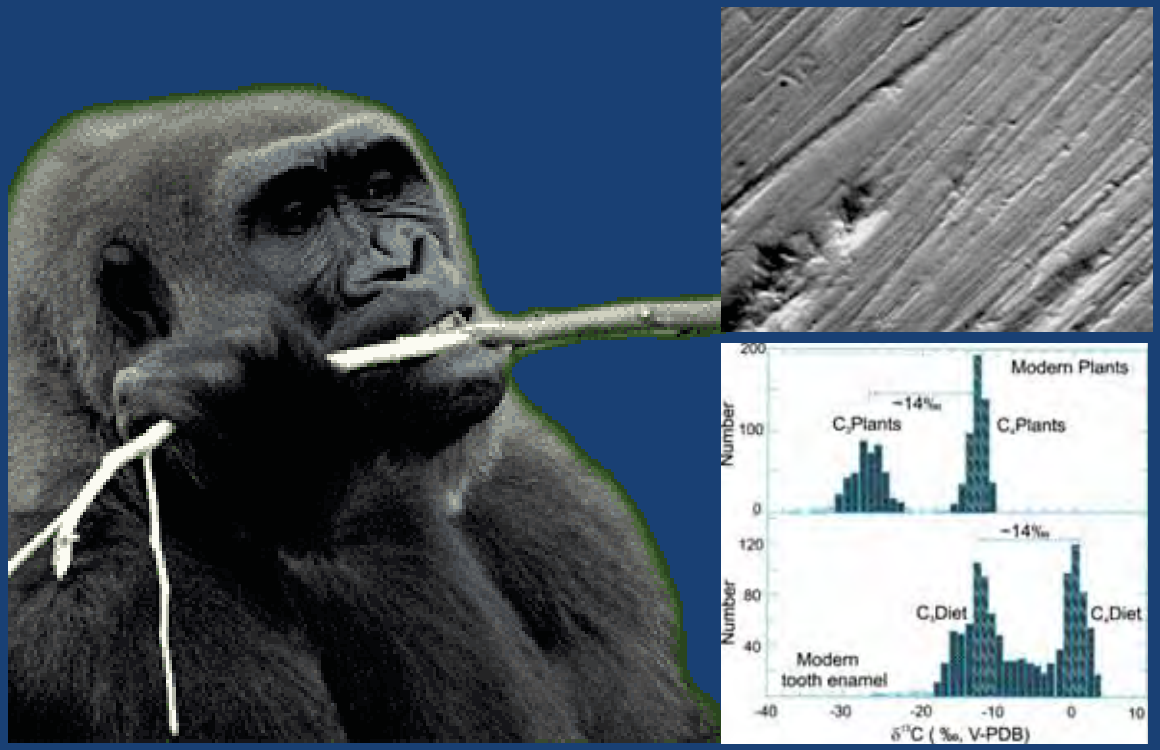
Reconstructing diet and environment of Ancient mammals of India using stable isotopes and microwear



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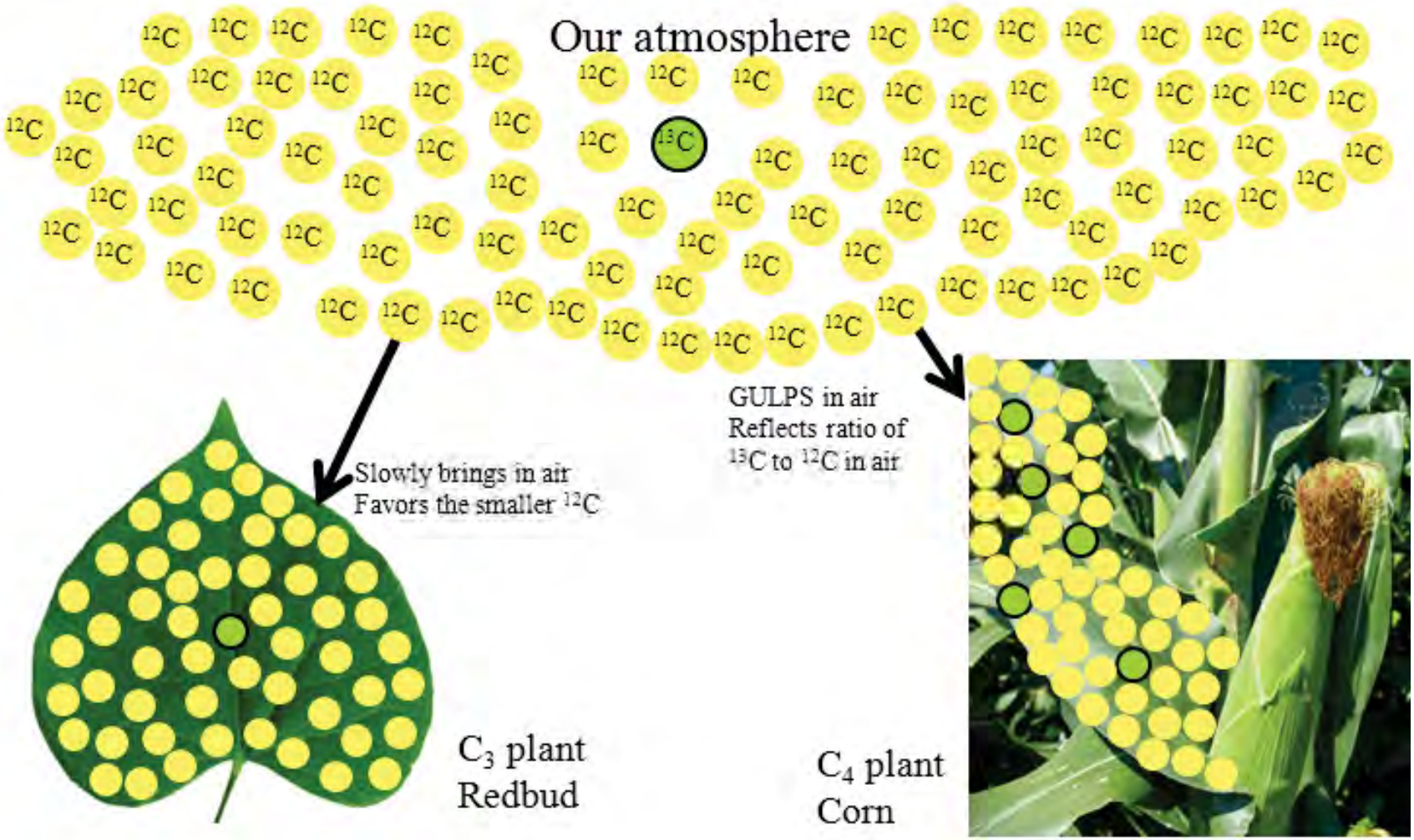
Overview

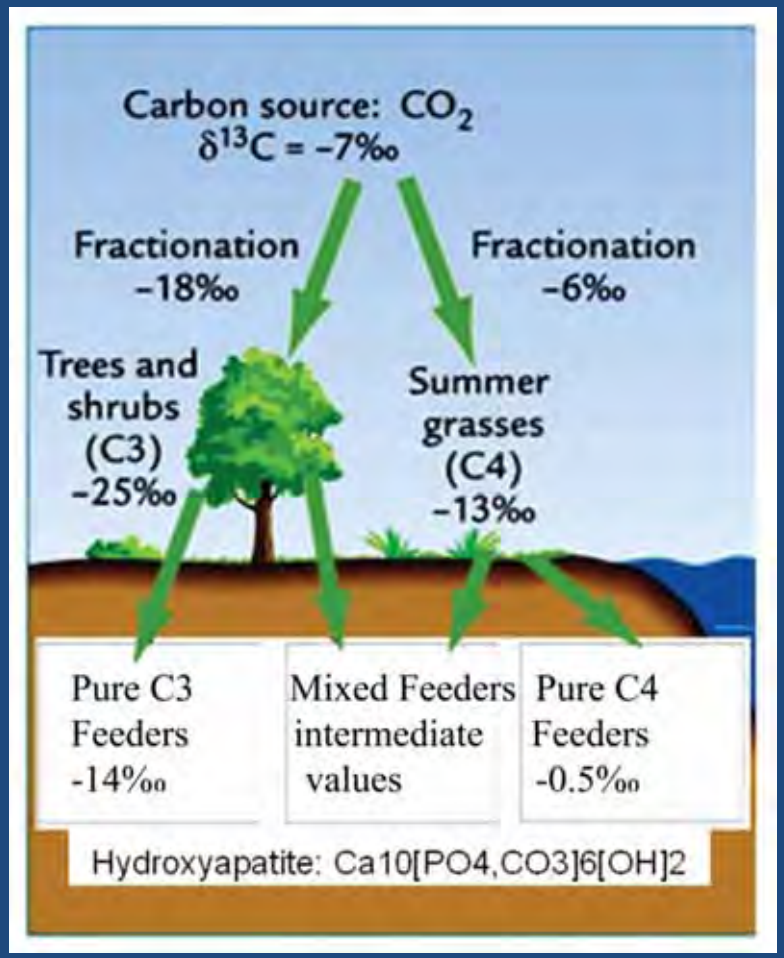
- **Stable carbon and Oxygen isotopes in mammalian teeth: an archive for diet and environment**
- **Micro-scratches preserved on tooth enamel**
- **Case studies on mammals (Elephants, Primates and Rodents) to reconstruct their Palaeodiet , Palaeoecology, Palaeoclimate**
- **Concluding remarks**

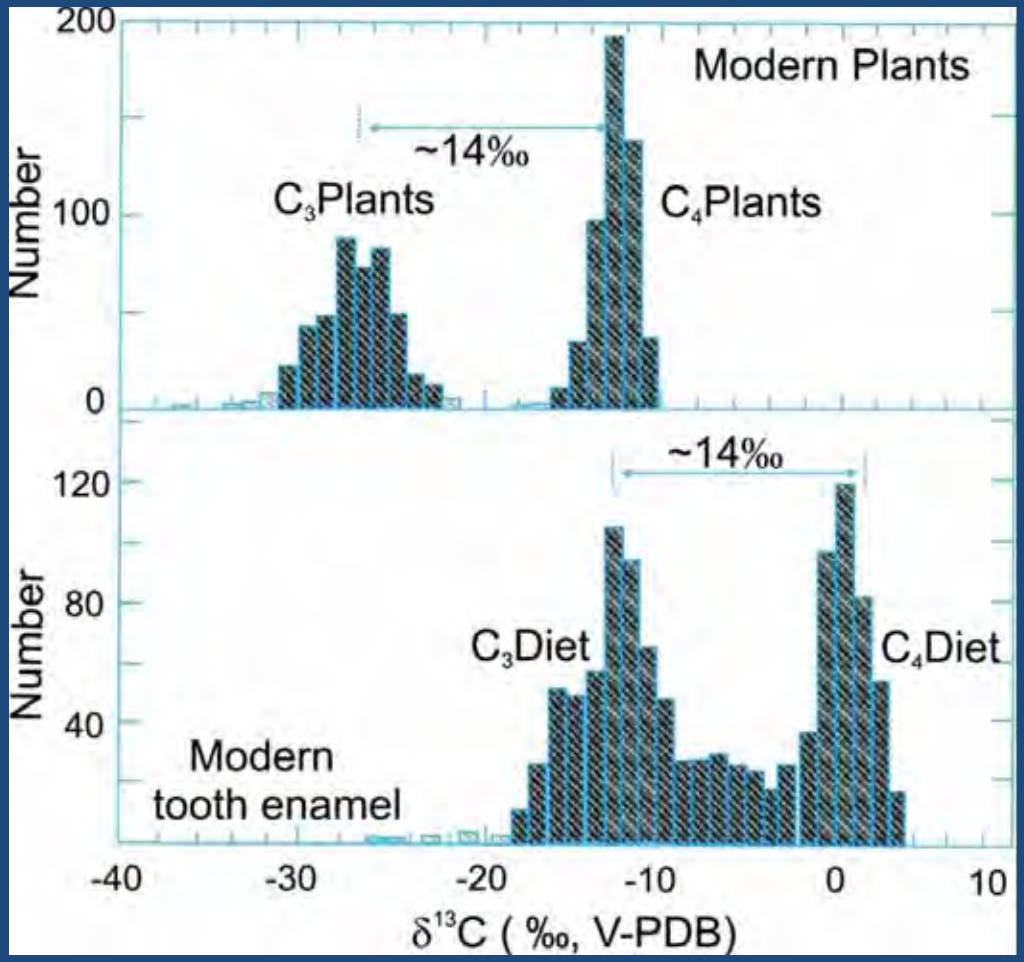
Isotopes in Dental Enamel

Sivapithecus sivalensis
(10 MILLION YEARS OLD)

- Tooth enamel (bioapatite) is highly resistant to isotopic alteration compared to dentine and bone and stays unaltered for Millions of Years
- *It is composed of tightly packed crystallites of biogenic* hydroxyapatite ($Ca_{10}[PO_4,CO_3]_6[OH]_2$)

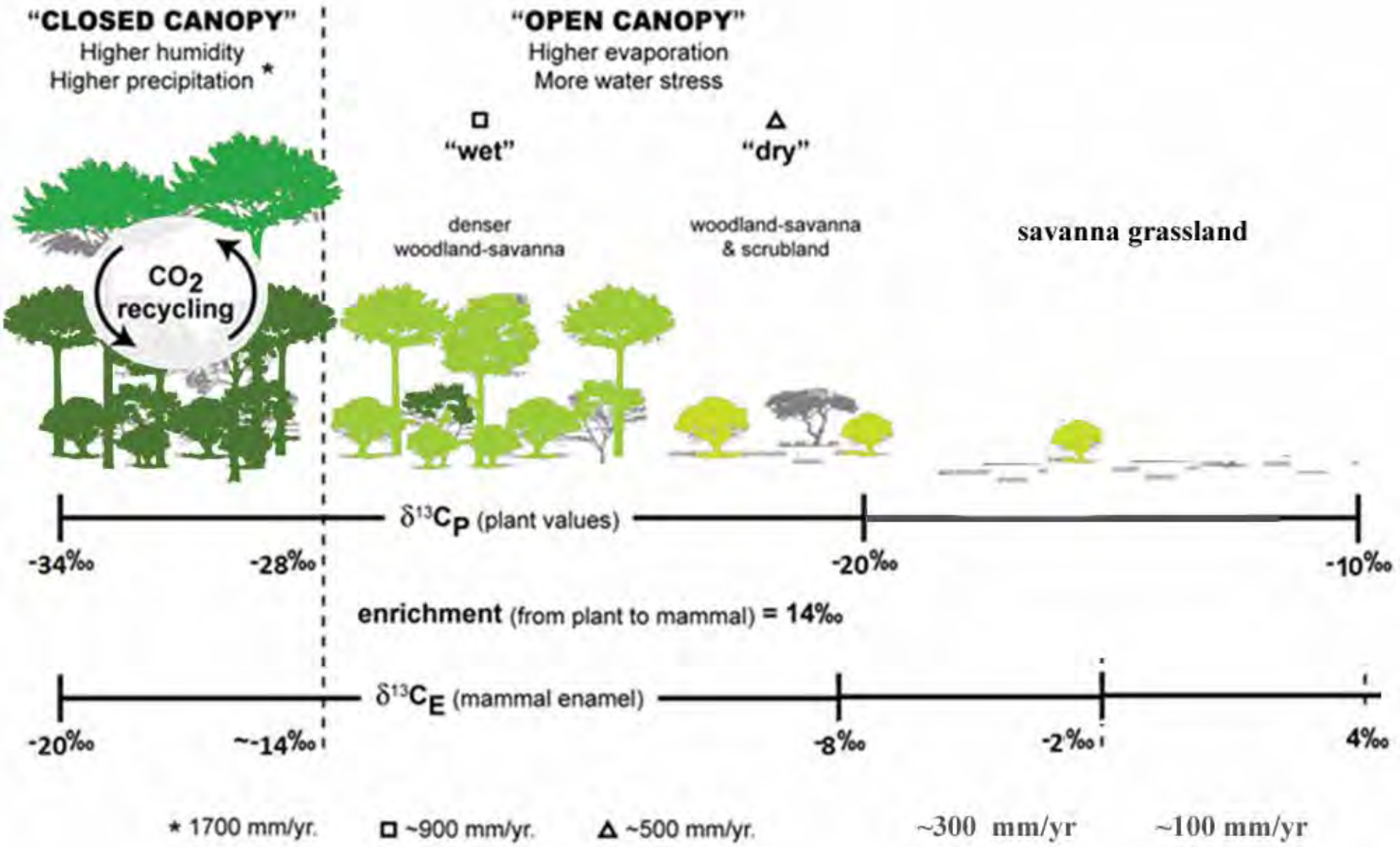

Our atmosphere
^{12}C
^{13}C
GULPS in air
Reflects ratio of
^{13}C to ^{12}C in air
Slowly brings in air
Favors the smaller ^{12}C
C_3 plant
Redbud
C_4 plant
Corn





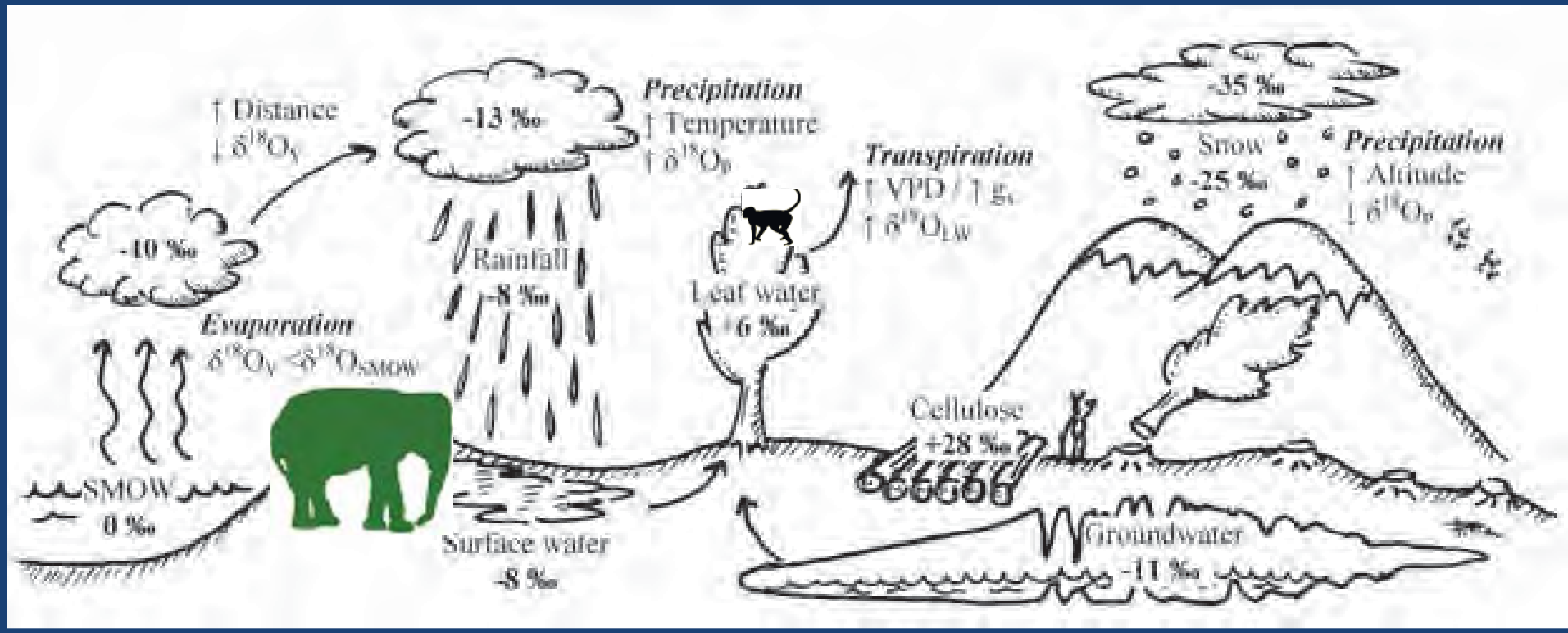
Carbon isotope concentration in plants and herbivorous mammalian enamel.

$$\delta^{13}C_{VPDB} = ([^{13}C/^{12}C]_{sample} / [^{13}C/^{12}C]_{VPDB} - 1) \times 1000 ‰$$



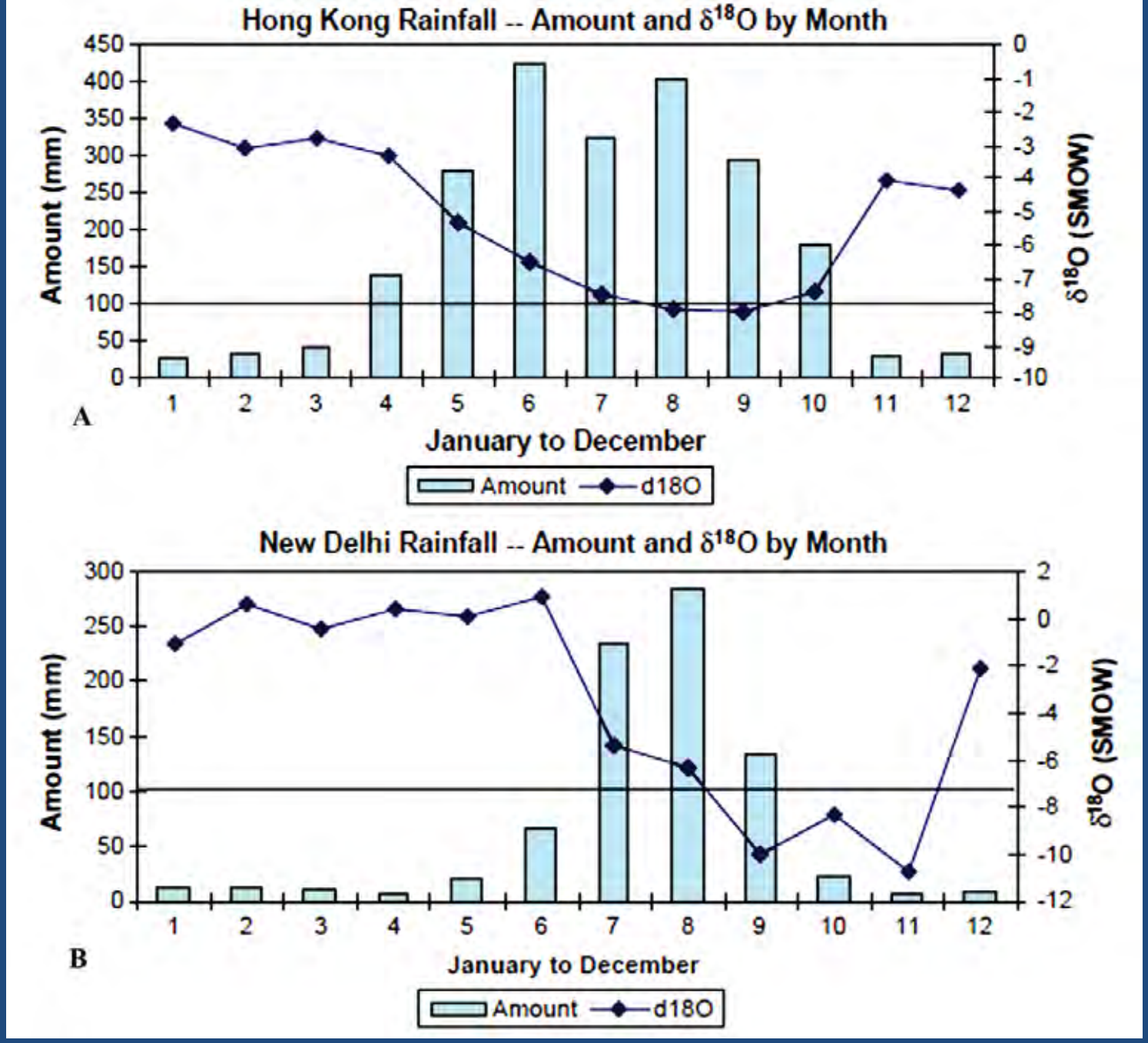
Boardman et al., 2013

Stable oxygen isotopes



The oxygen isotope composition of tooth enamel (or $\delta^{18}O$ bioapatite) is determined by the $\delta^{18}O$ value of herbivore body water ($\delta^{18}Obw$), which is primarily influenced by the ingested drinking and leaf water, reflecting the ambient temperature and rainfall.

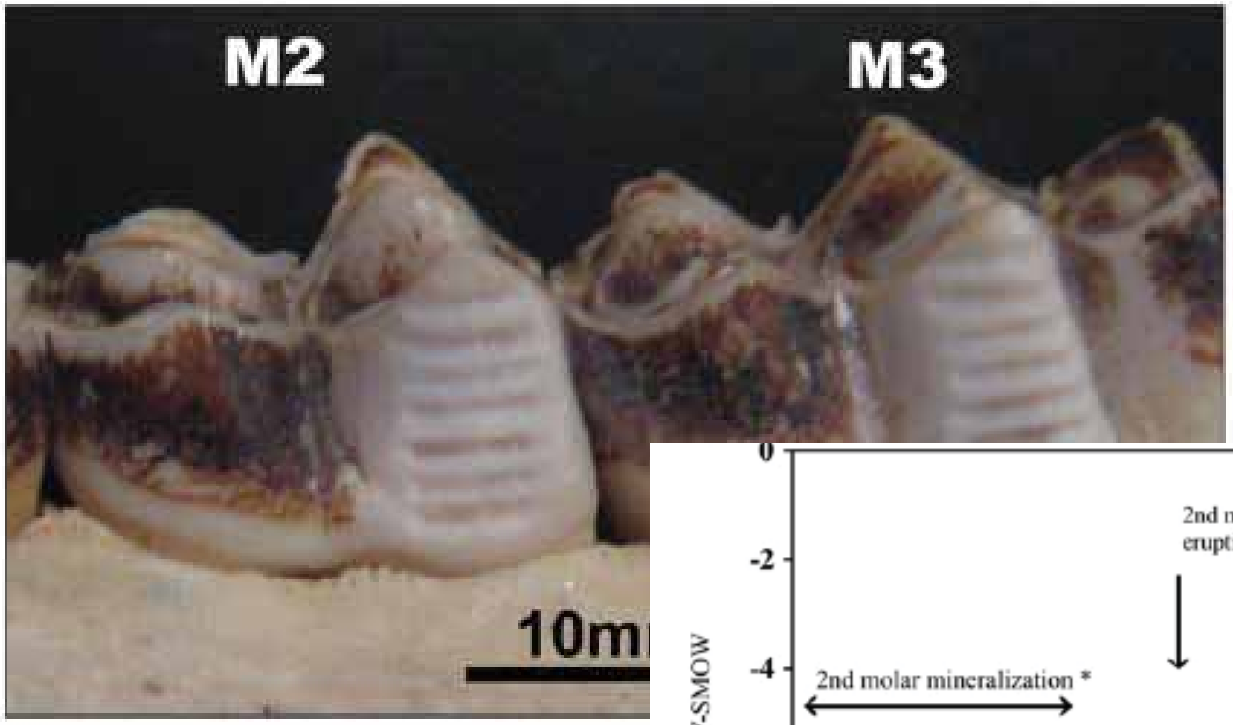
$$\delta^{18}O_{VPDB}=([^{18}O/^{16}O]_{sample}/[^{18}O/^{16}O]_{VPDB}-1)\times 1000\ ‰$$

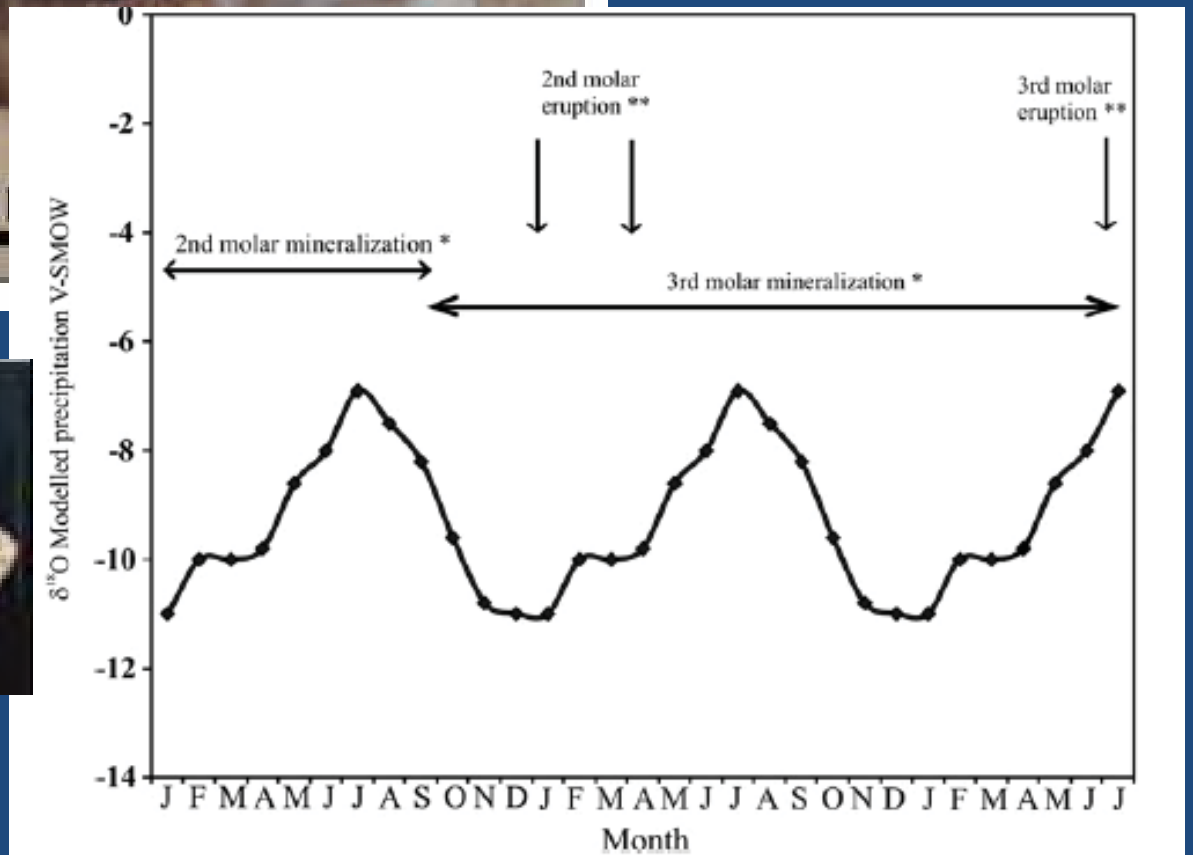


Monthly rainfall amount and $\delta^{18}O$ (SMOW) values for Hong Kong (A) and New Delhi (B), (IAEA 1981).

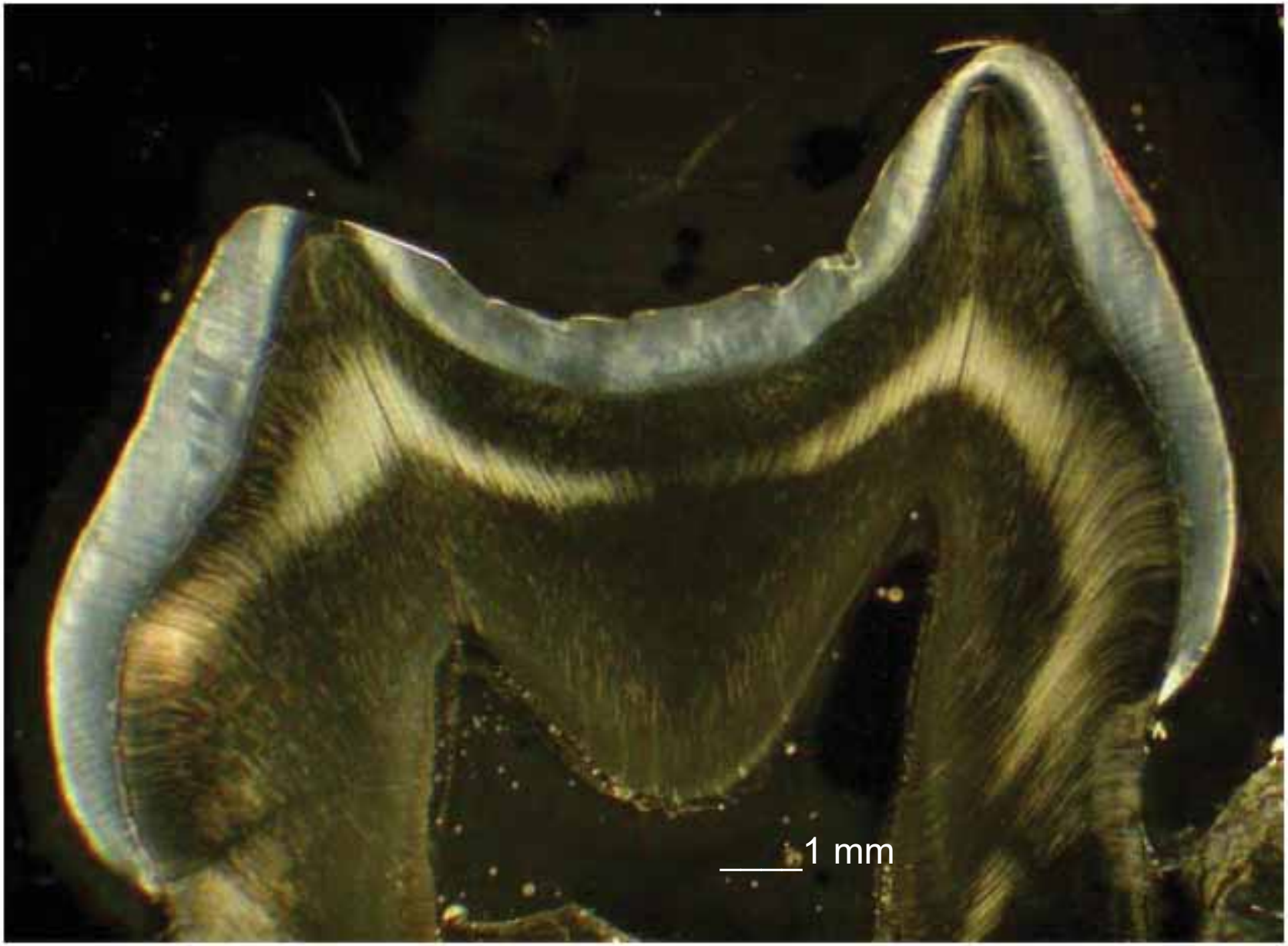
Patnaik et al., 2014

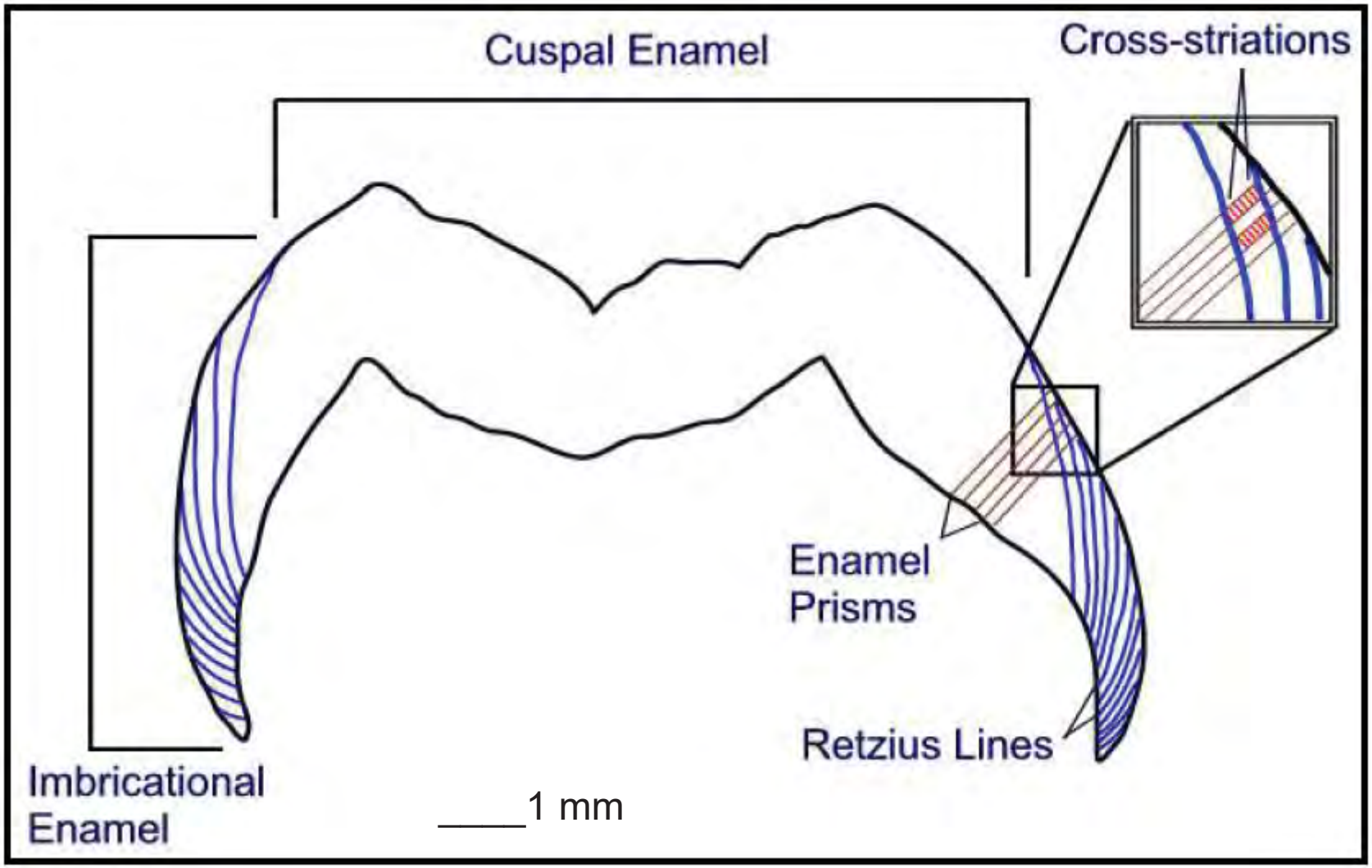
Stevens et al., 2011

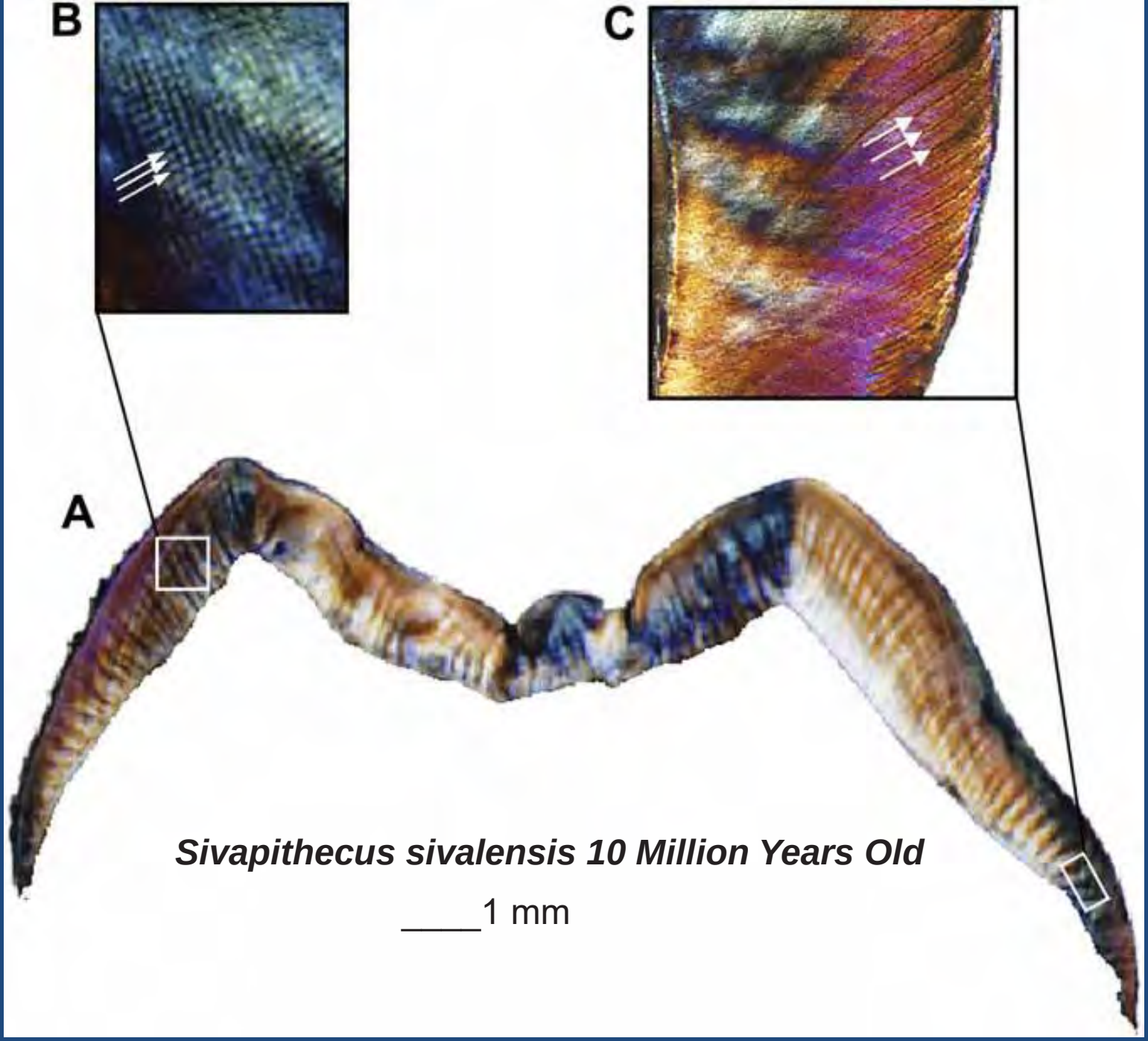


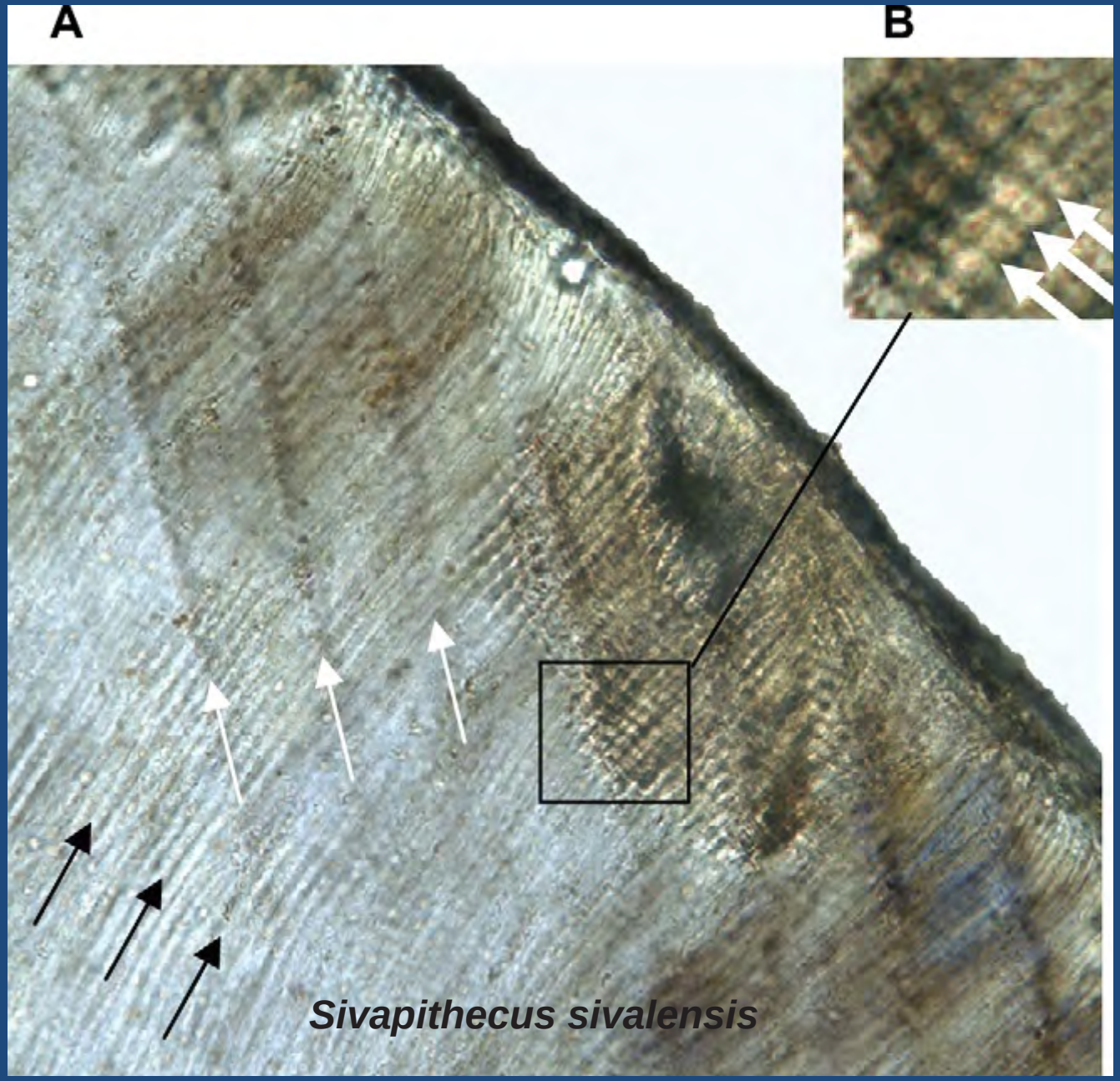


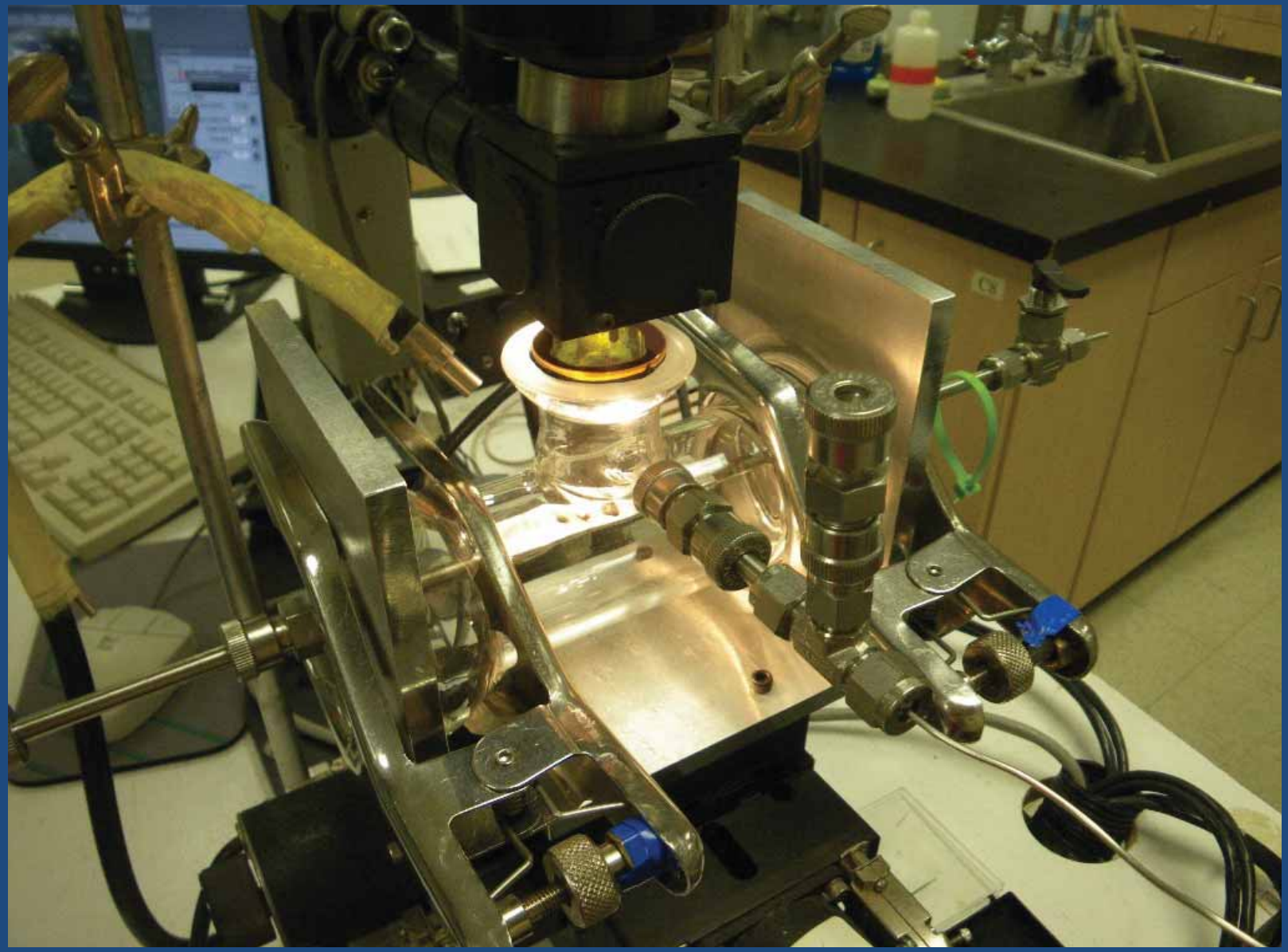
Palaeodiet and ecology of Extinct Apes

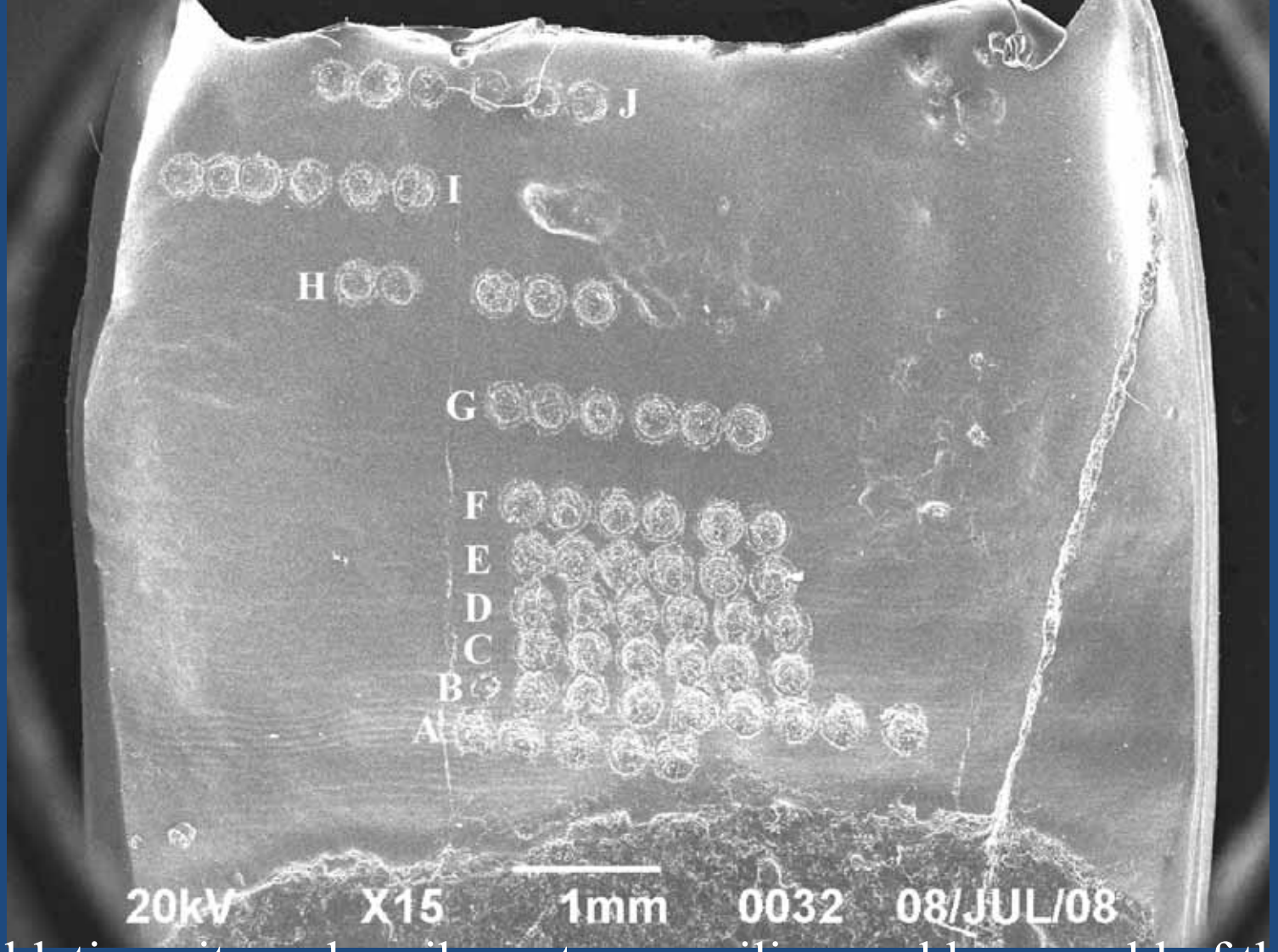

1 mm


Cuspal Enamel
Cross-striations
Enamel
Prisms
Retzius Lines
Imbricational
Enamel
1 mm


B
C
A
Sivapithecus sivalensis 10 Million Years Old
____1 mm

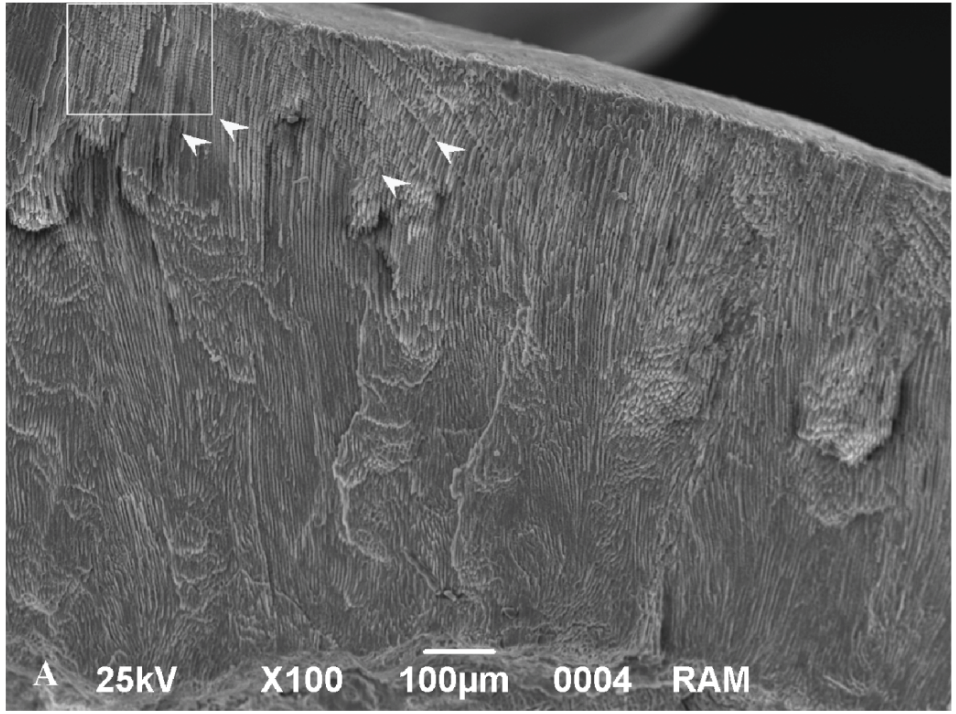

A
B
Sivapithecus sivalensis

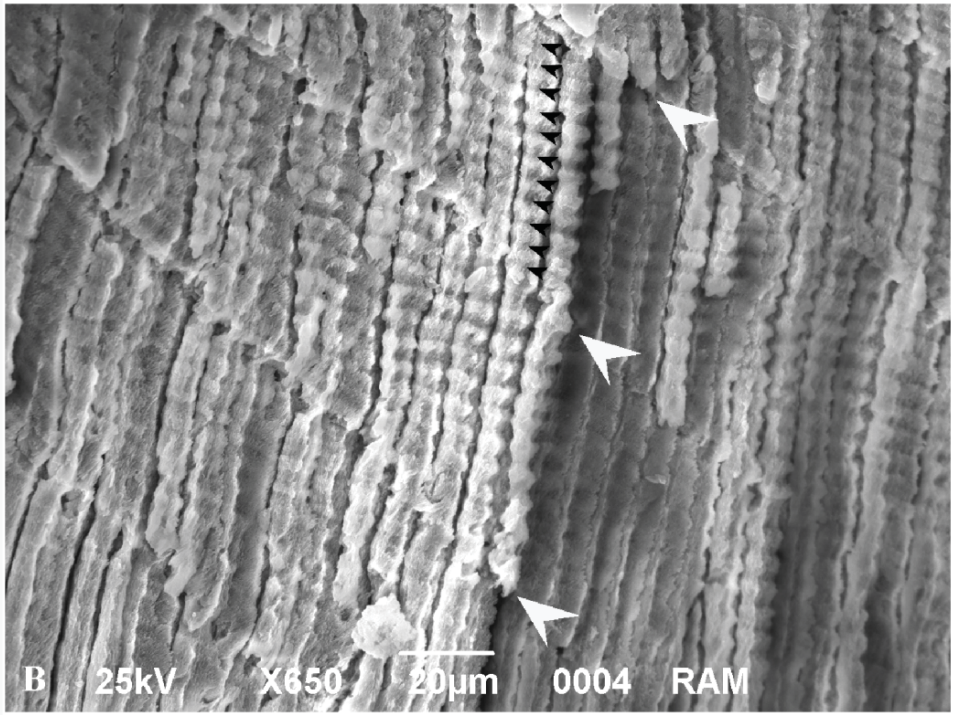


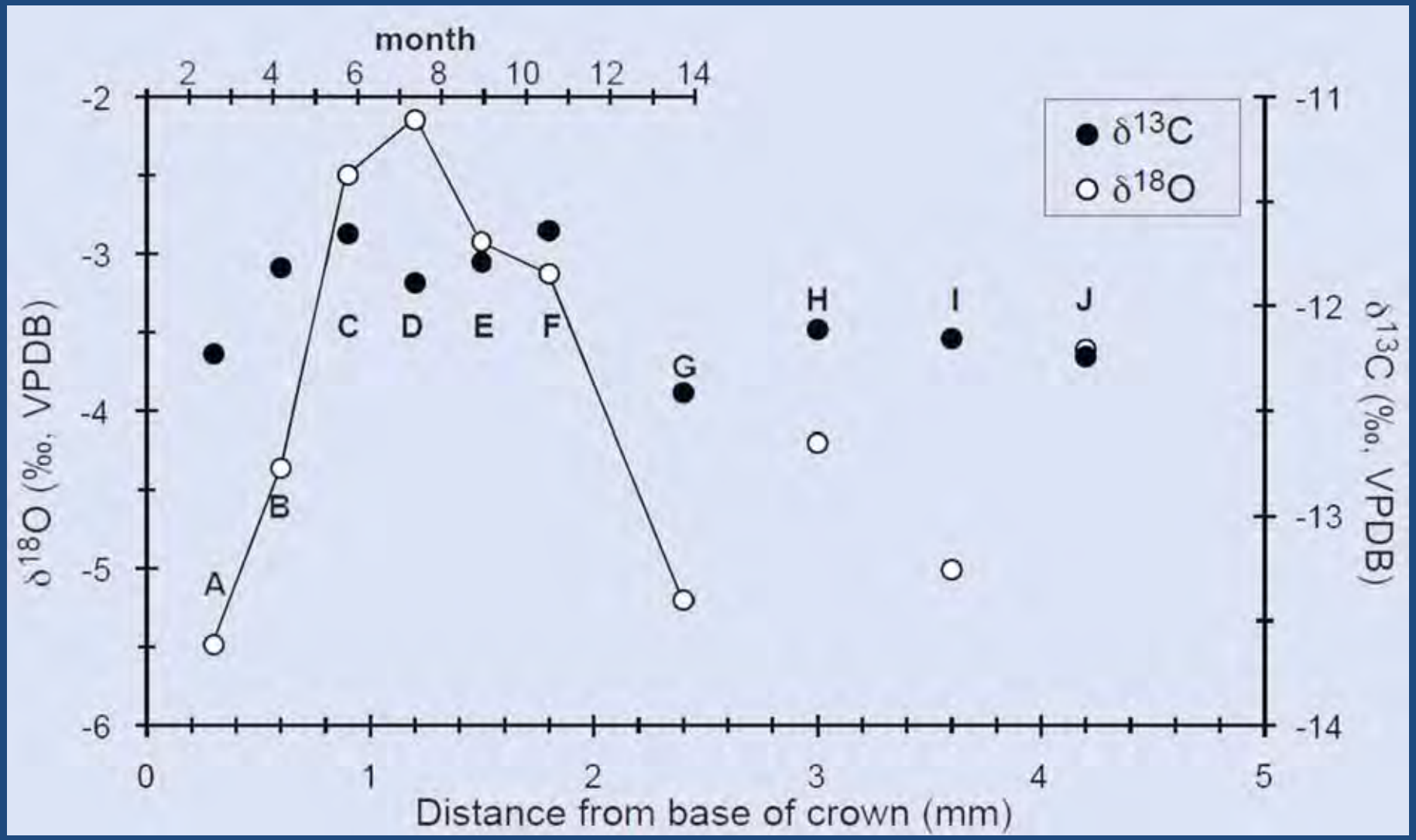


Laser ablation pits and perikymata on a silicon rubber mould of the *Hominoid*. There are 38 perikymata between samples A and G. (Patnaik et al., 2014)

Indopithecus (*Gigantopithecus*) .
(Patnaik et al., 2014)

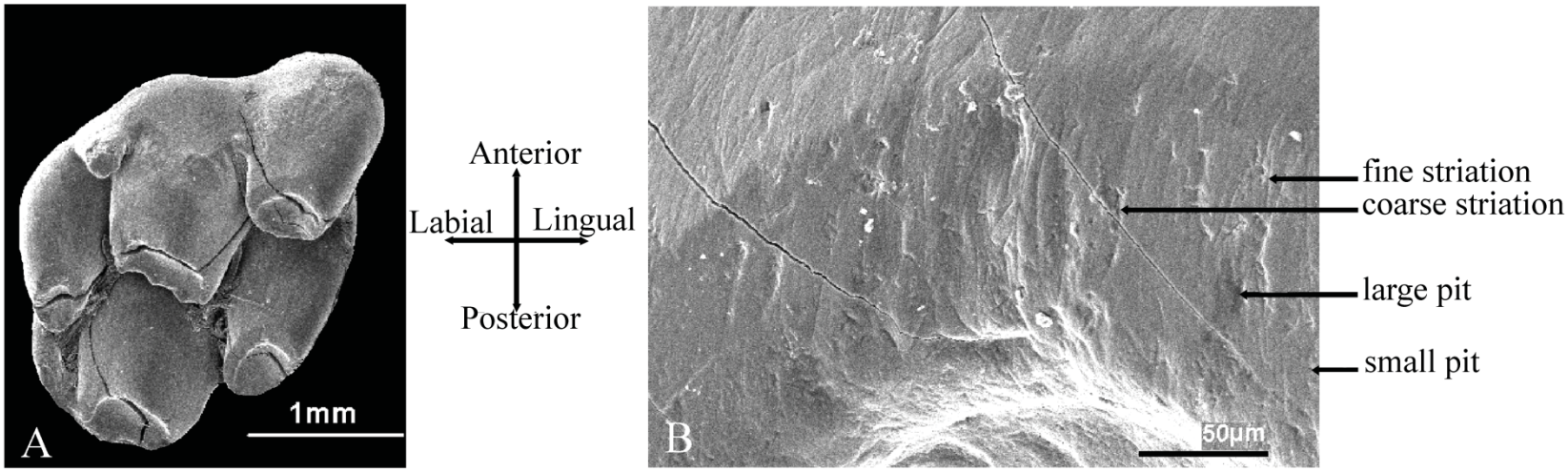






(Patnaik et al., 2014)

Dental Miocrowear



Golunda ellioti M2

(Patnaik , 2015)

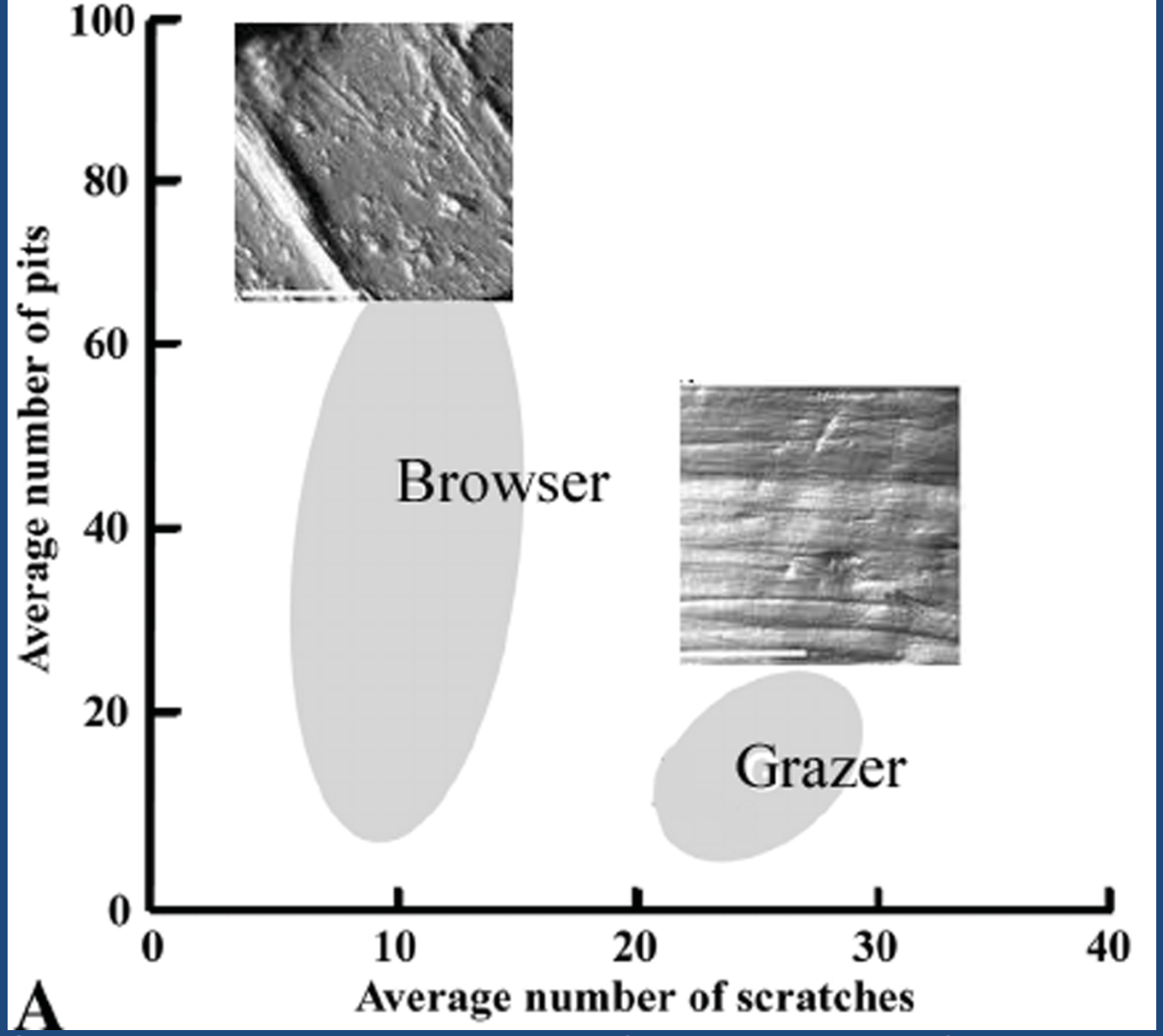


Figure 11. Graph showing the average number of pits and scratches found in a grazer and browser mammals, with SEM of the tooth surface (modified from Merceron et al., 2004).

Fig. 9. (**A**) *Indopithecus* M² (HDI-1) (scale 5 mm), and (**B**) scanning electron micrograph of the Phase II wear.

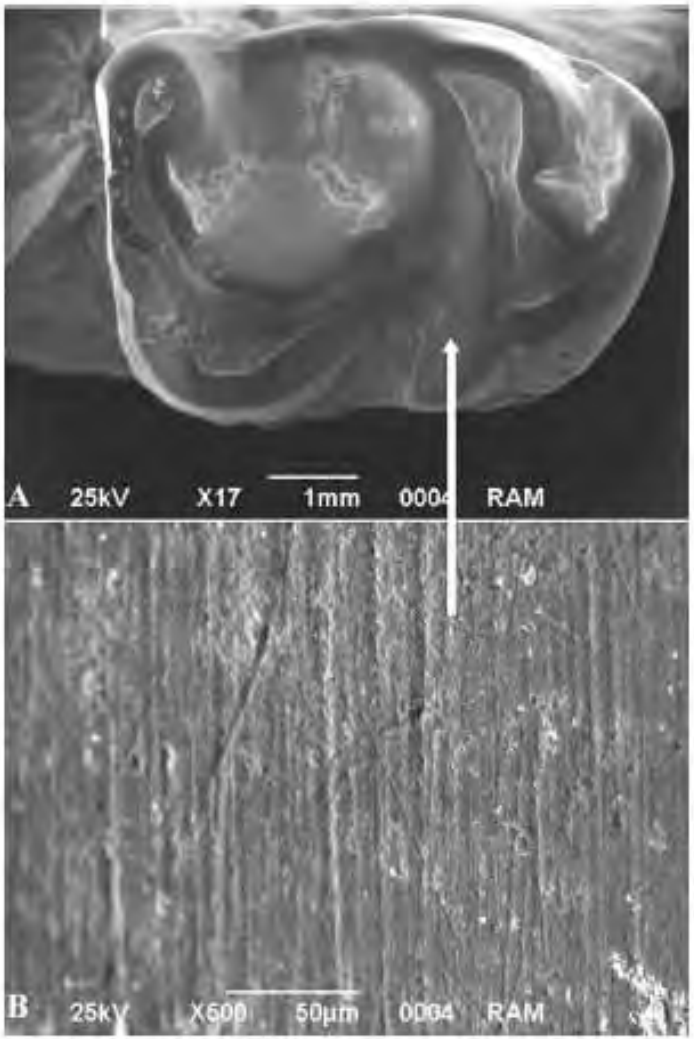
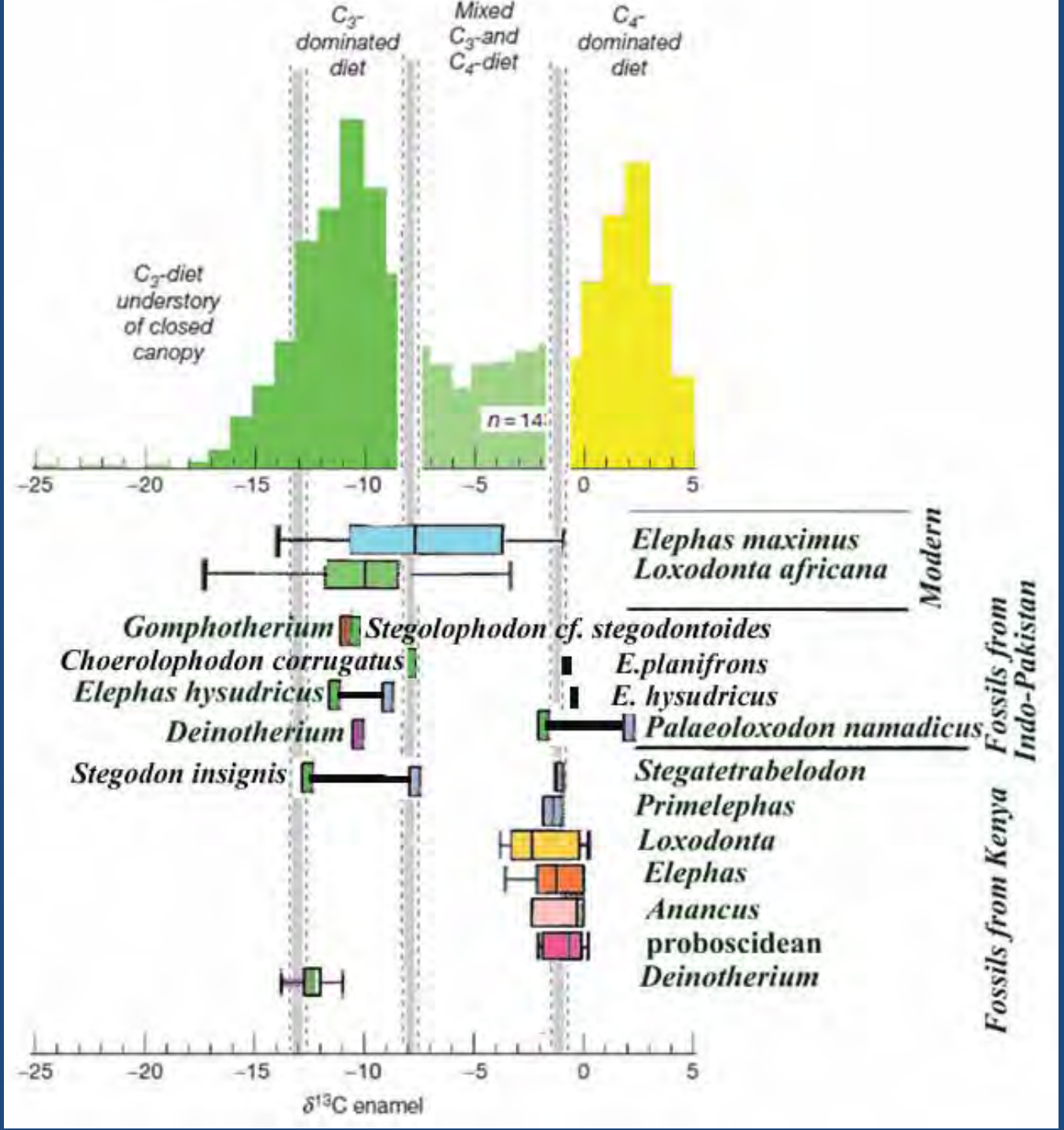


Fig. 10. (**A**) *Sivaladapis nagrii* P_4 (Hari I-6) and (**B**) scanning electron micrograph of the Phase II wear facet.

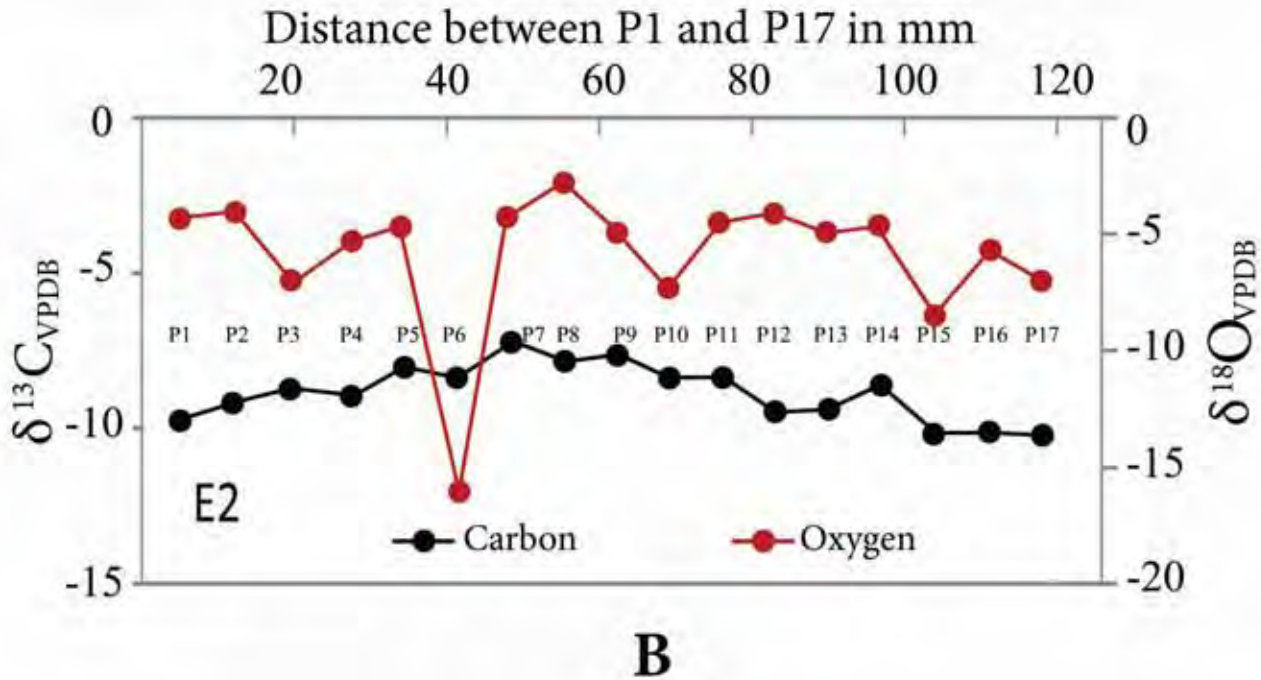
most pits are small, a few of the pits are very wide and long (Fig. 9). Such a high pit per-

(Patnaik et al., 2014)

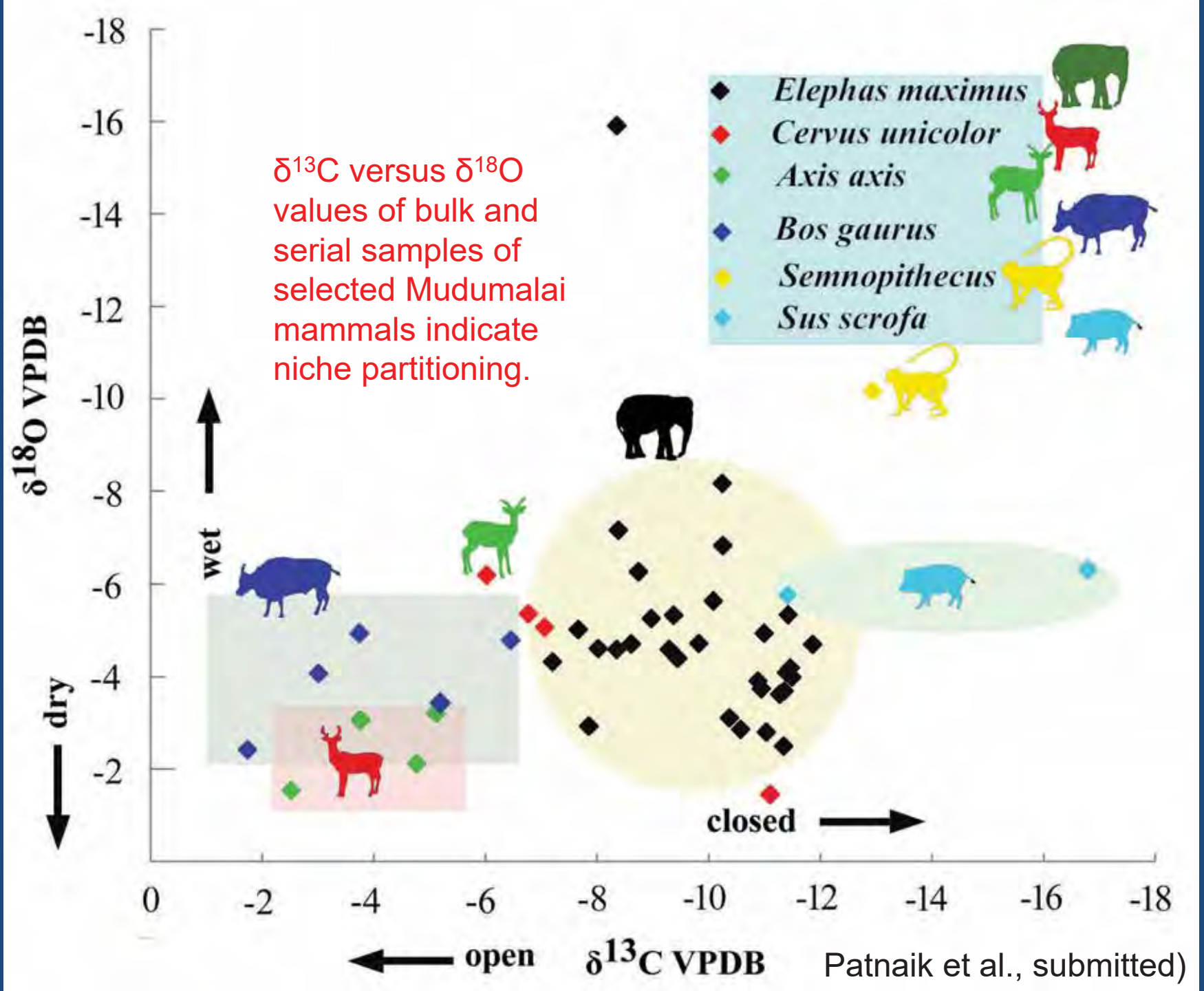
Palaeodiet and ecology of Elephants and their extinct relatives



Patnaik 2017 and references therein

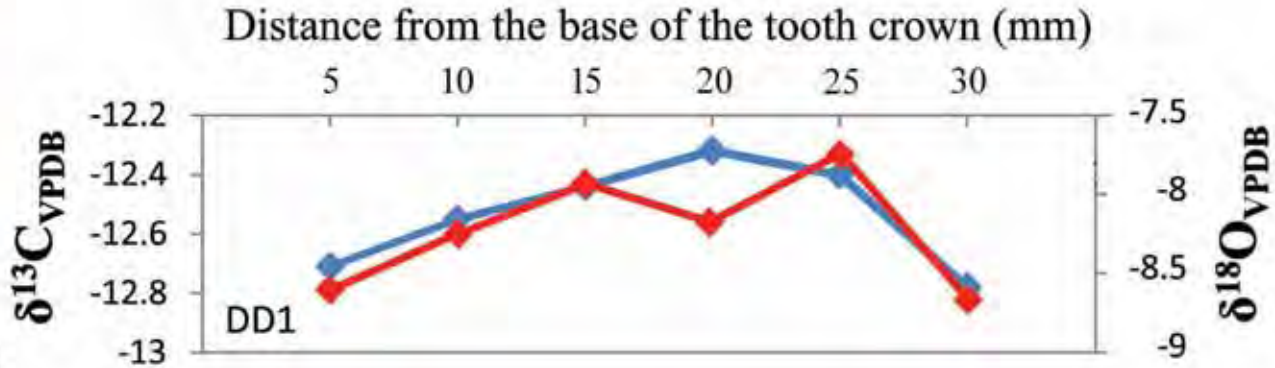


Serial sample sites on E2- *Elephas maximus* M3 from Mudumalai National Park. B, Serial $\delta^{13}C$ and $\delta^{18}O$ values from P1 close to the crown to P17 close to the roots (Patnaik et al., submitted)



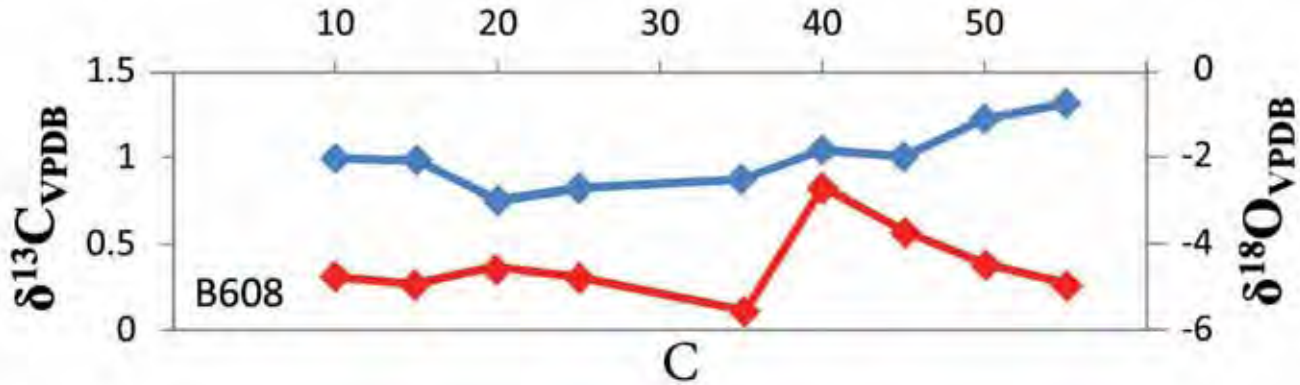
Patnaik et al., submitted)

DD 1
Deinotherium indicum



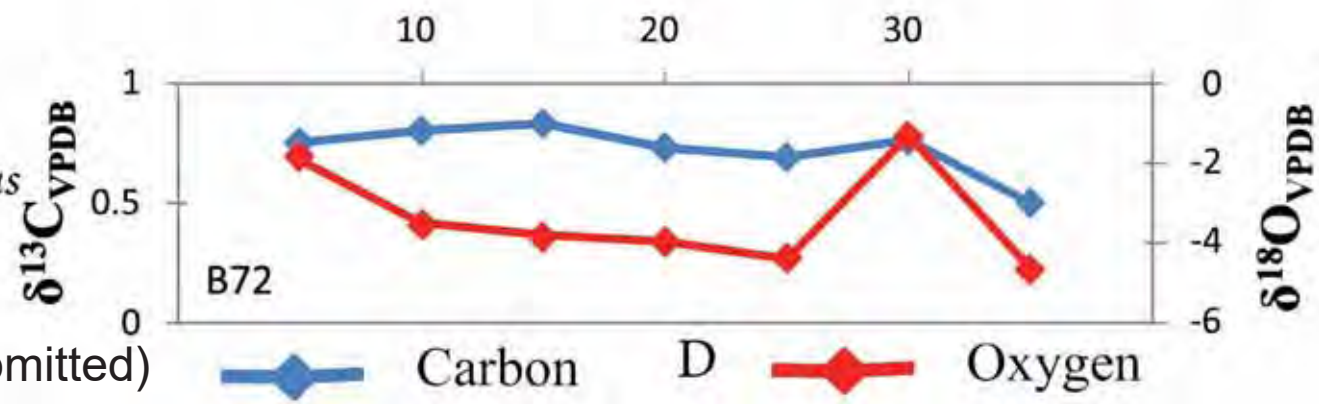
Elephas planifrons

~2.6 Ma



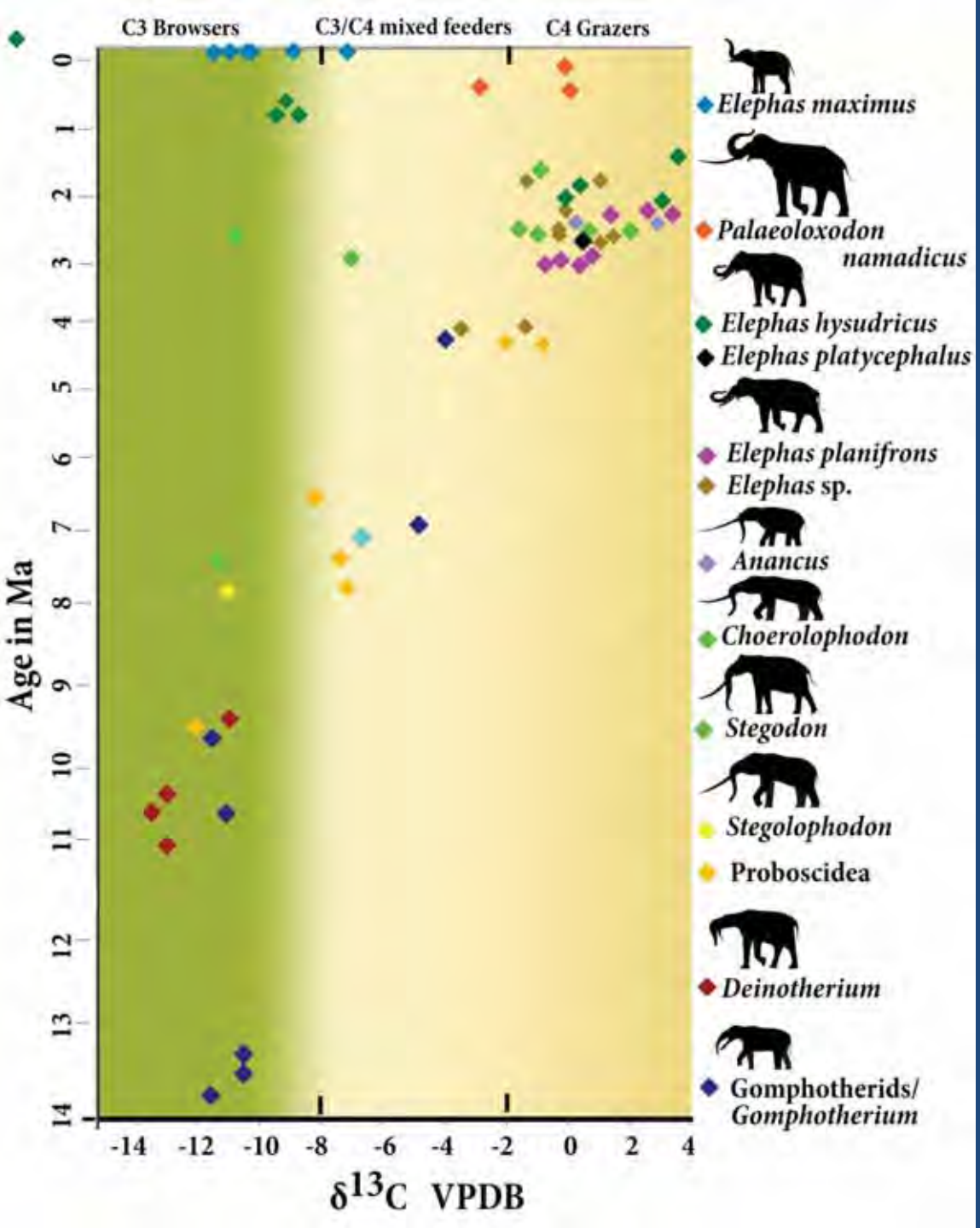
Elephas platycephalus

~2.6 Ma



(Patnaik et al., submitted)

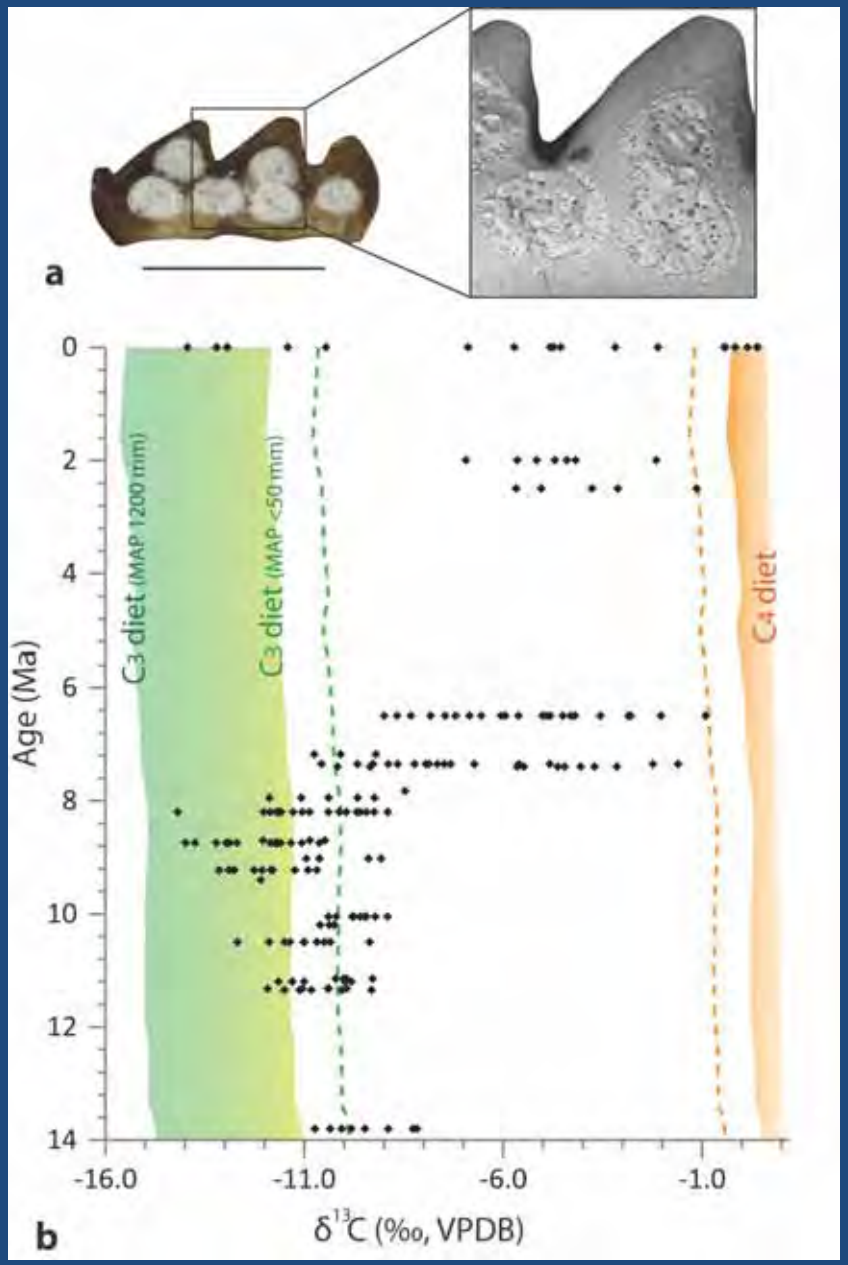
$\delta^{13}C$ value based scatter plot of the proboscideans representing the last 14 Ma. Data from India and Pakistan is based on published literature (Patnaik et al. submitted).



Palaeodiet and ecology of Rats and Mice

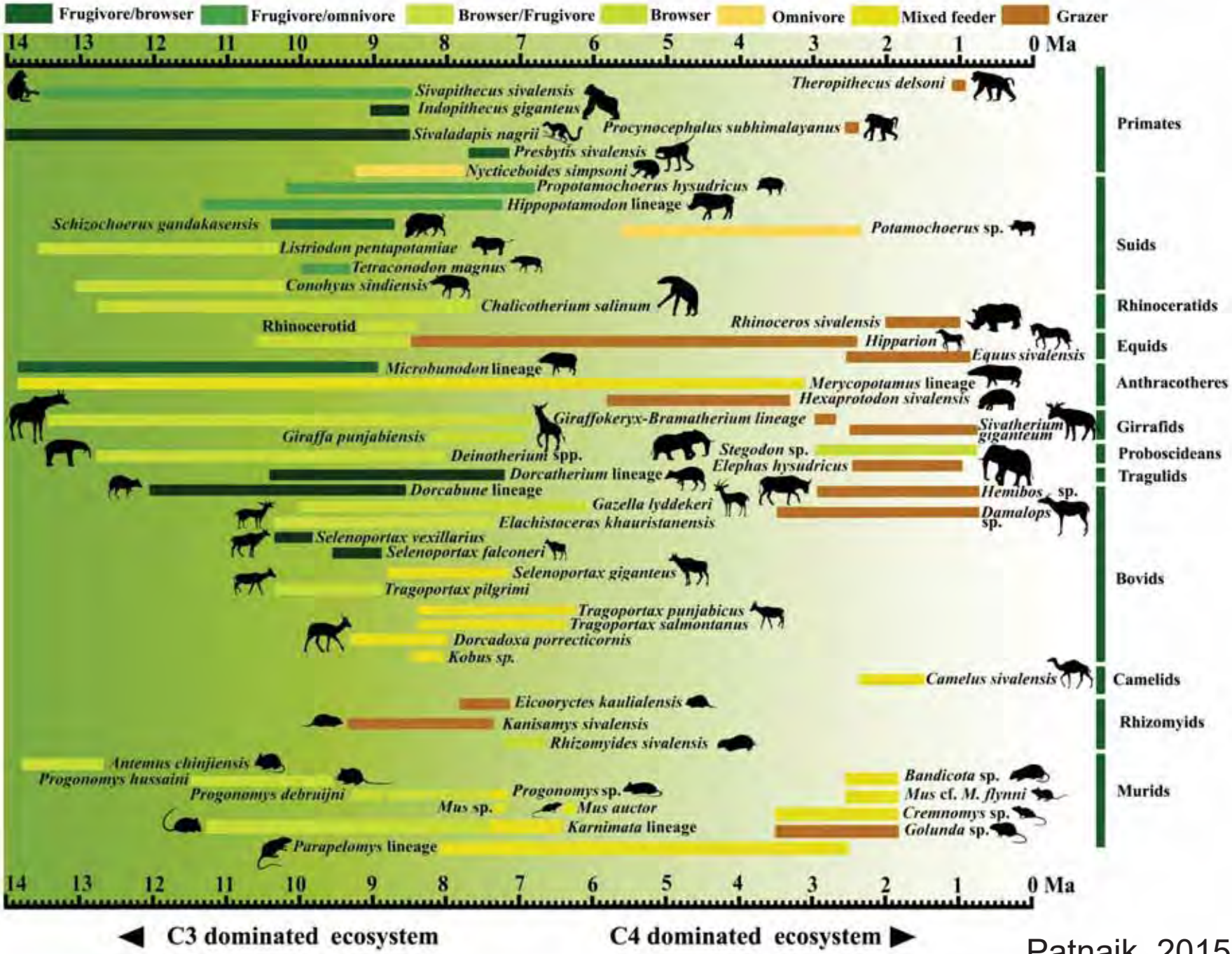
Laser Ablation

Ecological Shift leads to shift in diet.



Stable Isotopes of Small mammals

Kimura et al., 2013



Patnaik, 2015

Concluding remarks

- Dental enamel is an excellent archive to understand diet and environment of extinct mammals as they stay unaltered for millions of years.
- Intra-tooth variability in stable oxygen and carbon isotope concentration can provide very high resolution (inter-seasonal variability) palaeoclimatic and palaeocological data.

Acknowledgements:

- I extend my sincere thanks to the Indian Academy for giving me this opportunity to present my work.
- I acknowledge the financial support by DST, CSIR, MoES, Leakey foundation and National Geographic at various stages of my research.

Thank You