Stone City Member, Middle Eocene, Claiborne Group,
Stone City Bluff , Burleson Co., Texas
Main Glauconite Bed (MGB) Study Guide

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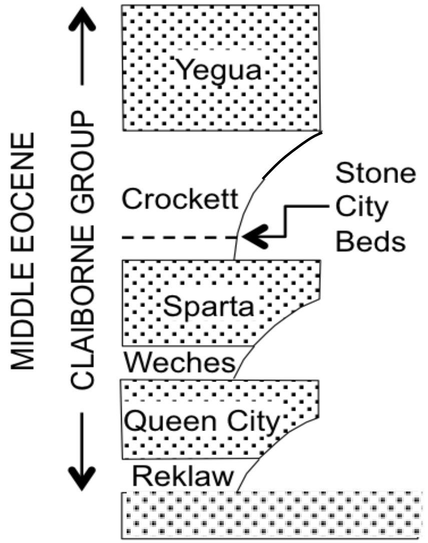
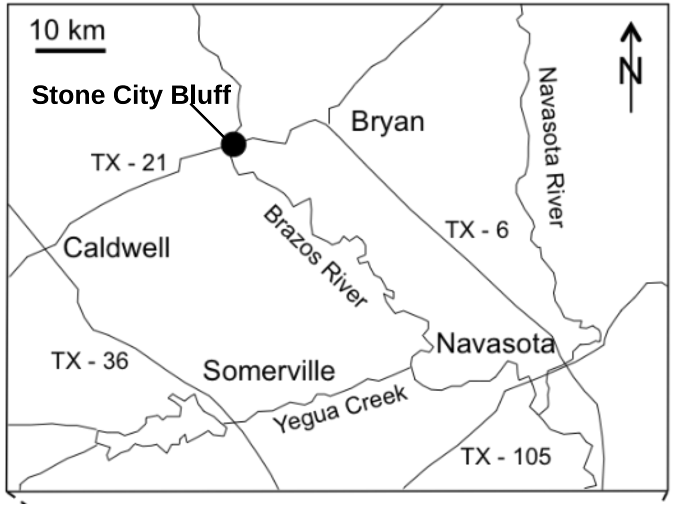
Main Glauconite Bed (MGB) Study Guide
Introduction:

The Stone City Bluff is a special location on the Texas Gulf Coast Plain. It is the best of relatively few places where marine rocks of Paleogene age are exposed and available for public access. This access provides a window into Middle Eocene rocks that were deposited in the Gulf of Mexico approximately 41.8 million years ago. Geologists study outcrops such as these to understand the environments of deposition and the processes controlling sediment deposition. Information gleaned from an outcrop can help in oil exploration, paleontology, understanding of ancient climate and groundwater hydrology. The objective of this Study Guide is to present a comprehensive summary of the Main Glauconite Bed (MGB) found at Stone City Bluff. This Bed contains a rich fossil fauna and lithology that has attracted explorers and researchers since the mid 1800's and research continues on this bed. It is hoped that with this Guide you, as an interested student, teacher or hobbiest can be part of that research. A bibliography of subject matter pertinent to the Stone City Bluff is attached with this Guide.

MGB Age and Location

- The Stone City Beds are a Middle Eocene age (41.8 million years old) geologic outcrop of the Crockett Formation, Claiborne Group. The outcrop is exposed in the bluff on the west bank of the Brazos River at Texas Route 21, 19 km (12 miles) west of Bryan, Texas.
- The bluff face is 15 meters (50 feet) high and is exposed east-west, 455 meters (1500 feet) along the rivers edge. Lower beds may be below water level.
- The Main Glauconite Bed (MGB) is one of many layers in the Stone City outcrop, but it contains the great majority of well preserved fossils found at Stone City Bluff.





Google Earth, 2012

MGB Historical

- The outcrop was first noted by Dr. Ferdinand Roemer in 1846 while on a expedition exploring the geology of Texas for the Academy of Sciences of Berlin.
- Francis Moore Jr. in 1859 provided the first taxonomic listing of MGB fossils found in the Bluff. His work identified the age as Middle Eocene.
- Dr. H.B.Stenzel of the Texas Bureau of Economic Geology first described the section in 1936 and published a detailed geologic description of the Bluff during the 1950's.
- Since then the Bluff has been extensively studied for its stratigraphy, sedimentology and paleontology, and visited by museums, other educational institutions and interested groups and individuals.
- This study guide will summarize the most recent insights and interpretations of the geology of the Main Glauconite Bed (MGB).

Source: Stenzel, H.B., E.K. Krause, and J.T.Twining, 1957

Stenzel et.al. 1957, Plate 1 with BEG permission

MGB Description

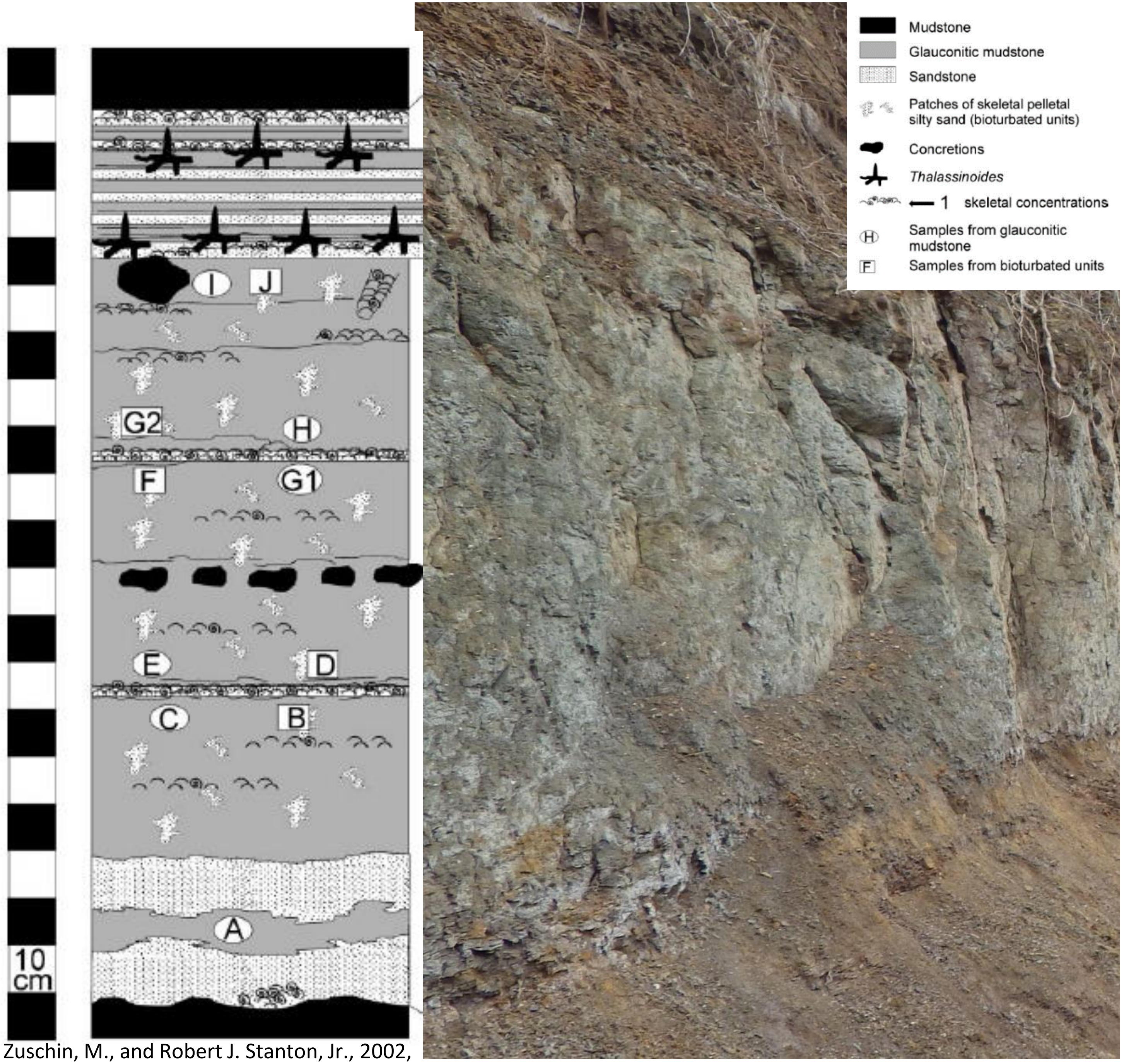
- The Bluff is conspicuous for its olive green mudstone and siltstone that Stenzel named the Main Glauconite Bed (MGB), although recent studies found it contains little glauconite.
- The MGB is a 1.7 meters (5.5 feet) thick strata identified by its green color and sharp base and irregular top which extends along the full length of the outcrop.
- The MGB mudstone has conjugate vertical joints. Large blocks of sediment spall off, forming steep vertical faces along the bed.
- The mudstone surface face is mottled and massive and from a distance does not appear to be internally layered. Recent work though shows some internal bedding.
- Recent detailed examination shows that the MGB is stratigraphically, mineralogically and depositionally complex.

Source: Yancey, T.E., 1995

MGB Sedimentology

- The lithology of the MGB is a mix of gray mudstone, greenish mudstone and siltstone that was deposited in a marine environment and subsequently burrowed and mixed by benthic animals.
- Examination of the MGB reveals sediment variability that results from varying depositional processes present on the marine sea floor. The details of the MGB are shown schematically by a vertical stratigraphic column.
- There are three main lithologies: green mudstone, bioturbated sediment and skeletal concentrations.
- The 3 lithologies are distinctive enough that they can be mapped and identified throughout the MGB. There is subtle layering, presence of erosional surfaces and scours, bioclastic shell layers, and shell patches, that relate to the depositional processes that produced them.
- After burial, the rock was subjected to chemical and physical alterations which are manifested in concretionary burrow fill clustered near the top of the MGB, forming a resistant ledge.

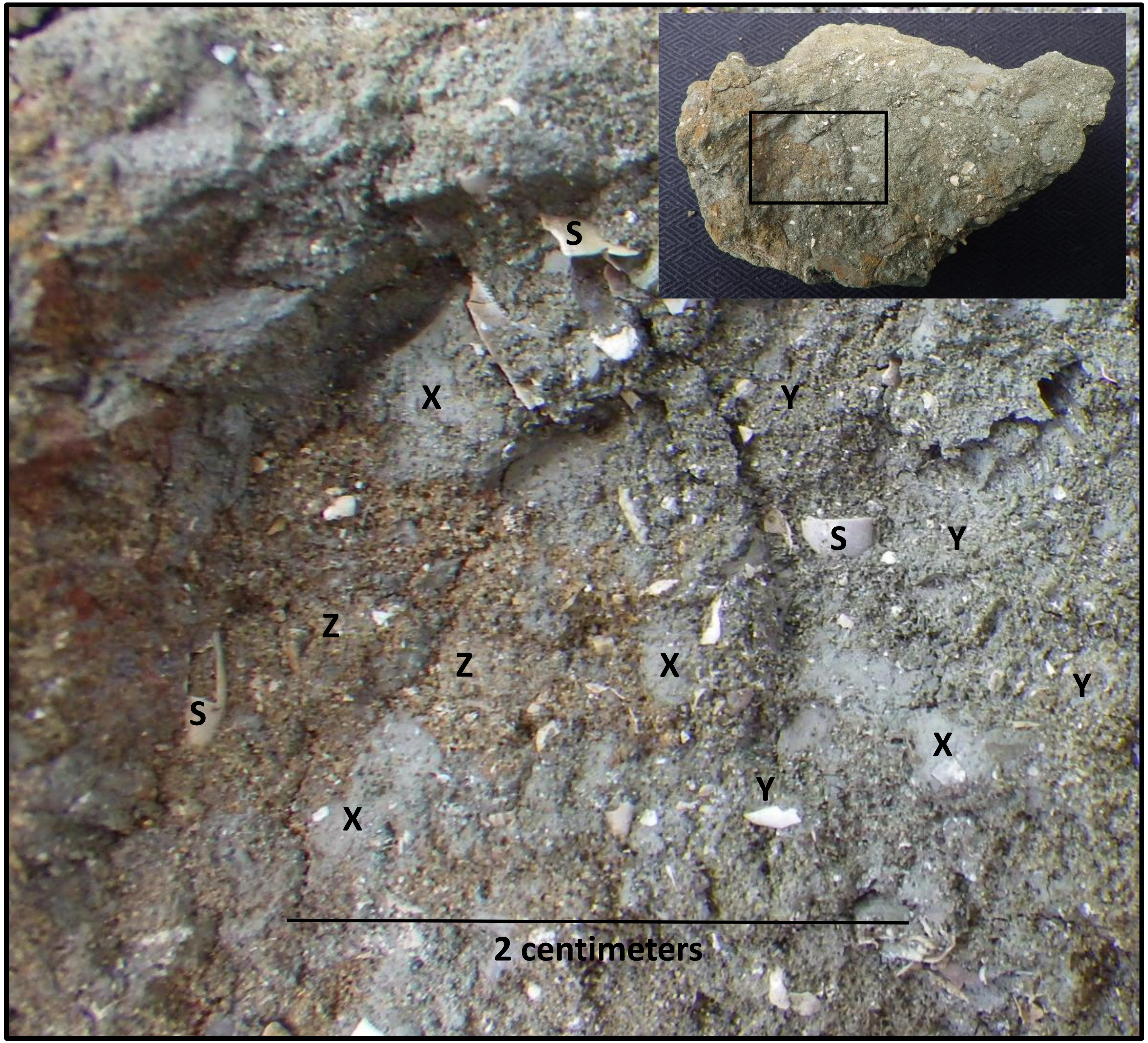
Source: Zuschin, M., and Robert J. Stanton, Jr., 2002



Zuschin, M., and Robert J. Stanton, Jr., 2002, Figure 3

MGB
Green Mudstone

- The primary MGB lithology is the pelletal silty green mudstone that formed the original muddy seafloor. It is fine grained and requires a hand lens for inspection.
- There are three distinct centimeter-scale to millimeter- scale lithologic-fabrics that reveal the depositional processes of the MGB mudstone. The litho-textures are the result of the different arrangements of green fecal pellets, quartz silt grains and mud.
- Close inspection shows a mix of gray mudrock (X), green pelleted silty mudstone (Y) and pelleted siltstone (Z). The orange areas are places of predominantly iron stained silts.
- These litho-textures are bioturbated showing that the resultant rock has been blended and homogenized. The original sedimentary bedding has been destroyed.
- Shell bioclast material (S) is scattered throughout the mudstone and occurs in lenses.

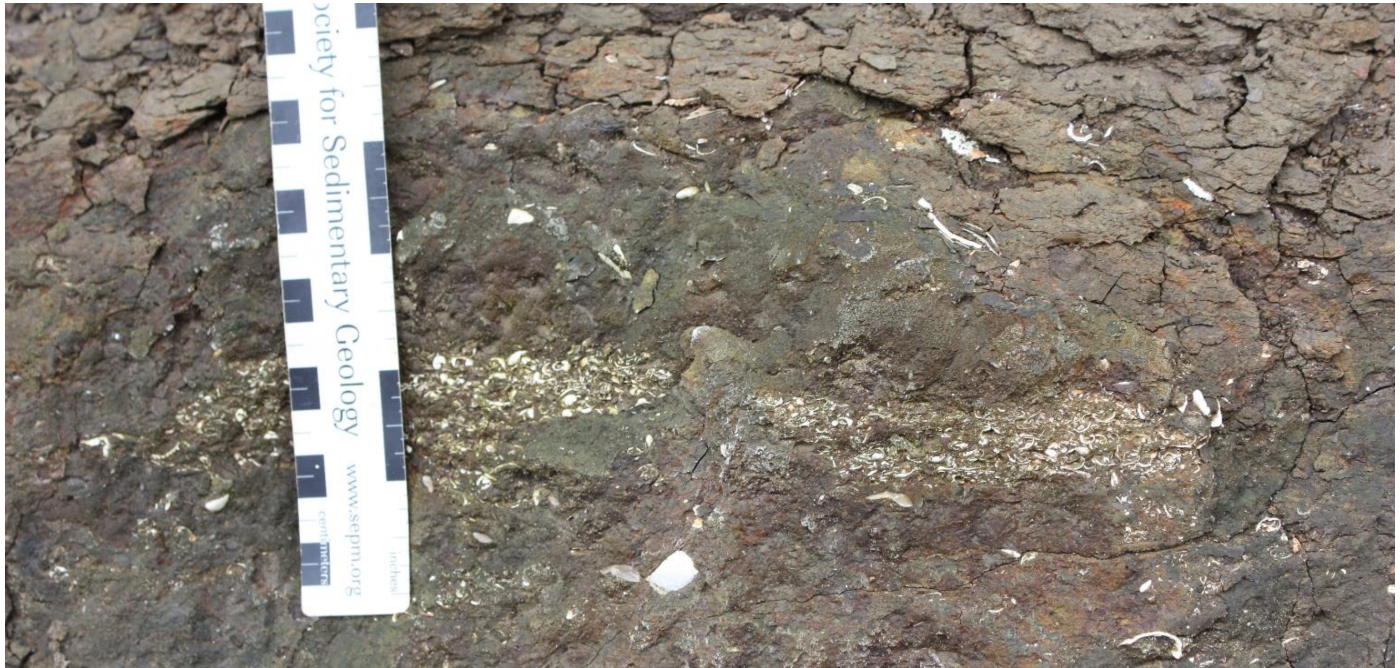


MGB
Bioturbated Sediment

- This occurs in irregular patches of silty sandstone with shells and pellets. Patches can be of any shape and are occasionally tabular.
- The shell material is matrix supported and randomly oriented.
- The shell bioclasts include perfectly preserved shells as well as intensely broken shells.
- There is no suggestion of current action or current-generated sedimentary structures , probably because of intense bioturbation of the sediment.

MGB
Skeletal Concentrates

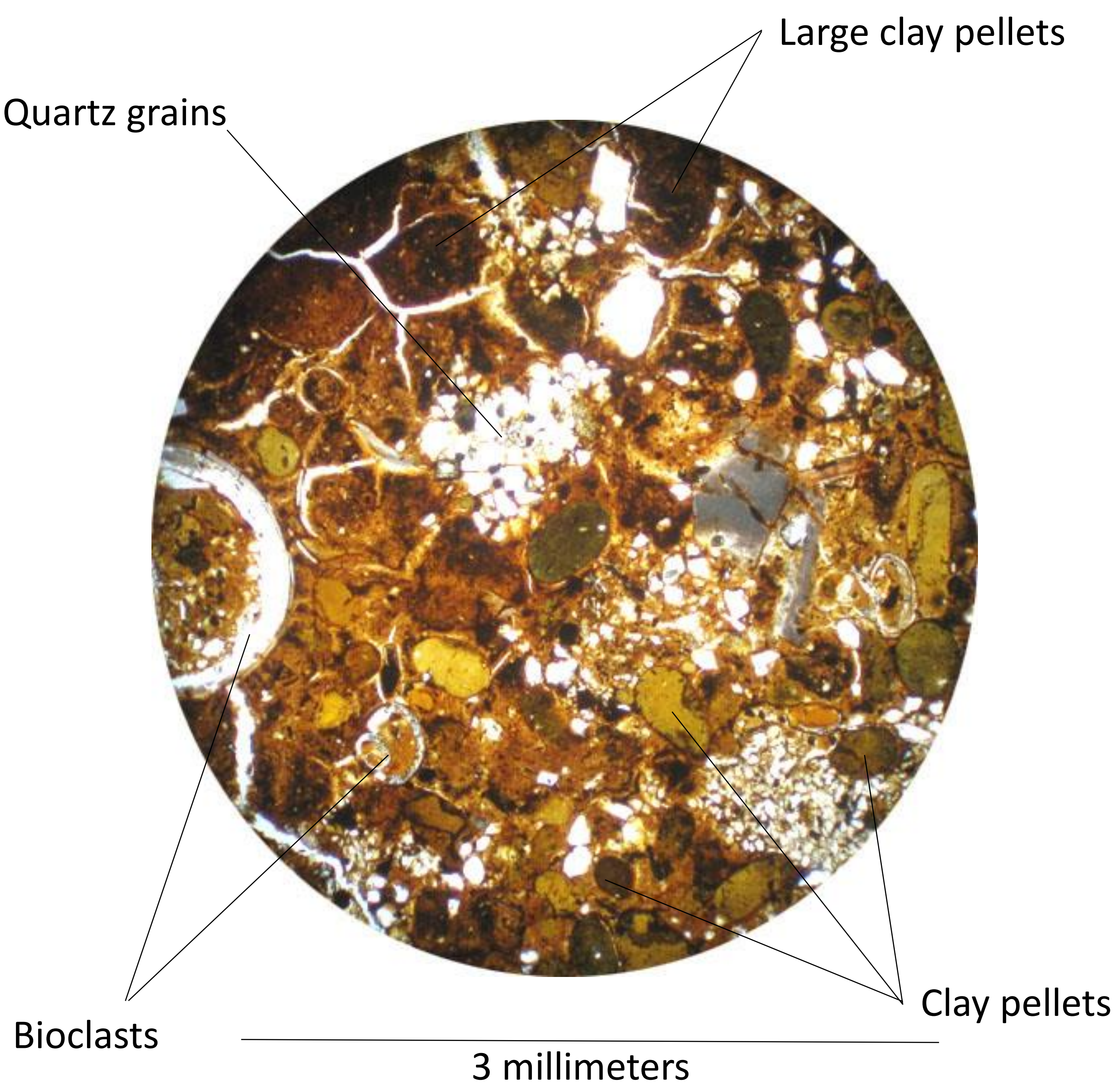
- Layers of shell bioclasts are up to 5 cm thick and have variable length. Most are only 10’s of cm in length and occur as lenses, clumps or pods. The most continuous shell layers occur near the top of the MGB.
- Skeletal layers usually have sharp bases and fine upwards into silts and mud. They are composed mostly of millimeter-sized shell and shell fragments in mostly random orientation within a silt matrix.
- The occurrence of convex-upward bivalve shells within the skeletal bands are sedimentary structures suggestive of bottom currents.
- The linear shell bands are associated with discontinuities or scour surfaces in the MGB. These scour surfaces are possibly developed by bottom currents generated during storms.



MGB Petrography

- This photomicrograph shows that the MGB sediment consists of silt-sized subangular quartz, ovoid fecal pellets and shell bioclasts in a clay matrix.
- The clay pellets are well indurated, with smooth surfaces. Colors range from dark green to olive green. There are two general populations of pellets: small pellets (0.2 X .09 mm) and large pellets (1.0 X 0.6 mm).
- All particles are randomly oriented and the silts appear to be clustered into packets.
- The mix of particles with different hydraulic properties such as pellets, silts and bioclasts strongly indicates bioturbation processes.

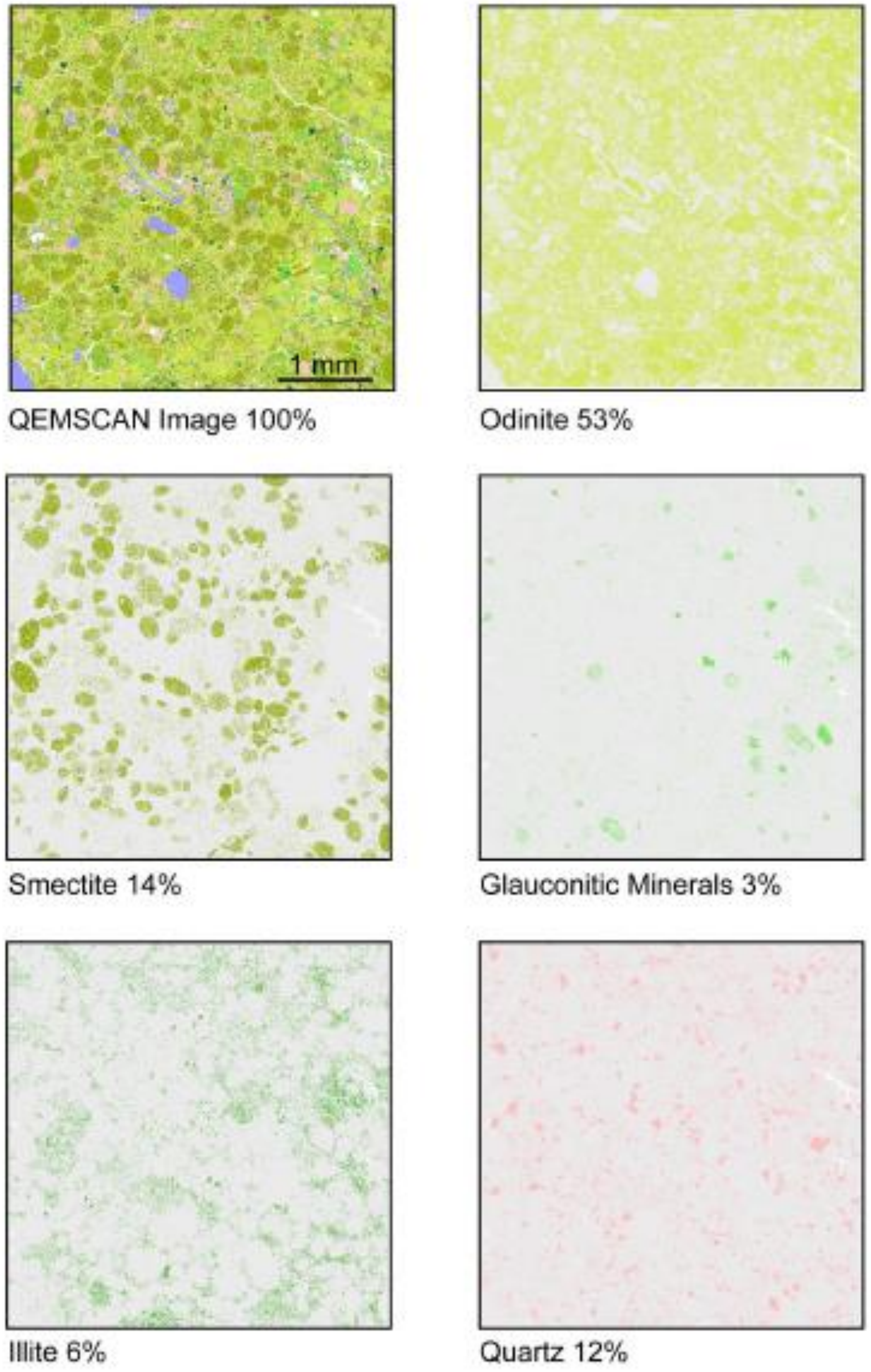
Source: Harding, S.C., Nash, B.P., Peterson, E.U., Ekdale, A.A., Bradbury, C.D., and M. Darby Dyar, 2014



MGB Clay Mineralogy

- Recent investigation has shown that the clay matrix and pellets of the MGB contain a wide variety of clay minerals in various proportions.
- Scanned mineral images (QEMSCAN) of the MGB show that the clay mineral odinite compositionally dominates (53%) the pellets and clay matrix while the clay mineral glauconite is a minor component (3%) along with smectite and illite.
- Odinite is a mixed layer iron-magnesium rich clay; single sheet phyllosilicate of the serpentine group.
- Simplified as $(Fe,Mg,Al,Fe,Ti,Mn)_{2.4}((Si,Al)_2O_5)(OH)_4$
- The Main Glauconite Bed (MGB) then is a misnomer and should be properly identified as the Main Odinite Bed (MOB) or the Main Green Bed!
- Green clay minerals like glauconite and odinite have sub-microscopic crystalline structures and chemical compositions that rely on several different methods of investigation, some complex, to determine their properties.

Source: Harding, S.C., Nash, B.P., Peterson, E.U., Ekdale, A.A., Bradbury, C.D., and M. Darby Dyar, 2014



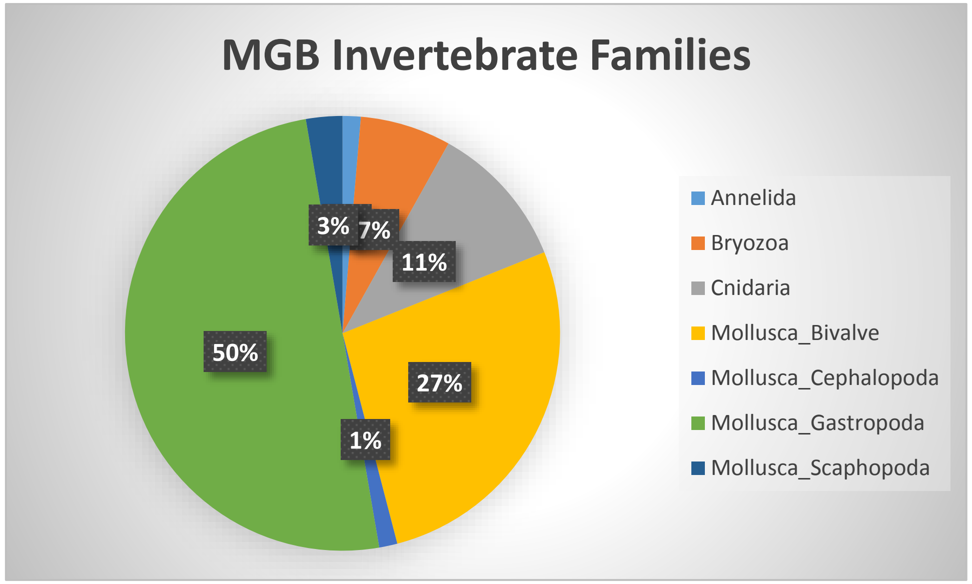
MGB Pellets

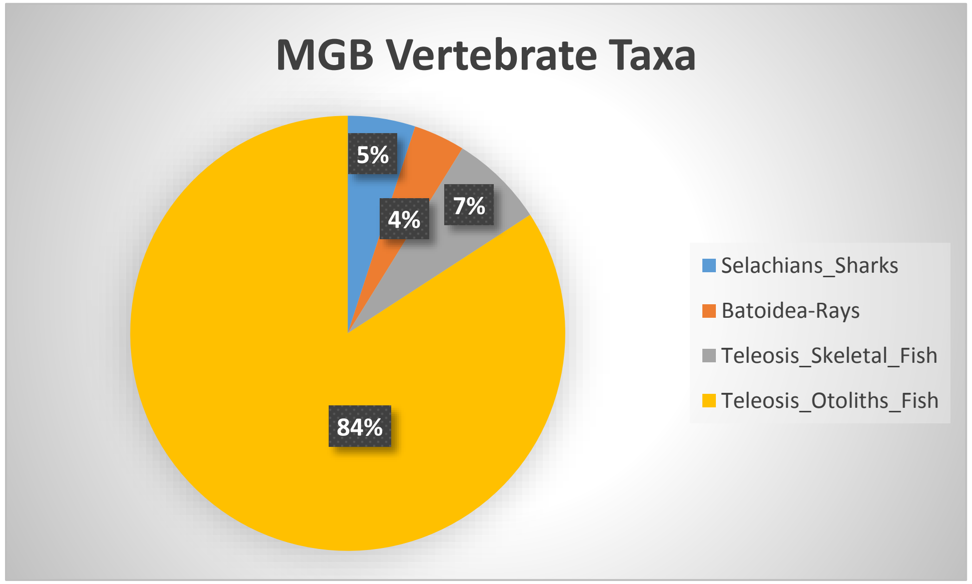
- Green pelleted clays are widespread on modern continental shelves, including the Gulf of Mexico.
- The clay mineral odinite forms today (called verdinization) under conditions of elevated sea temperatures, 15-60 meters water depth, and normal salinity in areas of iron-rich continental runoff and slow sedimentation rates.
- After expulsion onto and into the sea bed floor, the brown organic rich fecal pellets become micro-sites of clay recrystallization into green pigmented pellets .
- The time of exposure under these environmental conditions is for hundreds to thousands of years which continues to mature the clay pellets.
- Maturity increases the pellet into darker colors and expands in size, with the development of cracks and fissures.
- Once formed, the green pellets are indurated and geochemically stable in the marine environment and may be reworked and transported by bottom currents.
- The producers of the pellets, based on todays ocean bottom samples, are thought to be predominately polychaete worms of the Phylum Annelida.

MGB Fossils

- Many reports on fossil vertebrates, invertebrates, crustaceans, nanofossils, foraminiferans, pollen and spores from the MGB have been compiled and published by researchers since 1957. Statistics and sample identifications have been peer reviewed in industry journals, theses and field guides.
- Specimens of four invertebrate phyla account for the great majority of body fossils in the MGB; Annelida (worms), Bryozoa (lophophorates), Cnidaria (corals) and Mollusca (gastropods and bivalves). The two Mollusca classes; Gastropoda and Bivalvia, account for over 75% of the families and species found in the outcrop bed.
- Three classes of vertebrate fish have been collected: Selachians (sharks), Batoidea (rays) and Teleosts (bony fish). Over 80% of the vertebrate material collected are teleost teeth, bony skeletal remains, and fish otoliths (ear stones).
- Shell material exhibits fine morphological detail, original color and patina.

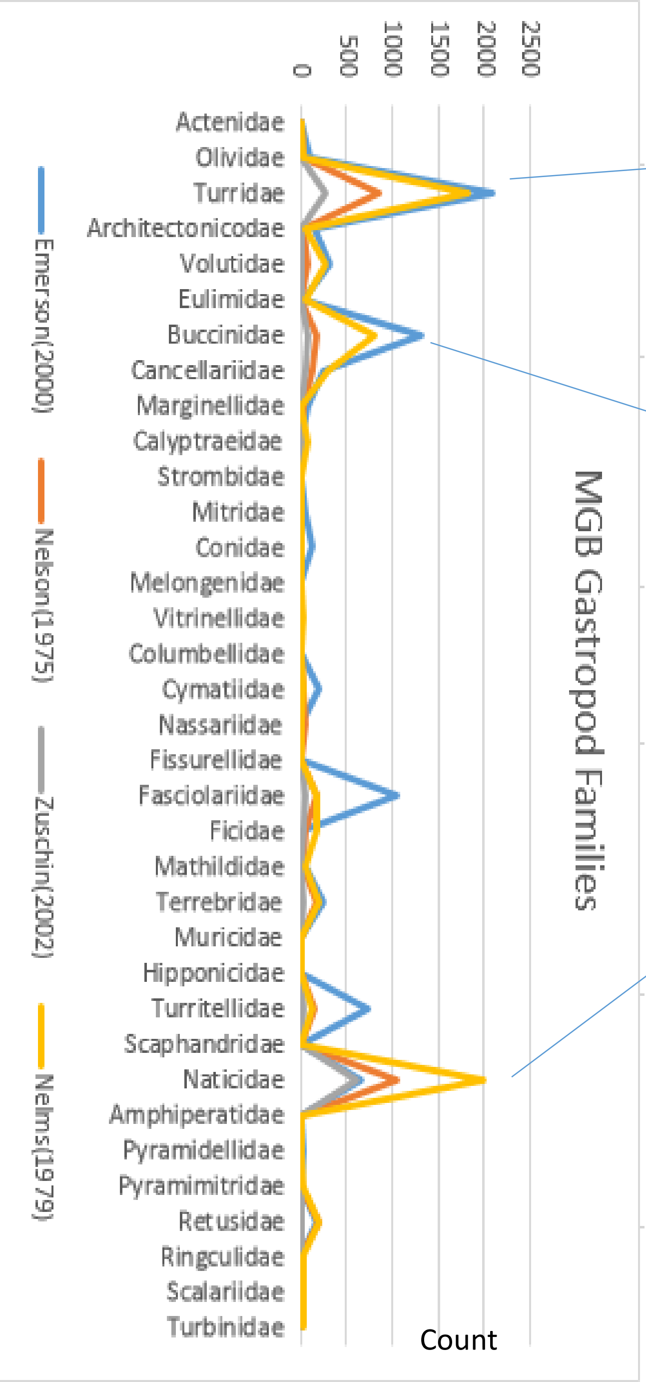
Source: Breard, S.Q., and Gary L. Stringer, 1999





MGB Gastropods

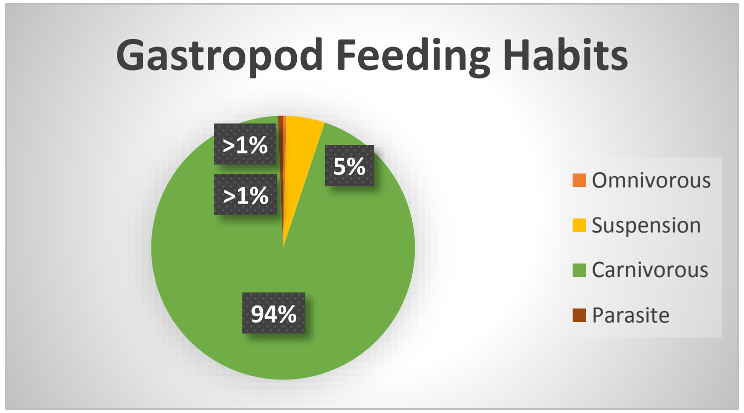
- Gastropods account for nearly 50% of all the families found in the MGB, and over 60% of the species.
- The most common MGB gastropods are species of the Turridae, Buccinidae and Naticidae families.
- Species of the Naticide are generalists, opportunistic species that reproduce quickly and mature rapidly to exploit unstable conditions.
- The majority of gastropods are mid level carnivores that preyed on other invertebrates.



Cochlespira engonata

Pseudoliva vetusta sp.

Polinices aratus

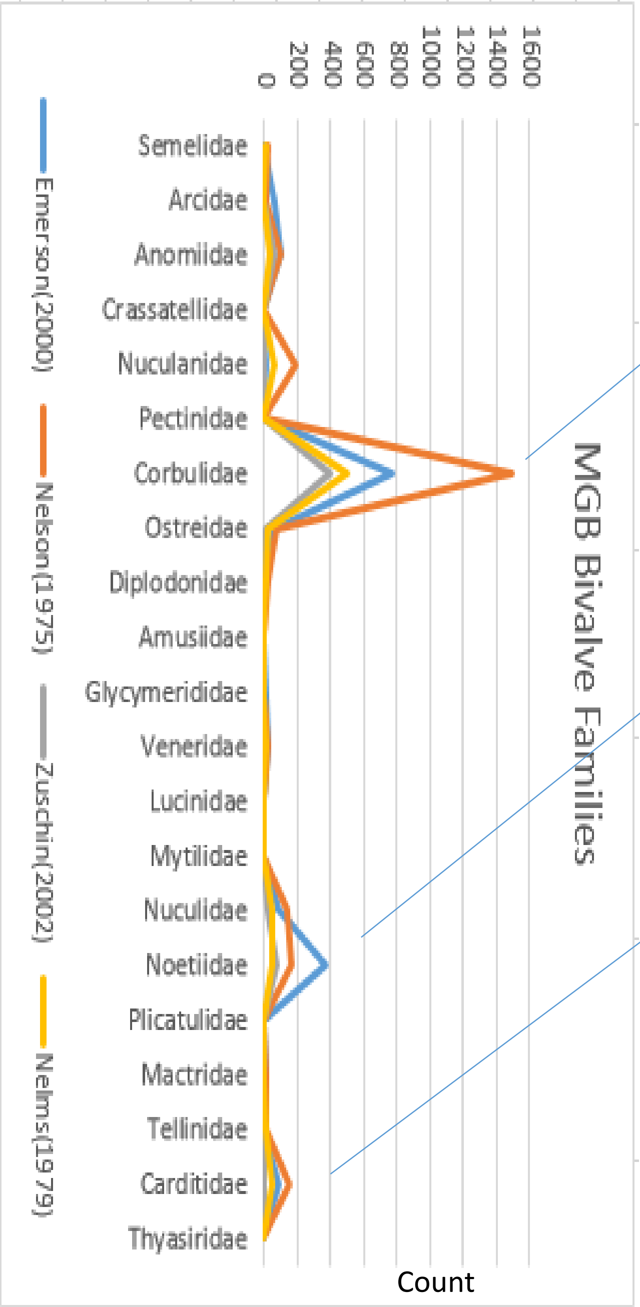


Source: **Zuschin, M., and Robert J. Stanton, Jr., 2002; Nelson, 1975; Nelms, 1979; Emerson, 2000**

MGB Bivalves

- Bivalves account for over 25% of the families in the MGB, and over 20% of the species.
- The most common MGB bivalves are species of the Corbulidae, Noetiidae and Carditidae families.
- Species of the family Corbulidae are generalists, opportunistic species that reproduce quickly and mature rapidly to exploit unstable conditions. They are the most common bivalve found in the MGB.
- Most bivalves in the MGB are thin shelled and fracture easily, making collection difficult.
- The majority of bivalves are suspension feeders on phytoplankton and larvae. Others are mud-detritus eaters that plough through the sediment.
- The family Ostreidae (oysters) are uncommon and occur as small juveniles in the MGB bed.

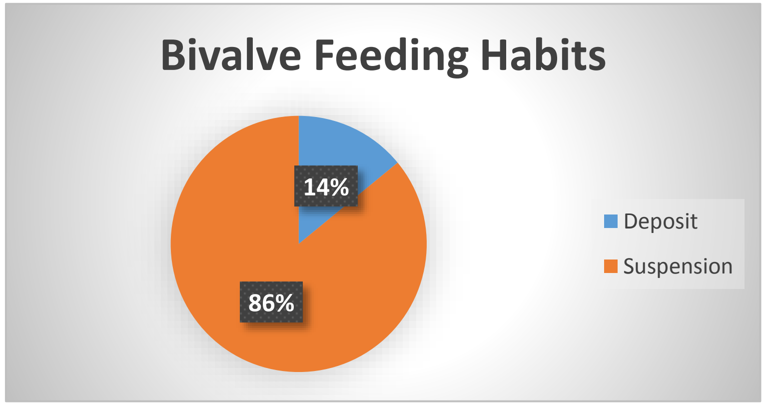
Source: Zuschin, M., and Robert J. Stanton, Jr., 2002; Nelson, 1975; Nelms, 1979; Emerson, 2000



Notocorbula texana

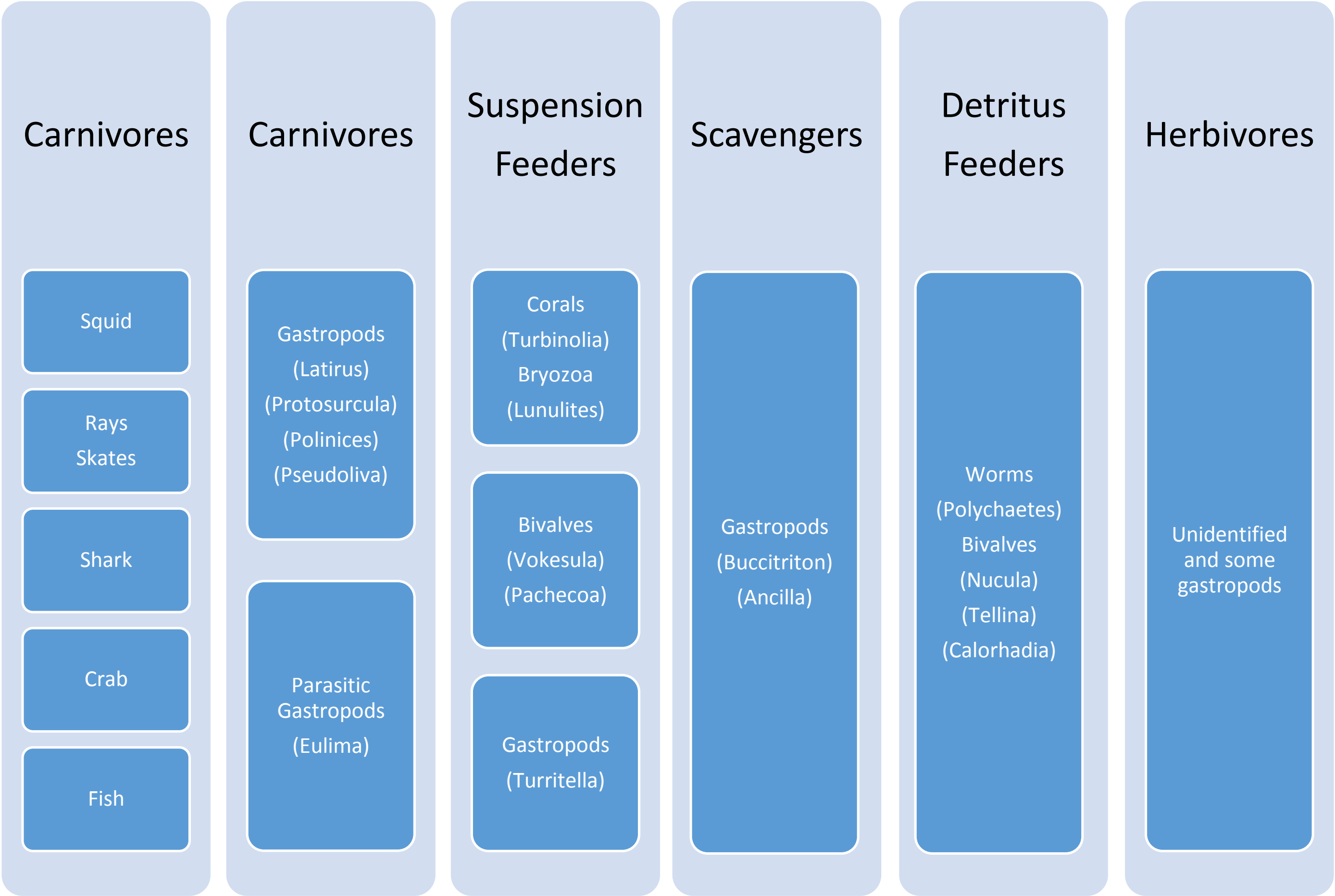
Pachecoa sp.

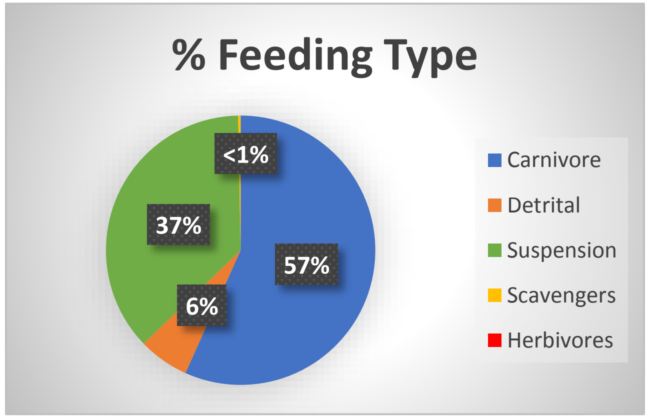

Venericardia densata



MGB Food Web

- The food web is a simplified map of the feeding connections of taxa and outlines the paleoecology of the community. Trophic levels are functional groups that have the same position in a food web.
- The determination of the trophic (eating level) environment, is based on applying predator-prey relationships, trace fossils and substrate character.
- Data from 6616 individuals representing 96 genera and 120 species were collected from the MGB for an evaluation of the food web.
- The MGB community contains carnivores, suspension feeders, detritus feeders, scavengers, and herbivores.
- Carnivores include sharks, fish, crustaceans, and gastropods. Suspension feeders include bivalves, corals and bryozoans. Detritus feeders include worms and bivalves. Some gastropods are herbivores.
- The MGB fossil assemblage contains a predominance of carnivores (57%) and suspension feeders (37%).
- The fossil assemblage lacks soft-bodied species without a skeleton which would represent the primary consumers. Only a small amount of the primary producers, such as plants and phytoplankton, are represented.

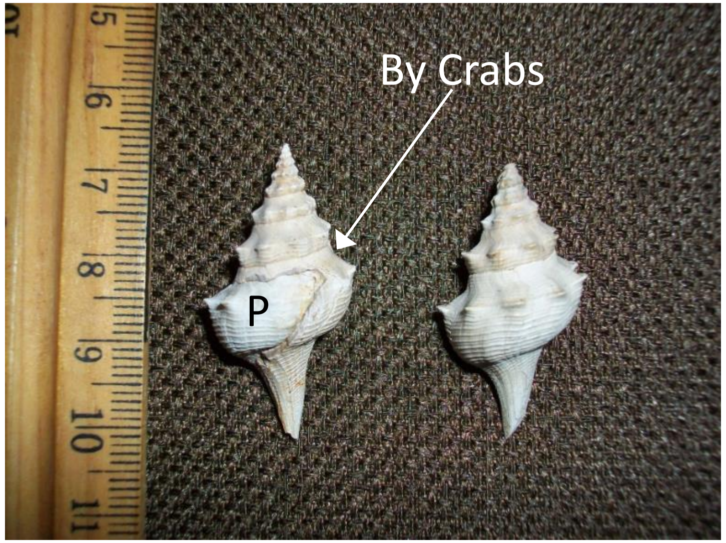




Source: Stanton Jr., R. J., and Penelope C. Nelson, 1980

MGB
Predator and Prey

- Predation can be easly seen by the presence of drill holes in shells and by shell breakage, patterns of peeling away the edges of clam shells and snail apertures.
- Drill holes are mostly produced by naticid gastropods in this MGB environment.
- Peeling of shell edges is mostly done by crabs.
- Cone snails are large predators that inject prey animals with poison and then eat the tissue, but do not create damage to the shell of prey.
- Small high-spired turrid gastropods also inject poison in prey animals, but they feed mostly on worms, so leave no record of predation.
- Encrustation and corrasion on shells indicates some periods of exposure on the sea floor.

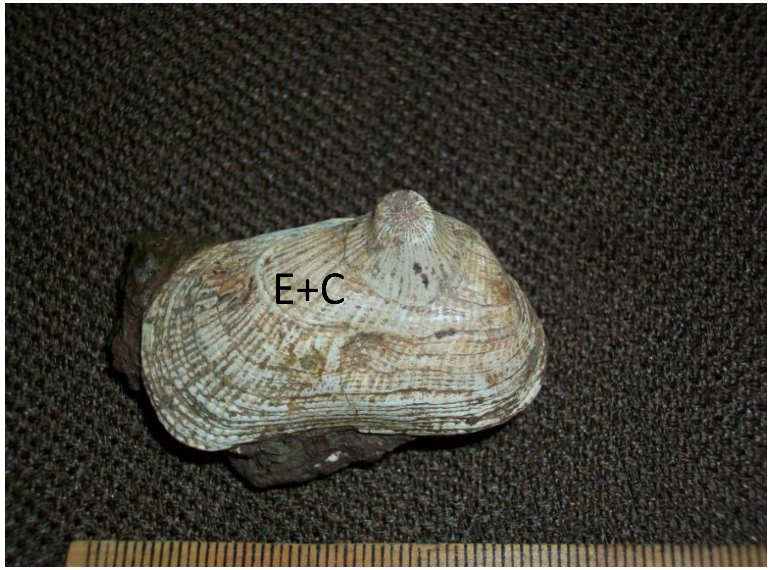


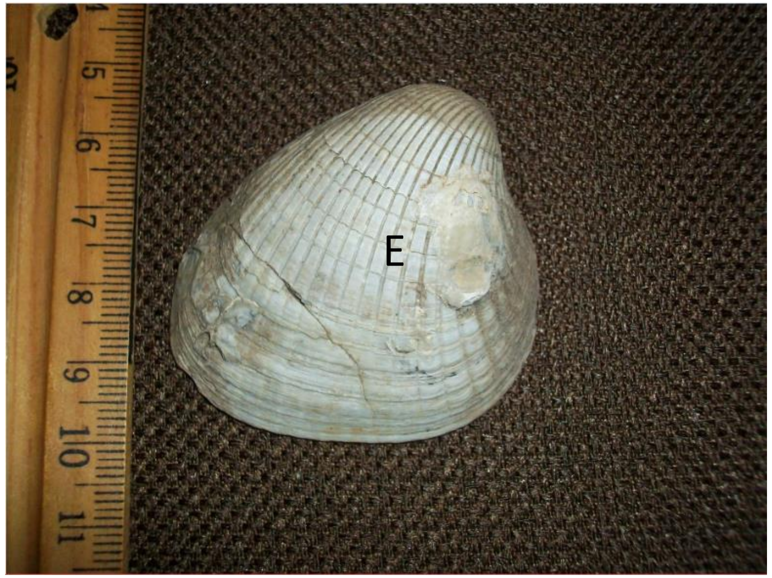
P=Predation

MGB Taphonomy

Zuschin and Stanton (2002) did an extensive analysis on the taphonomic conditions of the molluscan fauna (1818 specimens) in the MGB. The following is a summary of their observations:

1. 69.7% of all molluscan shells are in excellent condition. Only 8.2% have heavy corrasion.
2. Fragments comprise 89.5% of the total shelly faunas.
3. 11% of molluscan fauna have shells damaged by predatory crustaceans and vertebrates.
4. 14.6 % of molluscan shells have predominately naticid predatory drill holes.
5. Only seven shells were found encrusted and only those shells were found in the skeletal concentrates.
6. Only one articulated bivalve was found.
7. Only the upper valves of the bivalve Anomia were found.
8. Both valves of corbulids occur but greater percent of left valves are found.





E= Encrustation C= Corrasion

MGB Burrows

- The upper half meter of the MGB is extensively covered by large concretionary burrows exhibiting a variety of mazes, chambers, alcoves, nodes and branches (Thalassinoides). Some burrows consist of large loosely coiled spiral burrows (Gryolithies) several cms high and wide that connect chambers of the irregular burrows. The concretionary layer forms a protective bench on top of the MGB.
- The burrow system consists of smooth walled and scratched walled cylindrical components of variable diameters with Y to T shaped bifurcations.
- These biogenic structures are the result of dwelling/feeding activities of crustaceans, possibly shrimp, crabs and lobsters, that are not generally preserved due to their chitin exoskeleton. Several claws though have been collected from the MGB.
- The smooth walled burrows and scratch traces suggest a fine grained coherent substrate, not requiring wall reinforcement.

Source: Stanton Jr., R.J., and John E. Warme, 1971

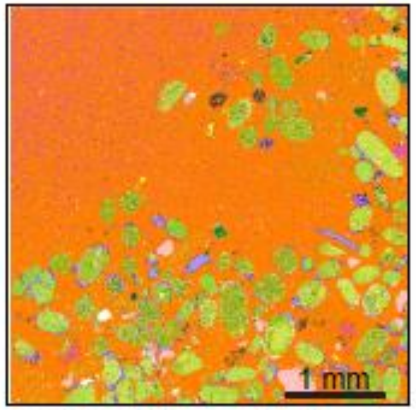
7 Cm

15 Cm

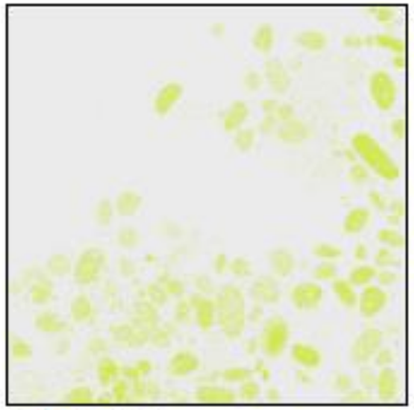
MGB Burrow Fill Mineralogy

- The burrow and tunnel system was subsequently sediment filled including pellets and quartz grains and cemented shortly after burial by early diagenetic concretionary processes.
- Scanned mineral textural maps (QEMSCAN) of the burrow fill indicate predominantely siderite and lesser amounts of apatite cement, encasing odinite, smectite and glauconitic clay pellets.
- The silicate component is similar in composition to the general matrix and pellets of the MGB.
- The pellets are a mixture of two mineralogically exclusive types. Unaltered small clay pellets of smectite and odinite and altered larger apatite rich pellets.
- Siderite is a replacement mineral and at Stone City Bluff is commonly found in concretionary burrow fill and in pelletal granular sediment layers.
- Siderite is an iron carbonate mineral: $FeCO_3$

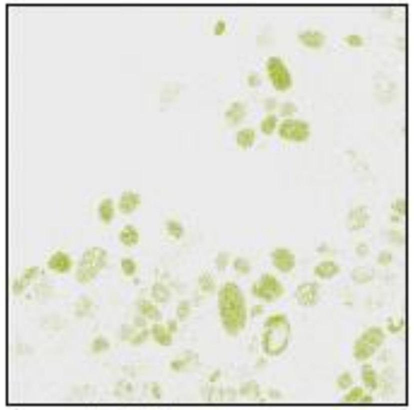
Source: Harding, S.C., Nash, B.P., Peterson, E.U., Ekdale, A.A., Bradbury, C.D., and M. Darby Dyar, 2014



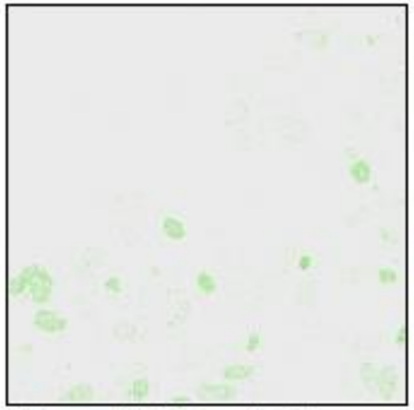
QEMSCAN Image 100%



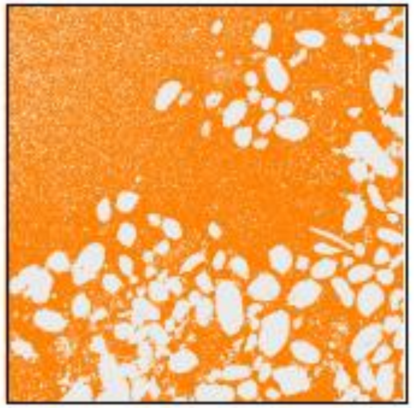
Odinite 13%



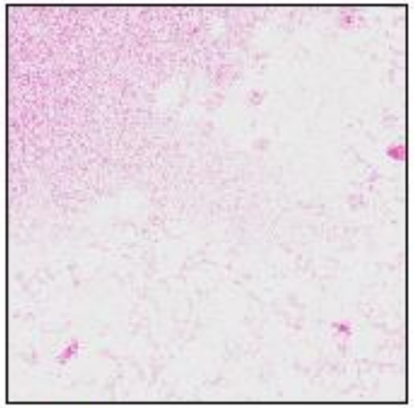
Smectite 5%



Glauconitic Minerals 2%



Siderite 63%



Apatite 8%

MGB Faunal Menus

- Common and rare species from the author's MGB collection are presented here.
- This collection is incomplete.
- Additional faunal listings can be found in the reference section and the HGMS web site.

Trigonostoma babylonicum

MGB Faunal Menus


Architectonica elaborata


Murex fusates


Cochlespira engonata


Latirus moorei


Ancilla staminea


Trigonostoma juniperum


Trigonostoma babylonicum


Athleta sp.


Athleta petrosus


Levifusus mortoniopsis


Acteon punctatus


Polinices aratus


Sinum inconstans


Lapparia crassa


Pseudoliva vetusta


Eodrillia texana


Vokesula petropolitana


Vokesula smithvillensis


Distorsio septemdentata


Bolis enterogramma

MGB Faunal Menus


Balanophyllia irrorata


Balanophyllia desmophyllum


Madracis johnsoni


Turbinolia pharetra


Endopachys maclurii


Lunulites bouei


Schizorthosecos sp.


Rotularia leptostoma


Cornulina armigera


Gegania antiquata


Conus (Lithoconus) sp.


Conus tortilis


Conus sauridens


Eosurcula moorei


Protosurcula gabbii


Buccitriton texanum


Michela trabeatoides


Awateria retifera


Hesperiturris nodocarinatus


Glyptotoma sp.


Eulima extremis

MGB Faunal Menus

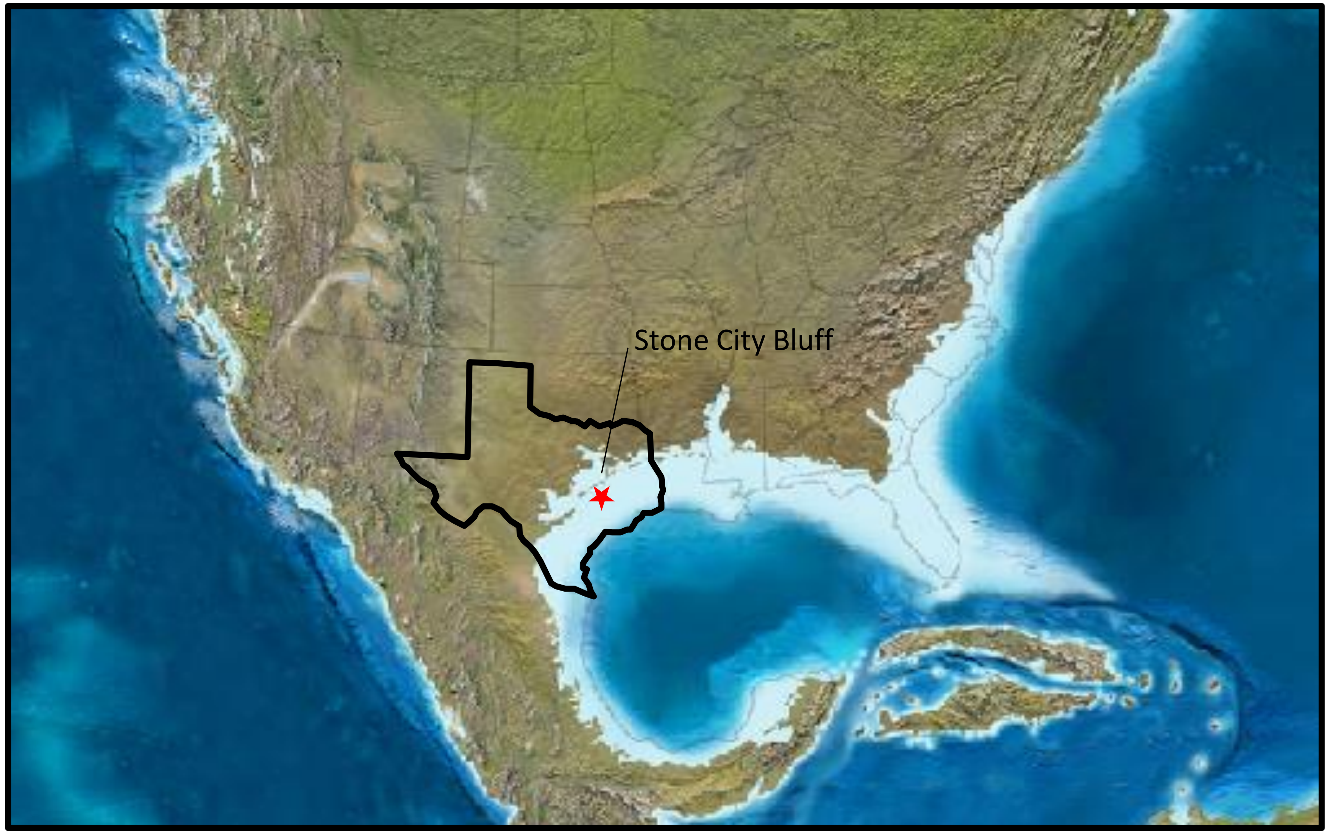
				
Hastula houstonia	Terebra texagyra	Eopleurotoma lisboncola	Fusimitra sp	Bonellitia parilis
				
Bullata semenoides	Ancistrosyrinx bastropensis	Ficopsis texana	Papillina dumosa sp.	Mesalia claibornensis
				
Turritella nasuta	Retusa sp.	Pyramimitra terebraeformis	Barbatia uxorispalmeri	Venericardia densata
				
Abra petropolitana	Notocorbula texana	Pachecoa sp.	Pteropsella lapidosa	Yoldia (Calorhadia) compsa

MGB Faunal Menus

				
Cadulus sp.	Dentalium sp.	Belosaepia ungula	Striatolamia macrota	Striatolamia macrota
				
Galeocerdo eaglesomei	tiny shark teeth	common shark teeth	Abdounia reticona	otoliths (ear stones)
				
Myliobatis sp. (ray teeth)	Trichiurides (cutlass fish)	Amia sp. (bowfin fish)	Scomberomorus (barracuda)	Ameiurus (catfish)
				
fish vertebrae	turtle shell	Paralbula sp. (drum fish)	Lepisosteus (garfish scale)	fish spine

MGB Summary

- The MGB was deposited in a marine subtropical inner shelf setting (15-60 meter water depth).
- Approximately 1.7 meters of fine grained muddy silt were deposited by suspension and mild currents. Occasional storms scoured the substrate. Intense bioturbation by molluscs and polychaete worms homogenized the entire strata. Sediment ingested by worms produced large amounts of organic pellets which added to the clay volume.
- Organic pellets on or near the seafloor were recrystallized to odinite, a green clay mineral with environmental implications.
- The MGB paleocommunity was prolific and highly diverse, dominated by suspension feeders and carnivorous molluscs that lived on the sea floor and within the substrate. After death they were exposed for only a short time before they were buried or bioturbated into the substrate. This accounts for the excellent condition of the collected shell material.
- The high occurrence of broken shells in the MGB suggests an active community of shell breaking predators, fish, crustaceans and sharks.
- The rich fauna collected indicates a palocommunity with sufficient physical and environmental tolerances and plentiful food resources but probably represents a small sampling of the original overall faunal community.



Middle Eocene Reconstruction (50Ma) courtesy of Dr. Ronald Blakey N. Arizona University, Flagstaff AZ
http://jan.ucc.nau.edu/rcb7/

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Stone City Bluff


Recent Fauna




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