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ON TWO ASEISMICALLY CREEPING AND INTERACTING VERTICAL STRIKE SLIP FAULTS - ONE BURIED AND THE OTHER EXTENDED UP TO THE SURFACE IN A TWO LAYER MODEL OF THE LITHOSPHERE

by

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ABSTRACT

Two vertical, interacting, creeping, strike-slip faults - one buried and the other surface breaking situated in the upper layer of a layered model of the lithosphere-asthenosphere system, consisting of an upper elastic layer in welded contact with a visco-elastic half space below it, is considered. Solutions are obtained for the displacements, stresses and strains in the model during aseismic periods in the case when no fault is creeping, the case when one fault is creeping and the other is locked and the case when both the faults are creeping.

The effect of seismic fault creep across one fault on the shear stress near the fault itself is investigated together with the effect of creep across the other fault. Some situations are identified where aseismic creep across one fault results in the release of shear stress near the other fault, reducing the possibility of seismic movements across it. Other situations are also identified where aseismic creep across one fault results in the accumulation of the shear stress near the other fault increasing the possibility of seismic faults movements. The possible uses of the theoretical model in obtaining greater insight into earthquake processes in seismically active regions with interacting faults are examined.

INTRODUCTION

Modelling of earthquake processes is one of the main concerns of theoretical seismology at present. When we try to model the dynamics of the generation of earthquakes in seismically active regions of the earth, we have to take into account the period of seismic activity when an earthquake is taken place as well as apparently quiet aseismic period during which slow and continuous aseismic surface movements are observed in seismically active regions with magnitude of a few cms. per year or less.

Some theoretical models for aseismic surface movements in seismically active regions have been discussed by Mukhopadhyay et al. (1980a, b, 1984, 1986, 1988) and Cohen et al. (1989). In most of these theoretical models, a single locked or creeping fault is considered. However, Mukhopadhyay et al. (1984, 1986, 1988) have considered theoretical models of the lithosphere-asthenosphere system with two surface breaking, two buried and one surface breaking and the other buried creeping and interacting faults respectively and have explained the significance of fault interaction in the process of stress accumulation and release in seismically active regions. But no theoretical models of interaction between faults situated in a layered model of the lithosphere-asthenosphere system have been developed till now. Keeping in view the fact that creep across surface-breaking and buried faults is supposed to be occurring in many seismically active regions [Kasahara (1981)], the case of two creeping and interacting vertical strike-slip faults, one surface-breaking and the other buried situated in an elastic layer which is resting and is in welded contact with a visco-elastic half-space representing lithosphere-asthenosphere system has been considered in this paper.

FORMULATION

We consider two long, vertical and interacting strike-slip faults-one surface-breaking (F_1) and the other buried (F_2) in an elastic layer of thickness H. The layer rests on and is in welded contact with a visco-elastic half-space. We introduce the rectangular cartesian co-ordinate system (y_1, y_2, y_3) as shown in the Fig. 1. y_1 - axis is parallel to the planes of the faults. Let D_1 be the depth of the lower edge of F_1 below the free-surface. Also let d_2 and D_2 be the depths of the upper and the lower edges of the fault F_2 below the free surface ($d_2 < D_2$). we take the planes of the faults F_1 and F_2 be given by $y_2 = 0$ and $y_2 = D$ respectively.

For long faults, we can take the displacements, strains and stresses to be independent of y_1 and depending on y_2, y_3 and t. We shall consider here the effect of strike-slip movements only. Associated with it the components of displacement, stress and strain are u, (τ_{12}, τ_{13}), (e_{12}, e_{13}) in the elastic layer and that for the visco-elastic half space are u', (τ'_{12}, τ'_{13}) , (e'_{12}, e'_{13}) respectively, and satisfy the relations

$$\tau_{12} = \mu_1 \frac{\partial u}{\partial y_2} \qquad \text{for} \quad 0 < y_3 < H$$

$$\tau_{13} = \mu_1 \frac{\partial u}{\partial y_3} \qquad (t \geq 0, -\infty < y_2 < \infty) \qquad .....(1)$$

and

$$\frac{1}{\mu_2} \frac{\partial}{\partial t} (\tau'_{12}) + \frac{\tau'_{12}}{\eta} = \frac{\partial^2 u'}{\partial t\, \partial y_2} \qquad y_3 > H$$

$$(t \geq 0, -\infty < y_2 < \infty)$$

$$\frac{1}{\mu_2} \frac{\partial}{\partial t} (\tau'_{13}) + \frac{\tau'_{13}}{\eta} = \frac{\partial^2 u'}{\partial t\, \partial y_3} \qquad .....(2)$$

where μ_1 and μ_2 are the effective rigidity for the layer and half-space respectively and η is the effective viscosity.

For the slow, aseismic quasi-static displacements we consider, the inertial forces are very small and are neglected. Hence the relevant stresses satisfy the relations -

$$\frac{\partial}{\partial y_2}(\tau_{12}) + \frac{\partial}{\partial y_3}(\tau_{13}) = 0, \quad 0 \le y_3 \le H$$

$$\frac{\partial}{\partial y_2}(\tau'_{12}) + \frac{\partial}{\partial y_3}(\tau'_{13}) = 0, \quad y_3 > H \qquad \text{.....(3)}$$

$$(t \ge 0, \ -\infty < y_2 < \infty)$$

From (1), (2) and (3) we find that

$$\nabla^2 u = 0 \quad \text{in} \quad 0 \le y_3 \le H \qquad (t \ge 0, \ -\infty < y_2 < \infty)$$

$$\nabla^2 u' = 0 \quad \text{in} \quad y_3 \ge H \qquad \text{.....(4)}$$

Boundary conditions are

$$\tau_{13} = 0 \quad \text{at} \quad y_3 = 0$$

$$\tau_{13} = \tau'_{13} \quad \text{at} \quad y_3 = H$$

$$u = u' \quad \text{at} \quad y_3 = H \qquad (t \ge 0, -\infty < y_2 < \infty)$$

$$\tau'_{13} \to 0 \quad \text{as} \quad y_3 \to \infty \qquad \text{.....(5)}$$

We assume that tectonic forces maintain a shear strain far away from the faults, we have then the boundary conditions

$$e_{12} \to (e_{12})_{o\infty} + f(t) \qquad \text{as } |y_2| \to \infty$$

$$e'_{12} \to (e'_{12})_{o\infty} + f(t) \qquad (t \ge 0) \qquad \text{.....(6)}$$

where

$$(e_{12})_{o\infty} = \lim_{|y_2| \to \infty} (e_{12})_o$$

$$(e'_{12})_{o\infty} = \lim_{|y_2| \to \infty} (e'_{12})_o$$

$(e_{12})_o$, $(e'_{12})_o$ are the values of e_{12} and e'_{12} at $t = 0$, where $f(t)$ is a continuous function of t, such that $f(o) = 0$. The same function is taken for both e_{12} and e'_{12}, to ensure that the boundary condition $u = u'$ at $y_3 = H$ is satisfied as $|y_2| \to \infty$.

We assume that at $t = 0$, when the aseismic state is established and the relations (1)-(6) become valid u, u', τ_{12} .... e'_{13} have the values $(u)_o$, $(u')_o$,

$(\tau_{12})_o$ ..... $(e'_{13})_o$ respectively, which may be constants or function of (y_2, y_3), satisfying the relations (1)-(6).

Since $(\tau_{13})_o$ and $(\tau'_{13})_o$ satisfy (1)-(6) they have the same value at $y_3 = H$. Let $T_H(y_2)$ be the common value of $(\tau_{13})_o$ and $(\tau'_{13})_o$ at $y_3 = H$

$$\text{i.e.} \quad T_H(y_2) = [(\tau_{13})_o]_{y_3=H} = [(\tau'_{13})_o]_{y_3=H}$$

DISPLACEMENTS AND STRESSES IN THE ABSENCE OF FAULT MOVEMENT

The initial and boundary value problem (1)-(6) is solved, following exactly the same method as in Mukhopadhyay et al. (1980b) using Laplace transforms in the case when $T_H(y_2) = T_H$ (a constant) $\neq 0$, to obtain

$$\begin{aligned}
u &= (u)_o + y_2\, f(t) + H\, T_H \cdot t/\eta \\
u' &= (u')_o + y_2\, f(t) + y_3\, T_H \cdot t/\eta \\
\tau_{12} &= (\tau_{12})_o + \mu_1\, f(t) \\
\tau_{13} &= (\tau_{13})_o \\
\tau'_{12} &= (\tau'_{12})_o\, e^{-\mu_2 t/\eta} + \mu_2 \int_o^t f'(t)\, e^{-\mu_2 (t-\tau)/\eta}\, dt \\
\tau'_{13} &= (\tau'_{13})_o\, e^{-\mu_2 t/\eta} + T_H \left(1 - e^{-\mu_2 t/\eta}\right) \qquad .....(7)
\end{aligned}$$

DISPLACEMENTS AND STRESSES AFTER THE COMMENCEMENT OF THE FAULT CREEP ACROSS THE FAULTS

If fault creep commences across F_1 or F_2 or both at time $t = T_1$ and $t = T_2$ for F_1 and F_2 respectively, the relations (1)-(6) are satisfied together with the following conditions of creep across F_1 and F_2 :

$$[u]_{F_1} = U_1(t_1)\; f_1(y_3)\; H(t_1) \qquad .....(8)$$

$$(t_1 > 0) \text{ across } F_1\, (y_2 = 0,\; 0 < y_3 < D_1)$$

where $H(t_1)$ is the Heaviside unit step function and $[u]_{F_1}$ is the discontinuity in u across F_1,

$$\text{i.e.} \quad [u]_{F_1} = \lim_{y_2 \to 0+0} u - \lim_{y_2 \to 0-0} u, \quad (0 \le y_3 \le D_1)$$

the velocity of creep $\frac{\partial}{\partial t}[u]_{F_1} = V_1(t_1)\, f_1(y_3)\, H(t_1)$

where $V_1(t_1) = \frac{\partial}{\partial t} U_1(t_1) = \frac{\partial}{\partial t_1} U_1(t_1)$

and $V_1(t_1)$, $U_1(t_1)$ vanish for $t_1 \leq 0$.

Similarly for the fault F_2, the creep condition is

$$[u]_{F_2} = U_2(t_2)\, f_2(y_3)\, H(t_2) \quad .....(9)$$

$$\text{across } F_2\ (t_2 \geq 0,\ y_2 = D,\ d_2 \leq y_3 \leq D_2)$$

The velocity of creep $\frac{\partial}{\partial t}[u]_{F_2} = V_2(t_2)\, f_2(y_3)\, H(t_2)$

and $V_2(t_2)$, $U_2(t_2)$ vanish for $t_2 \leq 0$.

We assume here that u', τ_{12}, τ_{13}, τ'_{12}, τ'_{13} are continuous everywhere in the model. Consider the model after the commencement of the fault creep across F_1 or F_2 or both, we try to find solutions for u, u', τ_{12}, ... τ'_{13} in the form

$$
\begin{aligned}
u &= (u)_1 + (u)_2 + (u)_3 \\
u' &= (u')_1 + (u')_2 + (u')_3 \\
\tau_{12} &= (\tau_{12})_1 + (\tau_{12})_2 + (\tau_{12})_3 \\
\tau_{13} &= (\tau_{13})_1 + (\tau_{13})_2 + (\tau_{13})_3 \\
\tau'_{12} &= (\tau'_{12})_1 + (\tau'_{12})_2 + (\tau'_{12})_3 \\
\tau'_{13} &= (\tau'_{13})_1 + (\tau'_{13})_2 + (\tau'_{13})_3 \quad .....(10)
\end{aligned}
$$

where $(u)_1$, $(u')_1$, ... $(\tau'_{13})_1$ are continuous everywhere in the model and satisfy (1)-(6) and are therefore given by (7).

The values of $(u)_2$, $(u')_2$, ... $(\tau'_{13})_2$ are assumed to be zero for $t \leq T_1$, satisfying (1)-(6). So for $(u)_2$, $(u')_2$,....... $(\tau'_{13})_2$, we have relations (1)-(5) and (8) and the condition which replace (6) by

$$
\begin{aligned}
(e_{12})_2 &\to 0 \qquad \text{as } |y_2| \to \infty \\
(e'_{12})_2 &\to 0 \qquad \text{for } t_1 \geq 0 \quad .....(11)
\end{aligned}
$$

Similar equations can be obtained (as for $(u)_2$, $(u')_2$, ... $(\tau'_{13})_2$) for $(u)_3$, $(u')_3$,......... $(\tau'_{13})_3$ by replacing y_2 by $y'_2 = y_2 - D$, y_3 by $y'_3 = y_3$, t_1 by $t_2 = t - T_2$, $U_1(t_1)$ by $U_2(t_2)$ and $f_1(y_3)$ by $f_2(y'_3)$. These new boundary value problems for, $(u)_2$, $(u')_2$, ... $(\tau'_{13})_2$ and $(u)_3$, $(u')_3$, ... $(\tau'_{13})_3$ can be solved by taking Laplace transform with respect to time and then by using a modified form of the Green's function technique developed by Maruyama (1966) and Rybicki (1971) and finally by taking Laplace inverse transform we get $(u)_2, (u')_2, \ldots (\tau'_{13})_2$ and $(u)_3, (u')_3, \ldots (\tau'_{13})_3$. Finally from (10), (7) and the solutions of $(u)_2, (u')_2, \ldots (\tau'_{13})_2$ and $(u)_3, (u')_3, \ldots (\tau'_{13})_3$, we get

$$
\begin{aligned}
u \;=\; & (u)_o + y_2 f(t) + H.\, T_H . t/\eta + \frac{H(t-T_1)}{2\pi} U_1 (t-T_1)\; \varphi_{01} (y_2, y_3) \\
& + \frac{H(t-T_1)}{2\pi} U_1 (t-T_1) \sum_{m=1}^{\infty} (a/b)^m \; \Psi_{m_o} (y_2, y_3) \\
& + \frac{H(t-T_1)}{2\pi} \sum_{m=1}^{\infty} (a/b)^m \sum_{r=1}^{m} \binom{m}{r} \frac{b_1^r}{\Gamma(r)} \Psi_{m_o} (y_2, y_3) \\
& \cdot \int_0^{t-T_1} U_1(\tau) (t-T_1-\tau)^{r-1} e^{-a_1 (t-T_1-\tau)} d\tau \\
& + \frac{H(t-T_2)}{2\pi} U_2 (t-T_2)\; \varphi'_{01} (y'_2, y'_3) + \frac{H(t-T_2)}{2\pi} U_2 (t-T_2) \\
& \cdot \sum_{m=1}^{\infty} (a/b)^m \; \Psi'_{m_o} (y'_2, y'_3) + \frac{H(t-T_2)}{2\pi} \sum_{m=1}^{\infty} (a/b)^m . \\
& \cdot \sum_{r=1}^{m} \binom{m}{r} \frac{b_1^r}{\Gamma(r)} \; \Psi'_{m_o} (y'_2, y'_3) \\
& \cdot \int_0^{t-T_2} U_2(\tau)(t-T_2-\tau)^{r-1} e^{-a_1 (t-T_2-\tau)} d\tau \\
& \qquad\qquad (y_2 \neq 0, \quad t \geq 0)
\end{aligned}
$$

$$
\begin{aligned}
\tau_{12} \;=\; & (\tau_{12})_o + \mu_1 f(t) + \frac{\mu_1 H(t-T_1)}{2\pi} U_1 (t-T_1) \left[\varphi_{02} (y_2, y_3) + \sum_{m=1}^{\infty} (a/b)^m \right. \\
& \cdot \left. \Psi_{m_1} (y_2, y_3) \right] + \frac{\mu_1 H(t-T_1)}{2\pi} \sum_{m=1}^{\infty} (a/b)^m \sum_{r=1}^{m} \binom{m}{r} \\
& \frac{b_1^r}{\Gamma(r)} \Psi_{m_1} (y_2, y_3) \int_o^{t-T_1} U_1(\tau) (t-T_1-\tau)^{r-1} e^{-a_1 (t-T_1-\tau)} d\tau \\
& + \frac{\mu_1 H(t-T_2)}{2\pi} U_2(t-T_2) \left[\varphi'_{02} (y'_2, y'_3) + \sum_{m=1}^{\infty} (a/b)^m \Psi'_{m_1} (y'_2, y'_3) \right] \\
& + \frac{\mu_1 H(t-T_2)}{2\pi} \sum_{m=1}^{\infty} (a/b)^m \sum_{r=1}^{m} \binom{m}{r} \frac{b_1^r}{\Gamma(r)} \; \Psi'_{m_1} (y'_2, y'_3) \\
& \cdot \int_0^{t-T_2} U_2(\tau) (t-T_2-\tau)^{r-1} e^{-a_1 (t-T_2-\tau)} d\tau \\
& \qquad\qquad (y_2 \neq 0, \quad t \geq 0) \qquad \ldots\ldots (12)
\end{aligned}
$$

[$\therefore$ we have $\tau_{12} = \mu_1 \frac{\partial u}{\partial y_2} = \mu_1 e_{12}$]

where

$$\varphi_{01}(y_2,y_3) = -\int_0^{D_1} f_1'(x_3)\left[\tan^{-1}\frac{x_3+y_3}{y_2} + \tan^{-1}\frac{x_3-y_3}{y_2}\right]dx_3$$

$$\varphi_{02}(y_2,y_3) = -f_1''(D_1)\ [(D_1+y_3)\log_e\{(D_1+y_3)^2+y_2^2\}$$
$$+ (D_1-y_3)\log_e\{(D_1-y_3)^2+y_2^2\} - 4D_1 + 2y_2\{\tan^{-1}\frac{D_1+y_3}{y_2}$$
$$+ \tan^{-1}\frac{D_1-y_3}{y_2}\}] + \int_{y_3}^{D_1+y_3} f_1'''(z-y_3)\{z\log(z^2+y_2^2)$$
$$- 2z + 2y_2\tan^{-1}(z/y_2)\}\,dz + \int_{-y_3}^{D_1-y_3} f_1'''(y+y_3)$$
$$\cdot \{y\log_e(y^2+y_2^2) - 2y + 2y_2\tan^{-1}(y/y_2)\}\,dy$$

here $z = x_3 + y_3$

$y = x_3 - y_3$

$$\Psi_{m_o}(y_2,y_3) = \varphi_{01}(y_2,c) + \varphi_{01}(y_2,d)$$

$$\Psi_{m_1}(y_2,y_3) = \varphi_{02}(y_2,c) + \varphi_{02}(y_2,d)$$

where

$c = 2mH + y_3$, $d = 2mH - y_3$,

$$\varphi_{01}'(y_2,y_3) = -\int_{d_2}^{D_2} f_1'(x_3)\left[\tan^{-1}\frac{x_3+y_3'}{y_2'} + \tan^{-1}\frac{x_3-y_3'}{y_2'}\right]dx_3$$

$$\varphi_{02}'(y_2',y_3') = -f_2''(D_2)\,[(D_2+y_3')\log_e\{(D_2+y_3')^2+y_2'^2\}$$
$$+ (D_2-y_3')\log_e\{(D_2-y_3')^2+y_2'^2\} - 4D_2 + 2y_2'[\{\tan^{-1}\frac{D_2+y_3'}{y_2'}$$
$$+ \tan^{-1}\frac{D_2-y_3'}{y_2'}\}] + f_2''(d_2)[(d_2+y_3')\log_e\{(d_2+y_3')^2+y_2'^2\}$$
$$+ (d_2-y_3')\log_e\{(d_2-y_3')^2+y_2'^2\} - 4d_2 + 2y_2'[\{\tan^{-1}\frac{d_2+y_3'}{y_2'}$$

$$+ \tan^{-1} \frac{d_2-y_3'}{y_2'} \}] + \int_{d_2+y_3'}^{D_2+y_3'} f_2''' (z'-y_3') \{ z' \log(z'^2+y_2'^2) - 2z'$$

$$+ 2y_2' \tan^{-1} (z'/y_2')\} \; dz' + \int_{d_2-y_3'}^{D_2-y_3'} f_2''' (y'+y_3') \{ y' \log_e$$

$$\ldots (y'^2 + y_2'^2) - 2y' + 2y_2' \tan^{-1} (y'/y_2') \} \, dy'$$

$$[\text{here } z' = x_3 + y_3', \; y' = x_3 - y_3']$$

$$\Psi'_{m_0} (y_2', y_3') = \varphi'_{01} (y_2', c') + \varphi'_{01} (y_2', d')$$

$$\Psi'_{m_1} (y_2', y_3') = \varphi'_{02} (y_2', c') + \varphi'_{02} (y_2', d')$$

where

$$c' = 2mH + y_3'$$

$$d' = 2mH - y_2'$$

and

$$a = \left(\frac{\mu_1}{\mu_2} - 1\right), \qquad b = \left(\frac{\mu_1}{\mu_2} + 1\right)$$

$$a_1 = \frac{\mu_1 \; \mu_2}{\eta \, (\mu_1+\mu_2)}, \qquad b_1 = \frac{\mu_1 \; \mu_2^2}{\eta \, (\mu_1^2 - \mu_2^2)}$$

$$y_2' = y_2 - D, \quad y_3' = y_3$$

The conditions for unique and finite displacements, stresses and strains and the condition for convergence of the series in (12) are exactly same as explained by Mukherji and Mukhopadhyay (1988) and Mukhopadhyay, Mukherji, Pal and Sen (1980b) respectively.

DISCUSSIONS OF THE RESULTS AND CONCLUSION

We now study in greater detail the rate of changes of surface displacement and surface shear strain as well as the shear stress due to fault creep in the neighbourhood of the faults in our model for a typical set of model parameters :

D_1 = the depth of the fault F_1 = 15 kms; d_2 = 10 kms. and
D_2 = 20 kms; i.e. the depth of the fault $F_2 = D_2 - d_2$ = 10 kms.

We note that the depths of the faults are taken as (10-15) kms, which are more or less physically realistic. We may take their depths to be equal, i.e. $D_1 = (D_2 - d_2)$ or may take $(D_2 - d_2) > D_1$. But in any case it is found that the results differ only a little quantitatively and do not have any qualitative difference. For the other model parameters, we assign the following values :

$$\mu_1 = 3 \times 10^{11} \text{ dynes/cm}^2 \quad \text{and} \quad \mu_2 = 3.15 \times 10^{11} \text{ dynes/cm}^2$$

$$\eta = 10^{20} \text{ poise}, \quad H = 80 \text{ kms}, \quad T_1 = 50 \text{ years}, \ T_2 = 100 \text{ years}.$$

$$V_1 = V_2 = 1 \text{ cm/year}. \quad \tau_H(y_2) = \tau_H = \text{constant} = 10^7 \text{ dynes/cm}^2$$

$$= 10 \text{ bars} \quad \text{and} \quad f(t) = 0.3 \times 10^{-6} \text{ per year}.$$

The creep displacements across F_1 and F_2 commencing at time $t = T_1$ and $t = T_2$ $(T_2 > T_1 > 0)$ have the following form :

$$[u] = V_1 \cdot t_1 \cdot f_1(y_3)\, H(t - T_1), \quad \text{across } F_1$$

and

$$[u] = V_2 \cdot t_2 \cdot f_2(y'_3)\, H(t - T_2), \quad \text{across } F_2$$

where

$$t_1 = t - T_1, \quad t_2 = t - T_2$$

$$f_1(y_3) = 1 - \frac{3y_3^2}{D_1^2} + \frac{2y_3^3}{D_1^3}$$

and

$$f_2(y'_3) = \frac{16\,(y'_3 - d_2)^2\,(D_2 - y'_3)^2}{(D_2 - d_2)^4}$$

V_1, V_2 are constants, representing the creep velocities on the free surface $y_3 = 0$. Such choice of model parameters and creep displacement across F_1 and F_2 have been explained by Mukhopadhyay et al. (1980b, 1988).

Figure 2 and Fig. 3 show the variation with the distance y_2 from the fault traces of the rate of change of surface displacement dw/dt due to the fault creep across F_1 and F_2, and the rate of change of total surface shear strain $(d/dt)E_{12}$ respectively for different values of t, where

$$w = \left[u - [(u)_o + y_2 f(t) + H.\,\tau_H.\, t/\eta\,]\right]_{\substack{y_3 \to 0 \\ y'_3 \to 0}}$$

and

$$E_{12} = [e_{12} - (e_{12})_o] \times 10^6 \quad \begin{matrix} y_3 \to 0 \\ y_3' \to 0 \end{matrix}$$

corresponding to the model parameters given above.

Before the commencement of fault creep, there is a uniform rate of accumulation of surface shear strain (0.3×10^{-6})/yr. This case is not shown in Fig. 3. From Fig. 2 and Fig. 3, it is shown that the rate of change of surface displacement due to creep across F_1 and the rate of change of surface shear strain do not change significantly from $t = 50$ to $t = 100$ years. These rates for $t = 98$ years are shown in Fig. 2 and Fig. 3. After the commencement of creep across F_2 there is a significant change in the rate of surface displacement due to fault creep across F_1 and F_2 and in the rate of surface shear strain. Later on the change is more or less same and these rates for $t = 200$ years are shown in Fig. 2 and Fig. 3. The computations show that when creep across any fault commences, it generally reduces the rate of accumulation of shear stress near itself and greater creep velocities result in greater reduction of the rate of accumulation of shear stress near the fault. For sufficiently large creep velocities across a fault there is a continuous aseismic release of shear stress near the fault, so that the possibility of a sudden fault movement, generating an earthquake is progressively reduced. The effect of creep across one fault of the model on the shear stress near the other is found to depend on the relative positions of the two faults and on their dimensions and creep velocities. If we consider any particular fault, say F_1, it is found that if the other fault F_2 lies in two particular regions of the model which we call A_1 and A_2, creep across F_1 tends to increase the rate of accumulation of shear stress near F_1. But if F_2 lies in two other regions of the model which we call R_1 and R_2, creep across F_1 reduces the rate of accumulation of shear stress near F_2. Similarly for creep across F_2. These regions are shown in Fig. 1 and Fig. 3, for creep across F_1 and F_2 respectively. The actual positions of the boundaries of these regions of the model depend on the model parameters including the variation with depth of the relative movements across the faults.

Figure 6 and Fig. 7 show the change with time of the shear stress τ_{12} near the fault F_1 and F_2 respectively, at points where the effect of fault creep on the shear stress is maximum.

Here $\tau_{F_1} = (\tau_{12})_{y_2 \to 0'} \quad 0 \leq y_3 \leq D_1$

and $\tau_{F_2} = (\tau_{12})_{y_2 \to D'} \quad d_2 \leq y_3' \leq D_2$

Corresponding to $V_1 = V_2 = 0.25$ cm/year and the other model parameters given above with $(\tau_{12})_o = 50$ bars.

From Fig. 6, we find that τ_{F_1} increases steadily upto $t = T_1$, when creep across F_1 commences. For $t > T_1$, there is a continuous aseismic release of

τ_{F_1} near the fault F_1, and for $t \geq T_2$, when creep across F_2 also commences, the rate of release of the shear stress τ_{F_1} near F_1 is increased. From Fig. 8, we find that τ_{F_2} increases steadily upto $t = T_1$, when creep across F_1 commences. For $t > T_1$, the creep across F_1, reduces the rate of increase of τ_{F_2} near F_2. After $t = T_2$, when creep across F_2 also commences there is a gradual release of τ_{F_2} near F_2. These results indicate that creep across any fault of the fault system we have considered, has a significant influence on the accumulation and release of shear stress and strain near the neighbouring fault of the system.

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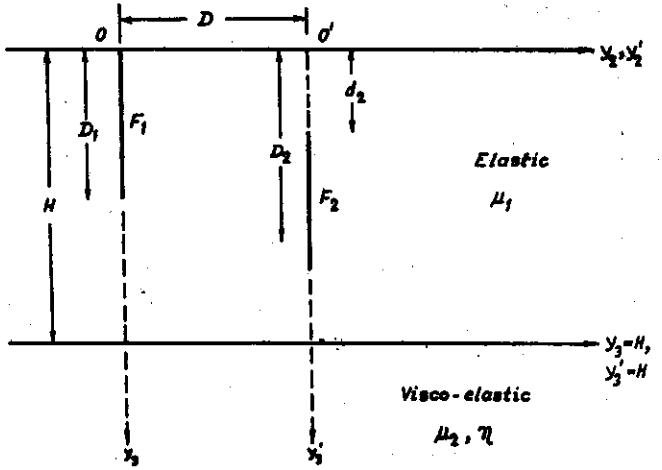
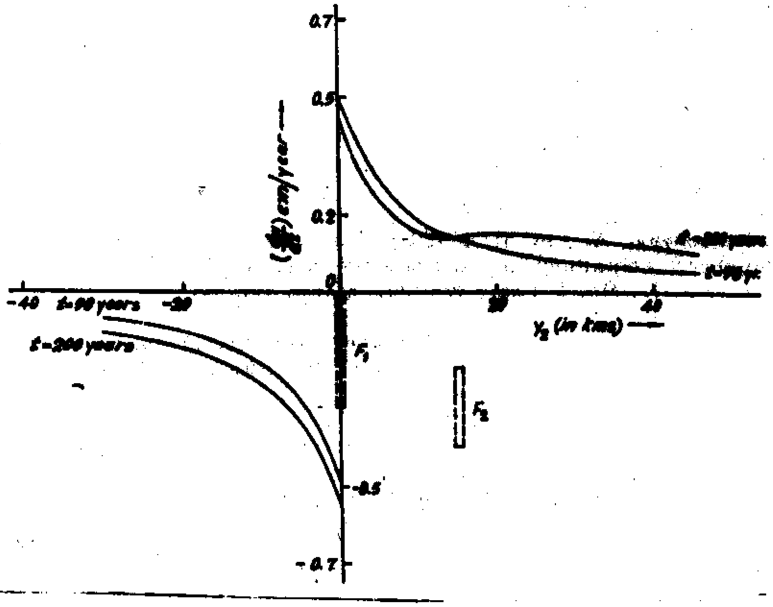


Fig. 1 Section of the model by the plane $y_1 = 0$



Fault creep commences across F_1 at time $T_1=50$ years and across F_2 at time $T_2=100$ years.

Fig. 2 Rate of change of surface displacement $(\frac{dw}{dt})$ cm/year due to fault creep across F_1 and F_2

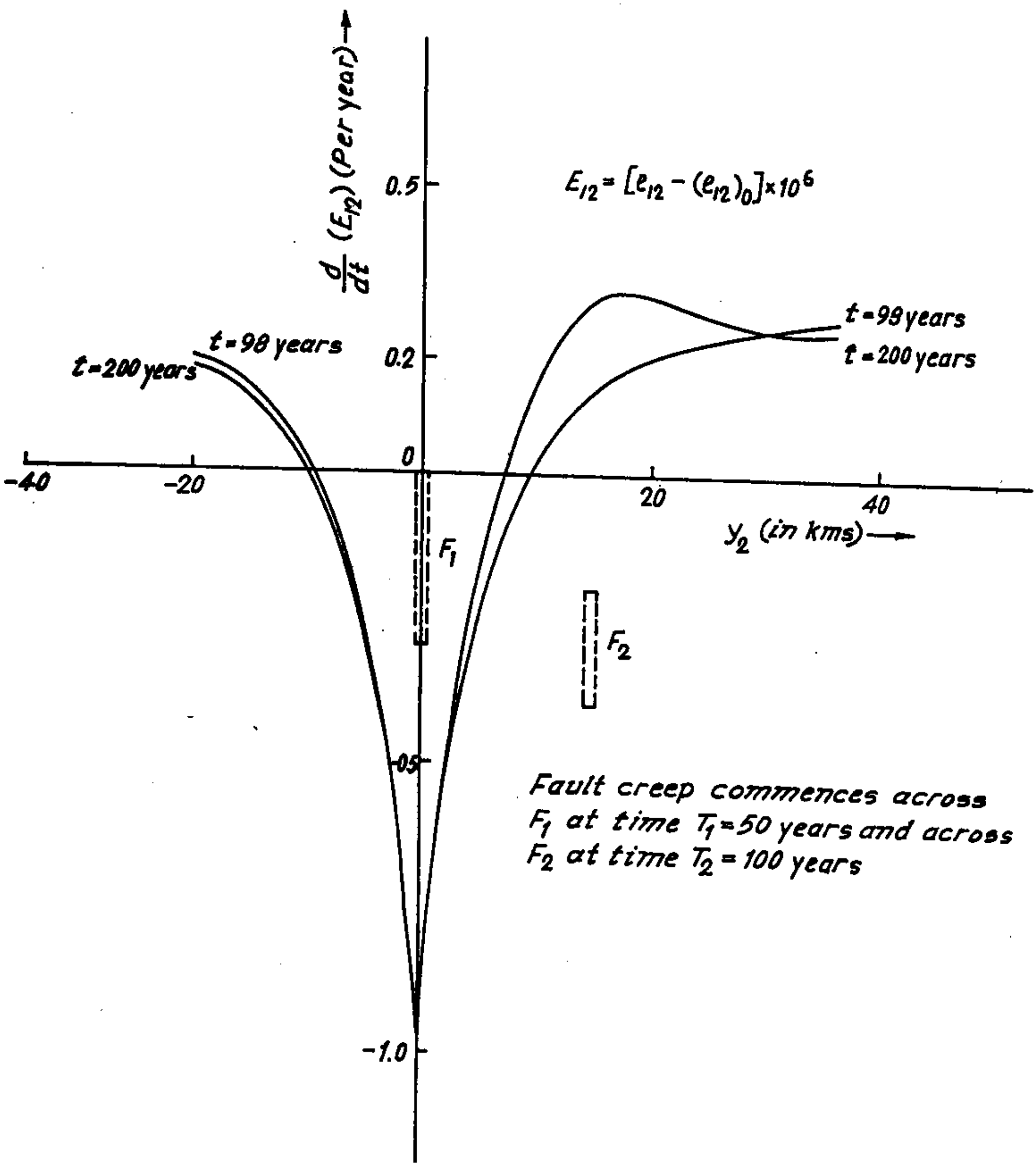


Fig. 3 Rate of change of total surface shear strain

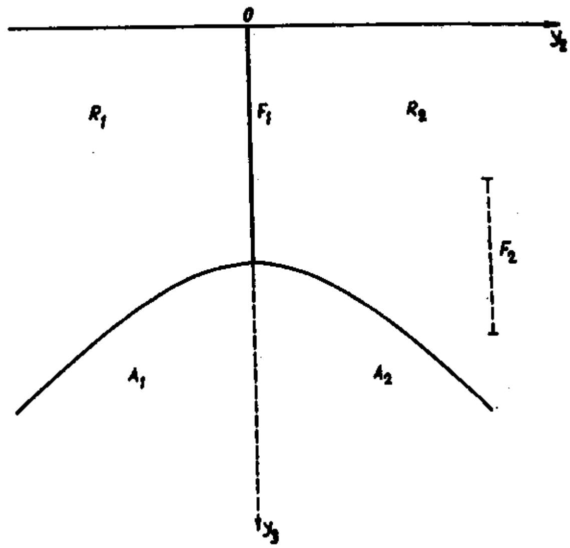


Fig. 4 Creep across F_1-regions of increase in shear stress accumulation (A_1, A_2) and decrease in shear stress accumulation (R_1, R_2)

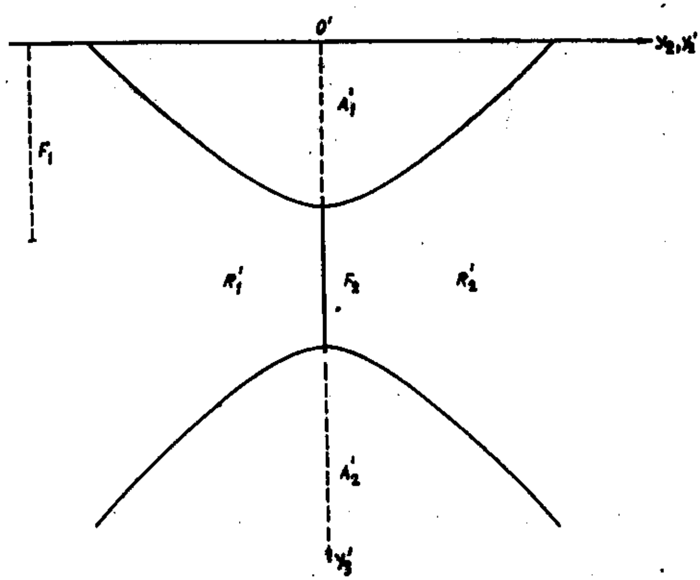


Fig. 5 Creep across F_2-regions of increase in shear stress accumulation (A'_1, A'_2) and decrease in shear stress accumulation (R'_1, R'_2)

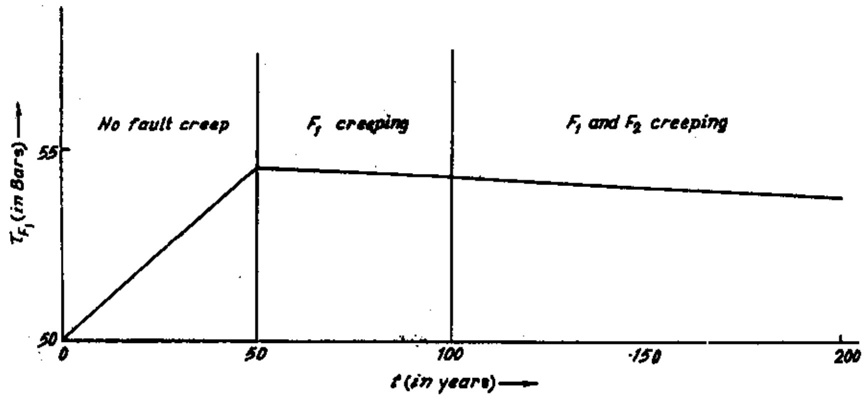


Fig. 6 The total shear stress near F_1 at the point where the effect of fault creep across F_1 and F_2 is greatest.

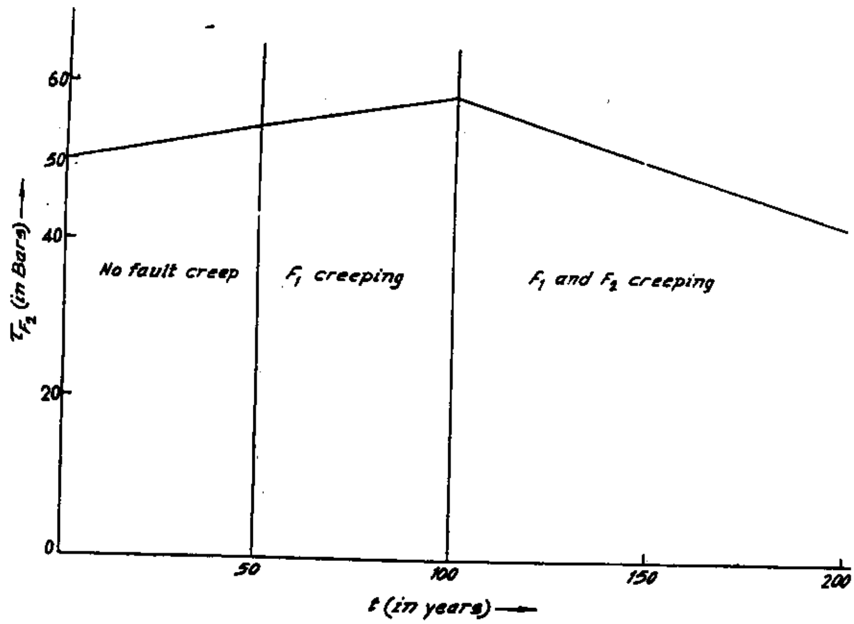


Fig. 7 The total shear stress near F_2 at the point where the effect of fault creep across F_1 and F_2 is greatest.