by the phrase "a force equal to the weight of 10 pounds," which is neither clumsy nor absurd.

(10) "Except for the parts criticized above, on the units of weight, mass, and force, the present treatise shows that the author has read with profit and discrimination the most recent treatises on dynamics." I have been under the impression that in my treatment of these units I had, in the main, followed the most recent treatises on dynamics. May I ask in which of them units are treated in what Prof. Greenhill considers the proper way?

I would like to say also that the elementary proofs of the chief properties of the common catenary, which are given by me, are, with slight modifications, those given in Prof. Goodeve's "Principles of Mechanics." My indebtedness to his book is acknowledged generally in the preface.

I fear my desire to be brief may have made me appear curt. Let me express, therefore, my appreciation of the trouble Prof. Greenhill has taken to form a just estimate of the merits of my book, and of the kindly way in which he has spoken of it.

J. G. MACGREGOR.

Dalhousie College, Halifax, N.S., March 1.

Coral Formations.

I AM glad to see the theory that the internal lagoons of coral atolls are excavated by the chemical action of sea-water and the removal of carbonate of lime in solution is now being brought to the test of figures.

Mr. J. G. Ross (NATURE, March 15, p. 462) calculates from his experiments that in this way a sheet of carbonate of calcium half an inch thick can be removed annually from the surface of a lagoon, but strangely adds, "In other words at the same rate it would require about a century to deepen the lagoon one fathom." According to this method of calculating, 144 years is "about a century."

These figures no doubt suit the theory of the formation of coral lagoons very well, but they appear to me quite destructive of the other and co-relative view that the platforms upon which atolls have been formed have been built up by the accretion of the dead shells of pelagic organisms showered down from the surface of the ocean together with the shells of those organisms which have lived on the bottom. I believe that at no place on the surface of the globe are such dead shells being supplied at a rate that would even balance this supposed rate of chemical destruction.

Yet if these figures be correct we shall have to reckon upon the removal from such platforms of more than half an inch annually in consequence of the quicker action which it is said takes place through greater pressure at greater depths.

If, therefore, we accept the dissolution theory of the origin of coral lagoons, it seems impossible to believe in the building up of platforms of calcium carbonate on volcanic or other peaks from varying and unknown depths to the levels necessary for the growth of reef corals. If, on the other hand, we believe that platforms are so built up, it appears equally destructive of the dissolution theory of the lagoons.

Dr. Darwin indicated this difficulty in his letter to me, published in NATURE, November 17, 1887, p. 54, but the figures we are now supplied with enable us to realize it much more vividly.

T. MELLARD READE.

Park Corner, Blundellsands, March 16.

The Movements of Scree-Material.

I PERUSED with interest the abstract of a paper on the above, read by Mr. Davison at the meeting of the Geological Society on the 29th ult.

The phenomenon seems somewhat akin to the movements in the "Stone Rivers" of the Falkland Islands, though another reason has been suggested by Sir Wyville Thomson as the cause of their progress.

Might it not be possible for motion to be produced in loose materials, and in the molecules of certain coherent substances situated at a high angle of slope, by continual though imperceptible vibrations in the earth's crust?

Apart from the changes wrought by alternating temperature, might not the "downward creep" in the lead on the roof of Bristol Cathedral—as observed by Canon Moseley—be due to a "settling down" of the molecules by the constant vibrations of sounds transmitted through the structure, and having their origin within and without?

CECIL CARUS-WILSON.

Bournemouth, March 15.

Were the Elephant and Mastodon contemporary in Europe?

MR. HOWORTH asks this question in NATURE for March 15 (p. 463). Perhaps this extract from a translation of a note from Prof. d'Ancona, of Florence, will satisfy Mr. Howorth: "The soil of the upper Val d'Arno is ascribed to formations of the Pliocene period." In it have been found "*Mastodon avernensis, Elephas meridionalis.*" Twenty-four other animal remains are identified, all differing from the remains of the bone-caves. In both places respectively these relics belong to contemporary animals.

9 Sinclair Road, W., March 15. H. P. MALET.

EXPERIMENTS IN MOUNTAIN BUILDING.[1]

THE primary object of these experiments was to explain on what mechanical principles the remarkable rock-structures recently discovered by the Geological Survey in the North-West Highlands might have been produced. In experimenting on the behaviour of strata when subjected to horizontal pressure, it has been usual to regard large rock-masses as practically plastic bodies, and to imitate in the laboratory the great flexures and plications of Nature by compressing layers of clay, cloth, and other plastic or flexible substances. It was, however, evident, as soon as the true structure of the North-West Highland area was unravelled, that the rocks had, to a very large extent, behaved like rigid bodies under the enormous lateral pressure to which they had once been subjected. Instead of following the usual method of using plastic materials, the author therefore set to work to devise strata sufficiently rigid to snap rather than bend and become folded on the application of lateral pressure. It is to this peculiarity in the character of the materials, rather than to any great novelty in the methods, that the interesting results obtained are mainly due.

The experiments were of three distinct kinds. The first series was designed to explain the behaviour of strata when thrust horizontally over an immovable surface, and thus to throw light on the phenomena of "thrust planes," such as are now known to occur abundantly in the North-West Highlands between Loch Eriboll and Skye (see NATURE, vol. xxxi. p. 33). To simulate natural strata, layers of damp sand, foundry loam, or in a few cases clay, with laminæ of dry stucco powder between, were employed. In a few minutes the anhydrous powder absorbed enough moisture from the damp beds to enable it to "set" into tolerably rigid sheets. The rock which had thus solidified *in situ*, was next compressed horizontally, by pushing in, by hand, or with the help of a screw, the movable end of the long box in which the strata were formed. One side of the box could be removed at pleasure, and at the end of each experiment it was lifted off, and the section inside revealed, so that it could be photographed or copied if desired.

Fig. 1, which is drawn to a scale of $\frac{1}{12}$ of the original, shows the character of the section produced after the end had been pressed in 20 inches. The central light-coloured band, bounded by stiff stucco laminæ, has undergone no folding, but has become heaped up by means of a series of slightly inclined reversed faults, along which the constant pressure from the right found relief. For this structure the author has proposed the name "wedge structure," as the advancing mass is really raised by being forced over a series of wedges of undisturbed rock.

After pushing the piled-up mass a certain distance

[1] Abstract of a Paper by Henry M. Cadell, B.Sc., F.R.S.E., H.M. Geological Survey of Scotland, read before the Royal Society of Edinburgh, February 20, 1888.

forward, the whole heap always showed a tendency to rise and ride forward *en masse* over the less disturbed beds in front. Fig. 2 shows a typical section produced at this more advanced stage of the movement. This new plane of shear may be called a "major thrust," as distinguished from the "minor thrusts" shown in Fig. 1, and in the upper part of this figure. The structure of these artificial rock-masses bears a remarkable resemblance to that of the great thrust areas of Sutherland

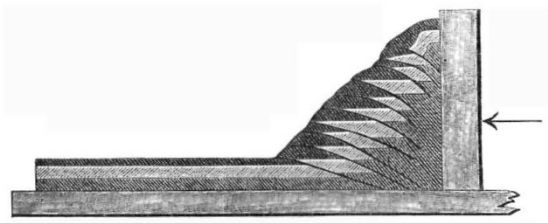


FIG. 1.

and Ross. Everywhere along that great region of earth movement major thrust planes are found truncating sets of minor thrusts, just as has taken place in this experiment. The extraordinary heaping up and local thickening of Silurian strata, and the superposition across their upturned edges of huge slices of Archæan gneiss and Cambrian sandstone, are phenomena which, before the thrust-plane theory had been originated, were quite inexplicable.[1]

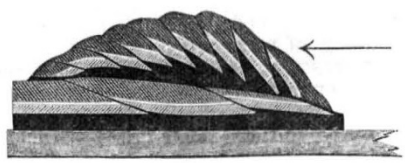


FIG. 2.

The second series of experiments was intended to ascertain how such great thrusts might have originated, and to trace their connection with folds and great terrestrial movements of upheaval and mountain building.

Stratified beds, similar to those employed before, were formed on a band of stout wax-cloth, about 2½ feet long, and 7 inches broad, secured at the ends to vertical blocks of wood. When pressure was applied to the ends, the wax-cloth was thrown into folds, but the folds did not

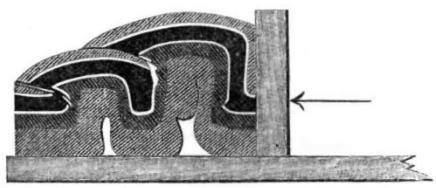


FIG. 3.

in all cases reach the surface, but found relief in thrusts, as shown in Fig. 3.

In this experiment an anticline was first formed at the end of the wax-cloth nearest the pressure. A thrust appeared at the surface, and, on examining the section, this was found to bend down and bury itself in the left monoclinal member of the fold. A second anticline was next started in advance of the first, and, on continuing the push, a second thrust, similarly situated with regard to the underlying fold, was produced. By this means it may be possible to explain how thrusts are connected with movements of deep-seated parts of the earth's crust, and also how, as in the Highlands, they occur over broad areas all inclined in the same general direction. If this section affords the true explanation of their origin, it is clear that thrusting is only a surface phenomenon, and that the complex structures of the North-West Highlands are structures which can only originate at the outer edge of a great mountain-system of elevation.

Fig. 4 represents a section produced with the same apparatus, but here the pressure was applied from both sides. An anticline was started at the centre of the

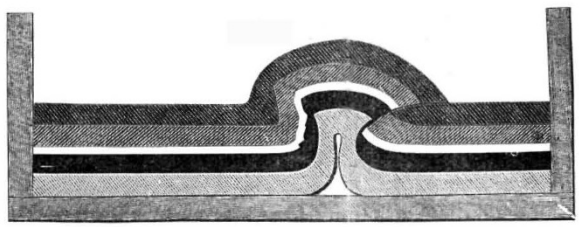


FIG. 4.

wax-cloth, and as the pressure was continued the strata were squeezed into a form closely resembling that known as "fan structure." Two small arches were next formed, one on each side of the original fold, and the pressure was continued. A second fan made its appearance outside the first, and at each side there was a tendency for thrusts to be produced, as shown in Fig. 5. Throughout the experiment the lowest stratum of damp sand next the wax-cloth was compressed and distorted, till, at the last stage of the movement, it became very much "staved together" above the synclinal folds of the wax-cloth on either side, and was completely "nipped out" at the crown of the central fold. During the movement in the mass it was, in fact, made to flow like a viscous body, along a series of approximately vertical planes, which in

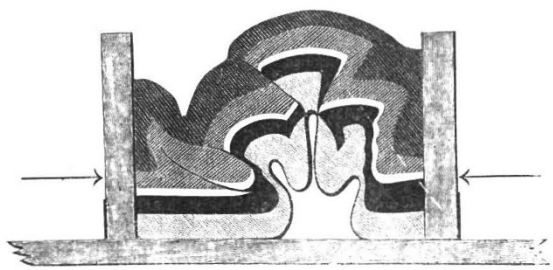


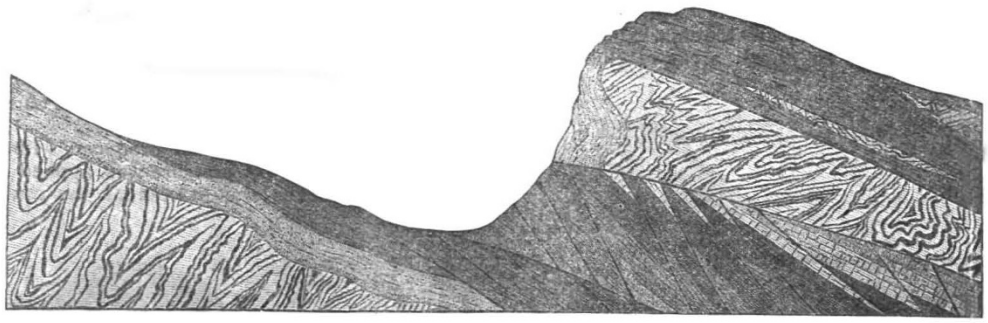
FIG. 5

Nature would be described as planes of foliation. This experiment, then, may help to explain not only the origin of the fan structure of the Alps, &c., but also the common occurrence in the centre of the fan of a core of crystalline rock with vertical foliation.

The experiments of the third series were modifications of those of Prof. A. Favre, of Geneva (see NATURE, vol. xix. p. 103), who covered a band of stretched caoutchouc with beds of adhesive clay, and on allowing the elastic sole to contract, observed the wrinkling up of the surface of the clay into a series of miniature Alpine ridges. The author modified Favre's experiments by separating the upper and lower portions of the clay with sheets of paper, so that the former could be stripped off at the end of the experiment without disturbing the lower part of

[1] The effect of major and minor thrusts is well seen in the section of the Durness and Eriboll district above the map in the second edition of Dr. A. Geikie's "Scenery of Scotland."

the section. After removing the superficial folded layer, the paper covering the lower bed was found to be covered with minute corrugations like those often seen on beds of mica-schist. On stripping off the paper, and again stretching the elastic substratum, the clay adhering to it did not become smoothed down to its original form, but split along a multitude of vertical rents, transverse to the direction of pressure, each of which corresponded to one



Section at head of Loch Eriboll.

of the little ripples on the paper before it was removed. The sides of the cracks were observed to be covered with minute vertical striations like the slickensides of a fault-fissure.

This experiment, the author suggests, may explain the vertical cleavage and foliation found in the deep-seated parts of many old mountain-systems.

SWISS FOREST LAWS.

THE Report of Mr. Conway Thornton to the Foreign Office, on the Swiss Forest Laws, is a careful and interesting piece of work. He divides his subject into two parts: in the first he treats of the history of forestry prior to 1875, the year in which the Act now in force, the Forestry Act of 1875, was proposed; and in the second part he deals with that Act, its provisions and its effects, and the measures taken under the "Règlement d'Exécution," which followed the Act, for the advancement of technical education amongst foresters in Switzerland. It is evident that from a very early date the various cantons endeavoured to preserve the forests. Thus, in 1314 the authorities of Zurich forbade "the felling, floating, or selling" of timber from the Sihlwald; in 1339, Schwyz forbade charcoal-burning near the chief towns of the canton, and a similar decree was promulgated in Fribourg in 1438. Industries using wood were in various cantons restricted in their operations; the laying out of new vineyards was prohibited under heavy penalties for centuries; and finally, during last century, the use of uncloven vine-props was forbidden. The exportation of timber took place only under great difficulties, and even the removal of timber from one place to another in Switzerland was, until 1848, very much restricted. In 1376, Zurich forbade clearings to be laid down in pasture, and Fribourg would not allow sheep-pastures to be established in clearings. Goats were not permitted to be let loose in the woods; and rosin-scrapers were excluded from many of the forests. None of these numerous decrees appear to have had much effect, the very number of them testifying to their powerlessness to check the evil. In many cases the general prohibition against wood-cutting gave way to a partial permission, as, for example, in Zurich, where the number felled was not permitted to exceed a stated total. This instance of Zurich gives us the first scientific treatment of the question, when the felling of the Sihlwald and other woods in the fourteenth century was regulated both as to the amount and the system of cutting.

In 1702, prior to which date attention was paid solely to the maintenance and protection of the timber, the Government appointed a Commission to inquire how the forests might be best preserved, enlarged, and improved; and subsequently issued a decree carrying the recommendations of the Commission into effect. In 1725, Berne followed the example of Zurich, and published forestry orders, which, like those of the latter, contained directions for the cultivation of timber and for permanent improvements. Similarly, in other cantons, improved systems were introduced; thus, in Fribourg, the compulsory planting of marshy meadow-land was decreed; in Lucerne a season was set apart for felling, the growth of oaks was recommended, and the formation of clearings was forbidden. In 1755 an excellent forestry code was drawn up by Joseph Wilhelm, Prince-Bishop of Bâle. About 1760, two scientific Societies—the Physical Society of Zurich and the Economical Society of Berne—made great efforts to introduce improved knowledge of woodcraft into Switzerland, and with this object they made strong representations to their respective Governments, and the Forestry Decrees of 1773 and 1786 were the results of their interference. The substance of these decrees may be stated to be the surveying of forests, the appointment of officials who would supervise planting, experiment on exotics, and help in teaching a more scientific system of wood-cutting. By means of these measures some real progress was made, which, however, was stopped by the general confusion during the beginning of this century; but, immediately peace was restored, the Helvetic Government turned their attention again to the forests, which by this time had suffered severely. Soleure was the first to start a system under which technical instruction, chiefly in forestry and geometrical surveying, was given to two citizens from each woodland district, the better qualified being chosen foresters. From this time until 1830, forest laws were drawn up universally, prescribing the modes in which timber was to be felled. Zug, in 1821, tried to give an increased value to her forests by endeavouring to extend scientific teaching among the people. In consequence of the disastrous floods in Switzerland in 1830, from this time we find that forest laws were more generally enacted and more rigidly enforced than they had ever been before. The number of officials was increased, and great attention was paid to their training. In fact, the spread of the science of forestry in Switzerland dates from this period. At first the people thwarted the officials in every way, but, becoming gradually enlightened as to the utility of the Government measures, they ceased from actual opposition. Even the most backward of the cantons began