Exploring dryland dynamics with portable luminescence readers

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Overview

- Port-OSL readers provide rapid insights into relative age and cast light on sediment characteristics (see Box. 1) [1].
- Is it possible to produce generalized chronologies for dryland dunes (and for one site lake shorelines)? In the:
  - Kalahari & Namib, southern Africa [2,3] (Fig. 1,2)
  - Thar Desert, India [4] (Fig. 4,5,7), & other dunefields…
- What else do we learn about our sediments?

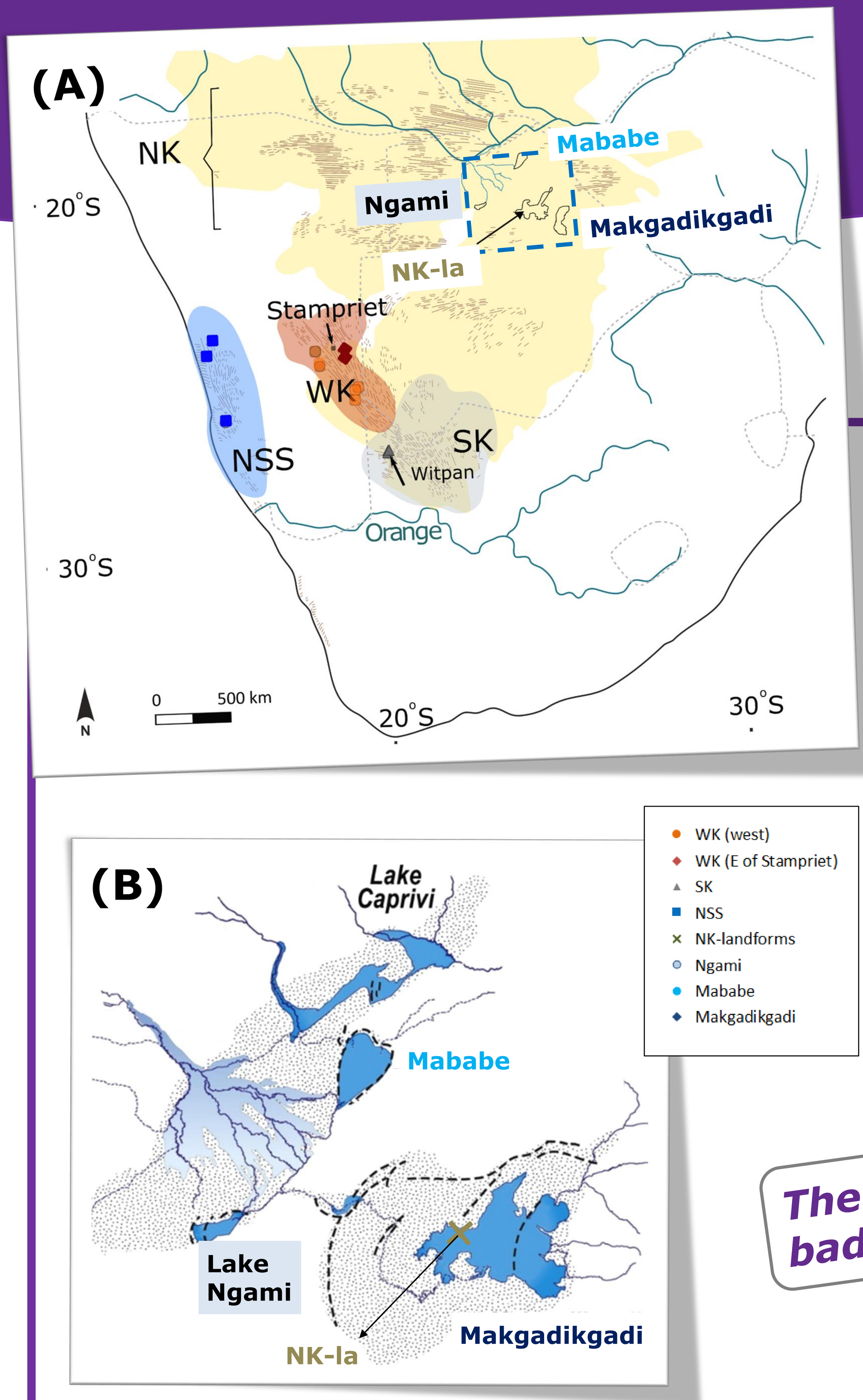


Fig.1. Sn African dune & shoreline locations

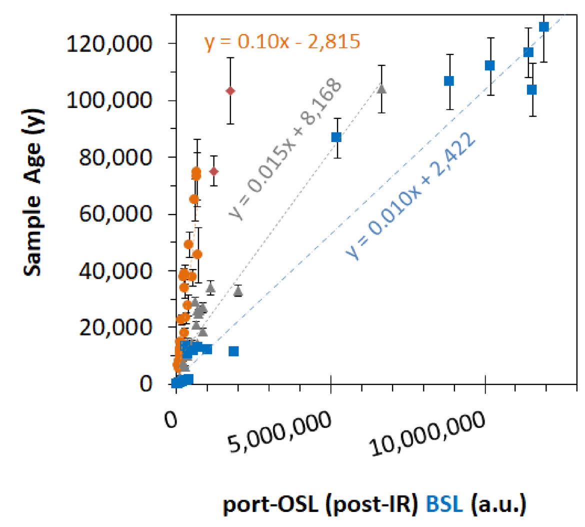
NSS = Namib Sand Sea [5,6], **WK-w** = western Kalahari, with an '**east of Stampriet**' subset [7], **SK** = southern Kalahari [8,9], **NK-landform** = on floor of Makgadigadi pans [10].
(B) shows lakes Ngami[11], **Mababe** [12] and **Makgadikgadi** [13].

The good, yet ugly

(we switched port-OSL sequence and data analysis to facilitate data comparison across literature, but lose data for NK-la)

Dunes

Region-specific calibrations



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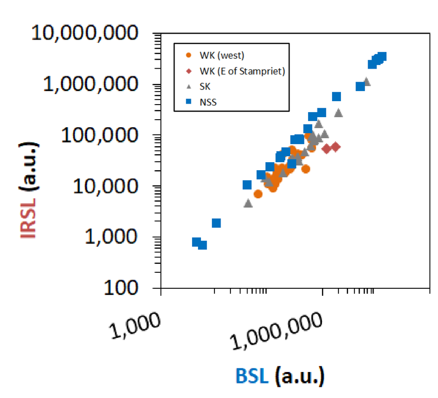
R **IRSL:BSL ratio**

Regions slightly separated
→ *reflects mineralogy*



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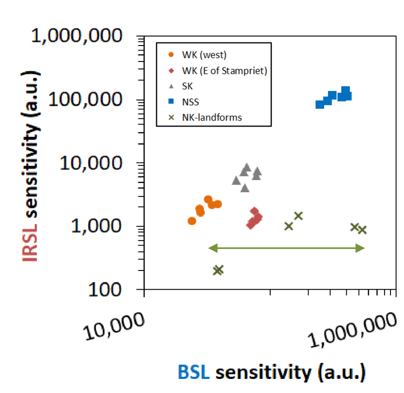
Sen **Lum sensitivity**

Regional groups, scattered **NK-la**
→ *NK-la dependence on texture*



- Regional petrology & port-OSL

Dunes

- **NSS:** feldspathoquartzose (fspq) (Q:F 3-4), rich heavy mineral suite (HMs) [14]
  High sensitivity, IRSL:BSL 0.26 ± 0.15.
- **SK:** Q-rich fspq (Q:F 4-10), poor HMs, local outcrops Karoo basalt [15]
  Med-sensitivity, IRSL:BSL 0.12 ± 0.03.
- **WK-w:** Q-rich fspq (Q:F 5-7), as SK [15]
  Low sensitivity, IRSL:BSL 0.10 ± 0.03.
- **WK-east:** Q-rich fspq (Q:F 6-10) [15]
  Low sensitivity (BSL), & ↓ IRSL, IRSL:BSL 0.04 ± 0.01.
- **NK-la:** Q-pure (Q:F 56), v-poor HMs [15]
  Variable sensitivity (BSL) & dim IRSL.

Shorelines are within Q-pure NK [15] (but no direct petrology)
Highly sensitive (BSL), v-low IRSL.

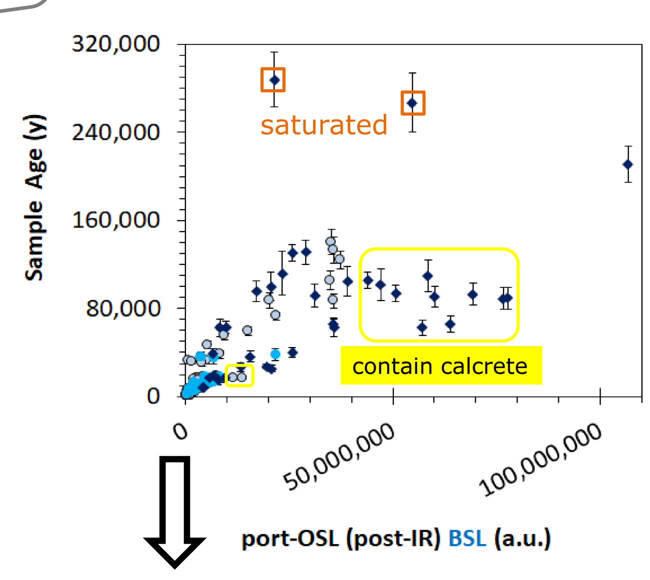
- Ngami: IRSL:BSL 0.002±0.001.
- **Mababe**: IRSL:BSL 0.001±0.001
- **Mak**: IRSL:BSL 0.001±0.000

→ Reflects composition = (f) provenance, transport and weathering histories. Lake sediments also influenced by textural variation.

The bad

Lake shorelines

More **scatter** in calibrations



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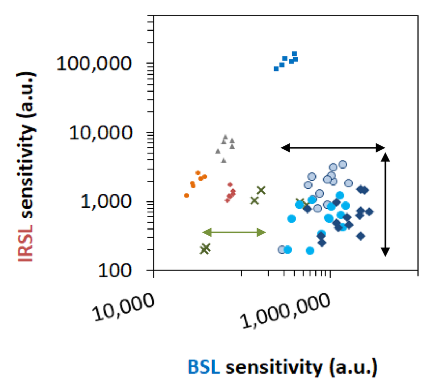
Sen **Lum sensitivity**

Range large for each shoreline as with **NK-la**
→ *what drives this?*



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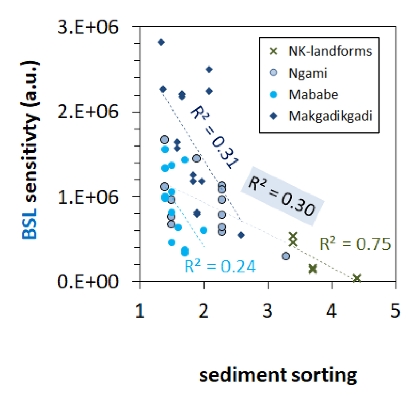
Sediment texture

Some dependence of BSS (& natural signals) on texture.



Can account for some of the scatter…
→ *Oldest ages saturated*
→ *Calcrete-rich samples are brighter*
→ *Two 'dim' Mababe outliers*

Fig. 2. port-OSL signal and sediment characteristics

Generalised chronologies?

[✓] for dunes, within region-specific boundaries
[?] for lake shorelines (sediment textural and compositional variation, including calcrete, and perhaps mixed provenances.

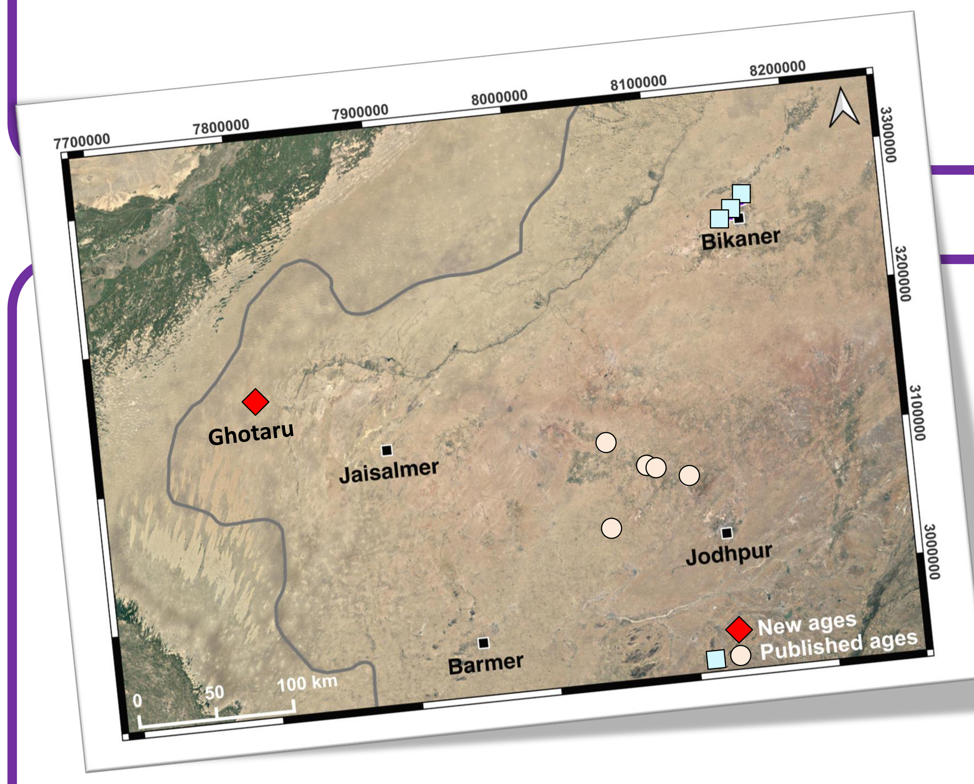
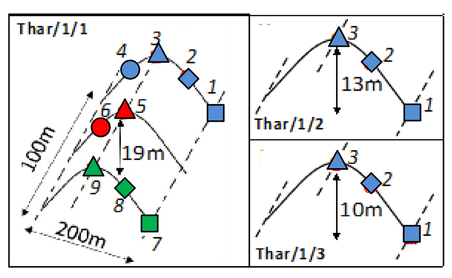
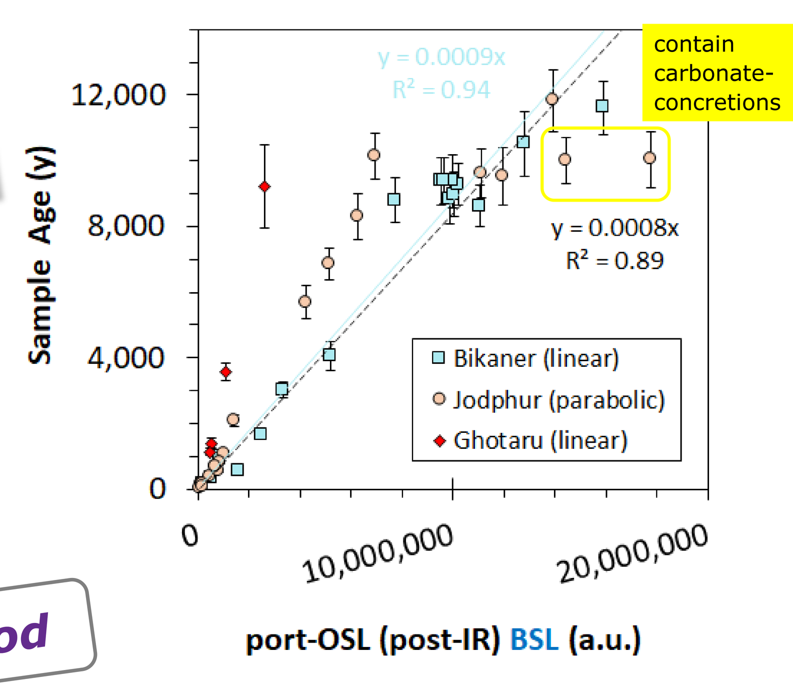


Fig. 4. Thar dune sites

Location of samples used to build calibration. Schematic shows additional samples used for age-estimation.



Existing Thar dune ages and new Wn-most samples (Fig. 4) to build calibration (Fig. 5).



The good

Fig. 5. port-OSL calibration

- Calibration uses 44 samples: 17 linear, Bikaner [16], 4 linear Ghotaru [(new)], 23 parabolic, Jodhpur [17] (Fig. 5).
- Bulk sample characteristics influence the calibration.
  - altering **moisture content**: 24% ↓ port-OSL signal at ~0.75% moisture (Fig. 6)
  - carbonate-concretions ↑ port-OSL signals
  - organics ↓ signals
- Applied the calibration to additional samples (Fig. 4 inset) to produce dune accumulation records (Fig. 7).
  - All ~2 m profiles are Holocene age.
  - Thar 1/1 contains older sediment than 1/2 & 1/3.
  - Interdunes oldest.
  - Thar 1/1 E dune flanks younger than W flanks and crests, but 1/2 & 1/3 have younger crests.

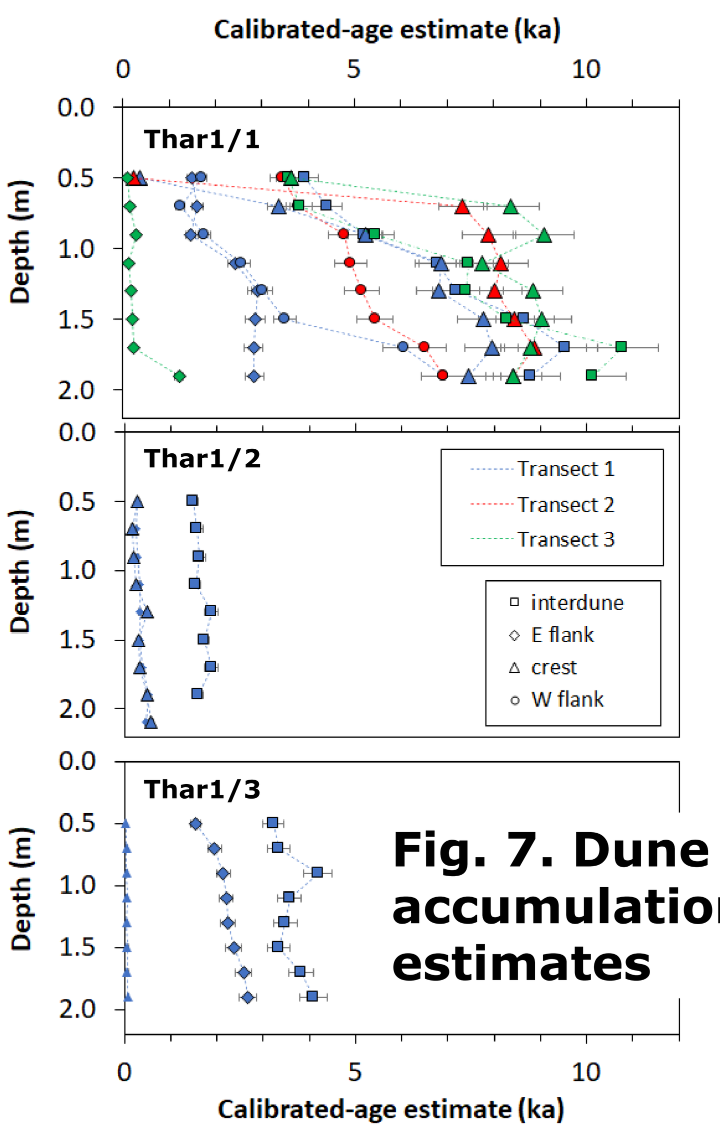
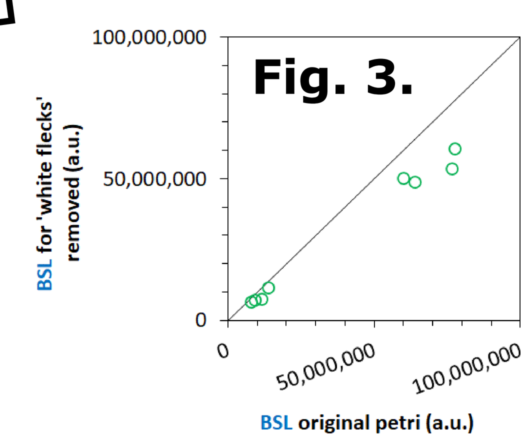
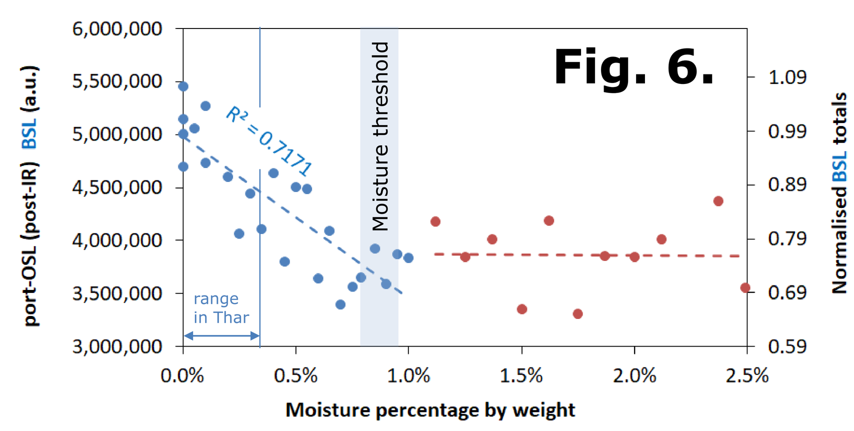


Fig. 7. Dune accumulation estimates

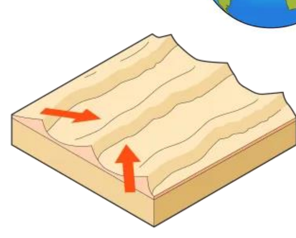
The ugly? *(the port-OSL rationale is to keep it simple with no sample preparation but…)*



The effect of removing calcrete in Sn African lake samples.



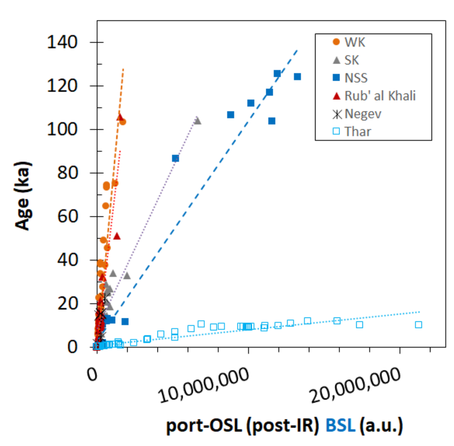
Attenuation of port-OSL signals by moisture using Thar samples [4].



Can you help us to go global?

Let's measure your dune sand bulks

with current thanks to Nick Lancaster, Christina Neudorf, Lotem Robbins, Joel Roskin, & Dave Thomas.



Box 1:

So, what can we learn from port-OSL signal characteristics?

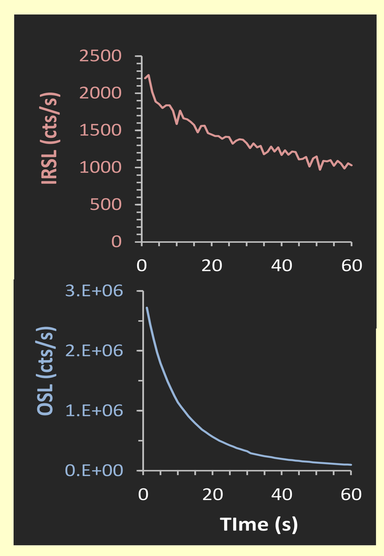
S **Signal size** (BSL & IRSL)
- Sample age (+ for BSL & IRSL)
- Luminescence sensitivity (+ for BSL & IRSL)
- Mineralogical variation (↑ feldspar = ↑ IRSL)

Sen **Sensitivity** Response to applied lab-dose
- Linked to minerology/provenance, sedimentary cycles (↑), heating (↑), *and may also reflect variations in sed colour/transparency & particle size*

R **IRSL:BSL ratio**
- Mineralogical variation (↑ feldspar = ↑ ratio) *reflects sediment provenance and/or weathering*

D **Depletion indices**
- Mineralogical variation (↑ feldspar = ↓ BSL index), and un-known influences from HMs
- Residual/ inherited luminescence (↑ = ↓ index)
- Grain coatings (cleaner surface = ↑ index)

NOTE: decay rate also shows an age (signal size) dependence



Affiliations, acknowledgements and references

1. University of Manchester, UK, 2. University of Sheffield, UK, 3. Scottish Universities Environmental Research Centre, UK, 4. University of St Andrews, UK (see abstract for full address details). * abi.stone@manchester.ac.uk @AbiStone

Thanks: A.S. thanks the Ministry of Environment and Tourism, Namibia for research/collecting permits during sampling in the NSS and Kalahari, and numerous field assistants (Hartmut Kolb, Prof. Heather Viles, Prof. David Thomas, Prof. Christine Lane, Dr Jerome Mayaud, and to Dr Sallie Burrough and Dr Matt Telfer for access to their bulk sediment samples. Funders for those periods of fieldwork are thanked via those papers. A.S. also thanks Dr Will Fletcher for guidance with regression model statistics and to the luminescence community for productive discussions around the port-OSL reader. The Thar work by S.N. was undertaken during his MSc in Environmental Monitory Modelling and Reconstruction, who thanks Ms Komal Songara and her team for support in the field and the University of Manchester, The Manchester Geographical Association and the QRA for financial support.

References: [1] Sanderson, Murphy (2010) *Quat. Geochron.* **5**, 299-305. [2] Stone et al. (2015) *Quat Geochron* **30**, 134-140. [3] Stone et al. (2019) *Quat. Geochron* **49**, 57-64. [4] Nitundil et al. (2022) MSc thesis; Nitundil et al. (2023, under revision) *Quat. Geochron.* [5] Stone et al. (2010) *PPP* **288**, *35-53.* [6] Bristow et al. (2007) *Geol.* **35**, 555-558. [7] Stone, Thomas (2008) *Quat. Sci. Rev.* **27**, 1667-1681. [8] Telfer, Thomas (2006) *Geol.* **34**, 853-856. [9] Telfer, Thomas (2007) *Quat. Sci. Rev.* **26**, 2617-2630. [10] Burrough, Thomas (2013) *Quat. Sci. Rev.* **80**, 29-46. [11] Brough et al. (2007) *PPP* **253**, 280-299. [12] Burrough, Thomas (2008) *Quat.Res.* **69**, 388-403. [13] Burrough, Thomas (2009) *Quat. Sci. Rev.* **28**, 1392-1411. [14] Garzanti et al. (2012) *Earth-Sci. Rev.* **112**, 173-189. [15] Garzanti et al. (2022) *Earth-Sci. Rev.* **224**, 103867. [16] Srivastava et al. (2019a) *Geomorph* **344**, 90-98. [17] Srivastava A. et al. (2019b) *Earth Surf. Process. Landform* **44**, 1407-1418.