Identification of a Missing Element.

IN two recent communications to the Paris Academy of Sciences (*Comptes rendus*, May 22), by M. A. Dauvillier and Prof. G. Urbain respectively, very definite conclusions have been reached as to the identity of celtium with the missing element of number 72 on the Moseley classification. This discovery is of special interest to British workers, since Moseley's last work dealt with this particular problem. Prof. Urbain adds a statement on the unpublished work of Moseley on the X-ray spectra of his preparations of the rare earths. In his paper M. Dauvillier announces the discovery of certain lines in the L X-ray spectrum of celtium which show that its atomic number is 72. An improved De Broglie photographic spectrometer was used, and the oxides of lutecium and ytterbium in a preparation of Urbain's were attached to the anti-cathode. The tube was run at a potential of 40 k.v., and nearly complete L-spectra of lutecium and ytterbium were obtained. In addition three lines of thulium were found and two feeble lines which were identified as the α_1 and β_2 radiations of celtium. These lines ($\alpha_1 = 1{\cdot}5618$ Å ; $\beta_2 = 1{\cdot}3194$ Å) fall in the correct places for the element of atomic number 72, between the corresponding lines of lutecium and ytterbium. The β_1 and γ_1 lines of celtium which might have been expected are coincident with the β'_2 and γ_3 lines of lutecium. Reasons are given why these lines of celtium cannot be due to any impurities, such as other rare earths.

The following is a translation of Prof. Urbain's paper in the *Comptes rendus*:

THE ATOMIC NUMBERS OF YTTERBIUM, LUTECIUM, AND CELTIUM.

"The results of M. Dauvillier's examination of my preparations containing celtium have a theoretical importance obvious to all who have followed recent scientific developments with regard to the chemical elements and their atomic structure.

"It is now unquestionable that the element of atomic number 72 is actually celtium. The atomic weight of celtium must therefore lie between 175 (lutecium) and 181·5 (tantalum). Characterised by two sets of spectral lines (arc and X-ray) and by the order of magnitude of its atomic weight, celtium has conclusively won its place among the chemical elements.

"Thus the problem of the constituent elements of Marignac's 'ytterbium' has been solved. The method of X-ray analysis is the most significant, and probably the crucial, test of a chemical element, and this method has confirmed the work I have done over a period of more than ten years on 'ytterbium,' using more difficult and probably less conclusive methods. Though I only succeeded in obtaining a partial separation, this was sufficient to permit the high-frequency spectra method to assign its atomic number to each of the constituents I discovered, namely, (neo-) ytterbium 70, lutecium 71, celtium 72.

"Now that these results are clear, I wish to outline a part of the history of these elements that has not yet become known to the scientific public. When I originally announced the discovery of celtium, Moseley's law of the atomic numbers was still unknown. After this law had been found it seemed evident that it should be possible to define the three elements of the ytterbium group by their X-ray spectra. Moseley himself put forward the hypothesis that celtium and the element with atomic number 72 were one and the same. On the other hand, Moseley, relying on the evidence of Auer von Welsbach, in his first lists of the elements had included two thuliums, while my experiments only permitted the existence of one.

"In order to settle this question, in June 1914 Ramsay and I visited Prof. Townsend's laboratory at Oxford, where Moseley was working. Our intention was to examine the different products of my separation of ytterbium by this young investigator's method, then unique.

"We found one thulium of atomic number 69, one ytterbium of atomic number 70, and one lutecium of atomic number 71. The spectra which Moseley obtained included only a few lines, and we could not find any corresponding to the element of atomic number 72. The first of these results was announced several years ago, but as the result of the researches of others. No claim of priority was possible, since Moseley himself was responsible for the publication of these results, and for this purpose had kept the necessary documents. But the war broke out before he had time to write his paper. He was among the first to enlist, and by great misfortune was killed at the Dardanelles.

"Sir Ernest Rutherford, who prepared the obituary notice of his pupil, wrote to me about these last researches of Moseley's, at which I had assisted. In the absence of precise data I thought I must forgo the publication of results that would rest on my memory alone.

"M. Dauvillier's discoveries complete the early results obtained at Oxford. They show that the negative result given by Moseley's method in the case of celtium was due only to the insensitiveness of the method, since the preparation examined by M. Dauvillier is the same as that used in Moseley's own X-ray tube."

Now that the missing element of number 72 has been identified, there remain only three vacant places of ordinal numbers—43, 61, 75—between hydrogen and bismuth in the Moseley classification of the elements. With the rapidly increasing perfection of technique of X-ray spectra and the use of powerful installations, it is to be anticipated that the missing elements should soon be identified if they exist in the earth. The law of the X-ray spectra, as found by Moseley, is an infallible guide in fixing the number of an element, even if present in only small proportion in the material under examination. E. RUTHERFORD.

Recent Excavations at Stonehenge.[1]

By Col. WILLIAM HAWLEY, F.S.A.

THE arrangement of the stones at Stonehenge includes on the outside a circle of sarsen stones, which were originally thirty in number and were capped with lintels, forming a continuous ring round the top. Inside this circle is another of smaller stones, originally forty-three in number, but without lintels and of a different rock from those of the outer circle.

Within the second circle of small stones were five

[1] Address to members of the Portsmouth Literary and Philosophical Society on the occasion of a visit to Stonehenge on May 6, 1922.

trilithons of large blocks of sarsen. Two only remain standing and one stone of the third. They have lintels, but the lintels were not continuous and merely formed a cap to the two upright stones.

The trilithons are not arranged in a circle but take the form of a crescent or horse-shoe, as also do a series of fifteen small stones within them, similar to the others in the second circle. The smaller stones (or foreign stones) are from metamorphic rocks and have been brought from a long distance, but how or when has not yet been determined. Dr. Thomas of the Geological Survey considers the source of two kinds to have been the Prescelly Mountains in Pembrokeshire, where he found identical specimens. He considered that their deposition here by glacial action to be contrary to sound geological reasoning, and that their assemblage here pointed to human selection and conveyance. One sort is a porphyritic diabase, another is a rhyolite, both of which are extremely hard. Another sort is an argyllite resembling hard slate, but being perishable, no standing stone remains, though many pieces are found in the soil below the surface. All these stones appear to have been brought in a rough state and in naturally long slabs, which were afterwards dressed.

The sarsens had less far to travel, and there can be little doubt that they were brought from the Marlborough Downs, where there are still many boulders of them strewn over the land.

These big blocks or boulders are composed of siliceous granules, and were formed in the Bagshot sand of the middle Eocene, and were left behind when the sand around them was denuded in a geological change.

Before being conveyed here they were roughly squared by cleavage to lighten them, and after arriving they were neatly dressed, partly by picking with pointed flint tools and partly by crushing and grinding with mauls made of a very hard quartzite.

After standing here for about 4000 years they have naturally become greatly weathered, some more than others, depending upon where softer patches in their substance occur, so that it is only on the durable parts that tooling marks can be seen, but these are very clear where the surface has not been exposed, where the stones are protected below ground, and where the lintels fit upon the uprights.

For many years several of the stones were leaning dangerously and had to be propped, notably the four on the north-east and two on the east, all bearing lintels. H.M. Office of Works has had these stones set upright, and their bases are now firmly fixed in beds of concrete.

In this operation it was necessary to take down the lintels, and we were much impressed by the elaborate care that had been bestowed upon fitting them to the tops of the stones. Every lintel has two cup-shaped holes, which fit upon tenons projecting from the upright stones, so that each lintel has two holes and each upright has two tenons (except the trilithons which only require one tenon on each upright).

The fitting of the lintels to the tops of the stones had been done with such accuracy as to leave little doubt that they had been worked in unison and the lintel frequently tried on until a perfect fit had been accomplished. The same care was observable in the fitting of the ends of the lintels, as each one has a projection which fits into a recess in the next following it, locking them all together, and all this must have been done when the stones were upright and to ensure evenness of the tops all the way round.

These stones were irregular in their depth below the surface, the longest having 8 feet and the shortest 4 feet 6 inches below ground. The bases end in a blunt point, to facilitate movement when getting them into position. Most of them seem to have been brought to their places down an inclined plane cut in the solid chalk, but two cases were met with where they had been put in vertically. The pieces broken off the bases when pointing them were used for propping them whilst adjusting their position and before the soil was returned to the hole around the stone. A great many other pieces of stone had to be used, and these had to be sought at places a few miles from Stonehenge, as there is no stone in this neighbourhood. Wooden posts were used for a similar purpose, their holes being found below the stones and sunk about two feet in the chalk. The acquired stone was of two sorts, a glauconite and a ragstone, the former from Hurdcote near Wilton and the latter from Chilmark, a few miles farther west. The same quarries appear to have been used ever since, as similar stone is frequently met with in the British villages of the Roman Period, and we found that they had supplied all the stone for the building of Old Sarum. In this case a freestone had been used and not the rough slabs found here. The freestone occurs at a lower level, and is extensively quarried at the present day.

Finds of interesting objects have been remarkably few; indeed nothing of any special interest. The things found consist chiefly of rough flints used for dressing the stone and stone mauls, or hammer stones, of various sizes up to 43 lbs. in weight. Immense quantities of chips were knocked off by the masons. Those of sarsen occur at all depths, but those of foreign stone not lower than 30 inches, as they were put in last of all, and the building was probably a long, continuous work. The rubble below the surface, besides containing chips, yielded a few pieces of Bronze Age pottery, very small and foot-worn. The firm rubble had arrested the descent of these and also of small pieces of Roman Period pottery, and very occasionally a coin of that time. These were mixed with other things that had reached the rubble at every succeeding age down to the present time.

It is remarkable that the great number of people employed upon the construction of the place have left nothing behind them, for life in the Stone Age was not incompatible with a fairly high state of culture, as has been noticed in many instances. There was pottery of excellent design at the Temple of Tel Harkien at Malta, of Neolithic times, some of it being beautifully inlaid.

The use of this place has not yet been determined. Among ancient races religious and secular matters were intimately mixed, but this place could not have been for secular use, as apparently it was not inhabited. There are perhaps as many theories about Stonehenge as the stones which compose it, yet nothing is known with certainty about the nature of the place. It is trusted, however, that when the present research is finished some definite conclusion may be arrived at.

The place has been surrounded by a circular

earthwork and outer ditch. Also, within the earthwork there are round patches of chalk. These have been placed there to mark the sites of holes which were discovered two years ago. We have named them Aubrey holes after an investigator of that name who, in 1666, hinted at their possible existence, but did not find them. Only about half the number has been opened, but we have ascertained that there are fifty-six. They are evenly spaced at 16 feet apart, and there can be little doubt that they once held stones forming a continuous circle, older than the existing monument. The old circle stones would have been rough, undressed ones, and perhaps of about the date of Avebury. When the present monument was built it is possible that the rough stones were taken out and dressed and erected as the smaller stones now visible, as it is not likely they would have been wasted, and, moreover, their number corresponds nearly with that of the holes.

The empty holes appear to have been used for human interments, as nearly all of them contained cremated bones. Only a portion of the cremated remains of a body are found in each hole and in one instance only fourteen pieces of charred bone. The actual cremations must have been carried out elsewhere and the remains brought here for interment, for up to the present time no sign of a large fire has been met with; and the burning of only one body would require several tons of wood to calcine it thoroughly, and the quantity of black wood ashes remaining, being indestructible, would have been noticed. These interments occurred in Neolithic times, as chips were found amongst the debris in the holes, and in one instance an implement maker had thrown all his discarded chips into a hole.

Lately I have been excavating the ditch outside the earthwork. It was probably the first work done here, and from it I trust to get a continuous linking up of periods from the earliest to the latest. So far this work has not been very profitable, but has given a good result in showing that a very long time must have elapsed between making the ditch and rampart and the building of Stonehenge. It seems to have fallen into neglect, and was nearly silted up when Stonehenge was built. This is conclusively shown by finding the masons' chips only 14 or 15 inches below the surface in the rubble covering the silt, where they cease abruptly, the silt containing no trace of anything relating to Stonehenge. It is devoid of any objects beyond occasional small fragments of animal bone, but when the bottom is reached at $4\frac{1}{2}$ to $5\frac{1}{2}$ feet below the surface, flint chips discarded by implement makers are found in great quantities, but rarely an actual implement. Many staghorn picks used in the excavation of the ditch are met with, and the upper parts of antlers cut off and thrown away when the picks were made.

This season I am again excavating the ditch, and this time on the north-east, to find out if it was a continuous circle or whether the avenue was made at that time or later, when Stonehenge was built, for I am inclined to think that there were two distinct periods here—an early one, when the circle of stones stood round the rampart, and a later one when this Stonehenge was built, with a considerable interval between them.

The Sense of Smell in Birds: a Debated Question.

ORGANS of smell are present in birds as a class and are well developed in many species, but much doubt attaches to the nature and extent of their usefulness. The South American vultures and the petrels are noteworthy for the size of their olfactory chambers, and the Apteryx possesses a complicated nasal labyrinth and is peculiar in having its nostrils at the extreme tip of the beak. Yet even in cases like these the practical demonstration of a sense of smell is beset with difficulties, and the existing evidence is conflicting and largely inconclusive. It seems difficult, of course, to believe that the apparatus serves no purpose, especially where it is highly developed or is specialised along particular lines, but apart from the unsatisfactory quality of *a priori* arguments the alternative must be borne in mind that the organs may have some other function than a sense of smell of the kind with which we are subjectively familiar.

The sense of smell is notoriously acute in the majority of mammals. Although they are generally also well endowed with sight and hearing, it is by smell that they chiefly find their food and by smell that they receive the first warning of the proximity of enemies: the importance of approaching four-footed game upwind is a commonplace. In birds the case is obviously very different, for with them vision must certainly be given pride of place. Hearing, too, is very well developed in birds, and there is also often a delicate sense of touch—witness the bill of the snipe—and possibly some power of discriminating food by taste. It may be argued that a sense of smell would be less useful to birds than to mammals: the great distances from which some birds detect their prey seem practically prohibitive for any sense but vision, and the spaces of the upper air must form a much less favourable medium for scent than the ground winds on which mammals so greatly rely.

Like so many other problems of natural history, this question attracted the attention of Charles Darwin, and in "A Naturalist's Voyage Round the World" we read of the experiment which he made in a garden in Chile where twenty or thirty captured condors were tethered in a long row at the bottom of a wall. "Having folded up a piece of meat in white paper," he says, "I walked backwards and forwards, carrying it in my hand at a distance of about three yards from them, but no notice whatever was taken. I then threw it on the ground, within one yard of an old male bird; he looked at it for a moment with attention, but then regarded it no more. With a stick I pushed it closer and closer, until at last he touched it with his beak; the paper was instantly torn off with fury; at the same moment, every bird in the long row began struggling and flapping its wings. Under the same circumstances it would have been quite impossible to have deceived a dog." In the same place Darwin