

checked by the large quantities of sand with which its channel is choked. During a considerable part of the year the stream bed is dry, all of the water moving slowly through the sand and hence powerless to erode or transport clastic materials while even in flood the transportation of large quantities of sand then in suspension must consume much of the stream's energy and reduce its cutting power. The fact that Little River, a tributary of the South Canadian, which is not sand choked, has been able to reduce its bed and much of its basin lower than the bed of the South Canadian in Eastern Cleveland and Pottawatomie counties supports the view that the sand choked character, particularly of the South Canadian, has been an important factor in its inability to degrade its basin. This sand not only retards downward cutting of the Canadian but also of its northern tributaries which are choked by sand blown from the stream bed by the south winds. Much of this sand must be removed by erosion before the streams can erode the underlying residual materials. This appears to be an important secondary factor in determining the location of the Cimarron-North Canadian divide. That the sand choked condition is of secondary, rather than primary, importance in the control of erosion appears evident, however, from the fact that the Cimarron, like the South Canadian, has a sand choked channel.

XXIV. SOME OBSERVATIONS ON THE SOUTH CANADIAN RIVER NEAR NORMAN

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The laws of stream action have been worked out mostly from the study of streams of the humid regions. The streams of the arid and semi-arid regions have been given less attention and it is quite common when such streams do not conform to the usual humid type to consider them as abnormal. However, the intermittent stream is just as normal a type for the dry regions as the permanent stream is for the humid regions. While the same laws of stream action hold for both types of streams yet the conditions of work are so different in the two cases that an attempt to interpret the phenomena of the streams of the arid districts by direct deductions resulting from the study of streams of the humid regions is apt to lead to erroneous conclusions. This paper is for the most part a result of observations made in the bed and valley of the

South Canadian river for about three miles above and below the Norman bridge.

The South Canadian is a type of stream very common to the Great Plains country. It has a broad flat valley and a sand choked bed which is usually much too broad for the amount of water carried, but at times of flood it is sometimes completely filled with water. In the humid regions, a sand choked stream is considered an aggrading stream but in a stream like the South Canadian which has such extremes of high and low water the determination as to whether it is aggrading or degrading depends on the amount of scour during high water compared with the amount of fill at times of low water. Probably the only way this can be accurately determined is by a series of observations extending over a number of years. While streams of this type are commonly spoken of as braided streams the South Canadian is not at all times a braided stream. At times of high water it fills its bed from side to side. At other times, if it maintains the same volume for any considerable length of time, it soon adjusts itself so that it flows mostly in one channel. This is especially noticeable at times of low water. It takes on more of a braided appearance at times when the water is rapidly rising or falling.

The valley of the river is nearly three miles wide at the bridge. On each side of the stream are two terraces which appear to be remnants of old flood plains. The highest one which is 15 to 20 feet above the present river bed is the older and is covered with good soil and the trees and other vegetation are of the more permanent type. The lower terrace is five or six feet above the river bed. The soil of this terrace is sandy much like the present stream bed and the prevailing timber growth is of small cottonwood. Remnants of old stream beds can be traced on both the terraces and especially on the lower one. About one and one-half miles above the bridge and on the south side of the river is a remnant of an old channel which at times is a shallow lake more than half a mile long and nearly half as wide. Upstream from the lake a channel can be traced to its junction with the present stream bed but its bottom is about four feet above the bottom of the present stream so the lake receives water only at times of high water in the river. Also about two miles below the bridge and on the same side of the river are remnants of stream channels which contain water much of the time and at times of high water are fed in the same way through narrow channels from the river.

A marked difference between the South Canadian and streams

of the humid region is in the way in which it changes its course. Sometimes because of storms higher up the stream a wall of water several feet high reaching from bank to bank will rush down the river. At such times the stream is apt to change its course very suddenly by cutting a new channel in the soft material of the lower terrace. Such a flood in 1915 cut a channel a short distance above the Norman bridge about one-third of a mile wide and a mile long and left an island of several acres between the old and new channels. The bed of the new channel was not cut as low as that of the old and now at low water the stream runs in the old channel. Drift material has been deposited to some extent in the upper end of the new channel and is being covered somewhat with dunes so that under the right conditions the stream may remain in the old channel.

At times of low water much sand is picked up from the river bed and blown about by the wind. As the prevailing winds are from the south this has resulted in a line of sand dunes on the north side of the river valley. This material is sometimes carried back from the river for a distance of two or three miles. The presence of sand dunes along the north banks of the rivers of Oklahoma has been mentioned by Gould in Water Supply Paper, No. 148 and it was suggested that because of this continuous drift of the sand to the north bank that most of the rivers of Oklahoma are migrating southward. Sand dunes are also found just at the north edge of the present stream bed. Remnants of lines of sand dunes are common on both old terraces and are apparently always situated on the north side of old river channels. During periods of low water dunes also form at places in the channel itself and it is probable that sometimes these lines of dunes are an important factor in changing the course of the stream. A line of sand dunes on the river bed would act as a dam and be quite effective when the water is slowly rising. This is the case in holding the water back from the old channel above the island. Along the north side of the lake above mentioned there is a line of large dunes. Their situation with regard to the old stream course is such that it is probable that a line of dunes formed across the old stream bed during a long dry spell and turned the stream aside and resulted in its cutting its present channel from there to some distance below the bridge.

A broad, flat, sandy flood-plain elevated only a small amount above the stream bed seems to be the usual condition in Oklahoma streams. This is due to the great difference between scour and fill at periods of high and low water and to a soil which

erodes readily and contains a considerable amount of sand. This is the condition, not only of the main streams, but also of the tributaries so far back from the main stream that change in its bed could not possibly affect them.

From the relation of the present stream bed of the South Canadian to its previous stream beds and also to the terraces it appears that the river at present is cutting its bed downward. However it may have aggraded its bed at times in the past and may do so again in the future.

XXV. BURIED MOUNTAIN RANGES IN OKLAHOMA

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It is a well known geologic axiom that granite (used in the sense of igneous and metamorphic rock) underlies all other rocks. Granite is the most common expression, on the earth's surface, of the basal complex or earth stuff, which occupies by far the larger portion of the planet on which we live. We were taught in our student days that if we drill deep enough anywhere on the earth's surface we would encounter granite.

So, academically, we have known that granite underlies all of Oklahoma, and that if the blanket of sedimentary rocks, including the sandstones, limestones and shales, could be removed, that this granite floor would be exposed. However, until recently, we have had very little definite information as to the occurrence of this granite, and especially as to the depth beneath the surface at which it occurs in various parts of the state.

Thanks largely to the work of the oil geologists we are now learning many things heretofore unknown. The records of the thousands of deep wells drilled in Oklahoma, Kansas and Texas, have been collected, tabulated and correlated, so that we now know more about subsurface conditions in many parts of the Mid-Continent Oil Field than in almost any other part of the United States.

It is a matter of general information that there are in Oklahoma four regions of mountain uplift, namely the Wichitas and Arbuckles, entirely within the state, and the Ouachitas and Ozarks, located partly within Oklahoma and partly in some other state. The essential structure of these four mountain regions is practically the same, being in each case an elevated, truncated dome, with the sedimentaries dipping quaquaversally from the core of the mountains. In the Arbuckles, Wichitas and Ozarks erosion has removed