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How do basin margins record long-term tectonic and climatic changes?

Supplementary documents

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1. Table S1. Rates of precipitation, uplift, subsidence, and eustatic sea level of Models 1-14

Model Number	Precipitation (m/yr)		Uplift rate (m/My)		Subsidence rate (m/My)	Rate of eustatic sea-level rise (m/My)
	0-15 My	15-30 My	0-15 My	15-30 My	15-30 My	15-30 My
1	1	1	250	500	-	-
2	1	1	250	125	-	-
3	1	2	250	250	-	-
4	1	0.5	250	250	-	-
5	1	2	250	500	-	-
6	1	0.5	250	500	-	-
7	1	2	250	125	-	-
8	1	0.5	250	125	-	-
9	1	1	250	500	0-100 (See Fig. 1B	-
10	1	1	250	500	0-100 (See Fig. 1B)	-
11	1	1	250	500	-	10

12	1	2	250	250	0-100 (See Fig. 1B	-
13	1	2	250	250	0-100 (See Fig. 1B	-
14	1	2	250	250	-	10

Table S1. Rates of precipitation, uplift, subsidence, and eustatic sea level of Models 1-14

2. Table S2. Input parameters for Models 1-14

Parameter	**Value**
Domain length (x axis) (km)	1500
Domain length (y axis) (km)	500
Grid spacing (km)	4
Run period (My)	30
Time Steps (My)	0.5
Precipitation (m/yr)	0.5-2 (See Table S1)
Uplift rate (m/My)	125-500 (See Table S1)
k_d (See Equation 2)	$6.5*10^{-7}$
l (See Equation 2)	0
m (See Equation 2)	0.5
n (See Equation 2)	1

Surface diffusion coefficient (m^2/yr)	$2.5*10^{-2}$
Marine diffusion coefficient (m^2/yr)	$5*10^{-2}$

2. Table S2. Input parameters for Models 1-14

3. Explanations for Animations 1-4

See attached GIF files ‘Animation1_Model1.gif’, ‘Animation2_Model2.gif’, ‘Animation3_Model3.gif’, and ‘Animation4_Model4.gif’. Each animation shows the time slides of inputs (uplift and precipitation), outputs (sediment discharge and basin-margin progradation rate), the map showing the deposition or erosion rates, and the topography map. The time steps are shown by the vertical lines in the ‘Input’ and ‘Output’ plots.

Figure S1 below highlights the erosion rate of source areas of Model 1 and Model 3 from 15 to 18 My. With increasing uplift rate, erosion rate increases the most in channels. With increasing precipitation, the changes of erosion rate are higher in the ridges between channels.

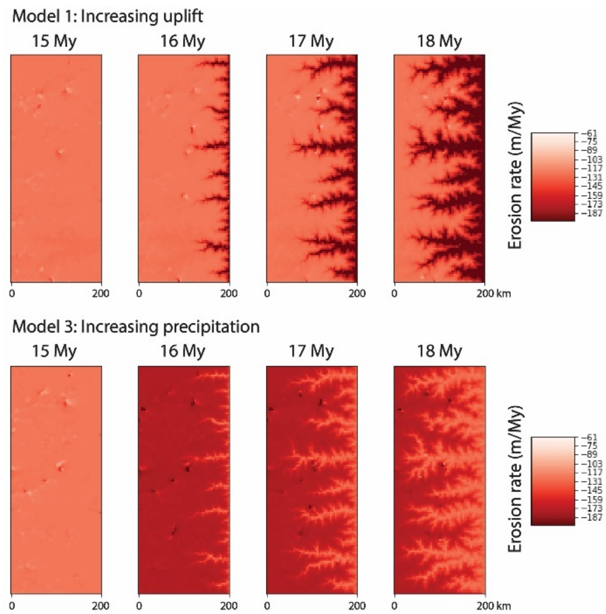

Figure S1. Maps showing the erosion rate of source areas of Models 1 and 3 from 15 to 18 My. Topography, sediment discharge, and margin progradation rate for each time step of Models 1 and 3 can be found in the attached GIF files.

4. Applications to interpreting ancient basin-margin evolutions

When the role of relative sea level can be ruled out (i.e., accelerating margin progradation under rising relative sea level or decelerating margin progradation under falling relative sea level), tectonic and climatic signals can be detected from basin-margin progradation. Field data from Cretaceous Colville basin (Alaska, US) shows the eastern shallowing foreland basin geometry and back-tilting subsidence geometry (Fig. S2A), favoring the autoacceleration of clinoform progradation (Lopez et al., 2014); however, it decelerated fourfold from 52 km/My during 115-107 Ma to 13 km/My during 107-98 My (Lease and Houseknecht, 2017; Houseknecht, 2019). The large magnitude of basin-margin progradation rate decrease, together with decreasing accommodation, indicates a decreasing uplift rate. The progradation rate of

Miocene-Holocene Qiongdongnan basin margin increases up to 7 times at 2.4 Ma (Fig. S2B). It achieved a higher steady state, 13 km/My, from 1.9-0 Ma, compared to 3-9 km/My from 10.5-2.4 Ma (Chen et al., 2019). We interpret that the Qiongdongnan basin-margin evolution is resulted by increasing precipitation and uplift rate, considering the rising relative sea level from Miocene to Holocene in Qiongdongnan basin (Zhao et al., 2016; Chen et al., 2019).

As Models 9-14 show, besides uplift and precipitation, long-term relative sea-level change, especially the tectonic-induced subsidence, can affect the basin-margin progradation rate. This often results in non-unique explanations on the controls on the basin-margin evolutions. For example, in Cretaceous Magallanes basin (Chile), the best estimate of basin-margin progradation rate abruptly increases from 28 km/My during 78.0-75.7 Ma to 40 km/My during 75.7-75.2 Ma then decreases to 8 km/My during 75.2-70.6 Ma (Fig. S2C) (Daniels et al., 2018). This trend could be explained by an increasing precipitation and decreasing uplift rate as the abrupt change and lower steady state of basin-margin progradation rate (See Model 6 in Fig. 2C). However, the lower basin-margin progradation rate during 75.2-70.6 Ma could be also caused by relative sea-level rise (See Models 12-14 in Fig. 3C). The dominant control is difficult to determine with the current temporal resolution of basin-margin progradation history.

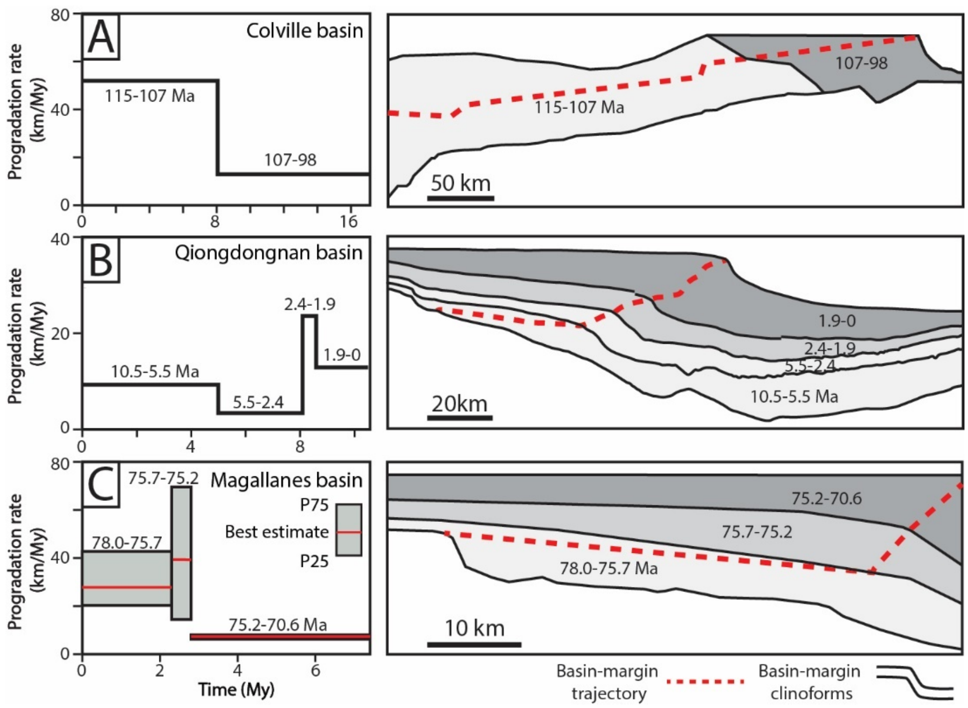

Figure S2. Basin-margin progradation rate and sketches of basin-margin evolutions of A) Cretaceous Colville basin (Alaska, US) (Lease and Houseknecht, 2017; Houseknecht, 2019), B) Miocene-Holocene Qiongdongnan basin (China) (Chen et al., 2019), and C) Cretaceous Magallanes basin (Chile) (Daniels et al., 2018).

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