

DOUBLE ZIRCONATES.

Two attempts at the formation of double zirconates were made.

1. Potassium calcium zirconate.

About two grams each of zirconia, potassium hydroxide and lime were heated together for about four hours. There was evidence of considerable action. The mass was treated with dilute acetic acid and thoroughly washed. Then on treatment with dilute hydrochloric acid nearly the whole residue went into solution. The analysis gave ZrO_2 , 67.21 per cent.; CaO , 31.06; K_2O , 1.11. This is a calcium zirconate, $(\text{CaO}.\text{ZrO}_2)$, with a small part of the CaO substituted by K_2O .

2. Potassium aluminum zirconate.

Two grams of zirconia were fused for eight hours with two grams potassium hydroxide and three grams of alumina. The mass was washed with dilute acetic acid until no more alumina was dissolved. The residue was treated with dilute hydrochloric acid and the insoluble portion removed by filtration. The analysis gave ZrO_2 , 72.38 per cent; Al_2O_3 , 7.66; K_2O , 20.00. These experiments indicate the possible existence of double zirconates, and when time permits this point will be further examined.

RIVER ADJUSTMENTS IN NORTH CAROLINA.

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NOTE.—In presenting this paper I beg to acknowledge my indebtedness to the lectures of Prof. Collier Cobb, and to his work and that of Messrs. Chas. Baskerville, R. H. Mitchell and other members of the class engaged in advanced work in Physical geography; but the mode of presentation is my own and I alone am responsible for any short-comings it may have. As my paper was presented for the Kerr Prize in Geol-

ogy it has not even had the critical reading of the head of the department, and lack of funds prevents my presenting as many maps as were contained in the paper.

North Carolina is naturally divided in three sections: (1) The Eastern or Costal plain; (2) The Piedmont Section, and, (3) The Western or Mountain District.

The costal plain runs inland about 100 or 125 miles. "Its western boundry line runs from the western part of Warren through Franklin, Wake, Cumberland, Chat-ham, Moore, Montgomery, and Anson counties." The whole coastal plain belongs to the Quarternary system, with frequent expanse of the Eocene and Miocene of the Tertiary along the rivers and ravines. As we go inland the country rises about one foot per mile, but from North to South is almost level. Over the whole section the primitive rocks are covered with a deep stratum of earth, principally sand. Along the western border and river courses we find granite, slate, and other rocks sparingly distributed, but no rocks of any kind can be found any where else in the region. The section is made up of beds of clay and sand with vast quantities of shell imbedded in them. The upland soil is mostly sandy loam which yields very good crops. There are vast areas of sand that will not yield anything but pines. In fact we know that this whole region has in recent geological time been raised above the sea level.¹

The Piedmont Section begins on the western edge of the coastal plain and runs west to the borders of the Blue Ridge. It is a rolling prairie in the east and gets rougher towards the west, including some small mountain ranges, the Brushy, Pilot, and King's Mountain. The mountain chains of the western part of the Piedmont belt run northeast and southwest; and as the rivers pass them they form rapids and falls that give excellent opportunity for manufacturers.

1. Handbook of North Carolina, 1885, published by Board of Agriculture.

Though you would expect a very rough hilly country on the West you do not find it so. The slope on the eastern side of the Blue Ridge is much steeper than that of the West. West of the Blue Ridge we have a very large valley bounded on the East by the Blue Ridge and on the West by the Great Smoky Mountains. This valley runs northeast and southwest between the two mountain chains and composes the mountainous districts of North Carolina.

This area has principally crystalline schists and gneisses with patches of conglomerates, sandstones, and shales and limestone. Both the Smokies on the West and the Blue Ridge on the East presents an anticlinal structure; the latter often having its monoclinical member absent. The area was in all probability once covered by an eastern extension of the Paleozoic rocks of East Tennessee, the sandstones of the western district being probably Cambrian (Chilhowee or Potsdam), the patches of limestone probably Silurian, and the grits and shales farther East possibly Carboniferous.¹ I assume that the folding that produced the Appalachian System was, as in Pennsylvania, rapid enough to deform the river systems. It gave rise to four great systems in North Carolina. The first we may call the Deep River syncline. It had its head in Chesterfield County, South Carolina, on the North Carolina line and ran northeast into Virginia. The second had its head in Caldwell County, North Carolina ran east of north and joined the first in Virginia. This one may be called the Dan River syncline. The third had its head in Catawba County, North Carolina, and ran south into South Carolina. This may be called the King's Mountain syncline. The fourth, which we may call the Asheville syncline was rather a canoe-shaped basin with a length of about 150 miles and a width of 20

1. Professor Collier Cobb's Lectures on General Critical Geology, 1893-94; see also Cobb's Map of North Carolina, 1887.

miles in Watauga county and 50 miles in Henderson. Its ends are in Virginia and Georgia, and it took a Northeast and Southwest course. It was probably a lake for a long time until it flowed over, most probably in Henderson county. We find evidences of shores in Transylvania county that were evidently made by a lake. These synclines and the rivers that occupied them may be seen on map (1) It can be seen from the map that the original drainage of western North Carolina was not as it now is. Yet the present rivers are in many cases in the original river beds. The original river of the Asheville syncline headed in the northwest with what is now New river, ran southwest and crossed near Boone into the head waters of Watauga river, ran along the head waters of Watauga, but in the opposite direction taken by the Wautaga now, for a few miles and crossed into the head of what is now Linville river, ran down the stream for about 20 miles and crossed into Brush creek and then into Toe river. At this point Linville river now enters what is known as the gorge. This is a very deep valley that has been cut since the original drainage we are describing. The river that cut through this great plateau has captured the Linville river and led it through, but at the time we are describing this gorge did not exist and the natural outlet was through Brush creek as stated. The river continued down Toe river as far as the fork known as South Toe, and there it crossed the present gap known as the Toe river gap. Down Swannanoa to French Broad and up French Broad and out through Mud creek into South Carolina, thence to sea. The drainage on the southwest began with the Hiwassee river which has since been captured and inverted, and ran east or a little south of east to Valley river, up Valley river, across Red Marble Gap and into Nantehala river, down this to its junction with Tuckaseege river, thence up Tuckaseege and across what is now known as Road Gap, down Richland creek to Pigeon river, up Pigeon to the great bend and

thence across Hominy Gap and down Hominy into the French Broad, up French Broad and out through Mud creek into South Carolina. We have many of our rivers in the original river beds. The Hiwassee has been captured and inverted but it still occupies the old bed. The Nantehala and Tuckaseege still occupy their old beds though there has been considerable change, a part of the latter having been inverted.

We would expect to find in these inverted rivers evidence of it in their sluggish movement but we must remember that most of them have since their inversion been so much lowered that they are the roughest to be found. The Little Tennessee River has cut a gorge through the Great Smoky Mountains over four thousand feet deep and we could hardly expect a river to be slow and sluggish whose lower waters had been lowered so much. Likewise the French Broad from above Hot Springs is very rough owing to the same fact. On the northwest the New river was made by cutting into the syncline and leading a part of the original river out. In map (I) we see that it is about to cut into the syncline and capture a part of the original river. Its headwaters push forward into the syncline until it has captured the headwaters of the original river and inverted a small part of it. This inverted part having a greater fall will move the divide southwest by degrees; and this continues until it reaches the mountain ranges near Boone which on account of its structure marks its final divide. The next stream that cut into our original river was the Watauga. It cut through the Smokies from Tennessee and led off a portion, but did its best work in determining the divide for the other rivers. The strata not all being of the same hardness we can see why these captures went as far as they did and no farther. When New River was inverted it probably would have led out much more of the streams of the northern and middle portions of the basin but for the fact that there was a ledge of rock that outcropped

about the central part of Watauga county and ran entirely across the basin at that point. These rocks had no influence upon the streams until the streams had levelled the country down to them. Then they formed a natural divide and fixed definitely the headwaters of New River. The Watauga was probably captured by a westward flowing stream on the southwest of these and therefore could not capture any of the New River's headwaters. Further on the south of the Watauga and running parallel to it there is another outcrop of rocks which run across the basin and join the Blue Ridge at Grandfather's Mountain, thus fixing definitely the divide between Linville and Watauga rivers. From this divide the river which goes south is Linville, which runs in the channel occupied formerly by the original river. This channel has the highlands of the Blue Ridge on the south and east; and on the west there is a range of mountains which separate Linville and Toe River. Linville River now runs down this valley about twenty miles and then enters what is known as the gorge. The original river formerly passed over and went down Brush Creek, Linville gorge not having been cut at that time, to Toe and down Toe as far as where South Toe enters. The Linville gradually gnawed its way back through a vast plateau and tapped the original river, thus leading off a few miles of it. We will also note that Linville is the only river that captured a stream from this basin and led it out to the east, all the rest have been captured and led off to the west through the Great Smokies.

The next capture was that of the headwaters of the Toe by the Nolichucky. This led all the North Fork of the original river out except the Swannanoa which still retains its old position. As the Nolichucky cuts through the Smoky Mountains it gradually lowers its channel and lowers the whole of the river. As the Nolichucky cuts its way back it furnishes a shorter route to the lowlands and being shorter it has a more rapid current which cuts

its channel faster and the divide migrates eastward until it is finally permanently located at Toe River gap, all the waters of the northwest having been captured by westward flowing streams. The next capture I shall take up belongs to the southwest tributary of the original river. The Hiwassee originally formed the headwaters of the river that drained the southern end of the Asheville syncline and led its waters up to the French Broad and thence out by that river. It is almost if not quite impossible to determine which of these captures took place first and in what order the others followed, but I am inclined to think that the rivers of the northeast were captured pretty much in the order that I have treated them, i. e., the headwaters (New River) were captured first, then a new stream cut in and took another deal off the head and so on down; in the southwest it is most probable that they did take this order. Considering the amount of erosion that the Little Tennessee has done I think that that stream was the first one to cut through and make a capture, thus draining all the basin west of the Balsam Mountains. Later the Hiwassee was captured and inverted and now runs out the southwest end of the basin. We can see by comparing the sketch of the original drainage with the map of to-day that the capture would turn a large volume of water through the Little Tennessee's gorge and thus help to sink it very rapidly. This is most probably what happened. As evidence of capture and inversion in the Little Tennessee River we have several rivers coming into it like the barbs on an arrow; i. e. they show their former tendency to run the other way. The Hiwassee also has several branches coming in in that manner, as the Nattely River and Shoal Creek. In map (I) we can see the river system of the Asheville syncline as it originally was. We see the little Tennessee and the river that captures the Hiwassee just cutting through the Great Smoky Mountains and looking in upon their prey. They are moving their respective divides to the

east and this continues until the divides have moved to their present position, and by this time the Little Tennessee has captured and inverted all the waters west of the Balsam Mountains and the divide has moved to Road Gap where it stops on account of the rocks that outcrop here. The Hiwassee is gradually overcome and captured in a similar manner. This only leaves Pigeon in its original position and running over what we now call Hominy Gap to the French Broad, and on the west we see the river that is to capture it cutting through the Smokies and gradually capturing its headwaters until they are finally all captured and led out through the Smokies. The New Found Mountains form a barrier between this river and Hominy Gap—the bed of the original stream is still the lowest gap in these Mountains.

The creek that flowed from the gap to French Broad is Hominy Creek and since the days of the readjustment it has recaptured two of its old tributaries; i. e. the two small branches that once ran to Pigeon River, now run into Hominy Creek and thence to French Broad*. All these waters that originally found their way to the sea through the upper French Broad valley would have made a large valley and such we find to-day. This stream has been cut into and captured by a stream from the west thus inverting the French Broad from its original course. The French Broad from the mouth of Swannanoa to Brevard, a distance of about forty miles, is a very smooth, sluggish river, so slow in its movements that one can but notice it and compare it to other mountain streams that usually go so rapidly. This is evidence of an inversion which has evidently taken place. From Asheville west, the French Broad is noted for its beauty, which consists in its rough, rugged course over rocks and through gorges, winding its way through the Great Smokies into the Appalachian River. There is very little fall in the French Broad between Brevard and Asheville while between Asheville

* National Geographic Magazine, vol. I, no. 4. By Bailey Willis,

and Paint Rock there is a great fall. At Asheville the altitude of the river is about 2100 feet while at Paint Rock it is 1264, thus giving a fall of 181 feet to the mile. The town of Brevard is lower than Asheville but both towns are above the river. However I believe that there would not be a difference of many feet in the altitude of the stream at the two places. We can see from map of the original drainage the French Broad as it ran south-east, with the river that is about to capture it cutting through the Smokies and having their divide just east of the Tennessee line. As in the other cases the divide has migrated east and the western river has captured and inverted the French Broad and led it out to the west. This finishes up the Asheville basin or syncline. Now let us look at the others. The next one I will take up is the old Dan River syncline which I have described above. It has had two changes. First it has been cut into by the Yadkin which has led about 50 miles of the Dan River headwaters to the sea through its channels and secondly it has had numerous readjustments through its headwaters and those of John's River, a tributary of the Catawba. In the drawing of the original drainage, map (I,) we can see the position of this syncline which originally extended into Virginia and met the Deep River syncline. In the drawing we see that the Yadkin is about to cut into the Dan and as soon as it cuts through it will take the waters to the sea because having a shorter distance to go it must have a greater fall and will hence take the Dan in preference to being captured. The Dan was thus turned from its course and led to the sea by the Yadkin. The present Dan River has a branch, Town Fork, that still follows the old bed. The headwaters of the Yadkin have extended themselves still further north and are now known as the Ararat River. We will now turn our attention to the captures made in the headwaters of the syncline; and this brings me to mention a fifth syncline in North Carolina which I had not noticed until after I had

begun my work on this paper. This syncline we may call the Round Knob syncline since Round Knob is in the syncline and near its head. It began in the west of McDowell and ran a little north of east through Burke and Iredell counties, and it is probable that it continued through Davidson, Randolph and Chatham and joined the Deep River syncline in the latter county although we have no definite evidence that it did. In Map (I) we can see the drainage of this syncline as well as the captures which its waters made on those of the Dan River Syncline. I was at first disposed to think that John's River had captured the branch of Yadkin called Yadkin and that later it had been retaken by the Yadkin, but upon examination I find that those branches near the head of the Yadkin come down from a high plateau and enter the Yadkin at right angles and I am convinced that the branch called Yadkin is merely conforming to the family trait and has never been captured by John's River. If we look at the branches now called John's River and Buffalo Creek we find they have the Yadkin family traits and they show they have been captured by John's River. As the Yadkin cut into and captured the Dan so the Round Knob Syncline has been cut into by the Yadkin and probably by the Catawba and its waters have not gone through the Deep River as they probably did at first. Third Creek is probably nearest the old channel that traversed Round Knob Syncline. The Catawba that cut into the Round Knob Syncline ran a little east of the King's Mountain Syncline originally and it was its tributaries that cut through the eastern side of this syncline and led its waters out. The River that originally occupied the syncline was most probably what we call West Fork of Catawba River. This joined the Catawba where it passes to South Carolina. We see from the original diagram that the tributaries of the Catawba are about to cut through the eastern border of the King's Mountain syncline and lead its waters to the Catawba, and as time

passed we see they kept pushing to the west until they have obtained the position they now occupy. Dutchman's Creek has cut through and branched in the syncline and now drains the whole of it. West Fork of the Catawba which was originally in the syncline has cut through the western border and now drains a large area northwest of the syncline; thus in time the rivers have changed their positions and have so greatly eroded the syncline that we only find traces of it left, such as Anderson and King's Mountain on the west, and on the east not even so much, however we can trace its borders between Dutchman's Creek and Catawba.

The Deep River syncline headed in Chesterfield county South Carolina, and ran northeast to Virginia where it joined the Dan River syncline. We can see its position by turning to the general drainage Map of North Carolina after the Permian uplift, (Map I). Its eastern border still makes the fall line in our rivers, but its western borders were not so well marked, and did not have so definite a boundary. In fact the eastern border was a wide spread of country gradually sloping into it. The eastern border may be seen by drawing a line from Cheraw, South Carolina, northeast passing about ten miles east of Raleigh and striking the Virginia line where Dan river enters North Carolina. Along this line is an outcrop of a number of the older rocks, principally granite. (Hand Book of North Carolina, 1886.) And a little west of this is the old Deep River bed. The river headed in South Carolina with Brown's Creek and ran northeast to the Pee Dee River which formed a part of its bed, up what is now Little river, across to Wolf's Creek, down this to Deep river and down Deep river to Haw river where it turned up what now is New Hope river and across to Stone Creek, down this and up Knopf of Reed's Creek across to Tar river, up this, and to Fox Creek, over to Grassy Creek and down to the Dan river. At this time the coast line was only a few miles east of

this and the rivers such as Roanoke, Tar, Neuse, Cape Fear and others had not cut back to the syncline, however the distance to the sea was small and the fall was comparatively great and they were gradually cutting away. In drawing (Map 1) we can see how they cut this original deep river up and send their streams on westward for other adventures. The Great Pee Dee cut into the syncline near its head and led off Brown's Creek and inverted and led off Little river, then sent one of its streams on northwest and at last under the name of the Yadkin it cuts into the Dan River Syncline and captures a large part of its headwaters as we have described above. Cape Fear cuts into the syncline and leads off the part we now call New Hope and sends its branches on to help drain the territory northwest of the syncline (note the slowness of New Hope River). The Neuse cuts in and leads off a small portion as does the Roanoke, and thus helps the waters to find a shorter route to sea. At last this syncline leaves us this remnant of its former self as evidence of what it has been. The inverted creeks and rivers are yet at a loss to know what to do and so move along slowly, but by and by when they get accustomed to their new environment they will pick up their spirits and move along joyously as they did of old, and later generations will never know what a deal of trouble they have had. Their rate of flow is probably even now being accelerated by the lowering of the eastern border of the central plain.

REDUCTION OF CONCENTRATED SULPHURIC ACID BY COPPER.

BY CHARLES BASKERVILLE.

In a previous communication¹ the writer noted that copper was acted upon by concentrated sulphuric acid

¹This Journal, 17, 90.



Fig. 1. Original Drainage.



Fig. 2. Present Drainage.