Ślady plejstoceńskich trzęsień ziemi w południowej części obszaru perybałtyckiego

Małgorzata Pisarska-Jamroży

& zespół GREBAL

Uniwersytet im. Adama Mickiewicza w Poznaniu
Instytut Geologii
pisanka@amu.edu.pl

grebal.amu.edu.pl

Narodowe Centrum Nauki

Szymon Belzyt
Albertas Bitinas
Andreas Börner
Małgorzata Bronikowska
Aldona Damusyte
Martyna Górska
Titt Hang
Gösta Hoffman
Heiko Hüneke
Michael Kenzler
Maris Krievans
Kristaps Lamsters
Mateusz Mleczak
Maris Nartis
Karsten Obst
Alar Rosentau
Henrik Rother
Holger Steffen
Rebekka Steffen
Barbara Woronko
Piotr P. Woźniak
Tom van Loon

Termin ***intraplate earthquake*** odnosi się do różnych trzęsień ziemi, które mają miejsce we wnętrzu płyty tektonicznej.

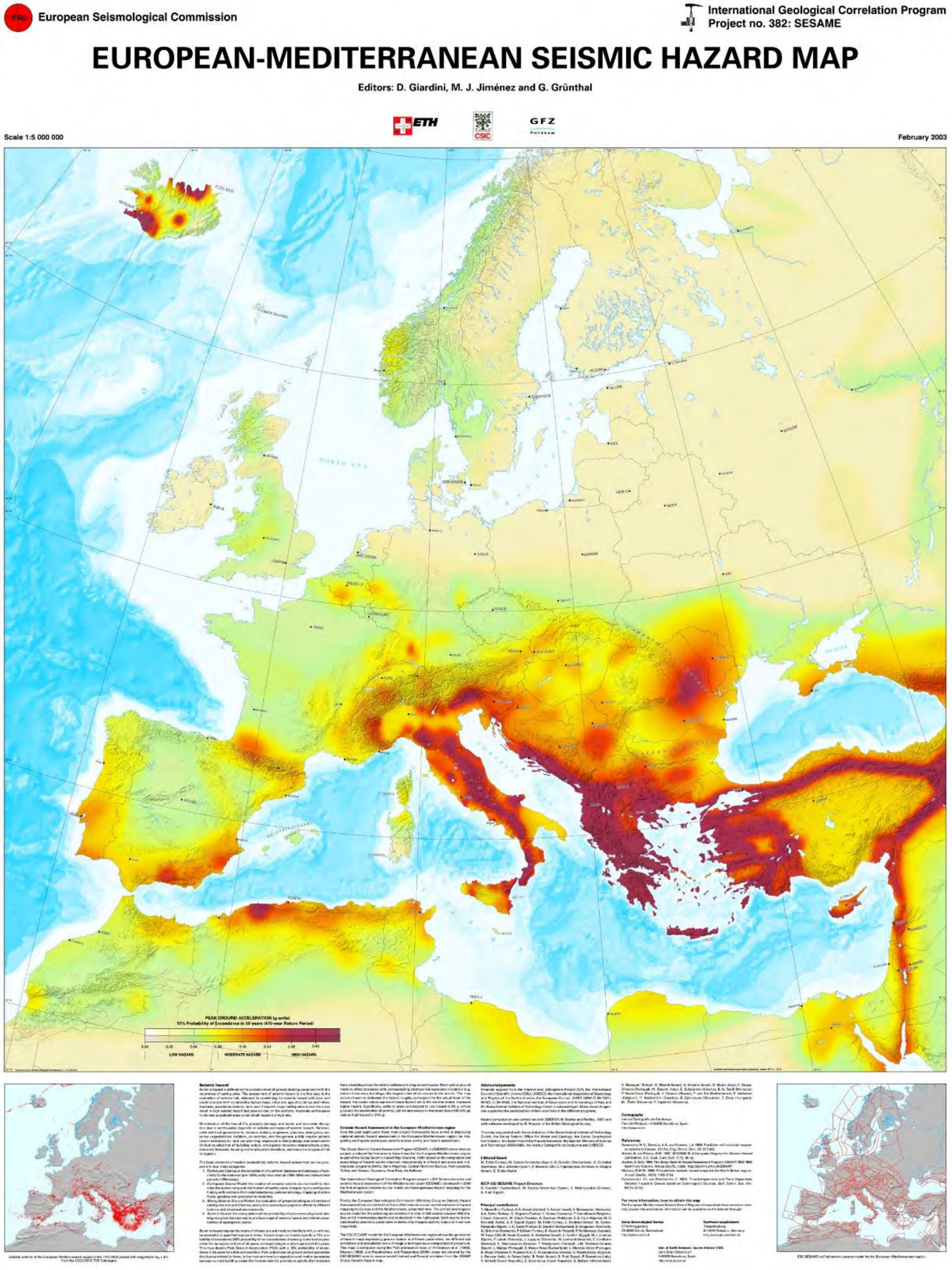
„Przeciwieństwiem” są trzęsienia ziemi między płytami (*interplate earthquakes*), które występują na granicy płyt tektonicznych.

Intraplate earthquake

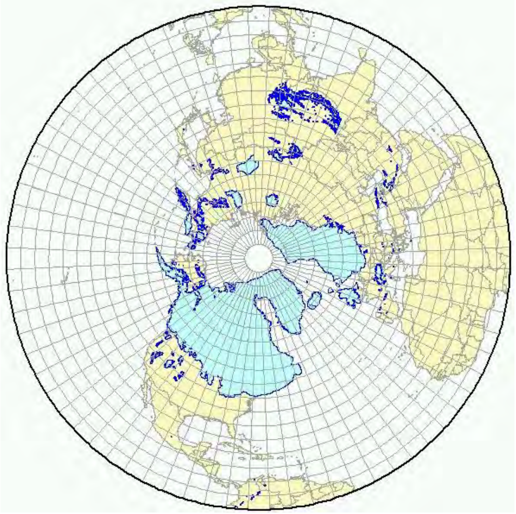
-nie są dobrze zbadane

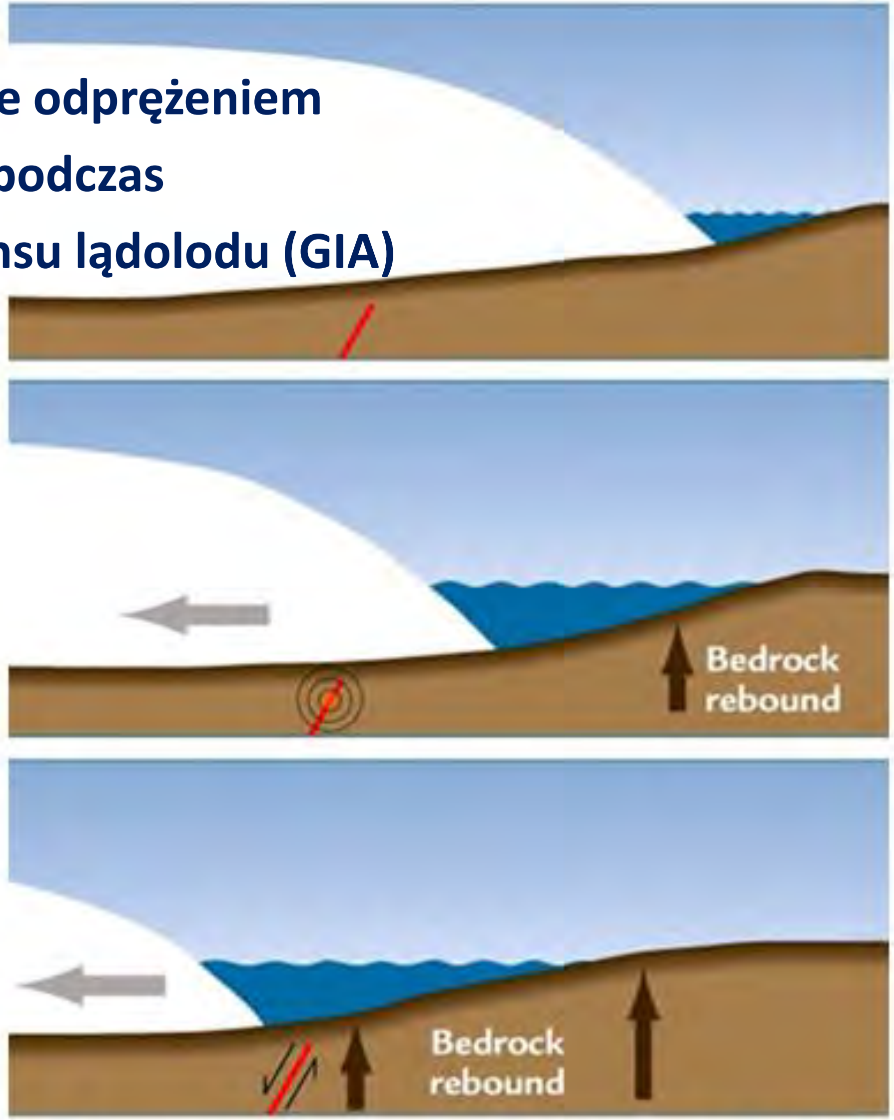
-występują w miejscach, gdzie nie są spodziewane

-występują głównie wzdłuż uskoków



Trzęsienia ziemi spowodowane odprężeniem glaciizostatycznym podczas deglacjacji lub awansu lądolodu (GIA)

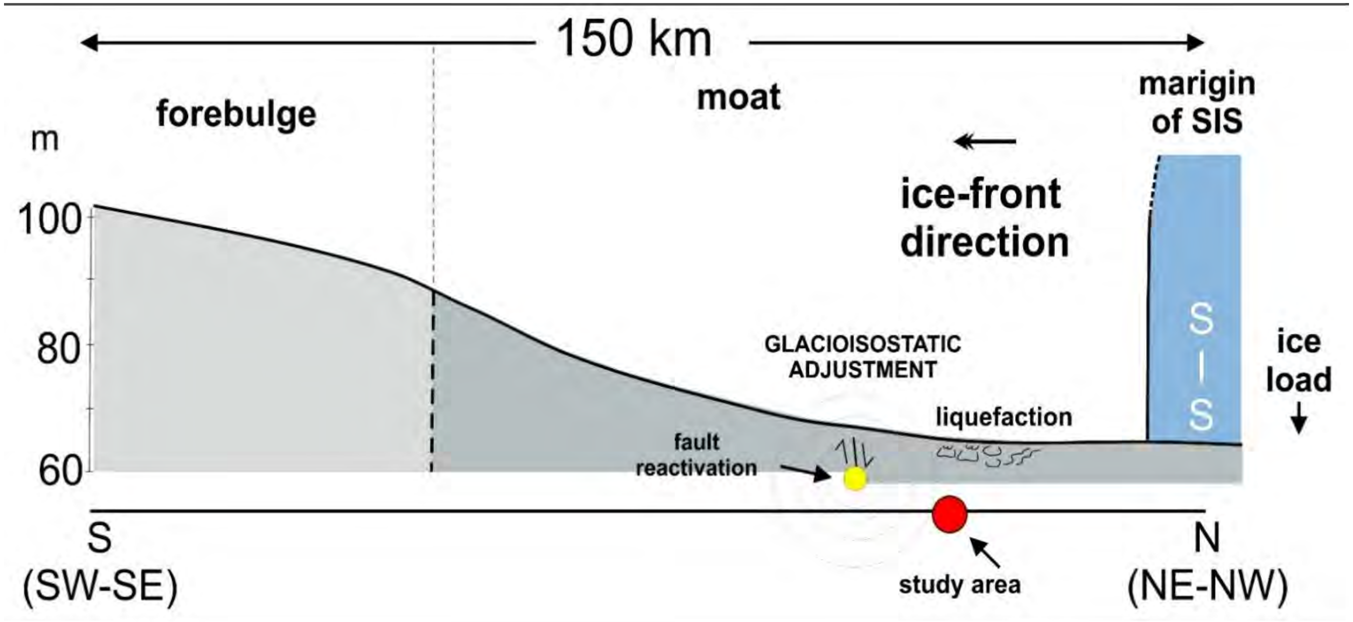




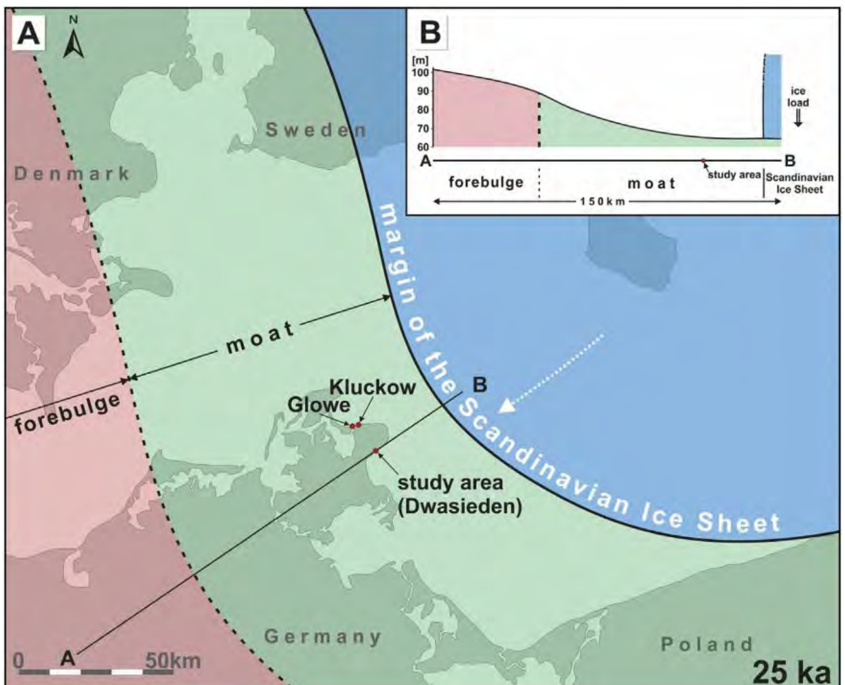
Schemat reaktywacji uskoków w podłożu wywołanej zanikaniem obciążenia lądolodem (www.sonoma.edu, zmienione)

Modelowanie numeryczne zmiany naprężeń wywołanych zlodowaceniem

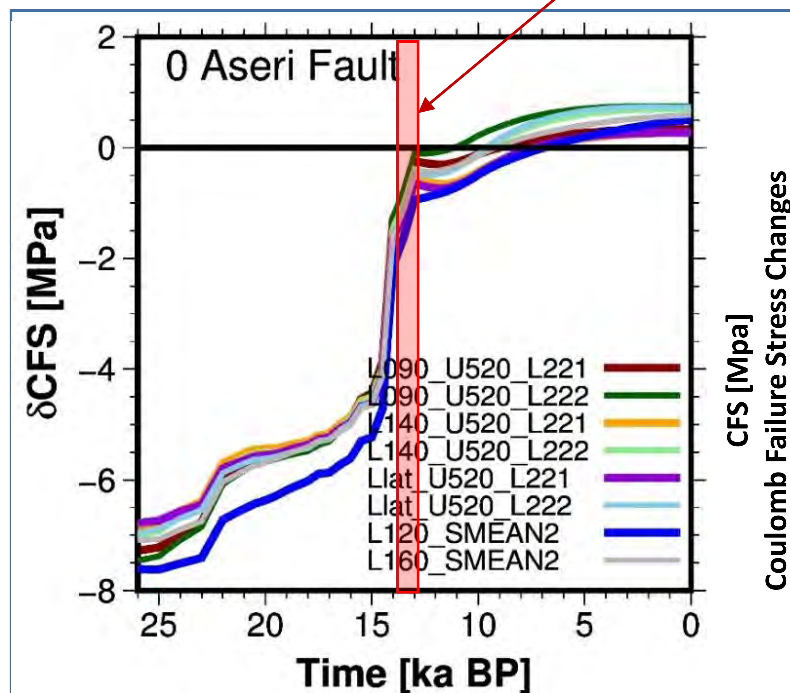
(Steffen et al., 2019)



Szacowany czas powstania deformacji



Pisarska-Jamroży et al., 2018



Steffen et al., 2019

Lodowcowe trzęsienie ziemi (glacial earthquake)

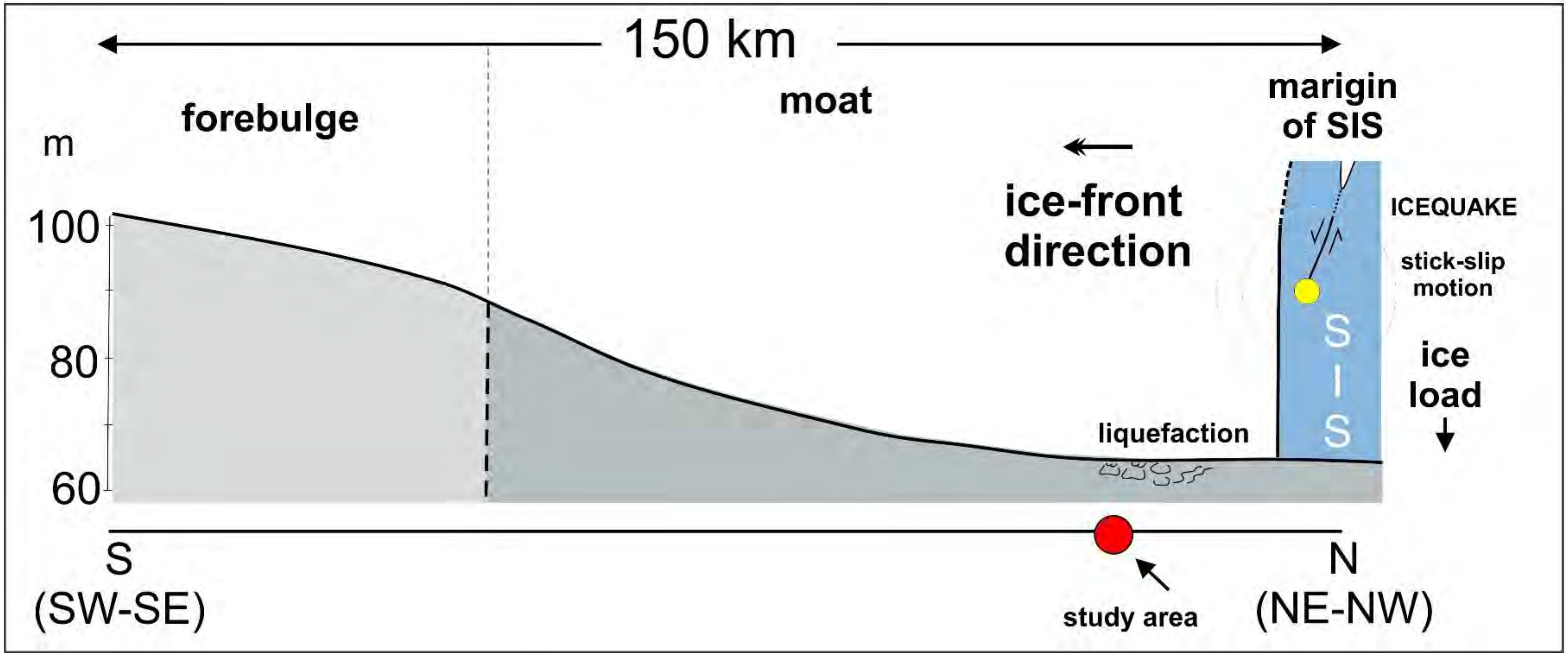
naprężenia podczas ruchu typu *stick-slip* w czołowej części lądolodu

cielenie się lądolodu

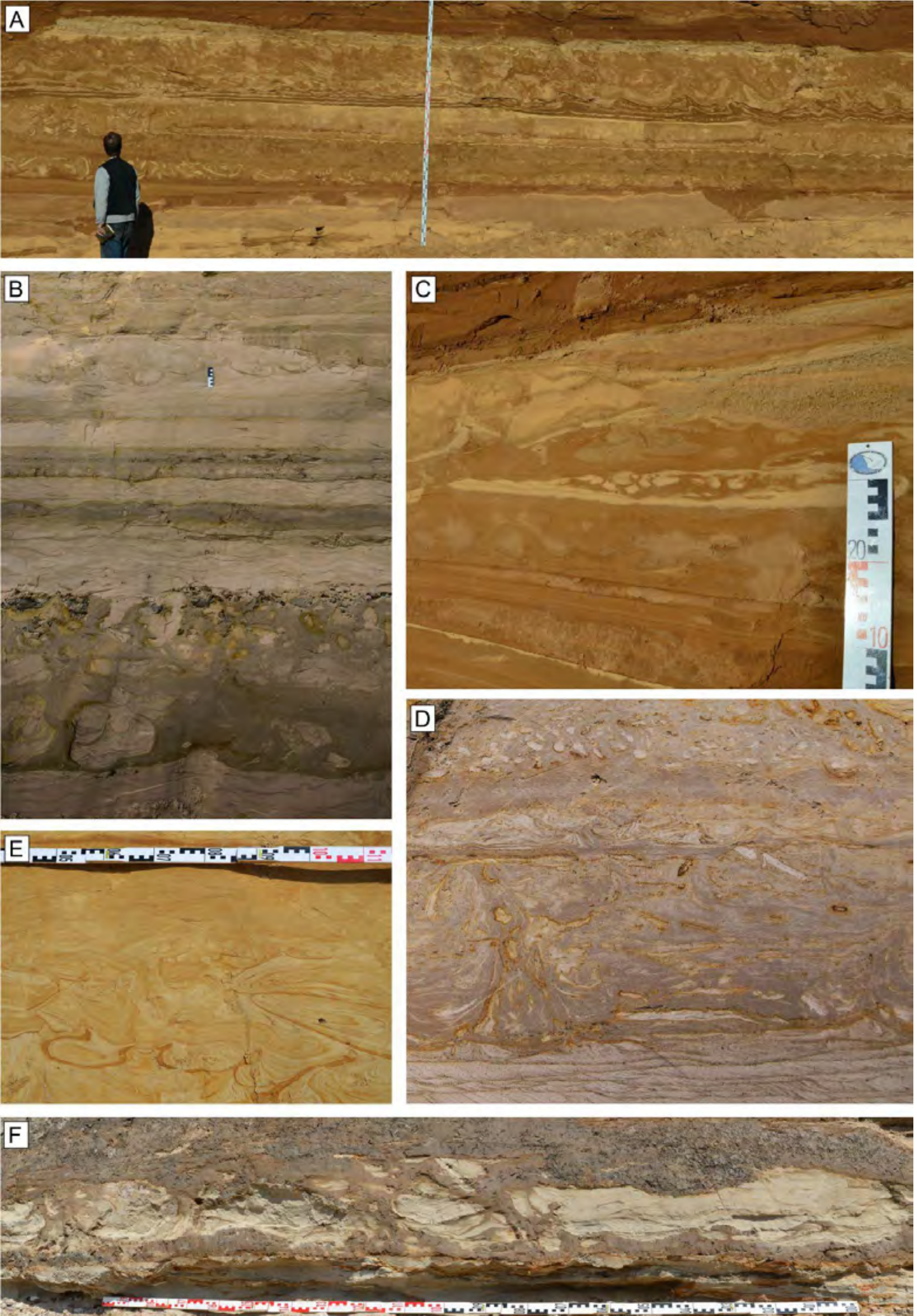
obracanie gór lodowych

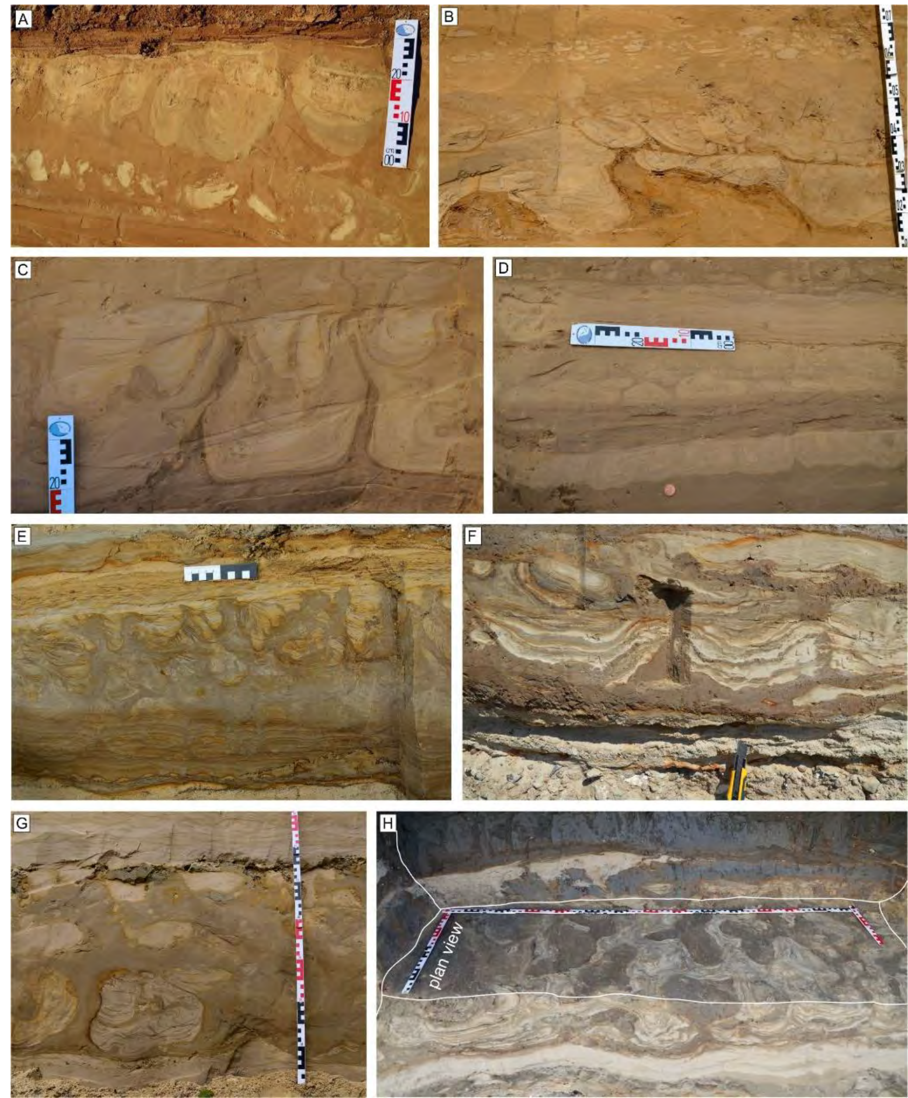
…

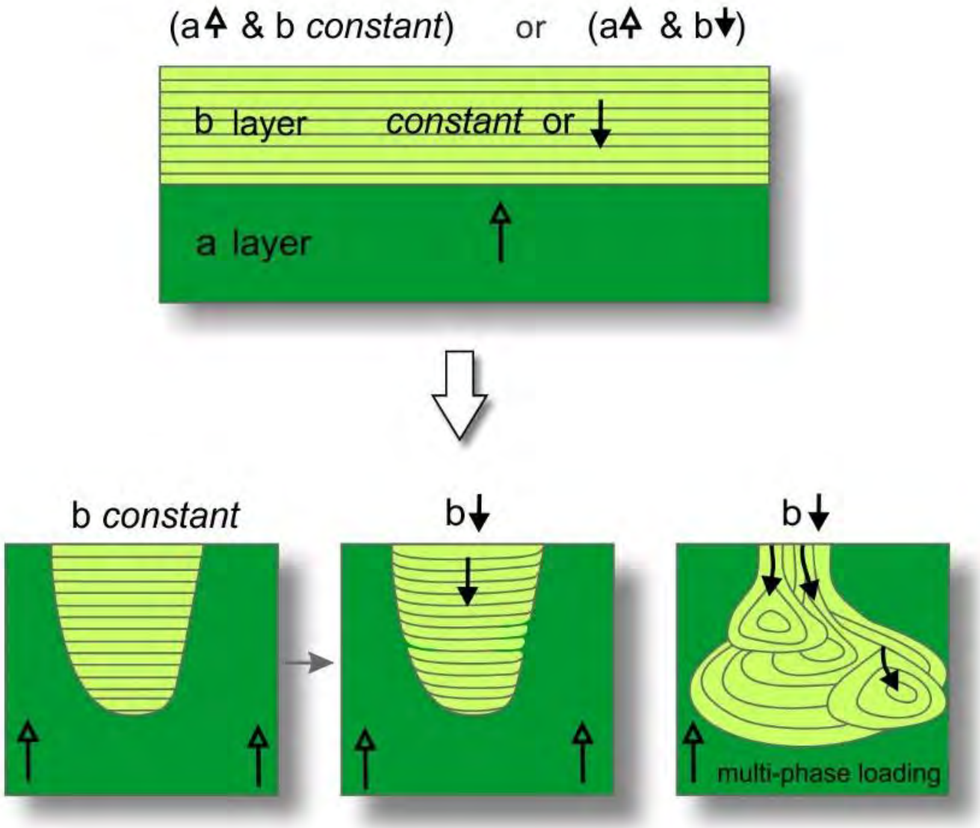
Nettles i Ekström (2010)
Hart i in. (2019)



sejsmit



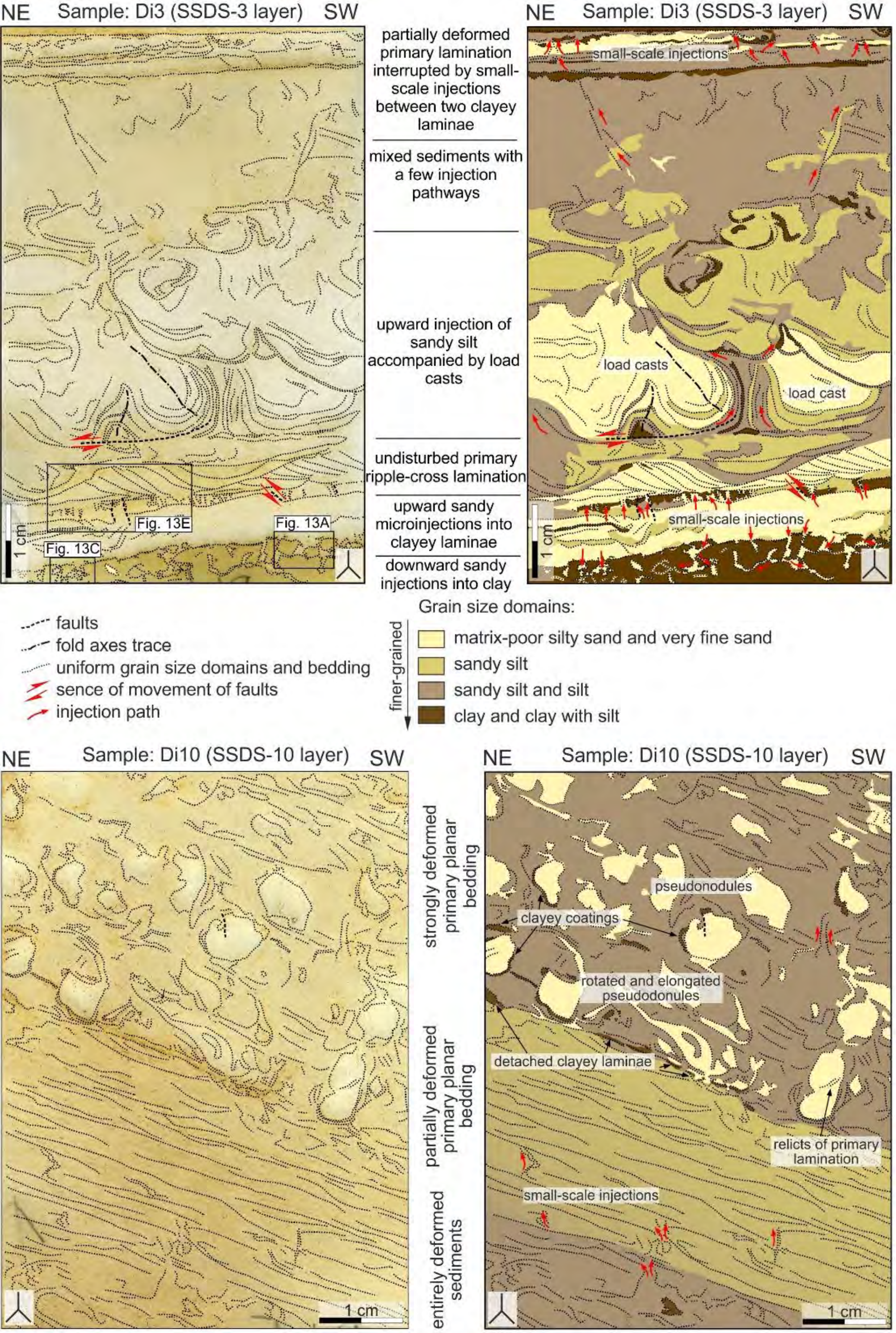


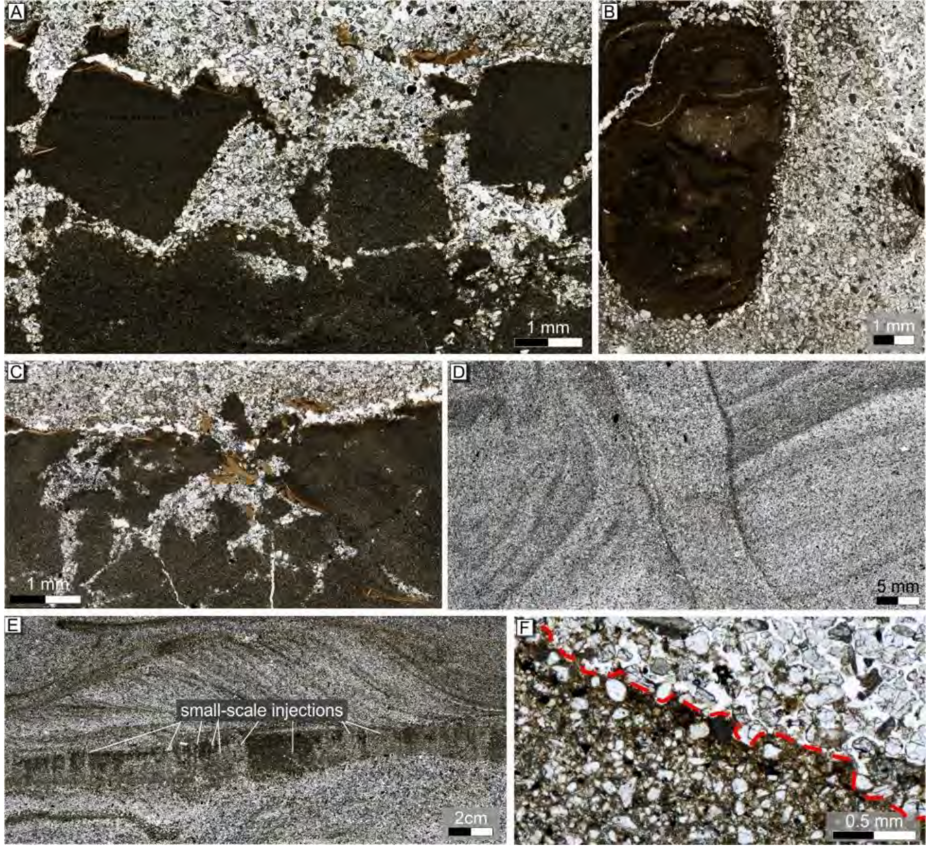


Uwodnienie (*fluidization*)

Upłynnienie (*liquefaction*)

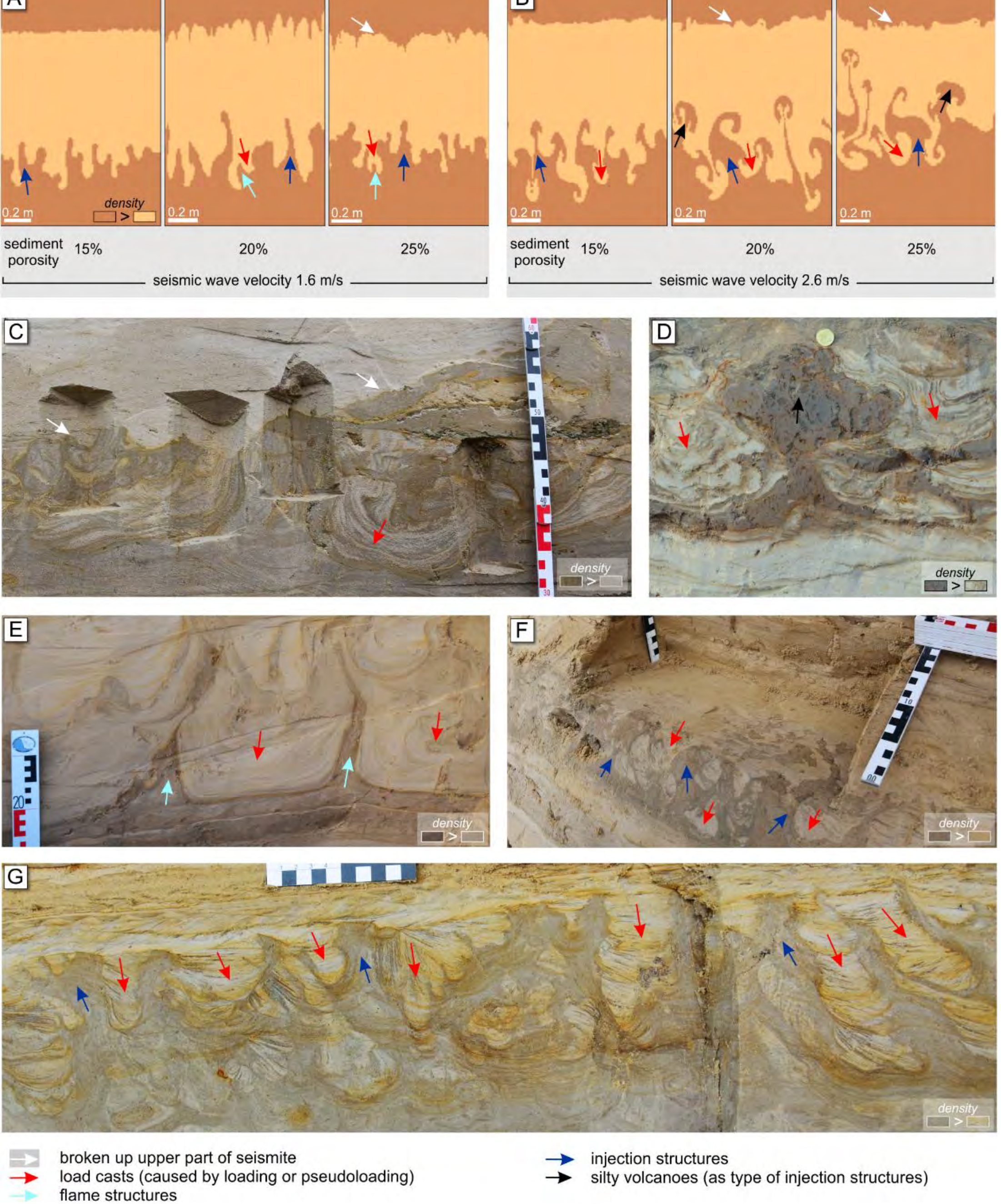
m.in. Belzyt i Pisarska-Jamroży, 2017

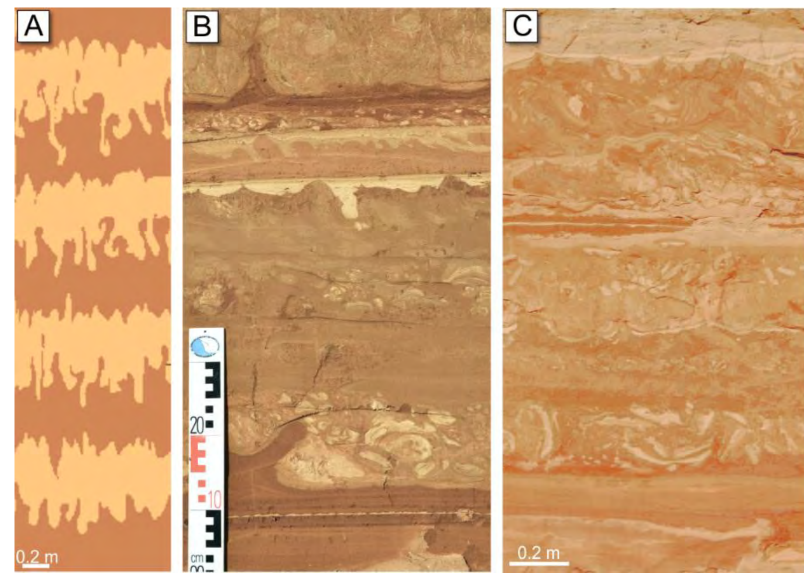




Belzyt et al., w przygotowaniu

Modelowanie numeryczne struktur deformacyjnych generowanych propagacją fali sejsmicznej





Bronikowska, M. & Pisarska-Jamroży, M. *w recenzji*

Obszar badawczy

Maximum ice-sheet extent during Quaternary

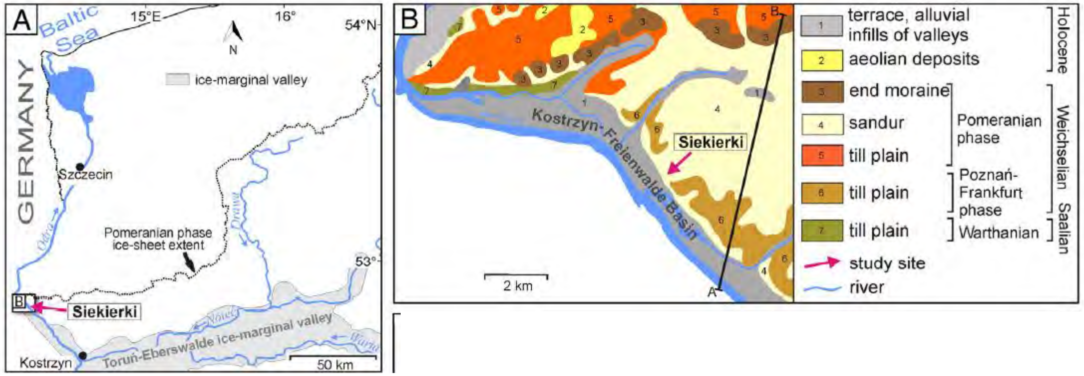
Sites with seismites

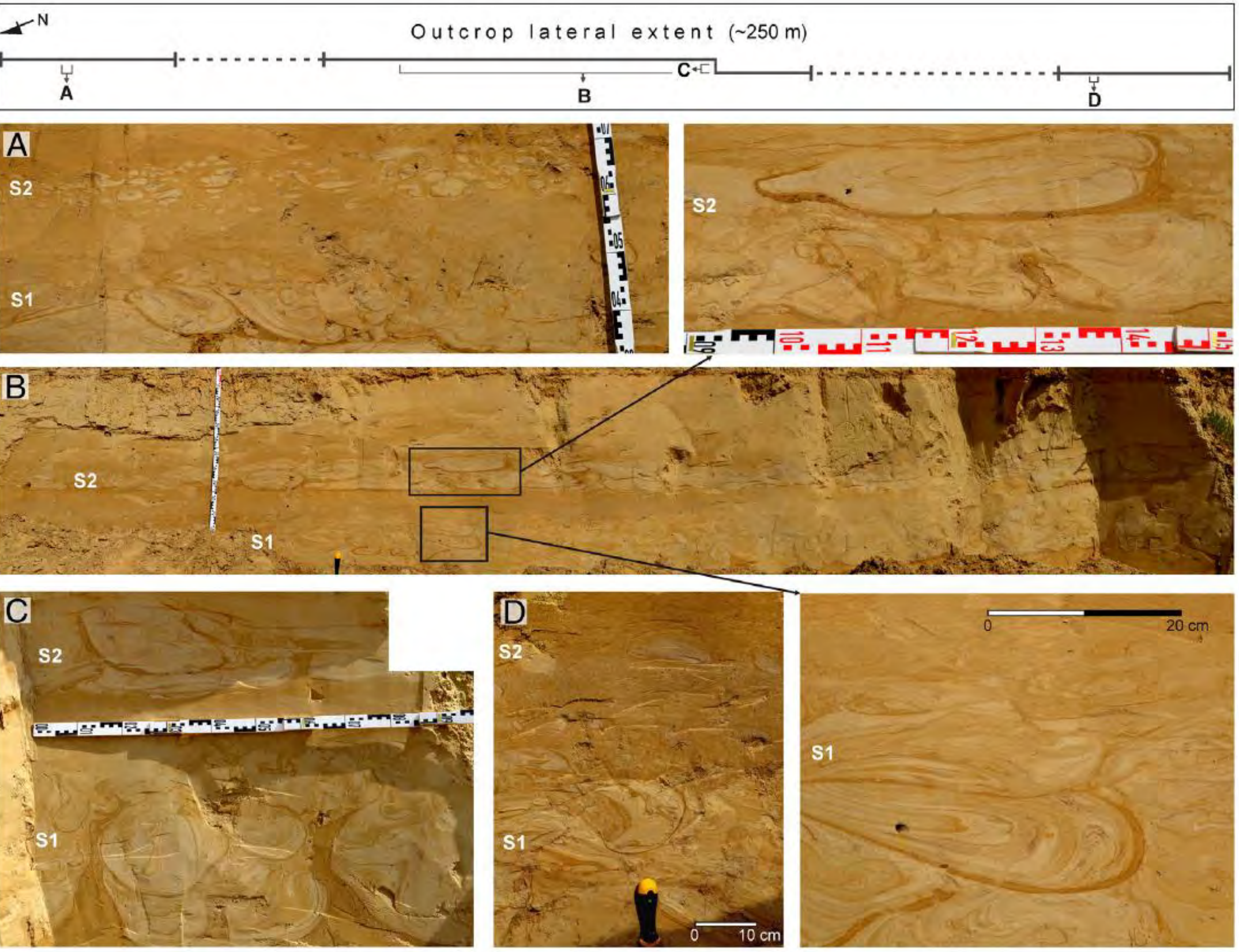
All study sites

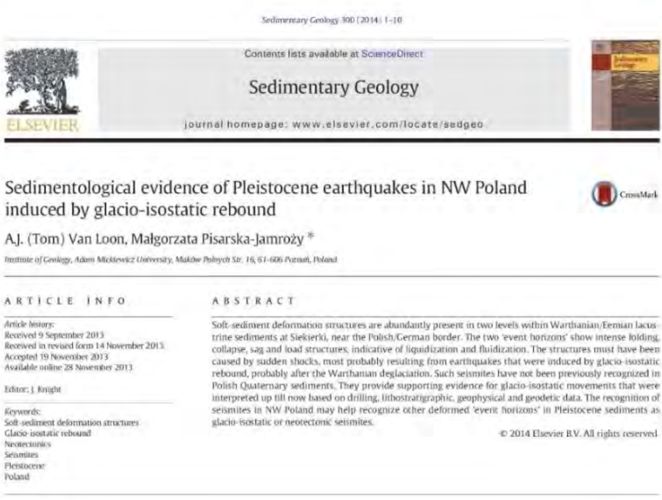
Siekierki
Ujście
Rzucewo

Siekierki

- 2 sejsmity
- osady glacilimniczne
- MIS 6
- GIA – podczas deglacjacji






Sedimentary Geology 300 (2014) 1–10

Contents lists available at ScienceDirect

Sedimentary Geology

journal homepage: www.elsevier.com/locate/sedgeo

Sedimentological evidence of Pleistocene earthquakes in NW Poland induced by glacio-isostatic rebound

A.J. (Tom) Van Loon, Małgorzata Pisarska-Jamroży *

Institute of Geology, Adam Mickiewicz University, Maków Polnych Str. 16, 61-606 Poznań, Poland

ARTICLE INFO

Article history:
Received 9 September 2013
Received in revised form 14 November 2013
Accepted 19 November 2013
Available online 28 November 2013

Editor: J. Knight

Keywords:
Soft-sediment deformation structures
Glacio-isostatic rebound
Neotectonics
Seismites
Pleistocene
Poland

ABSTRACT

Soft-sediment deformation structures are abundantly present in two levels within Warthanian/Eemian lacustrine sediments at Siekierki, near the Polish/German border. The two 'event horizons' show intense folding, collapse, sag and load structures, indicative of liquidization and fluidization. The structures must have been caused by sudden shocks, most probably resulting from earthquakes that were induced by glacio-isostatic rebound, probably after the Warthanian deglaciation. Such seismites have not been previously recognized in Polish Quaternary sediments. They provide supporting evidence for glacio-isostatic movements that were interpreted up till now based on drilling, lithostratigraphic, geophysical and geodetic data. The recognition of seismites in NW Poland may help recognize other deformed 'event horizons' in Pleistocene sediments as glacio-isostatic or neotectonic seismites.

pseudonodules

multi-loading structures

Ujście

- 2 sejsmity + debryt
- osady glacilimiczne
- MIS 6
- GIA-podczas deglacjacji

Contents lists available at ScienceDirect
Geomorphology
journal homepage: www.elsevier.com/locate/geomorph

Enigmatic gravity-flow deposits at Ujście (western Poland), triggered by earthquakes (as evidenced by seismites) caused by Saalian glacioisostatic crustal rebound

Małgorzata Pisarska-Jamroży [a], A.J. (Tom) Van Loon [b,c,*], Mateusz Mleczak [a], Małgorzata Roman [d]

[a] Institute of Geology, Adam Mickiewicz University, B. Krygowskiego 12, 61-680 Poznań, Poland
[b] College of Earth Science and Engineering, Shandong University of Science and Technology, Qingdao 266590, Shandong, China
[c] Geocom Consultants, Valle del Portet 17, 03726 Benitachell, Spain
[d] Department of Geomorphology and Palaeogeography, University of Łódź, Narutowicza 88, 90-139 Łódź, Poland

ARTICLE INFO

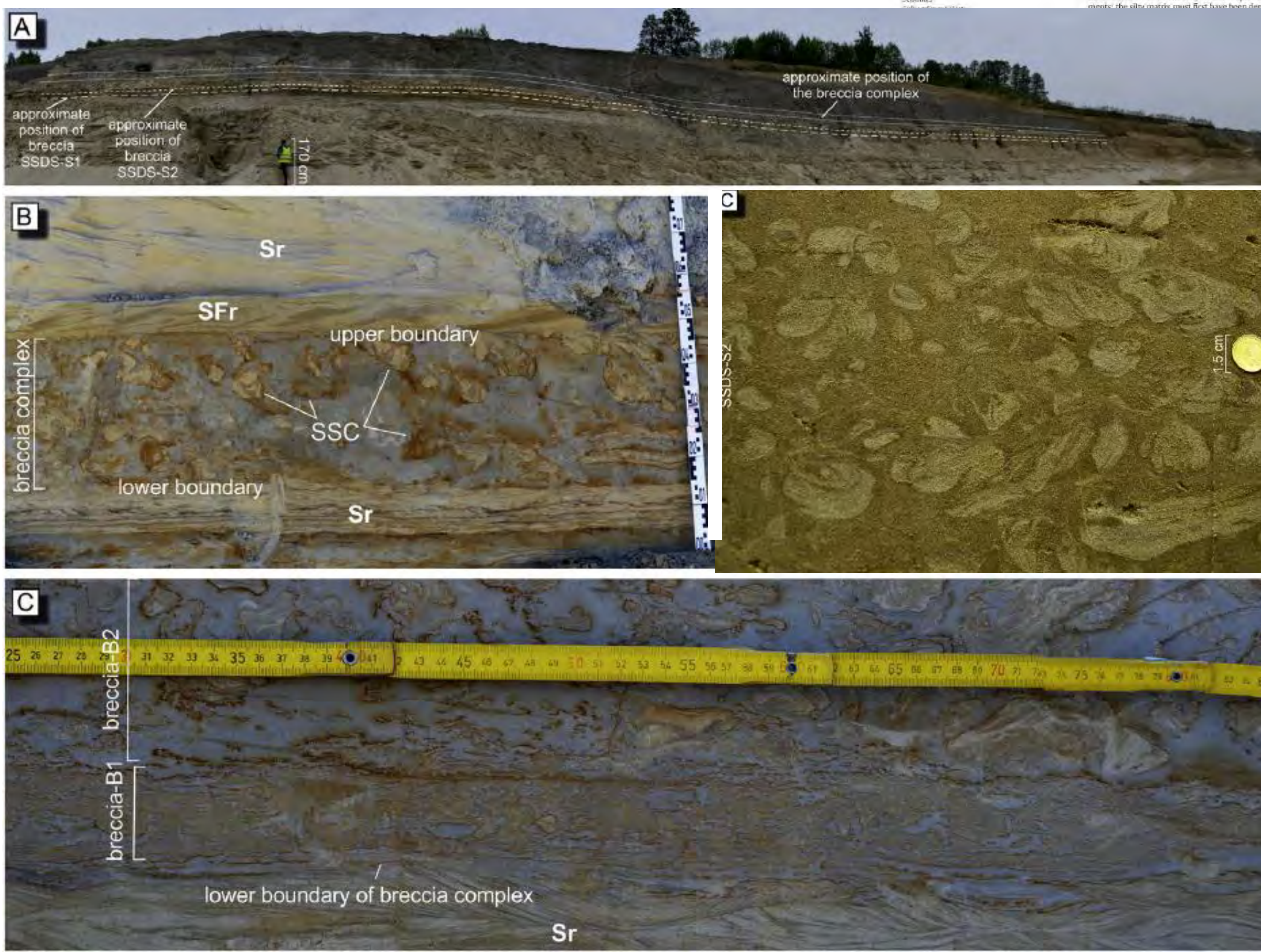
Article history:
Received 28 June 2017
Received in revised form 11 January 2018
Accepted 11 January 2018
Available online 16 January 2018

Keywords:
Seismites

ABSTRACT

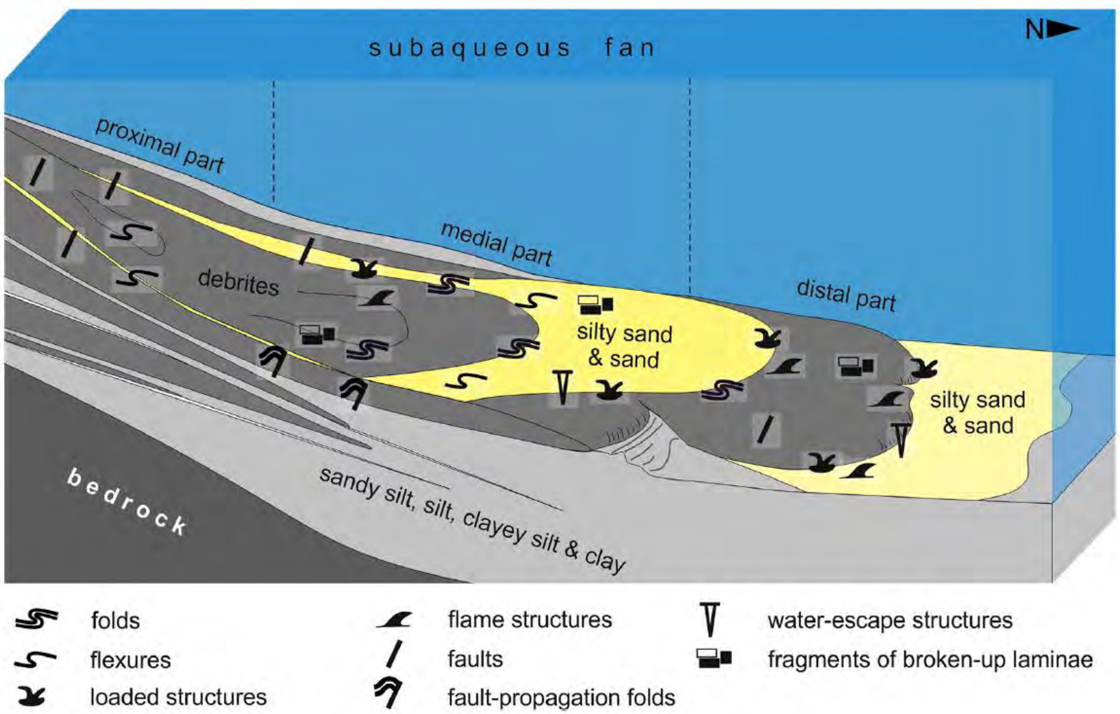
Two breccia layers occur directly stacked upon each other in a silty/sandy Saalian glaciolacustrine succession near Ujście (western Poland). This complex is exceptional because of two aspects: the two breccia layers consist of distinctly more fine-grained material (mainly silt) than the rest of the succession, and they contain numerous soft-sediment clasts of sandy silt with irregular shapes. The silty clasts are interpreted to represent fragments of eroded sediment from the more marginal (proximal) bottom of the lake. The fine-grained character of the breccia matrix excludes that the process responsible for their deposition had a sufficiently high erosional capability to erode the embedded clasts. The only feasible explanation is that this enigmatic breccia consists of a mixture of sediments: the silty matrix must first have been deposited on the bottom of a lake and afterward have been eroded … ufficient power to erode the lake margin over which they ran … igmatic because no sediments with similar lithology are cur… We must therefore deduce that such sediments existed pre… the Weichselian ice mass that had reached this area during …

…d by the presence of soft-sediment deformation structures in … wo levels show intense folding, collapse, and load structures … rmation is ascribed to shocks, most probably resulting from … bound during the Saalian deglaciation. Similar seismic shocks … ulted in the breccia layers.



Rzucewo

- stożek glacilimniczny
- MIS 3-4
- mechanizmy spustowe rozwoju SSDS: podwodny spływ mas + GIA



Geomorphology 326 (2019) 225–238

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Debris flow and glacioisostatic-induced soft-sediment deformation structures in a Pleistocene glaciolacustrine fan: The southern Baltic Sea coast, Poland

Małgorzata Pisarska-Jamroży [a,*], Piotr Paweł Woźniak [b]

[a] Institute of Geology, Adam Mickiewicz University, Krygowskiego St. 12, 61-680 Poznań, Poland
[b] Department of Geomorphology and Quaternary Geology, University of Gdańsk, Bażyńskiego St. 4, 80-309 Gdańsk, Poland

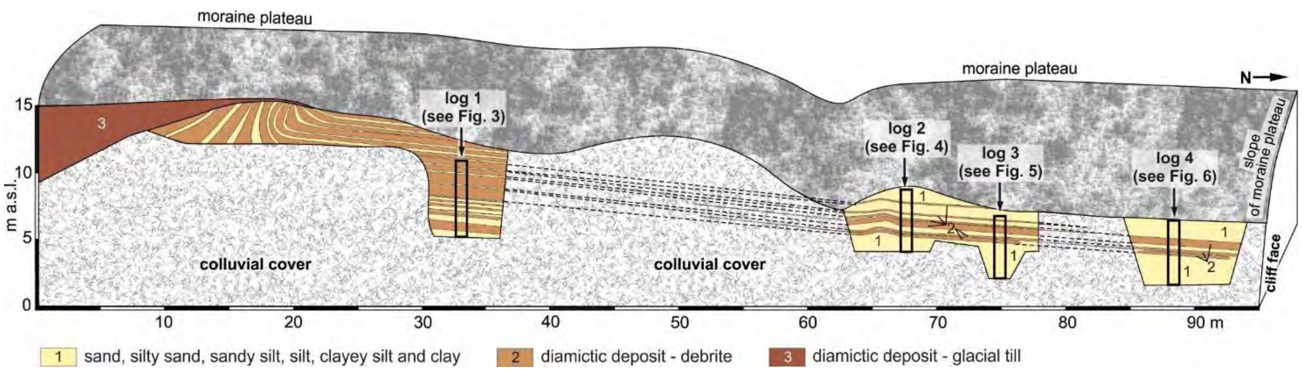
ARTICLE INFO

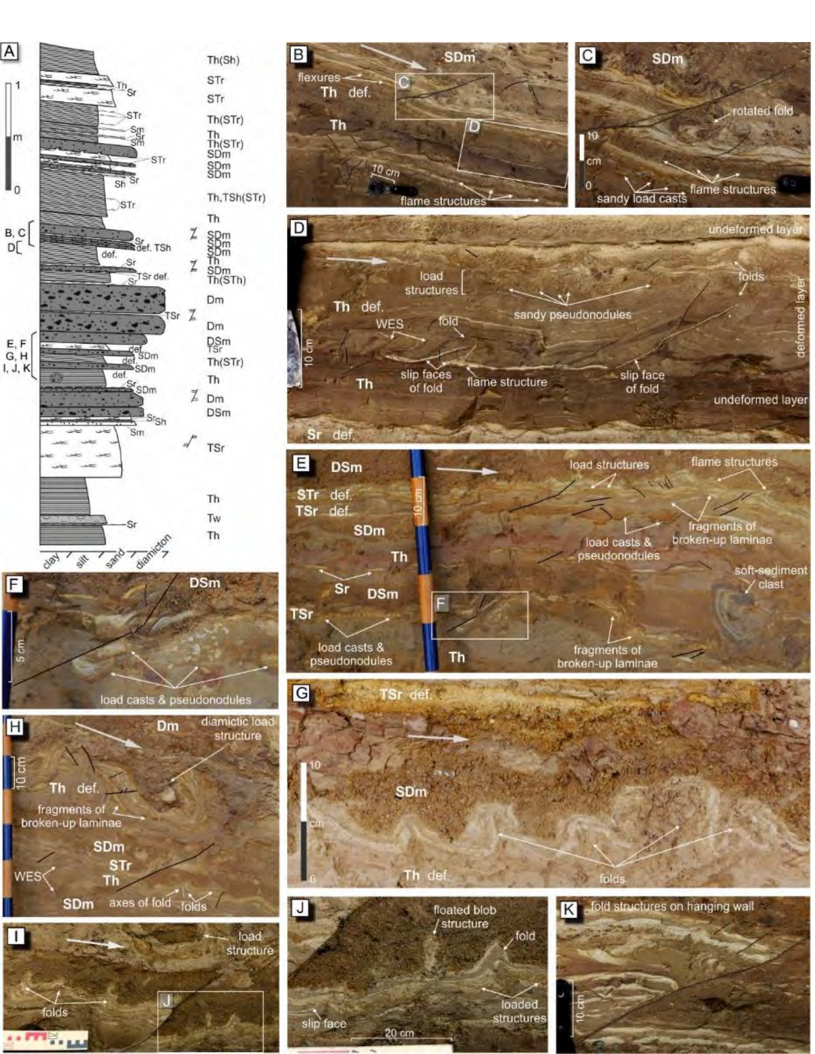
Article history:
Received 28 June 2017
Received in revised form 17 January 2018
Accepted 18 January 2018
Available online 31 January 2018

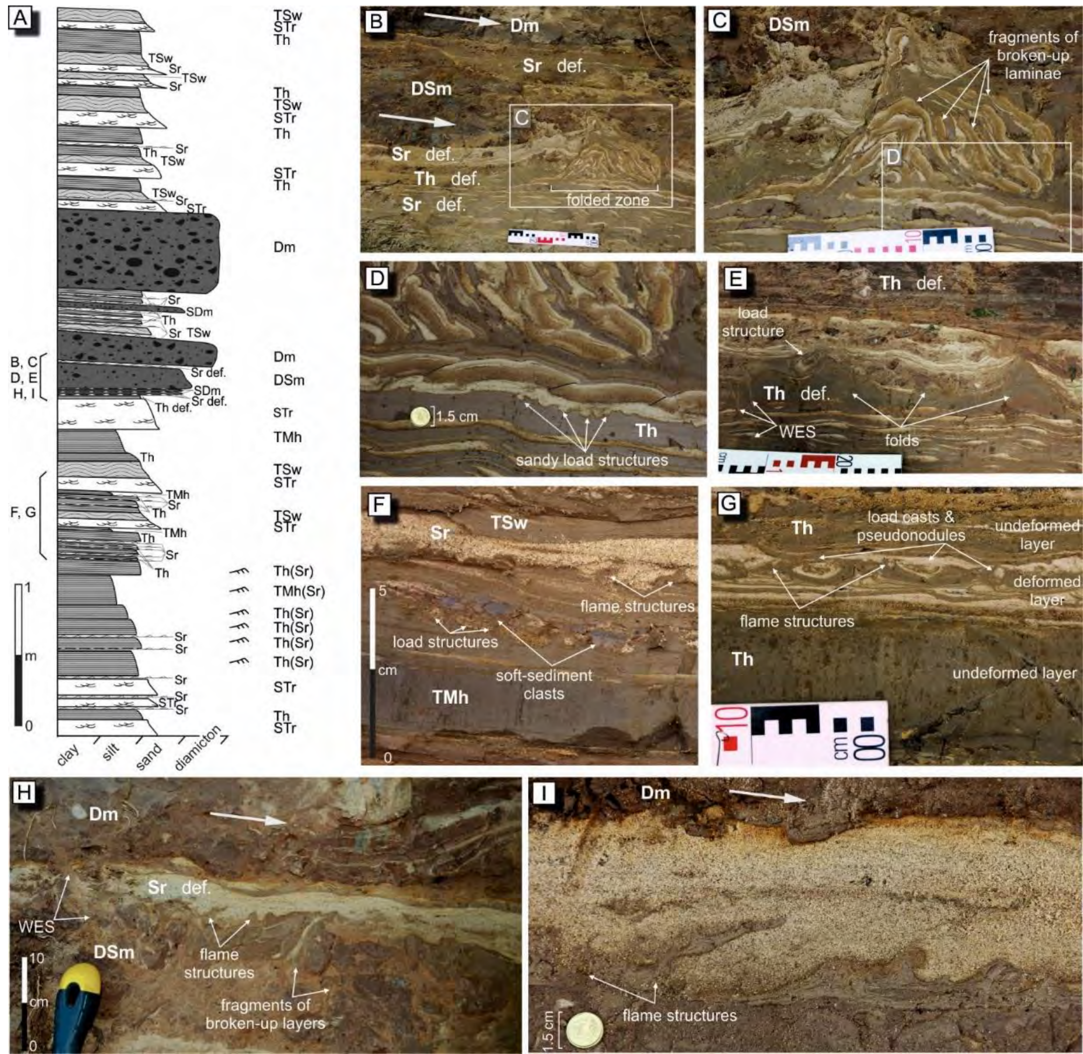
Keywords:
Soft-sediment deformation structures
Water-escape structures
Debrites
Seismites
Glacioisostatic rebound
Gravity-driven structures

ABSTRACT

Middle Pleistocene glaciolacustrine fan sediments are exposed along a cliff at the Baltic Sea coast, where plastic and brittle soft-sediment deformation structures (SSDS) commonly occur: (1) fold structures (various types of folds and flexures); (2) load structures (load casts, pseudonodules) and flame structures; (3) water-escape structures (WES); and (4) brittle deformation structures, such as faults (medium- and small-scale reverse and normal), and fragments of broken-up laminae. The origins of the SSDS can be linked to gravitational processes promoted by shear stresses in subaqueous debris flows on the glaciolacustrine fan and by the weight of overlying sediments; and/or to the glacial rebound of Earth's crust during deglaciation because in the Pleistocene the Baltic Sea and surrounding areas were covered by ice sheets many times. The question investigated here concerns recognition of the trigger mechanisms responsible for the development of SSDS, and the criteria needed to recognize those mechanisms based on the lithological and deformational features of the sediments involved. Some types of SSDS can look similar regardless of trigger mechanisms, but some occur more often as a result of a specific mechanism. Is it possible to distinguish SSDS of seismic origin in a glaciolacustrine fan succession affected by multiple debris flows and of SSDS that evolved as a consequence of slope processes? We suggest criteria to recognize SSDS triggered by the glacioisostatic rebound as well as those which can develop as a result of the rebound and slope processes.


moraine plateau
moraine plateau
N
log 1 (see Fig. 3)
log 2 (see Fig. 4)
log 3 (see Fig. 5)
log 4 (see Fig. 6)
slope of moraine plateau
cliff face
colluvial cover
colluvial cover
m a.s.l.
15
10
5
0
10
20
30
40
50
60
70
80
90 m
1 sand, silty sand, sandy silt, silt, clayey silt and clay
2 diamictic deposit - debrite
3 diamictic deposit - glacial till


A
Th(Sh)
STr
STr
Th(STr)
Th
Th(STr)
SDm
SDm
SDm
Th,TSh(STr)
Th
SDm
SDm
SDm
Th
SDm
Th(STh)
Dm
Dm
DSm
Th(STr)
Th
Dm
DSm
TSr
Th
Tw
Th
B, C
D
E, F
G, H
I, J, K
clay
silt
sand
diamicton
B
SDm
flexures
Th def.
Th
10 cm
flame structures
C
SDm
rotated fold
sandy load casts
flame structures
D
undeformed layer
load structures
sandy pseudonodules
folds
Th def.
WES
fold
slip faces of fold
flame structure
slip face of fold
deformed layer
undeformed layer
Th
Sr def.
10 cm
E
DSm
STr def.
TSr def.
SDm
Th
Sr
DSm
TSr
Th
load structures
flame structures
load casts & pseudonodules
fragments of broken-up laminae
soft-sediment clast
load casts & pseudonodules
fragments of broken-up laminae
F
DSm
5 cm
load casts & pseudonodules
G
TSr def.
SDm
folds
Th def.
H
Dm
diamictic load structure
Th def.
fragments of broken-up laminae
SDm
STr
Th
WES
SDm
axes of fold
folds
I
load structure
folds
J
floated blob structure
fold
slip face
loaded structures
20 cm
K
fold structures on hanging wall


A
TSw
STr
Th
Th
TSw
STr
Th
STr
Th
Dm
Dm
DSm
STr
TMh
TSw
STr
TSw
STr
Th(Sr)
TMh(Sr)
Th(Sr)
Th(Sr)
Th(Sr)
Th(Sr)
STr
Th
STr
B, C
D, E
H, I
F, G
clay
silt
sand
diamicton
B
Dm
DSm
Sr def.
Sr def.
Th def.
Sr def.
folded zone
C
DSm
fragments of broken-up laminae
D
1.5 cm
Th
sandy load structures
E
Th def.
load structure
Th def.
WES
folds
F
Sr
TSw
flame structures
load structures
soft-sediment clasts
TMh
G
Th
load casts & pseudonodules
undeformed layer
deformed layer
flame structures
Th
undeformed layer
H
Dm
Sr def.
WES
DSm
flame structures
fragments of broken-up layers
I
Dm
flame structures
1.5 cm

Dwasieden
Weisser Berg

Dwasieden

- 2 sejsmity
- osady glacilimniczne
- MIS 2
- GIA przed awansującym lądolodem


Tectonophysics
Available online 9 August 2018
In Press, Accepted Manuscript

Evidence from seismites for glacio-isostatically induced crustal faulting in front of an advancing land-ice mass (Rügen Island, SW Baltic Sea)

Małgorzata Pisarska-Jamroży [a], Szymon Belzyt [a], Andreas Börner [b], Gösta Hoffmann [c], Heiko Hüneke [d], Michael Kenzler [d], Karsten Obst [b], Henrik Rother [e], A.J. (Tom) van Loon [f, g]

Show more

https://doi.org/10.1016/j.tecto.2018.08.004

Get rights and conter

Highlights

- A section with Pleistocene sediments at Dwasieden (Germany) contains 2 seismites.
- The seismites were formed in tectonically stable region.
- The responsible faulting is attributed to the weight of the advancing Scandinavian Ice Sheet.
- It is for the first time that high-magnitude earthquakes related to ice *advance* are recognized.


DEUQUA Spec. Pub., 2, 1–7, 2019
https://doi.org/10.5194/deuquasp-2-1-2019

DEUQUA Special Publications

The sea cliff at Dwasieden: soft-sediment deformation structures triggered by glacial isostatic adjustment in front of the advancing Scandinavian Ice Sheet

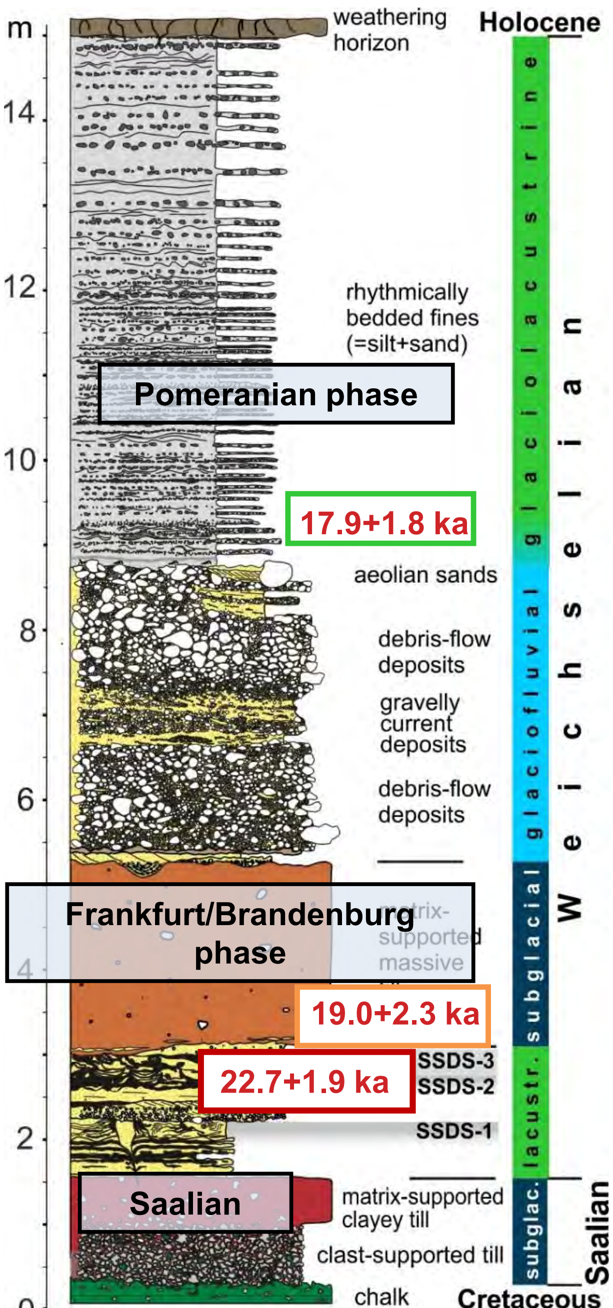
Małgorzata Pisarska-Jamroży[1], Szymon Belzyt[1], Andreas Börner[2], Gösta Hoffmann[3], Heiko Hüneke[4], Michael Kenzler[4], Karsten Obst[2], Henrik Rother[5], Holger Steffen[6], Rebekka Steffen[6], and Tom van Loon[7]

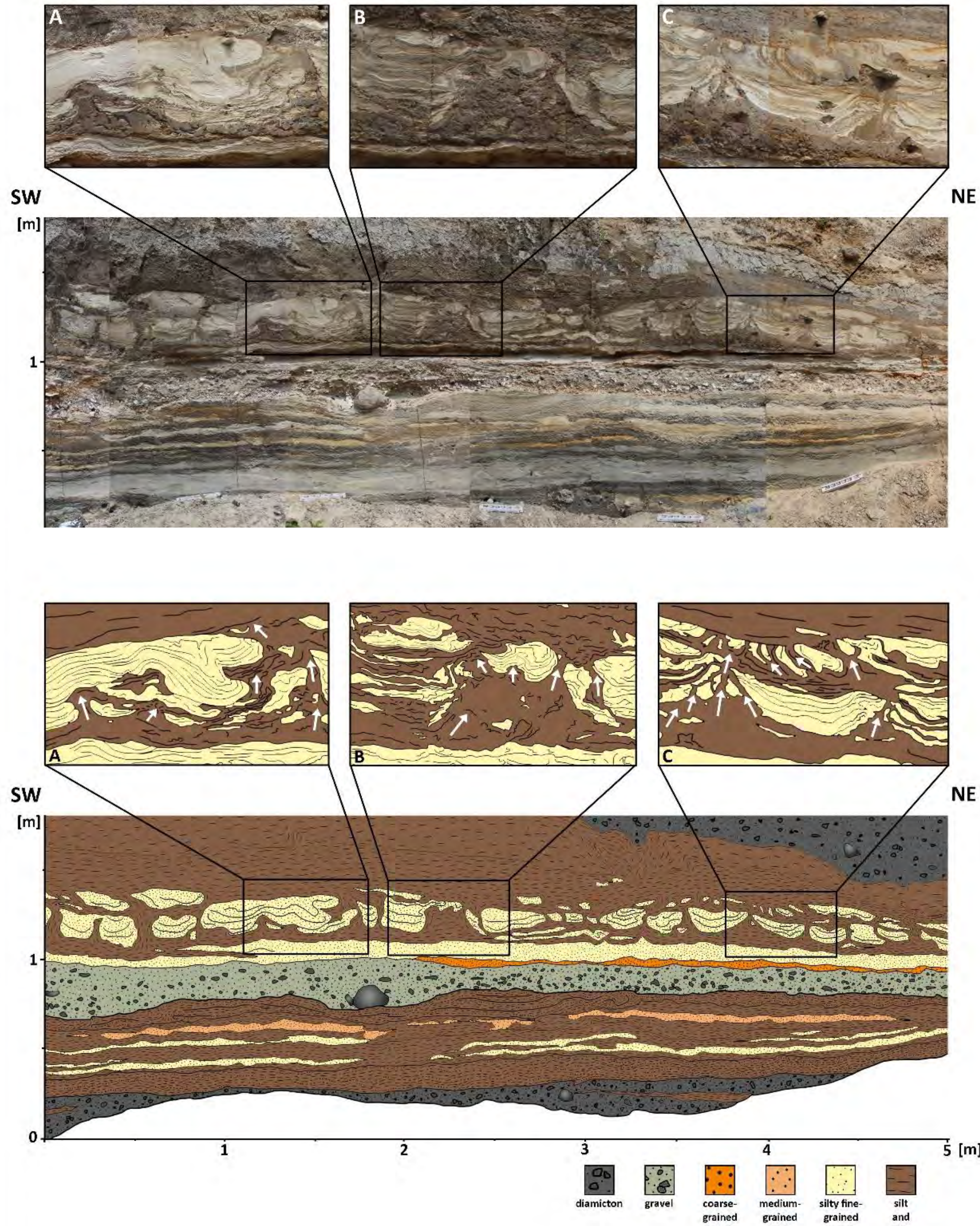
[1]Geological Institute, Adam Mickiewicz University, B. Krygowskiego 12, 61-680 Poznań, Poland
[2]State Authority of Environment, Nature Conservation and Geology Mecklenburg-Western Pomerania, Goldberger 12, 18273 Güstrow, Germany
[3]Steinmann Institute for Geology, Bonn University, Nussallee 8, 53115 Bonn, Germany
[4]Institute of Geography and Geology, University of Greifswald, F.-L. Jahn 17a, 17487 Greifswald, Germany
[5]Landesamt für Geologie und Bergwesen, Sachsen Anhalt, Dezernat Landesaufnahme und Analytik, Köthener 38, 06118 Halle, Germany
[6]Geodetic Infrastructure, Lantmäteriet, Lantmäterigatan 2C, 80182 Gävle, Sweden
[7]College of Earth Science and Engineering, Shandong University of Science and Technology, Qingdao 266590, Shandong, China

Correspondence: Małgorzata Pisarska-Jamroży (pisanka@amu.edu.pl)

Relevant dates: Published:

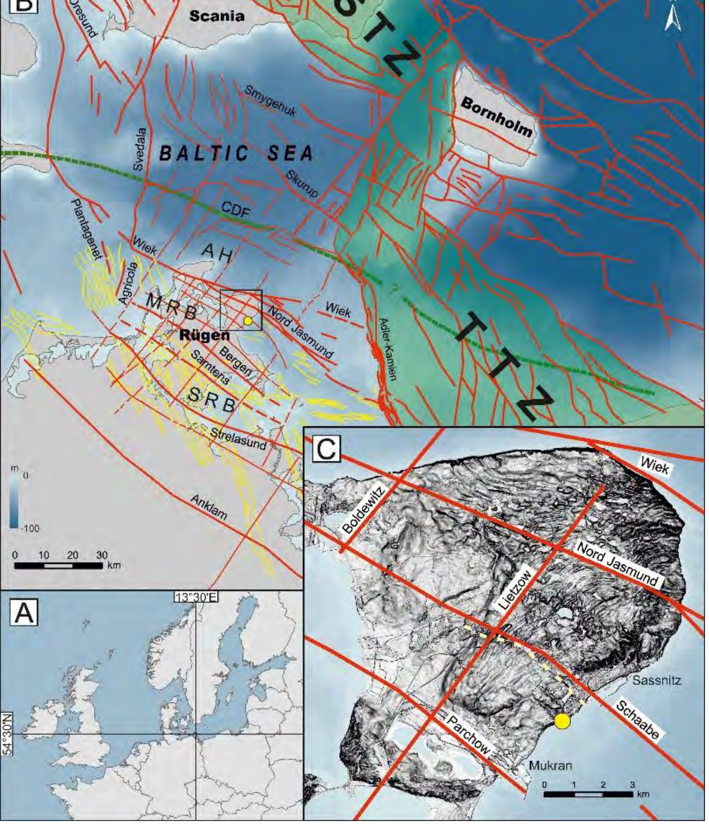
How to cite: Pisarska-Jamroży, M. G., Belzyt, S., Börner, A., Hoffmann, G., Hüneke, H., Kenzler, M., Obst, K., Rother, H., Steffen, H., Steffen, R., and van Loon, T.: The sea cliff at Dwasieden: soft-sediment deformation structures triggered by glacial isostatic adjustment in front of the advancing Scandinavian Ice Sheet, DEUQUA Spec. Pub., 2, 1–7, https://doi.org/10.5194/deuquasp-2-1-2019, 2019.

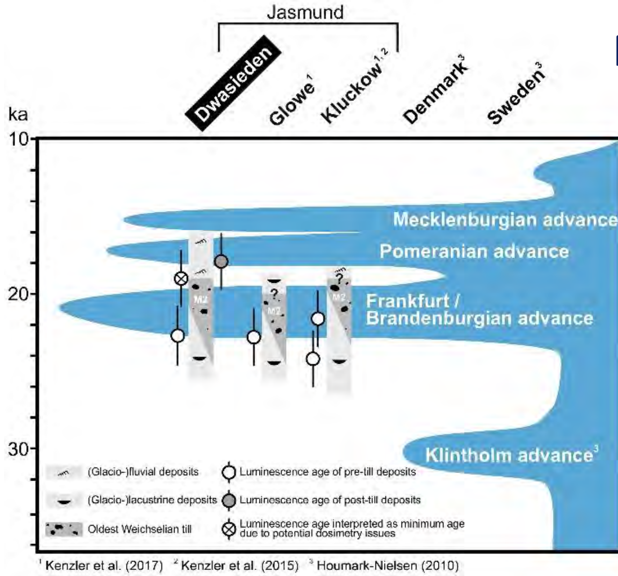


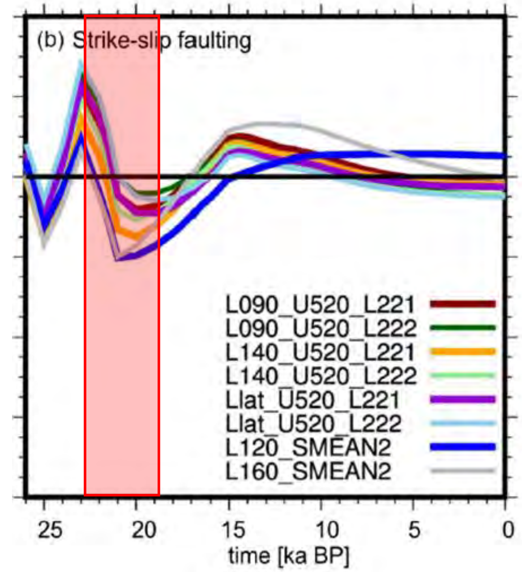


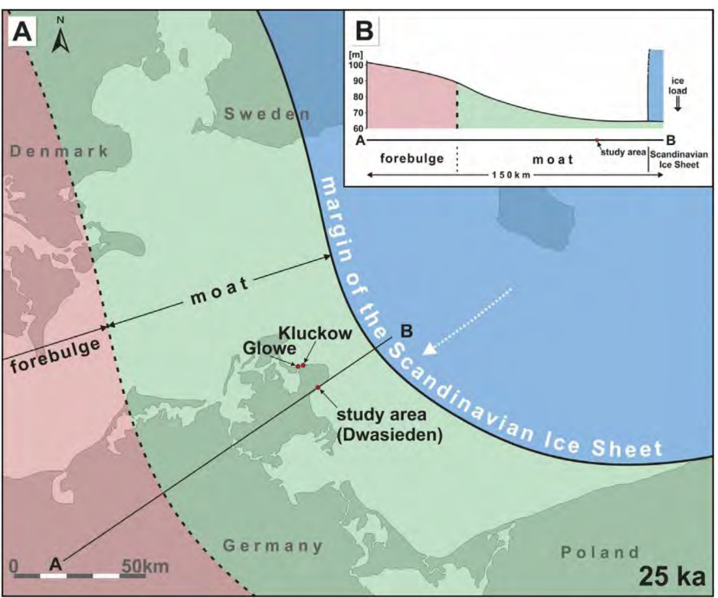
Pisarska-Jamroży et al., 2018

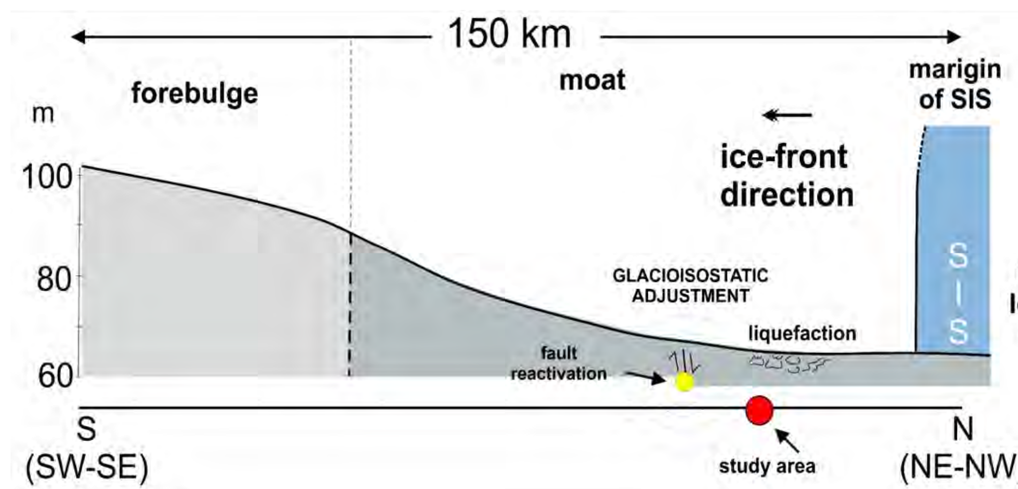

Pisarska-Jamroży et al., 2019



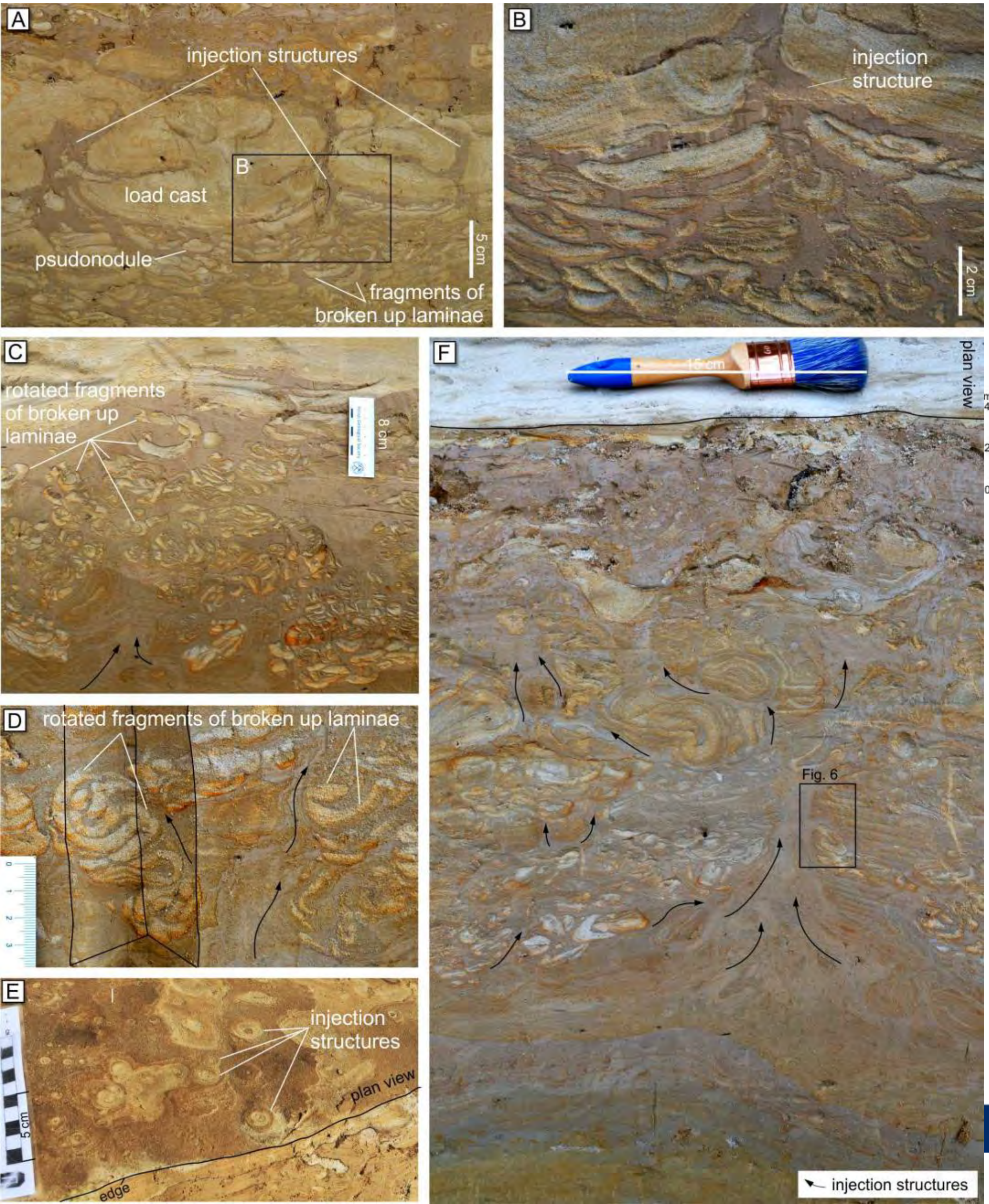


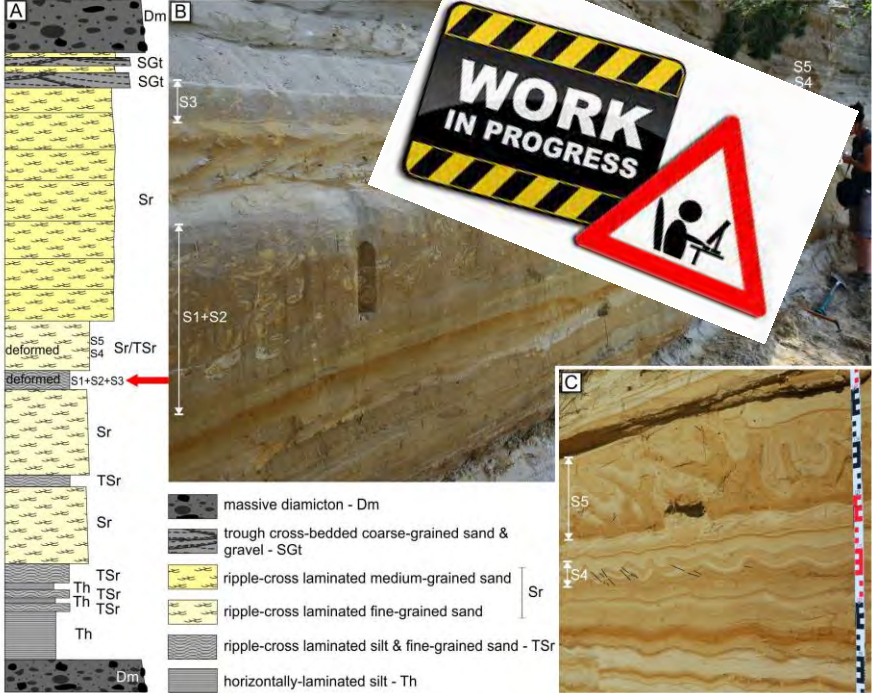


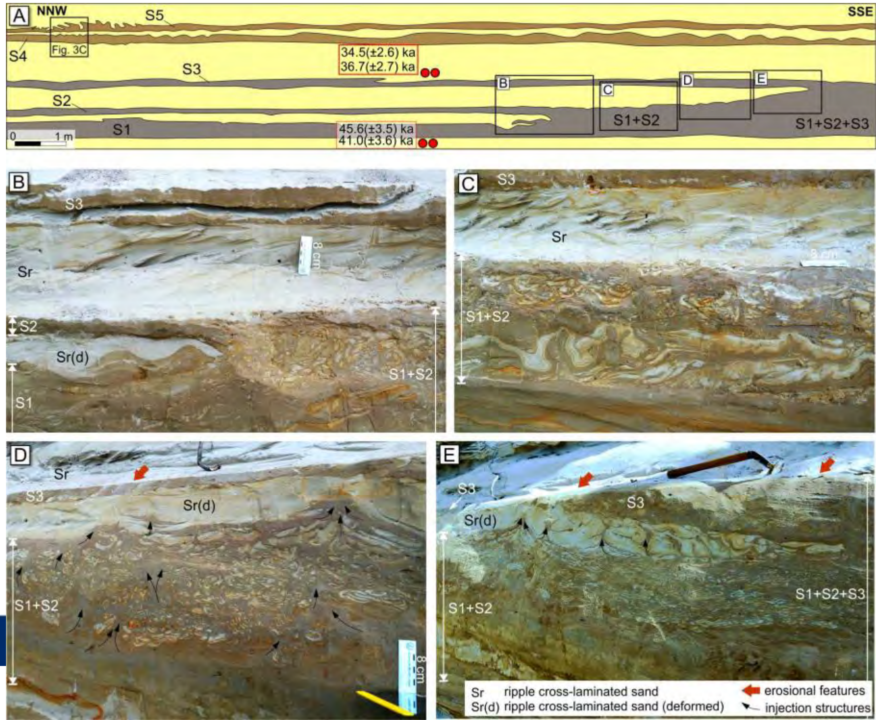




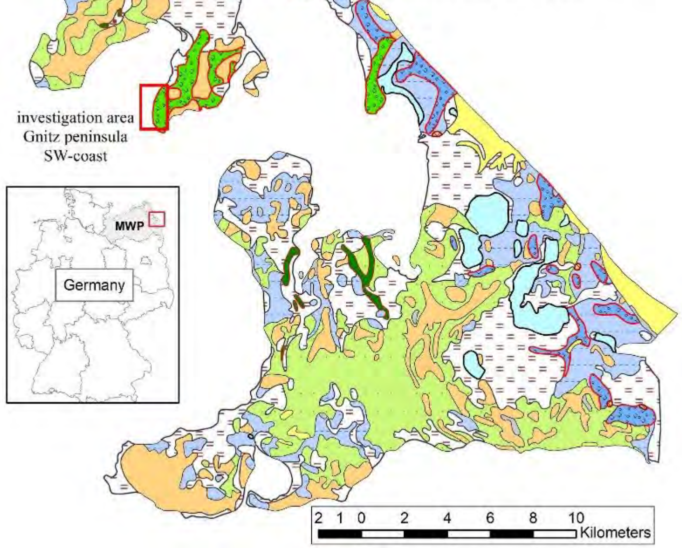
Weisser Berg

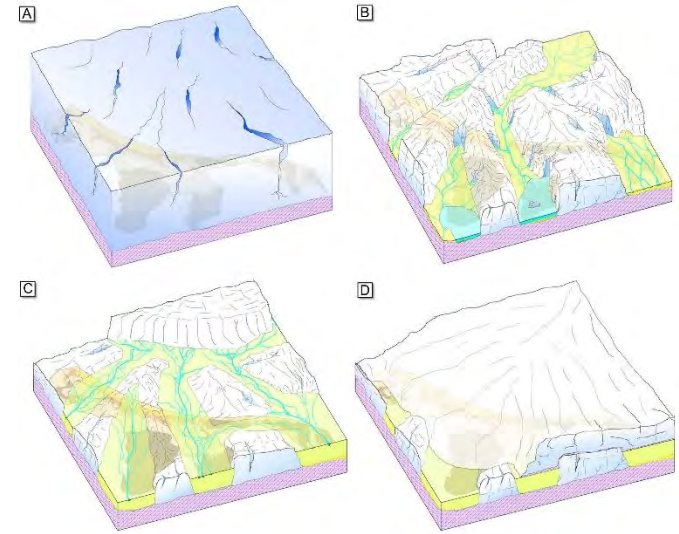


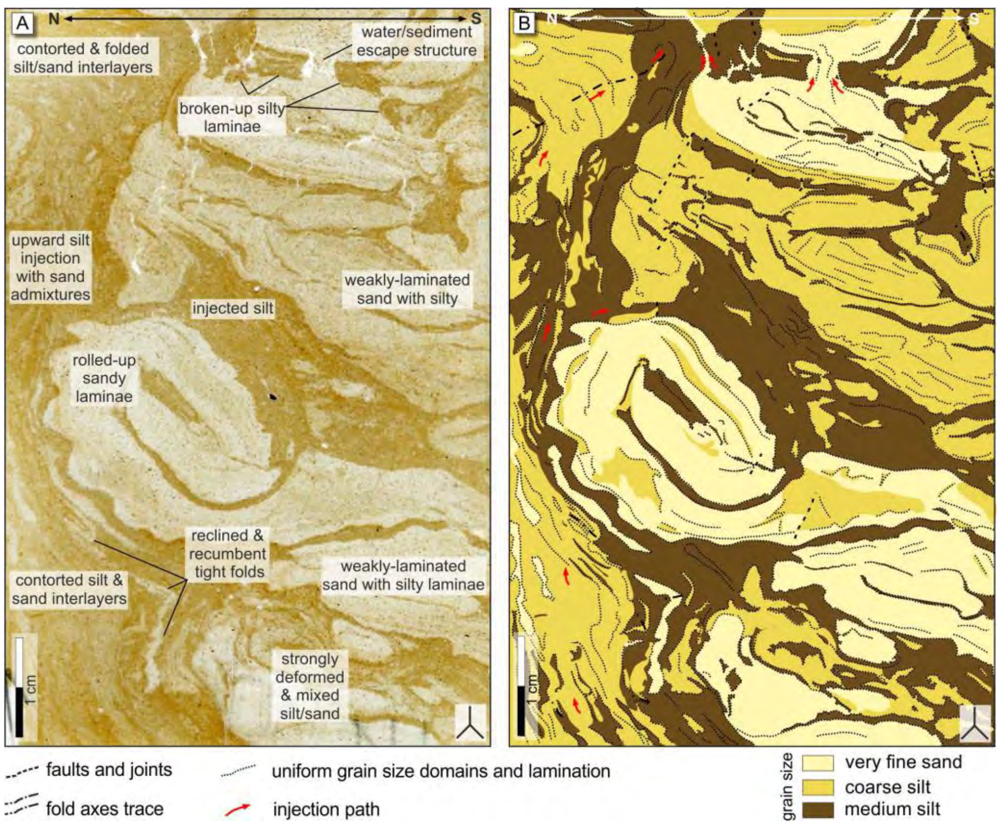


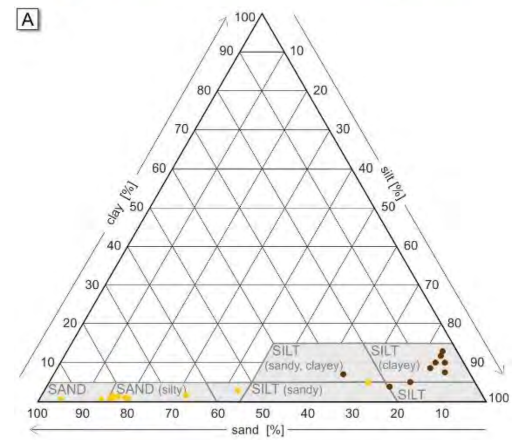


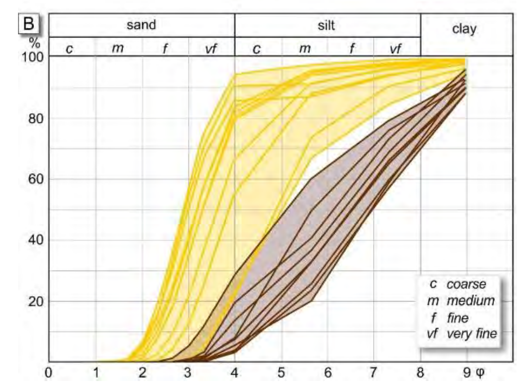
Weisser Berg











Slinkis
Dyburiai

since 1961

Baltica

BALTICA Volume 32 Number 1 June 2019: 63–77
https://doi.org/10.5200/baltica.2019.1.6

Seismic shocks, periglacial conditions and glaciotectonics as causes of the deformation of a Pleistocene meandering river succession in central Lithuania

Małgorzata Pisarska-Jamroży, Szymon Belzyt, Albertas Bitinas, Asta Jusienė, Barbara Woronko

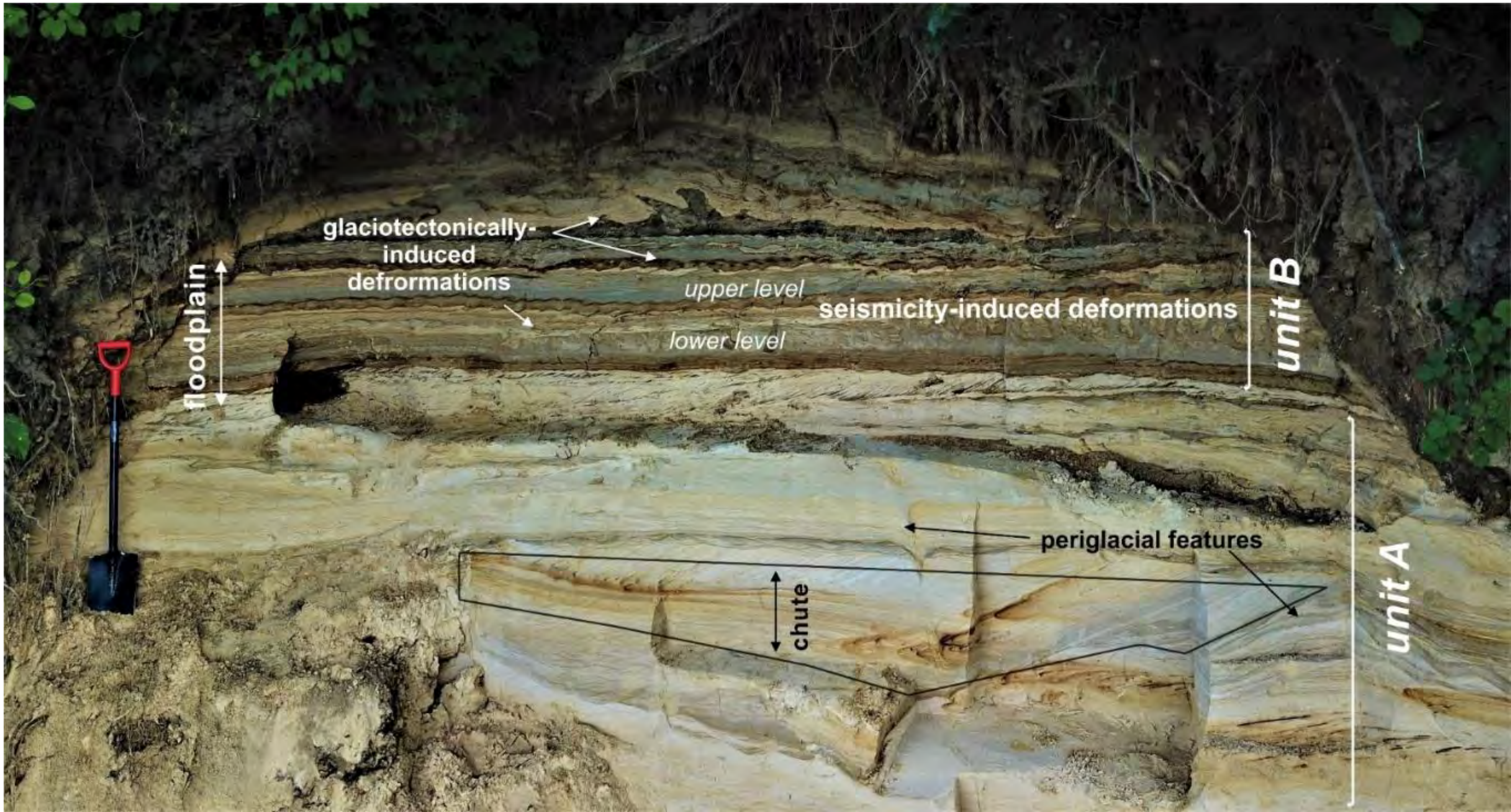
Pisarska-Jamroży, M., Belzyt S., Bitinas A., Jusienė A., Woronko B. 2019. Seismic shocks, periglacial conditions and glaciotectonics as causes of the deformation of a Pleistocene meandering river succession in central Lithuania. *Baltica, 32 (1)*, 63–77. Vilnius. ISSN 0067-3064.

Manuscript submitted 11 February 2019 / Accepted 08 May 2019 / Published online 20 June 2019

Abstract. An extraordinary variation of plastic and brittle deformation structures with periglacial, glaciotectonic and seismic features was observed within the unconsolidated, upper Pleistocene meandering river succession in the Slinkis outcrop in central Lithuania. Among these deformations, the following structures were described: (1) ice-wedge casts in the lower part of the sedimentary succession, linked to periglacial processes, (2) soft-sediment deformation structures, such as load structures (load casts, pseudonodules), flame structures and water/sediment-escape structures, all trapped in clearly defined layers in the upper part of the sedimentary succession, which are related to the propagation of seismic waves, and (3) faults occurring throughout the sedimentary succession, which are associated with glaciotectonic processes. To our knowledge, this is the first description and analysis of the combined presence of such a diverse range of deformation features caused by three trigger mechanisms in a meandering fluvial sedimentary succession.

Slinkis

- 2 sejsmity
- równia zalewowa zimnej rzeki meandrującej
- GIA – przed awansującym lądolodem



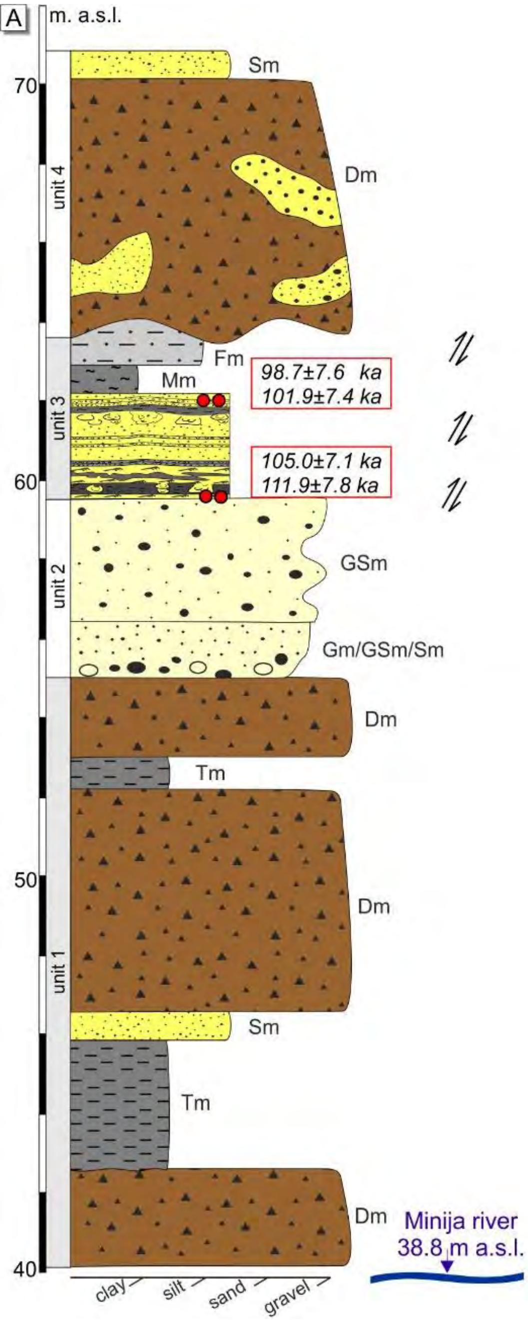
Pisarska-Jamroży et al., 2018

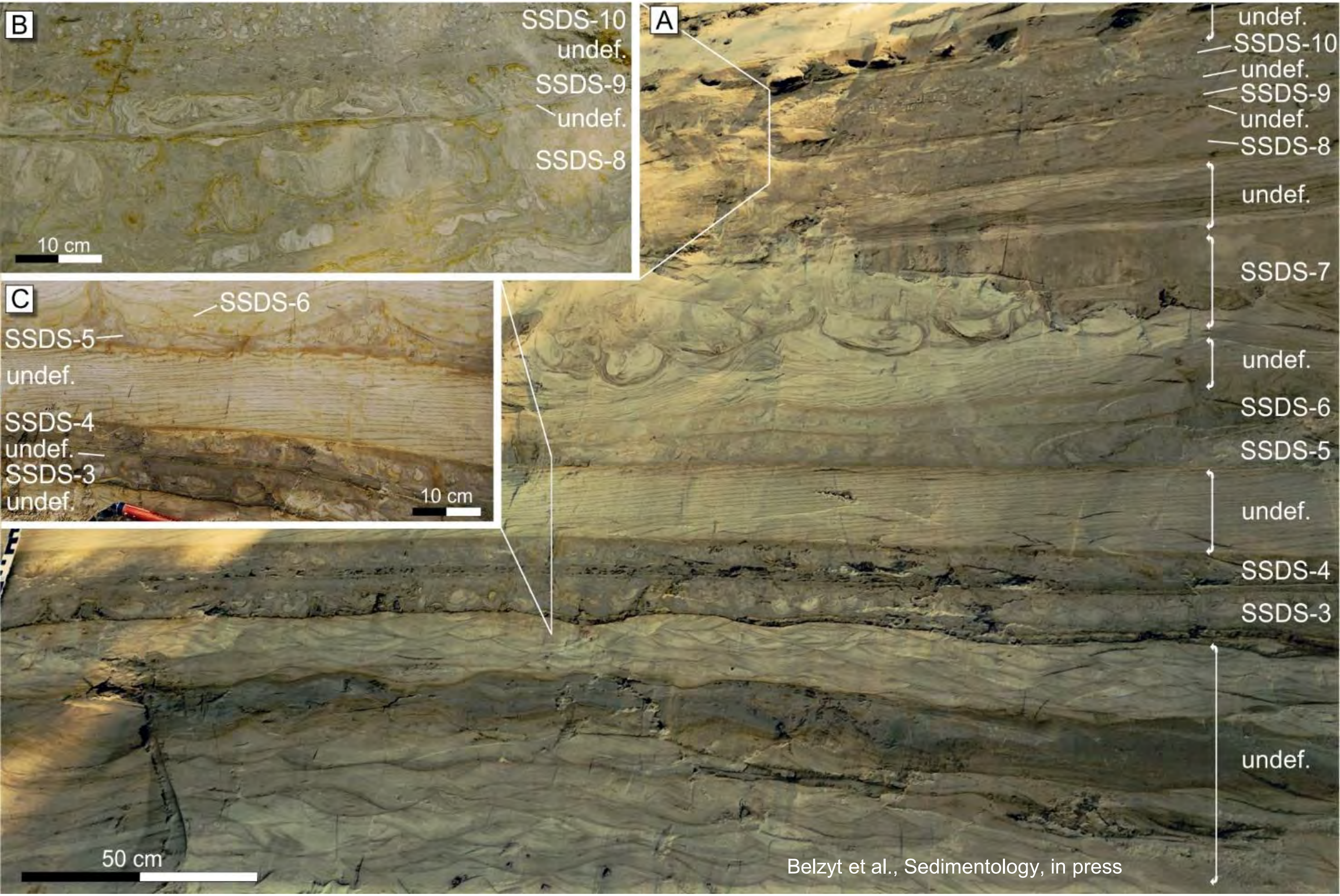
upper seismite

lower seismite

Dyburiai

- 10 sejsmitów
- osady jeziorne
- MIS 5d
- GIA – podczas deglacjacji

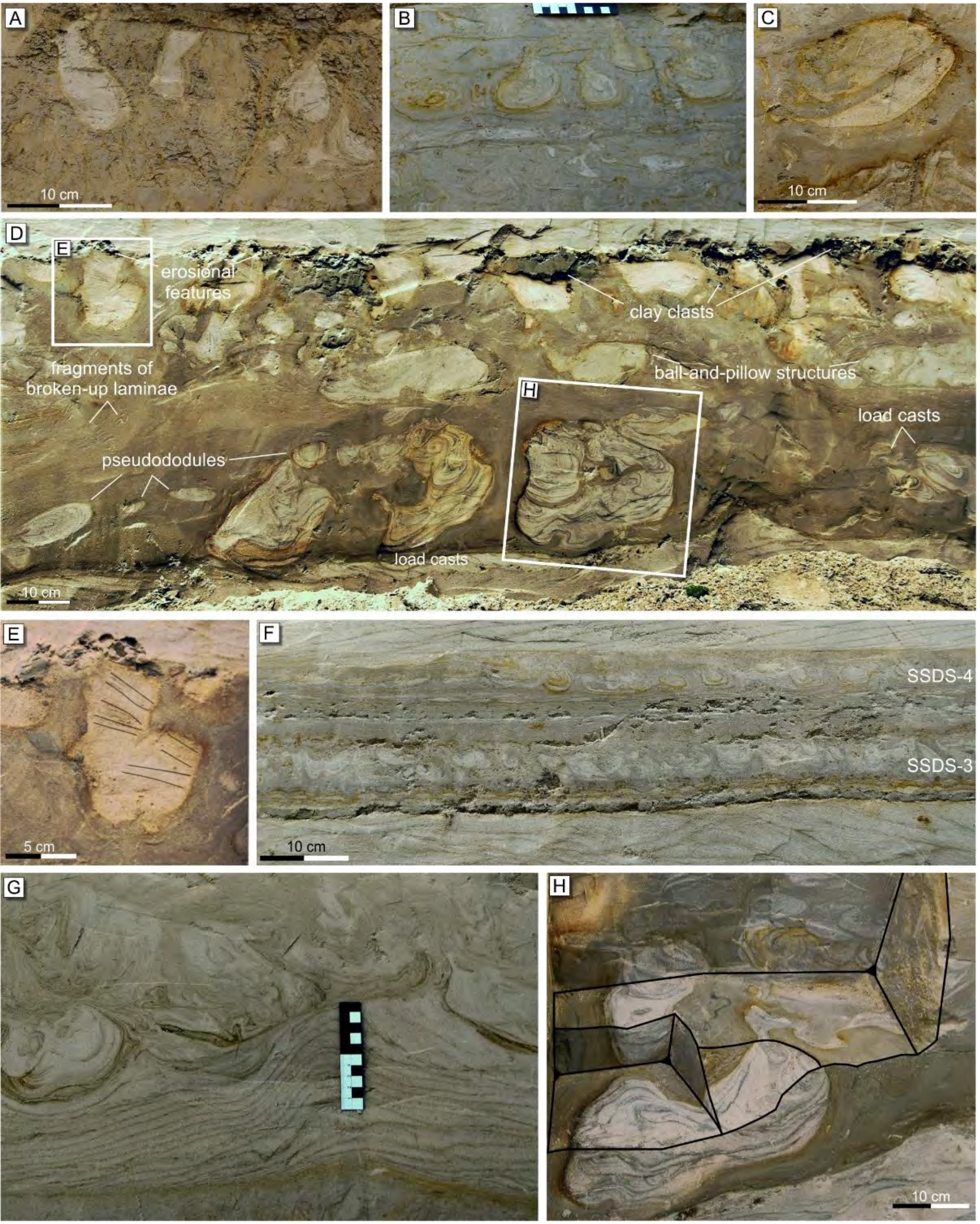




B
SSDS-10
undef.
SSDS-9
undef.
SSDS-8
10 cm
C
SSDS-6
SSDS-5
undef.
SSDS-4
undef.
SSDS-3
undef.
10 cm
A
undef.
SSDS-10
undef.
SSDS-9
undef.
SSDS-8
undef.
SSDS-7
undef.
SSDS-6
SSDS-5
undef.
SSDS-4
SSDS-3
undef.
50 cm
Belzyt et al., Sedimentology, in press

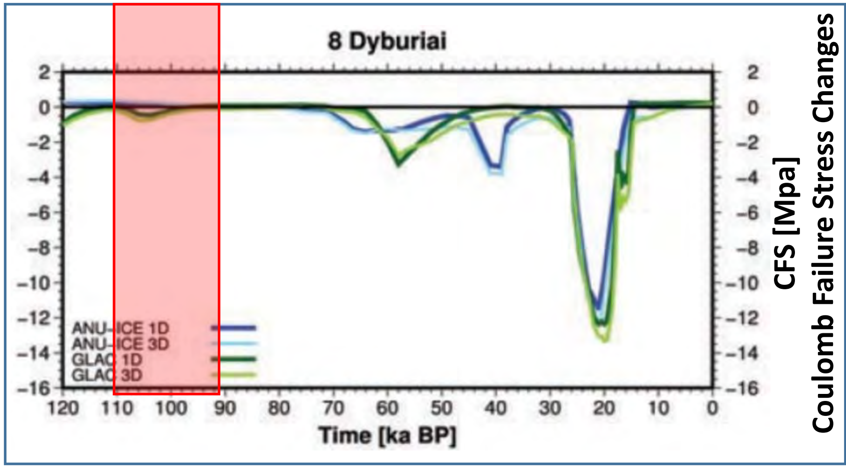
Belzyt et al., Sedimentology, in press

Belzyt et al., Sedimentology, in press



Szacowany czas powstania deformacji

119.7–91.1 ka



(Steffen et al., 2019)

Belzyt et al., Sedimentology, in press

Valmiera
Rakuti
Baltmuiza

Valmiera

- 7 sejsmitów
- drobnoziarniste osady glacifluwailne
- ~14.5 ky, 17-16 ky
- GIA – podczas deglacjacji

Journal of Palaeogeography, 2016, ■(■): 1–14 (26)

HOSTED BY ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.journals.elsevier.com/journal-of-palaeogeography/

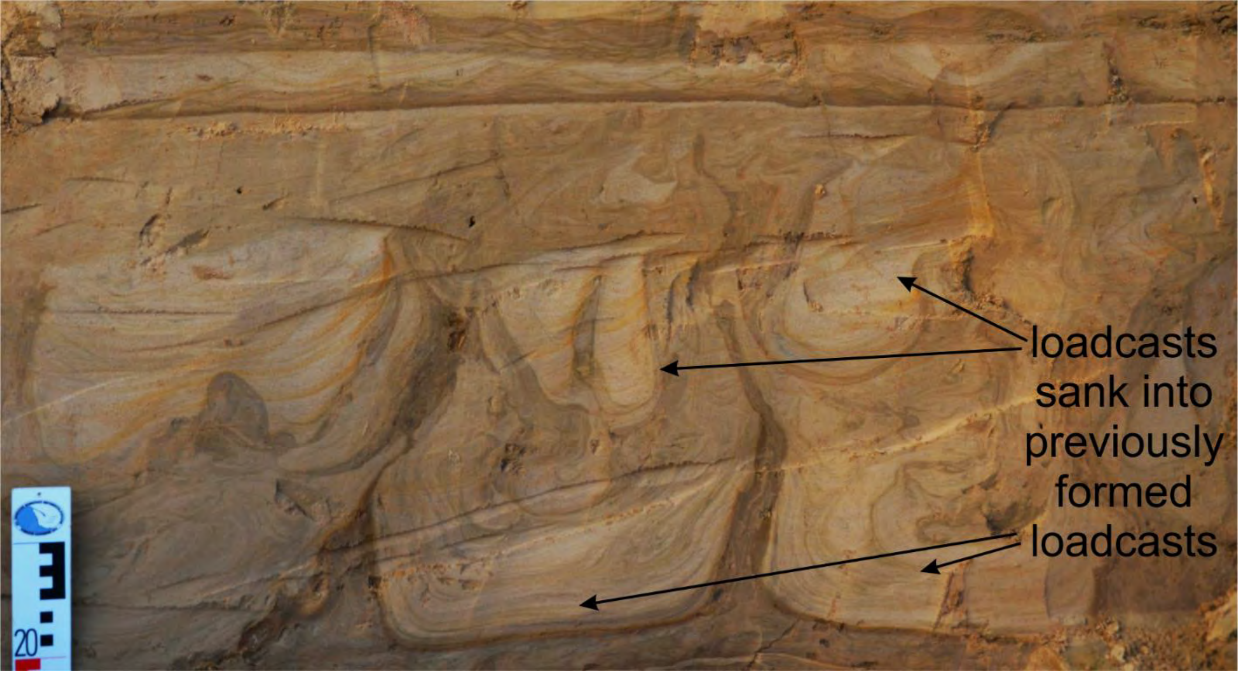
Palaeoseismology and seismites soft-sediment deformation structures

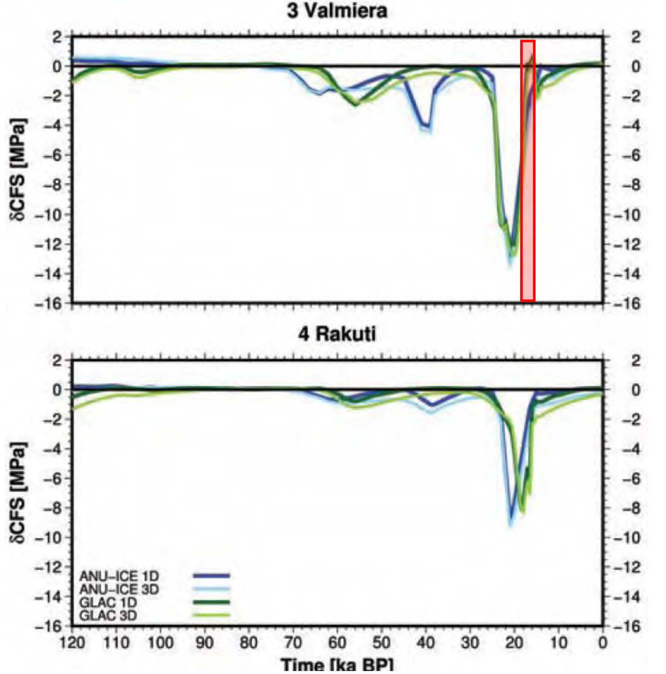
Seismites resulting from high-frequency, high-magnitude earthquakes in Latvia caused by Late Glacial glacio-isostatic uplift

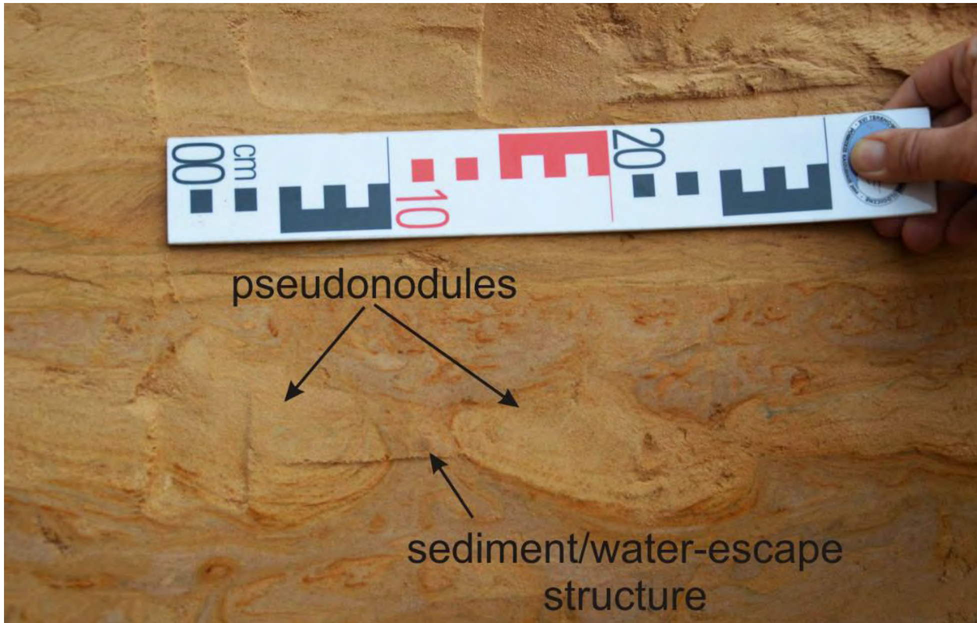
A.J. (Tom) van Loon [a,*], Małgorzata Pisarska-Jamroży [b], Māris Nartišs [c], Māris Krievāns [c], Juris Soms [d]

[a] Geocom Consultants, Valle del Portet 17, 03726 Benitachell, Spain
[b] Institute of Geology, Adam Mickiewicz University, Maków Polnych 16, 61-606 Poznań, Poland
[c] Faculty of Geography and Earth Sciences, University of Latvia, Rainis Blvd. 19, 1576 Riga, Latvia
[d] Department of Geography, Daugavpils University, Parades 1, LV 5401 Daugavpils, Latvia

Abstract Geologically extremely rapid changes in altitude by glacial rebound of the Earth crust after retreat of the Scandinavian Ice Sheet at the end of the last Weichselian glaciation influenced the palaeogeography of northern Europe. The uplift of the Earth crust apparently was not gradual, but shock-wise, as the uplift was accompanied by frequent, high-magnitude earthquakes. This can be deduced from strongly deformed layers which are interpreted as seismites. Such seismites have been described from several countries around the Baltic Sea, including Sweden, Germany and Poland.







Van Loon et al., 2016

Rakuti

- 12 sejsmitów
- osady glacilimniczne
- 17-16 ky
- GIA – podczas deglacjacji

Journal of Palaeogeography, 2016, ■(■): 1–14 (26)

HOSTED BY ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.journals.elsevier.com/journal-of-palaeogeography/

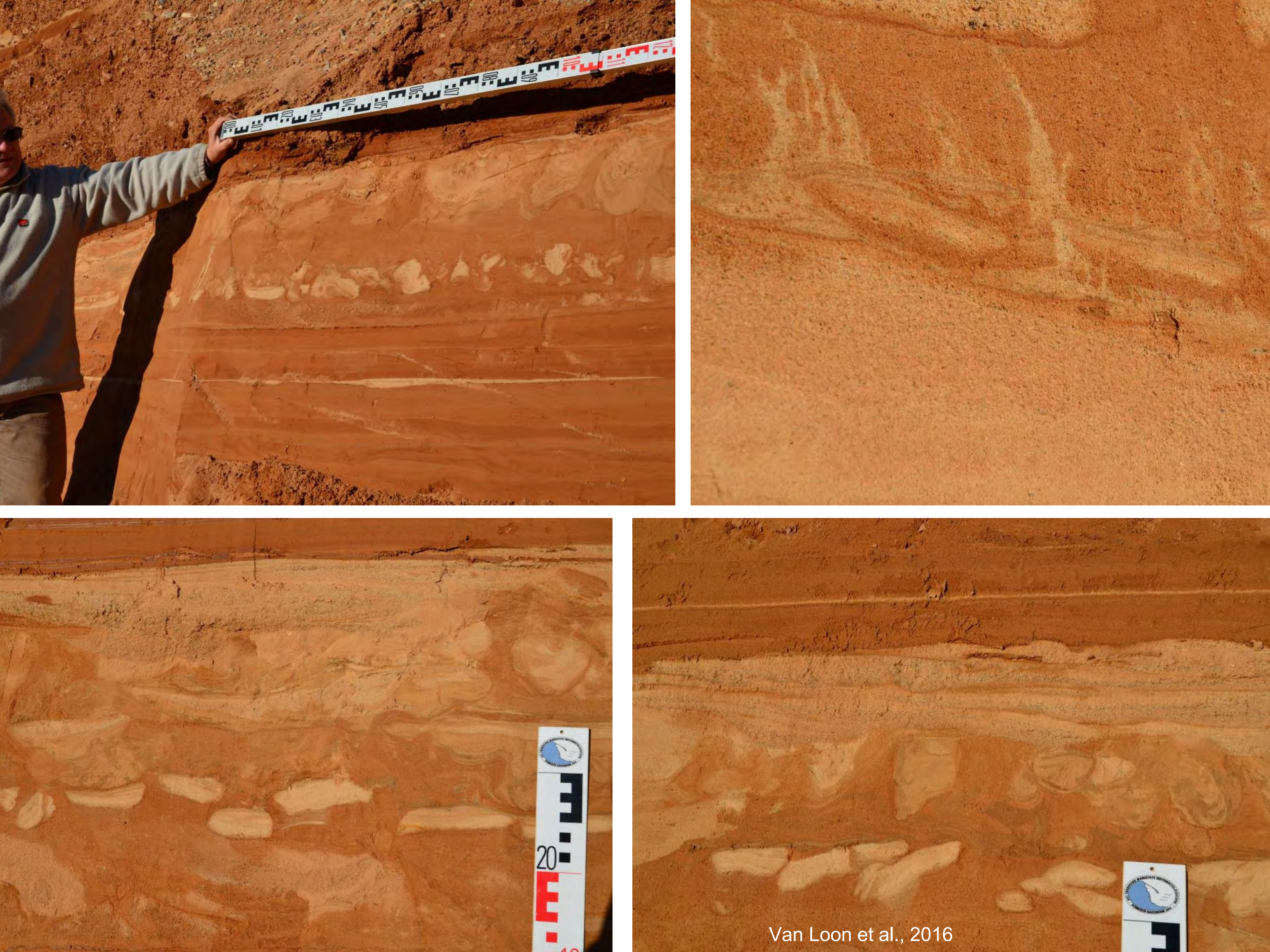
Palaeoseismology and seismites soft-sediment deformation structures

Seismites resulting from high-frequency, high-magnitude earthquakes in Latvia caused by Late Glacial glacio-isostatic uplift

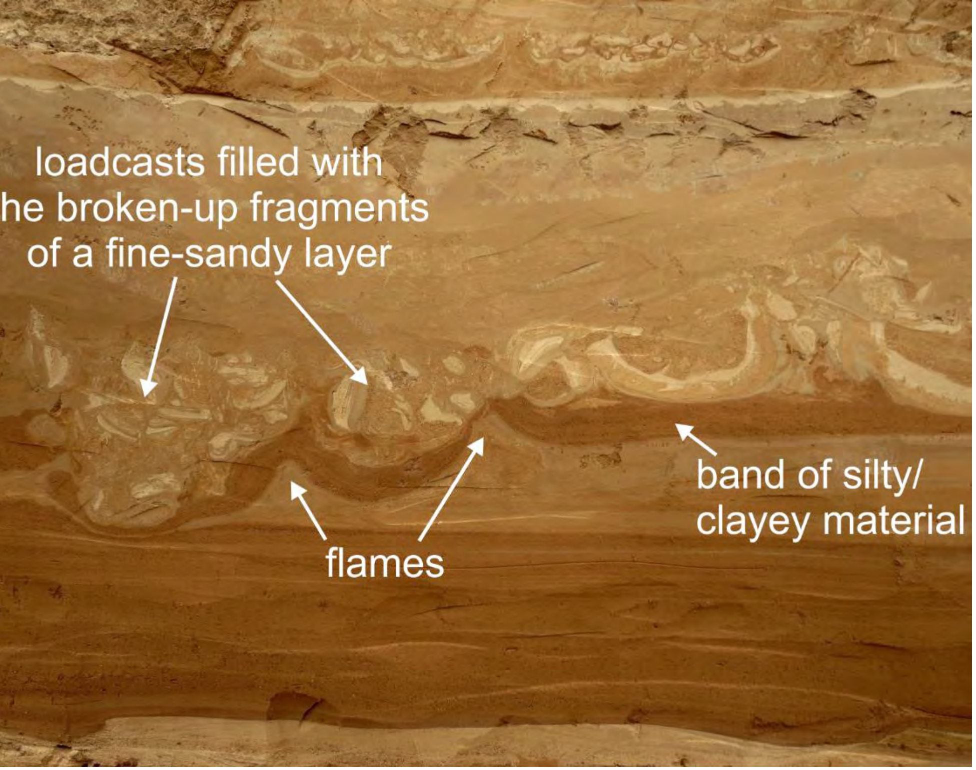
A.J. (Tom) van Loon [a,*], *Małgorzata Pisarska-Jamroży* [b], *Māris Nartišs* [c], *Māris Krievāns* [c], *Juris Soms* [d]

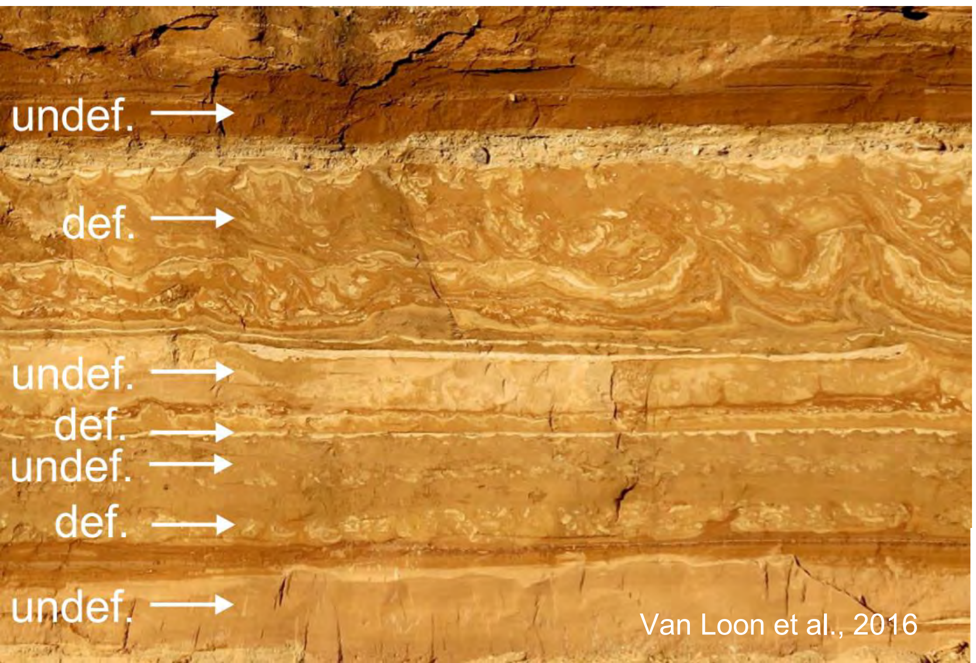
[a] Geocom Consultants, Valle del Portet 17, 03726 Benitachell, Spain
[b] Institute of Geology, Adam Mickiewicz University, Maków Polnych 16, 61-606 Poznań, Poland
[c] Faculty of Geography and Earth Sciences, University of Latvia, Rainis Blvd. 19, 1576 Riga, Latvia
[d] Department of Geography, Daugavpils University, Parades 1, LV 5401 Daugavpils, Latvia

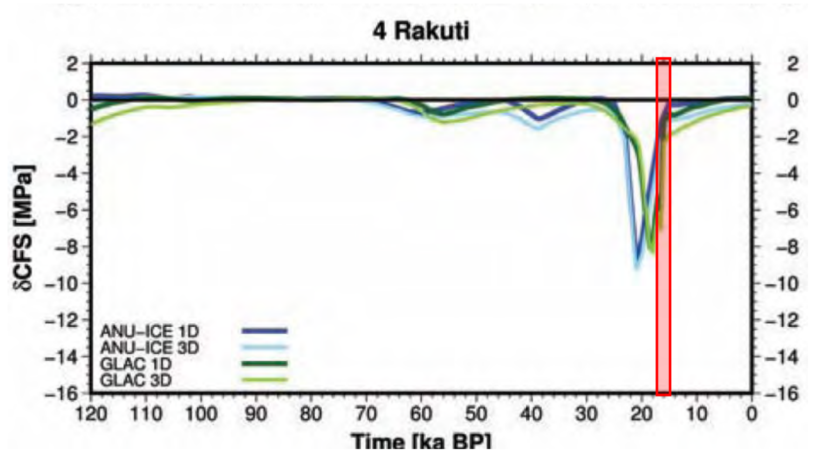
Abstract Geologically extremely rapid changes in altitude by glacial rebound of the Earth crust after retreat of the Scandinavian Ice Sheet at the end of the last Weichselian glaciation influenced the palaeogeography of northern Europe. The uplift of the Earth crust apparently was not gradual, but shock-wise, as the uplift was accompanied by frequent, high-magnitude earthquakes. This can be deduced from strongly deformed layers which are interpreted as seismites. Such seismites have been described from several countries around the Baltic Sea, including Sweden, Germany and Poland.



Van Loon et al., 2016

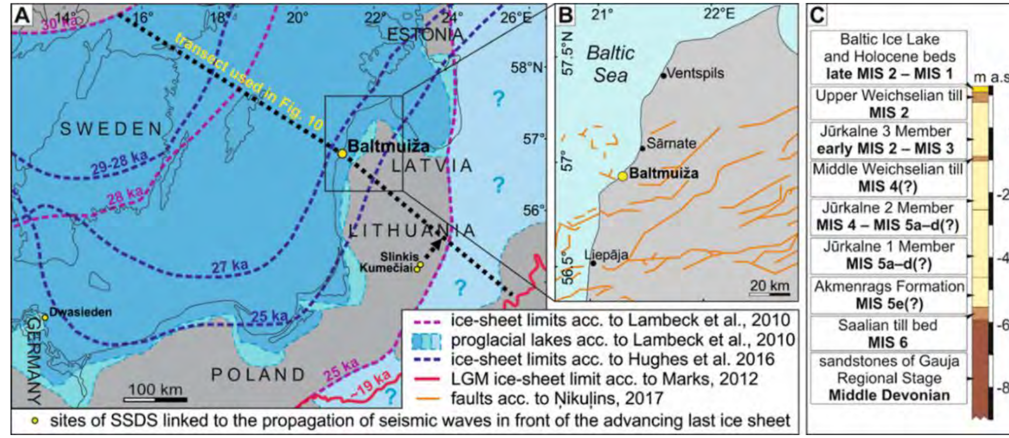

loadcasts filled with
he broken-up fragments
of a fine-sandy layer
band of silty/
clayey material
flames

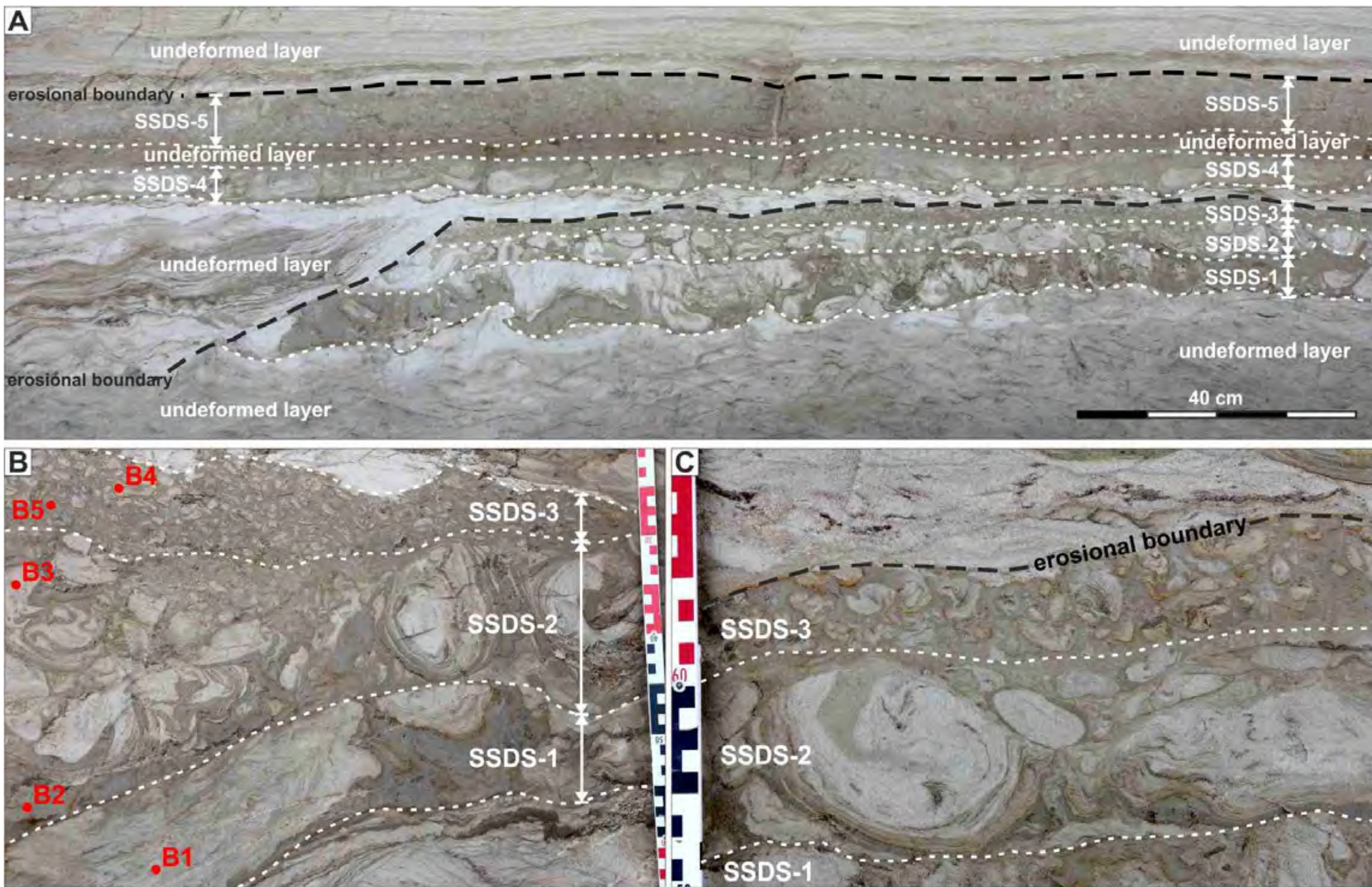

undef.
def.
undef.
def.
undef.
def.
undef.
Van Loon et al., 2016


4 Rakuti
δCFS [MPa]
Time [ka BP]
ANU–ICE 1D
ANU–ICE 3D
GLAC 1D
GLAC 3D
2
0
−2
−4
−6
−8
−10
−12
−14
−16
120
110
100
90
80
70
60
50
40
30
20
10
0

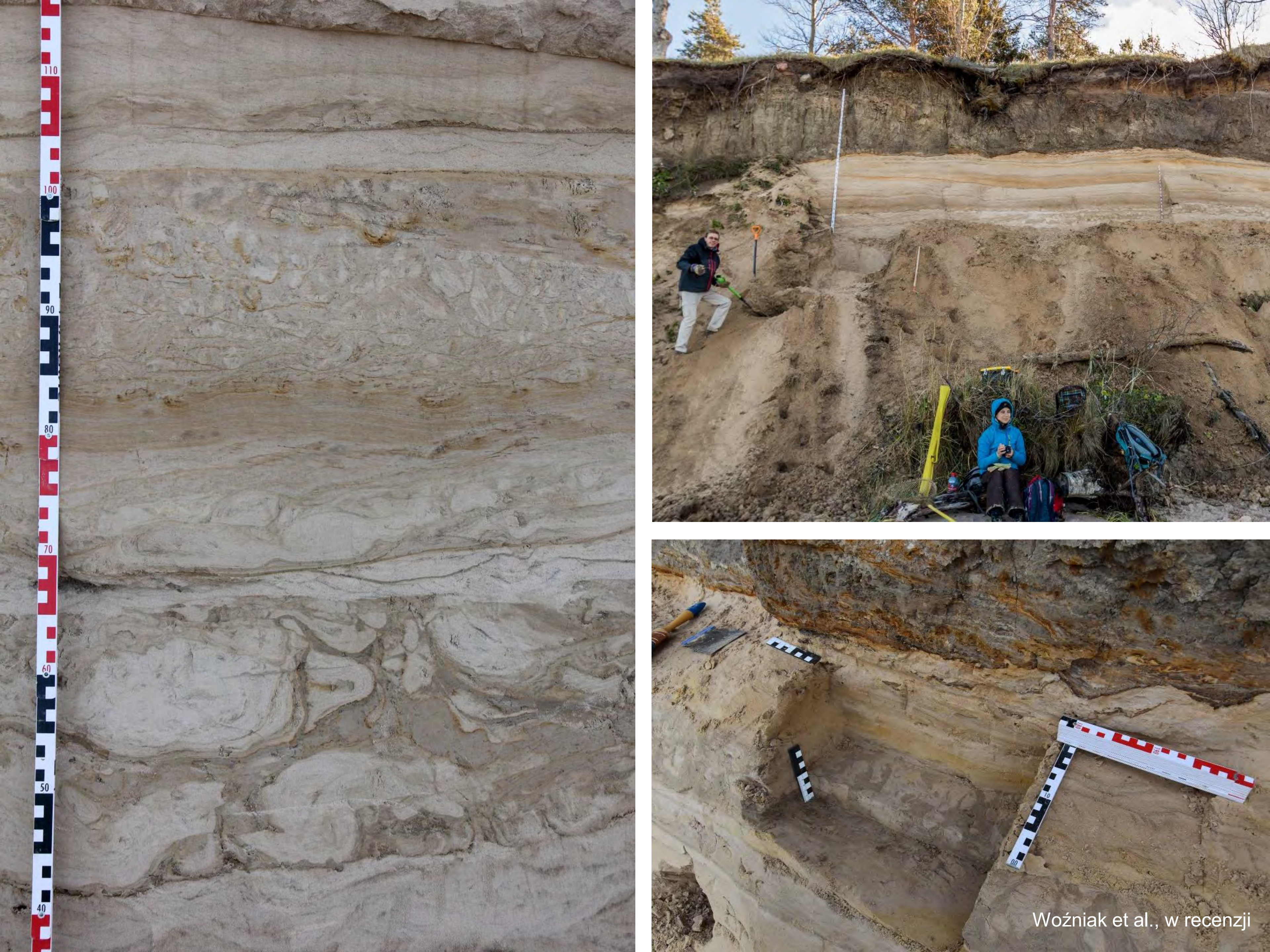
Baltmuiža

- 7 sejsmitów (upłynnienie i ponowne upłynnienie)
- Płytkomorskie morskie osady (zatoka)
- MIS
- GIA - przed awansującym lądolodem? lub lodowcowe trzęsienie ziemi

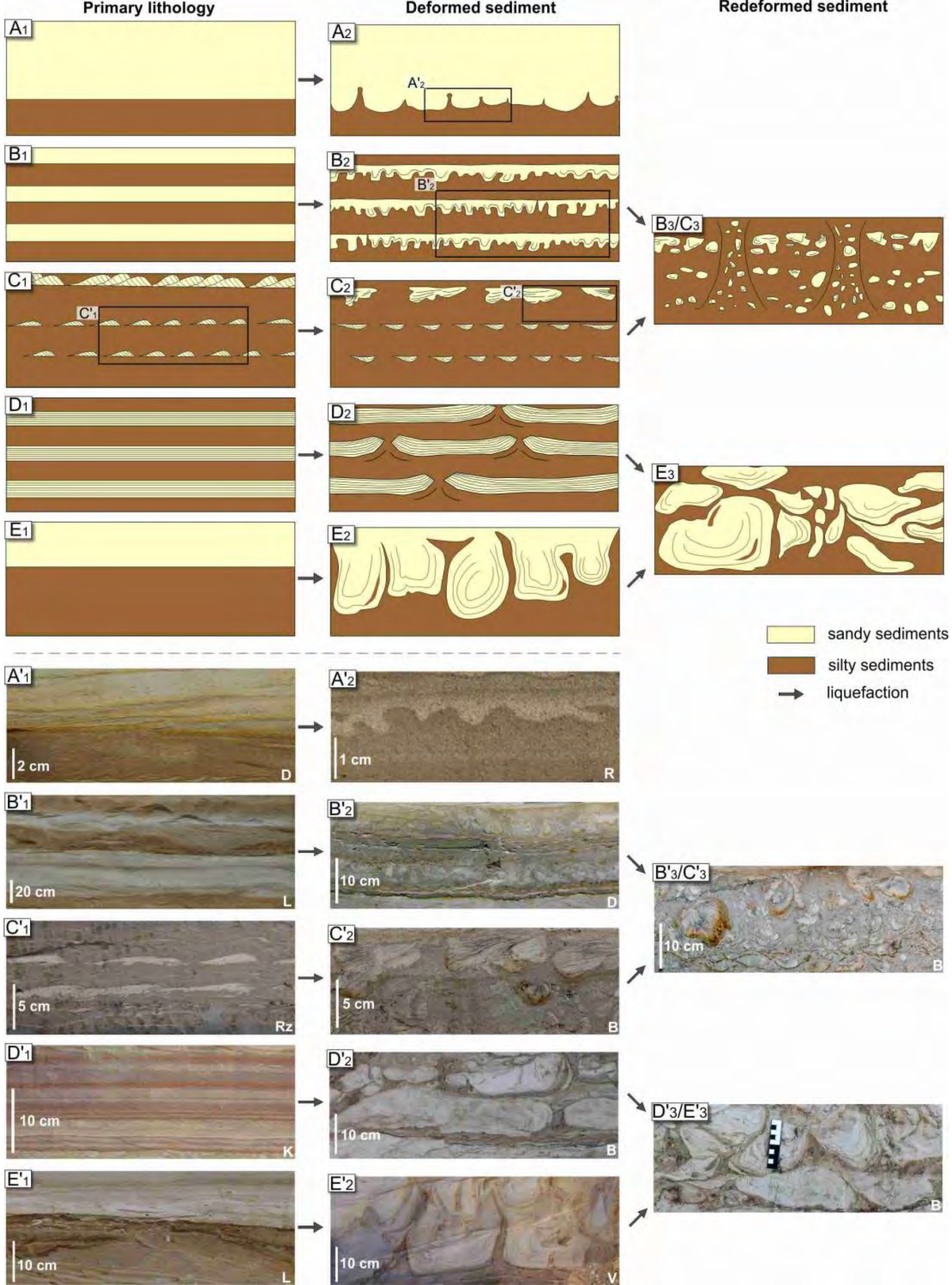




Woźniak et al., w recenzji



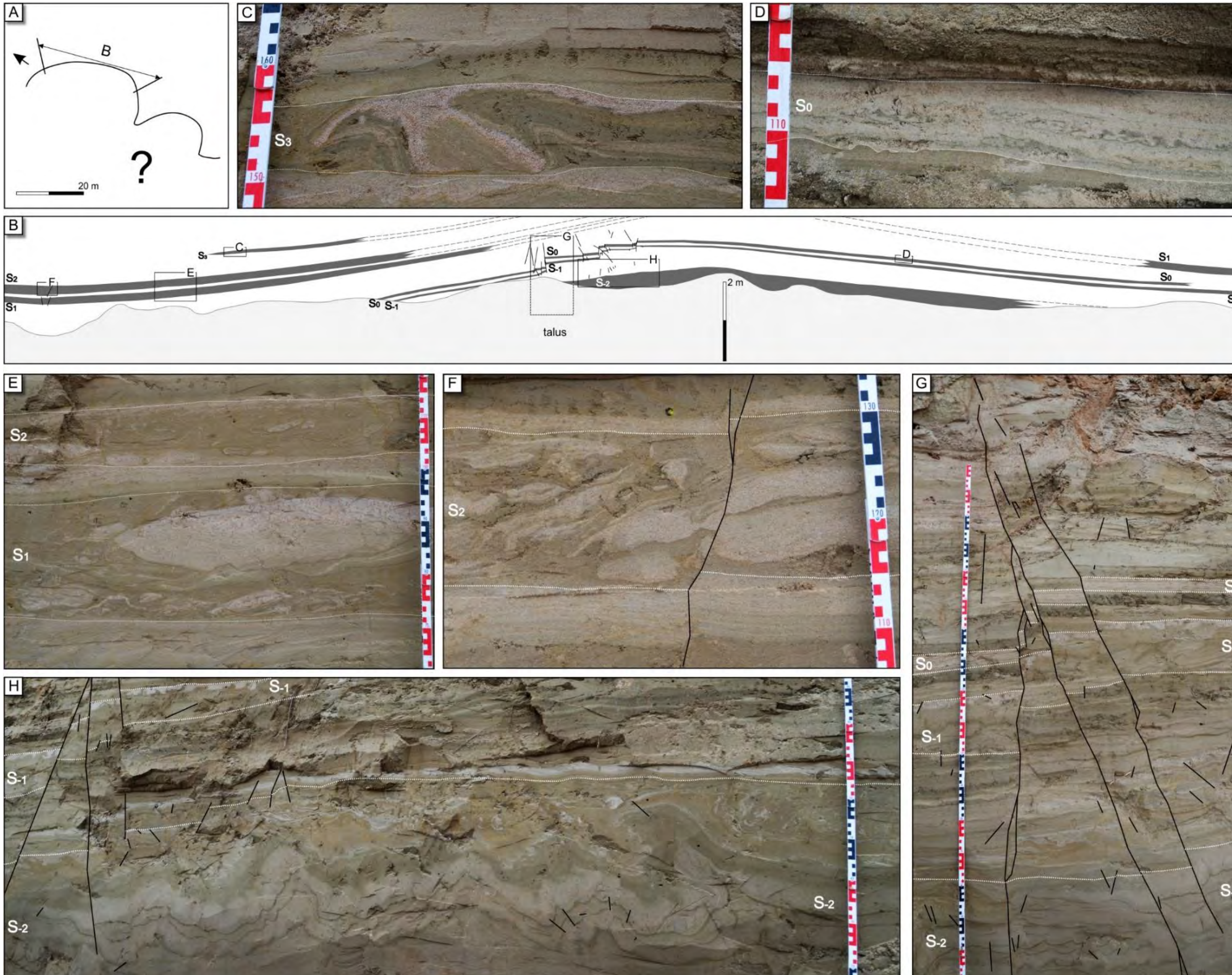
Woźniak et al., w recenzji


Primary lithology
Deformed sediment
Redeformed sediment
A1
A2
A'2
B1
B2
B'2
B3/C3
C1
C'1
C2
C'2
D1
D2
E3
E1
E2
sandy sediments
silty sediments
liquefaction
A'1
2 cm
D
A'2
1 cm
R
B'1
20 cm
L
B'2
10 cm
D
B'3/C'3
10 cm
B
C'1
5 cm
Rz
C'2
5 cm
B
D'1
10 cm
K
D'2
10 cm
B
D'3/E'3
B
E'1
10 cm
L
E'2
10 cm
V


Atlantic Ocean
Norwegian Sea
SCANDINAVIAN ICE-SHEET
Baltic Sea
ESTONIA
LATVIA
LITHUANIA
KALININGRAD DISTR. OF RUSSIA
North Sea
GERMANY
POLAND
Weichselian glaciation (LGM)
Saalian glaciation
0 200 km

Rakvere

Rakvere

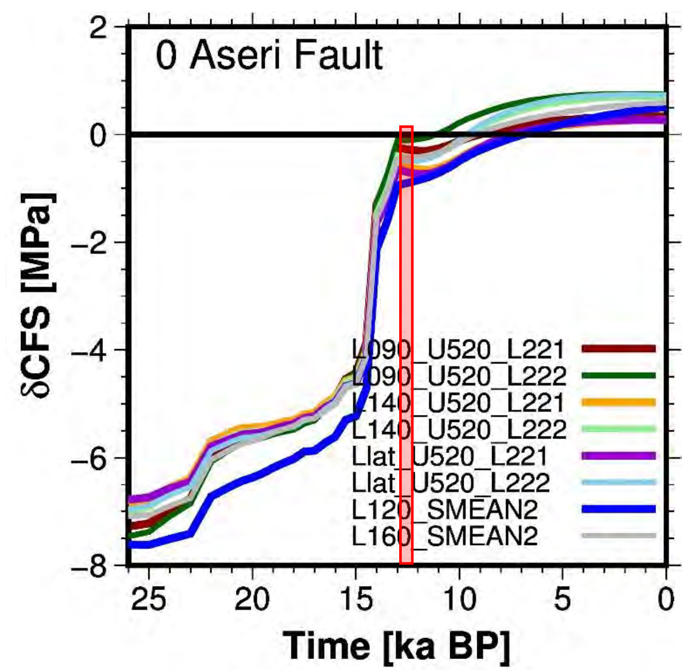


wstęgi deformacyjne

Estonia – Rakvere study site

Pandivere (12.4–12.2 C14 BP) acc. to Rattas & Kalm (2004)

wstęgi deformacyjne



Seismic, or not seismic,
that is the question

Geological Quarterly, 2020, **64** (3): 626–640
DOI: http://dx.doi.org/10.7306/gq.1546

Sedimentological distinction in glacigenic sediments between load casts induced by periglacial processes from those induced by seismic shocks

A.J. (Tom) VAN LOON[1, *], Małgorzata PISARSKA-JAMROŻY[2] and Barbara WORONKO[3]

[1] Shandong University of Science and Technology, College of Science and Engineering, Qingdao 266590, China
[2] Adam Mickiewicz University, Institute of Geology, B. Krygowskiego 12, 61-680 Poznań, Poland
[3] University of Warsaw, Faculty of Geology, Żwirki i Wigury 93, 02-089 Warszawa, Poland

Van Loon, A.J. (Tom), Pisarska-Jamroży, M., Woronko, B., 2020. Sedimentological distinction in glacigenic sediments between load casts induced by periglacial processes from those induced by seismic shocks. Geological Quarterly, **64** (3): 000–000, doi: 10.7306/gq.1546

Loading processes and the resulting load structures induced by processes related to periglacial conditions are compared to those induced by seismic shocks. The load structures themselves are relatively easily recognizable but the responsible trigger mechanism is, though depending on the geological context, commonly difficult to establish. Load structures like load casts, pseudonodules, ball-and-pillow structures and flame structures are commonly ascribed to instable density gradients within sediments and to differential loading, but their formation always requires liquefaction. In glacigenic sediments, deformation structures have most commonly been ascribed to periglacial processes (as a type of cryoturbations), but it becomes ever more clear that glacigenic sediments can, particularly during ice-front fluctuations, be affected by faulting-related earthquakes (due to glacio-isostatic adjustment), and the thus triggered seismic shocks may result in deformations, including – most commonly – load structures. We inventory the evidence that may help to distinguish, on the basis of textural and structural features, load structures with a seismic origin from those that result from periglacial processes, taking into account that truly diagnostic criteria do not exist.

Key words: load casts, pseudonodules, soft-sediment deformation structures, cryoturbation, seismites.

Literatura

- Belzyt, S. & Pisarska-Jamroży, M., 2017. W jaki sposób badać sejsmity? Przegląd metod badawczych [How to study seismites? A review of research methods]. *Acta Geographica Lodziensia* 106, 171-180. doi: 10.1016/AGL/2017/106/13.
- Belzyt, S., Pisarska-Jamroży, M., Bitinas, A., Woronko, B., Phillips, E.R., Piotrowski, J.A. & Jusienė, A., 2021. Repetitive Late Pleistocene soft-sediment deformation by seismicity-induced liquefaction in north-western Lithuania. *Sedimentology* DOI: 10.1111/sed.12883
- Bitinas, A., Lazauskienė, J. & Pisarska-Jamroży, M., 2022. Chapter 6.4 - Soft-sediment deformation structures in the Eastern Baltic Region: implication in seismicity and glacially-induced faulting [W:] Steffen, H., Olesen, O., Sutinen, R. (red.): *Glacially triggered faulting*. Cambridge University Press. *in press*
- Müller, K., Winsemann, J., Pisarska-Jamroży, M., Lege, T., Spies, T., Brandes, C. 2022. Chapter 3.2 - The Challenge to Distinguish Soft-Sediment Deformation Structures (SSDS) Formed by Glaciotectonic, Periglacial and Seismic Processes in a Formerly Glaciated Area: A Review and Synthesis [W:] Steffen, H., Olesen, O., Sutinen, R. (red.): *Glacially triggered faulting*. Cambridge University Press. *in press*
- Pisarska-Jamroży, M. & Woźniak, P.P., 2019. Debris flow and glacioisostatic-induced soft-sediment deformation structures in a Pleistocene glaciolacustrine fan: The southern Baltic Sea coast, Poland. *Geomorphology* 326, 225-238. https://doi.org/10.1016/j.geomorph.2018.01.015
- Pisarska-Jamroży, M., Belzyt, S, Börner, A., Hoffmann, G., Hüneke, H., Kenzler, M., Obst, K., Rother, H., Steffen, H., Steffen, R. & Van Loon, A.J., 2019. The sea cliff at Dwasieden: Soft-sediment deformation structures triggered by glacial isostatic adjustment in front of the advancing Scandinavian Ice Sheet. *E&G Quaternary Science Journal* 2: 61-64. https://doi.org/10.5194/deuquasp-2-61-2019, 2019.
- Pisarska-Jamroży, M., Belzyt, S., Bitinas, A., Jusienė, A. & Woronko, B., 2019. Seismic shocks, periglacial conditions and glaciotectonics as causes of the deformation of a Pleistocene meandering river succession in central Lithuania. *Baltica* 32, 63-77. https://doi.org/10.5200/baltica.2019.1.6
- Pisarska-Jamroży, M., Belzyt, S., Börner, A., Hoffmann, G., Hüneke, H., Kenzler, M., Obst, K., Rother, H. & Van Loon, A.J. (Tom), 2018. Evidence from seismites for glacio-isostatically induced crustal faulting in front of an advancing land-ice mass (Rügen Island, SW Baltic Sea). *Tectonophysics* 745, 338-348. https://doi.org/ 10.1016/j.tecto.2018.08.004
- Pisarska-Jamroży, M., Van Loon, A.J. (Tom), Bronikowska, M., 2018. Dumpstones as records of overturning ice rafts in a Weichselian proglacial lake (Rügen Island, NE Germany). *Geological Quarterly* 62, 917-924. http://dx.doi.org/10.7306/gq.1448
- Pisarska-Jamroży, M., Van Loon, A.J., Mleczak, M. & Roman, M. 2019. Enigmatic gravity-flow deposits at Ujście (western Poland), triggered by earthquakes (as evidenced by seismites) caused by Saalian glacioisostatic crustal rebound. *Geomorphology* 326, 239-251. doi.org/10.1016/j.geomorph.2018.01.010
- Pisarska-Jamroży, M., Woźniak, P.P. & Van Loon, A.J. 2022. Glacially-induced faulting in Poland [W:] Steffen, H., Olesen, O., Sutinen, R. (red.): *Glacially triggered faulting*. Cambridge University Press. *in press*
- Steffen, H., Steffen, R., Tarasov, L. 2019. Modelling of glacially-induced stress changes in Latvia, Lithuania and the Kaliningrad District of Russia. Baltica 32, 78-90.
- Van Loon, A.J. (Tom), Pisarska-Jamroży, M., Nartišs, M., Krievāns, M. & Soms, J., 2016. Seismites resulting from high-frequency, high-magnitude earthquakes in Latvia caused by Late Glacial glacio-isostatic uplift. *Journal of Palaeogeography* 5, 363-380. doi: 10.1016/j.jop.2016.05.002.
- Van Loon, A.J. (Tom), Soms, J., Nartišs, M., Krievāns, M. & Pisarska-Jamroży, M., 2019. Sedimentological traces of ice-raft grounding in a Weichselian glacial lake near Dukuli (NE Latvia). *Baltica* 32, 170–181. https://doi.org/10.5200/baltica.2019.2.4
- Van Loon, A.J., Pisarska-Jamroży, M. & Woronko, B., 2020. Sedimentological distinction in glacigenic sediments between load casts induced by periglacial processes from those induced by seismic shocks. *Geological Quarterly* 64, 626-640. http://dx.doi.org/10.7306/gq.1546
- Woźniak, P.P. & Pisarska-Jamroży, M., 2018. Debris flows with soft-sediment clasts in a Pleistocene glaciolacustrine fan (Gdańsk Bay, Poland). *Catena* 165, 178-191. https://doi.org/10.1016/j.catena.2018 01. 022