$$df' = V_p \, dN \tag{5.2}$$

where V_p is the constant average plate volume of a cluster. This treatment of plate volume is different from Fisher's[46] and more in accord with athermal experiments.

An expression for $1 - f'$ is obtained by combining Eqs. (5.1) and (5.2) and integrating, which gives

$$1 - f' = \exp\left(KV_p(G_2-G_1-A)\right) \tag{5.3}$$

where A is the value of $G_2 - G_1$ at the onset of transformation. Magee demonstrated that Eq. (5.3) or some equivalent accurately fits almost all results from athermal martensitic rapid cooling studies.

The volume fraction f' is equal to ρ_0/ρ_2 times the mass fraction f. Since ρ_0/ρ_2 is nearly 1, Eq. (5.3) is expected to be valid for mass fraction data. In fact, by using similar assumptions, Eq. (5.3) can be derived with f' replaced by f.

The search for a physical model to reproduce Eq. (5.3) is certainly a major problem in the physics and metallurgy of martensitic transformations. The technological importance of these transformations in commercial materials enhances interest in understanding such phenomena.

5.3. Nucleation of a New Phase

Various types of nucleation sites are discussed. A new concept is described in which nucleation sites are "frozen-in" by a sudden step in pressure.

5.3.1. Nucleation Sites

Energy considerations have led to the widely-accepted belief that nucleation of the second phase occurs on defects such as: (1) impurities, (2) grain boundaries, and (3) dislocations. Calculations of energy to nucleate on various defects show that a dislocation is most important.[51]

If nucleation occurs on defects, it is reasonable to assume that not all the sites are activated by the same driving force. An increase in active nucleation sites with increasing driving force provides a plausible explanation of the observed mixture of phases for final states in athermal martensitic and certain shock experiments. A satisfactory theory of transformation would provide a physical mechanism or mechanisms for such an increase, but such has not yet appeared.

Twins have been suggested as nucleation sites, but no detailed energy calculations have been made. Since twins can be formed from interacting dislocations, one might assume that energy requirements for nucleation at a twin are of about the same magnitude as for dislocations; in that case, twin surfaces would be important.

In some materials, like iron and steel, twinning is the dominant mechanism for plastic yielding under rapid compression.[52] In fact, the observed rapid increase in density of twins as the transformation stress in iron is approached has led German, et al.[30] to suggest twins as nucleation sites for the hcp phase.

Consideration of the bcc lattice shows that only a small change is required to obtain hcp structure along the