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

Perković, Ivor; Durn, Goran; Cvetko Tešović, Blanka; Škapin, Srečo D.; Matešić, Darko; Vlahović, Igor; Martinuš, Maja

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

Ivor Perković[1], Goran Durn[1], Blanka Cvetko Tešović[2], Srečo D. Škapin[3], Darko Matešić[1], Igor Vlahović[1], Maja Martinuš[2]

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

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

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

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).

WIANLab Hrzz Croatian Science Foundation RGNF

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 an 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 succesion of the Western Istrian anticline
- Bedrock: Oxfordian to early Kimmeridgian Muča unit
- Cover: upper Tithonian Kirmenjak unit

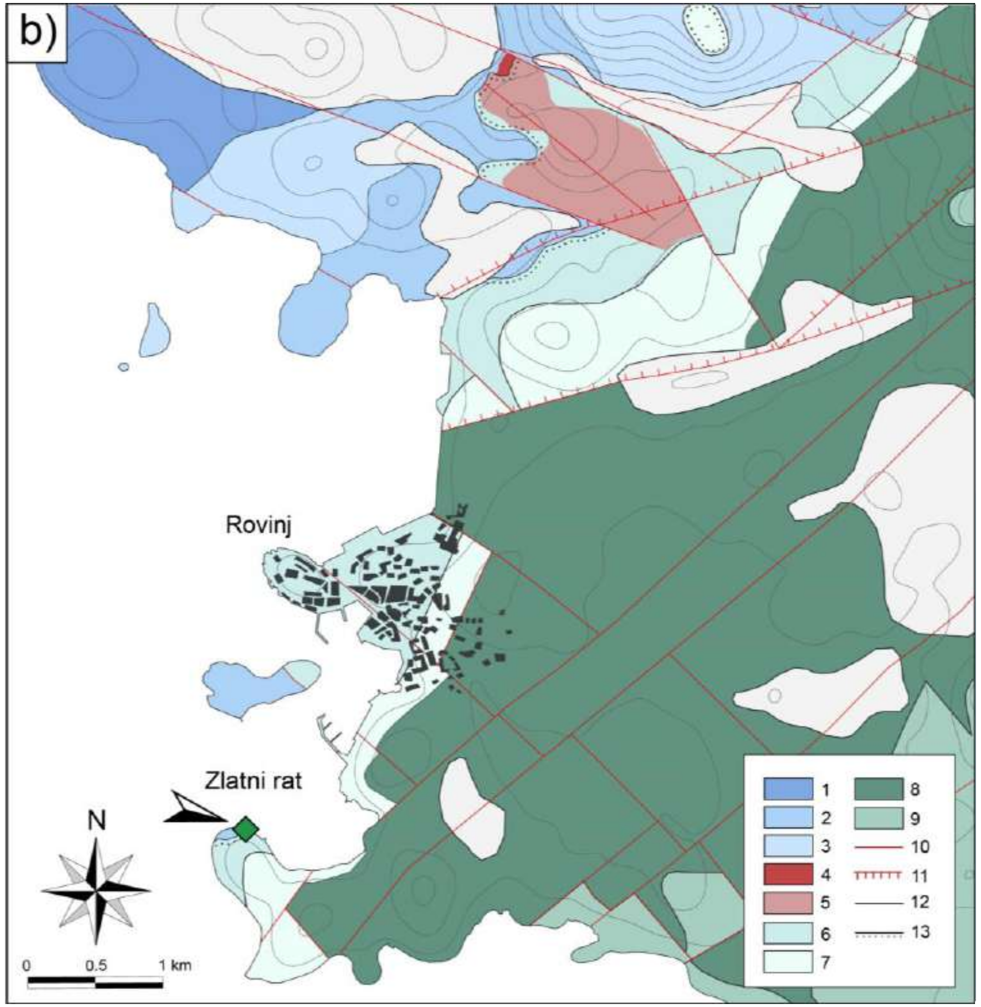


Figure. 2. *1 – Monsena unit, 2 – Muča unit, 3 – Lim unit, 4 –Bauxite (uncovered), 5- Bauxite (covered), 6 – Kirmenjak unit, 7 – Zlatni rt unit, 8 – Rovinj unit, 9 – Materada unit, 10 – Normal faults, 11 – Reverse faults, 12 – Normal geological boundary, 13 – Transgressive boundary*

Studied outcrop

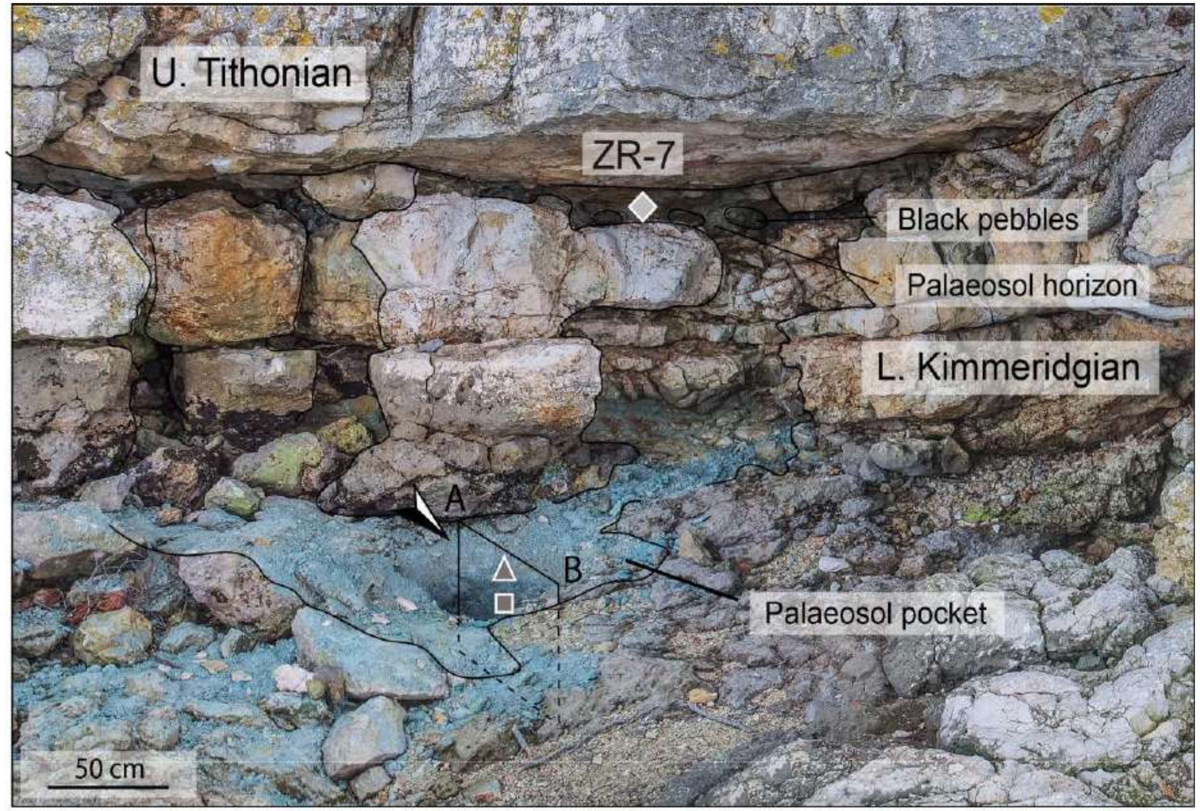


Figure. 3. *Zlatni rt outcrop with marked units*

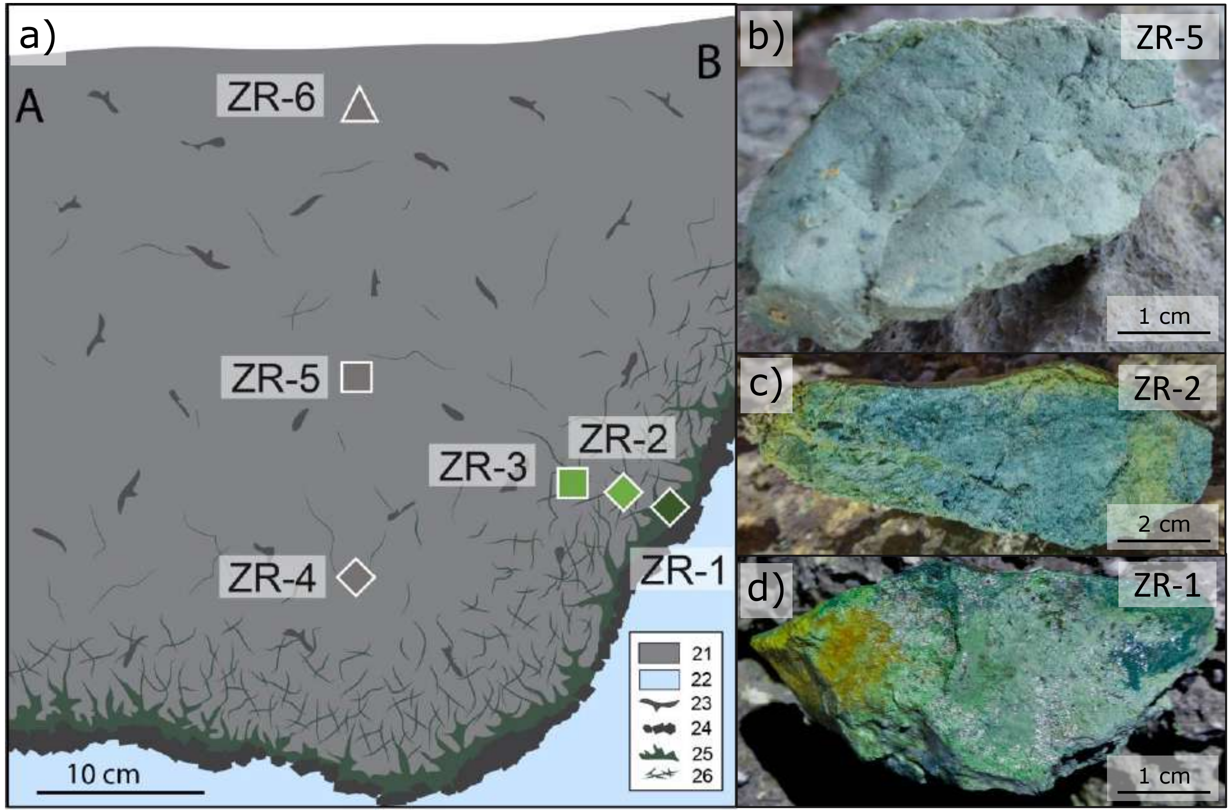


Figure 4. *photographs and schematic representation of the studied outcrop and samples. a – schematic representation of the studied profile in the ZR palaeosol, b – sample from the unglauconitised palaeosol, c – sample from the transitional zone, d – sample from the glauconite rich zone.*

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 μm 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

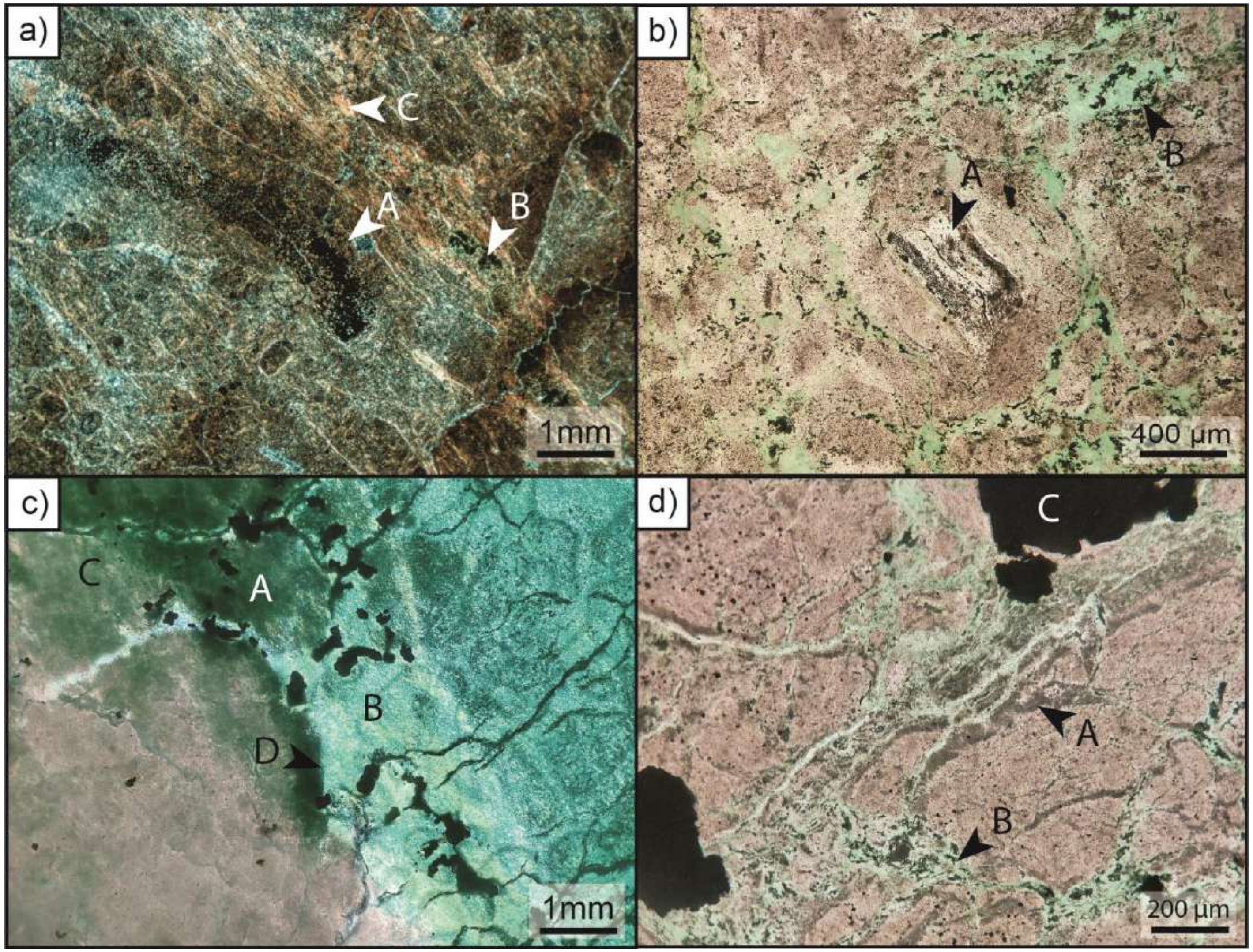


Figure. 7. *photomicrographs of the studied samples*

Mineralogy

- **Glauconite 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 Glauconite 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

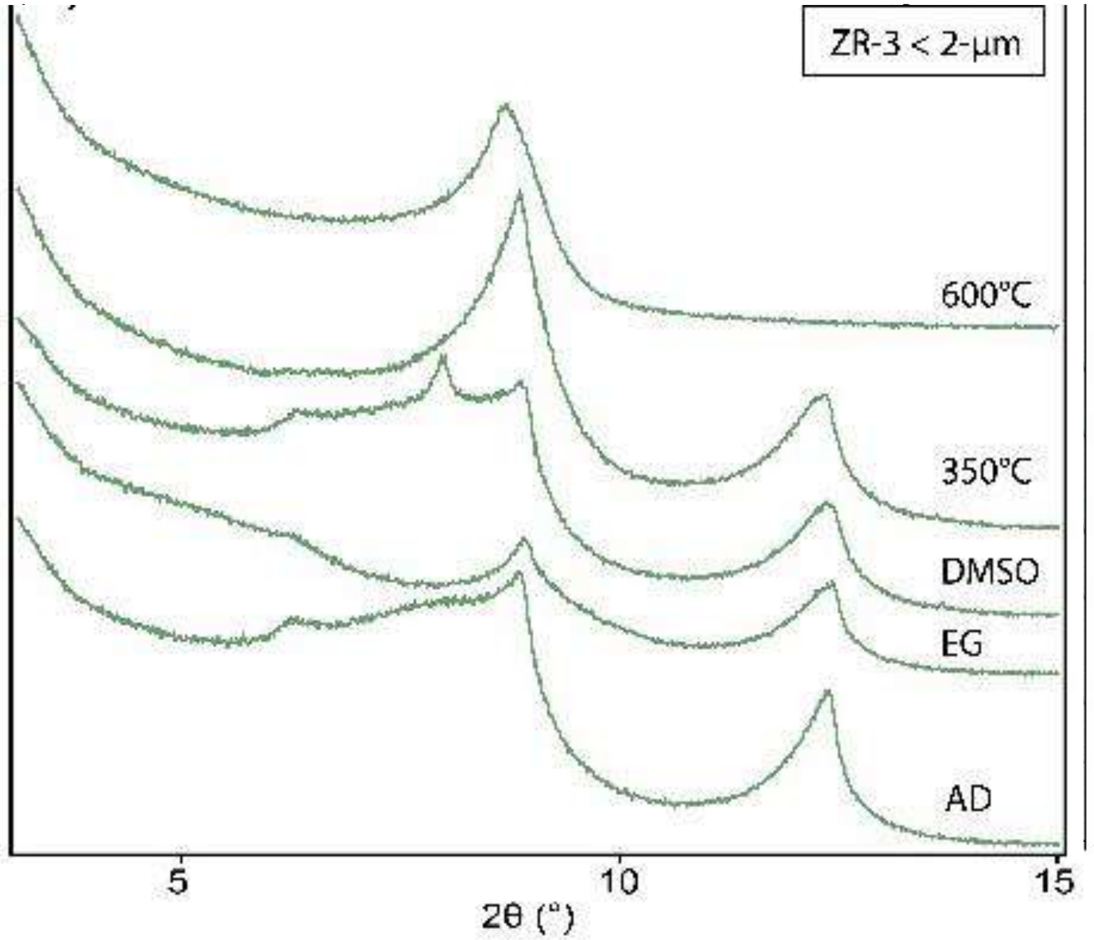


Figure 11. *XRD patterns of clay fraction from the transitional zone after diagnostic treatments*

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

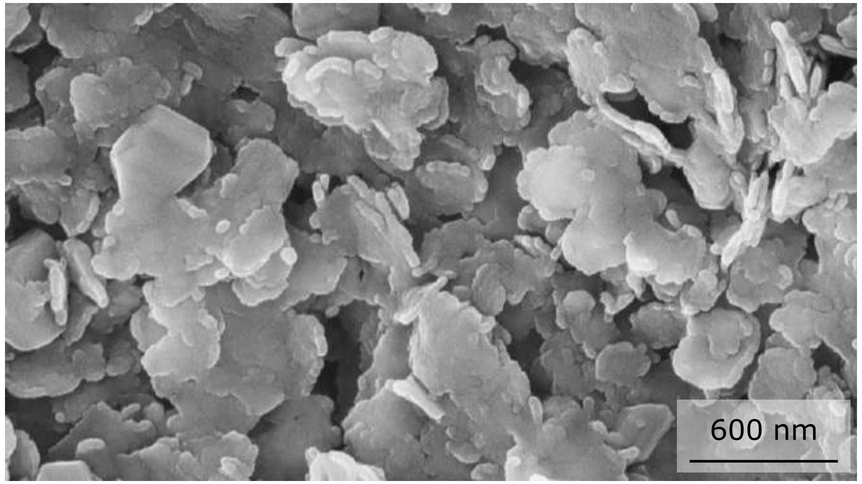


Figure 12. *caterpillar glauconite*

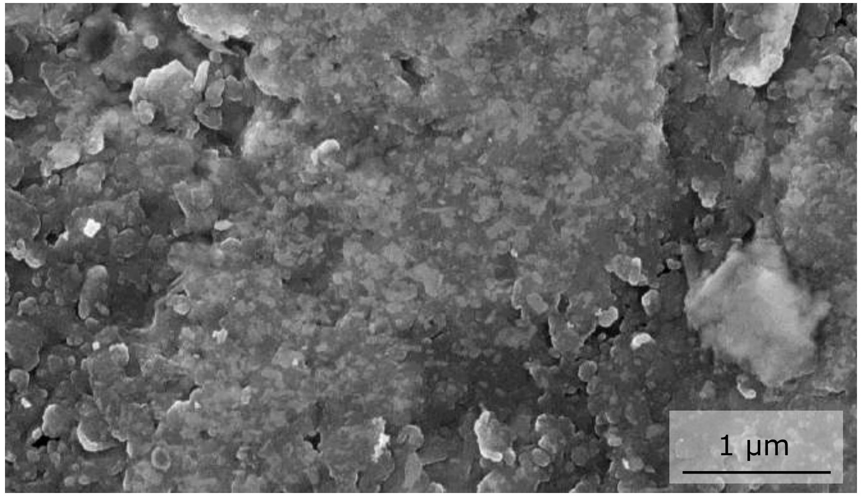


Figure 13. *glauconite replacing other clay minerals*

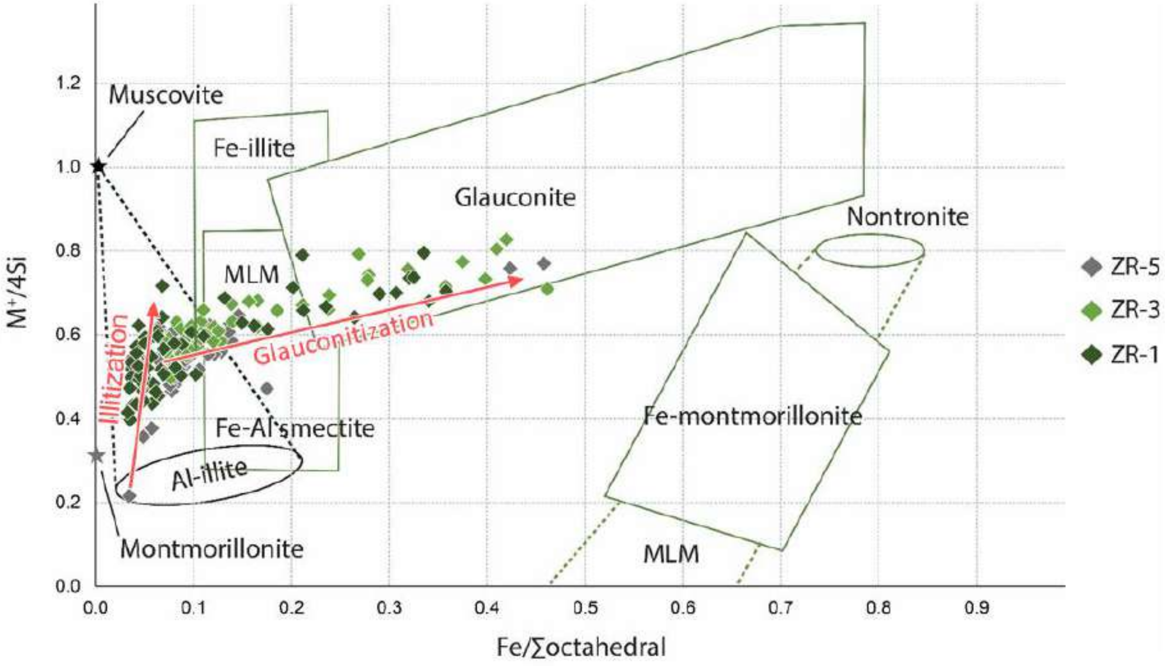


Figure 14. *M+/4Si vs. Fe/∑oct plot on which the EDS points measured in ZR-1, ZR-3 and ZR-5 samples have been plotted. Green fields represent data from Meunier and El Albani 2007, while the black fields and stars represent data from Baldermann et al 2014; MLM – mixed layered mineral.*

Bulk geochemistry

- Major oxides are compliant with mineralogical data, increase in MgO, K_2O, V_2O_5 and decrease in Al_2O_3 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 infulence 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	-

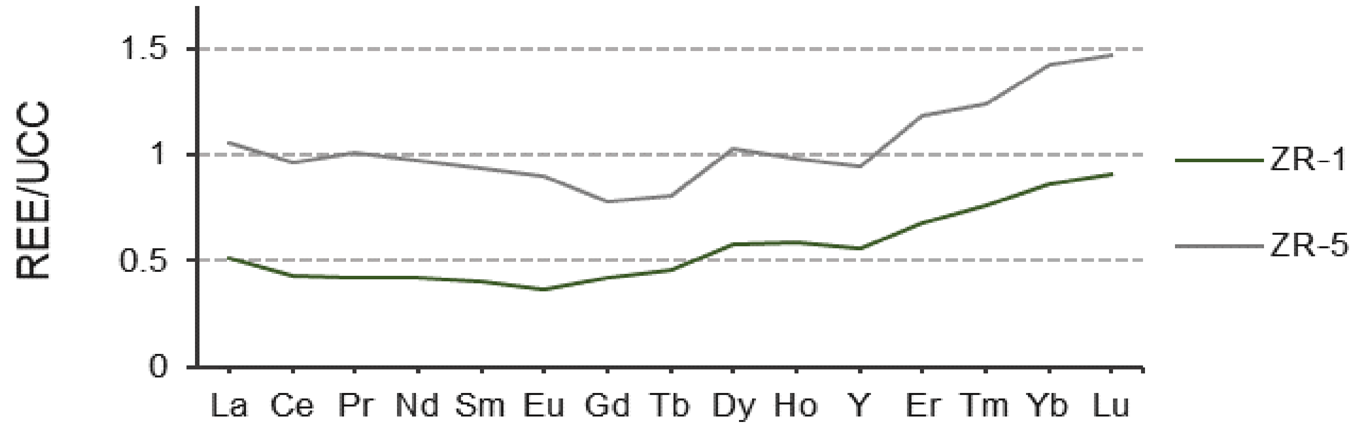
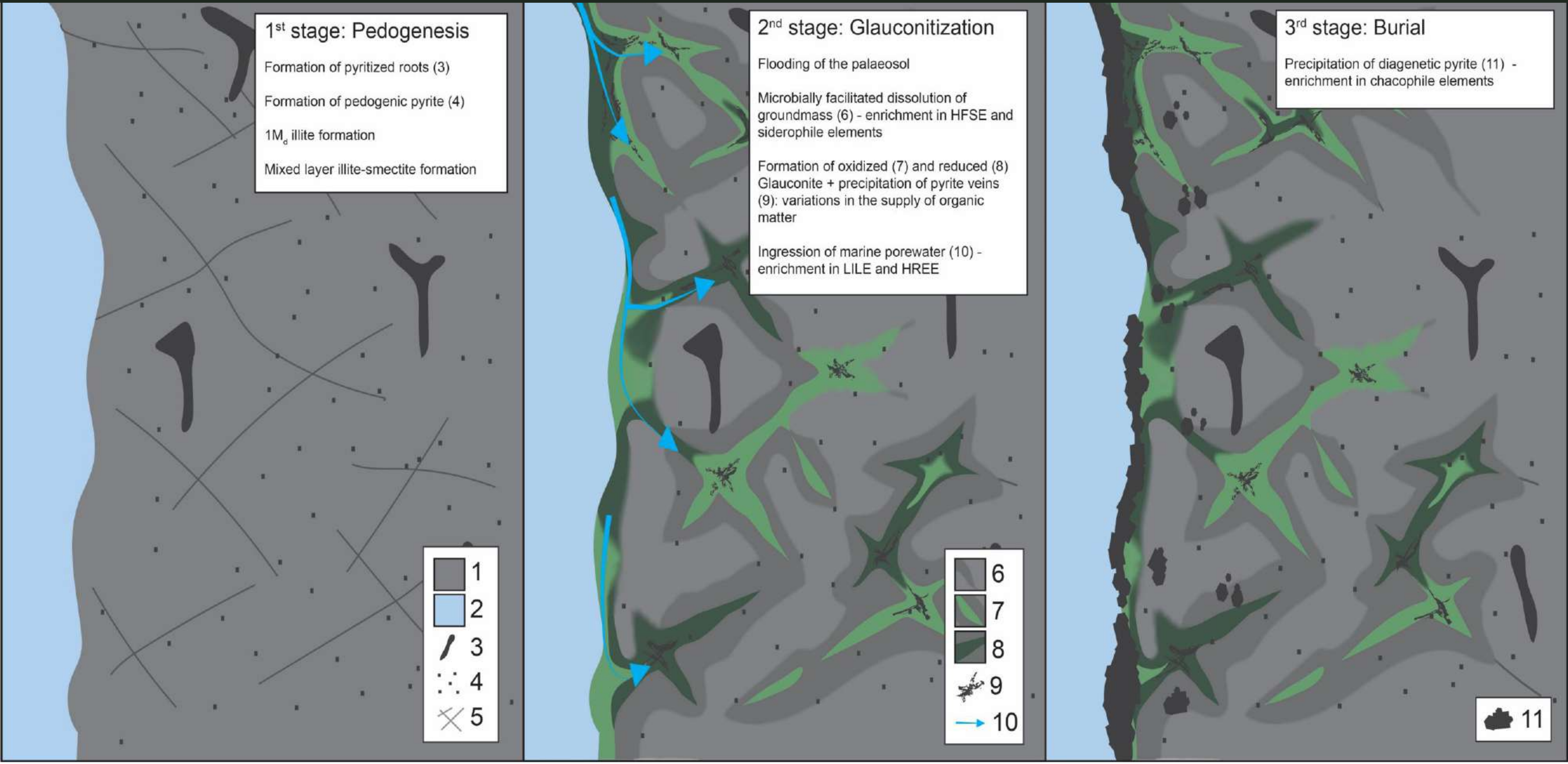


Figure 16. *Distribution of rare earth elements in the palaeosol, after normalized with their upper continental crust values (Taylor and McLennan, 1985)*

Model for the evolution of the Zlatni rt palaeosol




Thank you for your attention!

References

- Baldermann, A., Warr, L. N., Grathoff, G. H., & Dietzel, M. (2013). The rate and mechanism of deep-sea glauconite formation at the Ivory Coast-Ghana Marginal Ridge. *Clays and Clay Minerals*, *61*(3), 258–276.
- Doebelin, N., & Kleeberg, R. (2015). Profex: A graphical user interface for the Rietveld refinement program BGMN. *Journal of Applied Crystallography*, *48*.
- Meunier, A., & El Albani, A. (2007). The glauconite-Fe-illite-Fe-smectite problem: A critical review. In *Terra Nova* (Vol. 19, Issue 2, pp. 95–104). Moore, D. M., & Reynolds, R. C. jr. (1997). X-Ray Diffraction and the Identification and Analysis of Clay Minerals, second edition. In *Oxford University Press*.
- Taylor, S. R., & McLennan, S. M. (1985). The Continental Crust: its Composition and Evolution. An Examination of the Geochemical Record Preserved in Sedimentary Rocks. In *The Continental Crust: its Composition and Evolution. An Examination of the Geochemical Record Preserved in Sedimentary Rocks.*
- Velić, I., Matičec, D., Tišljar, J., & Vlahović, I. (1995). Opći prikaz geološke građe Istre (A review of the geology of Istria). *Lst Croatian Geological Congress, Excursion Guidebook*, 5–30.
- Wei, W., & Algeo, T. J. (2020). Elemental proxies for paleosalinity analysis of ancient shales and mudrocks. *Geochimica et Cosmochimica Acta*, *287*, 341–366