Rock-derived organic carbon (OC_{petro}) oxidation is a major source of atmospheric CO_2. However, the governing mechanisms, rates, and sensitivity to changing environmental conditions remain poorly constrained. We present geochemical characterizations of soils and riverine suspended sediments from the highly erosive Central Range (Taiwan) and demonstrate the importance of microbially-mediated OC_{petro} oxidation. Using a combination of bulk OC, lipid biomarkers, and Ramped PyrOx radiocarbon results, we show that 73^{+2}_{-3}% of OC_{petro} initially present in bedrock is respired to CO_2 within soils, and that the remainder is chemically altered during microbial assimilation. This corresponds to 5.6 – 17.1 tC km^{-2} yr^{-1} emitted as CO_2 within our study region, consistent with independent estimates. Our results indicate that microbially-mediated OC_{petro} oxidation is not kinetically limited despite high erosion rates and short residence times within the critical zone, and that erosion rates exhibit a first-order control on CO_2 emissions from mountain soils.