Lithofacies control on deformation bands

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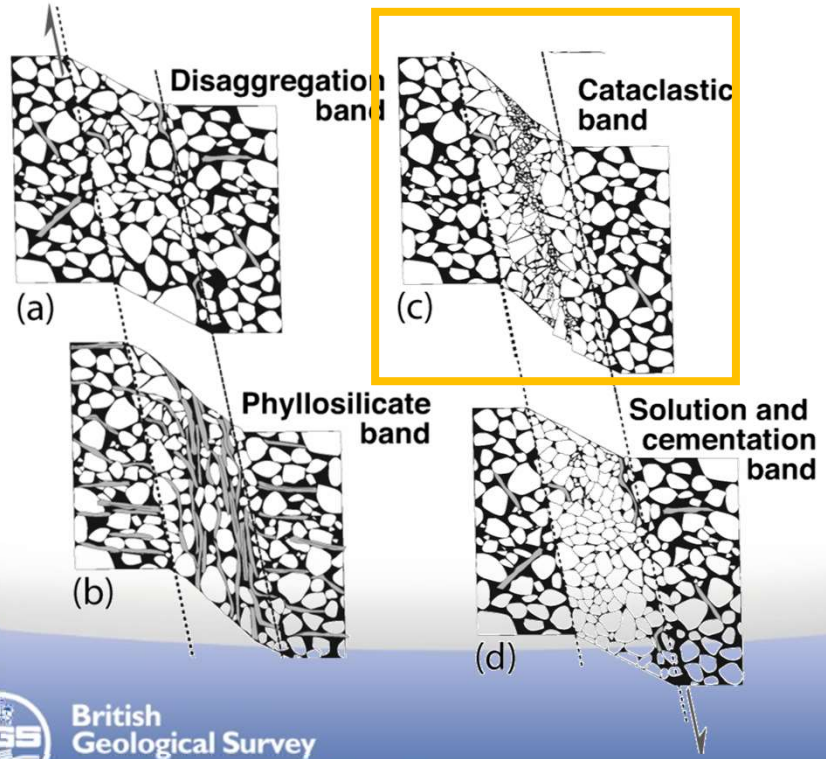
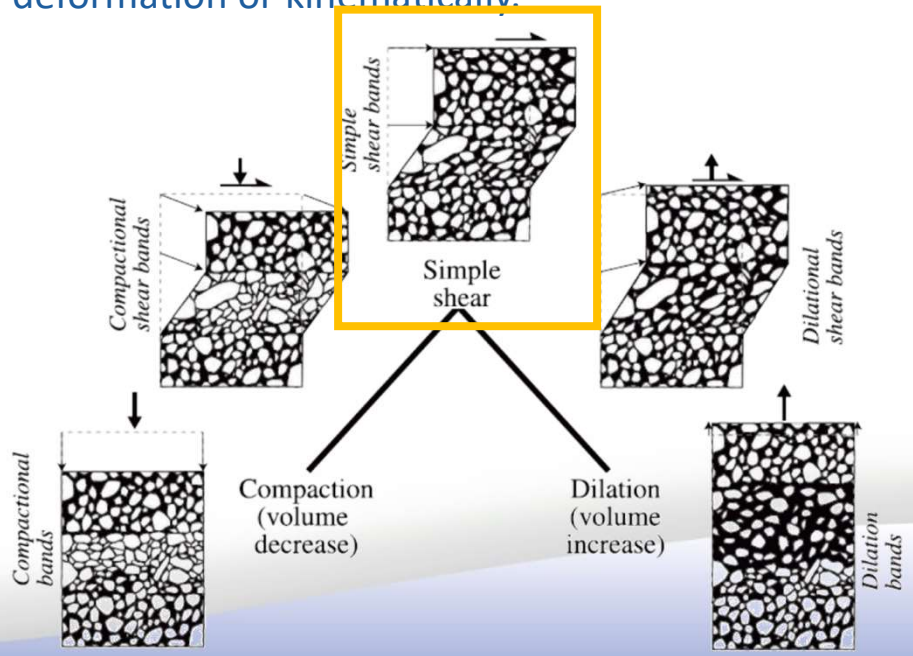
Overview

- Secondary strain induced localisation features (mostly planar) that typically develop in porous sandstones (Fossen et al., 2007).
- The development of deformation bands results in combinations of grain re-organisation, grain-dissolution, cataclasis (grain-breaking) and precipitation of new cements.
- Commonly have reduced permeability (orders of magnitude less) than the host rock.
- Classification schemes based on mechanism of deformation or kinematically.





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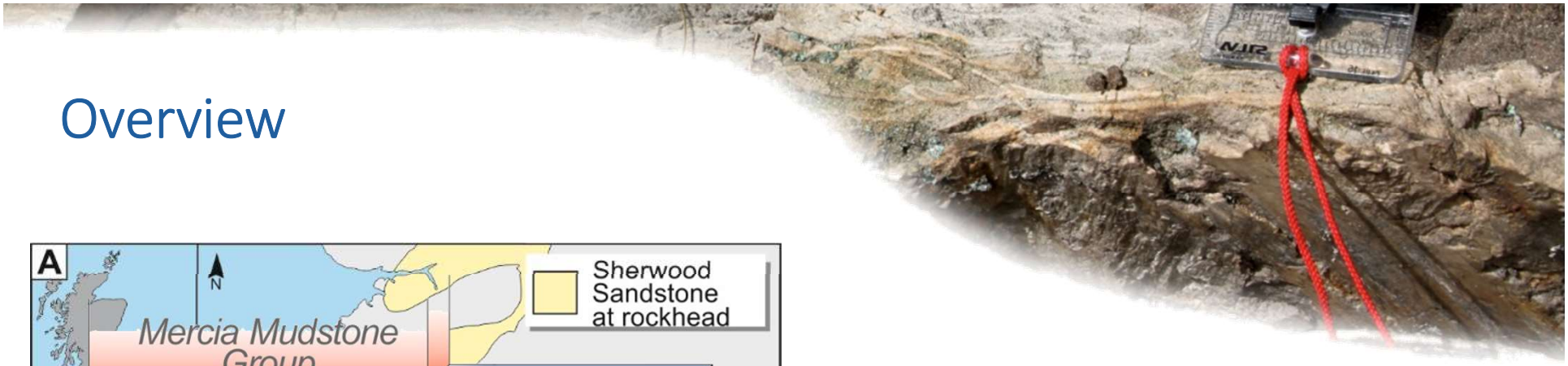
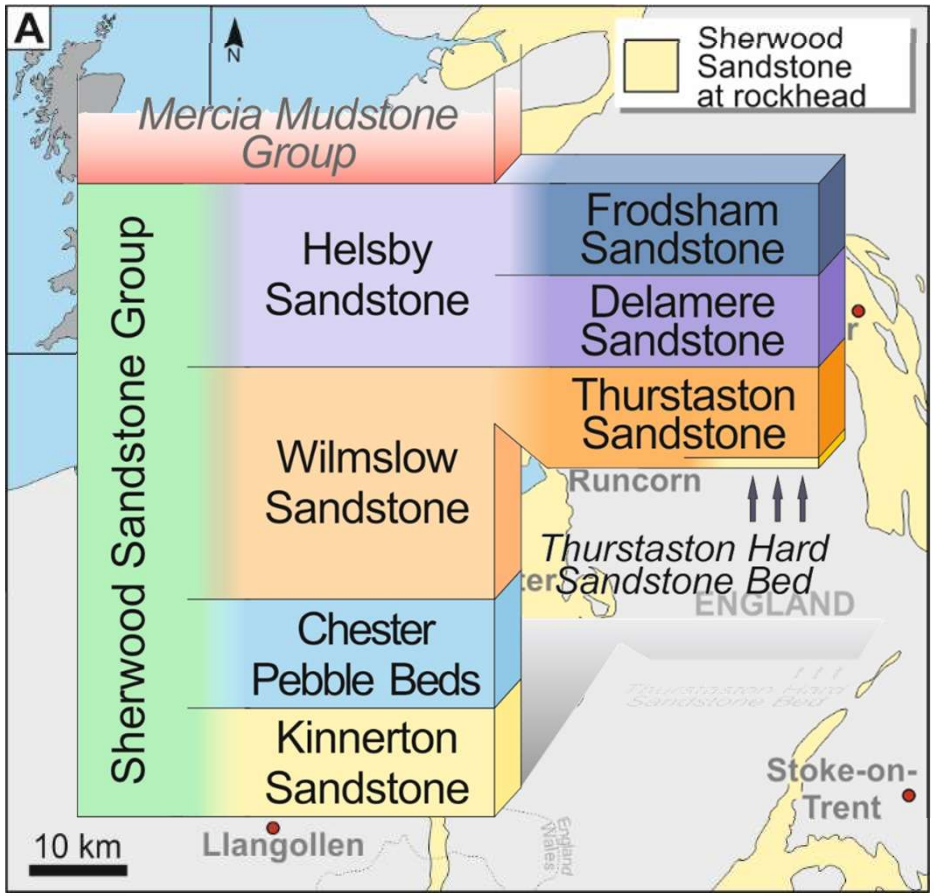
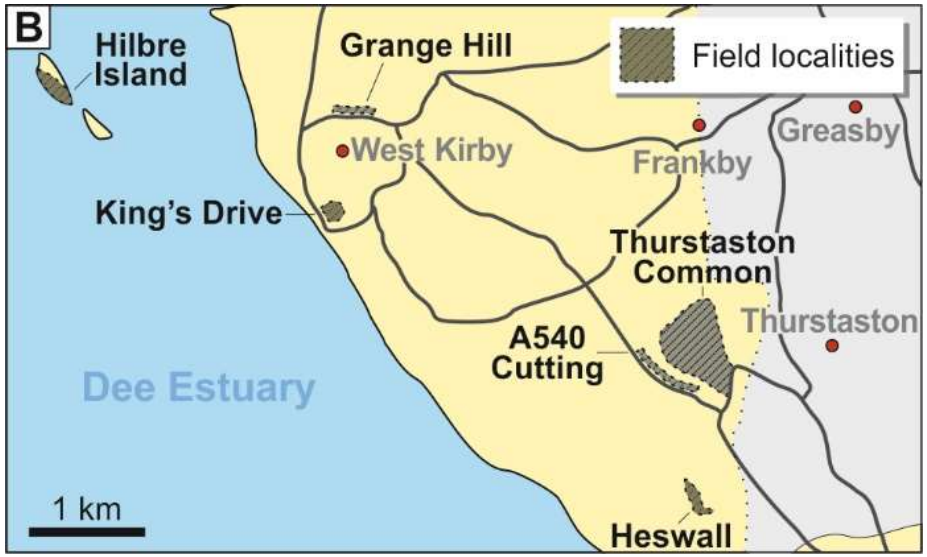
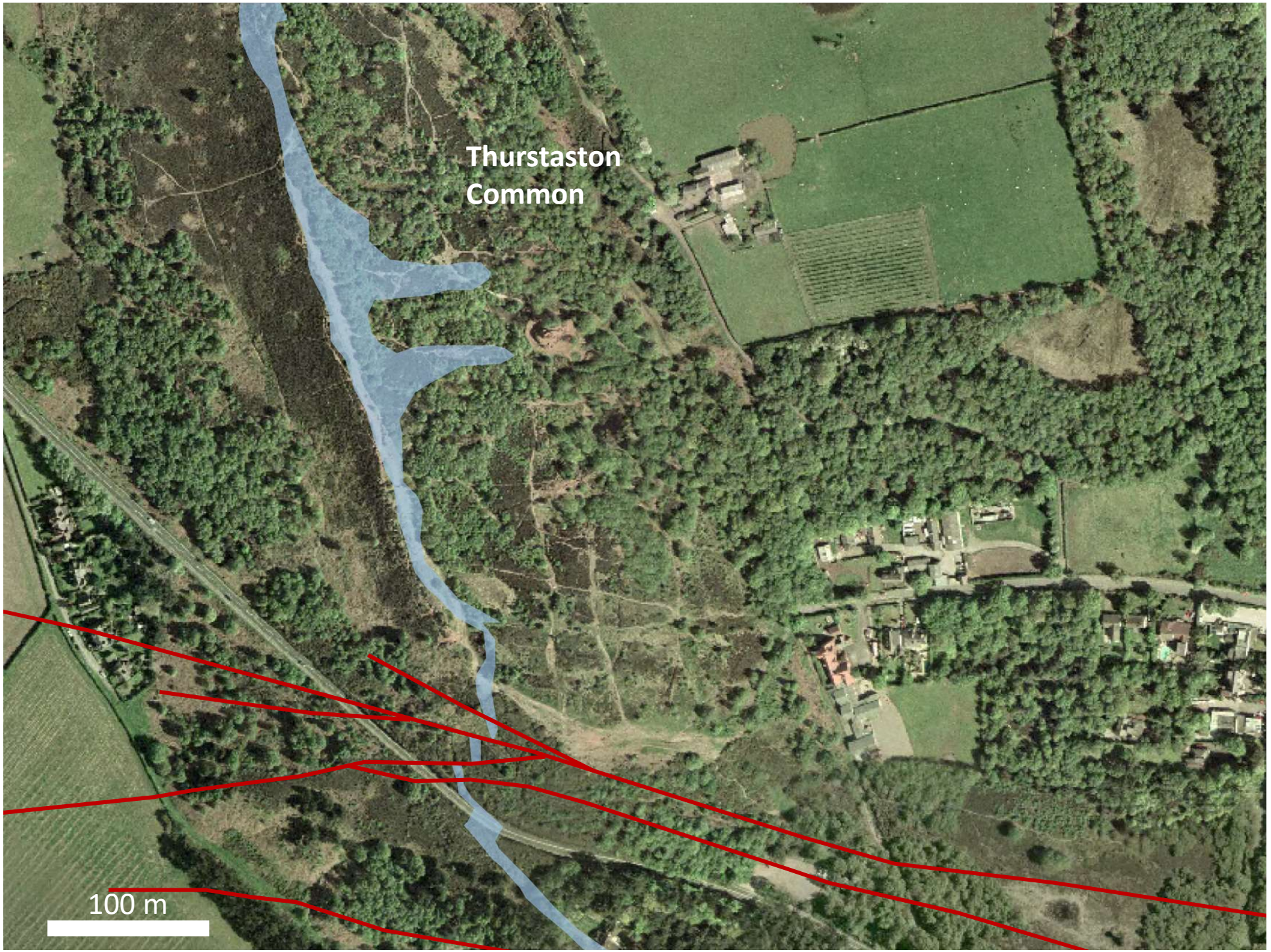
Griffiths et al., 2016

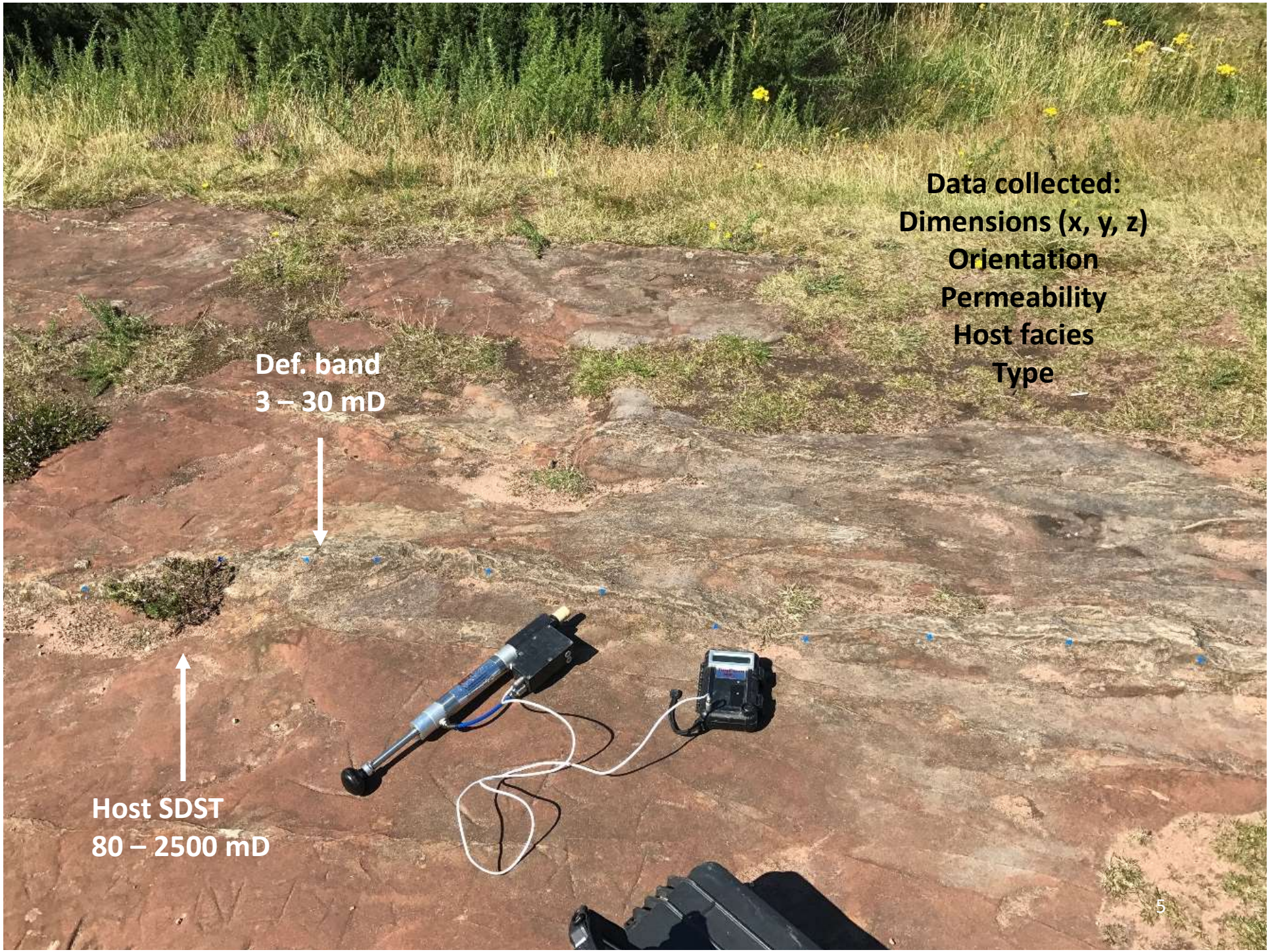
Overview




A
N
Sherwood Sandstone at rockhead
Mercia Mudstone Group
Sherwood Sandstone Group
Helsby Sandstone
Frodsham Sandstone
Delamere Sandstone
Thurstaston Sandstone
Wilmslow Sandstone
Chester Pebble Beds
Kinnerton Sandstone
Runcorn
Thurstaston Hard Sandstone Bed
ENGLAND
Stoke-on-Trent
Llangollen
10 km


B
Hilbre Island
Grange Hill
Field localities
West Kirby
Greasby
Frankby
King's Drive
Thurstaston Common
Thurstaston
A540 Cutting
Dee Estuary
1 km
Heswall


Thurstaston
Common
100 m


Data collected:
Dimensions (x, y, z)
Orientation
Permeability
Host facies
Type
Def. band
3 – 30 mD
Host SDST
80 – 2500 mD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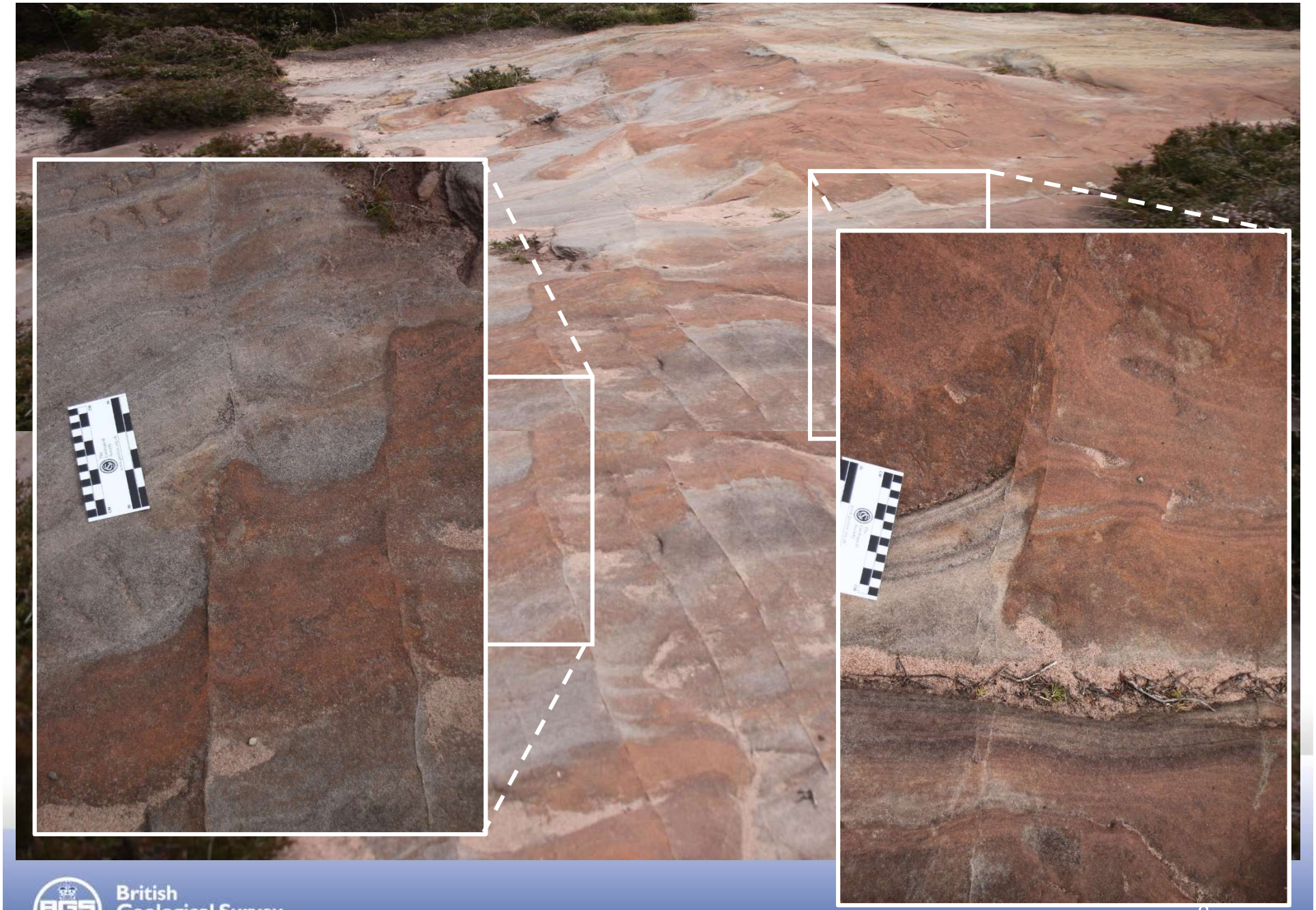
www.geolsoc.org.uk
CM
IN



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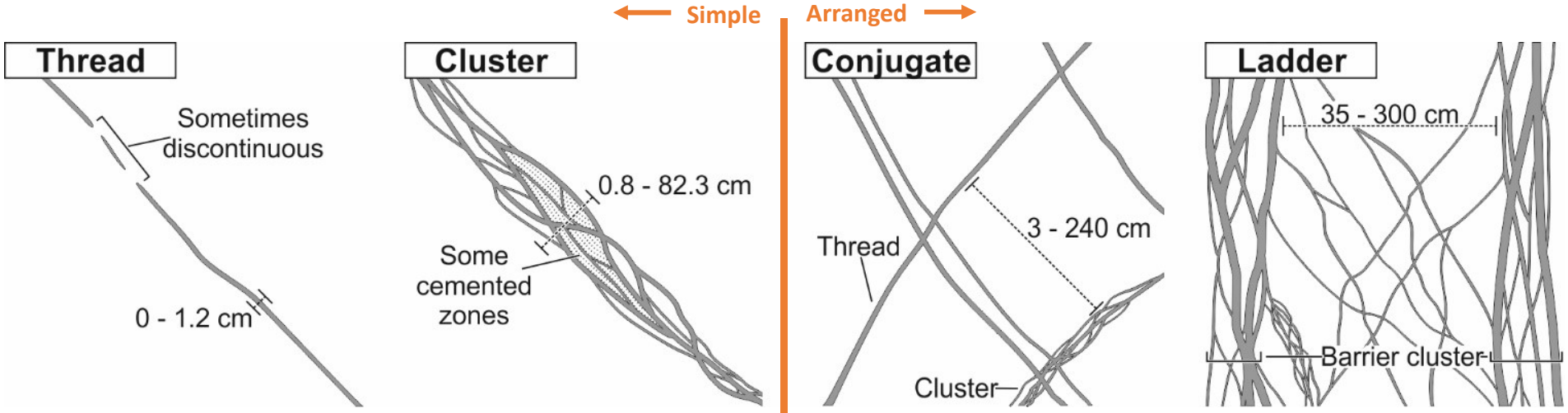
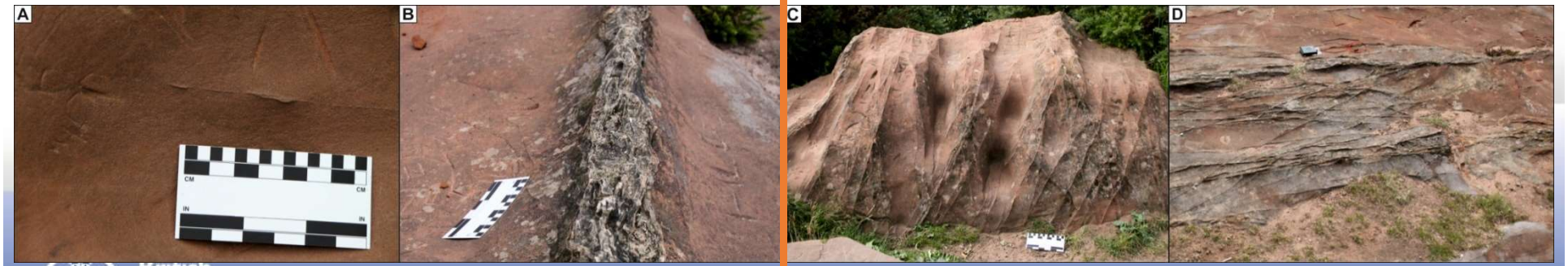
Classification Scheme

- Current classification schemes don't make assessments for deformation geometry.
- The following proposed scheme can be used in conjunction with others.





Facies Control? *cont'd.*

Factors known linked to the formation of deformation:

• grain size • grain sorting • grain/clast composition (mineralogy) • grain/clast roundness • porosity	**Primary Sedimentological**
• burial depth • lithification • amount and duration of stress • pressure exerted by porefluids during deformation	**Secondary 'Stuff'**

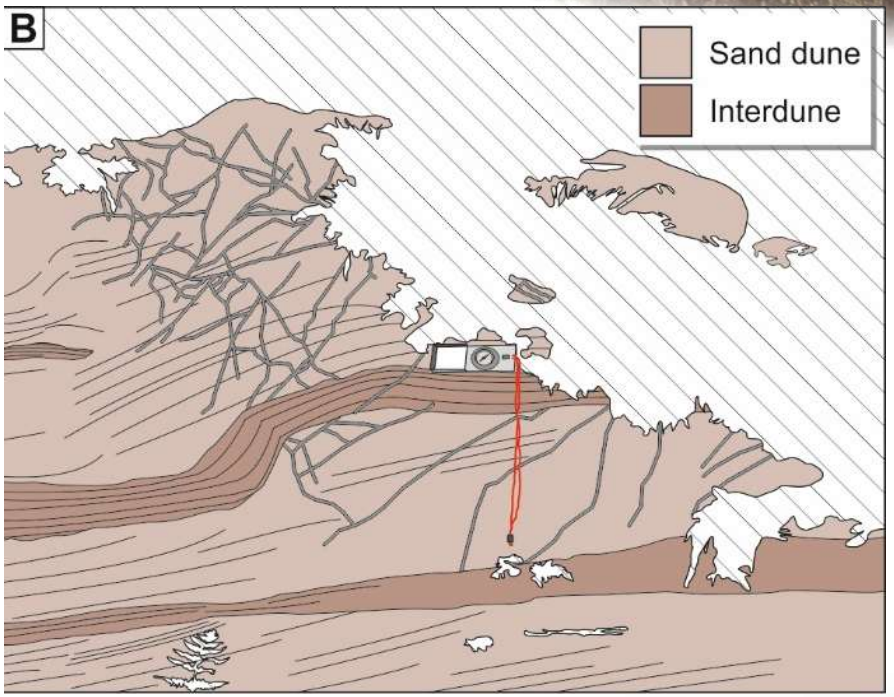
What about variations facies….?

Facies Control?

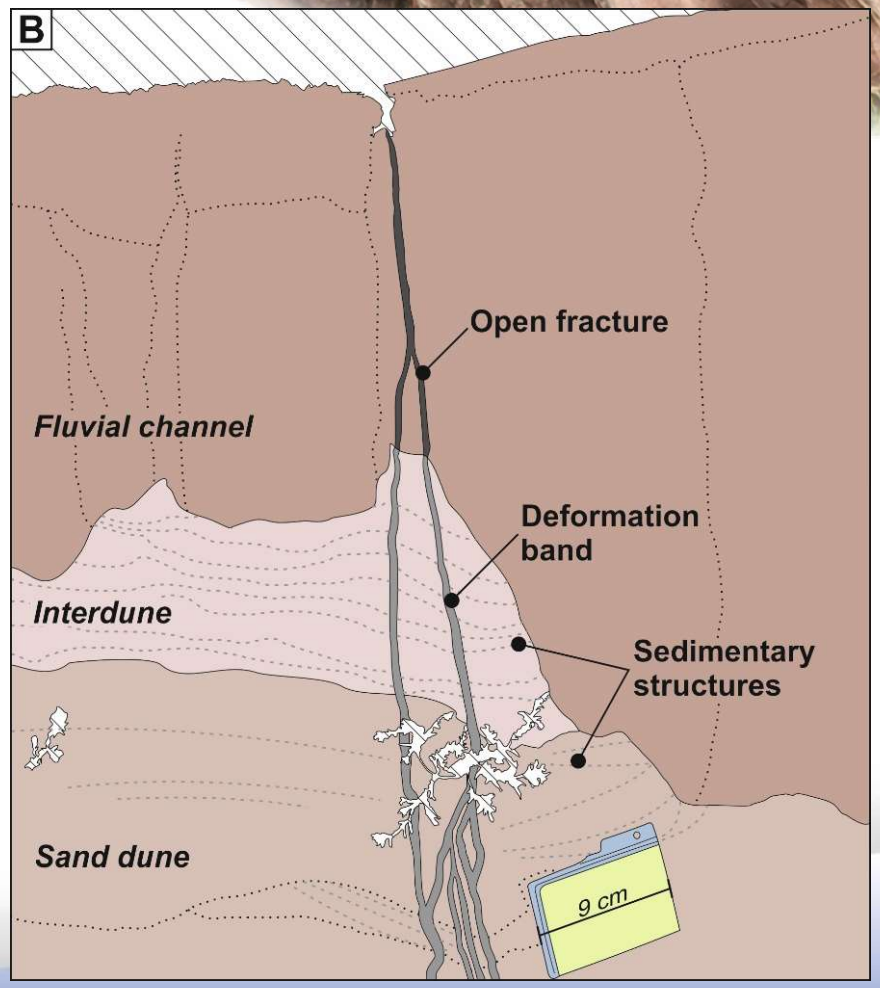
Reference	Host sucession	Depositional system
Antonellini et al. (1994)	Chinle Formation (Utah, USA) Wingate Sandstone Formation (Utah, USA) Kayenta Formations (Utah, USA)	Mixed fluvial, aeolian, lacustrine & palustrine Aeolian dunefield Aeolian dunefield
Aydin (1978)	Entrada Sandstone Formation (Utah, USA) Navajo Sandstone Formation (Utah, USA)	Aeolian; sabkha & dunefield Aeolian sand dune system
Cashman & Cashman (2000)		
Draganits et al. (2005)		
Edwards et al. (1993)	Hopeman Sandstone Formation (Moray Firth, UK)	Aeolian dunefield (with minor fluvial incursions)
Fossen (2010)	Entrada Sandstone Formation (Utah, USA) Navajo Sandstone Formation (Utah, USA)	Aeolian; sabkha & dunefield Aeolian dunefield
Fossen & Bale (2007)	Entrada Sandstone Formation (Utah, USA) Navajo Sandstone Formation (Utah, USA)	Aeolian; sabkha & dunefield Aeolian dunefield
Fowles & Burley (1994)	Penrith Sandstone Formation (Vale of Eden & Dumfries, UK)	Aeolian dunefield with fringing alluvial fans
Griffiths et al. (2016)	Sherwood Sandstone (Thurstaston, UK)	Mixed aeolian-fluviall (semi-arid)
Hodson et al. (2016)	Moab Tongue Member [Curtis Formation] (Utah, USA)	Aeolian dunefield
Johansen & Fossen (2008)	Carmel Formation (Utah, USA)	Aeolian; sabkha & dunefield
Johansen et al. (2005)	Moab Member [Entrada Sandstone Formation] (Utah, USA)	Aeolian; sabkha & dunefield
Main et al. (2000)	Hopeman Sandstone (Lossiemouth, Scotland)	Aeolian system (possibly wet)*
Mollema & Antonellini (1996)	Navajo Sandstone Formation (Utah, USA)	Aeolian dunefield
Parnell et al. (2004)	Upper Old Red Sandstone (Caithness, Scotland)	Aeolian dunefield
Parry et al. (2004)	Navajo Sandstone Formation (Utah, USA)	Aeolian dunefield
Raduha et al. (2016)	Entrada Sandstone Formation (Utah, USA)	Aeolian; sabkha & dunefield
Rotevatn et al. (2013)		
Schueller et al. (2013)	Entrada Sandstone Formation (Utah, USA) Navajo Sandstone Formation (Utah, USA)	Aeolian; sabkha & dunefield Aeolian dunefield
Schueller et al. (2013)	Aztec Sandstone (Nevada, USA)	Aeolian dunefield
Skurtveit et al. (2015)	Navajo Sandstone Formation (Utah, USA) Page Formations (Utah, USA)	Aeolian dunefield Aeolian dunefield
Sternlof et al.(2006)	Aztec Sandstone (Nevada, USA)	Aeolian dunefield
Taylor & Pollard (2000)	Aztec Sandstone (Nevada, USA)	Aeolian dunefield
Tindall & Davis (2003)	Navajo Sandstone Formation (Utah, USA)	Aeolian dunefield
Torabi & Fossen (2009)	Entrada Sandstone Formation (Utah, USA)	Aeolian; sabkha & dunefield
Torabi et al. (2008)	Navajo Sandstone Formation (Utah, USA) Entrada Sandstone Formation (Utah, USA)	Aeolian dunefield Aeolian; sabkha & dunefield
Zuluaga et al. (2014)	Navajo Sandstone Formation (Utah, USA)	Aeolian dunefield

31 of 42 the stratigraphic units are aeolian (exclusively or mixed).

Facies Control? *cont'd.*

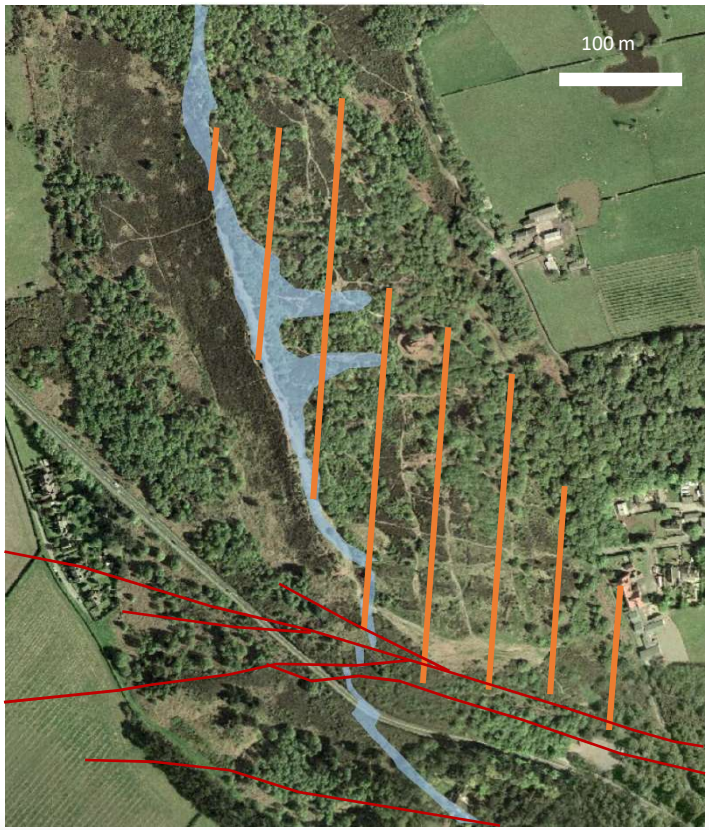


Facies Control? *cont'd.*



Transect data

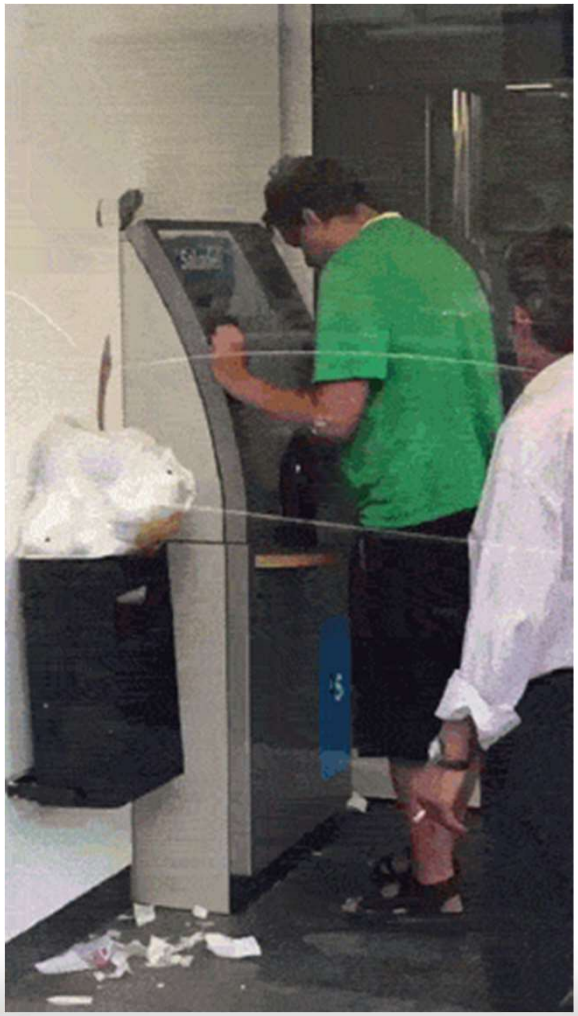
- Total transect length of ~1.7 km (T1 – T8), with 812 deformation bands counted.



Facies	Code	Total segment length %	Total number of bands %	Concentration factor *
Grainfall & grainflow	Sgl & Sgw	83.6	97.3	1.32
Trough xbedded sandstone	St	15.1	2.3	0.18
Wind-ripple facies	Sw	1.1	0.4	0.39
Massive sandstone	Sm	0.2	0	0
Deformed sandstone	Sa	>0.1	0	0
Upperplain beds	Sh	>0.1	0	0
Pebbly sandstone	Ss	>0.1	0	0
Low-angle inclined SDST	Sl	>0.1	0	0
Laminated sandstone	Sr	>0.1	0	0
Planas xbedded sandstone	Sp	>0.1	0	0

** - measure of def. band frequency per metre*

Conclusions?

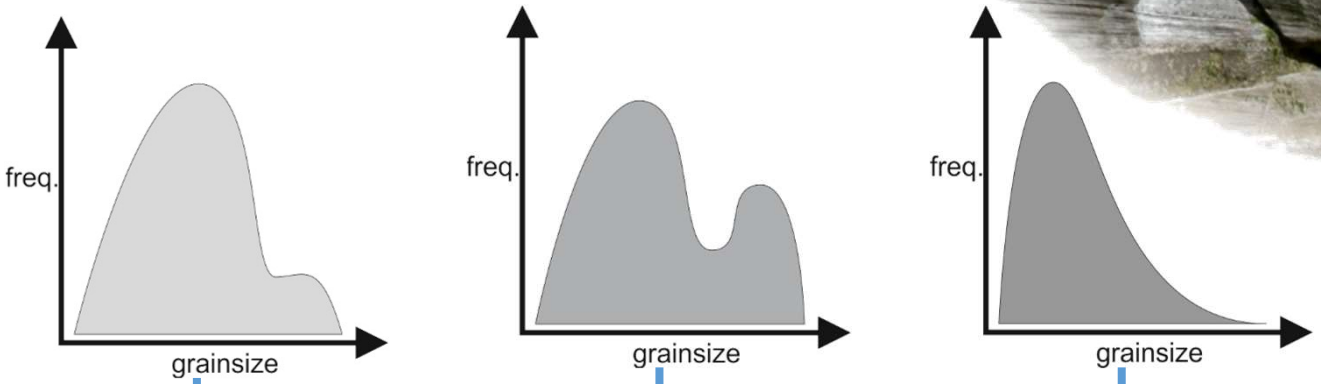


Question: *Do facies exert a control on deformation band frequency or style?*

Answer: *Yes… and…..no!..*

…..but for a good reason

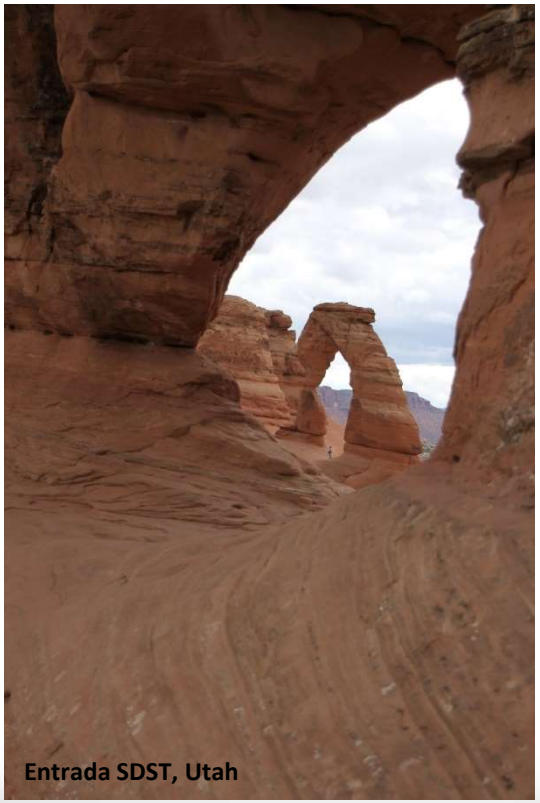
Conclusions…?



Conclusions…?

Aeolian transport

- Discriminating grain selection.
- Dominant saltation transport method.
- Density of air (~1.3kg/m^2).



Entrada SDST, Utah

≈

Wilmslow SDST, UK

Questions?