HIGH SIGNAL TO NOISE ANALYSIS OF THE CHEMICAL COMPOSITION OF STARS IN THE MAGELLANIC CLOUDS

M. Spite[1], F. Spite[1], and P. François[2]
[1] Observatoire de Paris-Meudon
92195 Meudon Cedex (France)
[2] E.S.O. , Karl Schwarzschild str. 2
8046 Garching bei München (F. R. G.)

ABSTRACT. A few high S/N spectra of F-G supergiants in the field of the Magellanic Clouds, and a spectrum of a star in the in the young SMC cluster NGC330 have been obtained at the échelle spectrograph of the 3.6m telescope of ESO (CASPEC). Preliminary results of the analysis of these stars and their consequences in the evolution of the clouds are presented here.

1. INTRODUCTION

In 1985 Stryker et al. from a photometric study of the metallicity of some clusters in the Small Magellanic cloud suggested that, at a fixed age, the metallicity is weaker in the SMC than in the solar vicinity of our Galaxy and that moreover, a strong and sudden enrichment of the matter has taken place in the SMC 2 billions years ago.

The installation of the échelle CASPEC spectrograph at the 3.6m telescope of ESO gave us the opportunity of studying the metallicity in the Magellanic Clouds as a function of age and place, from high Signal to Noise high resolution spectra.

2. THE YOUNG SMC CLUSTER NGC330

In 1983 Richtler and Nelles had derived from photometric measurements (in the Strömgren system), preliminary metallicities for Magellanic globular clusters; they found a very young SMC globular cluster (10^7 years) which was very metal deficient : NGC330.

It was important to confirm this large deficiency . A spectrum of a star in NGC330 was obtained and in collaboration with Cayrel and Richtler we analyzed it (Spite et al. 1986).

The spectrum shows indeed a large metal deficiency. The star is rather similar to the galactic globular cluster stars, so that the metal deficiency may be considered as reliable. The result of the analysis is [Fe/H]=-1.4.

The pattern of the abundances of the elements is different from the pattern found in the galactic halo field stars, but it is similar to the pattern found in the CN rich star in ω Cen (fig.1). A larger sample of stars in NGC330 is necessary in order to have an unbiased estimation of the primordial distribution of the elements in this cluster.

This observation extends the range of the "very large metal deficiency" to very small ages . This is an argument in favor of the scenario of globular cluster formation of Cayrel (1986).

3. THE FIELD SMC STARS AND THE ENRICHMENT OF THE SMC

It is also important to check the metal abundance of the field young stars of the SMC in particular because

G. Cayrel de Strobel and M. Spite (eds.), The Impact of Very High S/N Spectroscopy on Stellar Physics, 551–554.

these stars, in older publications, have been found metal-deficient by a factor of about 2, and the HII regions (following Dufour) by a factor of more than 4.
Thus we obtained spectra, with S/N ratios better than 200, for three F supergiants of the SMC. The temperatures of the stars were deduced, for the first iteration, from photometry. In the detailed analysis (using Kurucz models) the temperatures were defined by requiring the deduced abundances to be independent of the excitation potential of the line.
For each star we found a deficiency by a factor of 5 (-0.8 < [Fe/H]<-0.7) in good agreement with the HII regions.

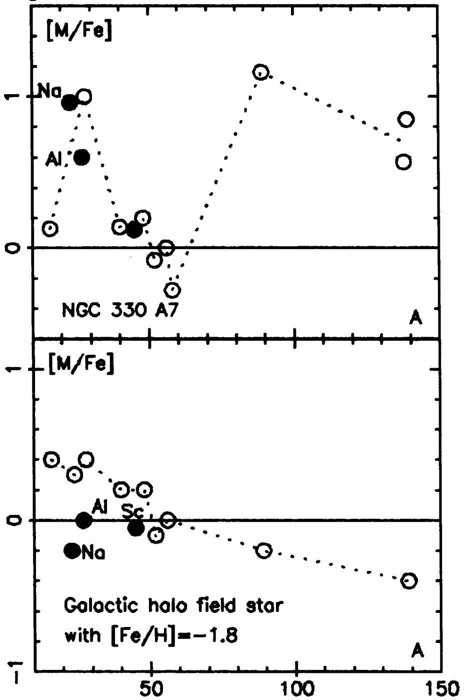

Fig.1 The pattern of the chemical elements in the star A7 of NGC 330 is compared to the pattern of the elements of a typical halo field star with the same mean metallicity.
In abscissa is plotted the atomic number of the element , and in ordinate:

$[M/Fe] = \log (M/Fe)_* - \log (M/Fe)_\odot$

where M/Fe represents the abundance of the element relative to iron.
The pattern of the elements in the star A7 of NGC 330 looks like the pattern of the elements in the CN rich stars of ω Cen.

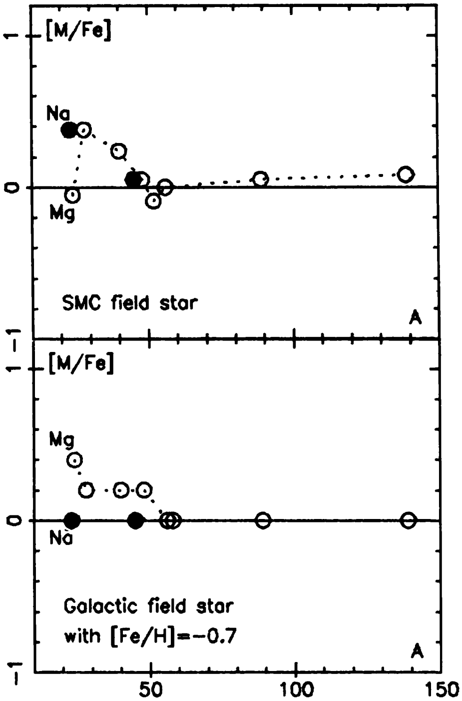

Fig.2 The pattern of the chemical elements in a SMC field star (mean of the three studied stars) is compared to the pattern of the elements in a typical galactic star with the same mean metallicity.
The pattern are similar, except for the light elements Na and Mg.

In the fig.1 and 2 the filled circles represent the odd light elements ^{23}Na, ^{27}Al, ^{45}Sc.

The pattern of the chemical elements is similar in the three observed stars, and is also similar to the pattern of the elements in the metal deficient galactic stars (fig.2). The main difference is in the ratio of the odd elements to the even ones (ratio Na/Mg) but this must be confirmed.
The data enable to derive a new image of the chemical enrichment of the SMC (fig.3) . It seems that it

https://doi.org/10.1017/S007418090003566X Published online by Cambridge University Press

exists:
-something like a **Halo Population** with practically no enrichment (solid line) during the last ten billions years
-something like a **Disk Population** with a slight enrichment . The dashed line is from Bica et al.(1986). But from these data it is difficult to decide whether this disk was subjected to a continuous enrichment, or only to a "burst " 2 billions years ago (dotted line) .

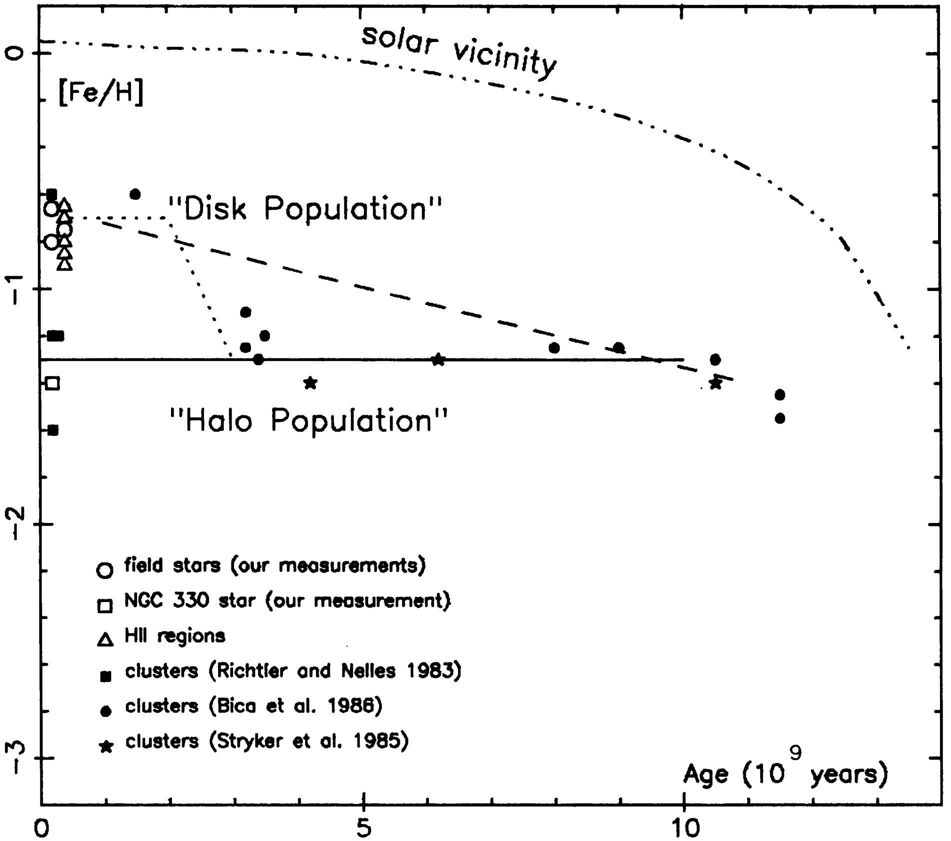

Fig.3 The chemical enrichment in the SMC. The dashed and the dotted lines represent two hypotheses of the evolution of the "disk population" in the SMC.

4. THE FIELD LMC STARS

In the LMC we observed only two field supergiants and only the reduction of G258 is almost completed. Exactly the same method and the same lines have been used in the study of the stars of the LMC and of the SMC . Thus the comparison of the metallicities must be reliable. The deficiency of G258 ([Fe/H]=-0.2) is about by a factor 1.5 . It is smaller than the deficiency factor generally observed in the SMC HII regions (2.5 according to Dufour, 1983) , but G258 could be located in the bar of the LMC and the metal enrichment could be particularly efficient in this region. Moreover, according to Bica et al. (1986) it seems that the LMC is not homogeneous.
The analysis of the other star could help to solve this problem.

REFERENCES

Bica,E., Dottori,H., Pastoriza,M. : 1986, *Astron.Astrophys.* **156**, 261
Cayrel,R. : 1986, *Astron.Astrophys.* **168**, 81
Dufour, R.J. : 1983, in IAU symposium108 p.353 (S. Van den Bergh and K. de Boer,eds.)
Richtler,T., Nelles,B. : *Astron.Astrophys.* **119**, 75
Spite,M., Cayrel,R., François,P., Richtler,T., Spite,F. : 1986, *Astron.Astrophys.* **168**, 197
Stryker, L.L., Da Costa,G.S., Mould,J.R. : 1986, *Astrophys.J.* **298**, 544

DISCUSSION

BOND What kind of stars did you analyse in the clusters and in the field (temperature gravity) ?

SPITE M. The parameters of the model of the cluster star are similar to the parameters of a galactic red giant cluster star : Teff=3900° log g=0.1. On the contrary the field stars are F supergiants; their temperature is about 6500° and their gravity log g=0.7.

CAYREL R. We have taken the habit of presenting relative abundances with respect of iron. However looking at the diagram showing the abundances in the star A7 of NGC330 we could perhaps more simply interpret it as a lack of iron peak elements (SN I yields) rather than an excess of all other elements.

SPITE M. This could be a good idea to keep in mind . However, if this star is really similar to the CN rich stars of ω Cen then the ratio [Mg/Fe] should be practically normal. Unfortunately we could not measure this ratio.

CAYREL G. Is the absence of the value of the abundance of Mg lacking in your diagram because the lines of Mg, are too weak in the spectrum of the star, or because you did not observed the appropriate spectral region ?

SPITE M. For the star A7 of NGC330 we covered only the spectral range $5900<\lambda<6900$. There are no measurable magnesium lines in this region. We hope to get soon a spectrum in the region 4700-5800 Å where several magnesium lines are measurable.

GRATTON It would be important to know the ratio between the abundance of α rich elements and Fe-group elements in the Magellanic clouds . We think at present that the variation of this ratio in the halo and disk of our Galaxy is due to a different time scale of production. These timescales interplay in a very different way with the timescale of stellar production (which is probably related to the overall metal abundance) in the Magellanic clouds and in our Galaxy. May you please comment on this point ?

SPITE M. For the field SMC stars, as you could see on the figure, there is a slight over abundance of the "even" light metals (Ca, Si) as in our Galaxy for stars with a metallicity of about [Fe/H]=-0.7 . However, magnesium seems to be more deficient and sodium more abundant than in the galactic similar stars, but this result must be considered as preliminary. In the field LMC stars, all the lines are stronger and therefore all these ratios become dependent of the microturbulent velocity. Thus, I cannot now comment on this point.

TRURAN The metallicity spread in the Large Magellanic cloud may be relevant to the interpretation of the blue supergiant progenitors of Supernova 1987A. Would you please comment on the observed spread in [Fe/H] in the LMC ?

SPITE M Up to now we completed the analysis of only one star of the LMC thus I cannot comment on the basis of our own measurements. Bica et al., through narrow band photometry of 41 clusters in the LMC, found an intrinsic metallicity dispersion in the LMC chemical evolution. Could E.Bica comment on this point ?

E. BICA The average spread found for the LMC at fixed age is 0.2-0.3 dex and extreme values amount to 0.5 dex, using narrow band Hβ and G band integrated photometry of stars clusters of intermediate and old ages (Bica et al. 1986). A similar metallicity range is indicated by H II region abundance studies (e.g. Pagel et al. 1978, *M.N.R.A.S.* **184**, 569).