abruptly from the depocenter, in the northern part of the basin is a significant fault bounded horst block or mid-basin platform.

The Pre-Tertiary section in the basin is not well imaged by the survey except for a few data segments on the western side.

KIRKLAND, JAMES I.

Brackish-water mollusks from the western margin of the western interior seaway: A tool for sorting out the stacked Cenomanian-Turonian marginal marine strata along the Wasatch Line.

The "middle" Cretaceous along the "Wasatch Line," extending from near Coalville, Utah, in the north to Cedar Canyon and the Pine Valley Mountains in the south, is represented by a thick sequence of marginal marine strata deposited near peak sea-level rise on the western margin of a rapidly subsiding foreland basin. Many brackish-water molluscan taxa were named from these strata during the latter third of the 19th century, but were often described from poorly preserved material at poorly documented sites. Though evolutionarily conservative, brackish-water mollusks generally display a great deal of morphologic variation, resulting in a number of previously described species being lumped together. Therefore, little systematic research on these faunas was undertaken after 1900, except for comparing the Utah taxa to fossils described from similar-age strata to the south in Texas and Arizona. Recently these brackish-water taxa have been found to be useful as a proxy for determining ancient substrate conditions, paleoturbidity, and paleosalinity gradients. Field research in the area of southwestern Utah has revealed that abundant, well-preserved molluscan fossils commonly characterize brackish-water strata in this area. Distinct species can be recognized at different stratigraphic levels, indicating the potential for some of these brackish-water taxa to have local biostratigraphic utility.

To test their utility, collections of brackish-water fossils were made at many stratigraphic levels and from different localities. These sites were tied into the standard ammonite biostratigraphy established for the Cretaceous Western Interior Seaway through intertonguing and onlap/offlap relations between the brackish-water facies and marine, ammonite-bearing strata. The type collections of the original taxa from the previous century were borrowed from the Smithsonian Institution and the type localities were revisited and fossils collected when accessible. Many type specimens were originally collected from the now-closed coal mines near Coalville in the lower Turonian Coalville Member of the Frontier Formation, so the "Wasatch" coal sites are no longer accessible.

Results of these studies indicate that several brackish-water species needlessly had been lumped together, and that a number of undescribed forms historically lumped with these species represent new undescribed species. While the systematic research of these collections continues, the preliminary results are clear: a number of brackish-water molluscan lineages reveal speciation rates much higher than would be considered typical of brackish-water taxa. Gastropods of the *Craginia coalvillensis-C. whitfieldi* and *Admetopsis rhomboides* lineages appear to have the most potential for biostratigraphy, but other gastropods and a number of bivalves also appear to have potential. Using all of these taxa, two "zones" per substage may be discerned. Although it is unlikely that this system will have utility outside the Colorado Plateau region, it appears to work well there. It is often difficult to correlate the lithologically similar stratigraphic succession of marginal marine Cretaceous strata along the "Wasatch Line" due to poor exposures and structural complexity. The brackish-water taxa found in strata along the "Wasatch Line" belt provide a new tool on which to base these correlations.

LOSEKE, T.D., and DILLIARD, K.A.

Significance of Middle Tertiary Sedimentary Rocks of Chino and Verde Valleys, Transition Zone, Arizona.

Oligocene and Miocene sedimentary rocks of Chino and Verde valleys record changes in drainage patterns along the southern edge of the Colorado Plateau. Strata of the Paulden and Beavertail Butte formations represent the first deposits of a southeast-flowing drainage system. Following the development of the Mogollon Rim, a significant deflection in drainage direction occurred, mainly from north- to southeast-directed flow and also a significant change in sediment sources. It is apparent that the Mogollon Rim formed prior to 15 Ma and that the topography of the rim was similar to that of the present day rim. Oligo-Miocene sedimentary deposits represent a period of aggradation that followed an extensive period of erosion that formed the Mogollon Rim.

The Beavertail Butte formation is an informal name given to conglomerates deposited near Sedona, Arizona, approximately 500-1000 meters below the present rim. Capping basalt flows from House Mountain volcano were dated at 13-15 Ma and brackets the upper age of these sedimentary rocks. Deposits of the Beavertail Butte formation consist of basal conglomerate, middle mudstone, and upper cong-lomerate unit. A change of provenance is recorded between the upper (Precambrian terrains to the west) and basal (Paleozoic strata of the Mogollon Rim) conglomerate, probably recording the development and expression of the Mogollon Rim. The upper conglomerate unit represents southeast-direct transport and possibly integration of stream systems.

The Paulden formation is probably older than the upper conglomerate of the Beavertail Butte formation. The Paulden formation outcrops to the northwest of Sedona and probably represents a similar drainage pattern as the Beavertail Butte formation. The Paulden formation is overlain by the 22-26 Ma Sullivan Buttes Latite. Clasts from the overlying Sullivan Buttes Latite are found in the upper conglomerate of the Beavertail Butte formation. This change in drainage direction correlates with the inception of Basin and Range extension in southern Arizona. These two formations help to document evolving drainage patterns of the Transition zone during a period of significant tectonic evolution.

NELSON, S.T. AND HARRIS, R.A.

The role of rheology in the tectonic history of the Colorado Plateau.

Interpretation of the geophysics, petrology, and structure of the Colorado Plateau indicates that it is a rheologically dis-

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tinct element of the Cordillera. During the Phanerozoic Era, areas surrounding the Colorado Plateau have been subjected to repeated tectonism, including contraction, extension, and magmatism while the plateau has been little affected by these processes. Deformation and magmatism mostly wrap around the Colorado Plateau, suggesting the plateau is a rigid body that has often transmitted forces across itself. Compiled geophysical and petrologic evidence indicates that the lithosphere of the Colorado Plateau has a higher strength than regions to the east, south and west. Strength differences may be attributed to a mafic crustal composition and long-term lower crust and mantle geothermal gradients, especially relative to the Basin and Range Province. Estimates of crustal and lithospheric thickness indicate that the ratio of the thickness of mantle to crust in the northern Basin and Range Province ranges from 0.8 to 1, whereas the same value in the Colorado Plateau is about 1.2. Given that mantle rocks are stronger on average than crustal rocks, the ratio of crust to mantle and the greater total thickness of the Colorado Plateau lithosphere also make it inherently strong.

Some evidence suggests that fertile or hydrated mantle may exist beneath the Colorado Plateau. Rock strength data show that mafic rocks in the crust and high pyroxene and amphibole contents in the upper mantle may enhance lithospheric strength, or, at a minimum, provide no reason to presuppose that a fertile, hydrated mantle should be weak.

The Colorado Plateau, although inferred to be stronger than regions to the west, south, and east, may not be as strong as the Archean Wyoming Province to the north. Higher seismic velocities in the lower crust and upper mantle north of the Cheyenne belt imply a higher strength in the middle Rocky Mountains. In this context, the Uinta aulacogen, which separates the Wyoming Province and the Colorado Plateau, developed as a "pop up" structure during Mesozoic to early Tertiary contraction. Thus, in understanding the tectonic history of the western U.S., or any region for that matter, it is important to assess the relative compositional and thermal structure of the lower crust and upper mantle. These factors have exerted considerable control over the partitioning of strain and magmatism throughout the Cordillera in the Colorado Plateau region during the last 1 Ga. Similar factors play an important role in the architecture of mountain systems throughout the world.

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Tectonic inheritance at the Colorado Plateau - Basin and Range margin – Miocene uplift of the Virgin Mountain anticline influenced by reactivation of Proterozoic and Laramide structures

TheVirgin Mountain anticline (VMA) is a NE-trending basement-cored uplift that straddles the Colorado Plateau – Basin and Range margin in southeast Nevada and northwest Arizona, approximately 15 km south of the Utah border. Our hypothesis is that this region has been an important zone of weakness from the Paleoproterozoic through to the present, and that Miocene extension and uplift was significantly influenced by inherited structures and tectonic boundaries. Two processes: 1) reactivation of basement structures, and 2) utilization of lower Paleozoic rheologic heterogeneities, influenced were the Colorado Plateau margin was originally defined and how Miocene extension was made manifest at this margin from ~20 to 5 Ma. Intense 1.7 Ga fabrics and the presence of exotic lithologies (ultramafics, pillow volcanics, chert) suggest that this structure may have been part of a Paleoproterozoic province boundary. NE-trending upper greenschist grade dextral-transpressional mylonites are ubiquitous throughout the VMA, suggesting that this area was a high strain zone during Mesoproterozoic (~1.4 Ga) transpressive deformation. N to NW-trending "monoclinal-type" geometries in the Paleozoic and Mesozoic sections, and the position of the VMA between the thin-skinned Sevier thrust belt and thick-skinned monoclines of the Colorado Plateau, suggest a Laramide (~65 Ma) component of deformation. Miocene extension was generally exhibited by brittle oblique dip-slip fault reactivations of strongly fissile mylonitic foliations in the basement, steep and shallow normal faulting in the Tapeats sandstone, basal-glide and westward tectonic thinning in the Bright Angel shale, and steep to moderate normal and antithetic normal faulting in the overlying Paleozoic carbonates. Highly angular (>60°) relationships are observed in the Lower Paleozoic section on the west limb of the VMA. This structural-rheological partitioning and deflection of strain may give insights into the complex Miocene strain field observed at the Colorado Plateau - Basin and Range margin.

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Tectonic Evolution of the Arizona Transition Zone

The Transition Zone (TZ) of Arizona lies between the Colorado Plateau (CP) and Basin and Range (BR) Provinces, and shares some physiographic, stratigraphic, and structural aspects with each. The oldest rocks in all three provinces are Proterozoic metavolcanic and metasedimentary rocks, which record the evolution from oceanic to continental environments from >1.75 to 1.65 Ga. These rocks were strongly deformed, mostly between 1.7 and 1.6 Ga, and structurally are dominated by north- to northeast-trending folds, cleavage, high-strain zones, and shear zones. The rocks were intruded by Proterozoic granites before, during, and after deformation, and subsequently overlain in places by sedimentary and volcanic rocks of the mid- to late Proterozoic Grand Canyon Supergroup and Apache Group. All three provinces then received a similar, ~1 km-thick cover of platformal Paleozoic clastic and carbonate rocks.

With the onset of subduction beneath the southwestern edge of North America in the Triassic, the stratigraphic and structural histories of the three provinces began to diverge. Triassic and Jurassic rocks are not preserved in the TZ, but sequences of these rocks in the BR and CP have stratigraphic ties and some commonalities, indicating that the TZ originally contained similar Lower Mesozoic sequences and did not block sediment transfer between neighboring provinces at this time. In the Early to Middle Jurassic, for example, the TZ evidently contained the facies change between volcanic-dominated sequences of the BR and sediment-dominated ones of the CP.