

if not absolutely futile, much of the work done by amateur theorists—namely, that observations for theoretical purposes must be made on objects of a structure which is perfectly known by some independent method, as otherwise we are moving in a “vicious circle.” It is clear that in the case of the higher powers of the microscope this difficulty cannot be avoided with delicately marked natural objects examined directly.

The numerical results obtained by Lister are still of great value.

For the naked eye he finds that there is practically no gain in resolving power when the pupil is opened beyond 0.095 in.; that the difference in keenness of vision of different individuals rapidly decreases when smaller and smaller apertures are placed before the eye, and that with apertures below about 0.025 in. all reasonably normal eyes have the same resolving power which corresponds to his general formula. In this section we find a remarkable instance of the accuracy of his observations; for he records the fact that—contrary to his preconceived idea—two or three lines are more easily separated than a larger number; this has in recent times been theoretically confirmed!

The telescopic section is the shortest, owing to difficulties from unsteady air and bad light. But it includes interesting measurements of the diffraction rings of the spurious star-disc. The limit of resolution arrived at is 4.33 seconds of arc divided by the diameter of the object-glass in inches.

Probably the most remarkable results are those recorded in the microscopical section, which also contains the most surprising proof of the extraordinary accuracy of Lister's observations. For these enabled him to deduce that the resolving power of microscope objectives did not increase in proportion to the angle of aperture, but to the chord of that angle—in modern language, to what Abbe, forty years later, called numerical aperture. When it is considered that the widest angle accessible to Lister was one of 80°, and that even for that the ratio of chord to angle is merely that of 10:13, it will be realised that this was a very creditable feat.

The limit of resolution for the microscope arrived at by Lister, when translated into modern terms, is 95,240 lines per inch for N.A. 1.00. It should, however, be stated that although there are a very few observations reaching or slightly exceeding the figures finally adopted in the paper, these are not the *mean* of all the observations. Unlike some modern microscopists, Lister understood the meaning of the word limit as a practically unsurmountable barrier which should only be closely approximated under extremely favourable conditions, and he adopted his final numbers accordingly.

In conclusion I should like once more to advise those interested in instrumental optics to read this extremely interesting paper *in extenso*.

A. E. CONRADY.

#### THE ANCIENT ARTISTS OF SOUTH-WESTERN EUROPE.

THE attention of readers of NATURE has been directed from time to time to the numerous and interesting archæological discoveries in the caves and rock-shelters of central and southern France and northern Spain, which are due to the energy and skill of Prof. l'Abbé H. Breuil, MM. L. Capitan, E. Cartailhac, Prof. H. Obermaier, E. Piette, and others. During the last two or three years similar investigations have been made in other parts of Spain, mainly by the indefatigable Abbé Breuil with the cooperation of Juan Cabré Aguilo, Pascual Serrano Gomez, and Gomez Moreno, and we should like to take this opportunity of congratulating the Spanish archæologists on pursuing this fascinating line of inquiry, which already has led to important results.

The epoch-making monograph “La Caverne d'Altamira,” by E. Cartailhac and H. Breuil (1906), is being followed by the publication of equally sumptuous memoirs on the more important French caves. These, together with the numerous papers and smaller memoirs that have already appeared (mainly in *l'Anthropologie*), prove that central and southern France and Spain north of the Cantabrian Mountains constituted an area throughout which the later stages of Palæolithic culture were spread with remarkable uniformity. This sequence consists of the Aurignacian, Solutrian, Magdalenian and Azilian industries, with their accompanying manifestations of glyptic and pictorial art.

The earliest phases of the art of the Franco-Cantabrian area are characterised by rude statuettes of the human figure, which are followed by beautifully executed carvings of animals in the round or in relief, and by large numbers of engravings on bone, ivory, and stone. The earliest engravings are linear scrawls, and even rude but vigorous drawings of animals on clay surfaces. The walls of numerous caves were also decorated with engravings and paintings of animals, of which the following sequence has been established.

First phase: the engravings consist of broad deep incisions; many of them are unrecognisable; some are profile representations of animals with but two legs drawn; the paintings have a similar character, but the earliest efforts were simple impressions in colour of the human hand and timid attempts at linear designs and grouped dots. Second phase: the incisions are still broad and deep, but the drawings are more lifelike; the four legs are shown, and hair is often indicated; the clever brush outlines of the earlier part of this phase are replaced by monochromes, some of which are beautifully shaded. Third phase: the engravings are now in thin lines; they vary in excellence, but some are real masterpieces; the paintings are deplorable, owing to an excessive use of pigment. Fourth phase: the engravings lose their importance, and in some cases are merely

employed as subsidiary to painting; the artists try to regain by the use of various colours the modelling lost in the preceding phase; at first they are timid, the animals are outlined in black and the paint laid on in masses, but they soon obtain a mastery of the technique, and produce wonderful shaded polychrome paintings of bisons, boars, and other animals in various positions. Fifth phase: there is no longer any mural engraving; nor are there paintings of animals, but merely painted bands, branched designs, dots, and so forth. With this decadence that marks the

all the animals are depicted with the same artistic feeling that is exhibited in the Magdalenian art of France and Cantabria; there is the same ability to seize forms and attitudes, the same certainty of execution. The number of human beings that are drawn marks a sharp contrast to the art of the north. At Cogul there was found a remarkable fresco representing a group of nine partially clothed women apparently dancing round a small nude male figure—doubtless a representation of a ceremony that may have had fecundity for its object; 300 kilometres south of Cogul, near Alpéra, two

very similar women were painted in the midst of a wonderful assemblage of men and animals. The men are always nude, often they wear feather head-dresses and tasselled leglets; they are drawn in various attitudes, and the majority of them are shooting with bow and arrows at deer and other animals (Fig. 3). The investigators have satisfied themselves that the paintings belong to the Magdalenian period, and now we have indisputable evidence that at all events in the latter part of the Palæolithic age the bow was a common weapon in Spain; its presence has not yet been proved in the Franco-Cantabrian area, but

we know that the spear-thrower was employed by the French Magdalenians. Two large male figures at Alpéra in a dancing attitude, wearing a feather head-dress and flourishing a bow and arrows, have doubtless a ceremonial significance, and may represent magicians.

There is nothing to show whether the above-mentioned schematic figures at Cogul were earlier

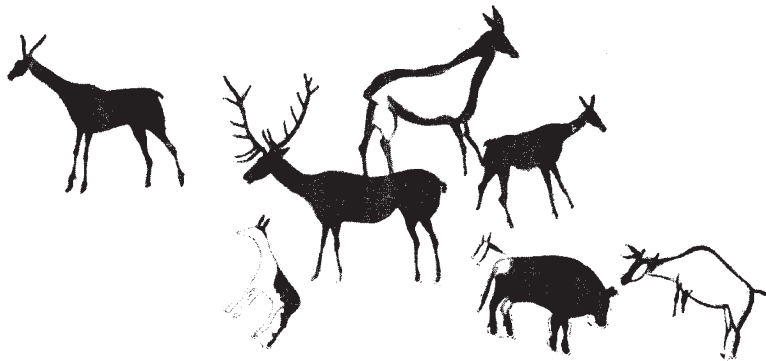


FIG. 1.—Group of red animals on a rock at Cogul: stag surrounded by hinds; to the right an ox and elk. Behind the ox is a black head of a hind of earlier date. Length of panel, 0.75 m.

Azilian period comes the close of the Palæolithic age.

The question naturally arises, whether the simple decoration and absence of naturalistic drawings of the Azilian period are due to a degeneration of the Magdalenian art, or whether they reflect a movement from elsewhere. The evidence certainly points to the latter explanation, as the implements are also different from the Magdalenian and agree with those from pre-Neolithic sites in Italy, Sicily, Tunis, Algeria, and south Spain.

In various other parts of Spain pictographs have been found in rock-shelters and on rocks in the open; these form an eastern and a southern group. The rock-paintings in the lower valley of the Ebro at Cretas were first noted in 1903, but not studied till 1908, while those at Cogul were discovered in 1907 (Fig. 1). In every case they are in full daylight and often exposed to the weather, whereas all those previously considered are in the deep recesses of dark and usually tortuous caves. The paintings of the Dordogne include bears, lions, mammoths, rhinoceroses, horses, bison, wild oxen and goats, deer, and reindeer. The reindeer and mammoth scarcely occur in the caves of the French Pyrenees, while in those of Cantabria the reindeer is entirely absent, and there are two elephants and one bear. Throughout the whole region representations of human beings are practically absent.

In the frescoes of eastern Spain the deer, primitive ox, and wild goat are very abundant; there are also a few wolves, one horse, one male elk, some fallow deer, and a bison. We are here in a different zoological area. With the exception of two very diagrammatic deer at Cogul (Fig. 2),



FIG. 2.—Hunting scene painted in red on the rock at Cogul: man shooting a deer; the figure to the right is a dead deer lying on its back with legs in air. Length of fresco, 0.75 m.

or later than the other naturalistic paintings, for assuredly they were not done by the same artists. The same style reappears at Alpéra, in the eastern area, where it is easy to see that it is later than the fine style.

At Batuecas, in west-central Spain, enormous panels are covered with dots, rows of lines, branched, scaliform, pectiform, and other signs, circles, and rayed figures, together with very schematic men and animals (Fig. 4), which are later than certain more naturalistic drawings. Precisely similar diagrammatic signs occur in pro-

fusion in Andalusia, and below a few of them l'Abbé Breuil has found small, poorly executed, but realistic figures of the same kind as those at Batuecas. The signs agree with those that are found superimposed on Magdalenian drawings in the Franco-Cantabrian area, so there is little doubt that they characterise the Azilian culture.



FIG. 3.—Hunting scene painted in a brownish red, older than the very diagrammatic red signs (in cross-hatching) and later than the light red hind in the centre. Scale, about  $\frac{1}{2}$ .

Prof. Breuil has given in *Rev. Arch.*, xix., 1912, p. 193, a large number of sketches from central and south Spain which are evidently degraded representations of the human form.

In the same article he points out that, so far as is known, the art of the Franco-Cantabrian area developed *in situ* throughout a considerable period during which the climate, vegetation, and fauna were modified several times, while migrations of peoples, all of whom were hunters and collectors, took place in different directions. The realistic representations of animals by the Aurignacians continued through Solutrian to the end of Magdalenian times, and until the extinction of the reindeer in France and central Europe. Human figures, as we have seen, were rarely portrayed except at the beginning of this series of cultures. Then an invasion from the Italian and Iberian peninsulas brought other peoples to north-west Europe, who painted schematic and geometric forms, often very like those painted on rocks in south and west Spain.

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These latter seem attributable for the most part to peoples who, while in the Palæolithic stage of evolution, did not progress through the Aurignacian-Solutrian-Magdalenian line of evolution that extends from Cantabria to Poland, but advanced in the direction of the industries termed "Capsian" by de Morgan and "Getulian" by Pallary. The eastern Spanish art may have been derived from north of the Pyrenees or influenced by it, at the same time undergoing a local development. On the other hand, Breuil notes that influences of the schematic art of the south-west were felt in the Magdalenian art of Cantabria and even of the Pyrenees, and that a cave in Ariège also shows pictorial influence from the artistic province of east and north-east Spain.

"As a result of the arrival of Neolithic man in the south of the Iberian peninsula, the Capsians flowed over the Magdalenian world, substituting their schematic art for the realistic art of the Magdalenians; borrowing from them some slightly modified industrial objects, like the harpoon, they spread not only to Gascony and Aquitaine, but to Dauphiné,

Switzerland, Bavaria, and even to Scotland. On the other hand, some Capsians of Andalusia and Murcia seem to have rallied to the new state of things, since certain painted rocks represent 'idols' known only in the ancient Neolithic age in these regions, and certain Portuguese dolmens

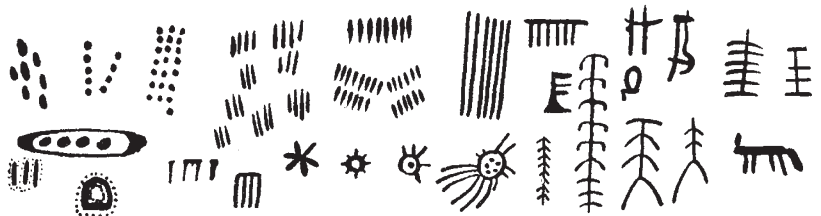


FIG. 4.—Azilian signs at Batuecas (Salamanca) which recall the coloured pebbles and petroglyphs of Andalusia.

preserve a mural decoration conceived in their style. Perhaps other Capsian groups, driven from Morocco by the newcomers, migrated into central Sudan, unless the strange analogy of the paintings found there with those of Andalusia be purely fortuitous."

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