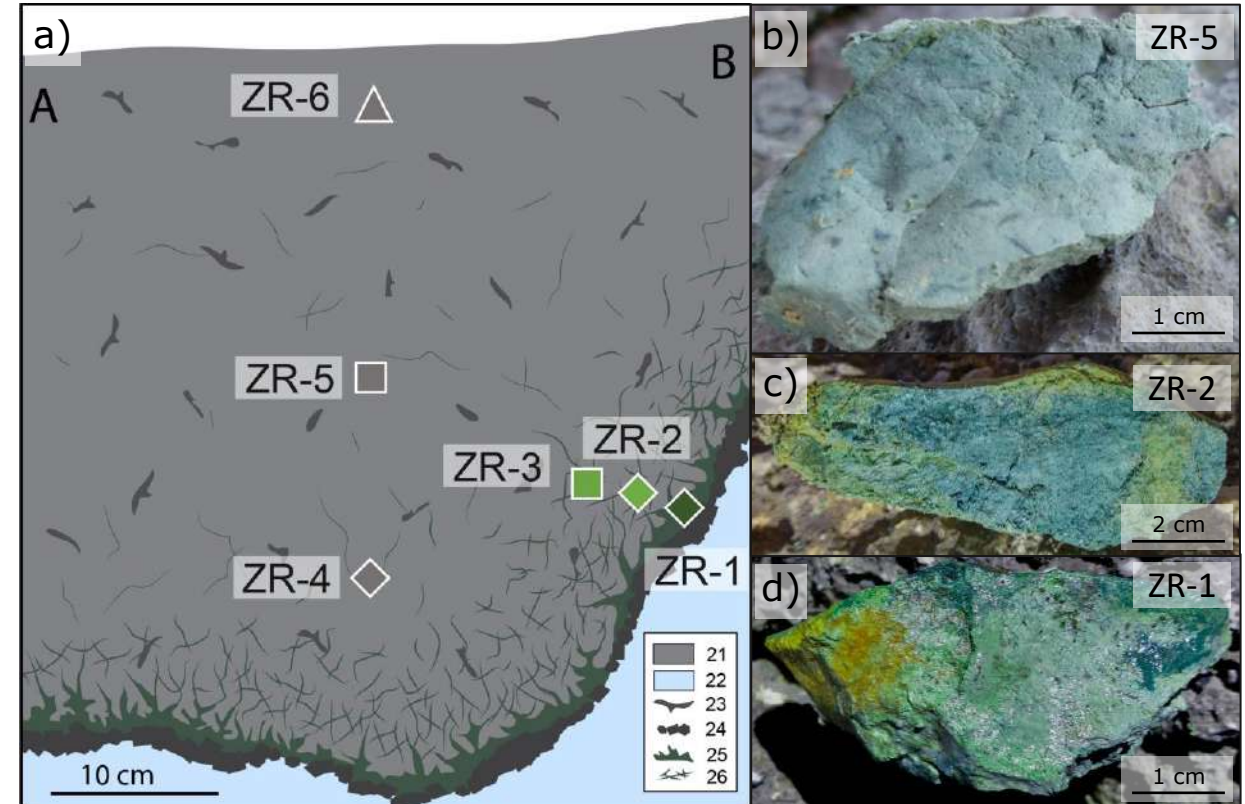


**Figure 2.** 1 – Monsena unit, 2 – Muča unit, 3 – Lim unit, 4 – Bauxite (uncovered), 5 – Bauxite (covered), 6 – Kirmenjak unit, 7 – Zlatni rt unit, 8 – Rovinj unit, 9 – Materada unit, 10 – Normal faults, 11 – Reverse faults, 12 – Normal geological boundary, 13 – Transgressive boundary

# Studied outcrop



**Figure 3.** Zlatni rt outcrop with marked units



**Figure 4.** photographs and schematic representation of the studied outcrop and samples. a – schematic representation of the studied profile in the ZR palaeosol, b – sample from the unglauconitised palaeosol, c – sample from the transitional zone, d – sample from the glauconite rich zone.



# Methods

- Petrography and micropedology (Stoops, 2021)
- XRPD
  - Bulk samples – Rietveld refinement in Profex software (Doebelin and Kleeberg 2015), polytype determination (Moore and Reynolds, 1997)
  - < 2  $\mu\text{m}$  fraction
- FTIR
- SEM-EDS
- XRF and ICP-MS

# Petrography and micropedology

- The palaeosol samples are mainly composed of cryptocrystalline clays and iron sulphides
- Presence of reworked clay coatings and cross striated b-fabric: vertisol
- Two types of glauconites: dark green (reduced) and light green (oxidised)
- Redox fluctuations during glauconite formation
- Present mainly in veins surrounded with a dissolutional halo

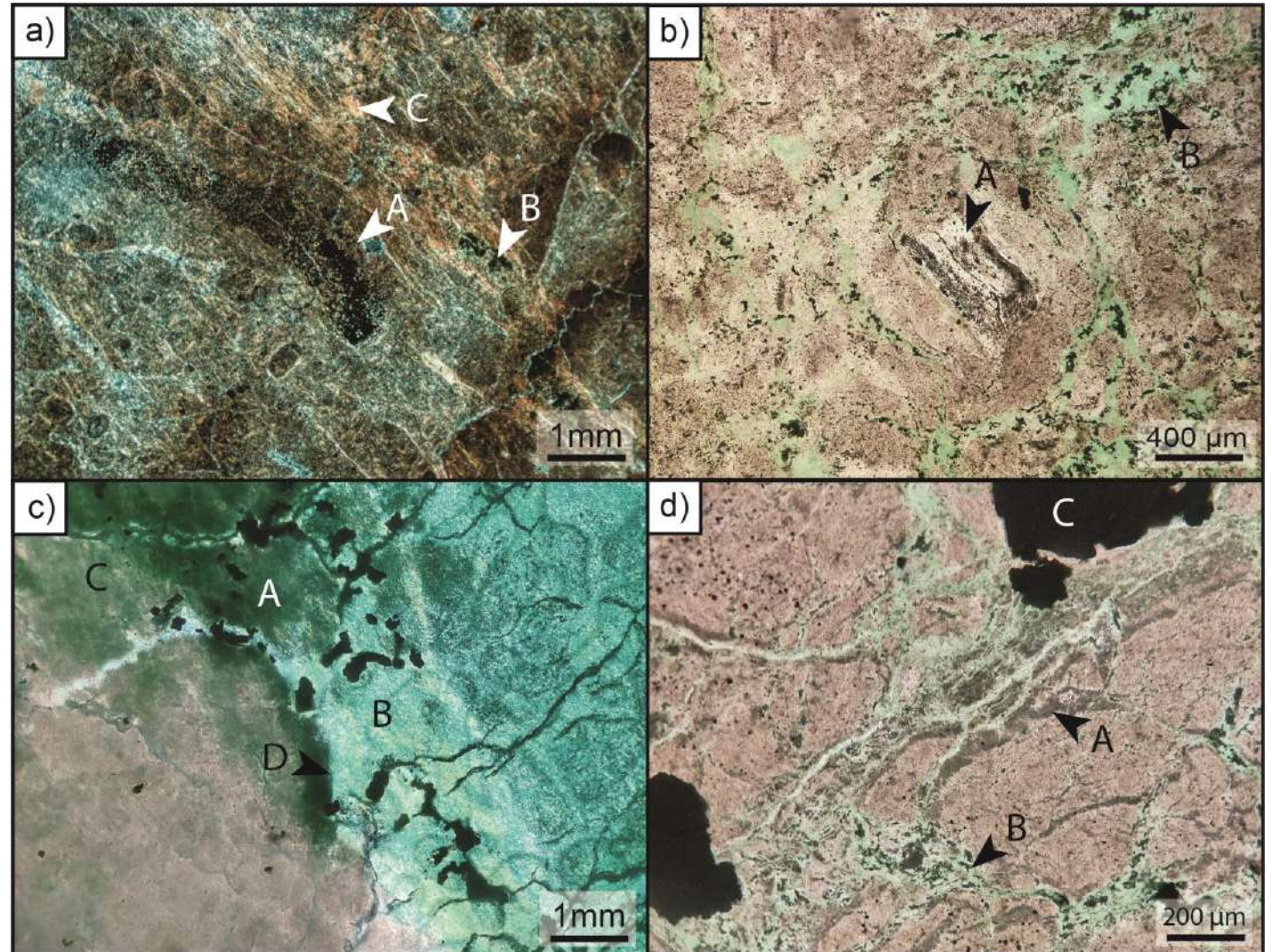


Figure 7. photomicrographs of the studied samples

# Mineralogy

- **Glaucanite rich zone (ZR-1)** – primarily glauconite and illite rich ( $2M_1$  and  $1M_d$ )
- **Transitional zone (ZR-2 and ZR-3)** – less glauconite than the Glaucanite rich zone
- **Palaeosol pocket (ZR-4, ZR-5 and ZR-6)** – mixed layered illite smectite, illite ( $2M_1$  and  $1M_d$ ) and kaolinite (poorly and well crystallized)
- **Poorly crystalline kaolinite** – input of feralitic material

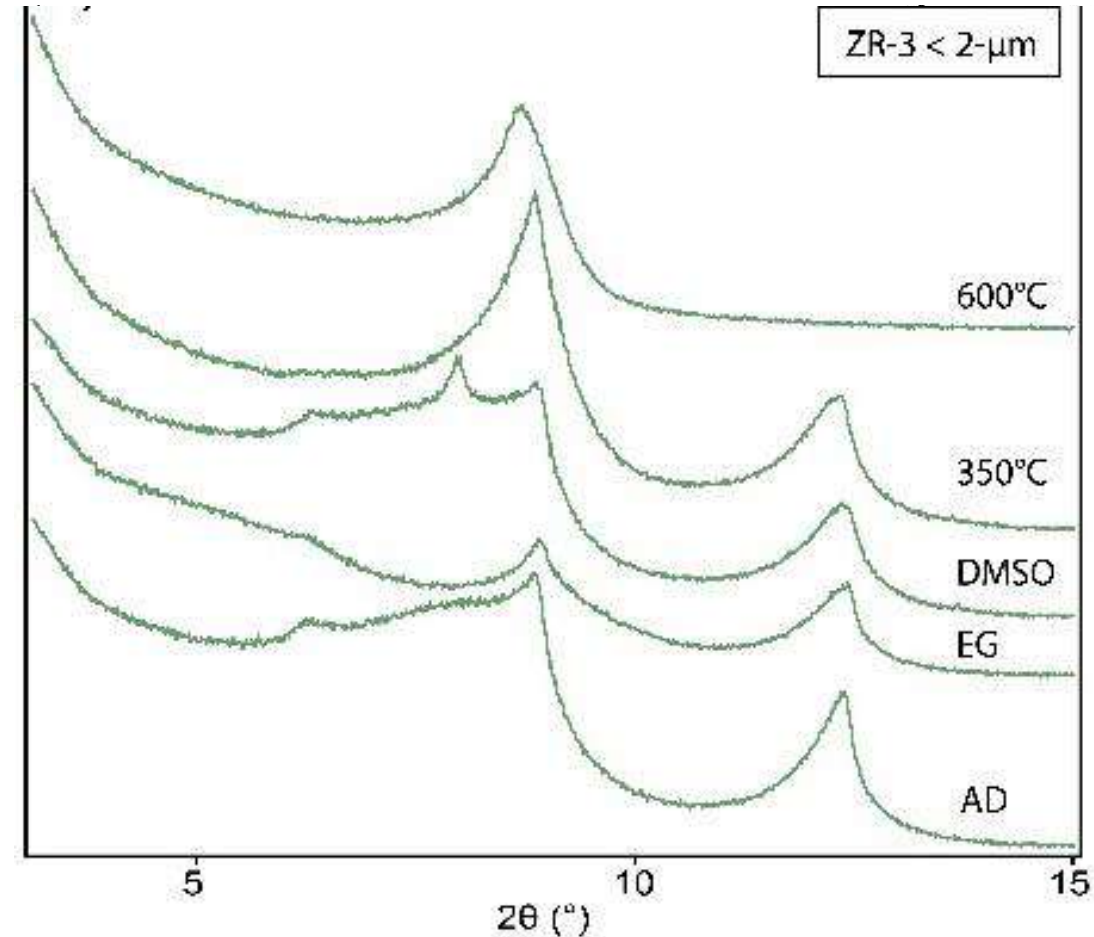


Figure 11. XRD patterns of clay fraction from the transitional zone after diagnostic treatments



# Micromorphology and geochemistry of glauconite

- Glauconite is mainly present in caterpillar morphologies and as a replacement of other clay minerals
- Glauconitization and illitization trends are visible in EDS data
- Source of iron – feralitic material

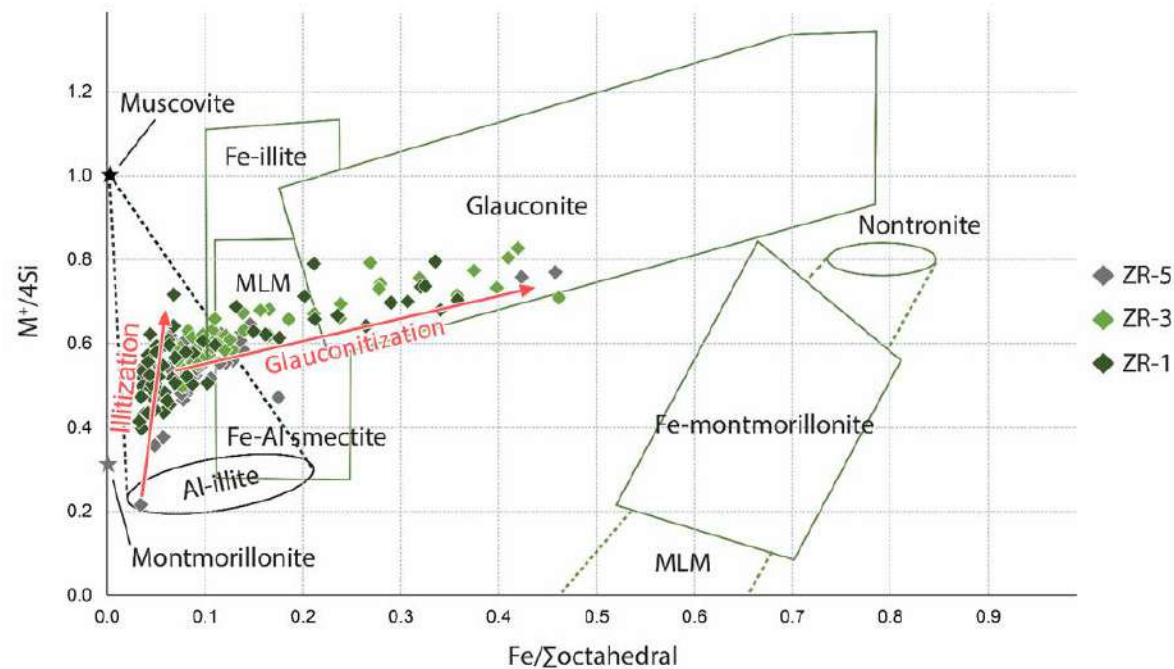


Figure 14.  $M^+/4Si$  vs.  $Fe/\Sigma_{oct}$  plot on which the EDS points measured in ZR-1, ZR-3 and ZR-5 samples have been plotted. Green fields represent data from Meunier and El Albani 2007, while the black fields and stars represent data from Baldermann et al 2014; MLM – mixed layered mineral.

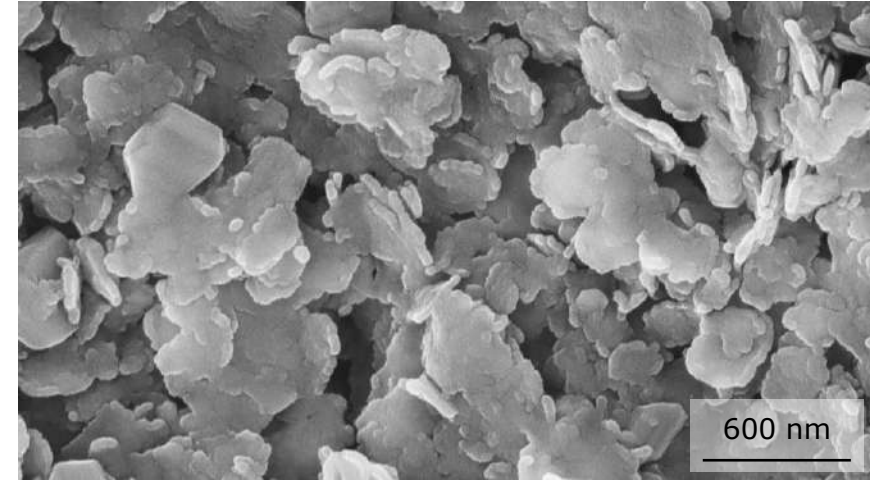


Figure 12. caterpillar glauconite

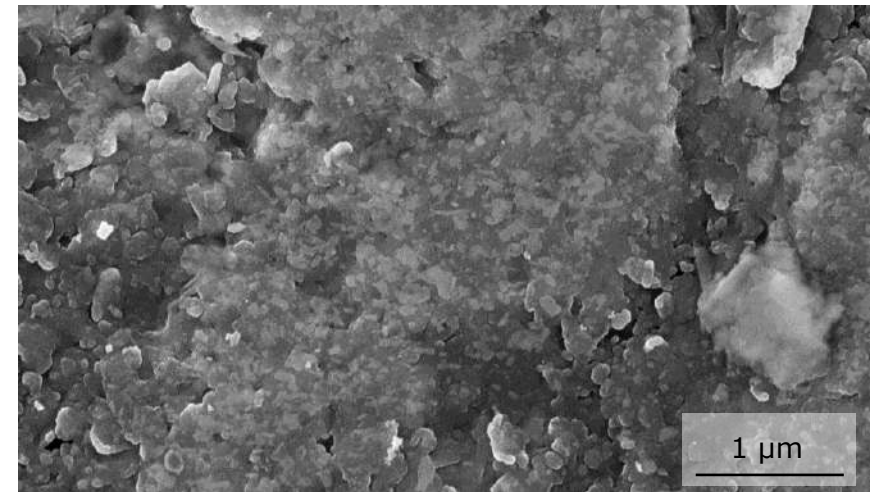


Figure 13. glauconite replacing other clay minerals

# Bulk geochemistry

- Major oxides are compliant with mineralogical data, increase in MgO, K<sub>2</sub>O, V<sub>2</sub>O<sub>5</sub> and decrease in Al<sub>2</sub>O<sub>3</sub> follow the increase in glauconite content
- **Glauconite rich zone (ZR-1)** – enriched in chalcophile elements
- **Transitional zone (ZR-2 and ZR-3)** – enriched in HFSE and LILE
- Sr/Ba ratios higher than 0.2 (Wei and Algeo, 2020) and HREE enrichment points to marine influence during paleosol formation

Table 1. Sr/Ba ratios throughout the palaeosol

	ZR-7	ZR-6	ZR-5	ZR-4	ZR-3	ZR-2	ZR-1
Sr/Ba	0.5	-	0.24	-	0.32	0.3	-

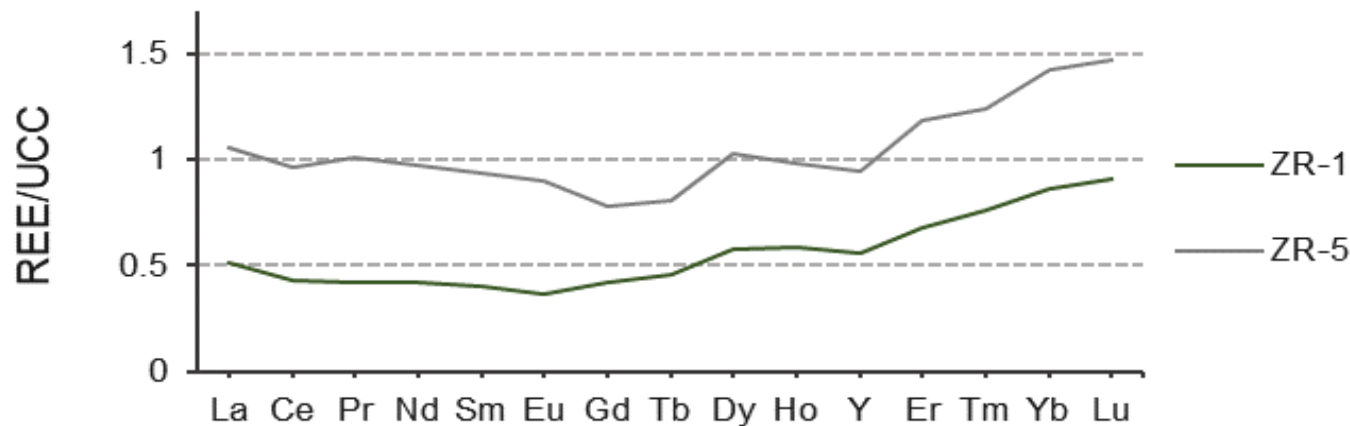


Figure 16. Distribution of rare earth elements in the palaeosol, after normalized with their upper continental crust values (Taylor and McLennan, 1985)



# Model for the evolution of the Zlatni rt palaeosol

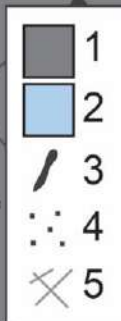
## 1<sup>st</sup> stage: Pedogenesis

Formation of pyritized roots (3)

Formation of pedogenic pyrite (4)

1M<sub>0</sub> illite formation

Mixed layer illite-smectite formation



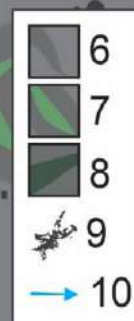
## 2<sup>nd</sup> stage: Glauconitization

Flooding of the palaeosol

Microbially facilitated dissolution of groundmass (6) - enrichment in HFSE and siderophile elements

Formation of oxidized (7) and reduced (8) Glauconite + precipitation of pyrite veins (9): variations in the supply of organic matter

Ingression of marine porewater (10) - enrichment in LILE and HREE



## 3<sup>rd</sup> stage: Burial

Precipitation of diagenetic pyrite (11) - enrichment in chalcophile elements



Thank you for your attention!





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