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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

Ivor Perković¹, Goran Durn¹, Blanka Cvetko Tešović², Srečo D. Škapin³, Darko Matešić¹, Igor Vlahović¹, Maja Martinuš²

¹University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, 10000 Zagreb Croatia,

²University of Zagreb, Faculty of Sciences, 10000 Zagreb, Croatia,

³Jožef Stefan Institute, Advanced Materials Department, 1000 Ljubljana, Slovenia

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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

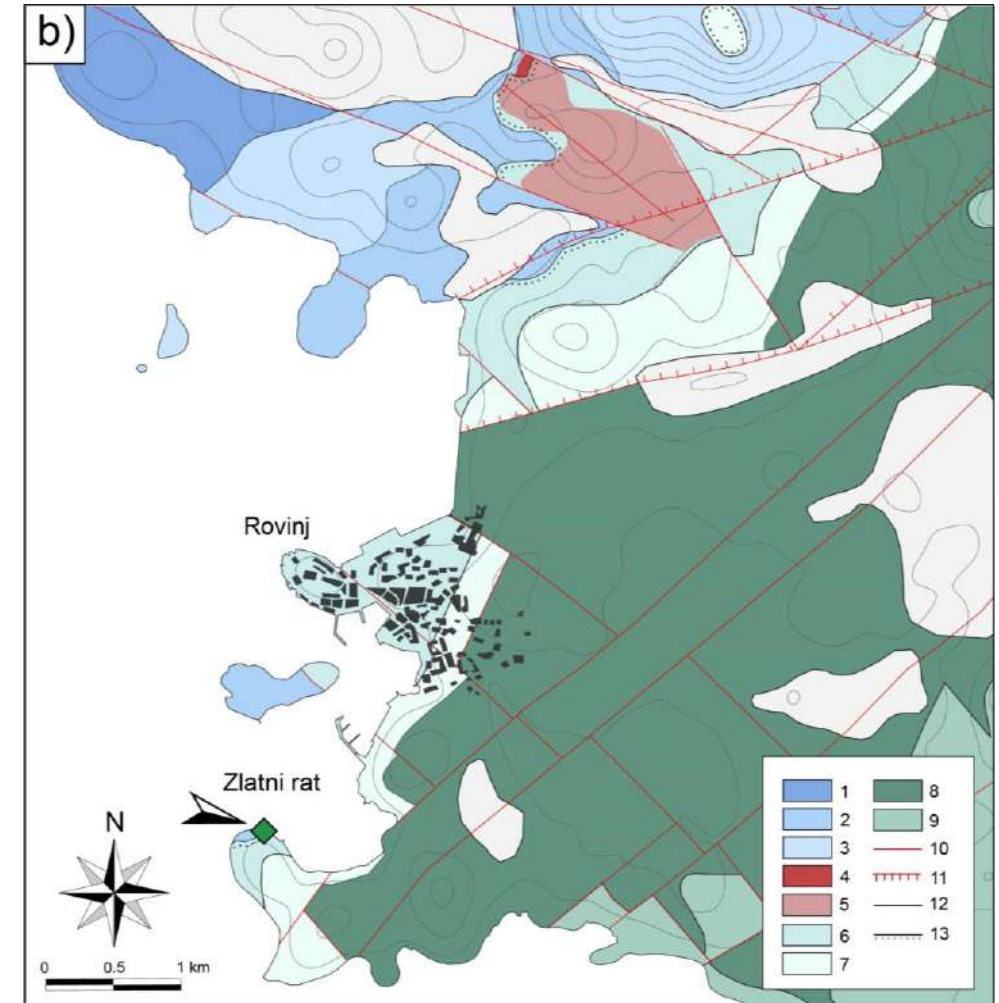


Figure 2. 1 – Monsena unit, 2 – Muča unit, 3 – Lim unit, 4 – Bauxite (uncovered), 5 – Bauxite (covered), 6 – Kirmenjak unit, 7 – Zlatni rt unit, 8 – Rovinj unit, 9 – Materada unit, 10 – Normal faults, 11 – Reverse faults, 12 – Normal geological boundary, 13 – Transgressive boundary

Studied outcrop

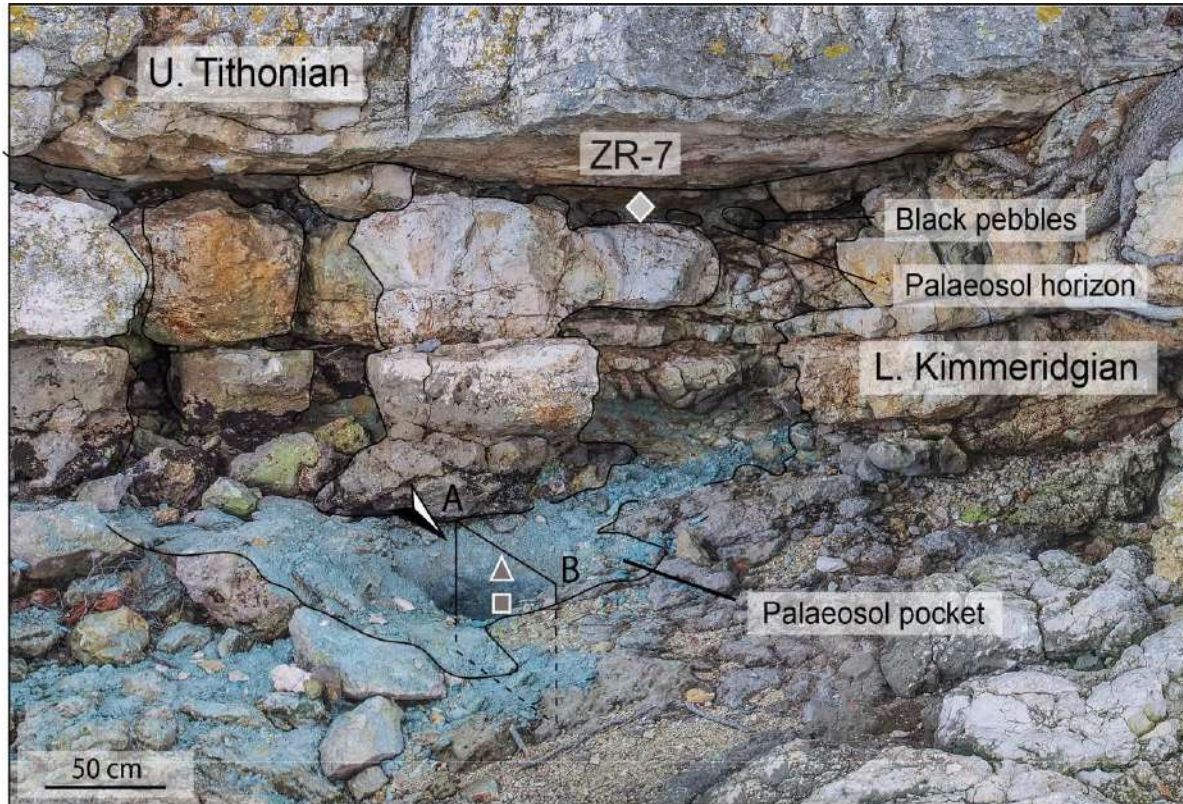


Figure 3. Zlatni rt outcrop with marked units

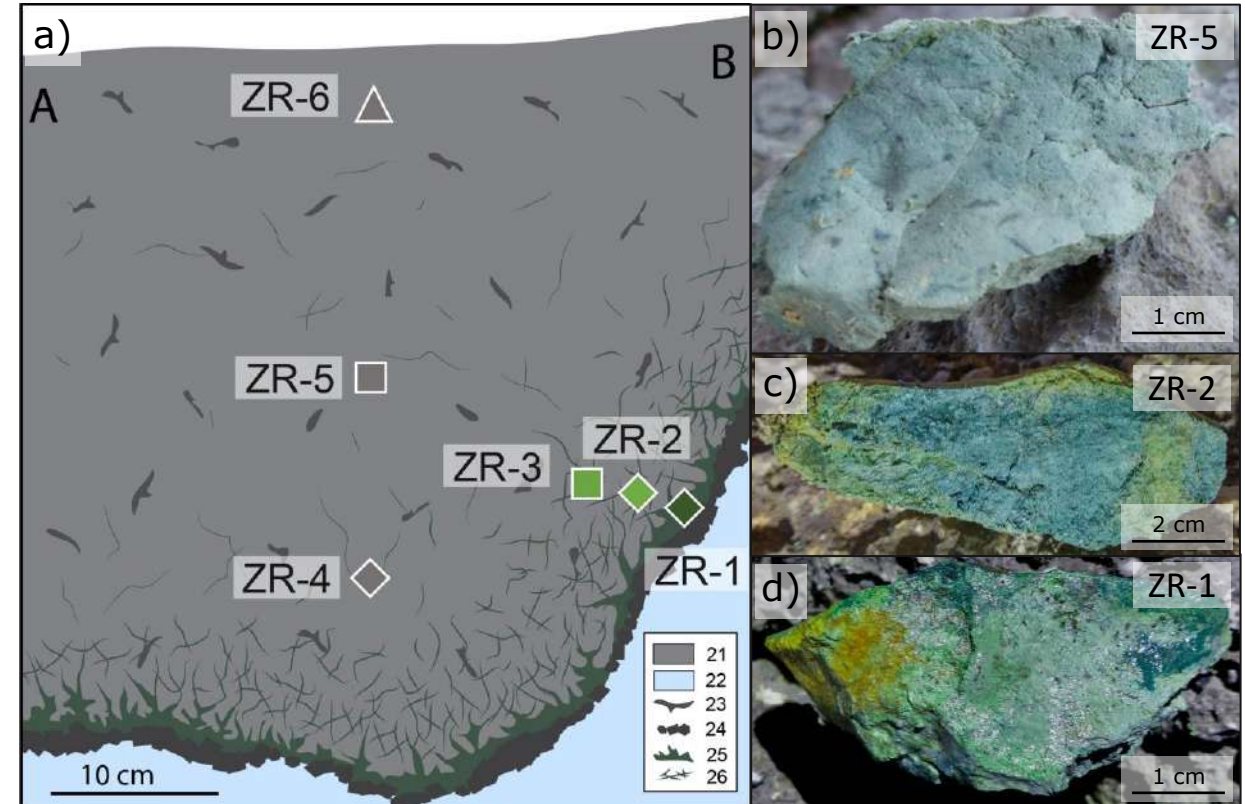


Figure 4. photographs and schematic representation of the studied outcrop and samples. a – schematic representation of the studied profile in the ZR palaeosol, b – sample from the unglauconitised palaeosol, c – sample from the transitional zone, d – sample from the glauconite rich zone.

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

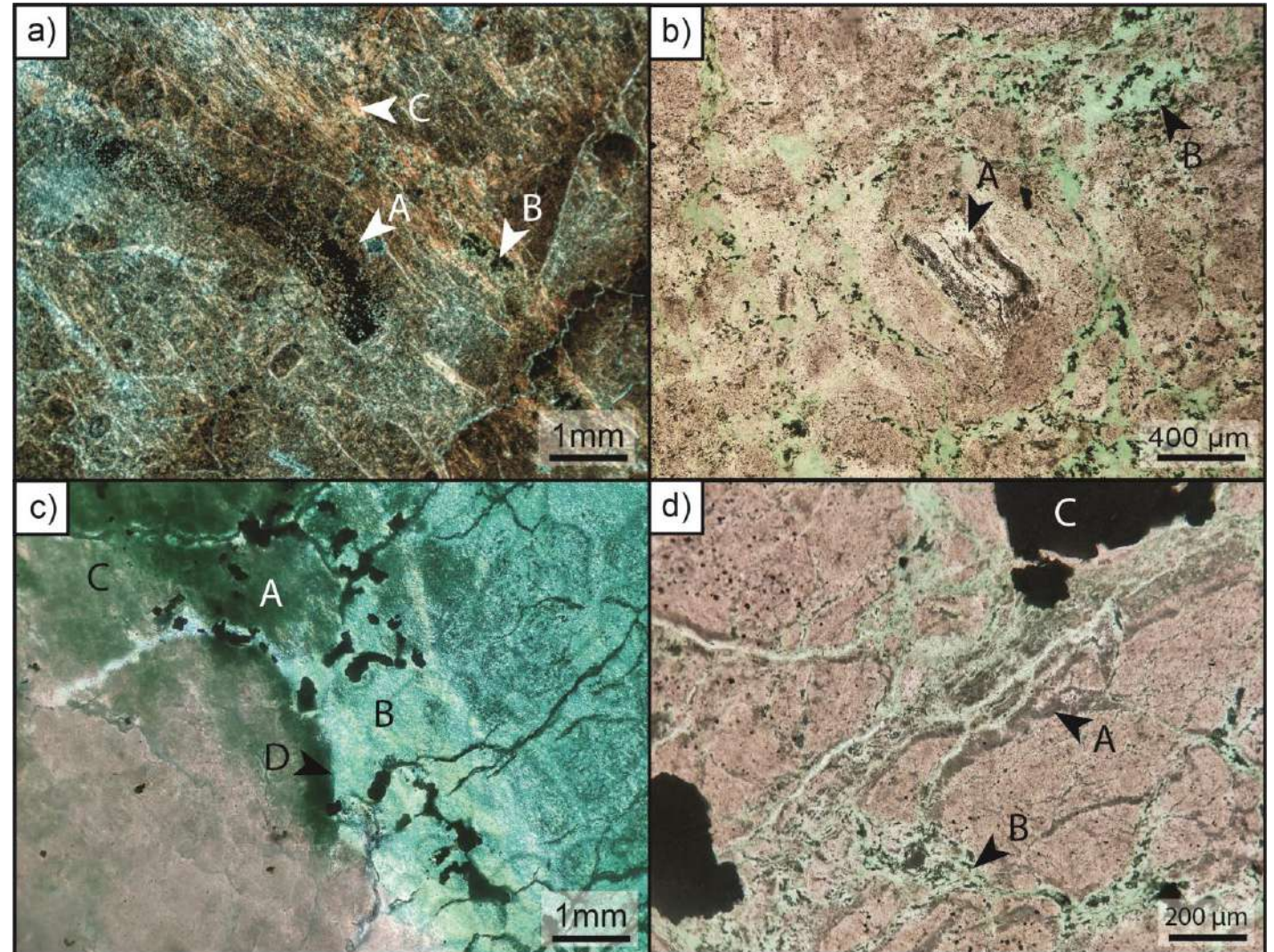


Figure 7. photomicrographs of the studied samples

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

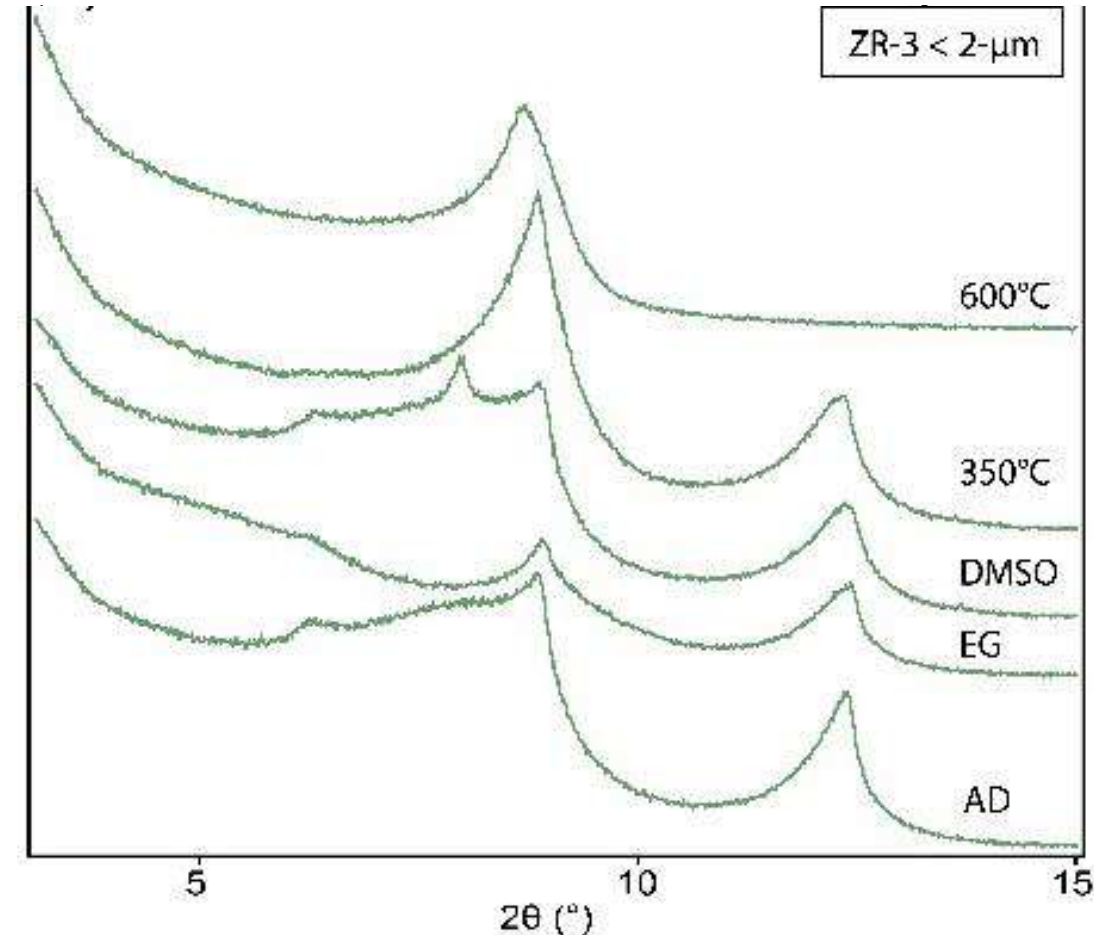


Figure 11. XRD patterns of clay fraction from the transitional zone after diagnostic treatments

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

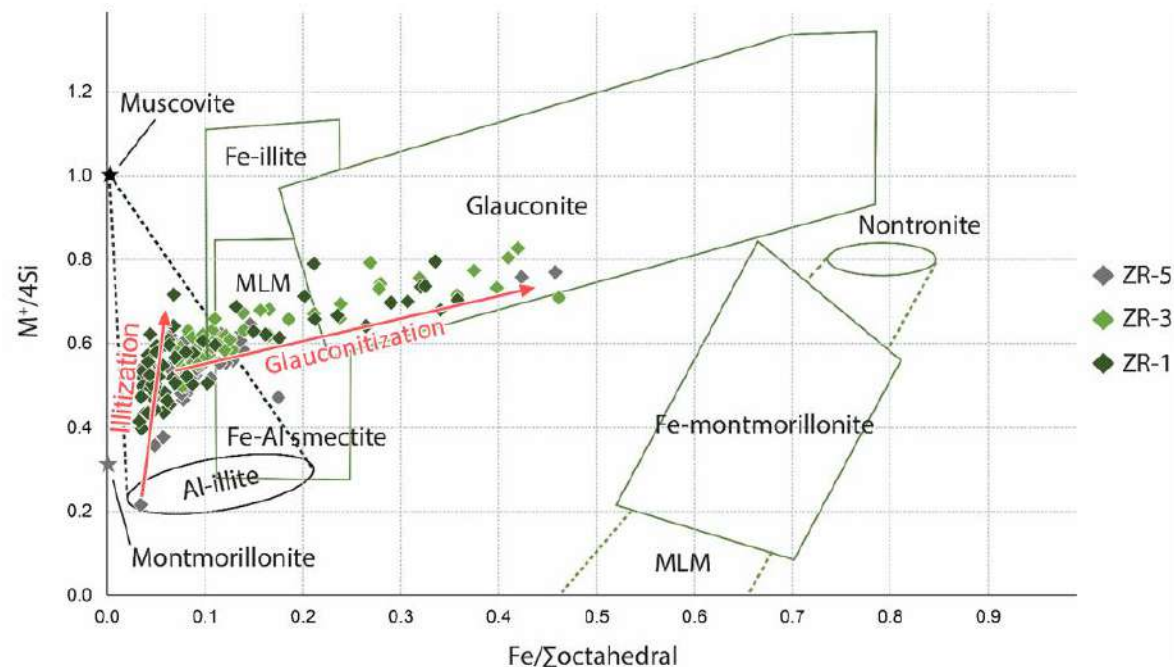


Figure 14. $M^+/4Si$ vs. Fe/Σ_{oct} plot on which the EDS points measured in ZR-1, ZR-3 and ZR-5 samples have been plotted. Green fields represent data from Meunier and El Albani 2007, while the black fields and stars represent data from Baldernann et al 2014; MLM – mixed layered mineral.

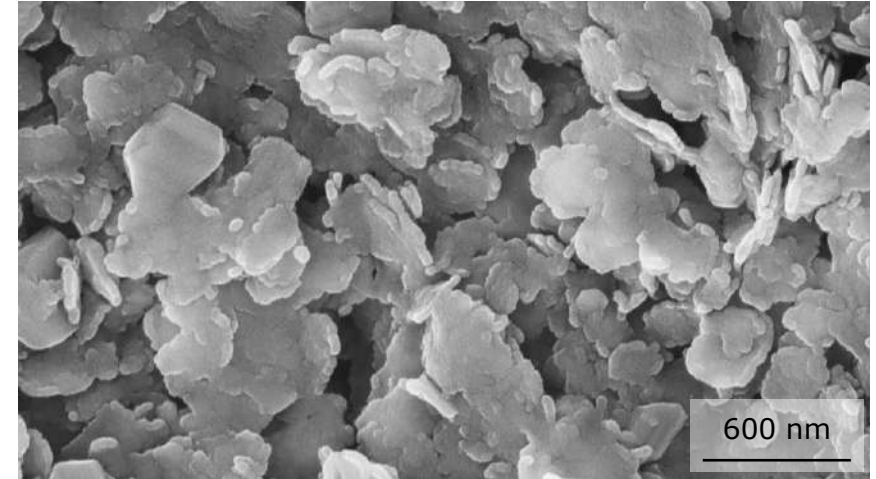


Figure 12. caterpillar glauconite

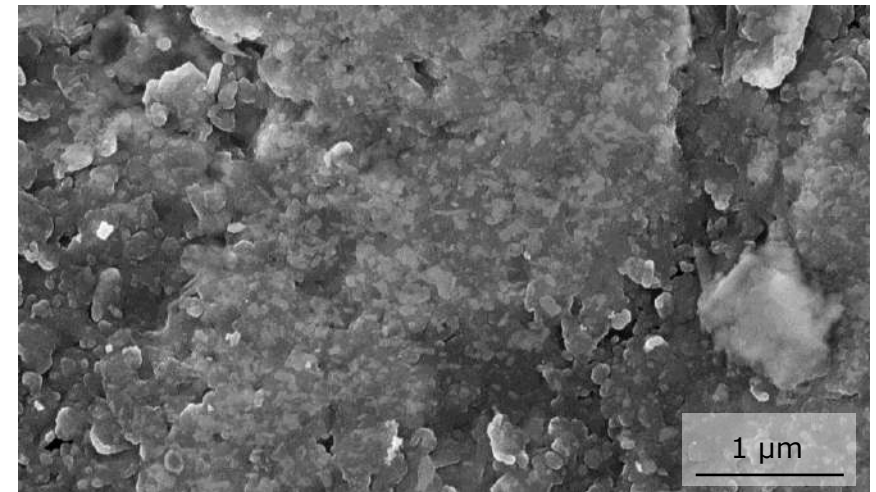


Figure 13. glauconite replacing other clay minerals

Bulk geochemistry

- Major oxides are compliant with mineralogical data, increase in MgO, K₂O, V₂O₅ and decrease in Al₂O₃ 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	-

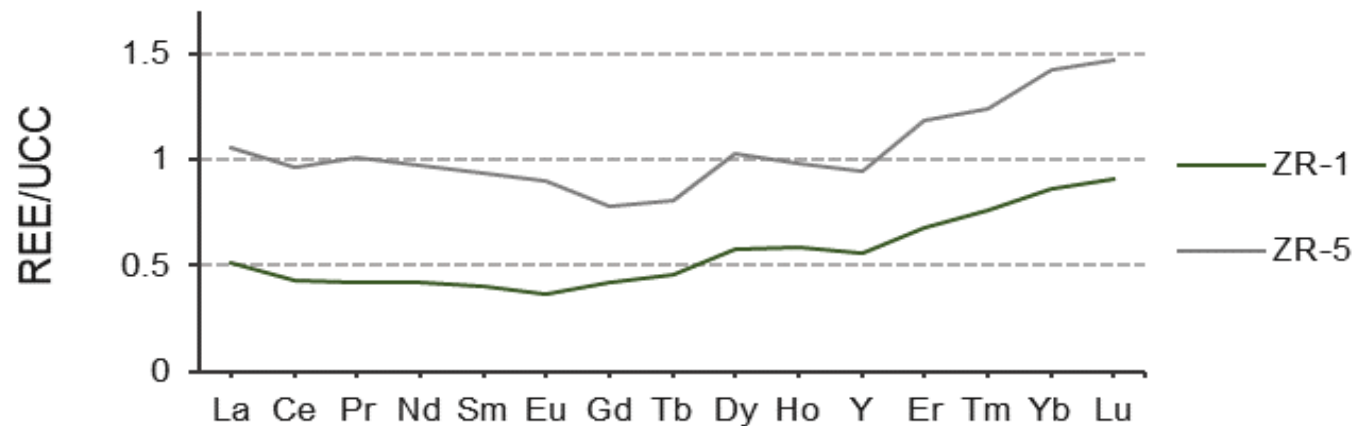


Figure 16. Distribution of rare earth elements in the palaeosol, after normalized with their upper continental crust values (Taylor and McLennan, 1985)

Model for the evolution of the Zlatni rt palaeosol

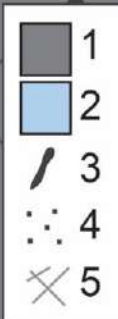
1st stage: Pedogenesis

Formation of pyritized roots (3)

Formation of pedogenic pyrite (4)

1M₀ illite formation

Mixed layer illite-smectite formation



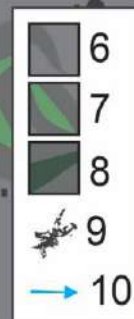
2nd stage: Glauconitization

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



3rd stage: Burial

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



Thank you for your attention!



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