ing to the ring is suddenly drawn out into a thin annular film, several millimeters long, yet retaining stability." This strongly suggests that the film method was the one actually realized.

Although I have not used the Du Noüy instrument, I am inclined to believe that the film method is the one most frequently realized. But, until the confusion just indicated has been removed by the publication of the results of a careful, detailed study of the behavior of the instrument, it is not possible to speak with certainty regarding it. That study should include a description of the essential features of what occurs during the process of tearing the ring from the liquid, as well as adequate numerical data.

The factors that must be considered in the reduction of observations obtained by means of the detachment method have been discussed by Weinberg, Cantor,[11] Lenard, Tichanowsky,[12] and others. They involve the inclinations of the liquid surfaces where they meet the ring, and the suction of the pendent column. No satisfactory, theoretical formula for computing any of these quantities has yet been derived, but Harkins has published empirical curves from which the surface tension can be deduced from the observed maximum pull on wire rings of certain sizes. Owing to the absence of such formulae, Weinberg had to make a number of assumptions in the reduction of his observations, and additional complications were introduced by the crossed diametral strips with which he braced his ring. The abnormally high value that he deduced for the surface tension of water is to be sought in errors in these assumptions. It certainly is not due, as has been suggested,[10] to an omission of the very elementary and well-known correction for the inclination of the balance beam at the instant of rupture, for he not only described in some detail the mirror system by which he determined the position of the beam, but also discussed this correction, which, in his case, was small.

In the film method, it is necessary to consider the effective radius of the tubular film, and the weight of the liquid lying between the ring and the top of the film. These have been discussed by Sondhauss, Lenard, and others, and Sondhauss has called attention to the fact that the form of the film suggests a portion of an inverted cone. Again satisfactory formulae are lacking, and empirical curves similar to those determined by Harkins for the detachment method would be of value.

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[11] M. Cantor. *Wied. Ann.*, 47: 399–423; 1892.

[12] I. I. Tichanowsky. *Physik. Zeits.*, 25: 299–302; 1924; 26: 522–525; 1925.

POSSIBLE WATER SUPPLY FOR THE CREATION OF CHANNELED SCAB LANDS

THE creation of the channeled scab lands in eastern Washington has been the subject of much discussion. Dr. J Harlen Bretz, of the University of Chicago, describes the formation of the channels, and the sweeping away of the loess that once occupied the surface, as being done in a short period of time with a huge volume of water, all channels being at high flood at one time with sufficient water flowing across country to cause the Columbia River to rise nine hundred feet at Wallula Gap, where the channel is about a mile wide between basalt bluffs.

A means of providing this volume of water, approximately fifty cubic miles per day, has puzzled Dr. Bretz and other geologists interested in the phenomenon. Dr. Bretz gives two possible explanations of such a flood: first, that the glacier was melted excessively in a short period of time by extreme heat and warm rains; or second, that the Spokane flood was a gigantic Jokulloup, such as has occurred in Iceland where volcanic activity has broken out beneath an ice-cap.

I am more inclined to believe that the flood was caused in a more natural and regular way, by the ponding of waters in natural reservoirs by ice obstructions.

The essential factors necessary to supply a sufficient amount of water to cause the channeled scab lands are as follows: first, a secure ice dam in the Columbia River below the Nespelem River to divert the water across the eastern Washington table-land; second, a reservoir large enough to hold a sufficient amount of water; third, a temporary dam sufficiently high to impound the water; fourth, water to fill the reservoir.

When the glacier was farthest advanced, probably its southern boundary was about as follows: commencing near Wenatchee, Washington, the extreme southwest corner of the Okanagan Lobe; thence, extending across the Columbia River, following the basalt bluffs along the west side of Badger Mountain; thence, along the north slope of the Big Bend plateau to near the upper end of Grand Coulee; thence, across the Columbia River near the mouth of the Nespelem River; thence, in an easterly direction, again crossing the river in the vicinity of Inchelium; thence, in a southeasterly direction, crossing the Spokane River and extending possibly to Spangle, the southern terminus, forming the Spokane Lobe; thence, in a northeasterly direction along the north and west slope of the Coeur D'Alene Mountains to Clark's Fork; thence, southeasterly, following Clark's Fork through the Bitter Root Mountains, completely damming the Clark's Fork Canyon through these mountains; thence, in a northeasterly direction to the base of the Rocky Mountains, forming a third lobe on the southeasterly corner.

From near Wenatchee to somewhere near the mouth of the Nespelem, the Columbia was obstructed with a continuous ice dam that withstood the impact of the Spokane flood, which probably occurred soon after the glacier reached its farthest point of advance. We will designate this obstruction as the Okanagan Dam. The Okanagan Dam created a lake, if not named before, to be known as San Poil Lake. This lake occupied the southeast corner of the Colville Indian Reservation, commencing at a point near the mouth of the Nespelem, and covering the land along the river where the elevation did not exceed that of the Grand Coulee Divide, and extending up river to the lower edge of the glacier.

From the lower edge of the glacier near Inchelium up to Clark's Fork, all of the Columbia River Basin in Canada, and the basin of Clark's Fork in Idaho to the Montana line, were covered with glacial ice to a depth of three thousand feet or more, thereby damming up the Columbia from Inchelium to the Montana line. To this obstruction we will give the name Spokane Dam.

It is evident from the above that the glacial ice occupied all the places for ponding water in the Columbia River watershed in Canada, and practically all the basin of Clark's Fork and the Kootenai in northern Idaho, but that the entire area of Clark's Fork and a portion of the Kootenai watershed in Montana, consisting of about twenty thousand square miles, was unoccupied by ice.

This unglaciated area was bounded on the north by the ice barrier, on the east and south by the Rocky Mountains, and on the west by the Bitter Root Mountains, thereby creating a reservoir known as Missoula Lake, which was filled with water to an elevation of about forty-two hundred feet.

All passes through these mountain ranges have a higher elevation than the Missoula Lake level, excepting that portion occupied by the ice barrier that existed in Clark's Fork Canyon through the Bitter Root Mountains.

During this period of the existence of the glacier, the Okanagan Dam played only a minor rôle, ponding the waters of the San Poil Lake and the waters of the Okanagan watershed. But the Spokane Dam ponded all the waters to the east, north and southeast of the junction of the Columbia and Clark's Fork.

The duration of the Spokane Dam was from the time the glacier advanced from the mouth of Clark's Fork to near Spangle, possibly one thousand years, and an additional length of time to allow the filling of Missoula Lake to an elevation of about forty-two hundred feet. The present annual rainfall in the area occupied by Missoula Lake is from fifteen to twenty inches and during the glacial period was probably more. Should we accept eighteen inches per annum as the average, then, during the one thousand years of advance of the glacier from the mouth of Clark's Fork to Spangle, we would have fifteen hundred feet of rainfall over the entire twenty thousand square miles of the Missoula Lake watershed. Allowing fifty per cent. of this rainfall for evaporation, seepage and dam leakage, we would have approximately twenty-eight hundred cubic miles of water ponded in Missoula Lake. Undoubtedly the dam gave way long before the recession of the glacier, for this amount of rainfall would fill Missoula Lake to the overflowing point long before the estimated stationary period of the glacier had elapsed.

The area for ponding water in the Missoula Lake Basin is limited on account of the high elevation of the southern end and the numerous mountain spurs extending into the basin. But, I am satisfied, the area was continuously enlarged as soon as the glacier ceased to advance, for at all points along the ice barrier in Montana where the glacier encountered the warmer waters of the lake, undercutting on the front of the glacier caused caving, and huge icebergs floated around in the lake and melted away, adding an additional supply of water to the annual rainfall.

It is also possible that the surface of the eastern slope of the glacier next to the Rocky Mountains was below the forty-two hundred foot level, which would allow Missoula Lake waters to cover and melt the glacier over the Kootenai Lake area in Canada, thereby greatly enlarging the volume of water that was impounded in Missoula Lake.

Undercutting by the lake waters probably caused the dam of ice to recede gradually through the Bitter Root Gorge, thereby allowing Missoula Lake to occupy a part of the area of the Clark's Fork watershed, west of the Bitter Root Mountains, possibly as far west as the present Pend D'Orille Lake in Idaho, before the Spokane Dam gave way.

When the Spokane Dam gave way soon after the last period of advance, the glacier's surface must have been uneven, broken and badly jumbled, for it had advanced through an extremely mountainous region, many peaks of which extended above the surface of the glacier. At its southern terminus, south and east of Pend D'Orille Lake, the ice probably piled high up on the northern slope of the Coeur D'Alene Mountains, leaving a ragged, elevated edge. Under such conditions, when the water found an outlet over the glacial obstructions, the flow could have occurred at any point in the area occupied by Pend D'Orille Lake, instead of following the southern rim of the glacier as it would have done if the break had occurred when the glacier was receding and its edges clear.

If the above hypothesis is right, it is evident that the escaping flood can pass to the north and west of Spokane and distribute itself over the glacier, wearing several channels in the ice to the glacier's edge, some of which deposited their water into San Poil Lake to fill and enlarge the preglacial channel known as Grand Coulee. Through other ice channels, the glacial water was poured over the rim of the glacier to fill, enlarge and widen all the then existing preglacial channels, and, in many instances, to form in the scab lands new channels of large dimensions.

It is the belief of the writer that during the different glaciation periods many floods occurred which were produced in a similar manner. Whenever large volumes of ponded water were released and passed through the well-eroded preglacial channels, they deposited along the main preglacial channels large gravel bars, some of which were miles in length, and from one hundred to two hundred feet in depth. These gravel bars were formed across the outlets of channels entering the main drainage channels, and could not be formed if the water flow in the side channels were simultaneous with the flow in the main channels. If the water flow in the side channels were simultaneous, there would be no opportunity for gravel bars to form across the mouth of the side channel at an elevation higher than its bed. The entrance to the side channel must have been filled by backwater from the main channel, thereby allowing the bars to be deposited across its front in comparatively quiet water.

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BLOOD RELATIONSHIP WITHIN THE ORDER RODENTIA

IN his classic study of phylogeny by means of precipitating antisera Nuttall left untouched the problem of the blood relationship of the rodents. The present serological study of the four species of mice, *Mus musculus, Mus wagneri, Mus faroensis* and the Japanese waltzing mouse of the genus *Mus,* was begun with an attempt to produce precipitating antisera in pigeons, using the serum or muscle extracts of these rodents as antigens. In spite of all modifications in manner of treatment of the birds the study of two hundred pigeons has not given an antiserum which would differentiate these mice. Several antisera have been obtained which reacted up to dilutions of 1:50 and 1:100, but these show a very broad reaction among the rodents and are absolutely non-specific in regard to the differentiation of the four types of mice considered. Similarly Nuttall failed to obtain any precipitin from the serum of a duck and a chicken treated with rabbit serum. Several workers, however, have considered that such an antiserum may be produced.

Recently, acting upon the suggestion of Dr. F. G. Novy and following the work of Uhlenhuth and Weidanz (1909) and R. Trommsdorf (1909), rabbits have been immunized against the serum of *Mus musculus.* By a modification of Nuttall's quantitative method of precipitin titration the blood of *Mus musculus* could readily be differentiated from that of Japanese waltzing mice and *Mus wagneri.* Serologically, the *Mus faroensis,* however, may be regarded at present as identical with *Mus musculus.* For these titrations precipitating antisera from the rabbit were used. These gave definite reactions at dilutions of antigen as high as 1:10,000 and in every instance the end point in the titration of *Mus faroensis* was the same as that of the homologous antigen, *Mus musculus.* Likewise *Mus wagneri* and the Japanese waltzer react to the same point, but this is always at a definitely lower level than the one at which *Mus musculus* and *Mus faroensis* were found positive. For example, in the case of a precipitating antiserum which reacted with *Mus musculus* and *faroensis* at 1:6,500, the Japanese waltzer and *Mus wagneri* consistently remained active only up to 1:4,000, and again with an antiserum active against *Mus musculus* and *Mus faroensis* in dilutions up to 1:10,000, Jap waltzer and *wagneri* were positive only in dilutions up to 1:4,500. With these antisera rat serum was active only in dilutions up to 1:100, a logical group reaction.

It was feared that rabbits might not be suitable animals for the production of rodent antisera, inasmuch as several investigators have considered that they might well contain natural precipitins for other rodents. In an effort to eliminate this factor of error sixty-eight normal rabbits of assorted types and sexes were titrated against both *Mus musculus* and *Rattus norvegicus* at dilutions ranging from 1:4 to 1:5,000 and were found to be consistently negative. In addition all experimental rabbits were tested for the presence of the precipitating antibody in their serum before the treatment was instituted and all final titrations contained controls with normal serum.

At present the pigeon may be considered unsuited for the production of precipitating antisera. The rabbit is free from natural mouse or rat precipitin and is suitable for the production of these antibodies. The four species of mice studied fall into two groups serologically distinct, the one being *Mus musculus* and *Mus faroensis* and the other Japanese waltzer and *Mus*