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Supporting Information for

**Simulate modern and past erosion rates in response to tectonic and climatic forcing: an example from Himalaya-Karakoram mountains and Indus River Basin in southwest Asia**

Han Feng, Huayu Lu\*, Xianyan Wang, Zhiyong Han

School of Geography and Ocean Science; Nanjing University, Nanjing 210023, China.

\*Corresponding author: Huayu Lu (huayulu@nju.edu.cn)

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Text S1

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**Additional Supporting Information (Files uploaded separately)**

Captions for Tables S1, S2, S4 and S5

**Text S1** Changes in exhumation rate would perturb the initial thermal profile and alter the closure temperature of the thermal system in orogeny system (Herman et al., 2010; Willett et al., 2013). In this study, we used the AGE2E-DOT program (Brandon et al. (1998); see also Ehlers et al., 2005) to convert bedrock AFT ages to surface erosion rate. The program assumes a steady state thermal field and solves the advection diffusion equation for user-defined heat flux and material properties. In fast-eroding orogens such as the Himalaya and Karakoram, a transient thermal field will approach steady state very quickly and a steady state thermal field can be assumed (Stüwe et al., 1994; Rahl et al., 2007). The thermal properties input to the program are listed in Table S6. Because data on the radioactive heat production of the Karakoram and Kohistan-Ladakh arc are scarce, we used the average heat production of global granodiorite (2.7 𝜇W·m-3) for the Kohistan-Ladakh arc and a range between granodiorite and schist (1.5 to 2.7 𝜇W·m-3) for the Karakoram (Rybach and Cermak, 1982). Some of the properties have measured values within a range (i.e. the upper and lower limit of the parameters), and thus maximum and minimum simulated erosion rates could be obtained when we surveyed each combination of input parameters (Table S1) (Thiede et al., 2009).

**Table S1.** Compiled apatite fission track data and corresponding sub-basins (Files uploaded separately).

**Table S2.** Sediment yield data from gauge stations along the Indus River trunk and tributaries, compared with the modeled erosion mass upstream for each gauge station (Files uploaded separately).

**Table S3.** Neogene and Paleogene sedimentary volumes of depositional localities in the Indus River Basin (Clift et al., 2001) and the corresponding sedimentation rate for each time interval based on age-thickness data (Burbank et al., 1996; Najman, 2006; White et al., 2001; Antoine et al., 2013).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Total Neogene sediment volume (103 km3) | Total Paleogene sediment volume (103 km3) | Sedimentation rate (Mt/yr) | | | | | |
|  | 0-  1.8  Ma | 1.8-  5.3  Ma | 5.3-11.4  Ma | 11.4-16.3  Ma | 16.3-23.6  Ma | 23.6-54.9  Ma |
| Indus Fan | 2670.5 | 1438 | 214.4 | 114.1 | 188.1 | 237.8 | 142.7 | 90.5 |
| Foreland Basin | 1114.2 | 278.6 | 107.8 | 88.6 | 75.9 | 48.2 | 48.9 | 12.5 |
| Katawaz Basin | 0 | 390 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 17.4 |
| Sulaiman and Kirthar | 390 | 0 | 11.9 | 46.3 | 46.3 | 18.8 | 10.9 | 3.0 |
| Makran | 0 | 1299.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 58.1 |
| Total | 4174.7 | 3406.5 | 334.1 | 249.0 | 310.3 | 304.7 | 202.4 | 181.6 |

**Table S4** Carbon and oxygen isotope record from pedogenic carbonates within the Indus River Basin (Files uploaded separately).

**Table S5** Carbon and oxygen isotope record from mammalian tooth enamel within the Indus River Basin (Files uploaded separately).

**Table S6.** Thermal properties of the rocks composing the tectonic blocks in the Indus River Basin which were input to the AGE2E-DOT program.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | | Published value | Reference |
| Heat production | GHS | 0.8 to 3.0 𝜇W·m-3 | England et al., 1992  Whipp et al., 2007 |
| THS | 0.5 𝜇W·m-3 | Rybach, 1976 |
| LHS | 0.8 𝜇W·m-3 | Roy and Rao, 2000 |
| Karakoram | 1.5 to 2.7 𝜇W·m-3 | Rybach, 1982 |
| Kohistan-Ladakh | 2.7 𝜇W·m-3 | Rybach, 1982 |
| Surface thermal gradient | | 20 to 40 °C·km-1 | Thiede et al., 2009 |
| Surface temperature | | 10 °C | Adlakha et al., 2019 |
| Upper crust thickness | | 30 km | Adlakha et al., 2019 |
| Thermal conductivity | | 2.0 to 3.5 W·m-1K-1 | Ray et al., 2007  Thiede et al., 2009 |