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8 Quantitative Modeling of Soil Forming Processes in Deserts: The CALDEP and CALGYP Models

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Many models have been developed to simulate $CaCO_3$ (calcite) formation in soils. Mechanistic models that focus primarily on the long-term formation of $CaCO_3$ are summarized in Table 8–1. These models differ with respect to: (i) the mechanism of $CaCO_3$ formation, (ii) Ca sources, (iii) the inclusion of chemical kinetics, (iv) spatial and temporal variability in pH and CO_2, (v) the type of rainfall model, and (vi) the inclusion of other minerals in the model. Calcium carbonate may precipitate in soil as the result of downward movement of Ca with percolating water from rainfall (the "illuvial" process); this is clearly the dominant process in the desert Southwest (Gile et al., 1981; Birkeland, 1984; Machette, 1985; Hendricks, 1991; McFadden et al., 1991). Alternatively, $CaCO_3$ may precipitate in the soil profile as the result of upward movement of Ca with evaporating waters from shallow water tables (the "evaporative" process); this process is locally important in a variety of habitats (Amundson & Lund, 1987; Knuteson et al., 1989; Marion et al., 1991). Calcium sources for the formation of $CaCO_3$ include weathering of both carbonate and noncarbonate minerals, groundwater, rainfall, and dust. The dominant Ca sources in southwestern deserts are dust and rainwater for soils developing on noncalcareous parent materials (Gile et al., 1981; Birkeland, 1984; Machette, 1985; Harden et al., 1991; McFadden et al., 1991). Only the Rogers and McFadden models consider chemical kinetics as a possible rate-limiting step in the dissolution of calcite, all other models assume that the solution phase is in chemical thermodynamic equilibria at all times. Most evidence suggest that calcite kinetics are fast and chemical thermodynamic equilibrium for calcite is a reasonable assumption for desert soils (McFadden et al., 1991). Most models consider spatial variability of CO_2 and pH, but few consider

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