23 0 in the storm on February 16. The values correspond with those reported by others, though the error in our case is somewhat larger.

It is remarkable that during the magnetic storms the cosmic-ray intensity and magnetic intensity variations may possess in some cases positive and in others a negative correlation, as has been found by other scientific workers. A complete account of our observations will be published elsewhere.

We are grateful to Dr. Alexandar Wolsky, chief scientific officer, Unesco, for obtaining meteorological observations from Pakistan, and to the director of the Colaba and Alibag Observatories for supplying us with detailed magnetic data necessary for the calculations.

H. R. Sarna
Om Parkash

Department of Physics,
East Punjab University,
Delhi University Buildings,
Delhi.
April 16.

[1] Parkash, Om, and Sarna, H. R., *Ind. J. Phys.*, **22**, 19 (1948).
[2] Johnson, T. H., *Rev. Mod. Phys.*, **10**, 229 (1938).
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Discovery of Neolithic Polished Bone Axe-Heads in Africa

An early occupation site at Esh Shaheinab on the west bank of the Nile about thirty miles north of Omdurman was excavated under the auspices of the Sudan Government Antiquities Service in January and February 1949. Polished stone axe-heads, gouges, chisels and planes, small disk beads of amazon-stone, and serrated bivalve shells show that the culture was closely connected with that of the Fayum Neolithic a thousand miles to the north. The type of settlement was also similar, with numerous hearths but no other trace of houses, and no burials in the settlement.

The most important discovery, however, was one that throws important light on the development of the handled axe. Eleven polished axe-heads made from the long bones of large mammals, together with sixty-five fragments of similar tools, were found associated with a comparable number of normal stone axe-heads. Both forms of axe-head were contemporary, specimens of each occurring together in the same hearth. The bone axe-heads vary in length from 194 mm. to 66 mm., and in width from 70 mm. to 33 mm., the average length being 131 mm. and the average width 43 mm. They have been narrowed slightly at the butt end, presumably for insertion into a wooden handle, and have been given a sharp cutting edge at the broad end by being rubbed, no doubt on one of the many sandstone grinders which abounded on the site, and which were usually used for grinding red ochre.

Though generally smaller than the bone axe-heads, some of the stone axe-heads were the same size as the bone specimens. Some of them had been only chipped, but others had been polished by rubbing as well at the cutting end, to an extent similar to the rubbing on the bone axe-heads.

It seems difficult to avoid the conclusion that these bone axe-heads are the prototype of the stone ones. The inhabitants of the site appear from the animal remains to have been hunters who killed large animals, including hippopotamus, rhinoceros and elephant. Probably large splinters of bone were used for hacking meat off the kill, the next step being to fit such a splinter into a wooden handle, thereby making a more efficient hacking tool. It would not be a difficult further step, for people who were using sandstone grinders for ochre, to give the new tool a sharp edge on a sandstone rubber. (Indeed, I am reminded by Dr. K. P. Oakley that the shaping of bone tools on a rubbing stone was not an unknown technique in Africa in pre-Neolithic times.) Having thus invented the axe, they probably transferred its use from meat to wood, for the gouges, of which nearly two hundred were found, must have been used for working wood, perhaps in making dug-out canoes and spear-throwers. When they discovered that a bone axe-head was not strong enough to cut any but the softest woods, it would be an obvious step for them to copy the bone axe-head in stone, and so the chipped and partly polished stone axe-head would be invented.

A full report of the excavation will be published at the first opportunity. In the meantime, it is of interest to report that another novel feature at Esh Shaheinab was a notched fish-hook made from bivalve shell, which may be ancestral to the perforated shell fish-hook of the Badarian; and also that the pottery was derived from that of the Khartoum Mesolithic[1] and includes what must be the earliest black-topped red ware known in the Nile Valley.

A. J. Arkell

Department of Egyptology,
University College,
London, W.C.1.
May 30.

[1] See "Early Khartoum" (Oxford University Press, 1949).

Thermal Conductivity of Powders

According to a note in *Physical Abstracts*[1], R. L. Mullokandov[2] finds that thermal conductivity of powders is practically due only to the convection in the surrounding gas, and that hence "a layer of smooth spherical particles in vacuum may be used as a good thermal insulator". This was discovered by M. Smoluchowski some forty years ago[3]. He investigated both theoretically and experimentally the thermal conductivity of powders, and concluded that filling the space between the walls of a Dewar vessel with a suitable powder would provide improved insulation by reducing the convective currents as well as the radiation and, moreover, would improve the vacuum by absorption. His application for a patent resulted in a long argument with the German Patent Office, whose examiners were reluctant to admit that any material agent could provide a better insulation than 'absolute' vacuum. At that time a large metallic Dewar vessel with its interstice filled with powdered active carbon was built at the Physical Institute of the University in Lwów, and showed the expected high insulating properties. As that work of Smoluchowski remained little known, I think that this information may be of interest.

Z. Klemensiewicz

29 Bramham Gardens,
London, S.W.5.

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