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A Diffusion Model for Weathering Rind Genesis in a Tropical Setting

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The rate of weathering rind growth as a function of time on andesitic clasts from fluvial terraces in Costa Rica has been evaluated using a radial diffusion model. The mountainous fore arc of the central Pacific coast of Costa Rica is subdivided into 8 fault-bounded blocks, characterized by differential rates of surface uplift. Several of these blocks preserve flights of alluvial fill terraces. One such block is the ~ 15 km wide Esterillos Block that preserves a flight of four fluvial terraces in the vicinity of the Rio Parrita where the stream gradient is 2 m/km. The four fluvial terraces are distinguished on the basis of pedogenic characteristics and the mean thicknesses of weathering rinds. These terraces display decreasing pedogenic maturity (i.e. B - horizon thickness, rubification, texture, and clay film development) and mean rind thicknesses with decreasing elevation above base level. The highest and pedogenically most mature of these terraces, El Diablo surface (>45 ka and <330 ka) (Qt1) characterized by a red (2.5 YR) matrix, a clayey texture, many clay films on both ped faces and pore linings and a mean rind thickness of 93 mm, is exposed up to 210 m above sea level. Inset into the El Diablo surface is the Qt2 terrace, a red (2.5 YR) matrix, a clayey texture, many clay films on both ped faces and pore linings, and a mean rind thickness of 44 mm, that is exposed at elevations up to 150 m above sea level. Inset into Qt2 is the 26.1 ka±330yr (Qt3) terrace with a yellowish red (5 YR) matrix, a clay loam texture, and common clay films on ped faces and pore linings, and mean rind thickness of 29 mm, that is exposed up to 70 m above sea level. The youngest unit is the Qt4 terrace, a deposit characterized by a yellowish brown (10YR) matrix, a silty clay loam texture, common clay films on both ped faces and in pore linings, and mean rind thickness of 15 mm, that is exposed up to 50 m above sea level.

In the field, measurements of the three principle (long, intermediate, and short) axes of 84 individual clasts from the Qt1, Qt2, and Qt3 units were made. When plotted on a Flinn diagram that plots the axial ratios (long/intermediate) vs. (intermediate/short), the points cluster about the point (1,1), indicative of a spherical clast shape. Thus, we use a radial diffusion to model the rate of rind genesis. Dated wood from a mangrove deposit at the base of Qt3 provides a calibration point for our model. In this unit both the rind thickness and deposit age by radiocarbon age are known permitting determination of a diffusion parameter (k). Solving the diffusion equation for Qt3 yields a diffusion parameter which then yields ages for Qt1, Qt2, and Qt4 that are coincident with sea level high stands. Intervals of terrace deposition should be coincident with rises in base level especially where the stream gradient is low. The diffusion parameter calculated in this model is higher than values obtained for similar rock types in temperate climates. Thus, accelerated weathering rates in tropical settings allow use of weathering rinds to date Quaternary soils at higher resolution compared to temperate climates.