DECODING ENVIRONMENTAL CONDITIONS DURING SILICIFICATION OF PLANT STEMS IN EQUATORIAL PANGAEA AND OMAN BY CATHODOLUMINESCENCE IMAGING AND ANALYSIS. P. Matysová[1,2*], J. Götze [3], G. Forbes[4], J. Leichmann[5], R. Rößler[6] and T. Grygar[7]
[1]Institute of Rock Structure and Mechanics, ASCR, v.v.i., V Holešovičkách 41, 182 09 Prague 8, Czech Republic; *e-mail: pmatysova@email.cz; matysova@irsm.cas.cz, [2]Institute of Geology and Palaeontology, Faculty of Science, Charles University, Czech Republic, [3]TU Bergakademie Freiberg, Germany; goetze@mineral.tu-freiberg.de, [4]Petroleum Development Oman, Muscat 113, Sultanate of Oman; gordon.forbes@pdo.co.om, [5]Masaryk University, Brno, Czech Republic; leichman@sci.muni.cz, [6]Museum für Naturkunde, Chemnitz, Germany; roessler@naturkunde-chemnitz.de, [7]Institute of Inorganic Chemistry, ASCR, v.v.i. Řež, Czech Republic; grygar@iic.cas.cz

Introduction: Our research of silicified stems from different localities around the world has been inspired by initial hot cathodoluminescence (CL) studies on silicified Permo-Carboniferous plants from two localities in Germany: Thuringian Forest Basin, e.g. [1], and Chemnitz Petrified Forest, e.g. [2,3].

After a two year gap and despite the fact that sedimentary authigenic quartz had been supposed to have no or only very weak cathodoluminescence [4,5], we used a similar methodology on Czech Upper Carboniferous material from alluvial deposits in the Intra Sudetic and Krkonoše Piedmont Basins [6,7]. The main aim was to extract more detailed information than mere palaeobotanical taxonomy because a silicified stem, trunk, root, branch, and wood represent a really unique association between fossil plant and mineral phases. Our approach is based on a combination of hot CL with other instrumental techniques (PPL, XPL, RL, SEM/EDS or WDS, and XRD). The data obtained were surprising; CL microscopy proved to be an unrivalled technique to distinguish primary and subsequent stages of silicification in samples from fluvial or possible lacustrine sediments and thus proved a multi-phase process of silicification within the basin. Hot CL microscopy revealed detailed anatomical and petrographical features not seen by other microscopic techniques, and also allowed the recognition of Fe_xO_y and allochthonous detrital grains. On the basis of distinct CL shades, we suggested two different schemes for CL interpretation; a petrographical one related to morphological types of SiO_2 crystals (each SiO_2 type gives a characteristic CL shade) and a genetic one that is based on the existence of a short-lived blue CL, which suggests more than one phase of silicification [6]. Fossils were permineralized mostly by highly crystalline SiO_2 (quartz, proved by XRD), often with allochthonous material, in fluvial sediments, and more variable silica mineralogy in specimens formed by burial in volcanoclastics. Overprints of recrystallization were evident in almost all samples and reflected a multiphase process of silicification in another way. Our CL results differ significantly from previous studies [1,2,3]; it follows that silicification is a very complex process which most probably relates to different mechanisms, related to various original palaeoenvironmental conditions [6,7].

To clarify CL signals in silicified plants and understand the previous results better we have started to study samples from further 'test' localities with well known geology that provide permineralized plant stems of similar or different age. From an analytical point of view, we added high resolution scanning CL (HR-CL) imaging and hot CL spectroscopy to better characterize the CL shades and reveal specific activators responsible for the signal. There is a chance to interpret specific mineral characteristics that connect the plant bodies with past environmental and burial conditions [unpublished data].

According to our results, alluvial and volcanoclastic environments of silicification mechanisms/pathways are very different and that variance is recorded in specific composition of silicified stems. Identification of SiO_2 polymorphs, carbonates, phosphates, fluorite, clay minerals and allochthonous components help to understand the process because such mineral phases record the geochemical conditions during all stages of silicification.

Fossils from alluvia, mostly fluvial facies, such as those from the Intra Sudetic, Krkonoše Piedmont and West and Central Bohemian Basins (Czech Republic), Tocantins (Brasil), North Cliffs (Sultanate of Oman), Autun (France), Arlit (Niger), showed mainly brownish, reddish and bluish CL shades, of a stable or short-lived nature, lacking relatively high-temperature mineral phases.

Fossils from localities highly (Chemnitz, Germany; Petrified Forest NP, Arizona; Jumbi province, Sumatra, Indonesia) or slightly (Antarctica; Mongolia; Balka, Czech Republic) influenced by volcanism often exhibit best preserved plant anatomy, and both SiO_2 and minor minerals often allow very detailed CL imaging. Hydrothermal secondary quartz is present as a consequence of later burial diagenesis. Prevailing CL shades are reddish and bluish, but also brownish and yellowish. Fluorite (intensive bright bluish CL) is a common component only in Chemnitz specimens. Opal-CT and moganite were found in some Mesozoic, i.e. younger, specimens, but also in Permian specimens from Chemnitz, but always in association with volcanic material. Moganite and goethite were present in Permian Omani samples from the vicinity of Saiwan [unpublished data]. We try to answer the question what caused the presence of moganite in the Omani wood where no volcanic activity has been evidenced until now. However, all pathways producing moganite are not known at present time.

In summary, silicified stems must be considered as unique and specific palaeo-environmental indicators. The cathodoluminescence technique can help to decode hidden characteristics in plant fossils that were permineralized by silica and substantially contribute to our understanding to palaeoenvironment, taphonomy and stratigraphy.

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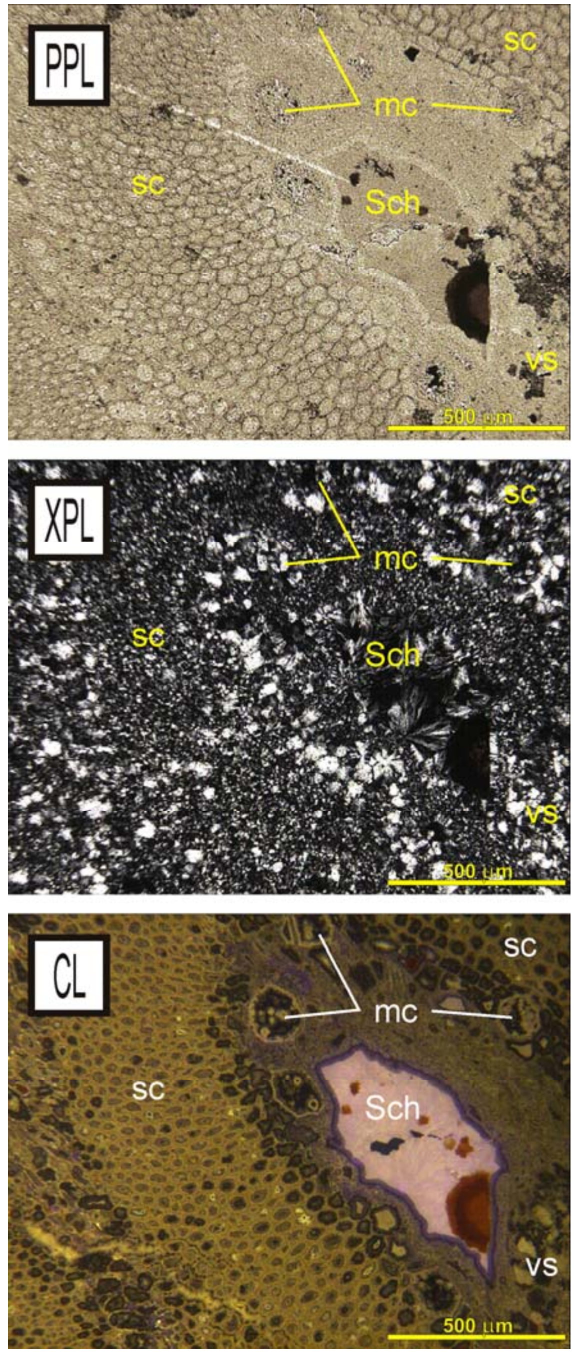

Figure on the right: Arborescent tree fern *Psaronius* sp. (# DS 6/98; Museum für Naturkunde, Chemnitz, Germany); Comparison of different microscopy imaging techniques: PPL, XPL, and CL. CL can highlight tiny anatomical and petrographical details in a part of an adventitious root from the inner root mantle. Yellow CL is typical of Chemnitz locality. Legend: *sc* – sclerenchyma, *mc* – mucilage canals, *vs* – vascular strand, *Sch* – spherulitic chalcedony creating agate-like structures in the root matrix.