

centre of the earth, the first external contact occurred on December 6, at 15h. 47.8m. Greenwich mean time, at 35° from the north point of the sun's disc towards E. for direct image, and the last external contact at 18h. 26.8m. about 4° towards W. At Paris the final contact took place at 18h. 50.3m. local mean time, but the sun did not rise till 19h. 39m.; the planet therefore had left his disc less than fifty minutes before he was on the horizon of Paris.

ARCTIC GEOLOGY*

IV.

Vardö Island, † at the end of a long promontory in the polar basin, is described by Mr. Campbell, of Islay, ‡ as consisting of metamorphic slates, dipping at 45°, and striking with the hollows and ridges north and south, ground into shape by ice, but since submerged and wave-worn; drifts packed and rolled by the sea are left in a grass-grown raised beach at 60 feet, a peat-covered beach at 100 feet, and rolled stones occur on the summit level of the island, 220 feet above the sea, resting on red sandstones, with fossil markings in concentric rings. At 30 feet above the sea occurred a "storm beach," with large and sub-angular stones, sweeping in a crescent round the bay, the fortress of Vardö, and the church of Vadsö. He describes it as built on coral sand, and refers to the warm equatorial current affecting the climate in the polar basin to lat. 80° in Spitzbergen, and to long. 66° E. in Novaya Zemlya, which enables a luxuriant vegetation to live on the shore at Yeredik, about 70° N., in spite of the winter's darkness.

The most northern island of Novaya Zemlya has been called Castanjenö by Capt. Mack, from the "Mimosa beans" or chestnuts found there, which tropical brown nuts in Spitzbergen reach 20° E.; § but Mr. Lamont considers the large quantities of drift wood found on that coast to be derived from pines (*Abies excelsa*) that have grown on the banks of the large Siberian rivers; || and states that when wood occurs inland it is associated with bones of whales. He therefore does not agree with Lord Dufferin that it is brought to Spitzbergen by the Gulf Stream, ¶ which Mr. Lamont states has no influence north and east of Black Point and the Thousand Isles, even during June, July, and August, while during the winter months ice-laden currents sweep round Spitzbergen on both sides from the north, and bear back the equatorial current, and envelop the entire island with a wall of ice.

These rapid changes of direction of currents, with accompanying marked alteration of climate, appear to bear a close analogy to those which must have obtained in South Britain when the alternating beds of boulder-clay and sands and gravels were being deposited, clay with scratched stones during the colder intervals, and sands during the warmer episodes, when the waves were fretting coasts unprotected by ice.

Icebergs appear to have ground the surface of the rudely columnar trap-rocks of the Thousand Islands, which are covered with countless smoothed and rounded boulders of the local trap, and of red granite derived from the centre of Spitzbergen, forty miles distant.

In one of the cluster of islands off the coast at Black Point is a channel 100 yards long, three or four feet wide, and four deep, running N.E. and S.W., excavated in the boulders, which Mr. Lamont believes to have been produced by the passage of an iceberg, when the land stood lower than at present. The power of bergs to groove and scoop out hollows has been denied, and it is to be hoped that the

* Continued from p. 494.

† In the following notes on Spitzbergen and other neighbouring islands, only those points have been touched on as have a direct bearing on the geology of the area already described.

‡ Quar. Jour. Geol. Soc., vol. xxx. p. 455; 1874.

§ "Frost and Fire," by J. F. Campbell, vol. i. p. 483.

|| "Seasons with the Sea Horses," London, 1861.

¶ "Letters from High Latitudes." (London.)

officers of the Arctic Expedition will have opportunities of ascertaining what the usual character of the bottom portion of a berg is, how far it is capable of grooving rocks and excavating hollows in soft sea beds, with or without coming to rest.

Separated from the great glacier of Deeva Bay by two miles of sea covered with fast ice, is a terminal moraine of mud, 3½ miles long, 200 to 400 yards broad, and 20 to 30 feet high, on the top of which grow Arctic plants. Observations as to what extent glaciers can extend into the sea, and push moraines before them without breaking off into bergs, would have great interest, for in this instance the sea must have been deeper during the maximum size of the glacier than now, as bones of whales occur at heights of more than forty feet above the present sea-level.

One of the three large glaciers that protrude into the sea between Black Point and Ryk-Yse Islands has a sea front of thirty miles, sweeping in three great arcs, five miles beyond the coast line, terminating in a precipitous wall from 20 to 100 feet in height, from which bergs are constantly tumbling into the sea, carrying stone and large quantities of clay and stones seawards. The position of the melting area of such bergs as these, and consequent deposition of erratic material, is a point of great interest in attempting to unravel the British glacial phenomena.

Prof. Wyville Thomson, dredging on the edge of the southern ice pack, brought up fine sand and greyish mud, with small pebbles of quartz, felspar, and small fragments of mica-slate, gneiss, and granite, derived from the melting of icebergs found in lat. 65° or 64° S., which represents their melting area, while further south in 200 to 250 fathoms of water, in which they first commence to float, land débris is much rarer; at the surface of the water in the melting area, *Globigerina* and diatoms are numerous, but do not form a deposit at the bottom, owing to the deposition of silt obliterating them.

Recent Elevation of Spitzbergen.—From the observations of Mr. Lamont it may be inferred that during the past 400 years Spitzbergen has been rising at the rate of thirteen feet per century.

Bear Island (lat. 74° 30' N.)—From the plants and specimens collected by Professors Nordenskjöld and Malmgren, the following classification of the rocks of the island has been established* :—

MILLSTONE GRIT.—Siliceous schists.

MOUNTAIN LIMESTONE STAGE.—*Productus* limestone, *spirifer* limestone with gypsum, resting on *Cyathophyllum*-bearing limestone and dolerite, possibly the equivalent of the Carboniferous shale with *Cyathophyllum* of the south of Ireland.

URSA STAGE of O. Heer.—Sandstones, with shale and coal-seams. All the beds contain plants.

DEVONIAN.—Russian Island limestone, red shale.

The Russian Island limestone, which spreads over so large an area in Spitzbergen, contains no determinable fossils, and, like the shales beneath it, is of doubtful geological age, probably, as suggested by Nordenskjöld, belonging to the Devonian. No true coal measures are present either in Spitzbergen or Bear Island.

The "Ursa Stage" Prof. Heer correlates with the Kiltorkan beds in Ireland, the Greywacke of the Vosges and southern Black Forest, and the *Spirifera Verneultii* shales of Aix, and the sandstones of Parry and Melville Islands in the Arctic Archipelago; and from the marked absence of Devonian and coal-measures species, regards the stage as of Lower Carboniferous age, the base of which he considered to be beneath the yellow sandstones; but Sir Charles Lyell, from the fact that these sandstones at Dura Den, in Fife, and in the co. Cork, contain the exclusively Devonian fish *Asterolepis* and *Glyptolepis*, believed these deposits to be Devonian, which

* Quar. Journ. Geol. Soc., vol. xxviii. p. 161. (Read Nov. 9, 1868.)