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.

BUTLER, T., CORNELL, D., HACKER, D., AND HOLM, D.

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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CHAPIN, CHARLES E.

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.

CORNELL, D., BUTLER, T., HOLM, D., HACKER, D., and SPELL, T. DEPT. OF GEOLOGY, KENT STATE UNIVERSITY, KENT, OH 44242

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, the most extensive rocks in the quadrangle are Tertiary volcanic units. These include regional ash-flow tuffs (Needles Range Group, Isom Formation, Quichapa Group, and Racer Canyon Tuff) from calderas outside the area to the NW and W, more local ash-flow tuffs (Rocks of Paradise and Rencher Formations) derived from Iron Axis laccoliths to the south, and local volcanic rocks from vents within the map area. In the map area the volcanic rocks generally get younger from west to east (Needles Range, Isom, Quichapa, Rocks of Paradise, Rencher, and Racer Canyon). In the east the 19 Ma Racer Canyon Tuff is subhorizontal. Erosion of the east-tilted fault-block resulted in semi-consolidated, late-Miocene (~8-9 Ma) alluvial deposits located in the southwest. The youngest igneous rocks are sub-horizontal to gently east-dipping basalts also restricted to the southwest.

Historically, K/Ar mineral dates provide the main age constraints on the Miocene volcanic stratigraphy and Iron Axis magmatism of this region. We present the results of 40Ar/39Ar incremental release dates on plagioclase separated from six volcanic samples collected in the Pinto Quadrangle. The age of the Harmony Hills tuff (Quichapa Group), a key unit deformed by all of the intrusions, is only poorly constrained by six prior K/Ar dates ranging from 24.4 to 20.3 Ma. We obtained a well-defined plateau age (8 steps constituting 91% of the total 39Ar) of 22.03±0.15 Ma. This date is indistinguishable from a 21.93±0.07 Ma date (40Ar/39Ar, biotite) reported for the immediately overlying ash-flow tuff member of the Rocks of Paradise Formation (Hacker et al., 1997, GSAA). We also obtained a well-defined plateau age of 21.83±0.17 Ma (4 steps, 55% total 39Ar) on the Rencher Formation (and concordant isochron age of 21.46±0.40 Ma) which directly overlies the Rocks of Paradise. These data tightly constrain the age of several key volcanic units in the area as well as their sources to the south and west (Stoddard Mountain, Pinto Peak, and Bull Valley intrusions). Unfortunately, four of our samples gave U-shaped, discordant, age spectra suggesting either the presence of excess argon or xenocrystic contamination. The least contaminated sample (an east-tilted capping basalt at the southwestern end of the map area; Gum Hill) yielded a minimum age increment of 5.7 Ma which we interpret as a maximum age for the rock. If correct, this interpretation suggests that some of the Miocene capping basalts throughout the area may be younger than indicated by prior K-Ar ages (i.e, ~7.7 Ma, Bull Valley Mountains, Best and others, 1980, AJS).

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ERSKINE, M.C.

Extensional tectonics in a regional thrust belt – a simplified structural model for the interpretation of the central Basin and Ranges in Utah and Nevada.

During the Mesozoic, the sedimentary rocks of the miogeocline of western Utah and eastern Nevada were thrust eastward over the North American continental margin. During the Cenozoic, this folded and thrusted terrain extended westward, essentially opposite to Mesozoic vergence. The miogeocline consists of Eocambrian to Jurassic paraconformable sedimentary rocks over 12 kilometers (40,000 feet) thick in western Utah and eastern Nevada.

Stratigraphic/structural Relief across the twenty mile width of Steptoe Valley, between outcrops of the Jurassic Navajo (Aztec) Sandstone at Curry Junction and outcrops of Eocambrian quartzite north of Cherry Creek, is as much as twelve kilometers. Clasts of Prospect Mountain Quartzite in the basal conglomerate of the Cretaceous(?) to Eocene Sheep Pass Formation indicate at least seven and a half kilometers of EXPOSED stratigraphic relief by early Sheep Pass time.

Regional Outcrop Patterns – The major mountain ranges (Fish Springs/House/Wah Wah Range; Raft River/Pilot/Goshute/Deep Creek Range/Snake/Highland; Ruby/White Pine/Grant/Quinn Canyon/Groom Range; Toiyabe Range) form antiformal linear structural culminations. Cambrian quartzite and older sedimentary rocks are in the core. The ranges are separated by synclinoria of structurally dismembered younger sedimentary rocks (Confusion Range; Buttes Range; Sulphur Springs-Monitor Ranges). The synclinoria show significant packages with clear westward structural vergence on their eastern limb. These synclinoria preserve miogeoclinal sedimentary rocks as young as Jurassic Navajo Sandstone in their cores (Buttes Range Synclinorium near Curry, Nevada). Outcrops of Cretaceous sedimentary rocks are rare and consist of nonmarine clastics. Outcrops of pre-miogeocline crystalline basement are rare beneath the thick sections of Eocambrian clastic rocks.

Structural Models – This poster presents a series of simplified balanced cross sections illustrating a model of Basin and Range tectonic development in time and space. The model demonstrates that the key to understanding of the Basin and Ranges tectonic development lies in understanding the style of Mesozoic thrusting.

FERGUSON, C.A., SKOTNICKI, S.J., and McINTOSH, W.C.

Temporal and spatial patterns of extension along the southern boundary of the Transition Zone, Superstition volcanic field, Arizona

The 20.5 – 18.0 Ma 5,000 km^2 Superstition volcanic field straddles the Transition Zone – Basin and Range structural boundary in central Arizona. High-precision, sanidine, single crystal, laser fusion $^{40}Ar/^{39}Ar$ dating of key volcanic units provide a detailed chronology of the evolution of tilt domains and magnitudes of extension throughout the life of the field. In the Transition Zone, even the oldest volcanic strata are either undeformed or only gently tilted, but locally, fanning dip sequences in narrow grabens are preserved. In the Basin and Range, northeast tilting began at about 20.5 Ma and was fairly evenly distributed along closely spaced faults throughout the field until eruption of Apache Leap Tuff at 18.6 Ma. Tilting ceased in most areas by 18.6 Ma, but continued along discrete zones, locally very rapidly, until about 18.0 Ma.

The E-W elongated 350 km^2 Superstition cauldron (source of the Apache Leap Tuff), lies in the northwestern corner of the field and is bisected by the southwestern structural boundary of the Transition Zone. Northwest of the cauldron, the boundary fault zone was active until about 18.0 Ma, and southwest-side-down normal motion was accompanied by