other metamorphic action subsequently to their formation. In order to acquire a knowledge of such facts, it is necessary to make a careful study of rocks in various stages of alteration,—a study of great interest, and of quite as much importance as the examination of specimens supposed to be unaltered; in fact, to select a typical specimen, and make a single section of it, is to leave off at the beginning of the work. By making a number of thin sections from well-selected specimens, a series may be obtained in which all the minerals are to be seen in various stages of alteration; and as some of the changes are very characteristic, it becomes possible to recognize the original composition of a rock, although it may now differ completely in appearance from its original state.

Since I first discovered the invariable presence of olivine or its pseudomorphs in the old basaltic rocks (melaphyres) of the Midland Counties, I have extended my inquiries to the Scottish Coal-fields and to other formations, and have obtained ample confirmation of previous observations, as well as many additional facts. The evidence appears to indicate very plainly that there is no essential original difference between the true eruptive rocks of early geological periods and those of recent or Tertiary age; the later glassy and trachytic rocks are closely analogous to the older pitchstones and porphyrites, while the occurrence in Skye and other places of granites and syenites of Tertiary age affords equally strong evidence in the same direction.

Satisfactory methods of investigation have been so recently employed, that very much remains to be done; but it is already tolerably clear that the difference now found to exist between the so-called *Plutonic* and the volcanic rocks is due to the metamorphic action to which the former have been exposed during the long periods which have elapsed since their original formation.

IV.—THE BUTLEY CRAG PITS.

By ALFRED BELL.

IN the July Number of the GEOLOGICAL MAGAZINE a well-known geologist¹ has endeavoured to prove the existence of sands of the Chillesford age in the Crag Pits near Butley, referring more especially to that on the Neutral Farm, near the Oyster Inn; and as I cannot agree with this opinion, I venture to lay before the readers of the MAGAZINE some of the notes upon which I ground my dissent.

The accompanying figure represents the section now presented by the excavation in question, which has been cut into a gently rising slope for nearly 300 feet in length, by about 35 feet in its deepest part. From the extreme right of the figure the side of the excavation returns at nearly a right angle to the road, thus showing a cross section.

The top of the pit is covered with drift sand (full of minute particles of quartz), containing a large number of rolled stones

¹ The Relation of the Red to the Norwich Crag, by J. E. Taylor, F.G.S., GEOL. MAG., July, p. 314.

(No. 1). Below this are reddish sands passing downwards into yellow (2), then into red again (3), and, lastly, a vein of fine white sand (4), the latter extending rather more than half way across the pit. At * a large mass of brownish clay, full of casts of the common mussel, and well-preserved Trochi (*T. cinerarius*), was to be seen. The remains of this fell down a few days ago while I was there, presenting to view the red sand above mentioned. These sands, etc., are about 18 to 20 feet thick, and are nearly, except where in contact with the Crag, *totally devoid* of organic remains. Finely comminuted shells occur at the lines of junction.

Below these sands are the Crag beds, the two main portions (5 and 6) being separated by a singular deposit of sand (7), the upper side of the angle of the sandy division becoming slightly fossiliferous and false bedded. The beds (5 and 6) themselves are composed of nearly horizontal layers of shells, with intercalated beds of sand. A series of layers of fine sand and shells, having a rapid dip, being the lowest deposit seen. Unfortunately, the Crag beds are largely covered by a talus of fallen sand.

SECTION OF PIT ON THE NEUTRAL FARM, BUTLEY, SUFFOLK.

1. Black sand with rounded water-worn stones.
 2. Red sands passing gradually down into
 3. Yellow sands.
 4. Pure white sand.
 5. Red Crag, full of shells.
 6. Red Crag, also full of shells.
 7. Unfossiliferous sand, partly false-bedded at the top, separating 5 and 6.
 8. Line of Freshwater shells.
 9. Red Crag, with shells.
- t, t* = talus, cut off artificially at the line *a, b*, to the right of which the lower part of the section is exposed.

The cross section gives traces of considerable erosion, bed 6 being worn away several feet (behind the talus), and then suddenly rising to a height of 17 or 18 feet above the level of the lowest Crag exposed on the floor of the pit, and then sinking till it is not more than 5 feet in thickness. The summit of this pinnacle is composed of horizontal layers of finely comminuted shells, with a few perfect valves, double and single, of *Maetra ovalis*.

Mr. Taylor remarks upon the absence of the Red Crag shells and the thorough Chillesford facies of the Upper deposits. I am not aware that in any deposit hitherto assigned to the Chillesford pre-Glacial stage, any of the following species, which are strikingly Red Crag forms, have been found: *Cardium venustum*, *C. interruptum* and *C. angustatum*, *Nucula levigata*, *Gastrana laminosa*, *Cancellaria scalaroides*, *Cypræa avellana*, or *Orula spelta*. These are but a few amongst

the number (see list). Secondly. The Fusi, if washed out of an older bed, would have suffered the loss of their apices. Thirdly. Of the seven species quoted as being undoubtedly Norwich Crag forms, all are common in the oldest Red (or Middle) Crag beds, and three occur in the Coralline (Lower) Crag also.

The condition of the shells is against the presumption that they have suffered from being rolled about; they are in general very perfect, except towards the extreme right of the pit, where the greatest amount of comminution obtains.

After the Crag bed (6) had been deposited or beached up, the fine sand (7) was thrown down, this passing under the Crag bed (5). In this Crag bed occurs a remarkable horizontal layer, about one foot thick (No. 8), of fossils, composed of land and freshwater forms interspersed amongst others purely marine. At present it is covered by the sandy talus. From this, and an overlying mass of red sand, several species were procured (see list), many of which range into the *topmost* layers of shelly matter.

The greater part of the Molluscan fauna are of recent forms, as they also are at the adjacent pits at Butley Mill, and the Chillesford Stackyard. This latter pit contains *Scrobicularia piperata* towards the top, upon which the *true* Chillesford sand is superimposed. This shell does not occur to my knowledge at Butley, and its presence in abundance implies a change in the depth and condition of the then sea.

Lastly. To compare the fauna of the Chillesford sands at Chillesford and Sudbourn Church Walks with those of the Butley Neutral Farm, and Mill Pits, the large form of *Mya truncata*, *Lucinopsis undata*, *Leda lanceolata* (except a large fragment), and *Scalaria Turtonis*, have not yet been obtained at either of the Red Crag pits mentioned; but if the whole series of Chillesford shells are collated with those of the earlier deposits, it will be found that *Scalaria* and *Lucinopsis* are the only shells out of nearly 130 species, peculiar to the Chillesford beds, and one *Echinus* (*E. lividus*). These cannot therefore be said to have a *facies peculiarly their own*.

Of the 192 species in the following list, not more than 20 are unknown in a recent state, and a comparison of this with the Chillesford fauna will best explain the reason why I consider the Butley pits do not contain deposits of Chillesford age.

Fossils from the Crag Pits at Butley, Suffolk.

† Peculiar to the "Neutral Farm" Pit.

* Peculiar to the Pit near the Mill.

The unmarked species are also found in some other Red Crag Pits.

PISCES.

Raia (not *antiqua*).

Lamna.

Platax Woodwardii.

ANNELIDA.

Ditrupa gadus.

CRUSTACEA.

Cancer pagurus.

Balanus crenatus.

" *Hameri*.

" *porcatus*.

RADIATA.

Echinocyamus pusillus.

* *Toxopneustes Dröbachiensis*.

MOLLUSCA.

† *Planorbis complanatus*.

† *Limnæa palustris*.
 † " " var. *Holbollii*.
 † " *pereger*.
 † " *truncatulus*.
 † *Helix hispida*.
 † *Pupa marginata*.
Melampus pyramidalis.
Terebratula grandis (a much worn
 valve).

Anomia ephippium.
 " *putelliformis*.
Ostræa edulis.
Pecten maximus.
 " *opercularis*.
 " " (var.) *gracilis*.

" *tigrinus*.
Perna rudis.
Mytilus edulis.
Modiola modiolus.
Arca lactea.
 " *tetragona*.
Pectunculus glycymeris.
Nucula lævigata.
 " *nucleus*.
 " *tenuis*.
Acila Cobboldiæ.

* " *Lyallii*.
 † *Yoldia hyperborea*.
 " *lanceolata*.
 † " *myalis*.

Cardium angustatum.
 " *lævigatum* ?
 " *edule*.
 " *interruptum*.
 " *nodosum*.
 " *venustum*.

Serripes Grænlandicus.
Lucina borealis.
Loripes divaricatus.
Diplodonta trigonula.

" *rotundata*.
Kellia ambigua.
Scacchia elliptica.
Cyprina Islandica.
Astarte compressa.

" *incrassata* ?
 " *obliquata*.
 " *Omalii*.
Woodia digitaria.
Cardita corbis.

" *chamaformis*.
 " *scalaris*.
 " *sulcata*.
Venus fasciata.

" *ovata*.
Cytherea rudis.
Artemis exoleta.
Mastra constricta.
 " *elliptica*.
 " *ovalis*.
 " *subtruncata*.

Tellina calcarea.
 " *obliqua*.
 " *pratenuis*.
 " *crassa*.
Gastrana laminosa.
Syndosmya alba.
Solen sitigua.
Mya arenaria.
 " *truncata*, (var.) *pullus* only.
Corbula gibba.
Corbulomya complanata.
Saxicava Norvegica.
 " *rugosa*.
Glycymeris angusta.
Pholas crispata.

† *Murex erinaceus*.
 " *tortuosus*.
 " *Lachesis*.
Cancellaria varicosa.
Admete viridula.
Fusus altus.
 " *antiquus*.
 " *contrarius*.
 " *costifer*.
 " *gracilis*.
 " *Sarsii*.

Trophon muricatum.
 " *Barvicense* ?
 " *scalariforme*.
Buccinopsis Dalei.
Buccinum undatum.

" *ciliatum*.
 " *Grænlandicum*.
Nassa granulata.
 " *incrassata*.
 " *labiosa*.
 " *propinqua*.
 " *monensis*.
 " *pygmæa*.
 " *reticosa*.
 " *variabilis*.
 " *Ascanias*.

Ringicula ventricosa.
Purpura lapillus.

" *tetragona*.
Columbella sulcata.
 " *abbreviata*.
Defrancia reticulata.

" *linearis*.
 " *purpurea*.
Pleurotoma bicarinata.

" *Bertrandii*.
 " *contigua*.
 " *costata*.
 " " (var.) *coarctata*.
 " *exarata*.
 " *harpularia*.
 " *mitrula*.
 " *nebula* ?
 " *nobilis* ?
 " *pyramidalis*.

- Pleurotoma rufa.*
 „ *turricula.*
 „ *violacea* ?
Voluta Lamberti.
Cypræa Europæa.
 „ *avellana.*
Ovula spelta.
 „ *Adriatica.*
Amaura candida.
Natica borealis.
 „ *catena.*
 „ *catenoides.*
 „ *affinis.*
 „ *occlusa.*
 „ *Grælandica.*
 „ *Alderi.*
 „ *Montacuti.*
 „ *Islandica.*
 „ *millepunctata.*
 „ *hemiclausa* (= *N. macilenta*).
 * *Odostomia*, sp.
Chemnitzia internodula, and var. *conica.*
 „ *plicatula.*
 † „ *communis.*
Cerithium borealis (*granosum*, S. W.).
 „ *tricinctum.*
 „ *reticulatum* ?
Aporrhais pes-pellicani.
Turritella incrassata.
Vermetus subcancellatus.
Scalaria clathratula.
 „ *Grælandica.*
- Littorina littorea.*
Laouma subaperta.
Rissoa pulchella (S. Wood, not Philippi).
Paludestrina pendula.
Trochus Adansonii.
 „ *cinerarius.*
 „ *granulatus.*
 „ *Montacuti.*
 „ *occidentalis.*
 „ *subexcavatus.*
 „ *tumidus.*
 „ *villicus.*
Fissurella Græca.
Emarginula fissura.
Calyptrea Chinensis.
Capulus Hungaricus.
Tectura virginea.
Lepeta cæca.
Dentalium dentale.
Actæon tornatilis.
 „ *subulatus.*
Cylichna cylindracea.
- POLYZOA.
- Cellepora compressa.*
Eschara sinuosa.
Fungella multifida.
- ACTINOZOA.
- Balanophyllia calyculus.*
Sphaenotrochus intermedius.
- PROTOZOA.
- Cliona celata.*

In a former paper, "On the English Crag, etc.," *GEOL. MAG.*, June, 1871, the Butley Crag was considered to be a shallow water deposit of the Upper Crag, and that near Shottisham Creek, by the river Deben, to be a deep water one; and in comparing the fauna, the latter, I think, should be contrasted with that of the Chillesford stage, which I consider to be indicative of much deeper water than either the Butley or Chillesford (*Scrobicularia*) pits. The following species do not occur in the shallow water deposits, and are from the Shottisham Creek pit.

d. = double bivalves.

- d. Terebratula grandis* (var.)
d. Rhynchonella psittacea.
Pecten pusio.
Cardium Parkinsoni.
Cyprina rustica.
Mastra arcuata.
Syndosmya obovalia.
Gastrochena dubia.
Fusus Largillierii.
 „ *cordatus.*
 „ *Turtonis.*
Purpura incrassata.
Terebra inversa.
Cassidaria bicaenata.
Columbella Borsoni.
Pleurotoma striolata.
 „ *pygmaeum* ?
Pleurotoma galerita.
- Pleurotoma valvula.*
Conopleura crassa ?
 „ *elegans* ?
Erato levis.
 „ *Maugeria.*
Cypræa retusa.
 „ *Anglia.*
 „ *Dertonense.*
Cerithiopsis tubercularæ.
Scalaria subulata.
 „ *varicosa.*
Trochus multigranus.
 „ *ziziphinus.*
Capulus unguis.
 „ *militaris.*
-
- Hornera infundibulata.*
Lunulites conica.

P.S. While I am upon the Crag formations, I shall beg leave to refer to the Palæontology of two papers in the September Number of the GEOLOGICAL MAGAZINE by Dr. Mörch, and Mr. S. V. Wood, jun.

I. Dr. Mörch's paper on the Mollusca of the Crag-formation of Iceland.

No. 4. *Natica varians*. The Crag shell so named I am inclined to refer to Brocchi's *N. helicina*,¹ on the authority of the Marquis Monterosata, to whom I submitted some Italian shells corresponding with those of the Crag. It is not *N. borealis* of Gray, which is a high Arctic form of *N. Grœnlandica*, and a Crag shell. (See Butley list.)

No. 5. *Natica hemiclausula*, Sow., except in size, cannot be distinguished from a living Mediterranean shell, *N. macilenta*, Phil.

No. 6. *Natica occlusa*, S. V. Wood, not Winkler.

No. 16. *Fusus Olavii*, Beck., var. *Spira longa*, is probably the shell for which I have suggested the name *F. cordatus*.

No. 20. *Nassa monensis*, Forbes. The figure of the type shell was not given, and the type specimen itself is lost. The determination of the species in the English Crag rests upon Forbes's identification. The Crag shell is not unlike some forms of Philippi's polymorphous *N. variabilis*.

Dr. Mörch is in error in assigning to the English Crag the following forms: *Patella pellucida*, *Cyrtodaria siliqua*, *Astarte crebricosta*, and *Modiolaria nigra*.

From the matrix of several specimens of Icelandic Crag (?) fossils kindly given me by Dr. Mörch, and the fact that most of the species recorded in his list, which are not fossil in the English Crag, such as *Natica aperta*, *Tritonium Tottenni*, *T. scalariforme*, *Cyrtodaria siliqua*, etc., are Northern forms, I am inclined to refer this very interesting deposit to a much later period than the age of any of our English Crag.

II. Mr. S. V. Wood, jun., Sequence of Glacial beds.

Nucula Cobboldia and *Astarte Omalii*, quoted as both extinct species. The former is an inhabitant of the Japanese seas, and is described by Dr. Gould (Otia. Conch. p. 175) as *N. insignis*. The opportunity of comparing the Japanese and the Crag shells I owe to the kindness of Mr. Jeffreys.

Astarte Omalii=*A. undulata*, Gould, living in Massachusetts Bay, etc.

Cardita corbis is a native of N.W. America. P. P. Carpenter.

Lastly. Does not the presence of *Melampus pyramidalis*, *Turritella incrassata*, and *Nassa semistriata* (or *labiosa*) in the Wexford drift, point to an age nearer the Chillesford pre-Glacial stage than to a later period.

¹ The *N. helicina* of Brocchi is assigned to *N. catena* by Mr. Jeffreys, and to *N. sordida* by some Italian naturalists. Michelotti figures a specimen of *N. millepunctata* as *N. helicina*, and Philippi also figures another (?) species under Brocchi's name!