xperimentally determined activation the process below 150°C is close to e diffusion of sodium atoms in glass. ggested that the sodium atoms cata-ydrolysis of the oxygen-silicon bond creating free hydroxyl ions. Equa- be written

$$B(L/L_{cr})^{n/2} \exp(-A/KT) \quad (24)$$

ng equation 24 with respect to time ion 25,

$$/L_{cr})^{-n/2}$$

$$= \int_0^{t_f} B \exp(-A/KT)\, dt$$

$$- 2)][(L_{cr}/L_0)^{(n-2)/2} - 1]$$

$$= B \exp(-A/KT)t_f \quad (25)$$

nd t_f are large, equation 25 can be

$$- 2)]$$

$$A/KT)(L_{cr}/L_0)^{(n-2)/2} = t_f \quad (26)$$

arithms of equation 26,

$$= (n/2) \log L_{cr} - \log D \quad (27)$$

$$^{(n-2)/2}(B/2)(n - 2) \exp(A/KT)$$

2 can be rewritten as equation 28,

$$L_{cr} = rS_{cr}^2/4S_y^2 \quad (28)$$

g equation 28 in equation 27,

$$t_f = -n \log S_y - \log D' \quad (29)$$

$$D' = (rS_{cr}^2/4)^{-n/2} \cdot D$$

29 gave the static-fatigue law (equa-The parameter n can be determined ope of a log t_f − log S_y plot. *Charles* orted a value of about 16.

wth of subcritical cracks under ten-now been directly observed in glass slides [*Wiederhorn*, 1967] and in *Wiederhorn*, 1968].

ound that the growth of a crack can into two stages: a stage where crack

motion is relatively slow, and a stage of catastrophic motion initiated when the crack is long enough to satisfy the Griffith criterion for crack initiation.

The time dependence of static fatigue is controlled by crack growth in the first region. The time taken to traverse the other region is negligible by comparison.

Wiederhorn's data on the stress dependence of crack growth in glass in the first region can be replotted on double logarithmic coordinates, $\log \dot{L} - \log P$, which is equivalent to assuming a stress dependence of the form $\dot{L} = CP^n$. Taking logarithms,

$$\log \dot{L} = \log C + n \log P$$

The data seem to be adequately explained by this relationship. Indeed, compared to the exponential relationship $\dot{L} = A \exp(BP)$ suggested by *Wiederhorn* [1968], the scatter of the data is reduced. A more detailed analysis cannot be justified since numerical values of $\dot{L}$ and P were not given and P has a small range. The parameter n can be determined approximately from the slope of the fitted line and has a value of about 19.

The agreement between Wiederhorn's data and that of *Charles* [1958] for the value of n for glass is reasonable, particularly as they were working on different glasses. Therefore the main assumption of Charles's theory is plausible. There seems little point in using the more sophisticated versions of Charles's model for glass under tension [*Wiederhorn*, 1967] while there is no experimental work on subcritical crack growth in glass under compression.

The Effect of Uniaxial Compression

The extension of Charles's theory to the growth of cracks under uniaxial compression involves some problems with the stresses at the crack margins.

The Griffith criterion for the initiation of crack propagation does not predict the behavior of a propagating crack. *Wells and Post* [1958] have shown that a propagating crack under uniaxial tension in a direction normal to its direction of propagation will extend its own plane to a surface boundary. This result has been confirmed experimentally by *Brace and Bombolakis* [1963] and by *Hoek* [1965] for cracks in glass sheet.

Because all Charles's experiments on static fatigue were performed on specimens under bending or uniaxial tension, his model of the process was adequate to describe his results.

Hoek has confirmed empirically the Griffith criterion for fracture initiation from open cracks in glass plates in uniaxial compression. In a modified form, to allow for friction between the crack surfaces, the criterion also applies to closed cracks. The behavior of the propagating crack in compression is much more complex than in tension.

Brace and Bombolakis [1963] reported experiments on open cracks in glass plates under uniaxial compression. At the critical stress, branch fractures propagated from the ends of the cracks and 'became nearly parallel with the direction of compression . . . . when this direction was attained further crack growth stopped, apparently because of the decrease of tensile stress-concentration at the tip of the crack . . . . considerable increase in compressive stress is required to cause additional growth of these cracks.' *Brace, Paulding, and Scholz* [1966] refer to this sequence of events as 'crack hardening.'

Presumably, the effect of tensile stress at the crack tips at the atomic level is to stretch the bonds between the atoms allowing easier passage to diffusing sodium ions and hence increasing corrosion rates. Compressive stress at the crack tips will inhibit corrosion, and the stress-dependent corrosion rate for compressive stresses may be less than the corrosion rate at zero stress. Under these conditions, crack growth may result in the elimination of the stress concentration.

Jaeger has reviewed the general problem of stress concentrations around holes in a perfectly elastic medium.

Consider an elliptical hole of major axis a and minor axis b in an infinite, perfectly elastic plane. The solution [*Jaeger*, 1962, pp. 198–199] for the stresses used elliptical coordinates, $x = \cosh z \cos u$, $y = c \sinh z \sin u$; then $a = c \cosh x$, $b = c \sinh z$, and the hole is bounded by $z = z_0$. The plane is subject to stress P_1 at infinity inclined to the x axis (which lies along the major axis of the ellipse) at an angle α.

The tangential stress S_r at the boundary of the hole is, according to *Jaeger* [1962, p. 199, eq. 29],