UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

January 21, 1980

MEMORANDUM FOR: R. E. Jackson, Chief, Geosciences Branch, DSS

THRU: L. Reiter, Section Leader, Geology and Seismology Section, Geosciences Branch, DSS

FROM: R. B. McMullen, Geologist, Geosciences Branch, DSS

SUBJECT: NEW SEISMIC REFLECTION DATA REGARDING STRUCTURAL RELATIONS OF OFFSHORE EXTENSIONS OF THE SAN SIMEON FAULT ZONE

On January 16, 1980, I was made aware of an abstract presented in the EOS, Vol. No. 46, November 13, 1979 entitled "Continuity and Recency of Movement on Offshore Extensions of the San Simeon Fault Zone, Central California," by R. B. Lesley, of the University of California, Santa Cruz. The abstract presents the author's interpretation of seismic reflection profiling data taken in shallow water across southern extensions of the San Simeon fault zone. Mr. Lesley interprets the data to show that the San Simeon fault can be traced approximately 10 km southeastward from San Simeon Bay where it joins a strand of the Hosgri fault zone. He also interprets the records as showing evidence for faulting of post-Wisconsinan sediments (less than 20,000 years old).

I called Jim Devine of the U. S. Geological Survey (USGS), who in turn contacted the USGS office in Menlo Park, Calif. Mr. Devine indicated that a marine geologist at Menlo Park who had seen the data, believes that the records are good and sees no reason to disagree with Lesley's interpretation at the present time.

Mr. Devine also said that this new data does not change the USGS's conclusion regarding the maximum earthquake on the Hosgri fault zone because a possible connection between these two faults at depth had been assumed in their analysis. Regarding post-Wisconsinan offsets, the Applicant had earlier mapped post-Wisconsinan offset within the San Simeon fault system onshore. In its safety evaluation of the Diablo Canyon site, the NRC accepted the USGS's recommendation regarding the SSE, therefore, we see no reason to alter our conclusion that the assumption of the occurrence of a 7.5 magnitude earthquake on the Hosgri fault at its closest approach to the site is appropriately conservative.

R. B. McMullen, Geologist
Geology and Seismology Section
Geosciences Branch
Division of Systems Safety

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[illegible] the [illegible] to the [illegible] 0.5 m?. This value is [illegible] and linear [illegible] used to [illegible] the [illegible].

T135

[illegible] OF SAN ANDREAS FAULT, [illegible] CALIFORNIA[1]

[illegible] (University of California at Santa [illegible] 93106, and [illegible] [illegible])

In this [illegible] stretch, the San Andreas fault [illegible] the effect of the 1857 earthquake [illegible], consists principally of: 1. a [illegible] trench up to 1[illegible] wide and [illegible] or more deep, interrupted by center-trough [illegible], [illegible] ridges, and splay ridges [illegible], and [illegible] by [illegible] and [illegible], and with frequent fault [illegible] ridges, and 2. a scarp or scarps, 1 [illegible] to 2[illegible] m or more high with [illegible] dips to [illegible] and [illegible]. [illegible] lengths of the trench or scarp are 2 to 4 km. Splay [illegible] faults diverge slightly from the main [illegible]. [illegible] features are: sag ponds, closed depressions, sometimes filled with peat (2 [illegible]), [illegible], and [illegible]. Recent displacement [illegible] are not as abundant as in other [illegible]. [illegible] right-lateral [illegible] of [illegible] and gullies range between [illegible]. [illegible] offset by [illegible]. [illegible] offsets are [illegible] event. [illegible] is found north [illegible] about 3.[illegible] [illegible] by [illegible] surface.

[1] Partially supported by U. S. Geological Survey.

T136

[illegible] IN THE [illegible] AREA

[illegible] Survey, Menlo Park, CA [illegible]

A numerical model based on dislocation theory is used to study the interaction of fault segments in an elastic medium. Given an arbitrary [illegible] distribution of fault segments (either intersecting or isolated), the fault stress and slip distribution is found resulting from [illegible] applied stress and prescribed friction law. [illegible] is actively [illegible] on the fault [illegible] relative to the [illegible] applied field. For example, a [illegible] km length of the San Andreas fault [illegible] the San Francisco Bay area was [illegible] stress applied parallel to the [illegible] plate motion. The model predicts most of the fault to be tightly locked except for a [illegible] km section between [illegible] and Pacifica. This variation is due to changes in the fault strike. A more complex picture arises in the [illegible] area where several faults at different [illegible] interact. For example, a model [illegible] of the slip associated with the 1979 [illegible] earthquake on the [illegible] fault predicts [illegible] of the Calaveras fault, and fault locking on other portions. This result is consistent with creep observations.

T137

FINITE ELEMENT MODELING OF STRESS ALONG THE SAN ANDREAS FAULT

[illegible] (Dept. of Geosciences, University of Arizona, Tucson, AZ 85721)
Eric A. [illegible] (Dept. of Earth and Planetary Sciences, M.I.T., Cambridge, MA 02139)

Stress in the lithosphere along the San Andreas fault from approximately 30°N to 33°N has been [illegible] using elastic finite element analysis. [illegible] portion of the fault along the big [illegible] fault are [illegible]. [illegible] of 3[illegible] plane strain elastic finite elements have been used, with [illegible] spacing of about 30 km along the fault. The elastic thickness of the model is 100 km, although the results scale linearly with the [illegible] of thickness.

For stress boundary condition models, forces equivalent to 100 bars of shear stress have been applied to the edges of the model. Near the ends of the locked portions of the fault the shear stresses are [illegible], while along the locked portion the shear stress level is fairly constant with [illegible] than 100 bars. Models with [illegible] corresponding to the [illegible] of North America with respect to the Pacific plate since the 1857 earthquake [illegible] considered. Calculated [illegible] strain rates. The [illegible] fault is [illegible] fault and [illegible] the fault of a few [illegible] with observed strain [illegible] stress levels during [illegible] on the order of tens of bars [illegible] of the locked section and a few [illegible] portion with a slight [illegible] of stresses in the California [illegible]. [illegible] creep, displacement boundary [illegible] are applied to the northern and [illegible] of the fault. Calculated stresses are similar to other models along the locked portion of the fault, although significant differences in the orientations of stresses occur near the ends of the locked portion.

T138 POSTER PAPER

CONTINUITY AND [illegible] OF MOVEMENT ON OFFSHORE EXTENSIONS OF THE SAN SIMEON FAULT ZONE, CENTRAL CALIFORNIA

F.B. Leslie (Earth Sciences Board, University of California, Santa Cruz, Ca. 95064)
([illegible] A. Silver)

The San Simeon fault zone is a [illegible] structural break separating [illegible] rocks from a thick section of [illegible] sediments. Reflection profiles [illegible] in very shallow near shore [illegible] interpreted in [illegible] with [illegible] profiles and [illegible] data for [illegible] study of structural relations of offshore extensions of the San Simeon fault zone. The zone is 2 to [illegible] km wide and composed of numerous anastomosing fault strands. The offshore extension of the San Simeon fault zone to the northwest acts primarily as a boundary between Mesozoic [illegible] and Miocene sediments. A zone of [illegible] deformed Miocene sediments [illegible] a near surface mass of acoustic basement. This uplifted basement, lying southwest of the fault, produces a [illegible] trending [illegible] and is associated with [illegible] structural character in the overlying sediments. The southern extension of the San Simeon fault zone, which may act in part as a boundary between Upper Cretaceous forearc basin deposits ([illegible]) and Franciscan assemblage rocks, can be followed approximately 10 km [illegible] from San Simeon Bay where it joins a strand of the Hosgri fault zone. [illegible] folds in Miocene sediments are truncated by the fault on the west side and are consistent with a right lateral shear [illegible] along the fault trend. [illegible] major [illegible] along faults occurred during Miocene and Pliocene time, faulting [illegible] as late Pleistocene or Holocene. [illegible] for relatively recent movement [illegible] offset of [illegible] sediments [illegible], and linear trends of [illegible] on the sea floor.

T139

[illegible] FOR STRIKE-SLIP AND [illegible] FAULTS

Albert T. Smith (Earth Sciences Board, University of California, Santa Cruz, CA 95064)

[illegible] and uplift in Southern California are attributed to locking of the San Andreas fault and to aseismic creep on associated faults (Thatcher, 1976; [illegible] and Savage, 1976; [illegible], 1977). These models assume insignificant stress relaxation in the [illegible] plate and a thick lithosphere. To understand the significance of these assumptions, a series of two- and three-dimensional finite element models are presented for simple fault configurations. [illegible] deformations [illegible] with thrust faults strongly [illegible]

T140

[illegible]

[illegible] Wang
[illegible]

[illegible] for the Coyote Lake earthquake 6 August 1979 to predict [illegible] deformation and stress [illegible]. Results indicate that the [illegible] behavior is controlled by the [illegible] value in the model. If [illegible] viscosity region [illegible] depth under the fault, [illegible]

T141

[illegible]

[illegible]
J. R. Rice ([illegible] Brown University, Providence, RI [illegible])

A mechanism is [illegible] of seismic activity, [illegible] earthquakes, [illegible] from the coupling of an elastic [illegible] a viscoelastic [illegible] is studied [illegible] stress plate/[illegible] model. [illegible] (crustal material caused by [illegible] or suddenly introduced [illegible] along transform or [illegible] boundaries. [illegible] stress fields [illegible] due to [illegible] higher, and [illegible] effects up to [illegible] for the [illegible] modulus of 5×10^{10} Pa for [illegible] elastic relaxation of [illegible] to a buildup of stress [illegible] suddenly arrested [illegible] disturbances, [illegible] in time. This [illegible] triggering effect for [illegible] with speeds [illegible] migration. It also [illegible] mechanism of time dependent stress [illegible] from major seismic ruptures into [illegible] gap zones at rates which [illegible] average tectonic rates of straining.

T142

ANALYTICAL [illegible] TION IN A [illegible]

[illegible] Ho
Albert T. Smith (both at: Earth Sciences Board, University of California, Santa Cruz, CA 95064).

[illegible] and variable [illegible] in space and time [illegible]

[illegible]

T138 [illegible]

[illegible]

T139

[illegible] FOR STRIKE-SLIP AND THRUST FAULTS

Albert T. Smith (Earth Science Board, University of California, Santa Cruz, CA 95064)

[illegible]

[illegible] based on the configuration of the fault [illegible] the subducting lithosphere. A [illegible] strike-slip fault demonstrates [illegible] significant variations in vertical deformation at the fault tip arising from asthenospheric relaxation. [illegible] deformations associated with a bend in the fault are compared to simple [illegible] creep.

T140

FINITE ELEMENT MODELS OF TIME DEPENDENT DEFORMATION AND STRESS DUE TO STRIKE-SLIP EARTHQUAKES

Wei Yang
M. Nafi Toksöz (Both at: Dept. of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139)

Time dependent stress relaxation after strike-slip earthquakes is calculated using three dimensional finite element models. A step by step integration scheme is used to calculate the time dependence due to viscoelastic interaction. Stresses, strains and displacements are calculated for several model earthquakes. Special calculations are made for the Coyote Lake earthquake of [illegible] August 1979 to predict post earthquake deformation and stress diffusion. [illegible] indicate that the time dependent behavior is controlled by the viscosity [illegible] in the model. If there is a low [illegible] region extending to shallow [illegible] below the fault, there is a stress [illegible] effect even for intermediate [illegible] earthquakes. The region in front of the fault tip experiences an [illegible] stress level and deformations [illegible] for years after the event.

T141

[illegible] IN THE ASTHENOSPHERE AND [illegible] PLATE BOUNDARIES

[illegible]
J. R. Rice (All at: Brown University, [illegible], Box D, Providence, RI 02912)

[illegible] is analyzed which may be fundamental to [illegible] and migration of seismic activity, in particular of large [illegible], along plate boundaries. It arises from the coupling of an elastic lithosphere to a viscoelastic [illegible] asthenosphere and [illegible] by [illegible] plane stress [illegible] model. Solutions are given describing the quasistatic stressing of [illegible] caused by steadily propagating or suddenly introduced slip or rupture events along transform or subduction type plate boundaries. [illegible] the stress fields [illegible] with travelling distance [illegible] attenuation, due to viscoelastic [illegible] of the asthenosphere, at speeds of the order of [illegible] and higher, and exhibit significant viscosity effects up to speeds of [illegible] assuming a viscosity of the order of 10^{19} Pa s for the asthenosphere and an effective shear modulus of 5×10^{10} Pa for both layers. Viscoelastic relaxation of the asthenosphere leads to a buildup of stress in time ahead of [illegible] crack-like [illegible] stress [illegible] to be [illegible]. This suggests a delayed [illegible] effect for disturbances travelling with speeds comparable to observed speeds of [illegible] migration. It also furnishes a mechanism of time dependent stress transfer from major seismic ruptures into neighboring [illegible] at rates which may greatly exceed average tectonic rates of stressing.

T142

ANALYTICAL SOLUTION TO STRESS PROPAGATION IN A TWO DIMENSIONAL LITHOSPHERE

[illegible] Ho
Albert T. Smith (Both at: Earth Science Board, University of California, Santa Cruz, CA 95064)

[illegible] variations of [illegible] have

[illegible] been investigated analytically in two dimensions. [illegible] rectangular [illegible] lithosphere of constant [illegible] overlying a Maxwellian viscoelastic [illegible]. The [illegible] equation [illegible] numerical [illegible] using the [illegible] of the solutions. A [illegible] boundary condition is applied to simulate the earthquake slip along a finite rupture zone at the convergent plate boundary. The "ridge" is [illegible] to be stress free, and shear stress vanishes on the other two boundaries.

The velocity and displacement within the lithosphere are similar to the one dimensional case (EOS, Trans. AGU, 58, 1234, 1977). The model uses a 100 km thick lithosphere overlying an 80 km thick asthenosphere with viscosity of 5×10^{19} poise. At a distance of 400 km from an 800 km wide rupture zone, the maximum velocity is 2.8 cm/yr for 1.6 m slip, which is 15% less than the one dimensional case.

The solution, however, depends on the boundary conditions. The finite element method is being used to allow more general boundary conditions.

The Rio Grande and Other Continental Rifts
Gold Rush (HI)
Thursday 1400 h
Kathleen Crane (Lamont-Doherty), Presiding

T143

CONSTRAINTS ON THE THERMAL STRUCTURE OF THE RIO GRANDE RIFT

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Published heat flow values spanning the linear heat flow high along the Rio Grande Rift in New Mexico are used to determine greatest lower bounds on the maximum and average crustal temperatures as a function of depth. Calculations are performed using linear programming, under the simplifying restrictions of two-dimensional steady-state conduction. Conservative lower and upper bounds on the crustal radioactive heat production are incorporated into the optimization. It is found that the paucity of data and the large uncertainties which must be assigned to them result in bounds which are considerably [illegible] not [illegible] within the [illegible] temperatures normally attributed to this region. This conclusion is not [illegible] if we make the additional [illegible] that the temperature at any depth is nowhere less than an assumed background model consisting of "characteristic" Basin and Range temperatures to the west of the rift and lower Great Plains temperatures to the east.

T144

P-WAVE VELOCITY STRUCTURE BENEATH THE CENTRAL RIO GRANDE RIFT

William [illegible] (U.S. Geological Survey, [illegible], Denver, CO 80225)
[illegible] (CIRES, U. of Colorado, Boulder, CO 80309)
[illegible] (U.S. Geological Survey, Albuquerque, NM 87115)

We have used the [illegible] to determine P-wave [illegible] distributed teleseismic [illegible] recorded at a [illegible] array that spans the Rio Grande Rift. Using a reference station [illegible] individual [illegible]

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