POSTER ABSTRACTS

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Structures recording synextensional shortening along and near the boundary between the Basin and Range and Colorado Plateau between Salina, Utah and Lake Mead, Nevada.

In the Basin and Range between Salina, Utah and Lake Mead, Nevada, several types of late Tertiary synextensional structures record contrasting styles of extension-normal contraction at or near the Basin and Range/Colorado Plateau (BR/CP) boundary. The structures include 1) conjugate northeast-striking sinistral and northwest-striking dextral faults, 2) zones of tectonic escape, 3) components of strike slip on northerly striking non-conjugate faults, 4) zones of steep-axis bending and associated faulting, and 5) east-west trending, extension-parallel folds, many of which appear to absorb strain associated with faults of categories 1 and 2. Following are large-scale examples of each type, but each ranges widely in scale. 1) The broadly contemporaneous northwest-striking right-lateral Las Vegas Valley shear zone and northeast-striking left-lateral Lake Mead fault system, each with tens of kilometers of displacement, displace the Great Basin sector of the Basin and Range southward. These faults intersect in the Lake Mead area where 20-50 km of Miocene north-south shortening has occurred. 2) Temporally and genetically associated with the fault intersection in 1) is a mobile zone of westerly tectonic escape that accommodated much of the displacement on the conjugate faults by at least 65 km of westerly tectonic transport of an east-narrowing structural wedge. Frenchman Mountain and the basin beneath Las Vegas to the west are part of the escaped wedge, which may be a unique boundary-condition feature in the cordillera. 3) Directly west of the BR/CP boundary at Salina and Gunlock, Utah and in the vicinity of Virgin Canyon, Arizona, subparallel right- and left-slip faults bound km-scale blocks that appear to have been displaced approximately parallel to BR/CP, as though by a component of basal traction related to boundary-parallel flow of substrate. 4) West of Cedar City, geologic and paleomagnetic data define a crudely triangular zone of strong counterclockwise steep-axis rotation and associated faulting extending for as much as 120 km east-west and 40 km north-south—the Caliente-Enterprise zone. This large rotational strain has been interpreted as driven by basal traction and, depending on the traction model chosen, the strain could record 0- 20 km of north-south shortening. I favor traction caused by complexly deflected ductile flow subparallel to the province boundary, a choice that allows for the maximum amount of north-south shortening. A large area of clockwise steep-axis rotation in the vicinity of Lake Mead probably also reflects large north-south shortening associated with tractional forces. These interpretations are at odds with widely accepted interpretations of the rotations as shear-related bending strains. 5) Syn-extension folds with axes subparallel to the extension direction are widespread in the vicinity of the BR/CP boundary. As with the structures of category 4), there is no general agreement on their tectonic significance. Folds range from outcrop size to crustal scale with amplitudes as much as 10 km. Many are well developed and excellently exposed in the Lake Mead area where they reflect the late stages of extension-normal contraction associated with the conjugate faults of category 1) above. Some folds absorb components of strike slip on faults of category 3) above, an interpretation I apply to the deep basins along Interstate 15 directly west of Virgin Canyon. Others appear to reflect fault-parallel plan-view rock flowage commonly exhibiting displacement gradients that increase toward the faults, and still others may simply reflect variations in displacement gradients along the trace of normal faults with possible examples beneath the Rush Lake and Quichapa portions of Cedar Valley. At most, the latter would reflect small amounts of extension-normal contraction. Future progress in understanding the tectonic evolution of the BR/CP boundary will depend more on investigations of the extreme variation in structure along it than across it. Much of that extreme variation is associated with extension-normal contraction.

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Chasing Basalts - Age and Correlation of Basalt Flows in Southwest Utah

The UGS recently obtained nearly 30 $^{40}Ar/^{39}Ar$ ages and over 200 geochemical analyses on basaltic flows or groups of flows from 27 volcanic centers in southwestern Utah. These analyses were obtained in support of new geologic mapping in the St. George basin and Zion National Park areas, and additional sampling is underway. We intend to present these data as the core of a new geochemical database of basaltic flows in southwest Utah. When complete, major oxides, minor and trace elements, isotopic ages, sample numbers and locations, flow names, and other information will be tabulated. We will include published information from other reliable sources. The database is being developed with the intent of providing researchers with purely descriptive information on these flows based on new detailed geologic mapping.

Our preliminary interpretations of data from these flows: (1) show that regional downcutting rates are largely a function of relative uplift, implying that flows of markedly different ages can have similar erosional profiles depending on their location in relation to major faults in the area, (2) constrain the displacement history of the Hurricane fault zone over the past 1 million years, and (3) show that while commonly indistinguishable in hand sample, the flows are chemically distinct. The new geochemistry and ages, together with detailed mapping, has improved our understanding of the extent of and relationships among basaltic flows in the region.

We find that the most useful major oxides and minor and trace elements for correlating flows are, in addition to the total alkali versus silica diagram, TiO_2, P_2O_5, Ba, Cr, Sr, and

Zr. These variables typically show small but significant variation between flows, but only minor variation within flows. We are currently assessing other variation diagrams for their suitability in distinguishing flows.

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Progress report of geologic mapping and remote sensing analysis of the Pinto Quadrangle, Colorado Plateau transition zone, SW Utah.

The Pinto Quadrangle, located along the southern extension of the Antelope Range, remains one of the key unmapped areas in the eastern Caliente-Enterprise zone (Hudson et al., 1998 and Axen, 1998, GASP 323), a regional east-northeast trending transfer zone. Current detailed (1:16,000) geologic mapping in conjunction with LANDSAT imagery reconnaissance has revealed different structural elements in the study area related to Tertiary plutonism and crustal extension. Early structural features related to plutonism include laccolithic doming (Pinto Dome) and gravity slide sheets originating from the west (Bull Valley Mountains). These features dominate the southern portion of the quadrangle, and reflect Miocene (22-20 Ma) Iron Axis plutonism.

Sedimentary and volcanic stratigraphy in the central and northern portions of the quadrangle (see Cornell et al., 2001, this volume) are cross-cut by sinistral NW faults and by throughgoing E-W oblique-slip faults associated with mid-Miocene Basin and Range faulting. Field relations show that the NW faults terminate into and are offset by the E-W fault set. These fault sets reside within a footwall block unroofed by the late Miocene to Quaternary west-dipping Antelope Range Fault. LANDSAT imagery analysis is proving to be useful in interpreting important structural and geomorphic details (i.e., range-front alluvial fan development) throughout the study area. Here we illustrate the mid-Miocene to Quaternary fault pattern based upon field mapping data augmented by remote sensing technology.

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Geologic History of the Eastern Margin of the Colorado Plateau

The east side of the Colorado Plateau follows a north-trending zone of weakness deformed during Proterozoic, Ancestral Rocky Mountain, Laramide, and late Cenozoic tectonism. Northward displacement of the Colorado Plateau during late Laramide flat-plate subduction (late Paleocene-middle Eocene) formed a broad zone of right-lateral faulting accompanied by an echelon series of strike-slip basins. A regional surface of relatively low relief developed across beveled Laramide uplifts and aggraded basins during a prolonged period of erosion and tectonic quiescence in late Eocene. Volcanism spread across the Southern Rocky Mountain-Colorado Plateau boundary as the subducted slab steepened and sank. The earliest calderas (37-33 Ma, central Colorado; 29 Ma, San Juan field; 36-32 Ma, Mogollon-Datil field) formed along the west edge of the incipient Rio Grande rift; the foci of ignimbrite volcanism then migrated westward.

As tensional stresses strengthened, the Rio Grande rift collapsed along the north-trending Colorado Plateau boundary previously weakened by multiple deformations and high heat flow. Several Laramide uplifts collapsed and became basin floors. Structural inversion and basin subsidence began at about 35 Ma, coincident with a change to bimodal volcanism. Local areas of extreme extension, with domino-style block rotation and low-angle normal faults formed above, or proximal to, batholithic intrusions in the Socorro (29-27 Ma) and Questa (26-25 Ma) areas. Apatite fission-track (AFT) cooling ages show strong uplift and denudation of ranges flanking rift basins beginning about 24 Ma. Basin subsidence was particularly rapid between about 16 and 10 Ma. Rifting began more or less concurrently along the Rio Grande rift but proceeded more rapidly in the south; estimates of total extension are: San Luis Basin 8-12%, Albuquerque Basin 17-28%, and Socorro 50%. Isotopic and trace element compositions of basalt flows indicate a change from lithospheric to asthenospheric sources beginning about 10 Ma south of Socorro and progressing northward to the Jemez Mountains by 2 Ma; source regions for magmas north of the Jemez lineament are all in the lithosphere. Changes to a wetter, stormier climate at about 7 Ma lead to integration of closed basins, regional incision of drainages, and development of the Rio Grande.

The physiographic eastern margin of the Colorado Plateau is actually an intra-plateau boundary separating elements of a broad orogenic plateau formed during the Laramide. Mapped and dated remnants of the late Eocene surface and similarities in post-Laramide tectonic, volcanic, and erosion history link together the High Plains, Southern Rocky Mountains, Colorado Plateau, and adjacent portions of the Basin and Range and Wyoming provinces. Key data are: 1) similar Laramide apatite fission-track cooling histories (80-45 Ma) for the Colorado Plateau and Front Range; 2) paleobotanical evidence that the 34.1 Ma Florissant lake beds were deposited at an elevation (2.2-3.3 km) on the Front Range similar to today (2.5 km); 3) lack of differential structural relief between the Front Range and High Plains since late Eocene as evidenced by preservation of old (>100 Ma) AFT cooling ages along the Range margin and lack of significant offset of the 37 Ma Wall Mountain Tuff deposited across the boundary; and 4) similar timing and magnitude of late Miocene-Recent excavation of basin-fill deposits and incision of drainages.

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Stratigraphy and Ar/Ar ages of volcanic rocks of the Pinto Quadrangle, Colorado Plateau Transition zone, SW Utah

Current detailed (1:16,000) geologic mapping along the southern extension of the Antelope Range is focusing on stratigraphy, 40Ar/39Ar dating and structural and remote-sensing analysis (see also Butler et al., 2001, this volume). East-dipping Cretaceous (Iron Springs Formation) and Tertiary (Claron Formation) sedimentary rocks are bounded to the west by the NE-SW striking Antelope Range Fault. However,