higher lands to the east. These landslides are concentrated in several segments of the bluffs that constitute about 17 km of the total bluff length of some 50 km. In these places, seepage at discrete levels has initiated rapid development of complex landslides consisting of earth falls, earth and debris slides, and flows. We have identified about 50 such landslides; 14 of them have surface areas exceeding 10,000 m^2 each.

The largest active landslide, northeast of Savage Island and about 1.8 km from the river, covers some 440,000 m^2. This complex landslide has been activated by seepage from nearby irrigated fields and involves adjacent parts of these fields. Another area of major active landslides lies along the east side of the river, opposite Locke Island. Here complex landslides result from toe erosion by the river and from seepage from a now-drained irrigation waste-water pond. They are adding silt to the river and constricting its channel.

RECONNAISSANCE GRAVITY SURVEYING; A TOOL FOR INVESTIGATING BASIN AND RANGE STRUCTURE

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Gravity surveying is a rapid and relatively inexpensive geophysical technique that has helped to resolve regional rock structure beneath many alluvium-filled valleys in western U.S. Extensive reconnaissance gravity data for the Nevada-Utah region of the Basin and Range province, provides an excellent example of the value of gravity exploration. A terrain corrected Bouguer anomaly map of east-central Nevada and west-central Utah shows the effect of structural features such as normal basin-bounding faults, horst and graben blocks, assymetrical tilt blocks, and fractured caldera complexes on the regional gravitational field. Examples of typical interpreted features are illustrated and keyed to the regional Bouguer anomaly map.

SURFACE FAULTING IN THE SONORA, MEXICO, EARTHQUAKE OF 1887

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About 2:13 p.m. (local time) May 3, 1887, the Southwestern United States and northwestern Mexico were strongly shaken by a large earthquake centered in San Bernardino Valley, ∿50 km southeast of Agua Prieta, Sonora. Expeditions dispatched to the epicentral area several weeks after the tremor reported that a normal fault had ruptured along the east side of the valley and produced a break ∿56 km in length, with an average throw of 2.1 m.

During fieldwork in 1980 and 1981, we traced the 1887 rupture nearly 76 km southward. Beginning 8 km south of the U.S.-Mexico border, the main rupture trends generally S. 8° W. in a sinuous line of west-facing scarps along the southeast edge of the valley. At the south end of the valley, the rupture steps westward ∿2.5 km, then continues 21 km southward in the Sierra Pilares de Teras, following a remarkably linear S. 12° W. trend. The main break is paralleled in the San Bernardino Valley ∿4-7 km west by a 30-km-long zone of secondary faults.

The throw on the main break increases rapidly southward to at least 5.1 m ∿30 km south of the border, then gradually diminishes to ∿1 m in the Sierra Pilares de Teras. Overall reduction of the scarp slopes by erosion (almost all 1887 scarps are now gravity- and debris-controlled slopes) enhances the apparent dip-slip locally to as much as 6.9 m. In 1887 the scarp faces reportedly stood at 45-90°; today they slope (crest to toe) at angles generally ≲50°. Judging from our 1980-81 measurements, the average dip-slip in 1887 (area under slip curve divided by fault length) must have been at least 1.9 m (average throw) but less than 3.8 m (apparent dip-slip).

If the 1887 rupture is assumed to have extended to 15-km depth along a fault dipping 70°, the seismic-moment magnitude (**M**) of the 1887 earthquake can be estimated at between 7.2 and 7.4. The 1887 rupture is now the longest documented surface break of any normal fault in the world (the Pleasant Valley, Nev. of 1915: 61 km long).

ALLUVIAL STRATIGRAPHY AND DISCHARGE OF THE LITTLE COLORADO RIVER, ARIZONA SINCE 1927

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The Little Colorado River, an ephemeral stream flowing in a sandy channel, drains 44,000 km^2 of the arid and semiarid southern Colorado Plateaus province. Since 1927, when discharge measurements began, non-native saltcedar (Tamarix pentandra Pall.) has invaded the river system, and the river has developed a flood plain. Saltcedar was not present in the channel until after 1937, although it was cultivated within 1 km of the river as early as 1909. The invasion of saltcedar and the development of the flood plain were controlled by the discharge regimen of the river. Until 1941, the discharge was characterized by large annual floods, which maintained a broad sandy channel and inhibited the buildup of a flood plain. After 1941 the frequency of large floods decreased and saltcedar and other riparian plants became established on higher parts of the channel. Vegetation stabilized higher ground and trapped fine-grained sediment during overbank flow, thus building the flood-plain to higher levels. As a consequence, the buried trunks of saltcedar trees occur at several levels in the flood plain. Germination dates of living trees, as determined from ring counts, indicate three periods of flood-plain stability 1942-1951, 1953-1969 or 1970, and 1974-1977 corresponding with times of low annual discharge. On the other hand, the intervening times of deposition (1952, 1969 or 1970-1973, and 1978) represent flood-plain aggradation by high-volume floods during moist years when annual precipitation and discharge were high. Although the flood-plain deposits are discontinuous, several stratigraphic sections indicate the same general periods of stability and deposition along 160 km of the river. In short, the stratigraphy suggests that deposition was controlled by the discharge of the river and ultimately by variations in climate.

GENETIC INTERPRETATION OF GRANITIC GNEISSES IN METAMORPHIC CORE COMPLEXES

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Granitic gneisses represent a major component of metamorphic core complexes such as occur in the North American Cordillera, and their genetic interpretation is necessarily important in the structural modeling of the complexes. "Orthogneisses" occurring as marginal envelopes of directionless granitic stocks are commonly considered to have had a protoclastic origin. Many gneisses occurring as tabular layers and lenses in metamorphic complexes have certain textures the same as those in the protoclastic gneisses and these textures are considered to be genetically diagnostic. There are two types of gneisses in metamorphic complexes with magmatic parentage: (1) gneisses resulting from dynamothermal metamorphism of previously crystallized magmatic bodies, and (2) gneisses deriving from syntectonic emplacement of crystallizing granitic magmas that develop both magmatic and metamorphic textures (protoclasis). A number of textural features are described for each case. In (1) there is a breakdown of a magmatic fabric, including mechanical reshaping, comminution, and rotations that may be accompanied by recrystallization, and in which relict magmatic textures may or may not survive. In (2), the results of deformation of a crystal-liquid system include: (a) relocation of fluids into fractured crystals, (b) "pooling" of K-rich fluids into zones of reduced pressure, and (c) magmatic crystallization of aplitic mosaics that mimic recrystallization textures. Cataclasis and recrystallization also occur in (2) meaning that magmatic and metamorphic textures develop together. The mechanical difference between metamorphism of an already-emplaced and crystallized magmatic system, and metamorphism during syntectonic emplacement of a crystal-melt mush can be expected to be reflected in the larger-scale tectonic evolution of a given area, underscoring the importance of distinction between cases (1) and (2).

PROBABLE SURFICIAL GRAVITY SLIDE ASSOCIATED WITH REGIONAL THRUSTS NEAR ANAKTUVUK PASS, CENTRAL BROOKS RANGE, ALASKA

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Northwest of Anaktuvuk Pass several klippen, composed chiefly of Lisburne Group carbonates of Mississippian age, overlie folded Permian and Triassic shales and cherts. Imbricate geometry and north-verging folds within the klippen indicate northward transport. Stratigraphic overlap requires a minimum of 13 km of displacement of the more northerly klippen, but the origin of the klippen is uncertain.

The klippen could represent: (1) erosional outliers of a regional thrust sheet involving Lisburne strata that is exposed 25-30 km to the south, (2) the higher level part of a more northerly regional thrust sheet, (3) a gravity-driven sheet derived from (2), or (4) gravity-slide blocks from the overturned limb of a syncline in the immediately underlying sequence. Stratigraphic contrasts make (1) unlikely and the absence of a generally overturned sequence in the klippen eliminates (4).

A gravity-sliding origin is favored because of the thinness of the allochthonous sequence, the development of intense imbrication and cascade folds within the klippen, and the emplacement of the sheet at a shallow level following folding and possible erosion of the underlying sequence. The glide sheet probably became detached from the upper level part of a regional thrust sheet and moved 15-20 km down an undulating surface that currently dips to the north at 1°-12°. In topographic lows the glide sheet was thickened by imbrication and development of cascade folds. On strike, the upper part of the regional sheet is preserved. It consists of flat-lying slices of Lisburne and is believed to resemble the pre-sliding situation at Anaktuvak Pass.

NEW TECTONIC BOUNDARIES IN THE NORTH CENTRAL KLAMATH MOUNTAINS BETWEEN HAPPY CAMP AND SEIAD VALLEY, CALIFORNIA

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A structural window previously delineated along the Klamath River between Happy Camp and Seiad Valley California was originally suggested by Klein (1977) to join the metasediments and metavolcanics of the Galice Formation with similar rocks of the Condrey Mountain Schist . Detailed mapping in 1981 has revealed a metamorphosed mafic dike complex occupying the Klamath River Valley between Thompson Creek and Seaid Valley. Three distinct lithotectonic plates are now thought to occupy this area as a result of this mapping.

To the south of Thompson Creek rests the lowest structural unit, a layered greenschist whose protolith may have been a mafic tuff. This greenschist unit may be equivalent to the unmetamorphosed Galice volcanics located to the west. To the northeast of Thompson Creek the greenschist unit is tectonically in contact with the newly discovered mafic dike complex which contains both fine and coarse grained dikes with local gabbroic screens, commonly showing clear intrusive