Mountain, numerous falling-head injection tests have been conducted in test holes penetrating the saturated zone.

Analyses of 26 falling-head injection tests in test well Ue-25c#1 indicate that conventional type-curve solutions for radial, porous-media flow with infinite outer boundaries do not apply to the injection tests. Recovery curves of normalized hydraulic head versus log time exhibit steeper tails than do the Cooper-Bredehoeft-Papadopulos type curves. In an attempt to explain the recovery curves with steeper tails, solutions for falling-head injection tests with the following combinations of flow field and boundary conditions were derived analytically by Karasaki and compared to the test results: (1) spherical flow, infinite outer boundary; (2) linear flow, infinite outer boundary; (3) radial flow, linear constant-head boundary; (4) radial flow, radial constant-head outer boundary; (5) linear flow developing into radial flow, infinite outer boundary; and (6) radial flow developing into spherical flow, infinite outer boundary. In addition to these six solutions, a solution that incorporates a skin of finite thickness also was used in the analysis.

Several of the solutions had steeper tails than did the Cooper-Bredehoeft-Papadopulos type curves, but none matched the responses observed in test well Ue-25c#1. The occurrence of nonlaminar flow in the fractures would result in curves with steeper tails and may explain the test results. In general, the assumption of laminar flow for falling-head injection tests may not be valid for fractured media.

SEDIMENTOLOGIC AND TECTONIC ASPECTS OF THE ARCHEAN LIMPOPO BELT

№ 72650

ERIKSSON, Kenneth A., Dept. of Geological Sciences, V.P.I. & S.U., Blacksburg, VA 24061; and KIDD, William S.F., Dept. of Geological Sciences, SUNY at Albany, Albany, NY 12222.

There are marked lithic differences between the central Limpopo belt and other well-studied Archean high-grade and greenstone-granitoid terranes, in particular the presence, in thick sections of supracrustals including ∿15% of each of 1) carbonate and calc-silicate rocks and 2) pure metaquartzite, often fuchsite-bearing, with the lithic character of quartz arenite, not metachert. These two suites overlie basement gneisses; they probably formed on a shallow-marine platform of substantial size and are similar to those associations known to have formed on Atlantic-type continental margins. Isotopic ages suggest these sediments are 3.3-3.5 Ga old. The sequence and distribution of lithic, plutonic, metamorphic, and structural events in the Limpopo belt resembles that in younger orogens where there has been rifting of continental lithosphere, deposition of sediments at an Atlantic-type margin, then convergence and collision with another continental block. The structural and metamorphic condition of the rocks largely reflect crustal thickening during final collision. The southern margin of the central Limpopo belt is a wide (20 km) zone of vertically-dipping, horizontally-lineated mylonites, clearly representing the deeper ductile levels of a major strike-slip fault. This fault resembles large strike-slip systems that allow tectonic escape during collision in young orogenic belts. We conclude that continental fragments large enough to provide a substrate for significant platform arenite and carbonate sedimentation existed by 3.3-3.5 Ga, and that Tibetan-Himalayan style collisional tectonics $\geq$2.6 Ga ago accounts for the large-scale relationships between the Limpopo belt and the adjacent Archean greenstone-granitoid terrane cratons. By inference, other more fragmentary Archean gneissic terranes may have once been part of such collisional zones.

CONSTRAINTS ON LOW-ANGLE FAULTING KINEMATICS IN THE EASTERN PENINSULAR RANGES MYLONITE ZONE, AND IMPLICATIONS ON SOUTHERN CALIFORNIA TECTONICS

№ 60747

ERSKINE, Bradley G., Dept. Geology and Geophysics, Univ. of Calif., Berkeley, CA 94720

Spatially associated with the eastern Peninsular Ranges mylonite zone (EPRMZ) are a complex series of regionally significant east-dipping low-angle faults whose kinematics are controversial. At issue is whether the faults represent west-directed thrusts, east-directed detachment faults, or a superposition of the latter on the former. The question has critical implications on late Mesozoic and Cenozoic tectonics of southern California.

In the northern Santa Rosa Mountains south of Palm Springs, a relatively complete stack of five imbricate low-angle faults possess characteristics of well known thrust belts. Four of the faults, floored by the Palm Canyon and roofed by the Asbestos Mountain fault, comprise a west-directed duplex system, while the fifth may be a relic of an upper duplex. Relative offsets and the geometrically complex fold, basin, and domal structure of fault surfaces suggest that faults were initiated, folded synkinematically and subsequently locked promoting the initiation of new fault surfaces at upper levels. Total minimum offset is 20 km.

Recent proposals correlating low-angle faults with metamorphic core complex / detachment terrains located to the east across the San Andreas fault are unfounded. Most geological relationships apparently conflicting with west-directed thrusting may be attributed to downdip eastward-reactivation of fault surfaces related, in part, to the creation of the topographically and structurally depressed Salton Trough flanking the belt to the east.

The EPRMZ appears to represent an 8-10 km wide late Cretaceous post-intrusive deformation belt between two terrains: continental rocks to the east, and continent-fringing "transitional" crust to the west. If it is accepted that the faults are west-directed and kinematically related to the EPRMZ, then the entire belt may be envisaged as a result of crustal convergence, shortening, and underthrusting of the western terrain relative to the east accompanied by crustal thickening, anatexis, and regional uplift and erosion. Rocks deforming through a decreasing temperature and pressure regime were ultimately overprinted by brittle thrusts producing stacked slices of EPRMZ- related rocks capped by granodiorite previously located inboard (east) of the mylonite zone.

LATE PALEOZOIC SUBULITACEA (MOLLUSCA:GASTROPODA), MASS EXTINCTIONS AND THE REPLACEMENT OF EVOLUTIONARY FAUNAS

№ 61298

ERWIN, Douglas H., Dept. of Geological Sciences, Michigan State University, East Lansing, MI 48824-1115

Mesogastropod subulitaceans possess characteristics typical of active carnivores (columellar folds and an enlarged anterior aperture indicating a developed siphon) and occupied a trophic regime typical of the Mesozoic-Cenozoic evolutionary fauna. Despite occupying a vacant niche, subulitaceans are low in both diversity and abundance (the latter typically below 1%) in late Paleozoic gastropod faunas.

In addition, Paleozoic Archaeogastropoda and Mesogastropoda are taxonomically and functionally distinct from Mesozoic groups and display diversity dynamics typical of the Paleozoic evolutionary fauna, not the Mesozoic-Cenozoic fauna with which they were grouped by Sepkoski (1981, 1984). Late Paleozoic gastropods are different from pre-Carboniferous taxa, but there is no preferential expansion of the major Mesozoic taxa, nor is there any pattern of exploitation of a major niche utilized by later groups but under-used by Paleozoic taxa. The high taxonomic level used Sepkoski's factor analysis neglects the finer scale of replacement and diversification, with the Mesozoic-Cenozoic radiation of meso- and neogastropods obscuring the very different behavior of the Paleozoic gastropod taxa.

This distinct evolutionary behavior of Paleozoic gastropods may be typical of other taxa as well. It weakens the assertions of Kitchell and Carr (1985) and Sepkoksi and Miller (1985) that the replacement of evolutionary Fauna II by Fauna III began in the Late Paleozoic and would have occured even without the Guadelupian-Dzulfian mass extinction. Thus for gastropods at least, the Late Permian mass extinction did not merely speed up an ongoing process, but probably determined the evolutionary outcome.

X-RADIOGRAPHY OF TRACE FOSSILS IN LIMESTONES AND DOLOSTONES FROM THE JURASSIC SMACKOVER FORMATION, SOUTH ALABAMA

№ 78122

ESPOSITO, Richard A., CASTLEMAN, Stephen P., and KING, David T., Jr., Department of Geology, Auburn University, AL 36849

X-radiography has been useful in studying biogenic sedimentary structures in unconsolidated sediments but the technique has not been applied often to the study of hard carbonate rock. We have applied x-radiography to the study of the lower part of the Smackover to enhance the complete petrologic description of the rock. The lower Smackover has many dense micrite intervals and intervals of monotonous, thin graded beds. Parts of the lower Smackover is also dolomitized. None of the above rocks contains significant amount of skeletal debris and trace fossils are not generally obvious in an etched slab of core. In limestone, we have detected well-preserved trace fossils by x-radiography, however. The dolostones show no traces using our method. In limestones, the traces are marked by minute amounts of finely divided iron sulfides. This causes a slight density difference resulting in greater x-ray absorption. We recognize two main trace-fossil types: a Thalassinoides (branching burrow) best seen in slabs cut parallel to bedding and a Zoophycos (concave-up trace) best seen in slabs cut perpendicular to bedding. The technique requires a slab cut 8 mm thick with parallel flat surfaces and a medical x-ray unit using accelerating voltages of 66 kV and 10 mas. Traces are most successfully imaged on industrial-quality films.

OCCURRENCE OF NATIVE SILICON IN A FULGURITE AND IMPLICATIONS OF EXTREME REDUCTION AS A GEOLOGIC PROCESS

№ 67215

ESSENE, ERIC J, Dept. Geol. Sci., Univ. Michigan, Ann Arbor, MI 48109

Native silicon was discovered in fulgurite recently formed on till near Winan's Lake, MI. Further examination of immiscible metallic globules in fulgurite glass reported by Essene and Fisher (GSA Abstr. w. Prog., 1984) has revealed native silicon as euhedral crystals in metal and intergrown with SiO_2-rich glass in the fulgurite matrix. Microprobe analysis gives $Si_{99.5}Al_{0.2}P_{0.2}Ti_{0.1}$, more than 99+44/100 % pure Si for elements with Z > 10. Although difficult to distinguish from moissanite(SiC), sinoite (Si_2N_2O) or silica (SiO_2) on the microprobe, the identity of silicon was confirmed by scans showing no N, C or O at 0.2% detection limits. X-ray powder data revealed the major peaks for Si, and confirmed its existence as a mineral. The native Si occurs in a highly reducing assemblage with Fe_3Si_7, FeSi, FeTiP and more rarely Au, Ag that unmixed as metallic liquid from silicate liquid at T > 2100°K during a lightning strike.

The stability of Si is limited by the reaction:

$$SiO_2(c,l) = Si(c,l) + O_2(v),$$

which requires fO_2 some 10 to 15 log units below that necessary to stabilize native iron. This reaction may be driven by a loss of O_2 and/or conversion of carbon compounds to CO or CO_2 during an ephemeral pulse of extreme temperature. This remarkable process of reduction may also occur during other ultra-high temperature phenomena such as (extra)terrestrial meteoritic and cometary impacts, or even atomic-bomb blasts. Lightning strikes possibly involving carbon compounds in primitive stellar nebulae may have produced similar reduction. Asteroidal impacts may also yield similar results and impact glasses should be searched for highly reduced metals, carbides and silicides. Fulgurite and impact events may also be recorded by persistent reports of other highly reduced minerals, such as SiC, Al, Cr, Cr_2C, TaC, or Mg_2Si. Their identity as minerals should not be discounted a priori unless such ultra-high temperature events can be conclusively rejected.

PRECAMBRIAN GEOLOGY II
South Hall B, Convention Center, 1:00 p.m.

William S.F. Kidd and Warren C. Day, Presiding

1 **John C. Green*, Val C. Chandler:** DIABASE DIKES OF THE MIDCONTINENT RIFT IN MINNESOTA: A RECORD OF KEWEENAWAN MAGMATISM AND TECTONIC DEVELOPMENT [64738] .... 1:00 P

2 **M.E. Bickford*, W.R. Van Schmus:** RESETTING OF WHOLE ROCK AND MINERAL Rb-Sr AGES BY SUBSEQUENT PROTEROZOIC OROGENIES [76907] ...... 1:15 P

3 **Richard I. Grauch*, John N. Aleinikoff:** MULTIPLE THERMAL EVENTS IN THE GRENVILLIAN OROGENIC CYCLE: GEOCHRONOLOGIC EVIDENCE FROM THE NORTHERN READING PRONG, NEW YORK-NEW JERSEY [63509] .... 1:30 P

4 **M.M. Cheatham, W.J. Olszewski, Jr., H.E. Gaudette*:** THE CHAIN LAKES MASSIF, WEST CENTRAL MAINE; NORTHERN APPALACHIAN BASEMENT OR SUSPECT TERRANE? [75572] .... 1:45 P

5 **David B. Ward*, Jeffrey A. Grambling:** DATING A PROTEROZOIC METAMORPHIC EVENT USING Rb-Sr GEOCHRONOLOGY: AN EXAMPLE FROM NORTHERN NEW MEXICO [78372] .... 2:00 P

6 **H.K. Brueckner*, K.C. Hardcastle, R.F. Hanson, T.J. Wilson:** A Rb-Sr AGE FROM THE CHOMA-KALOMO BATHOLITH, EVIDENCE FOR THE IRUMIDE BELT IN SOUTHERN ZAMBIA, AFRICA [64310] .... 2:15 P

7 **R.E. Hanson*, T.J. Wilson, M.S. Wardlaw:** STRUCTURE, AGE, AND REGIONAL SIGNIFICANCE OF SYNTECTONIC AUGEN GNEISSES IN THE PAN-AFRICAN ZAMBEZI BELT, SOUTH-CENTRAL ZAMBIA [74092] .... 2:30 P

8 **A.K. Gibbs*, K.R. Wirth:** LITHOSTRATIGRAPHY OF THE GRAO PARA GROUP, SERRA DOS CARAJAS, BRAZIL [57967] .... 2:45 P

9 **Wm. J. Olszewski, Jr.*, A.K. Gibbs, K.R. Wirth:** Rb-Sr AND Sm-Nd WHOLE ROCK ANALYSES OF BASALTS OF THE GRAO PARA GROUP, SERRA DOS CARAJAS, BRAZIL [76007] .... 3:00 P

COFFEE BREAK .... 3:15 P

TECTONICS V: PRECAMBRIAN TECTONICS

10 **Kevin Burke, W.S.F. Kidd, T.M. Kusky*:** ARCHEAN FORELAND BASIN TECTONICS FROM THE WITWATERSRAND, SOUTH AFRICA [67100] .... 3:30 P

11 **Kenneth A. Eriksson, William S.F. Kidd*:** SEDIMENTOLOGIC AND TECTONIC ASPECTS OF THE ARCHEAN LIMPOPO BELT [72650] .... 3:45 P

12 **George M. Fairer*:** EVOLUTION OF THE ASIR TERRANE AND PHANEROZOIC RIFTING IN SOUTHWESTERN SAUDI ARABIA [73996] .... 4:00 P

13 **John N. Aleinikoff*, John C. Reed, Jr., John S. Pallister:** TECTONIC IMPLICATIONS FROM U-Pb DATING OF DETRITAL ZIRCONS FROM THE EARLY PROTEROZIC TERRANE OF THE CENTRAL ROCKY MOUNTAINS [73479] .... 4:15 P

14 **P.K. Sims*, Z.E. Peterman:** EARLY PROTEROZOIC TECTONICS IN THE NORTH-CENTRAL UNITED STATES [73481] .... 4:30 P

15 **David B. Bieler*, David C. Schuster:** JUXTAPOSED MELANGES: THE RESULT OF POLYPHASE TECTONISM IN A FOREARC TERRANE [58132] .... 4:45 P

SEDIMENTARY GEOLOGY III
8EF Orange Blossom, Convention Center, 1:00 p.m.

W. F. Tanner and Paul A. Baker, Presiding

1 **Ellen A. Cowan*, James D. Duncker, Ross D. Powell:** PROCESSES OF DEPOSITION OF INTERLAMINATED SAND-AND-MUD AT A TEMPERATE TIDEWTER GLACIER [64840] .... 1:00 P

2 **William F. Tanner*:** HYDRODYNAMIC MEASURES AND GRAIN SIZE ANALYSIS [69505] .... 1:15 P

3 **Robert Ehrlich, Margaret R. Eggers*, Emery D. Goodman:** QUARTZ SIZE/SHAPE RELATIONSHIPS: VARIABLE SIZE/SHAPE RELATIONSHIPS OF DETRITAL QUARTZ REFLECT DIFFERENCES IN SOURCE/TRANSPORT PARAMETERS [76627] .... 1:30 P

4 **Paul D. Komar*:** GRAVEL THRESHOLD, SELECTIVE ENTRAINMENT AND FLOW COMPETENCE [76195] .... 1:45 P

5 **Anthony R. Prave*:** CAN HUMMOCKY CROSS STRATIFICATION BE FORMED BELOW EFFECTIVE WAVE BASE? [72802] .... 2:00 P

6 **C. Paola*, M.A. Reinhart, S.M. Wiele:** UPPER-FLAT-BED PARALLEL LAMINATION DEPOSITED IN A SMALL FLUME: PRELIMINARY RESULTS [73809] .... 2:15 P

7 **John M. Lambie*, John B. Southard:** AN EXPERIMENTAL STUDY OF THE STABILITY OF OSCILLATORY-FLOW BED PHASES [66092] .... 2:30 P

8 **Charles E. Savrda*, David J. Bottjer:** BIOGENIC SEDIMENTARY STRUCTURES AS INDICATORS OF PALEO-BOTTOM-WATER REDOX CONDITIONS [78663] .... 2:45 P

9 **M. Carmela Cuomo*, Donald C. Rhoads:** BIOGENIC SEDIMENTARY FABRICS ASSOCIATED WITH PIONEERING POLYCHAETE ASSEMBLAGES [68361] .... 3:00 P

10 **R.C. Marty*, R.B. Dunbar, P. Baker:** NEOGENE BIOGENIC SEDIMENTS OF ONSHORE PERU: PART I, SEDIMENTOLOGY AND STRATIGRAPHY [73035] .... 3:15 P

11 **Paul A. Baker*, Robert B. Dunbar, Richard C. Marty:** NEOGENE BIOGENIC SEDIMENTS OF ONSHORE PERU: PART 2. GEOCHEMISTRY AND DIAGENESIS [66133] .... 3:30 P

12 **Brooks B. Ellwood*, William L. Balsam:** ANOMALOUS MAGNETIZATION IN THE AUSTIN CHALK: IMPLICATIONS FOR MAGNETIC STUDIES IN ROCKS AND SEDIMENTS [62096] .... 3:45 P

VOLCANOLOGY: CHEMICAL AND PHYSICAL PROCESSES
8AB Orange Blossom, Convention Center, 1:00 p.m.

Stephen A. Nelson and W. K. Hart, Presiding

1 **P.v.d. Bogaard*, H.-U. Schmincke:** DYNAMICS OF THE PLINIAN ERUPTIVE PHASE OF LAACHER SEE VOLCANO (EIFEL, WEST GERMANY) [67304] ..... 1:00 P

2 **Daniel R. Shawe*:** ASH-FLOW ERUPTIVE MEGABRECCIAS IN THE SOUTHERN TOQUIMA RANGE, NYE COUNTY, NEVADA [74284] .... 1:15 P

3 **Michael J. Kunk*, John F. Sutter, Charles W. Naeser:** HIGH-PRECISION 40Ar/39Ar AGES OF SANIDINE, BIOTITE, HORNBLENDE, AND PLAGIOCLASE FROM THE FISH CANYON TUFF, SAN JUAN VOLCANIC FIELD, SOUTH-CENTRAL COLORADO [71754] .... 1:30 P

4 **Laura L. Kedzie, John F. Sutter*, C.E. Chapin:** HIGH-PRECISION 40Ar/39Ar AGES OF WIDESPREAD OLIGOCENE ASH-FLOW TUFF SHEETS NEAR SOCORRO, NEW MEXICO [71775] .... 1:45 P

5 **Lisa A. Gilbert*, K.A. Foland:** EXCESS 40Ar IN MINERALS OF A SHALLOW PLUTON, THE MOUNT ST. HILAIRE COMPLEX, QUEBEC [73364] .... 2:00 P

6 **T.P. Flood*, B.C. Schuraytz, T.A. Vogel, L.W. Younker:** CYCLIC EVOLUTION OF A MAGMATIC SYSTEM: THE PAINTBRUSH TUFF, SW NEVADA VOLCANIC FIELD [77355] .... 2:15 P

7 **JoAnn Hegre*, Stephen A. Nelson:** GEOLOGY OF VOLCAN LAS NAVAJAS, A PLEISTOCENE TRACHYTE/PERALKALINE RHYOLITE VOLCANIC CENTER IN NAYARIT, MEXICO [55755] .... 2:30 P

8 **Stephen A. Nelson*, JoAnn Hegre:** COMENDITIC AND PANTELLERITIC ASH-FLOW TUFFS FROM VOLCAN LAS NAVAJAS, NAYARIT, MEXICO [55752] .... 2:45 P

9 **Lori A. DeRemer*, Stephen A. Nelson:** GEOLOGIC AND CHEMICAL EVOLUTION OF VOLCAN TEPETILTIC, NAYARIT, MEXICO [64641] .... 3:00 P

10 **Marc J. Defant*, Paul C. Ragland, A.L. Odom:** PETROGENESIS OF WESTERN PHILIPPINE ISLAND ARC MAGMAS: POTENTIAL ORIGIN OF THE POTASSIUM-DEPTH RELATIONSHIP [68038] ...... 3:15 P

11 **Craig A. Chesner*:** HIGHLY EVOLVED RHYOLITIC GLASS COMPOSITIONS FROM THE TOBA CALDERA, SUMATRA [63565] .... 3:30 P

12 **Kathleen R. Schwindinger*, Alfred T. Anderson, Jr.:** DIFFERENTIATION IN THE CUMULATES FROM A MAUNA LOA, HAWAII MAGMA CHAMBER [79554] .... 3:45 P

13 **R.L. Badger*, A.K. Sinha:** THE CATOCTIN VOLCANIC PROVINCE: THE BEARING OF STRATIGRAPHY AND GEOCHEMISTRY ON PETROGENESIS [63163] .... 4:00 P

ABSTRACTS WITH PROGRAMS, VOL. 17, NO. 7, 1985 ANNUAL MEETING

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ABSTRACTS with PROGRAMS 1985

98th Annual Meeting

The Geological Society of America

The Paleontological Society (77th)
The Mineralogical Society of America (66th)
The Society of Economic Geologists (65th)
Cushman Foundation (36th)
Geochemical Society (30th)
National Association of Geology Teachers (26th)
Geoscience Information Society (20th)

OCTOBER 28–31, 1985 ORLANDO, FLORIDA
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