INVESTIGATION OF THE SYSTEM $Co_{94-x}Nb_xB_6$ BY THE DILATOMETRIC METHOD WITH THE ISOTHERMAL TREATMENT

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Abstract

An original method of isothermal dilatometry has been applied to the system $Co_{94-x}Nb_xB_6$. The values of x were 10, 14 and 18. Because the system $Co_{80}Nb_{14}B_6$ is an eutectic composition the measurements were thus carried out around the eutectic point. It has been observed that samples of different x-values subjected to the same stress behaved differently. The hypoeutectic composition, x=18, exhibits only shrinkage while the hypereutectic composition, x=10, tends towards dilatation only. The eutectic composition (x=14) has characteristics found in both of the above mentioned compositions, i.e. there is a tendency of samples to shrink as well as to dilate during the isothermal treatment.

INTRODUCTION

The metallic glass $Co_{94-x}Nb_xB_6$ is a system exhibiting a first-order phase transformatiron [1]. This unexpected behaviour is probably due to the specific shape of clusters that form the basis of the structure. On the basis of comparison with the crystal structure of the same composition a model has been constructed in which the central atom B is surrounded with Nb and Co atoms. The cluster is assumed to be spherical. The idea of spherical clusters comes from a number of papers ([1] and [2]). The model has to a large extent explained the reversible magnetic transformation in $Co_{80}Nb_{14}B_6$. This composition is assumed to correspond to the eutectic and its spherical clusters to have a diameter of 1,7 nm. The magnetic transformation which takes place at about 90°C and 160°C is explained as due to a change in the cluster shape which takes place trough shear [2].

We assume therefore that the structure of the eutectic composition consists of spherical clusters and that they do not change during the transformation. This means that this eutectic composition can be described by the model of equal spheres. Such a model cannot generally be applied to any composition of Co, Nb and B because in the general case the atoms represent spheres of different size. An equal-sphere model enables solutions of problems in a simple way. This is why theorries of relaxational processes are mainly based on such models.

We thus take the eutectic $Co_{80}Nb_{14}B_6$ to consist of equal spheres i.e. of equal spherical clusters which contain 13 atoms and measure 1,7 nm across. We also note that small differences in concentration around the eutectic cause large changes in physical parameters and thus expect them to occur in the dilatometry. Since samples having the eutectic concentration are not homogenious we can expect that hypoeutectic and hypereutectic elements will contribute to the sample behaviour.

Large differences in the physical parameters that occur with structural changes are due to the alteration of cluster shape and/or the decomposition of clusters. Alternatively the clusters could remain the same but compositional changes may occur at the expense of free volume.

Both possibilities should be observable through our measurements and this was the purpose of the present work.

EXPERIMENT

The experimental techniques used have been described in detail in [3] and [4]. Samples 1,7 cm wide and 28 ± 2 μm thick were subjected to the same stress. The dilatometer is computerised using the Hewlett-Packard system and the data can be displayed or plotted on-line. The graphic representation is given here The measurements were taken at constant temperature of 473 K [3] and recorded at 15 s intervals. The temperature control system used was Artronix. Temperature excursion was ± 0,2 K. Measurements at stresses of 25, 180 and 270 MPa have been taken. Prior to mounting into the dilatometer every sample was measured with precision and its cross sectional area calculated. All samples belonged to the same ribbon.

RESULTS AND CONCLUSION

The results of measurements are shawn in fig. 1, 2 and 3. The different behaviour of the samples is evident and may be explained by assuming the structure around the eutectic, for both hypo- and hyper-eutectic region and using the model of mechanisms outlined in the Introduction.

The fact that $Co_{80}Nb_{14}B_6$ has characteristics observed with $Co_{76}NB_{18}B_6$ as well as those of $Co_{84}Nb_{10}B_6$ (see fig 2) is in agreement with the assumption of a eutectic structure. Large change in the system characteristics with even small excursion in the concentration of Co or Nb are very much in evidence.

The behaviour of $Co_{80}Nb_{14}B_6$ seems to point to the plausibility of our hard--sphere model since for small loads the stress is relieved by the loss of excess free volume while for larger loads flow occurs as a consequence of interaction between spherical clusters.

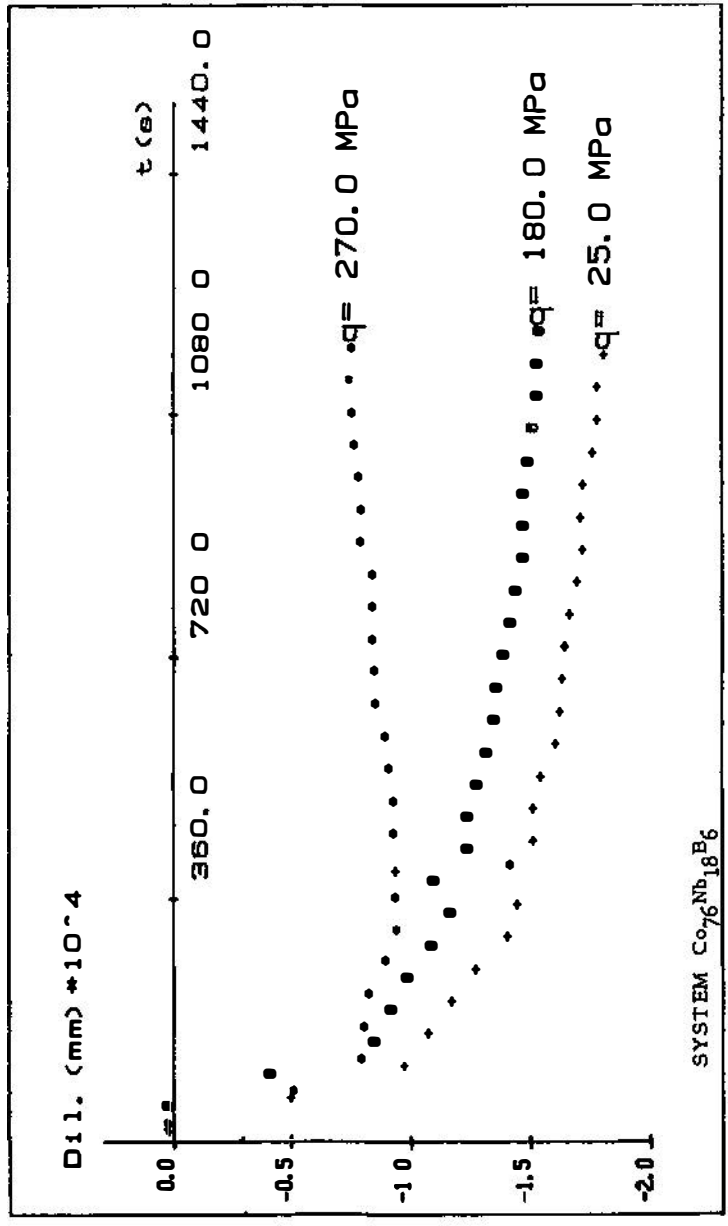
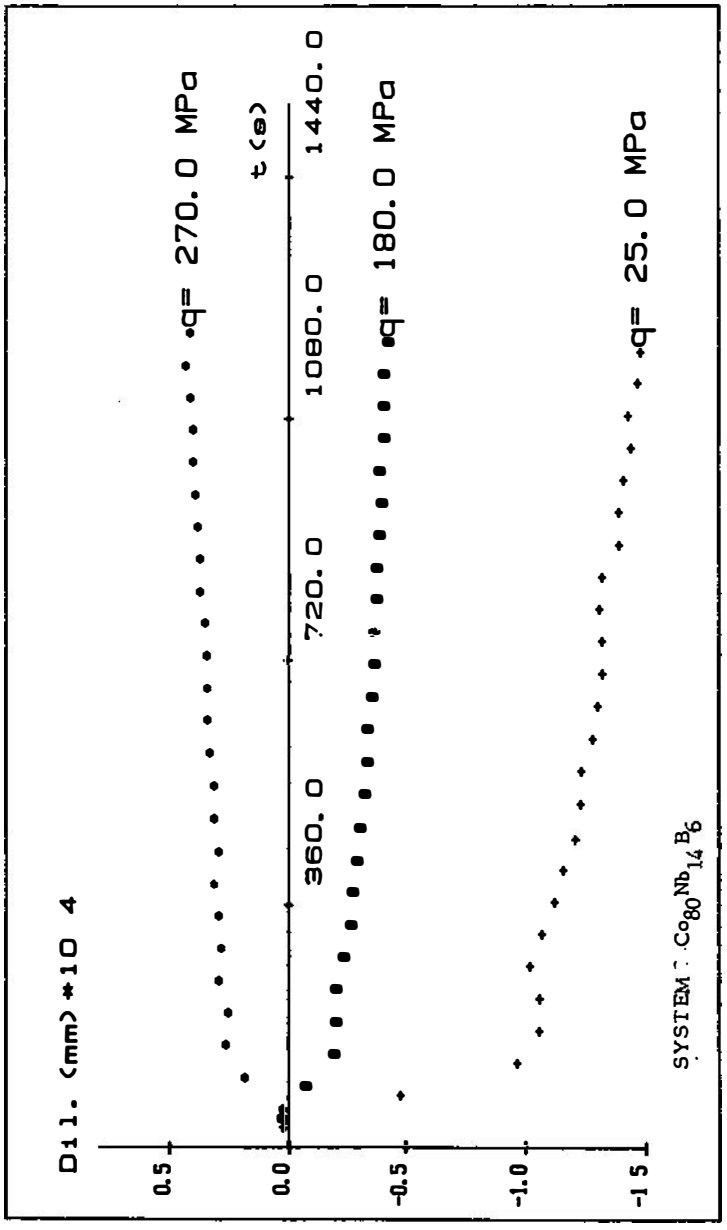


Figure 1.

The composition $Co_{76}Nb_{18}B_6$ (fig 1) behaves as an amorphous system of large free volume and within the concept of our model may be regarded as lacking fully formed clusters. Agglomerations of three kinds of atoms are already present but lack well defined short-range order. This is why the system first exhibits a large free-volume loss before the onset of flow (as seen in fig 1).



Finally, in fig 3, isothermal dilatometric behaviour of $Co_{84}Nb_{10}B_6$ is shown. Its structure appears devoid of excess free volume so that stress relaxation manifest itself solely through flow. In this system only freshly quenched samples show behaviour which indicates short-range order [2].

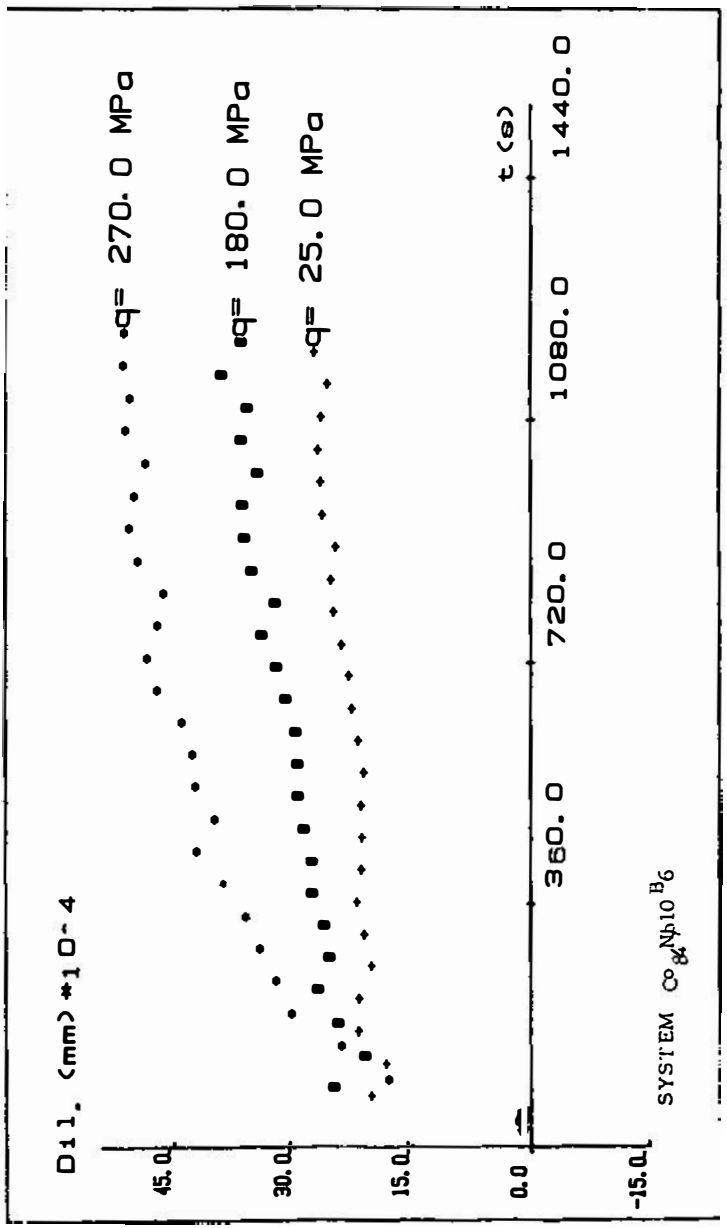


Figure 3.

These results indicate that isothermal dilatometry can be used to explore eutectic systems and the method may serve to identify accurately the eutectic concentration.

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