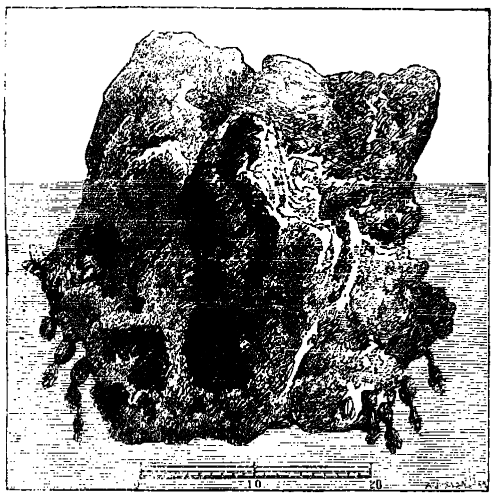
huge masses of earth piled up the vast waves which swept with such destructive force upon the islands of Java and Sumatra, and destroyed forty thousand human beings. Some lesser explosions were heard during the rest of the 27th, and the day of the 28th.

Scarcely any thing is known of Krakatoa before this eruption; but there are records of a similar, though less extensive, eruption in May, 1680. For two hundred years it has fallen into an uninterrupted sleep to be awakened with such terrible violence in 1883. At the time of the eruption it was uninhabited. There are certain legends handed down by the natives of the neighboring islands from which we can see that the existence of Krakatoa as an eruptive volcano antedates Javanese heroic history.

The travellers had little difficulty in landing on the extreme west of the cliff, on the shores of a small inlet following a deep ravine newly eroded by the rain through both the light material recently ejected, and



PUMICE FOUND FLOATING FIFTEEN MILES FROM MADAGASCAR, AUG. 13, 1884 (*La nature*).

the underlying older solid lava-beds. The ashes at this place were from sixty to eighty metres in depth, and were well separated from the black and gray lava by their white color. Although more than nine months had elapsed since this matter had been thrown out, still, in some places, it was so warm that steam escaped from among the ashes, leaving a layer of sulphur and sal-ammoniac behind. A bituminous odor was also noticeable, and this was no doubt due to the dry distillation of the vegetation buried beneath the warm cinders. After taking photographs, they left the island, and proceeded toward Lang and Verlaten, two small islands, probably a part of Krakatoa torn asunder during some remote eruption. These islands, like all their neighbors, are covered with a mass of pulverized pumice thirty metres deep, furrowed by the rain. The aspect of the islands reminds one of the front of certain glaciers; but the temperature of 40° C., due to the absorption of the sun's heat, will not allow this deception to last long. The surface of these two islands is much increased by the piling up of material on their sides during the eruption. To counteract this increase of surface, an island, Poolsche Hood, which was situated to the east of Verlaten, and a reef, Polish Hat, which rose to the west of Lang, have disappeared. Save the escape of steam, mentioned above, and which is independent of volcanic activity, absolute tranquillity reigns in these desolated regions. There are neither fumeroles, nor jets of vapor under pressure, which generally persist a long time after the eruptive period. The natural equilibrium is re-established. But it is to be remembered that the fires merely sleep, and that probably some day they may awake from their lethargy.

In conclusion, it may be well to give a brief account of the geological structure of Krakatoa and the neighboring islands. The series of volcanic islands to which Krakatoa belongs, follows a line extending N.N.W., obliquely across the straits of Sunda, and forming an angle with the lines of the principal volcanoes of Java and western Sumatra. The point where these three lines meet is found approximately at Krakatoa. The base of the island is made up of solid columns of a crystalline basalt, and of augite and labradorite, all very basic, and in which pyroxine augite made an abundant part of the second consolidation. These basic formations have been found at Krakatoa, Sebuku, Protection, and Sebesie. Above these various basaltics is a compact column of andesite, becoming more and more acid in its upper part, and nearly barren of the microliths of augite which are abundant near its base. There are layers of pumice between the sheets of lava, showing that the eruptions of the volcano have been of two kinds succeeding each other.

The ashes ejected by the last eruption are composed principally of a light spongy pumice, and of irregular blocks of a compact dark glass, in which may be distinguished the brilliant crystals of labradorite. This acid glass (70-72 in a hundred parts of Si.) presents a very simple constitution. It contains a good number of crystals (first consolidation) of labradorite, augite, hypersthene, and titaniferous oxide of iron; also elements of the second consolidation in the form of felspathic microliths, attributable to oligoclase. In addition to these truly volcanic matters, we may mention some *débris* in terrains, composed of fragments of quartziferous diorite, and balls of a calciferous marl, regular, and polished by erosion with pumice. These *débris* products are relatively rare; and, to all external appearance, the islands are one mass of volcanic ash.

TOUGHENED GLASS.[1]

UPON investigating the De la Bastie invention of the so-called toughened glass, Mr. Frederick Siemens has found that the process is not a manufacturing process at all, but, rather, a somewhat impracticable

[1] Condensed from a paper read before the Society of arts, London.

addition to known methods of glass-making. The new invention was based upon a very complicated and costly process. The objects were likely to have their shapes spoiled or their surfaces injured, and, in addition to these objections, the toughened glass was liable to burst spontaneously or by a sudden shock. The cooling influence, which acts from the surface inwards, is not in proportion to the bulk of the glass, but to its surface, and must always act more quickly where the surface is large in comparison with the volume: in a sheet, for instance, the edges cool more quickly than the middle, and the sheet is liable to explode.

Mr. Siemens has invented a process by which hardened glass may be manufactured and thoroughly toughened without this objection. His method consists of placing the parts of the object which have the least surface between slabs of a cold material suitable for the purpose. The edges are not exposed to this rapid-cooling process, and hence a uniform cooling of the whole mass is secured. The plan employed for various articles varies with their shapes, but each is based upon the same principle. He has three processes, — press-hardening, casting, and a third, theoretically less perfect than the other, viz., semi-hardening, or hard-tempering, which may be employed advantageously in cases where the others cannot be used, as in the case of lamp-chimneys, bottles, etc.

Press-hardened glass has now been manufactured for six years, and is constantly increasing in importance. Besides plain work, decorated sheets, inscriptions, and ornaments form an important part of the goods produced: the process is therefore one of manufacture, not simply one of hardening and toughening. The glass is so hard that the diamond will not touch it; and it cannot, therefore, be cut or bent after manufacture. It may, however, be polished, etched, and slightly ground. Its strength is at least eight times that of ordinary glass.

The process of manufacture is as follows: The glass is cut and shaped in the ordinary way, and is then exposed to the *radiant* heat of a peculiarly constructed furnace until quite soft. As soon as it has attained the required temperature, it is placed between cold metal plates to be cooled down with a rapidity which varies with the thickness of the glass, but is always very great. The heating of a sheet of glass of ordinary thickness requires one minute; the cooling, half a minute.

It is a remarkable circumstance that glass can be thus quickly heated and cooled without causing it to break. This is altogether due, in heating, to the fact that all the heat comes by radiation in a uniform manner. The success of the cooling is entirely due to the uniform temperature of the glass and metal plates during the cooling process. It is owing to the very high temperature of the glass during the process that it can be moulded, enamelled, and decorated at the same time it is being hardened. By this method an enamel can be produced that is as hard and refractory as the glass itself.

The hardness depends upon the rapidity of cooling; so that, if the glass is to be hardened to a very high degree, a very good conductor of heat, as copper, is used; if to a lower degree, iron is substituted; and, for a still lower degree, the iron press may be lined with asbestos or clay-stone. Much care must be used in the entire process; the furnace floor must be smooth, and be dusted with talc-powder; the whole process must be by radiation, and must be conducted uniformly.

Semi-hardened glass is made by the same process, except that, instead of using a press, the article is placed in a casing of iron provided with projecting internal ribs, which prevent contact except at a few points. The object is then allowed to cool in air. By this means a glass three times as strong as ordinary glass is produced. It is absolutely necessary that there shall be no draught at any time during the process, and the method can only be used for objects nearly uniform in thickness; thick-bottomed bottles, for instance, being liable to break.

The third process, that of casting, has not yet been introduced on a manufacturing scale; but Mr. Siemens considers it the most valuable of the three. The experimental castings have been very successful, and the objects consist of floor-plates, grindstones, pulleys, tramway sleepers, and various ornamental work. Mr. Siemens is of the opinion that castings might be produced with advantage for other purposes, especially to be used in connection with the building-trades.

Glass made by this process is four times as strong as ordinary glass, can be made much more cheaply, and cast into a variety of forms which it would be impossible to produce with ordinary glass without its cracking. It is manufactured in the following manner: Glass is melted in an ordinary tank-furnace, and run into moulds, as with iron castings. The process differs from that of casting iron in that a special substance is used in place of sand, and the mould and the glass inside of it are heated and cooled together. The material to be used in place of sand must be selected so as to have, as nearly as possible, the same conductivity and capacity for heat as glass. In such a case — the glass and mould forming, as it were, one homogeneous body — the glass will cool without cracking, even if the cooling process is comparatively quick, which is quite necessary. When fully heated, the glass and mould are taken out, and allowed to cool in the open air. This process differs from the other two, in that glass of any thickness may be cast, whereas in the others only glass of a uniform thickness can be made.

It will be seen from the description that these three methods, although very different from each other, are but different ways of treating differently shaped articles, and that all three are based upon the principle of keeping the whole body of the glass at a uniform temperature during the operations of heating and cooling. These processes are likely to cause an important revolution in glass-making; and it seems, that, in the future, tempered glass will bear the same relation to ordinary glass that steel does to iron.