A SURVEY OF NORTHERN BOK GLOBULES AND THE MON OB1/RI ASSOCIATION FOR H-ALPHA EMISSION STARS

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1. INTRODUCTION

The most direct approach to the suggested relationship of Bok globules to star formation is to search for actual spots of star birth in or around them. But no protostellar objects have hitherto been found by infrared and/or radio observations. Optically relevant to this are the discoveries of some Herbig-Haro objects and pre-main sequence stars associated with cometary globules inside the Gum Nebula (Reipurth 1983).

Young objects which are found most often in regions of star formation are emission-line stars of T Tau and related types. We have made a systematic survey of Bok globules in search for such stars. Objects are taken from the catalogue by Bok and Cordwell(1973). Among them the globule in NGC 2264 is rather peculiar; it is located in a well known site of recent and active star formation. So we searched for new emission-line stars in a larger area, i.e., in the whole association Monoceros OB1 and R1.

2. OBSERVATIONS AND REDUCTIONS

Deep objective-prism plates in the red were taken with the 105/150-cm Schmidt telescope at Kiso Observatory. A 4° objective prism was employed in conjunction with a Schott RG610 or RG645 filter and Kodak 103aE emulsion (hypersensitized), giving a dispersion of 700 Å/mm at Hα-line. Exposure time was 90-120 min, and no widening was applied. The limiting magnitude of the detected emission-line stars is estimated as $m_r \sim 15.4$ for the globules and $m_r \sim 17.0$ for Mon OB1 and R1.

We also took 4° objective-prism plates in the blue-violet. Kodak IIaO emulsion (hypersensitized) and a Fuji SP-4 filter were used. This combination isolates the spectral interval 3700-4500 Å which includes CaII H and K lines, at a dispersion of 120 Å/mm, as well as higher Balmer lines. The limiting magnitude is, however, rather bright: $m_b \sim 12.5$.

The summary of our results is presented in the table. Approximate red

M. Capaccioli (ed.), Astronomy with Schmidt-Type Telescopes, 283–286.

Objects Name	Surveyed Area	Detected Stars	Known Stars	Suspected Stars	Comparison Fields
Barnard 335	20'	0	0	0	0
Barnard 145	30'x105' E-W	5	1	1	0
Barnard 343	40'	5	1	5	1
Barnard 361	68'	6	4	2	0
Barnard 362	50'	7	0	3	3
Barnard 157	20'	1	0	1	0
Barnard 161	15'	2	0	0	2
Barnard 163	20'	2	0	0	1
Barnard 367	15'	1	0	0	0
Barnard 164	30'x48' NW-SE	1	0	0	1
Lynds 1225	30'	4	0	0	1
Barnard 5	45'x66' NE-SW	3	2	1	0
Barnard 34	80'	3	0	2	2
Lynds 1622	90'	16	4	2	0
Barnard 227	50'	4	0	0	2
Mon OB1 and R1	7.11□°	137	-	-	-

and blue magnitudes of the stars were estimated from their image diameters on the Palomar Sky Survey prints. We determined their celestial coordinates from the positions on the PSS prints as well.

3. DISCUSSION

3.1. Globules

Out of the 60 emission-line stars detected near the 15 northern globules, 80% are newly discovered stars (cf. the fourth column). We are concerned mainly about how many of the stars in the table are associated with the globules and are of T Tau type. Six of them (two in B5 and four in L1622) are already known as T Tau stars. Spectral classification with our prism plates in the blue-violet can be applied only to 11 brighter stars, most of which are found to be of early type. But one star in L1622 shows H and K lines in emission, and probably a new T Tau star. As to the rest of the stars, we have no information on their nature at present.

Simple statistics show about half of these objects can be young stars associated with globules. We have set up arbitrarily a comparison field of 30'-diameter circle for each globule. A total of 13 emission-line stars are found in the 15 comparison fields (the last column). This means 4.4 stars/square degree. On the other hands the average density near the globules amounts up to 7.6 stars/square degree. Therefore, the surface density of emission-line stars in the vicinities of globules is higher than that in ordinary fields by a factor near 2, or more if we take the depression of star numbers in globules into consideration.

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The present survey has mainly picked up the candidates for young stars possibly associated with Bok globules. But it is now clear that some globules do have T Tau stars in their vicinities. At least these are B5, L1622 and the globule in NGC 2264. We can infer the evolutionaly status of these globules either that they have already formed some young stars, or that they are also the products of star-forming processes themselves.

These three, however, are not typical globules on account of their incomplete isolation. On the other hand, the most typical globule B335 has no emission-line stars in its vicinity. This may suggest that Bok globules have some varieties in regard to their origin and/or evolutionaly status, and that we may have a higher possibility to find young objects near globules subjected to some external forces rather than near isolated ones.

3.2. Monoceros OB1 and R1

In addition to 84 Hα-emission stars found by Herbig (1954), we discovered even larger number (about 100) of new stars concentrating on NGC 2264. Indeed a considerable part of the stars in the cluster show Hα emission.

The distribution of emission-line stars in Mon R1 is rather sparce, particularly in its northern portion; star formation in this region seems to be well separated from and less active than that in Mon OB1. Here, however, we notice a very interesting feature, a horseshoe-shaped concentration of emission-line stars in the southwestern part. This is just coincident with the structure of the CO cloud revealed by Kutner et al (1979). As discussed by them and by Herbst (1981), star formation in Mon R1 is thought to have triggered by some energitic event in its southwestern part, which is now associated with an incomplete ring of a CO cloud and an expanding HI shell.

Further details of these works can be found in Ogura and Hasegawa (1983) and Ogura (1983). We have just finished the observations to extend the survey to the southern globules in the catalogue by Bok and Cordwell (1973) with the Schmidt telescope at Bosscha Observatory.

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DISCUSSION

M. McCARTHY: I too congratulate Dr. Ogura and colleagues for the fine exploration of Bok globules. This spring I was able to obtain slit spectra with the Reticon attached to the Steward Observatory 1.3 m reflector at Kitt Peak and I can confirm the reality of Hα features in 15 of these stars and note additional spectral features in several of these. Our reductions are not yet fully done. It is a new exciting research project.

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