Gas hydrates, fluid venting and slope stability on the upper Amazon deep-sea fan

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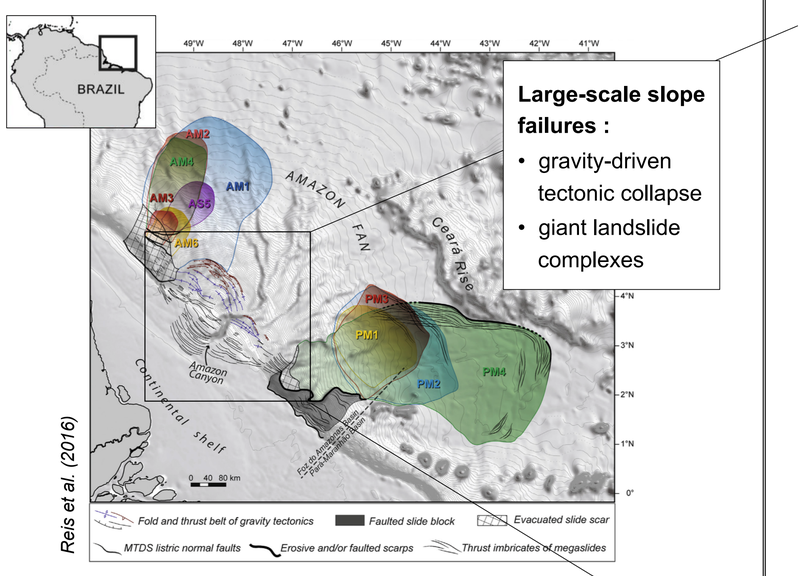
1. Amazon fan & slope instabilities



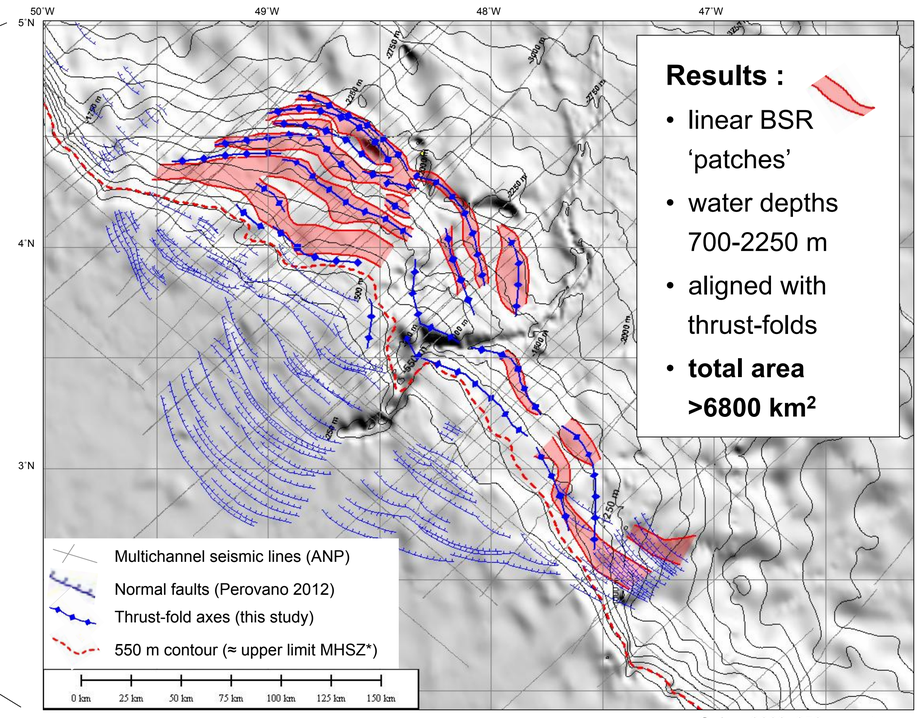
Large-scale slope failures :

- gravity-driven tectonic collapse
- giant landslide complexes

Possible triggers of recurrent upper slope failures :

- Changes in gas hydrate stability (Maslin et al. 1998)
- Syn-sedimentary collapse tectonics (Reis et al. 2016)

2. Mapping bottom simulating reflections (BSRs)



Results :

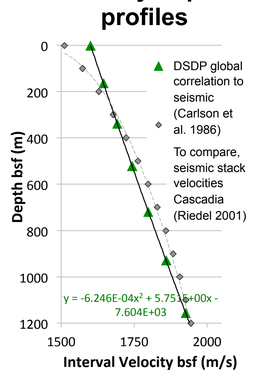
- linear BSR 'patches'
- water depths 700-2250 m
- aligned with thrust-folds
- **total area >6800 km²**

3. BSR depth inversion to temperatures

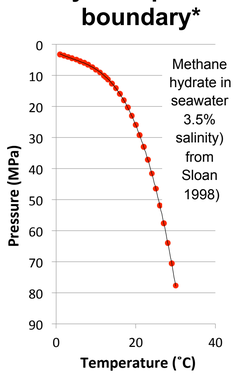
Inversion method (after Riedel et al. 2010)

- BSR TWT → depth (velocity profile from Carlson et al. 1986)
- Depth of BSR → hydrostatic pressure
- Pressure at BSR → temperature at phase boundary (MHSZ*)
- Bottom water temperatures (WOD) → geothermal gradients

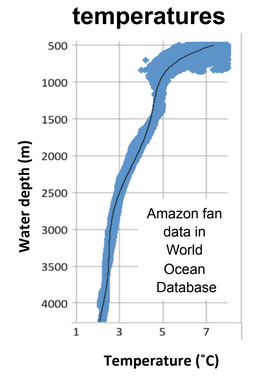
Velocity-depth profiles



Hydrate phase boundary*

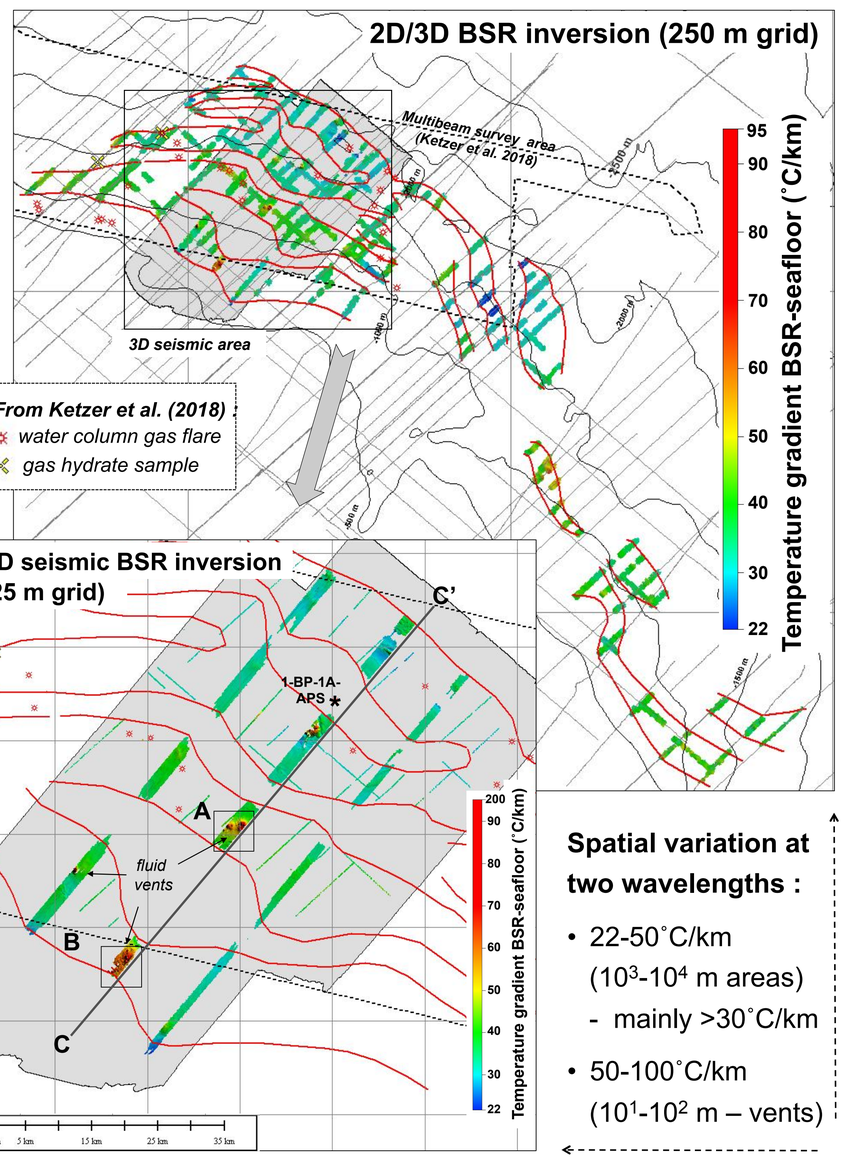


Bottom water temperatures



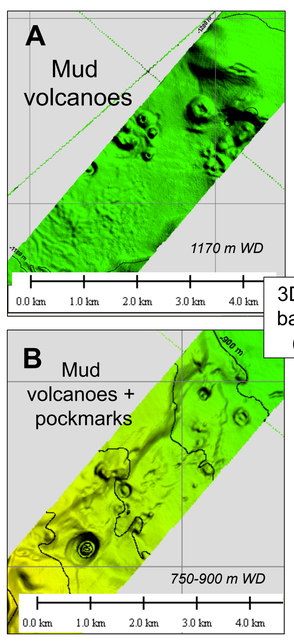
***MHSZ = Methane hydrate stability zone**

4. BSR patches → spatially variable temperature gradients + seafloor fluid vents



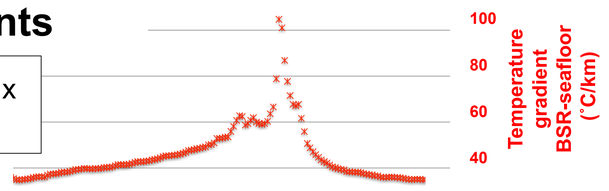
Spatial variation at two wavelengths :

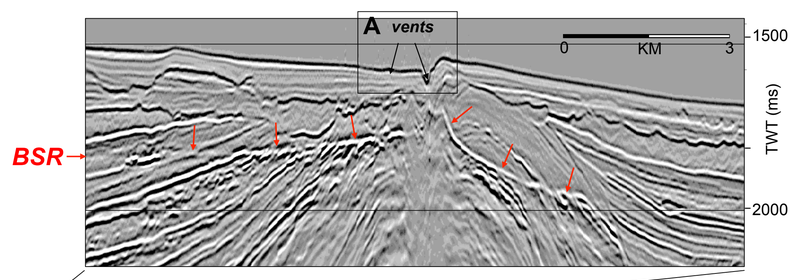
- 22-50˚C/km (10^3-10^4 m areas) - mainly >30˚C/km
- 50-100˚C/km (10^1-10^2 m – vents)

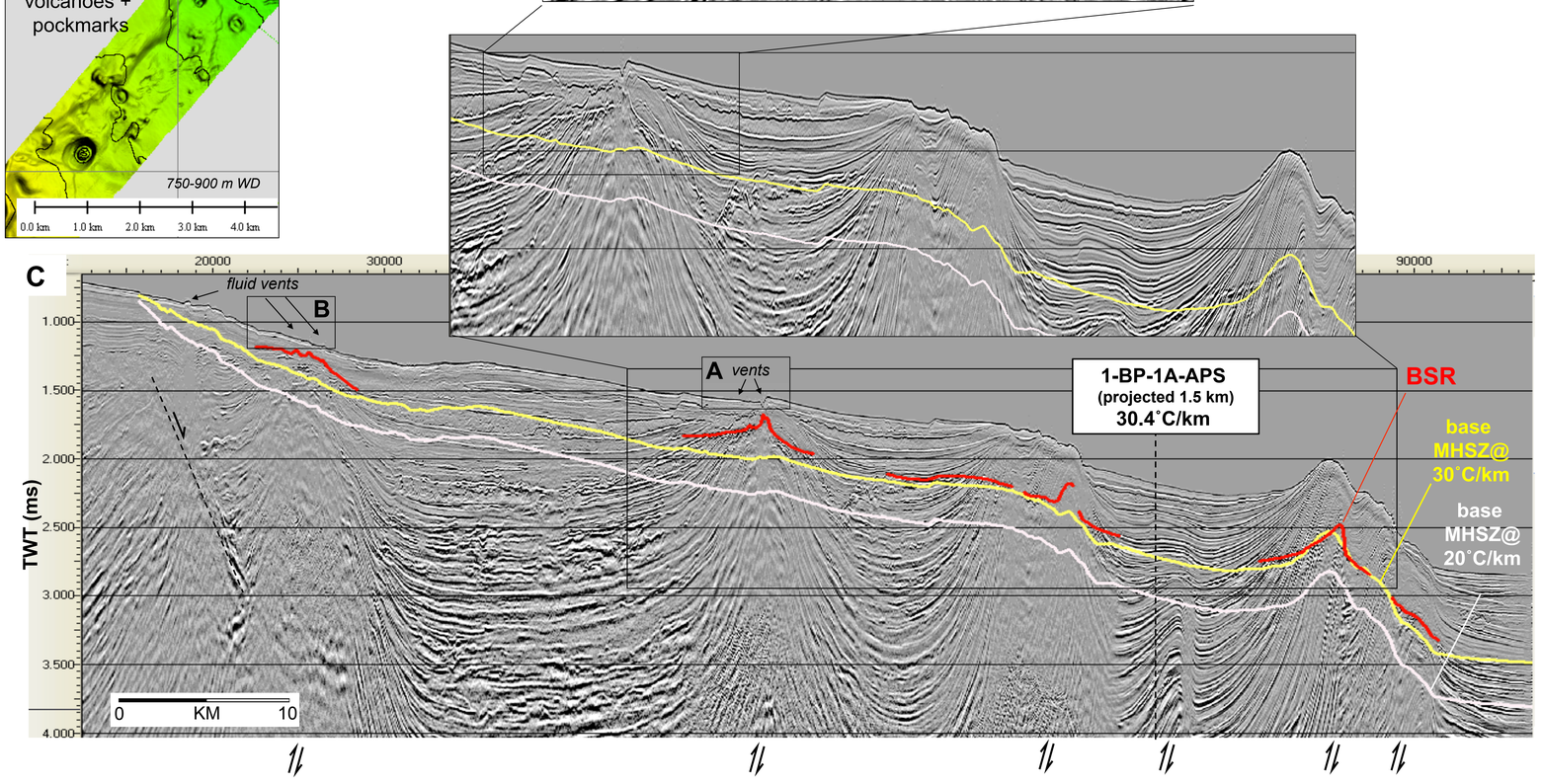


3D seismic bathymetry (12.5 m)

Gradients 1.5-10 x background



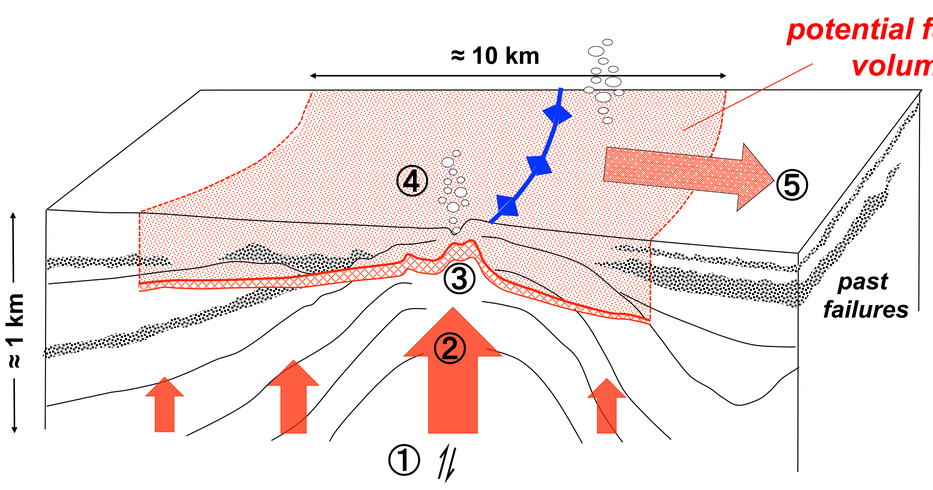




Evidence of upward flux of warm gas-rich fluids through thrust-folds (rooted on detachments at depths of kms)

5. Bottom-up gas hydrate & slope dynamics

- Changes in upward flux of fluid (heat) will modify gas hydrate stability from below
- Increased flux during thrust episodes will thin hydrate-rich zone over wide areas
- Reduced sediment strength at base of stability zone may trigger large landslides



6. Conclusions

- Elongate BSR patches on the upper Amazon fan linked to upward flux of gas-rich fluids through thrust-folds recording collapse above deep detachments
- Tectonically-driven changes in fluid flux will thin gas hydrate-rich zones from below and may trigger recurrent giant slope failures from the upper fan
- Bottom-up mechanism independent of climate-driven changes in hydrate stability

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