

Origin of Brecciated Carbonate Reservoirs

Carbonate breccias with mineral cement matrix such as saddle dolomite likely to form due to faulting and hydrothermal fluid flow, not karst

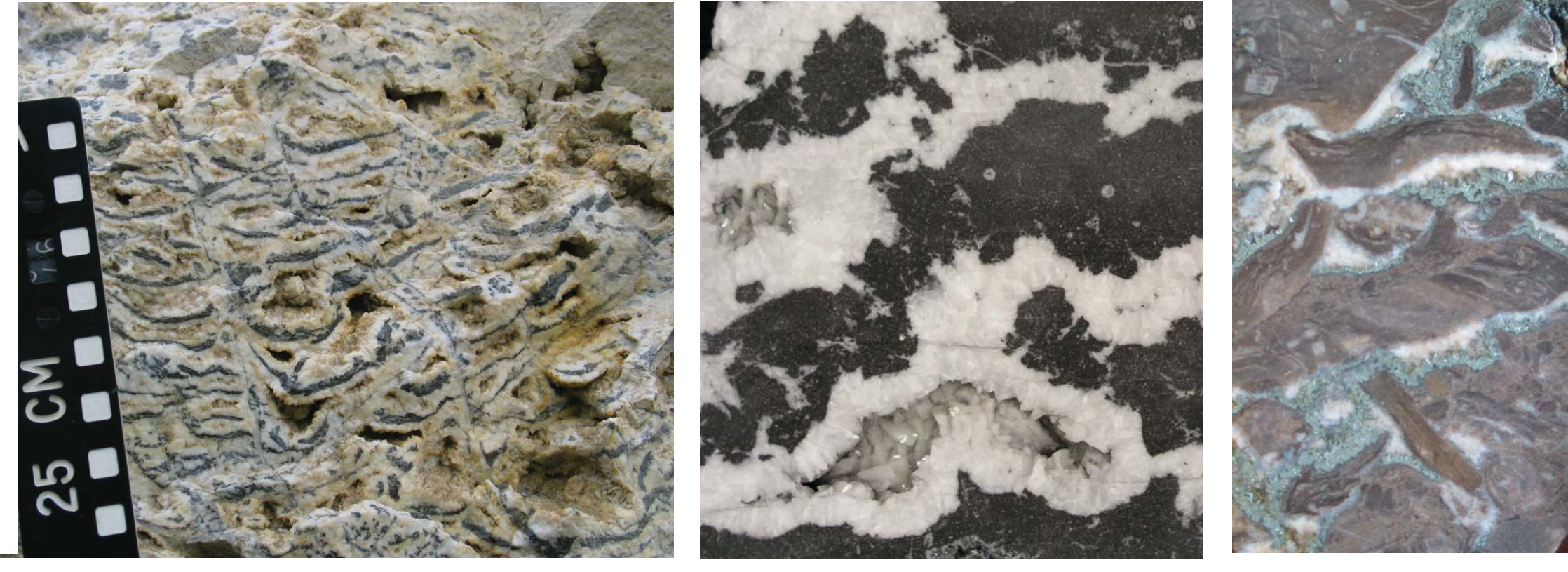
Breccias in Question - Matrix Primarily Composed of Saddle Dolomite Cement



Ellenburger Fm, Marble Falls, TX



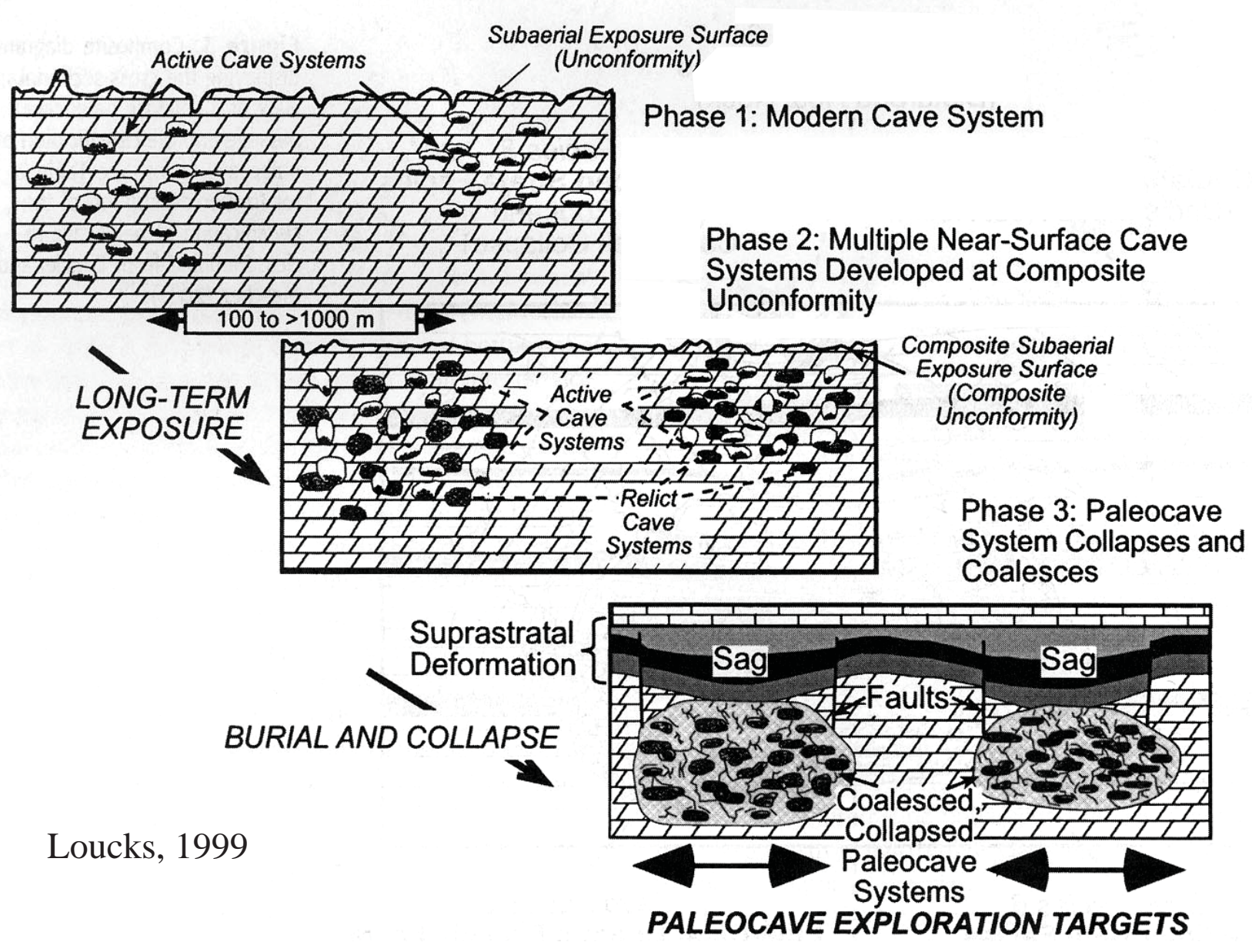
Middle Cambrian, WCSB



Commonly associated with zebra and boxwork fabrics, vugs, sulfides, matrix dolomite

Breccias with saddle dolomite, sulfide and other mineral cements are commonly interpreted to be of a meteoric karst origin. Many of these breccias are likely to be of a fault-related hydrothermal origin. If the matrix of a breccia largely consists of mineral cements and especially saddle dolomite, occurs in a dolomitized host and has no speleothems, it almost certainly has a hydrothermal overprint and is very likely to be of a hydrothermal origin.

Existing Paradigm: Meteoric Karst and/or Coalesced Cave Collapse



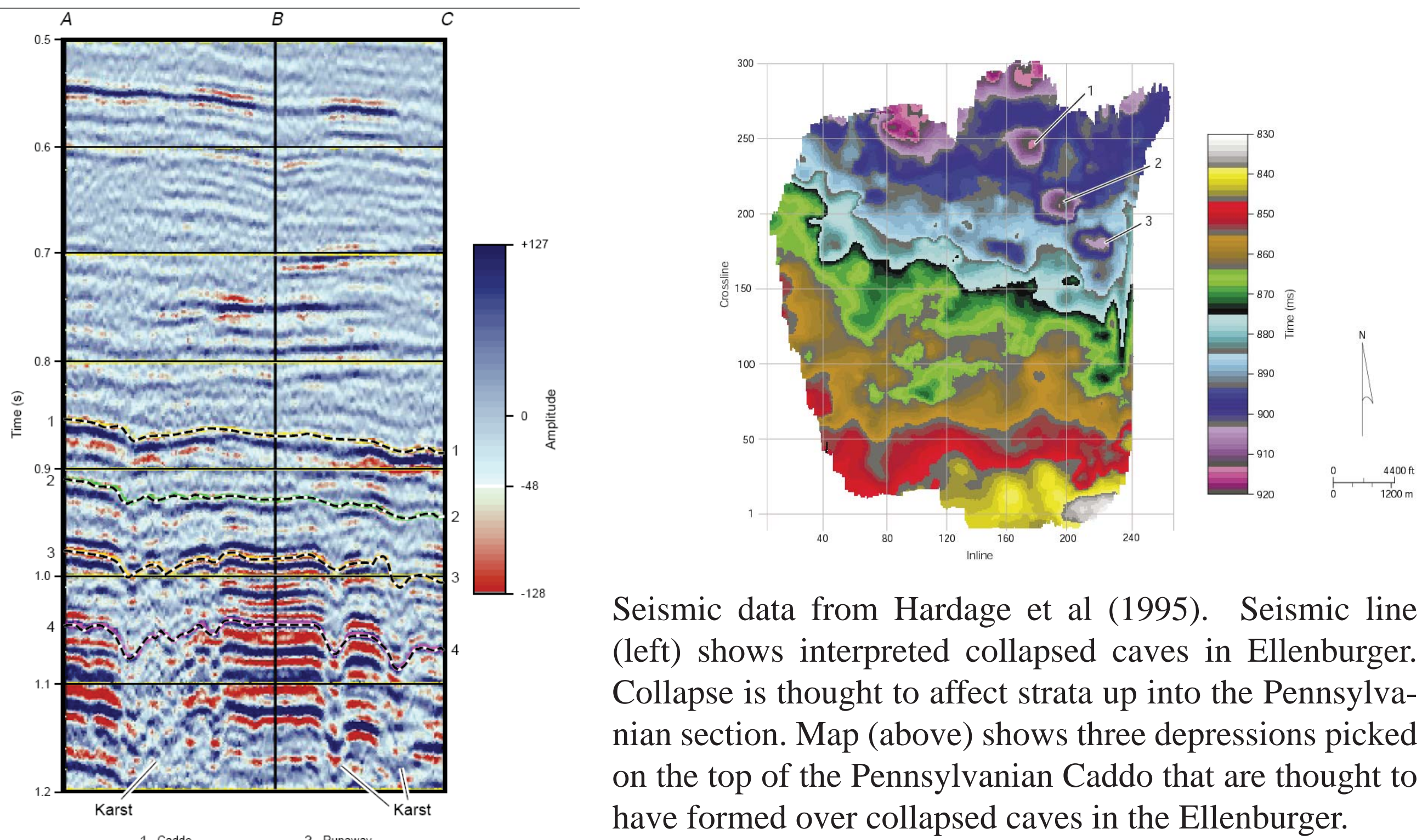
Loucks, 1999

Is the scenario at left a likely one? Caves would probably not all form next to each other when they could use nearby existing passages at same depth

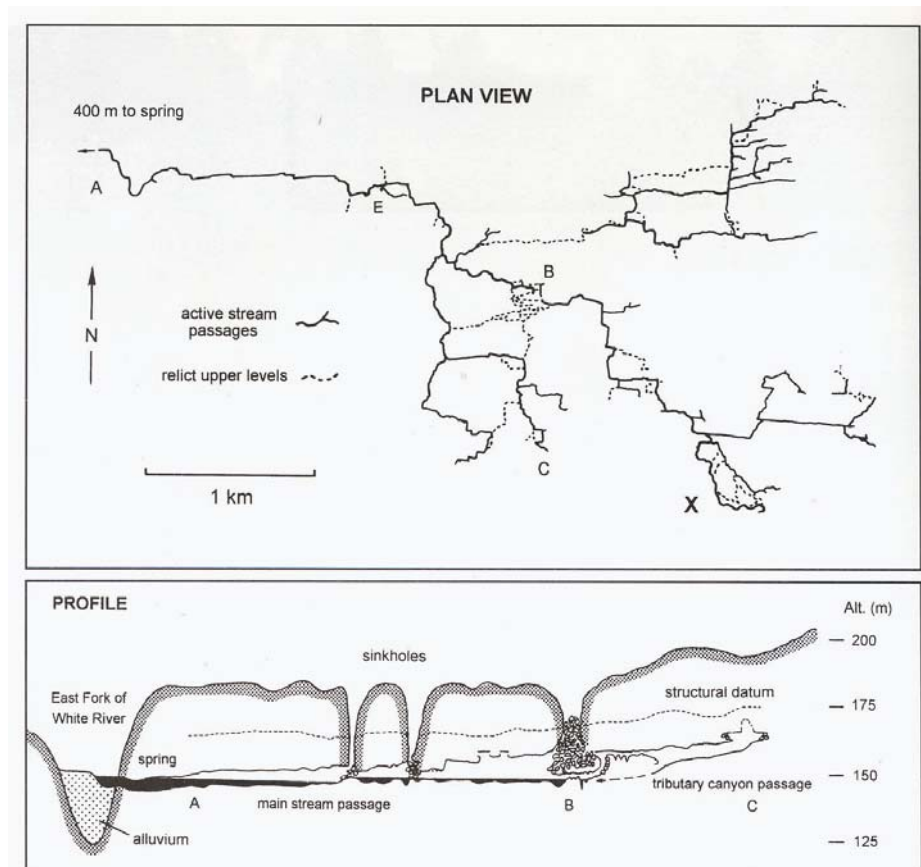
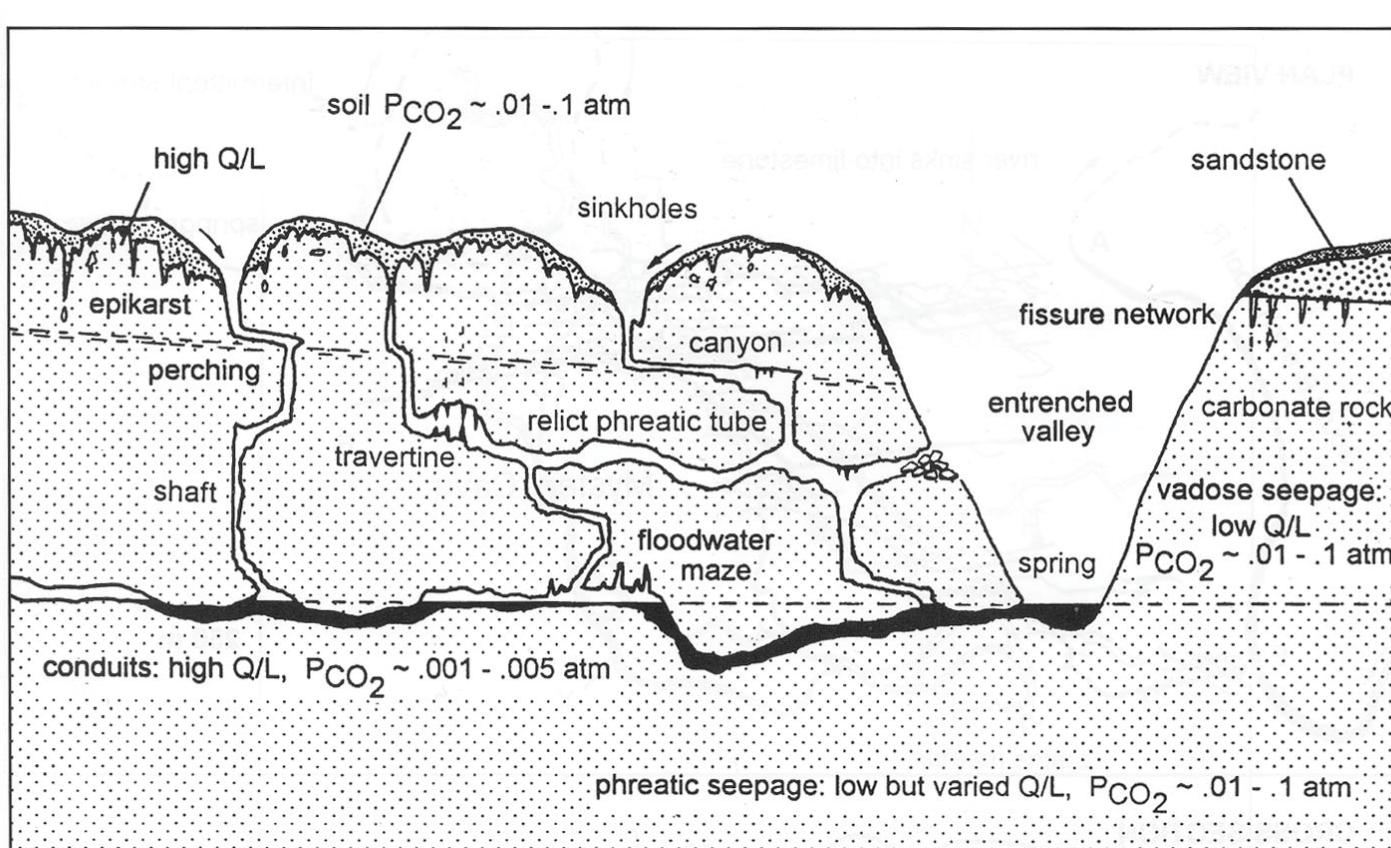
Soil and clay likely to occur in between breccia clasts decreasing reservoir quality



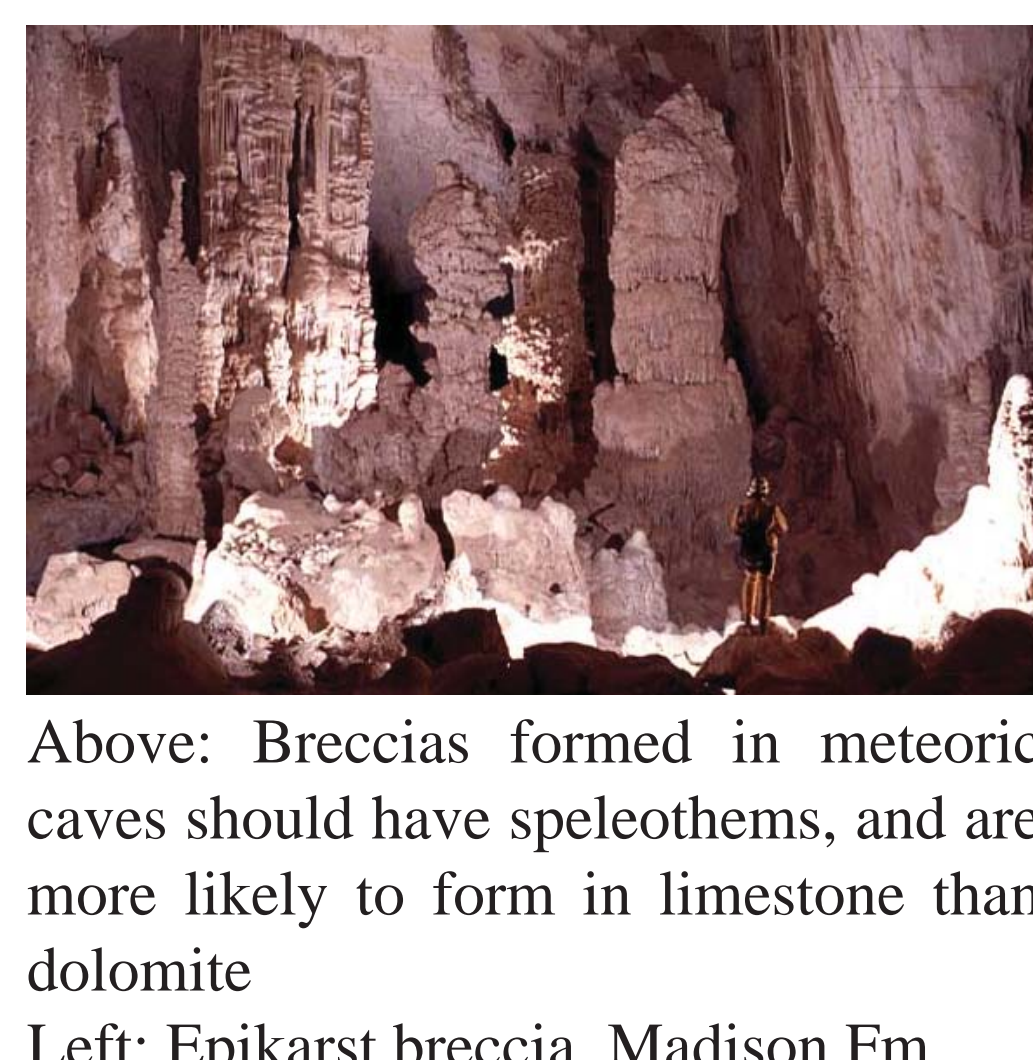
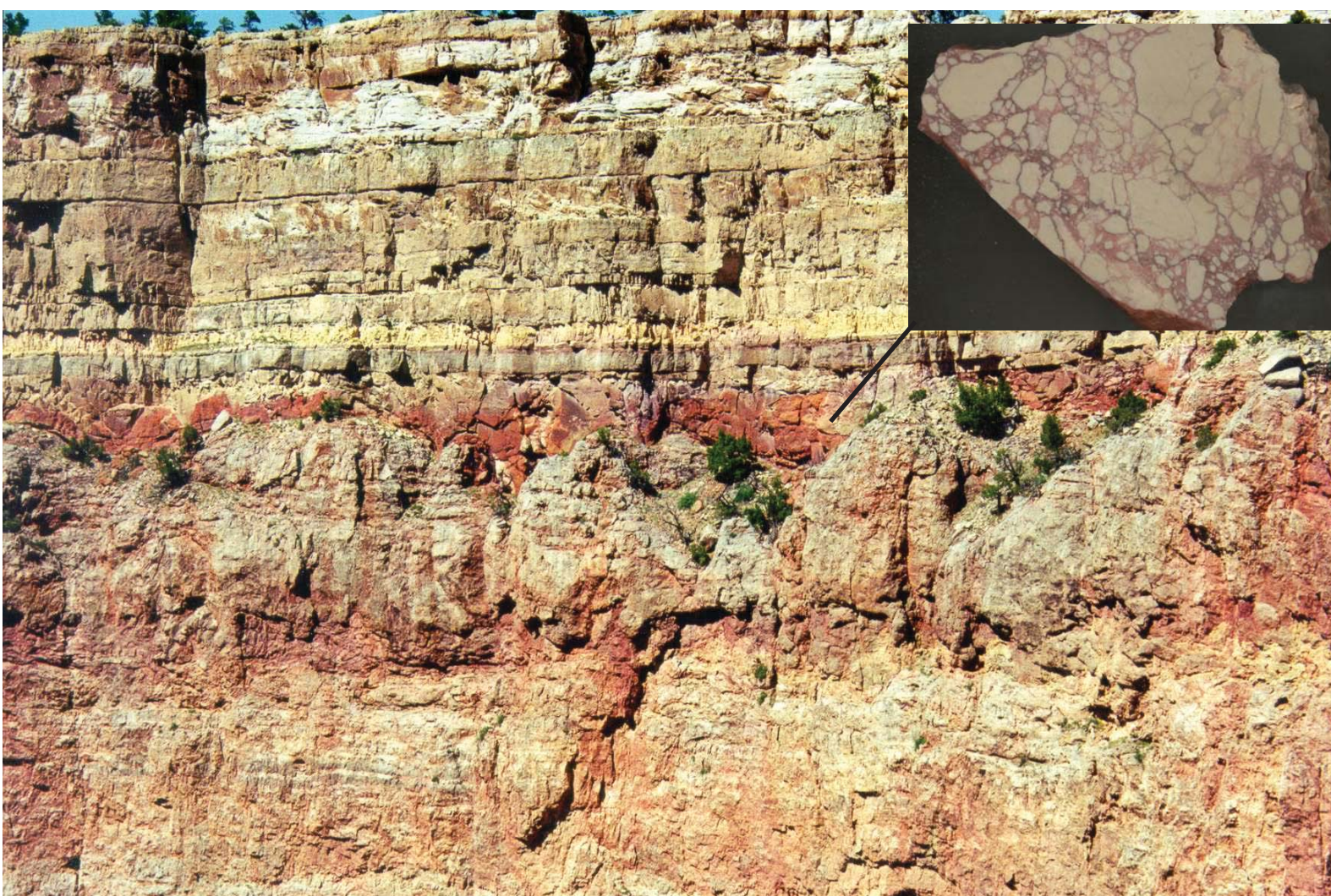
Loucks model for coalesced collapsed caves (1999) - Many caves form near each other and collapse to create massive brecciation followed by deep burial and cementation with saddle dolomite and other high-T minerals (porosity up to 50% remains open until then) - faults stop at cave level



Seismic data from Hardage et al (1995). Seismic line (left) shows interpreted collapsed caves in Ellenburger. Collapse is thought to affect strata up into the Pennsylvanian section. Map (above) shows three depressions picked on the top of the Pennsylvanian Caddo that are thought to have formed over collapsed caves in the Ellenburger.

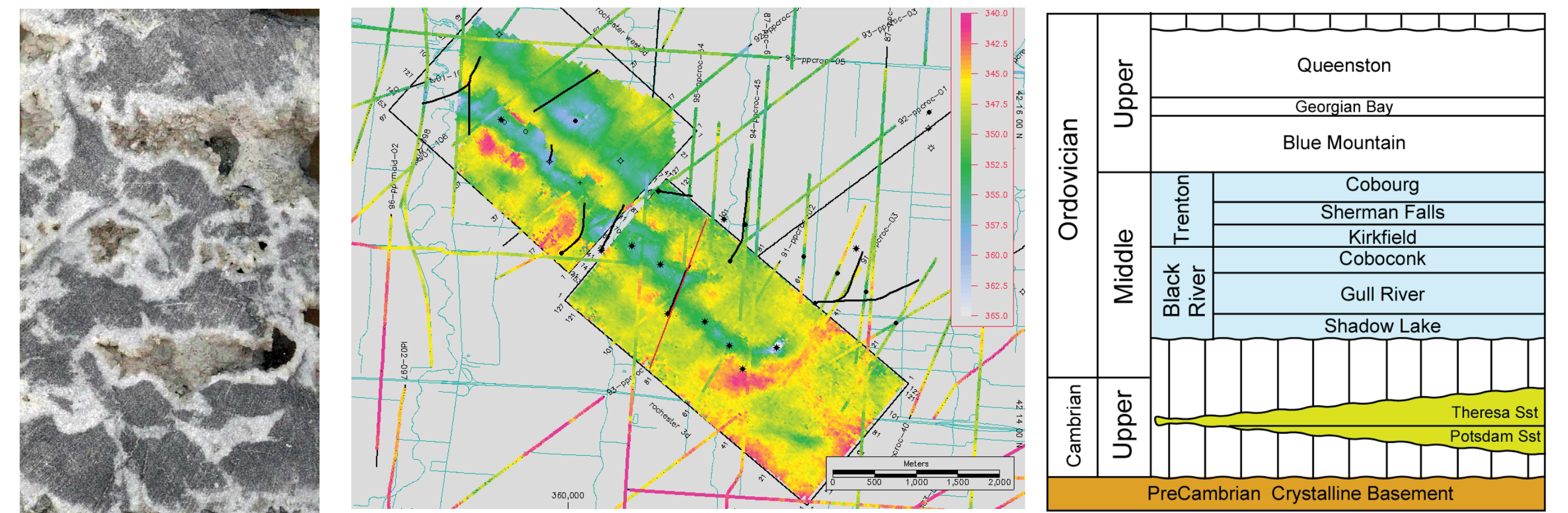


Epikarst forms on and just below exposed surface - generally has poor reservoir characteristics. Penetrative karst forms down to and just below water table - it will not form much below the level of nearby surface discharge. Incised valleys should occur where paleocaves are interpreted.

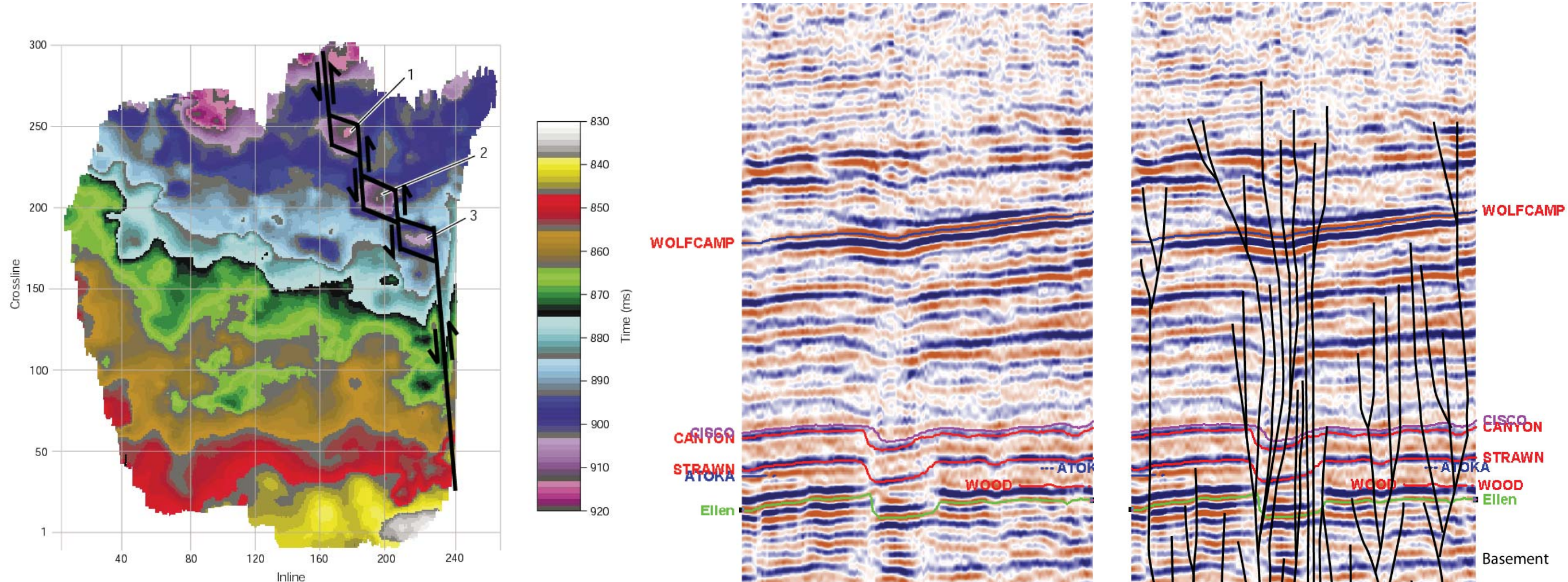


Above: Breccias formed in meteoric caves should have speleothems, and are more likely to form in limestone than dolomite
Left: Epikarst breccia, Madison Fm

New Paradigm: Transtensional Faulting, Hydrothermal Fluid Flow

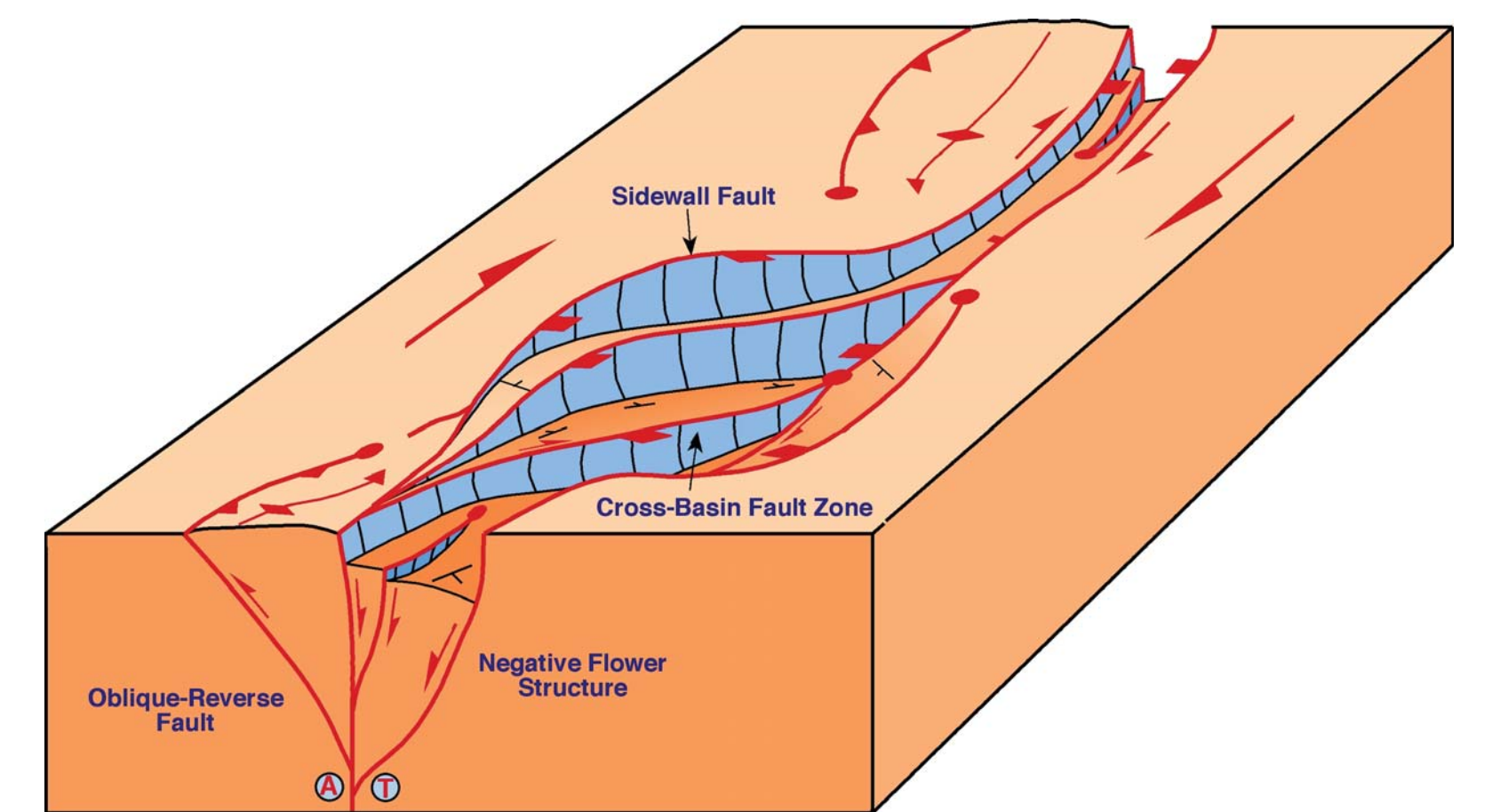
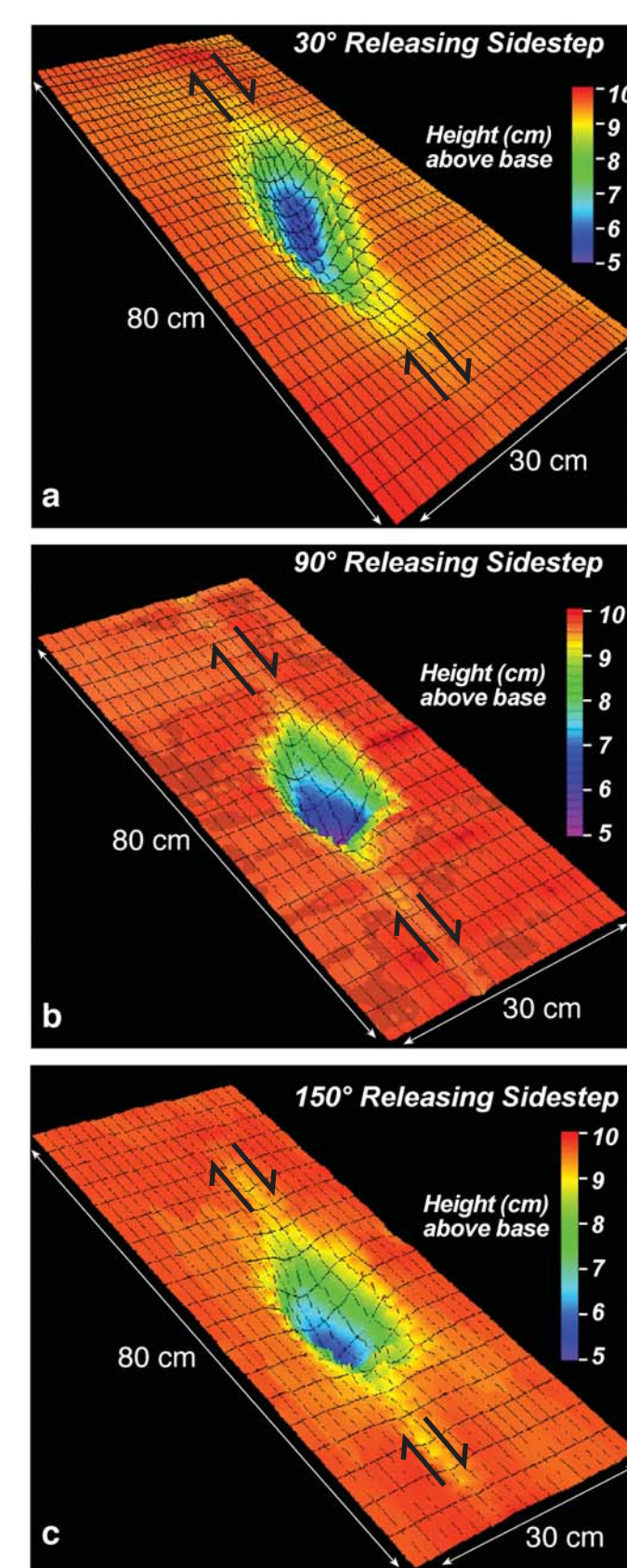


Loucks (2003) suggested that brecciated dolomite (above left) in the Trenton Black River sags may have formed due to collapse into caves in the underlying Beekmantown - In the place where the sags (above left) form in Ontario, the Beekmantown is absent (above center) so Loucks' model is not applicable. Seismic data also shows little vertical offset in Beekmantown in most cases (see Poster 2)



Hardage et al (1995) stated that the "karst" appeared to overlie a strike-slip fault system - Features might be better described as pull-aparts produced by faulting alone rather than karst - these features are probably too big to be collapsed caves

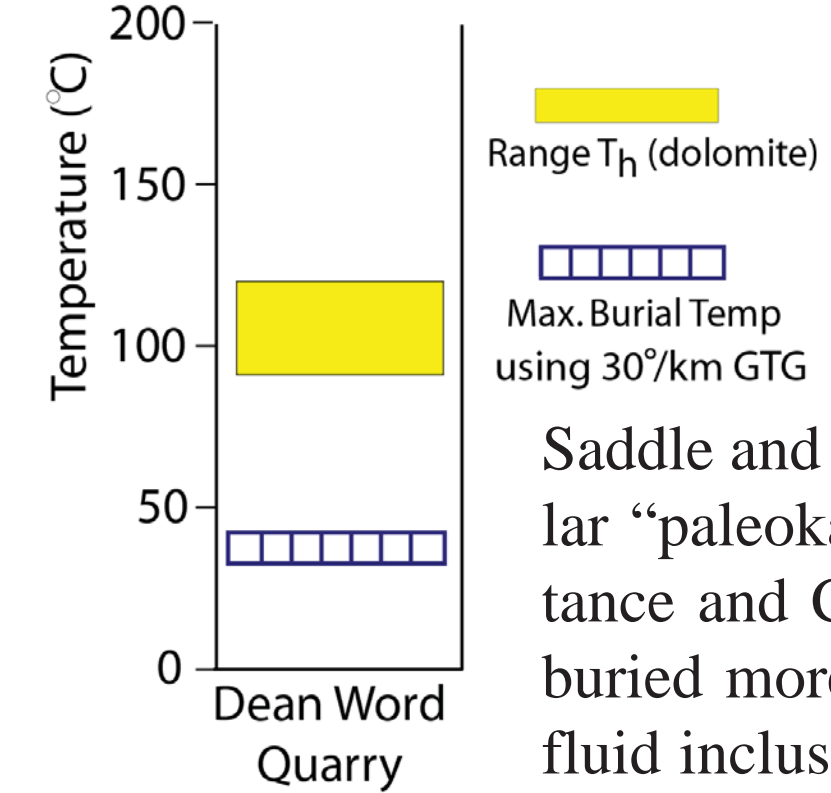
Uninterpreted and interpreted line of feature thought to be a collapsed cave in Ellenburger - The sag clearly extends into the basement and is fault-controlled - no thinning in Ellenburger (lines courtesy of Paul Lake)



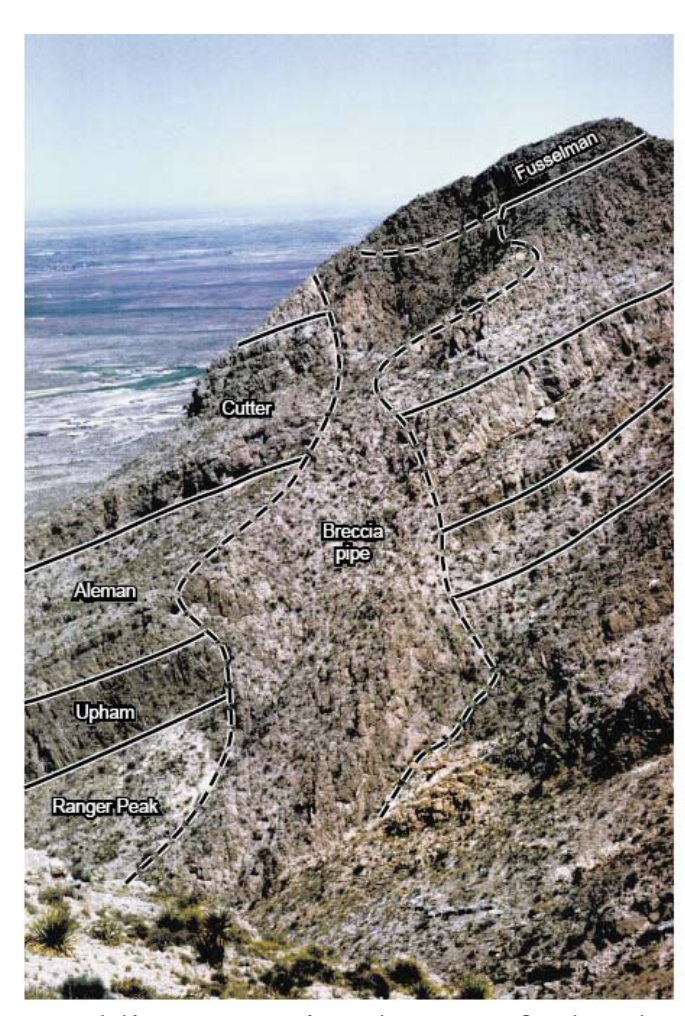
Sags produced by strike slip faulting can range from near circular to elongated linear structures. There is no dissolution of any kind required to make these features - they are also scale independent and can range from a few mm to tens of kilometers in width (both figures from Dooley and McClay, 1997)

Table 8: EF-2, Marble Falls Quarry		
Population	Th ag (°C)	Sal (wt%)
pr: outer clear dol A	95-105 (6)	20.2-21.0
pr: outer clear dol B	95-100 (4)	21.0-21.7
pr: outermost clr dol C	110-120 (4)	21.7-22.4
pr: core/rim dol D	100-105 (4)	20.2-21.0
pr: outer clear dol E	91 (1)	20.2
pr: outer clear dol F	90-100 (7)	21.0-21.7
pr: outermost clr dol G	119 (1)	22.4
pr: outermost clr dol H	110-120 (7)	21.0-21.7
pr: core saddle dol I	100-110 (5)	21.7-22.4
pr: core saddle dol J	105-110 (3)	21.7

Ellenburger Group Dolomite, Marble Falls TX

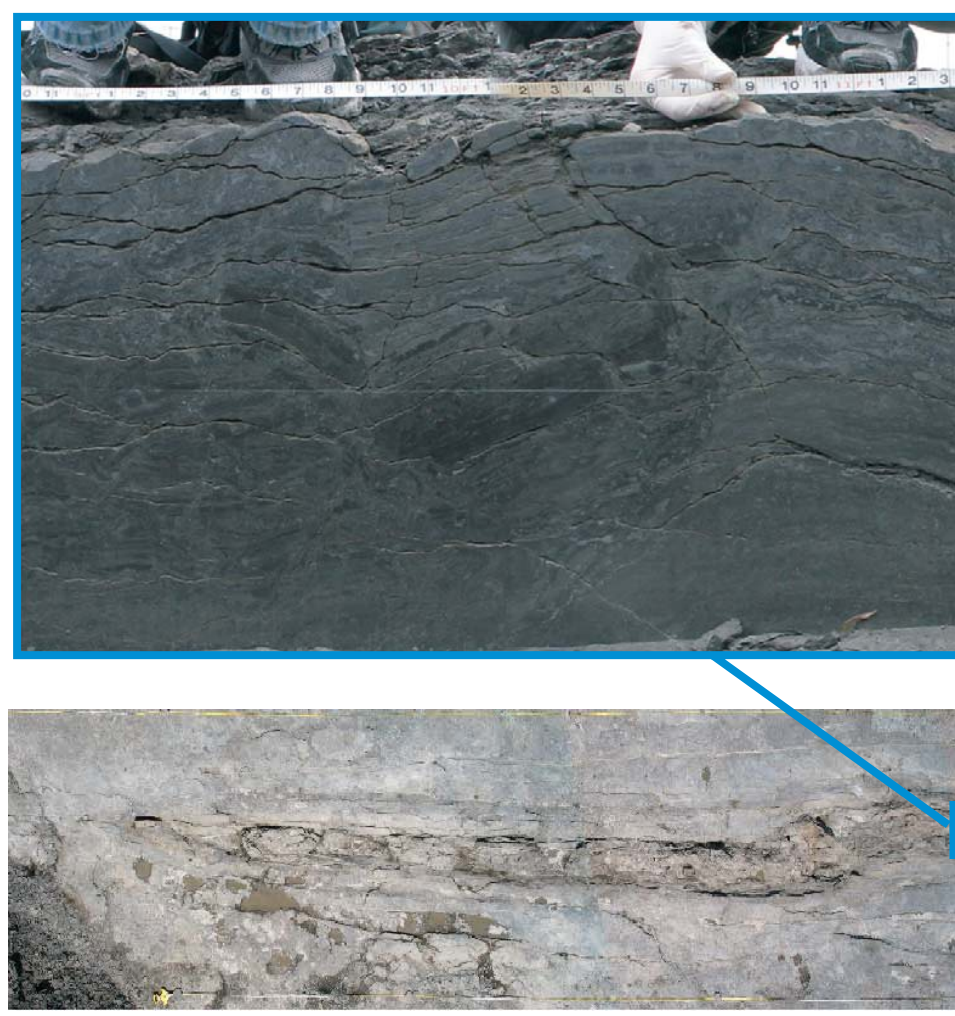


Saddle and some matrix dolomite from Ellenburger in Marble Falls, TX where popular "paleokarst" field trips are run are unequivocally hydrothermal. Vitrinite reflectance and CAI data from the Barnett Shale suggest that the Ellenburger was never buried more than 350m and never saw temps above 45C here. Primary two-phase fluid inclusions abundant in the dolomites and have consistent homogenization temperatures of 90-120C. Breccias likely to be fault-related with little karst influence.



Franklin Mountains: karst or fault related?

	Karst Cave Collapse	Fault-Related Hydrothermal
Matrix Composition	Oxidized clay, soil or siliciclastics	Saddle dolomite, calcite, sulfides, sulfates, other mineral cements
Speleothems	Yes	No
Host rock	Almost always limestone	Dolomite or limestone (very commonly dolomite)
Incised valleys	Yes	No
Width	Cm to 10s of meters 99% of caves <10m	mm to km
Overlying unconformity	Essential	Possible, not essential



Similar Breccias found in outcrop analog for Trenton Black River hydrothermal dolomite reservoirs -mainly at tips and in central sag portion of outcrop feature

