Science Camp #170802.8

02-04 August 2016 @ the Condo, the Nelson Cabin, and surrounding area

Advisors

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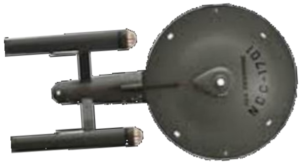
6. Geology



The science that deals with the history of the earth and its life especially as recorded in rocks.

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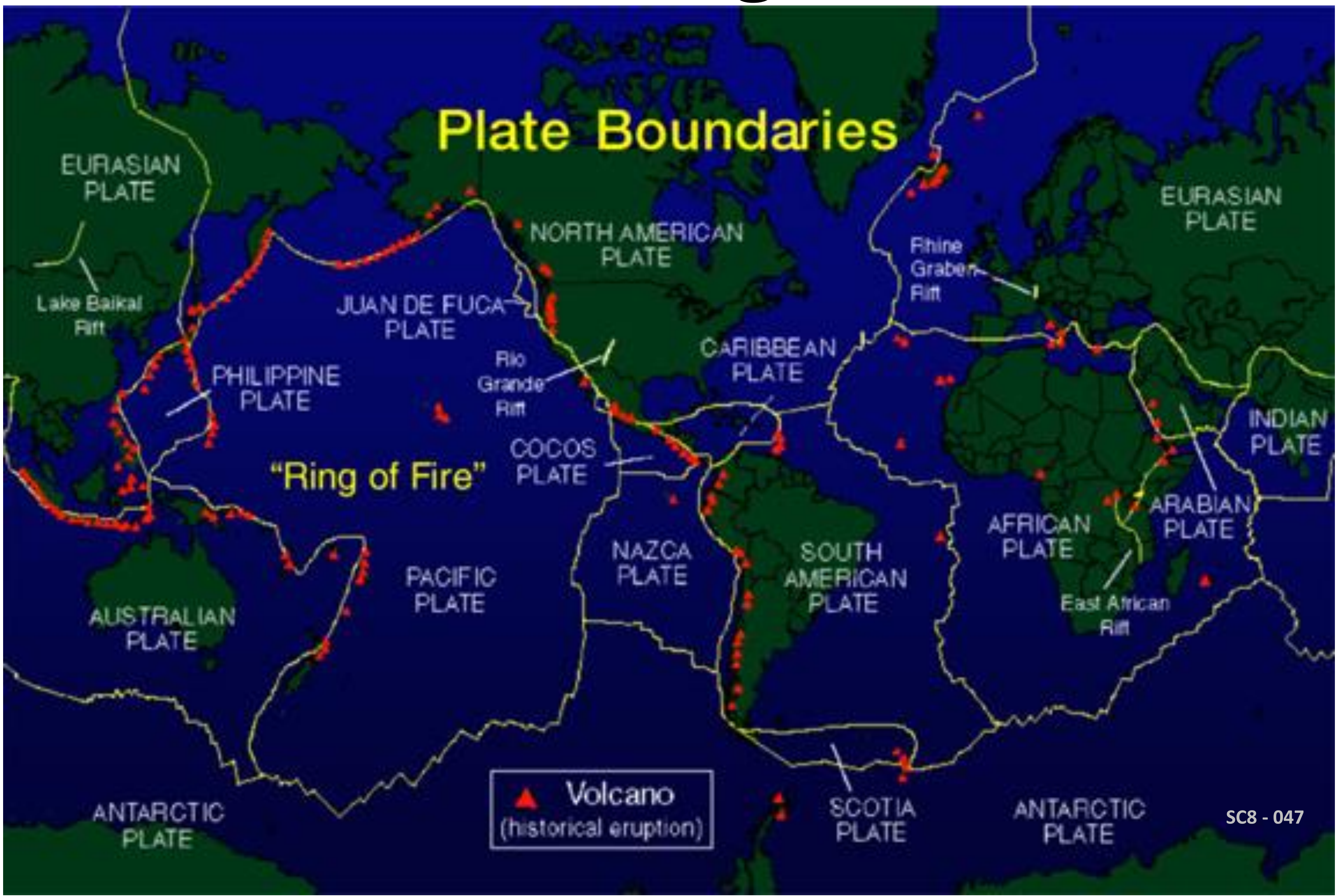
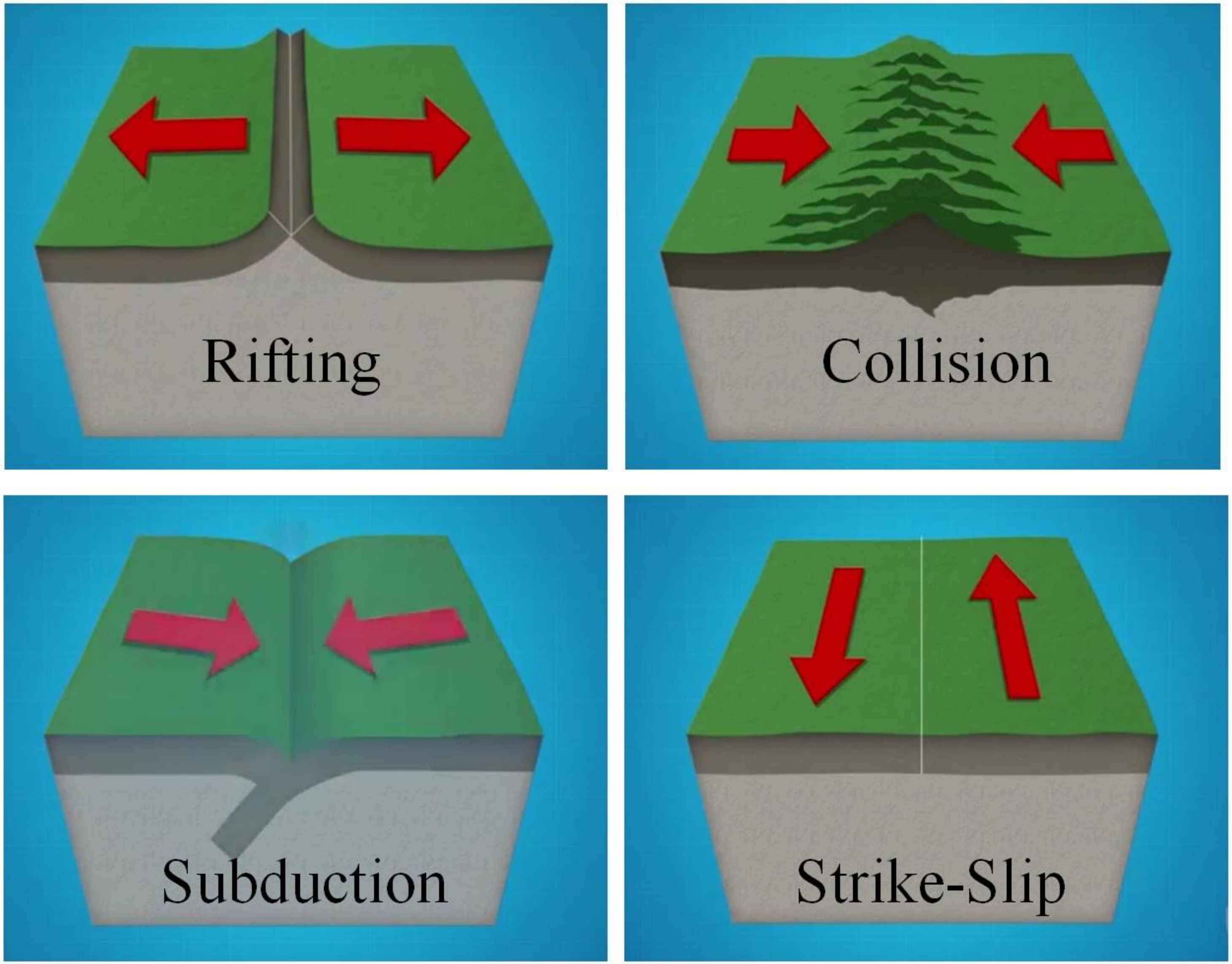
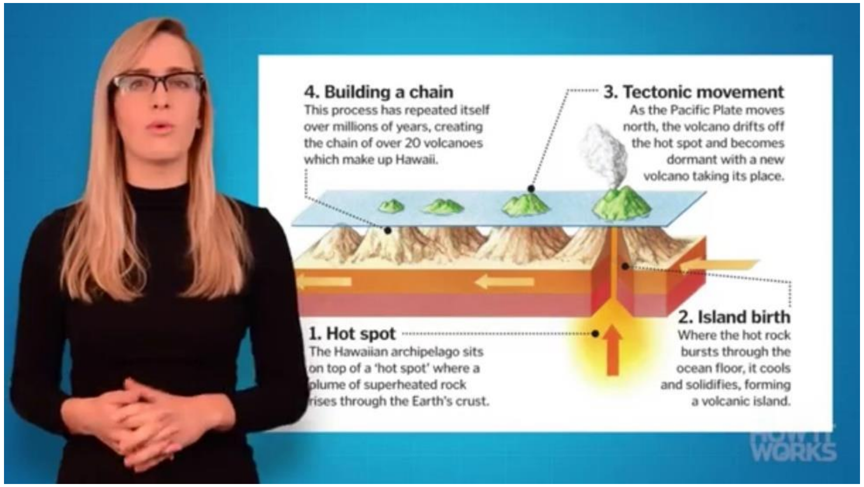
Plate Tectonic Movements Control Geologic Growth



Types of Plate Movement

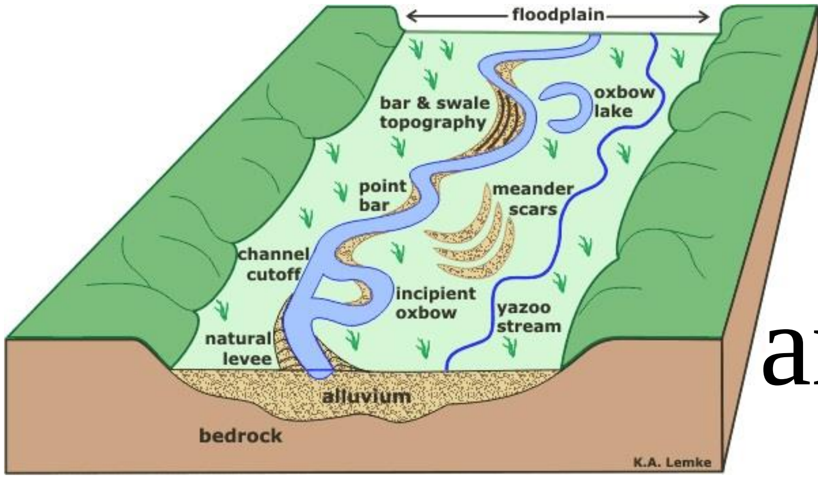


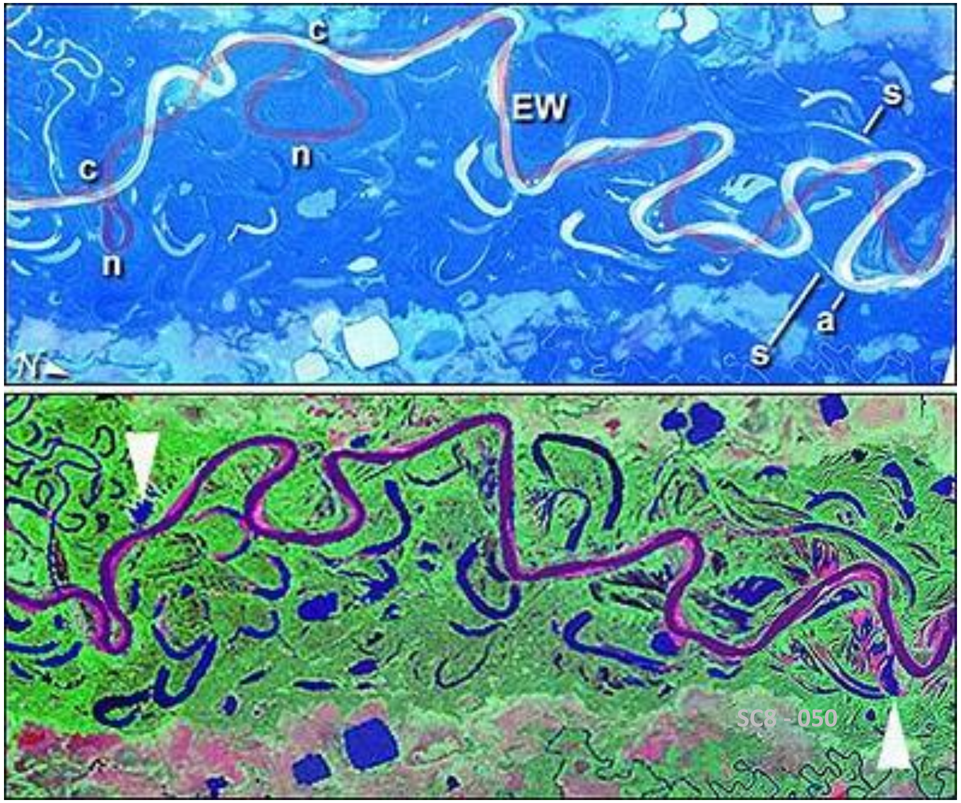
As Plates Move over Hot Spots Volcanic Islands Form



From: http://en.wikipedia.org/wiki/Santa_Clara_Volcano

As Mountains Erode, they form deltas, alluvial flood plains, and sedimentary layers





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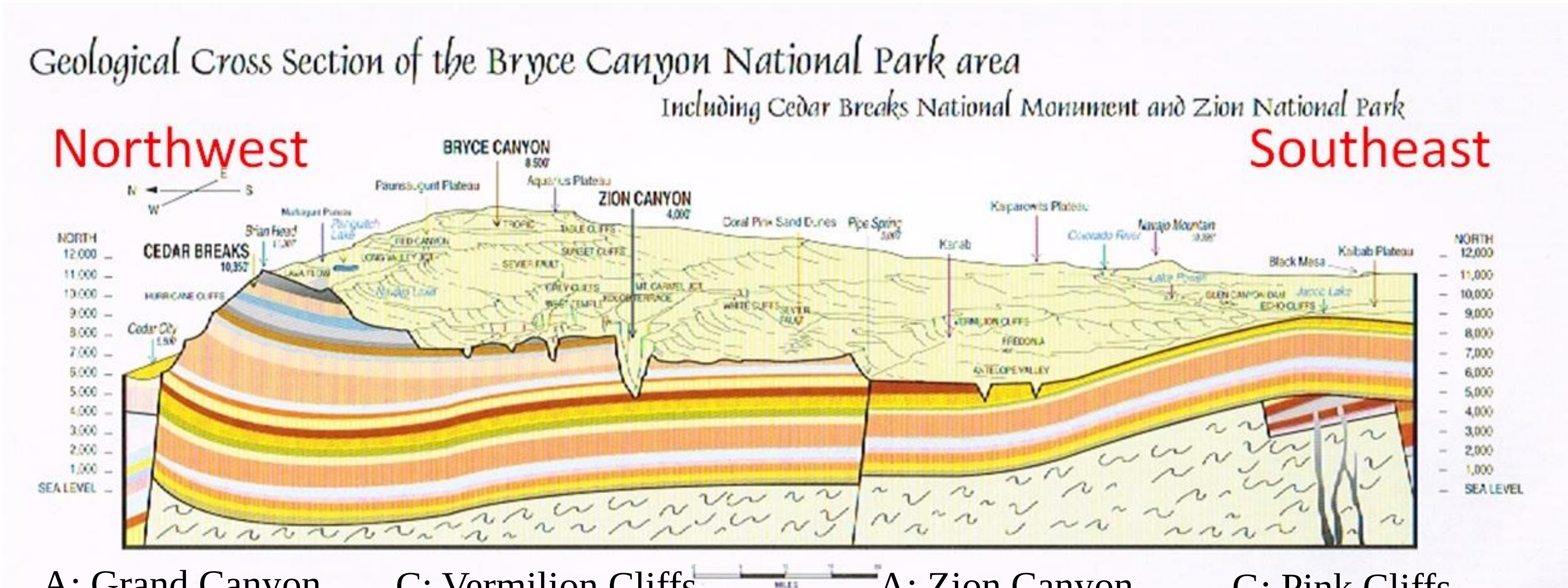
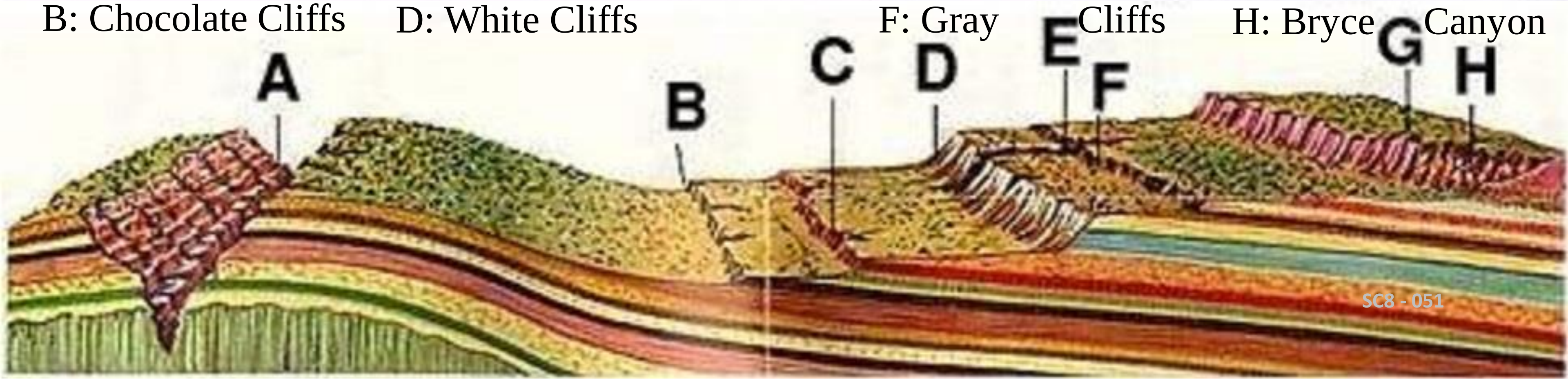
Layers define Southern Utah



A: Grand Canyon
B: Chocolate Cliffs
C: Vermilion Cliffs
D: White Cliffs
A: Zion Canyon
F: Gray Cliffs
G: Pink Cliffs
H: Bryce Canyon



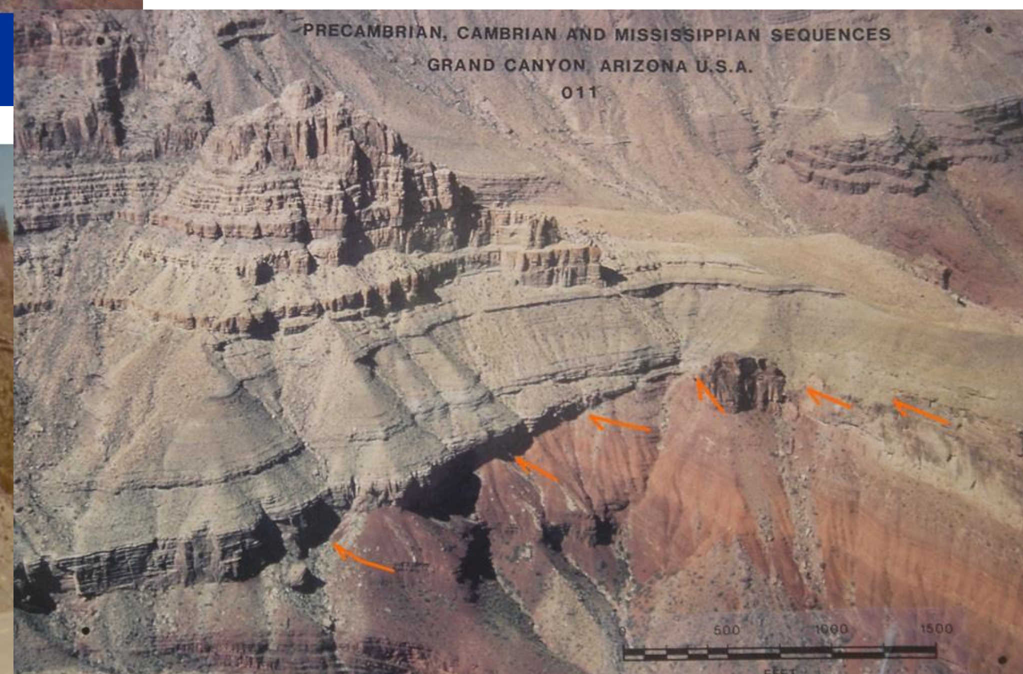
Layered Cliffs by The Glitter Pit

Layers Include Petrified Sand Dunes

Geologic Patterns, Like Sand Dunes Occur at Multiple Scales

These Boundaries Define Major Geologic Change Like Sea Levels

Sequence Boundaries



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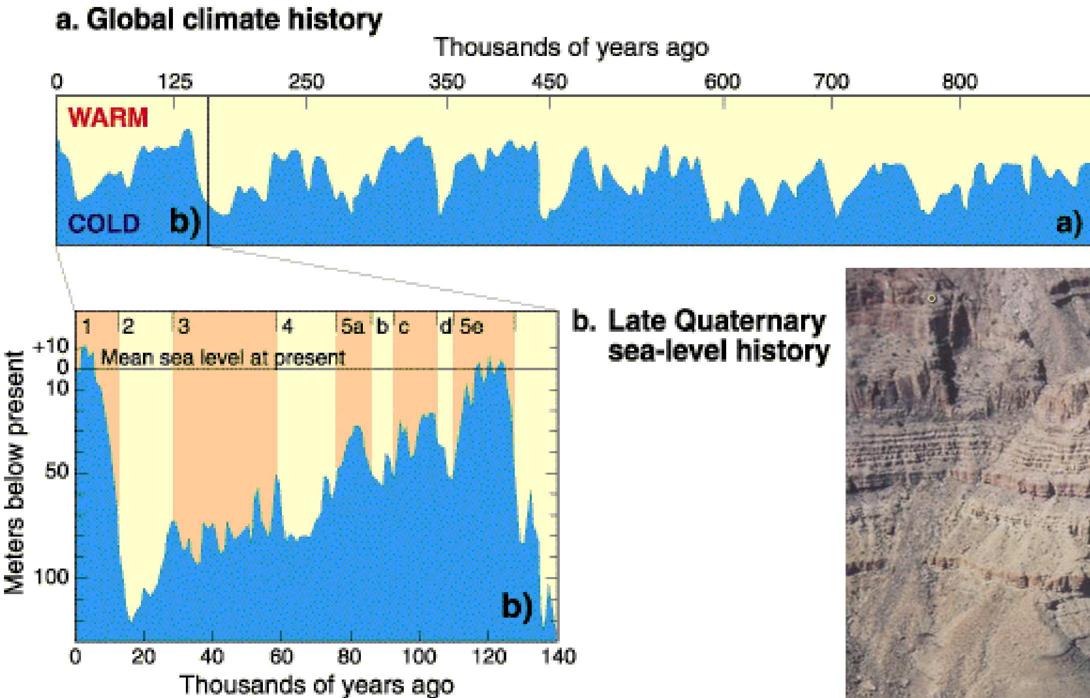
Truncations

As Sea Level Rises, Sands Are Deposited on Erosional Surfaces



Basal Transgressive Sand

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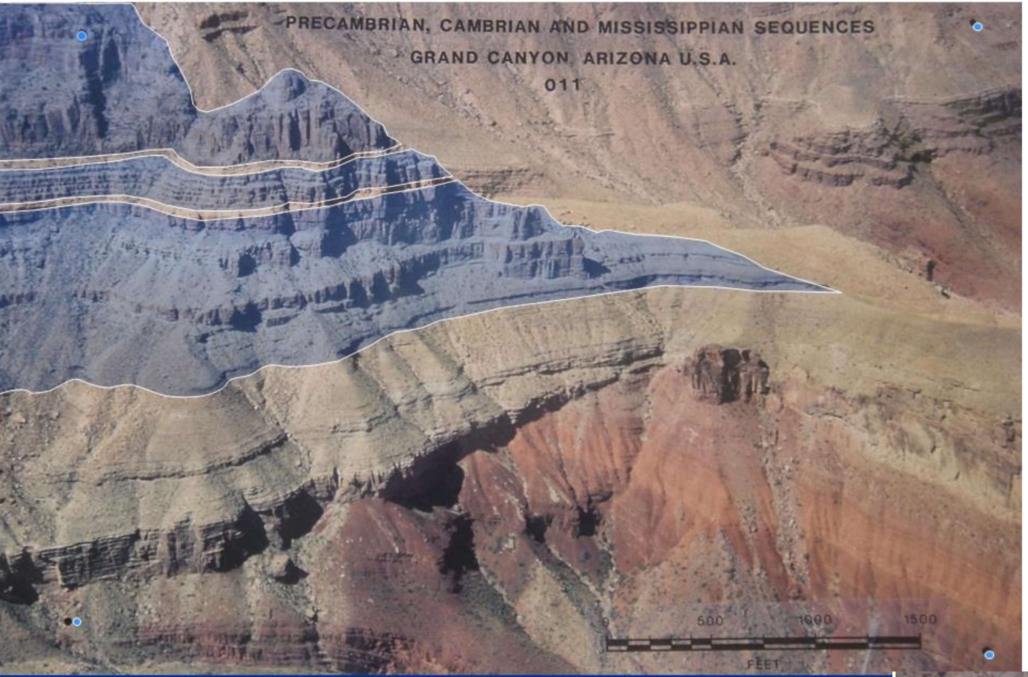
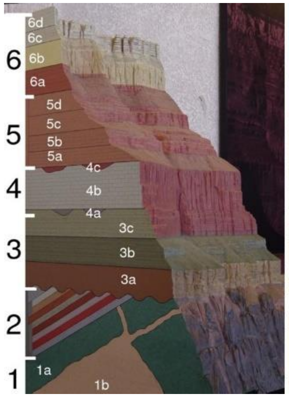
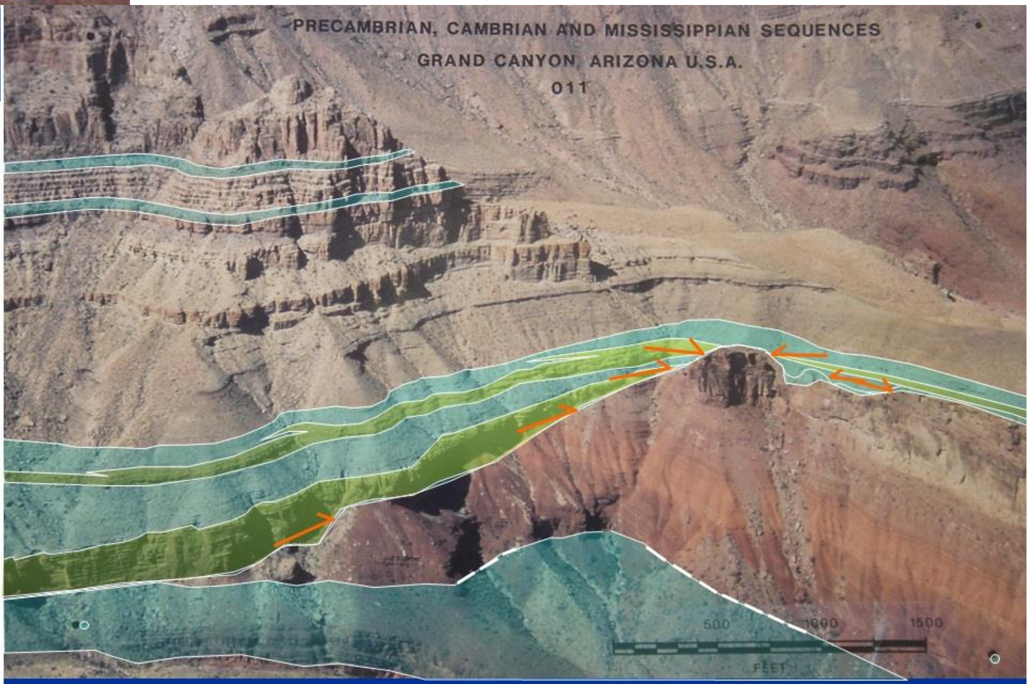
Inter-High Sea-Level Times Form Similar Geologic Layers



Shelf Carbonates



Worldwide, these layers are best studied in Southern Utah and at the Grand Canyon



Transgressive Systems Tracts

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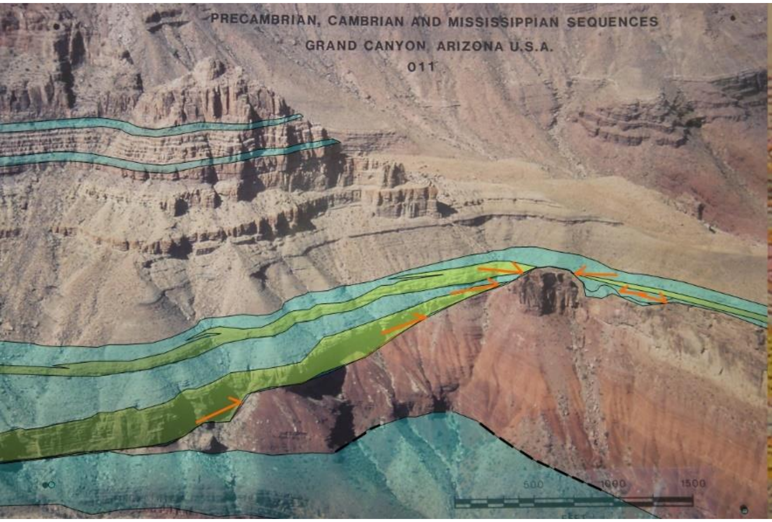
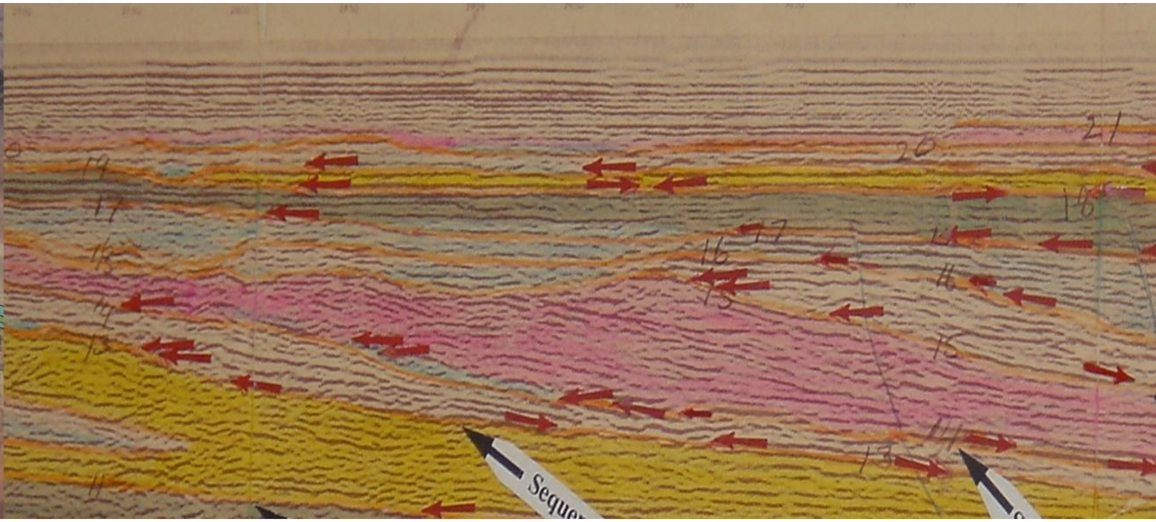
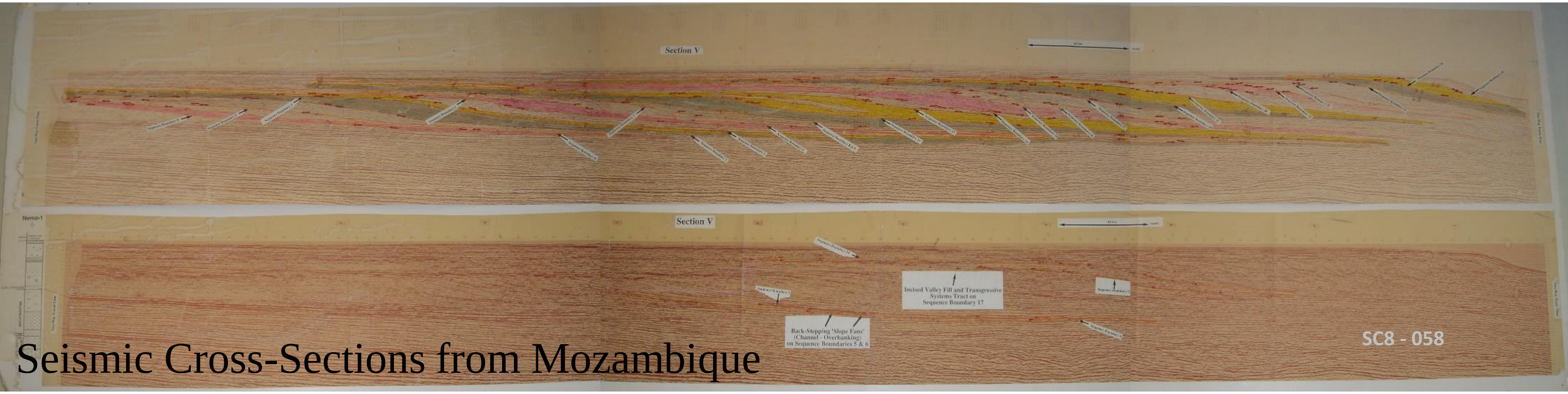
Geologist Compare Outcrops to Seismic Cross-Sections







Seismic Cross-Sections from Mozambique

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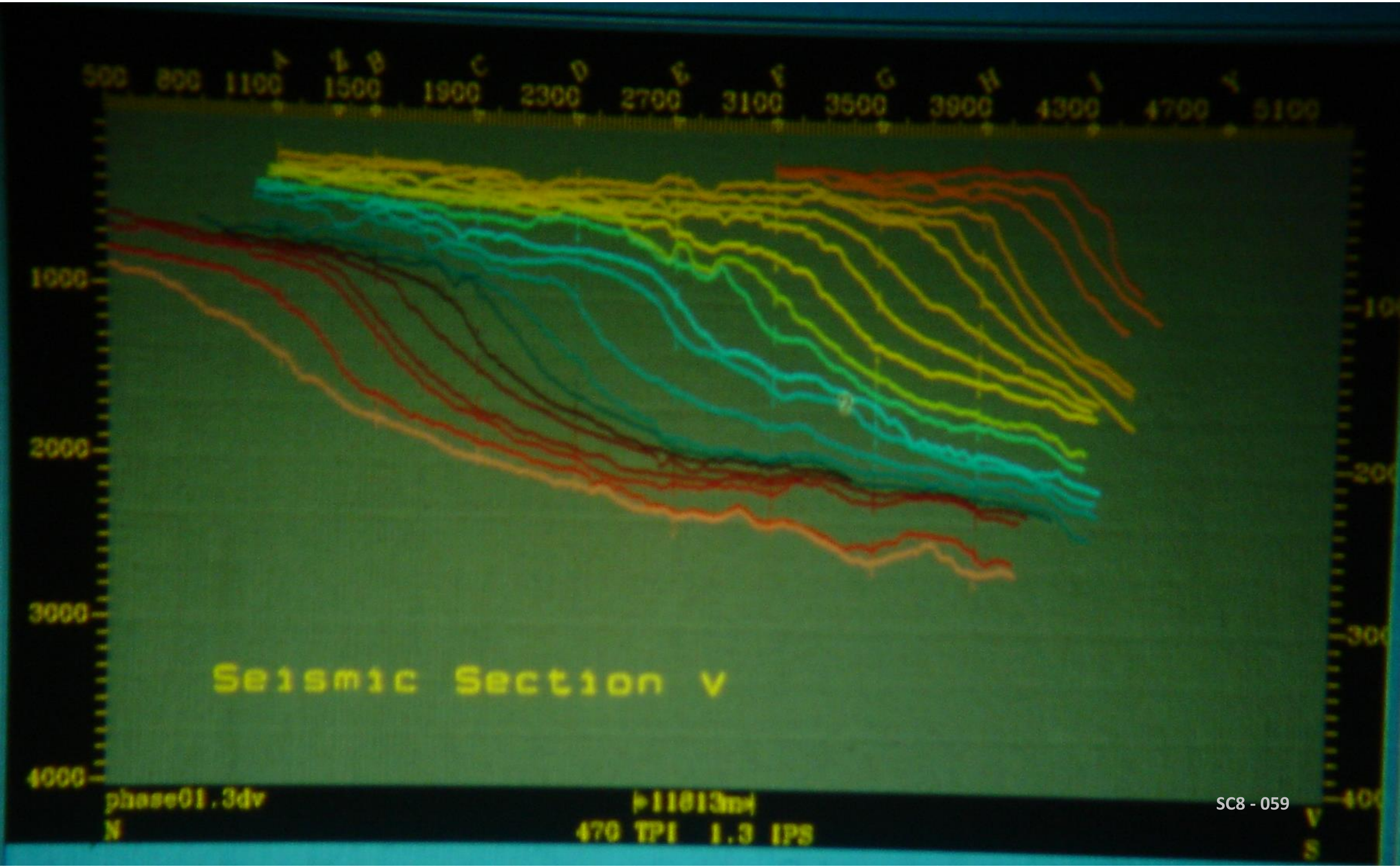
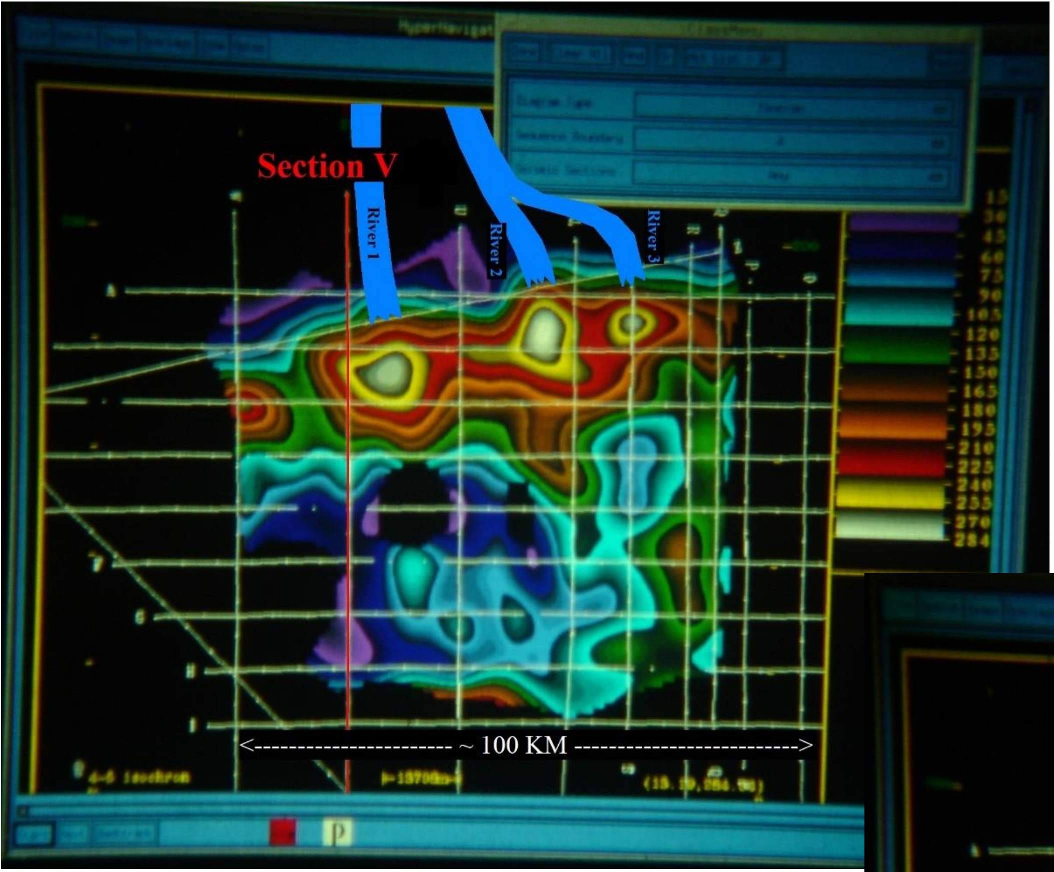
Screen Capture of Digitized Horizons



Maps of Sequence Thickness



Explain Ancient River Locations

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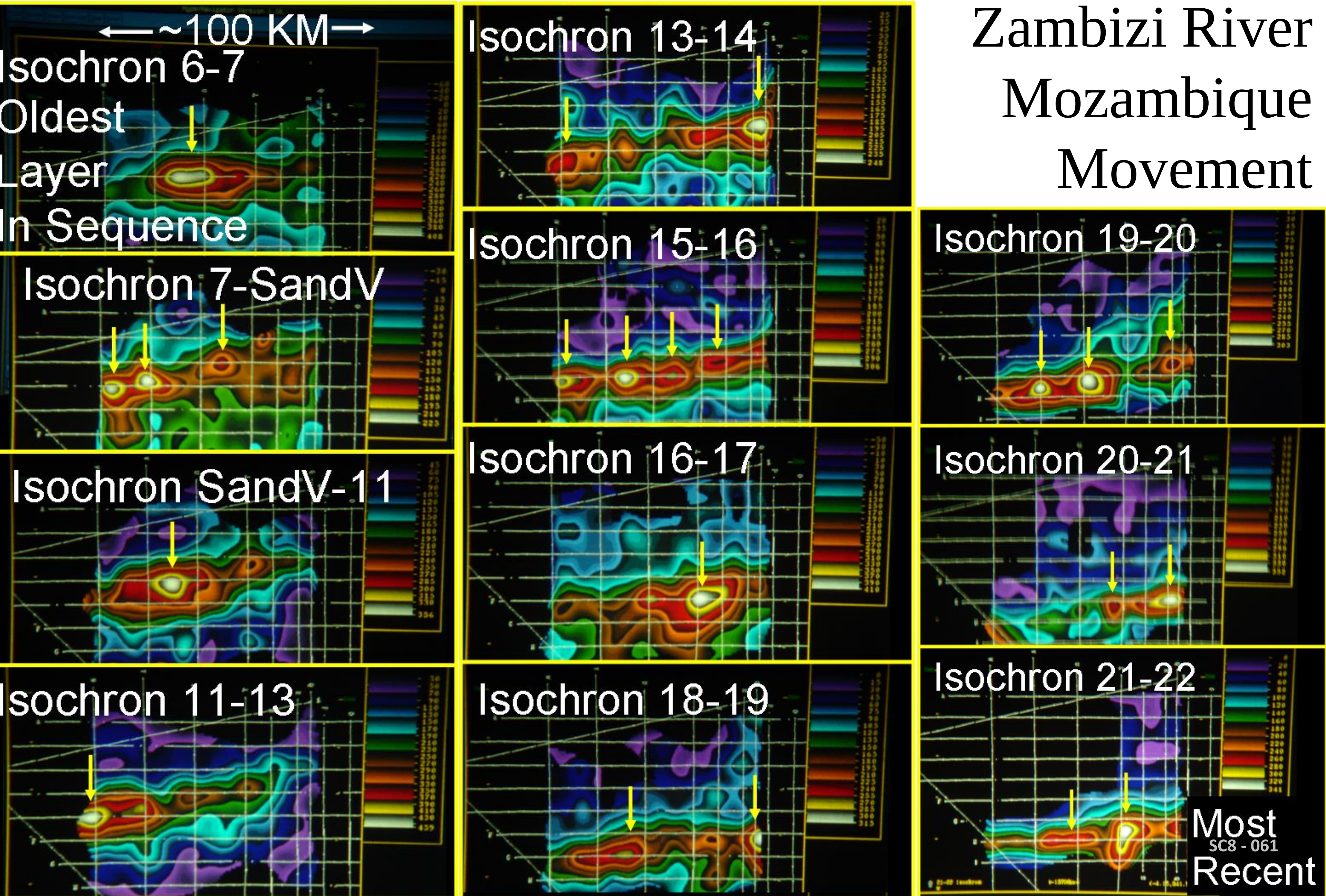
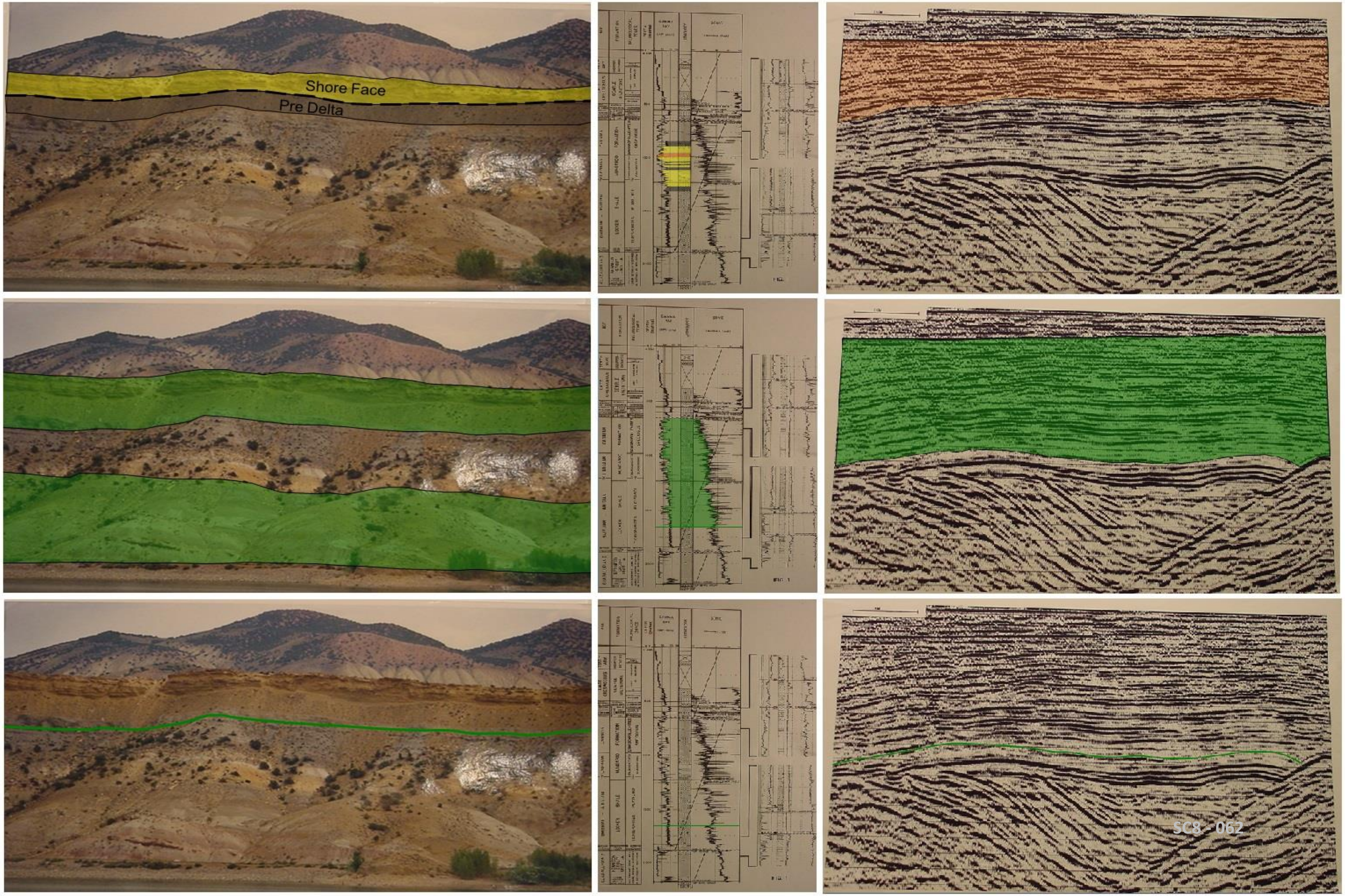
Isochron (Thickness) Maps Showing

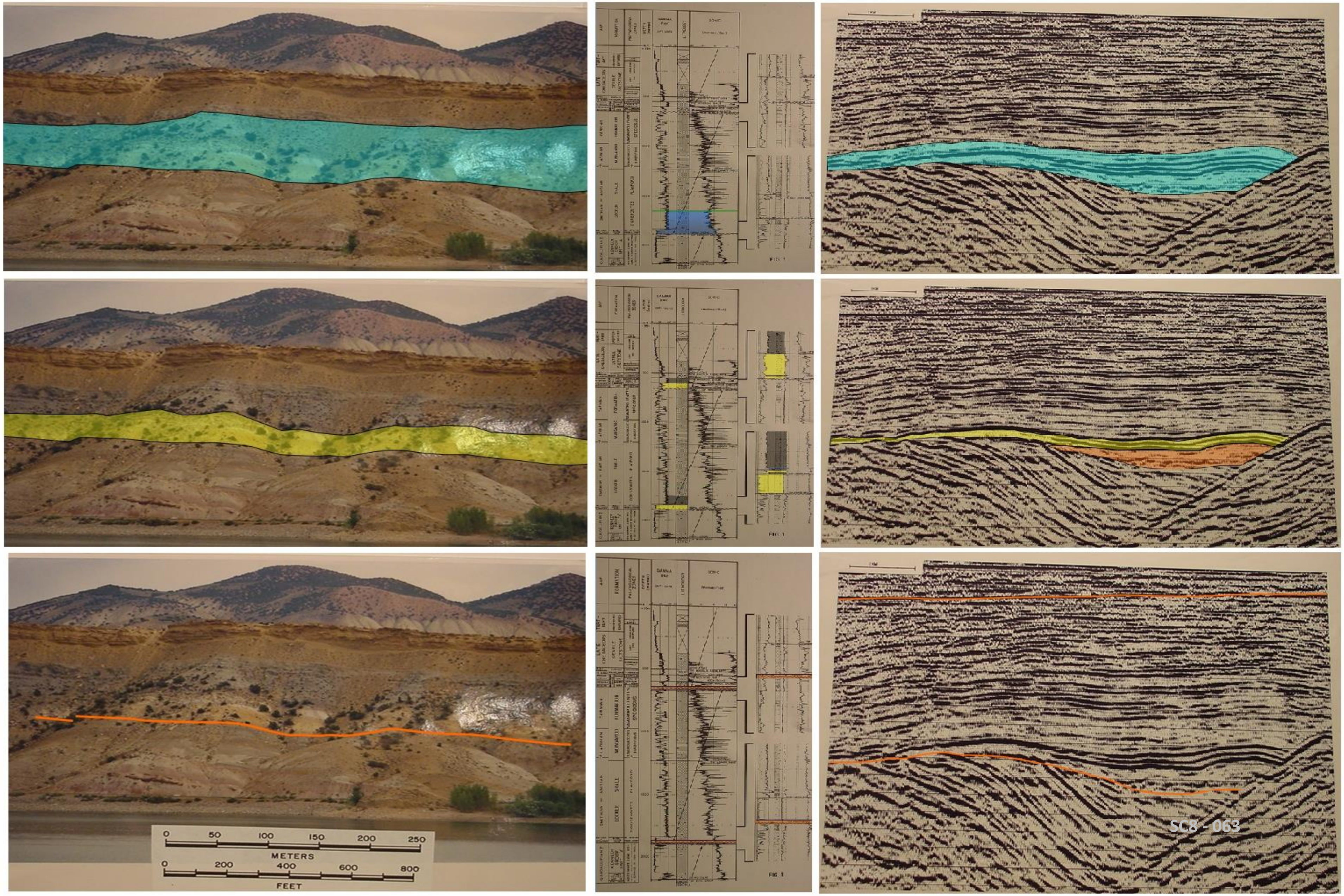
Zambizi River
Mozambique
Movement



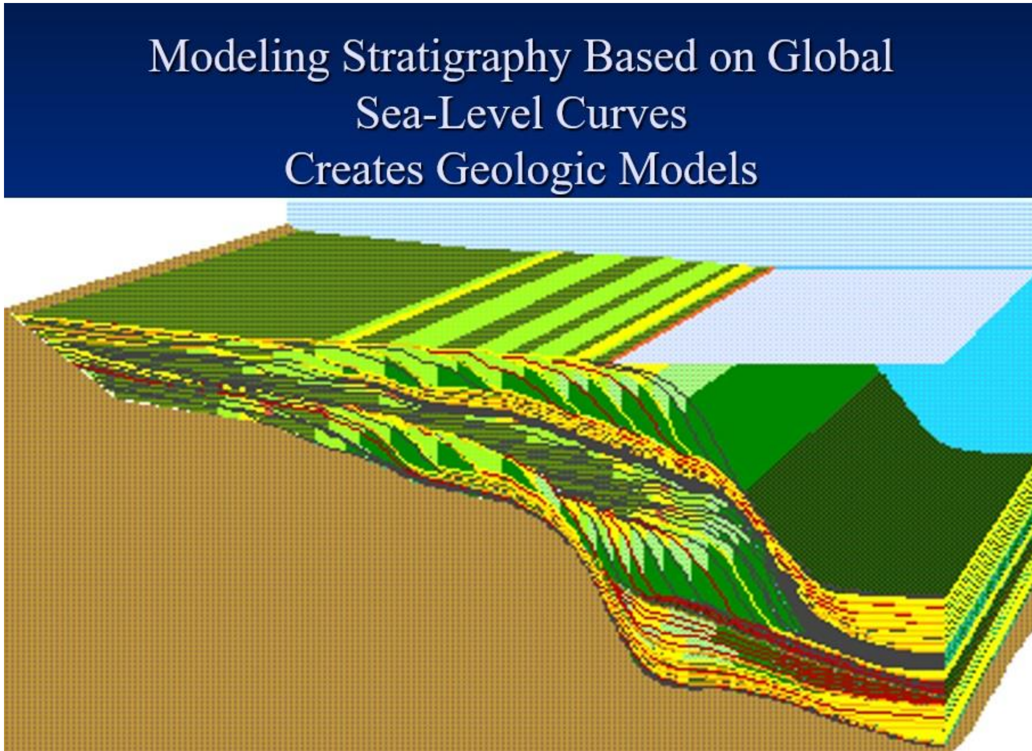
Outcrop Log Seismic



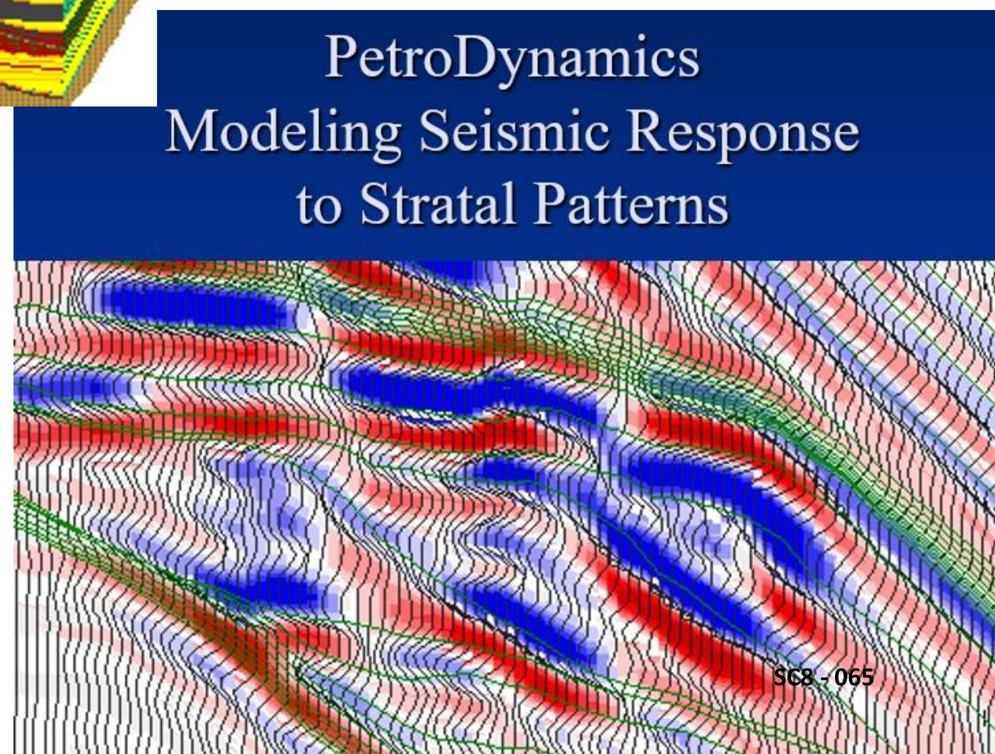
Outcrop Log Seismic



Impact of Sea Level Changes



These Models Are Converted to Seismic Trace Models



Seismic Models Help Explain Seismic Data

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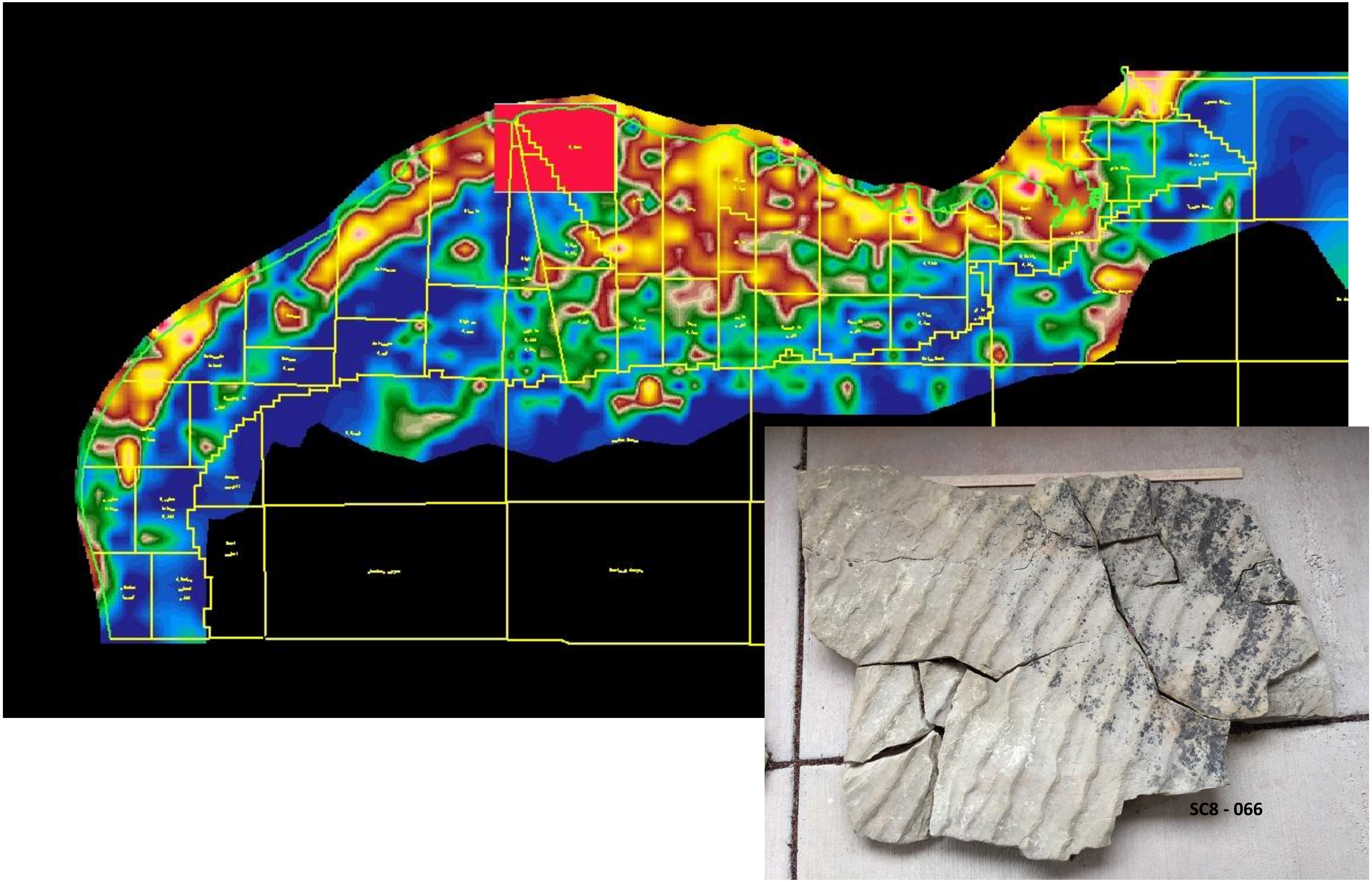
Sand Thickness Map Gulf of Mexico



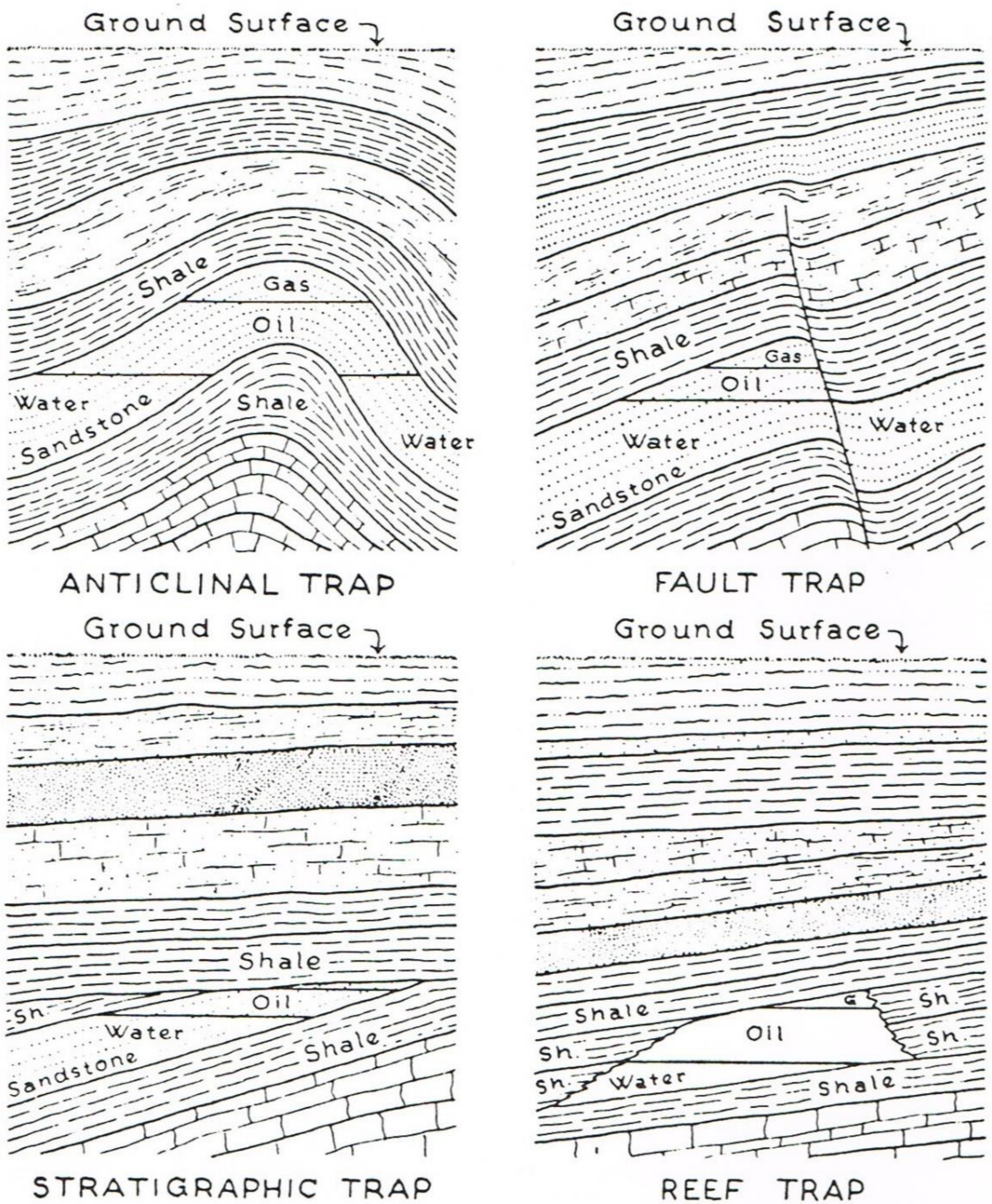
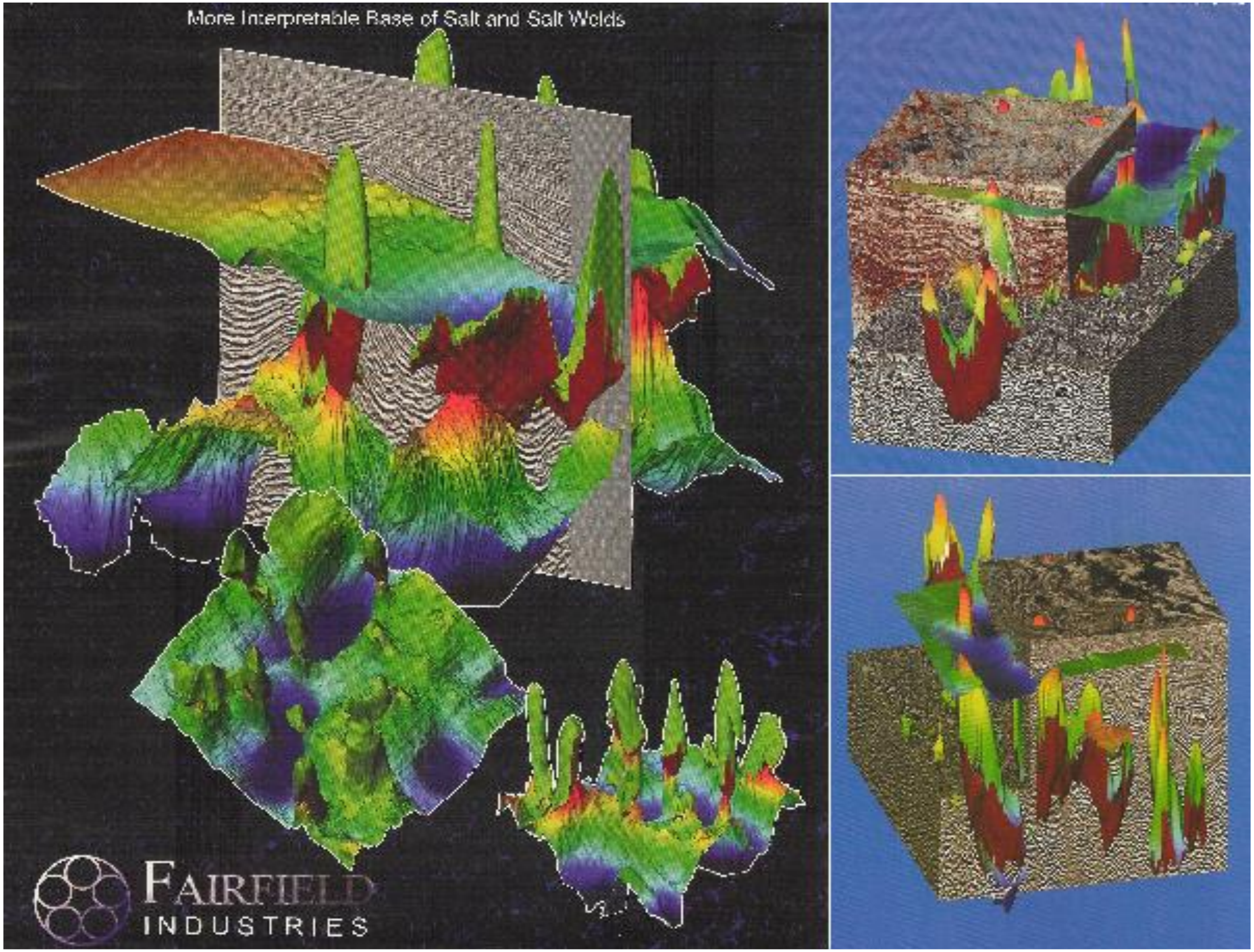


Figure 1-4. Typical examples of hydrocarbon traps. (After Dix.[10])

Geologic Layers have to be folded, faulted, eroded, or deposited to trap oil & gas

Notes

Salt Domes in the Gulf Coast Fold



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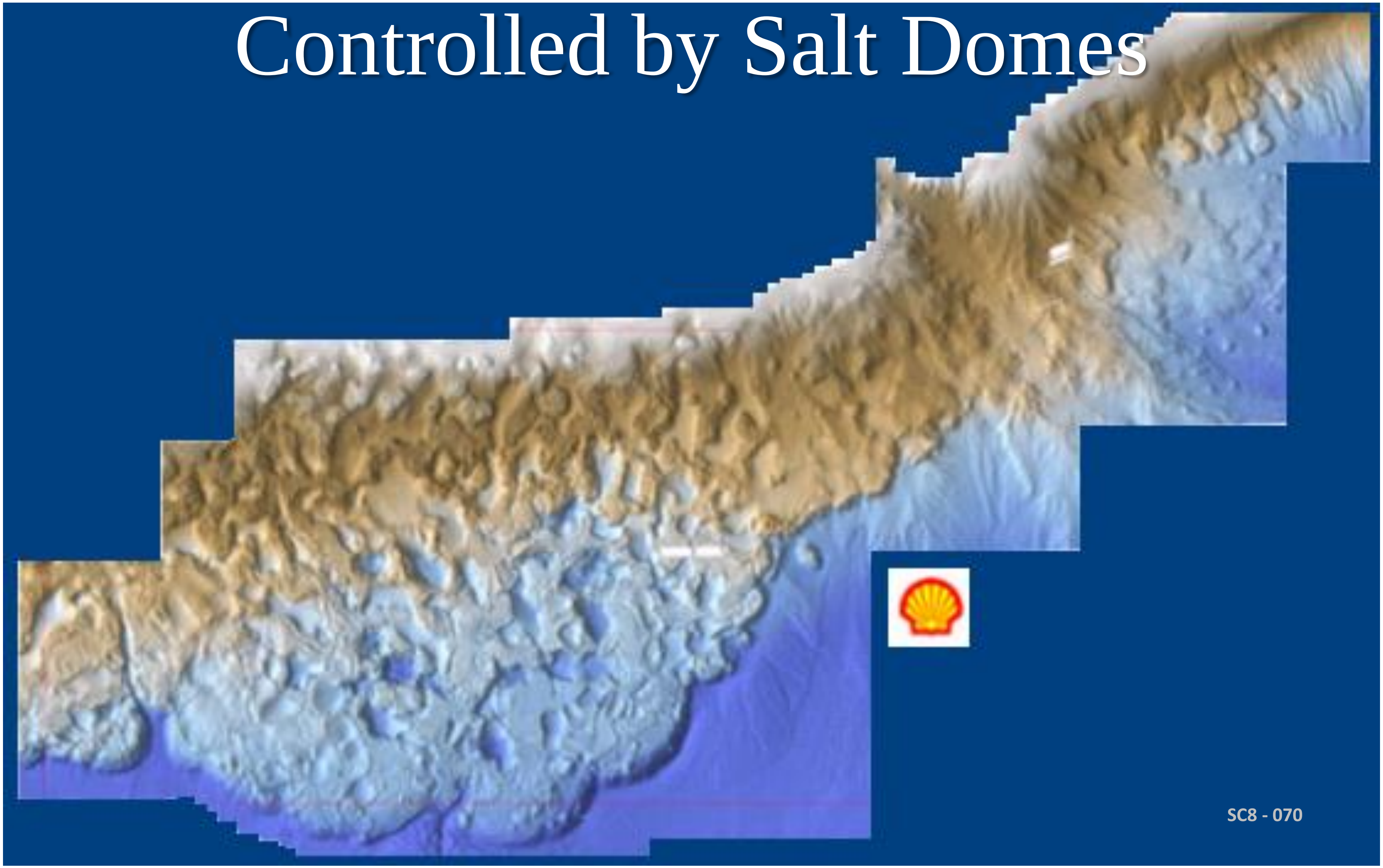
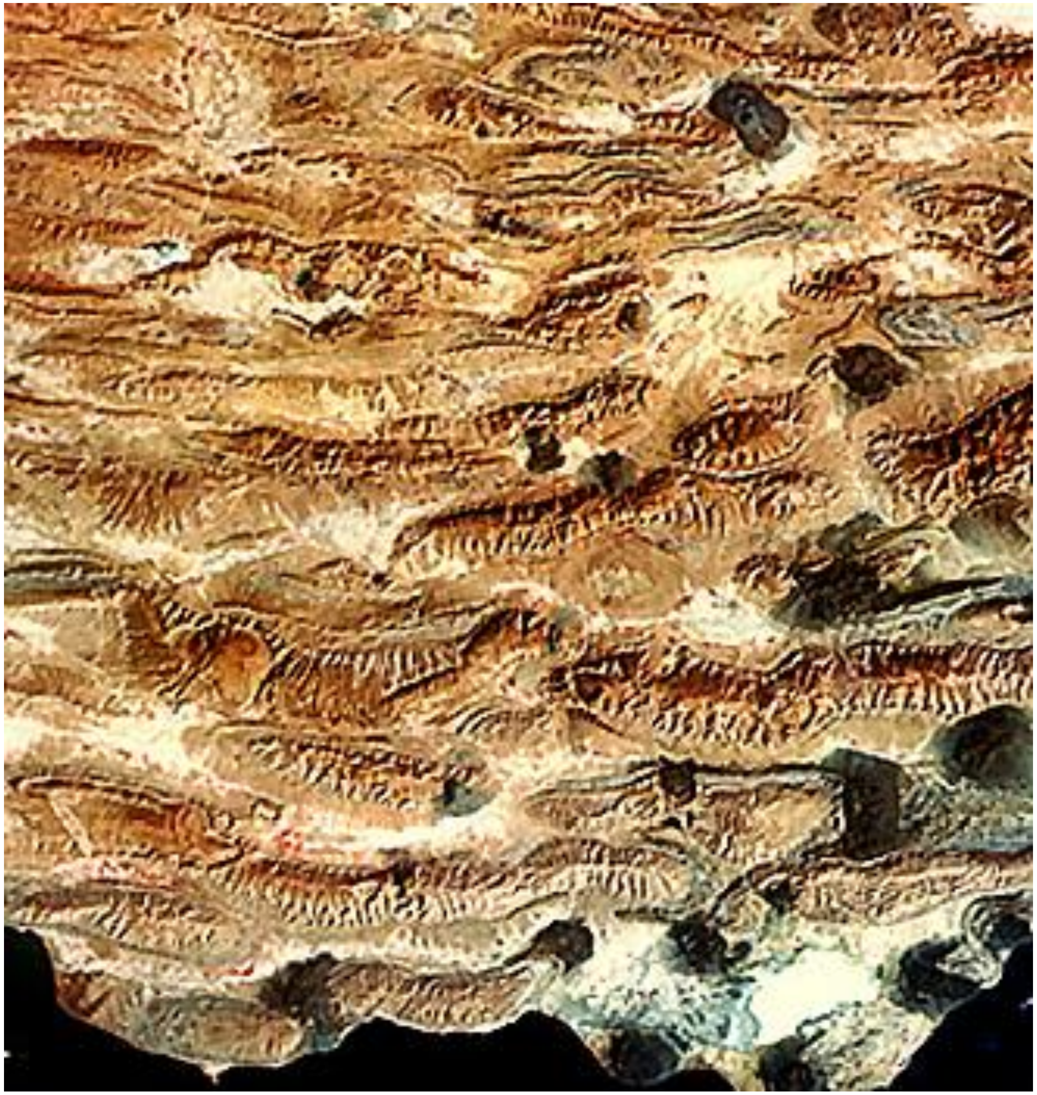
http://www.walden3d.com/photos/Grandkids_Science_Camps/170802-04_Science_Camp/6_Geology-structure.pdf

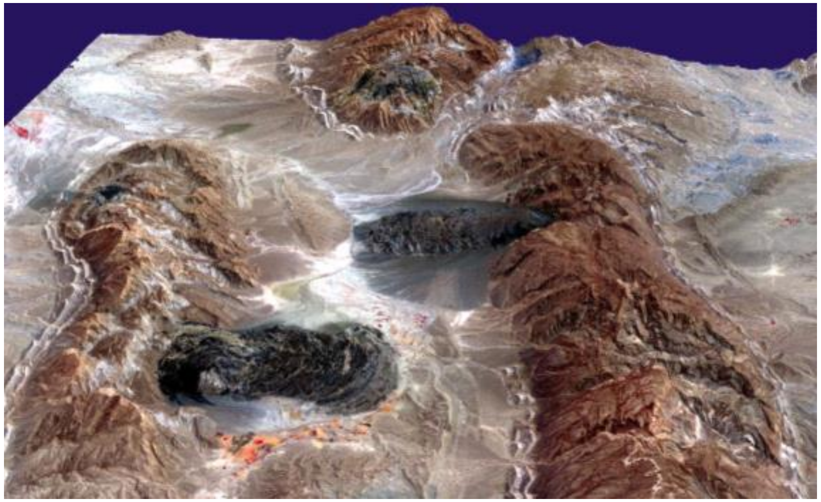
Bathymetry Gulf of Mexico

Controlled by Salt Domes

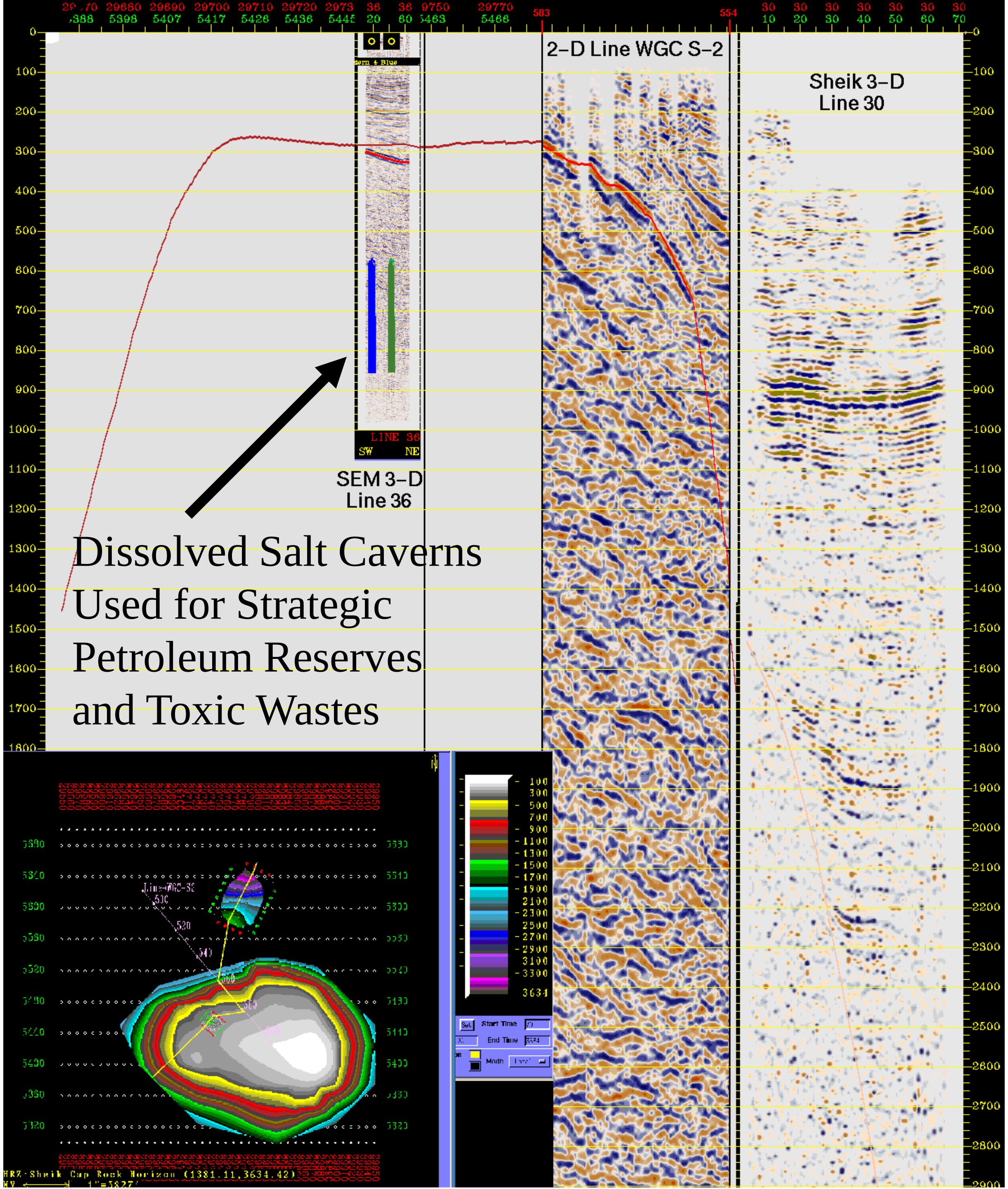


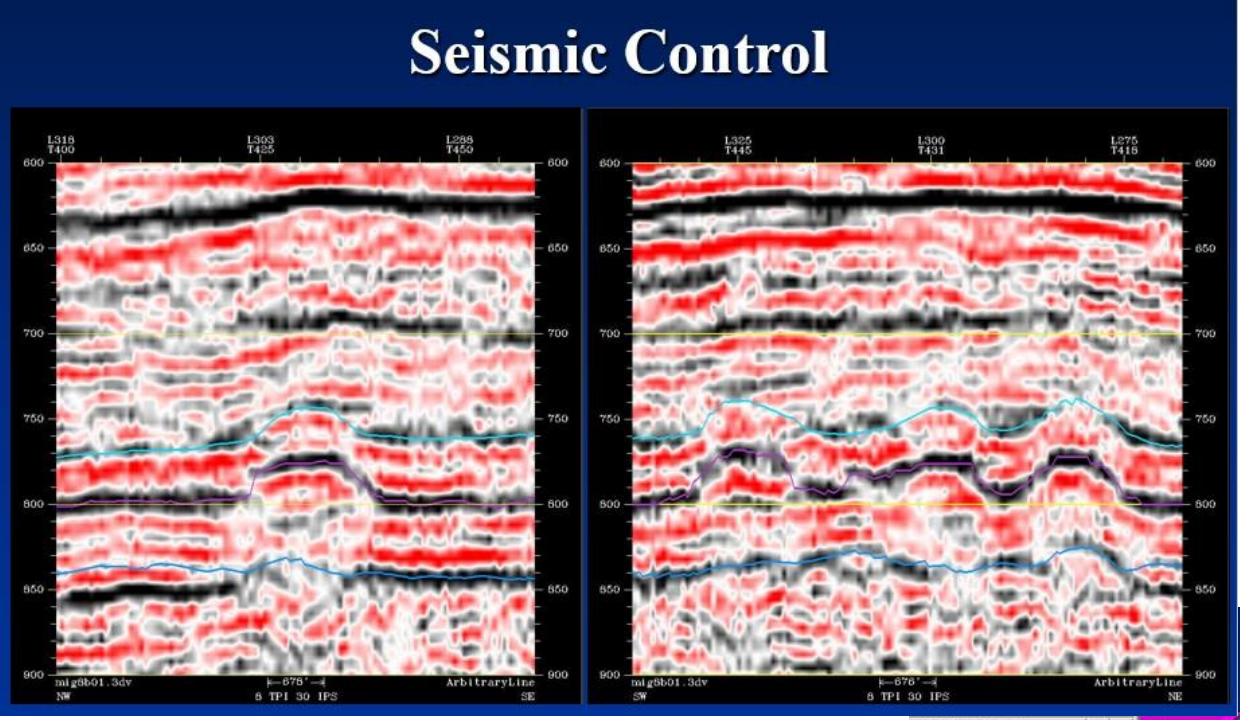
Topography Southern Iran Controlled by Salt Domes



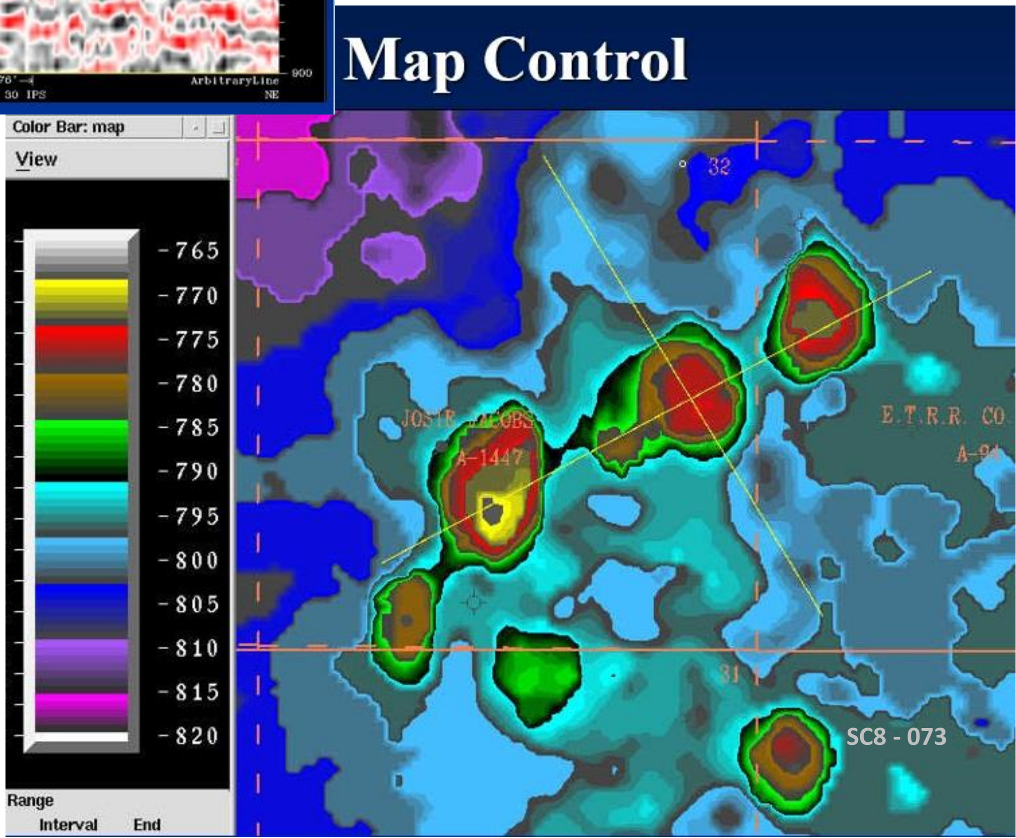


Cross-Section Through The Boling Salt Dome south of Katy, Texas

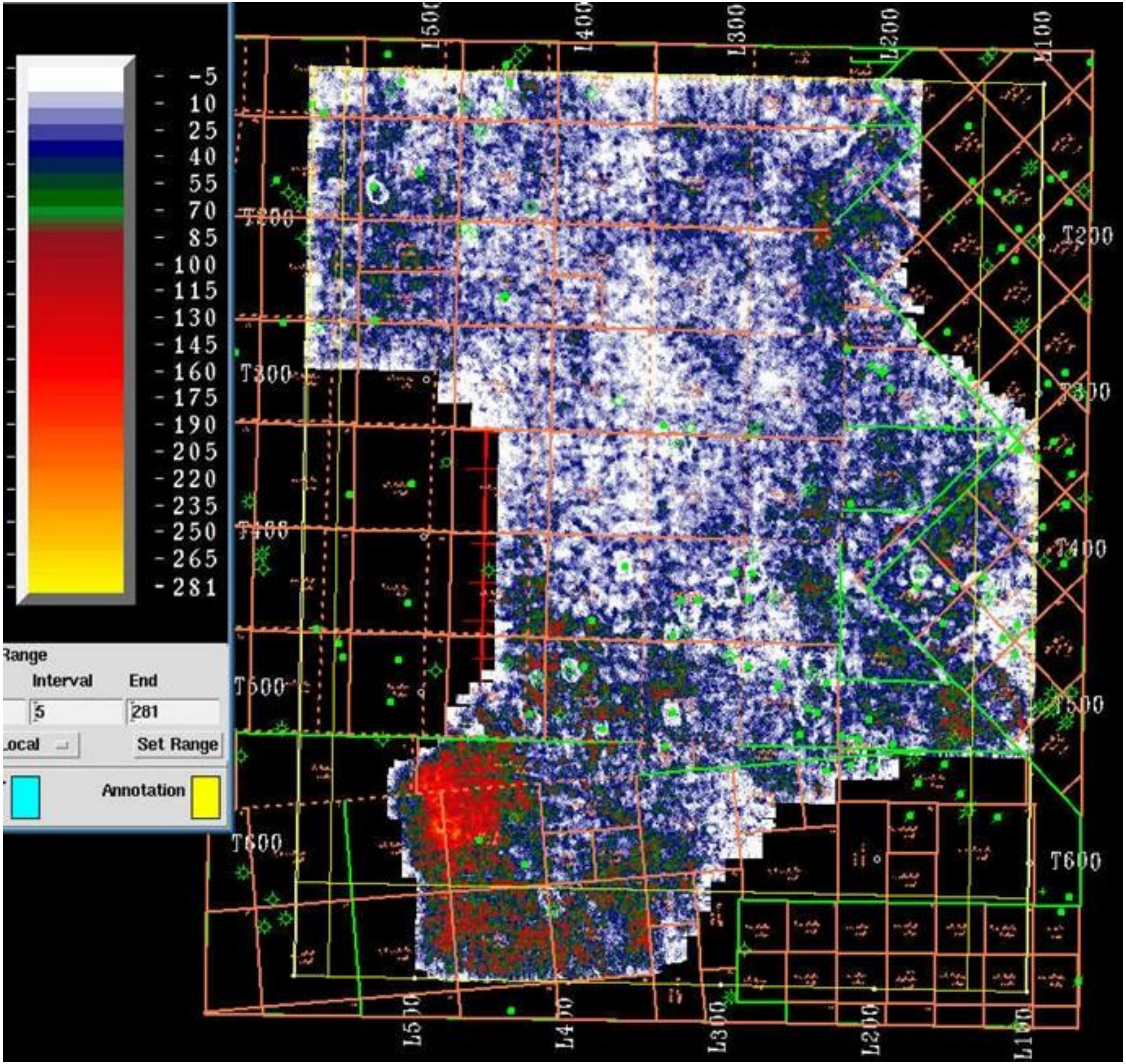




Reefs Also Impact Horizontal Layering



Project in Shackelford County, Texas where the Fandango is Located

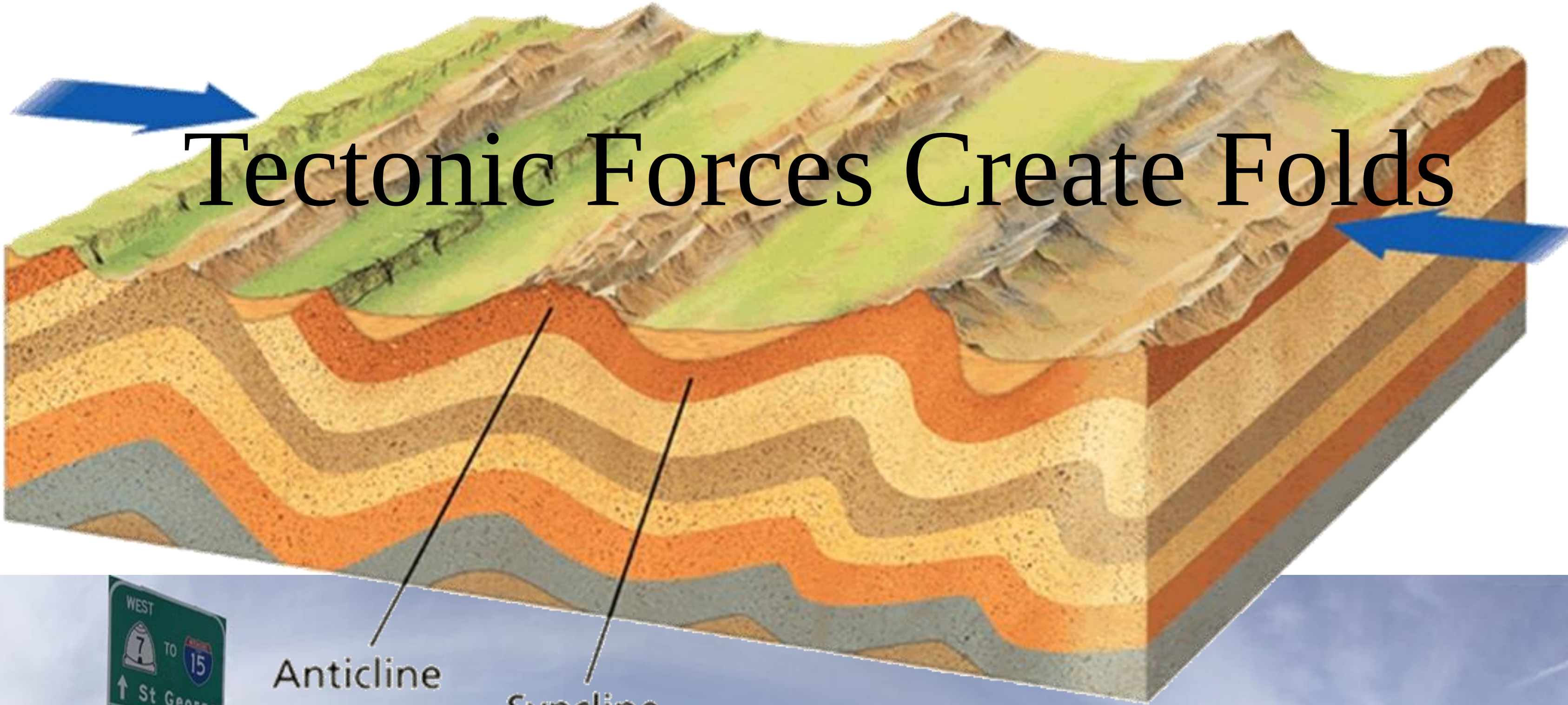


3-D Seismic Slice Shows

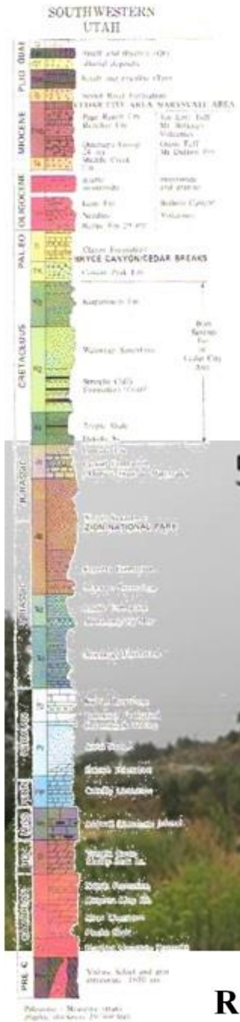
Production

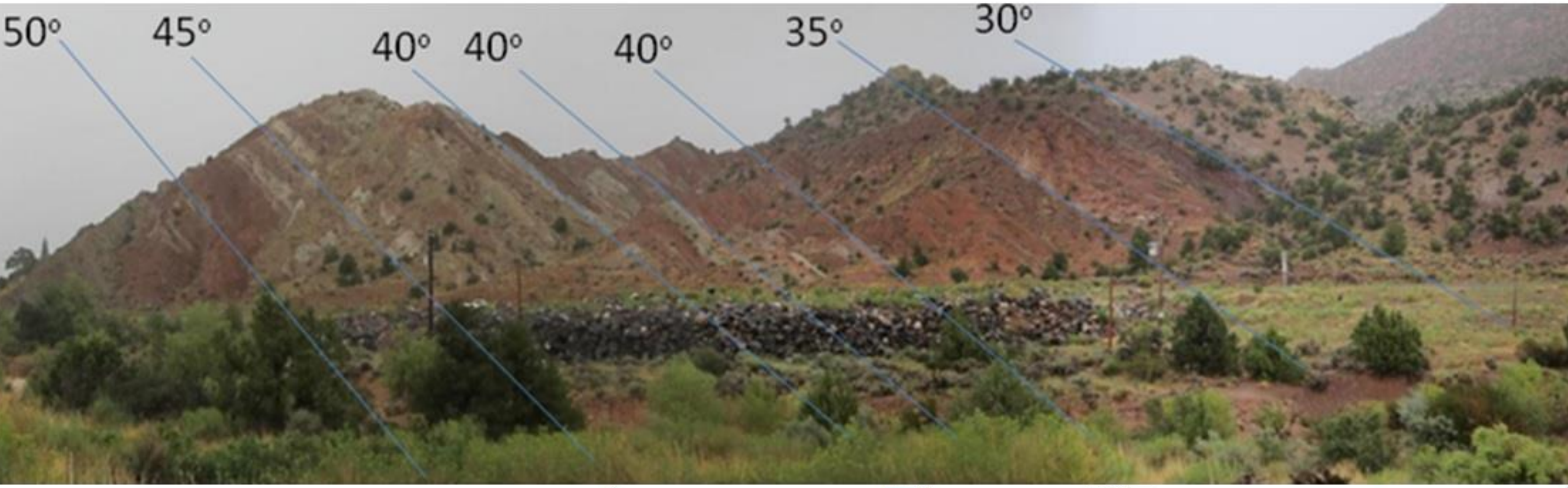
Halos and Rubble Beds

Tectonic Forces Create Folds

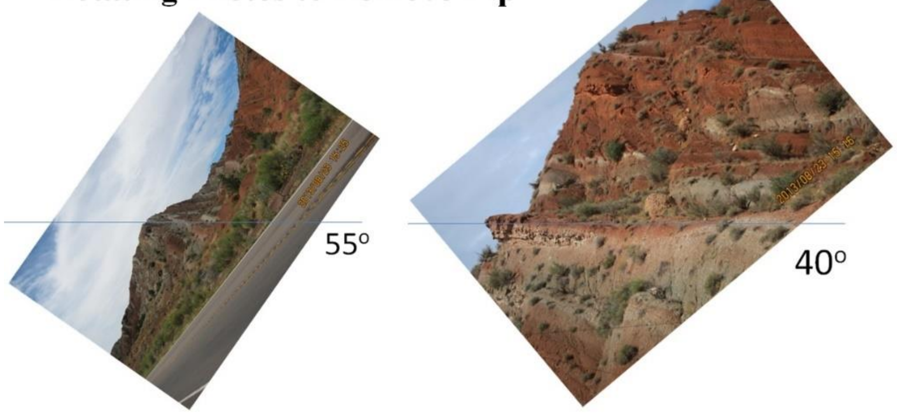


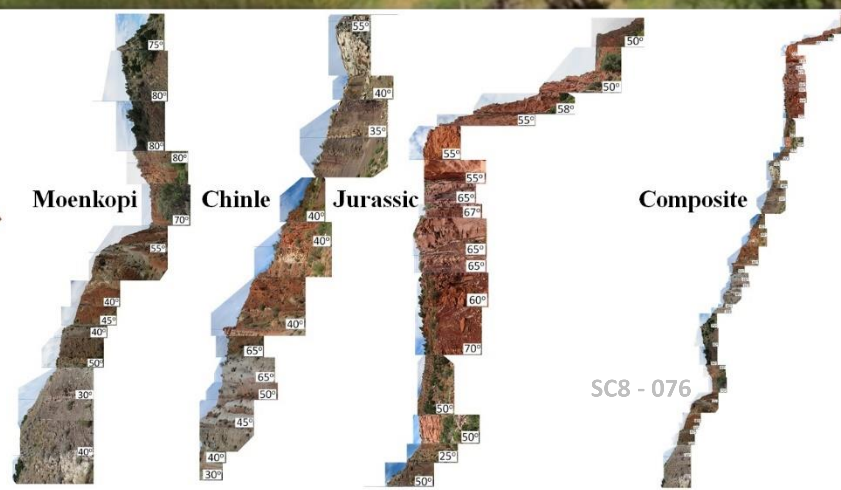
Cedar Canyon – Some of the Best Examples Worldwide of Folding and Faulting





Rotating Photos to Remove Dip





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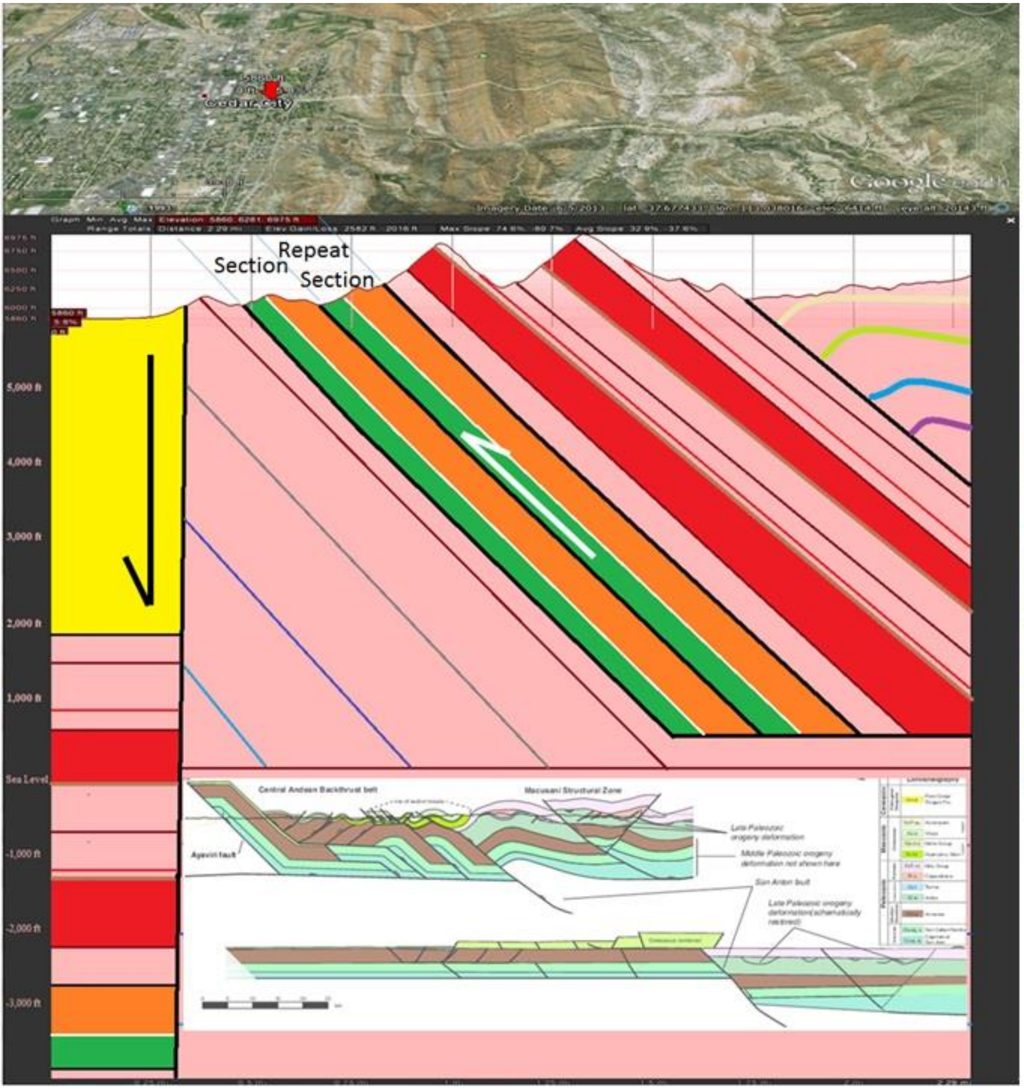
Classic Back Thrust Example



Cedar's Red Hill

excellent example of backthrust

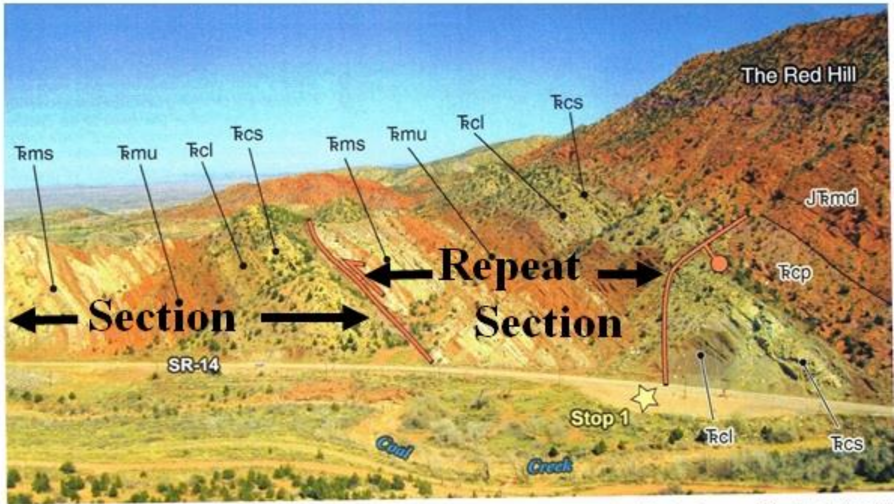
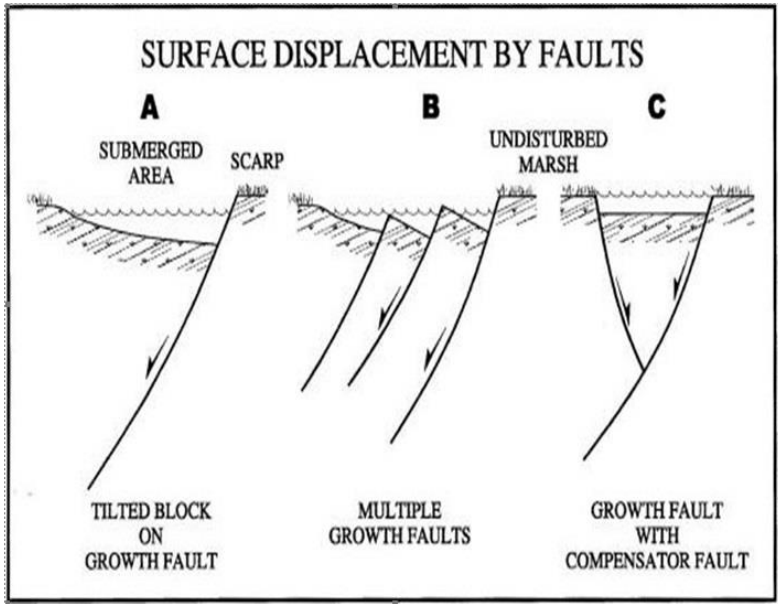


Figure 2. North-directed view of east-dipping Triassic and Jurassic strata near mouth of Cedar Canyon. Shnabkaib through Shinarump strata are repeated along a thrust fault. Bar and ball on downthrown side of normal fault. Ŧms =Shnabkaib Member of the Moenkopi Formation, Ŧmu =upper red member of the Moenkopi Formation, Ŧcl =lower member of the Chinle Formation, Ŧcs =Shinarump Conglomerate Member of the Chinle Formation, Ŧcp =Petrified Forest Member of the Chinle Formation, JŦcs =Dinosaur Canyon Member of the Moenave Formation. Photo courtesy of Tyler Knudsen.

MacLean, J.S., Biek, R.F., and Huntoon, J.E., editors



Structural Traps
Key to Traditional
Oil & Gas Exploration

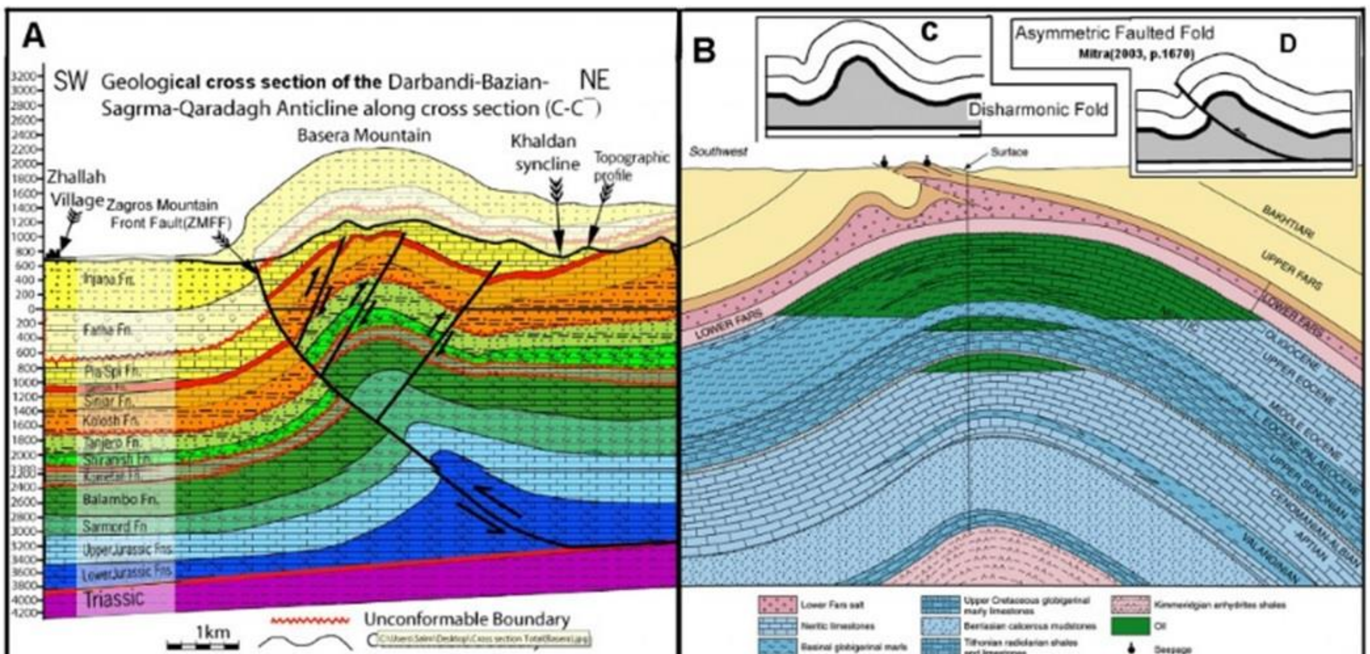
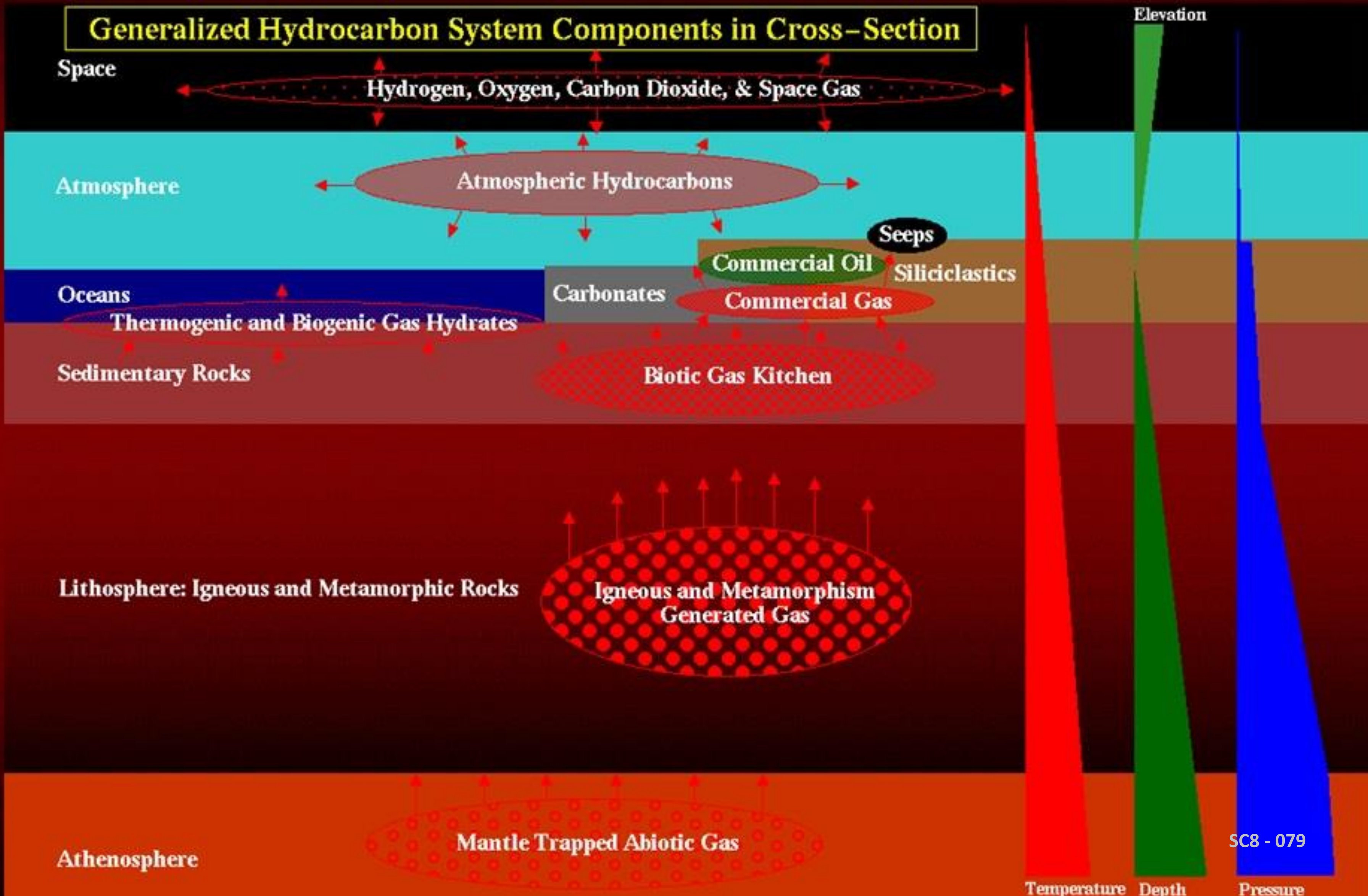


Figure 10. A) Geologic cross section of Sarma-Darbandi Bazian (Al-Hakari, 2011) and Omer et al. (2015) which assumed as fault propagation fault. B) Kirkuk anticline is detachment fold (disharmonic fold) formed by limb rotation not by Fault propagation fold. C) Disharmonic detachment fold (Mitra, 2003) which similar to Kirkuk anticline. D) Asymmetric faulted fold (Mira, 2003) which is similar to the faulted anticline near the crest of latter anticline

The Hydrocarbon Cycle



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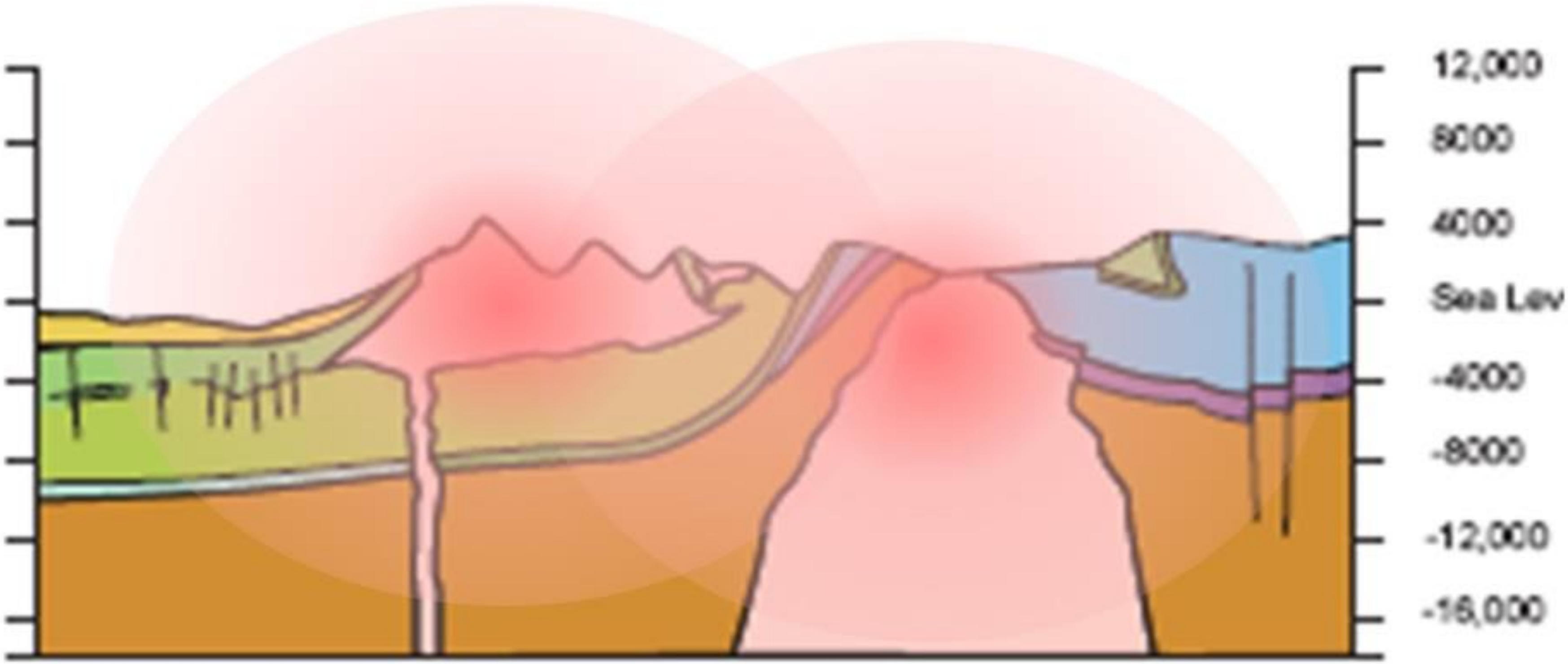
Notes

Temperature Cooks Off Hydrocarbons and Creates Mineralization




Temperature Anomalies from Intrusive Rocks


Mineralization Occurs in Heated Fluids in Faults

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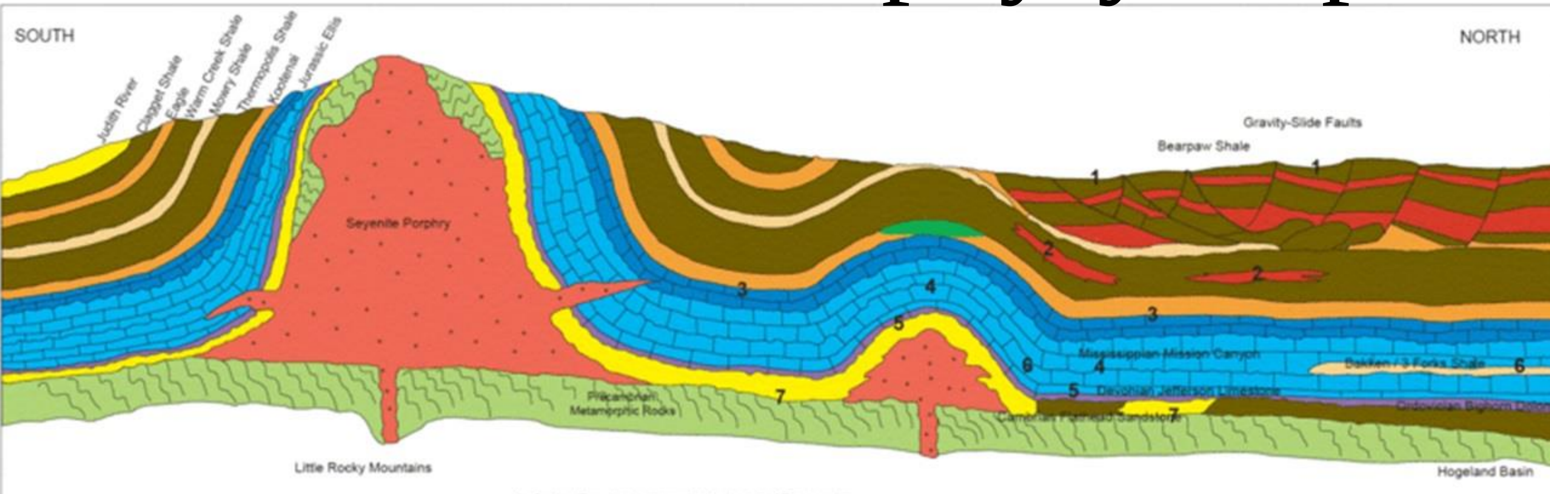
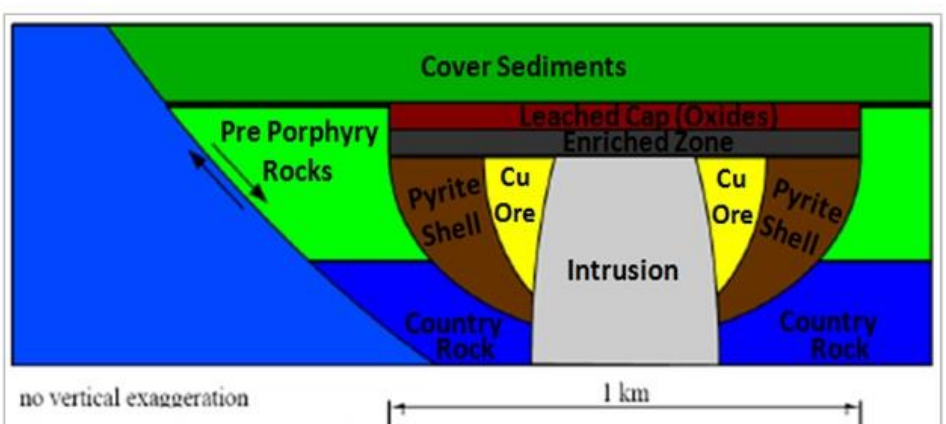
Intrusions and Porphyry Deposits



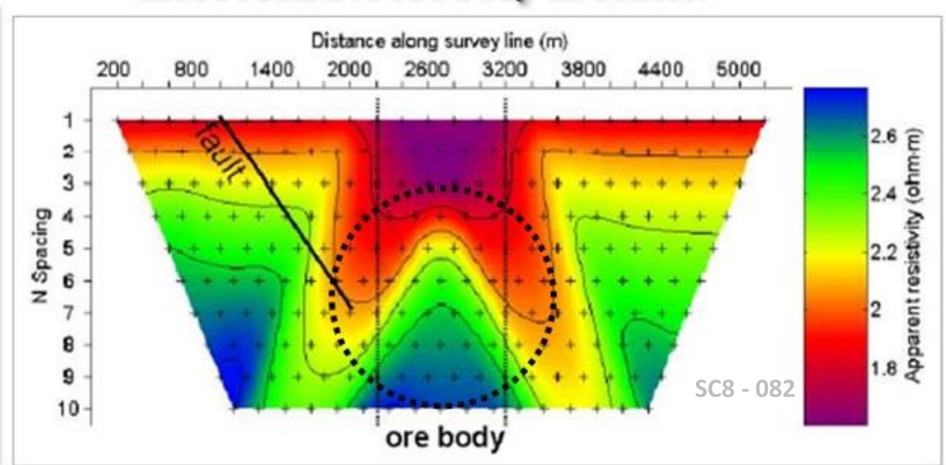
Simplified Porphyry Copper Deposit Model

Typical Mineral Zones of a Porphyry Deposit

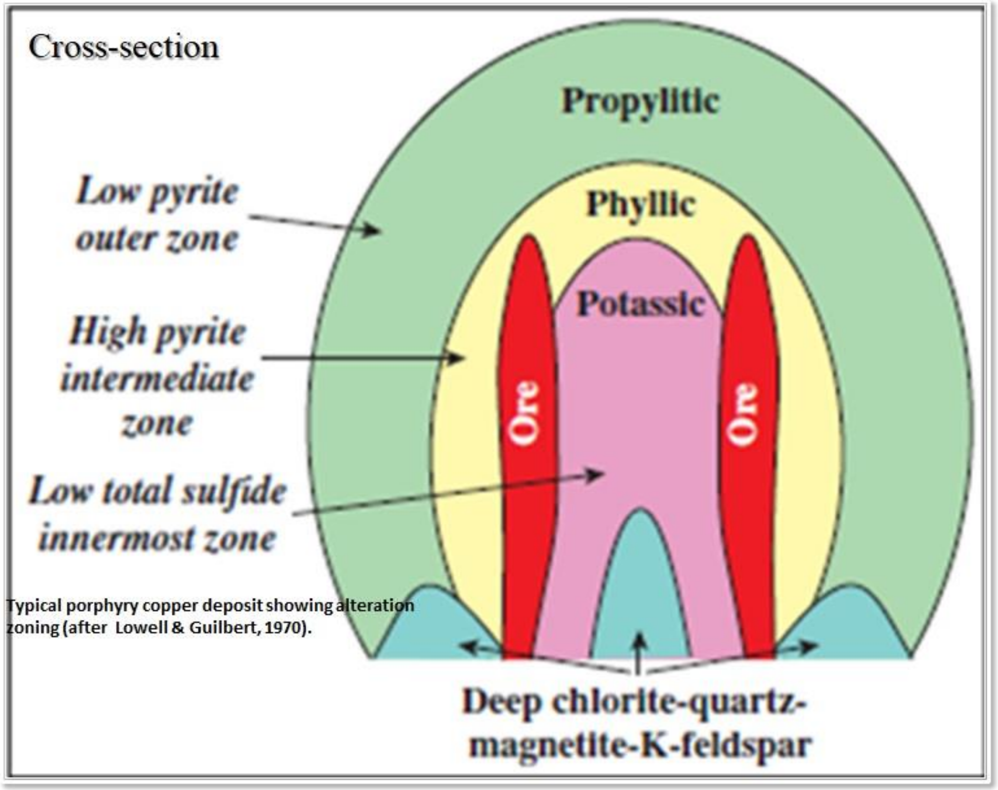
Conductivity anomaly surrounds more resistive ore body in center.



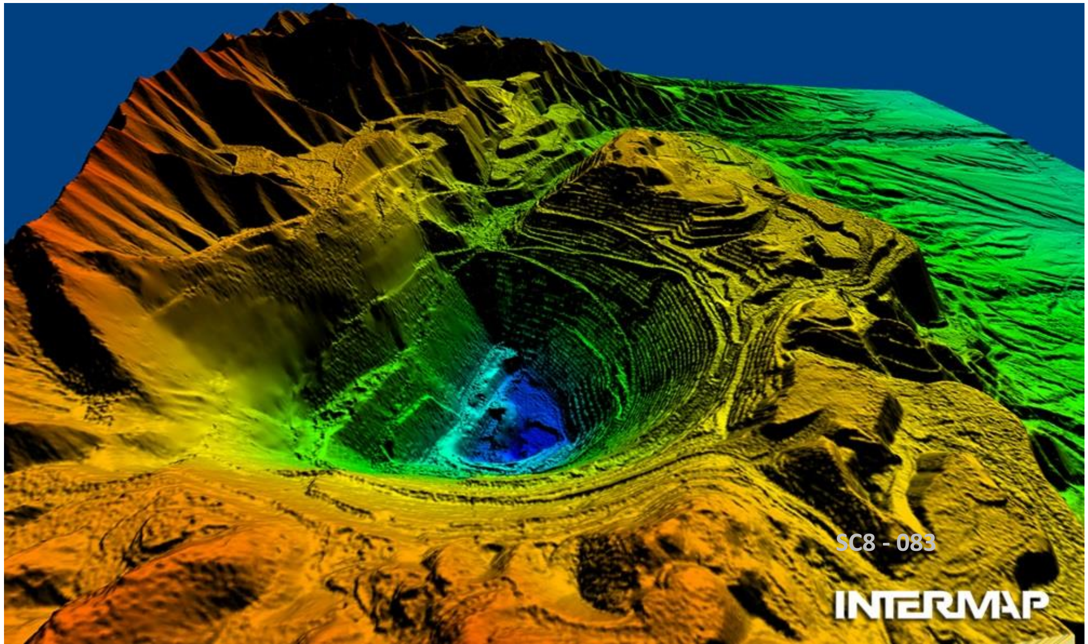
(after Emond, Zhdanov & Petersen, 1970)



Kennecott Copper Mine is an Example of a Copper Porphyry Deposit



Typical porphyry copper deposit showing alteration zoning (after Lowell & Guilbert, 1970).



Sedimentary Rocks


Chalcedony, Glitter Rocks, & Obsidian


Red Rocks & Wonder Stone


Temple Agates


Blue & Pigeon Blood Agates
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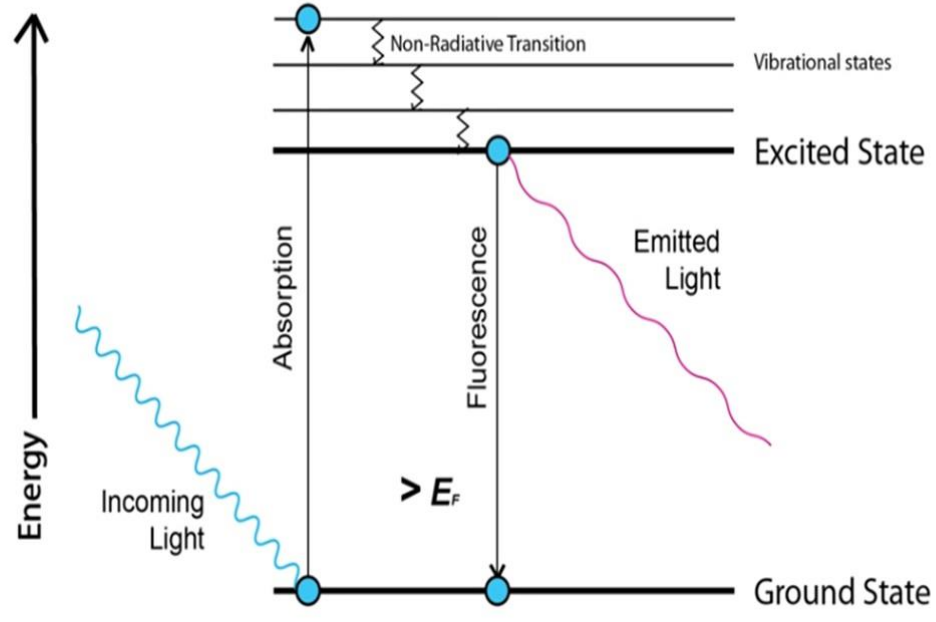
Azurite & Malachite


Volcanic Rock & Gold Matrix


Pyrite


Moapa Volcanic Glass
SCB - 086

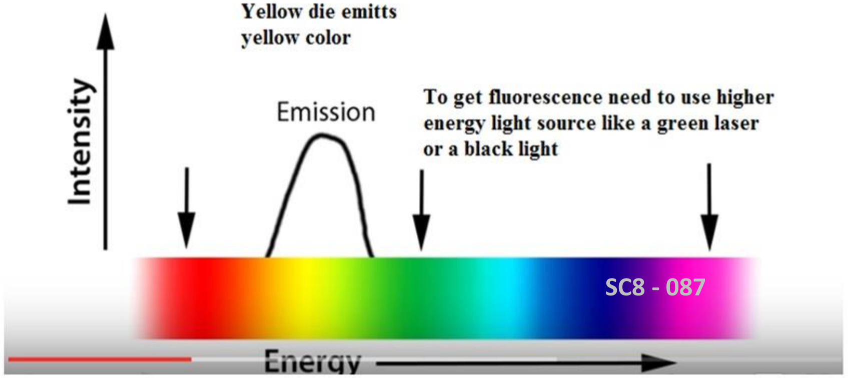
Fluorescent Rocks



Red laser
no fluorescence

Yellow die emitts
yellow color

To get fluorescence need to use higher energy light source like a green laser or a black light



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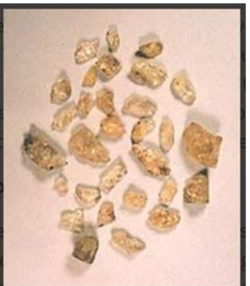
Is it an accident these rocks are here?

Other Rocks In the Area

Sunstones and Topaz deposits are associated with lightning mappable underground geologic processes



Sunstones collected at Sunstone Knoll, Millard County. 1 / 4

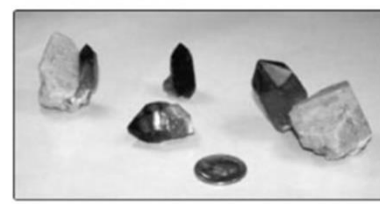
Topaz crystals. 1 / 7

One of the numerous pits that collectors excavated in their search for topaz and other minerals. 6 / 7

Smoky Quartz vugs tie hydrothermal alteration

Geologic information:

The Mineral Mountains, located in Beaver County, make up the largest exposed plutonic body in Utah. Rock compositions range from quartz monzonite in the northern half of the pluton to granite around Rock Corral Canyon in the south. Excellent crystals of smoky quartz and feldspar are found in vugs or cavities in the granite. They formed when cooling fractures in the granite were filled by late-stage pegmatites consisting of quartz, microcline, and plagioclase. Quartz occurs as clear to smoky, euhedral crystals up to three inches long while microcline is commonly found as euhedral, equidimensional crystals averaging approximately 0.75 inches in width. Occasionally, large pseudomorphs of limonite after pyrite can be found in these areas as well.



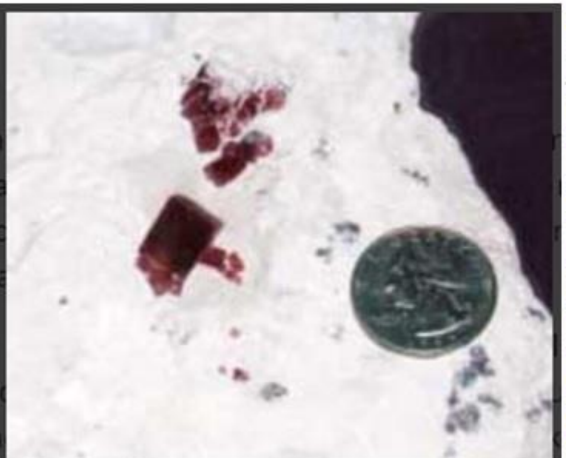
Trilobites

Abundant trilobite fossils, including Elrathia kingi shown here, can be found within the Wheeler Shale east of Notch Peak in the House Range. Many of the dry desert peaks of western Utah tell a story of shallow tropical seas. As much as 500 million years of deep burial, uplift, and erosion have changed layers of organic mud to cliffs and ledges of layered limestone. Closer inspection reveals abundant fossils, evidence of ancient sea life. Notch Peak, House Range, Millard County, Utah Photographer: Michael Vanden Berg 2 / 2

Cambrian-age shales from western Utah's House Range contain millions of fossilized trilobites, such as this specimen of Elrathia kingi. Trilobite, House Range, Millard County, Utah Photographer: Michael Vanden Berg 1 / 2

Very Rare Gems

Red & Green Beryl
are a direct result of hydrothermal alteration



Specimen of red beryl from the Ruby-Violet claims in the Wah Wah Mountains. U.S. quarter for scale.

Green Gold

Oh, what a little hot water can do to boring old shale

BY ROBERT KUNZIG

Before the Spanish conquest of what is now Colombia, people in the mountains north of Bogotá are said to have thrown emeralds into Lake Guatavita. Once a year the Indian ruler would cover himself with honey and gold dust and at daybreak have his men row him out into the lake. As he plunged into the water, offering the gold to his god, the crowd on shore would throw in their own offerings. The rich ones chucked in emeralds.

When the Spaniards finally found the Indian emerald mines after decades of bloody searching, the Old World went crazy for the New World's gems. Although the Egyptians had begun mining emeralds near the Red Sea as early as 1650 B.C.—and emeralds had long been symbols of immortality, cures for dysentery, and preservers of chastity—the new Colombian gems were the clearest, biggest, and greenest anyone in Europe had ever seen. They still are: the same mines remain in operation, accounting for 60 percent of the world's production.

Emeralds are valuable because they are rare, rarer than diamonds. They are rare, says geologist Alain Cheilletz of the Center for Petrographic and Geochemical Research in Nancy, France, because they are a mixture of elements that don't ordinarily get a chance to mix: "They are a mineral that shouldn't exist at all."

For centuries emeralds were thought to cure dysentery and even preserve chastity

An emerald is a type of beryl, a mineral made of beryllium, aluminum, silicon, and oxygen. All those elements are common in the continental crust, so beryls are not rare. But whereas ordinary beryls are colorless, emeralds are green because a few of the aluminum atoms in their crystal structure have been replaced by atoms of chromium or vanadium. Neither of those elements has any reason to meet up with beryllium; they and it belong to two different chemical families that drifted apart billions of years ago.

Soon after Earth was born, when it was young and mostly molten, a lot of silicon and aluminum rose to the surface, like a kind of scum, then cooled, forming the first continents. Most of the iron stayed behind in the mantle or sank into the planet's core. Other elements chose one of those two fates, too, based on their weight and size.

A sparkling Colombian emerald born of the drabbest black shale.

Because of this parting of the elements, Earth's surface rocks are segregated into two realms, like yang and yin: light and dark, crust and mantle, continent and ocean bottom. Geologists call the light minerals felsic and the dark ones mafic. The paradox of the emeralds, as Cheilletz calls it, is that beryllium belongs to the light, felsic, continental side, whereas chromium and vanadium are from the dark, mafic, oceanic side. Emeralds, in other words, are yin and yang in a single crystal. "The whole problem in our research," says Cheilletz, "was to figure out the geologic conditions that could permit these two elements to meet at the same time and place."

The answer, they discovered, has to do with plate tectonics, the ceaseless shifting of Earth's crust that smashes continents together to build mountains. Every now and then, when an ocean disappears between two colliding continents, a chain of volcanic islands or a slab of seafloor gets beached on land. As a result, the continental crust has over the eons lost its original purity; it has become a patchwork that includes oceanic rocks, and thus traces of chromium and vanadium, along with the continental rocks that are laced with beryllium.

To make an emerald, though, those elements have to come together in a single hot liquid. The most common place for it to happen is underneath a young mountain

range. Where the edges of two colliding plates stack up, continental rocks can get dunked so deep into Earth that they melt again, liberating a great balloon of magma that rises back through the crust. At a depth of around six miles, the magma reaches its level of neutral buoyancy, stops, and begins to cool and solidify as granite. From the top of this cooling mass, streams of superhot, mineral-laden water—granite juice—migrate upward into fissures in the surrounding rock and begin to leach out elements.

Ninety-five times out of a hundred that surrounding rock is some ordinary bit of continent, and nothing terribly novel happens. "But if by chance the granite happens to hit a zone of mafic rock incorporated in the continental crust, then the chemistry will be completely different," says Cheilletz. "It will include iron, magnesium, and calcium—and traces of chromium and vanadium." When the felsic-mafic mixture finally freezes, the fissure will be filled with biotite, a kind of mica—black, flaky, and useless. But scattered through the mica, like green snowflakes, may be emeralds.

Most of the world's known emerald deposits, from the 3-billion-year-old ones in South Africa to the 9-million-year-old ones in Pakistan, were formed by granite intrusions. In the 1980s, Cheilletz and his colleague Gaston Giuliani studied deposits like that in Brazil. Then they went on to Colombia to have a look at the most renowned emerald mines—and soon saw that they didn't fit the standard picture. "In Colombia, geologists had been looking for granites but not finding them," Giuliani says. "When I arrived, I saw right away that the rocks were not the same."

Inside each emerald is a small pocket of fluid, called a garden. In the fluid is a crystal of salt. Often that microscopic evidence is the only way to tell a fake

Instead of granites intruding from below, in Colombia there are black shales laid down from above—sedimentary rocks deposited on the floor of a shallow inland sea during the Cretaceous Period, 100 million years ago. The sea must have been shallow, because the shales are sandwiched among layers of salt, which precipitated out of the water at times when it had all but evaporated. Black shales, besides being progenitors of oil fields (of which Colombia has a few), also contain everything that washed off the various rocks that made up the neighboring land. The Colombian shales contain, in dispersed form, all the ingredients of emeralds.

According to Giuliani and Cheilletz, those ingredients came together on two distinct occasions, 65 million and 38 million years ago. Surges in plate motions—the Atlantic Ocean was getting wider, pushing South America against the Pacific and raising the Andes—caused the thick stack of sediments under the shallow sea to buckle. Large sloping faults formed several miles down in the sediments, and hot water was squeezed out of them, escaping upward along the faults. Rising through layers of salt, the 570-degree water became extremely corrosive. Continuing through layers of shale, it dissolved out the emerald ingredients. Finally it pooled under a layer of especially impermeable shale until the pressure became great enough to shatter that layer explosively.

Then the hot solution shot up through empty cracks in the rock. As its temperature and pressure plummeted, emerald crystals snowed out of it immediately. It all happened so fast, says Giuliani, that the emeralds had no time to grow around grains in the surrounding shale. They grew unconstrained and pure, without the minerals that often cloud emeralds found in other parts of the world. That is why Europeans were so enraptured with the Colombian stones when they first laid eyes on them in the sixteenth century.

Like other emeralds, those from Colombia contain tiny pockets of fluid, typically no more than a hundredth of an inch across—gardens, as they're called in the gem trade. If you look at one of the Colombian gardens under a microscope, says Giuliani, you will see that it contains a crystal of salt, ordinary sodium chloride. The crystal is a trapped fossil of the brine from which the emerald itself crystallized, tens of millions of years ago.

Except for those inclusions, emerald manufacturers today are able to mimic natural processes so well that it can be difficult for a layman to tell synthetics from the real thing. Perhaps that's one reason emeralds don't pack the same emotive resonance for us that they did for bygone Indians and kings. We no longer see links to divinity or immortality in an emerald's limpid green depths. What we might imagin[illegible] the stones is history: the entire hi[illegible] the [illegible] distilled into a single miraculous (scientifically speaking) crystal. That's resonance enough for a rock.

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Notes

2017 Science Camp

- What was best about 2017 Science Camp?
  - ______________________________
  - ______________________________
  - ______________________________

- What would be your ideal 2018 Science Camp Theme?
  - ______________________________
  - ______________________________
  - ______________________________