$$df = -\theta(.93-f)\, d(G_{21}) \,, \qquad (5.18)$$

which corresponds closely with the relation found by Magee[47] to describe athermal results for the gamma to alpha transformation, Eq. (5.3). Although there is no obvious connection, Magee found, for carbon alloys with less than 1.2 percent carbon, a value for θ which is 14 times larger than θ from Fig. 5.6.

Due to the large uncertainties in $1-f$ for large values of P shown in Fig. 5.6, one might consider data only for stresses less than or equal to 204 kbar. These data are well fitted by a linear relation between $\ell n(1-f)$ and G_{21}. They yield a value of θ equal to 4,048 gm/Mbar cm^3, less than two-thirds the previous value.

Equation (5.17) can be interpreted in the following way: G_{21} is driving force which causes the transformation to proceed. It must exceed a threshold value, A, before the transformation is initiated. For unknown reasons the transformation proceeds only as G_{21} is increased. If, for example, nucleation sites exist which are activated at different stress levels, increases in P produce increases in G_{21}, more nucleation sites are activated, and the transformation proceeds incrementally. The calculation of nucleation sites described in Section 5.3 provides a detailed model of such a situation, Eq. (5.14). In that case, however, the proportionality parameter θ is not constant but varies over a wide range of values in the mixed phase region. If this transformation is martensitic and transformation occurs with constant average plate volume, V_p, of 10^{-8} cm^3, then

values of θ are obtained by multiplying V_p by entries in the last column of Table 5.2. This gives $\theta \simeq 7 \times 10^{-23}$/Mbar cm^3 for $G_{21} = A$ and $\theta = 1.2 \times 10^{14}$ gm/Mbar cm^3 for $G_{21} = 2A$. These values are far from observed values, which is not surprising considering the unreality of the basic assumption that nucleation is occurring in the homogeneous lattice.

Values for θ calculated from Eq. (5.14) come much closer to the measured value when the homogeneous model is modified by assuming spherical pre-existing embryos of phase 2. For this case, if martensitic plate volume $V_p = 10^{-8}$ cm^3 is 1 percent of the grain volume for 0.1-mm-diameter grains, N_0 can be calculated by dividing values of dN^*/dG_{21} in the last column of Table 5.2 into $-N/V_p\,\theta = 6.4 \times 10^{34}$. This gives $N_0 = 8.3 \times 10^{48}$/cm^3 for $G_{21} = A$, $N_0 = 5.3 \times 10^{12}$/cm^3 for $G_{21} = 2A$, and $N_0 = 1.28 \times 10^{9}$/cm^3 for $G_{21} = 3A$. These values for N_0 approach seemingly realistic values for pre-existing sites since the number of twins required to account for all the plastic strain in shocked iron at 130 kbar was inferred from Johnson and Rhode[56] to be about 10^7/cm^3.

The above calculations show how a relation between dN and dG_{21} can be established, and although a detailed model to explain the form of Eq. (5.17) has not been produced, its similarity to the Magee equation strengthens the link between the alpha to epsilon, shock-induced transformation and the athermal, martensitic, gamma to alpha transformations in iron. The calculation also suggests a basis for understanding of both athermal gamma to alpha and shock-induced alpha to epsilon transformations.