Upwelling as a Control on Regional Distribution of Heterozoan and Photozoan Carbonate Facies in a Low-latitude Setting, Lower Mississippian, Continental U.S.

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KANSAS GEOLOGICAL SURVEY

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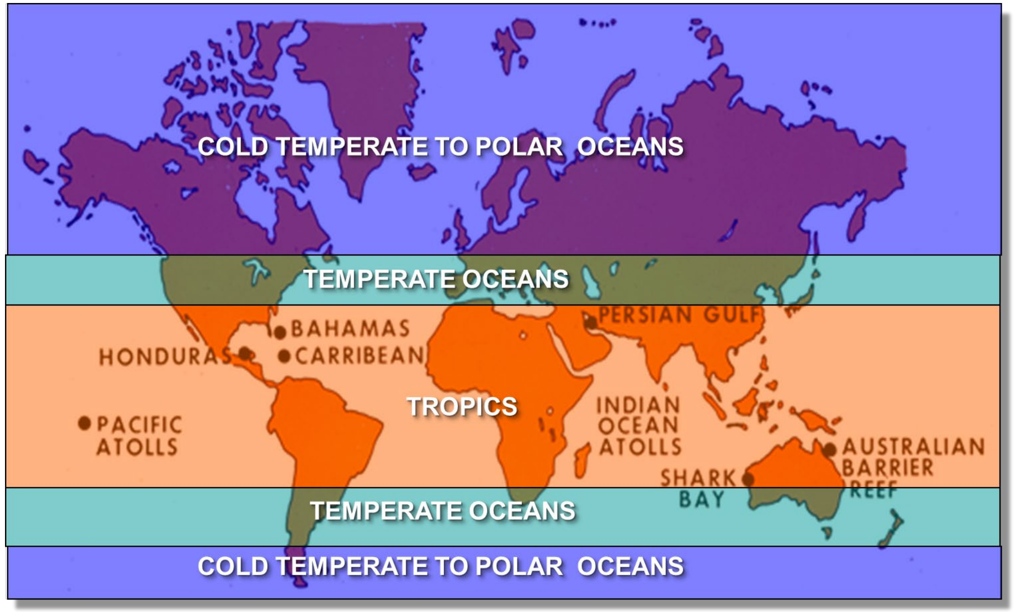
Kansas Interdisciplinary Consortium on Earth Energy and Environment

Significance

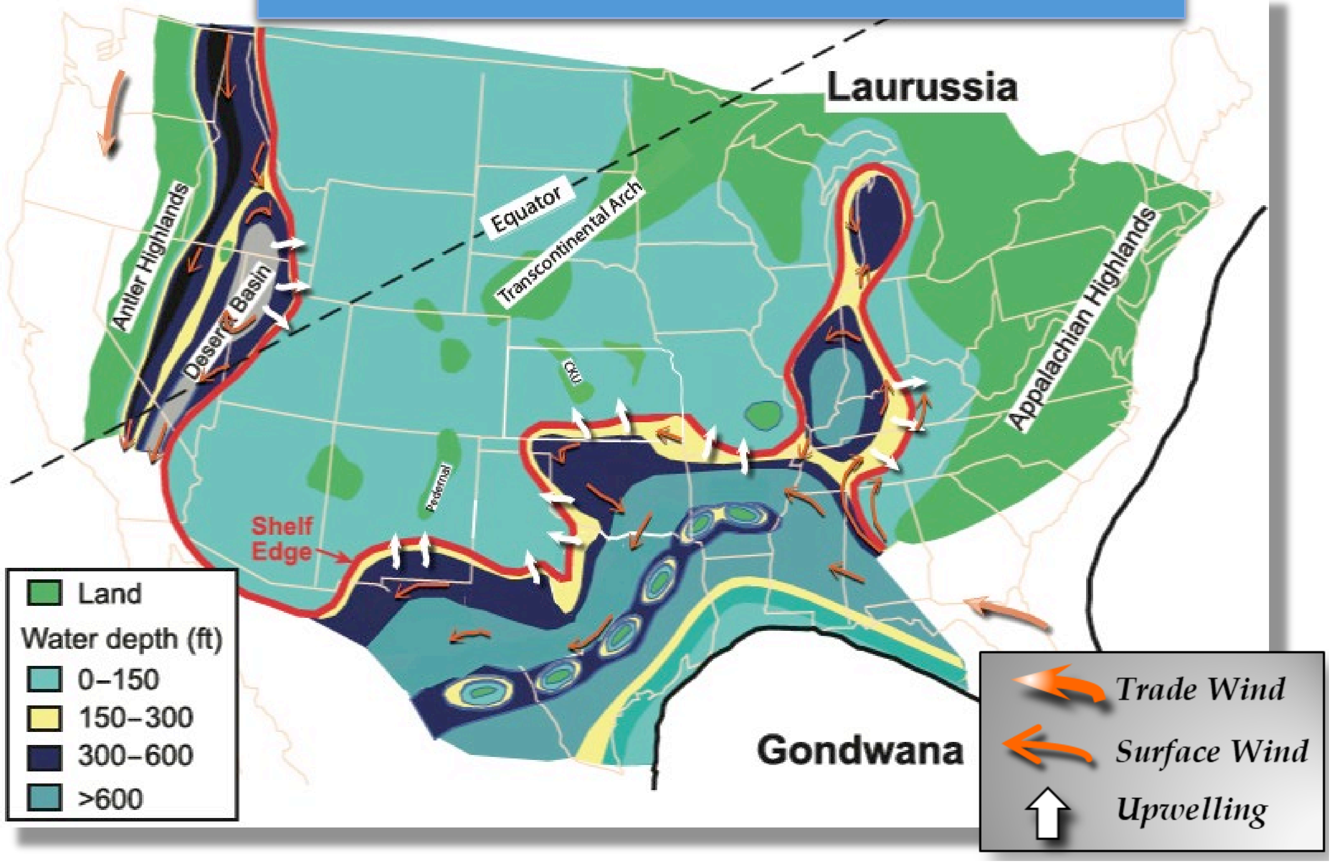
- Lower Mississippian carbonates in continental U.S. developed in low-latitude shallow-water areas affected by **adverse photic-zone conditions**
  - These type of systems are increasingly being recognized in the rock record and can form important petroleum reservoirs
    - … are still not well understood
  - can be characterized by complex associations and distributions of photozoan and heterozoan components
    - can significantly impact reservoir character
- Provides an opportunity to ID local-to-regional shallow-water facies distribution patterns to aid in:
  - determining controls on deposition
  - prediction of reservoir character

In low-latitude areas, photozoan association carbonates are common in shallow water

Areas of modern carbonate deposition



Early Mississippian Paleogeography
Low Latitude

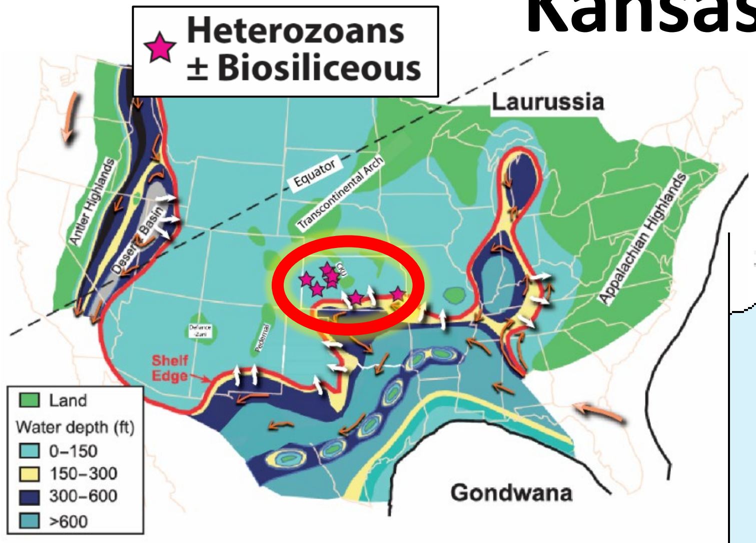


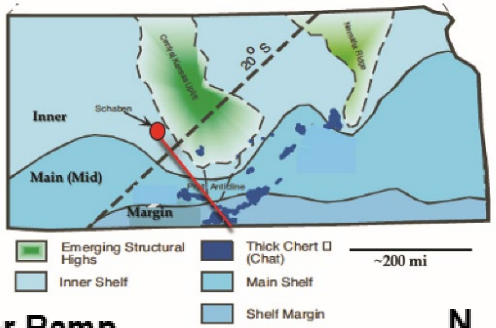
Lowe, 1975; Lane & DeKeyser, 1980; Parrish, 1982; Gutschick & Sandberg, 1983

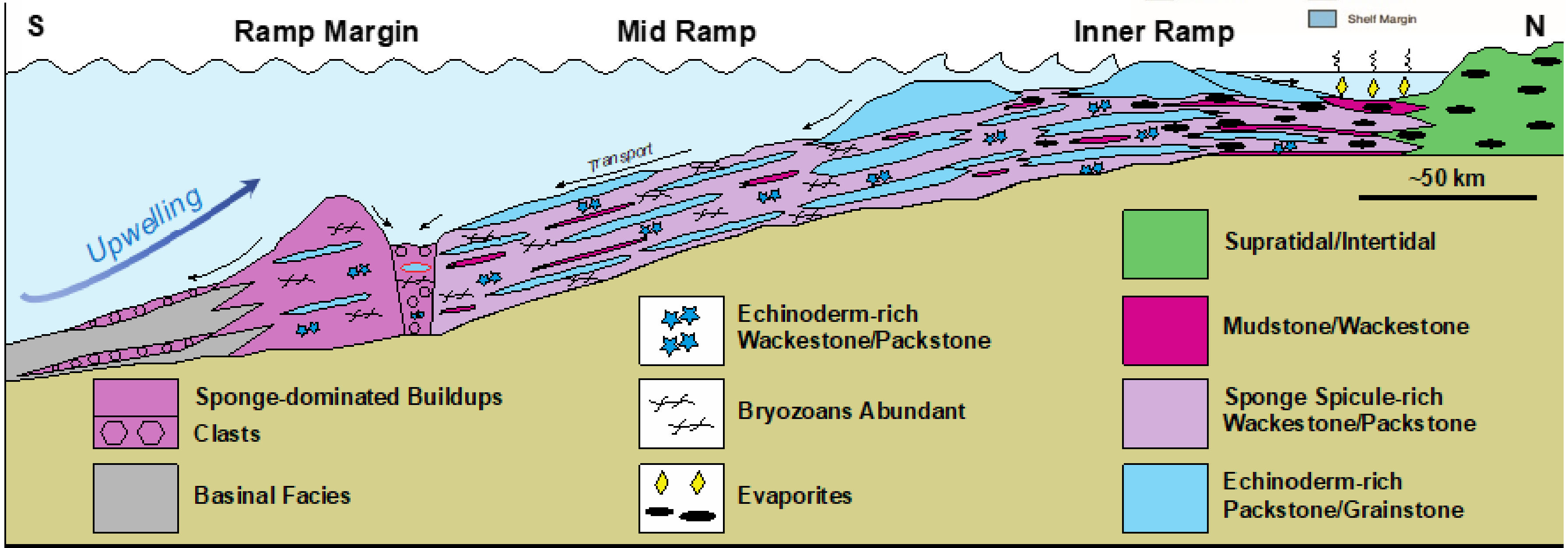
Photozoans – organisms that are either photosynthetic or are zooxanthelate, with symbiotic photosynthetic organisms

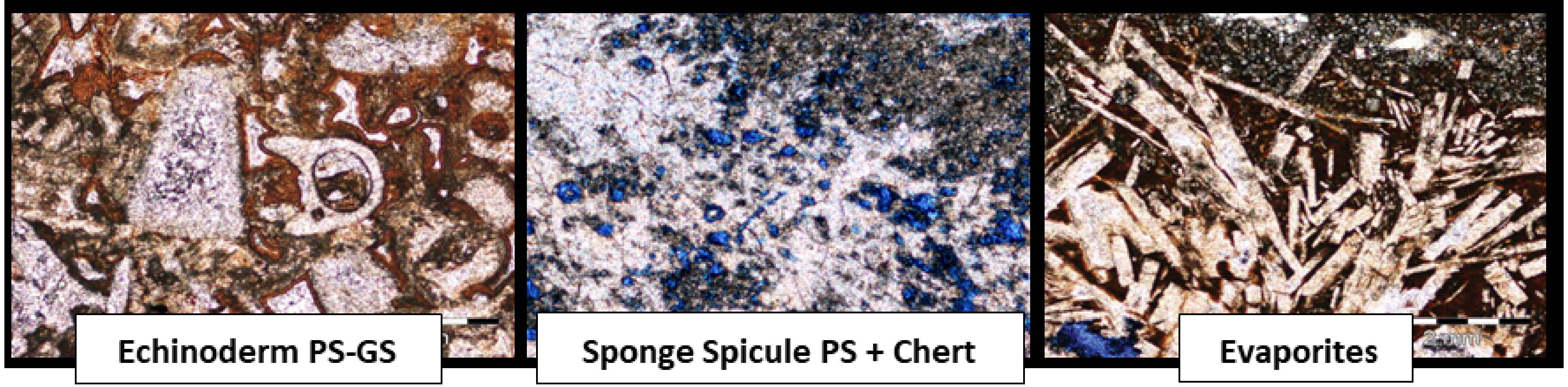
Heterozoans – organisms are non-photosynthetic & lack photosynthetic symbionts (light independent)

Kansas Region Bordering Anadarko Basin





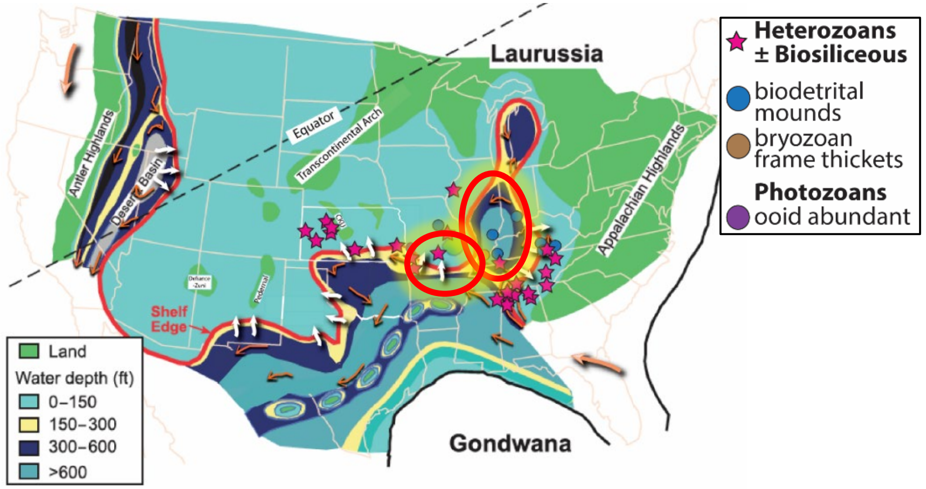




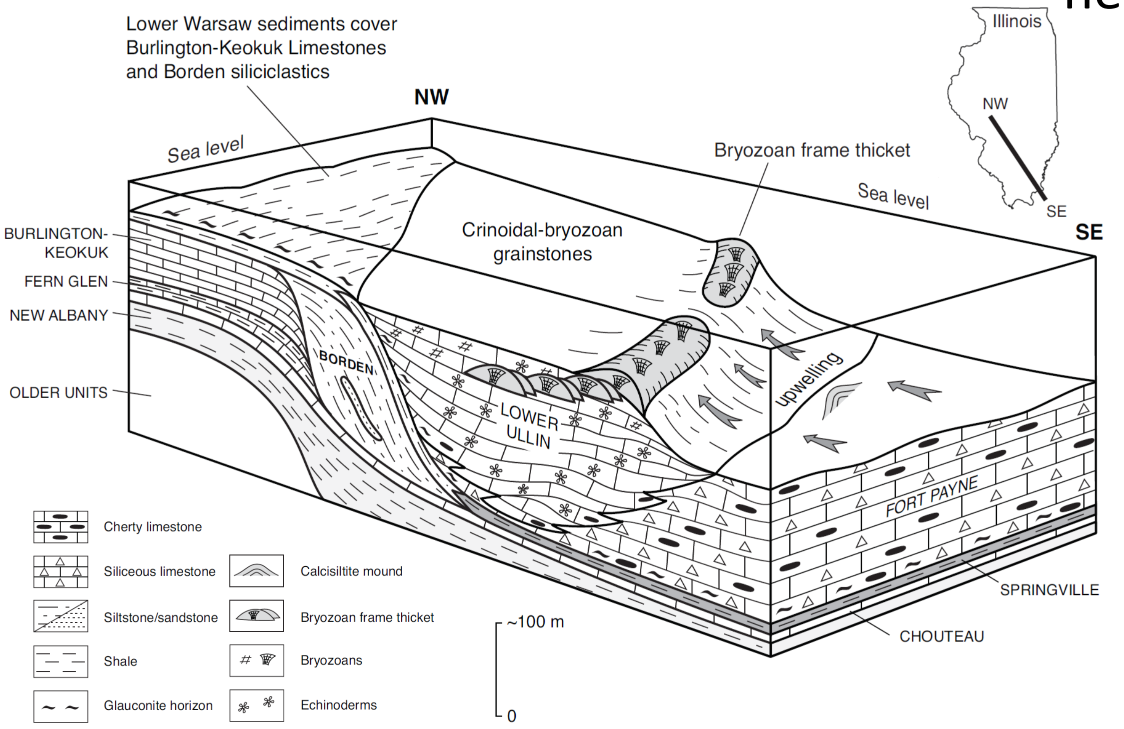
- Distally steepened Osagean ramp
- Dominantly composed of heterozoans including echinoderms, siliceous sponge spicules, bryozoans and evaporites (inner ramp)
- Silica in the form of chert is generally abundant
- Inner ramp areas lack photozoans

Franseen, 2006; Watney et al., 2001; Ramaker et al., 2015; Ortega-Ariza and Franseen, 2021

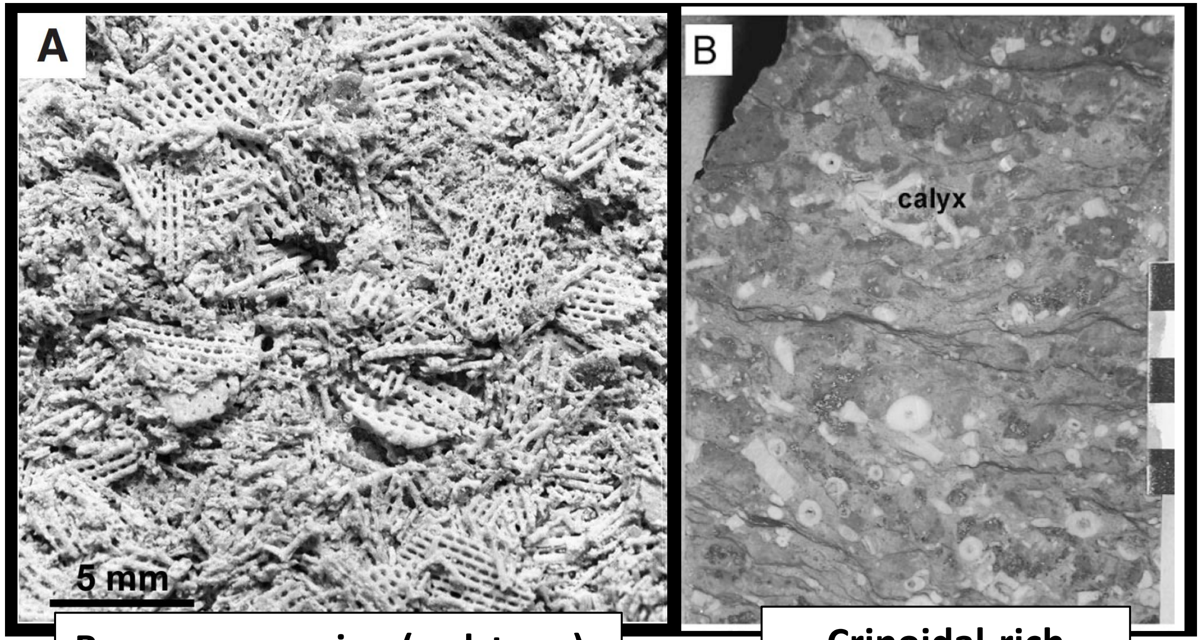
Arkoma and Illinois Basins



- Osagean ramp
- Crinoid-bryozoan biodetrital mounds are common in the basin and basin-margin areas, as well as shallower-water ramp areas and the character stay the same even into the shallow waters
- Mounds occur in shallow waters, associated with more heterozoan grainy facies



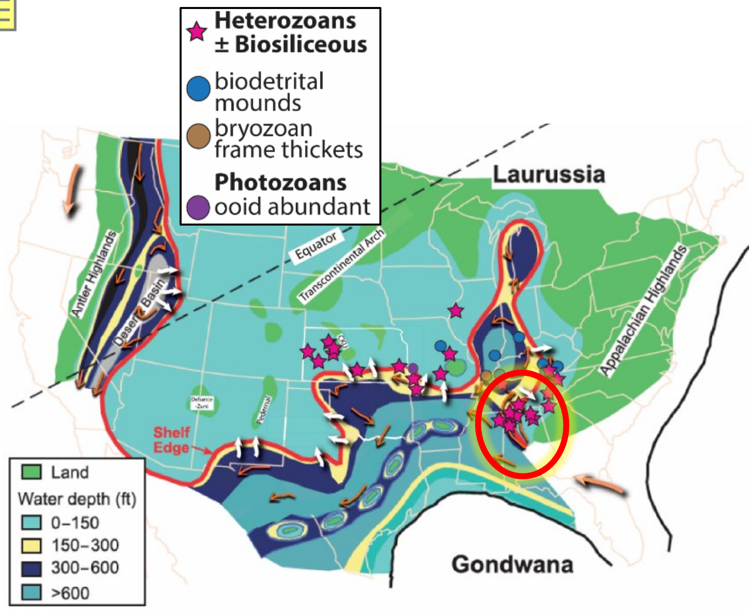
e.g., Lasemi et al., 2003; Krause and Meyer, 2004



Bryozoan coquina (rudstone)

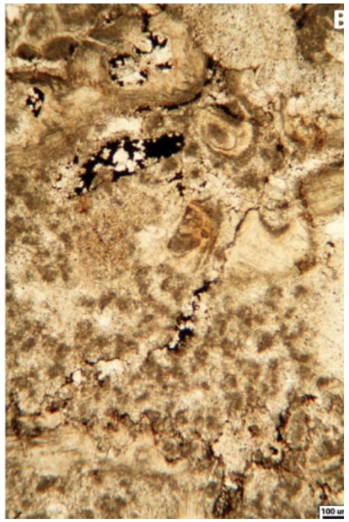
Crinoidal-rich shaly packstone

Southern Appalachians

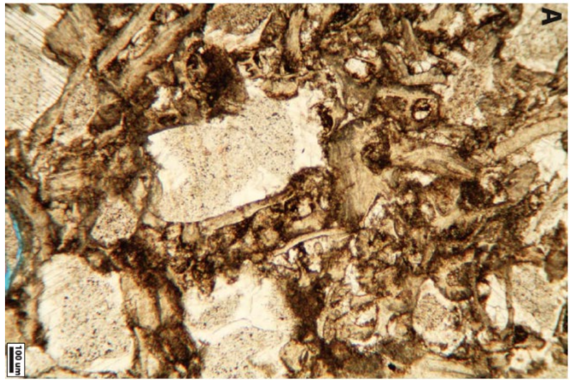


- Distally steepened ramp, Osagean-early Meramecian
- Heterozoans: bryozoans, echinoderms, brachiopods + siliceous sponge spicules, solitary rugose corals (inner ramp)
- Silica in the form of chert is generally abundant
- Small sponge-microbial mound (not Waulsortian), shallow, photic zone, inner mid-ramp

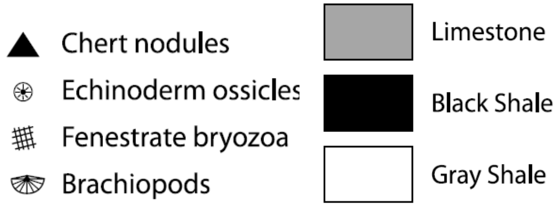
Silicified microbially bound spiculite

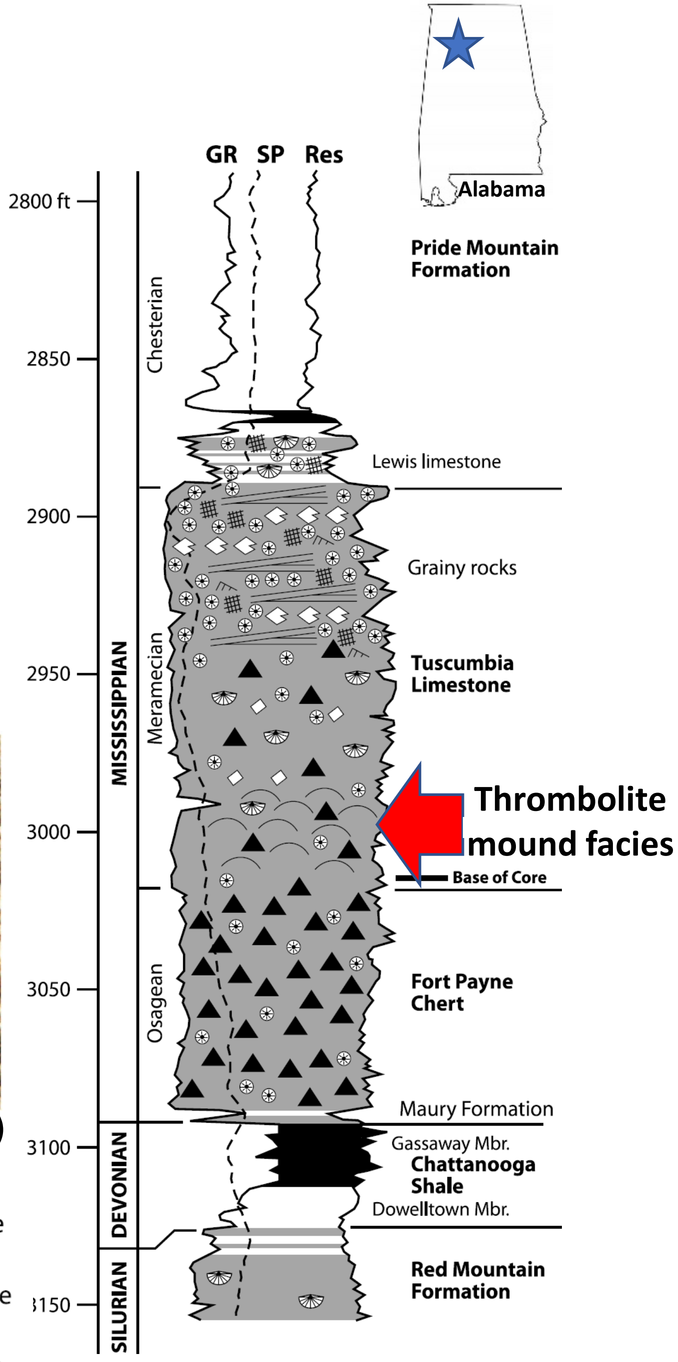


Micropelletal thrombolite binding skeletal debris



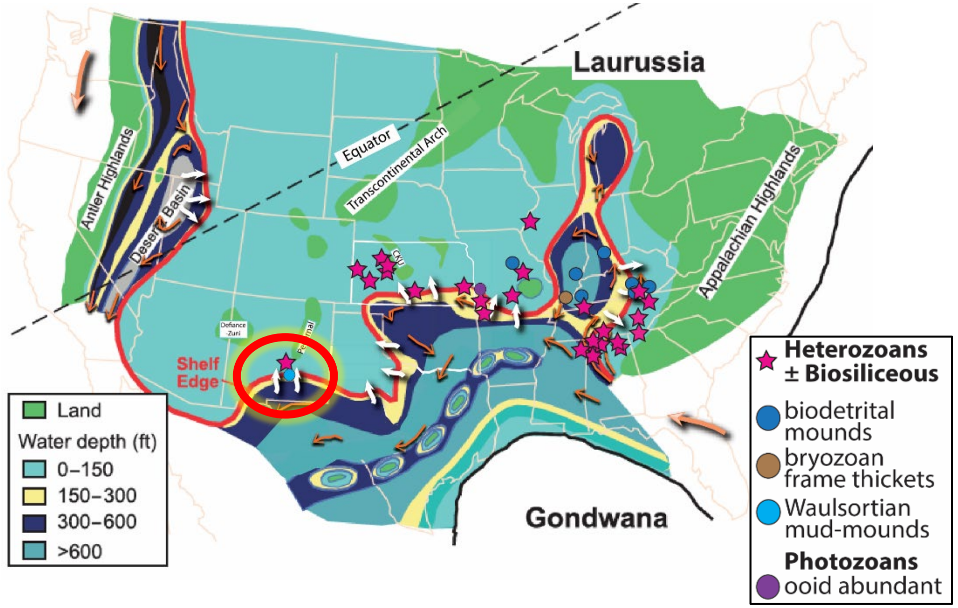
Fenestrate pack-grainstone (echinoderms)



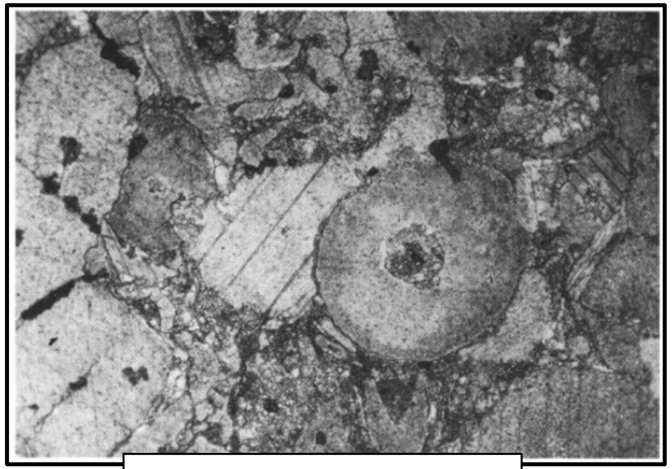


e.g., Kopaska-Merkel et al., 2013

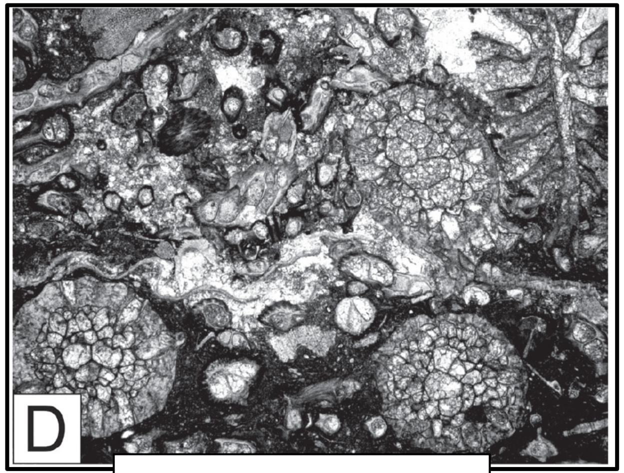
Sacramento and San Andres Mountains, NM



- Osagean ramp system
- Dominantly composed of heterozoans: mainly crinoids and bryozoans; brachiopods, minor horn corals
- Basin margin Waulsortian mounds common

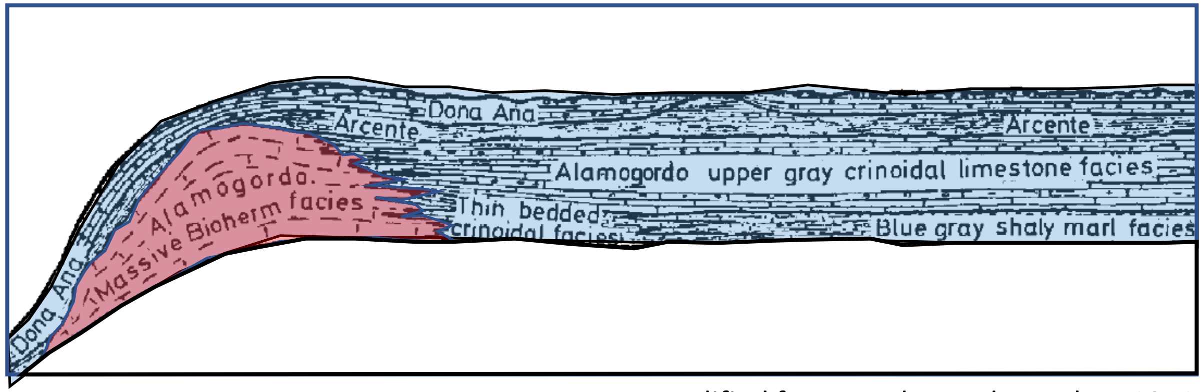


Crinoidal grainstone



Bryozoan rudstone

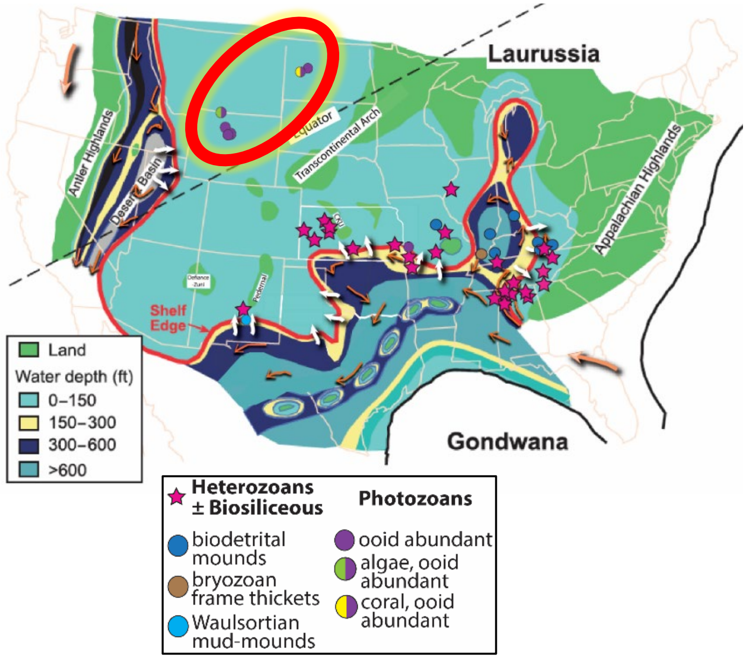
Lake Valley ramp in San Andres Mountains



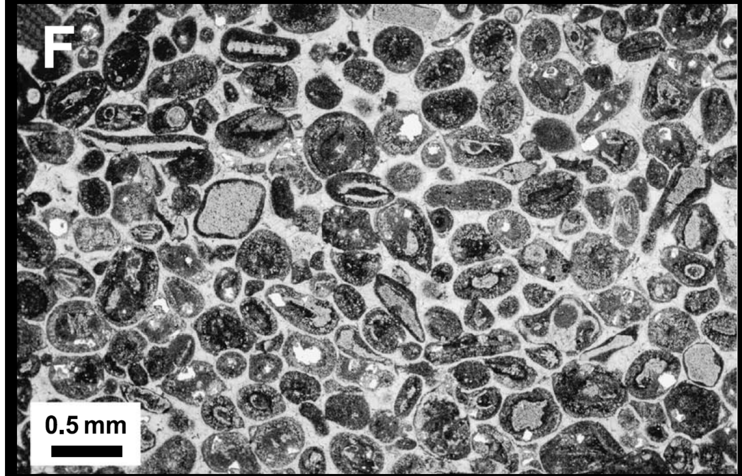
Modified from Laudon and Bowsher, 1941

e.g., Kirkby and Hunt, 1996; Ahr, 1989; Bachtel & Dorobek, 1998

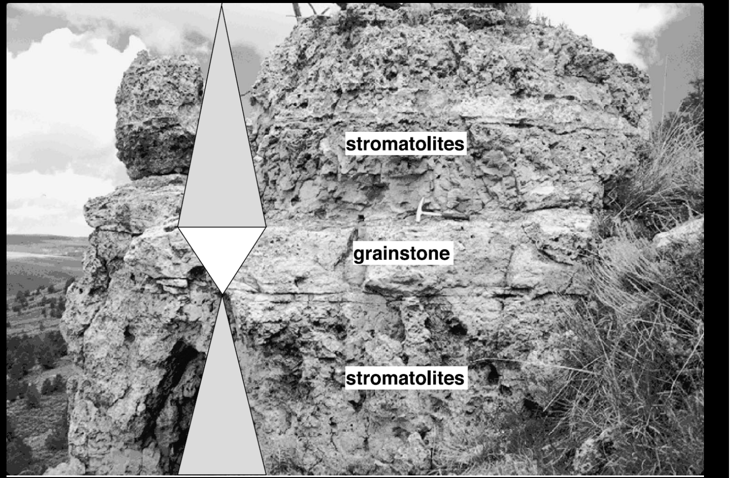
West and North of the Transcontinental Arch



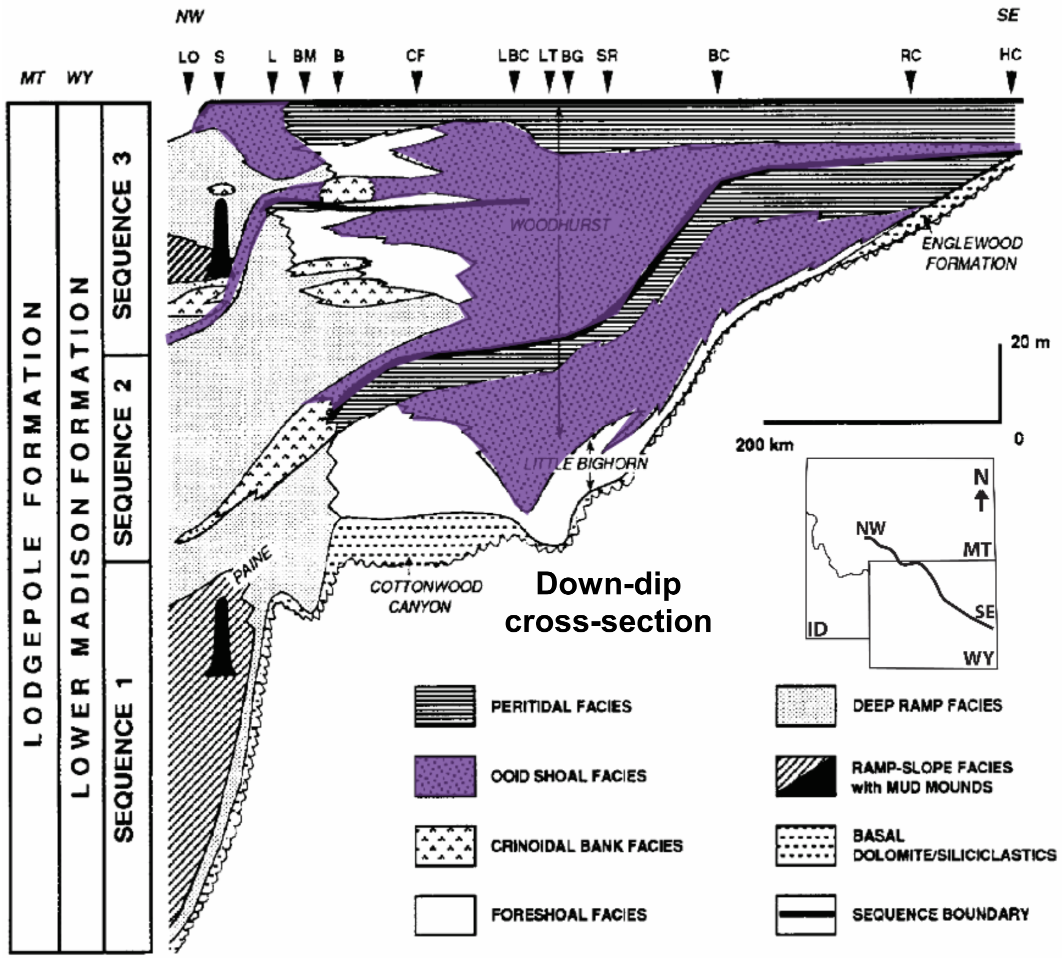
- Osagean shallow pericratonic ramp composed of photozoans and heterozoans; Williston basin
- Inner-ramp photozoan components include: abundant ooids; stromatolites, benthic forams, dasycladacean and phylloid algae, and corals
- Heterozoan components include: abundant crinoids and brachiopods; bryozoans, molluscs
- Local ramp-slope Waulsortian-type mud mounds



Skeletal ooid grainstone

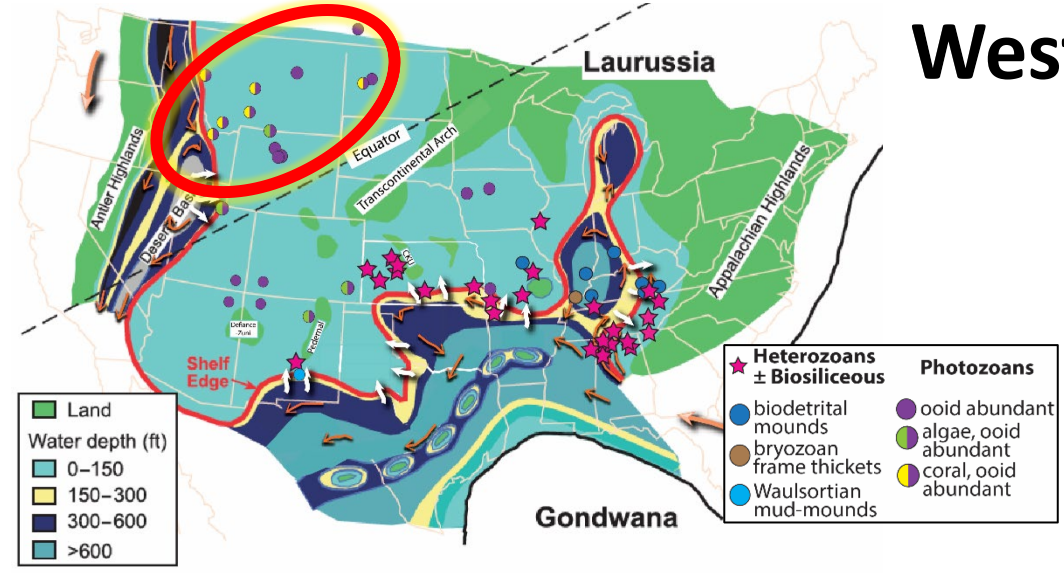


Stromatolites



e.g., Lindsay and Roth, 1982; Vice and Utgaard, 1989; Elrick and Read, 1991; Westphal et al., 2004

Other ooid-rich and ooid- & coral-rich locations



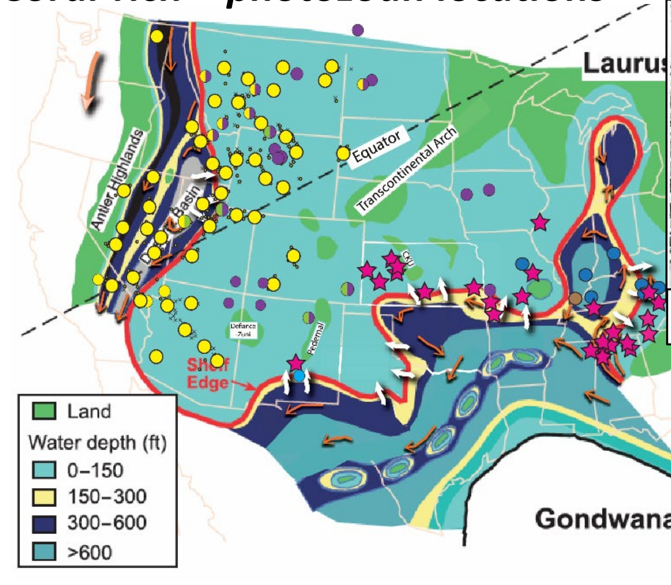
West and North of the Transcontinental Arch

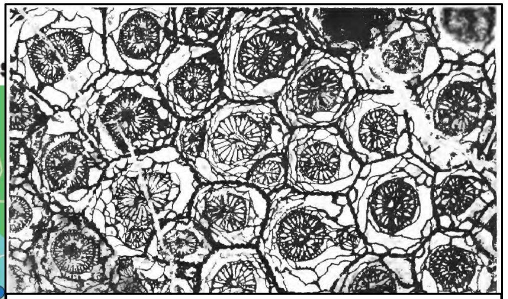
Corals:

- Deep- and very shallow-water corals, tropical shelf
- Rugosa (colonial and solitary), Tabulate
- Osagean-Meramecian corals **predominantly lived in shallow-water environments**

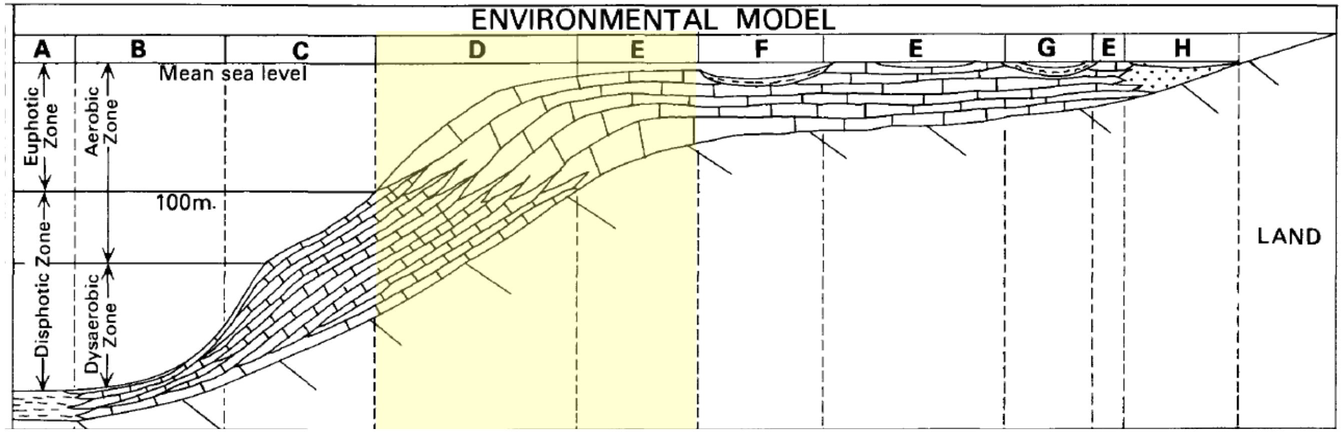
Lithofacies (D & E, shallow-water basinal and shelf, euphotic, subtidal to supratidal, **mostly <50 m deep**): corals + common ooids, benthic forams, benthic red, green, and blue-green calcareous algae, stromatolites

Coral-rich + photozoan locations





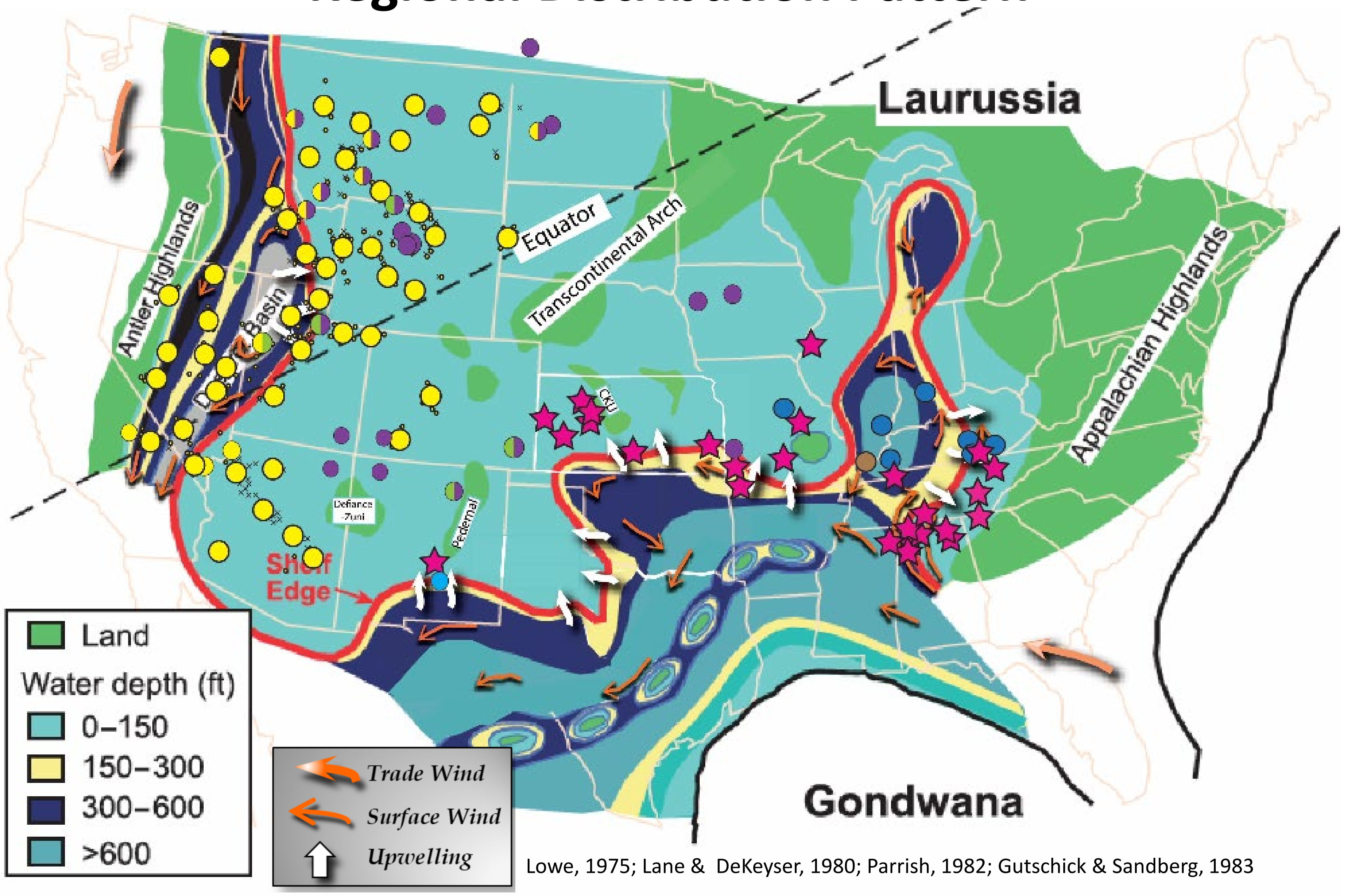
Coral colony example from Wyoming



Sando, 1980; Sando and Bamber, 1985

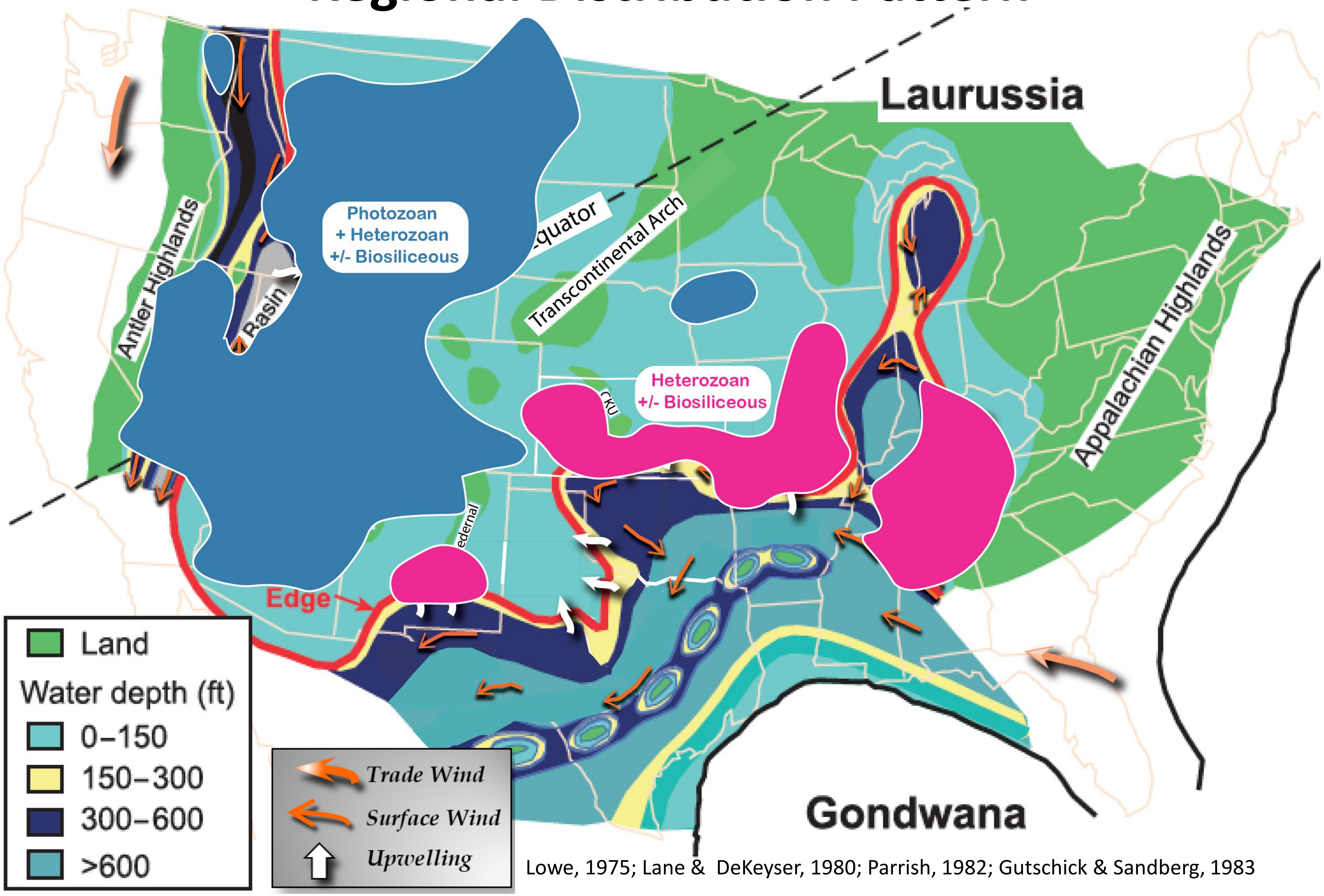
e.g., NM: Armstrong and Holcomb (1989); MT: Buoniconti (2008); UT: Nichols and Silberling (1991); CO: Ramirez (1973); Canada: Rott and Qing (2013); IA: Brenckle and Groves (1986)

Regional Distribution Pattern



Lowe, 1975; Lane & DeKeyser, 1980; Parrish, 1982; Gutschick & Sandberg, 1983

Regional Distribution Pattern



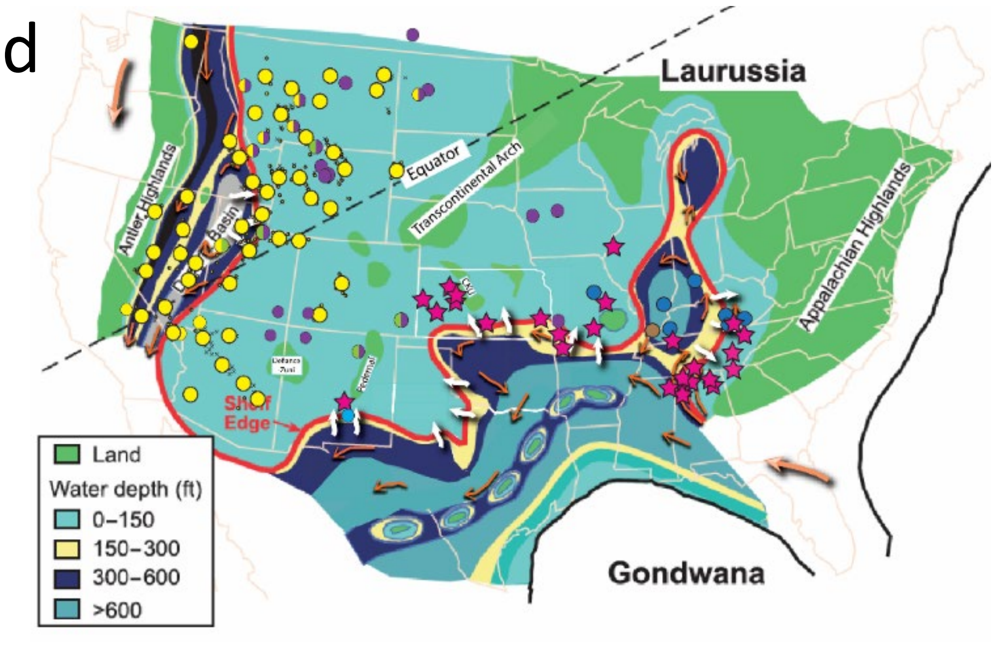
Lowe, 1975; Lane & DeKeyser, 1980; Parrish, 1982; Gutschick & Sandberg, 1983

Concluding Remarks

- Lower Mississippian shallow-water ramp carbonates developed in a low-latitude (tropical) setting throughout the U.S. and show distinct regional facies composition patterns.

- Areas bordering the Anadarko, Arkoma and Illinois basins, and New Mexico and southern Appalachians are dominated by **heterozoan components (± siliceous sponges).**
  - Photozoan components are lacking.

- Areas W, N, NW of (TA) show **significant abundances of photozoan components.**



Concluding Remarks

- Distribution patterns support **documented basinal upwelling S of TA** as a process delivering nutrients, silica, cooler water to shallowest-water ramp environments, thereby creating conditions that hindered development of photozoans.

- Documenting facies distributions on regional scales can aid in determining controls on systems.

- Photozoan and heterozoan systems can have significantly different reservoir character.

    - Understanding controls on facies distribution provides predictive capability.