and minor Bi, Pb, Ag, and Au (Tem Piute, Monte Cristo, Little Boulder Creek). S-type magmas found in post-subduction settings are granitic and associated skarns are mined mainly for Sn although Be, B, Bi, F, W, Cu, Zn, Pb, and U may be of local economic importance (Lost River, Iron Mtn, Moina). The space-time distribution and metal associations of skarn deposits reflects their strong link with igneous sources and the multiple processes involved in concentration and deposition of economic metals.

SLIP-RATE, OFFSET AND HISTORY OF THE CLEGHORN FAULT, WESTERN SAN BERNARDINO MOUNTAINS, SOUTHERN CALIFORNIA.

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Detailed mapping in the western San Bernardino Mountains, California, shows the Cleghorn fault to be an active structure, with a cumulative left-lateral offset of 3.5 to 4.0 km. A steeply-dipping basement contact that forms the eastern limit of the Miocene Punchbowl Formation in Cajon Pass is offset left-laterally about 4 km along the Cleghorn fault. A north-plunging anticline-syncline pair in the late-Pliocene Crowder Formation southeast of Silverwood Lake is also displaced 3-4 km in a left-lateral sense. Restoration of this 3-4 km offset results in the alignment of unique members of a Plio-Pleistocene reverse fault system that permits a refined cumulative offset estimate of 3.5 to 4.0 km to be made. Lateral motion on the Cleghorn fault began in early Pleistocene following the integration of an ancestral zone of major reverse faulting as evidenced by bends and cusps in the Cleghorn fault at old reverse-fault intersections. These findings yield a minimum rate of left-lateral displacement on the Cleghorn fault of roughly 0.9 mm/yr (3.5 km since Crowder deposition about 4 mya). This calculation allows no time for reverse faulting and associated tilting that postdate the deposition of the Crowder Formation and predate the onset of left-lateral faulting. Pleistocene alluvial fan and terrace deposits, estimated to be about 500,000 years old based on soils, elevation and offset along the San Andreas fault, appear to be displaced left-laterally about 1.1 km on the Cleghorn fault. Streams cut in an approximately 100,000 year-old terrace level are offset up to 200 m in a left-lateral sense. Both offsets suggest a higher left-lateral slip-rate of 2 mm/yr for the Cleghorn. At 2 mm/yr, the observed offset on the Cleghorn would accumulate in 2 my. Topography of scarps along the Cleghorn fault west of Silverwood Lake strongly suggest Holocene activity with dominantly left-lateral strike-slip displacement.

QUATERNARY FAULTING IN SOUTHEAST ARIZONA AND ADJACENT SONORA, MEXICO

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Stratigraphic-geomorphic studies in the Basin-Range province of southeast Arizona and adjacent Sonora, Mexico, indicate that Quaternary faults are rare and have histories of infrequent ruptures. The principal scarps--located at the Santa Rita, Pitaycachi, Safford, Swisshelm and possibly Huachuca and San Bernardino sites--commonly occur on piedmonts, basinward from topographic mountain fronts. The Sonoran Pitaycachi fault experienced surface rupture in 1887, and there is evidence for earlier displacements extending through the Quaternary into Pliocene(?). The other scarps displace geomorphic surfaces and associated poorly-indurated gravelly deposits ranging in age from late to early Pleistocene. Individual NNW- to NE-trending scarps extend discontinuously for lengths of 5-70(ave. 10-40)km, and vary in height from 1-40 (ave.2-6)m. They dip basinward with maximum slope angles of 3^o-25^o (ave. 6^o-15^o), except for 30^o->70^o slopes of the 1887 rupture. A few exposures reveal steeply-dipping (≥70°), normal-separation, high-angle-oblique to dip-slip faults. Composite scarps, with greater offset of older Pleistocene surfaces, suggest multiple Quaternary displacements, with estimated recurrences of 10^5 yrs, on at least the Santa Rita, Pitaycachi and possibly Safford faults.

Development of 2-7 km-wide bedrock pediments and burial of most mountain-bounding faults by undeformed upper basin-fill indicate that large-scale Basin-Range tectonism had ceased in southeast Arizona by the latest Miocene to Pliocene. Exceptions include small-scale pre-Quaternary deformation of Pliocene basin fill in some basin interiors and fault-related subsidence of post-3 m.y.B.P. basalts in the San Bernardino valley. The scarp data imply localized and widely-dispersed late Pliocene-Quaternary reactivation of basin-margin normal faulting in the region, at lower rates than the earlier Basin-Range event.

THE EXTENSION OF THE CALAVERAS-SHOO FLY THRUST (CSFT) TO THE SOUTHERN END OF THE SIERRA NEVADA METAMORPHIC BELT (SNMB), CALIFORNIA

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The CSFT has now been mapped within the SNMB as far south as Lat. 37°30'N in Mariposa County, where the belt is engulfed by the Sierra Nevada batholith (SNB). The thrust has been folded and overturned north of the Tuolumne R. by forceful intrusion of the 170 m.y. Standard Pluton. It is truncated by granite (SNB) south of Hunter Bend of the Clavey R. and re-emerges trending parallel to, but northeast of, Pilot Ridge. The CSFT is cut by the Hazel Green Pluton and then, with a more southerly trend, extends 16 km beyond the Merced R. The sub-vertical ductile thrust separates polydeformed quartzite, mica-quartz schist ± garnet and graphite, calc-silicate rock, and augen gneiss of the upper plate Lower Paleozoic Shoo Fly Complex on the east from argillite, chert, marble, and talc-schist of the lower plate Calaveras Complex on the west. Within the 250 m-wide CSFT zone, syn-metamorphic imbrication of rock units and intense silicification is common. Slices of the Calaveras occur as flattened and disarticulated meter-scale sheets of recrystallized argillite, massive and rhythmic-bedded chert, quartz sandstone and mylonitic marble intruded locally by syn-tectonic granite. In the Shoo Fly, the CSFT fabric (S_3) is marked by the development of blastomylonite with 0.1-1.0 cm-spaced syn-metamorphic shears and attendant isoclinal folding and transposition of pre-thrust penetrative fabrics (S_1 and S_2) into S_3. Since the Shoo Fly, with its distinctive structural style, occurs in the upper plate of the CSFT as far south as Lat. 37°30'N, roof pendants to the east and southeast must be restudied to ascertain the full extent of Lower Paleozoic wallrocks and the tectonic significance of the CSFT.

WATER-LEVEL MONITORING ALONG SAN ANDREAS AND SAN JACINTO FAULT ZONES FOR EARTHQUAKE PREDICTION RESEARCH

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Water levels in over thirty abandoned water wells along the San Andreas and San Jacinto fault zones have been monitored for the past five years. About a dozen wells are monitored continuously, mostly with Stevens Type F recorders, which are simple, float-actuated mechanical recorders. The disadvantage of these reliable recorders is that the data are collected only when the charts are changed once a month. Several recorders have been modified to operate with the Caltech Remote Observatory Support System (CROSS), utilizing microprocessor-based data logging and telecommunications units. Water levels are sampled at one minute intervals; the data are stored and telephoned twice daily to the Caltech central computer system. Therefore, these units provide data collection nearly in real time. In this study we are looking for changes in the state of stress or strain premonitory to earthquakes; water-level changes from other causes must be identified and separated to the maximum extent possible. Wells responding to barometric pressure and tidal forces and showing minimal response to rainfall or local pumping are considered most likely to detect tectonic strain or earthquake precursors. Geochemical parameters, including radon utilizing the track-etch technique, temperature, salinity and conductivity, are also measured at ten wells. Earthquakes show as vertical spikes on the continuous water-level records; possible creep events appear as increases in water level over a period of several hours. One such event preceded the M5.5 Anza earthquake of 25 February 1980 by about four days.

BRAIDED STREAM DEPOSITS OF THE EOCENE IONE FORMATION EAST-CENTRAL CALIFORNIA

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Immediately west of the Sierra Nevada in central California are scattered outcrops of the Eocene Ione Formation. The southern part of the Ione consists of interbedded arkosic sandstone and conglomerate that was deposited on Sierran type basement rock by braided streams.

Physical sedimentary structures and bedding units represent a braided stream complex that graded eastward into what was probably a thin alluvial fan system with some channels flowing on bedrock. Some debris flow deposits in this system may have been volcanically-influenced mudflows while others were most likely reworked volcanic and stream-influenced debris-mudflows. Horizontally-laminated beds with lag gravels and their associated large scale tabular cross-laminated beds were deposited as longitudunal bars during flood stage. The lag gravels represent bar-top winnowing during waning flood stage. Capping these large scale structures are small scale trough, wedge and tabular cross-laminated beds formed as bar-top channels containing small transverse sand waves. These small-scale sedimentary structures formed during falling water and are locally capped by thin mud drapes. Some of these longitudinal bar sandstones contain traces of Ophiomorpha nodosa and other trace fossils, thus extending the range of Ophiomorpha nodosa to terrestrial environments.

TEPHROSTRATIGRAPHY AND POTASSIUM-ARGON AGE DETERMINATIONS OF SEVERAL VOLCANIC ASH LAYERS IN SOUTHERN NEVADA

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Seven silicic tephra layers occur in alluvial deposits of the Muddy Creek Formation and its equivalents at three localities in Lincoln, Clark, and Nye counties in southern Nevada. The tephra have been chemically characterized, by electron microprobe and x-ray fluorescence analyses of the glass, and petrographically characterized according to mineralogy, glass shard morphology, and glass refractive index. Results indicate the tephra were derived from seven different volcanic eruptions and do not represent any previously known tephra layers.

Potassium-argon age determinations were performed on glass or mineral phases from each layer. The glass ages, from two layers in stratigraphic succession, are probably too young due to hydration of the glass; 7-9 m.y. ages are likely. The mineral determinations on multiple phases from the other five layers yielded discordant ages for each layer. This is attributed to incorporation of detrital contaminants in the unconsolidated tephra layers. Field evidence and the probable source and percent of contaminants indicate a 7-12 m.y. age