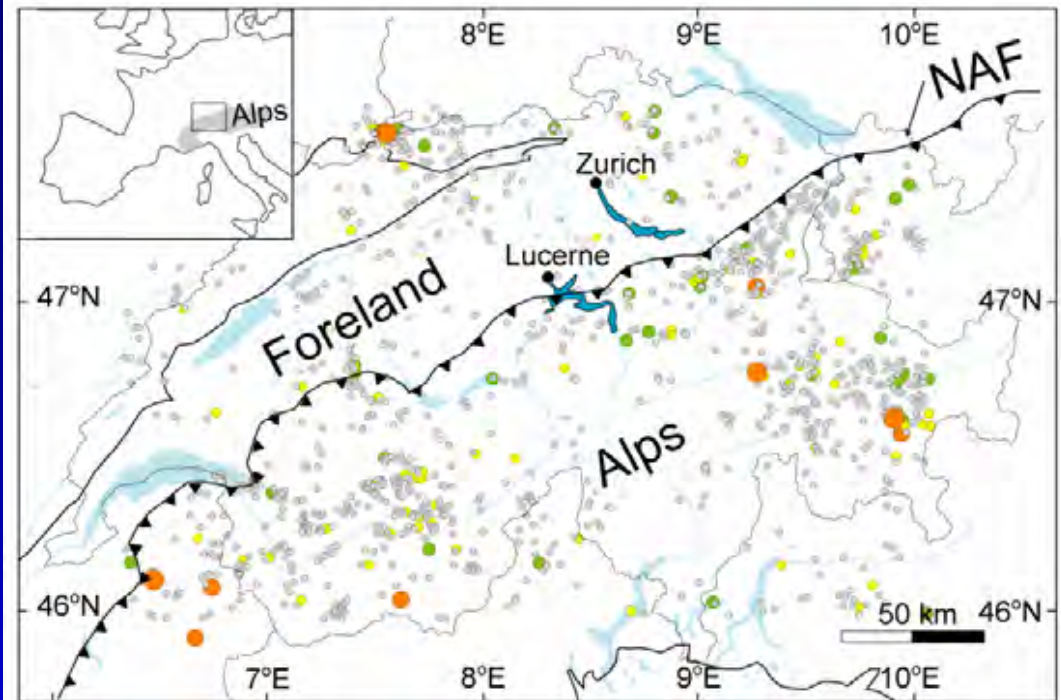


CH-Erdbebenkatalog

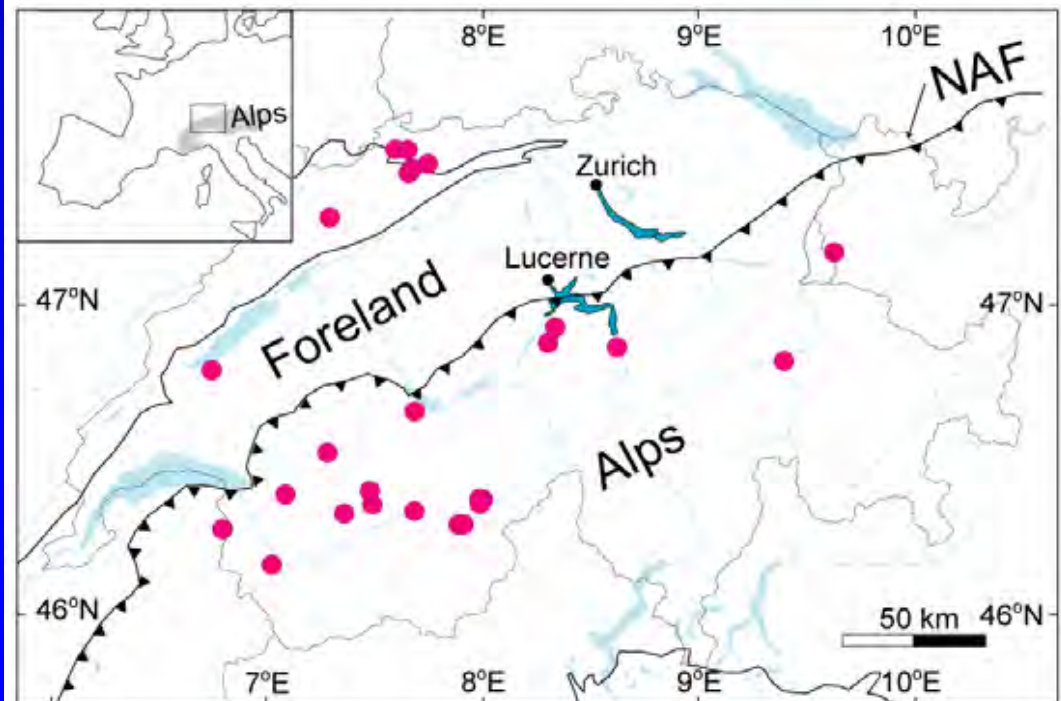
<http://histserver.ethz.ch/>



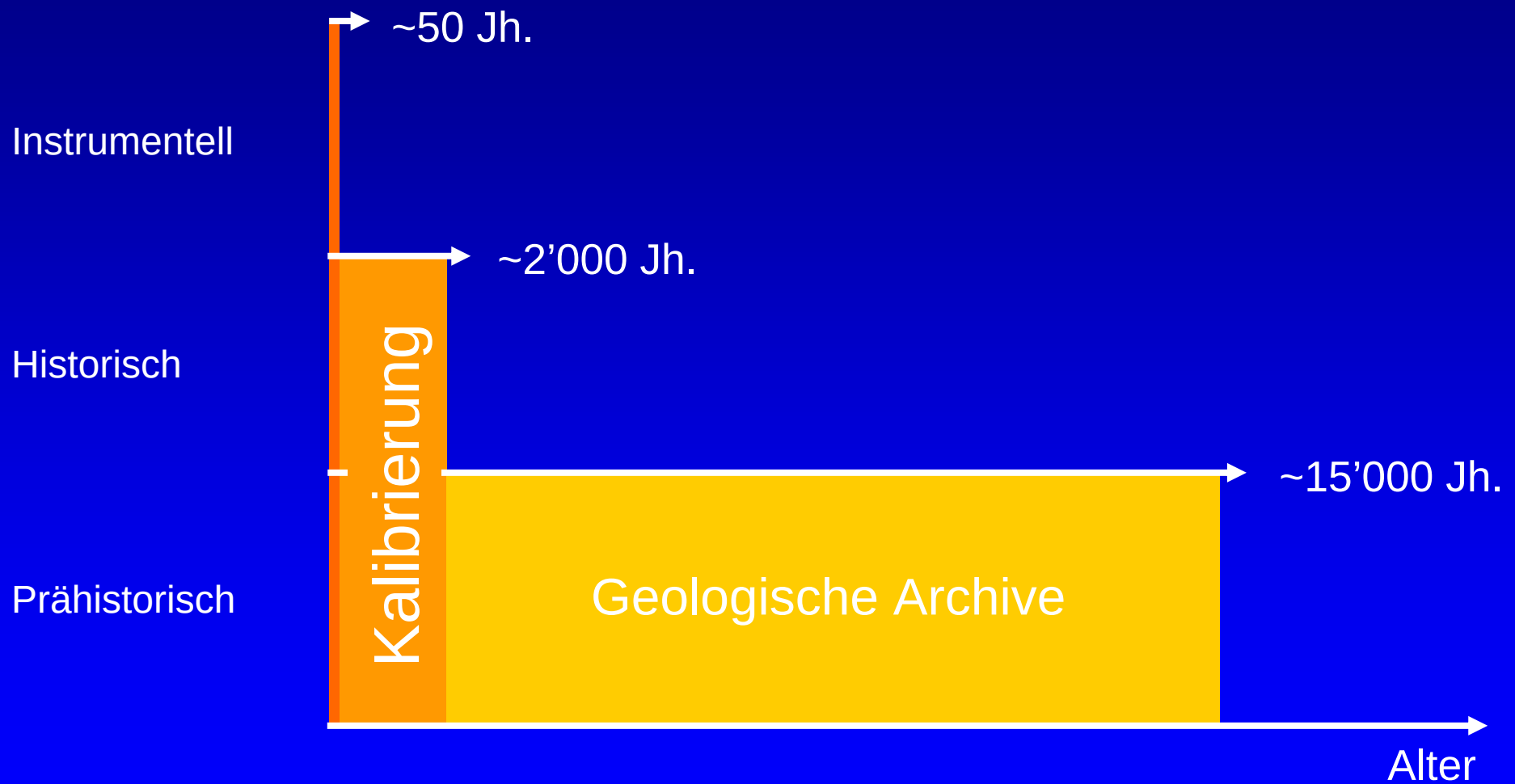
Instrumentale
Periode
(1975 – 2006)
 $M_w < 5.3$



Historische
Periode
(250 – 2006)
 $M_w > 5.4$



Aufzeichnungen von vergangenen Erdbeben



Paläoseismologie nördlich der Alpen

Auf der Jagd nach prähistorischen Erdbeben

Flavio Anselmetti

Eawag

Swiss Federal Institute of Aquatic Science and Technology

Dübendorf, Switzerland

flavio.anselmetti@eawag.ch

eawag
aquatic research ooo

Mit Unterstützung von:

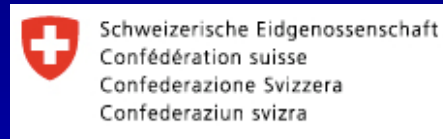


Arnfried Becker
Felix Bussmann
Beni Dürr
Donat Fäh
Matthieu Ferry
Domenico Giardini
Michael Hilbe
Robert Hofmann
Achim Kopf
Katrin Monecke
Michael Schnellmann
Gabriela Schwarz-Zanetti
Sylvie Stegmann
Michael Strasser

...



Swiss National Science Foundation



Swisstopo, Bafu, VBS



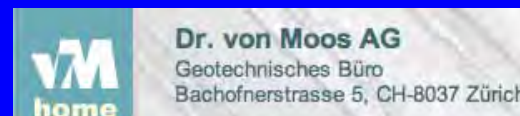
Swiss Federal Nuclear Safety Inspectorate



Swiss Seismologic Survey



Ocean Margin Center



Geotechnical Analysis von Moos

Prähistorische geologische Erdbebenarchive

1) Direkte Spuren: Bruchflächen

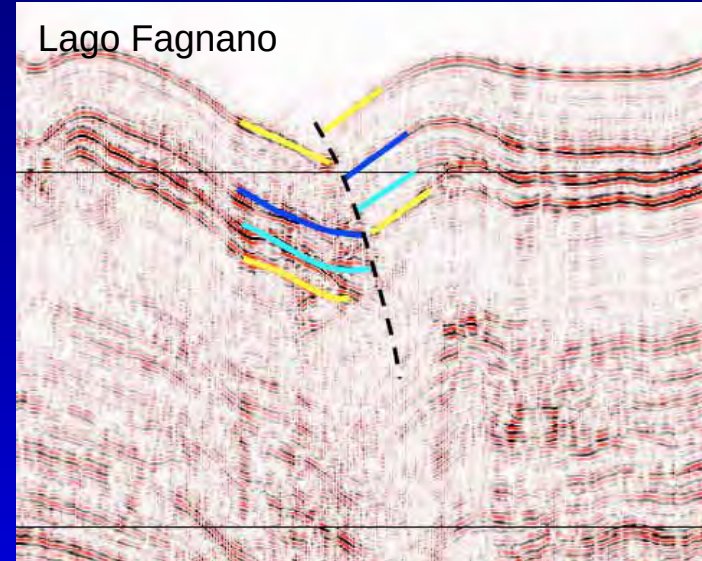
Ferry et al, 2004



Rodriguez-Pascua, 2005



Lago Fagnano



2) Indirekte Spuren: Lokale Effekte der Erdbeben

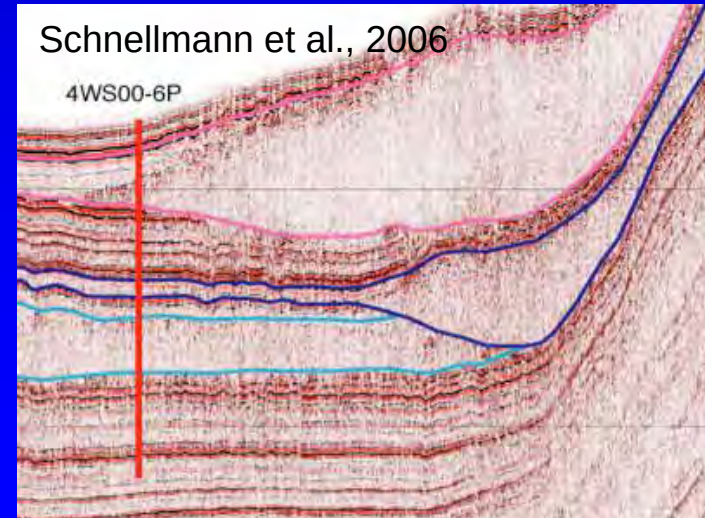
Becker et al, 2005



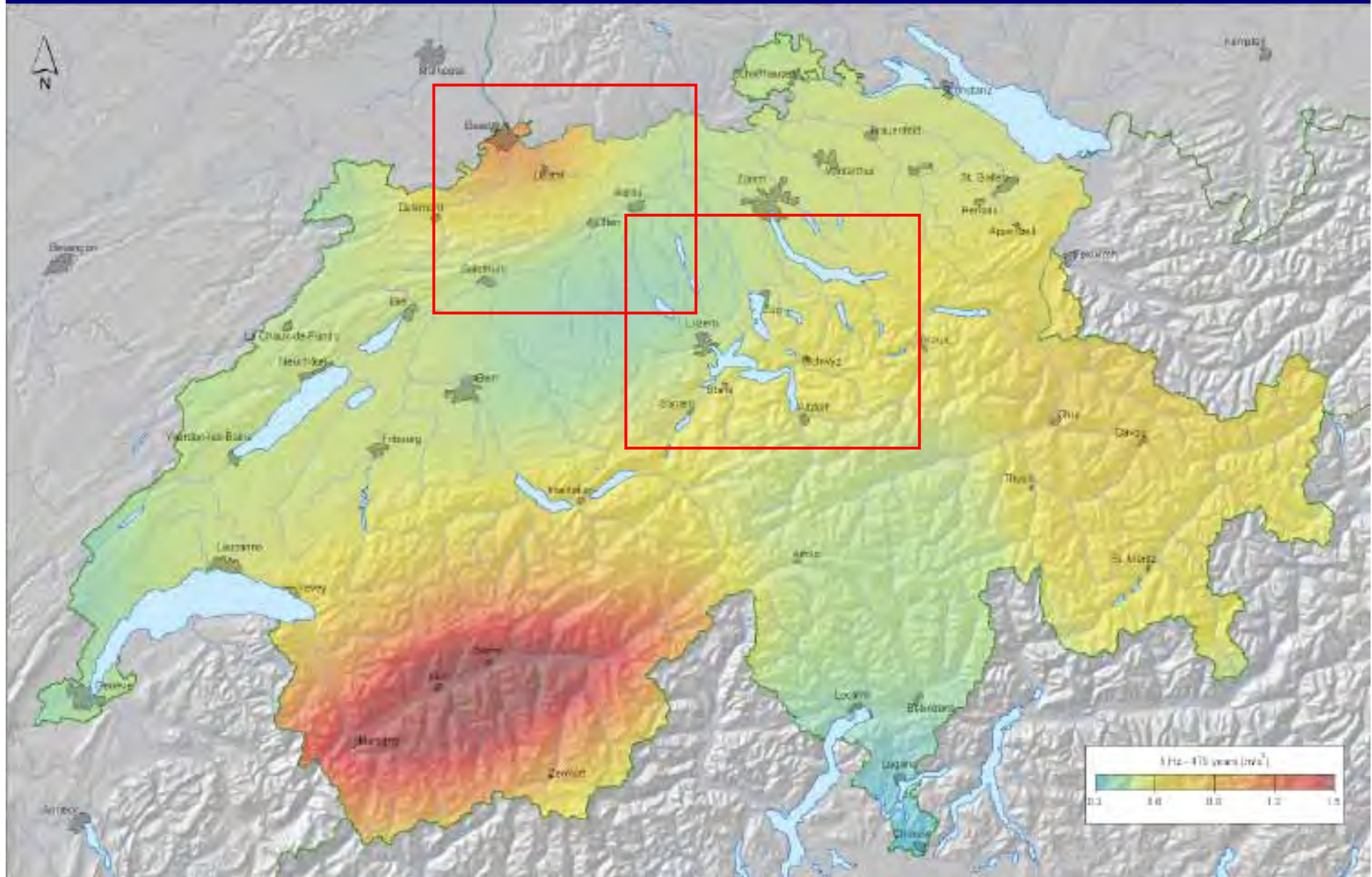
Monecke et al, 2004



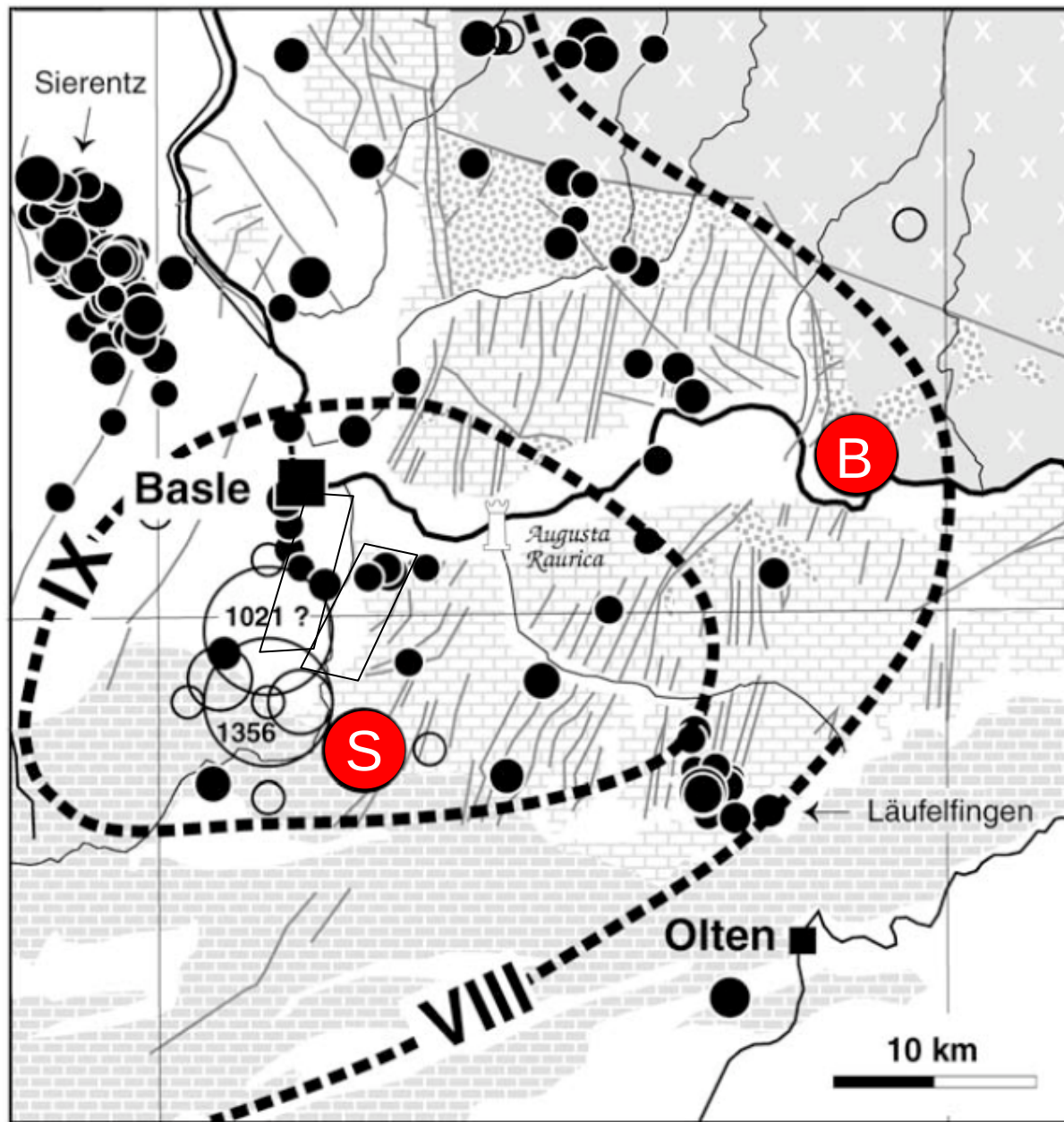
Schnellmann et al., 2006



Swiss Hazard Map: Horizontal ground motion (475 years) at 5 Hz



Swiss Seismologic Survey



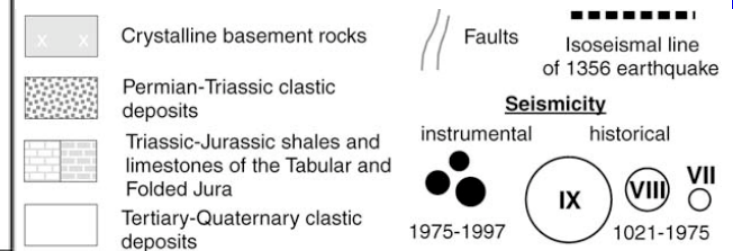
Erdbebenarchive

 Trenches:
Basel-Reinach Fault

 Bergsturzböcke

 Seewer See

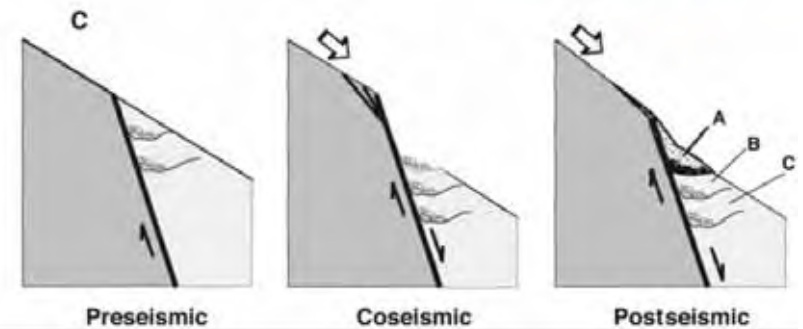
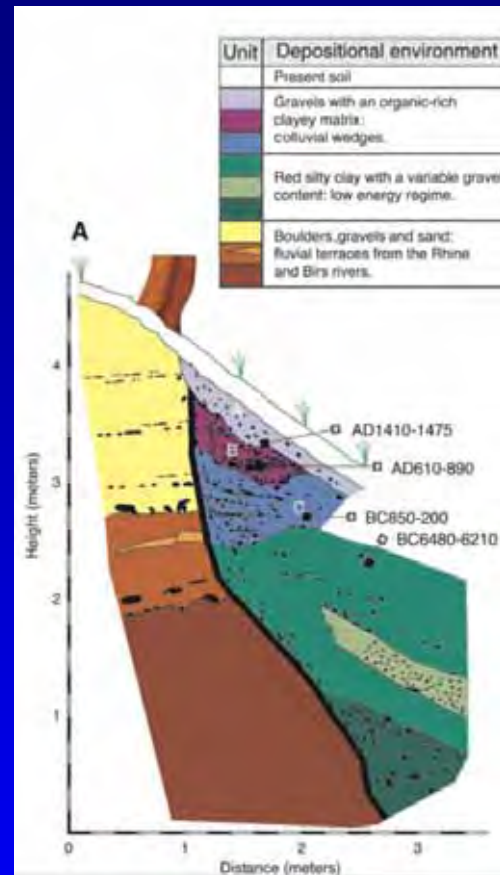
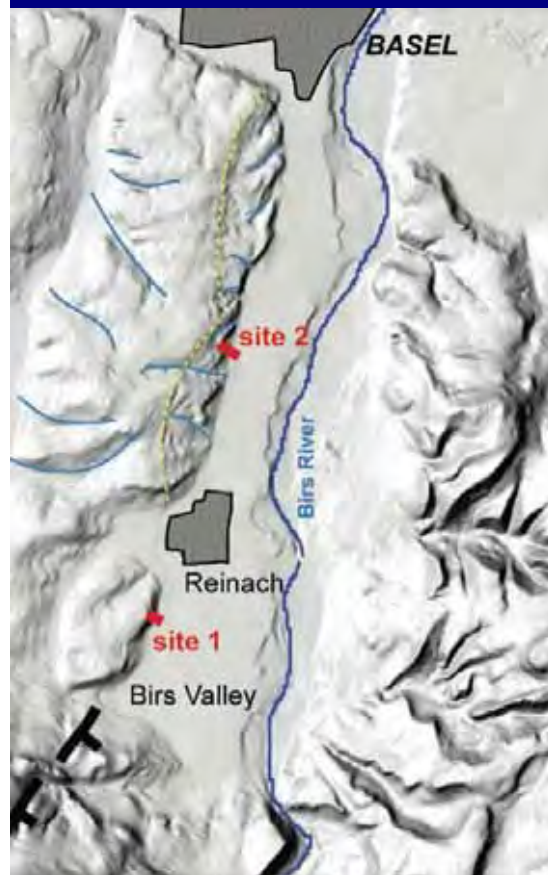
 Bergsee



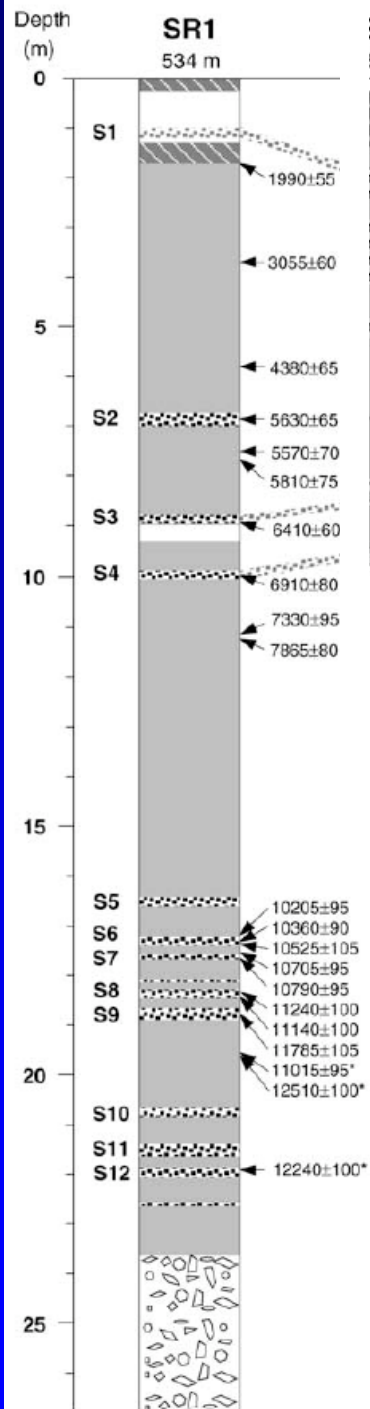
Paläoseismologie Region Basel
(Kalibrierung durch 1356 AD Ereignis)

(Becker et al., 2002)

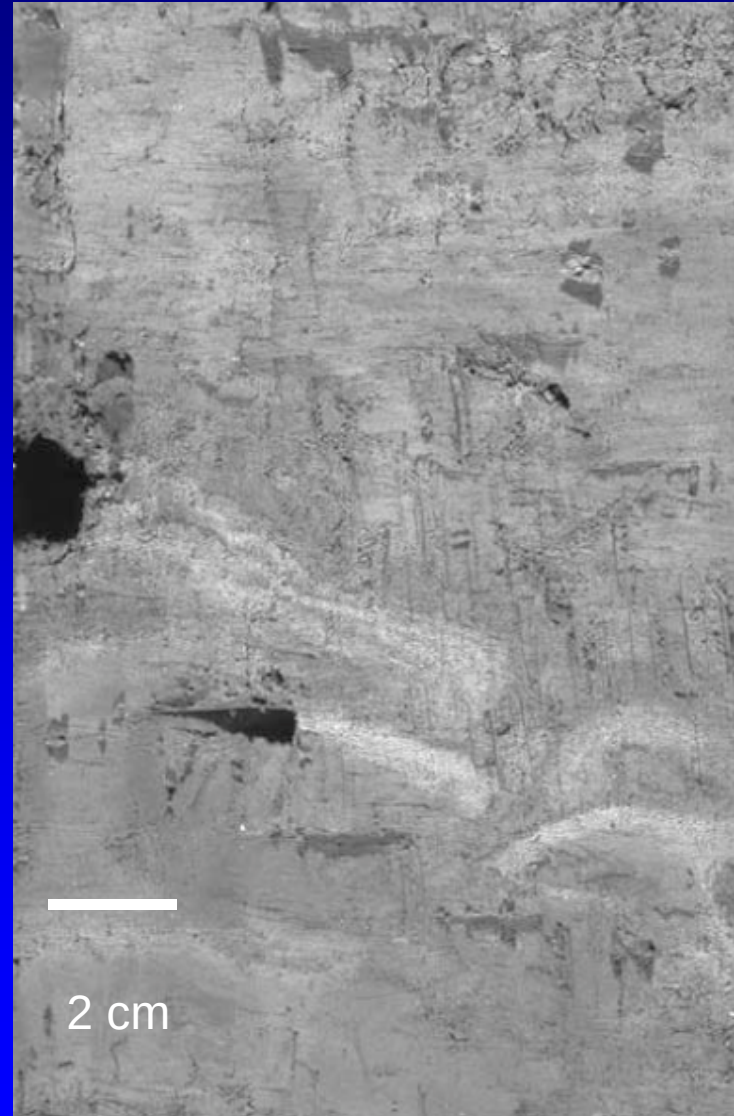
Der Basel-Reinach Bruch



Meghraoui et al., 2001



S5 Ereignis
(Mikrobrüche, Mikrofalten,
Entwässerungen)



Mikrodeformation im ehemaligen Seewener See

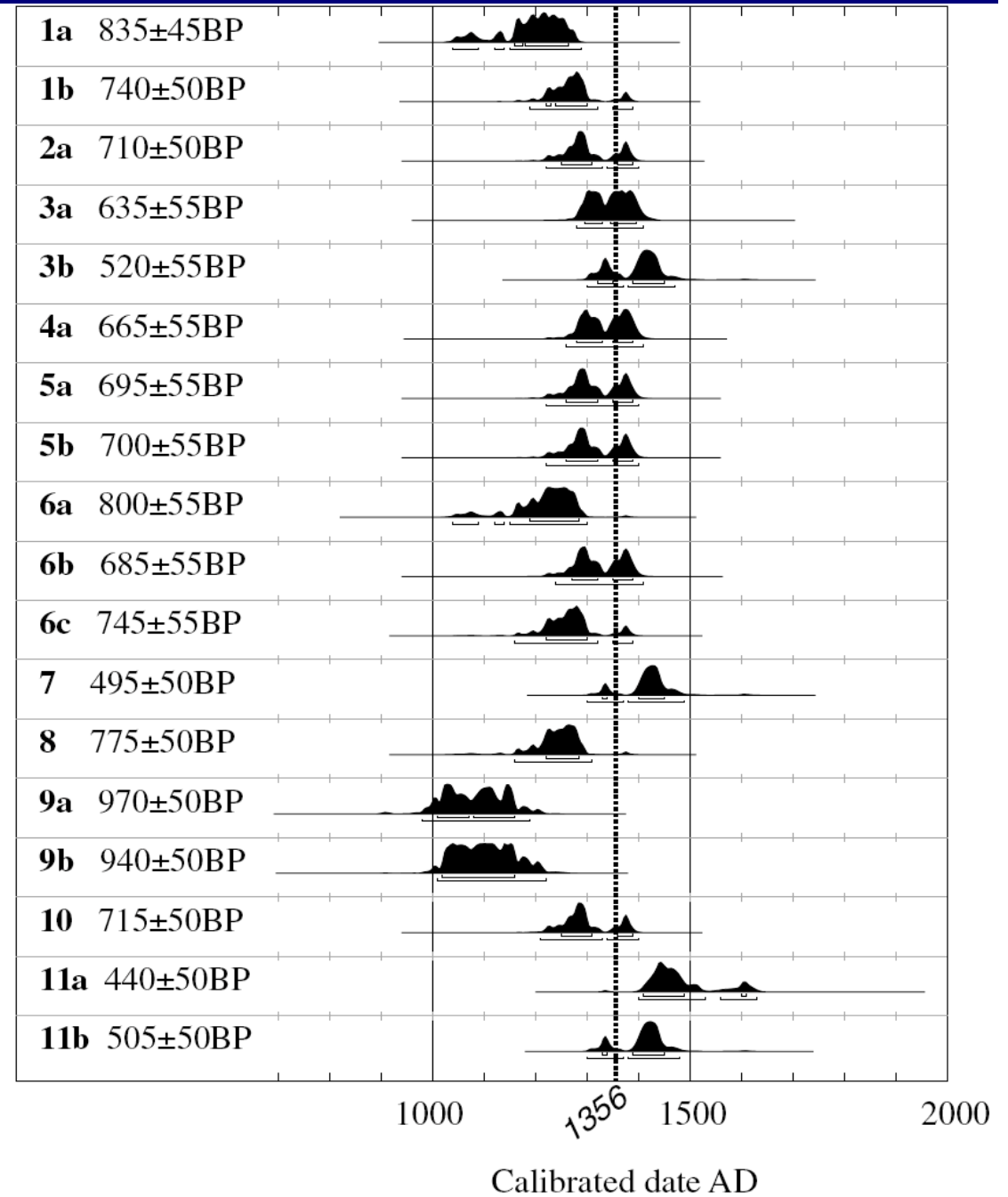
S9 Ereignis:
Sand dyke (Liquefaktion)



(Becker et al., 2002)

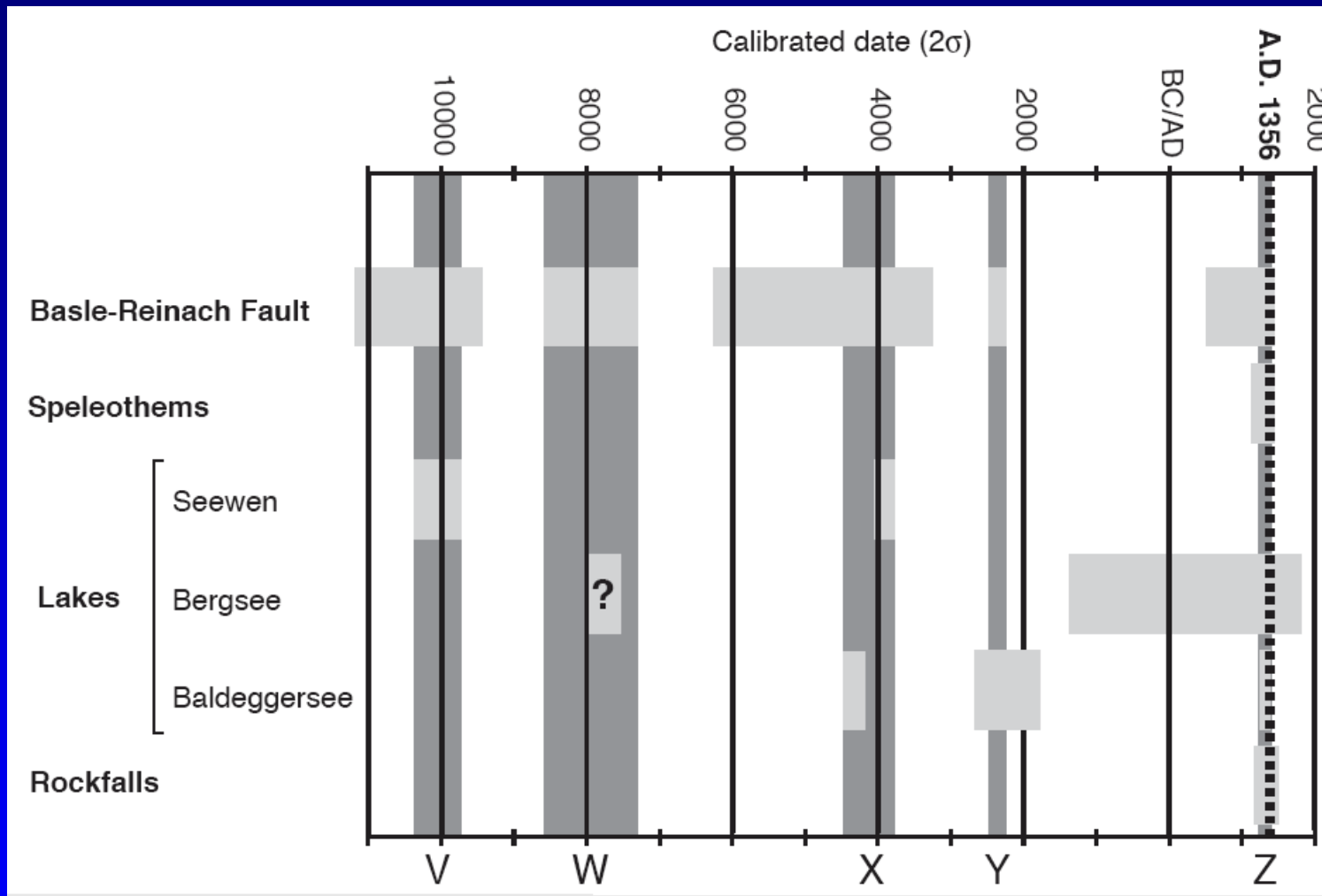


Bergsturzdaterungen in der Region Basel



(Becker and Davenport, 2003)

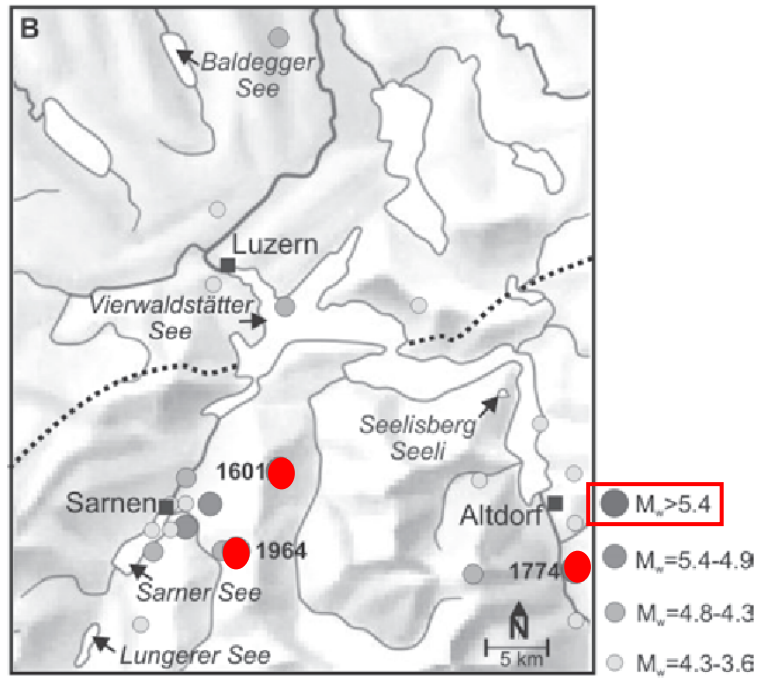
Zusammenfassung Paläoseismologie Region Basel



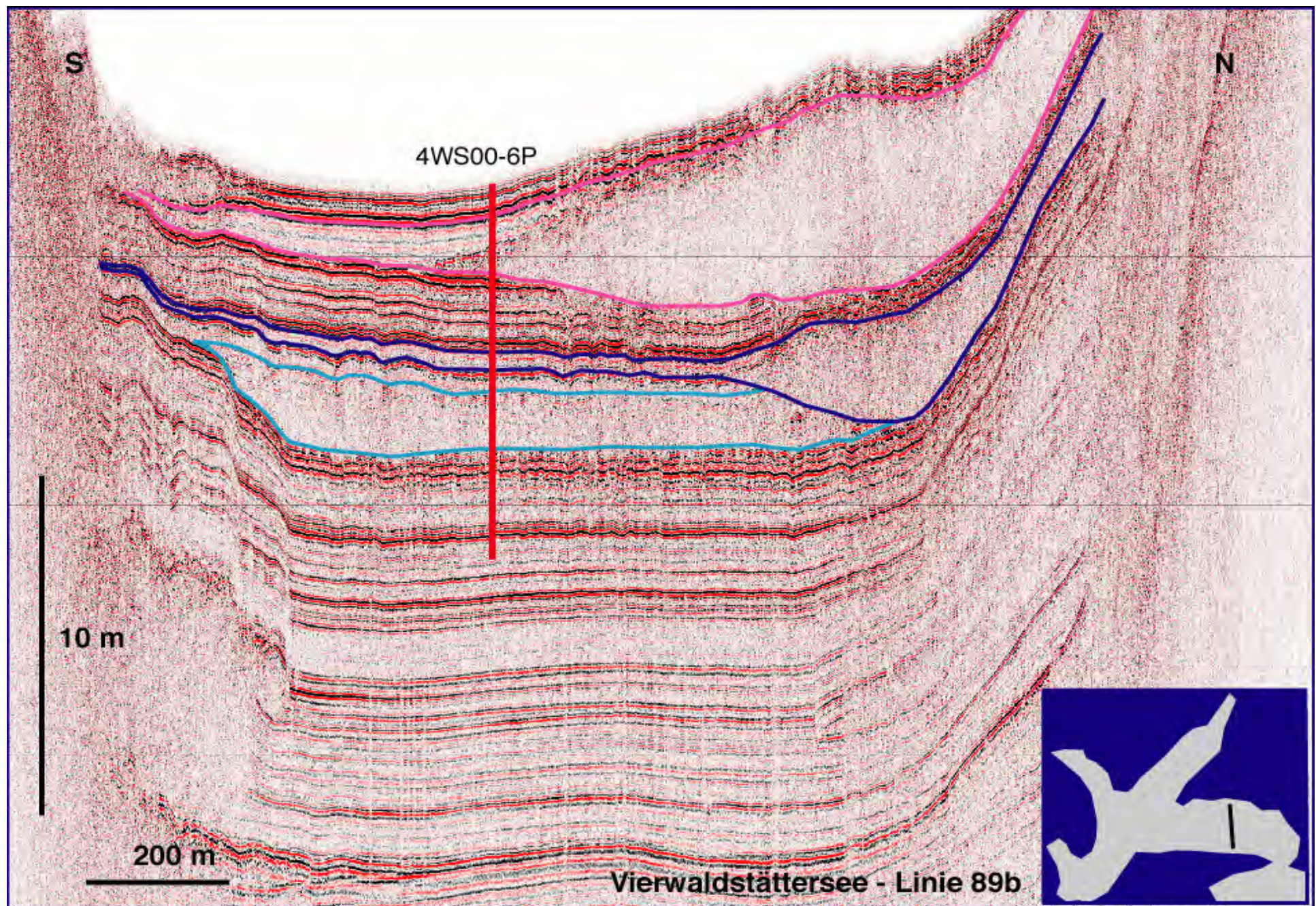
(Becker et al., 2005)

Historische Erdbeben in der Zentralschweiz

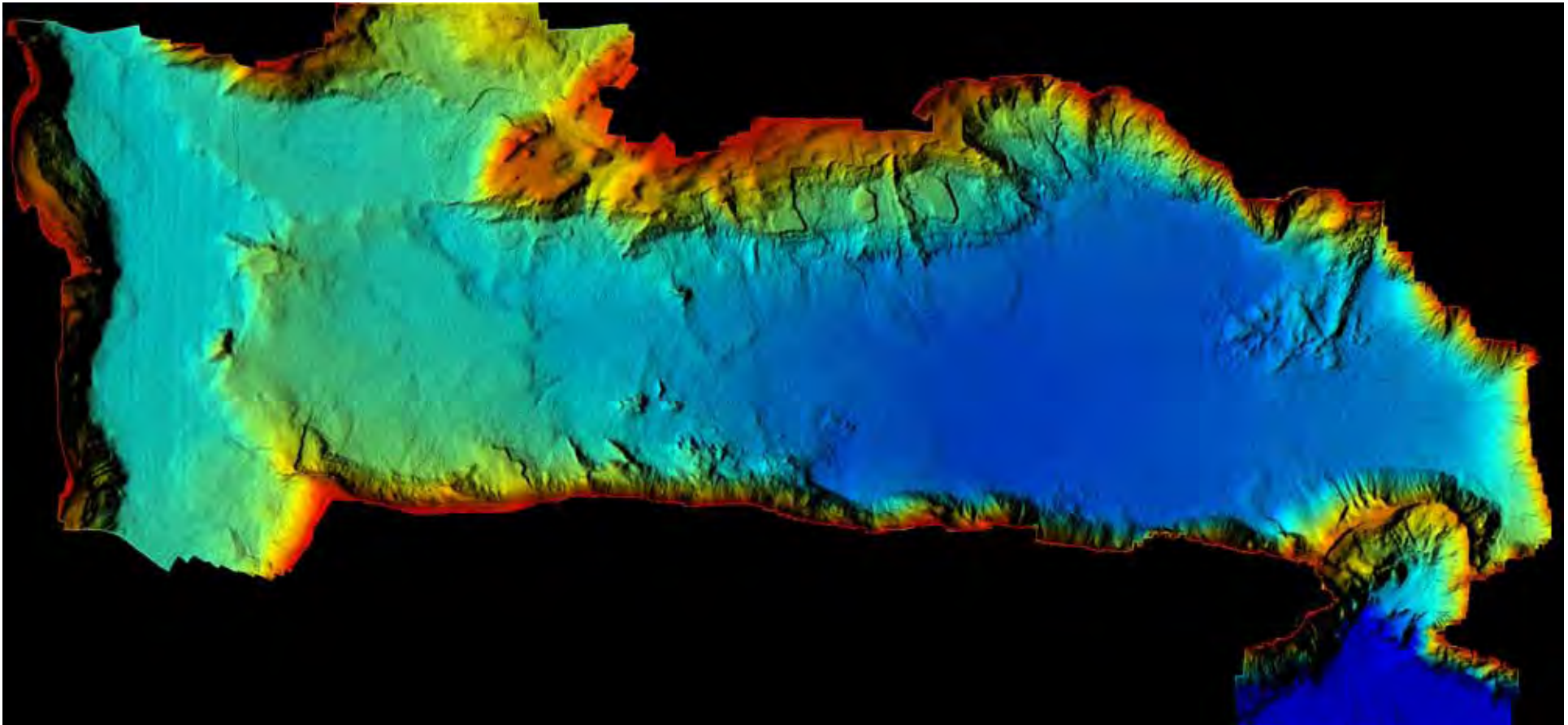
- 1) 7 März 1964: Alpnach ($M_w = 5.7$)
- 2) 8 September 1774, Altdorf ($M_w = 5.9$)
- 3) 18 September 1601, Unterwalden ($M_w = 6.2$)



Hinterliessen diese Erdbeben Spuren in den Seesedimenten?

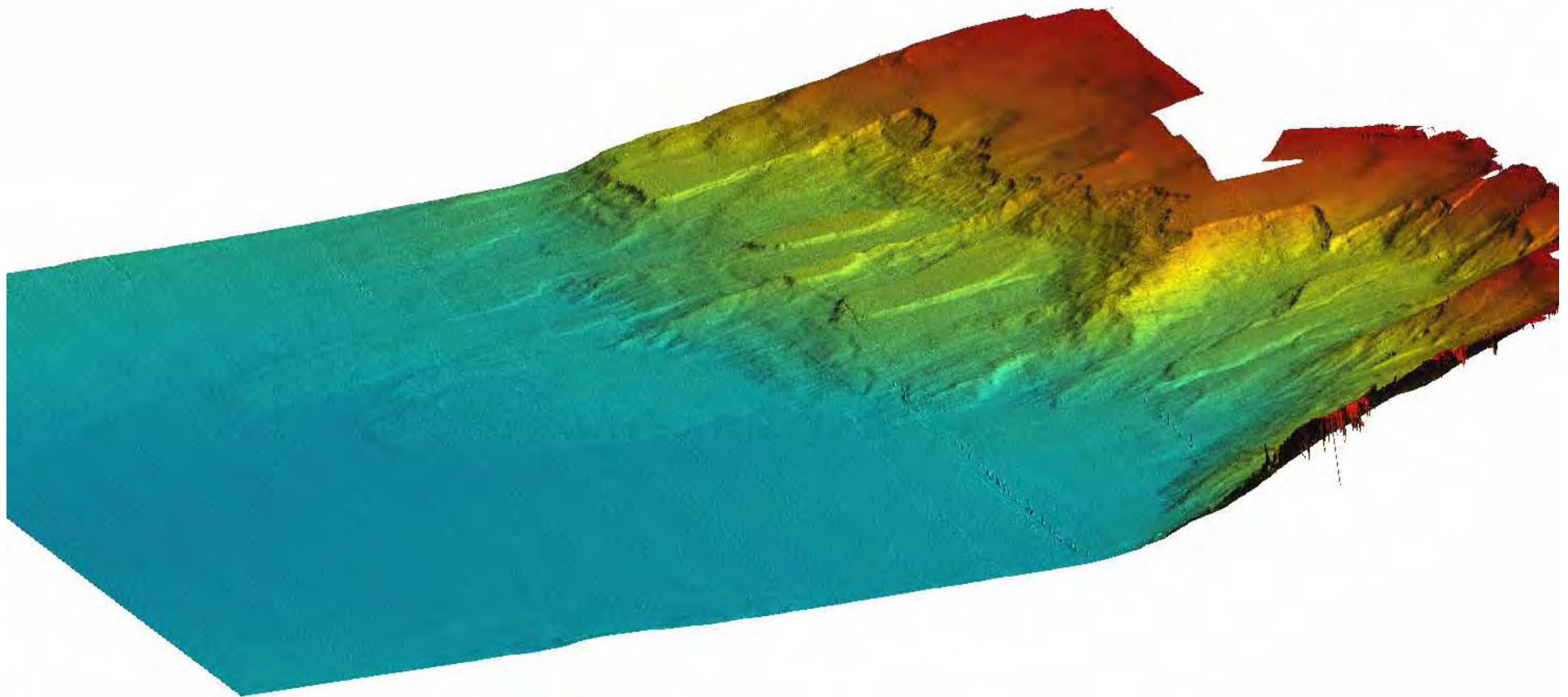


Subaquatische Rutschungen

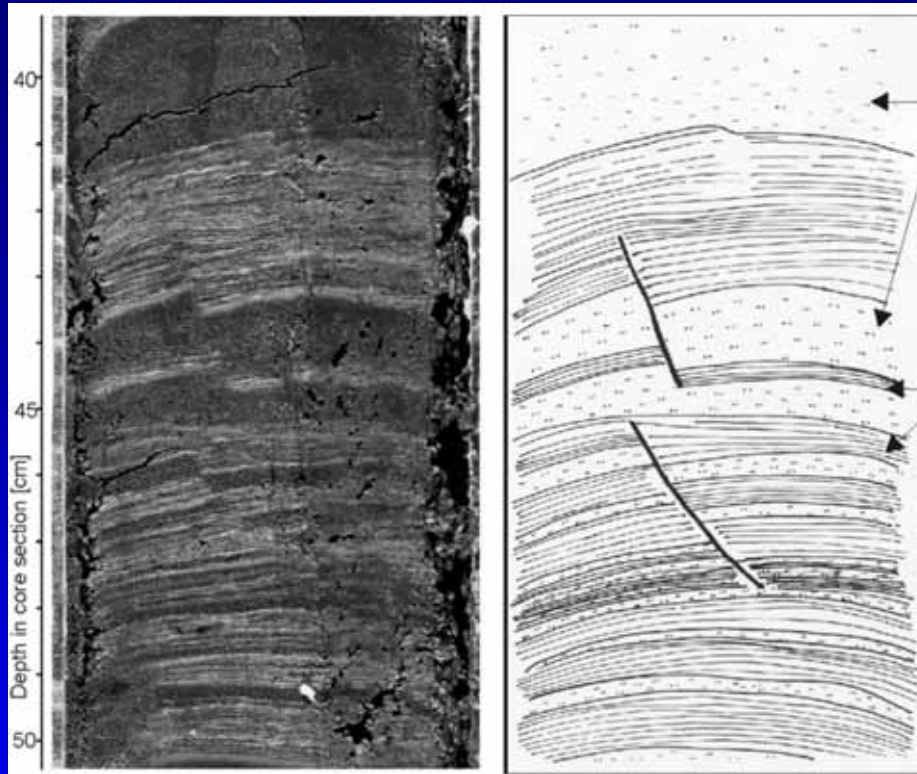


Chrüztrichter und Vitznaubecken: hochauflösende 3D-Bathymetrie

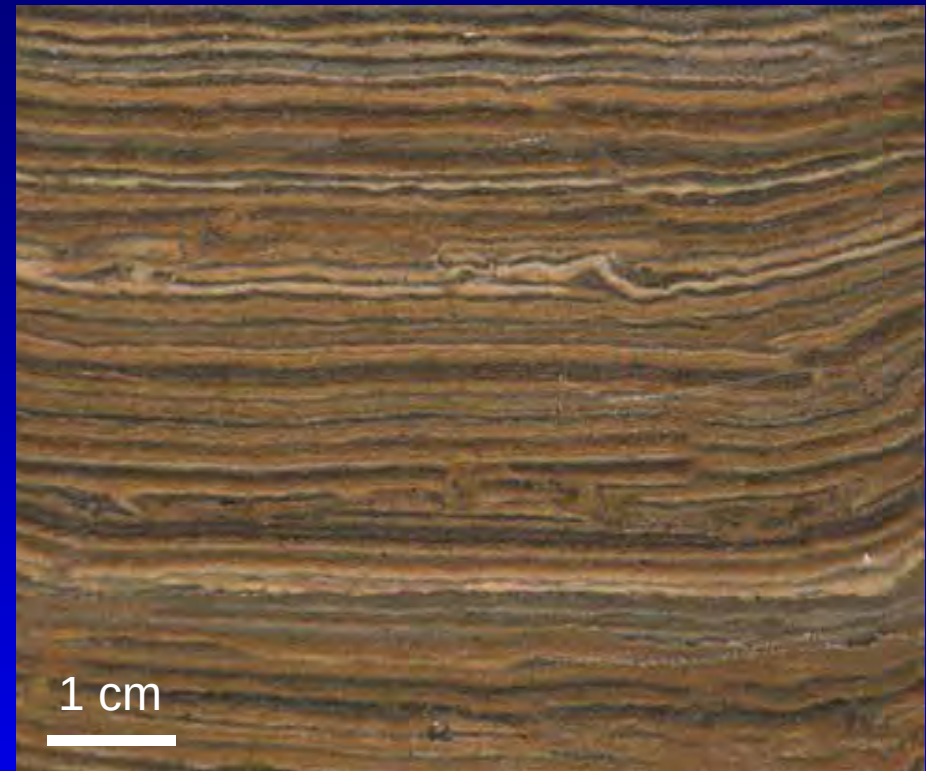
Weggis Rutschung (nicht überhöht)



Mikrodeformationen in laminierten Seesedimenten:



Mikrobrüche (Seelisbergsee)



Deformierte Varven (Baldeggersee)

(Monecke, 2004)

Kalibrierung: Grenzwert (Intensität) für Deformationen in Seesedimenten

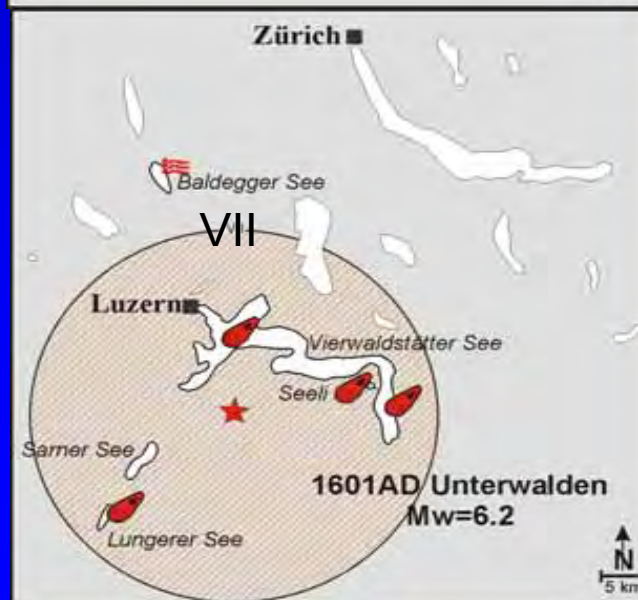
1964
Alpnach
 $M_w=5.7$



1774
Altdorf
 $M_w=5.9$



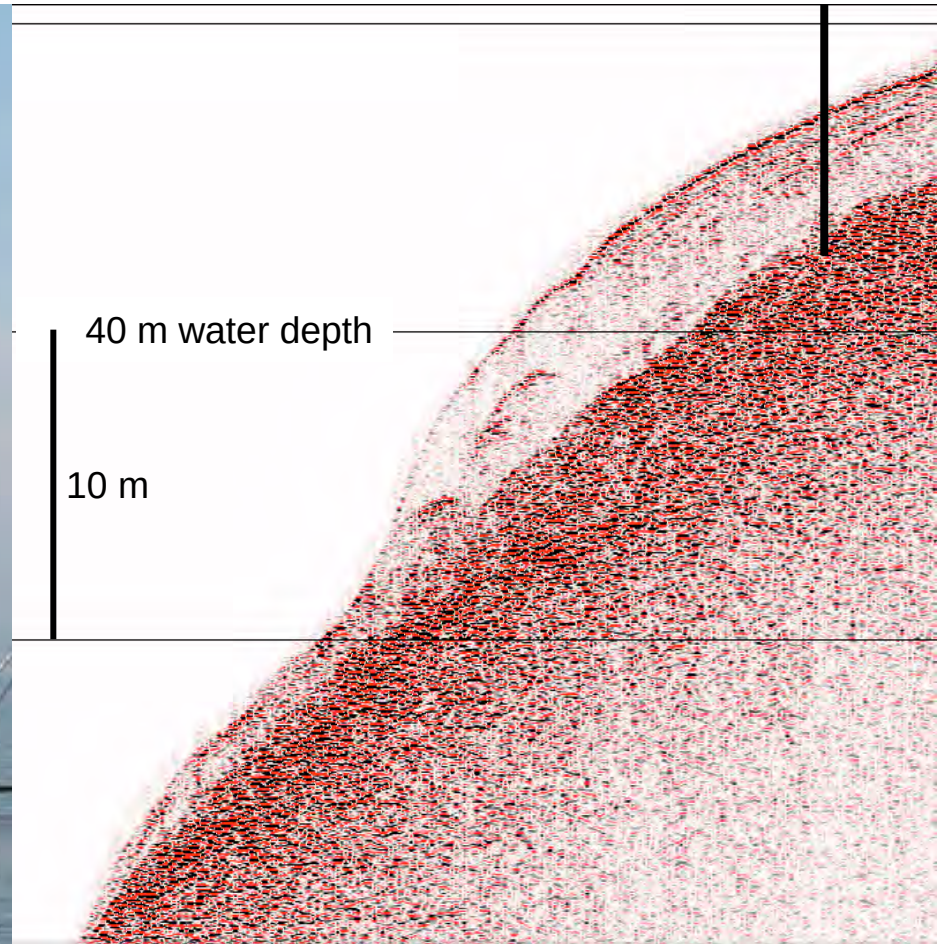
1601
Unterwalden
 $M_w=6.2$



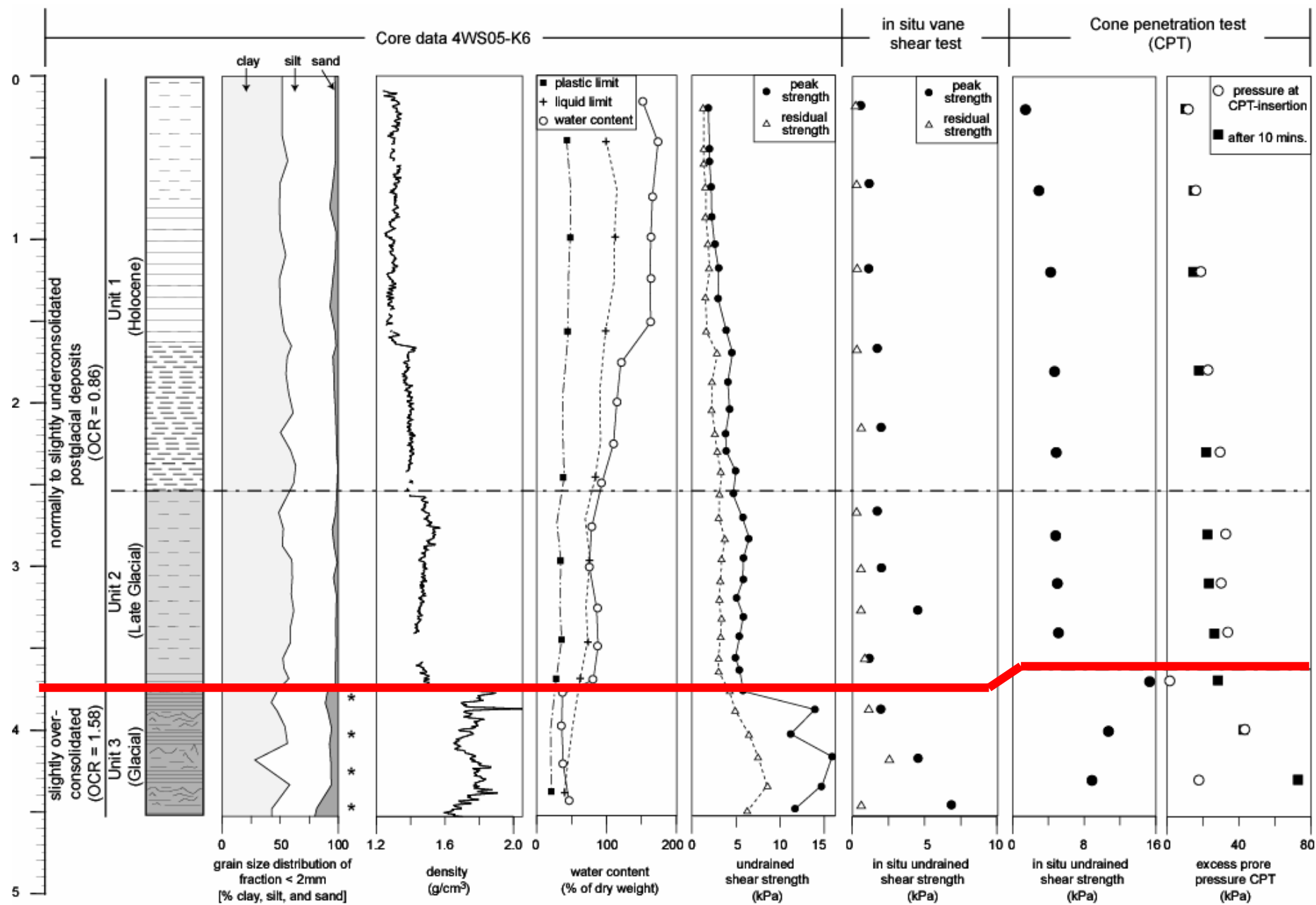
1356
Basel
 $M_w=6.9$



Monecke et al.,
2004

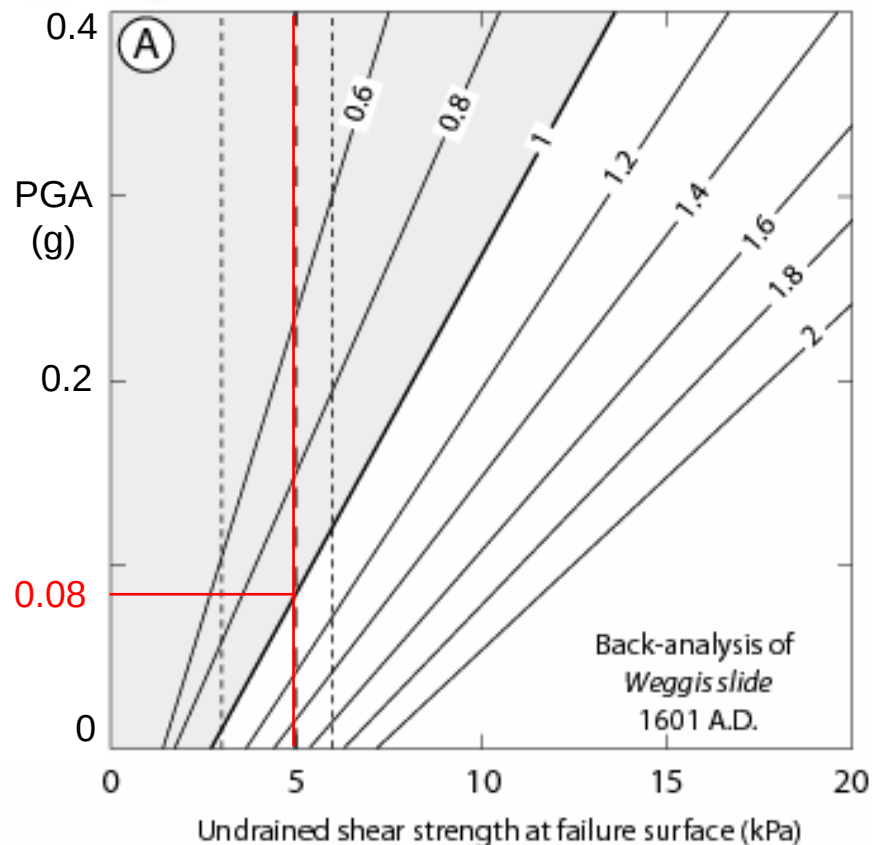
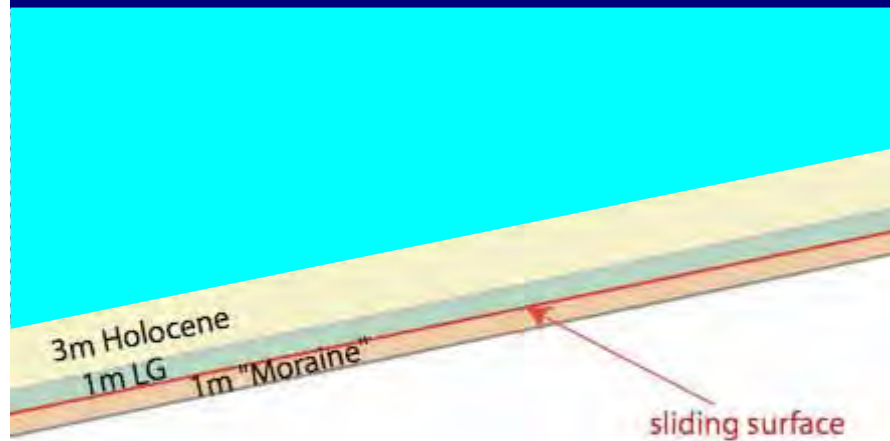


In situ geotechnische Messungen in einem ‚geladenen‘ Hang



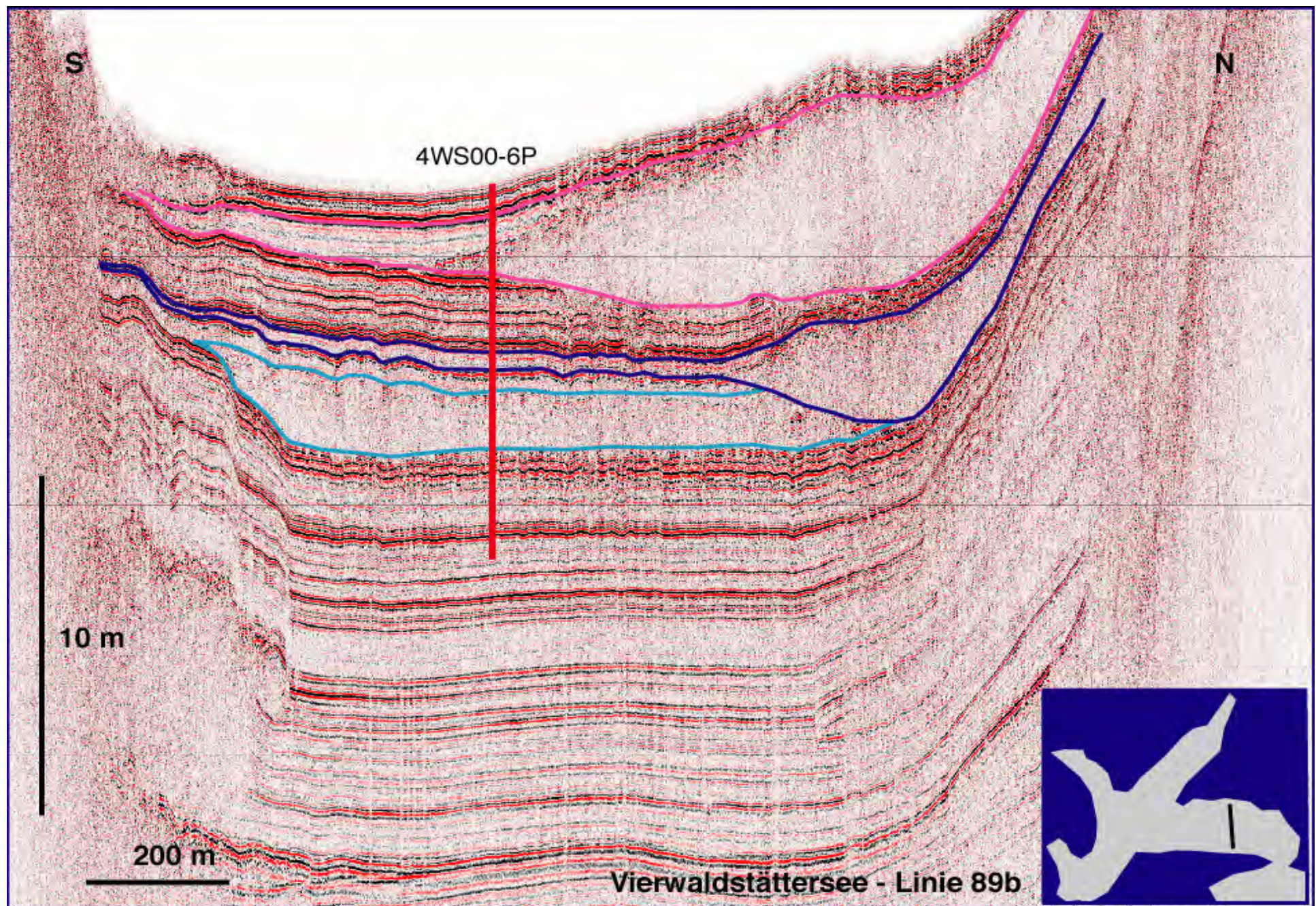
(Strasser et al., 2007)

Limit equilibrium slope stability back analyses

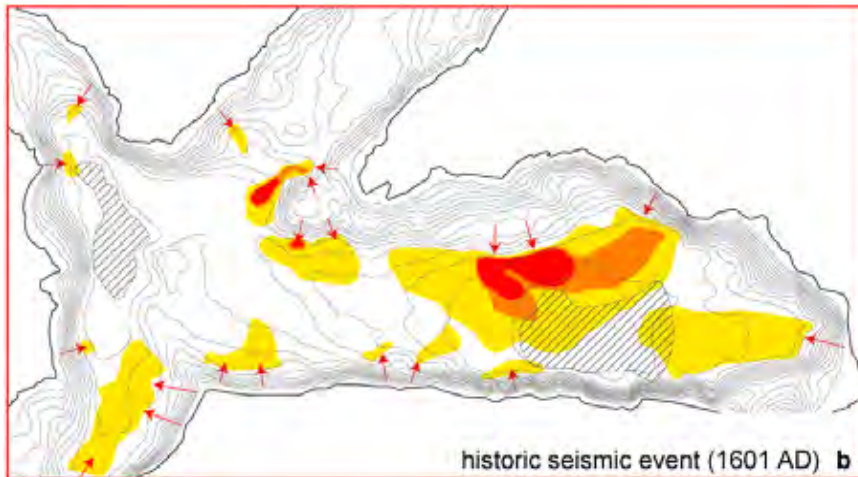


- Abhänge sind unter statischen Bedingungen stabil (FS ~1.5)
- > ~0.08 g Beschleunigung nötig um die Abhänge auszulösen
- Vergleichbar zu Intensitäten VII (via Korrelationsfunktion von Murry and O'Brien, 1977)

(Strasser et al., 2007)

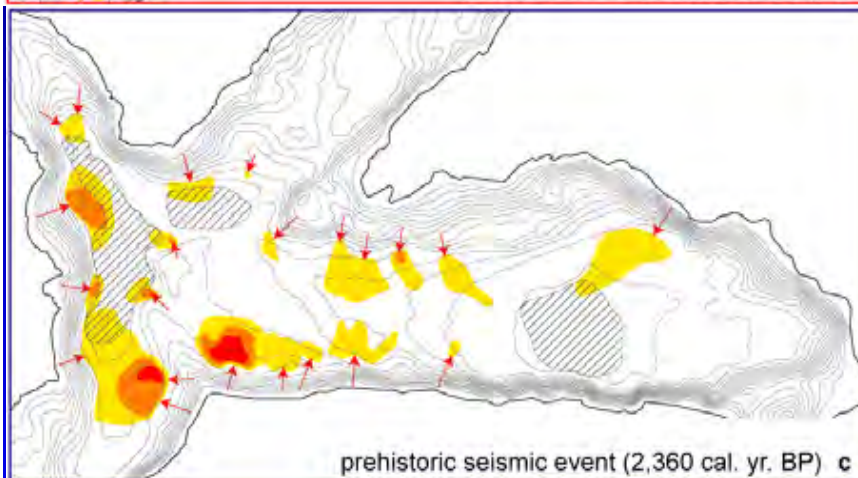


Sind alle Rutschungen durch Beben ausgelöst?

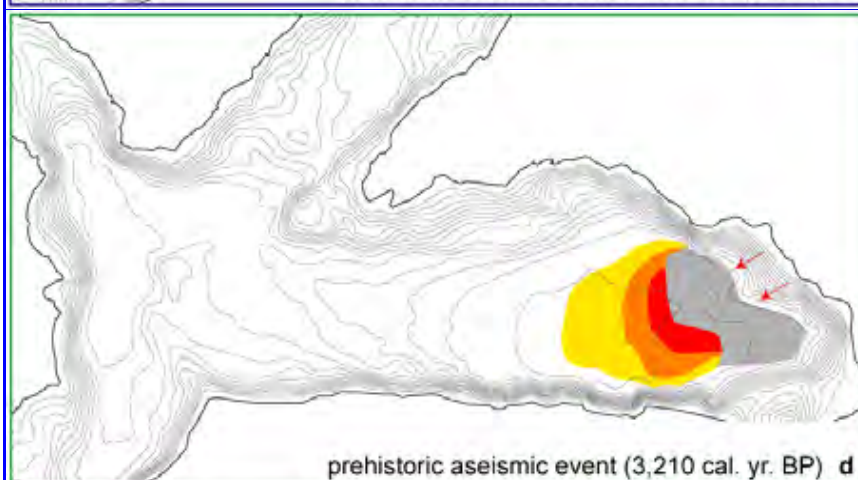


Rutschungen
des 1601 AD
Bebens

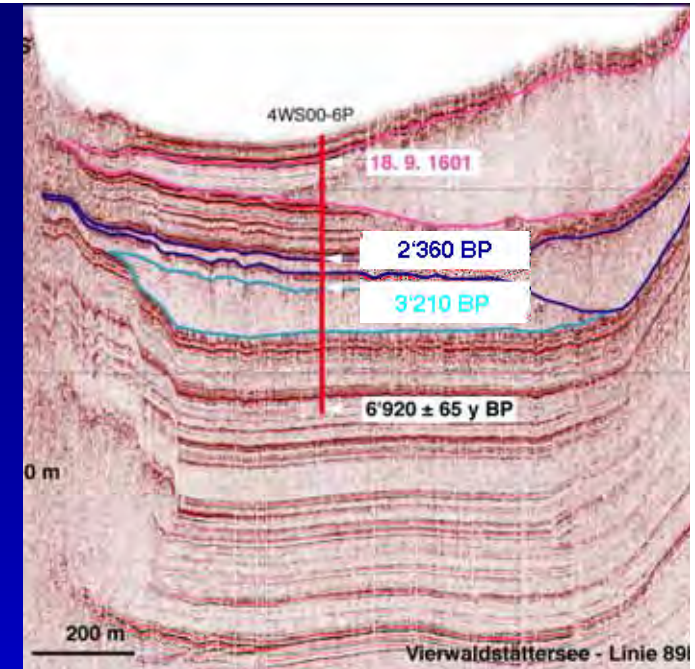
„historische
Kalibrierung“



Rutschungen
von ~2300
yrs. BP.



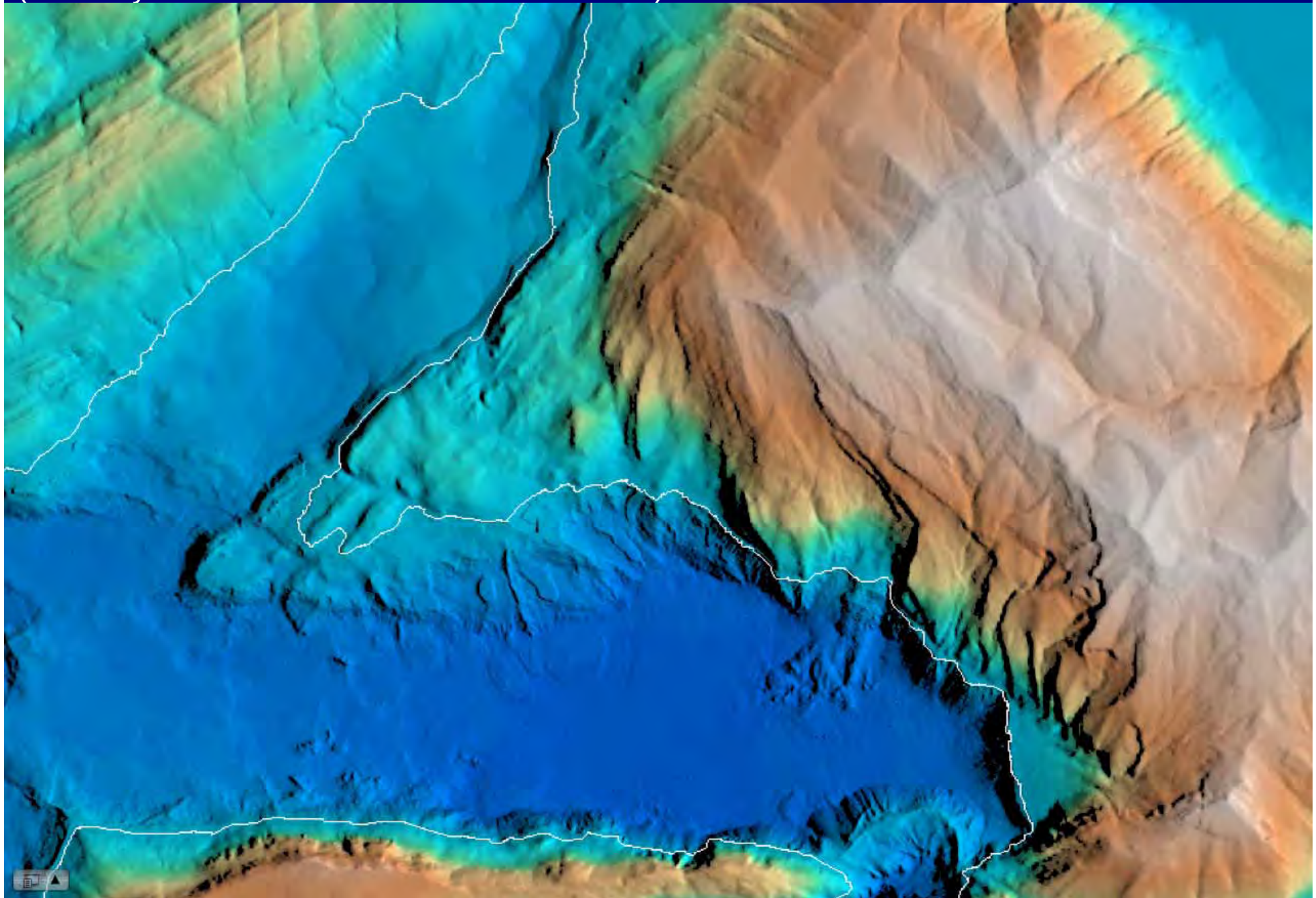
Rutschung von
~3200 yrs. BP.



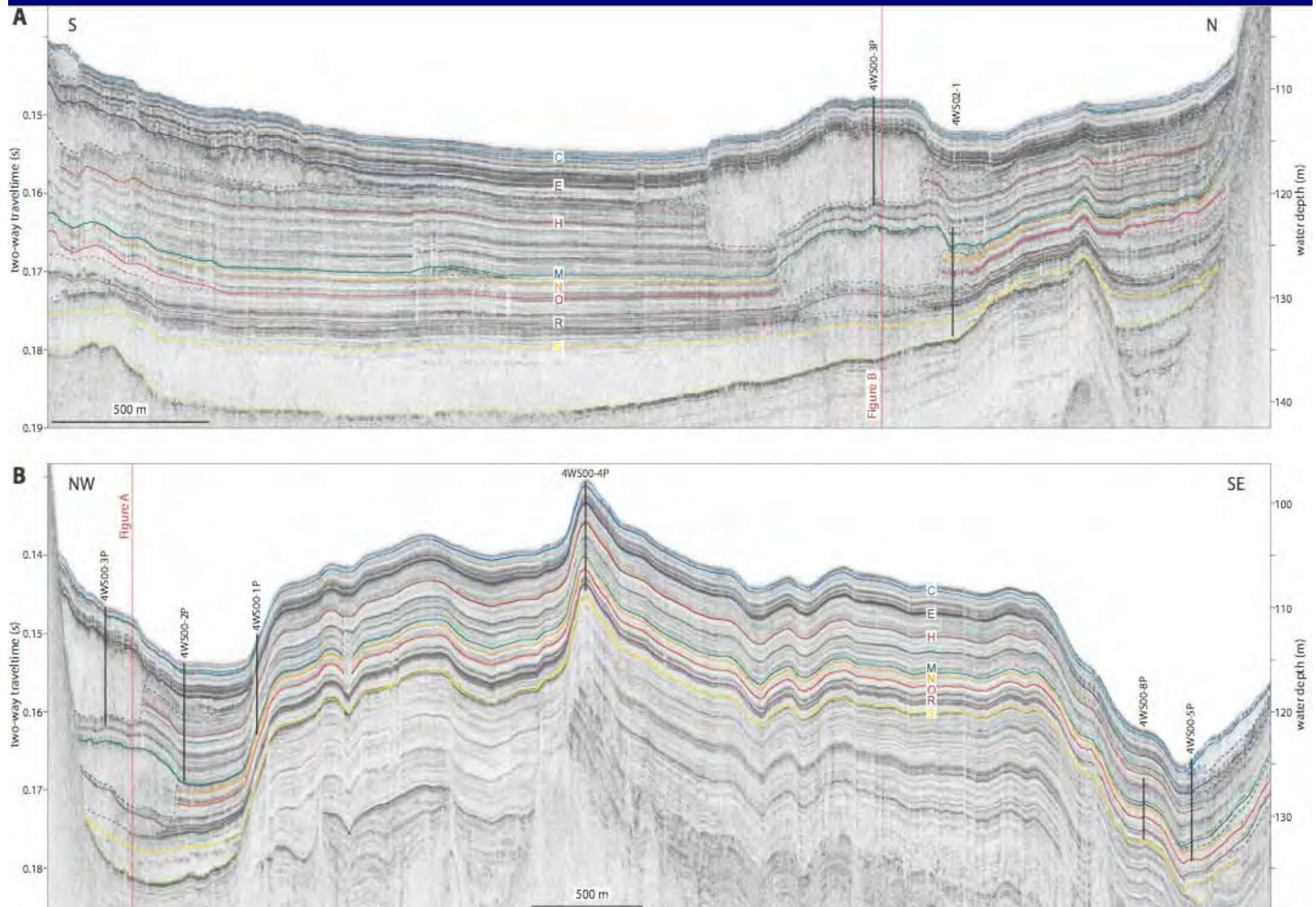
Seismisch-
stratigraphisches
Kriterium:
multiple Rutschungen

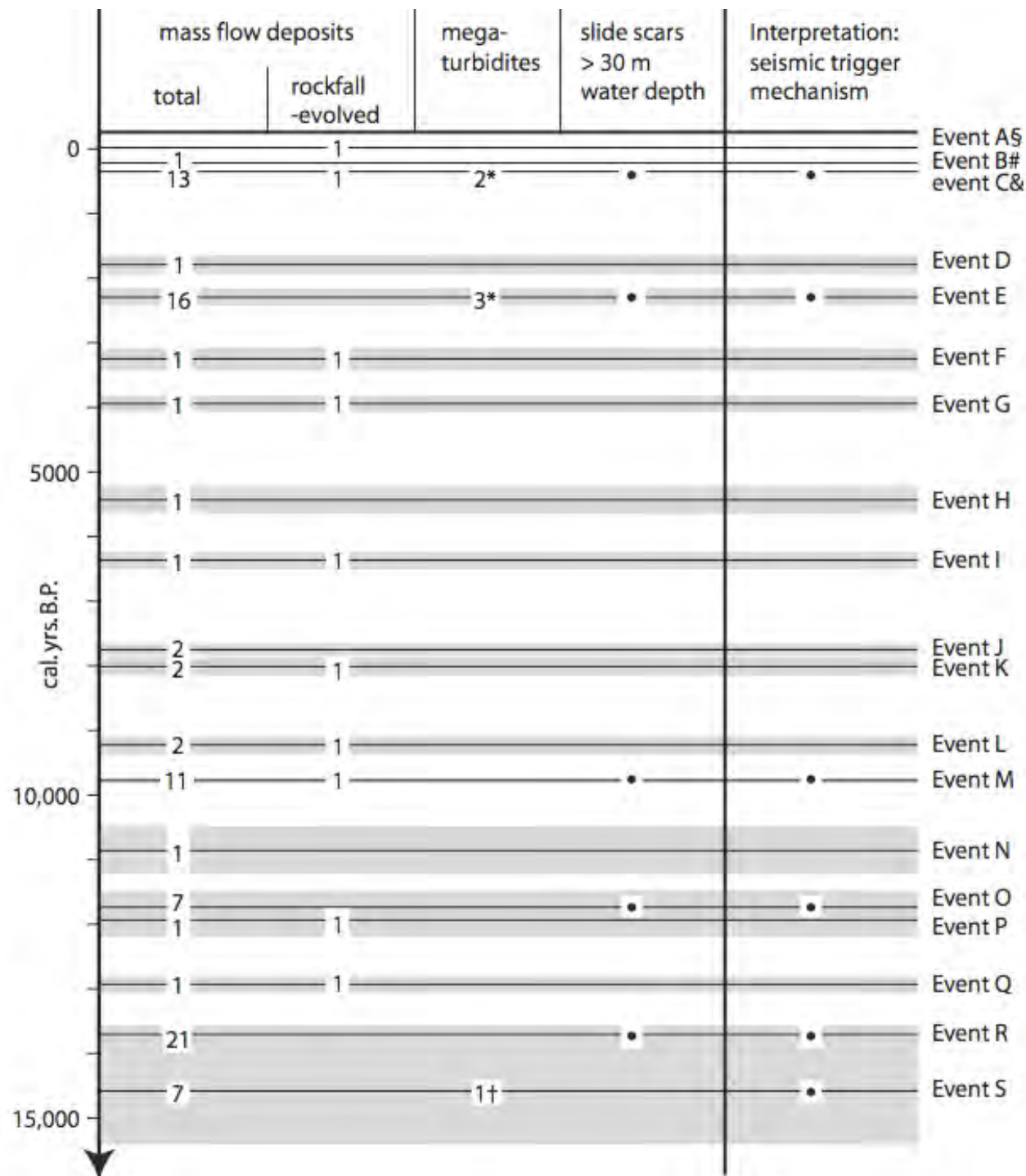
(Schnellmann et al., 2002)

Kombination mit existierenden Höhenmodellen (3D Bathymetriedaten und DHM25 über dem See)



Seismische Stratigraphie der Beckenfüllung





Ereigniskatalog der Massenbewegungen der letzten 15'000 Jh:

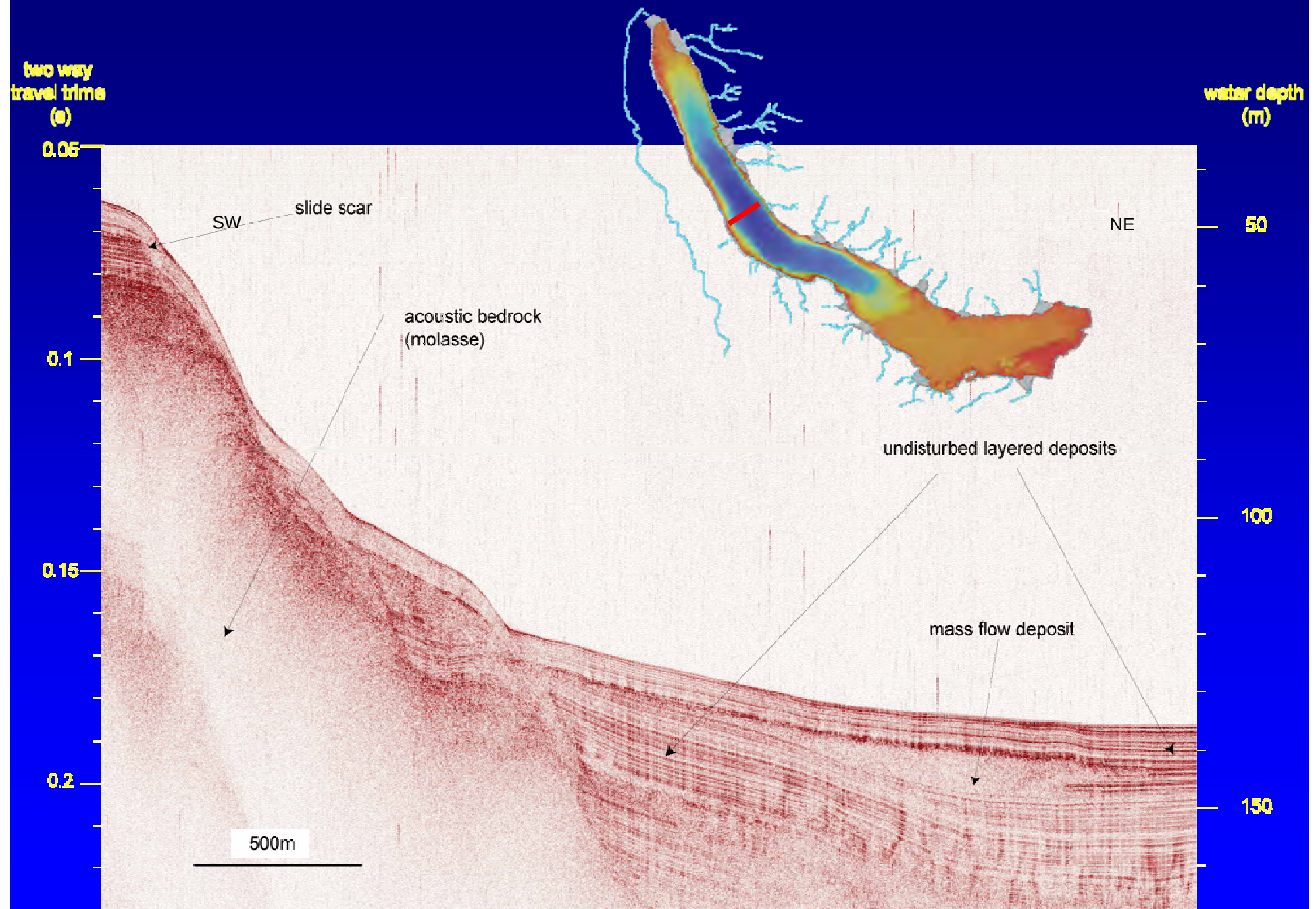
6 Ereignisse in Stärke ,vergleichbar' mit dem 1601 Event (Mw=6.2)

Schnellmann et al., 2006

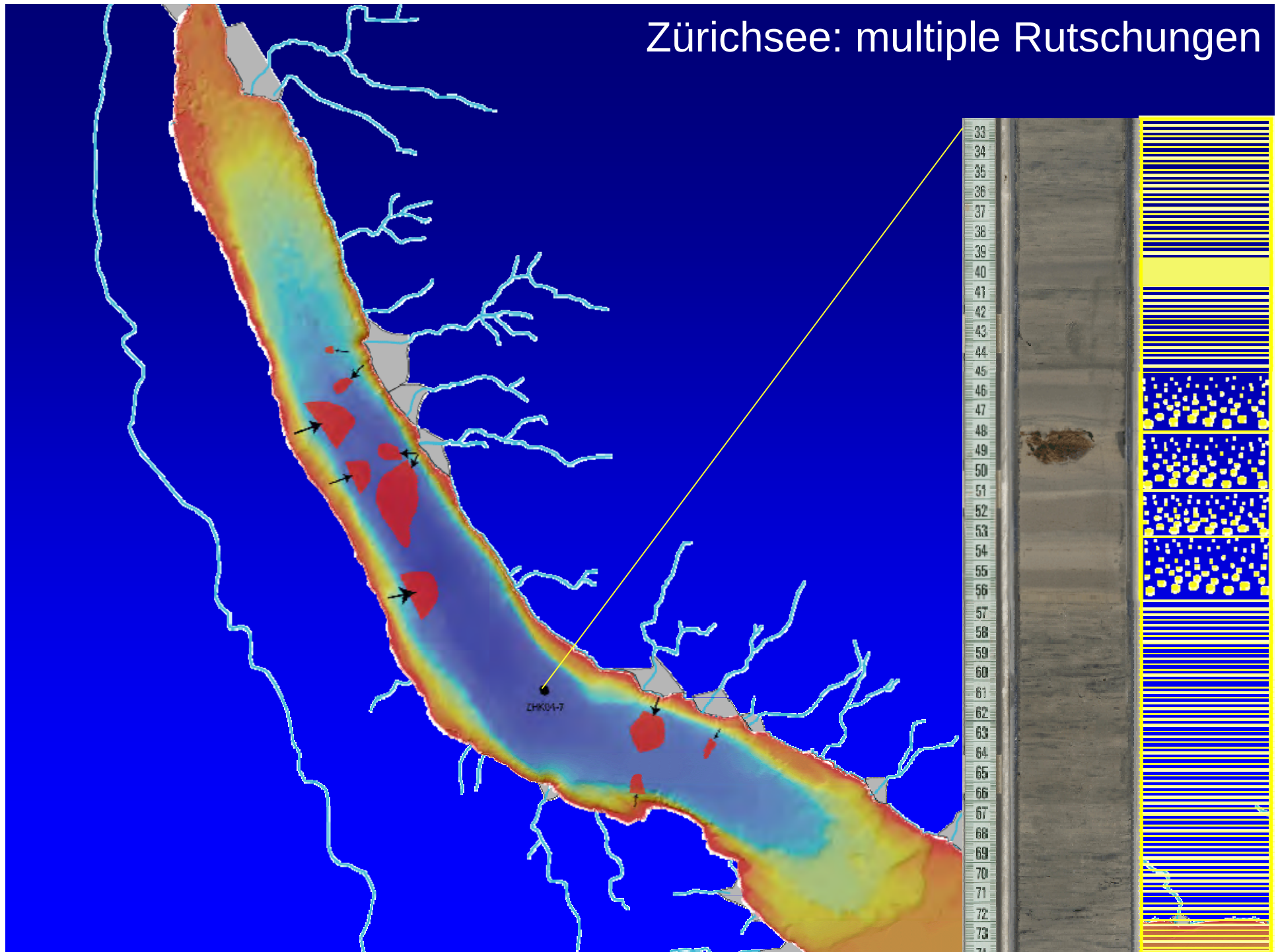
Höhere Seismizität im Spätglazial!

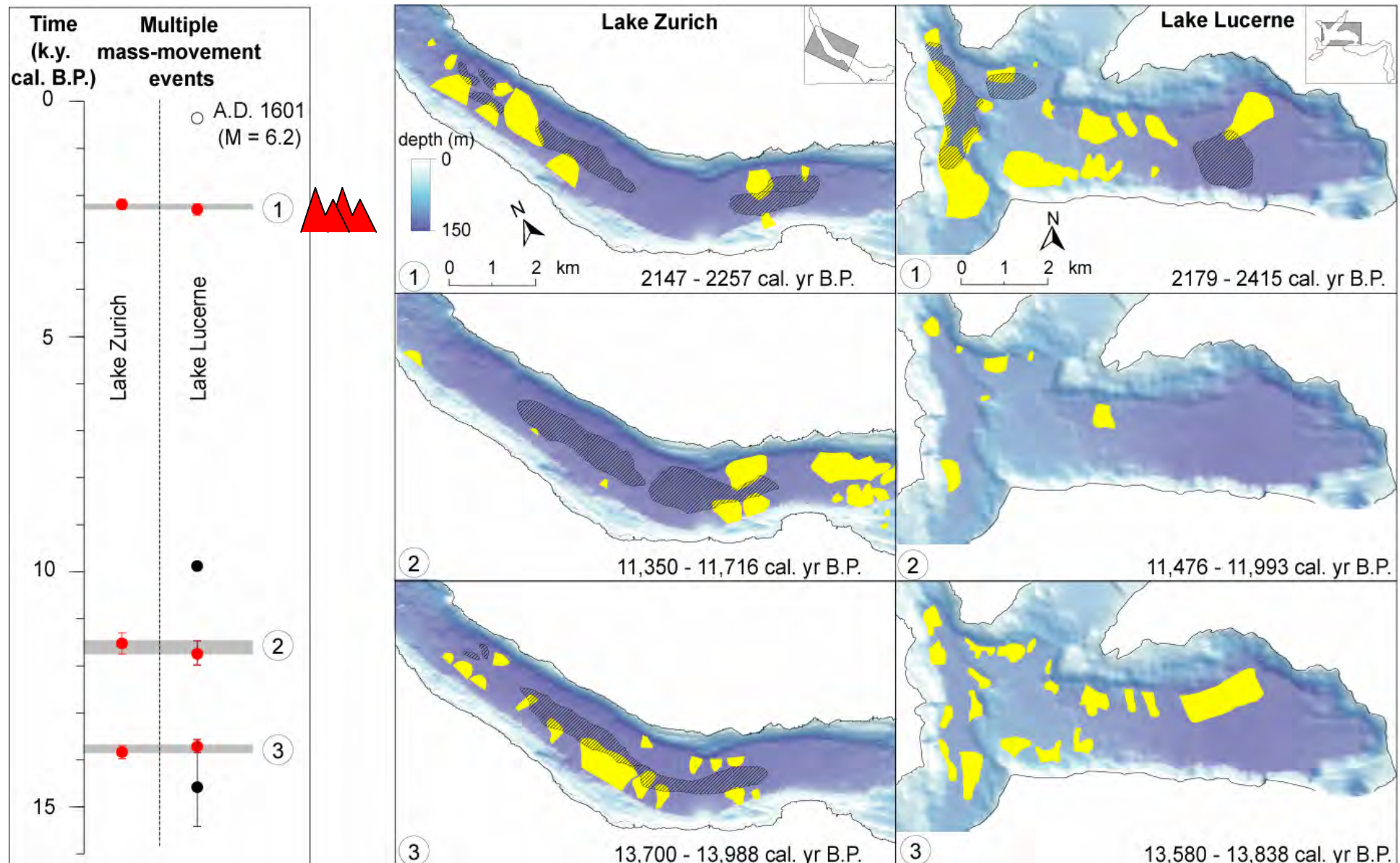
Hinweis auf Enlastungs-Glaziotekttonik?

Zürichsee



Zürichsee: multiple Rutschungen

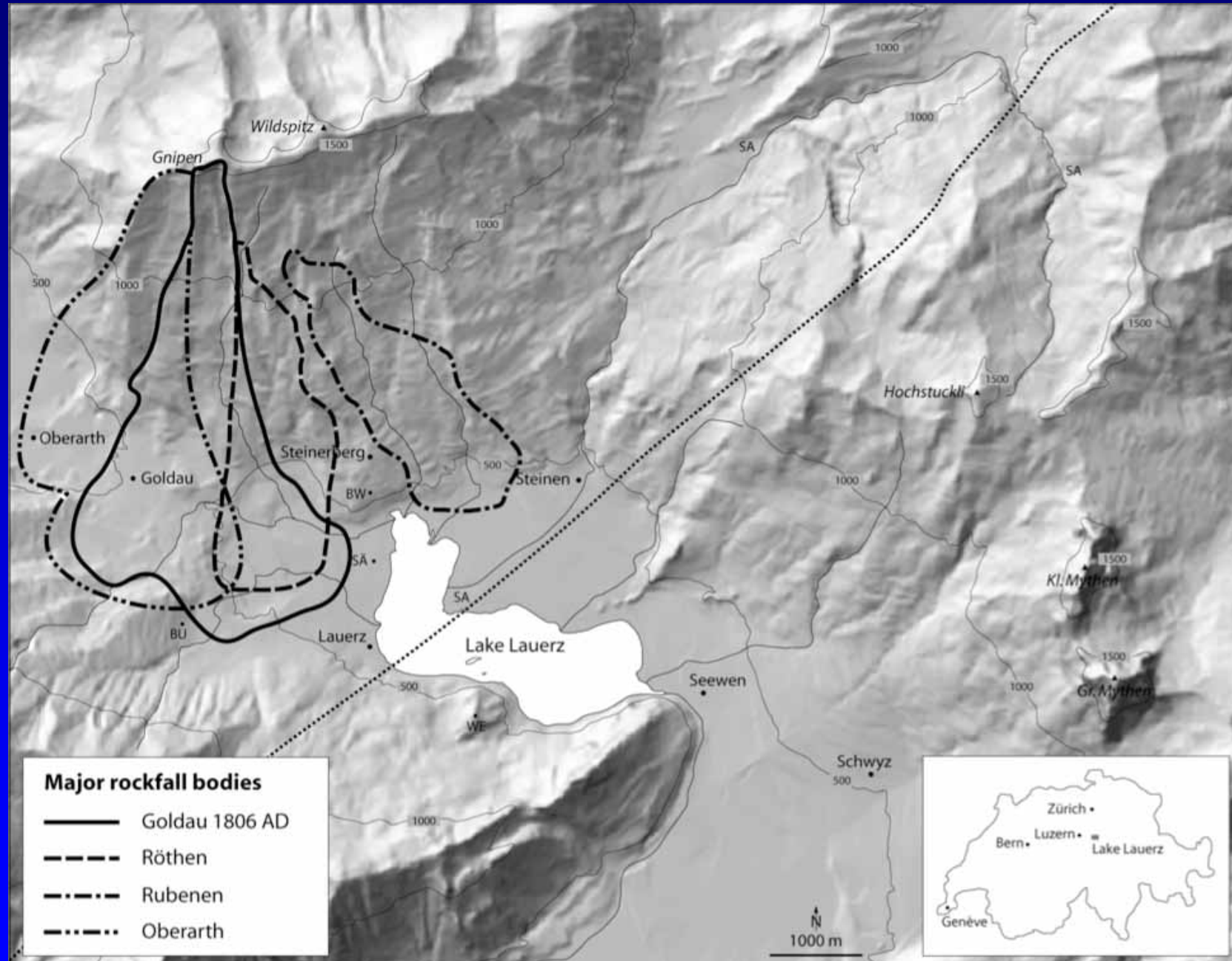




Bergstürze:
B. Keller, pers.
comm

Gleichzeitige multiple Rutschungen im Zürichsee
und Vierwaldstättersee
Strasser et al., 2006

Bergstürze Rossberg

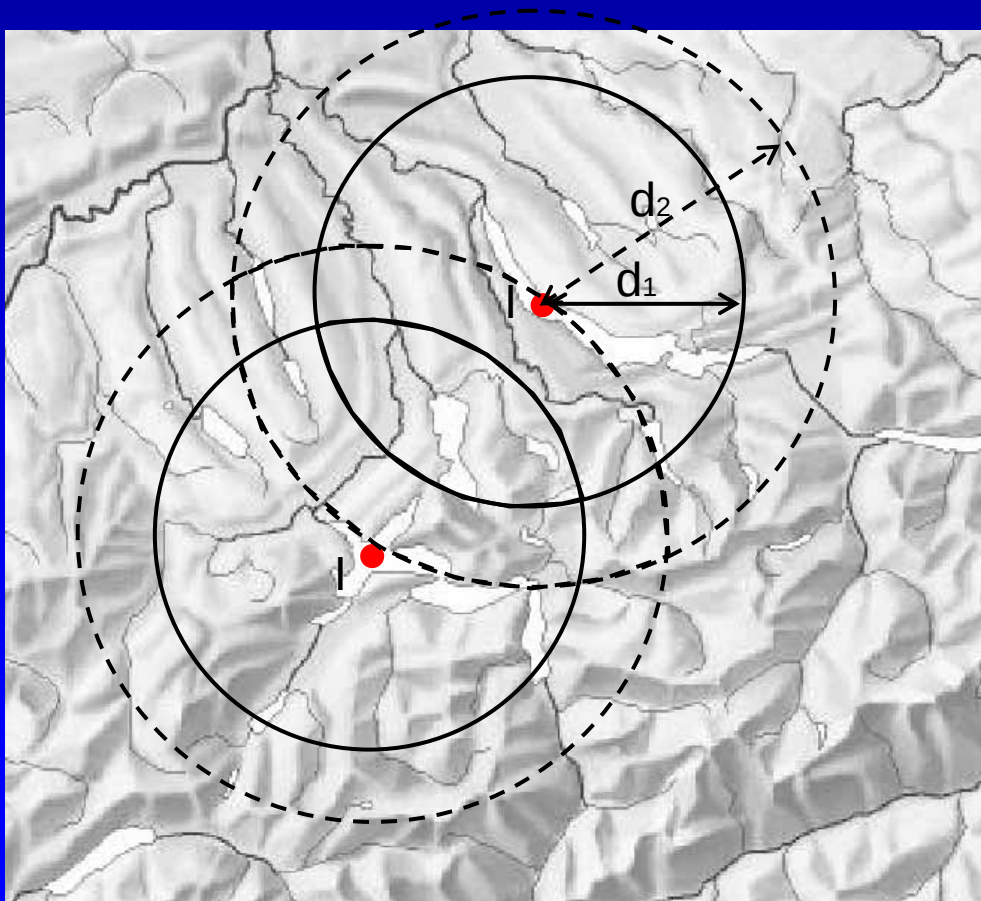


(Gasser, 2003; Bussmann and Anselmetti, subm.)

Grid search approach (Bakun and Wentworth, 1997)

Magnitude calculations over a grid of trial source locations (i) using a calibrated empirical attenuation relation (Fäh et al, 2003)

$$M_{(i)} = (I_{(i)} + c_0 + c_1 * d_{(i)}) / c_2$$



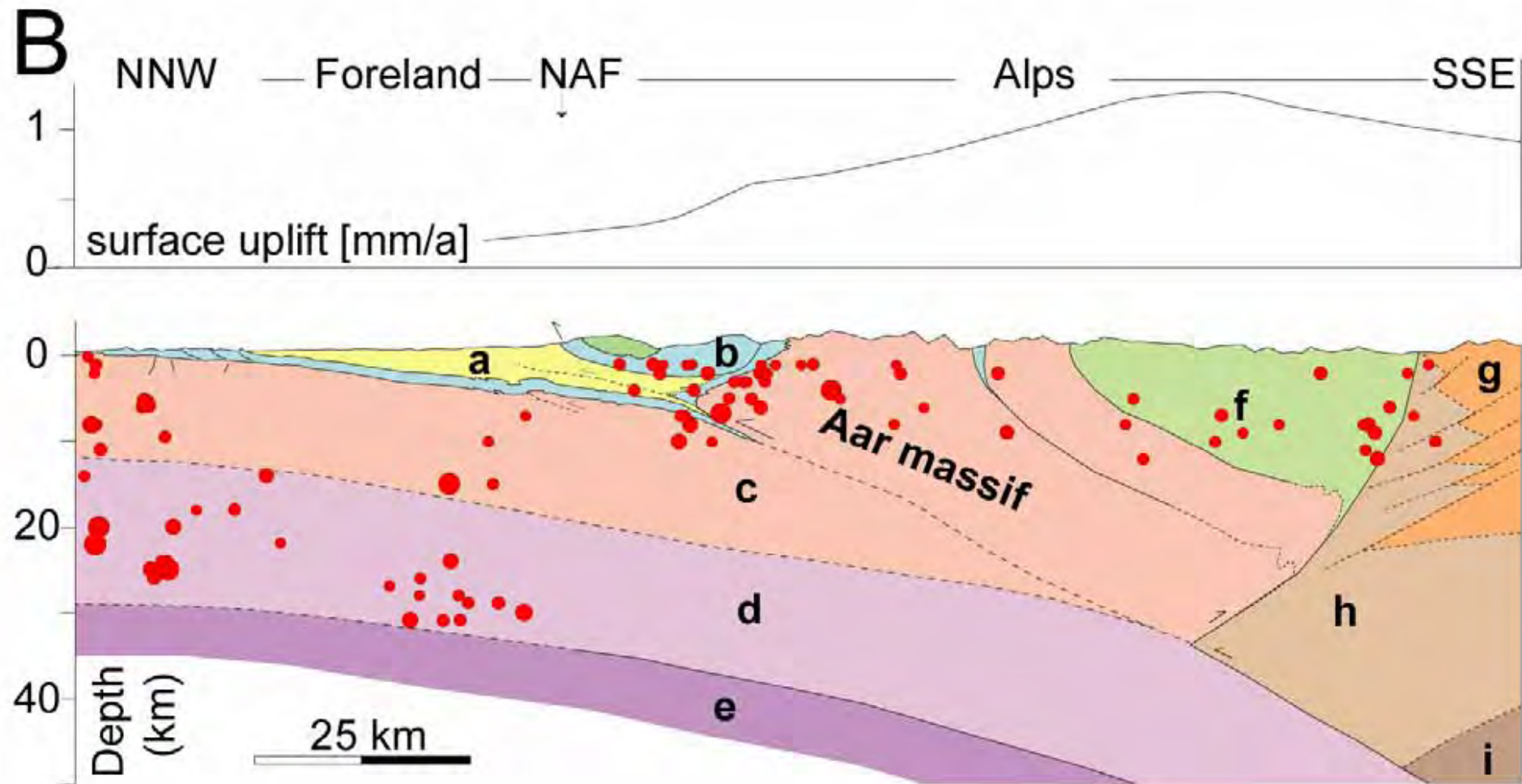
$M_{(i)}$ = moment magnitude

$I_{(i)}$ = Macroseismic intensity value at site i (EMS98)

$d_{(i)}$ = epicentral distance

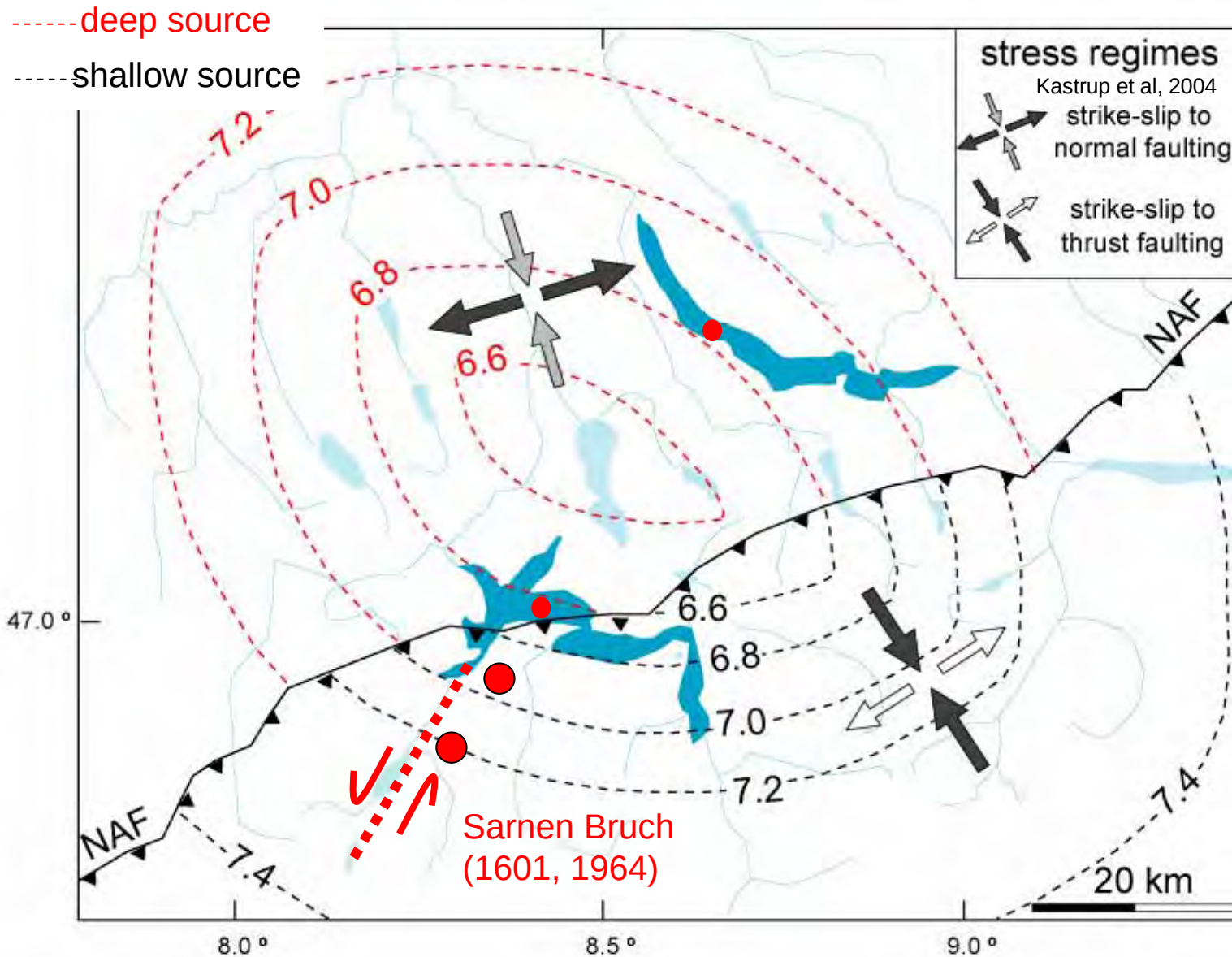
c_{0-2} = constants for shallow and deep earthquake source, respectively (Fäh et al, 2003)

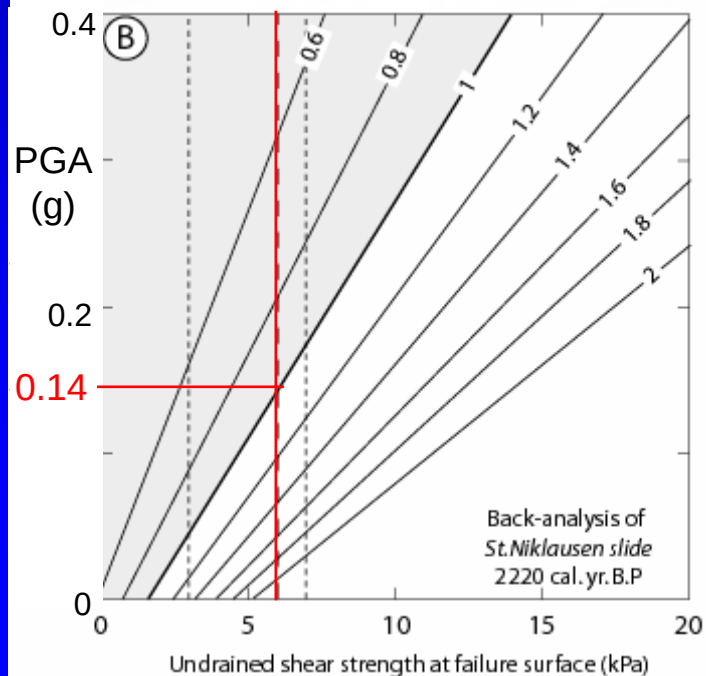
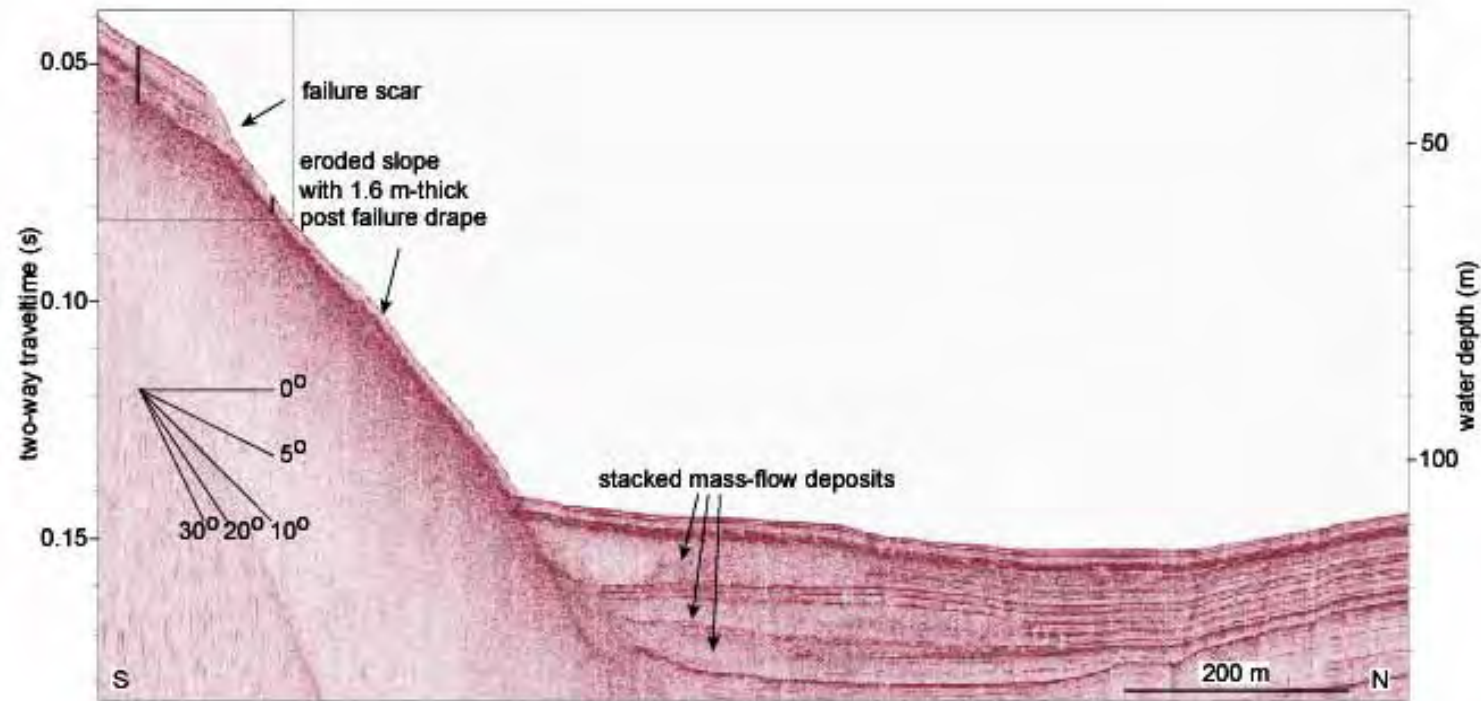
Tiefe der instrumentellen Beben



(modified after Schlatter and Marti, 2002, Pfiffner and Heitzmann, 1997, Pfiffner and Kühni, 2001, Deichmann et al., 2000)

Mögliche Epizentren und Magnituden der starken prähistorischen Beben (Grid search approach; Strasser et al., 2006)

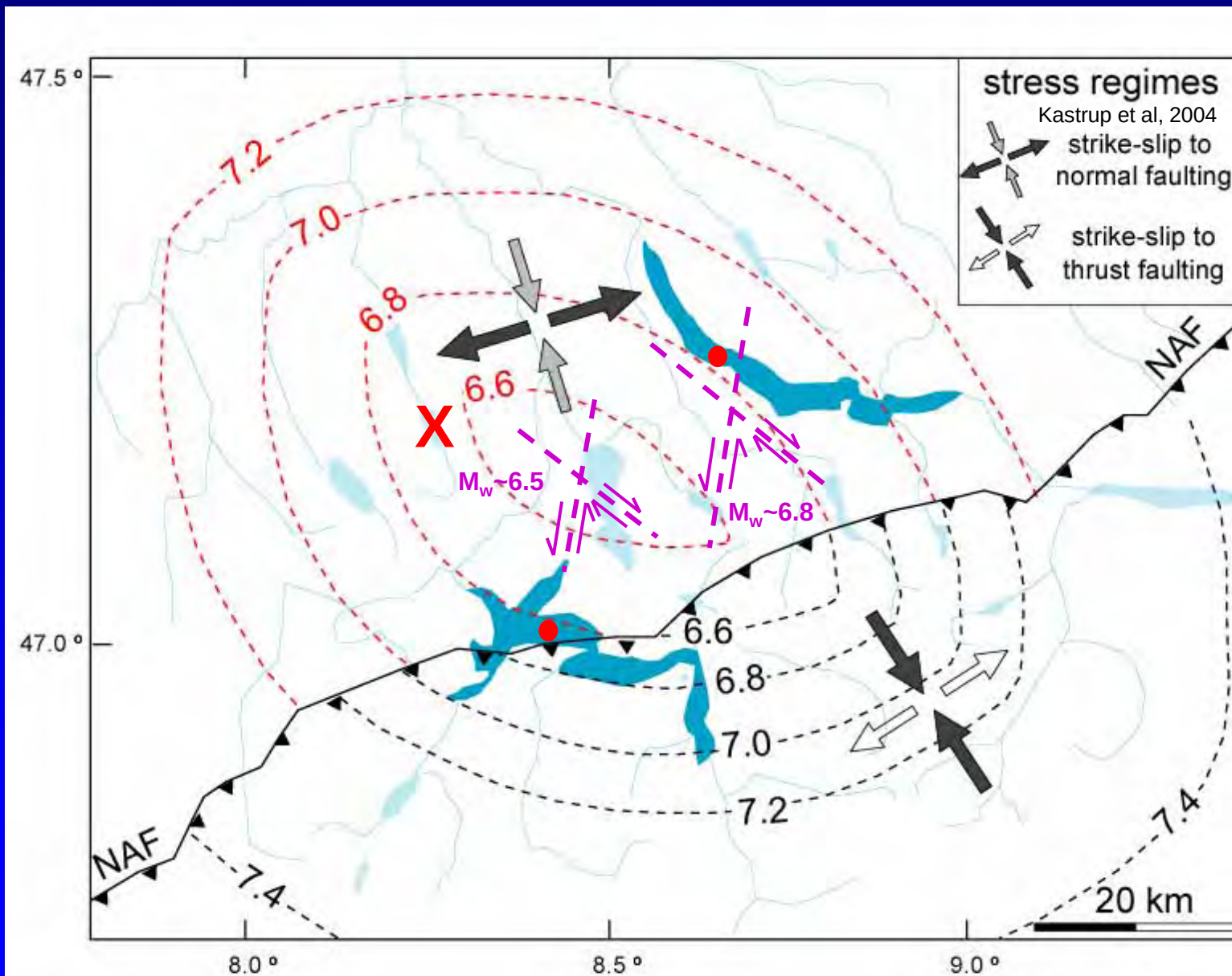




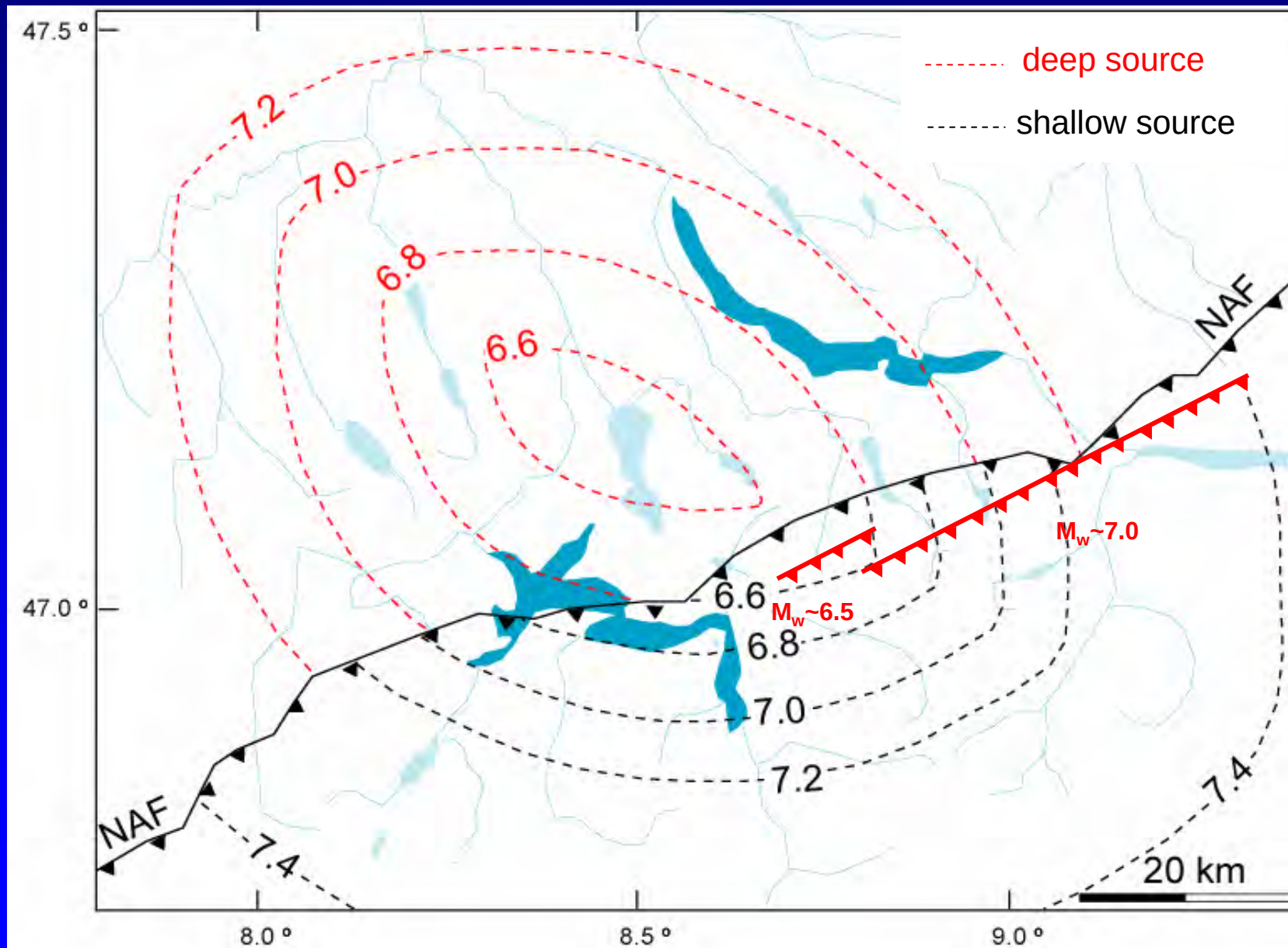
Back Analysis des 2220 BP Ereignis:
Abhang war statisch stabil ($FS > 2$)

Höhere Beschleunigung von 0.14 g
nötig um den Abhang auszulösen
(verglichen mit 0.08 g des 1601
Ereignisses)

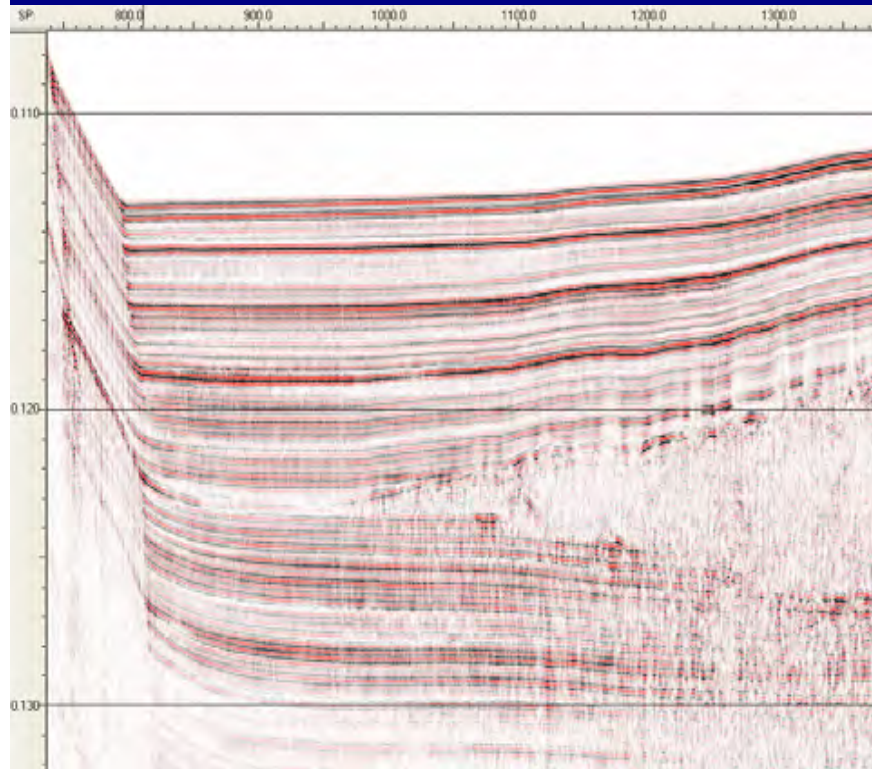
Mögliche Epizentren und Magnituden der starken prähistorischen Beben (Grid search approach; Strasser et al., 2006)



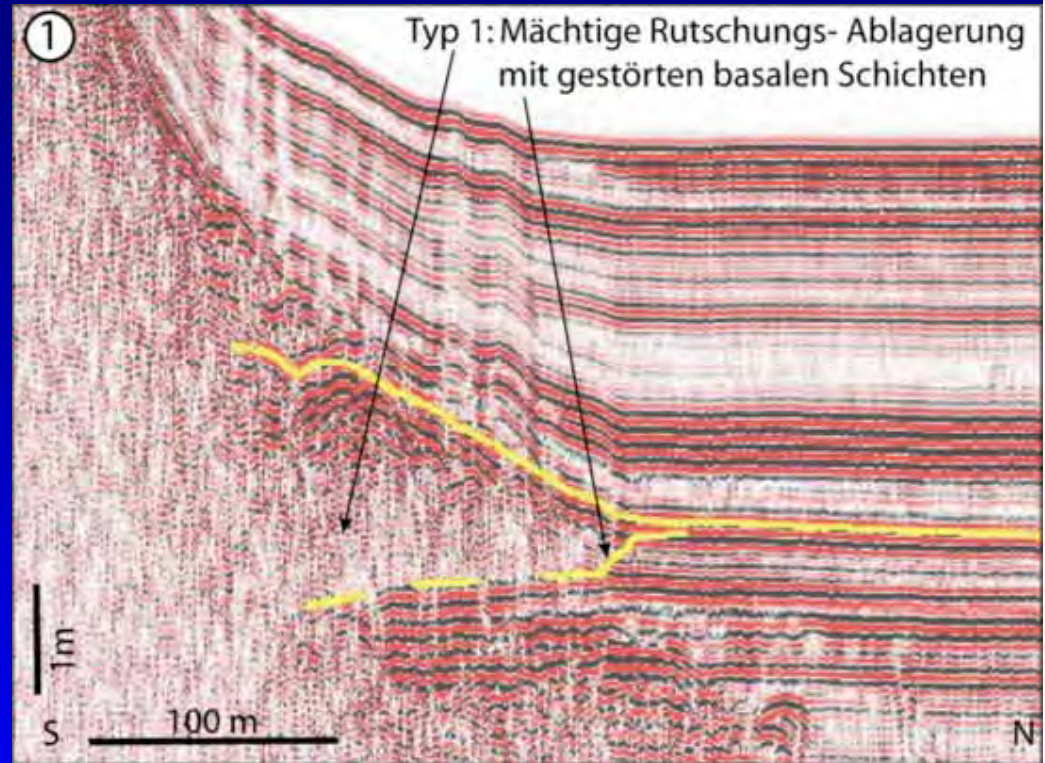
Mögliche Epizentren und Magnituden der starken prähistorischen Beben (Grid search approach; Strasser et al., 2006)



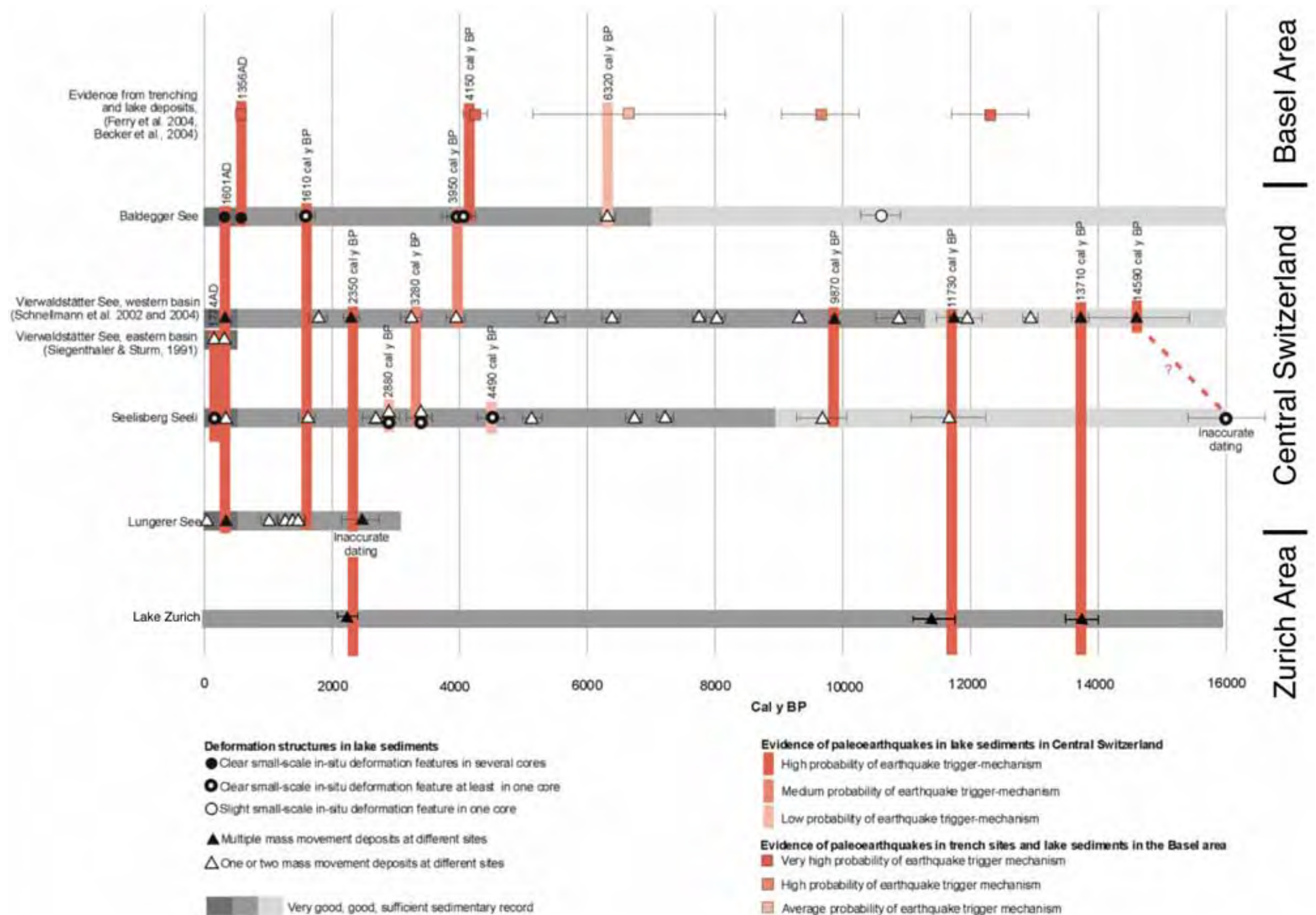
Genauere Lokalisierung der Epizentren: Regionale Ausweitung der paläoseismischen Analysen



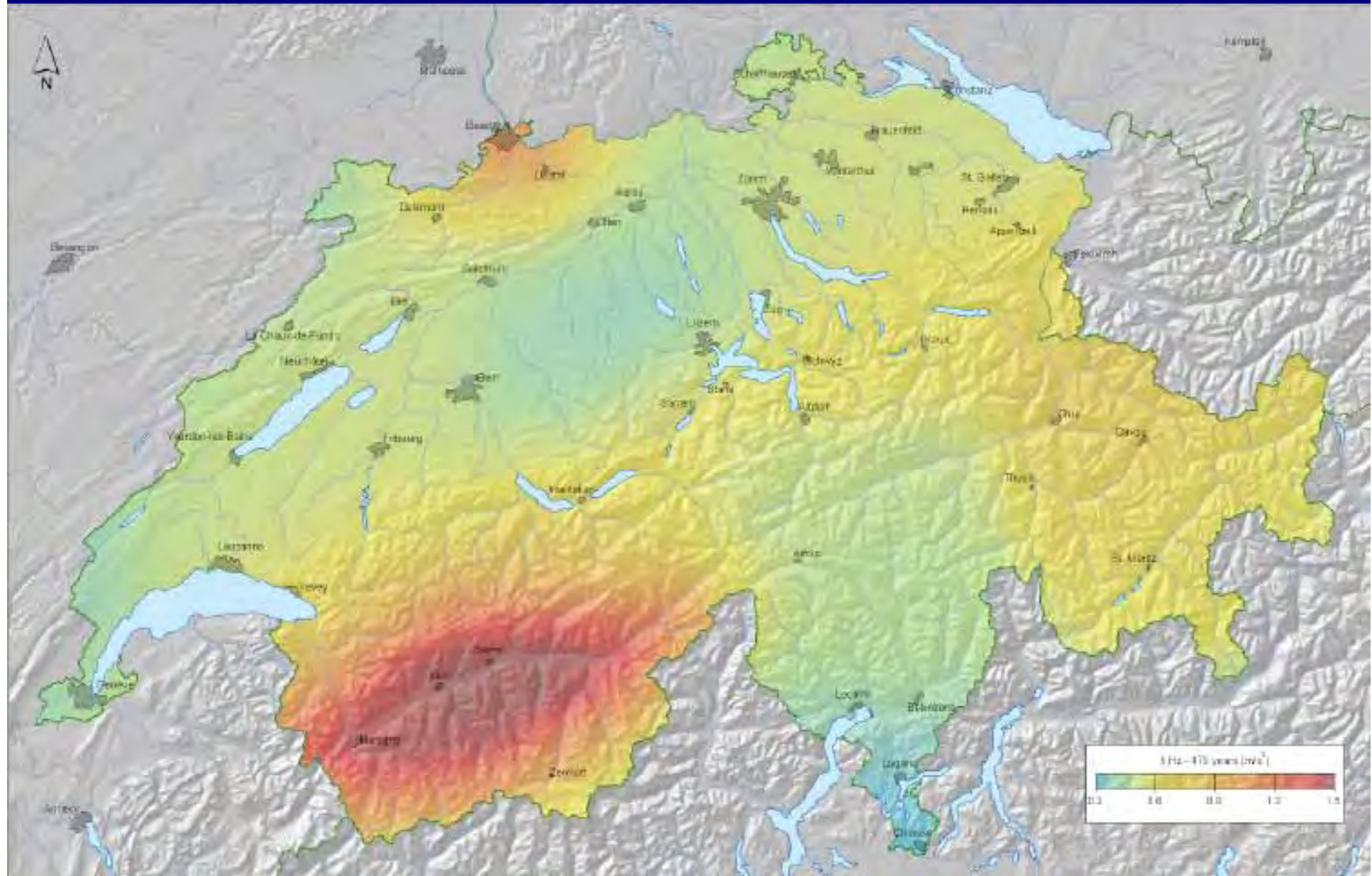
Aegerisee
(Müller, 2007)



Walensee
(Zimmermann, 2008)



Swiss Hazard Map: Horizontal ground motion (475 years) at 5 Hz



Swiss Seismologic Survey