STUDY OF AN ACTIVE REGION OF THE SUN DURING THREE ROTATION PERIODS*

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ABSTRACT

The abnormal evolution of an active region during three solar rotations is studied. The high density of flares during the second and third rotation seems to be caused by the collision of new active centres with existing ones.

The increase of the activity is probably due to the disturbance of the magnetic field which became more complex because of the appearance of new centres near the original one.

1. General Description of the Centre of Activity under Study

A. SPOTS, FACULAE, AND MAGNETIC FIELD OF THE CENTRE OF ACTIVITY

A centre of activity having as coordinates $\varphi = +21$, and $L = 144$ has been studied during three solar rotations including spots and magnetic fields and during four rotations for faculae. As this centre presented certain particularities, it was chosen to be studied.

On February 20th, 1966, a small facula was born in the N-E part of the visible solar hemisphere; it was the result of the creation of a bipolar magnetic field. Some hours later one of the poles of the bipolar centre appeared in the form of a class-A spot. The following day, February 21st, the centre quickly developed in a clear bipolic shape. The area and brightness of the plage increased swiftly. The intensity of the magnetic field of the spot group reached high values: 1000 gauss for pole S (leading spot) and 500 gauss for pole N (following spot).

After optical observations of the sunspots carried out at the National Observatory of Athens by D. P. Elias, and according to the Zürich Classification of Sunspots, the class of the spot group was normally evolved; and passing through the classes B, C, and D on February 25th, evolved into a class E, which it conserved steadily till the West-limb passage of the centre on March 1st.

The evolution of the faculae followed that of the spots. The plage remaining compact increased in area and brightness.

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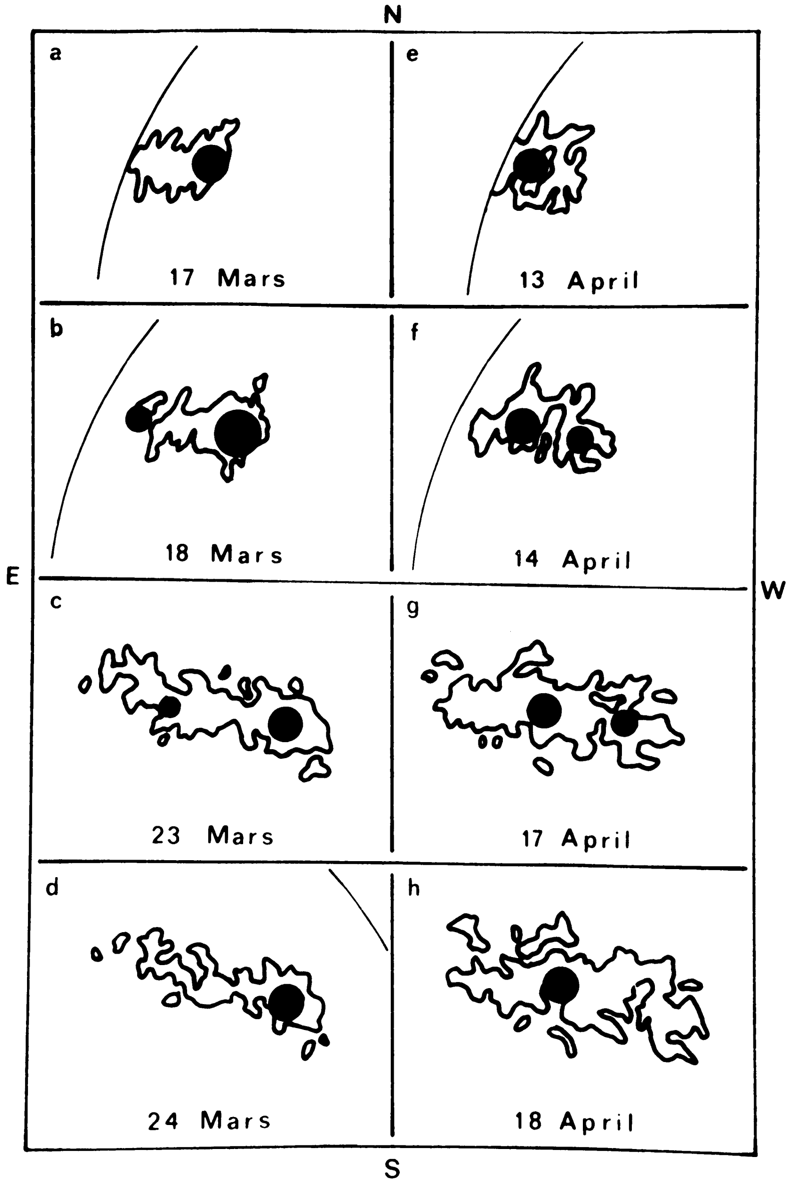

FIG. 1. *The appearance of new centres in the Active Region during the second and third rotations.*

The C.A. reappeared on March 14th, 1966, and its structure became more complicated because of the appearance of a new active centre in its Eastern part; that active centre, incorporated with the former one, constituted a centre of multipolar shape (Figure 1a, b, c, d). From a magnetic point of view, the type of the spots became

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γ from β, according to the Mount Wilson magnetic classification. The plage took a great area and its brightness continued to increase. The intensities of the magnetic field of the spot group reached high values: 3400 gauss for pole S and 2500 gauss for pole N.

The centre accomplished West-limb passage on March 28th, and appeared again on the East limb on April 11th. During the third rotation of the A.R. a new centre appeared in the Western part of the initial A.R., which suddenly reinforced the dwindling centre and made it more active than the usual (Figure 1e, f, g, h). The plage was extended to the West and the new spots, together with the previous ones, constituted a unique Brunner type E group. The values of the intensity of the magnetic field of the former rotation remained quite high: 2400 gauss for pole S and 1700 gauss for pole N.

The C.A. passed over the West limb on April 25th, and reappeared on May 9th, while the spots were observed for the last day on April 23rd. The plage was conserved, appearing for a fourth time: it was, however, completely broken up, its brightness was weak and the pictures taken in the light of K showed that the region of faculae had begun to take the shape of a bright network. We had no observations of the magnetic field, which, however, most likely had to exist.

B. FLARES

In the active centre under study, a total of 217 flares were observed. The centre lived in fact for 63 days. Observations were taken every day that it was upon the visible hemisphere of the Sun. So from its appearance to its West-limb passage (20 February – 1 March, 1966: i.e. 10 days) a total of 15 flares were observed. From the time of its reappearance on the Eastern limb of the Sun till its West-limb passage (14–28 March, 1966: i.e. 15 days) the flare activity was important. 162 flares had been observed – about one flare every 2 hours. During the third rotation of the centre (11–25 April, 1966: i.e. 15 days) the number of observed flares was 40.

Table 1 gives the distribution according to the importance of the observed flares for the three rotations.

Table 1

Number and importance of the observed flares in the C.A. under study

Rotation	Importance S	1	2	3	4	Total
1	7	7	1	–	–	15
2	94	56	8	4	–	162
3	31	8	1	–	–	40
Total	132	71	10	4	–	217

C. RADIO EMISSION

The radio emissions followed the evolution of the centre. The flux density on 2980 MHz (Penteli Station, Athens), in 2800 MHz (Ottawa A.P.O. Station, Canada) and in 600 MHz (Humain Station, Belgium) that is to say in centimetric and decimetric frequencies, reached its highest value during the second rotation of the centre (14–28 March 1966). In its third appearance and in the three frequencies the value of flux density remained inferior to that of the second rotation but higher than that of the first one. Let us say that the values of the flux density are the average daily values, containing also the values during the bursts. As the centimetric bursts have their origin from thermal radiation connected with flares (De Jager, 1959) it is natural for the flux density to take higher values, as the number of flares during the second and third rotations is higher than that of the first rotation.

The contrary was observed in a frequency of 327 MHz (Bologna Station, Italy). The average values of the flux density during the first rotation are far higher than the corresponding values during the third rotation.

2. The Cause of the Abnormal Evolution of the C.A.

The behaviour of a C.A. concerning the appearance of flares is mostly the following: The number of flares and flare surges increased steadily from the 6th till the 13th day of its life. From the 14th till the 30th day the number of flares decreased, while from the 30th till the 60th day of its life, its activity was continuously decreasing.

The C.A. under study behaved in a way opposite to the expected one. So from the time of its appearance (20th February 1966) to its 10th day of life included (the C.A. set on March 1st, 1966) its activity was very restricted. Figure 2 shows that the greatest activity of the C.A. was observed between the 24th and 37th day of its life. Duirng the third rotation of the centre, its activity in flares remained inferior to that of the second rotation but much higher than the activity of the first one.

This increased activity of the centre from the 24th till the 37th day of its life, can be attributed to the appearance of a new C.A. in contact with the original C.A. and to the collision with it. Indeed, during the day when the A.R. under study rose performing its second rotation, a new C.A. emerged beside the A.R. and in its Eastern limb, and quickly joined together with the former one. (Figure 1b, c).

The collision of such active centres or magnetic fields, originated by moving or rapidly developing sunspots, may lead to a high concentration of electric-current density along the neutral lines of the field, with a great probability of flares occurring as Dungey (1958) and Sweet (1958) had shown.

Figure 2 shows that the intensity of the magnetic field during the second and the third rotations, as well as those of the C.A., reached high values. The flare production during the third rotation (between the 51st and 64th day of its life) can be explained in

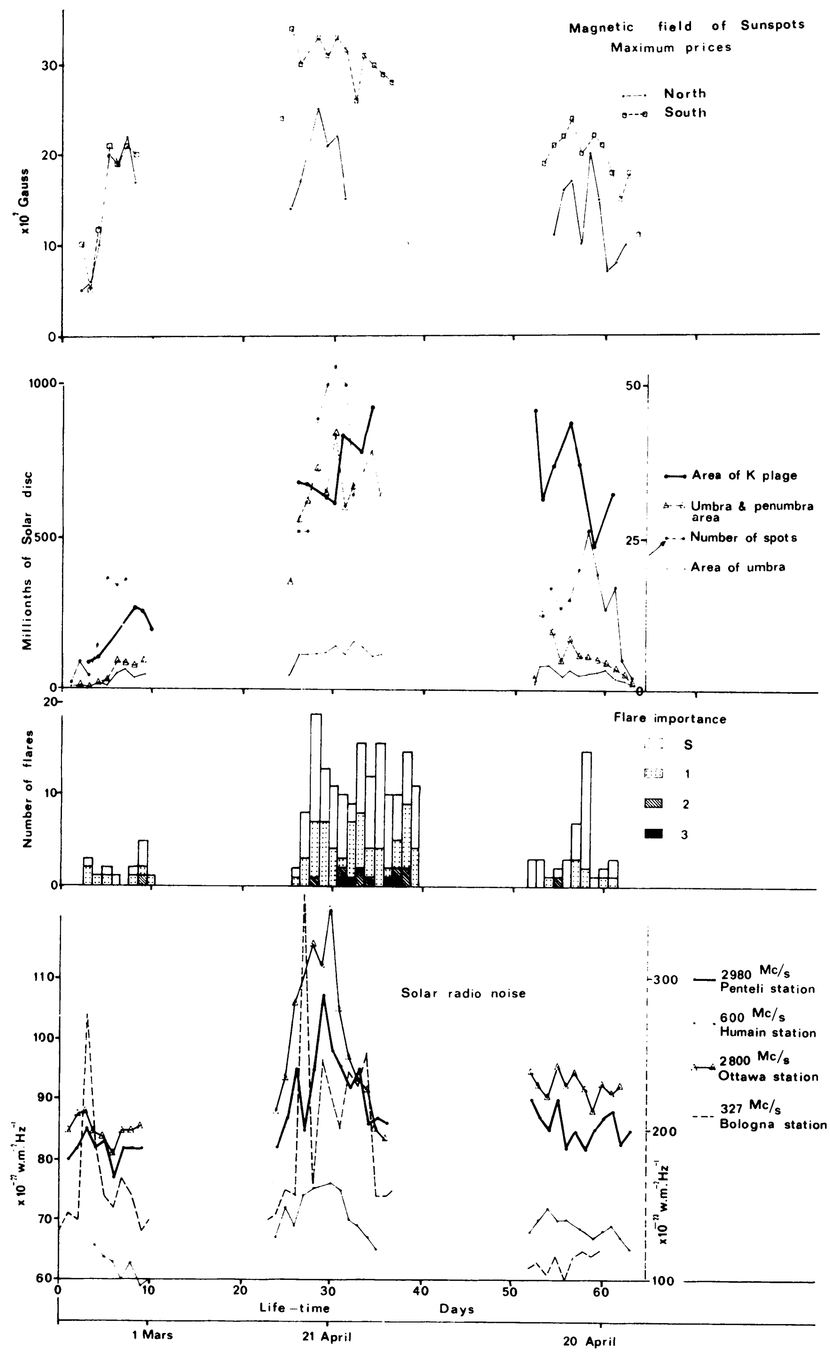

FIG. 2. *Different phenomena – magnetic fields, flare importance, radio data, etc. – during the life-time of the Active Region.*

the same way. It appeared in the Western part of the centre and collided with a magnetic region (Figure 1f, g), which caused the rekindling of the centre. This caused spot areas, flux density in centimetric and decimetric frequencies, number of spots, etc., to reach higher values in comparison to those of the first rotation.

So, when the emergence of a magnetic field takes place beside or within an existing A.R. under the shape of faculae or group of spots, according to Banos (1967), we shall have 'acquired' neutral lines. These lines will be 'abnormal' according to the meaning given by Martres *et al.* (1966); according to the same authors 97% of the flares are created in such lines because of a magnetic inconstancy and complexity.

During the second rotation of the C.A. (14–28 March 1966), 45 flares out of the 162 observed have been photographed at Athens Observatory. We have investigated the position of the appearance of these flares within the centre of activity, and have found that in two parts of the C.A. we have the greatest frequency of flares occurrence (see Figure 3).

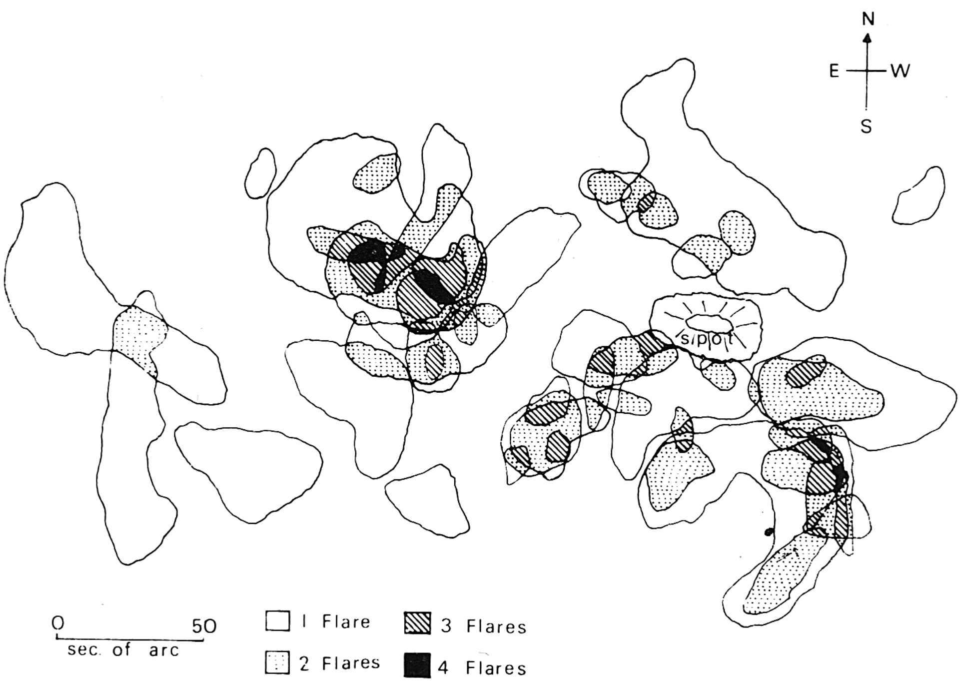

FIG. 3. *Flares density during second rotation of the lifetime of the Active Region.*

Parts A and B in Figure 3 were in the near vicinity of a line of zero intensity of the longitudinal component, i.e., a neutral line. The work of Severny (1964) showed that the flares are connected with particular configurations of the magnetic field of the A.R.

Consequently the increase of activity in the A.R. during the second and third

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rotations could be attributed to two separate magnetic arches, the interaction of which produce neutral lines characterized as 'abnormal', and it is well established that the majority of flares appear in the vicinity of such lines.

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