

SUBMARINE CANYONS AND OCEANIC REGRESSION (1)

by

ANDRÉ MEYNIER.

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Submarine cartography developments have drawn the attention of American Geographers on the existence of deep submerged valleys which cut into the continental shelf near its outer edge. Extending their investigations to other littorals of the world, they have enumerated 102 canyons of this kind, 46 of which are situated around North America. Their depth reaches nearly always 1000 feet and, in more than 50 cases, exceeds 5000 feet. In general, they are a prolongation of more or less large continental rivers. Sometimes, however, they look as if disconnected from the present estuaries of these rivers such is the case of two canyons on the southern coasts of Portugal. Sometimes also, they prolong the old water course and not the present one of the river; such as the Cape Breton trench, possibly a former bed of the Adour. They appear more frequently off flat and straight coasts such as the American Coast from Cape Cod to the Hudson River, the Gulf of Bengal and the Gulf of Guinea. There is therefore no question of a prolongation of rias such as may be found in Brittany or in Galicia. Neither have they any connection with fjords. Their cross profile is shaped after a fairly sharp V, suggesting a form of juvenile valley. Their longitudinal section presents steps and platforms such as that of continental rivers, generally speaking, their slope decreases down stream. Whenever they prolong rivers with a big flow, their slope is less steep than when prolonging rivers of minor importance. This slope is however always abnormally steep: 1 per cent after the largest rivers, 2 to 3 per cent in other cases. A survey of their distribution disposes of any idea of a connection with latitude, the width of the continental plateau and the stability or instability of the coast.

On the basis of various hypothesis as to their origin, Mr. SHEPHARD, builds up an ingenious theory. These canyons are supposed to have been dug by rivers at the time of a sea regression, and once submerged, to have been entirely filled up by sediments which have also buried all traces of continental relief on the platform. Still, thus accumulated in deep hollows, such sediments would be instable and unconsolidated, with a tendency to slide downstream; periodically, heavy landslides resulting from earthquakes would partially clear the valley. In fact, the George Bank Canyons (near Cape Cod) have only been discovered subsequently to the 1929 earthquake although situated on one of the most frequented sea routes in the world. Since 1896, deepenings of from 20 to 200 feet have been recorded in a canyon of the Equator. The absence of submarine canyons on certain littorals would be accounted for by a more rapid cementation of sediments.

(1) FRANCIS SHEPHARD, "Submarine Valleys" (Geographical Review, 1933, p. 77-90).
F. SHEPHARD and Ch. N. BEARD, "Submarine Canyons" (Geographical Review, 1938, p. 439-451).

PAUL A. SMITH, "Atlantic Submarine Valleys of the U.S." (Geographical Review, 1939, p. 648-653).

BOURCART, "Essai sur les régressions et transgressions marines" (Bulletin de la Société Géologique de France" 5^{me} Série, Tome VIII, 1938, p. 393-475).

JOHNSON, "Origin of Submarine canyons" ("Journal of Geomorphology" 1938, April, October and December 1939, January, March and May).

BUCHER, "Submarine Valleys and related geologic problems of the North Atlantic" (Bulletin of the Geological Society of America, April 1st 1940, p. 489-512).

See also: "The Hydrographic Review" Vol. XI, N° 1 p. 143, Vol. XI, N° 2 p. 188, Vol. XV, N° 1 p. 61 and 66, Vol. N° 2, p. 120, Vol. XVI, N° 1, p. 121, Vol. XVIII, N° 1, p. 31, Vol. XVIII, N° 2, p. 53, Vol. XIX, p. 46.

Mr. JOHNSON raises objections to this hypothesis which involves the assumption that sediments so accumulated are sufficiently solid and compact to remain in position in the canyon and at the same time, be sufficiently fluid to be shifted eventually. Are not these two conditions contradictory? On the other hand, cones of débris resulting from the recent clearing of these submarine valleys should be found down these canyons. So far, nothing of the kind has been recorded.

Thus, Mr. JOHNSON, after discarding hypotheses previously put forward and re-examining the different terms of the problem, suggests a new one according to which the edge of the continental talus would be the breaking out spot of artesian springs flowing from the interior of the continent. In former periods, when tertiary erosional surfaces had not yet removed the highest reliefs, artesian hydrostatic pressure was stronger than it is to-day. Moreover, enormous quantities of water are driven out of the sediments in process of consolidation. Under the action of all these springs, some adequately effective sapping work would result in the clearing of the mock valleys. The sediments might have been removed in a dissolved state, even if they are little susceptible of dissolution, provided it is assumed that the change extends over an adequate period.

It is on the contrary on the tectonic side that Mr. BOURCART seeks an explanation. After a minute study of oceanic transgression and regression problems, this scientist finds that our standard notion of a continental platform slowly subsiding from 0 to 200 meters and bordered by a steep talus of 200 to 2000 meters must be re-considered. In nearly every case the slope increases from observing spot — 180 to — 400 or — 500 and it is only when this is exceeded that one may speak of a real talus. In fewer cases, a second slope acceleration is noted from — 500 and it is only under — 1000 that the talus begins. Now, submarine canyons do not cut into the first continental shelf (0-180) but into the second (180-400). Up stream, these canyons are precisely truncated by the first shelf.

On the other hand, the perfect evenness of every one of these shelves as well as their width can only be accounted for by a combined action of subaerial forces and sea abrasion at the time of a transgression. The second plateau (180-400) would be a remnant of a platform resulting from a continental erosion and dating from the upper Pliocene regression. The next transgression is supposed to have been provoked by a flexure of the whole of the continental margin, the second plateau slope would then have been accentuated at the same time as the continental erosion was laying the foundation for platform 0-180. The Flandrian transgression would finally swamp this platform. Juvenile valleys would naturally follow the raising of the 180-400 plateau, which would account for both their steep slope and disappearance upstream. Mr. BUCHER who was not acquainted with Mr. BOURCART'S investigations accepts like the latter the notion of instability of the oceanic continental margin. But his conclusions as regards submarine canyons are quite different. He discards those that are a prolongation of river valleys and to which he concedes a continental origin (glacial overdeepening, for instance). His new hypothesis concerns only canyons which do not prolong any watercourse. The George Bank valley system, which is well known to-day evokes a phase of "mature dissection". They are therefore *forms of erosion*. They affect nearly always comparatively *recent* rock terraces resting on a bottom of hard old rock. They are moreover sharp continuous forms, otherwise land slips and slides would soon fill them up. As no continental water flows at such great depths and as, on the other hand, artesian springs could only account for accessory details, the erosional factor must be sought in the ocean itself; only a *wave* with a length greater than the canyon depth can supply a satisfactory explanation. These waves are twofold: *tides* with a velocity of 11 cm. per second, measured at the bottom of the canyons, seem capable of keeping up canyons but undoubtedly not of building them up: *tsunamis*, whose back currents reach a velocity of 1 m. 5 per second are alone capable of indenting the continental talus and, in the long run, to lay out a system of valleys. The paucity of tsunamis in the course of time (two per annum on an average) is no obstacle to this explanation: flowing in sub-desertic countries is not more frequent and is sufficient however to work up special features.

