

the ice, and so firmly was it fixed, that the force of the moving ice broke a chain-cable suited for a 10-gun brig, and which had rode the *Gulnare* during the heaviest gales in the gulf. Had not this anchor been cut out of the ice, it would have been carried into deep water and lost.\*

The scene represented in the annexed plate (pl. 4.), from a drawing by Lieutenant Bowen, R. N., will enable the reader to comprehend the incessant changes which the transport of boulders produces annually on the low islands, shores, and bed of the St. Lawrence above Quebec. The fundamental rocks at Richelieu Rapid, situated in lat.  $46^{\circ}$  N., are limestone and slate, which are seen at low water to be covered with boulders of granite. These boulders owe their spheroidal form chiefly to weathering, or the action of frost, which causes the surface to exfoliate in concentric plates, so that all the more prominent angles are removed. At the point *a* is a cavity in the mud or sand of the beach, now filled with water, which was occupied during the preceding winter (1835) by the huge erratic *b*, a mass of granite, 70 tons' weight, found in the spring following (1836) at the distance of several feet from its former position. Many small islands are seen on the river, such as *c d*, which afford still more striking proofs of the carrying and propelling power of ice. These islets are never under water, yet every winter ice is thrown upon them in such abundance, that it *packs* to the height of 20, and even 30 feet, bringing with it a continual supply of large stones or boulders, and carrying away others; the greatest number being deposited, according to Lieutenant Bowen, on the edge of deep water. On the island *d*, on the left of the accompanying view, a lighthouse is represented, consisting of a square wooden building, which having no other foundation than the boulders, requires to be taken down every winter, and rebuilt on the re-opening of the river.

These effects of frost, which are so striking on the St. Lawrence above Quebec, are by no means displayed on a smaller scale below that city, where the gulf rises and falls with the tide. On the contrary, it is in the estuary, between the latitudes  $47^{\circ}$  and  $49^{\circ}$ , that the greatest quantity of gravel and boulders of large dimensions are carried down annually towards the sea. Here the frost is so intense, that a dense sheet of ice is formed at low water, which, on the rise of the tide, is lifted up, broken, and thrown in heaps on the extensive shoals which border the estuary. When the tide recedes, this packed ice is exposed to a temperature sometimes  $30^{\circ}$  below zero, which freezes together all the loose pieces of ice, as well as the granitic and other boulders. The whole of these are often swept away by a high tide, or when the river is swollen by the melting of the snow in spring. One huge block of granite, 15 feet long by 10 feet both in width and height, and estimated to contain 1500 cubic feet, was conveyed in this manner to some distance in the year 1837, its previous position being well known, as up to that time it had been used by Captain Bayfield as a mark for the surveying station.

\* Capt. Bayfield, Geol. Soc. Proceedings, vol. ii. p. 223.