# PRESENTATION GROUP #3 - GEOLOGY AND TECTONICS OF CANYON SIN NOMBRE

## Question Sets that Presentation Group #3 needs to know the answers to:

## *STOP 4: CANYON SIN NOMBRE*

**Station 1. Crystalline Basement Rocks (Pre-Batholithic Rocks)**

As we begin or hike into the mouth of the canyon along the dirt road

**A. What are the three major pre-batholithic crystalline metamorphic rock types cropping out in this region?**

**B. What are the parent or "protolith" rocks for each of the three above rock types?**

**C. Describe the general formational (tectonic) setting for each of the above three parent rocks.**

**D. What is the estimated age of the "protolith" or parent rock sedimentary rocks"?**

**E. What is the estimated age of metamorphism and deformation for the pre-batholithic country rocks?**

**F. What caused the metamorphism and deformation to these country rocks?**

**Station 2. Pegmatite Dike**

As we walk just beyond this outcrop you will see a near vertical white pegmatite dike on both sides of the road.

**A. Identify and discuss the minerals in the dike.**

**B. What is compositional name for this plutonic rock? Hint: What is the color index (mineralogy)?**

**C. What is the texture of this rock? Check the grain size. Hint: What does pegmatite mean?**

**D. What is the relative age (crosscutting relations) of the dike in realtion to the metamorphic rocks?**

**E. What is the estimated absolute age of the pegmatite dike?**

**Station 3. Faulted dikes in a basement rock of metasedimentary rocks and Light-gray large Igneous Intrusion**

After passing the large pegmatite dike, progress to next bend

**A. Draw a cross section of the west side of the canyon. Label the dikes, faults, metamorphic rocks, and grey intrutions**

**B. What sense of displacement along the faults in the felsic dikes? Why?**

**C. Outline the geologic history of the events (relative dating using cross-cutting principle)**

**1) Take account of ALL THE FEATURES you see in the outcrop that are shown in your cross section**

**2) Start with the oldest Paleozoic basement metamorphic rocks, then the grey intrusion, and on, up to the present**

**D. What is compositional name for this light gray plutonic rock? Hint: What is the color index (mineralogy)?**

**D. What is the estimated absolute age of the light-gray intrusion?**

**Station 4. Contact Between Sedimentary Cover and Crystalline Basement Rocks**

As we begin or hike into the mouth of the canyon along the dirt road

**A. Find the contact between the sedimentary cover (3 Ma Olla Formation) and the much older crystalline metamorphic basement rocks**

**B. What are the ages of both the Olla Fm. and the much older Basement rocks?**

**C. What type of unconformity is present here?**

**D. Explain how very young sedimentary rocks can be in contact with much older crystalline basement rocks.**

**Station 5. Folds in the Olla Formation**

**A. Plot location and sketch the set of folded Olla Fm rocks in the canyon wall.**

**B. What type of tectonic stress could account for causing this rock formation to get folded up?**

**C. Note the similarities to the soft-sed deformation seen at Tourmaline Beach in the Scripps Fm.**

**D. What is the timing in which this the folding event had to have occurred?**

**F. What tectonic stage would the folding be a part of?**

**G. What sort of special fault characteristic of the right-lateral Elsinore fault would most likely be involved to help cause this folding event?**

**Station 6. Types of Sedimentary Rocks in Canyon Sin Nombre**

**A. List ALL the various types of young sedimentary rocks that you observe along this stretch of Canyon Sin Nombre**

**B. Describe the general texture and mineral composition for each rock type.**

**C. List the most likely depositional environment for each sedimentary rock type.**

**D. What causes graded bedding to form in some of the rocks?**

**F. Describe the general relationship between depositing sediment grain size and the level of energy in the depositional environment**

## PROFESSOR'S COMPILED INFORMATION ON CANYON SIN NOMBRE

## A. Tectonic Origin of the Crystalline Metamorphic Basement (Pre-batholithic) Rocks

### 1. Tectonic setting for the metamorphic rock protoliths (parent rock) found in Canyon Sin Nombre

**a) Paleozoic passive margin along the western edge of North America**

- ✓ **Tectonic Stage #1 in San Diego's tectonic history**
- ✓ **Continental margin (slope and rise) was far from an active plate boundary**
- ✓ **Site of massive apron of continentally-derived sediment piled on top of oceanic crust sitting adjacent to continental margin**
- ✓ **Siliciclastic sediment (Sand, silt and clay) was inter-layered with oceanic carbonate pelagic sediment (ooze)**
    - o **These sediments would eventually form sedimentary rock: sandstone, siltstone, shale, and limestone, respectively**
    - o **These Paleozoic sedimentary rocks were resting on basaltic ocean crust (originally derived at a MOR)**
- ✓ **Period of sediment deposition lasted from Early Paleozoic (Ordovician) to Early Mesozoic (Triassic) time**

**b) The passive margin would later become an <u>enclosed backarc basin (seaway)</u> with the onset of Tectonic Stage #2**

- ✓ **Initiation of subduction and the formation of a new island arc (the western zone of PRB) to the west of this location**
- ✓ **Enclosed backarc basin (seaway) occurred between Jurassic to Mid Cretaceous time**
- ✓ **The addition of a new source of sediment coming from the newly established island arc to the west.**

**2. Metamorphism and deformation of the pre-batholithic protoliths (parent rock) found in Canyon Sin Nombre**

**a) The backarc basin (the seaway separating the fringing island arc and the edge of the NA continent) collapsed and was heavily intruded and metamorphosed during Mid- to Late Cretaceous time**

- ✓ **Compressional tectonic episode between offshore island arc and continental margin**
- ✓ **Initiation of continental margin arc-style subduction (eastern zone of PRB) to the east of the earlier batholith magmatism**
- ✓ **<u>This occured during tectonic Stage #2 - the middle subduction period</u> of San Diego's tectonic development (100 Ma to 80 Ma)**
- ✓ **The very massive eastern zone PRB magma intrusions heavily deformed and metamophosed the enclosed backarc basin sedimentary rocks and oceanic basement basalts**
- ✓ **The continental margin sedimentary rock package (protoliths) became the crystalline metamorphic prebatholithic rocks**

**b) Multiple episodes of metamorphism of the protoliths reached high grade conditions**

- ✓ **Amphibolite grade regional metamorphism**
- ✓ **High temp contact metamorphism**

**c) Very strong deformation of the protoliths during emplacement of the eastern zone PRB plutons**

- ✓ **Intense folding, stretching, and refolding of the rocks**

- ✓ **Nearly all of the original sedimentary features and structures were completely obliterated**

## B. Petrology and Metamorphism of the Crystalline Metamorphic Basement (Pre-batholithic) Rocks

**1. Protoliths of the Pre-batholithic rocks - 5 major rocks types**

**a) Sandstone, Siltstone, Shale, Limestone, and Basalt**

- ✓ **Siliciclastic rocks derived mostly from nearby continent**
- ✓ **Limestone derived from offshore carbonate sources (pelagic carbonate material)**
- ✓ **Basalt was most likely the basement MOR-derived ocean crust that the other rocks rested on**

**2) All five protoliths were caught up in intensive episodes of compressional tectonics and magma intrusions**

**a) Protoliths underwent recrystallization and neocrystallization**

**b) Original bedding and textures were obliterated**

**c) Rocks became highly deformed and foliated**

**3) All five rock types underwent similar levels of deformation and metamorphism**

**a) Sandstone metamorphosed into quartzite**

**b) Siltstone and shale metamorphosed into quartz-feldspar-mica-rich (quartzo-feldspathic-micaceous) schist**

**c) Limestone turned metamorphosed marble**

**d) Basalt turned metamorphosed amphibolite**

## C. Petrology of the Crystalline Igneous (Batholithic) Basement Rocks

### 1. Batholithic rocks - 2 major rocks types

#### a) Granodiorite -

- ✓ La Posta-type rock - 92 Ma to 93 Ma
- ✓ Medium-grained phaneritic texture
- ✓ Consists of quartz, feldspar, and biotite
- ✓ Gray-colored - very homogenous looking
- ✓ Intrudes the prebatholithic rocks
- ✓ Intruded by the granite pegmatites

#### a) Granodiorite -

- ✓ Youngest batholithic rock - 90 Ma to 80 Ma
- ✓ Coarse phaneritic to very coarse-grained pegmatitic texture
- ✓ Consists of quartz, feldspar, muscovite, garnet, tourmaline and biotite
- ✓ White-colored - very inhomogeneous looking
- ✓ Intrudes the prebatholithic rocks
- ✓ Intrudes the granodiorite

## D. Later Tectonism of the Crystalline Metamorphic (Prebatholithic) and Igneous (Batholithic) Basement Rocks

### 1. Prebatholith rocks caught up in Tectonic Stage #3 - Extensional Detachment Faulting

**a) Detachment faulting extended and rotated blocks of the crystalline basement into sets of basins and ranges**

- ✓ **Occurred between 30 Ma and 10 Ma during the extensional tectonic stage #3**
- ✓ **Elevated "range" blocks of crystalline basement rocks shed material into the adjacent, lowered "basin" blocks**
- ✓ **The sediments trapped in the basins would later form sedimentary rocks that now make up part of the Salton Trough geology**

**2) Prebatholith rocks caught up in Tectonic Stage #4 - Transform Strike-slip Faulting**

**a) Right-lateral strike-slip faulting broke up the extensional "basin and range" structure into elongate crustal slivers**

- ✓ **Occurred between 10 Ma to Present day during the transform tectonic stage #4**
- ✓ **Set of right-lateral strike-slip faults have right-laterally extended the crystalline basement with clockwise rotation**
- ✓ **Alluvial fan aprons along the foot of the crystalline basement ranges are getting offset by strike-slip motion**

**b) Right- and left-jogging kinks in the right-lateral strike slip faults have produced compressional and extensional structural features along the faults, respectively**

- ✓ **Left-jogging kinks have created uplifted topographic highs, and exposed deeper level basement rocks**
- ✓ **Right-jogging kinks have created subsided topographic lows, where new sediments are depositing**

You should be able to find the needed information to most of these questions from the links
that I provided below for you:

## Internet Links for Canyon Sin Nombre Rock Information

**1) Oldest Rocks in Anza Borrego Region: San Diego Natural History Museum - http://www.sdnhm.org/research/geology/geo_oldrocks.html**

**2) The Geology of the Anza Borrego Region: Paul Remeika and Lowell Lindsay - http://personal.linkline.com/shoe62/anza/geology.html**