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Unique Fossils from Virginia

by H. B. WHITTINGTON

Many a discovery in science has been made accidentally, as a by-product of another investigation. The fossils discussed here were such a discovery, made in 1935 by Dr. G. Arthur Cooper and his colleagues of the U. S. National Museum. Blocks of limestone were first collected from quarries, railroad cuts and pastures in the neighborhood of Strasburg, Shenandoah County, in the hope of obtaining from the minute chambered shells of fossil Foraminifera. The blocks of limestone were put in a tank of dilute hydrochloric acid and the acid renewed at intervals until all the lime had dissolved. At the bottom of the tank there remained a sludge of black mud and other material not affected by the acid. When this sludge was examined, it was found not to contain any fossil Foraminifera, but from some blocks came an abundance of bivalved shells of Ostracoda (Figure 2B), sticklike branching skeletons of Bryozoa (Figure 2A, B), and parts of trilobite shells (Figure 2A, B). Other fossils such as corals, brachiopods, and parts of echinoderms, although they could be seen in the rock when it was collected, were dissolved by the acid. The particular fossils that resist acid, do so because the original shell has been replaced by minutely granular quartz, which is not affected by hydrochloric acid. The sludge remaining after a block of limestone is dissolved has first to be sieved carefully under water to separate the fossils from the mud. The residue on the sieve is then washed and dried (Figure 2B), and individual delicate fossils picked out with a fine, wetted camel hair brush. Dr. G. Arthur Cooper accumulated a considerable collection of these fossils before inviting me in 1946 to begin study of them. By that time Dr. William R. Evitt independently had discovered similar fossils in a road section near Strasburg, and begun to study them. Dr. Evitt and I joined forces in 1947, and from that time on have collaborated in a program of preparation and study that will continue for many more years. We have sampled the limestones from a variety of natural and artificial exposures in the region between Strasburg, Shenandoah County, and Staunton, Augusta County, most of the localities lying within a few miles of U.S. Route 11. The belt of Middle Ordovician limestones containing these fossils is about 600 feet thick, and is exposed frequently in this general region. It is a fortunate circumstance that these fossils are silicified, for though preparation is laborious, the results are exquisite. A glance at Figures 1, 3-5, will show their remarkable delicacy and beauty. They could not possibly be dug out from the limestones by any mechanical method. Further, mechanical breaking and chipping of the limestones, no matter how delicate, not only would break many of the fossils, but also would fail to reveal many of the tiniest things (less than half a millimeter in length).

Dr. Evitt and I have been interested in the trilobites, extinct marine animals which belong to the Arthropoda. Typical arthropods on the land today are insects, spiders and scorpions, while in the sea are king- (or horseshoe-) crabs, lobsters, crabs and shrimps. Trilobites, distantly

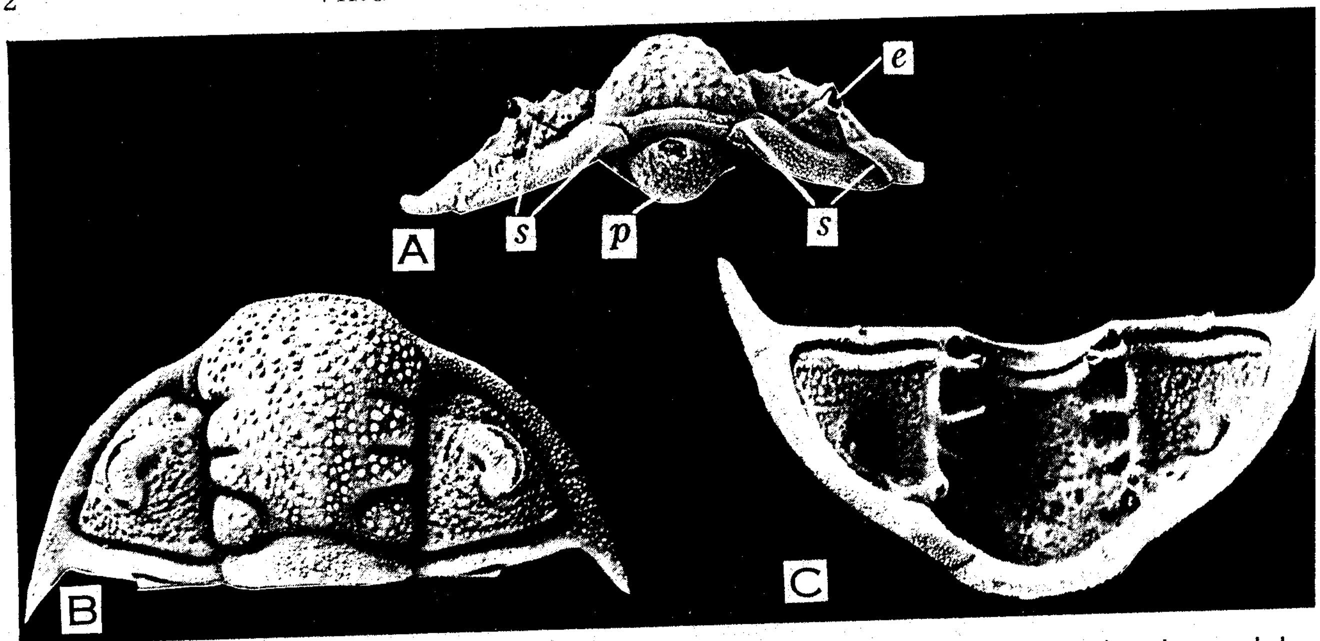

Figure 1—A, **Ceraurus,** front view of head. X 3. e, eye lobe; s, suture line; p, plate beneath he B, C, **Ceraurinella,** a trilobite closely related to **Ceraurus,** X 4½, top view of head o underneath view from front showing exoskeleton extending a short distance in fr edges, but plate beneath head is missing.

related to some of the modern marine arthropods, first appeared on the earth 500 million years ago, and are among its earliest known inhabitants. They became extinct toward the end of the Permian period, some 200 or more million years ago. The body (Figure 5J) included a head, on the upper surface of which were the prominent eyes, and beneath which was the mouth. Behind the head came a number of segments, between each of which was a movable joint. Following this thorax was a tail portion consisting of fused segments similar to those of the thorax. The raised, longitudinal middle region and the similar side regions form three lobes which give rise to the name trilobite. Like lobsters and crabs, trilobites had a shell on the upper surface which was of organic material strengthened by secretion of calcium carbonate. This shell extended on the underside for a short distance (Figure 1C), and also formed a plate beneath the head (Figure 1A). It is this shell, and this shell only, which has been replaced by quartz and is preserved in these Virginia trilobites. Specimens from other areas, preserved in a different way, have shown that on the under side of the body in trilobites there was a pair of walking legs on each segment. A branch from each leg, bearing many filaments, probably served as a gill. Extending forward from under the head were a pair of feelers. The walk limbs and gill branches seem to have been c ered by a thin but stiff organic exoskelet which was not strengthened by calcium carbor and so not replaced by quartz and preserved the Virginia specimens. The trilobite shel an exoskeleton, that is, it is on the outside of body. The soft parts are closely related tc and it acts as a protection and also as a r framework to which muscles may be attac Like an ancient suit of armor, it cannot be creased in size as the animal grows. It ha be shed at intervals and a new and larger s grown to replace it, a process which is fam in arthropods. Many of the Virginia fossils probably the remains of these moulted sh abandoned after being split along a special su line around the front (Figure 1A) which ena the animal to crawl out. These moults, probably also the decaying bodies of trilob lay about on the sea and probably were wa to and fro by currents. In most cases moulted exoskeletons broke up into sepa pieces, along the joints between the head, ments of the thorax, and the tail, and along suture line. Thus the residue of fossil mat that is obtained after dissolving the limes rarely contains a complete or almost com exoskeleton. A remarkable example of su shell (Figure 3A, B, C) lacks only part of the exoskeleton at the right front and the plate beneath the head—these have become detached along the suture line. Such specimens give us a wonderfully clear impression of what the trilobite body looked like. In the majority of cases, however, the bits and pieces of the shell have to be matched by a jig-saw process, which leads in the manner shown in Figure 5E, F, G, I, to the reconstruction (Figure 5J). To make such reconstructions individual specimens can be manipulated under the microscope using a wetted brush, or each part may be mounted on a pin and brought in close juxtaposition to its neighbor (Figure 5I). The shape of the parts, and the beautifully preserved sculpture on the outer surface of the shell, help in this process of matching and reconstructing. Unless the whole specimen is obtained the number of segments in the body cannot be decided upon, so there is a gap in the restoration in Figure 5J.

When the trilobite hatched out of the egg it was a minute spherical creature, perhaps like the early nauplius developmental stage of today's lobsters and crabs. The tiny animal probably floated and drifted about in the ocean, and quite soon an exoskeleton was formed on the upper or dorsal surface. Figure 5A shows an example of such a minute shield, less than 1 mm. in length, but showing the typical trilobite form—along the middle of the body runs the raised axial region, the regions by the side of it flattened and symmetrical; a division may also be seen between a larger head part and the smaller tail portion. Periodical moulting gave a size series of shells, such as those of the head shown in Figure 5B-E. Changes that take place in the outline and convexity of the axial region may readily be seen, as well as changes in the relative length of the spines on the border. In general the early stages are spinier, perhaps reflecting a floating mode of life, as opposed to a bottom dwelling mode of life when the animal grew larger. New segments are grown posteriorly in the tail portion, and as they become fully formed at the front edge they are released to become freely jointed between the head and tail. Thus the characteristic number of segments of each species is grown. Size series of some twenty species have so far been described, many from the earliest tiny shield to the adult. Many more such series remain to be described, and the material has provided a great increase in knowledge

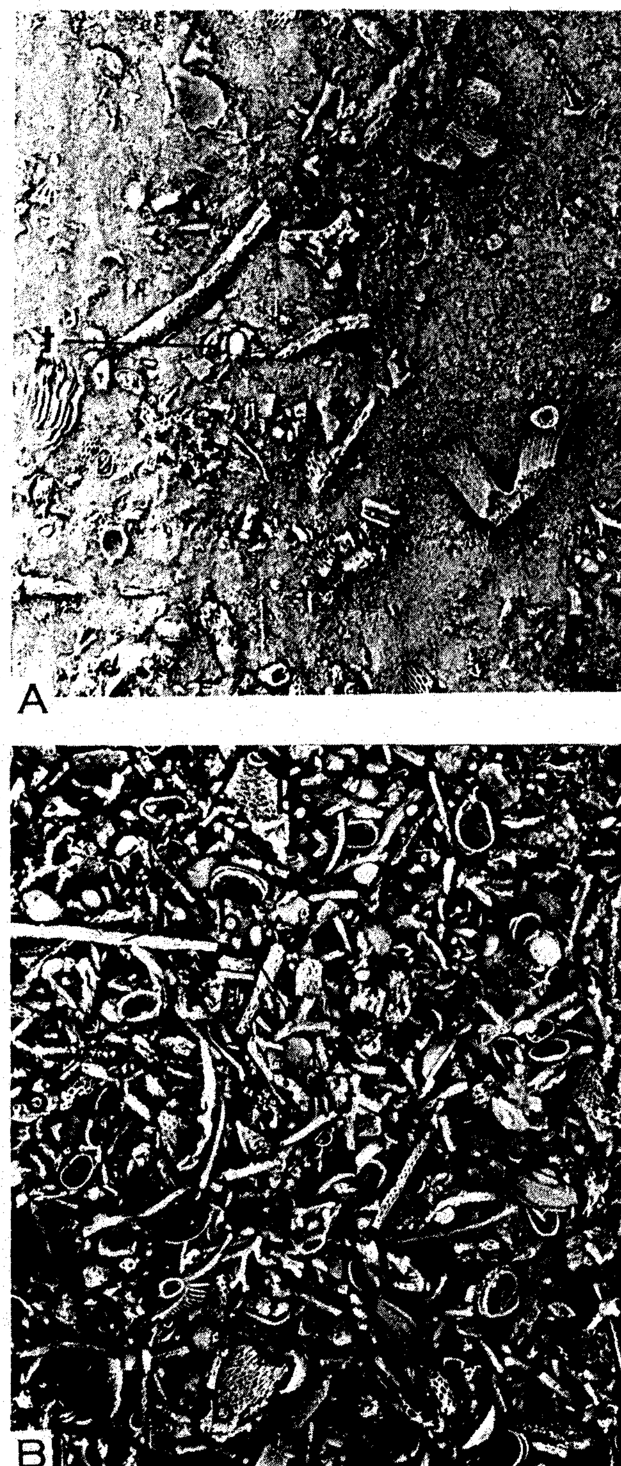

Figure 2—A, surface of block of Middle Ordovician limestone from near Strasburg, showing silicified fossils weathering out, X 3. B, residue of fossils obtained from dissolving block of limestone in acid, X 3. o = ostracod; b = bryozoan; t = trilobite.

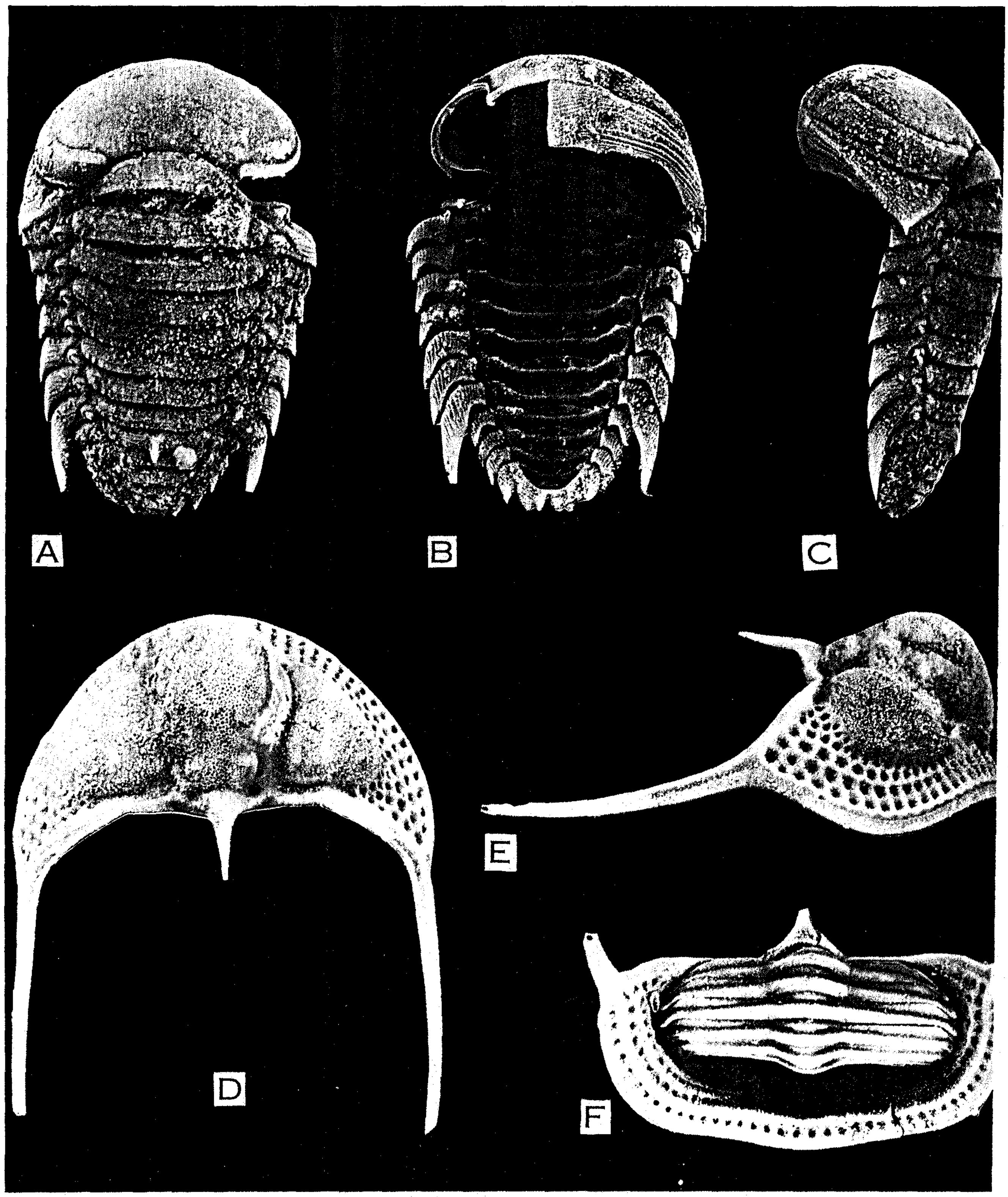

Figure 3—A, B, C, **Remopleurides,** top, underneath and left side views, X 4, of a remarkal complete exoskeleton.
D, E, F, **Cryptolithus,** top and right side views of a head, X 6; underneath view of co plete exoskeleton, body rolled up and tail tucked in out of sight, X 6.

way in which different kinds of trilobites oped.

e preservation of the fossils is of such fidelity minute details of the outer surface of the are revealed—spines (Figures 4, 5), and small spines on larger spines, raised lines tubercles (Figures 1, 3), and even canals ugh the shell in which in life sensory hairs probably situated. The eye in trilobites es in size, being exceptionally large in *Remo-rides* (Figure 3A-C, the eye being the rec-ular strip outlined by grooves on the side e head in Figure 3C), and was a compound composed of many facets. The hard covering this eye may preserve the shape and outline e facets (Figure 5H). Other trilobites, like *otolithus* (Figure 3D-F), did not have such , but the head is surrounded by a pitted ge. This fringe may have had some sensory tion, but certainly it propped the head in tion when the animal rested on the sea floor, long spines extending back from the fringe helping to keep the animal in position. The ies could be stretched out horizontally. *ptolithus* consisted of six segments and a small gular tail. Most trilobites had the ability nroll the thorax and tail underneath the head, limbs presumably being tucked inside so that hard skeleton formed a protective covering. specimen (Figure 3F) shows the body en-ed in this fashion, the tail being out of sight this picture. The plate that was situated be-th the middle part of the head often occurs lated. In an extremely rare specimen it is nd in place (Figure 1A). Such a specimen ws exactly how this plate fitted beneath the d, and the suture line along which the shell ned during moulting. The mouth was prob-y situated just above and inside the back edge the plate, the plate itself, with the swollen ddle part of the head, forming a capsule in ich the stomach and other organs were en-sed. Behind this the alimentary canal ex-ded back beneath the thorax to the tail. What known of the appendages of trilobites does not ggest that any were specialized (for example, ncers of a crab) for grasping food or cutting it up. Probably, therefore, trilobites l on the particles of organic matter in the mud the sea floor, perhaps burrowing in this mud stirring it up with the legs and creating cur-nts that carried food to the mouth. Such spiny ilobites as *Apianurus* (Figure 4) probably did not burrow in the soft mud of the sea floor, but the spines may have aided them to float and drift in the sea. That trilobites lived in shallow

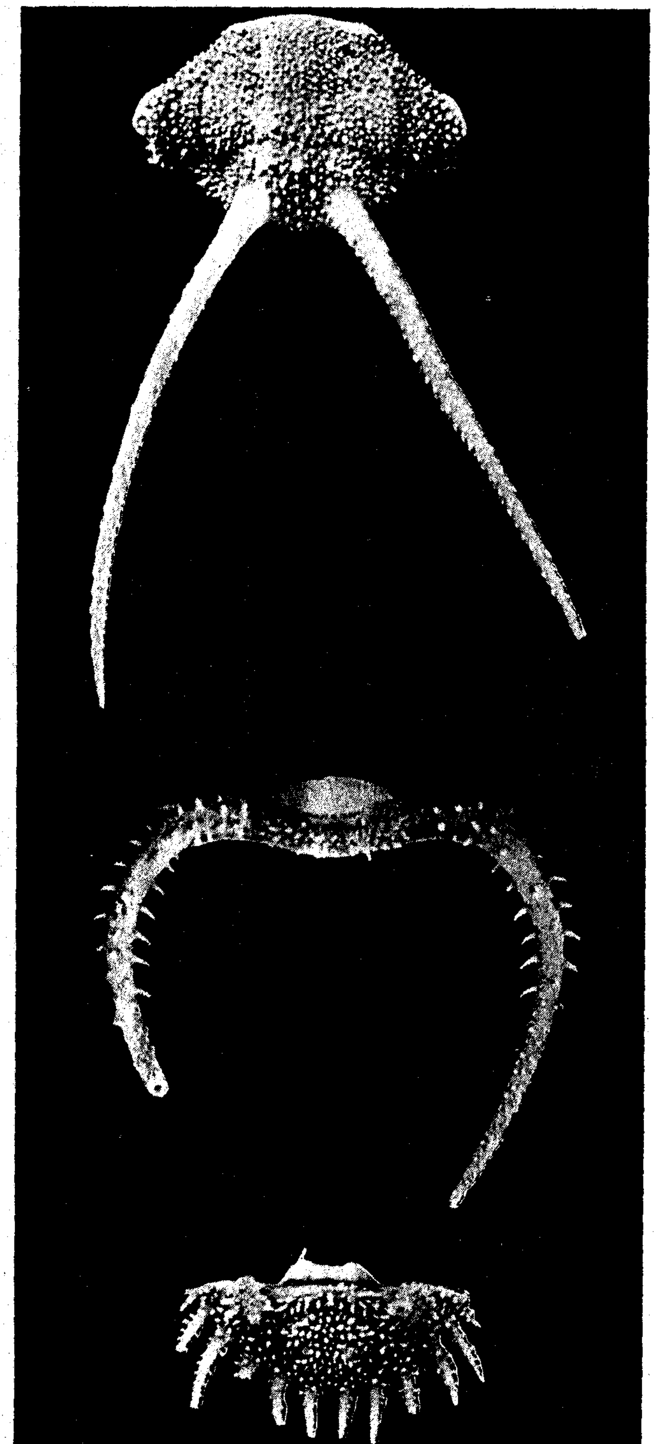

Figure 4—**Apianurus,** a spiny trilobite. At top is the middle part of the head, beneath this a segment and the tail, X 8.

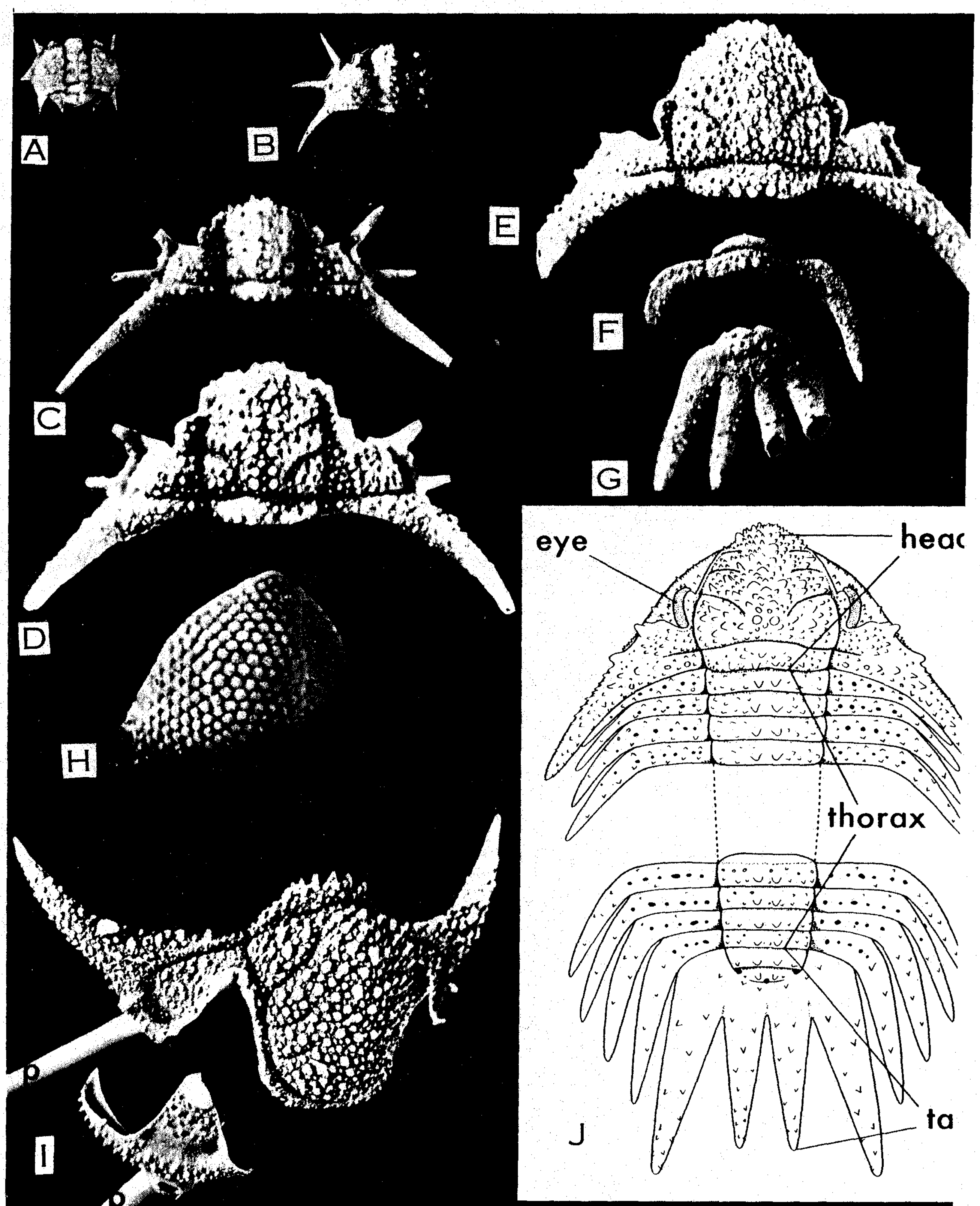

Figure 5—**Acanthoparypha.** A, the first-formed exoskeleton of the larva, X 20. B, C, D, size of the middle part of the head, X 20. E, F, G, middle part of head, X 9, a seg and the tail, X 7½. H, surface of compound eye showing facets, X 30. I, two of head mounted on pins (p) and placed close together to show how they fit, X reconstruction of exoskeleton, based on E, F, G, I and other specimens, number o ments in thorax not known.

marine waters can hardly be doubted. Fossils that occur with them include corals, brachiopods, and echinoderms, the descendants of which today are all confined to the seas and never occur in fresh water. That this sea in Virginia was somewhat muddy is shown by the amount of mud left when the limestone blocks are dissolved with acid. Probably this sea was shallow and the mud brought in from land not many tens of miles away.

Detailed examination of the limestones and sampling for blocks to dissolve in acid shows that the fossils do not occur uniformly throughout the rock. Some layers are almost barren, and in layers where they are abundant the fossils tend to occur in patches. This may be seen on the weathered bare surfaces of the limestone, and different blocks will produce very different quantities of silicified fossils. As has been suggested, it seems likely that the trilobite remains are partly from dead adult individuals but largely from moulted exoskeletons which were being winnowed and drifted about gently by currents. Such currents and sorting may account for the fact that large individuals (trilobites more than 1½″ in length) are rarely found, most of the material being small. The small specimens seem to have escaped damage by transportation, broken fragments attesting to the damage done to larger specimens. One may imagine drifted patches of these shells resting on the muddy sea floor and being gradually buried in fine mud, which was later cemented together with lime. Some time after the rock had become solid, the silicification took place, but where the silica came from, and when, is not known. The original calcium carbonate of the trilobite shells was probably replaced by quartz immediately the lime was dissolved, for only in this way does it seem possible to preserve with such fidelity the sculpture and structure of the shell. No distortion or loss of detail appears to have taken place. Today where the gray surfaces of the limestones are exposed in pastures and on slopes, rain water (which is a weak acid) dissolves away the lime and the silicified fossils project from the surface (Figure 2A). Such weathering takes a long time, much longer than the time that has elapsed since railroad and highway cuts were made. Thus much of our material has come from blocks that were picked up in natural exposures and showed abundant fossils weathering out. Another method that has been used in road cuts is to take samples at regular intervals and dissolve the limestone to see what may be yielded. It was in this way that Dr. Evitt discovered a trilobite fauna in dark limestone that showed little or no sign of fossils on the outer surface.

Paleontologists are always searching for more and better preserved specimens that will tell them in more detail the nature of ancient animals and afford clues to the way in which these animals lived. In many rocks no amount of searching or care in preparation will yield either well preserved or abundant material. The great value of these finds in Virginia lies in the exquisite preservation and large numbers of fossils available. It is like a searchlight illuminating a dark corner of the ancient sea floor. Thus we know that some 350 million years ago a fauna of some 40 kinds of trilobites was present in the seas that covered the Shenandoah Valley. Through the successive layers of rock we can trace the changes that took place in the numbers and kinds of these trilobite populations with the passing aeons. The details of what these trilobites looked like are infinitely better known than those of their contemporaries in seas in other parts of the world. Not only this, but we know what their growth stages were like, and the nature of these stages affords a valuable clue to relationships of different kinds of trilobites.

In trying to identify some of these trilobites, I studied photographs, descriptions and specimens from rocks of a similar age in Scotland, the Scandinavian countries and Estonia, and found trilobites of astonishingly similar appearance to those in Virginia. Because of these similarities, it is believed that the rocks are approximately of the same age. If this is so, then there can be little doubt but that the shallow seas of Virginia were connected at that time to the seas of northwestern Europe. Whether or not the ocean over this long distance was everywhere shallow, is less certain. Perhaps if there were occasional deep waters the floating, early developmental stages of the trilobites could be carried across the deep water by the currents, to settle and grow up in shallow water in a different place.

As in all scientific discoveries, much work remains to be done, and while some questions are answered other new questions are raised. Because of their perfection these unique fossils from Virginia are of interest to paleontologists all over the world, and their discovery has added significantly to our knowledge of the ancient world.

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New Publication

Bulletin 75. GEOLOGY AND GROUND-WATER RESOURCES OF PITTSYLVANIA AND HALIFAX COUNTIES, VIRGINIA by Harry E. LeGrand. 87 p., map. Price: $1.25

Ground water in Pittsylvania and Halifax counties is utilized by about two-thirds of the population. It is used in all rural areas, some industrial areas and the town of Halifax. Surface water is used by the municipalities of Chatham, Danville, Gretna, and South Boston.

These counties are located in the south central part of Virginia and are in the Piedmont province. Topography within these counties consists of low, rounded hills with gentle slopes and a few isolated ridges. Three rivers in the counties, the Roanoke River to the north, the Bannister River in the middle, and the Dan River to the south, flow eastward in channels that were cut more than 100 feet below the upland area. These rivers receive drainage from a close network of tributary streams. Parts of all streams flow directly on bedrock and other parts flow over a few feet thickness of channel sand. Flood-plain deposits that contain an upper zone of clay and a lower zone of sand and gravel, occur as bordering parts of all streams. Bedrock is exposed on many steep slopes adjacent to valley floors. A residuum that is composed of surface soil and as much as 60 feet of soft weathered rock covers much of the upland area.

The geology of the counties is described, and the structural and topographic characteristics of the bedrock are shown to be important factors that govern the yield of individual wells. The water table generally occurs in soft weathered rock, a few feet above the hard fresh rock much of which is fractured. Small amounts of water are obtained from dug and bored wells in soft weathered rock. Adequate domestic supplies are obtained in most cases from drilled wells in fractured hard fresh rock. Drilled wells range in yield from less than one gallon per minute to more than 100 gallons per minute; they range in depth from about 60 to 500 feet.

The amount of water available from a particular well is correlated with the surrounding topography. The average yield of wells located in draws is several times that of wells on hills and more than that of wells in other topographic locations. More than 90 percent of the wells are drilled in hilly, upland areas where conditions are unfavorable for large supplies of water.

The withdrawal of water from wells is only a fraction of that available for recharging the underground reservoir. Recharge, derived from about 44 inches of rainfall annually, occurs in the upland areas; discharge occurs mainly in adjacent lowlands. The annual recharge and discharge are in balance, and therefore there is no increase or decrease in the annual trend in the fluctuation of the water table.

Good quality water is obtained from fracture zones within schists and gneisses. Water from only a few wells contains objectionable amounts of the iron impurities. Water from wells in Triassic sediments is hard in many cases.