The Rate of Deposition Depends on How Long It Is Measured, and Over One Year It Looks 80.152928 Times the Long-Run Rate

— the boundary time is $(\sigma/\mu)^2 = 10000$ years, and shorter windows measure the surface's fluctuation while longer windows measure the mean build-up — the separator is whether the surface goes back and forth (whether there is erosion) — [Paper 785]

Yuuki YAMAGISHI (山岸 勇輝)
Yamagishi Complexity Torus Lab, Japan
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— From thinking to syncing. —

Abstract

Dividing a layer's thickness by the time it took to accumulate gives a rate of deposition. It is well known that short intervals give large rates and long intervals small ones.With a simple model of a surface that builds up and wears down, how much the window length changes the rate is counted.No new theorem or law is claimed. First, the rate over a short window is far larger than the long-run rate——1.603059 mm per year over a 1-year window, 80.152928 times the long-run rate (Section 2). **Second, lengthening the window lowers the rate roughly as the inverse square root of the window——the logarithmic slope for short windows is -0.491030** (Section 2). **Third, and this is the core. Beyond a boundary time, the rate flattens to the mean build-up——boundary $(\sigma/\mu)^2 = 10000$ years; 1.287600 times at 10000 years, 1.000851 times at 100000 years** (Section 2). **Fourth, the share of windows that keep any thickness also depends on window length——0.503989 for 1 year, 0.841345 for 10000 years** (Section 2). **Fifth, a random walk gives the same——over one million years the slope is -0.492504 and the largest departure from the formula is 1.046 standard errors** (Section 3). **Sixth, the separator is whether the surface goes back and forth (whether there is erosion)——"this layer accumulated quickly" has no truth value until one says over what length of window it was measured** (Section 4). **Keywords**: deposition rate, Sadler effect, stratigraphic gaps, random walk, measurement span, erosion.

Scope of this paper (scope note): **No new theorem or law is claimed——longer measurement spans giving smaller deposition rates (the Sadler effect), its origin in gaps left in the record by alternating build-up and erosion, and the properties of a random walk with drift are all known (Sadler 1981, Feller 1968).Only one model——yearly change is taken as normal with mean 0.02 mm and spread 2 mm, and rates are measured only over windows that kept thickness.No real basin is treated——which layers accumulated at what rate is not claimed.Compaction and diagenesis are left out——changes in thickness after deposition are not treated.Dating is not treated——window lengths are taken as known exactly.Relation to earlier papers**: **Paper 312 showed that some noise falls when you measure longer, and some does not——its scope note stated that no theory of noise was built, using only two formulas and one crossing. There the noise floor changed with measuring time and swapped at a crossing. Here the rate itself changes with measuring time and settles to the mean build-up past a boundary time. The noise floor, and the rate itself.**What is added is **writing the rate over windows that kept thickness as a conditional mean of the normal distribution**, **tabulating rates and surviving shares over nine windows and showing the boundary at 10000 years**, **counting the same rates and slope from a one-million-year random walk**, and **placing the separator on whether the surface goes back and forth**.

1. Notation and the Question

Setting: **let the yearly change in surface height be normal with mean μ and spread σ. The change ΔH over a window of D years is also normal, and measuring the rate only over windows that kept thickness ($\Delta H > 0$) gives the following (ϕ and Φ are the standard normal density and cumulative distribution).**

$$\Delta H \sim \mathcal{N}\left(\mu D,\, \sigma^2 D\right), \qquad r(D) = \frac{\mu D + \sigma\sqrt{D}\,\phi(z)/\Phi(z)}{D}, \qquad z = \frac{\mu\sqrt{D}}{\sigma}$$

Take $\mu = 0.02$ mm and $\sigma = 2$ mm. For short windows r goes as $\sigma/\sqrt{D}$, for long ones it approaches μ, and the boundary is $D^* = (\sigma/\mu)^2$.

Question: **is the deposition rate measured from layers a single number independent of window length?**

2. Window Length and Rate

Computation 2.1: **for nine windows, the rate over windows that kept thickness, its ratio to the long-run rate of 0.02 mm per year, and the share of windows that keep thickness were derived.**

window	measured rate	ratio to long run	share keeping thickness
1 year	1.603059 mm/yr	80.152928	0.503989
10 years	0.511963 mm/yr	25.598172	0.512614
100 years	0.167066 mm/yr	8.353317	0.539828
1000 years	0.058458 mm/yr	2.922877	0.624085
10000 years	0.025752 mm/yr	1.287600	0.841345
100000 years	0.020017 mm/yr	1.000851	0.999217
10^6 years	0.020000 mm/yr	1.000000	1.000000
10^7 years	0.020000 mm/yr	1.000000	1.000000
10^8 years	0.020000 mm/yr	1.000000	1.000000

Observation 2.2

the rate over a short window is far larger than the long-run rate.Over a 1-year window it is 1.603059 mm per year, 80.152928 times the long-run rate. The logarithmic slope over 1 to 100 years is -0.491030, so the rate falls nearly as the inverse square root of the window——a short window measures not the mean build-up but the size of the surface's fluctuation.

Observation 2.3

this is the core: beyond a boundary time, the rate flattens to the mean build-up.The boundary is $(\sigma/\mu)^2 = 10000$ years; the ratio is 1.287600 at 10000 years, 1.000851 at 100000 years, and the slope over 10^6 to 10^8 years is 0.000000——extending a slope of $-1/2$ over eight decades would give 10^{-4} at 10^8 years, but with a mean build-up it stops at $1/80.152928$.

Observation 2.4

the share of windows that keep any thickness also depends on window length.For a 1-year window it is 0.503989, so half are worn away leaving nothing, rising to 0.841345 at 10000 years and 0.999217 at 100000 years——a short window can only measure where some thickness happened to survive.

3. A Random Walk

Computation 3.1: **one million years of yearly changes were drawn at random and summed into a surface height, and rates and surviving shares counted over non-overlapping windows.**

window	rate (random)	rate (formula)	share (random)	share (formula)
1 year	1.602541	1.603059	0.503426	0.503989
10 years	0.513115	0.511963	0.509910	0.512614
100 years	0.165883	0.167066	0.537600	0.539828
1000 years	0.058575	0.058458	0.593000	0.624085
10000 years	0.023975	0.025752	0.810000	0.841345

Observation 3.2

a random walk gives the same.The largest departure of the rates from the formula is 1.046 standard errors, the slope over 1 to 100 years is −0.492504 (formula −0.491030), and the ratio of rates at 1 and 10000 years is 66.840993——one single surface history gives different rates just by changing window length.

4. The Separator

Observation 4.1

the separator is whether the surface goes back and forth (whether there is erosion).If the surface only ever moved one way, every window would give 0.02 mm per year. If it goes back and forth, windows shorter than the 10000-year boundary measure the fluctuation, looking 80.152928 times faster over one year——"this layer accumulated quickly" has no truth value until one says over what length of window it was measured.

Observation 4.2

beside Paper 312.Paper 312 showed that some noise falls when measured longer and some does not, swapping at a crossing——here what falls when measured longer is not noise but the rate itself, settling to the mean build-up past a boundary time.

Observation 4.3

what is not said.Neither the rates of real layers, nor compaction, nor dating is treated——what is shown is that the rate is a function of window length, and windows shorter than the boundary measure fluctuation.

5. Roll Call and Closing

1. **1.603059 mm per year over 1 year** (Computation 2.1): **a short-window rate.**
2. **80.152928 times the long run** (Observation 2.2): **looks large.**
3. **slope −0.491030** (Observation 2.2): **inverse square root.**
4. **boundary 10000 years** (Observation 2.3): **$(\sigma/\mu)^2$.**
5. **1.000851 times at 100000 years** (Observation 2.3): **the core.**
6. **surviving share 0.503989 to 0.841345** (Observation 2.4): **changes with window.**
7. **random-walk slope −0.492504** (Observation 3.2): **the same shape.**
8. **largest departure 1.046 standard errors** (Observation 3.2): **matching the formula.**
9. **ratio of 1-year to 10000-year rates 66.840993** (Observation 3.2): **from one history.**
10. **back and forth or not** (Observation 4.1): **the separator; Paper 312.**

Closing: **The rate of deposition depends on how long it is measured, and over one year it looks 80.152928 times the long-run rate.On a surface that builds up and wears down each year with mean 0.02 mm and spread 2 mm, the rate measured over windows that kept thickness is 1.603059 mm per year for one year, 8.353317 times for 100 years, 1.287600 times for 10000 years and 1.000851 times for 100000 years——the short-window slope is −0.491030, and past the 10000-year boundary the rate flattens to the mean build-up.A one-million-year random walk gives the same shape, with slope −0.492504 and departures of at most 1.046 standard errors——short windows measure fluctuation and long windows the mean build-up.The separator is whether the surface goes back and forth (whether there is erosion).Placed among the earlier papers——Paper 312 counted a noise floor changing with measuring time; this counts the rate itself changing.To be honest——there is only one model, and neither real layers, compaction nor dating is treated.**

References

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Yuuki YAMAGISHI (山岸 勇輝)

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