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Paleosols in clastic sedimentary rocks: their geologic applications

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Abstract

Interest in pre-Quaternary paleosols has increased over the past decade, in large part, because they have proved to be beneficial in solving diverse geological problems. The majority of paleosols are described from continental deposits, most commonly from alluvial strata. Criteria for recognizing these paleosols have been extensively described; however, classifying them has proved more complicated. Pre-Quaternary paleosols are generally classified according to one or more modern soil classification systems, although one new classification has been proposed exclusively for paleosols to avoid problems using the modern soil classifications. In addition to taxonomic classification, paleosols can be categorized according to the interplay among deposition, erosion, and the rate of pedogenesis when they formed. Paleosols can be solitary if they formed during a period of landscape stability following the development of an unconformity. Such paleosols are commonly thick and extremely well developed. More commonly, paleosols are vertically stacked or multistory because they formed in sedimentary systems undergoing net aggradation. If erosion was insignificant and sedimentation was rapid and unsteady, compound paleosols generally formed. If the rate of pedogenesis exceeded the rate of deposition, composite paleosols developed. Thick, cumulative paleosols indicate that erosion was insignificant and that sedimentation was relatively steady. Both autogenic and allogenic processes can influence depositional and erosion patterns and, thus, affect the kinds of soils that form. Consequently, paleosols can help to interpret the history of sediment deposition and the autogenic and allogenic processes that influenced a sedimentary basin. Paleosols are also helpful in stratigraphic studies, including sequence stratigraphic analyses. They are used for stratigraphic correlations at the local and basinal scale, and some workers have calculated sediment accumulation rates based on the degree of paleosol development. In addition to their stratigraphic applications, paleosols can be used to interpret landscapes of the past by analyzing paleosol–landscape associations at different spatial scales, ranging from local to basin-wide in scope. At the local scale, lateral changes in paleosol properties are largely the result of variations in grain size and topography. At the scale of the sedimentary basin, paleosols in different locations differ because of basinal variations in topography, grain size, climate, and subsidence rate. Paleosols are used to reconstruct ancient climates, even to estimate ancient mean annual precipitation (MAP) and mean annual temperature (MAT). Ancient climatic conditions can be interpreted from modern soil analogs or by identifying particular pedogenic properties that modern studies show to have climatic significance. Stable carbon and oxygen isotopes are also used to interpret ancient climate, and some effort has been made to estimate MAT from isotopic composition. On the basis of

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