Image supplemental to abstract EGU2020-11869
Session NH3.1

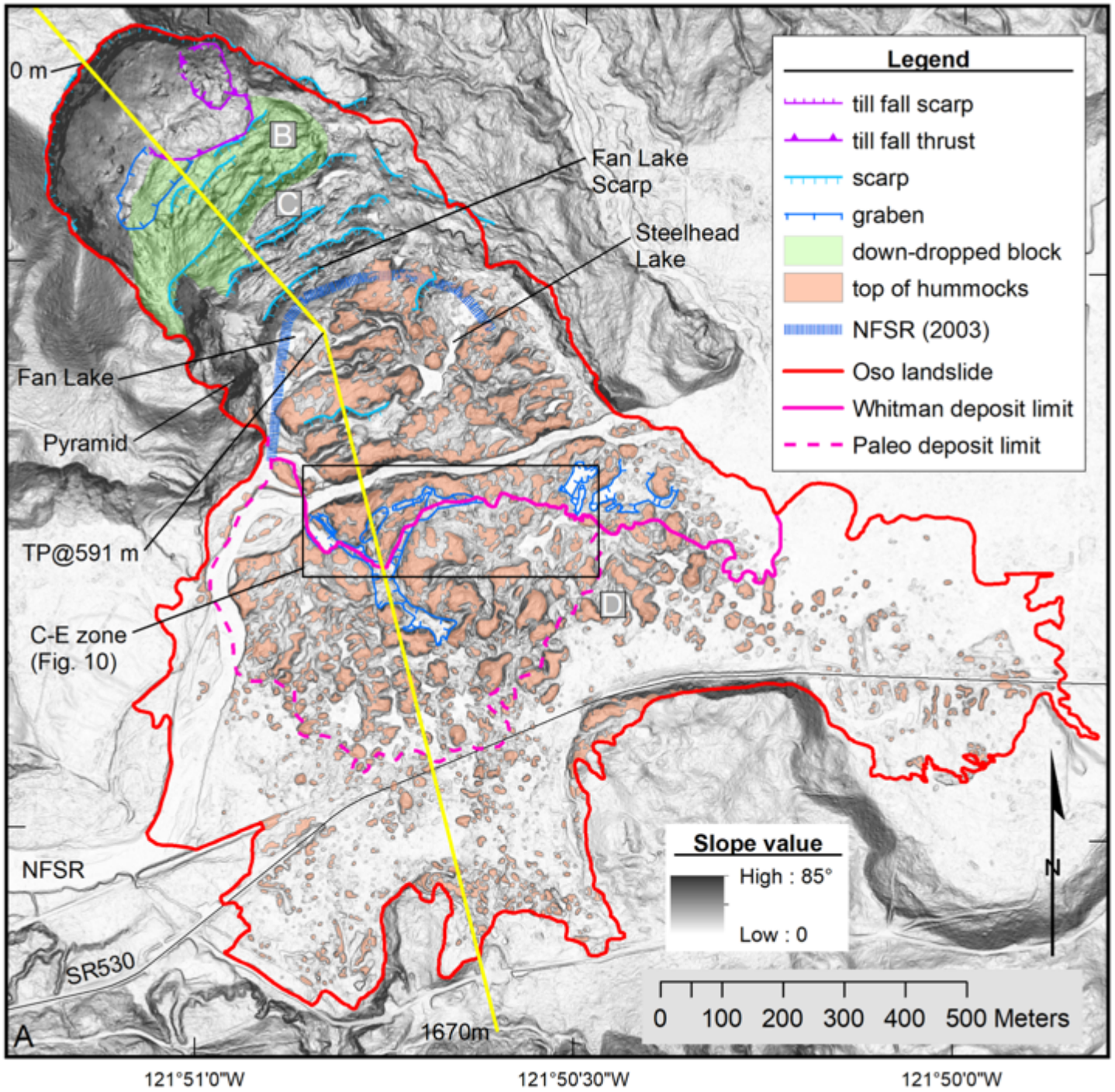
Enhanced landslide mobility promoted by liquefaction of underlying sediments: Evidence from detailed field, lab, and modelling investigations of the deadly Oso, USA landslide

Mark E. Reid
Brian D. Collins
U.S. Geological Survey

Overview of 22 March 2014 catastrophic Oso landslide, which swept more than 1 km across the river and valley flats, destroyed a neighborhood, and killed 43 people.

(Images from Collins & Reid, GSA Bulletin, 2020)

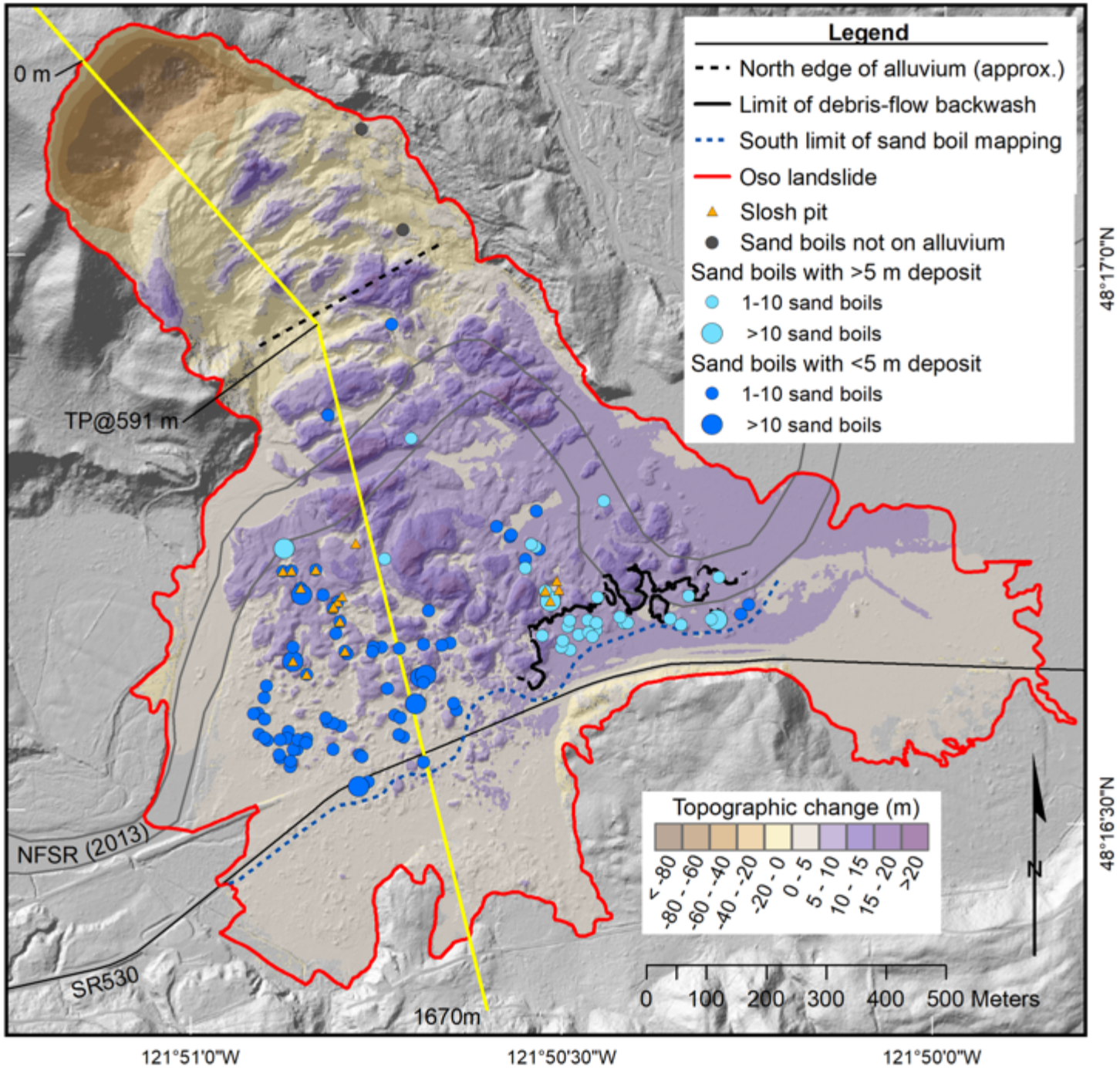
USGS



Nearly all mapped structural features of the 2014 Oso landslide indicate extension of the slide mass, as shown by major scarps, grabens, thrusts, and hummocks. A hummocky debris-avalanche deposit covers most of the valley flats with debris-flow deposits forming the southern distal margin. This slide exhibited high mobility for a debris avalanche.

(From Collins & Reid, 2020)

USGS



We mapped widespread sand boils, a classic liquefaction feature, throughout the hummock field of the 2014 Oso landslide. Hummocks (purple) range up to >20 m high and decrease in size to the south. We found abundant, but transient, sand boils (blue) between hummocks soon after the slide event. Some sand boils erupted through >5 m of slide deposit (light blue). The hummocks themselves did not liquefy.

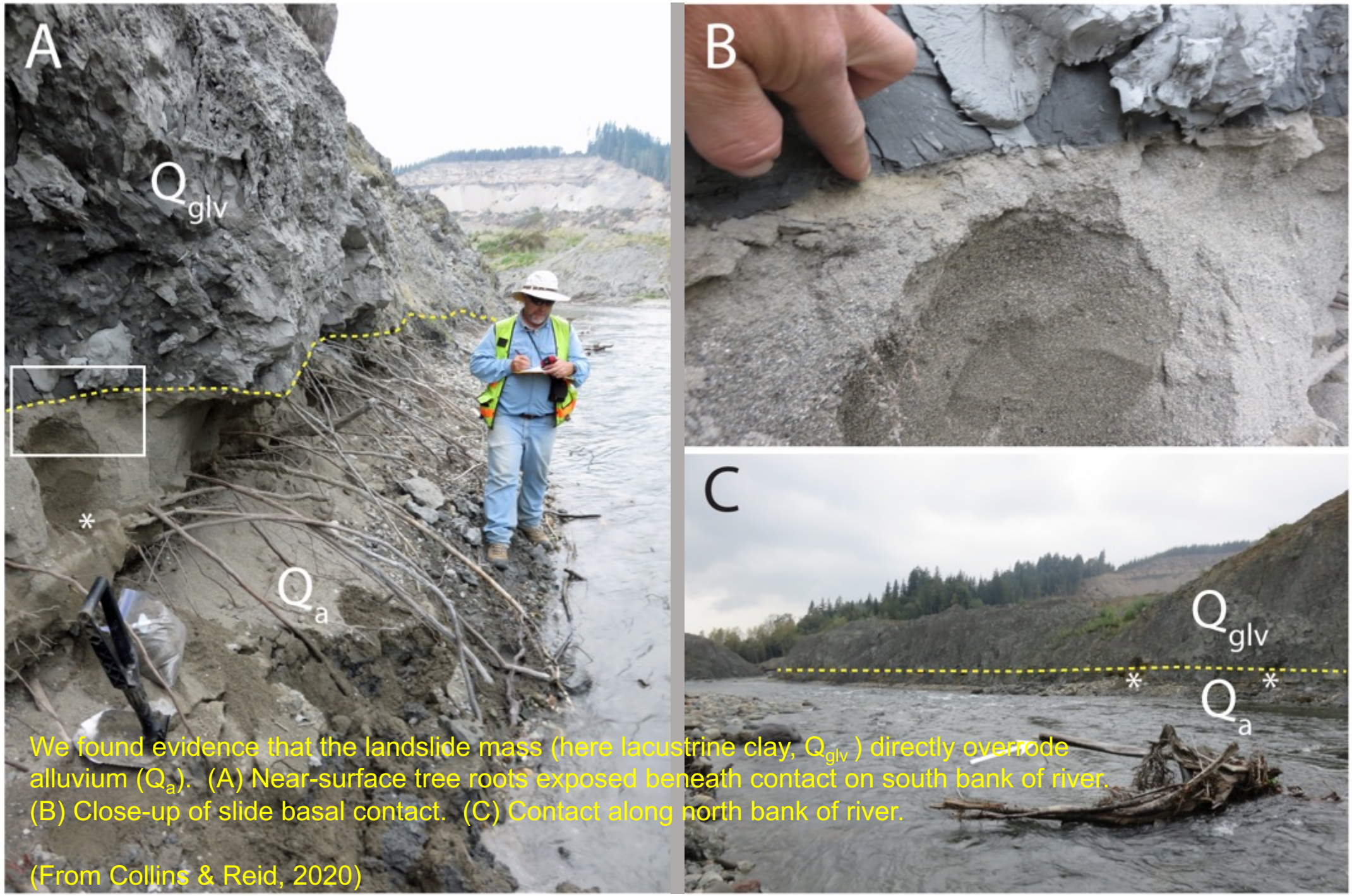
(From Collins & Reid, 2020)

USGS

Abundant sand boils in the 2014 Oso landslide deposit indicate widespread liquefaction of underlying sediment. Photos show examples of: (A) subaqueous eruption into a former pond between hummocks, (B) subaerial eruption, and (C) eruption through lacustrine clay area.

(From Collins & Reid, 2020)

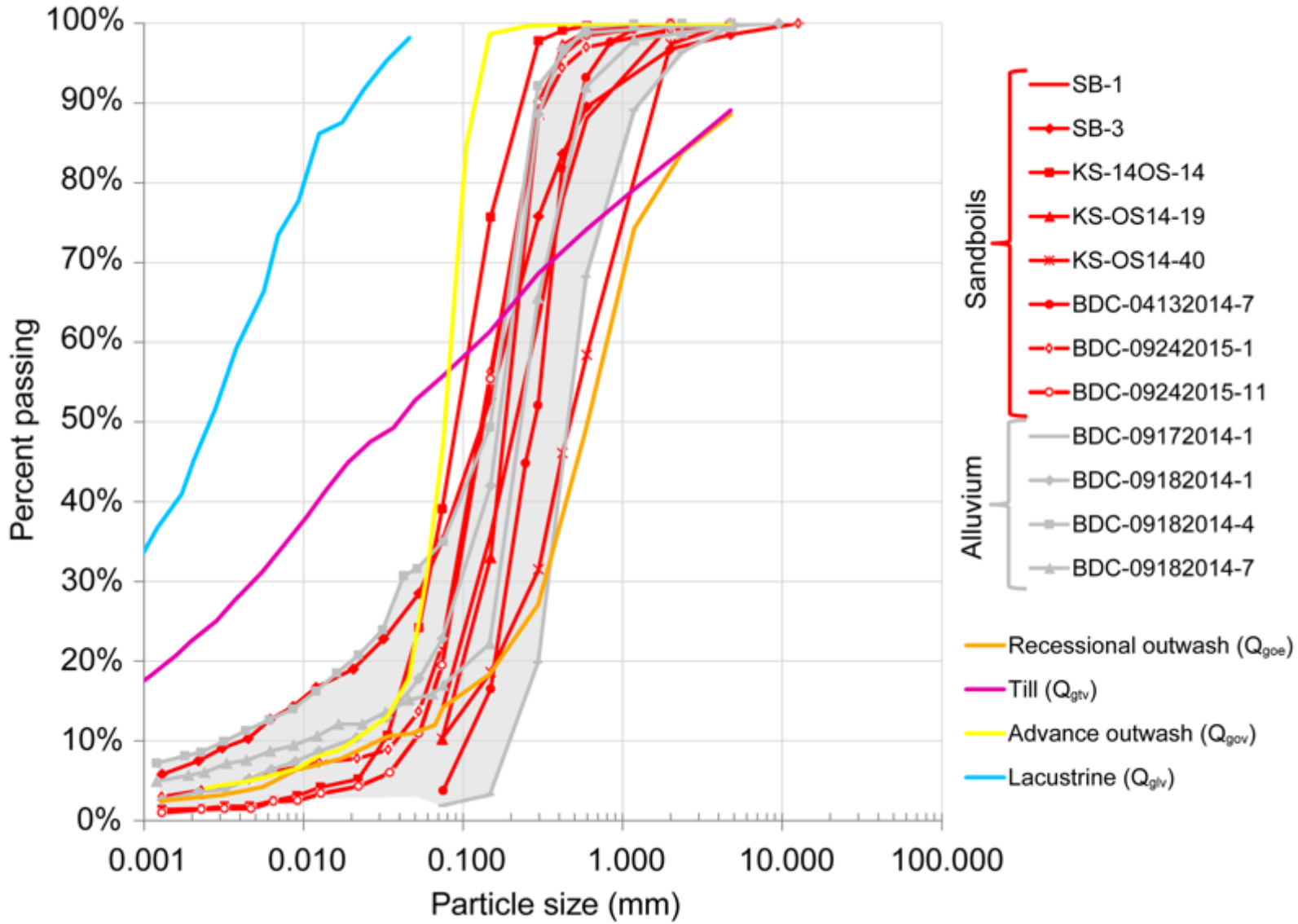
USGS



We found evidence that the landslide mass (here lacustrine clay, Q_{glv}) directly overrode alluvium (Q_a). (A) Near-surface tree roots exposed beneath contact on south bank of river. (B) Close-up of slide basal contact. (C) Contact along north bank of river.

(From Collins & Reid, 2020)

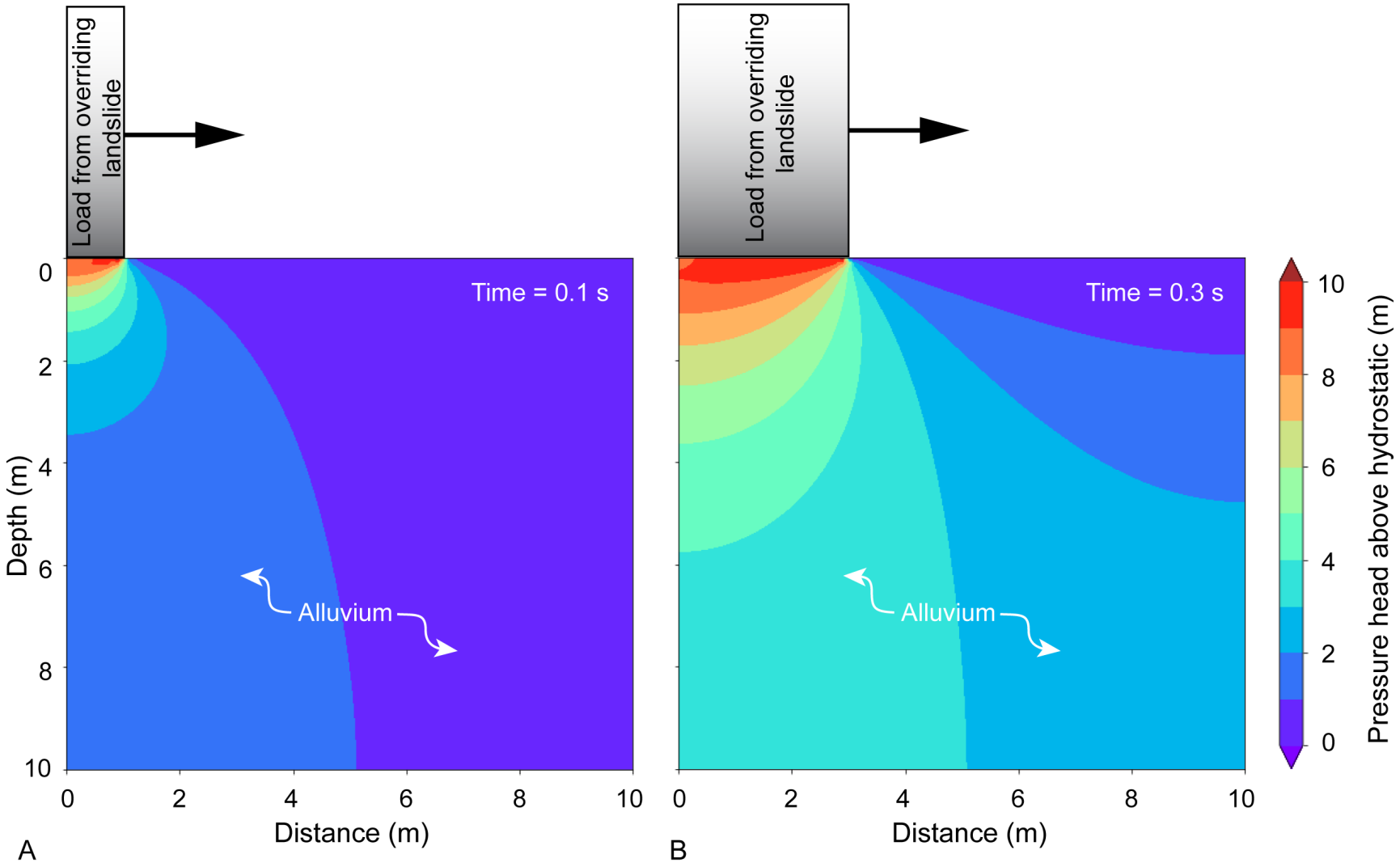
USGS



Grain-size distributions from sand boil samples that we collected (red lines) closely match the underlying alluvium (grey), and not the glacial materials composing the slide mass.

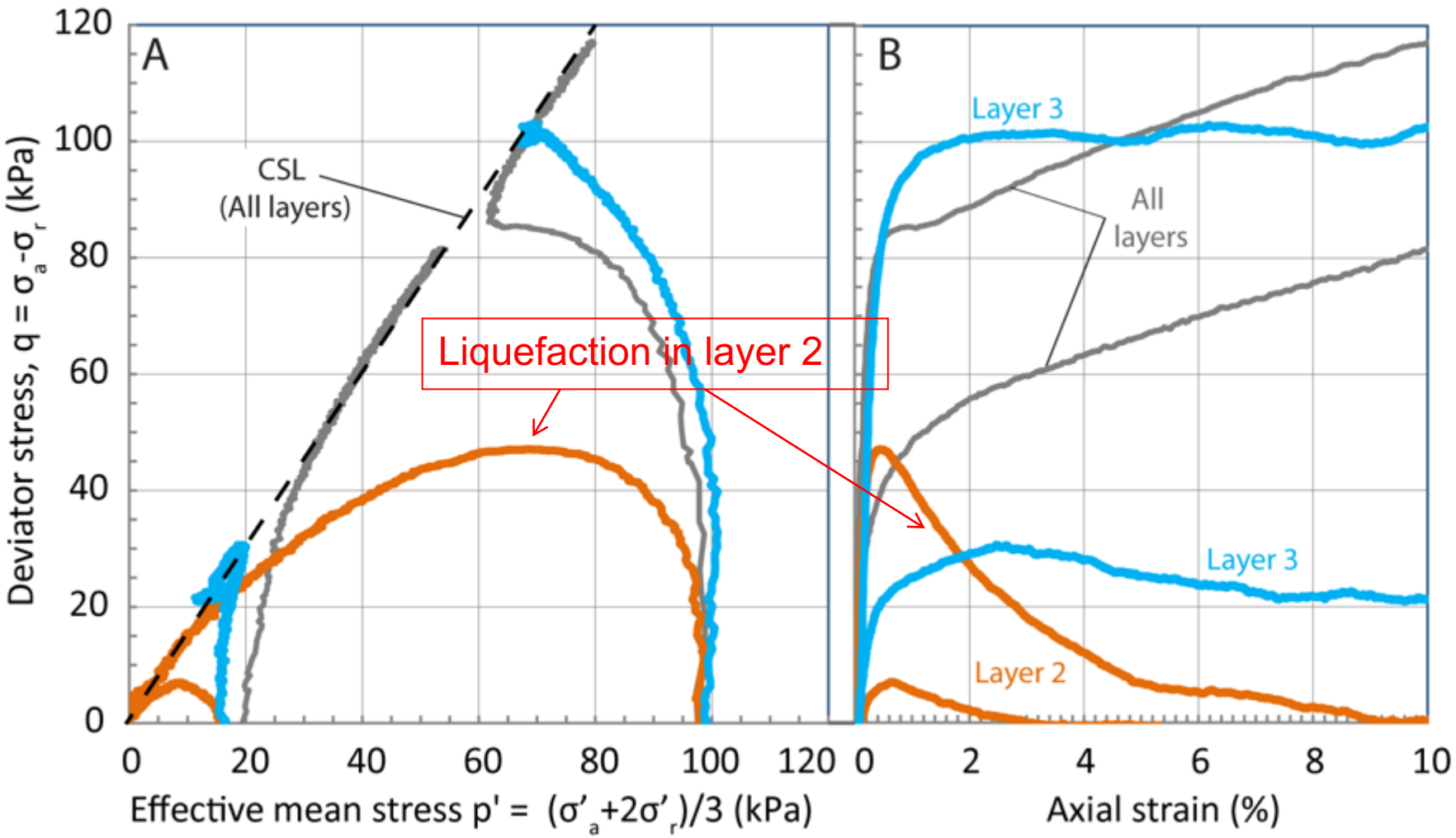
(From Collins and Reid, 2020)

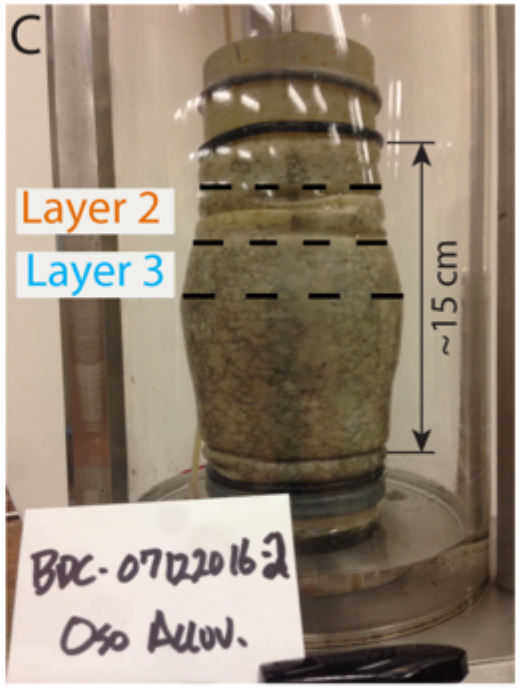
USGS



Our poroelastic model simulations show that rapid loading of alluvial sediment can increase underlying pore pressures to near liquefaction levels. The model simulates an overriding landslide moving across part of an alluvial domain from left to right at a speed of 10 m/s.

(From Collins and Reid, 2020)





Triaxial tests show complete strength loss and liquefaction in select alluvial layers sampled from the slide site. Results from layer 2 (orange lines) and wrinkled membrane in photo indicate strength loss.

(From Collins and Reid, 2020)

- The deadly Oso landslide was highly mobile and travelled far across valley flats

- We found widespread field evidence for liquefaction of alluvium beneath the overriding debris-avalanche hummocks of the slide

- Our poroelastic model analyses of Oso demonstrate that rapid failure onto saturated alluvial sediments promotes undrained loading and liquefaction

- In addition, triaxial lab tests show that Oso alluvial materials can liquefy and lose strength

- Liquefaction of the the underlying sediment differs from liquefaction of the slide mass itself – basal liquefaction may enhance the mobility of other slides

For more details see:
Collins, B. D., & Reid, M. E. (2020). Enhanced landslide mobility by basal liquefaction: The 2014 State Route 530 (Oso), Washington, landslide. *GSA Bulletin*, *132*(3-4), 451-476, https://doi.org/10.1130/B35146.1

USGS