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CLAYS IN THE CRITICAL ZONE: AN INTRODUCTION

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The Earth's Critical Zone (CZ) is described as the permeable near-surface layer from the tops of the trees to the bottom of the groundwater. It is a living, breathing, and constantly evolving boundary layer where rock, soil, water, air, and living organisms interact. These complex interactions regulate the natural habitat and determine the availability of life-sustaining resources, including food production and water quality. Clays and clay minerals are the most abundant and reactive components of the CZ. It was for this reason that a thematic session entitled 'Clays in the Critical Zone' was convened at the 2015 EuroClay Conference in Edinburgh, Scotland. The keynote speaker, Dan Richter, started the session with an admittedly oblique reference to Arthur O. Lovejoy's 1936 book *The Great Chain of Being* by quoting "There are not many differences in mental habit more significant than that between thinking in discrete, well defined class concepts and that of thinking in terms of continuity, of infinitely delicate shading of everything into something else, of overlapping of essences, so that the whole notion of species comes to seem an artifact of thought." The point made by Richter is that clay science is now part of the accelerated development of interactions amongst many disciplines that include biology, geology, physics, chemistry, archeology, and history.

The direction of critical zone clay research is exemplified in topics presented at the EuroClay session and in this thematic group of papers in *Clays and Clay Minerals*. Clay minerals serve to proxy information about the deep time history of Earth and give us insight as to how and how fast our own CZ will change as we move into the future. Contributions to the EuroClay session and this volume embrace the diversity of Hans Jenny's factors of climate, parent rock, biota, topography, and time, which are driving forces in CZ science.

In this volume, the exquisite preservation of paleosols in Russia described by Alekseeva *et al*. (2016) reminds us that the Earth's deep history of the CZ has been under the influence of arborescence since the Devonian (~410–360 Ma). Few would have imagined before today that major petroleum reserves could be stored in saprolitic granite 2 km under the today's North Sea, where Riber *et al*. (2016) bring to light the essentials of CZ factors responsible for their genesis. Unraveling differences between diagenetic clays and CZ weathering clays to aid in paleoenvironmental interpretations have been addressed by Šegvić *et al*. (2016) in the study of North Sea tunnel valleys. This is germane to all CZ systems hosted in sedimentary parent rocks that cover nearly 80% of Earth's land surface. The complexities of organic matter (the other ''most reactive'' component in the CZ) is considered by Chotzen *et al*. (2016), where they found that absorption of humic acid on a range of common clay minerals is very dependent on pH and solution chemistry, which bears directly on our understanding of today's changing CZ environments. Very cold climates are assumed to contribute to physical weathering *via* freeze-thaw stresses only. This paradigm is changed by Lessovaia *et al*. (2016) who document the release of smectites and glasses from Siberian traprocks into the CZ, thus realizing a greater potential for soil biogeochemical reactivity in boreal environments than previously thought. Perhaps the least constrained aspect of CZ science is knowing how long it takes for a system to change regardless of whether it is subject to a human or other natural forcing function. The study of chronosequence clay mineralogy is well documented by Ryan *et al*. (2016) where they explore clays in tropical landscapes controlled by periodic tectonic, volcanic, and geomorphic activities on millennial time scales.

Clay science plays an important role in CZ science as the future challenge is the development of a unified theory for CZ evolution. The tools to integrate the knowledge needed include geophysics to define CZ architecture, stochastic and deterministic numerical modeling to predict landscape response scenarios for possible human behaviors (*e.g.* carbon use), and real-time sensing of environmental conditions to note changes are taking place (*e.g.* remote sensing and data logging of hydro-biogeochemical activity). The human perception and value of CZ science can mean many things to many people. For example, a forested landscape can have resource value (*e.g.* a place to harvest timber), environmental value (*e.g.* a place to filter water that reaches aquifers), recreational

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value (*e.g.* a place to ride a bike), or spiritual value (*e.g.* a place to hit our reset button and enjoy the wonders of nature). The study of clays plays an important part in CZ science and this issue of *Clays and Clay Minerals* is a manifestation of Lovejoy's realization that class concepts are an artifact of thought. It is time to parlay the great body of knowledge that clay mineralogy has to offer to CZ scientists. This set of papers is a bright sign of the possibilities that lie ahead for collaborative clay-CZ science.

Alekseeva, T., Kabanov, P., Alekseev, A., Kalinin, P., and Alekseeva, V. (2016) Characteristics of early Earth's Critical Zone based on middle-late Devonian paleosol properties (Voronezh High, Russia). *Clays and Clay Minerals*, **64**, 677–694.

Chotzen, R.A., Polubesova, T., Chefetz, B., and Mishael, Y.G. (2016) Adsorption of soil-derived humic acid by seven clay minerals: a systematic study. *Clays and Clay Minerals*, **64**, 628–638.

Lessovaia, S.N., Plötze, M., Inozemzev, S., and Goryachkin, S. (2016) Traprocks transformation to clayey material in soil environment (Central Siberian Plateau, Russia). *Clays and Clay Minerals*, **64**, 668–676.

Lovejoy, A.O. (1936) *The Great Chain of Being: A Study of the History of an Idea*. Harvard University Press, Massachusetts, USA.

Riber, L., Dypvik, H., Sørlie, H., and Ferrell, R.E., Jr. (2016) Clay minerals in deeply buried paleoregolith profiles Norwegian North Sea. *Clays and Clay Minerals*, **64**, 588–607.

Ryan, P.C., Huertas, F.J., Hobbs, F.W.C., and Pincus, L.N. (2016) Kaolinite and halloysite derived from sequential transformation of pedogenic smectite and kaolinite-smectite in a 120 ka tropical soil chronosequence. *Clays and Clay Minerals*, **64**, 639–667.

Šegvić, B., Benvenuti, A., and Moscariello, A. (2016) Illite-smectite-rich clay parageneses from Quaternary tunnel valley sediments of the Dutch southern North Sea – mineral origin and paleoenvironment implications. *Clays and Clay Minerals*, **64**, 608–627.