Table 1

	Stress (*lb.in*$^{-2}$)	*Temperature* (°*K*)	$\frac{d}{dt}\left(\frac{\rho}{P}\right)^{\frac{2}{3}}$ (h^{-1})	*Q* (*kcal.mole*$^{-1}$)
1	5000	1581 1527	2·36 0·66	116 ± 4
2	4000	1634 1581	2·42 0·75	117 ± 4
3	3000	1684 1634	4·24 1·54	114 ± 4
4	5000	1527 1473	0·66 0·167	116 ± 4

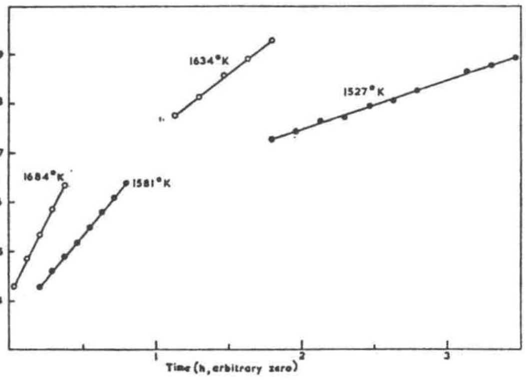

FIGURE 3

Examples of densification-data plots obtained during temperature-dependence experiments.

vacancies. This consideration will be examined more closely in a later section.

Measured quantities of magnesia were added to Linde A alumina by mixing the two powders while in suspension in alcohol. The alcohol was then removed by evaporation.

A first set of experiments was performed using a mixture containing 0·25$^w/_o$ of magnesia, but the results obtained were very erratic, with apparent activation energies ranging between 37 and 116 kcal.mole^{-1}. It was considered possible that, in the presence of excess magnesium ions at the grain boundaries, the concentration of magnesium within the crystals might be varying with temperature, or else that the results were being affected by the formation of spinel.

A second set of five experiments using alumina containing 0·025$^w/_o$ of magnesia was then performed. This time, consistent values of activation energy were obtained over a temperature range from 1469 to 1668°K. The results are summarized in Table 2. It is seen that the addition of magnesium caused the activation energy for diffusion to be increased from 115 to 130 kcal.mole^{-1}.

4.4 Experiments with Specimens containing Tantalum Pentoxide.

Tantalum was chosen as a doping cation because its valency (+5) is higher than that of aluminium, and an excess concentration of aluminium vacancies will be expected to exist in an alumina lattice containing this impurity. This consideration will be examined more fully in a later section.

Table 2

	Stress (*lb.in*$^{-2}$)	*Temperature* (°*K*)	$\frac{d}{dt}\left(\frac{\rho}{P}\right)^{\frac{2}{3}}$ (h^{-1})	*Q* (*kcal.mole*$^{-1}$)
5	4000	1577 1523	3·32 0·76	130 ± 6
6	2000	1668 1617	1·98 0·60	129 ± 5
7	5000	1539 1482	1·47 0·30	129 ± 5
8	2000	1665 1617	1·36 0·44	129 ± 5
9	5000	1523 1469	1·44 0·305	133 ± 6

It was not known for certain whether tantalum would enter the corundum lattice, nor was the most satisfactory method of doping the alumina specimens known, but it was decided that a first attempt would be made by mixing the oxide powders while in suspension in alcohol.

The tantalum pentoxide was first ground with an alumina pestle and mortar. The ground powder was then stirred into a beaker of alcohol and allowed to settle for 10 min. The alcohol, containing the oxide particles sufficiently fine to stay in suspension, was then decanted, and the oxide was recovered by permitting the alcohol to evaporate. A weighed amount of this selected oxide was then mixed with alumina powder whilst in suspension in alcohol, to give a mixture containing 0·125$^w/_o$ of tantalum pentoxide. This percentage was chosen so that the molecular concentration of Ta_2O_5 in the alumina would be similar to that of MgO in the specimens containing 0·025$^w/_o$ (Section 4.3).

Shrinkage rates at three pairs of temperatures were measured; the results are summarized in Table 3.

Table 3

	Stress (*lb.in*$^{-2}$)	*Temperature* (°*K*)	$\frac{d}{dt}\left(\frac{\rho}{P}\right)^{\frac{2}{3}}$ (h^{-1})	*Q* (*kcal.mole*$^{-1}$)
10	4000	1577 1509	2·15 0·27	147 ± 10
11	3000	1655 1590	2·0 0·34	145 ± 10
12	4000	1617 1563	2·64 0·52	154 ± 10

It is seen that the addition of tantalum pentoxide caused the activation energy for diffusion to be increased from about 115 kcal.mole^{-1} for undoped alumina to about 150 kcal.mole^{-1}. So marked a change in the diffusion kinetics was taken to confirm that the tantalum pentoxide had been able to enter the corundum lattice.

5. DIFFUSION COEFFICIENTS

Effective "molecular" diffusion coefficients may be calculated from the re-arranged form of Equation (6)

$$D_M = 3(\pm 2)\,10^{-4}\,\frac{l^2kT}{\sigma\Omega_s}\,\frac{d}{dt}\left(\frac{\rho}{P}\right)^{\frac{2}{3}}$$