

Partial Resetting on Hf-W System by Giant Impacts

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1. Hf-W Chronometry

- $^{182}\text{Hf} \rightarrow ^{182}\text{W}$ (half-life $\sim 9\text{My}$)
 - Hf: lithophile W: siderophile
 - Hf, W: both highly refractory

Ideal chronometer for metal/silicate segregation

$$\varepsilon(t) = \left[\frac{\left(^{182}\text{W} / ^{184}\text{W} \right)}{\left(^{182}\text{W} / ^{184}\text{W} \right)_{CHUR}} - 1 \right] \times 10^4$$

metal/silicate segregation
at $t = \tau$



observable value $\varepsilon(t)$ is
described as a function
of the age τ

2. Previous Studies

[Lee & Halliday, 1995]

Core formation age

[Yin et al., 2002]

Revised data → Core formation age ~ 29 My

[Jacobsen & Harper, 1990]

[Halliday, 2003]

Considering part

giant impact

→ perfect equilibration
of Hf-W system

giant impact

→ non-perfect equilibration
of Hf-W system

We will show you the physics
of non-perfect equilibration

3. Equilibration by G.I.

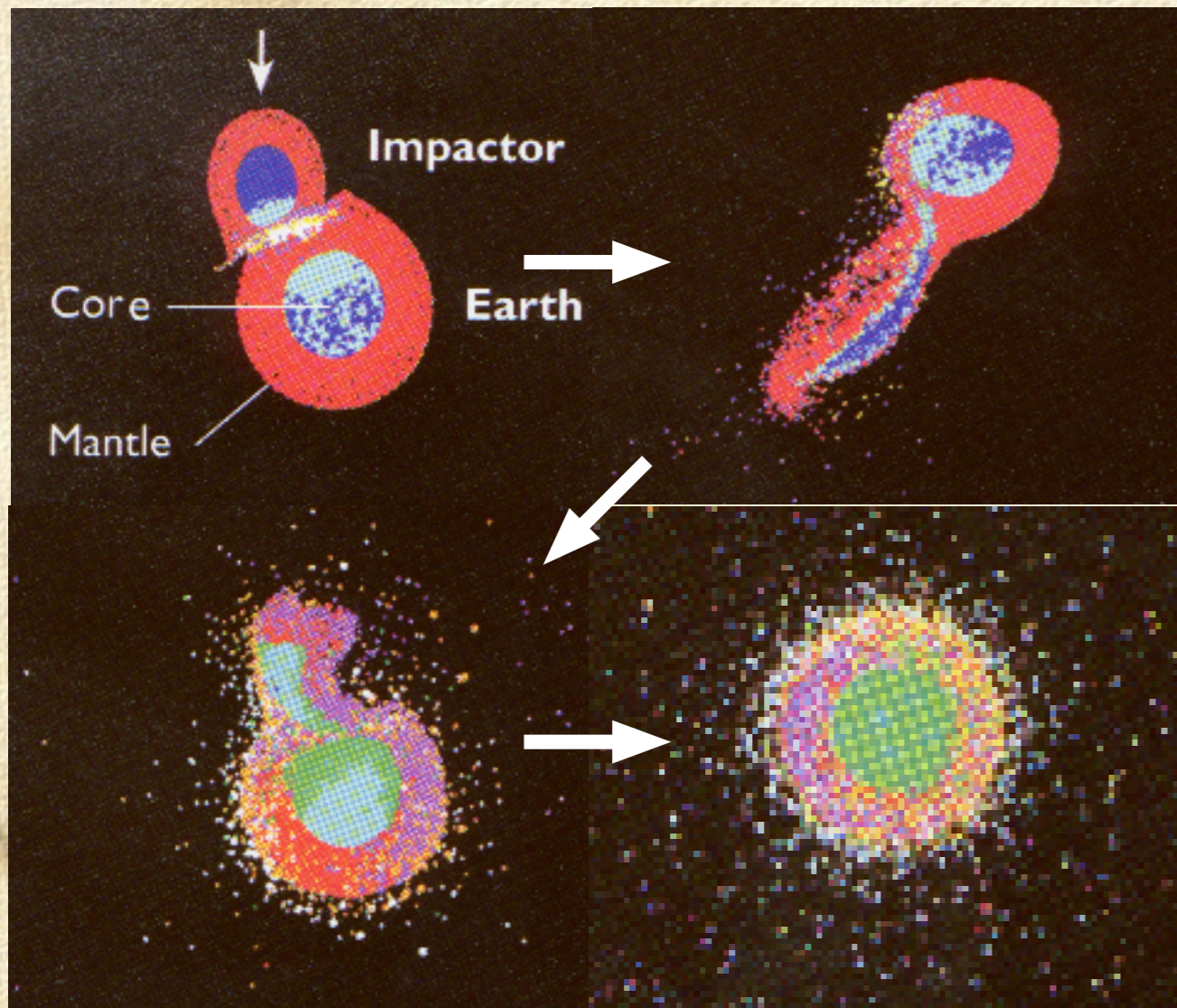


Fig : Result of Smooth Particle Hydrodynamics simulation

[Cameron, 1997]

Impactor's core breaks into pieces and accrete to the Earth

↓
equilibrate Hf-W system during sinking in the Earth's mantle

Small size ($\sim 50\text{cm}$) metal must be formed to achieve perfect equilibration of Hf-W system

[Sasaki & Abe, 2003]

but

SPH simulations don't have enough resolutions

- Small sized metal spheres can be formed

[Rubie et al., 2003]

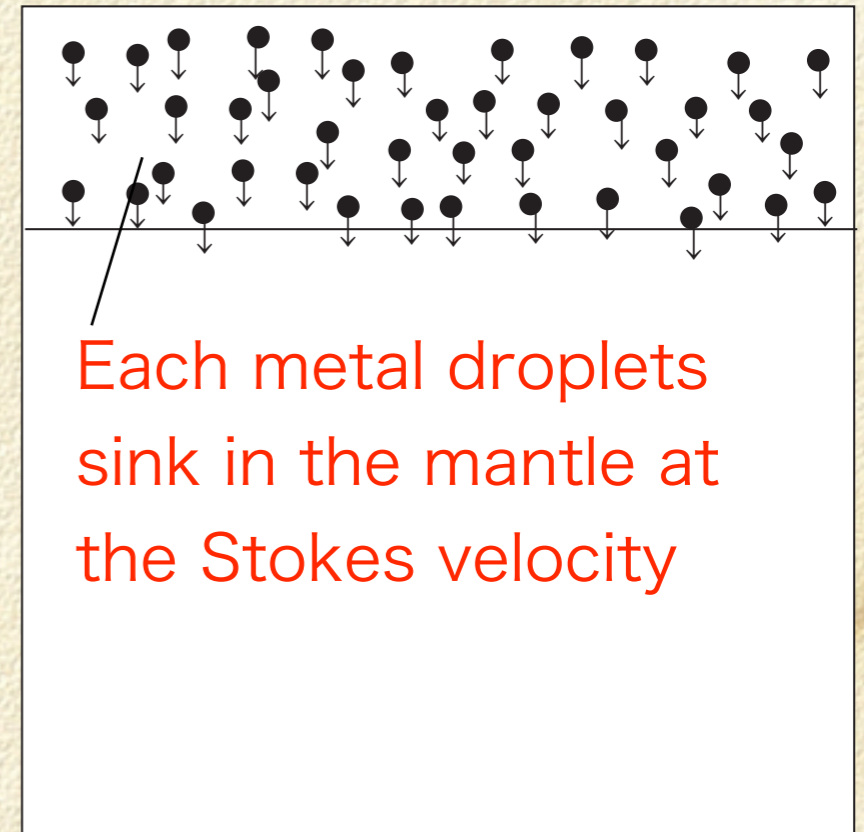
Splitting of accreted metal
by the Rayleigh-Taylor instability

→ form **cm-sized droplets**

(“rainfall droplets”)



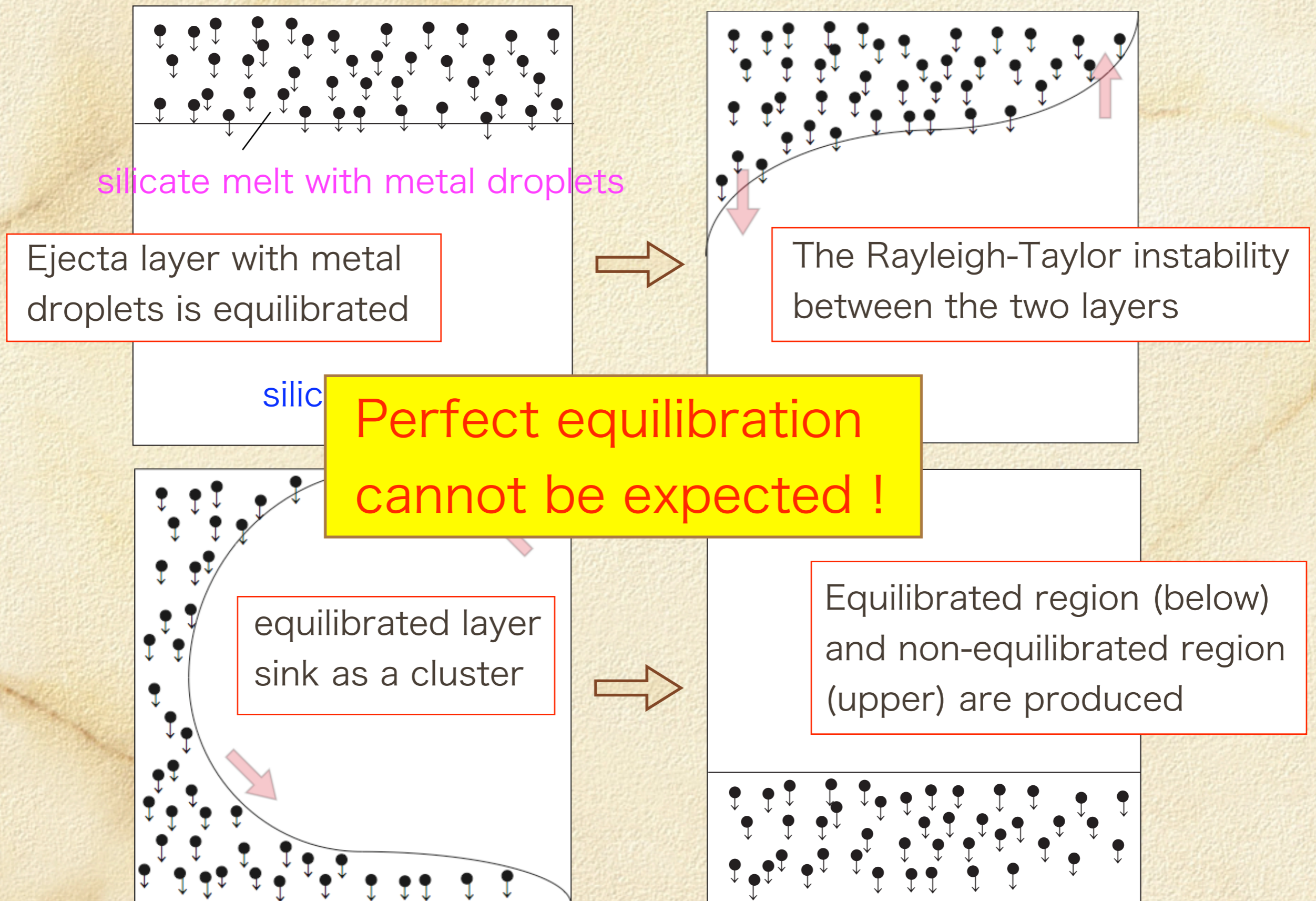
Perfect equilibration is realized?



We point out

another type of R-T instability between the ejecta layer
with metal droplets and silicate layer of metal free

■ Fig 1 . Sketch of metal droplet's behavior after G.I.



4. Model Calculations

- We calculate the isotopic evolution parameters: **resetting ratio by a giant impact** and **the number of giant impacts**

equilibrated volume of mantle

||

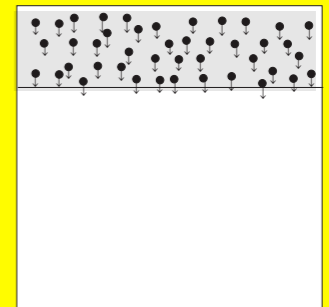
the volume of layer with metal droplets

||

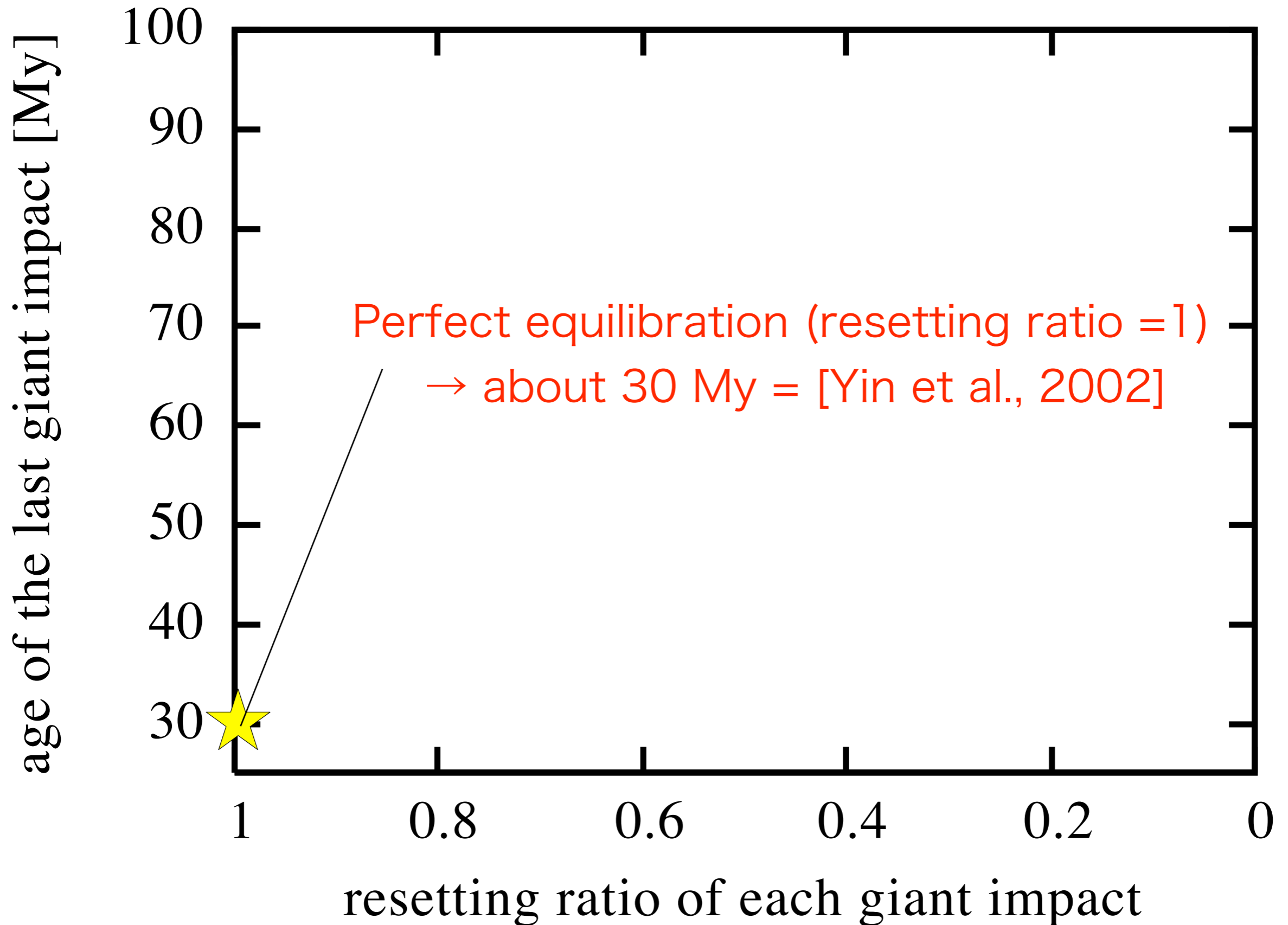
the volume of ejecta formed by a giant impact



“resetting ratio”



■ Fig 2. Age of last G.I. assuming a resetting ratio



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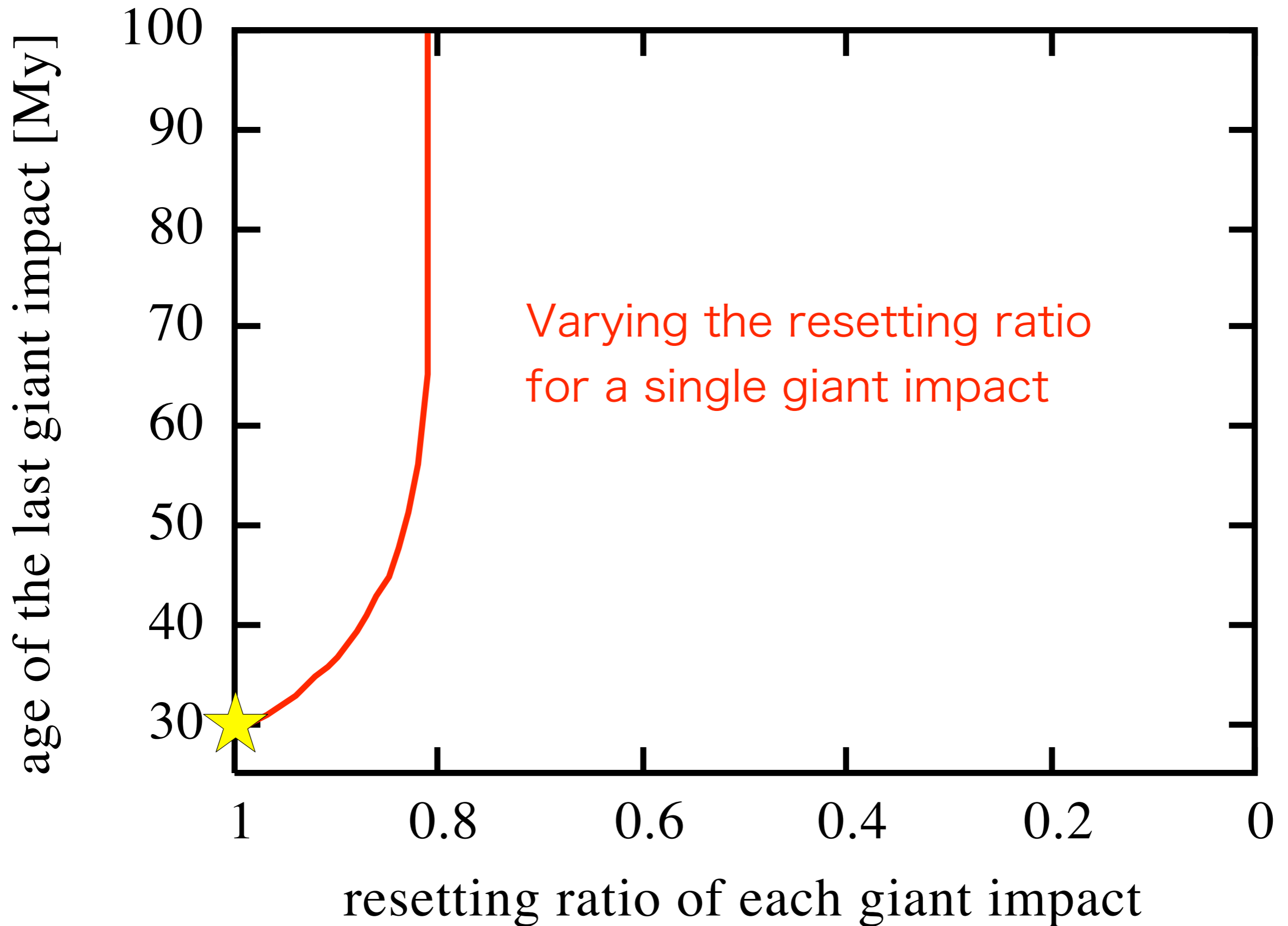
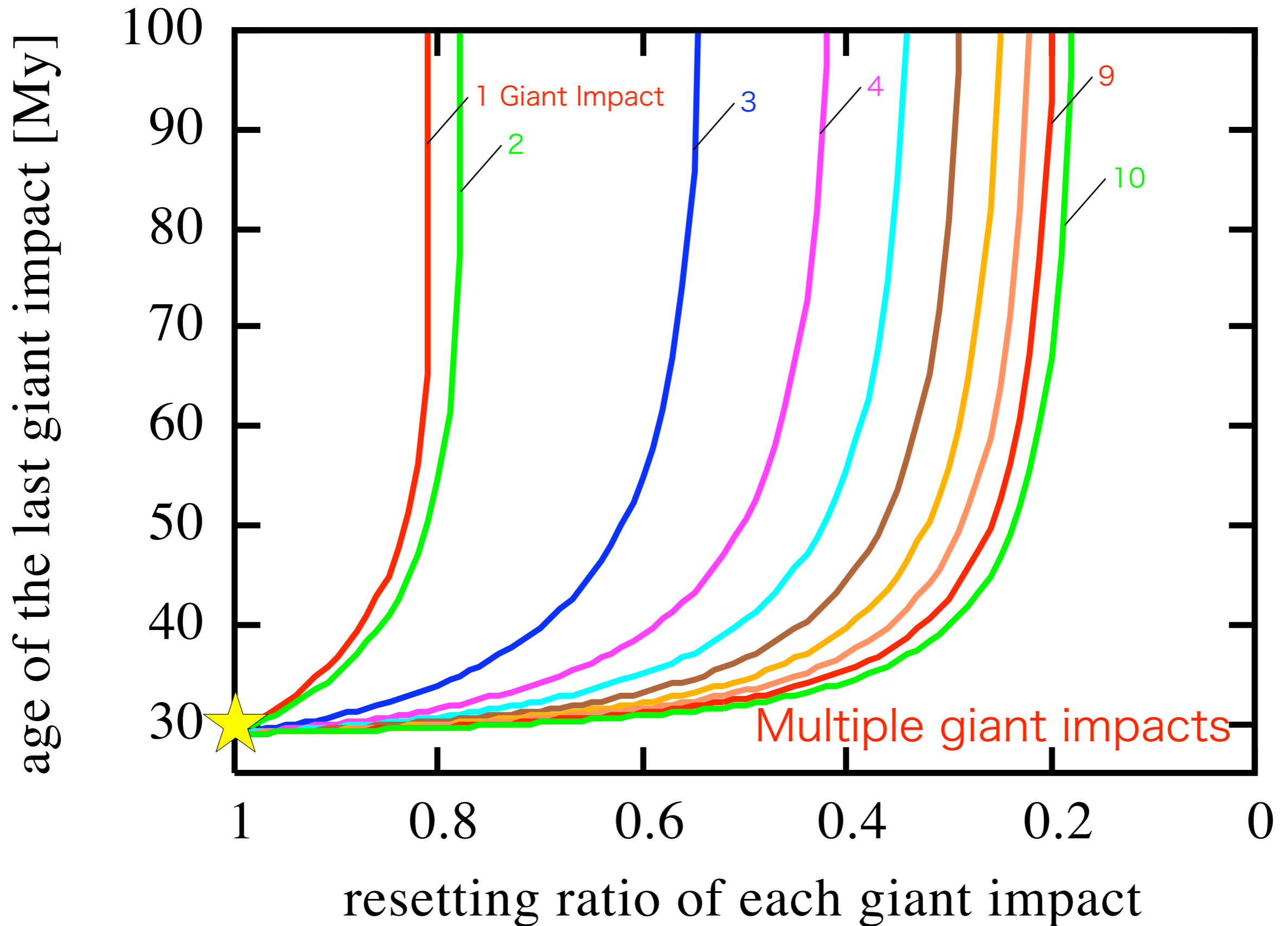


Fig 2. Age of last G.I. assuming a resetting ratio



5. Discussions (1)

- Age vary dramatically along with varying of resetting ratio and the number of giant impacts



Considering collision conditions and the number of G.I. is essential to age estimation by Hf-W system

- Reseting ratio of each giant impact is required > 0.2



Ejecta volume should be more than two-tenth volume of whole mantle of protoearth

5. Discussions (2)

□ ϵ values of the Mars' samples

SNC meteorites values : $\epsilon = 2 \sim 5$ [Lee & Halliday, 1997]

→ The lowest value ($\epsilon = 2$) may be valid

[Yin, personal communication]

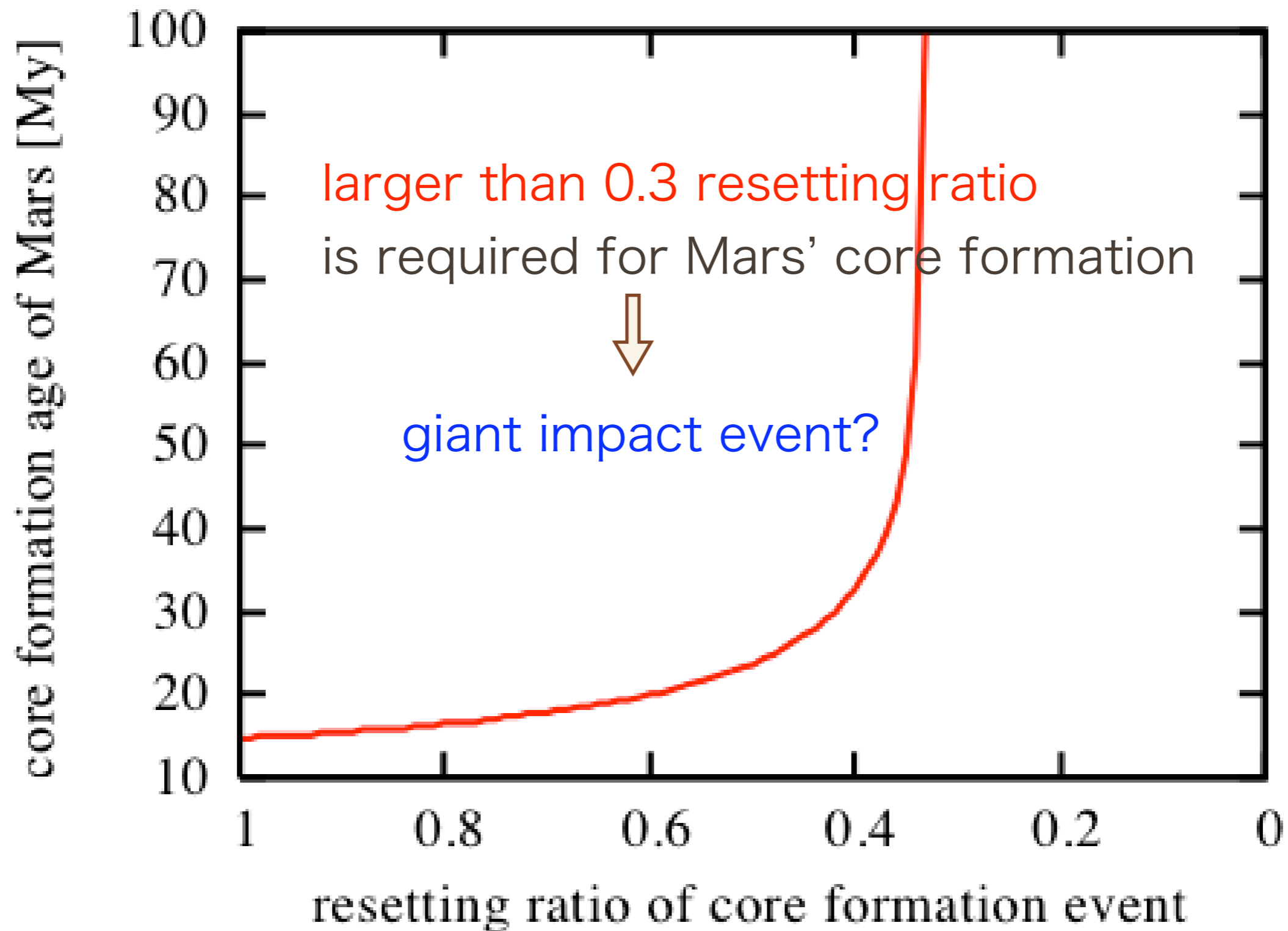


We calculate the isotopic evolution for Mars as the same way of the Earth's case using $\epsilon = 2$



We discuss the core formation event of Mars

■ Fig 3. Age of core formation of Mars



Summary

- Non-perfect equilibration of Hf-W system by giant impacts can be actually realized.
- Collision conditions and the number of giant impacts affect the estimation of the average formation age of the Earth by Hf-W chronometer.
- The ejecta volume should be more than two-tenth of volume of protoearth's mantle.
- Mars should have experienced a certain severe event, which is potentially a single giant impact.