THE "AGE" OF OB ASSOCIATIONS

C. DOOM
J.P. DE GREVE
C. de LOORE

I. INTRODUCTION.

For the determination of ages of OB associations, the traditional approach is to compare isochrones, derived from theoretical models to the observed distribution of stars in the HR diagram (see e.g. Stothers, 1972). However, even a casual look at the HR diagram of the association Per OB1 (Fig.1) shows that it is impossible to fit a unique isochrone to all stars of the group, even by allowing some scatter. We will therefore adopt a different approach and determine the initial mass and the age of each individual star in a given association. As an example, we will discuss Per OB1.

II. METHOD AND INPUT DATA.

The fundamental data for stars in OB associations are taken from the catalog of luminous galactic stars of Humphreys (1978). This catalog is complete for O and early B stars, and for stars of all spectral types, having $M_{bol} < -7$ in associations with d < 2.5 kpc. This implies that all stars in these associations, having an initial mass M_i larger than 15 $M_\odot$ are contained in the catalog.

In order to determine M_i and the age t of each star, we assume that :

- all O and B stars within the main sequence band are evolving from ZAMS towards Red Point;
- all Of stars are evolving from Red Point towards the end of core hydrogen burning and have a hydrogen deficient atmosphere;
- all stars outside the main sequence band are evolving towards the right in the HR diagram.

M_i and t are then interpolated between the evolutionary tracks of Doom (1982) and Doom and De Grève (1983), using log Te and log $L/L_\odot$ as basic quantities. The evolutionary tracks include mass loss and overshooting. Log T_e and the bolometric corrections were determined using the calibration compiled by Vansina and De Grève (1982), extended to M5 with the calibration given by Humphreys (1978).

III. RESULTS.

Figure 1 also shows all stars of Per OB1 in a M_i vs t diagram.

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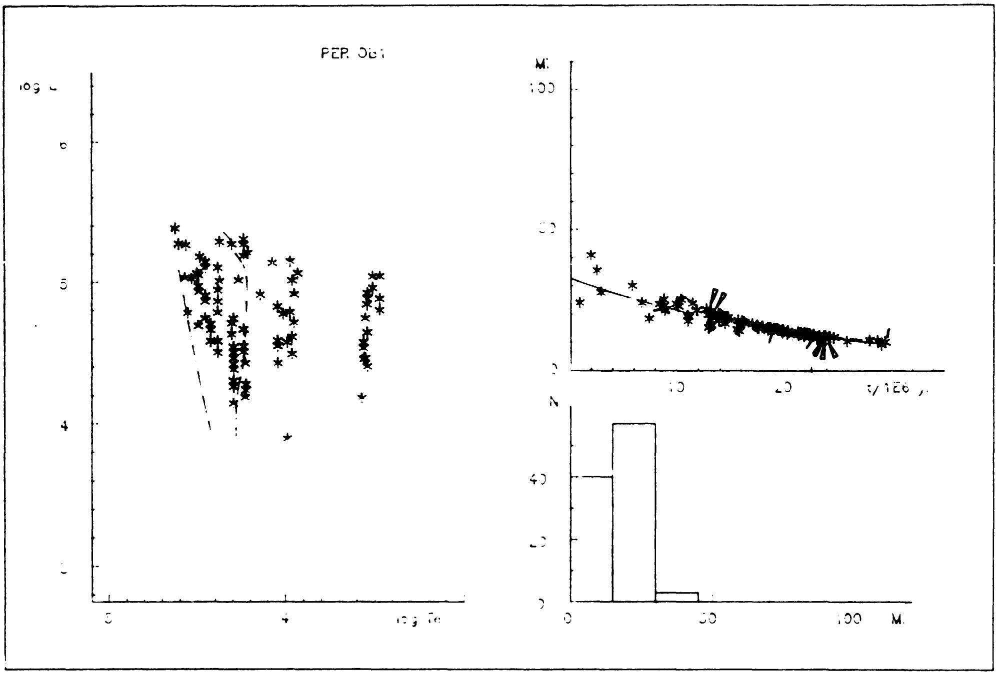

Figure Caption.

Fig. 1 : The HR diagram of Per OB1 (fundamental data are from Humphreys (1978) (left) and the M_i vs t diagram for Per OB1 (right). The curve gives the main sequence lifetime the lower curve is a least squares fit: $M_i \sim \exp(-t/2.4\ 10^6\ \mathrm{yr})$.

This diagram shows clearly that the lower mass stars in this association ($M_i \simeq 15\ M_\odot$) are some 20 million year older than the most massive stars ($M_i \simeq 40\ M_\odot$). The same trend is visible in many other associations, contained in the Humphreys catalog, but not shown here.

IV. INTERPRETATION.

The M_i vs t diagram of individual OB associations reveals the absence of young lower mass stars, and shows many 10-20 $M_\odot$ stars outside the main sequence band. We interpret this as being due to the fact that the lower mass stars in associations are formed before the more massive stars. The same effect has been found for contracting 1-5 $M_\odot$ stars in young associations by Iben and Talbot (1966).

The effects of binarity and rotation on the age determination will be discussed in a forthcoming paper (Doom, De Grève and de Loore, 1984) The results of this analysis show that binarity or rotation cannot explain the observed age spread.

The fact that the lower mass stars are formed first in many associations, contained in the Humphreys catalog explains why the same effect is observed in her complete HR diagram (a lack of lower mass ZAMS stars, "too many" stars outside the main sequence). This HR diagram can therefore be fully understood in terms of stellar evolution including mass loss and overshooting.

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DISCUSSION

Tayler: If you had associations of all ages there would be no change in the ratio of stars in different stages of evolution as a result of low mass stars being formed first; there would be both very massive post-main sequence stars left over from older associations and young associations with only lower mass main sequence stars. Are you saying, for example, that there are no extremely young associations and that there is also a shortage of very massive evolved stars from older associations?

Doom: There is indeed a certain selection effect in the presence of OB associations with different ages. On the one hand, very young associations, containing only lower mass stars, are found (e.g. the young Ori OB1 group). However, in this stage of evolution, the association is more difficult to detect: it is embedded in the cloud from which it is formed and does not yet contain very massive, luminous stars. Only when the latter type of stars are formed, the association is seen as a "real" OB association. On the other hand, associations being much older than the OB associations are not found: due to the age spread, all stars will disappear from the association (SN explosions) in a relative short time. It is also possible that the association is dispersed by that time.

Walborn: Observationally OB associations contain subgroups of different ages with overlapping mass ranges, e.g. the comparison between the Orion Belt and Orion Nebula clusters. Also in h/χ Persei the two concentrated clusters should be considered separately from the extended halo of the association.