cords a change from estuarine swamp/marsh depositional environments to a more open-marine environment around the time of the Cenomanian-Turonian boundary.

KARLSTROM, K.E., QUIGLEY, M.C., BOWRING, S., KIRBY, E., HOOK, S., and HEIZLER, M.

Low angle detachment along the Great Unconformity near the Colorado Plateau- Basin and Range breakaway: arguments against a tipped crustal section in the Gold Butte area, southern Nevada

Low angle extensional faults in the southern Virgin Mountains follow the Great Unconformity over lateral distances of >1000 km^2. Detachment took place along subhorizontal bedding horizons in Cambrian Tapeats, Bright Angel, and Muav formations such that thinned flat-lying para-autochthonous sections of these lower Paleozoic rocks remain in the footwall adjacent to Proterozoic basement over a wide region. Above the detachment, extensional allochthons containing upper Paleozoic through Tertiary (18 Ma) rocks exhibit 30-80° E-tilting due to westward translation. This implies that major breakaway faults in this region initiated and moved at low angle and had ramp-flat geometry analogous to thrusts. Thus, isostatic footwall uplift is not required to explain the presence of low angle faults. Instead, Paleozoic cover was translated westward in domino blocks sliding generally along the Great Unconformity for tens of km west of the Grand Wash fault. Similar relationships are observed in the North Virgin Mountains and other para-autochthonous Proterozoic culminations north of the Gold Butte block, suggesting that this low-angle fault system forms a regional ramp-flat detachment system west of the Colorado Plateau. Ar-Ar dating of K-feldspars across the Gold Butte block show Proterozoic cooling ages and a general younging to the west, consistent with deeper exposed levels. Thermal models suggest the west end of the block was at depths <10 km prior to Miocene extension rather than at 15-18 km deep as suggested by the tilted crustal section model.

KELLER, G. RANDY

Lithospheric Architecture of the Colorado Plateau and Its Margins

Because of its tectonic significance, the lithosphere of the Colorado Plateau and its margins has been the subject of much recent debate and interest. On the Plateau itself, recent seismic results present conflicting values for crustal thickness. Some of this variation probably reflects actual complexities in crustal structure. However, some of these results suggest the presence of a high-velocity (>7.0 km/s) layer at the base of the crust. A variety of technical and physical considerations make such a layer hard to detect unless it is ~10 km thick. Our group has used receiver function analysis to determine crustal thickness and Vp/Vs ratio estimates for the southern Colorado Plateau based on the analysis of teleseismic P-waves recorded at Canyon de Chelly National Monument, Arizona and at Chaco Culture National Historic Park, New Mexico. These new data were combined with seismic refraction and gravity data in an integrated analysis of lithospheric structure. The receiver functions were stacked together in clusters of similar back azimuths and epicentral distances. Using crustal velocity values from previous studies as constraints, the receiver functions from the two stations suggest an upper crustal layer approximately 24 km thick with a Vp/Vs ratio of 1.85 (which corresponds to a Poisson's ratio of 0.29). The lower crust is about 23 km thick with a Vp/Vs ratio of 1.88 (corresponding to a Poisson's ratio of 0.3). The thickness for the whole crust is approximately 47 km. Although errors in this number may be as large as +/- 5 km, this result supports arguments based on seismic reflection and refraction data for a thick crust (45-50 km) for the Colorado Plateau, and for a crust that is more mafic in composition than typical continental crust. Based on buoyancy arguments, gravity data in the region agree with seismic results and suggest that no major variations in crustal thickness occur across the southern plateau. This crustal structure is in fact very similar to that of the Great Plains in eastern New Mexico, which is an area that shares many of the geologic characteristics of the Plateau. The Basin and Range province has also been the target of several recent seismic experiments. The results from the SSCD, DELTA FORCE, and PACE experiments in the Basin and Range province of southern Nevada, California, and western Arizona show that while the crustal thickness is surprisingly uniform, there are some intriguing variations. The velocity models derived from these experiments coupled with analysis of gravity data reveal some intracrustal features that can be correlated with extensional regimes. In particular, the lower crust in the seismic models thickens in regions where extension is greater. The regions with thickened lower crust also correlate with long wavelength gravity highs. These results suggest that the mechanism for maintaining crustal thickness during extension can be either magmatic underplating or lower crustal flow or a combination of these processes. The margins of the plateau are associated with a variety of lithospheric structures. The Wasatch Front margin is particularly interesting and can be interpreted as a "rift within a rift" because of its velocity structure and the abrupt transition in crustal thickness into the Plateau. The southwestern and eastern margins are more gradual in terms of variations in crustal thickness but both have strong reflectors in the lithospheric mantle. These reflectors can be interpreted to lie at or near the lithosphere-asthenosphere boundary.

KENDELL, CARL F.

Structure and Stratigraphy of Late Tertiary Rocks in the Subsurface: Rush Lake Area, Iron County, Utah

In 1992-1993 a 2-D seismic grid was shot in the Rush Lake-Parowan Gap area of Iron County, Utah. The grid is comprised of 7 lines of high resolution 40 fold vibroseis data totaling about 36.5 line miles. The shoot was supplimented with about 12 miles of preexisting purchase data to fill in some gaps in the grid.

The resulting processed record sections from the shoot not only show the half-graben nature of the valley and it's bounding faults, but also clearly defines much detail in the faulting which occurs within the Late Tertiary sediments themselves. The thickest section of sediments, and apparent depocenter of the basin, is located beneath Rush Lake. Rising

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-