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Modelling of pedogenic carbonates formation in karst soils – a case from Dalmatia (Croatia)

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Pedogenic carbonates are secondary carbonate deposits that are often found in soils developed over carbonate rocks in Mediterranean region. Their formation is a result of dissolution and reprecipitation of existing geogenic, biogenic and/or pedogenic carbonates. Intensity of the dissolution processes affecting carbonates depends on multitude of factors but is mostly controlled by soil water drainage and concentration of soil air CO_2.

While percolating through soils and carbonate rocks, water dissolves carbonate minerals until reaching saturation state. Change in environmental conditions impacting concentration of soil air CO_2 (e.g., increase of temperature, decrease of soil water content), change of the soil water chemistry and evapotranspiration can lead to supersaturation of water in regard to Calcite and formation of pedogenic carbonates. In case of physicochemical precipitation, pedogenic carbonates precipitate in form of diffuse, small crystals and nodules. On the other hand, biologically influenced precipitation commonly results in different morphologies such as rhizolits, bacterial/fungal mats, etc. Pedogenic carbonates can occur in wide range of climates, thus their morphology and accumulation depth depend on mean annual precipitation. If sufficient time has passed, translocation of carbonates in the soil profile results in formation of calcic horizon.

We studied a 0.6 m deep Red Mediterranean Soil profile in Dalmatia (Croatia) having a calcic horizon at the bottom. Diffuse calcite particles and small nodules forming this horizon record different events of dissolution and precipitation. Based on data on soil temperature, soil water content, soil bulk electrical conductivity and soil air CO_2 collected during a 3-month monitoring period we developed a thermodynamic model for dissolution and precipitation of calcite in the soil. Results show that soil air CO_2 (affected by soil water content and temperature) is the main control of the calcite reactions. Furthermore, during the monitoring period 83% of the calcite dissolved was reprecipitated as pedogenic carbonate. Therefore, although dissolution is the main process governing denudation rate of karst areas (i.e., lowering of the surface), formation of pedogenic carbonates in soils could impact denudation rate of carbonate terrains.

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