Geological Calibration update - (early) summer, 2008

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Sampled - mostly measured:

- *Bonneville shorelines (^{10}Be, ^{3}He, ^{14}C, $^{36}Cl_{WR}$, $^{36}Cl_{K}$)*
- *Breque, Peruvian Andes (^{10}Be)*
- *Scotland (^{10}Be, ^{14}C, $^{36}Cl_{K}$)*
- *Saturated Antarctic bedrock (^{3}He, ^{21}Ne, ^{10}Be, ^{26}Al, ^{14}C, $^{36}Cl_{K}$)*

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Sampled - mostly measured:

- *Bonneville shorelines (^{10}Be, ^{3}He, ^{14}C, $^{36}Cl_{WR}$, $^{36}Cl_{K}$)* *(^{26}Al, $^{36}Cl_{Ca}$, ^{21}Ne)*
- *Breque, Peruvian Andes (^{10}Be)*
- *Scotland (^{10}Be, ^{14}C, $^{36}Cl_{K}$)* *(^{26}Al, ^{3}He, $^{36}Cl_{Ca}$)*
- *Saturated Antarctic bedrock (^{3}He, ^{21}Ne, ^{10}Be, ^{26}Al, ^{14}C, $^{36}Cl_{K}$)* *($^{36}Cl_{Ca}$, ...)*

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Sampled - yet to be measured:

- *Puget lowlands* *(^{10}Be, ^{26}Al, ^{14}C, $^{36}Cl_{WR}$, $^{36}Cl_{K}$)*
- *New England moraines* *(^{10}Be, ^{26}Al, ^{14}C, $^{36}Cl_{K}$)*
- *Quelccaya moraine* *(^{10}Be, ^{26}Al, ^{14}C, $^{36}Cl_{K}$, ^{21}Ne)*
- *Hawaii (Mauna Loa Holocene lavas)* *(^{3}He, $^{36}Cl_{WR}$)*

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Upcoming:

- *Dry Valleys deep cores - muon calibration* *(^{10}Be, ^{26}Al, ^{14}C, $^{36}Cl_{Ca}$, ^{3}He, ^{21}Ne)*

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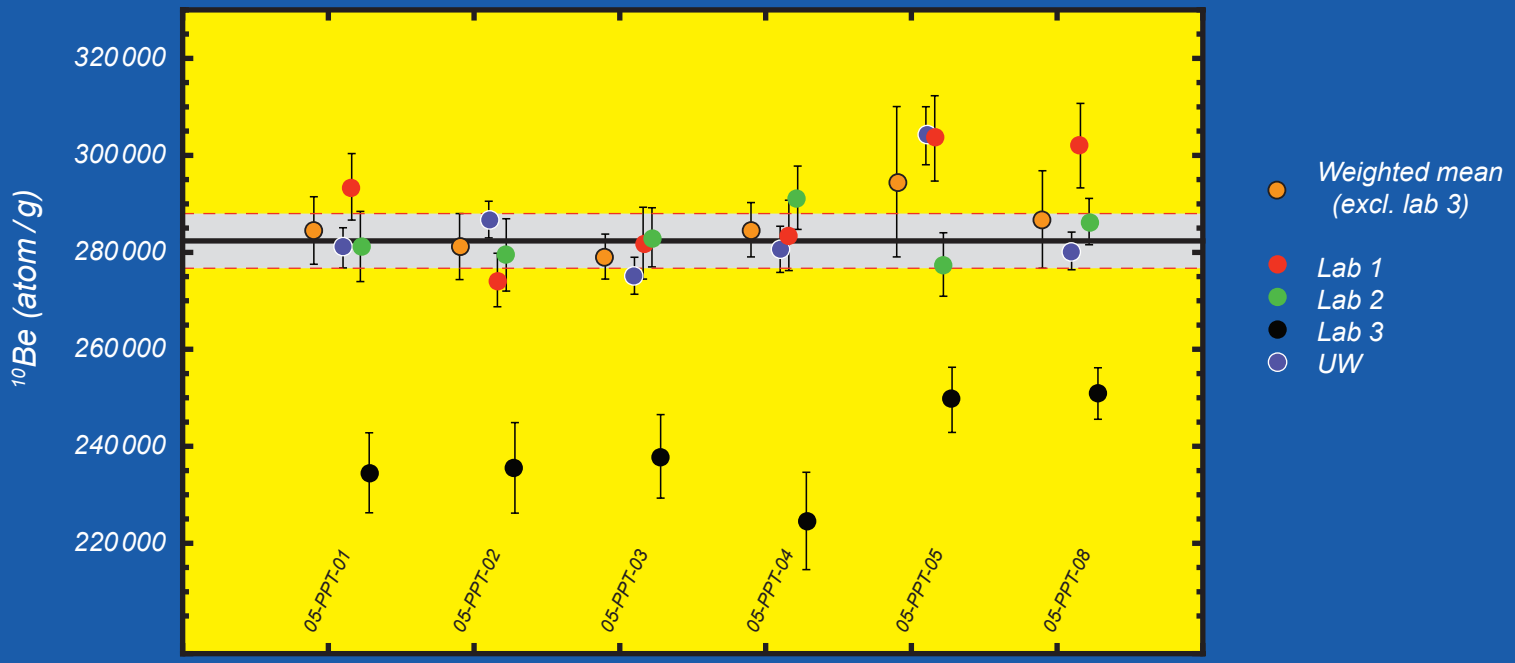
Additional sites and projects:

- *Recess Peak moraines, Sierra Nevada* (^{10}Be, ^{26}Al, ^{14}C, $^{36}Cl_K$, ^{21}Ne)
- *New Zealand landslides* (^{10}Be, ^{26}Al, ^{14}C)
- *Historic lavas - Canary Islands, Mauna Loa* ($^{36}Cl_{Ca}$, $^{36}Cl_K$, $^{36}Cl_n$)
- *Deep roadcuts - muon calibration* (^{10}Be, ^{26}Al, ^{21}Ne)

Geological Calibration update - (early) summer, 2008

- *Bonneville shorelines (^{10}Be, ^{3}He, ^{14}C, $^{36}Cl_{WR}$, $^{36}Cl_{K}$)* *(^{26}Al, $^{36}Cl_{Ca}$, ^{21}Ne)*



- *39°- 41° N, 1440-1610 m*
- *Exposure age: 17.4 ± 0.2 cal kyr BP*
- *Quartzite, olivine basalt*
- *$P_{Be\text{-}10}$ = 14.0 ± 0.2 atom/g/yr (1 SD)*

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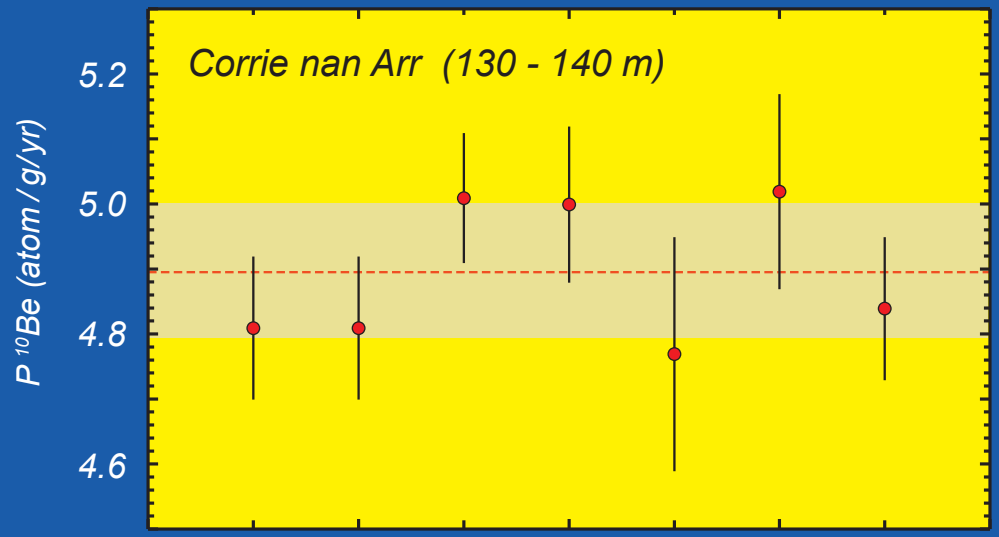
- *Scotland (^{10}Be, ^{14}C, $^{36}Cl_K$)* *(^{26}Al, ^{3}He, $^{36}Cl_{Ca}$)*



- *Corrie nan Arr 57.4°N, 130-140 m*
- *Exposure age: 11.6 ± 0.2 cal kyr BP*
- *Arkose (15-20% K-feldspar)*
- *$P_{Be\text{-}10}$ = 4.89 ± 0.07 atom/g/yr (1 SD)*

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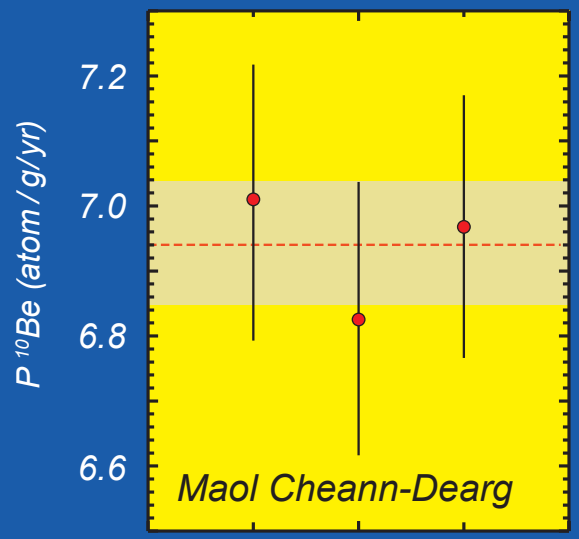
- *Scotland (^{10}Be, ^{14}C, $^{36}Cl_K$)* *(^{26}Al, ^{3}He, $^{36}Cl_{Ca}$)*



- *Maol Cheann-Dearg 57.5°N, 510-530 m*
- *Exposure age: 11.6 ± 0.2 cal kyr BP*
- *Quartzite*
- *$P_{Be\text{-}10}$ = 6.94 ± 0.09 atom/g/yr (1 SD)*

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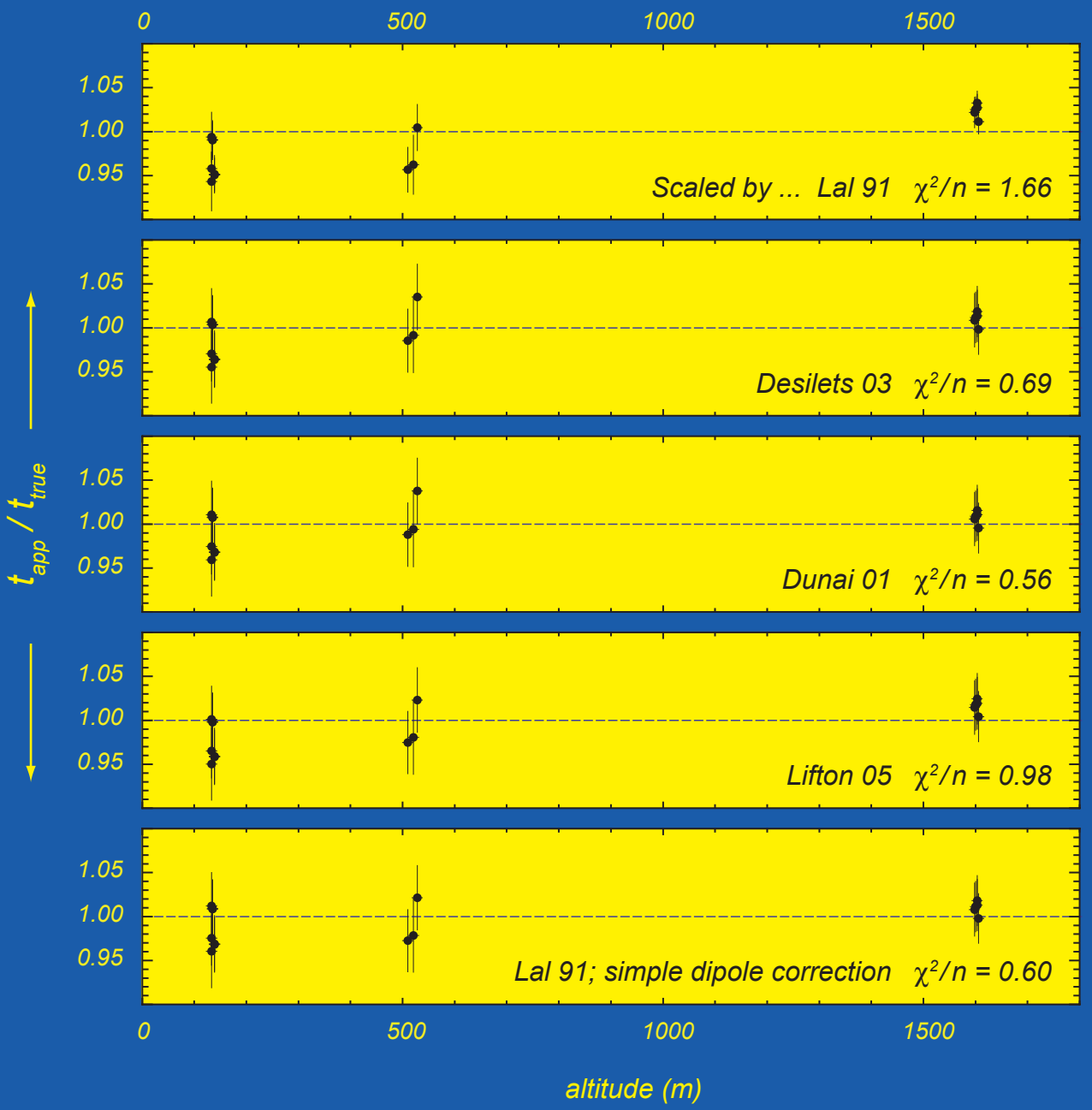
- *New CRONUS data*
- *$P_{Be\text{-}10}$ at three sites*
- *each ± 2-3%*
- *How well do scaling factors connect these rates?*
- *Compare recalculated calibration sample ages to their known ages*
- *Paleomag-based methods **all** reconcile these data within their uncertainties.*



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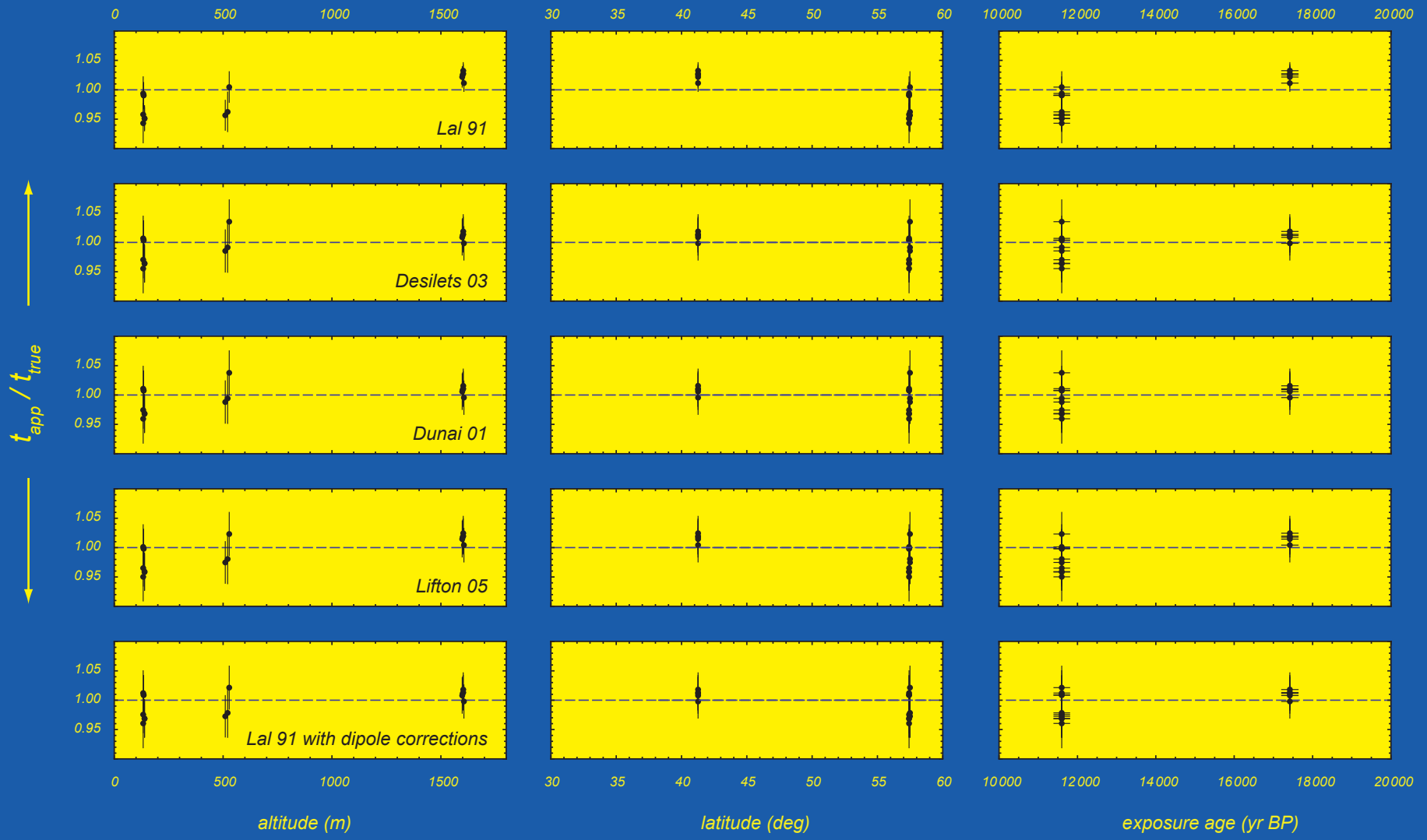

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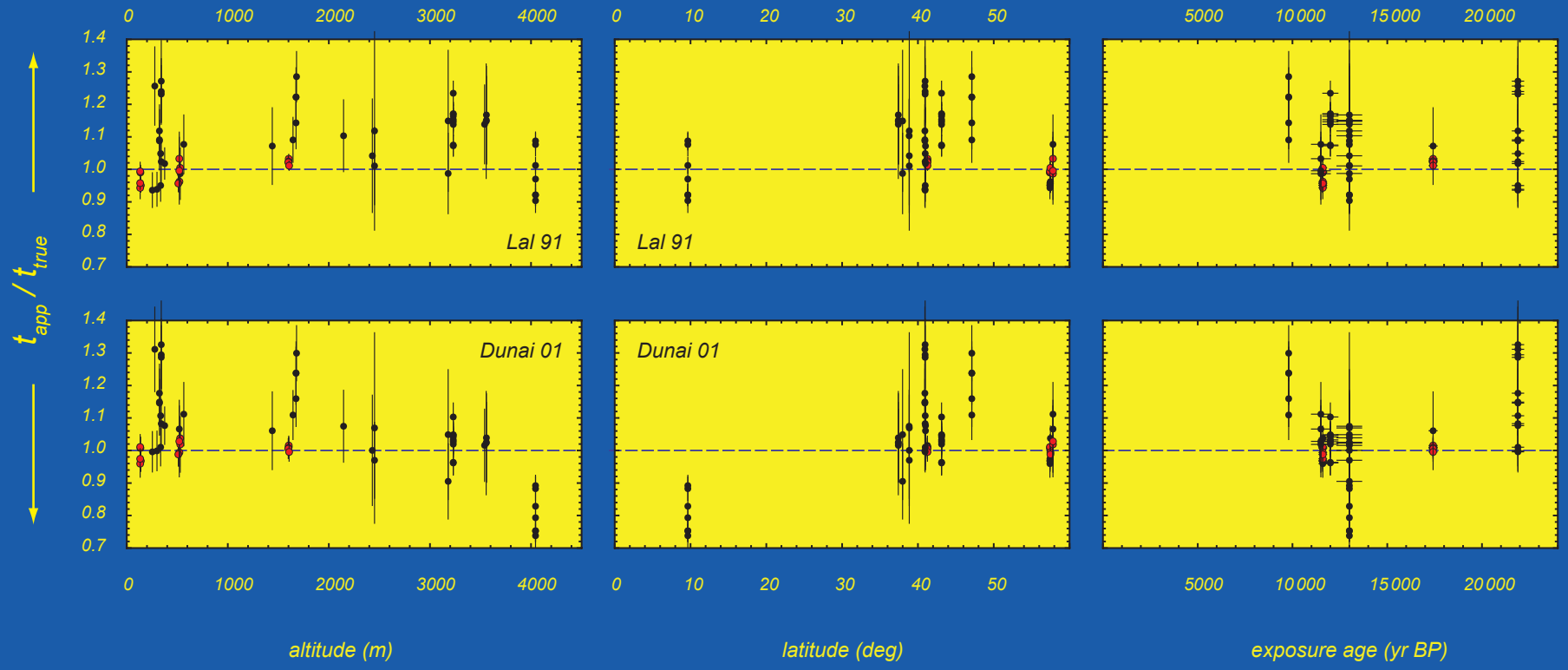

- *Published calibration data (basis of existing calibration):*
- *Scattered*
- *Biased ~5-6% high*

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- *Puget lowlands*
- *New England moraines*
- *Quelccaya moraines*

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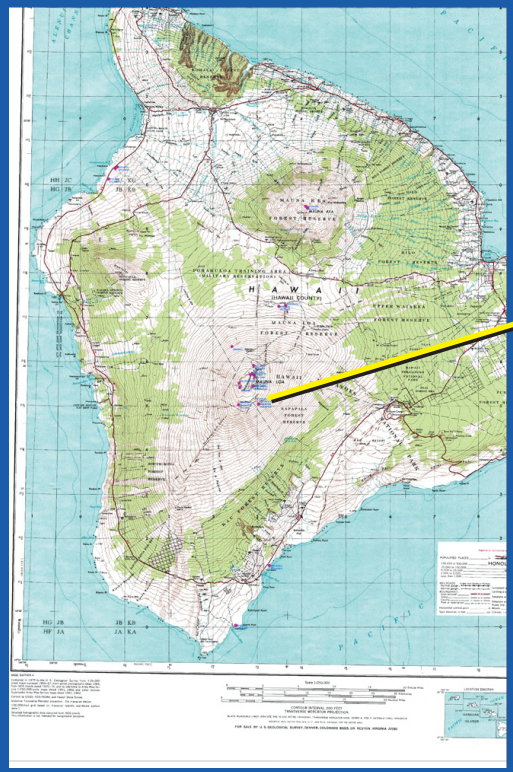

Ainapo Trail flow
1510 cal yr BP

- *Hawaii*
- *Holocene lavas - 1510 - 4080 yr BP*

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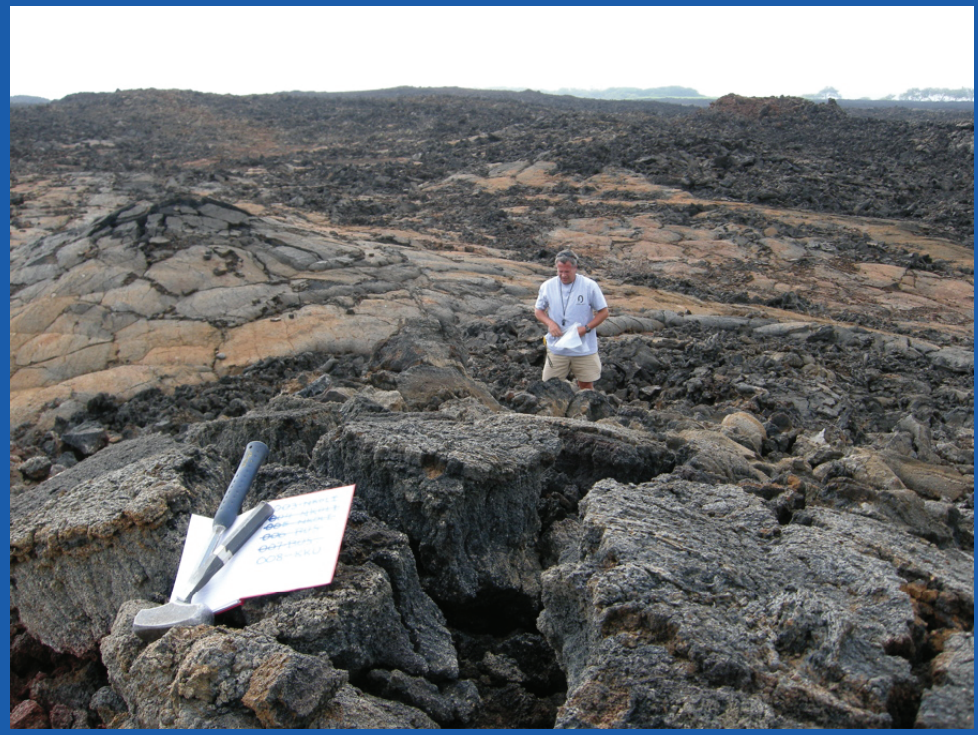
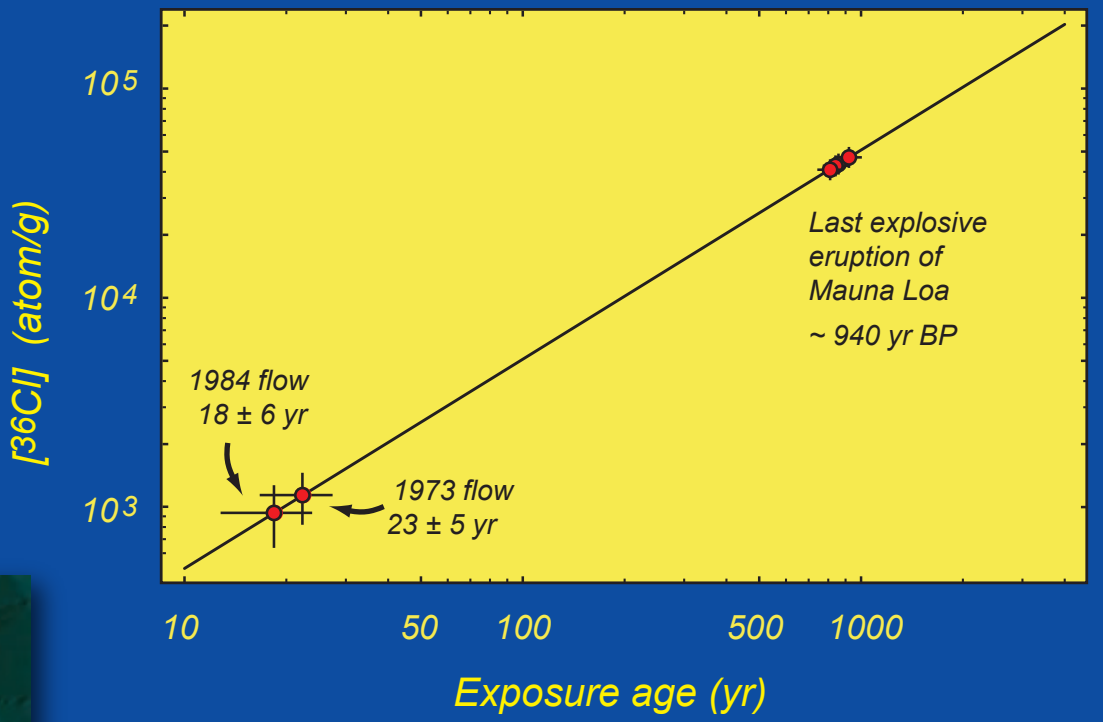


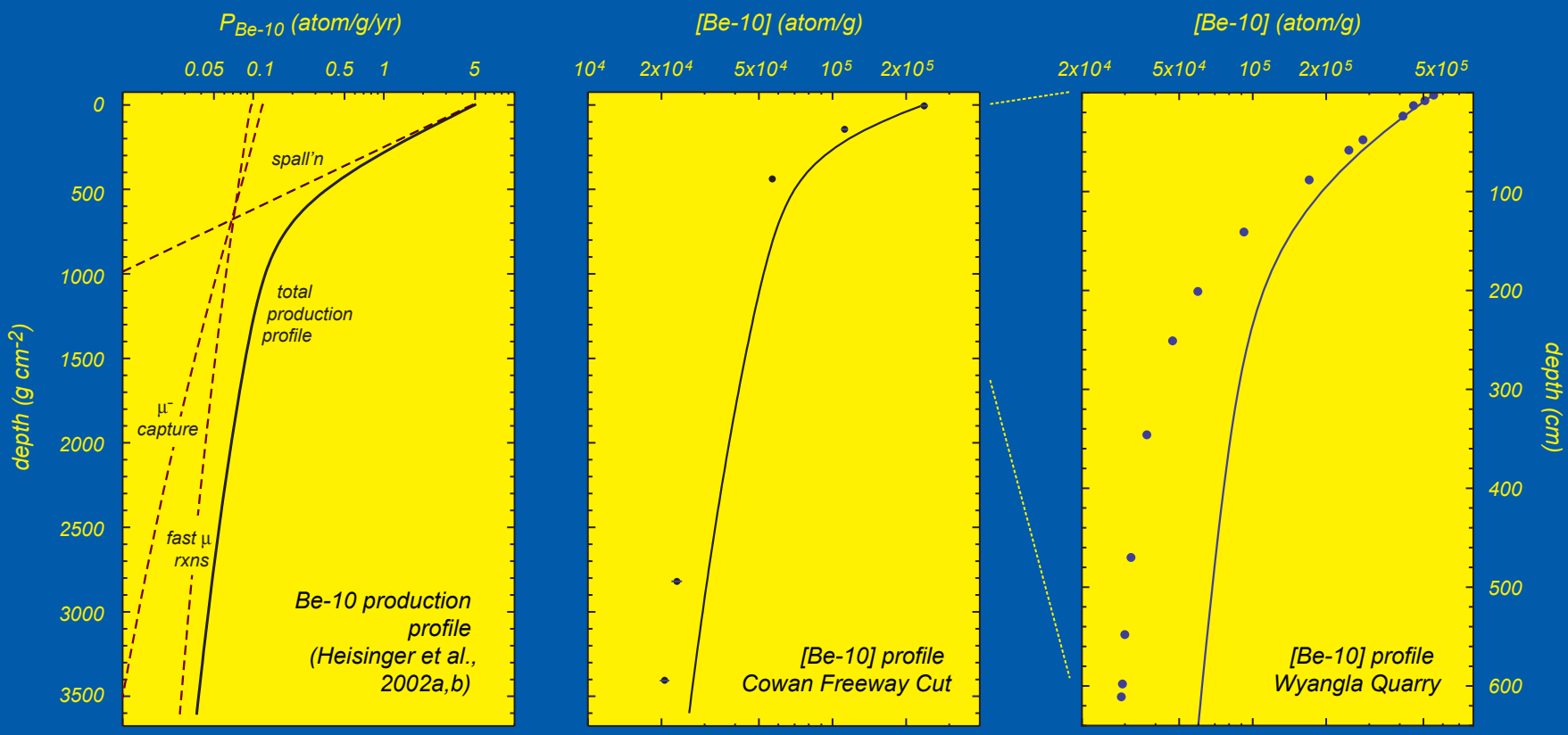
Kaniku flow

3360 cal yr BP; 60 m altitude

- *Hawaii*
- *Holocene lavas - 1510 - 4080 yr BP*

Dating Hawaiian volcanic eruptions





- *Depth profiles can be used to check muon production model (left panel).*
- *Surface concentrations are determined by erosion rate; they depend mainly on near-surface production rates.*
- *Be-10 depth profiles shown above calculated to fit surface concentrations.*
- ***Concentrations at depth are systematically lower (~0.5x) than predicted.***
- *Same result from road-cut profile (0-15m; center panel) and quarry profile (0-6m; right panel).*
- *Likely explanation is that fast muon reaction rates have been overestimated.*
- *Antarctic and Yucca Mtn profiles planned.*
- *Surfaces have erosion rates <1m/Myr.*
- *For such low erosion rates, $P \sim \lambda N$.*
- *Cores planned in – quartz sandstone (Be-10, Al-26, Ne-21)*
  dolerite (Cl-36, He-3, Ne-21, possibly Mn-53)
  tuff (Be-10, Al-26, Ne-21 from quartz; Cl-36 from sanidine).

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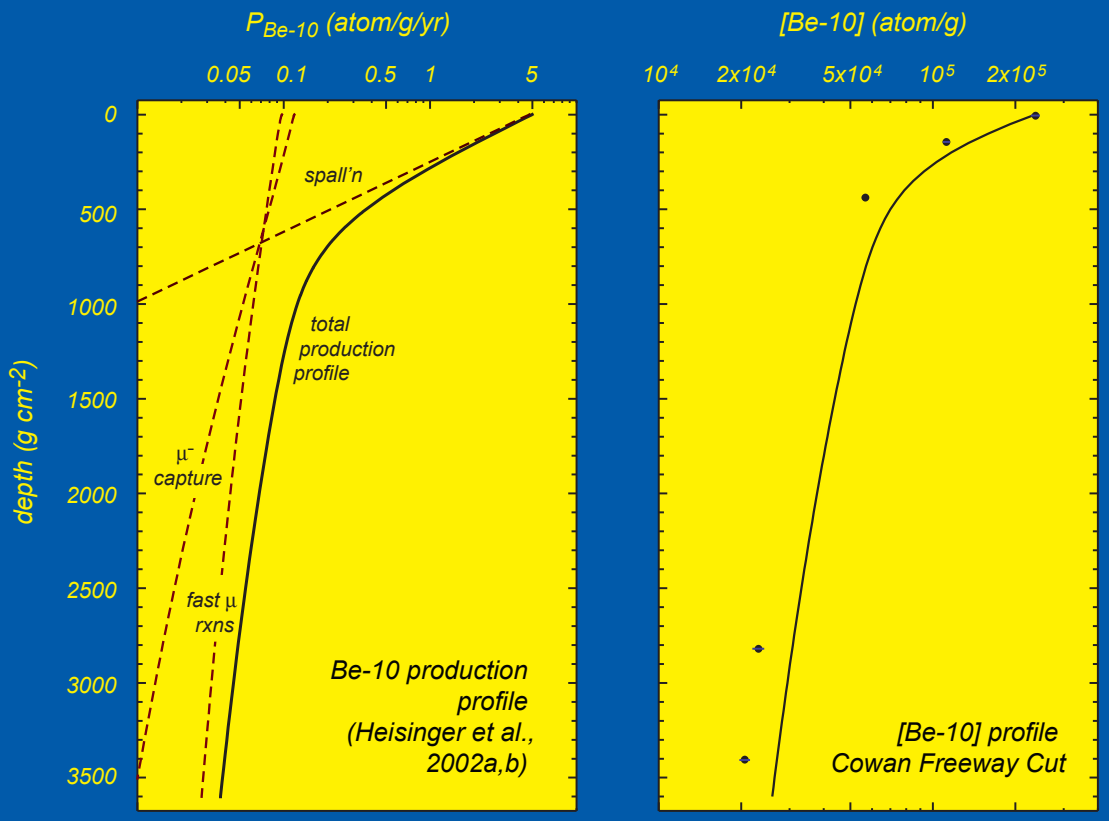
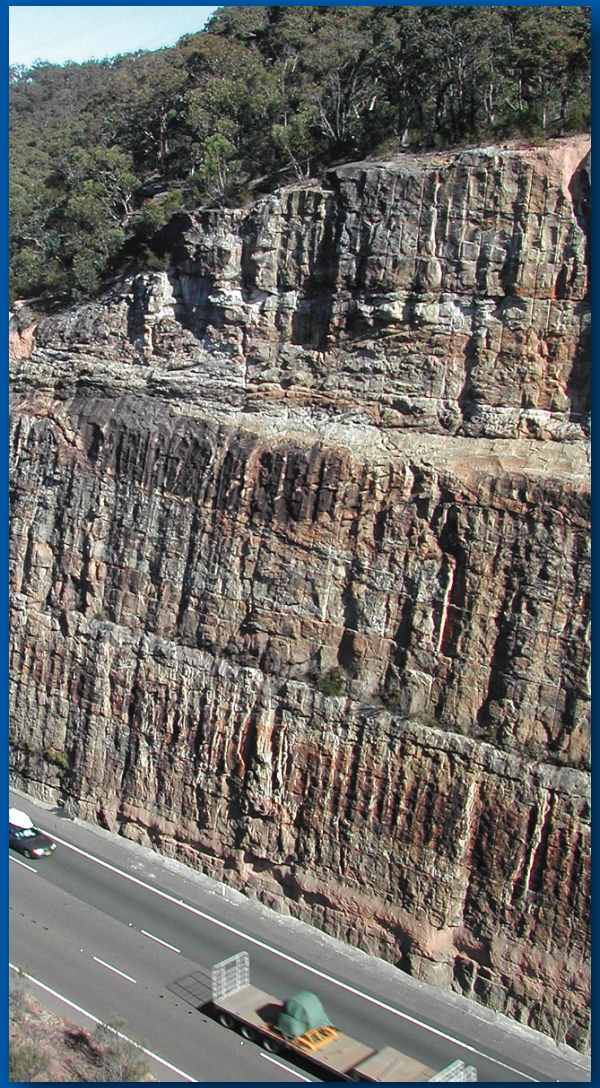
Dry Valleys core sites
(Hoping to ..) drill to 30 m
Additional 1-2 m cores

- *Mt Insel – Ferrar dolerite*
- *Erosion rate:*
  0.2 m/Myr (Schaefer et al. 2001)
- *1600 m altitude*
- *$^{36}Cl_{Ca}$, ^{3}He, ^{21}Ne, possibly ^{53}Mn*

- *University Peak – Beacon sandstone*
- *Erosion rate:*
  0.2 m/Myr
- *2300 m altitude*
- *^{10}Be, ^{26}Al, ^{21}Ne, possibly $^{36}Cl_{K}$*





- *Freeway cut depth profiles.*
- *Three profiles 15 - 41m.*
  Two have additional samples from 0 - 3 m.
- *Surface erosion rates: 7 - 15 m/Myr.*
  Not for calibration - use to check Dry Valleys calibration.
- *Ne-21 depth profiles? Need erosion to attain steady state.*
  Permian exposure may be a problem?