OSL rock surface exposure dating as a novel approach for reconstructing transport histories of coastal boulders over decadal to centennial timescales

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Why OSL rock surface dating of coastal boulders?

- ✓ Coastal boulders provide valuable long-term records of storm and tsunami impact
- ✓ Limitation of available dating approaches (radiocarbon, U/Th, ESR, cosmogenic nuclides, palaeomagnetics) to certain lithologies, settings and/or time ranges
- ✓ The OSL rock surface exposure technique (i) directly dates boulder transport; (ii) is applicable to all lithologies containing quartz or potassium feldspar; and (iii) is predestined for Holocene time scales when most boulder records were formed

Calcarenite boulder at Haroura, Rabat coast, Morocco (~18 t)

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Principles of OSL rock surface dating coastal boulders

- ✓ Approach is based on time- and depth-dependent OSL signal resetting in rock surfaces (Sohbati et al. 2011). For Holocene boulders with low dose rates this process can be expressed by:

$$L_f(x) = L_i e^{-\overline{\sigma\varphi_0} t_e e^{-\mu x}}$$

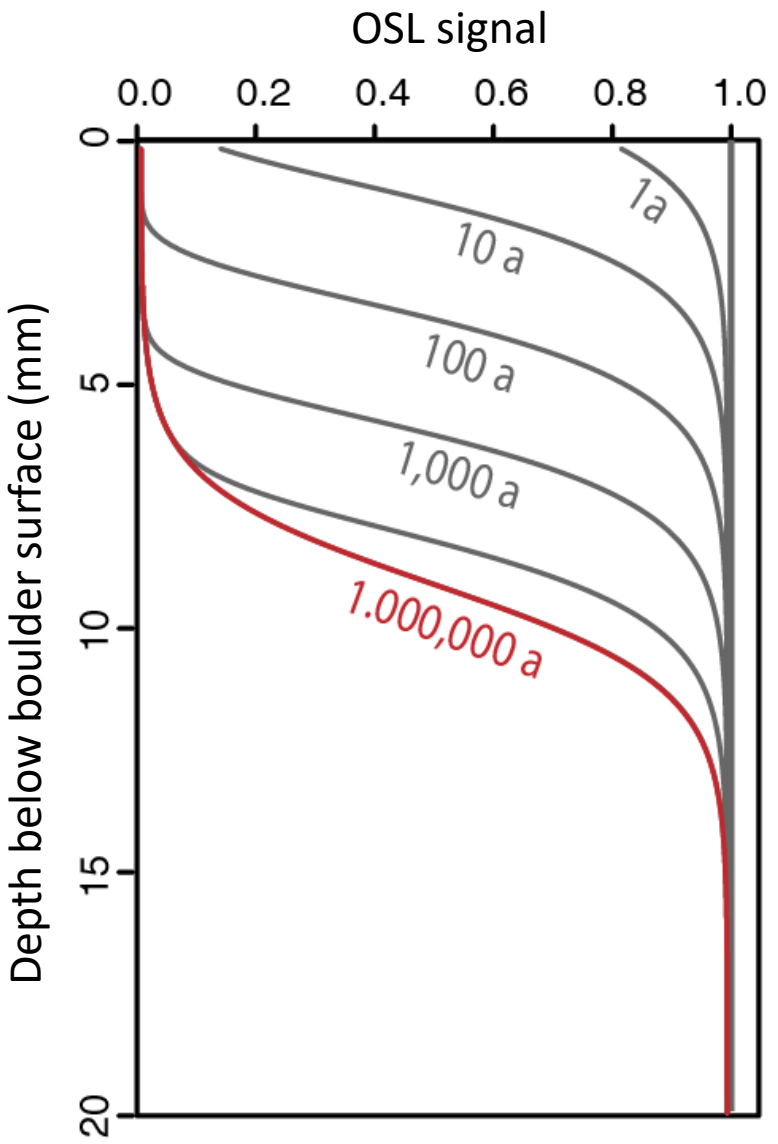
L_f = residual OSL signal at depth *x* (mm)

L_i = signal intensity prior to exposure

t_e (s) = exposure time

$\overline{\sigma\varphi_0}$ *(s-1) = effective bleaching rate of OSL signal at rock surface*

μ (mm^{-1}) = light attenuation coefficient in rock



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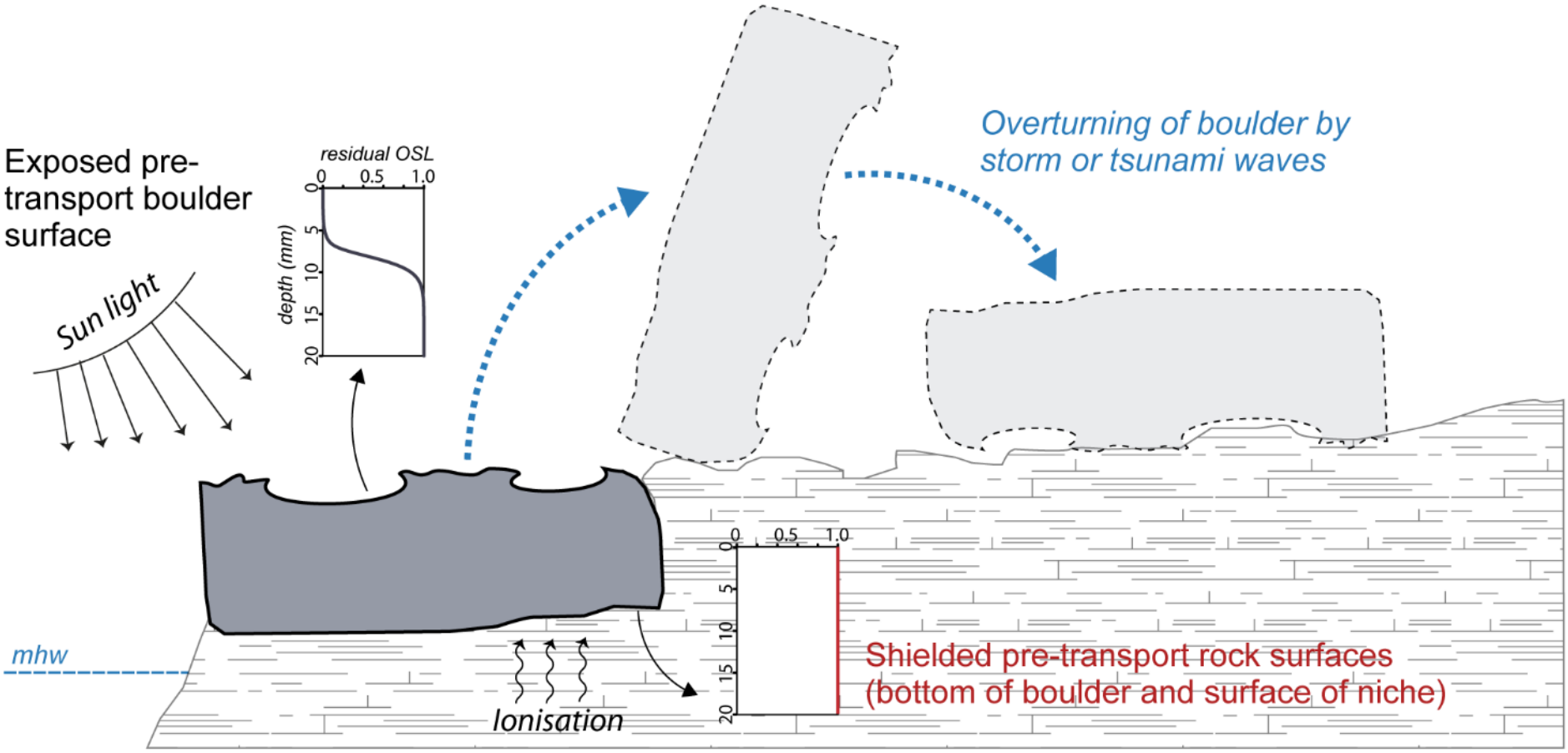
Principles of OSL rock surface dating coastal boulders

(1) Pre-transport situation

- ✓ Bleaching of OSL signals in upper millimetres of exposed pre-transport surface
- ✓ Saturated OSL signals in shielded pre-transport surfaces



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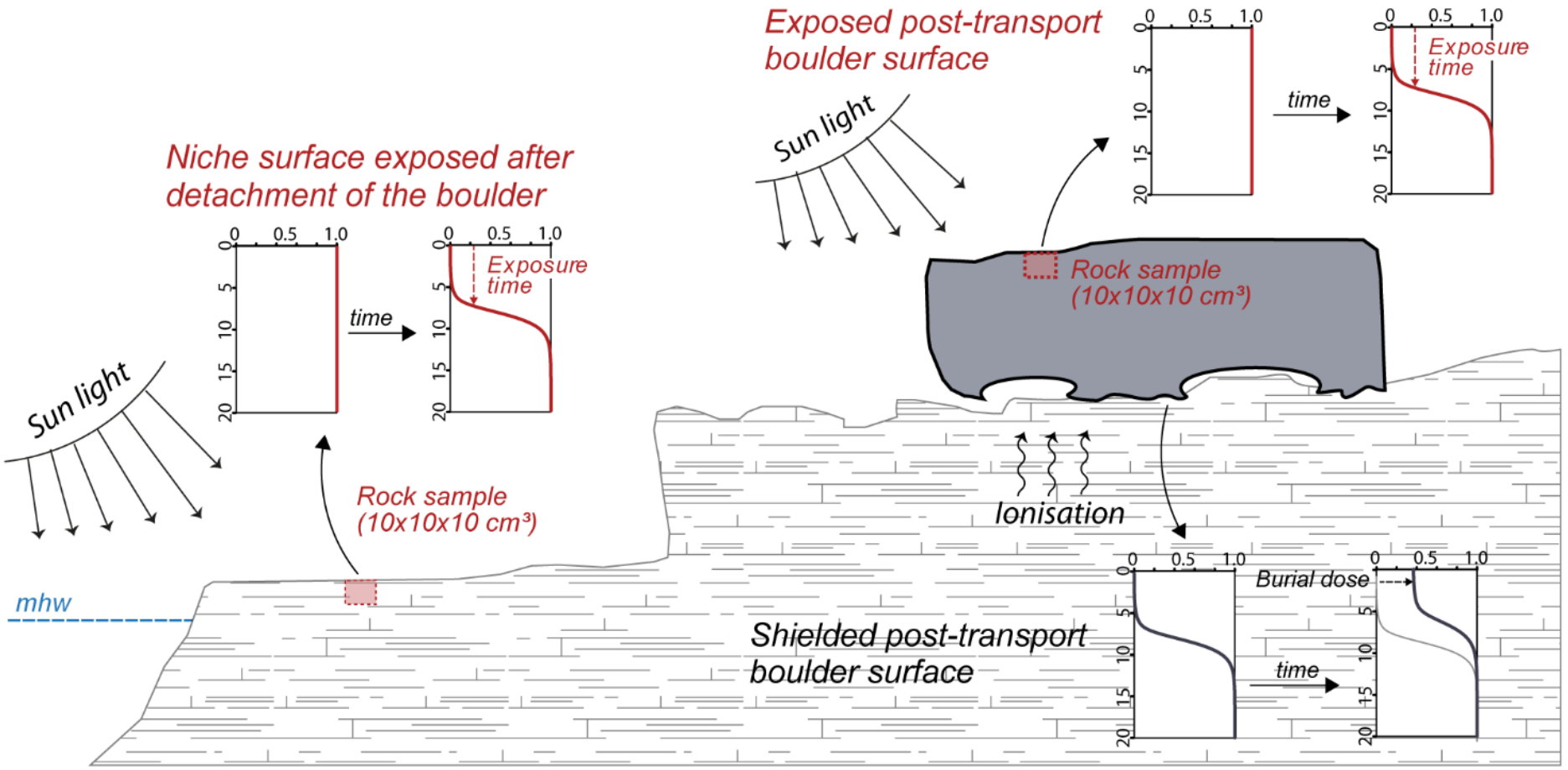
Principles of OSL rock surface dating coastal boulders

(2) Post-transport situation

- ✓ Burial dating of shielded post-transport surface → logistical limitations!
- ✓ Exposure dating of freshly exposed surfaces (boulder and erosive niche)



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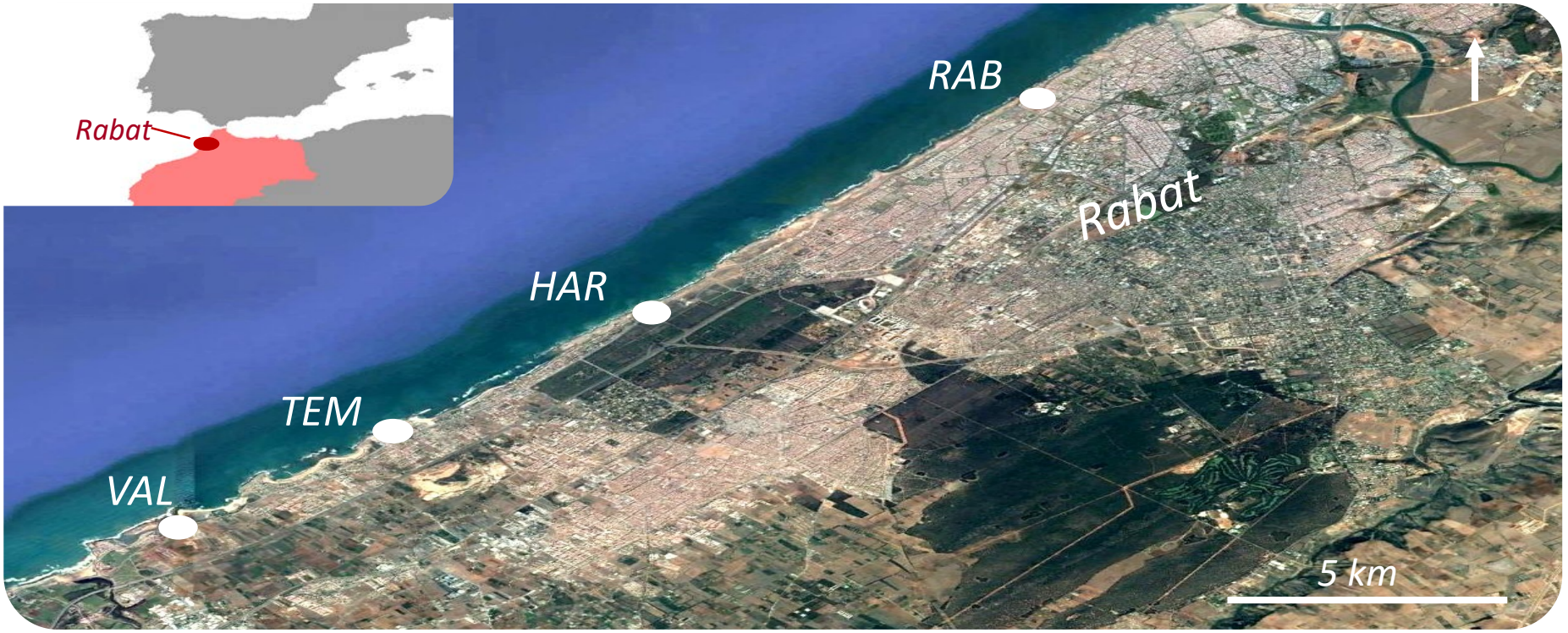
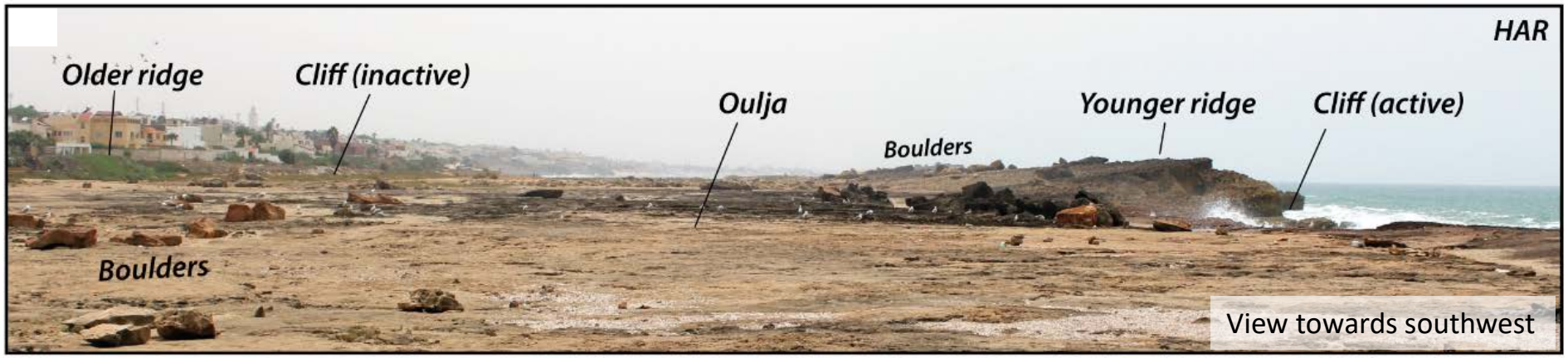
The Rabat boulder fields (Atlantic coast, Morocco)





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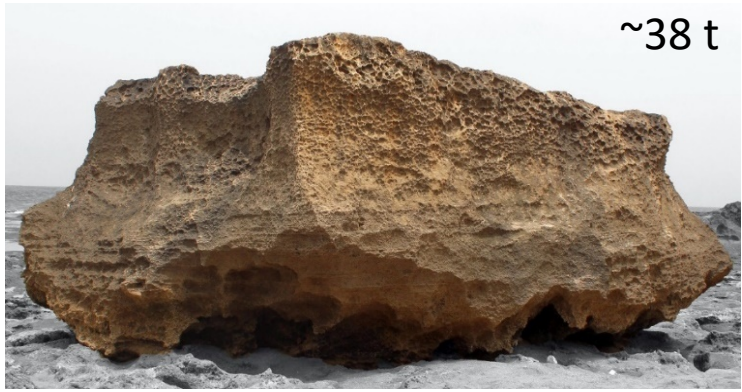
Boulder samples for OSL rock surface dating

Samples for dating

- ✓ Surface samples of nine overturned calcarenite boulders (down-facing rock pools) with approximately horizontal post-transport surfaces
- ✓ Surface samples of two erosive niches left in the coastal cliff after detachment of boulders
- ✓ Minimum ages from satellite images and eye-witness reports available for some boulders



Samples for model calibration (surfaces with known eposure age of ~2 years)

- ✓ Rock surfaces created in July 2016:
  two on a nearby roof top (left) and three on boulders in the field (right)

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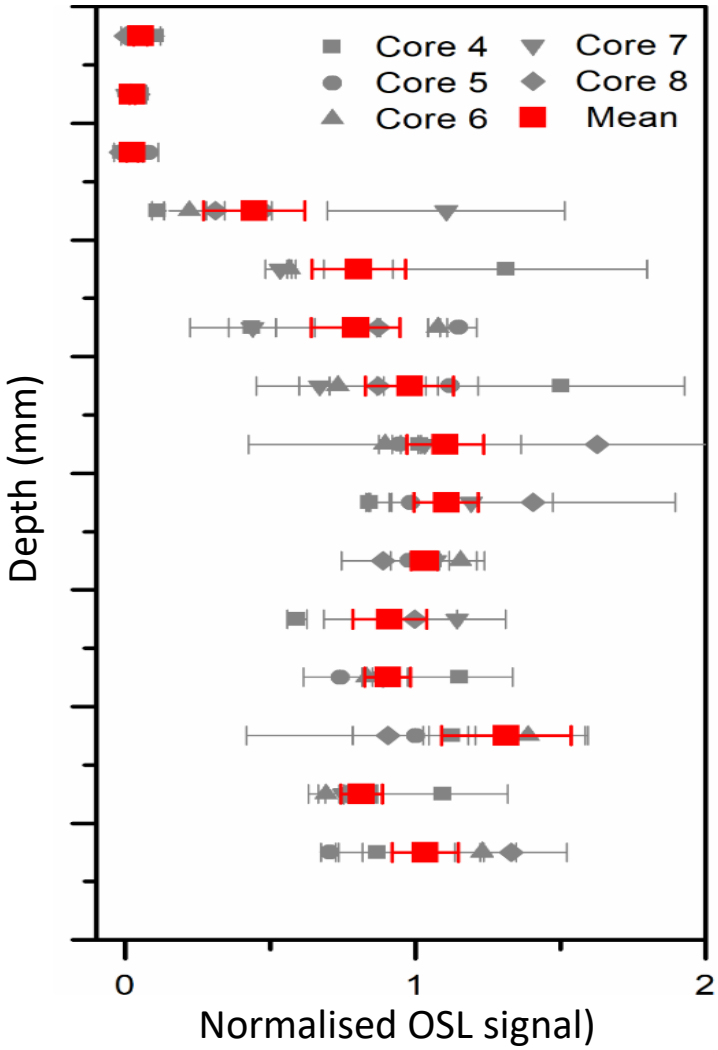
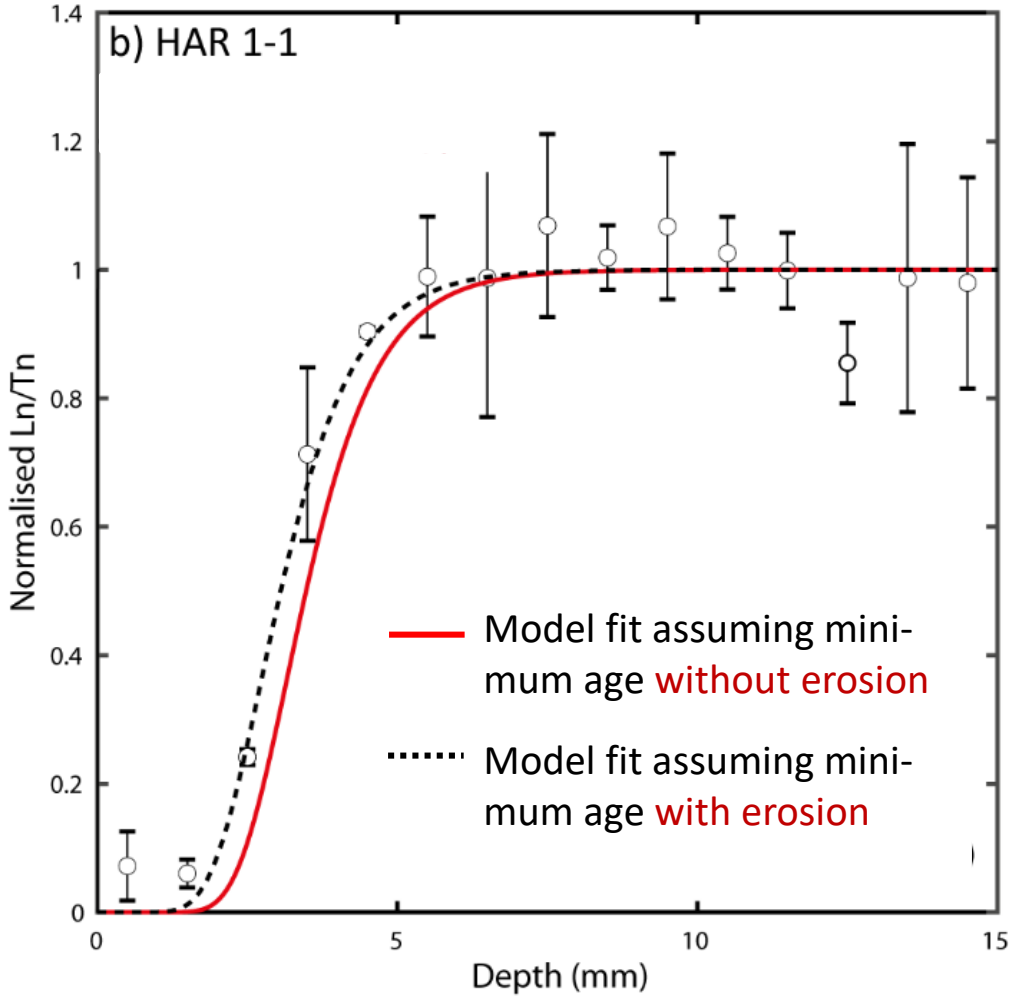
Challenges for dating calcarenite boulders at the Rabat coast

Low signal intensities → Comparably large dating uncertainties



Post-depositional erosion → Age underesti-mation (depending on boulder taphonomy)



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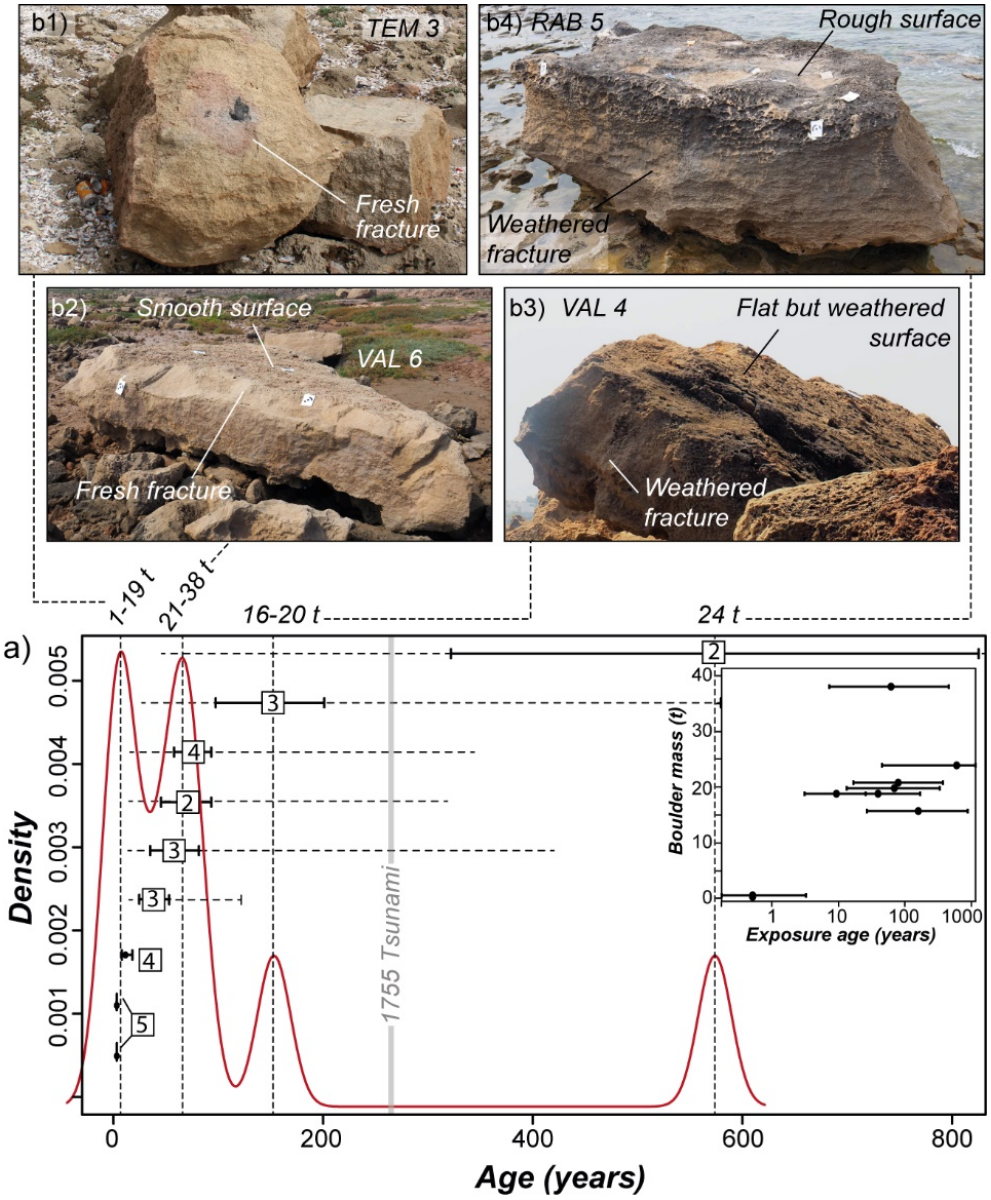
First ages for Rabat boulder fields



- ✓ Absolute OSL rock surface exposure ages likely affected by erosion – correlation with specific events not possible.
- ✓ Correlation of OSL exposure ages and boulder taphonomy expressed by roughness of surfaces and fractures (left), indicates that OSL rock surface exposure ages provide a robust relative chronology.
- ✓ No significant correlation between age and boulder mass was observed (left, inset).

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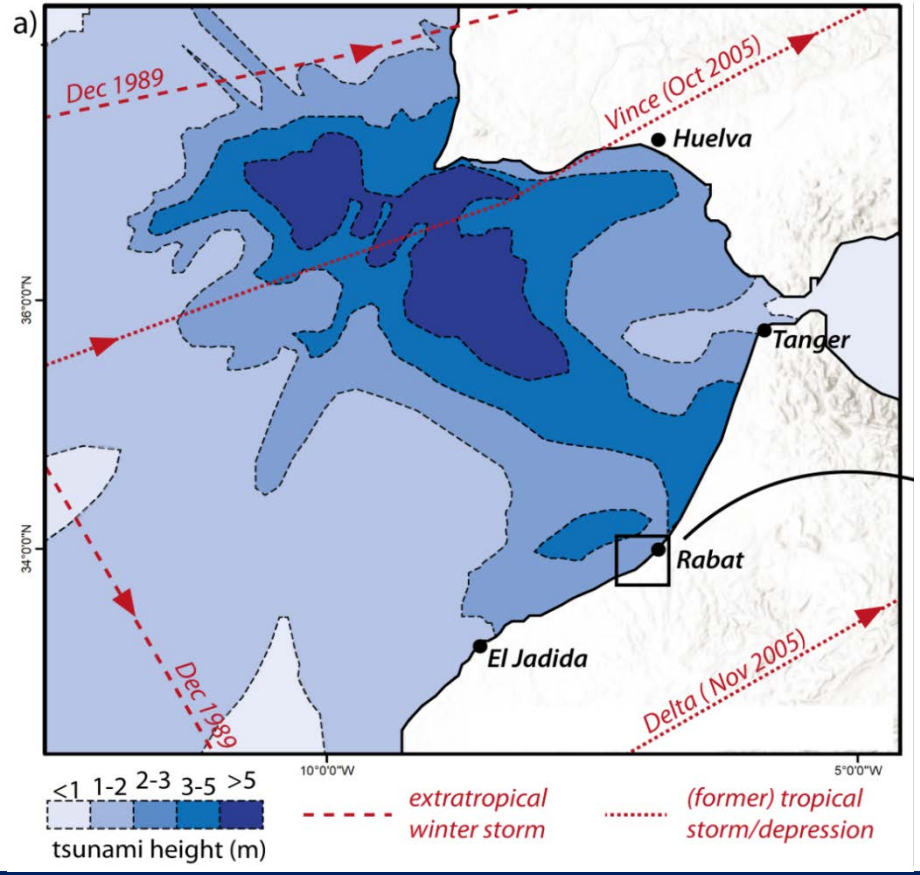
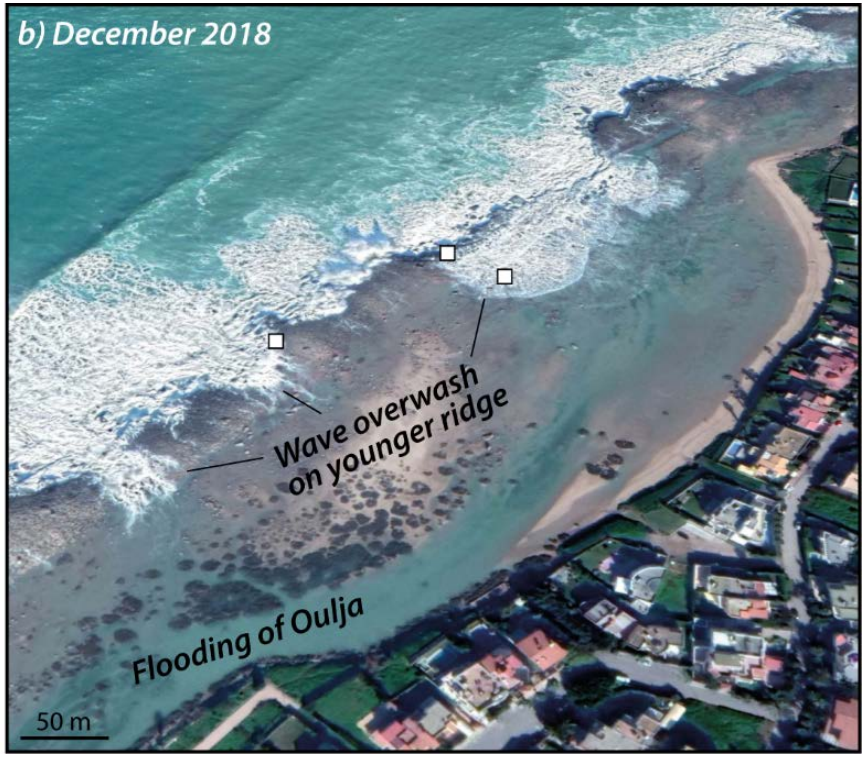
Implications for storm and tsunami hazard

- ✓ Significant flooding at Rabat coast during strong winter storms (every few years, Mhammdi et al. 2020) and during 1755 Lisbon tsunami (Renou et al. 2011)
- ✓ Relative OSL exposure chronology indicates that most boulders were moved by storms
- ✓ Storm boulders reach masses of up to 40 t, pointing to important role of storms for formation of boulder deposits in general





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Conclusions and Perspectives

- ✓ OSL rock surface exposure dating has the potential to provide chronological information for the displacement of coastal boulders wherefore as yet no other dating techniques are applicable.
- ✓ Even relative chronologies (as at the Rabat coast) provide valuable information for interpreting the origin and transport mechanisms of coastal boulders.
- ✓ Erosion of post-transport surfaces and low OSL signal intensities – the main limiting factors for boulder dating at the Rabat coast – might be reduced significantly for boulders with other lithologies (e.g. quartz sandstones or magmatites).

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References

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