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Supporting information for

Continental-Scale Landscape Evolution: A History of North American Topography

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Contents of this file
Figures S1 to S6
Captions for Datasets S1 to S6
Isostatic balance calculation

Additional Supporting Information (Files uploaded separately)
Datasets S1 to S6
Introduction
The Supporting Information contains compilations of stratigraphic and low temperature thermochronologic observations. It also includes a complete reference list. These compilations, together with the interpreted data from the Paleobiology Database (PBDB), are provided as csv-formatted files and the reference list is provided as a PDF file.

Six figures included in this document as arranged in the following way. First, comparisons between observed uplift rates and those calculated by inverting North American drainage patterns when the erosional parameter, $v$, is either increased or decreased by one order of magnitude (Figures S1–S2). These diagrams show that changing $v$ in this way yields significantly poorer matches between observed and calculated uplift rates, which implies that the calibrated value we exploit for the purposes of this study is of the correct order of magnitude. Secondly, a suite of figures show the results from Badlands forward models that were generated using different starting conditions (Figures S3–S5). These starting conditions include those with no topography, with 1% and with 10% of present-day topography. Thirdly, a figure is included that shows the results of a test in which the spatial pattern of uplift rate history has been rotated by $90^\circ$ prior to being inserted into the Badlands model. The resultant drainage pattern demonstrates that the landscape model we employ is sufficiently flexible to permit drainage planforms to migrate. Hence any individual starting condition plays a minor role in determining the calculated history of landscape evolution.

Finally, the Supporting Information shows the isostatic balance and associated parameters used to determine the thickening factor for the lithosphere beneath the Colorado Plateau required to generate observed regional uplift.
Supporting Information: Figures

Figure S1 Testing effects of reducing value of erosional parameter, $v$, by one order of magnitude. (a) Comparison of uplift rates calculated by inverting drainage patterns and those determined from stratigraphic observations (see Figure 9 of main text for further details). Solid diagonal line $= 1:1$ relationship. (b) Comparison of uplift rates calculated by inverting drainage patterns and those determined from biosтратigraphic inventory. Blue circles $= $ significantly under-predicted values obtained by inverting drainage patterns. (c) Comparison of observed and calculated uplift rates as function of space. Labeled box shows panel d. Note that these results were obtained using parameterization with unrealistically small value of $v$, tends to under-predict uplift rates. (d) Zoom of panel c.
Figure S2 Testing effects of increasing value of erosional parameter, $v$, by one order of magnitude. (a) Comparison of uplift rates calculated by inverting drainage patterns and those determined from stratigraphic observations (see Figure 9 of main text for further details). Solid diagonal line = 1:1 relationship. (b) Comparison of uplift rates calculated by inverting drainage patterns and those determined from biosтратigraphic inventory. Red/blue circles = significantly over/under-predicted values obtained by inverting drainage patterns. (c) Comparison of observed and calculated uplift rates as function of space. Labeled box shows panel d. Note that these results were obtained using parameterization with unrealistically large value of $v$, tends to over-predict uplift rates. (d) Zoom of panel c.
Figure S3 Testing impact of alternative starting conditions used to initiate landscape evolution model. In this example initial topography was set to zero. Note that Badlands algorithm randomizes slopes to ensure channelisation.
Figure S4 Landscape evolution model where initial topography is 1% of present-day topography extracted from ASTER GDEM.
Figure S5 Landscape evolution model where initial topography is 10% of present-day topography extracted from ASTER GDEM.
Figure S6 Testing impact of alternative uplift history used to externally force landscape evolution model. Here, uplift history calculated by inverting drainage patterns was rotated by 90° and Badlands model was rerun. This approach largely preserves lengthscale and aspect ratio of inserted uplift pattern. Initial topography was set to 5% of present-day topography (i.e. initial condition was not rotated).
Supporting Information: Datasets

Dataset S1. Stratigraphic constraints: Marine to terrestrial transitions. This spreadsheet contains raw data compilation of youngest outcropping marine to non-marine transitions that include outcrop locations, formation names, ages, errors and generalized interpreted paleoenvironments.

Dataset S2. Stratigraphic constraints: Marine to terrestrial transitions. This PDF contains references for compiled stratigraphic data and geologic maps used to extract locations.

Dataset S3. Denudation constraints: Low-temperature thermochronology. This spreadsheet contains compiled thermochronometric Apatite Fission Track and (U-Th)/He measurements. It includes location, elevation, ages, errors, published geothermal profile and surface temperature.

Dataset S4. Denudation constraints: Low-temperature thermochronology. This PDF provides references for compiled dataset.

Dataset S5. Biostratigraphic constraints: PBDB. This spreadsheet contains unique fossil collection locations, elevations extracted from ASTER GDEM, ages, interpreted paleo-water depths, calculated cumulative uplift, uplift rate, and associated errors. X and Y coordinates are given for Albers Equal Area projection centered on 96°W, 40°N where standard parallels are 50°N and 70°N. PBDB inventory was downloaded from https://paleobiodb.org/ on 25th October 2017 for Campanian, Maastrichtian and Cenozoic time intervals.

Supporting datasets can be found at https://doi.org/10.14469/hpc/6019.
Supporting Information: Isostatic Calculation

A reference column of continental lithosphere is shortened uniformly by thickening factor, \( f \), to estimate value of \( f \) required to generate regional uplift, \( U \), where

\[
U = \frac{a \left[ (\rho_m - \rho_c) \frac{t_c}{a} \left( 1 - \frac{\alpha T_1}{2} \frac{t_c}{a} \right) - \alpha T_1 \rho_m \right]}{\rho_m (1 - \alpha T_1)} (f - 1).
\]

(1)

Respective densities of mantle and crustal rocks are \( \rho_m = 3.33 \) and \( \rho_c = 2.8 \) Mg m\(^{-3}\) at standard temperature and pressure, thermal expansion coefficient is \( \alpha = 3.28 \times 10^{-5} \) K\(^{-1}\), and temperature at the base of the plate is \( T_1 = 1333^\circ\)C. We assume a linear geothermal gradient and initial crust and lithospheric thicknesses of \( t_c = 30 \) km and \( a = 125 \) km, which are appropriate for a reference lithospheric column with zero elevation (i.e. \( U = 0 \)). Substitution of the values of these parameters yields \( U = 2.1(f - 1) \).

To produce 1.5 km of relief difference between Colorado Plateau and Great Plains (e.g. Figure 1a) by lithospheric thickening alone, requires crust and lithosphere beneath Colorado Plateau to be \( f = 1.7 \) times thicker than that beneath Great Plains.