omitted to mention the free cheeks of that species. Now, if we turn to his fragment of *Zethus*, figured in his book, and by comparing it with the specimens which are now on the table, and a drawing of which there is on the wall, it will be seen that his fragment of *Zethus* is actually the free cheeks of his *Encrinurus expansus*; at any rate, I am able to present you with a complete specimen (so far as a Trilobite has been found complete) of this new species of *Encrinurus* from the Pentland beds. In shape it is broadly ovate; length, about an inch and a quarter; breadth, two-thirds of the length; cephalic shield semicircular, tuberculated, posterior angles rounded; the glabella pear-shaped, convex, and covered with tubercles, and punctured between the tubercles; large tubercles, occupying the place of lateral lobes; cheeks triangular, convex, and embracing the front of the glabella; eyes pedunculated, and placed between the centre of the cheek and the glabella, obovate, and covered with a fine net-work of facets,—a character which has never been well determined in the genus *Encrinurus*, but is easily distinguished in this specimen, about twenty facets occupying the same amount of space as one of those of *Phacops Stokesii*; facial suture, which is easily distinguished in this species, runs along the anterior margin of the glabella, to the anterior lobe, when, with an oblique curve through the cheek behind the eye, it comes out in front of the posterior angles; labrum ovate, limb produced to the anterior margin of the glabella; body composed of eleven rings, slightly tapering; axis about one-fourth of the width of the body; axial furrows deep; pygidium triangular, of seven pleuræ, ending in a recurved mucro-axis, smooth in the centre, tapering to a point, with one or two faint tubercles near the top.

There are several other fragments of Trilobites in these beds, but I have not as yet been able to determine the species, though hopeful to be able to do so at some future time.

III. *Short Notice of the Discovery of Specimens of Strophomena Walmstedii in the Silurian Beds of the Pentland Hills.* By D. J. BROWN.

IV.—*On the Silurian Rocks of the Pentland Hills.* By Messrs D. J. BROWN and JOHN HENDERSON. *With Notes on the Brachiopoda.* By THOS. DAVIDSON, F.R.S., F.G.S.

Although a great many of the rocks of Scotland belong to the Silurian system, most of them belong to the lower division, those belonging to the upper divisions being best developed in Lanarkshire and in the sections occurring in the Pentland Hills. When

Edinburgh was the centre of the controversy between the Huttonians and the Wernerians, the rocks of the Pentlands were doubtless often explored and discussed. These for the most part were the *igneous* rocks of which they are mostly composed. But it is in Mr Maclaren's "Geology of Fife and the Lothians," under the name of "Vertical Greywacke," where we first get anything like a detailed account of them. We are also indebted to Mr Maclaren for the first notice of fossils from them, he having discovered an *Orthoceras* in the beds. From this, and another speci-

men found by Mr Geikie, Sir R. Murchison, in the last edition of his "Siluria," speaks of them as Wenlock; but, from the materials at his command, Murchison's determination of the age of the beds could be little more than a guess. From the publication of Mr Maclaren's book, the Silurian rocks of the Pentlands seem to have excited little interest until the publication of the Memoir of the Geological Survey, which gives us a short but very good description of the beds, and in the appendix we get a list of the then known fossils, accompanied by a plate. Mr Salter's list contained several new species, which he could not describe, owing to his being limited to a single plate. In the Survey's Memoir we get the best information regarding these beds. Shortly after its (the Memoir's) publication, there was a paper read before this Society by Mr G. C. Haswell, upon the largest patch that occurs at the North Esk reservoir. This paper he has since published. It being later than the Memoir, the supposition naturally is that it would have been a clearer and better exposition of the beds. Mr Haswell's paper, however, contains so many errors, or what has appeared to us in our investigations to be errors, that we cannot look upon it as having added to our knowledge of the subject to any great extent. To show what we mean, we will point out one or two of these errors. Mr Geikie discovered in the Pentlands a *Theca*, of which there is a figure given in the Memoir. The *Theca* was found at the section near Bevelaw Castle, consequently in the lowest beds of the series. So far as we know, Mr Geikie's specimen is the only one that has been found. Regarding this organism, Mr Haswell says that they occur in great abundance (though badly preserved) in what he styles the Deerhope Burn section, which is much higher in the series. He may have found them there in great abundance, as he says, but the officers of the Survey did not find them, nor have we; and as

Mr Haswell has reproduced the surveyor's figures, we have no other alternative but to hold it an error, till we know of an undoubted specimen of *Theca* being got from this part of the section. Regarding this same organism, Mr Haswell terms it crustacean, whereas it is generally by palæontologists termed a pteropod; he may be right in this, and the palæontologists wrong, but in differing from them so widely, he should have given his reasons, which he has not done. Mistakes such as these make Mr Haswell's paper of much less weight than it otherwise would have been in any discussion on these beds.

Since the publication of the Memoir, the number of species found in these beds have very much increased, which tends to excite greater interest in them; and as investigation goes on, it shows that they are—if not the most prolific—at least equal to any in Scotland. Considering the extent of surface exposed, they will yield more species than any of the Girvan sections, and we hope to be able to show you that they represent a part of the Silurian series better developed than in any other part of Scotland. Such being the case, and we being able to bring forward a more numerous list of fossils, enabling us better to determine the age of the beds, and other new facts that were not known at the time the Survey published their Memoir, we thought a paper on the subject would be interesting to the Society.

The Silurian Rocks within the Pentlands.

The upper Silurian rocks in the Pentlands, as described by the Survey, occupy three or probably four separate patches, the largest and most prolific in fossils occurring at the North Esk reservoir. At the section occurring at Habbies How we have not been able to find any fossils, but at Bevelaw Castle section, in one of the ravines in the same series, where Mr Geikie found his *Graptolithus priodon* and *Aythya compressa* (*R. compressa*) we have only been able to find the latter form, although we found many forms too imperfect for identification. From finding both the *G. priodon* and *A. compressa* in the lower beds of the Esk section, and from their mineral character being much the same, it shows very conclusively that the Bevelaw and Habbies How sections are the equivalents of the lower one occurring at the North Esk, so that description of the North Esk section includes the whole Silurian rocks of the Pentlands, excepting those in the Lynn Water.

The Silurian Patch at the North Esk and Lynn Water.

The Silurian patch occurring at the North Esk and Lynn Water has an elongated form on the map, with the river Esk cutting it at nearly right angles, and as the rocks strike obliquely

across the patch, it brings out the lower beds at its eastern end; that is, in the section formed by the Esk river. Though it is the only continuous section to be found, it does not cut the whole of the beds, for though it exposes them at nearly their lowest point, it breaks off before bringing in the highest beds. During last summer we examined every bed from the base of the section to the top of the river Esk, but we have not been able to overtake the Lynn Water section, so that our reason for placing them highest in the series is based on inference. We meant to explore them this summer, and put what we now bring forward concerning them to the test of facts; we did attempt it towards the end of last year, but we found the hills covered with snow, and of course had to give up all hopes of further explorations at that time. We have prepared a diagram which shows that when the beds are carried out according to their strike, the Lynn Water beds are seen to occupy a very high place in the series, coming in above the red beds, termed by Mr Geikie the base of the Old Red Sandstone, but which we expect will prove to be only a series of red sandstone and conglomerate beds occurring in the Ludlow series. These red beds on the map come down into the Silurian in a sort of triangular form, but this is not their true position, for we have traced them a great deal further than Mr Geikie has them marked on the map. We opened up the rocks on the hillside nearly half way across the place marked Silurian, and found the red rocks there, where they are not put in on the map, and we conclude from this that they stretch across the whole area. At the same place we found fossils in the red beds, viz., *Entomis tuberosa* and *Platyschisma simulans*, or *Trochus helicitus*.

Description of the Sections formed by the Esk River.

The following is Mr Geikie's description of the sections formed by the river Esk:—

"The series, when thus examined (*i.e.*, going from Carlups) up the stream, is an ascending one, as shown in the section (given in the Memoir). The lowest beds are green, grey, and reddish shales, with bands of grit and sandstone (A), which contain abundant remains of *Dictyocaris*, a large crustacean. These beds extend from where the Silurians first appear, to the quarries below the mouth of the second rivulet above the reservoir, as they are at very high angles all the way. The thickness of this portion of them, after making allowance for one or two flexures, cannot be less than 2500 feet. The quarries referred to have been opened in a band of hard sandstone and quartz grit (B). The lowest beds of these quarries contain a shell like *Trochus helicitus*, an *Orthoceras*, *Mytilus*, *Orthonota*, *Avicula*, &c. A shaly band in the centre of the large quarry contains *Orthonota amygdala*.

lina, and the hard felspathic and quartz grit which lies above this band show numerous fragments, which look like fish plates, along with Encrinites and some obscure bivalves. The thickness of these arenaceous beds is probably about 200 feet, above them comes a group of olive and brown sandy shales and sandstones (C), weathering with a concretionary structure, and usually full of well-preserved fossils. These beds become less concretionary higher up, until, about half a mile below the Bore stane, they pass into soft red shale and red conglomerate. (D), The base of the lower Old Red Sandstone, which is here overlaid unconformably by the upper Old Red and Carboniferous Sandstones. From the middle zone of grit to these red shales there cannot be less than 1000 feet, so that the entire thickness of upper Silurian strata visible in this locality is probably from 3500 to 4000 feet." In our section the letters B C E and F, answer to the A B C and D, of the Survey's section. At A, in our section, which is a grey sandy shale at a small knot nearly opposite the cottage at the reservoir, we found (partly by the assistance of Mr John Garnock, occupant of the cottage), specimens of *Aythya compressa*, *Graptolites priodon*, and *Retiolites Geinitzianus*. The first of these is a well-known Wenlock fossil, and the latter occurs in great abundance at the base of the Wenlock formation, and indeed is confined to the Wenlock shale. Coming higher up the section we come to the Dictyocaris beds of Mr Geikie. The water of the reservoir covers up the section here, but we find the rocks well exposed in the bed of Gutterford burn, and though the fragments of Dictyocaris occur in great abundance, they are generally not in a good state of preservation. Returning to the other side, after passing the trap dyke mentioned by Mr Haswell, we come to a number of beds which have as yet yielded no fossils; these are succeeded by the beds of sandstone and conglomerate (C), which contain the fossils mentioned by Mr Geikie. However, we have not been able to confirm Mr Salter's doubts about fish plates, as we have found nothing that could be identified as belonging to fish. Immediately above these grit bands comes a bed of greenish marly shale; this bed has not been noticed by Mr Geikie, neither is it noticed in Mr Haswell's paper. This bed (or beds) has a peculiar structure, and weathers into cubical fragments. When unweathered, it is very tough, and not easily broken. In it you sometimes meet with little pebbles of quartz. Although they can scarcely be called conglomerates, they are full of well-preserved fossils, belonging to many genera and species; the genus *Strophomena* is the most abundantly represented. There also occur in it many well-known Wenlock fossils, and the whole fauna has a strongly-marked Wenlock facies. Immediately above this or these beds come some beds of brown shale or mudstone, exposed in a small scar made by the Esk.

The Esk at this place, both in the Survey's Memoir and Mr Haswell's paper, is termed *Deerhope Burn*, but this is a mistake. At this little scar the beds are full of well-preserved fossils, having *Leptena* very abundant in the lower beds. Above these, at F., we have beds with large specimens of *O. Maclareni* and a *Spirifera*, with very fine striations, and a *Pterinea* above these. At G we found a specimen of *Lingula lata*. Passing over some beds that have as yet yielded no fossils, we come to H, where we get a series of beds yielding a *Rhynchonella* in great abundance. This Rhyn. was figured by Mr Salter without giving it a name. Mr Haswell calls it *Rhyn. Pentlandica*. This shale is accompanied by *Spirifera crispa*, a well-known Wenlock Ludlow form, and also by a Trilobite, and numerous fragments of large crustacea belonging to the Eurypteridæ. These beds are succeeded by loose yellow sandy beds, which very much resemble Gilmerton yellow sand; these yield abundant large *Entomes* and whorled shells. These shells, as far as we can make them out, resemble the *Trochus helicitus* of the Ludlow rocks. These yellow beds pass into the red beds (the lower Old Red of Mr Geikie), with which they are quite conformable; we have ascertained this by opening the junction at two separate places. The first of these red beds is a soft red shale, with numerous fossils at one place where we opened it up, on the side of Deerhope Hill, the *Entomis tuberosa* and *Trochus helicitus* above mentioned, but, like the yellow beds, their fossils are not well preserved. Professor T. Rupert Jones has identified the *Entomis* as *E. tuberosa*, and a Ludlow species. Above these come red conglomerate and sandstone, which continue till they are overlaid by the upper formation of the hills. All these beds strike obliquely across the valley of the Esk, which runs nearly parallel with the valley of the Lynn Water; and should there be no break in the rocks, the higher beds of the section should be brought out in the Lynn Water valley. We have followed the beds by making openings in the hill side, half way across the hills that separate the valleys, and have found the rocks intact; and as the Survey's map brings in the Silurian rocks in the Lynn Water, we have come to the conclusion that they are the higher beds of the section, coming out above the red beds, and that Mr Geikie's lower Old Red Sandstone beds are just a series of red beds in the Silurian rocks; but this subject requires further research in the Lynn Water, which we intend doing next summer. This, at any rate, we are sure of, that we have found the Silurian fossils in the red beds, and that in our numerous catalogue of fossils there is only a single form, *Beyrichia Kleidoni*, and it occurs in beds D and E. It is also a form common to the lower rocks belonging to the passage beds of Sir R. Murchison; and also, that the triangular shaped way the red rocks are brought in on the map is an error,

for, as we said before, we have traced the red rocks half way across the hills, and were only prevented from tracing them farther because of their being covered up by the overlying rocks on the top of the hills, and a dense coating of peat moss on the other side.

The Age of the Beds.—These Silurian rocks of the Pentlands were by Mr Maclaren termed Greywacke, and said to be of transition age. Later, when Mr Geikie had discovered a specimen of *Aythya compressa* (*R. compressa*), Sir R. Murchison regarded them of Wenlock age. The Geological Survey, in their Memoir, term them of Ludlow age, and the equivalent of the Lesmahagow beds. Mr Haswell in his paper seems to have arrived at no definite conclusion, but hovers between Wenlock and Ludlow, although in his table he includes both the Ludlow and Wenlock. We have taken the fossils from each bed and tabulated them, and the conclusion we have arrived at is, that from the base of the section at the North Esk, in which beds we found *Graptolithus priodon*, *Retiolitus Geinitzianus*, and *Athyris compressa*, up to the beds where the *Leptena transversails* dies out (beds E. and F), are all of Wenlock age, after which they gradually pass into the Ludlow. At H, where fossils are plentiful, they are either of Ludlow age or new to the beds. No passage-bed fossils are found in them; and since these Ludlow fossils pass into the red beds, we hold them as forming part of the Ludlow division, as developed in this locality. Not having examined the Silurian rocks in the Lynn Water, we are unable to state the thickness of the Ludlow, though we hope to be able to do so next year. These conclusions as to the age of the rocks have been arrived at principally through fossil evidence. We have collected a great number of species from these beds, above a hundred (the Survey records about fifty) that we have been able to name, the others left unnamed in many cases from want of books of reference. We shall now give you a brief analysis of the tables we have prepared. The position of the species in the Silurian rocks have been taken from Murchison's *Siluria*, as the most reliable source of information on this point. In making our analysis we may state, that we are most inclined to rely on the evidence derived from the Brachiopoda,—first, because they are the most numerous; second, because through the labours of Mr Davidson, they are the best known class of fossils; and lastly, because Mr Davidson has given those from our Pentland beds a most thorough investigation, hence they are the most reliable. Of Brachiopoda we have 25 species, only one (*R. pentlandica*) of which is undoubtedly new. Twenty of these are Wenlock species, eighteen of which we found in bed D. Ten species pass up to the Ludlow, only one of which is exclusive, Ludlow *Lingula lata*; of the other eight we found six in what

we consider the Ludlow beds. Of the other forms of life, the next in importance are the crustacea, of which we have 12 species. Five are undetermined or new; two are exclusively Ludlow, one (*Slimonia acuminata*), found in bed H; the other (*Entomis tuberosa*) begins at bed D, and passes up into the red beds. Through the kindness of Professor Rupert Jones, we have been able to determine all the forms belonging to the Entomostraca, of Polyzoa, and Zoophyta. We have a number from these beds, but of only about six are we able to determine the species. One of these (*R. Geinitzianus*) has been previously brought before the Society as new to Scotland; we found it at the base of the section at the North Esk reservoir. Of Gasteropoda we have 11 species, five of which are new; one of them (*Platyschisma simulans* or *Trochus helicitus*) passes into the red beds; five are Wenlock, all found in bed D; and one exclusive Ludlow, from the same bed. Of Pteropoda, Heteropoda, and Cephalopoda, we have 15 species, many of which are new. Of *Lamellibranchiata* we have about 19 or 20 species, many of which are new; but what is remarkable in this class of life is, that six appear to be exclusive Ludlow, all of which are from bed D, that we think Wenlock. We must, however, observe of these bivalves, that they are very difficult to deal with, from the difficulty of investigating them, and from no one having specially devoted attention to them. Hence, though they go a considerable way against our conclusions, still, until they are better investigated, we must regard them as of minor importance.

Conclusion.—We will now briefly give you the results at which we have arrived, after making the subject our most particular study. First, as to the age of the beds, we think (taking the section of the Esk as our guide) that from the base of the section up to the bed E, we have beds of the Wenlock age; from bed E we pass into the Ludlow, and that all the remaining Silurian rocks in the North Esk section are included in this division. Second, that the *red beds*, containing as they do Ludlow fossils, are only a part of that division, and are not the lower division of the Old Red Sandstone. Third, that the map of the Geological Survey is wrong in having the red beds cut off, and made to appear as if they did not continue across the whole area, the same as the other beds. Fourth, that the Silurian rocks on the Geological map in Lynn Water, lying above the red beds, are the upper beds of the Ludlow.

ON THE SILURIAN ROCKS OF THE PENTLAND HILLS.

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	Caradoc.	Llandovery.	Wenlock.	Ludlow.	Passage Beds.	PENTLAND HILLS, WENLOCK, LUDLOW.								
						A	B	C	D	E	F	G	H	I
CRUSTACEA.														
<i>Slimonia acuminata</i>				x									x	
<i>Dictyocaris Ramsayi</i>						x								
<i>Entomis tuberosa</i>				x					x	x	x	x	x	
<i>impedens</i>									x	x		x	x	
<i>Beyrichia Kledeni</i>		x	x	x	x				x	x		x	x	
<i>Cythere umbilicata</i>									x	x				
<i>Antifopsis</i> (Bra.)													x	
<i>Phacops Stokesii</i>		x	x	x					x	x			x	
<i>Calymene Blumenbachii</i>	x	x	x	x					x					
<i>Encrinurus</i> sp.									x	x			x	
<i>Turrilepas Wrightii</i>			x							x				
sp.													x	
CEPHALOPODA.														
<i>Orthoceras Maclareni</i>											x			
<i>subundulatum</i>	x	x	x	x									x	
<i>gregarium</i>				x									x	
<i>excentricum</i>			x						x					
<i>angulatum</i>	x	x	x	x					x	x				
sp.									x					
sp.									x					
sp.									x					
<i>Phragmoceras compressum</i>		x	x	x					x					
<i>Lituites</i> ? sp.									x					
GASTEROPODA.														
<i>Acroculia antiquata</i>										x	x	x	x	
sp.										x	x	x	x	
<i>Euomphalus fanatus</i>		x	x	x					x	x				
<i>sculptus</i>			x	x					x	x				
<i>rugosus</i>			x						x					
<i>alatus</i>			x	x					x					
sp.									x					
<i>Loxonema elegans</i> ?				x					x					
<i>Holopella obsoleta</i> ?		x	x	x			x	x	x				x	
<i>tenuicincta</i> ?			x						x					
<i>Cyclonema</i> sp.									x	x				
sp.									x					
<i>Platyschisma simulans</i>							x	x	x				x	x
<i>Pleurotomaria</i> sp.								x						
<i>Bellerophon expansus</i>				x									x	
<i>dilatatus</i>	x	x	x	x					x					
<i>carinatus</i>		x								x				
sp.									x					

	Caradoc.	Llandovery.	Wenlock.	Ludlow.	Passage Beds.	PENTLAND HILLS, WENLOCK, LUDLOW.								
						A	B	C	D	E	F	G	H	I
PTEROPODA.														
Conularia Sowerbyi	x	x	x	x							x		x	
sp.									x					
Crytolites sp.									x					
sp.									x					
Theca sp.					x									
LAMELLIBRANCHIATA.														
Pterinea retroflexa		x	x	x							x	x	x	
asperula			x	x					x					
tenuistriata			x	x					x					
sp.									x					
Mytilus mytilimeris		x	x						x					
Orthonota truncata				x					x					
impressa				x					x					
amygdalina				x					x					
bulia									x					
rigida				x					x					
rotundata				x					x					
thracioides							x							
Anodontopsis bulla		x	x	x					x	x				
lucina				x					x					
Cucullella antique				x					x				x	
Ctenodonta obesa									x					
sp.									x					
sp.									x					
Goniophora cymbæformis				x					x					
BRACHIOPODA.														
Lingula lata				x									x	
Discina rugata			x	x						x				
Crania implicata		x	x	x						x	x			
Spirifera exporrecta		x	x	x						x			x	
crispa		x	x	x						x			x	
Aythis compressa						x	x							
Meristella Maclareni ?													?	
Nucleospira frustum			x						x	x				
Atrypa reticularis		x	x	x					x	x				
Rhynchonella Wilsoni		x	x	x					x					
nucula		x	x	x					x					
Pentlandica									x?				x	
borealis			x						x					
Orthis elegantula	x	x	x	x					x	x				
Lewesii		x	x						x					
biloba	x	x	x						x					

ON THE SILURIAN ROCKS OF THE PENTLAND HILLS.

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	Caradoc.	Llandovery.	Wenlock.	Ludlow.	assage Beds.	PENTLAND HILLS, WENLOCK, LUDLOW.								
						A	B	C	D	E	F	G	H	I
BRACHIOPODA—continued.														
Orthis polygramma		x							x	x				
Strophomena pecten	x	x	x					x	x					
rhomboidalis	x	x	x	x				x	x					
antiquata	x	x	x					x	x	x				
applanata		x	x					x	x					
compressa		x						x						
Walmstedii			x					x						
Leptena transversails	x	x	x					x	x					
Maristella tumida								x						
Chonetes lata		x?	x	x				x						
Orthis sp.								x						
Strophomena sp.									x					
ECHINODERMATA.														
Protaster Sedgwicki				x									x	
POLYZOA.														
Ceriopora granulosa			x					x	x					
Ptilodictya fucoides	x							x						
Graptolithus priodon	x	x	x	x		x								
Retiolites Geinitzianus			x		x	x								
ZOOPHYTA.														
Petraia subduplicata	x	x						x						
sp.								x	x					
Stenopora fibrosa	x	x	x	x				x	x					
Chaetetes Fletcheri			x					x						
Favosites alveolaris	x	x	x	x					x					
PLANTÆ.														
Chondrites verisimilis									x					