tween 29 and 250 fathoms. The association of species of the two genera may be more apparent than real, for the species of *Cyclogaster* are typically bottom-inhabiting forms and those of *Careproctus* free-swimming. The distribution of the light-colored and black forms overlap between 400 and 1,000 fathoms. The gradual merging of one environment into another and the force of heredity may account for the overlapping of the faunas, but, as is the case with the shallow-water species, the differently colored ones may not intermingle. Let us imagine a portion of the ocean bottom as illuminated by a lantern. A black fish on a dark bottom or near the margin of the illuminated area would be practically invisible. A transparent or a reddish translucent fish would be little more discernible. Away from the bottom and near the source of light a black fish would be more conspicuous than the others. At such depths it is difficult to decide which species rest upon the bottom and which swim freely some distance above it. The deep-sea Cyclogasterids, which, from their structure, we assume to be free-swimming, are nearly all light-colored. Nearly all of those which appear to live upon the bottom are black. It should be noted that among other deep-sea fishes a number of free-swimming species are black and also that some of the bottom-inhabiting species may be light-colored. It can be seen from the above discussion that the light-colored species in the depths below the penetration of sunlight may be as protectively colored as the black forms. The disparity in the numbers of light-colored and black species suggests that this is not true or that the majority of the species live upon or very close to the bottom.

The significance of the predominance of reddish color in the light-colored species is unknown. This type of coloration may be considered as being intermediate between the translucent and black types and having the partial advantages of both. In dealing with this question the color perception of the eyes of fishes should be taken into consideration. If the eyes of fishes lack the color perception of our own and are simply camera eyes the reddish species will appear gray and be inconspicuous in their environment.

We have intimated that, in addition to a change in coloration, the deep-water species become translucent. The tide-pool species are soft and flabby and no great change is required for them to assume a translucent jelly-like appearance.

In concluding I wish to express my appreciation of the work of the *Michael Sars* in 1910. The observation made on this expedition that the coloration and bathymetrical distribution of the young fishes are correlated from the earliest stages is confirmed by my work on the Cyclogasteridæ. The young of these fishes inhabit the same regions as the adults and are similarly colored. Dr. Hjort's suggestion that the 500-meter or 273-fathom level marks the border between two differently colored faunas does not harmonize with the conclusions I have reached from a study of the Cyclogasteridæ. The acquisition of more carefully taken records of these fishes resulting from expeditions as carefully planned as that of the *Michael Sars* may cause us to modify our conclusions concerning the importance of the 273-fathom level in relation to the distribution and coloration of the Cyclogasteridæ and bring them more in accord with those of Dr. Hjort.

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SPECIAL ARTICLES

ISOSTASY, OCEANIC PRECIPITATION AND THE FORMATION OF MOUNTAIN SYSTEMS

THE theory of isostasy postulates the uniformity of the weight of the earth's crust over the surface of the earth. It was suggested by Major Sutton[1] in 1889. It has recently received considerable attention by geodesists and geologists and has received quantitative confirmation by the researches of Hayford.[2] Recent work has been along the line of investigating the effect of displacement by erosion and the resulting equilibrium flow.

[1] *Bull. Phil. Soc. Washington*, 11: 51–64, 1889.

[2] See SCIENCE, February 10, 1911; also H. F. Reid, *Proc. Am. Phil. Soc.*, 50: 444–451, 1911.

No one appears to have considered the effect of oceanic precipitation in the middle geologic ages.

It is sufficient for this discussion to divide the earth's geologic history into three periods; the fluid age, the crust-steam age, and the crust-ocean age. During the crust-steam age the crust increased gradually from nothing at all to an effective thickness, including the layer of partial solidification, of several miles. During the larger part of this age, the water now forming the oceans was probably all in the atmosphere. The period of oceanic precipitation was probably quite extended on account of the heat liberated by condensation as well as the increased admission of solar radiation due to the clearing of the atmosphere.

At the time when liquid water began to exist in quantity, the cooling of the earth's crust had progressed far below the freezing-points of nearly all the materials of the crust, and the most plausible assumption is that the crust was of considerable thickness. It is also probable that the earth's surface was fairly level, the flatness depending upon the uniformity of distribution of rock materials of different densities.

Consider now the effect of superposing on this early crust a great quantity of material of low density, namely, the water of the oceans. Near the borders of the great oceans, we should then expect to find a severe outward thrust of crust comparable in mass to the mass of the ocean, but in volume less in inverse proportion to its density.

The isostatic conditions would further lead us to look for the accommodation to this displacement material farther inland, in a general continental elevation increasing toward and up to the border ranges.

This suggestion is put forward for what it may prove to be worth. Whatever may have been its consequences in detail, if the isostatic condition has been even approximately adhered to during the earth's history, the precipitation of the oceans must have had a profound effect on the elevation and depression of portions of the earth's crust. With more definite knowledge of the physical properties of geological materials it should be a mere mathematical problem to determine what those effects have been.

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Washington, D. C.,
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MUSICAL ECHOES

The phenomenon of musical echoes has been known for a long time and has secured recognition in the text-books on sound. Thus we read:[1]

> Frequently, a sharp sound, such as the clapping of the hands or of two boards together, is reflected in a room or a corridor with smooth, parallel walls as a more or less musical sound. A similar effect is often observed when one is walking near palisading, each footstep of the observer being followed by a musical ring. The effect is only noted after some sudden sound, and may often be heard very distinctly on clapping the hands or on knocking two stones together.

The Greek Theater at the University of California presents a pronounced musical echo, the conditions being especially favorable to the production of the phenomenon. The seats are made up of a series of large concrete steps that are semicircular in shape and that rise regularly towards the back. If an observer generates a sharp sound in front of the stage at the center of the circles of steps the sound passes out symmetrically and strikes the steps in perpendicular planes and is reflected and diffracted back to the source of sound. The pulses of sound reflected from the successive steps follow each other regularly and thus set up a musical sound which is heard by the observer.

It occurred to the author that the pitch of the sound might be determined. The method of experiment was to generate a musical echo as already described and to compare the pitch of this sound with that of an adjustable turning fork. A check on the final result was found by calculating the pitch from the relation $n = v \div \lambda$ where n is the pitch of the sound, λ the wave-length and v the velocity of sound at the temperature of the theater. It is

[1] Poynting and Thomson, "Sound," pp. 31, 32.