

He next states, in addition to the evidences afforded by Mrs. Calcot of the change of level produced by the earthquake of 1822, that persons who escaped on board vessels, remarked that the sentries before an old fort on the summit of the hill over the ruins of the town, and previously visible from the feet upwards, had, subsequently to the event, half the body concealed by the fore part of the cliffs\*. He also says that the street or causeway, which wound round an old fort, and in 1821 was washed by the sea at every high tide, is now seven feet above the wash of the sea at the high water line of ordinary tides.

In conclusion, Mr. Caldeleugh gave an account of the effects produced by the earthquake of 1835, chiefly from the observations of Capt. Fitzroy, full details of which have been published in the Transactions of the Royal Society † and the Royal Geographical Society ‡.

The President then announced that he had received from the Foreign Office the translation of an article published in the South American Journal, *El Arancano*, by Don Mariano Rivero; but as none except original communications were read before the Society, he could only state that Don Mariano dissents entirely from the belief, that earthquakes have produced vertical changes of level on the coast of Chili.

This communication was accompanied by a letter from Col. Walpole addressed to Lord Palmerston, an extract from which, read by the Secretary, strongly supported Don Mariano Rivero's views.

A paper entitled "Observations of proofs of recent elevation on the coast of Chili, made during the survey of His Majesty's ship *Beagle*, commanded by Capt. Fitzroy, R.N.," by Charles Darwin, Esq., F.G.S., was afterwards read.

The subject of recent elevations on the coast of Chili being, in the opinion of many, still open to discussion, Mr. Darwin gives, in this memoir, the results of his own observations. The portion of the coast, more particularly examined by the author, extends from the river Rapel, about sixty miles south of Valparaiso, to Conchali, about eighty miles north of it.

Close to the mouth of the Rapel, dead barnacles occur adhering to rocks three or four feet above the highest tidal level; and in the neighbouring country recent marine shells are scattered abundantly to the height of about 100 feet. Ten miles to the north, and at an equal distance from the sea, is the village of Bucalemu, in the neighbourhood of which are very extensive beds of recent shells. At the bottom of the great valley of Maypo, and some miles from the coast, marine shells of existing species are also numerous; and at St. An-

\* In the following page a part of the fort previously invisible is stated to have become visible; but this apparent discrepancy arises from the observations alluded to by Mr. Caldeleugh having been made from the shipping, and those by Mr. Darwin from a point on the land.

† Mr. Caldeleugh on the Great Earthquake in Chili, 1835. *Phil. Trans.* 1836, p. 21.

‡ Sketch of the surveying Voyage of His Majesty's Ship *Beagle*. *Journal Royal Geographical Society*, vol. vi. p. 319.

tonio, near the northern point of that river, are large quarries of shells. Between this point and Valparaiso in the ravine, Quebrada Onda, the remains of a species of shell common on the coast, were noticed by the author. Along the bold granitic coast south of the promontory which forms the bay of Valparaiso, are numerous level and horizontal beds of shells, constituting an almost continuous band, elevated from 60 to 230 feet above the level of the sea. The shells are brittle, but of various kinds, and are all similar and in similar proportional numbers to those on the beach. They are mingled with some earth, though packed closely together, and overlie a partially consolidated breccia of granitic fragments which rests on the solid rock. After a careful examination of these deposits, first by himself, and afterwards with Mr. Alison, guarded by a recent inspection of the heaps of shells accumulated by the natives in Tierra del Fuego, Mr. Darwin was convinced that the shelly beds near Valparaiso, were formed when the sea occupied a different level. The following are the principal circumstances which lead to this conviction. The great number of the shells forming extensive, horizontal beds, whereas the heaps in Tierra del Fuego collected by the inhabitants, always retain a conical figure: their position, at the extremities of headlands inaccessible from the sea, and unfit for strongholds, being without fresh water: the large proportional number of extremely small shells: and lastly, their brittle and decayed condition, the state of decomposition having an evident relation to the comparative heights at which the shells were lying. Comminuted shells were noticed by Mr. Darwin at the heights of 560 and 1300 feet, but the evidence of their having been part of a beach was not convincing.

At San Lorenzo in the bay of Callao, Mr. Darwin traced a similar process of decay from perfect shells in the lowest beds to a mere layer of calcareous powder in the highest. This phenomenon, he adds, can be observed only in countries where rain never falls.

On the north side of the bay of Valparaiso, near the Viña del Mar, is an abundance of elevated shells. Mr. Alison, by climbing a point of rock about fourteen feet above high water, and removing the dung of sea fowls, discovered Balani adhering to the stone.

With respect to the historical evidence of the earthquake of 1822, Mr. Darwin says that he met with no intelligent person who doubted the rise of the land, or with any of the lower order who doubted that the sea had fallen. He mentions also the altered position of the wreck and of the rock in the bay; and from a part of the fort being invisible from a point on the land before the earthquake, but visible afterwards, he infers that the movement of the land was unequal\*. A further proof of change, obtained for the author by Mr. Alison, is shown by the remains of a sea-wall built in 1680, and over which, up to 1817, the sea broke during the northerly gales. Mr. John Martin, a ship carpenter of Valparaiso, remembers walking in 1819 on the beach at the foot of this wall, and he has been frequently obliged to climb up to the street to avoid the sea. This wall is now separated from the bay by two rows of houses, but a portion of what

\* See note \* in the preceding page.

appeared to be its base, carefully levelled by a resident engineer, was found to be 11 feet 6 inches above high water mark. Mr. Darwin does not ascribe the whole of this change to the earthquake of 1822, and is of opinion that the alteration then produced was under three feet. The church of San Augustin is believed to have been built in 1634, and the base of its walls is 19 feet 6 inches above high tide level; but there is a tradition that the sea formerly approached very close to its foundations. Allowing, therefore, 4 feet 6 inches for its protection when built, the amount of change in 220 years is only 15 feet. The granite rocks which form the coast are also water-worn and hollowed at about the same height, namely, 14 feet above the present sea level. These data, Mr. Darwin is of opinion, prove, that though the changes in 220 years have been small, yet that they were preceded by a period of comparative rest, during which there was time for any former marks on the rocks to become obliterated.

The author then described the beds of recent shells between Concon and Quintero, about 100 feet above the sea level; the deposits near Plazilla and Catapilco; and in the valley of Longotomo. On the hills to the north of the latter, about 200 feet above the sea, immense quantities of recent shells coat the surface or the sides of the ravines; and hence Mr. Darwin infers that the action of the sea determined the minor inequalities of the land. Similar deposits, more or less abounding in shells, were noticed by him near Guachen, and in the valley of Quilimap. Close to Conchali, on the south side of the bay, are two very distinct terrace-like plains, the lower being about sixty feet high.

Mr. Darwin then gave a very brief notice respecting the marine origin of the terraces at Coquimbo, described by Capt. Basil Hall and discussed by Mr. Lyell. The proofs of the origin assigned to them rest on the occurrence of recent shells in a friable calcareous rock elevated 250 feet above the sea. This calcareous stratum passes downwards into a shelly mass chiefly composed of fragments of Balanidae, and this again overlies a sandstone abounding with silicified bones of gigantic sharks mingled with extinct species of oysters and *Pernæ* of a great size. The intermediate bed contains some shells in common with the upper, in which all are recent, and with the lowest in which the greater number are extinct. The phenomena of the parallel terraces and the elevated shells occur in a strongly marked manner in the villages of Guasco and Copiapo, the latter being 350 miles to the north of Valparaiso: recent shells also occur at different elevations at an equal distance to the south of it at Concepcion and Imperial. Mr. Darwin believes that the land on the coast of Chili has risen, though insensibly, since 1822. In the Island of Chiloe he is fully convinced, from oral testimony and the state of the coast, that a change effected imperceptibly is now in progress. In support of this gradual rise, independent of earthquakes, he states, that the eastern coast of South America, bordering the Atlantic from the Rio Plata to the Strait of Magellan, presents terraces containing recent shells; yet in the provinces near the mouth of the Plata, earthquakes are never experienced; and it is impossible to suppose that the most violent of the Chilian earth-

quakes could produce these effects, as the shocks are scarcely transmitted to the plains at the western foot of the Cordilleras. Hence, he concludes, that the earthquakes, volcanic eruptions, and sudden elevations on the coast line of the Pacific, ought to be considered as irregularities of action in some more widely extended phenomenon.

January 18.—Benjamin Tucker, Esq., of Mecklenburgh Square; Cæsar Coldough, Esq., of Tintern Abbey in the county of Wexford, Ireland; George Such, M.D., F.L.S., New Street, Dorset Square; Travers Twiss, Esq., B.C.L., Fellow of University College, Oxford; Joseph Henry Barchard, Esq., of Putney Heath, Surrey; Gilpin Gorst, Esq., of the Old Trinity House, and William Edmund Logan, Esq., of Swansea, were elected Fellows of this Society.

A paper entitled, "An Account of a deposit containing land shells at Gore Cliff, Isle of Wight," by J. S. Bowerbank, Esq., F.G.S., was first read.

During a recent examination of the greensand of Gore Cliff, Mr. Bowerbank discovered on the top of the cliff and overlying the chalk marl by which it is capped, a bed consisting of detritus of chalk and chalk marl, and inclosing, in every part examined by him, numerous specimens of existing species of land shells. The deposit extends from nearly the edge of the cliff to the foot of St. Catherine's Down, a distance of about 660 yards. The range of the deposit he could not ascertain, as at a short distance from the spot examined, the cliff assumed its usual perpendicular form; but he is of opinion that it is considerable, or else that there are many such deposits, as he found fallen masses of a similar bed near St. Lawrence and between Ventnor and Bonchurch.

A letter addressed to Dr. Buckland by J. Wyatt, Esq., respecting a trap dyke in the Penrhyn Slate Quarries near Bangor, Carmarthenshire, was then read.

These quarries were opened fifty years since, and the excavation is now about 700 yards in length, 300 in breadth, and 90 below the natural surface. In carrying on the highest opening of the quarry, the men, a few months since, came suddenly in contact with a trap dyke, which has since been cut through and proved to be 11 feet in width. Its direction appears to be between W.N.W. and N.W., and it intersects the bedding of the slate nearly at right angles. The dip at present is almost  $90^{\circ}$ , the slight inclination being to the N.E. The "cheeks" of the dyke on the N.W. side, are broken conformably with the natural joints of the schist. The slate immediately in contact with the trap is, in some parts, quite flinty, having lost its fissile properties, and the colour is changed from purple to black; but at the distance of two or three feet the slate recovers its natural colour and cleavage.

A notice of a successful attempt at boring for water at Mortlake in Surrey, by William Richardson, Esq., F.G.S., was next read.