Washington could acquire such knowledge. Much can be done by cooperation, so long as this does not degenerate into invidious competition; but the autonomy and initiative of the stations are assuredly the best means of maintaining their usefulness to the people of their several states, and to the progress of agricultural science in its widest sense, viz., its application to the actually existing conditions, even though these may appear 'abnormal' to the dwellers in the temperate humid regions where that science has been first developed.

E. W. Hilgard.
University of California,
March 24, 1902.

THE SUBMARINE VALLEYS OF THE CALIFORNIA COAST.

In Science for January 10, Professor Wm. E. Ritter, reporting the dredging work done last summer off the coast of southern California, states that 'the bottom deposits of some, at least,' of the submarine valleys which characterize the California coast, 'even at a distance of several miles from shore, are of a character to prove that close inshore material is carried into them in large quantities.' And to him this 'observation suggests, though of course does not prove, that the valleys are natural channels through which currents flow, at times, at least, from *the shore out to deeper water.*'

On entirely different grounds, the present writer had reached a somewhat similar conclusion—that the majority of the submarine channels of the California coast have been formed, or are at least kept open, by some cause now in operation, and that cause coastal currents. These views and the reasons for them were given by the writer in a paper read before a meeting of some members of the U. S. Geological Survey, about a year ago; they can be only briefly outlined here.

The mature Coast Ranges of California, taken as a whole, lie close to and parallel with the coast line, and the coastal topography is therefore rugged. As the larger stream courses follow the trend of the ranges and the coast for long distances, there are few coastal breaks of importance. Fringing this rugged coast and the coastal islands is a narrow submarine terrace or platform, the 'continental shelf,' which has been formed mainly by marine abrasion, and whose outer margin is marked approximately by the 100-fathom submarine contour. Its width ranges from a minimum of about a mile to a maximum of about thirty-two miles, the average being between five and ten miles. The submarine valleys (of which between twenty-five and thirty have been described along the Pacific coast of California and Lower California) notch this terrace and its outer escarpment. The valleys, for the most part, begin at or near the shore line and continue to depths ranging from about 400 feet to more than 3,000 feet, the majority descending to at least 2,000 feet. Most of the valleys follow a course roughly at right angles to the shore. Their forms are both simple and branched. Some of them head opposite the mouths of large valleys on the land, and some opposite abrupt and rugged portions of the coast, where there is no break in the Coast Ranges. The valleys in general are quite open, none of them being 'chasm,' as is frequently supposed. This may be easily seen in the cross sections of the valleys. While the general slope of their walls differs considerably, in any given case it is comparatively gentle, taken as a whole. Two cases of unusual steepness have an angle of only about 20°, while the maximum angle measured was about 31°, in Cape Mendocino valley. The grade (profile) of the valleys is considerably greater than that of the lower parts of the larger coastal valleys. Vincente valley, from the shore line to a depth of 1,800 feet, has an average grade of about 260 feet to the mile, while the grade for the first quarter-mile from shore is about 720 feet to the mile.

Two explanations of these submarine valleys have been proposed: one that they are structural in origin (Lawson); the other that they are submerged stream valleys (Le Conte, Fairbanks, Davidson).

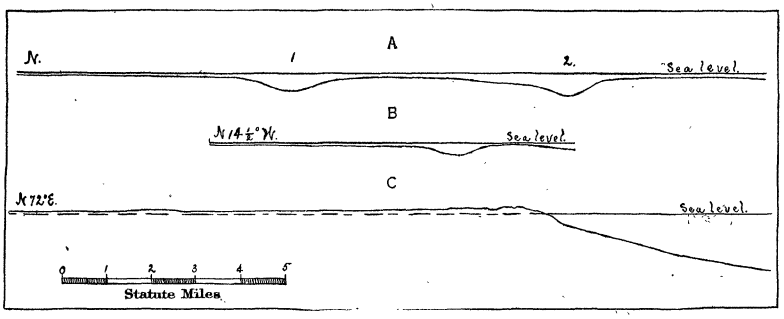
There can be little doubt that *some* of the valleys are due to coastal deformation; but this interpretation is unsatisfactory in accounting for the majority of them, for the following reasons:

(1) Many of the more important valleys *stop abruptly at or near the shore line,* and no corresponding valley or depression exists on the land, so far as known; nor (2) are there, except in a very few instances, corresponding embayments in the coast line, as there should be if the valleys are of comparatively late origin, and especially if developed subsequent to the formation of the 'continental shelf' (submarine platform).

(3) The submarine platform, except in one or two places, shows nothing that could be interpreted as warping in their neighborhood, as it should if they were of subsequent development. (4) On the other hand, unless the valleys belong to the very latest stage of coastal development, the submarine platform should be developed between the head of the valley and the shore, or the head of the valley should be filled with shore detritus. This is not the case with most of the valleys.

(5) The objection raised by Fairbanks that their course is transverse to the principal structural lines of the coast, appears to the present writer to have little weight, since minor structural lines might occur at any angle with the main lines.

The interpretation as submerged stream valleys is also unsatisfactory because: (1) The submarine valleys do not, in general, correspond in position to valley openings on the shore, and, *vice versa,* the coast drainage lines (except in a very few instances) have no corresponding submarine channels. (2) Where they are opposite important valleys on the shore, the submarine valleys do not correspond to them in size, shape or grade. (3) The submarine platform, in the case of many of the more important valleys, has not been developed through cutting between the head of the valley and the shore, nor have the heads of the valleys been filled in with sediments, even in regions of deposition. Two of the valleys head near the points of cuspate forelands, the valleys, in both instances, running in close to the beach. A third valley heads near a form having the general appearance of a blunt cusp. If the submarine valleys were developed prior to the formation of the platform, they would have been modified by its development; if subsequently developed (as stream valleys), it should be possible to trace them inland, and there should be corresponding embayments in the coast line.



A. Section across (1) Cape Mendocino and (2) Punta Corda submarine valleys, where the valley bottom of the former has a depth of 2,000 feet, and of the latter a depth of 2,400 feet.

B. Section across Vincente submarine valley, where the valley bottom has a depth of 1,500 feet.

C. Profile of Vincente submarine valley and of the mainland along the same general line. Vertical scale in *C* five times horizontal.

In view of the fact that so many of the valleys (about one-half) stop abruptly close to the present shore line, it would hardly seem that this could be accidental, and the reason for it is the critical point in attempting an explanation of the valleys. This fact, together with the other objections given above, would point to the conclusion that some of the valleys at least must be wholly or partly due to present causes. The only cause capable of producing such results—keeping the valley head open close to shore in the face of active

cutting or deposition—would seem to be coastal currents of some sort. Such currents must be either marine, or else subterranean streams from the land, and it does not seem altogether unlikely that they might be the latter. The emergence of subterranean streams might at least account, in some cases, for the absence of deposits in the valley heads and their nearness to the shore, if not for the formation of the valley as a whole. The occurrence of an oil well in Vincente valley near its head is significant in this connection. The larger pre-Pliocene valleys of the Pacific coast, which were much deeper than those of the present time, were filled to a greater or less extent during the Pliocene depression of the coast, and have been as yet only partially re-excavated. There are therefore at intervals along the coast, deposits of loose materials extending to a considerable depth below sea level, and through these, underground waters, under sufficient head, might find a submarine outlet.

It is possible that many if not most of the valleys are due, not to any one cause, but to several causes which have all contributed to their formation or preservation. Much careful and detailed investigation is necessary before the problem can be solved, and the statements made here are intended as suggestive rather than final. Such work as Professor Ritter reports gives valuable information. Observations in the vicinity of the valleys on surface currents, their strength, direction and persistence, and on the temperature and salinity of the surface waters, and also similar observations made, as far as possible, near the bottoms of the valleys and in their neighborhood, as well as a study of the materials covering their floors, might throw much light on the question of their origin. Further than this, detailed geological study of the mainland adjacent to the valleys is necessary. The physiographic conditions, both subaerial and submarine, have been taken into account, to a certain extent, in this discussion, but a fuller knowledge of them is needed. Finally, as has been stated elsewhere by the writer, each valley must be considered by itself, since the explanation for any one is not necessarily the explanation for all.

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Washington, D. C.

SHORTER ARTICLES.

How many one-dollar bills will equal in weight a five-dollar gold piece?

If the reader will answer the above question in his own mind before going further he will better appreciate what follows. This question was asked of a number of students and professors, and the answers recorded. The answers were surprising and for the most part extravagant. It seems that the idea of value is so prominently associated with currency that definite ideas of weight are somewhat wanting, although most people have fairly correct ideas of the weight of paper in other forms. The number of persons answering the question was 97. The average estimate was 2,291 bills, the median estimate was 45. In order to see if there is any tendency to confuse the categories of value and weight unconsciously, other persons were asked to answer the question: How many five-dollar bills will equal in weight a five-dollar gold piece? Some were asked a similar question with reference to twenty-dollar bills. Putting the fives and twenties together, there were 74 answers given. The average estimate was 97, the median 25. The great difference in the averages is due to a half dozen very large answers to the first question, but these do not materially affect the median estimates, which are the really significant figures. The answers are all from males. A number of answers were given by female students, but their answers, either by chance or by nature, were of such a great variety—ranging from one to one million—that it seemed best to leave them out in making the comparison. After these calculations were made I received answers, through the kindness of Professor Templin, of the University of Kansas, from two divisions of a class of both sexes. The figures with reference to the one-dollar bills show an average of 2,749, and a median estimate of 99, while with the five-dollar bills the