the earth from equator to poles in the more ancient geological periods. Underground heat, though certainly greater in the earlier geological times, cannot, as I have shown elsewhere,* have ever sensibly influenced the climate. Ten, twenty, thirty times the present rate of augmentation of temperature downwards could not raise the surface temperature of the earth and air in contact with it by more than a small fraction of a degree Fahrenheit. The earth might be a globe of white hot iron covered with a crust of rock 2000 feet, or there might be an ice-cold temperature everywhere within 30 feet of the surface, yet the climate could not on that account be sensibly different from what it is, or the soil be sensibly more or less genial than it is for the roots of trees or smaller plants. Yet greater underground heat is the hypothesis which has been most complacently dealt with by geologists to account for the warmer climates of ancient times. The one hypothesis of all hitherto suggested that has received no favour from any professed geologist is that of a warmer sun—the one hypothesis that is rendered almost infinitely probable by independent physical evidence and mathematical calculation.

XVIII.—NOTES *on the FOSSILS OF THE ORCHARD LIMESTONE*
SERIES. By JAMES ARMSTRONG and JOHN YOUNG, F.G.S.

[Read 13th May, 1875].

IN this paper we purpose giving a list of all the named fossils from the shales and limestone of the Orchard series, so far as known to us. The Orchard limestone, so called from having long been worked as a valuable cement on the farm of Orchard, near Pollokshaws, Renfrewshire, lies at the base of the upper limestone series in the coal basin of the Clyde. In the district south of the Clyde it is known in different localities under different names, viz., as the Lyoncross limestone at Nitshill and Barrhead, and as the Williamwood limestone at Cathcart. Orchard, however, is the place where it has been longest worked, and where it has been most thoroughly explored for its fossil remains, and where specimens may still be obtained at the workings, or by searching the old shale heaps. As already

* "Secular Cooling of the Earth," Trans. R.S.E., 1862, and Thomson and Tait's Natural Philosophy, Vol. I., App. D.

stated, it is a cement limestone of the calmy variety, and in the above districts varies from 18 to 30 inches in thickness, being sometimes separated into two bands by a thin parting of shale. It is of a bluish-grey colour when newly quarried, but on exposure to the atmosphere it weathers into a yellowish-grey, from the presence of a little iron in the stone. It is worked both by open cast quarries and by mining, and is burnt in open kilns, and afterwards ground to a powder before being sent to the market. It sets with a strong band under water, and brings a good price as a hydraulic cement, although its rather dark reddish-brown colour prevents it from being as largely employed for external work as the lighter coloured Portland cement from England.

Taking the Index or Cowglen limestone of the Pollokshaws district as the lowest limestone of the upper limestone series of the Clyde coal basin, we have, in ascending series over it, first, the thick-bedded sandstones of the Giffnock and Bishopbriggs quarries; second, a little higher in the series, the Orchard cement limestone and shales; and third, the Arden and Robroyston limestone on a still higher horizon; the latter being made the boundary stratum between the higher beds of the carboniferous limestone and the millstone grit group. This upper group of limestones, with their accompanying strata, forms a well marked division between the overlying millstone grit on the one hand, and the underlying coals and ironstones on the other, these latter in their turn resting on the lower group of carboniferous limestone strata. The stratum of impure cement limestone found overlying the sandstone of the Bishopbriggs quarries north of the Clyde is believed to be the equivalent of the Orchard limestone; but with the accompanying shale, is much more ferruginous and arenaceous. It is held in little esteem as a cement, only a small quantity having been brought to market; but, nevertheless, is laid aside in heaps at the quarries, with the expectation that should richer cements become scarce in the district, it might rise in value. These cement heaps at Bishopbriggs quarries, from their bright orange-brown colour when weathered, afford a strong contrast to the sandstone heaps which are of a white and whitish-grey colour.

The differences of this cement stratum in the districts north and south of the Clyde may have been produced by varying conditions of the sea bottom at the period of deposition; that at Bishopbriggs having probably been laid down in shallower water.

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These varying conditions have also effected to a certain extent the character and distribution of the marine life present, the upper thin band of cement-stone at Bishopbriggs being characterized by the occurrence of *Myacites* and *Pinna* in the erect position in which they lived in the deposit, while these shells are absent in the lower stratum of cement at this place, as well as in the limestone at Orchard. The list of species given at the end of our paper shows the species that are found in these beds north and south of the Clyde, as well as those that have only been found in one or other of the localities.

The Orchard limestone, like many of the cement or calmy limestones of Western Scotland, is not rich in fossils, and we are not aware that it contains any species which has not been found in the more rich overlying fossiliferous shale. It is therefore more a chemically than an organically formed limestone, its few fossils only occurring throughout the bed at intervals, in a crushed and often poorly preserved condition. The shale, above the limestone, in which the fossils are found is of a dark bluish-grey colour. It forms only a comparatively thin bed, and passes upwards into a dark clay shale of a slaty structure, in which few fossils are to be obtained. It breaks up readily into a soft clay under the influence of the weather, and while in this state it can either be readily washed for the more minute organisms, or searched upon the old shale heaps for the larger forms, the shale heaps having yielded from time to time many interesting specimens. As the locality is within easy reach of members of this Society, it has consequently been often visited; we are therefore able to give a more complete list of the organisms it contains, than of localities that lie at a greater distance from the city. It may here be remarked that the Orchard shale is rich neither in species of crinoids, corals, nor polyzoa, its characteristic fossils being shells of the univalve and bivalve groups, along with Entomostraca and Foraminifera, these latter groups of organisms never being so abundant in strata in which crinoids, corals, or polyzoa abound. Such being the case, it points to the conclusion that depth of water, temperature, and nature of the sediments laid down over the various areas of the carboniferous old sea bottom, may each have had their influence in regulating the kind of life that flourished over the several tracts.

CATALOGUE OF THE ORCHARD FOSSILS.

PLANTÆ.

Pieces of flattened carbonized stems are not uncommon in the shale.

PROTOZOA.

FORAMINIFERA.

1. *ENDOTHYRA AMMONOIDES*, *Brady*.

This and the following species of Foraminifera, except No. 3, are obtained from the shale washings.

2. *E. RADIATA*, *Brady*.

Rare.

3. *STACHEIA POLYTREMOIDES*, *Brady*.

Common on crinoid stems at Williamwood.

4. *TROCHAMMINA INCERTA*, *D'Orbigny*.

Rare.

5. *VALVULINA PALEOTROCHUS*, *Ehrenberg*.

Rare.

ACTINOZOA.

1. *LITHODENDRON JUNCEUM*, *Fleming*.

Rare. In the shale.

2. *STENOPORA TUMIDA*, *Phillips*.

Rare. In the shale.

3. *ZAPHRENTIS PHILLIPSI*, *Milne Edwards*.

Common. In the shale.

4. *ZAPHRENTIS*, *sp.*

Rare. In the shale.

ECHINODERMATA.

1. *ARCHÆOCIDARIS UREI*, *Flem.*

Fragments of spines and plates found in the shale, but very rare.

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2. *PISOCRINUS GLOBULARIS*, *De Koninck*.

Rare. Plates of the calyx in the shale.

3. *PLATYCRINUS TRIGINTIDACTYLUS*, *Austin*.

Rare. Pieces of the arms in the shale.

4. *POTERIOCRINUS CRASSUS*, *Miller*.

Portions of stems are common, but remains of the calyx are of very rare occurrence.

ANNELIDA.

1. *SERPULITES MEMBRANACEUS*, *M'Coy*.

Very rare. In the shale.

2. *ORTONIA CARBONARIA*, *J. Young*.

Very rare. In the Shale.

CRUSTACEA.

1. *BAIRDIA CURTA*, *var. PLEBEIA*, *Jones and Kirkby*.

Common. Found in the shale washings along with the following species, except Nos. 11 and 12.

2. *B. SUBCYLINDRICA*, *Münster*.

Common.

3. *B. SUBMUCRONATA*, *J. and K.*

Rare.

4. *BEYRICHIA BITUBERCULATA*, *M'Coy*.

Common.

5. *B. COLLICULUS*, ? *D'Eichwald*.

Rare.

B. RADIATA, *J. and K.*

Common.

7. *B. RIGIDA*, *J. and K.*

Moderately common.

8. *CYTHERA CORNIGERA*, *J. and K.*

Common.

9. *C. CUNEOLA*, *J. and K.*

Common.

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10. *C. VENTRICORNIS*, *J. and K.*
Common.
11. *DITHYROCARIS TESTUDINEUS*, *Scouler.*
Teeth are not uncommon in small nodules in the shale, but no portions of the carapace have been found.
12. *GRIFFITHIDES EICHWALDI*, *Fischer.*
Very rare. In the shale.
13. *KIRKBYA ANNETENS*, *J. and K.*
Rare.
14. *K. BIPARTITA*, *J. and K.*
Rare.
15. *K. PERMIANA*, *Jones.*
Moderately common.
16. *LEPERDITIA OKENI*, *Münst.*
Common.

POLYZOA.

1. *CABINELLA CELLULIFERA*, *Etheridge.*
Very rare. In the shale.
2. *FENESTELLA*, *sp.*
Small fragments of probably more than one species found in the shale, but they are of rare occurrence.

BRACHIOPODA.

1. *ATHYRIS AMBIGUA*, *Sowerby.*
Common and of larger dimensions than in most Scottish localities, but perfect examples are rather rare. The detached valves are frequently found shewing the muscular impressions in fine preservation.
2. *CHONETES LAGUESSIANA*, *De Kon.*
Rare, and of small size.
3. *CRANIA QUADRATA*, *M'Coy.*
Rare. Chiefly on shells.
4. *DISCINA NITIDA*, *Phill.*
Common, and in fine preservation.

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5. *LINGULA MYTILOIDES*, *Sow.*

Common. Chiefly in small nodules, and in beautiful preservation.
Found similarly at Bishopbriggs in the shale above the limestone.

6. *L. SQUAMIFORMIS*, *Phill.*

Very rare. Found along with the preceding species at Bishopbriggs,
where it is common.

7. *ORTHIS MICHELINI*, *Léveillé.*

Very rare. In the shale, and in pieces.

8. *O. RESUPINATA*, *Martin.*

Very rare. In the shale, of small size, in fair preservation.

9. *PRODUCTUS CORA*, *D'Orb.*

Very rare. An imperfect ventral valve.

10. *P. COSTATUS*, *J. de C. Sow.*

Common. In the shale, of full size, and in excellent preservation.
Usually the ventral valve only is found; the dorsal, with the muscular
impressions, is rare. This would seem to be the metropolis of this
species in the West of Scotland.

11. *P. GIGANTEUS*, *Mart.*

Very rare. Both in the limestone and shale; of small dimensions.

12. *P. LONGISPINUS*, *Sow.*

Rare. In the shale.

13. *P. SCABRICULUS*, *Mart.*

A single example. In the shale.

14. *P. SEMIRETICULATUS*, *Mart.*

Rare. In the shale. Found in the limestone at Bishopbriggs.

15. *P. YOUNGIANUS*, *Davidson.*

Rare. In the shale.

16. *SPIRIFERA GLABRA*, *Mart.*

Very rare. In the shale.

17. *S. OVALIS.*

Very rare. In the limestone; one imperfect example.

18. *S. LINEATA*, *Mart.*

Very rare. In the shale; of small size, but good preservation.

19. *S. TRIGONALIS*, *var. BISULCATA*, *Sow.*

Very rare. In the shale, in fragments.

20. *S. UREI*, *Flem.*
Very rare. In the shale.
21. *SPIRIFERINA INSCULPTA*, *Phill.*
Very rare. In the shale.
22. *STREPTORHYNCHUS ORENISTRIA*, *Phill.*
Common. In the shale. Many examples are large and but little crushed, and the external sculpture is sharp and distinct, while the characters of the hinge area and the muscular impressions are well displayed in many of the separated valves. The variety *radialis* occurs but it is very rare.
23. *STROPHOMENA RHOMBOIDALIS*, *var. ANALOGA*, *Phill.*
Very rare. In the shale.

LAMELLIBRANCHIATA.

MONOMYARIA.

1. *AVICULOPECTEN CCELATUS*, *M'Coy.*
Very rare. In the shale.
2. *A. SIMPLEX*, *De Kon.*
Very rare. A single example in the shale.

DIMYARIA.

3. *PINNA SPATULA*, *M'Coy.*
A single fragment in the shale.
4. *POSIDONOMYA CORRUGATA*, *Ether.*
Very rare.
5. *ARCA LACORDAIREANA*, *De Kon.*
Very rare. In the limestone and shale. In the latter the specimens are in a beautiful state of preservation.
6. *AXINUS CARBONARIUS*, *Portlock.*
Very rare. In the shale.
7. *A. DELTOIDEUS*, *Phill.*
Very rare. In the limestone.
8. *CARDIOMORPHA*, *sp.*
A single example in the shale.
9. *CONOCARDIUM DEOUSSATUM*, *Ether.* *Geol. Mag.*, Decade 1, Vol. X., p. 112.
Very rare. Williamwood shale. One example only.
10. *CYPRICARDIA ACUTICARINATA*, *Armstrong.*
Rare. Perfect examples in the shale and limestone. The best locality in the West of Scotland for this beautiful shell.

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11. *C. RHOMBEA*, *Phill.*

Common. In the limestone and shale ; well preserved,

12. *LEDA ATTENUATA*, *Flem.*

Common. In the shale ; large and well preserved. Occurs also in the shale above the limestone at Bishopbriggs.

13. *L. OLAVATA*, *M'Coy.*

Common. In the shale, well preserved, and in the limestone.

14. *L. INTERMEDIA*, *Ether.*

Rare. In the shale, and well preserved.

15. *L. OBLONGA*, ? *M'Coy.*

Rare. In the shale ; well preserved.

16. *MYACITES SULCATA*, *Flem.*

Very rare. In the shale.

17. *NUCULA ACUTA*, *Sow.*

Very rare. Three or four examples in the shale in perfect condition.

18. *N. GIBBOSA*, *Flem.*

Common. In the limestone and shale, Bishopbriggs.

19. *N. LINEATA*, *Phill.*

Common. In the shale.

20. *N. LUCINIFORMIS*, *Phill.*

Rare. In the shale, Bishopbriggs.

21. *N. YOUNGI*, *Ether.* Ann. and Mag. Nat. Hist., Series 4, Vol. XVIII.,
p. 104, pl. iv., figs. 11-13.

Common. In the shale.

22. *SOLENOPSIS MINOR*, *M'Coy.*

Very rare. A single example in the shale.

23. *VENUS ELLIPTICA*, ? *Phill.*

Very rare. A single valve.

24. *VENUS*, ? *sp.*

A small species, rarely exceeding $\frac{1}{4}$ of an inch in size, is common, and easily obtained in the shale workings.

GASTEROPODA.

1. *CHITON BURROWIANUS*, ? *Kirkby.*

Very rare. A posterior plate in the Williamwood shale.

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2. *DENTALIUM INORNATUM*, *M'Coy*.
Very rare. In the shale.
3. *D. PRISCUM*, *Goldfuss*.
Very rare. In the shale.
4. *EULIMA PHILLIPSIANA*, *De Kon*.
Common. In the shale.
5. *EUOMPHALUS CARBONARIUS*, *Sow*.
In the shale, and very abundant.
6. *E. PILEOPSIDEUS*, *Phill*.
A single example in the Williamwood shale.
7. *LOXONEMA CONSTRICTA*, ? *Mart*.
Very rare. A single example in the shale, which closely approaches this species.
8. *L. CLATHERATULA*, *Young and Armst*.
Very rare. In the shale.
9. *L. LEFEBVREI*, ? *Lév*.
Very rare. In the shale.
10. *L. SCALAROIDEA*, *Phill*.
Common. In the shale.
11. *MACROCHEILUS ACUTUS*, *Sow*.
Common. In the shale ; small examples.
12. *M. IMBRICATUS*, *Sow*.
Rare. In the shale ; Bishopbriggs in the shale above the limestone.
13. *M. SEMISTRIATUS*, *Y. and A*.
Very rare. In the shale.
14. *MURCHISONIA STRIATULA*, *De Kon*.
Common. In the shale.
15. *NATICOPSIS ROBBOYSTONENSIS*, *Y. and A*.
Not uncommon. Small specimens in the shale.
16. *N. VARIATA*, *Phill*.
Very rare. One or two specimens in the shale.
17. *PLATYGERAS NERITOIDES*, *Phill*.
Very rare. A single example in the shale.
18. *PLEUROTOMARIA FRENOYANA*, *De Kon*.
Very rare. A few examples in the shale.

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19. *P. MONILIFERA*, *Phill.*

Common. In the shale and limestone ; well preserved.

20. *P. YVANII*, *Lév.*

Not common, and of small size both in the limestone and shale.

HETEROPODA.

1. *BELLEROPHON DECUSSATUS*, *Flem.*

Rare. In the limestone and shale.

2. *B. LEVEILLEANUS*, ? *De Kon.*

In the shale ; not abundant, but in very fair preservation. Prof. de Koninck, who has examined our specimens, is of opinion that this is a species distinct from the Belgian form.

3. *B. UREI*, *Flem.*

Common. In the shale ; tolerably large.

4. *PORCELLIA ARMATA*, *De Verneuil.*

One example in the shale.

PTEROPODA.

1. *CONULARIA IRREGULARIS*, *De Kon.*

Very rare. A fragment in the shale.

2. *C. QUADRISULCATA*, *Sow.*

Rare. In the Shale.

CEPHALOPODA.

1. *ACTINOCERAS GIGANTEUM*, *Sow.*

Rare ; but usually in good preservation, and useful for polished sections. Some of the examples have the shell eroded on one side, so as to show the siphuncle and chambers. A specimen in the Hunterian Museum measures 3 feet in length.

2. *CYRTOCERAS EUGOSUM*, *Flem.*

Very rare. A few fragments in the shale.

3. *C. UNGUIS*, *Phill.*

Very rare. In the shale.

4. *GONIATITES STRIOLATUS*, *Phill.*

Very rare. In the shale.

5. *G. VESICA*, *Phill.*

Very rare. One or two in the shale in indifferent preservation.

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6. NAUTILUS GLOBATUS, *Sow.*
Very rare. A single example in the shale.
7. N. NODIFERUS, *Armst.*
A few fragments have been found in the shale.
8. N. QUADRATUS, *Flem.*
Very rare. In small pieces in the shale.
9. ORTHOCERAS ATTENUATUM, *Flem.*
Common. In the shale, in fragments.
10. O. OVALE, *Phill.*
Not uncommon. In the shale.
11. O. SUBCENTRALE, *De Kon.*
Rare. In the shale; in well preserved pieces, sometimes upwards of a foot in length, and showing the surface ornamentation.
12. O. UNDATUM, *Flem.*
Rare. In the shale; in short fragments, but with the shell well preserved.

PISCES.

1. TOMODUS CONVEXUS, *Agassiz.*
Very rare.
2. RHIZODOPSIS GRANULATUS, *Ag.*
Common. In ironstone nodules in the shale.

ABSTRACT.

No.	CLASSES.	GENERA.	SPECIES.
1	Protozoa,	4	5
2	Actinozoa,	3	4
3	Echinodermata,	4	4
4	Annelida,	2	2
5	Crustacea,	7	16
6	Polyzoa,	2	2
7	Brachiopoda,	11	23
8	Lamellibranchiata,	13	24
9	Gasteropoda,	10	20
10	Heteropoda,	2	4
11	Pteropoda,	1	2
12	Cephalopoda,	5	12
13	Pisces,	2	2
	Total,	66	120