Wavelets

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Wavelets: an alternative tool for MS-stratigraphic correlation

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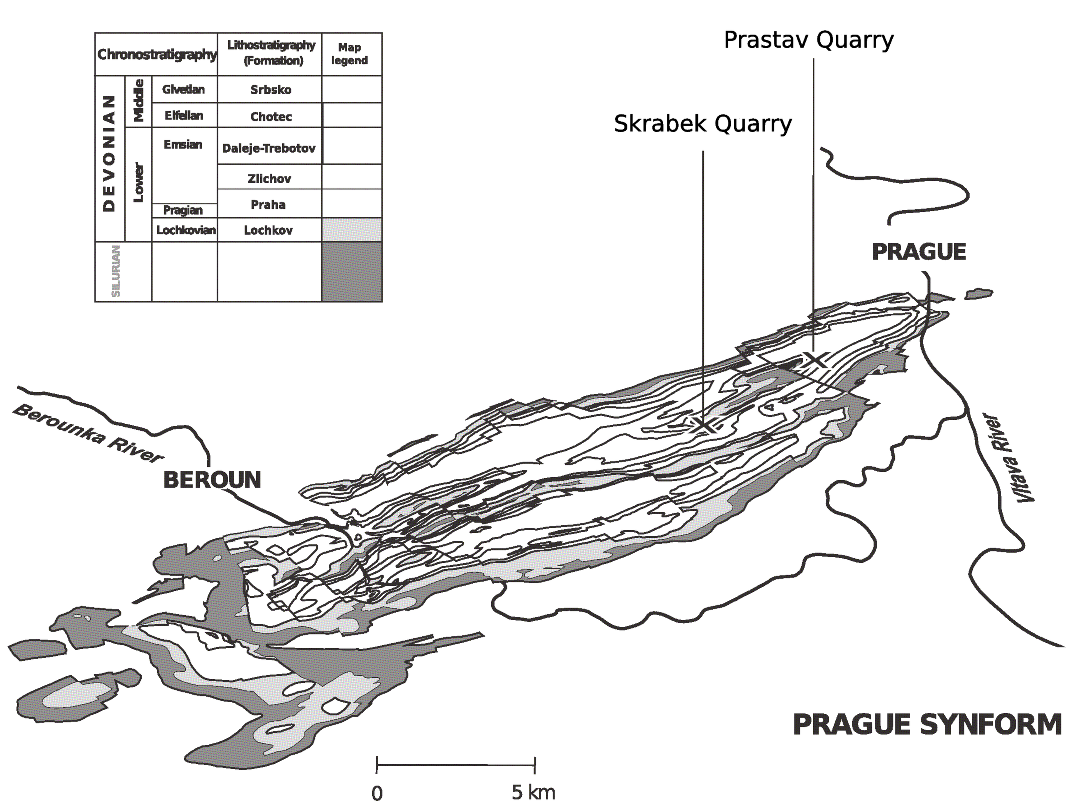
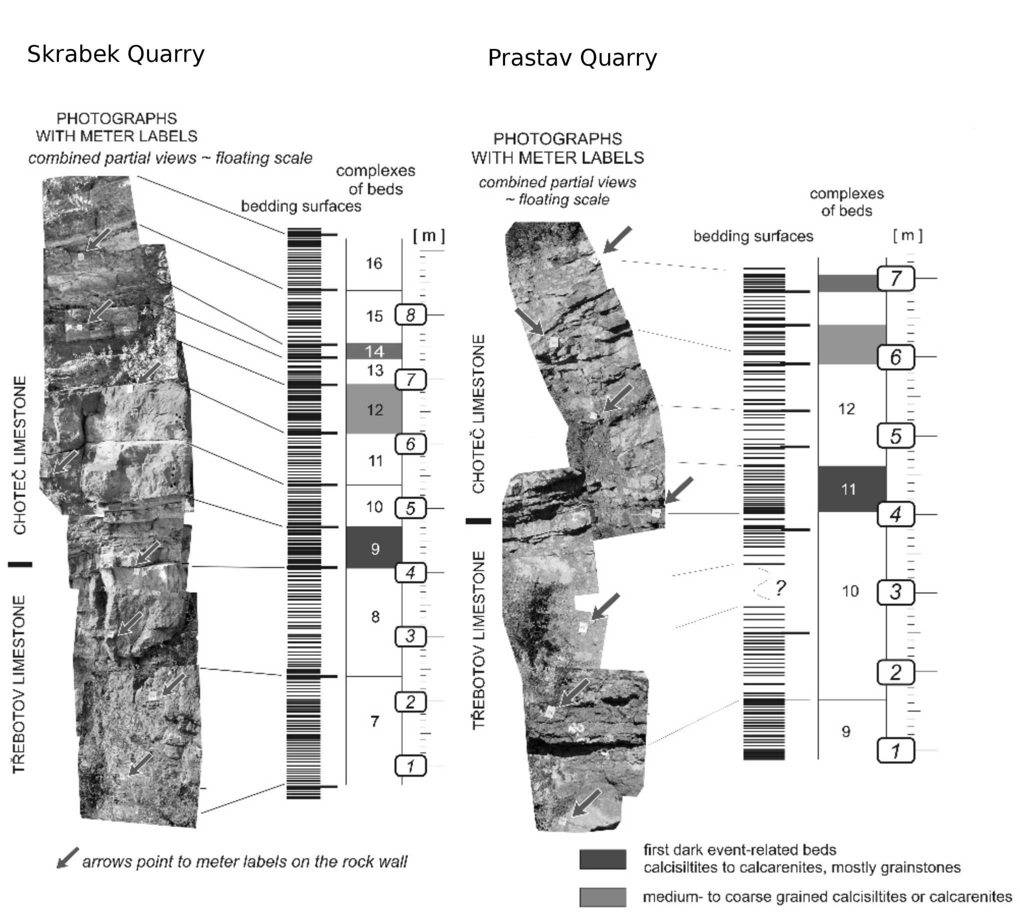
Motivation. MS-signal of rocks / dissolution residues may be useful for stratigraphic correlation [1-2]. Despite the assumed common background magnetic-particle input process, the MS-signals from different sites are distorted due to variable sedimentation rate, input of magnetic particles rate, and variation in mineral/chemical composition of MS-signal carriers. Thus, a problem arises, how to match (align, correlate) the distorted signals. This problem is common in many areas of discrete signal processing, ranging from speech recognition to image registration. The major motivation and objective of this work is to apply the wavelet correlation analysis in the MS-stratigraphic context.

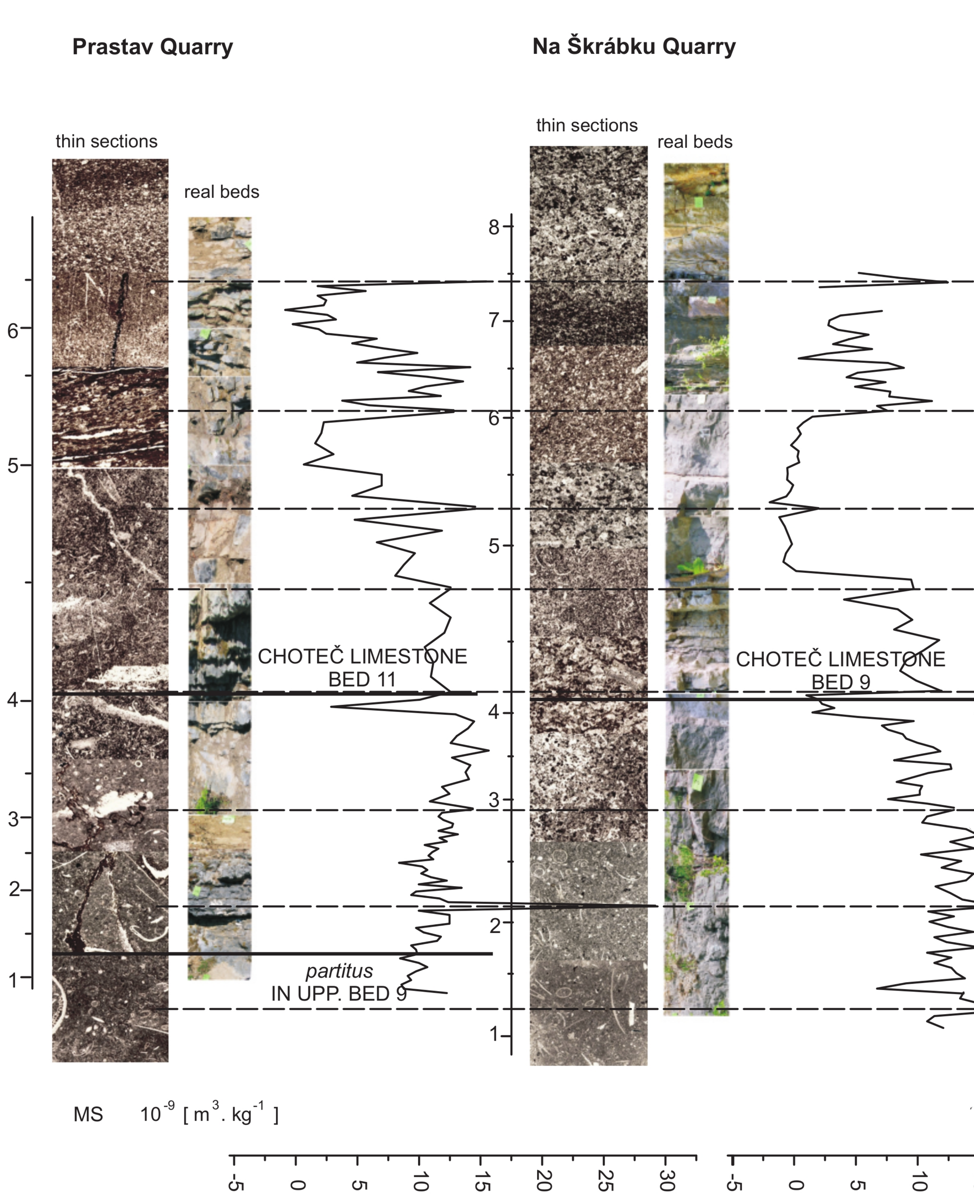
Currently used methods. Observation of raw signals is still the prevailing method of matching the MS curves. It is based on subjective recognition of patterns of peaks and valleys in the signal, and matching corresponding points by hand. Cross-correlation is a measure of similarity of two waveforms as a function of a time-lag applied to one of them. It is useful in case when there is no difference in sedimentation rates, and other conditions, and the signals are only displaced in time [3-4]. Dynamic time warping in other hand can match two sequences which vary in time, speed, and amplitude. Similarities can be detected, if there were differences in amplitude and even if there were accelerations and decelerations during the course of the observatons. In general, it is a method that allows a computer to find an optimal match between two given sequences (e.g. time series) with certain restrictions, i.e. the sequences are "warped" non-linearly to match each other. It was used for correlation of MS-sequences in [5].





Why wavelets? A continuous wavelet transform (CWT) is used to divide a continuous-time function into wavelets. Unlike Fourier transform, the continuous wavelet transform possesses the ability to construct a time-frequency representation of a signal that offers very good time and frequency localization. Scaleogram is a visual method of displaying a wavelet transform. It has 3 axes: first representing timing of an event, second its scale, and third its intensity. The third axis is usually visualized by varying colour or brightness. A scaleogram is an equivalent of a spectrogram for wavelets. By decomposing a time series into time–frequency space, one is able to determine both the dominant modes of variability and how those modes vary in time [6].

Material, methods and results. Two MS logs from two sections across the Emsian - Eifelian boundary (Devonian, Czechia) developed in limestones, were used for testing of applicability of the wavelet scaleograms in stratigraphic correlation. Approximately 20-40 g samples of unweathered rock without calcite veins or dissolution seams were taken in 5 centimetre-spaced rows in a vertical section across the boundary interval. In total, 6 to 8 metres were sampled at each section.



For measurements, a Kappabridge KLY-2 device with a magnetic field intensity of 300 A.m-1, an operating frequency of 920 Hz and a sensitivity for specimen 4.10-8 SI was used. Raw and normalized mass-specific MS [m3.kg-1] of whole-rock samples were transformed by the CWT using the 'Mexican Hat' (degree 2 Derivative of Gaussian) mother wavelet.
We used the resulting wavelet scaleograms to find similar matching patterns in frequency and amplitude domain. The results correspond well to those obtained by classical method in the previous study [7].

References

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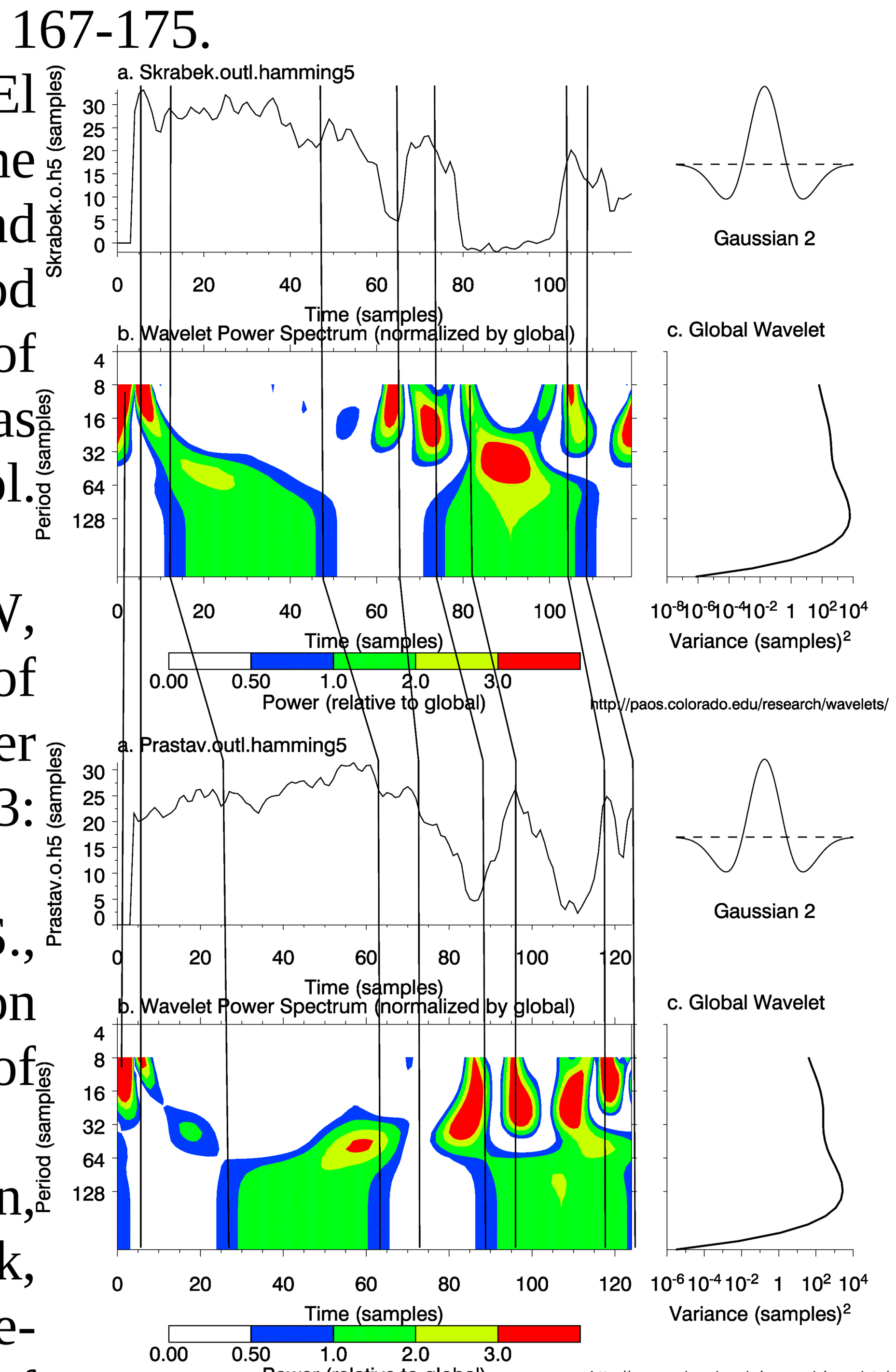

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