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in doing so it acts like a submarine, by changing its overall specific gravity for ascent and descent. Recent work on distribution and buoyancy regulation of *Nautilus pompilius* and *Nautilus macromphalus* at various Western Pacific localities indicates that these assumptions are only partially true. Migration of *Nautilus* to surface depths has only been observed during the austral winter in New Caledonia, the Loyalty Islands, and the New Hebrides, where surface waters at that time of year are cool. Studies on buoyancy regulation indicate that rapid specific gravity changes to produce ascent or descent do not take place. Rather, the formation of new chambers and subsequent removal of cameral liquid is a long term process. All observed vertical movements appear to be produced by hyponome-powered swimming.

DEPOSITIONAL SETTING OF THE ROBERTS MOUNTAINS FORMATION (SILURIAN) IN THE SOUTHERN GREAT BASIN

WARE, Don W., Department of Geological Sciences, San Diego State University, San Diego, California 92182
The southernmost exposures of the Roberts Mountains Formation occur within the Bullfrog and Bare Mountain quadrangles near Beatty, Nevada. The formation conformably (?) overlies the Ely Springs Dolomite and is gradational with the overlying Lone Mountain Dolomite. Conodonts and macrofossils indicate the formation ranges from late Llandoveryan near the base to at least late Ludlovian at the top. The two study sections may provide a link between coeval alloclastic carbonate sediments extending from central Nevada to eastern California.

The Roberts Mountains Formation consists of argillaceous, evenly laminated lime-mudstones interbedded with alloclastic graded and non-graded skeletal wackestones and packstones, and is dolomitic and massive near the top. Alloclastic skeletal and nonskeletal material was derived from a shelf margin (platform edge) and transported (by turbidity currents and grain/debris flows) down a northwest facing foreslope. The Bare Mountain section is thinner, more dolomitic and more fossiliferous than the Bullfrog section, suggesting a shelf margin was located southeast of Bare Mountain. Lithofacies are similar to described sections of the Roberts Mountains Formation in central Nevada as well as to the lower portion of the Vaughn Gulch Limestone in the Inyo Mountains, California.

Vertical facies changes exhibit basin, basin margin/toe of foreslope, foreslope and shelf margin depositional environments, suggesting regressive sequence and northwestward progradation of the shelf margin. Lateral facies interrelationships between sections suggest the Bare Mountain locality was situated more landward and on a steeper slope than the Bullfrog locality.

TIME-AVERAGED MOLLUSCAN ASSEMBLAGES FROM CHOLLA BAY, GULF OF CALIFORNIA

WATSON, Mary K. and FLESSA, Karl W., Department of Geosciences, University of Arizona, Tucson, Arizona 85721
Assemblages of live and dead molluscs from Cholla Bay, Sonora, Mexico were compared to evaluate the preservational biases resulting from transportation and time-averaging.

Cholla Bay, a four square km complex of intertidal mudflats, sand flats and channels, is characterized by low biological productivity and a low sedimentation rate. Tidal amplitudes range from 0.7 m to 8.7 m.

Fifty-five quadrats of 0.25 m were sampled to a depth of 5 cm along five transects across the bay. Specimens greater than 6 mm in size were identified and counted.

Diversity within samples of dead molluscs was up to two orders of magnitude greater than that observed among the live molluscs. Although cluster analysis was able to distinguish environmentally controlled assemblages among samples of both the living and the dead molluscs, the live and dead assemblages did not correspond well with each other. This discrepancy results from post-mortem transport and time-averaging. Cholla Bay samples commonly contain species from adjacent rocky intertidal habitats, the nearest of which are 3.7 km from the sand flats. The large number of dead shells (as many as 1336 in a single sample) in various states of preservation suggest time-averaging over a long interval.

Fossil communities recognized from high tidal amplitude, low sedimentation rate sedimentary environments are not likely to faithfully represent the living communities' species composition, diversity, or relative abundance.

MINIMIZING CONCENTRATED RUNOFF, SURFACE EROSION AND MASS SLOPE MOVEMENT IN REDWOOD NATIONAL PARK BY REMOVING FORMER LOGGING HAUL ROADS

WEAVER, William E., KELSEY, Harvey M., MADEJ, Mary Ann, BUNDROS, Gregory, and HAGANS, Danny, Redwood National Park, Orick, California 95555

Ground disturbance and drainage alterations due to the construction of logging haul roads are major factors in the increased transport of sediment caused by logging in steep drainages of the northern California Coast Ranges. The recent expansion of Redwood National Park to include 30,000 acres of recently logged mountainous land provides an opportunity to rehabilitate extensively disturbed watersheds. Logging haul roads on these lands cause major erosional problems: road cut banks intercept ground water and increase surface runoff; the outside of the road bench frequently consists of unstable fill prone to failure; inboard ditches gather runoff and concentrate this runoff via culverts at a few downslope locations where drainages must erode to

accommodate increased flows; culverts can be blocked during storm events, causing mass slope failures and severe gullying. To minimize or eliminate these problems, Redwood Park has utilized a combination of heavy equipment and manual labor to implement erosion control measures on the terminal portions of two former logging haul roads. Heavy equipment (crane or backhoe, and a caterpillar tractor) excavates the outside of the road bench and deposits the fill against the cut bank, burying the inboard ditch. The fill is then graded to achieve an out-slope so that water will run across, not along, the road alignment. Culverts are removed and all watercourses are opened up to eliminate drainage concentration. This work is followed by labor intensive erosion control crews, which carry out site specific projects to minimize gullying and plant sprouting trees and shrubs as well as grass to accelerate revegetation of raw areas. These projects started in July, 1978, and allow only preliminary evaluation of the results.

CHANGES IN BEACH SEDIMENT SUPPLY AND COASTAL EROSION RATES NEAR POINT ANO NUEVO, SAN MATEO COUNTY CALIFORNIA

WEBER, Gerald E., Weber and Associates Geologic Consultants, Santa Cruz, California 95060

Comparison of the original coastline surveys of the 1850's with subsequent maps indicates that the large beach south of Point Ano Nuevo has been slowly decreasing in size over the past 120 years. In the past two winters (1976-77 & 77-78) the sea cliff behind this beach has been subjected to severe wave erosion and has been cut back 16-20 feet. Between 1972-76 there had been no erosion of these cliffs and historic data suggests that there has been no erosion of these cliffs during the past 114 years. This tentative conclusion is based on the presence of a piling in the beach which is the lone remnant of "Waddell's Wharf", built in 1862. Its distance from the sea cliff prior to 1976 was four to five feet which suggests that this cliff had not experienced wave erosion in the 114 years since the wharf was built. Other evidence of a long term decrease in the amount of beach sediment at Point Ano Nuevo is the stabilization of the active dune field at the point. The dune field is dependent on a continuous supply of sand being present in the beach along the north shore of the point. For at least 70-100 years insufficient sand has been present to replenish the dune field and consequently the dune field is dying. The reasons for the decrease in sediment supply is not known, but it appears to be a long term decrease which has been ongoing for at least the past 100-125 years. The effect of two drought years (1976-77 & 77-78) has been to decrease the volume of sediment entering the littoral zone from coastal streams but this change and the changes associated with man's usage of the land are thought to be minor and intermittent changes superimposed on a greater long term decrease in sediment supply.

RECURRENCE INTERVALS FOR SURFACE FAULTING ALONG THE FRIJOLES FAULT AND THE ANO NUEVO THRUST FAULT OF THE SAN GREGORIO FAULT ZONE, SAN MATEO COUNTY, CALIFORNIA

WEBER, Gerald E., Weber and Associates Geologic Consultants, Santa Cruz, California 95060; COTTON, William R., William Cotton and Associates Geologic Consultants, Los Gatos, California 95030
The Ano Nuevo thrust fault and a reverse fault within the Frijoles fault complex of the San Gregorio fault zone both show evidence of multiple faulting events and associated surface rupture. Each of these events was large enough to form a scarp and is represented by a wedge of sediment eroded off of the fault scarp and the upthrown block and deposited on the down dropped block where the sediments have been protected from erosion by the overthrust plate. Analysis of the stratigraphy and fault geometry exposed in the sea cliff at Point Ano Nuevo indicates that the Ano Nuevo thrust fault has experienced a minimum of six episodes of surface faulting during the past 105,000 years, resulting in an average recurrence interval of approximately 16,000 years. Detailed mapping of the geology exposed in an abandoned quarry and in exploratory trenches has resulted in the recognition of a minimum of six buried soils which indicate a minimum of seven faulting episodes over the past 40-50,000 years. This roughly indicates an average recurrence interval of about 6,000 years for earthquakes resulting in surface rupture and the formation of a scarp along the Frijoles fault. It is highly probable that more faulting events resulting in surface rupture have occurred along both of these faults but that these events were too small to be preserved in the stratigraphic record as sediment wedges eroded off of the scarp. The geometric relationship of the fault traces to the sediments eroded off the scarp suggest that faulting events occurred more frequently than the intervals indicated above.

SUPERPOSED MESOZOIC DEFORMATIONS IN THE SOUTHERN WHITE MOUNTAINS, EASTERN CALIFORNIA

WELCH, Tim C., Department of Geosciences, California State University, Northridge, CA 91330

Mapping of Precambrian and Cambrian Eastern Sierran wallrocks along the western flank of the Southern White Mountains shows this area to have been affected by two principal phases of Mesozoic deformation abruptly decreasing away from the batholith. The oldest fold generation (F1) produced during deformation consists of NE to E trending, tight to isoclinal, SE overturned to recumbent folds that plunge moderately to the NE, and SW. Superimposed upon and locally refolding (F1) folds are younger (F2) modified parallel folds, which are typically N to NW trending, east

STRUCTURAL ANALYSIS OF THE EARLY PALEOZOIC SHOO FLY FORMATION, LAKES BASIN REGION, NORTHERN SIERRA NEVADA RANGE: EVIDENCE FOR PRE-LATE DEVONIAN TECTONISM.

VARGA, Robert J., Department of Geology, University of California, Davis, California, 95616

The uppermost portion of the early Paleozoic Shoo Fly Formation (SFF) in the Lakes Basin region of the northern Sierra Nevada range consists primarily of phyllite, silicic tuff, dolomite, chert and chert breccia, quartzite, and minor ultramafic pods. This sequence is unconformably overlain by dacitic volcanics of the Devonian(?) Sierra Buttes Formation. The serpentinite-matrix melange unit, which locally occurs beneath this unconformity in areas to the north and south, is not recognized in the Lakes Basin region.

Two periods of folding have been distinguished within the SFF. Pre-Nevadan isoclinal folds (F_1) are only locally well developed and have highly variable orientations. Irregular F_1 fold profiles and associated soft sediment features suggests that the upper SFF may have been partially unconsolidated during deformation. Boulder conglomerate, containing clasts of SFF lithologies, was deposited with small angular discordance over the folded terrain prior to Sierra Buttes volcanism.

South plunging lineations and isoclinal folds (F_2) of Nevadan age are contained within a regional, steeply west-dipping, NNW-trending metamorphic cleavage (S_1). Type 2 and 3 interference structures occur where F_1 folds crosscut F_2 folds. Analysis of deformed F_1 recumbent folds yields a Nevadan slip line orientation of $72^\circ\text{N}28^\circ\text{W}$. This flow direction may be the deep-seated response to Nevadan compression which resulted in east-directed thrusting in the overlying cover rocks.

QUATERNARY TECTONIC EVOLUTION OF THE SOUTHERN PART OF THE CALAVERAS FAULT ZONE, SOUTHERN SANTA CLARA COUNTY, CALIFORNIA

WAGNER, David L., California Division of Mines and Geology, Ferry Building, San Francisco, California 94111

The Calaveras fault zone is composed of several historically active, right-lateral faults which extend from just south of Hollister northward for about 160 km. Southeast of Anderson Lake the Calaveras fault zone is a prominent, linear zone composed of interlaced strands which are well marked by fault-produced geomorphic features. Fault creep has been documented from south of Hollister to Cochrane Bridge east of Morgan Hill. North of Anderson Lake, the zone becomes diffuse and complex. In this area, the Hayward fault impinges on the Calaveras, and there is complex interaction between the two zones. Moreover, the Silver Creek fault joins the Calaveras at the south end of Anderson Lake.

Detailed mapping of the Calaveras fault zone has revealed evidence suggesting that the segment of the Calaveras between San Felipe Valley and Highway 152 developed during Plio-Pleistocene time. Flows of olivine basalt containing ultramafic inclusions are restricted to this segment of the fault zone and have been dated at 3.5 million years. The petrology of these flows suggest they were derived from a deep source, and the close spatial association of the basalt with the Calaveras suggests the fault served as a conduit for the magma. The Calaveras fault zone and the basalt flows post-date the Coyote Creek fault, an east-dipping thrust along which Mesozoic bedrock has been thrust over Plio-Pleistocene gravels.

In summary, it is postulated that prior to the development of this segment of the Calaveras and the subsequent eruption of the basalt 3.5 million years ago, the local tectonic regime was dominated by westward thrust faulting.

SIGNIFICANCE OF ASYMMETRIC SCHLIEREN FOR CRYSTALLIZATION OF GRANITES IN THE SIERRA NEVADA BATHOLITH, CALIFORNIA

WARRHAFTIG, Clyde, Department of Geology and Geophysics, University of California, Berkeley, California, 94720

Asymmetric schlieren--alternating layers rich in light and in dark minerals, with contacts gradational on one side and sharp on the other of the dark bands--that occur in parallel sets of up to 50, are in many of the plutons of the Sierra Nevada batholith and common in Cathedral Peak-type porphyritic granites. Some layers truncate others, and "cross-bedding" and "channelling" are common. If interpreted as they appear--as sedimentation of crystals from a melt against or upon a solid surface--all features suggest that they are younger toward the gradational side of the dark bands. In flat dikes they parallel the contacts and are consistently younger upward; along contacts, even vertical, with older rocks, they parallel the contact and are younger inward. Associated tabular K-feldspar phenocrysts lie generally parallel to the schlieren.

In a 2500-m band along the south side of the Topaz Lake granite in Tower Peak Quadrangle, sets of schlieren 1--5 m thick, 30--120 m long, with 5--40 in a set, are spaced 30--300 m apart, strike roughly parallel to the essentially vertical, sharply intrusive contact with older granodiorite that lies 300 m to 3000 m to the south, dip 20° -- 70° south toward that contact, and are younger south and upward. Splayed ends, gradational contacts, and other features show they are not in dikes but formed with the enclosing granite. If interpreted as episodes of "turbidite-like" sedimentation from fluid magma onto essentially solid crystal mush, they indicate solidification upward and outward toward the walls, possibly even as the pluton was enlarging.

FORTY LATE-WISCONSIN CATASTROPHIC LAKE MISSOULA BACKFLOODINGS OF WALLA WALLA AND LOWER YAKIMA VALLEYS, SOUTHERN WASHINGTON

WATTS, Richard B., Jr., U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025

More than 38 superposed, internally unweathered, graded sand to silt rhythmites of the Touchet Beds testify of about 40 separate late-Wisconsin turbid backfloodings of the Walla Walla and lower Yakima valleys, arms of the episodic hydraulic lake behind Wallula Gap that, during each of the largest floods, briefly impounded an astonishing 930 km^3 of the 2130 km^3 of water that catastrophically fled glacial Lake Missoula. Evidence for catastrophic backflooding by fugitive Missoula water are 1) indicators of vigorous upvalley paleocurrents, 2) dramatic upvalley fining and thinning of coarse, locally derived bedload, and 3) abundant quartzite and crystalline erratics ice-rafted from the Pend Oreille lobe of Cordilleran ice. Ice-rafted Columbia River Basalt clasts show that many floods contemporaneously quarried the Okanogan lobe. Evidence contrary to the old single-flood hypothesis but demanding of multiple floods includes 1) channels at the tops of the rhythmites filled with terrestrial slopewash, aeolian, and lacustrine sediment, 2) channels as steep as 80° into these deposits and into the silty top of the underlying rhythmites, and which are filled by the sandy base of the next overlying rhythmites, 3) the uncontaminated Mount St. Helens "set S" tephra atop one rhythmite over more than 10^3 km^2 and 100 to 230 m below the maximum level of turbid flooding, 4) semiconsolidated, evidently Pleistocene fillings of rodent burrows as deep as 30 m within the rhythmites, and 5) enclosed semarticulated to dispersed skeletons of mammoth, bison, rodents, and birds. The Touchet Beds murmur of millennia of ordinary terrestrial environment while shouting of 40 momentary exceptions. Eleven great floods having followed the "set S" eruptions, the Pend Oreille lobe retained a near-maximum profile until after 13,000 BP, by when the Puget Lobe had retreated some 250 km.

DEGRADATION OF THE HEBGEN LAKE AND MADISON RANGE FRONT FAULT SCARPS, MONTANA

WALLACE, Robert E., U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025

Fault scarps produced during the Hebgen Lake earthquake of 1959 appear fresh after 19 years, but reoccupation of 1959 photo sites of Wickind and Stacy documents significant changes. Profiles measured in 1978 show that free faces are still abundant along the fault scarp, but debris slopes have developed much more extensively in 19 years than, for example, they have in 63 years along the 1915 fault scarp in Pleasant Valley, Nevada. The debris slopes on the Hebgen Lake scarps commonly lie at angles of between 40° and 45° which appear to be quasi-stable in contrast to slope maxima of between 33° and 37° on stable debris slopes in north-central Nevada. A large clay fraction in the colluvium and alluvium in some of the Hebgen Lake scarps introduces factors of plasticity that probably account for the steeper slopes. Small slumps occur when the debris slopes are very wet, but when relatively dry an indurated crust develops that stabilizes the slopes.

The Madison Range fault scarp, reactivated for a length of 3 km in 1959, appears to be a composite of older scarps of several ages, as indicated by a range in the degree of degradation along its 90-km length. Facets on the scarp also suggest multiple displacements along individual segments of the fault. Whereas most parts of a given profile may slope 30° to 35° , segments a meter or two high may be as steep as 40° to 45° . The steepness of the steeper parts of the slopes suggests that the last displacement before 1959 occurred not long before the recorded history of the area.

HYDROLOGY OF HUNGRY VALLEY, CALIFORNIA

WALSH, Barbara L., and Griggs, Gary B., Board of Earth Sciences, University of California, Santa Cruz, California 95064

Managing the effects of the growing recreational use of off-road vehicles (ORV's) continues to be a challenge especially in southern California. This on-going study of Hungry Valley, a proposed ORV park site, describes the hydrology, quantifies erosion and sediment transport and deposition rates, and determines the relationship between areas and sites of erosion and deposition. The goal is to develop long term monitoring and management strategies. Hungry Valley includes approximately 65 sq km of public and private land, located in the Transverse Ranges, 1 km north of Gorman, California near Tejon Pass. Its proximity to Los Angeles (90 km) and Bakersfield (60 km) makes it an easily accessible location for many ORV users. Hungry Valley trends NW to SE at an average elevation of 1097 m, and slopes gently at about 2 degrees. The climate is semi-arid, with precipitation averaging approximately 35 cm/yr. Vegetation varies from grass, chaparral, and sage brush with some juniper in the valley to pine and fir forest at higher elevations. The principal drainage channels in Hungry Valley are ephemeral, draining into the Canada de los Almos which then empties into Pyramid Lake reservoir 2 km to the south of the valley. The area was used primarily for ranching until about 1971. Since then ORV activity has dominated, causing severe impact on the hydrology of the northern one-third of the valley and moderate impact in the southern two-thirds of the valley. The observed effects of ORV use include: 1) vegetation removal, 2) accelerated gully development both on and adjacent to bike trails, 3) compaction of soils on trails, 4) increased down-cutting and erosion by natural channels, and 5) sediment deposition in low lying areas.

BUOYANCY REGULATION AND DIURNAL MIGRATION IN NAUTILUS.

WARD, Peter D., Department of Geology, University of California, Davis, California 95616

Two generalizations have long been considered valid concerning the Recent *Nautilus*: that it migrates to the surface each night, and that