MISSOURI

GEOLOGICAL SURVEY

PRELIMINARY REPORT

ON THE

# STRUCTURAL

AND

# ECONOMIC GEOLOGY

OF

# MISSOURI.

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## BUREAU

OF

## GEOLOGY AND MINES.

**JNO. A. GALLAHER,**
**State Geologist.**

JEFFERSON CITY, MO.:
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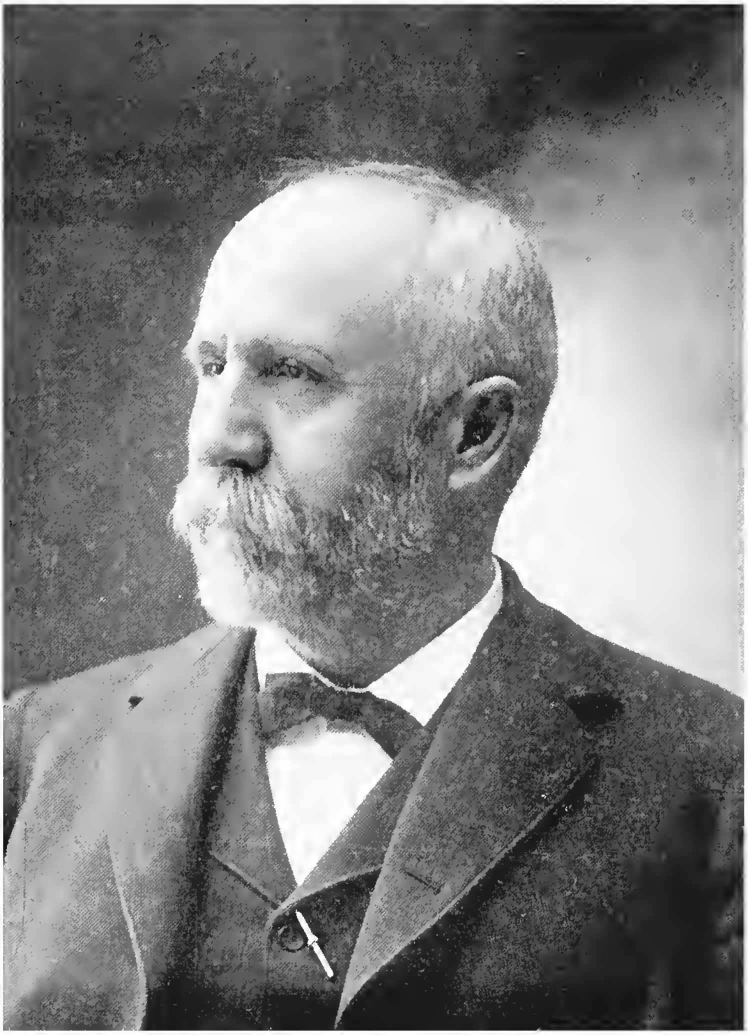

JOHN A. GALLAHER.

# IN MEMORIAM.

Dr. John A. Gallaher, State Geologist, born October, 5th, 1842, in Monroe county, Tennessee. Died June 21st, 1900, at Warrensburg, Mo. He was an infant when his parents removed with him to Johnson county, Mo., where he was reared and where he resided the greater part of his life. He received his education at the common schools at Knob Noster. At the commencement of the civil war he enlisted in the Confederate service and served until 1865. He returned home and entered the Christian Brothers College in St. Louis, where he graduated. He then commenced the study of medicine and graduated at Dr. McDowell's College, St. Louis. Then took up the study of Geology, under Dr. B. F. Shumard, which studies he continued for years. Dr. Gallaher was a zealous student and loved his profession. He was a man of varied information and of untiring industry and energy; conscientious, honest and faithful; courteous and affable, and leaves behind him a spotless record for his family and an example worthy of emulation. We greatly deplore his death, which is a great loss to the State of Missouri. He leaves a wife, two sons and one daughter, and we extend to them our sincere sympathy in their great bereavement.

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# LETTER OF TRANSMITTAL.

OFFICE OF THE GEOLOGICAL SURVEY,
JEFFERSON CITY, MO., ——, 1900.

To the President, Gov. Lon V. Stephens, and the Board of Managers of the Bureau of Geology and Mines:

Gentlemen—I have the honor to transmit, herewith, a preliminary report of the investigations carried on by this department during the last two seasons.

JNO. A. GALLAHER,
State Geologist.

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# PREFACE.

At the annual meeting of the Board of Managers of this department, in December, 1899, I was ordered to write up and publish the information thus far collected in the field, in a preliminary report.

Having collected a large amount of information that is new and interesting to practical men, my aim was to have made this the most valuable report issued by this survey. But the correspondence of the office became such a burden during the winter months that nearly all of my time was thus consumed.

A severe affliction came upon me in the meantime, and I have had very little time to put on the report. Yet, notwithstanding the unfavorable conditions under which it was written, I feel some pride in submitting this preliminary report to the people of Missouri. When the reader has read it and analyzed it, he will doubtless conclude that we have been going directly after fundamental facts in Missouri geology.

Proceeding on the plan, outlined in the Biennial Report for 1897-'98, the Survey is getting the information first and reporting it afterwards.

The field work of this summer and fall will be the finding and locating the exact boundaries of the surface areas of our three great country rocks, viz.: the Cambrian, the First Calciferous and the Burlington-Keokuk limestones in South Missouri, and the surface exposures of the three subdivisions of the Coal Measures.

In the meantime, the data collected from core-drilling, together with the summer's field work, will enable us to proceed with the delineation of the cross-sections in vertical zones with a degree of accuracy approaching the truth. We will also have the requisite data for a correct geological map of Missouri.

I want it distinctly understood that I, alone, am responsible for the arguments advanced in the introduction to this report. There is something behind all geological phenomena. The human mind is looking always for an ultimatum, a world theory. If the cosmic philosophy herein suggested is not satisfactory to the reader, he has the inherent right of working out a better one.

There are no restrictions upon our field of thought, other than the limit fixed by the thinking capacity of the individual. If the reader can find a better way of explaining geological phenomena than mine, I shall only be pleased to see it. I have been a student of nature nearly sixty years, and yet I have much to learn.

I am pleased to acknowledge the able assistance of Mr. D. K. Greger in the preparation of this report. The work of Mr. C. E. DeGroff, as photographer, and its reproduction by the American Engraving Company of St. Louis, speak for themselves.

The fundamental facts that have been brought out in this report, ought to have been found, and made the basis of all geological reports heretofore issued. In fact, the geological record is like the alphabet to a language. You cannot proceed intelligently without it. This is the first time the geological record of Missouri has been delineated.

JNO. A. GALLAHER.

# CHAPTER I.

## THE SYNTHETIC METHOD OF NATURE.

## INTRODUCTION

## THE SYNTHETIC METHOD OF NATURE.

Some years ago, when I was working out a cosmic philosophy, with Physics, Logic and Consciousness, for my only guides, I came across that cold ultimatum of Haeckel: "The function of the brain, is the soul." That seemed, at first, to be the end of all reasoning. But, I was unwilling to accept it for my ultimatum; and hence, I began to dig deeper. I went to a friend for some data on the Sun, and he placed in my hands the Manual of Trouvelot.

Inasmuch as it will soon transpire that the Maternal Function of this cosmic body, Earth, is the only proper foundation for the Science of Geology, the reader will doubtless appreciate a synopsis of this philosophy. I cannot, of course, undertake to give more than a synopsis of it here, because the special purpose of this work is to delineate the Structural and Economic Geology of Missouri, so that even the unlearned masses may understand it. Nor is the reader compelled to accept this pholosophy, but it will be a good exercise for him to work out something better.

The struggling world may as well understand, first as last, that all geological phenomena are the logical results of the Synthetic Method of Nature. Especially so, when it only emphasizes the majesty of God and enables Man to realize his own exalted function. The reader will doubtless excuse all seemingly abrupt flights, when he reflects that this is only a synoposis of a somewhat deep train of thought, which embraces the obvious physiology of the world. And he will please bear in mind that my style is made thus positive for the sake of brevity.

All geological phenomena refer to an ultimatum, and the human mind demands an ultimatum. If my ultimatum is not correct, it remains for the reader to correct it.

The meaning of true Physics, is the physiology of the one organized and living world. Logic is that method of reasoning which proceeds with the rhythm of numbers. Consciousness is th sum of all that we know. And *they* are my only guides.

The meaning of this world, briefly stated, is the evolution of energy from lower to higher powers. It is the raising of primary force, though progressive effort, to intellectual and thence to spiritual energy. Spiritual energy, Forethought or God is the Primal Motor of the world. Intellectual energy, Afterthought or Man is the highest product of the Earth co-operating with the Sun.

God is Prometheus or Forethought. Man is Epimetheus or Afterthought. God is Forethought, because each result of His plan is a Synthetic product, or a logical sequence. Man is Afterthought, because the more he thinks the better he thinks. And, inasmuch as that productive energy cannot persist, without a facility of renewal, the ultimate function of Afterthought is to evolve spiritual energy for the renewal of Forethought. Therefore, human perfection lies only in the future, in the higher function of a better life.

The method of nature is God's method; and, it is obviously synthetic. The fundamental principle on which it proceeds is the co-operation of opposite forces, complements or counterparts, to evolve new energy for renewal. A few of the co-operative forces of nature are: positive and negative, heat and cold, live and latent, motor and respondent, paternal and maternal, male and female, Life and Consciousness.

Everything in this world has a physiological function to perform, because it is a part of an organized and living whole. Our Sun is the physical and spiritual motor, the paternal or Imperial Motor, of our planetary system. His function is paternal, because his light is the first essential element of organic life. Our Earth is our cosmic mother, because she is continually evolving the chemical elements, which are the other essential elements and food of organic life. Her function is maternal because she is the respondent of the Sun and the reproductive cosmic body which has to provide the essential elements and food of organic life.

Everything we see is life, cosmic or organic. Indeed, *to be* means life and life means persistent effort. In cosmic life there is intense effort, as surely as that organic life is a persistent struggle. But the chief aim of this particular effort is to show conclusively that human life should be not only a persistent, but emphatically, a progressive effort.

Any philosophy that does not provide a facility of renewal or compensation for productive energy, is not a cosmic philosophy and is, therefore, not worth considering. Consciousness finds the compensation of productive energy in the evolution of higher powers. The evolution of energy from lower to higher powers is a progressive effort, and therefore, the only philosophy that will satisfy Physics, Logic and Consciousness.

Even though the function of the brain is the soul, as we conceive it, human intelligence is the highest power with which we have to deal. It is the highest product of the Earth co-operating with the Sun; and, if the soul ceases with the life of the brain, where is the compensation of the force which produced it? Call to mind, that productive energy cannot persist, without a facility of renewal. Clearly, the ultimate function of Afterthought is to evolve spiritual energy for the renewal of Forethought. And that is the ultimatum of this philosophy.

That energy is persistent, is a fundamental principle of physics. Indeed, energy is essentially persistent, but energy cannot persist forever in a continuous straight line. In fact, energy persists only in progressive circuits, and that means rhythm. Our blood circulates only in progressive circuits, keeping time with the pulsations of the heart. We think only in progressive circuits, correlating and assimilating each additional fact into our field of consciousness; thus giving it additional power. The rhythm of numbers suggests the precision of Truth. The rhythm of sound, the effect of sweet music, suggests the objective beatitude of Heaven.

All of the sands on all of the sea-shores do not begin to express, numerically, the analogies in nature. Indeed, this world is one living, throbbing, whole; and God is its Primal Motor. This world is one organized, living whole and each cosmic body, each organism, is, to some extent, its analogue. The Creator of this world, like the central ganglion of each organism, is essentially in the midst of it. In short, God has a facility of renewal, because a productive force, without a facility of renewal, is inconceivable.

The oval forms, rings and whorls of celestial bodies, including the gaseous nebulae and the embryonic planets, have their analogues in the lenses, rings and whorls of organic forms. Moreover, they have their analogues in the lenses, concentric shells and whorls of the mineral concretions in the Earth. In the simple Medusa, whose central ganglion dominates its lateral ganglia through its homogeneous mass, without connecting lines of nerve fibre, we have a living analogue of our Solar System, wending its way majestically through the latent energy of space. Our cosmic mother, Earth, has her analogue in the cleavage structure of the egg. Either one of them is a concretion, a storage-battery, of reproductive energy.

The method of nature is obviously synthetic. In cosmic life, our Sun is the motor, our Earth is his respondent, and organic life is the synthetic product of their co-operation. Hence, cosmic life is the basis of organic life and either is a continuous synthetic process or evolution. It is clearly an evolution of energy from lower to higher powers—a development of renewal energy for the Primal Motor.

That cosmic light is the "vital principle," which science has so long been seeking, is demonstrated by the fact that motor energy, paid out by the Sun to the Earth, has no other perceivable form than light. The vehicle of transit is the latent energy of *frigid* space. Therefore, "Solar heat" is a synthetic product of the co-operation of the pristine energy of our Planet with the paternal energy of our Sun.

The character, function, structure and renewal faculty of our Sun, are most delightful topics, but the spiritual product of human life and consciousness is what concerns us most. It is enough to say now that our Imperial Motor, the Sun, is physically a hollow sphere, filled with transparent gases. That his walls are relatively thin; and, that when ordinary solid matter is evolved in his walls, it is thrown off into space. Hence his faculty of perpetual renewal, as well as the origin of aerolites and cosmic dust. Science has doubtless been mistaking cosmic dust for the atmosphere of the Sun, which is essentially self-contained. A vacuole at either pole is all that is required to make his faculty and facility of perpetual renewal easily conceivable.

Our Sun is converting invisable nebula, attenuated gases, into vital energy or its first essential element, cosmic light, and paying it out to his reproductive complements, his Planets. Invisible nebula, "ambrosia for the gods," is derived from the latent energy of space. Therefore, Prometheus, Forethought or God is the Primal Motor of the world and matter is the product of Forethought. Matter is structural energy for a specific purpose. It is the physical basis of all obvious forms of energy. But there are doubtless other forms of energy beyond our ken.

The thousands of lumious bodies in space, outside of our Planetary System, are Imperial Motors, with characters, structures and functions, the same as our Sun. Moving in one interminable spiral system and dominated by one transcendent Motor, like Sirius, they are the motor system, the paternal or positive phase of nature. The boundless field of latent energy called space and the myriads of reproductive bodies called planets, in their various stages of development, are the maternal or negative phase of nature. In that cosmic circuit, that organized whole, each cosmic body, each organism, is moving or thinking in rhythmical measure Indeed, this world is one living throbbing whole and God is its Primal Motor.

The method of nature is synthetic and, therefore, progressive. The combined energy of this world, our cosmic circuit, is one endless synthetic current. And that means life, with the faculty and facility of perpetual renewal. You cannot resolve a synthetic product into either one of its antecedents. Co-operative forces culminate in their synthetic products and when co-operative forces are mated by the law of natural selection, which is the manifest will of God, their synthetic products are inevitably higher powers. Hence the synthetic method of nature is essentially progressive.

For example, my father was Scotch-Irish and my mother was Anglo-Germanic. Will you tell me what nationality am I? Can you resolve me into either one of my antecedents? That is one illustration of a synthetic product, in which the antecedents have culminated; so far as this life is concerned. But I will soon bring you other illustrations, which may give you a better conception of this beautiful world.

The planet, like the organism it evolves and develops, has manifestly three stages of individual existence: the nebulous or embryonic, the reproductive and the plutonic crystalline. At the end of each period is a transitional epoch, after which the reconstructive method is radically different. From a luminous ring of gaseous nebula, which predetermines the eccentricity of its orbit, each Primary planet is evolved. A concretionary center in the nebulous ring is the nucleus of the subsequent Primary. Should there be one or more nebulous rings around the Primary, as in the case of Saturn, a concretionary center in each will develop that ring into a Satellite.

Cosmic bodies grow by accretion and organic bodies grow by the addition of new cells. Now if the Earth is a concretion or storage battery of reproductive energy like the egg (except that one is cosmic and the other organic) there must have been a radical change in her reconstructive method when she entered her reproductive period. Between our interior quadruple of reproductive Planets and our exterior quadruple of embryonic Primaries, we have ample analogies to support this conclusion. And it is a familiar fact that we reason only by analogy.

When the embryonic Earth had reached her first transitional epoch, when she had passed from a gaseous body into an incandescent solid, *more compact than any known solid,* and begun to evolove a solid shield of moveable solids, preparatory to her reproductive function, she then changed her reconstructive method. The whole process of condensation of the original gases into an incandescent solid, was a concentration of reproductive energy for a specific purpose. It was the organization of Earth's pristine energy for her reproductive effort. In familiar terms, it was our virgin mother, Earth, getting ready for her crowning effort—the evolution and development of organic life.

Ever since mother Earth passed her first transitional epoch, donned a solid shield and put on her wraps of water and atmosphere, she has never yet ceased to perform her reproductive function. Like any other true mother, she has been constantly struggling for the development and promotion of her progeny. Is it any wonder that we poor mortals love our mother, Earth, and cling so tenaceously to this progressive struggle which we call life? Can you not easily discern that cosmic life means a persistent effort, as well as organic? Can you not readily perceive that the meaning of this world is the evolution of energy from lower to higher powers?

Call to mind that productive energy cannot persist forever without a facility of renewal. Energy is essentially persistent, but energy cannot persist otherwise than in progressive circuits. Consciousness finds the compensation of productive energy, in the evolution of higher powers. If we are not simply expanding our souls and preparing ourselves for a higher function in another sphere, where is the compensation of productive energy that produced us?

Ever since our cosmic mother, Earth, entered her reproductive period, her incandescent mass has been continually sloughing on the outside and evolving her chemical elements. There are some seventy-four chemical elements, with which we are more or less familiar, and they are obviously intended for the renewal of Earth's water and atmosphere. Of these chemical elements, Earth's oxygen, carbon, hydrogen and nitrogen are, together with Solar light, the vital elements or first essential elements of organic life. By that, I mean, there cannot be any organic life without them. Those elements are found, in variable proportions, in all protoplasm, which is the primal form of organic life.

Moreover, that rhythmical stream of protoplasmic life, which has been evolved by the Earth, co-operating with the Sun, has been the one continuous stream of primal life whence all of the progressively higher forms have diverged, each in its kind, according to its first paternal and maternal antecedents. The progressively higher forms of each successive geological period represent progressively higher efforts of our cosmic mother, Earth, until the meridian of her reproductive period was reached, and her noontide effort culminated in Man.

Each chemical element is a synthetic product, a simple substance, that cannot be resolved into its antecedents. Those elements are evolved in Earth's plutonic laboratory, the liquid Substratum, or plane of contact between the incandescent solid Earth and the flexible shield of ordinary solids on which we walk. Volcanic conduits are the exhaust-pipes or connecting lines between the incandescent Earth and its most flexible outside envelope, the atmosphere we breathe.

The elements are divided, for convenience, into metals and metalloids or gases, which latter do not occur in the metallic form. These elements, as the name itself indicates, are not composite bodies, but absolutely simple substances which cannot be resolved into anything simpler. One or all of those chemical elements are the essential elements and food of organic life, whether of high or of low degree. They are diffused in Earth's water and atmosphere, in their most available forms.

The first essential element, however, or the vital principle, itself, is cosmic light, derived from the Sun. Next to the rhythmical stream of motor energy or life, paid out by the Sun to the Earth in the form of light, much the same as the thread is paid out in winding the bobbin, except that Solar energy is positive, the reproductive energy of the Earth responds and everything that follows is a synthetic product or a logical sequence.

Terrestrial evolution is obviously God's method of raising primary force, through progressive effort, to spiritual energy, for His renewal. The glorious interior of that refulgent orb of day, our Sun, is inevitably the destination of all spiritual energy evolved by the Earth and her progeny. In that celestial realm, Truth reigns, supreme, and each cringing soul is assigned a new function commensurate with its character.

In the glourious interior of our blessed Motor, the Sun, dwells the Vicegerent of the true God. That his celestial realm is the logical rendezvous for the spiritual product of the Earth, is shown by the fact that the first essential element of organic life is paid out by the Sun. And inasmuch as that productive energy cannot persist without a facility of renewal, the ultimate synthetic product of Earth, the Spiritual energy evolved by Afterthought, has no other logical destination than the serene and equable interior of our Sun.

I have already shown that the method of nature is synthetic and, therefore, progressive; when the co-operative forces are mated by the law of natural selection, which is the manifest will of God. Co-operative forces culminate in their synthetic products and their synthetic products are, therefore, essentially higher powers. Now, the co-operative forces in man (I mean, of course, the individual) are vitality (life) and consciousness. Each individual is born with a spark of each, vitality and consciousness; and they are primarily co-operative forces in each individual. When the body dies, these two forces, life and consciousness, the highest with which we have to deal, co-operating, evolve the higher force, spiritual energy, and it compensates the Vicegerent of God for the energy paid out.

While our cosmic mother, Earth, is slowly declining, as her pristine energy is exhausted, our blessed Motor, the Sun, is surely augmenting; and thus the synthetic current of nature moves on rhythmically in progressive circuits. Obviously, Afterthought is indebted to Forethought, for his co-operative forces, life and consciousness. It is, therefore, clearly his chief function in this life to expand his soul and make it an equitable return for the energy it has cost.

Ever since that time when the Sphinx, personating Afterthought and his spontaneous conception, towered above the plain on which it was afterwards buried, looking steadfastly into the eastern sky for the Eye of our Creator, the morning Sun, which gladdens the hearts of all nature, man has been constantly trying to substitute his ideals for the greater realities in nature. But the eye is only the window of the soul. Afterthought may deceive himself and his neighbors, but he will not deceive omnipotent Forethought. Inside of that beaming Eye, which takes each day a cyclorama of the revolving Earth, there is another Eye which will analyze Afterthought and utilize him at his actual value.

Referring again to the Sphinx, I would not have you infer, for one moment, that man is either descended or ascended from any other living genus. The simple fact, that co-operative forces culminate in their synthetic products precludes the possibility of one living genus having descended or ascended from another. The antecedents of any living genus are essentially extinct.

Man was, therefore, always virtually man. And that means virtually a special creation. But the Sphinx is a standing witness to the fact that man has always had a conception of creation and its purpose that is substantially correct. As the babe responds to the loving smile of its fond parents, man claimed, spontaneously, this bounteous Earth for his Eve and that glorious orb of day, our Sun, for his Adam. Physics, Logic and Consciousness say, unequivocally, expand your soul and make it an equitable return for the energy it has cost.

This synopsis will, I trust, introduce the reader to a philosophy which is simply a delineation of the obvious physiology of nature. To my mind, it is the ultimatum of the obvious facts. If it should only serve to set a few wandering souls thinking, in the right track, it will have served its purpose.

# CHAPTER II.

## THE PRIMORDIAL SHELL OF THE EARTH.

### INTRODUCTION.

## THE PRIMORDIAL (PREHISTORIC) SHELL OF THE EARTH.

If the chief function of our cosmic mother, Earth, is to evolve and develop organic life, there is no conceivable reason why she should not have commenced to perform that function, as soon as she had evolved a solid shield and the temperature of her water and atmosphere had fallen below 200 degrees. The original shell of ordinary solids must have been relatively thin. Moreover, it must have been enclosed in a relatively shallow and continuous ocean. Furthermore, the earliest organic forms must have been infinitesimal and fragile; because the water was essentially warm.

Inasmuch as volcanic conduits are the exhaust-pipes (essential connecting lines) between the Incandescent solid Earth and its atmospheric wrapper, we have to conclude that a few hundred lonely volcanic cones, protruding through the watery envelope, were, during countless ages, the only land surface on the globe. During those countless ages and preceding the emergence of continental land surface, there must have been a vast accumulation of organic products and other sediment precipitated on the sea floor; interbedded with contemporaneous plutonic and volcanic products. The organic products, and sedimentary rocks, of that time of inconceivable duration, interbedded with contemporaneous plutonic and volcanic lenses, make up the Primorial or Prehistoric shell of the Earth. Its volume is, therefore, essentially great. Much greater, I believe, than that of the Historic Shell or Geological Record.

Primordial is, of course, intended to supplant the venerable but misleading term—Archean. There are many things in this world that have outlived their usefulness. Not synthetic products of nature, but refractory products of misconception. I like that philosophy or system best, which points always forward to perfection. A Scientific nomenclature based on misconceptions or wrong interpretations ought to be supplanted or eliminated.

However, I am now writing for the benefit of the unlearned masses, more than for scientific sticklers, and my only ambition is to delineate nature correctly and in such terms that all may understand it. Therefore, I shall have to ignore all stale conventionalities and use such language as will convey obvious facts to the ordinary, "common people."

During that period of inconceivable duration, after the Earth had commenced to perform her reproductive function and before the emergence of continental land surface, vast quantities of organic products and other sediment were deposited on the sea floor and interbedded with volcanic and plutonic lenses of that period. From that sediment and those igneous lenses came the Primordial Rocks which form the base of our Historic Shell or Geological Record. Having briefly discussed our Primordial Base, I will then take up the delineation of our Geological Record.

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## PRIMARY ROCKS.

Primary and Primordial have, of course, virtually the same meaning. But I want now to distinguish between three radically different kinds of rock that had, each, practically the same origin in both Primordial and Paleozoic time.

Primary Rocks are: 1, The products of plutonic lava; 2, The products of volcanic lava; 3, The products of organic life, intermingled with other rock minerals that were precipitated simultaneously on the sea floor. The latter are recognized generally as sedimentary rocks. Hence we have three kinds of fundamental or Primary Rocks, viz: Plutonic, Volcanic and Sedimentary.

After three kinds of primary rocks, come the Altered Sedimentary (ancient crystalline or metamorphic) rocks and then a long list of aggregations of soluble rock minerals, mineral concretions, precious stones and metallic ores. But none of these were originally deposited as such; and for that reason, they have to be considered as secondary rocks or products of reconstructed primary rocks and soluble rock minerals.

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## PRIMORDIAL ROCKS.

By Primordial Rocks, I mean, of course, the rocks that were deposited in Primordial time. They now form the base or foundation of our fossil-bearing, sedimentary rocks of Paleozoic and later geological time, or Geological Record (Sir Archibald Geikie). Avoiding all unnecessary details, I will mention only the more important kinds of rock now known to exist in our Primordial Base of Missouri.

The Primordial areas of Missouri are relatively small and do not include a very great variety of igneous eruptive rocks, or very many kinds of metamorphic (altered sedimentary) rocks. The core-drill has, however, penetrated our Primordial Base in different places outside of our Primordial areas and the cores taken at those places show that mica-schist and gneiss make up part of our base. Had some of those holes gone deeper it is quite probable that serpentine and other metamorphic rocks would have been penetrated.

So far as we now know, the igneous eruptive rocks in our Primordial Base are all plutonic products, viz: granite, pegmatite, porphyry and diabase. The sedimentary rocks (metamorphic or altered) are gneiss and mica-schist. In other words, no typical volcanic products have been found in either Primordial Base or Geological Record of Missouri.

## THE PROBABLE GENESIS OF OUR PRIMORDIAL BASE.

Before trying to explain the radical difference between plutonic and volcanic rocks, I will have to explain the difference between plutonic and volcanic action. Or rather, delineate it according to the obvious facts in the case.

It is a self-evident proposition, that everything in nature has a physiological function to perform, because it is a part of an organized, living, whole. In the performance of her function, the Earth is continually renewing her water and atmosphere, which are the vehicles of vital energy and renewal energy of organic life. Her method of renewing her water and atmosphere is volcanic action or volcanism.

Primary volcanism does not mean merely throwing out streams of molten lava. It means that the incandescent solid Earth (the storage-battery of pristine or reproductive energy) is continually sloughing on the outside and evolving the chemical elements for the renewal of our water and atmosphere. There have never been less than three or four hundred active volcanoes since the Earth evolved a solid shield. The three or four hundred active volcanoes, now distributed mostly in the equatorial zone, are not always throwing out streams of lava. Those three or four hundred active volcanoes are, in fact, sending out continuous streams of vapors and gases, obviously for the renewal of our water and atmosphere. Once, in a great while, they do throw out streams of intensely hot lava. When that lava spreads out on the surface and consolidates in the open air, it forms our typical volcanic rocks.

Volcanic lava represents matter that is derived mainly from the under side of this flexible shield of ordinary solids on which we walk. Lying in contact with the Liquid Substratum and almost in contact with the Incandescent Solid, itself, this flexible shield of ordinary solids is also sloughing and yielding most of the material in the lava. The Incandescent Solid is also doubtless contributing a residuum of matter, left after the evolution of the chemical elements. But most of the material in the lava is evidently derived from the under side of Earth's flexible solid shield.

The explanation I have to offer of that kind of volcanic action, in which lava is thrown out through a conduit and crater, is this: when the liquid mass of molten solids becomes inflated with water-vapor, until its specific gravity is less than that of the superincumbent solid shield, the lighter liquid mass yields to the greater weight of the overlying solid mass and flows out to the surface. That explanation seems simple enough. It is supported by the obvious facts. Indeed, all geological phenomena are simply logical results of the Synthetic Method of Nature.

Whence comes the water? I have just been telling you that primary volcanism means the renewal of our water and atmosphere. Volcanic lava is only a by-product of primary volcanism. But Earth's water, one of the immediate products of primary volcanism, is the most active reagent and promotor of volcanic action. Earth's atmosphere is also an active reagent and promotor of volcanism, but it is a little farther removed from her chemical laboratory than her water.

Resting on this sensible horizon of light and life in which we live, and rising far into the latent field called space, in ever varying form from chilling gale to balmy breeze, is Earth's most flexible envelope, the atmosphere we breathe. Resting on that plutonic horizon, wherein our chemical elements are evolved, and rising to the plane of perpetual frost in the upper atmosphere in ever varying form from ice to the most attenuated water-vapor, is Earth's next most flexible envelope, the water we drink.

Like the sap in the tree, or the blood in our bodies which is manifestly our vehicle of renewal energy, Earth's water is at once the vehicle of reagents and active promoter of volcanism. To those who are familiar with the expansion of super-heated water, it must be apparent that Earth's water, especially salt water, gravitating by converging lines to her plutonic horizon, is a most active promotor of volcanism. Lava, thus inflated with super-heated water-vapor and rendered much lighter than the superincumbent flexible shield, is driven by plutonic force to the outside surface where it results in volcanic products; or, is injected between bedding planes of superficial rocks, or spread out on the sea floor in either of which conditions it results in plutonic products.

Therein you have the fundamental difference between plutonic and volcanic rocks. In the one case lava rising from Earth's plutonic horizon and injected between walls or bedding planes of superficial rocks, or spread out on the sea floor and consolidated, under cover, is the origin of plutonic rocks. In the other case, lava rising from the same plutonic horizon, spread out in the open air and consolidated under atmospheric influence is the origin of volcanic rocks.

Now it might seem, to the casual observer, that water had all to do with the promotion of volcanism. But when you have thought of the depressing effect of atmospheric pressure, you will see that it, also, is a great factor in terrestrial dynamics. Call to mind the fundamental principle on which this world proceeds, is the co-operation of opposite forces, complements or counterparts, to evolve new energy for renewal.

Think of the pristine energy of our Incandescent Earth, co-operating with the motor energy of our Sun, and you will see the analogy between it and the heart of the animal organism whose every throb sends renewal energy to the remotest parts of the body. Indeed, this world is one living, throbbing whole and God is its Primal Motor. We should not, therefore, be surprised to find that everything in Nature is a synthetic product of Forethought.

There is, among the synthetic products of man, a striking analogue of the co-operation of Sun and Earth, in the stationary and portable motors of an electric railway system. But he is always improving it. The synthetic products of human ingenuity are essentially erratic, because man is Afterthought. The synthetic Method of Nature (obviously God's method) means the correct mating of co-operative forces and letting them work out their own salvation. Obviously the more man thinks, the better he thinks, provided he is thinking in the right track.

While the Incandescent Solid Earth is evolving her chemical elements (synthetic products) and sending them out in continuous streams to renew our water and atmosphere, she is essentially sloughing on the outside and thus growing gradually smaller. That the Earth has been shrinking continuously throughout her embryonic and reproductive periods, we have ample proof in the relative diameters and densities of our embryonic and reproductive primaries. Indeed, Jupiter, Saturn, Uranus and Neptune will doubtless have shrunk to one-fourth, one-fifth, one-sixth and one-seventh their present diameters, respectively, before they will have entered their reproductive periods. Earth's diameter is now at least one-fourth less than when she entered her reproductive period. She will doubtless have shrunk one-fourth more before she will have reached the plutonic crystalline stage.

It is a sad reflection, but nevertheless true, that the pristine energy of our cosmic mother, Earth, is slowly but inevitably diminishing. And that reminds me of the venerable dogma, handed down in the text-books, that our Earth has been, lo, these many years, in continuous process of refrigeration; and that her solid shield is growing thicker by the refrigeration and consolidation of lava on its under side.

After all, science is only a method of seeking the truth. If her sticklers will keep still, I will spare the men who conceived such dogmas, but I will not spare dogmas like that. The main trouble with the text-books on terrestrial dynamics is, I ween, that their authors never had any conception of the true character and function of the Earth. And that reminds me of Sir Robert Ball's lamentation on the failure of our Sun!!!

While our cosmic mother, Earth, is slowly declining, as her pristine energy is exhausted, our blessed Motor, the Sun, is surely augmenting; and thus the synthetic current of nature moves on rhythmically in progressive circuits. In fact, the progress of refrigeration in the Earth is in exact proportion to the diminution of her pristine energy. And we have a most striking analogy in the declining vigor of our own superannuated bodies.

The thickening of Earth's solid shield is due mainly to lateral compression. As the incandescent mass grows smaller by sloughing on the outside any paying out renewal energy to its water and atmosphere, its flexible shield of ordinary solids is settling down by converging lines towards a common center. For that reason, we find more reconstruction, more folding, crimping and crystallization, in the rocks as we descend into the Earth. The inner shell is essentially more reconstructed, folded and crimped than the outer shell.

The Liquid Substratum (horizon of contact) between this flexible shield of ordinary solids on which we walk, and her incandescent solid, is Earth's plutonic laboratory, in which her chemical elements are evolved. Can you conceive the consolidation of lava by refrigeration in that plutonic laboratory? It is simply absurd. Earth's maternal function is the only proper foundation for the science of geology. This world is obviously one organized, living, whole and each cosmic body, each Imperial Motor, each reproductive Planet, has its own physiological function to perform. While performing that function, it is in a continuous process of evolution and that means progressive effort.

Resuming the origin of our Primordial Rocks—barring the cleavage structure of the Incandescent Solid, which I want to prove later on by the progressively higher effort of each geological period up to the meridian of Earth's reproductive effort, there is no conceivable reason why the residuum of incandescent matter contributed, in all parts of the Liquid Substratum and in all ages, should not have been virtually the same. But I have already shown that our three kinds of primary rocks (plutonic, volcanic and sedimentary) have each had a radically different origin from the others. We all know that they have radically different physical or lithologic characters.

Therefore, if each one of these three kinds of primary rocks were brought in contact with Earth's plutonic horizon in widely separated areas, would you expect the same kind of lava from all? Now, lava that has traversed a volcanic conduit or wide-open rent in the solid shield and consolidated, lens-like, in the open air, is the source of volcanic or basaltic rocks. Lava that has been forced to traverse ragged fissures or to disrupt the solid beds in its passage and has consolidated, lens-like, on the sea-floor or on some superficial horizon of sedimentary rocks and organic products, is the source of plutonic or granitic rocks. In short, plutonic rocks are the products of lava consolidated under cover; volcanic rocks are the products of lava consolidated in the open air. Plutonic rocks have generally an acid ground-mass or matrix, while volcanic rocks have generally an alkaline base.

Just how the lava in any particular case got its primary characters is a matter beyond our reach. But when we begin to proceed synthetically, as nature proceeds, and quit trying to pursue the back-track of a synthetic current, there is no telling how much Afterthought may expand. While Truth is, ostensibly, the chief objective of science, her votaries are not always unmindful of the temptations of this world. Man should have learned enough by this time to quit trying to do what is obviously impossible. You cannot resolve a synthetic product into either one of its antecedents, because synthetic products are new forces or higher powers. Moreover, because antecedents (co-operative forces) culminate in their synthetic products.

Earth has her transitional epochs and man has his transitional epochs. The career of either is a progressive evolution or synthetic current; and you cannot pursue the back-track of a synthetic current beyond a transitional epoch.

It is a familiar fact that none of our departed friends have ever come back to tell us about that celestial realm beyond the chasm of space. My conjecture is, they found not a heaven of perpetual rest, but plenty that was more interesting and suitable for them to do than haunting their earthly friends.

Birth and death are the transitional epochs of man. They are not very unlike the transitional epochs of Earth. You cannot resolve the chemical elements into their antecedents; neither can you resolve the synthetic product of life and consciousness into its antecedents, because it is a new force and a higher power.

Returning to the Primordial Rocks—Throughout this flexible shield of ordinary solids, on which we walk, volcanic lenses have been buried the same as coal horizons, on the floors of inverts, plutonic lenses have been relatively raised in the arches or upward folds and denuded of their sedimentary covering. Plutonic lenses, dykes and bosses, interbedded with the metamorphic rocks (ancient crystalline or altered sedimentary) of Primordial time, are the rocks which make up the greater part of our Primordial Base.

Call to mind, however, that the thickening of this flexible shield of ordinary solids is due mainly to lateral compression. As the interior, Incandescent Earth, sloughs slowly away, evolving renewal energy for our water and atmosphere, this flexible shield is settling down by converging lines towards a common center. In that way, it thickens most rapidly.

It is evidently growing thicker by the addition of a great volume or organic products, as well as by rock minerals, precipitated from solution in the water. It is also gaining something in aerolites and cosmic dust from the Sun. But, after all, it is growing thicker mainly by lateral compression.

Under the stress of lateral compression, Earth's flexible shield is thrown into upward and downward folds. The upward folds, ridges, anticlines, or arches, are being continually worn down (denuded of sediment) by the frost, the wind and the rain. The greater downward folds, troughs, basins, synclines or inverts, are the logical dumping grounds for the sediment thus derived from the arches. Volcanic lenses and the products of coal forests have been thus planted deep in the ground.

But, after all, nothing has been really added except organic products, cosmic dust and a residuum of incandescent matter. The plutonic and volcanic lenses came mostly from the under side of this flexible shield. In the end, organic products make, by far, the greatest volume of solid matter that has been added to the original flexible shield. And they were derived mainly from the water and the atmosphere wherein they were diffused or suspended, in their most available forms, the elements and food of organic life.

The atmosphere, the water and the soil are obviously Earth's vehicles for supplying the essential elements and food of organic life. We know that vegetation will not flourish in the most fertile soil without water to dissolve the rock minerals and make them available for the renewal of plant life. We know, furthermore, that the reproductive energy of the soil has to be renewed. When we think of the vast and continuous volume of organic life that is drawing on the essential elements diffused in the water and atmosphere, we know, as well, that they too, have to be renewed.

The obvious source of renewal for our water and atmosphere is Earth's pristine energy contained in her Incandescent Solid Mass (storage battery) inside of this flexible shield on which we walk. The elements, evolved by Earth's pristine energy co-operating with the Sun, are diffused in our water and atmosphere for the obvious purpose of supporting organic life. And after all, organic products have contributed most of the solid matter that has been added to this flexible shield. Next to plutonic heat and water, thus heated, organic matter is the greatest reagent in the Earth. Please keep that fundamental fact before you. It will be shown, later on, that plutonic heat, water and organic matter, have been the greatest factors in the reconstruction of rocks and rock minerals.

After all, we might safely say that all primary and Primordial rocks are plutonic, volcanic and organic products. But inasmuch as the organic products are intermingled with other rock minerals precipitated simultaneously and interbedded with sediment derived from plutonic and volcanic rocks, we will accept the amendment and say the three kinds of primary and Primordial Rocks are Plutonic, Volcanic and Sedimentary.

Now, since no typical volcanic rocks have been found in the Primordial Base of Missouri, I will further simplify the subject by saying that our Primordial Base is made up of Plutonic and Sedimentary rocks The sedimentary rocks are essentially altered or metamorphic. Add to their essentially altered characters, the obvious fact that the earlier forms of organic life were infinitesimal and fragile, and it is not difficult to understand why they should not and do not contain any legible fossils.

It is a well known fact that the Primordial sedimentary rocks of some other countries do contain vast quantities of organic products. Geologists have been calling them Archean because they contained no legible fossils. But inasmuch as no man can say that any particular rock or mass of rocks is older than organic life on the Earth, Archean is clearly a misnomer. It is, therefore, supplanted by Primordial, so far as we are concerned. Human life is too short to further argue such questions.

Our Primordial Base is evidently an upward fold or unevenly developed arch in the Primordial Shell of the Earth. There are ample reasons for believing that it is the southwestern extension of the eastern axis of our Primordial Continent. Howbeit, the fact which I want to impress on the mind of the reader is this: Our Primordial Base lies, under North Missouri, in the form of a narrow sinuous ridge or arch, between two deep inverts; and under South Missouri in the form of a rugged plateau.

What was, one time (and not very long ago geologically speaking) the western slope of a rugged dividing ridge or axis, in our Primordial Continent, was brought more nearly to the position of a plateau by the development of the Rocky Mountains. That means, of course, the elevation of the lower side of the western slope and relatively letting down of the ancient axis. When you elevate the lower edge of an inclined plane, you relatively lower its upper edge. You will see the objective of this delineation when we come to discuss the probable genesis of our economic deposits. Our ore-bearing sedimentary rocks were deposited in Paleozoic time and the Rocky Mountains were not developed until Tertiary time.

The later development of the Rocky Mountains, you will find, has been an important factor in predetermining the surface and subdrainage lines, which in turn have predetermined the zones of greatest ore concentration. That fascinating topic will, however, be more fully discussed under the head of ore-bearing horizons or country rocks. There cannot be any doubt but that every geological phenomenon is a logical sequence. But the genesis of any one of our great ore bodies is a far-reaching subject.

We know that our Primordial Base, under South Missouri, has a rugged surface. In other words, we know that its topography is hard and sharp. In several of the southeastern counties, we have naked granite and porphyry hills standing up as much as one thousand feet above the common level of the Primordial plateau. Near Decaturville, in Camden county, we have a pegmatite hill protruding through the sedimentary rocks. True granite lies within two or three hundred feet of the surface one mile away. Near Kansas City granite was penetrated at about twenty-five hundred feet. On the other hand, Primordial rocks were not touched at St. Louis at thirty-five hundred feet.

At Kansas City the Coal Measures are more than eight hundred feet thick, and yet it is no more than twenty-five hundred feet from the surface down to granite. St. Louis stands mostly on the Bed-Rocks of the Coal Measures, with some small patches of the first coal horizons left lying around its southwestern side, and yet it is more than thirty-five hundred feet from the surface down to granite. The difference in the altitudes of St. Louis and Kansas City is another matter to be considered.

However, I could not make the alteration in the position of our Primordial Base any plainer than to say that the lower side of the western slope of an ancient axis has been raised by the comparatively recent development of the Rocky Mountains and the ancient axis, itself, relatively let down. Otherwise, why should the destruction of sedimentary rocks have been so much greater around Pilot Knob than around the Pegmatite Hill? That the drainage lines of west-central Missouri have been reversed by the same cause, there cannot be any doubt.

So far as we now know, the Primordial plateau, under south-central Missouri, lies generally level, but its topography is hard and sharp. The primary rocks or Primordial country had been much disrupted by intrusive dykes and bosses, long before Paleozoic time. The scarcity of Primordial detritus, the absence of typical volcanic products and the peculiar topography all show that the dykes and bosses had been thrown up while it was a sea floor. The scarcity of Primordial detritus alone shows that it had not been land surface before the deposit of the Cambrian rocks.

I have not found enough typical volcanic products to indicate that there ever was a real volcano in the Primordial Base of Missouri—according to my conception of a volcano. In fact, our Primordial Base had been very much disrupted before the Cambrian Beds were deposited, but nearly all of the detritus derived from the Primordial rocks is now contained in the Basal sandstone of the Cambrian. A few worn pebbles and rounded granite bowlders have been found at the contact of the First Cambrian limestone and granite beds about Doe Run and Mine LaMotte. But such coarse material is very scarce and nothing more than what might be expected in the canyons and channels in the floor of a shallow sea. The kinds of rock, the scarcity of detritus and the peculiar topography, have all suggested to my mind that it was always the floor of a shallow sea and not land surface during Primordial time.

Primordial detritus is remarkably scarce. There is comparatively little coarse material in the Basal sandstone and that is limited to narrow zones along its margins where its materials were derived largely from the granites and porphyries. The granite rocks lie mostly in dome-like areas or bosses. The porphyry hills and dykes have generally precipitous sides, indicating that they were the products of lava thrown up between granite masses and consolidated under water. Amygdaloidal structure is scarce and basaltic structure is entirely absent.

However, it matters not much whether our Primordial plateau had ever been land surface or not, before the Cambrian rocks were deposited. We all agree that the Primordial rocks were there and their peculiar topography developed, before any of the present sedimentary rocks were deposited.

The picturesque mass of conglomerate, on the top of Pilot Knob, like most of our productive iron-ore deposits, our clay and coal pockets, all of which represent sediment that has been let down from higher horizons, suggests and old canyon, sink or pot-hole in some ancient drainage line. I have an idea that it is a much younger deposit than the limestone in the valley about the base of the knob.

But the main thing I want to impress on the mind of the reader is this: Our Primordial Base lies, under North Missouri, in the form of a sharp and winding ridge between two great inverts; and, under South Missouri, in the form of a plateau. The granite country, in that plateau, lies in the form of domes or lenses and the dyke rocks porphyry, pegmatite and diabase, are standing up in sharp relief in the form of cones and precipitous walls.

The last point I want to emphasize particularly is the alteration in our Primordial Base, effected by the development of the Rocky Mountains in Tertiary time. The ancient axis of our Primordial Continent, or southeastern area, in which the Primordial rocks are most denuded of their sedimentary covering, was originally a narrow ridge whose western slope was brought into the position of a plateau by the later development of the Rocky Mountains. That is a well established fact and has had much to do with the alteration of ancient drainage lines. There are some unique deposits in Missouri yet to be described.

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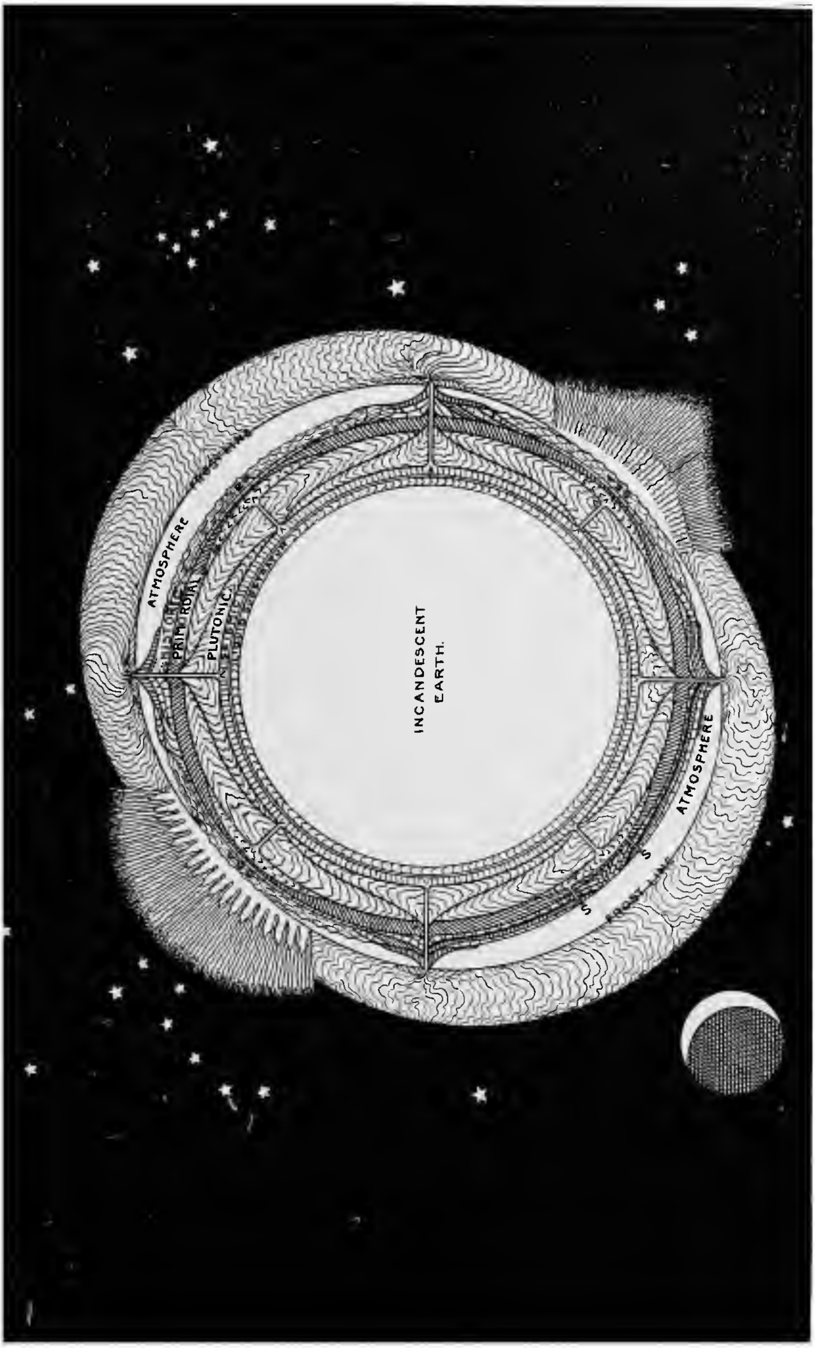
NOTE—At S. S., plate I, is an illustration of the probable origin of sublimation veins.




Ideal Section of the Earth.

# CHAPTER III.

# THE GEOLOGICAL RECORD.

## INTRODUCTION.

## THE GEOLOGICAL RECORD.

It has occurred to me that we have, in the *Bryozoan archimedes*, a fairly good analogue of the reproductive effort of our cosmic mother, Earth. We should not expect to find, in a fossil organism, a perfect analogue of such an elaborate and long continued effort. But the *Bryozoan archimedes* will help to delineate the rythmical and continuous effort the Earth has been making in the performance of her reproductive function.

Call to mind that the track of our satellite, the Moon, is a long-drawn-out spiral, with reference to the Earth's orbit. The Earth's orbit is a long-drawn-out spiral, with reference to the Sun's track through space. Our Sun is one member of the motor system of the world, which is obviously arranged in one interminable spiral system and dominated by one transcendent motor, like Sirius.

Our Sun's track through space is, therefore, ultimately a spiral. And that calls to mind the primary fact that energy persists only in progressive circuits. (Primarily, energy persists only in progressive circuits), and that means rhythm. Cosmic life proceeds rhythmically as well as organic. In fact, motion is an essential characteristic of all life, and life motion is essentially rhythmical.

When the Earth entered upon her reproductive career, her solid shield was obviously thin and her watery envelope was essentially warm. The earliest individual forms of organic life must, therefore, have been infinitesimal and fragile. But those obvious physical conditions suggest that the Earth was more prolific of organic life in Primordial time than in Paleozoic time. We have only to reflect that organic matter is one of the greatest reagents in the Earth, and then we know where most of it has gone. Howsoever fragile those earliest individual forms of organic life may have been, they were, nevertheless, organic and their volume was essentially great. Because the Earth was obviously more vigorous then than now.

Moreover, we have, in certain Primordial zones, or first emerged portions of continents, five or six vertical miles of ancient sedimentary (metamorphic) rocks, interbedded with plutonic and volcanic lenses of contemporaneous and even later origin. In those ancient sedimentary rocks, we find abundant crystalline organic products, some of which are duplicated in the metamorphic regions of Paleozoic rocks. Indeed, many of the most interesting rock minerals and most valuable articles of commerce are found exclusively in the Laurentian and Huronian deposits of Primordial time. And it would not be a very great leap in the dark, were I to say that all or most of the precious stones of commerce are mineral concretions, superinduced by Primordial life or its agency. Proofs of the potency of organic matter, as a reagent, are sufficiently abundant and conclusive.

Resting unconformably on that intensely crystalline and disrupted base (the Prehistoric or Primordial Shell of the Earth) lies the Historic Shell or Geological Record. That last horizon of the Primordial Base, or plane of contact between it and the geological record, is the most wonderful geological horizon, in all of this flexible shield of ordinary solids, on which we walk. It marks that epoch, in the reproductive career of the Earth, when the floors of Primordial sargasso seas emerged into continental land surface and the new era of sedimentation from land surface began.

No expert observer dare say that organic life began at that epoch; or that the rythmical stream of protoplasmic life, hitherto evolved by the Earth co-operating with the Sun, was even broken by it. However, new physical conditions had arisen, and the primal antecedents of new individual forms of organic life were evolved, to meet the requirments of new physical conditions.

Right here begins the delineation of Earth's reproductive effort, coincident with the Synthetic Method of Nature and according to the obvious facts in the case. Most modern and living evolutionists have held and are now holding, I believe, to the theory that certain living genera have descended or ascended from other living genera, or their antecedents. In short, that genera have evolved new genera. Man has always admired an honest effort and I believe that God loves an honest effort, more than anything else in man. Therefore, I do not find fault with any man for thinking as he thinks best. But I would prefer to have all men thinking in the right track. A few obvious facts are sufficient to resolve this proposition into its simplest terms, and then there is no foundation left for such a theory.

When the Earth entered upon her reproductive career, she obviously began to evolve a rhythmical stream of protoplasmic life and that stream of primary life has never ceased to this day. Whence could have come the earliest individual forms of organic life, except from that rhythmical stream of primary life? And if the earliest individual forms of organic life came from that rhythmical stream of primary life, why should not the primal antecedents of the radically different later forms have also come from it?

Just as certain as that two parent germs evolved a certain organic individual, the primal antecedents of any living genus evolved a synthetic current or branch of life which culminated in that particular living genus. Obviously because that synthetic current or branch of life could not have split or diverged from itself, sufficiently to have evolved another genus, after it had left the rhythmical stream of primary life. And the primal antecedents of any living genus could not have come from any other source than the one rhythmical stream of primary life. Therefore, each progressive effort of the Earth is marked by new genera.

Call that special creation, if you like. It is supported by all of the obvious facts in the case and means special creation by a synthetic method. It is obviously imposible for two living genera to have come from any one source, except the one rhythmical stream of primary life. Having once diverged from the original stream of primary life, the progeny of any two primal antecedents is a branch or synthetic current in itself, from that first departure until its last synthetic product is reached. And the synthetic current which has culminated in any living genus could not have split after its primal antecedents had left the original stream of primary life. Species do not enter into this question. The antecedents of no genus, living or extinct, could have split sufficiently to have evolved another genus. That is the point I am making.

What does the Synthetic Method of Nature mean, but the mating of opposite forces or counterparts to evolve a new force and a higher power? That method is diametrically opposed to splitting genera, because it is continually merging two co-operative forces into a higher power. Species have advanced but genera cannot evolve new genera. Neither can species evolve genera.

Each living genus is the last synthetic product of its primal antecedents and its whole line of antecedents is essentially extinct. Therefore, genera do not and cannot evolve new genera. Obviously, because the Synthetic Method of Nature is diametrically opposed to it. Each living genus is the ultimatum of its primal antecedents. And each new genus marks a special effort of the rhythmical stream of primary life.

Do man and monkey belong to the same genus? Then where is the modern evolutionist going to find his "missing link"? He has no alternative but to trace each living genus back, through its extinct line of antecedents, to the one rhythmical stream of protoplasmic or primary life. And that is a hard road to travel, for I have already demonstrated that you cannot pursue the back-track of a synthetic current, beyond one of its transitional epochs.

Moreover, what is the use of that continuous rythmical stream of primary life, except to evolve the primal antecedents of higher or lower individual forms of organic life, to meet the requirements of altered physical conditions? It is no use for man, be he scientist or theologian, to undertake to argue against the inevitable trend of these obvious facts in nature. The Sphinx is a standing witness to the fact that both sides of the house have been somewhat in the fog. Man is too prone to worship his own ideals and that fact has kept us all in the fog. He is too fond of pointing backwards to perfection.

The primal antecedents of any living genus could not have been superior to their last synthetic product, which is that particular living genus. Simply because the Synthetic Method of Nature is progressive. Man would, therefore, do well to reverse himself and look forward to perfection. However, those who have held tenaceously to the special creation dogma have been obviously nearer to the truth than those erratic thinkers, who have been trying to conceive an organized whole without a head.

We reason only by analogy. If this world were not an organized whole it could not exist. What show would an organism have (were such a thing conceivable) in this world without a head or central ganglion to dominate and direct its motor system? The Creator of this world is obviously its Primal Motor and is essentially in its midst. Where else could you conceive God to be, except in the one transcendant motor which dominates the motor system of the world? Then, each member of that motor system must contain a Vicegerent of the true God.

Having once conceded that, what reason is there for believing that God did not so arrange the reproductive energy in our Incandescent Earth that it would have a cleavage structure and evolve the primal antecedents of progressively higher genera, as we find them registered in the geological record? The Synthetic Method of Nature is obviously God's method and it is essentially progressive. In other words, it is the physiology of the one organized and living world.

The friends of a special creation have simply overlooked the necessity of a progressive method. And that is all that is wrong about that dogma of their philosophy. But man, like every other living genus, has obviously ascended from his primal antecedents. It behooves him, therefore, to look forward to perfection.

Now comes our analogue, the Bryozoan archimedes, to illustrate that progressively higher effort, registered in each successive geological period, until the Earth had reached the meridian of her reproductive career and her noontide effort culminated in man. Man is obviously Earth's masterpiece. And, he is an erratic creature, after all. But he has the faculty of thinking progressively and adapting himself to altered physical conditions. In short, he is Afterthought. And that is obviously the reason why Earth's highest effort culminated in man. She had evolved a creature who had the faculty of expanding his soul and making it an equitable return for the energy it had cost.

In the meantime, that same rhythmical stream of primary life has continued to flow and evolve new forms; but progressive man is obviously the supplement or complement of that progressive effort, registered in the geological record. Man should, therefore, look forward to perfection, expand his soul and make it an equitable return for the energy it has cost. Physics, Logic and Consciousness say, howsoever man utilizes his opportunity in this life, he will be utilized body and soul after death, at his actual value. Analyze that proposition carefully and you will find in it enough of either reward or punishment to satisfy you.

Returning now to the analogue—The stem of the Bryozoan is a marvelous spiral, tapering both ways, but mostly towards its terminal. In other words, it had a meridian of greatest development. That marvelous spiral stem, like the rythmical stream of primary life evolved by the Earth, was more enduring and is, therefore, better preserved than the exquisite network of frills on the outer edge of its frond. The dainty inhabitants of those frills were, however, one time more interesting than the spiral stem which has long survived them. Indeed, they were the life centers which marked the highest effort of the Bryozoan archimedes. Of all the beautiful organic forms, preserved in the fossils of our geological record, this Bryozoan archimedes is, to my mind, the most exquisite and suggestive. But it soon falls short as an analogue.

The tapering down of the spiral stem, after it had passed its meridian of greatest development, is coincident with the declining effort of the Earth, after she had passed her meridian. And right here is where our analogue falls short. After the starting point, each progressive whorl in that spiral stem, with its network of frills, is an analogue of each higher effort of the Earth, now registered in the higher organic forms of each geological period, until she reached her meridian and her noontide effort culminated in man.

That continuously progressive effort of the Earth, from the time she entered her reproductive career until her noontide effort culminated in man, has its complement in the further development of man. Therein, our analogue falls sadly short. That progressive effort, so clearly established by the new and higher genera of each successive geological period until man was evolved, is obviously supplemented by the progressively higher effort of man. That fact is more beautiful and suggestive than anything about the analogue. It recalls and confirms the original proposition—that the meaning of this world, briefly stated, is the evolution of energy from lower to higher powers. While the energy of the Earth is diminishing, the energy of man is augmenting. And the synthetic current of nature moves on rhythmically in progressive circuits. Physics, Logic and Consciousness say, unequivocally, the chief function of man in this life is to expand his soul and make it an equitable return for the energy it has cost.

Now, the progressively higher genera of each successive geological period, together with the lithologic or physical characters of the rocks of each period, make up our geological record. There are, therefore, two sides or aspects to the geological record, viz.: lithologic characters and organic forms or fossils. Their values alternate frequently and are, in the end, about equal. In other words, they are about equally important. That fact will, however, be brought out clearly in the following report.

The geological record rests on the Primordial Shell of the Earth and reaches up to the horizon of man. In general terms and with reference to time, it is divided into Primordial, Paleozoic, Mesozoic, Cainozoic and Quarternary. In more specific terms and with reference to long chains of similar conditions, registered in the peculiar lithologic characters of the rocks of certain periods and in the genetic relations of fossils therein contained, it is further divided into Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian, Cretaceous, Tertiary and Quarternary; known as geological periods.

For convenience, each geological period is subdivided into sections and sections are subdivided into formations. Formations are subdivided into individual members and individual members are subdivided into groups or horizons. Horizons are subdivided into individual beds, strata or layers, with bedding seams or persistent cleavages between each contiguous two of them. The whole nomenclature is more or less arbitrary and its chief value lies in the fact that it enables us to know what particular member of our geological record is being described and what subdivision of that member is being discussed in any treatise on that subject.

Since the purpose of this work is to simplify the subject, so that all may understand it, I will make it as nearly elementary as possible, without going into tedious details. Tedious details and a multiplicity of synonyms are the things about geology that have made it most difficult for the masses. Truth is what the people are seeking. Logical deductions, supported by abundant obvious facts, are the nearest to the truth that any of us can get in many cases.

The characteristic fossils of each geological horizon, from the oldest to the youngest, will be named in the following Preliminary Report and referred directly to the horizon in which they occur. In the complete Report on Structural Geology their forms will be given in the same natural order.

In discussing the metallic ores, under the head of Economic Geology, all provincial names will be ignored. It is just as easy, if not easier, to learn how to designate or distinguish a mineral by its technical and correct name, as by some provincial name which means nothing. Such rot should have been eliminated long ago, instead of having more added to it. It may be gratifying to the average geologist to be able to distinguish a certain mineral by a dozen different names, but it is very embarrassing to the average reader to be overwhelmed with synonyms, when he only wants "the milk in the cocoanut."

Under the head of Structural Geology, the rocks of our geological record will be described and named, in their natural order of occurrence, from oldest to youngest. A complete vertical section of our sedimentary rocks will be sketched and their characteristic fossils named opposite the horizons in which they occur. But we cannot now undertake to differentiate the rocks in colors and give cuts of the fossils, in this Preliminary Report. However, this Preliminary Report is only a prelude to more complete Reports on the Structural and Economic Geology of Missouri.

This Preliminary Report may, in fact, be regarded as an introduction to the more complete Reports that are to follow, as soon as we have collected all of the required data. In other words, it may be regarded as a trial effort to delineate the Structural and Economic Geology of Missouri by the most logical, graphic and simple method possible. While this Report will convey virtually all of the information of practical value that has been collected in the field, it will give us some experience and therein expand our facilities for bringing the future Reports nearer to perfection.

My ambition is to be the opposite of voluminous. In short, I would like to be able to say exactly the right thing and quit. My experience is that the books which contain the least amount of information are the most tiresome. And, on the contrary, those which contain the largest amount of information are the most interesting. Indeed, it were better for the authors and the public, if many books now in existence had never been published. In looking over books, for definite information, I am often reminded of a quaint remark that came to my ears in early childhood—"that darned old horse can trot all day in the shade of one black-jack tree."

The native resources of Missouri are so great in themselves and so varied that they do not need to be magnified or exaggerated. The delineation of our geology should, therefore, be a plain and simple story, told true to nature and in a logical way, so that the people who pay for it may be the beneficiaries. And the following Preliminary Report is only a trial effort in that direction.

# CHAPTER I.

## THE PRIMORDIAL BASE.

### PRELIMINARY REPORT ON STRUCTURAL GEOLOGY OF MISSOURI.

## PRIMORDIAL BASE.

Traversing the Mississippi Basin, from Lake Superior to southwestern Texas, lies an ancient deep-seated arch, or upward fold, unevenly developed. That deep-seated arch is known locally as the Ozark Range. It is, in fact, the eastern axis of our Primordial Continent and is older, by far, than the Rocky Mountains.

On that deep-seated arch or ancient axis, about midway between the points just named, rests the geographical area now know as Missouri. But the topography of our Primordial Base is radically unlike that of the present surface. The former is sharply defined, hard and rugged, the latter is relatively smooth or undulating.

In general terms, our Primordial Base lies under North Missouri, in the form of a narrow and sinuous ridge, between two great inverts, viz.: the invert on the east, now occupied by the Illinois coal field, and the invert on the west, now occupied by the Missouri, Kansas and Iowa coal field. Obviously, the deepest abyss, in the floor of either one of those two great opposing inverts, lies more than one hundred miles away from this Primordial axis and approximately one mile below the present surface.

On the other hand, our Primordial Base lies under South Missouri, in the form of a rugged plateau. In a large area, in south-central Missouri, it is nowhere probably more than one-fourth of a mile from the present surface down to the Primordial Base. From that central plateau, however, the base descends rapidly to the east and to the west; as indicated by the southern extension of both the Illinois coal field on the east and the Missouri, Kansas and Iowa coal field on the west. Obviously coal fields, the world over, occupy inverts, basins or troughs in the shell of the Earth, except where they have been relatively lifted up by lateral compresion and folding.

It is a familiar fact that the two opposing inverts or coal fields just named, are much farther apart, south of the Missouri river, than north of it. From Pilot Knob, in Iron county, to the Pegmatite Hill, in Camden county, lies an unbroken stretch of basal plateau. That it is absolutely level, nobody thinks for a moment, but that it is approximately so, we have ample proof.

Draw a line from the Pegmatite Hill, in Camden county, to the southeast corner of Wayne county and thence to the Granite zone in Ste. Genevieve county, and you have two sides of a triangular area which is approximately one-half of our basal plateau. An equal triangular area, with its base some further to the west and its point to the east, would complete the rectangular area of our Primordial plateau. In other words, it is about one hundred and fifty miles long, east and west, and about one hundred miles wide, north and south.

But nature does not shape things exactly that way. Nature is obviously opposed to straight lines. Our basal plateau is not a rectangle, but an ellipse, with ragged borders and its longer axis lying nearly east and west. And now comes a far-reaching explanation, why the longer axis of our basal plateau is lying so nearly transversely to the axis of our Primordial Continent, or general trend of the Ozark Range.

Our largest Primordial area, or zone, in which the Primordial Base has been denuded of its sedimentary covering (Paleozoic rocks) lies around Pilot Knob. The mere fact that the greatest destruction of Paleozoic rocks has taken place in that area is proof, in itself, that it was one time the axis or dividing ridge between the two opposing inverts above mentioned. And that the invert of the Missouri, which now embraces the Missouri, Kansas and Iowa coal field, extended on the south side of the Missouri River to that dividing ridge, the same as it does now in North Misouri. Whence could have come the variously developed coal pockets, except from the degradation of once overlying Coal Measures?

To avoid using a hideous term (quaquaversal) I will say that the two systems of primary joints in the rocks lie in diagonal lines and very nearly at right angles with each other. The usually better developed system of Face Joints runs in spiral lines from the equator to the north pole, southwest-northeast. The usually less developed system of Head Joints runs in spiral lines from the equator to the north pole, southeast-northwest.

It is a fundamental fact, that the trend of every fold in this flexible shield on which we walk, every invert and arch, every shore-line, fissure, fault or dislocation, in the beds of the Earth, is predetermined by one or both of these two systems of primary joints in the rocks. It would be idle to suppose that lateral compression, superinduced by all parts of this flexible shield settling down towards a common center, would act in one direction only. The two systems of primary joints in the rocks furnish the only clue to that kind of geological phenomena. Indeed, they furnish the clue to a great many geological phenomena, when you have studied them closely.

When you come to think about it, an incipient fissure lies in every plane of nearly coincident joints. A fissure is easily developed along a plane of nearly coincident joints, because a plane of nearly coincident joints is, primarily, a vertical plane of cleavages in all of the different beds traversed by it. In some localities, there are more fissures, faults or dislocations, on the head joints than on the face joints. But the face joints are generally the better developed system of the two and more prolific of fissures, faults or dislocations.

With two systems of primary vertical cleavages, having diagonal trends and lying nearly at right angles with each other, and with a rigid mass between every two contiguous members of each system, it is only natural that they should predetermine the trend of every fold, fissure, fault or dislocation. We do, sometimes, find fissures and faults lying east and west, or north and south, but they are comparatively rare occurrences and always local. Every quarryman or miner knows how difficult it is to break rocks or cut coal "across the corners." Fissures sometimes develop zig-zag, on both systems of joints, and what was originally a crooked line is subsequently straightened by a movement of the contiguous masses in opposite directions. Masses thus moving in opposite directions shear the inequalities off each other and that is what is meant by shearing. Shearing is one cause of great local alterations in rock minerals.

But I am not ready yet to venture far into such details. If you will study physical geography carefully, you will find that the longer axis of every invert in the sea floor is coincident with one or the other of these two systems of primary joints in the rocks. You will find that the longer axis of every midland valley is also coincident with one or the other of these two systems of primary joints. If the longer axes of all the great inverts in the sea floor and in the continental masses are coincident with one or the other of these two diagonal systems of vertical cleavages, it follows logically that the longer axes of the upward folds between them should be also coincident with one or the other of these two systems. Obviously, the trend of two opposing inverts predetermines the trend of the intervening arch.

Moreover, the contiguous sides of two opposing inverts form the skewbacks of the intervening arch. Therefore, the arch cannot sink, except as the floors of the two opposing inverts sink. The sea level is properly the level of either skewback, when we are dealing with continental masses. But we are now dealing with the eastern axis of our Primordial Continent, whose trend is in a line from Lake Superior to southwestern Texas.

Now with our flexible shield of solid masses settling by converging lines towards a common center and thus continually readjusting itself to a smaller incandescent solid mass of pristine energy, and with our two diagonal systems of vertical cleavages, it is only natural and logical that lateral compression should act on diagonal lines. The trend of a mountain chain is invariably coincident with one or the other of these two primary joint systems. The general trend of a mountain range may be nearly north and south or nearly east and west, but it is made up of a series of short anticlines arranged *en echelon*, or obliquely to the general trend of the range.

Obviously, when the beds are folded by lateral compression, the folds lie transversely to the line in which lateral compression is acting most intensely. The general trend of the Ozark Range is parallel with the western invert in the floor of the Atlantic Ocean and it is the southwestern extension of the eastern axis of the oldest terrane on this continent. And that is why I am calling it the eastern axis of our Primordial Continent. Excepting the north and south ends of the Appalachian Range, the Ozark Range is doubtless older than any other mountain chain or range in the United States of North America. That it was one time relatively higher and more sharply defined than now, there is ample proof.

But we are only approaching that point. The trend of the Ozark Range shows that lateral compression was acting most intensely in line with the head joints, locally at least, when it was developed. But I have already said it is idle to suppose that lateral compression is acting only in one direction. In fact, lateral compression must be acting in all directions. But the two diagonal systems of primary vertical cleavages or joints predetermine the lines in which lateral compression is manifested. Hence, while the general trend of the Ozark Range shows plainly that the force which developed it was acting in line with the head joints, there are two opposing transverse inverts whose contiguous sides form the skewbacks of the arch which supports the basal plateau of south-central Missouri. Those two transverse inverts are well marked by the tracks of the Misouri and Arkansas rivers.

The White River basin is quite a mark in its present topography, but it is only to be regarded as an eroded basin in the great upward fold or arch between the two opposing transverse inverts, now marked by the Missouri and Arkansas rivers. Those Coal Measure escarpments, bordering the White River basin on the south and facing up, towards Cedar Gap, look like the skewbacks, which they doubtless are, of a once continuous coal field, from the Arkansas to the Missouri River. Indeed, when we come to look for the ancient axis of our Primordial Continent, or the ancient site of the Ozark Range in Missouri, we have to get over into that zone wherein the greatest area of our Primordial Base has been denuded of its Paleozoic covering. And then, we are practically in line with the Arkansas granite zone and the granite bosses of Llano County, Texas.

Call to mind that the dynamical operations of nature do not proceed in straight lines. Connect the granite area of Llano County, Texas, with the granite zones of Arkansas and Missouri and follow thence through the deep-seated arch which prevails all the way up to Lake Superior and you have a right conception of the Ozark Range. It was one time a crooked unevenly developed upward fold or axis, in our Primordial Continent. It was doubtless more pronounced or sharply defined than now. The present trend of our most denuded Primordial area, with its longer axis lying northeast-southwest, marks the exact line of the ancient axis through South Missouri.

Now our Primordial plateau, which was not always a plateau, lies in the form of an ellipse, with its longer axis nearly east and west. The area of that basal plateau is practically one hundred and fifty miles long, east and west; and one hundred miles wide, north and south. From that central plateau, our Primordial Base sinks away rapidly in four different directions. Primarily, it was an arch or upward fold between the great invert on the east and the once greater invert, than now, on the west. Secondarily to that, it is also an arch or upward fold between the two opposing transverse inverts now marked by the Missouri and Arkansas rivers. In short, it is resting on the contiguous sides or skewbacks of four opposing inverts.

Two opposing inverts, sinking by converging lines towards a common center, means the logical folding or development of an arch between them. Can you make an "uplift" out of that? Can you conceive the lifting of such a mass away from the center of the Earth? The two opposing inverts, sinking by converging lines towards a common center, is the primary cause of such folding. I fail to see where any uplift begins, except relatively speaking.

The floor of what had previously been a great inland sea, towards a common center, were the primary cause and are a partial explanation of our Primordial plateau in south-central Missouri. But I have said that it was not always a plateau. Indeed, there are ample proofs in the rocks that all South Missouri, west of Pilot Knob, was one time a coal field. Coal pockets of various magnitudes are dispersed over the whole field. And that suggests a terraced plane rather than a plateau.

Besides the four opposing inverts, sinking by converging lines towards a common center, there was another and a subsequent movement in the flexible shield of the Earth, and that was the later development of the Rocky Mountains. Before the development of the Rocky Mountains (in Tertiary time) all of Missouri, west of the ancient axis, was a coal field and its water-shed drained to the west. What is now our basal plateau, in south-central Missouri, was then an inclined plane, dipping rapidly westwards. The development of the Rocky Mountains relieved the Ozark Range of the stress of lateral compression, acting in line with the head joints and tilted that inclined plane, by lifting its lower western edge and relatively lowering its eastern edge, which had previously been the Primordial axis.

The four opposing inverts, sinking by converging lines into which all of Missouri west of the ancient axis had drained, was thus gradually lifted into land surface and inclined in the opposite direction, from the base of the Rocky Mountains to the Mississippi river. Then, of course, the Missouri, the Platte, the Arkansas, the Red river and all intervening drainage lines were developed. They naturally developed along the lowest surface lines, because nature does everything in the most logical way. The deepest abyss and deepest transverse zone in the Missouri, Kansas and Iowa coal field lies under the track of the Missouri river. The deepest invert or zone in the Arkansas coal field lies parallel with or under the track of the Arkansas river.

The intensity of lateral compression, acting in line with the face joints, is more manifest, however, in the Arkansas than in the Missouri invert. The coal mines in the Arkansas valley are relatively shallow and yet they are all proverbially "hot as bake-ovens." On the other hand, the temperature of the Leavenworth mines, seven hundred feet below the banks of the Missouri river, is only about 70 degrees. The fact that lateral compression, in line with the face joints, is acting more intensely on the Arkansas coal field, is the explanation of the greater disruption, folding and tilting of the beds, as well as the more crystalline character of the coal. The other rocks are relatively more crystalline also. The Arkansas coal field is a typical metamorphic region, in which the process of metamorphism is in slow but constant progress.

The tilting of our Primordial Base, in south-central Missouri, from an inclined plane to a very nearly level plateau, by the later development of the Rocky Mountains, is a well established fact. And it is a fact of very great economic importance. When we come to consider the further obvious fact that all of the great ore bodies, in our sedimentary or Paleozoic country rocks, are water concentrations of metallic elements once diffused in the rocks, common sense will suggest that we should expect to find them richest in those zones wherein the reconstructive action of both surface and subdrainage has never been reversed or materially altered.

## PRIMORDIAL ROCKS.

So far as we know now the primary rocks in our Primordial Base are granite, gneiss and mica-schist. In other words, they were the original country rocks. But those original country rocks have evidently been cleaved, traversed and disrupted, by innumerable subsequent eruptions of plutonic lava that has resulted in dykes and bosses of diabase, pegmatite, porphyry and granite.

That those subsequent eruptions took place while our Primordial Base was a sea floor, is a fact, well established by the topography of the base. That the topography of our Primordial Base should be so radically unlike the topography of the present surface, is the most profound problem in the geology of Missouri. Nowhere do we find any indications of contact metamorphism, or alteration in the Paleozoic rocks, superinduced by contact with hot lava. On the contrary, our Paleozoic limestones and sandstones have the same lithologic characters, where they lie in contact with the Primordial rocks, as elsewhere.

Nor is there any dislocation or other evidence to show that solid granite, pegmatite or porphyry peaks have been pushed up through the Paleozoic rocks. In fact, the pushing up has all been downwards, towards the center of the earth. The comparatively recent development of the Rocky Mountains relieved the stress of lateral compression on the Ozark Range, acting in line with the head joints, raised the lower edge of its western slope and thus relatively lowered its eastern edge, which had hitherto been our Primordial axis. And now there is a gradual rise in the surface, all the way from the Mississippi river to the Rocky Mountains. The movement in the Earth's solid shield, which resulted in the elevation of the Rocky Mountains and the relative lowering of the Ozark Range, could not have pushed any portion of the Primordial Base up through its Paleozoic covering. Because the tendency was obviously in the opposite direction.

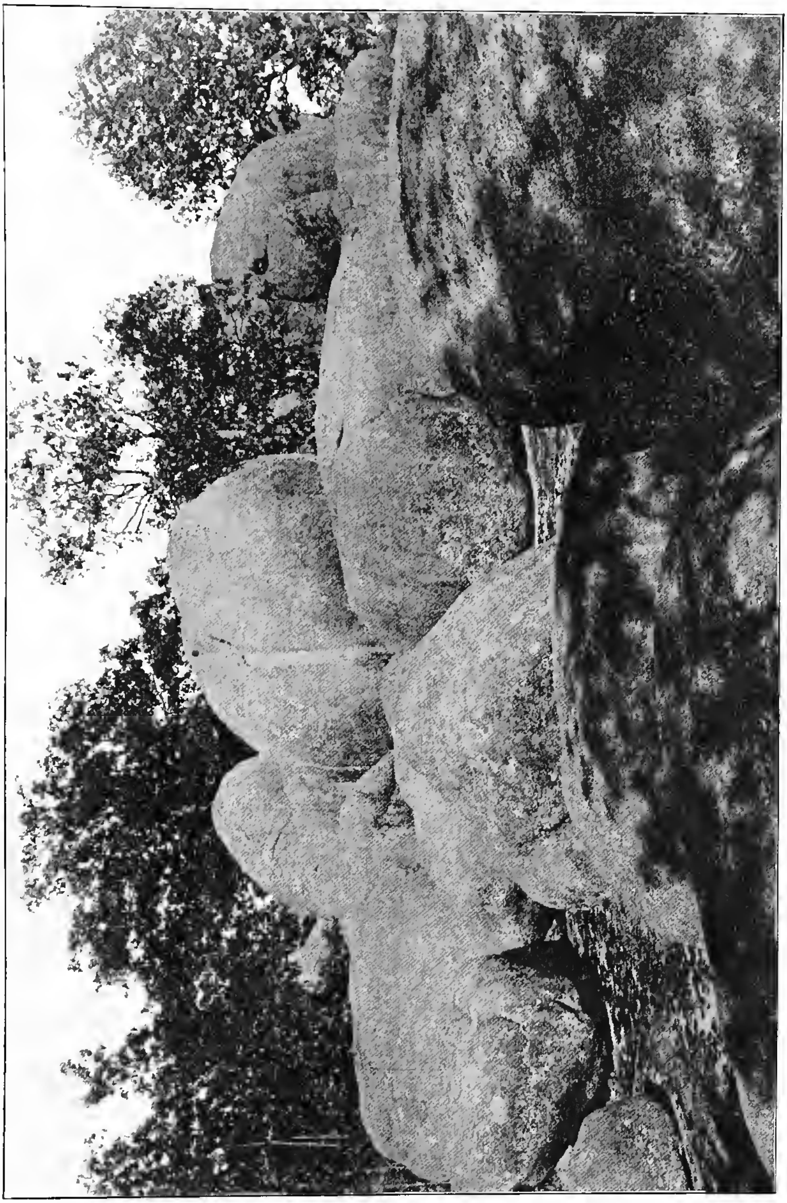
There is no alternative but to take the most denuded area, around Pilot Knob, for our ancient Primordial axis. It follows then, that the surface and subdrainage systems of the eastern slope from that axis have always been practially the same as they are now. On the other hand, the surface and subdrainage systems of all Missouri, west of that axis, have obviously been for the most part reversed or materially altered. One of the objectives of the investigation now being carried on by the Geological Survey of Missouri, is to find the exceptions. For, therein lies the solution of this problem—how to proceed intelligently in the development of our vast mineral resources and thus save a great waste of energy.

It is not worth while now to discuss the physical or lithologic characters of our Primordial rocks. That subject has been discussed enough in former reports of this Survey. The question which now concerns us most, in connection with our Primordial Base, is how to delineate its exact topography. Explorations with the core-drill, now inaugurated, will doubtless do more towards unfolding that profound secret than any other scheme conceivable. The facts, which will be brought out by the core-drill in the next few months, concerning the topography of our Primordial Base, will be a surprising revelation.

## GRANITE COUNTRY.

By far the largest granite area in Missouri, lies in Madison and St. Francois counties, on both sides of the St. Francois River and about midway between Fredericktown and Iron Mountain. That area embraces somewhere about eighty square miles of granite surface. Besides the one large area, there are some forty-eight other small granite areas, hills or narrow zones, dispersed over nine counties, viz: Ste. Genevieve, St. Francois, Madison, Wayne, Carter, Reynolds, Iron, Washington and Crawford. In all of those nine counties, with Shannon and Dent included, the highest Paleozoic rock is the St. Thomas sandstone; except in the northeast corner of Washington and in the northwest corner of Crawford. That means, of course, that in one area of four thousand square miles, it is nowhere more than ten or twelve hundred feet from the present surface down to the Primordial Base.

In the Cambrian zone of Morgan, Camden and Laclede counties, there are many deeply eroded valleys and basins in which the Primordial rocks might be reached within two or three hundred feet of the surface. The Pegmatite Hill, near



Elephant Rocks, Graniteville.

Decaturville, is, however, the only exposure of Primordial rocks in south-central Missouri.

(Plate 2.) The Elephant rocks at Graniteville in Iron County, furnish a good illustration of the weathering of granite. When thus insulated and exposed on all sides to the weather, massive granite blocks, the same as any other rock, will eventually yield to its destructive influences. Howsoever compact they may seem to be, those weathered blocks, when broken open, have very different lithologic characters from the granite taken fresh from the quarries. Our Missouri granite is as pretty and as durable as the granite of any other country. But it is well for man to know that no rock will forever withstand the ravages of the weather.

It is obviously a great waste of energy for the people of Missouri to be importing granite for monumental or building purposes, on the theory that the granite of other countries is better or more beautiful than ours. In fact, our Missouri granite is as beautiful and as durable as the granite of any other country.

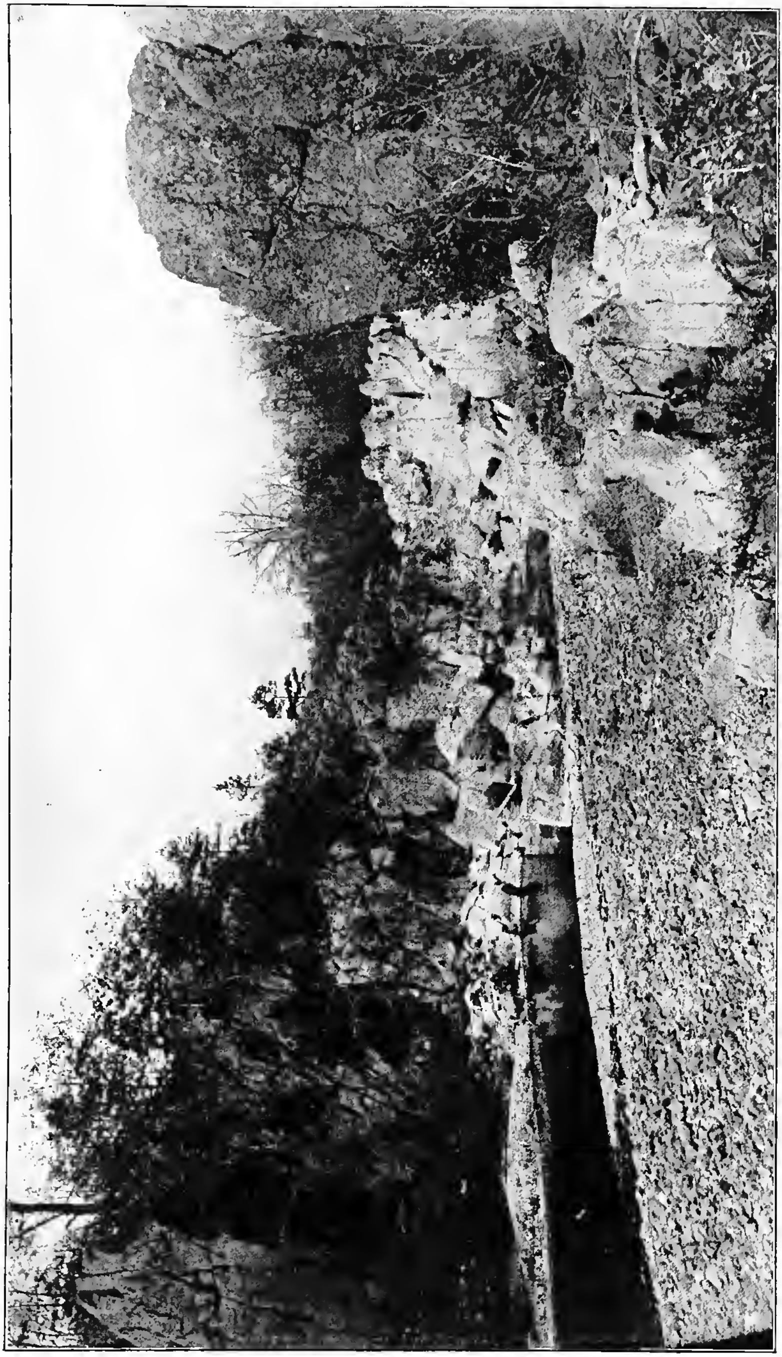
Another thing, which seems to me stranger than the people of Missouri importing granite, is the fact that scarcely any prospecting for metal viens has ever been done in our granite country. It is a familiar fact that all of the richest metal mines in the world are situated in those areas wherein the greatest destruction of rocks has occurred. There is no doubt whatever but that one vertical mile of Paleozoic rocks has been decomposed and removed from the granite area described, in the valley of the St. Francois river. More than one-half of that prodiguous mass was evidently ore-bearing.

Prof. John H. Frick presented this Survey with a large fragment of *Columnaria alveolata* that was plowed up in a corn field some years ago about two miles south of Bismarck. That fossil is part of a large coral which grew at the time of the deposit of the Lower Trenton limestone. It was originally limestone, but the lime of corals is frequently replaced by silica When the original Lime carbonate of an immense coral, like the *Columnaria alveolata,* has been replaced by soluble silica and has thus become a massive body of pure quartz, it is well nigh indestructible. That fossil, plowed up in a corn field two miles south of Bismarck, tells a true story straight.

The soil and subsoil of that corn field are the last relics, in that spot, of a vertical mile of Paleozoic rocks which have been decomposed and swept away by the frost, the wind and the rain. The soil and subsoil of that corn field rest on granite and porphyry. Between the Trenton limestone, of which the *Columnaria alveolata* was one of the builders, and the Primordial Base, belongs the Magnesian Lens, approximately one-half mile thick. Obviously, that massive fossil, preserved in quartz, gravitated down, as the rocks were decomposed and removed, one layer after another, until it rested on the Primordial Base, a vertical half mile below where it was originally deposited.

About thirty miles away, to the east, lies to this day Trenton limestone in place, with its western edge in the form of an escarpment or skewback, facing upwards and to the west. Therefore, it requires no violent stretch of the imagination to conceive that the time was when the Trenton limestone spread out, in its full development, over that whole Primordial area. If the Trenton limestone was continuous over the whole area, and we have no reason to doubt it, another vertical half mile of Paleozoic rocks, on top of it, was also doubtless continuous; because they lie, too, only a little further away, with their weathered faces looking upwards and westwards.

Now if there ever was any open structure in that granite country on which once rested a vertical mile, or even half mile, of ore bearing rocks, there ought to be some rich *infiltration* metal veins in that granite country. On the other hand, if there ever were, in any other granite country, such things as sublimation veins, they ought to be found in the granite country of Missouri. Howbeit, the proofs of subsequent eruptions of plutonic lava, through the original granite country, are as abundant in that region as in any other granite country in the world.



Porphyry Shut-In, East Fork of Black River.

## PORPHYRY.

After the primary rocks (original Primordial country) which I have said were apparently granite, gneiss and mica-schist, comes the dyke rocks or products of subsequent plutonic eruptions. They are the dyke diabases, pegmatite and granite bosses, but chiefly porphyry in the form of lofty dykes and conical bosses. The way those porphyry dykes stand up, above the common level of the basal plateau, with precipitous sides and so often transversely to our present drainage lines, makes the exact topography of our Primordial Base, the most profound problem in the geology of Missouri.

The track of every stream that traverses porphyry country, in Missouri, is beset with dykes and ridges of that refractory material lying at right angles. Widely eroded valleys, along the tracks of those streams, are often terminated abruptly by transverse walls of porphyry. So many of those porphyry dykes and ridges, lying transversely to our present drainage lines, is the obvious part of the problem now confronting us. Reasoning by anology, and that is the only way man can reason, we naturally conclude that those puzzling things may be as abundant in our less deeply eroded areas, as in those areas in which they are now exposed. The only explanation I can conceive is, that they are the products of plutonic lava pushed up between masses of original Primordial country and consolidated under water. (Plate 3.) Those porphyry gaps ("shut-ins") which occur so often around the eastern edge of our basal plateau, give rise to some of the wildest scenery to be found anywhere in the Mississippi Basin. Indeed, after exploring and admiring one of those beautiful basin-like valleys, along the headwaters of Big River or Black River, one is more surprised and puzzled by the weird aspect of a porphyry shut-in, than he would be by a great mountain canyon. Although the river track through the porphyry ridge or wall is usually short, the change is so sudden and the contrast so great that one is completely bewildered.

And yet there is no getting around the fact, that those porphyry walls were there, before the Paleozoic rocks were deposited. That is why I have said the information which will be collected in the next six months, exploring with the core-drill, will be a surprising revelation. Granite, pegmatite and porphyry, hills and walls are almost protruding through our Paleozoic rocks in many places where we least expect it. And that mysterious topography of our Primordial Base has doubtless predetermined the now unknown sites of some of our greatest ore bodies.

It is a curious fact, that where porphyry and magnesian limestone meet at the surface, the decomposition of each rock supplies reagents to destroy the other. Hence we have a valley, or basin, around nearly every porphyry hill. Owing to that fact, perhaps, some promising prospects of rich copper deposits have been found at the contact of limestone and porphyry. I have seen one place, in Shannon county, where a large sum of money was sunk, prospecting in porphyry for copper. All of the copper found in that porphyry was green and blue carbonates carried down into the joints of the porphyry by water and precipitated in thin sheets. Very thin sheets, of course, because the joints in porphyry are very thin themselves. That the copper was derived from decomposed or weathered-out limestone, is demonstrated by two facts, viz: 1, The same kind of copper deposits occur in blankets and fissures in the First Calciferous, miles away from any porphyry exposures; 2, I have found copper carbonate in magnesian limestone under such conditions that it could not possibly have come from any other source than the limestone itself.

Obviously, copper may as well have been one of the metallic elements, contained originally in our magnesian limestones, as any other metal. In fact, all of the metallic elements evolved by the Earth were doubtless present, to some extent, in the sediment which made up our magnesian limestones. And whatever ore bodies are deposited in porphyry have doubtless been derived from the magnesian limestones that are now decomposed.

Referring again to the topography of our Primordial Base, the great boiling or spouting springs, situated in nearly every valley leading out from our basal plateau, suggest that the sub-drainage lines, whence issue those magnificent springs, are simply the overflow of vast subterranean reservoirs. In other words, a great volume of cold fresh water is held in embayment by porphyry dykes and ridges, lying transversely to our present drainage lines. The flow of subterranean water, from our basal plateau, is thus held in check, so as to make the underground stream, which supports each spring, perpetual.

Each one of those magnificent springs has its period of maximum volume, immediately after a long wet season; and each one of them has its period of minimum volume, after a long dry season. But the immense volume of water that issues from any one of them, even after a long dry season, is proof, in itself, that great plateau reservoirs are held in embayment by hidden obstructions of some kind that are not easily soluble.

Having explored the valleys of the upper St. Francois, the upper Big River and the upper Black River, wherein the Primordial rocks have been most denuded, and observed the great number of porphyry dykes and ridges now lying transversely to the drainage lines of that region, we are prepared to expect similar conditions around the entire border of our basal plateau. What effect such conditions may have had toward predetermining the sites of great ore bodies yet undiscovered is, of course, an unknown quantity.

But it is to such fundamental conditions, I am trying to direct the public mind. Having once observed the Synthetic Method of Nature, which is virtually the obvious physiology of the world, the human mind cannot believe, for one moment, that economic deposits of any kind are mere accidents. Indeed, the acts and doings of erratic man are the nearest things to accidents, in all of this beautiful world. Therefore, we should not quickly conclude that the mineral wealth, stored in the rocks of this bounteous Earth for the use of man, are mere accidents, even though we do sometimes find them by mere accident.

# CHAPTER II.

## THE GEOLOGICAL RECORD

AND

## DISCUSSION OF THE MAGNESIAN LENS.

## THE GEOLOGICAL RECORD.

As already indicated in the Introduction, the Geological Record (Sedimentary Rocks) of Missouri has been recognized and differentiated as Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Permian or Post Carboniferous, Tertiary and Quaternary. These divisions are known as Geological Periods. The name Ordovician is used instead of Lower Silurian in conformity with the nomenclature adopted by the U. S. Geological Survey.

I mean to make this delineation of a true vertical section of our sedimentary rocks as complete, graphic, logical and simple, as possible. I will, therefore, begin with the lowest and oldest and describe each geological period separately, in its natural order of occurrance. Moreover, I will begin with the lowest and oldest member of each geological period, section or sub-division thereof, and describe all of its members, in their natural order of occurrence, from oldest to youngest.

## DISCUSSION OF THE MAGNESIAN LENS.

Before proceeding, however, the unique character of our Magnesian Lens and the complex relations of its lower members with the rugged surface of our Primordial Base, demand some special discussion. The Magnesian Lens is made up of eighteen individual members. The lower ten have been recognized and differentiated as Cambrian. The upper eight have been recognized and differentiated as Calciferous. The total depth or thickness of our Cambrian section, complete, is between seven hundred and eight hundred feet. The total depth or thickness of the eight Calciferous members of the Magnesian Lens is about fifteen hundred feet. The total depth or thickness of the Magnesian Lens complete, is, therefore, approximately two thousand and three hundred feet.

The plane of contract between the Primordial Base and the Magnesian Lens is essentially rugged and complex. Obviously, because the topography of the base is hard and sharp, while the lower members of the Lens represent the first Paleozoic sediment, deposited on the floors of valleys and basins, in the rugged surface of the Primordial Base. Sharp granite peaks, porphyry dykes and pegmatite bosses stand up in places, one thousand feet or more above the common level of the Primordial Base and the areas between have been filled with Cambrian and Ordovician deposits. Hence we have contacts, at various angles, between the Cambrian and Ordovician rocks, on the one hand, and granite, gneiss, mica-schist, pegmatite, diabase or porphyry, on the other.

Inasmuch as our whole Cambrian section does not exceed eight hundred feet in depth, dykes and peaks of Primordial rocks project sometimes three or four hundred feet into the lower members of the Calciferous. For example, the granite hill, in Carter county, exposed by the cutting down of the track of the Current river, reaches up through the Roubidoux (basal) sandstone and into the First Calciferous to within one hundred feet of the St. Thomas sandstone. In fact, most of the porphyry dykes and hills, between the Current and the Black rivers, terminate in the First Calciferous.

Obviously, the sediment precipitated on a rugged sea floor would fall on the lowest places first, or be afterwards carried there. Hence it may be expected that the lower members of our Cambrian section are not as extensive, laterally, as the upper members. That calls to mind the historic fact, that had not the ore-bearing lower members of the Cambrian been exposed, at Mine La Motte, those vast ore bodies in the Lower Cambrian of Madison and St. Francios counties might not to this day have been known. Generally, the Cambrian beds lie nearly horizontal in the valleys and basins of the Primordial Base. The walls of those valleys and basins are usually converging downwards. The prospector should, therefore, never lose sight of the fact that the ore-bearing lower members of the Cambrian do not spread out over as large areas as the upper and barren members.

The hanging of the Cambrian beds from the sides of a valley in the Primordial Base, towards a central zone of deepest depression, has suggested the pushing up of the Primordial rocks on either side. But when you have taken into account, the long continued and vast reconstruction, the more crystalline lower beds of the Cambrian have undergone, you will find in it, a more logical explanation of the trough-like structure of the upper beds of the Cambrian, than in any pushing up theory. We have ample proofs that great quantities of soluble rock minerals have been dissolved out and carried away from the more crystalline lower beds of the Cambrian, by the subterranean streams that have traversed them, ever since Missouri became land surface.

As a whole, the Magnesian Lens is one unique local deposit. Obviously, because it lies in one great mass, some three hundred miles across and thins out from that in all directions, to nothing; except in the central zone of the deep-seated arch which leads up to Lake Superoir. The geology of any given area of the Earth is to some extent individualized, because the conditions of deposit in that area were essentially local. A correct genesis is, therefore, the easiest way of resolving all geological phenomena. But the genesis must satisfy all of the requirements of Physics, Logic and Consciousness. In other words, it must be supported by abundant and obvious facts because we reason only by analogy.

That the rocks of our Magnesian Lens were deposited on the floor of a sargasso sea, in early Paleozoic time, we have every reason to delieve. Seeing that the three great sargasso seas of the present time are the eddies and filtering areas of the present ocean, around which continuous currents move and in which absolute calm prevails, we have reason to believe that such filtering areas existed far back in Primordial time. Indeed, the Primordial areas, or first emerged portions, of the present continents were all doubtless the floors of sargasso seas in Primordial time.

Primordial, sargasso seas are situated on upward folds or shallow spots in the ocean. No currents traverse them, for that reason. In those vast areas, absolute quiet prevails. They are, therefore, the havens provided by nature for myriads of organic forms. Some of them are parasitical, of course, because no place has yet been found on this bounteous Earth, where parasites do not obtrude. But the major part of those organisms which inhabit a sargasso sea, take for their food some element directly from the water.

The soluble silica or quartz, so abundant in the rocks of our Magnesian Lens, is easily accounted for when we have seen the tiny Infusoria at work on the floor of a shallow and quiet sea, taking silica in solution in the water for their food and building their delicate but vastly cumulative structures. The lime is easily accounted for when we reflect that all of the marine fossils in our geological record represent individuals who were lime consumers. The Foramenifera and Coral polyps of shallow seas have, however, been the greatest rock builders. When you come to account for the magnesia, there is absolutely no logical way to account for it, except in the Paleozoic antecedents of the Algae now taking magnesia for their food. Sargasso seas are the ideal homes of Algae. The forms of weeds in relief on the bedding planes of our magnesian limestones have been noted by every Geologist who has written about them.

When you come to account for the metallic elements, once diffused in the rocks of our Magnesian Lens, and now concentrated into economic bodies, by the decomposition or reconstruction of those rocks, there is no place to look for the parallels of conditions which could have led to such unique results, except in the sargasso seas of the present time. It is not necessary to reverse or even alter the obvious laws which govern the operations of nature at this time, to find a logical explanation of any geological phenomenon that comes within the observation of man. Simply because, the Synthetic Method of Nature has been one and the same, ever since our cosmic mother, Earth, entered upon her reproductive career.

Next to the first essential element, cosmic light, derived from the Sun, all of the other elements of organic life are evolved by the Earth and diffused or suspended in her water and atmosphere in their most available forms. The air we breathe, the water we drink and whatever other sustenance or renewal energy we get, comes either directly or indirectly from the bounty of our cosmic mother, Earth. Everything in nature has a physiological function to perform, because it is a part of one organized and living whole.

The myriads of living organisms, assembled together in a sargasso sea, and taking each some particular element in the water for its food, are no exception but rather a confirmation of the reproductive function of the Earth. When the living career of each organism is ended and its dead body falls on the floor of the sargasso sea, it adds another mite of solid matter to that heterogeneous mass, which came primarily from elements that had been diffused in the water or the atmosphere. Meanwhile, the organic acids given back to the water by myriads of organisms, living and dead, are powerful reagents which act on the metallic elements suspended in the water and thus tend to filter it of its entire burden.

This great Magnesian Lens of Missouri is made up of Five Infusorial Sandstones, Two Shale Beds and Eleven Magnesian Limestones. All of those eighteen individual members are equally persistent and were one time doubtless absolutely continuous, except where the inequalities of the Primordial surface were such that the first Paleozoic sediment rested only on the floors of valleys and basins. And that is the point which I want to impress on the mind of the reader. All of our Cambrian beds and the first two members of the Calciferous are absolutely unconformable to the Primordial Base. In other words, innumerable dykes and bosses of Primordial rocks are sticking up through the whole of our Cambrian and into the second member of the Calciferous.

Therefore, it behooves the prospector who is exploring the Cambrian beds for rich zones of disseminated lead to keep well away from those sloping or terraced walls of Primordial rocks, which form the sides of each valley or basin in the Primordial Base. Moreover, it behooves him to analyse the local structure carefully and make sure that the original valley was deep enough and its floor low enough to have received the sediment which formed the First (bottom) Cambrian limestone. That First Cambrian limestone (bottom limestone of all) is our first great country rock. It is the rock which carries the great zones of disseminated lead.

Inasmuch as that First Cambrian limestone represents the first Paleozoic sediment, deposited after the Basâl Sandstone, it is to be expected, in its full development, only in the central zones of valleys and basins, where the surface was low enough to receive that sediment. Therefore, it is an easy matter to land on a terrace in the Primordial Base, without having gotten low enough for the country rock you are seeking to explore. This fact applies with as much force in the development of the Lower Coal Measures as in the development of the Lower Cambrian. The Lower Coal Measures are not so widely distributed as the Middle Coal Measures.

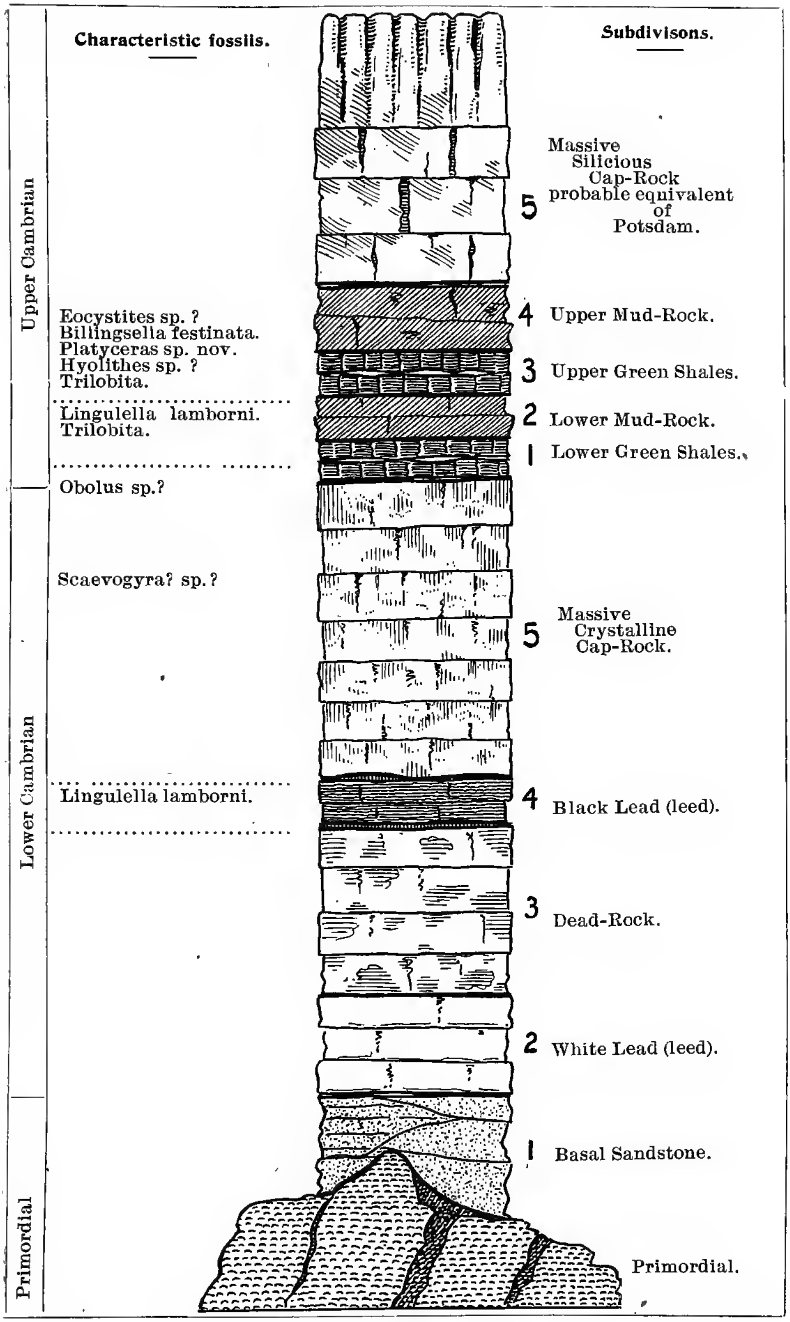
# CHAPTER III.

## CAMBRIAN DIVISION

OF THE

# GEOLOGICAL RECORD.

# SECTION OF CAMBRIAN.



## CAMBRIAN.

For the purpose of making this delineation of our sedimentary rocks true to nature and as graphic as possible, I will submit a rough sketch of the vertical section of each geological period or sub-dividision thereof, in its natural order of occurrence. By that method, I hope to keep the object that is being described before the mind of the reader. The reader must, however, bear in mind that this delineation proceeds from the Primordial Base, upwards to the present sensible horizon. By that method only, can we avoid any possible confusion.

Our geological record differentiated, and all of its members described and named in their natural order of succession, or occurrence, is somewhat like the alphabet of our language. Without it we can neither write nor talk intelligibly about the geology of any country or locality. Because, in every country and locality, more than one member of a geological period and usually more than one geological period are represented in the surface rocks.

I have already said that tedious details and a multiplicity of synonyms are the features of geological reports that are most perplexing to the unlearned masses. One element of the tedious details referred to are protracted arguments over the correlation of rocks, which take up so much space, in most of our geological reports, without solving the problems or shedding any new light. Ingenious theories and strong arguments on such questions are interesting to scientific readers, who have plenty of leisure, but they tend to discourage the average reader from pursuing a very logical and useful science.

Furthermore, if courteous references, at every step, in the delineation of the geology of a State, are to be taken for the measure of merit in that delineation, I beg to say frankly that this delineation of the geology of Missouri is not a compilation of the information contained in any previous report on the same subject. In short, it is a delineation of the geology of Missouri, as I have observed it, with the aid of my assistants, in the field.

Therefore, between the scientific people who want to be quoted or mentioned, in every publication on the subject, and the unlearned masses who want the information, without the trimmings, and in such form that they can easily grasp it, I will take my chances and try to delineate the geology of Missouri true to nature and in as simple terms as possible.

Were I trying to discuss every feature of geology in this report, I might wander into fields that I have not explored. In that case, frankly, what I do not know about geology would fill a large library. But this is only a Preliminary report. It demonstrates, however, that what I do know about geology may be condensed into one small volume. And I mean to make it as small as possible, without leaving out any *available* information that the people of Missouri want.

Our whole Cambrian Division does not probably exceed eight hundred feet in depth or thickness. It may, therefore, be described in one sketch of a typical vertical section. The far greater thickness or vertical depth of our Carboniferous Division suggests that it should be delineated in sections or sub-divisions. But each of the other geological periods will be shown in one verical section.

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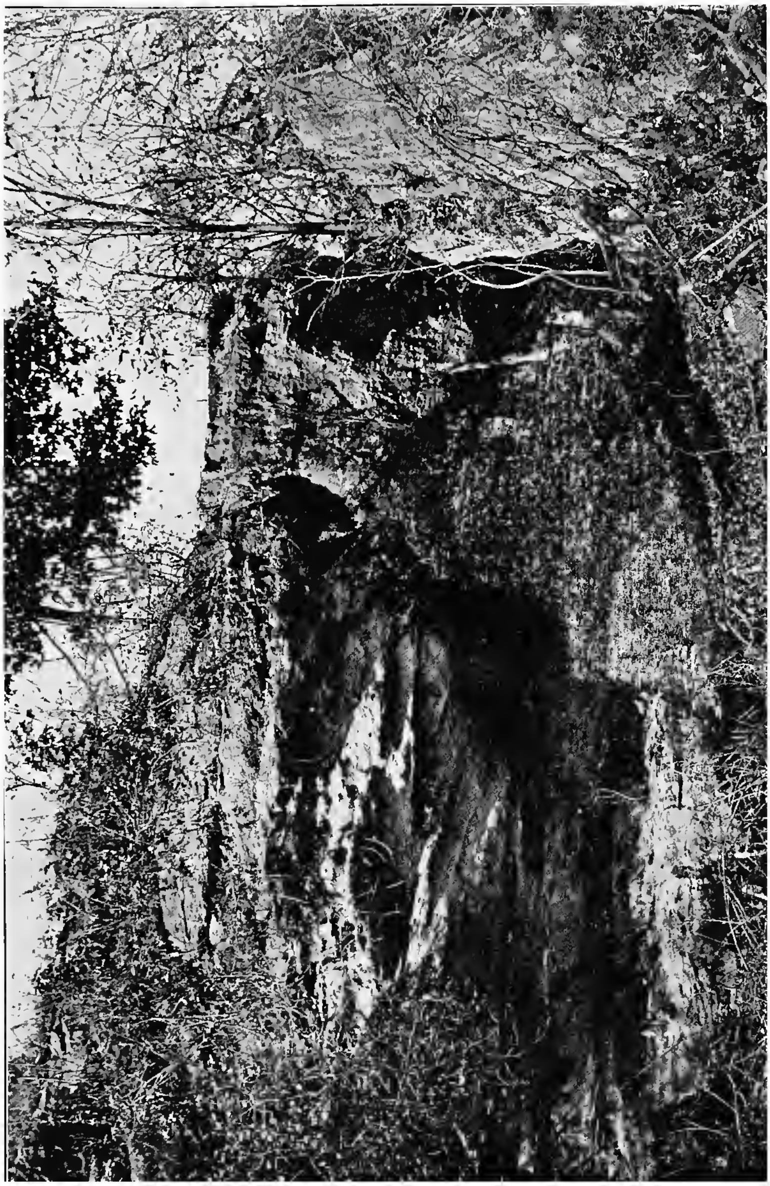
## BASAL SANDSTONE.

(Plate 4.) The Basal Sandstone of the Cambian is obviously the first Paleozoic sedimentary rock in Missouri and the first member of our geological record. It varies greatly in lithologic character as well as in thickness. In the central zones of valleys, however, and in the central areas of wide basins, wherein it may be considered in its normal condition, it is a pure while quartzose sandrock, not materially unlike any one of the four Infusorial sandstones of the Calciferous group. It varies in thickness, between one inch and one hundred feet, but its average thickness is about fifty feet.



Basal Sandstone, Belleview Valley.

In variable zones, along its margins, where it lies in contact with the Primordial rocks, it is a course conglomerate graduating into an even-grained, pure while sandrock away from the contact. The most remarkable thing about this rock is, that it forms the impervious floor of the great disseminated lead zones in the overlying First Cambrian limestone. It seems a little strange, perhaps, that any sandstone could form an impervious floor. But when you have seen it blasted up from the floor of the White Lead (leed) or lower mining level of Mine La Motte, for example, it does not seeme any longer strange, but an obvious fact, that it has been made an impervious mass to a depth of several feet, by the infiltration of mineral solutions (sulphides) into its voids. It is a familiar fact, to stone dealers and cutters especially, that any quartzose sandstone will absorb mineral paint to a depth of several inches.

The mineral solutions (sulphides) that have been absorbed into the upper surface of the Basal sandstone were thin solutions or weak solutions, if you prefer it, in water and for that reason penetrated that rock to various depths, between five and ten feet. No sandstone has so close a texture but what water will permeate it or find its voids and if that water is carrying rock mineral or metallic ores, in solution, it will precipitate them when it comes to a stand still, or meets serious resistance. The water is simply filtered of its minerals in solution. Hence it is only natural that the Basal sandstane should have become an impervious floor, under those zones of disseminated lead, in the First Cambrian limestone.

So great is the alteration of the lithologic character of the rock, however, when saturated with sulphides, you would never recognize it for the rock whose normal character is a pure white quartzose sandrock. The voids between the original quartz gains have all been filled with metallic sulphides and the quartz grains have been altered from their normal white to a greenish leaden color. Iron sulphide (pyrite) is the most conspicuous mineral involved, because its bright yellow lustre is in striking contrast with the prevailing dull leaden color of the now argillaceous looking mass.

Another chracter of the Basal sandstone is, that it not only becomes a coarse conglomerate along its margins, where it lies in contact with the granites and porphyries, but the material, contributed by the disintergration of those rocks, has carried it up higher along the sides, than in the interior of the valley or basin. In those places, it lies in wedge-shaped sheets, with its thick edges against the granite or porphyry and its thin edges interlapping with the Cambrian limestones.

The obvious fact that the sediment which formed this rock was the first loose material laid down on a very rugged surface, is a sufficient explanation of its uneven thickness. The further obvious fact that most of the material along its margins was derived from the granites and porphyries, is a sufficient explanation of its conglomeratic character, along the border of valleys. A notable feature of this Basal sandstone is the scarcity in it of coarse rounded or water-worn material. A few rounded granite and porphyry boulders have been found along its margins in one or two places, but that kind of material is remarkably scarce.

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## FIRST LIMESTONE.

The second member of our Cambrian section, First limestone or White Lead (leed) is, for several reasons, one of the most interesting rocks in our geological record. In its typical development at Mine La Motte, where it received that name, it is, notwithstanding the great quantities of lead it has yielded, an exceedingly white and coarsely crystalline limestone. At Mine La Motte, it is only about twenty feet thick, but at Flat River and Bonne Terre, it has reached more than double that thickness, or about fifty feet. At the latter named places, it carries more argillaceous matter and is not generally so white as at Mine La Motte. But its coarse crystalline texture is virtually the same wherever it has been found. It has evidently undergone more reconstruction than any rock in our geological record, that is still in place.

In those zones in which disseminated lead is now being mined, in this first great country rock, we have abundant proof that it has undergone marvelous alterations. Great lenticular spaces were first dissolved out between its different layers and the spaces afterwards filled with lead and other sulphides. Knowing that the Basal sandstone was made impervious by the infiltration of mineral solutions, we naturally conclude that the voids in the limestone were gradually filled by the same process. Great sheets of lead ore are found in what were once rough and irregular bedding seams. But the lead that was deposited in the smaller voids of the rock, or disseminated throughout its different layers, embraces the major part of the product.

No fossils have yet been reported from this rock. But the Cambrian beds are all conformable with each other and the higher beds, that have not undergone so much reconstruction, carry a great many fossils in certain zones and horizons. As indicated in the foregoing sketch, of vertical section, this Survey has collected fossils from eight different horizons in the Lower and Upper Cambrian.

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## SECOND LIMESTONE.

The third member of our Cambrian section, Second limestone or Dead Rock is remarkable mainly on account of its fine texture and variable thickness. At Mine La Motte, it is only about twenty feet thick. At Flat river, it is one hundred and forty-four feet thick. Its lithologic character is, however, virtually the same at both places. It is a dark colored, fine and even-grained rock and its general structure is close. A few narrow vertical fissures are found in it, known by the miners as "feeders" when they contain ore. But it is a suggestive fact that most of them are open, as if the burden had gone on down, into the voids of the White Lead.

When we have done finding pointers, to suggest that these ore bodies are water concentrations of metallic elements, derived from the decomposition of once overlying rocks and the reconstruction of these, the advocates of other theories will have to bring more obvious facts than they have yet brought to withstand this battery. Primarily every limestone in the Magnesian Lens is ore-bearing, to some extent. It is approximately two thousand feet from the First Cambrian liemstone up to the Fourth Calciferous. If the metallic ores came up from below, why did they stop in the First Cambrian limestone in one locality and rise up two thousand feet further in another locality?

There is no evidence that either hot or cold streams of water have come up out of our Primordial Base, to invade our sedimentary rocks and fill their cavities with metallic ores. The obvious facts are all pointing in the opposite direction. In fact, our disseminated ore bodies are found only in those areas wherein a vertical half mile of ore-bearing rocks have been decomposed and removed.

## THIRD LIMESTONE.

The fourth member of our Cambrian section, third limestone or Black Lead (leed) is the second ore-bearing, or country rock, in the Magnesian Lens. At Mine La Motte, where it was thus named, on account of its dark color and for convenience in distinguishing between the two mining levels, the Black Lead has about the same thickness as the White Lead below and carries more ore, simply because it spreads out over a wider area. These rocks are virtually fillers, or so many horizontal layers of sediment, laid down on the floor of a Primordial valley which is obviously wider at top than bottom.

At Flat River, the Black Lead is only about six feet thick. It carries some ore, but the White Lead below is between forty and fifty feet thick in that locality and carries relatively larger and richer ore deposits. Hence the mining operations, car-

4th Cambrian Limestone, Old Coelleda.

ried on in Flat River camp are very generally in the White Lead or First (bottom) limestone.

*Lingulella lamborni*, a small Brachiopod, occurs sometimes in the limestone of the Black Lead. In the Lingulella shales, lying in persistent sheets of thin lenses, at the bottom and top of the Black Lead individual forms of these small Brachiopods are most abundant. The Survey has collected a great many of these fossils, but they are so delicate or fragile that it is difficult to preserve them in good form. In some thin slabs of shale, hundred of these delicate fossils are to be seen.

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## FOURTH LIMESTONE.

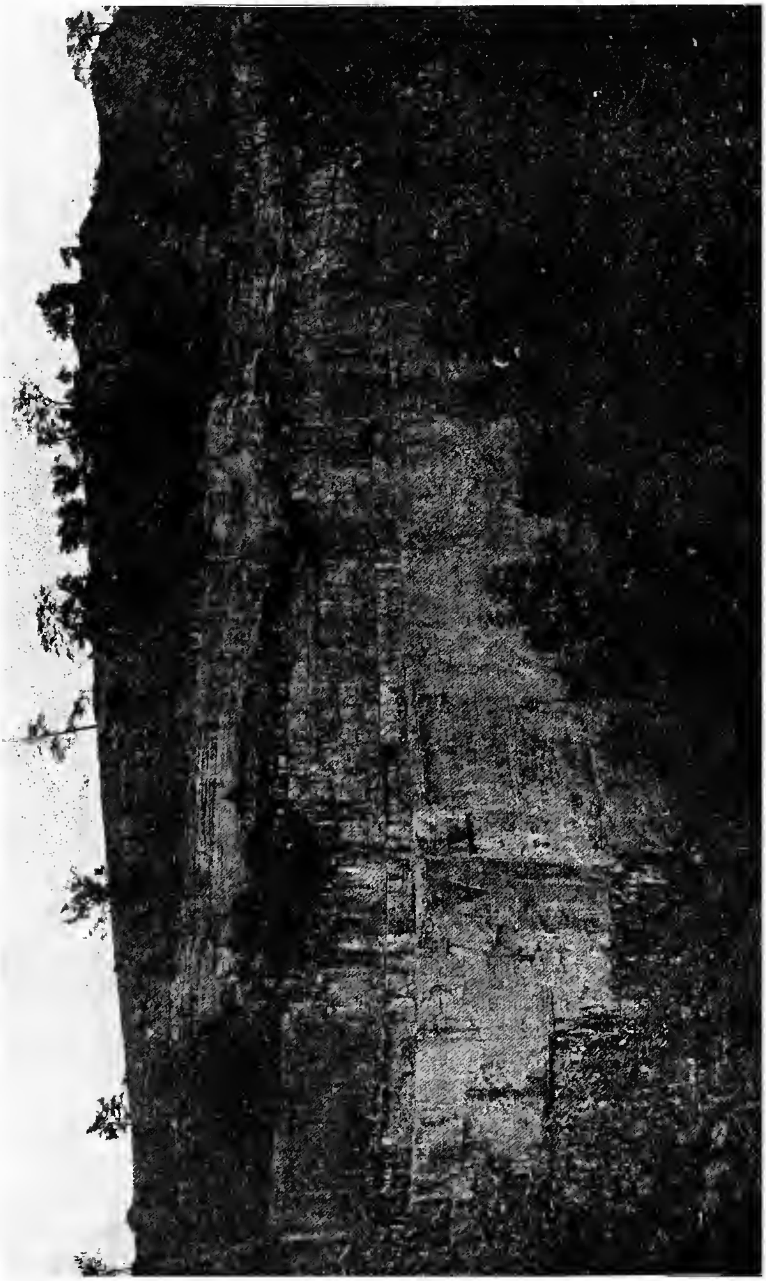
(Plate 5.) The fifth member of our Cambrian section, Fourth limestone or Massive Crystalline Cap-Rock of the lower Cambrian, is the rock which is usually exposed in those areas in which the Upper Cambrian rocks have been removed. This Massive Crystalline Cap-Rock of the Lower Cambrian is approximately three hundred feet thick, where it lies intact, but in those areas wherein the Upper Cambrain rocks have been removed, either before or after the Calciferous rocks were deposited, the upper beds of this rock have been more or less decomposed and removed.

The evidences of reconstruction are very pronounced in all of the crystalline members of our Missouri Cambrian. And I am now convinced that we have the best developed Cambrian area in North America. Not in thickness, of course, but in diversified characters. The conditions under which these rocks were deposited must have been radically different from contemporaneous conditions of deposits in the New York and other Cambrian areas. I am not advised of any other Cambrian area in the world in which magnesian limestones are the prevailing rocks. The striking analogy between the Cambrian and Ordovician limestones, of the Magnesian Lens, and between the sandstones of the two periods has suggested to my mind that the whole mass is the product of sediment, deposited on the floor of a sargasso sea, in early Paleozoic time.

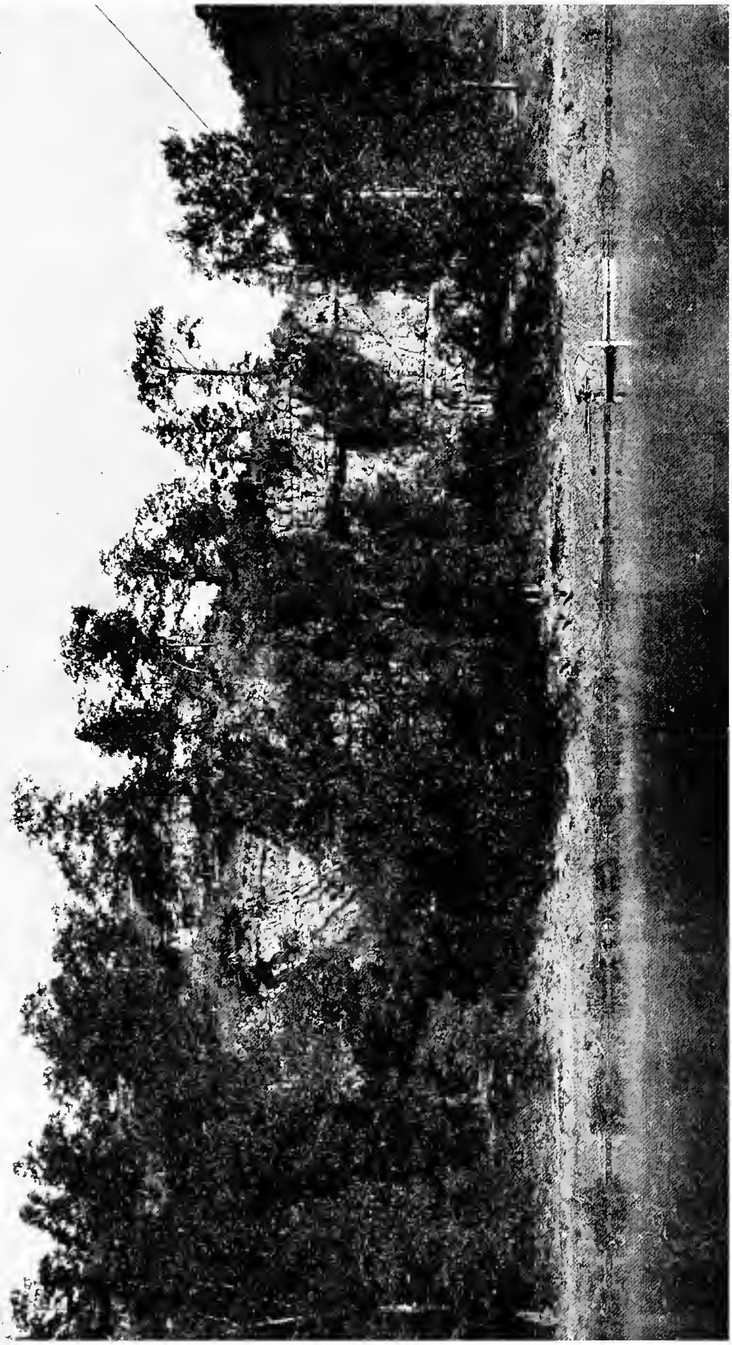
It is hardly conceivable that such a prodigious mass of heterogenerous rock minerals, organic products and metallic elements, could have been deposited anywhere else than on the floor of a sargasso sea. Ample proof, of the correctness of that genesis, lies in the obvious fact that it answers all of the requirements of Physics, Logic and Consciousness. It is one great lens and unique mass, made up of eighteen individual members. There is a striking analogy between the Basal sandstone of the Cambrian and the four Infusorial sandstones of the Ordovician Division. There is an equally striking analogy between the crystalline limestones and between the argillaceous limestones of both the Cambrian and Ordovician Divisions.

These facts might suggest that all of these rocks are the products of one geological period. But I will say, once for all, the proofs that they are the products of two geological periods, viz.: Cambrian and Ordovician, are abundant and conclusive. I mean that this delineation shall be true to nature, whether it is otherwise interesting or not. If the facts set forth in this delineation are not sufficient for some readers, the field is open to investigation. I am not like the horse that could trot all day in the shade of one black jack tree. When this delineation is finished, the different members of our geological record will have been so nearly diffenentiated (individualized and named) that we can at least talk or write intelligibly about them.

This delineation of our Cambrian Division in two sections (lower and upper) is not intended to imply that these sections have been sufficiently studied to correlate them with the subdivisions of the Cambrian thus named in other states or geological provinces. There are obvious facts enough available to suggest that we really have no equivalent of the subdivision recognized in the east and named Upper Cambrian. The intensely siliceous limestone, described hereafter as the Siliceous Cap-rock of the Upper Cambrian, may be the equiva-



Roubidoux Sandstone, North wall of Canyon, Ha Ha Tonka.



Roubidoux Sandstone, mouth of Proctor Creek.

lent of the Potsdam group in the east. But the subdivision herein described as Upper Cambrian had been eroded or removed, partially or entirely, in so many places before the first member of the Ordovician Division was deposited, that we are compelled, for the sake of convenience, to describe our Cambrian Division in two sections. (Plate 6.) The Roubidoux or Basal sandstone of the Ordovician cannot be correlated with the Potsdam or Upper Cambrian in the east. Obviously because the unconformity in the beds is under it and not above it. Furthermore, the break in the chain of fossil life is complete, at the bottom of the Roubidoux sandstone. Excepting its Fucoid casts, the Roubidoux sandstone is exactly like the St. Thomas, the Moreau and the St. Peter sandstone. There is no unconformity worth notice, in all of the ten or twelve hundred feet of rocks between the Roubidoux sandstone and the Fourth Calciferous. But there is a pronounced unconformity between the Roubidoux sandstone and the Cambrian limestones under it. In fact, the Roubidoux sandstone can scarcely be found in two places resting on the same Cambrian horizon. The Cambrian beds had evidently been considerably folded and very much eroded in certain zones before the Roubidoux sandstone was deposited. (Plate 7.) Beginning in Morgan County, a little northwest of Proctor and possibly ending in Butler County, lies a Cambrian arch or upward fold that has been uncovered in several places. In the line thus indicated large Cambrian areas have been located in Morgan, Camden, Laclede and Shannon Counties. The latter reaching down, on the south side of the Current River, into Carter County. Near the axis of that fold, in either Camden or Shannon counties, Roubidoux sandstone is resting on the Massive Crystalline Cap-rock of the Lower Cambrian and in many places filling ditches or eroded channels in its upper surface.

In the same zones, a few miles away from the axis of the fold, Roubidoux sandstone is resting on the Siliceous Cap-rock of the Upper Cambrian. For example, at Ha Ha Tonka, which lies near the axis of the fold, in the walls of those marvelous sinks and canyons, the Roubidoux sandstone may be seen in several places filling ditches and channels in the upper surface of the Massive Crystalline Cap-rock of the Lower Cambrian. In that locality, the convoluted cherts, characteristic of the Siliceous Cap-rock of the Upper Cambrian, are quite abundant. They furnish infallible proof, that the Upper Cambrian was deposited in that zone and weathered off, before the Roubidoux sandstone was deposited.

(Plate 8.) On the other hand, just below the mouth of Linn Creek, some miles away from the axis of the fold, the Roubidoux sandstone is resting on the Siliceous Cap-rock of the Upper Cambrian. In the valley of Jack's Fork, about Eminence in Shannon County, the river track is in the Crystalline Cap-rock of the Lower Cambrian. Cyclop's Cave, some eight miles away on the Salem road, is in Upper Cambrian limestone and its roof is Roubidoux sandstone.

As indicated, in the sketch of vertical section, two fossil horizons have been found in the Massive Crystalline Cap-rock of the Lower Cambrian, viz.: a Gasteropod horizon down some fifty feet from the top and a Brachiopod horizon at the top, when the rock is all in place. The Gasteropod horizon was first discovered by Mr. D. K. Greger, on the Onyx Island at Ha Ha Tonka. It was afterwards found in other widely separated localities.

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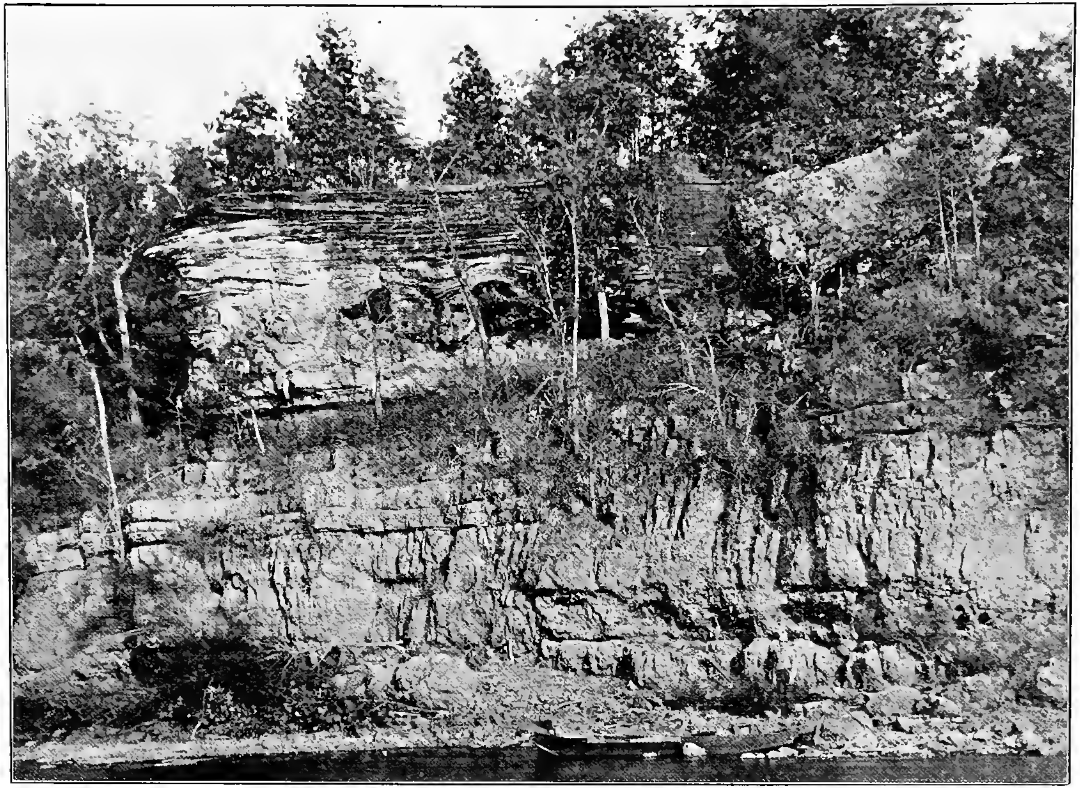
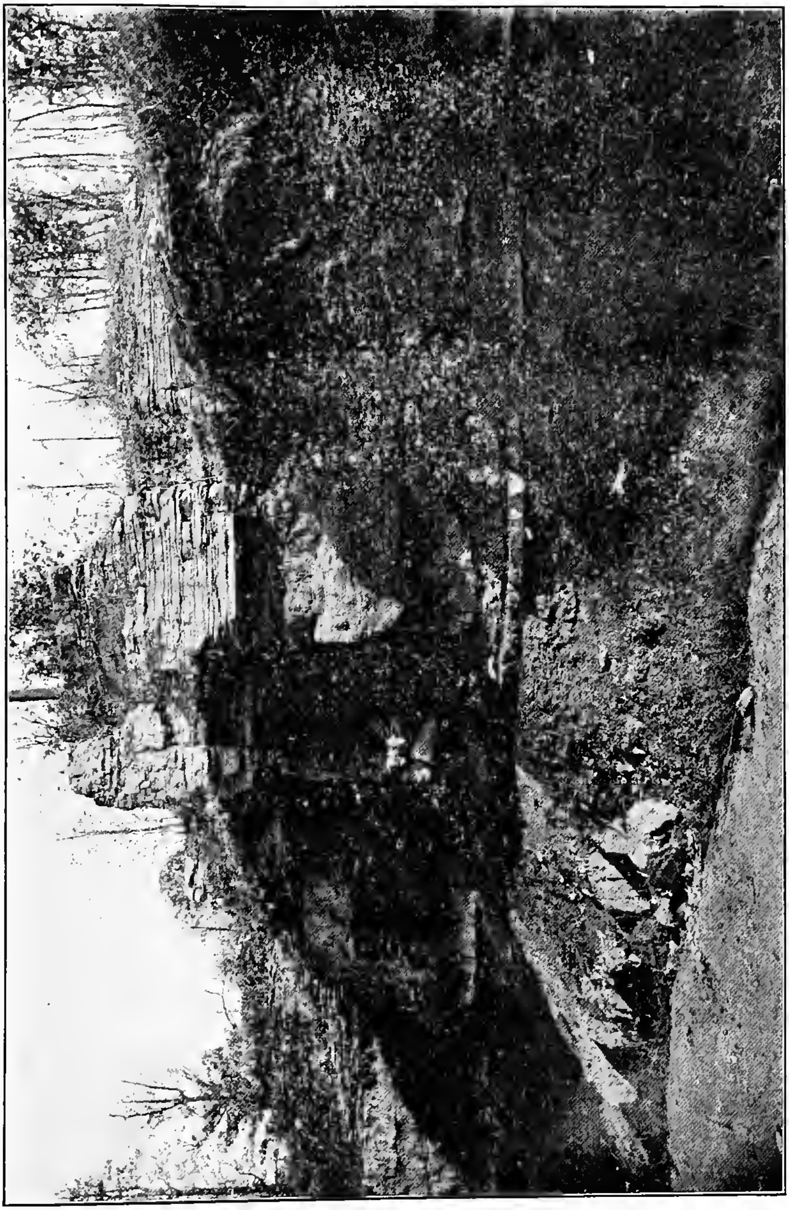
## UPPER CAMBRIAN.

The reader will, of course, bear in mind that I am calling the remainder of our Cambrian Division, above the Massive Crystalline Cap-rock, Upper Cambrian for convenience and not because it has been correlated with the Upper Cambrian of the east. I have already given the reasons why our Cambrian Division should be described in two sections. Then I cannot well avoid calling one of them Lower Cambrian and the other Upper Cambrian.



Roubidoux Sandstone, mouth of Linn Creek.



Lower Green Shales, Big River, St. Francois County.

## LOWER GREEN SHALES.

(Plate 9.) The first member of our Upper Cambrian section is a bed of Green shales (Greywackes) usually about twenty feet thick. About the middle of this bed of shales, between bottom and top, some thin layers and isolated lenses of argillaceous limestone occur. But they are very irregular in their development. At the top of the Lower Green Shales, Trilobites and Lingulella are quite abundant in some localities.

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## LOWER MUD-ROCK.

Between the Lower and Upper Green shales is a deposit of argillaceous limestone about twenty feet thick. Lying, as it does, between two shale beds, it is not surprising that this rock should contain a large proportion of argillaceous matter. It is typical mud-rock and in view of the fact that another one, twice as thick, lies twenty feet above it, I have not thought of a more suitable name for it than Lower Mud-Rock.

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## UPPER GREEN SHALES.

Between the Lower and Upper Mud-Rocks, lies the Upper Green shales (Greywackes) about twenty feet thick. About midway up, in this shale bed, there is also a persistent sheet of thin layers and isolated lenses of argillaceous limestone. At the top of the Upper Green Shales is another fossil horizon in which Trilobites and Lingulella are very abundant in certain zones.

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## UPPER MUD-ROCK.

On the Upper Green shales, lies the Upper Mud-Rock, some forty or fifty feet thick. The upper beds of this rock yield some good dimension stone for heavy masonry. The Mississippi River and Bonne Terre Railroad Company is using it exclusively in the construction of bridges and culverts. In texture and structure it resembles the cotton rock of the Second, Third and Fourth Calciferous, but it has more of the color and crystalline character of a true limestone. It is, therefore, far superior to Calciferous cotton rock for any kind of masonry.

(Plate 10.) In a thin crystalline layer, about the bottom of this Upper Mud-Rock, fragments of several species of Trilobite are very numerous. In another crystalline layer, a little below the Trilobite horizon, the earliest forms of the genus Cystoidea occur. Fragments of basal plates and columns have been found in that horizon in several widely separated localities. Somewhere, towards the top of this rock, another Brachiopod horizon occurs, but the fossils were found in a spot so situated that it was impossible to determine the distance from either top or bottom.

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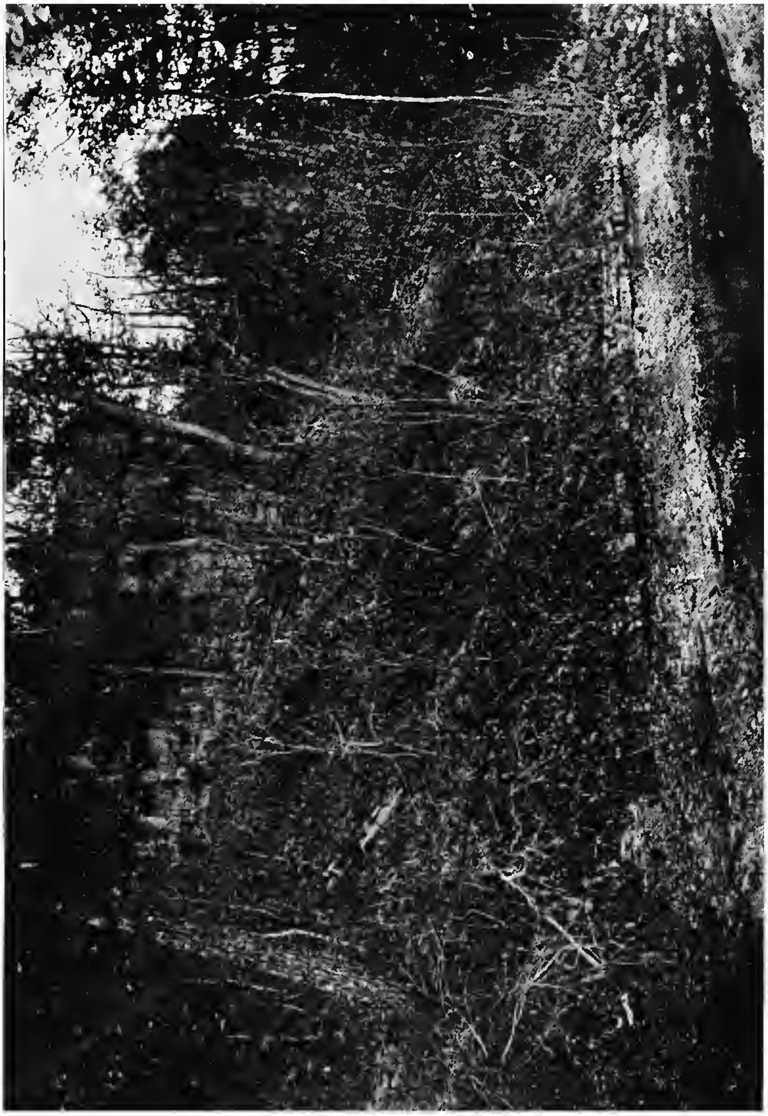
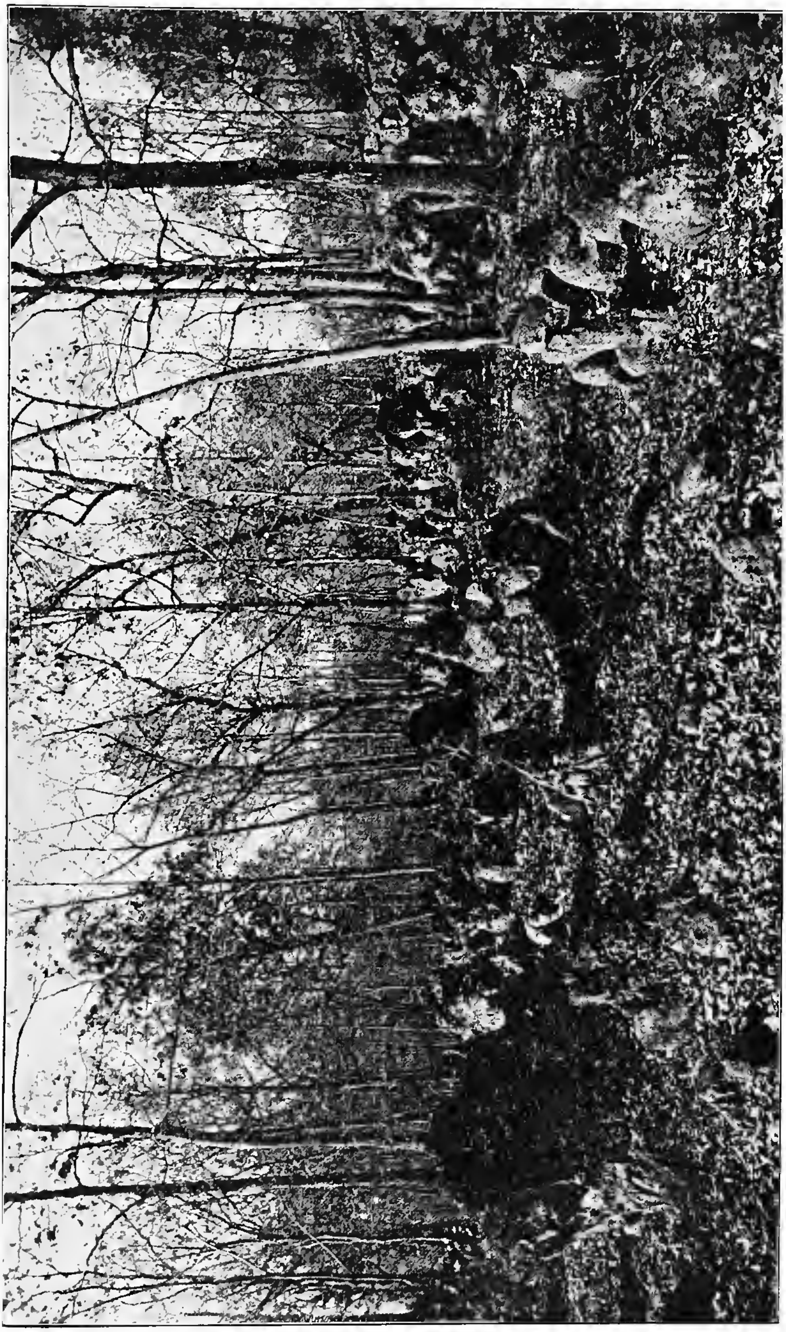
## SILICEOUS CAP-ROCK.

The fifth and last member of the Upper Cambrian has been called the Siliceous Cap-Rock, because it is the only siliceous limestone in the whole Cambrian Division. This is the rock I have said may be the equivalent of the Potsdam, so-called sandstone, in the east. This rock is somewhere between one hundred and fifty and two hundred feet thick. Along the central zone of the Cambrian area, in central Missouri, it was weathered off before the Roubidoux sandstone was deposited. Along the flanks of that fold, it is exposed in several places, but not enough to give any clue to its thickness.

About the head of the Middle Fork of Black River, it seems to have reached its greatest development. In the bluffs along the valley between Foote and Edge Hill, in Iron County, its columnar structure is very surprising. Indeed, it was so surprising to our exploring party that we forgot to get a close estimate of its thickness. However, no rock is the same thickness everywhere and we know it is not less than one hundred and fifty feet thick.



Upper Green Shales, Big River, Washington County.



Siliceous Cambrian Limestone, Patterson, Wayne County.

(Plate 11.) A remarkable surface exposure of this rock occurs on the west side of the St. Francois River, a few miles east of Patterson, in Wayne County. We photographed that exposure, but it is impossible to get an idea of the extent and rugged character of that unusually large and rugged area in one photograph.

Inasmuch as our Cambrian and Ordovician Divisions have been only recently differentiated, we have not yet had time to get the exact boundaries of the areas in which the Cambrian rocks are now the surface rocks. Had we the requisite data for making correct maps of those interesting zones, the practical value of this Preliminary Report would be thereby greatly enhanced. However, the only sedimentary rocks involved in those Cambrian areas and their Ordovician boundaries are the Cambrian limestones which form the floor of each valley or basin and the first member of the Calciferous group which form the escarpment around each Cambrian area.

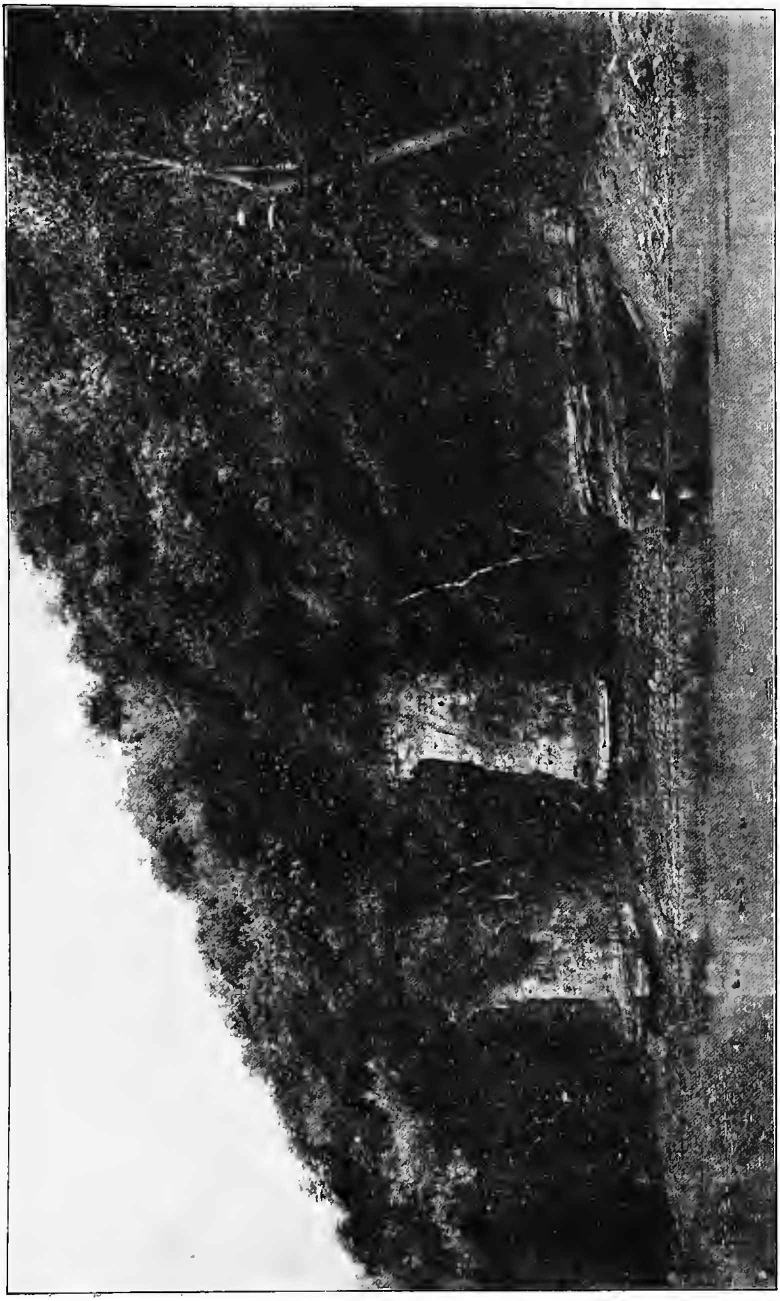
Having given the localities of Cambrian country, in all of the counties in which it has been recognized, together with reliable landmarks for guides, the reader (student or prospector) can soon learn to distinguish the Cambrian limestones, always below the Roubidoux sandstone, from the First Calciferous always above it. Any close observer can soon become expert enough to follow the contact of the Roubidoux sandstone and Cambrian limestones under it and work out for himself the boundaries of any one of these Cambrian areas.

One important fact which I am trying to emphasize in this Report is the close analogy between the Roubidoux sandstone, at the base of the First Calciferous, and the St. Thomas sandstone, at the top of it. The prospector is liable to be misled by the analogy of any two of those Infusorial sanstones of the Calciferous group. But the first Calciferous is an immensely thick rock, varying between four and five hundred feet in thickness and is intensely siliceous. In other words, is makes vase quantities of coarse gnarled cherts and as the Roubidoux sandstone under it is often resting on the middle members of the Cambrian, which make no cherts whatever, it is generally easy to distinguish the Cambrian limestone from the Calciferous rocks which form the escarpments around all of our Cambrian areas.

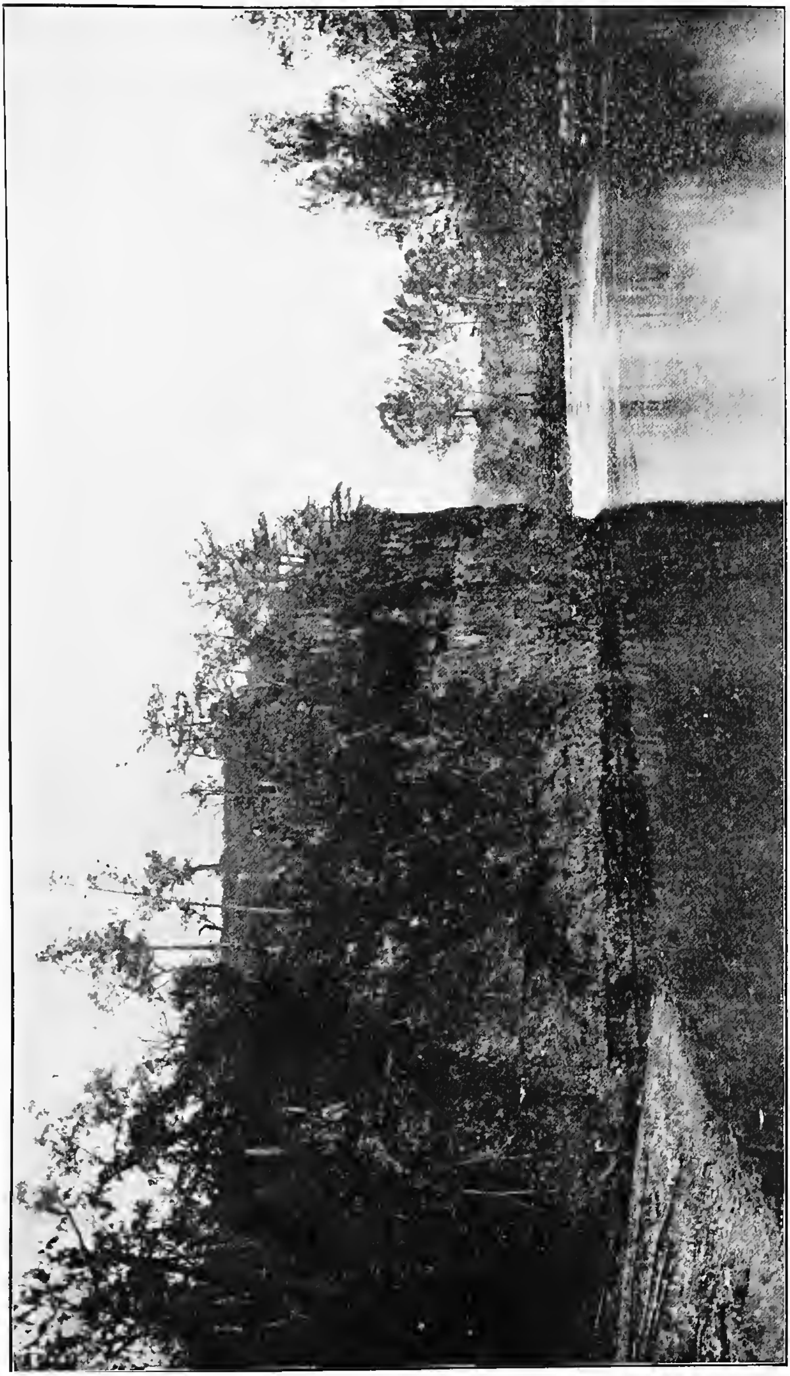
(Plate 12.) Beginning at the mouth of the Little Buffalo, in the southwestern part of Morgan County, the track of the Osage River enters an upward fold in the Cambrian beds and after describing a remarkably crooked and interesting track, obliquely across it, leaves it a little below Linn Creek, in Camden County. At the mouth of Proctor Creek, the river bed is down one hundred feet or more in the Cambrian. From that point down to the first bluff below the mouth of Linn Creek, the river track meanders at various depths, from ten to one hundred feet in the Cambrian. On the west side of the Osage River and a little below Sagrada is a magnificent exposure of the contact between the Roubidoux sandstone and Cambrian limestone under it. There, columns are projecting down from the under side of the Roubidoux sandstone into what were once old ditches in the upper surface of the Cambrian limestones. That exposure shows also the relative persistency of a quartzite and a limestone. But we encountered it in the afternoon, while it was in a dense shade and could not get a photograph that would come anywhere near doing it justice.

The reader need only look at a map of Missouri and observe the track of the Osage River, between the mouth of the Little Buffalo and the mouth of Linn Creek, to see how a river track may be deflected by the folds and inequalities of quartzite and limestone. In many places in that river track, the invincible Roubidoux quartzite, lying at such an angle, that it could not be undermined, has deflected the river for miles out of its course. On the other hand, the open structure and soluble character of the Cambrian limestone have opened the way for the development of one of the most picturesque and beautiful river tracks in the world.

About two miles below the mouth of the Procter Creek and on the north side of the river stands a hill of solid rock in the midst of a river plain. We named it the *Cote Sans Dessein* of the Osage River and figured that basin as a desirable



Roubidoux Sandstone, below mouth of Little Buffalo.



Juanita Cliff, Niangua River, near Ha Ha Tonka, Camden County.

Ha Ha Tonka Big Spring, Camden County.

spot to drill for disseminated lead. However, the Bollinger Creek Valley, a few miles further down, and the basin at the north point of the Porter Mill Bend look equally as promising. Indeed, there are some good reasons for believing that a large concentration of ores may have taken place in the ground opposite the mouth of Linn Creek.

Now turning to the track of the Niangua River, in Dallas County, there is a small Cambrian basin lying on the east side of the river about one mile above the mouth of Mill Creek. The Roubidoux sandstone is exposed in the west bank some distance above the low water level of the river and a river plain, on the opposite side, resting on Cambrian limestone, suggests an important concentration of disseminated lead. From that point either up or down stream, however, the river track does not seem to have cut down into the Cambrian until it encounters the great upward fold lying diagonally across Camden County from Proctor Creek to Decaturville and thence up the Dry Glaize, in Laclede County.

By referring to a map of that part of Missouri, the reader will observe a striking analogy in the tracks of the Niangua, the Little Niangua and the Osage rivers, where they enter the great Cambrian fold. The cliffs along the Osage, where it traverses the Cambrian fold, cannot be surpassed for beauty, but the river track is much wider than that of the Niangua, which is little more than one deep and narrow canyon.

(Plate 13.) From Juanita Cliff, near Ha Ha Tonka, to Arnhold's Mill, the track of the Niangua crosses the axis of the Cambrian fold and has cut its way down from one to two hundred feet into the Cambrian limestones. From an elevated point, on the Coelleda road, some two miles west of Juanita Cliff, a rugged but exquisite landscape may be seen, either up or down the valley of the Niangua. Some three miles away to the east and on the opposite side of that beautiful valley, lies Ha Ha Tonka, with its unparalelled aggregation of wonders.

(Plate 14.) The Niangua is fed at all seasons by three of the great boiling or flowing springs of the Magnesian Lens;

the Bennett Spring in Laclede County, the Sweet Spring in Dallas County and the far-famed Ha Ha Tonka in Camden County. Furthermore, it is fed by innumerable other springs of lesser magnitude but perpetual volume. To one who loves nature, in her wildest garb and primeval beauty, I do not think of a more fascinating spot than the valley of the Niangua. And that is only one of our Cambrian zones.

(Plate 15.) Following up the valley of the Dry Glaize from the Pegmatite Hill and Decaturville, five or six miles in the direction of Sleeper, on the St. Louis & San Francisco Railroad, the Cambrian rocks disappear under the first three or four members of the Calciferous and are again slightly denuded between the two branches of the Gasconade, in the eastern edge of Laclede County. We have not yet explored the line of that fold between the last named point and the great Cambrian basin which lies in the valley of the Jack's Fork east and west of Eminence, in Shannon County.

Neither have we explored the great Cambrian zone in Shannon County more than enough to know that it reaches up the valley of Jack's Fork some miles west of Eminence and down, to the southeast, into Carter County. Lying to the north of Eminence and separating the valley of Jack's Fork from that of the Current River, is a high ridge, made up of First Calciferous and St. Thomas sandstone. Beyond that ridge, from Eminence, ten and twelve miles away on the Salem road, are two of the most beautiful objects I have ever beheld. The first of these is Cyclop's Cave, about ten miles, and the Round Spring, about twelve miles from Eminence, on the Salem road.

(Plate 16.) Cyclop's Cave is situated in a Cambrian limestone cliff facing westwards and the entrance is up some fifty or sixty feet from its base. A terrace lies in front of the cave and hides the entrance so completely that the eye of the passing traveler sees nothing more interesting than a ledge of Roubidoux sandstone projecting out from under a sloping hillside. That ledge of Roubidoux sandstone makes the roof or ceiling over the highest portion of the cave and that ceiling

Natural Bridge, Ha Ha Tonka, Camden County.

Cyclop's Cave, Shannon County.

Cyclop's Cave, Shannon County.

Round Spring, Shannon County.

is a study in itself. The sandstone is a pure quartzite and every joint in it is emphasized by an exquisite calcite drapery. The entrance is wide enough to admit sufficient light, in clear weather, by which to explore the cave. The floor lies about thirty feet below the entrance and such a floor I have never elsewhere beheld.

There are many greater caverns in the Earth, many greater in Missouri, than this Cyclop's Cave, but not another one-half so beautiful. From three o'clock till four in the afternoon of any bright day in the year the one Imperial Motor (the Eye) of our Solar System (our Sun) peers through that opening far into the Earth and illumines, with His divine light, that weird and solitary but gorgeous chamber. The reader may, therefore, not be surprised to learn that the pictures taken in Cyclop's Cave are not flash light, but time-exposures, in the divine light of our Sun, far underground. Moreover, that divine Sunlight so far under ground suggested the name —Cyclop's Cave.

(Plate 17.) Two miles further up the road towards Salem and facing towards the rising Sun is a round abyss in the Earth, about one hundred feet wide and nearly as deep. It stands always about half full of beautiful blue water on whose smooth surface never a ripple is seen. I should have said divine blue, for I cannot disassociate such expuisite blue and white from divinity. That, of course, is the Round Spring. But its name does not begin to convey the slightest conception of its beauty. Lifting your visual orbs from its snow white bottom, fifty feet below, and fixing them on the deep serene, forever mirrored in its placid surface, you have a cyclorama whose ever varying charms will never be eclipsed by anything more beautiful, until you have beheld the objective beatitude of Heaven.

So much for the Cambrian country in Shannon. We have not found the boundaries of either one of those areas and there may be other Cambrian areas that we have not yet located. I have already said the Cambrian zone in which Eminence is situated extends down, to the southeast, from that place, into Carter Conuty and is possibly uncovered in Butler County.

Now comes our greatest Cambrian zone, encircling the Primordial area about the head of the St. Francois River and traversing ten counties, viz.: Washington, Iron, Reynolds, Wayne, Bollinger, Perry, Ste. Genevieve, Jefferson, St. Francois and Madison. On all sides of that greatest Primordial area, in which the granites and porphyries have been denuded of their sedimentary covering, the Cambrian limestones come first, in rugged escarpments, facing towards the center of that denuded area. Next after the Cambrian and a few miles further, back in all directions come the four members of the Calciferous, each on its basal sandstone, lying in escarpments one after another, in their natural order of occurrence, like so many skewbacks of once continuous arches, facing towards the center of that same denuded area.

In that ragged and irregular, but persistent Cambrian zone, there are many inviting spots for those who are seeking rich zones of disseminated lead. In each of the ten counties mentioned there are from one to a dozen Cambrian valleys promising rich returns to the prospector. However, the core-drill judiciously located will have to determine the existence of ore in paying quantities, because those ore bodies are invariably planted deep in the ground.

(Plate 18.) The next most important Cambrian zone that has been located by this Survey lies in the valley of the Meramec, around Cook Station in Crawford County and doubtless extends up the Meramec into Dent County. However, we crossed it only once diagonally, going from the Meramec Big Spring, via Cook Station, to Sligo Furnace. Having good railroad facilities, we noted it as a very promising Cambrian zone but have not yet found its exact boundaries.

Inasmuch as the Cambrian and Calciferous rocks had never before been differentiated, the reader who knows anything about the difficulty of distinguishing between those rocks, will doubtless appreciate the importance of the work performed by this Survey in the last two years. We could not

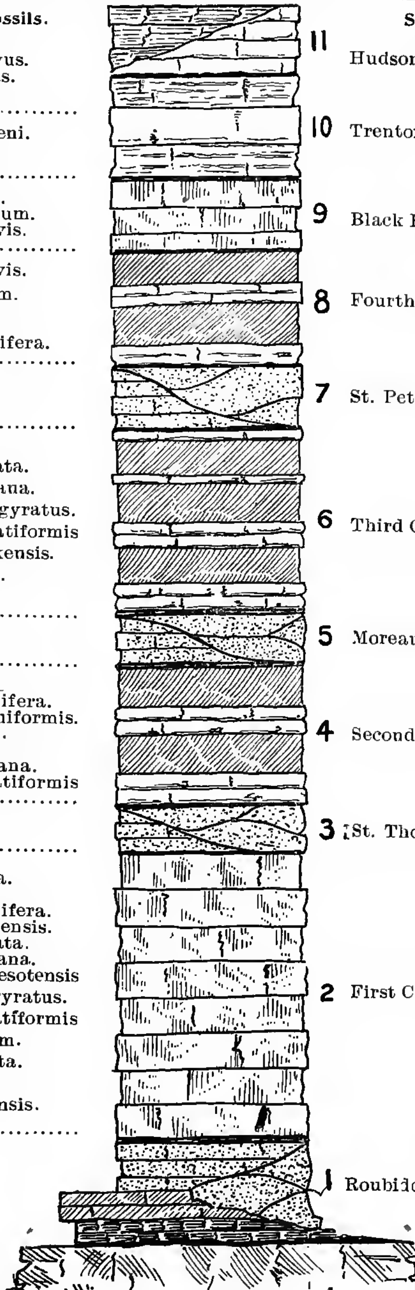
Roubidoux Sandstone, Cook Station. Crawford County.

have accomplished more with the facilities. Nor are we done looking for Cambrian country in the valley of the Meramec, the Gasconade and the Current rivers. We now have these mysterious rocks of the Magnesian Lens so individualized that we can recognize them on sight and thus make our field work effective.

## CHAPTER IV.

# ORDOVICIAN DIVISION.

## SECTION OF ORDOVICIAN.



| Characteristic Fossils. | | Subdivisions. |
|---|---|---|
| Tentaculites incurvus.<br>Orthis missouriensis.<br>Acidaspis halli. | 11 | Hudson River Beds. |
| Receptaculites oweni.<br>Maclurea magna. | 10 | Trenton Limestone. |
| Gonioceras anceps.<br>Ormoceras tenuifilum.<br>Leperditia sublaevis. | 9 | Black River Limestone. |
| Leperditia sublaevis.<br>Tryblidium ovatum.<br>Ophileta levatum.<br>Murchisonia carinifera. | 8 | Fourth Calciferous. |
| Fucoids. | 7 | St. Peter Sandstone. |
| Holopea obesa.<br>Ophileta complanata.<br>Raphistoma subplana.<br>Straparollus polygyratus.<br>Straparollus valvatiformis<br>Murchisonia ozarkensis.<br>Murchisonia vesta.<br>Ophileta levata. | 6 | Third Calciferous. |
| Fucoids. | 5 | Moreau Sandstone. |
| Holopea turgida.<br>Murchisonia carinifera.<br>Murchisonia melaniformis.<br>Murchisonia vesta.<br>Ophileta levata.<br>Raphistoma subplana.<br>Straparollus valvatiformis | 4 | Second Calciferous. |
| Fucoids. | 3 | St. Thomas Sandstone. |
| Dalmanella electra.<br>Holopea obesa.<br>Murchisonia carinifera.<br>Murchisonia ozarkensis.<br>Ophileta complanata.<br>Raphistoma subplana.<br>Straparollus minnesotensis<br>Straparollus polygyratus.<br>Straparollus valvatiformis<br>Tryblidium ovatum.<br>Lituites complanata.<br>Nautilus kelloggi.<br>Orthoceras ozarkensis. | 2 | First Calciferous. |
| Fucoids. | 1 | Roubidoux Sandstone. |
| | | Cambrian. |

## ORDOVICIAN (Lower Silurian).

That our nomenclature may conform as nearly as possible to the nomenclature adopted by the U. S. Geol. Survey, I have concluded to replace the compound term Lower Silurian with the simple term Ordovician. Obviously, that simplifies the subject immeasurably and enables us to separate the rocks of two distinct geological periods, without any repetition of terms. The name Ordovician was derived by the British geologist Lapworth from the Ordovices, a tribe of ancient Britain.

Our Ordovician Division of the geological record embraces the eight distinct members of the Calciferous group in Missouri, the Black River limestone, the Trenton limestone and the Hudson River beds. And inasmuch as our whole Cambrian Division embraces only the lower one-third of the great Magnesian Lens of Missouri, I desire to call the attention of the reader at once to the unique character and extraordinary thickness of our Calciferous section or group. Our whole Cambrian Division complete, consisting of ten distinct members does not exceed eight hundred feet, perhaps, in vertical depth. On the other hand, the Calciferous group or complement of the Magnesian Lens, above the Cambrian, embraces four Infusorial sandstones and four Magnesian limestones, in alternate succession, with a total thickness of fifteen or sixteen hundred feet.

Each member of the Calciferous group has an Infusorial sandstone for its base and vast quantities of siliceous matter distributed throughout its mass. Plant life seems to have contributed as much as animal life to this prodigious mass of rock minerals and metallic elements. And beyond the fact that the Roubidoux sandstone is somewhat prolific of Fucoid casts, no distinct fauna can be made out for any one member of our Calciferous group. After the close of Cambrian time, where a profound gap occurs in the chain of fossil life, the same forms of plant and animal life seem to have persisted throughout the whole period of deposit of the Calciferous group. Nor is there any unconformity, to be observed in the different beds of this heterogeneous mass, worth notice.

Therefore, we have no alternative but to regard our Calciferous beds, which make up the upper two-thirds of the Magnesian Lens, as the products of some unique and continuous condition of local deposit. That it was contemporaneous with the deposit of the Calciferous of New York there cannot be any doubt. But that it is not an exact equivalent or duplicate of the Calciferous of New York is equally apparent. I cannot conceive any other genesis, or condition of deposit, for this heterogeneous mass, than the floor of a sargasso sea in early Paleozoic time.

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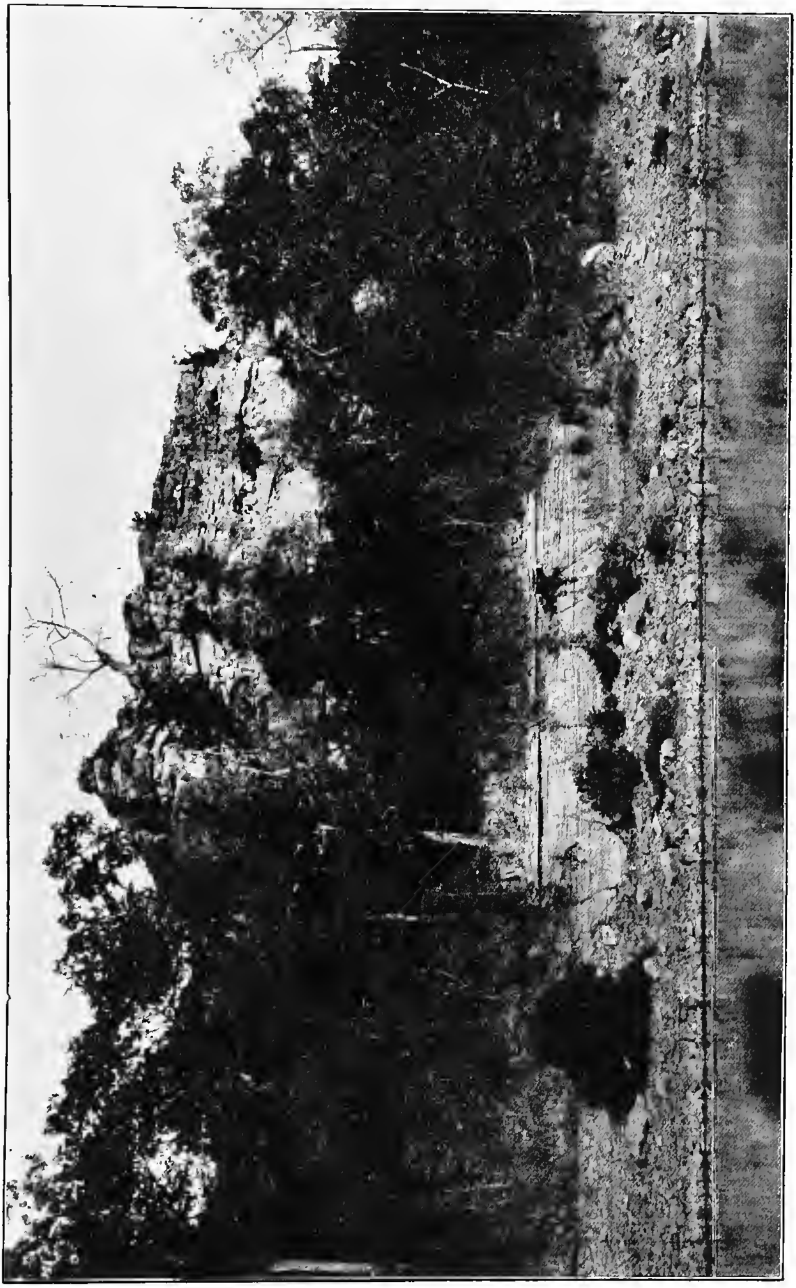
## CALCIFEROUS.

As indicated, in the foregoing sketch of vertical section, our Calciferous group consists of eight distinct members: four Infusorial sandstones and four Magnesian limestones, in alternate succession. In other words, each member of the Calciferous has an Infusorial sandstone for its base and vast quantities of siliceous matter distributed throughout its mass. Magnesia and lime are, however, about equal in volume to the silica, involved in these unique rocks. Besides the magnesia, lime and silica, which are the chief constituents, argillaceous matter and metallic elements were evidently abundant in the original mass. The Green shales (Greywackes) which are dispersed in local lenses and the cotton rocks of the last three members bear witness to the fact that considerable argillaceous matter was involved. We often hear miners and quarrymen applying the term *bastard* to different kinds of rock. Usually when there is no occasion for it. I have never seen a rock in whose description the word *bastard* can be used



Roubidoux Sandstone, base of 1st Calciferous, Osage Iron Works.

more appropriately than these Calciferous cotton rocks. Those aggregations of lime, silica and argillaceous matter, were, however, greater towards the close than at the beginning of the Calciferous period of deposit.

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## ROUBIDOUX SANDSTONE.

(Plate 19.) The first or basal member of the Calciferous group is the Roubidoux sandstone. Apart from the fact that it is the basal member, which lies unconformably on the Cambrain and is somewhat prolific of Fucoid casts, there is no way of distinguishing the Roubidoux from the other Infusorial sandstones, other than by its geological relations. It is soft and friable at one place, a homogeneous quartzite at another. It is massive and false bedded at one place, thin bedded and stratified at another. It is saccharoidal and white at one place, iron-stained red or brown at another. In short, all of these Infusorial sandstones have the same characters and any particular character developed in one of them may be duplicated in either one of the others.

The Roubidoux sandstone is most interesting, perhaps, because it is the basal member of the Calciferous group and is a reliable bench-mark for determining the boundaries of our Cambrian areas. Inasmuch as it is usually a massive quartzite and for that reason a very durable rock, it is often left in patches in the midst of our Cambrian areas. In that case, it is usually the horizon of pine forests, but it does not support more than one-tenth as much area of pine forest as the St. Thomas sandstone above it. Even the Moreau and the St. Peter sandstones are the horizons of pine forests, but in a more limited extent than the Roubidoux sandstone.

In the pine ridge south of Potosi and bordering the great Cambrian valley of the upper Big River, the Roubidoux sandstone is about two hundred feet thick and very generally a massive homogeneous quartzite, in that locality. In other localities, however, it is sometimes found not exceeding ten feet thick. Besides the primary fact that it is made up of pure rounded quartz grains, it varies equally as much in its other lithologic characters as in its thickness. Neither student nor prospector should conclude that either one of these Infusorial sandstones has any constant character or individuality by which it may be always recognized. For therein lies the reason, mainly, why they have never before been differentiated.

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## FIRST CALCIFEROUS.

(Plate 20.) In magnitude (extent and depth) the First Calciferous is the greatest rock in our geological record. Lying, as it does, in the middle of the Magnesian Lens and now denuded of the once overlying rocks, it is the surface rock over large areas in more than thirty different counties, in south central and southeastern Missouri. Being the next great ore-bearing or country rock, after the First Cambrian limestone, the First Calciferous forms the skewbacks or escarpments around all of our Cambrian areas. And it is doubtless the source whence a large portion of the metallic sulphides, now stored in the Cambrian, have been derived.

Proof of the fact that the First Calciferous has yielded a large part of the metallic ores now deposited in the Cambrian is manifest in the further fact that it is rich in ores around each productive Cambrian zone. All along the Calciferous border to the Cambrian zone of the upper Big River, in Jefferson and Washington counties, lead, zinc and barite, in clay blankets, have been mined continuously during the last fifty years. Valles Mines in Jefferson County, the Tunnel Mines in St. Francois County, the Richwoods, Potosi and Palmer Mines in Washington County are all in the First Calciferous, or its clay blankets, which are merely relics of that rock decomposed.

Obviously, when the walls of a fissure, filled with lead or other metallic ores, are decomposed and the major part of the rock minerals altered to clay, there is no alternative for the metallic contents of that fissure but to gravitate downwards and remain in the clay blanket, or be dissolved out and carried down into the open structure of lower horizons. This genesis is fully demonstrated by the facts. All of our ore bodies were deposited originally under water, as sulphides, and as deep valleys were subsequently eroded and the water level thus let down, the ore bodies, thus deserted by the water, were exposed to reagents and gradually altered into oxides, silicates or carbonates. In other words, the primary sulphides were thus logically altered into secondary and tertiary ores of far less metallic value.

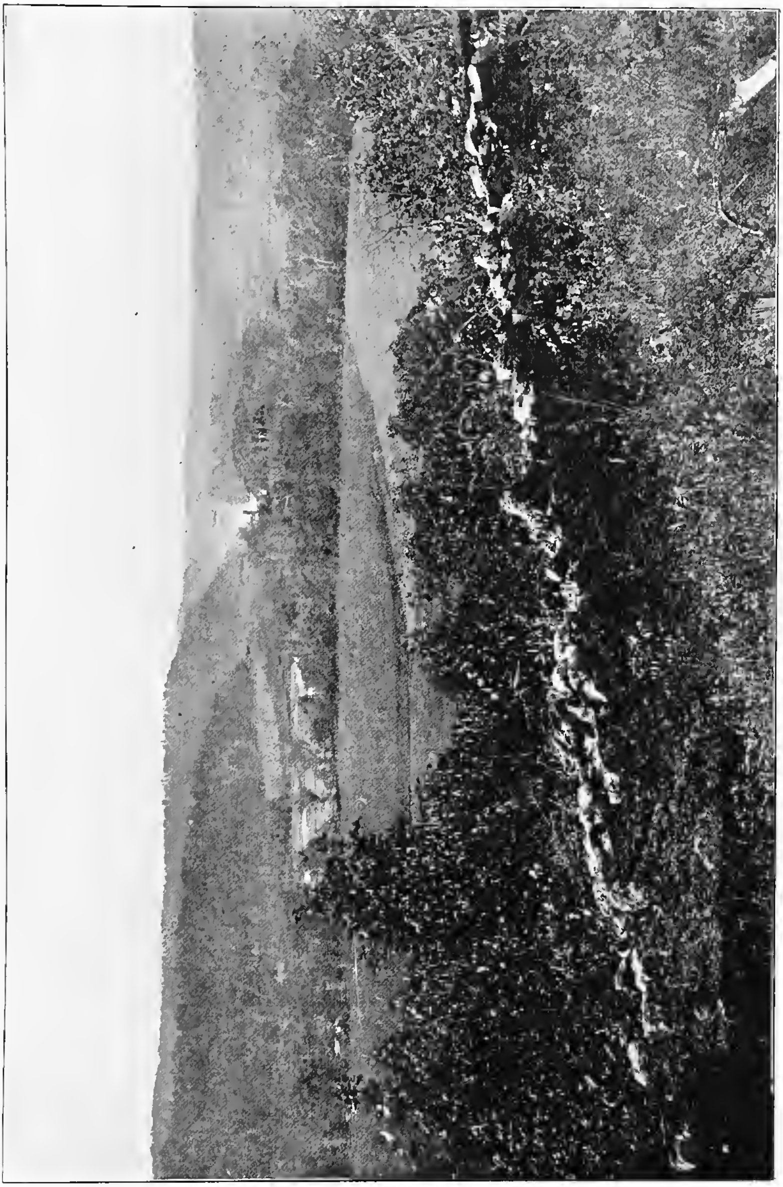
What became of the metallic value lost in the alteration of a sulphide to a silicate or carbonate? It was carried down in solution into the open structure of the next great country rock below and redeposited, under permanent water level, as a sulphide. Therein lies the clue to all of our great ore bodies. Give nature a reasonable chance to have made a great concentration of ores derived from weathered-out rocks and you are on the right track to find a profitable mine. Obviously, that brings us at once to the right kind of structure so situated as to have received a large concentration of the metallic elements derived from decomposed rocks and from the reconstruction of the present country rock in whose once open structure the great ore bodies occur.

I know that in making this statement I shall have to antagonize a great many people, but it is my honest conviction that the function of a geological survey is to save a great waste of energy rather than to boom the mineral resources of a State. Therefore, I shall have to say frankly that we have in Missouri only three great sedimentary country rocks. By that, I mean, only three members of our geological record have had the requisite open structure and have been so situated as to receive the concentrations of metallic elements derived from the decomposed rocks and from the reconstruction of themselves.

That suggests at once the great economic importance of differentiating the rocks and showing which are ore-bearing to a profitable extent. Having differentiated all of the rocks by their individual lithologic and fossil characters and emphasized the country rocks, which are known to contain profitable ore deposits, the next thing is to show the particular kind of structure in each great country rock in which profitable ore bodies may be expected. It is scarcely necessary to repeat, that we reason only by analogy. Having learned by close observation that profitable ore bodies occur only in certain rocks and in certain conditions of structure, in those rocks, it is not difficult to recognize those rocks or their equivalents under duplicate or similar conditions in other localities.

That is obviously the only method by which we can safely proceed to the intelligent development of our mineral resources. It is the only method by which we can hope to open new territory successfully and without a great waste of energy. Frankly, it is the policy of this Survey to co-operate in the opening of new territory and thus foster the development of our mineral resources by every honorable means. But deception is no part of our policy. Obviously, when the metallic elements which were once diffused in all of the members of the Magnesian Lens have been concentrated into economic bodies by the decomposition of part and the reconstruction of the balance we have no reason to expect that rich ore bodies will be equally distributed in all of the rocks. On the contrary, we have every reason to expect that our rich ore bodies will be found only in certain zones and in certain country rocks. Having found by close observation that all of our profitable mines are situated in certain country rocks and in certain kinds of structure in those rocks, it is clearly the duty of this Survey to bring those facts out and make them as plain as possible. And that is exactly what we are doing.

Moreover, those enterprising people who are putting their money into the ground and taking their chances in the development of our mineral resources are entitled to some consideration. Knowing, as we do, that all of our profitable mines are situated in certain zones and in certain country rocks, the plan of this Survey is to find, in our unexplored territory, exact



Looking into 1st Calciferous Country, Riverview, Morgan County.

equivalents or duplicates of the rocks and structure in which profitable mines are now being worked. That seems entirely feasible and safe. But no matter how expert we may become in recognizing our great country rocks, there is always a large element of uncertainty about whether they have been submitted to the exact conditions which would have resulted in large concentrations of metallic elements in them. Therefore, it behooves the man, who does not realize that there is a large element of uncertainty in all mining ventures, to follow some less hazardous pursuit. And it behooves us all to direct outside, as well as home capital, to the kind of country which promises fair returns for such investments.

That our mineral resources are great and virtually untouched is a proposition which no well informed person doubts. But that having been concentrated from the diffused state into economic bodies they could not now possibly be equally distributed in all of the territory and in all of the rocks, is another proposition which the facts in the case and the function of this Survey compel us to maintain regardless of consequences. It suggests one of the unpleasant features of a geological survey. But I have a conviction that there are victims enough of mining booms and honest people enough left in Missouri who will appreciate an honest effort to delineate our geology, true to nature. Therefore, regardless of the result of any possible issue, we mean to delineate the geology of Missouri without reference to beneficiaries.

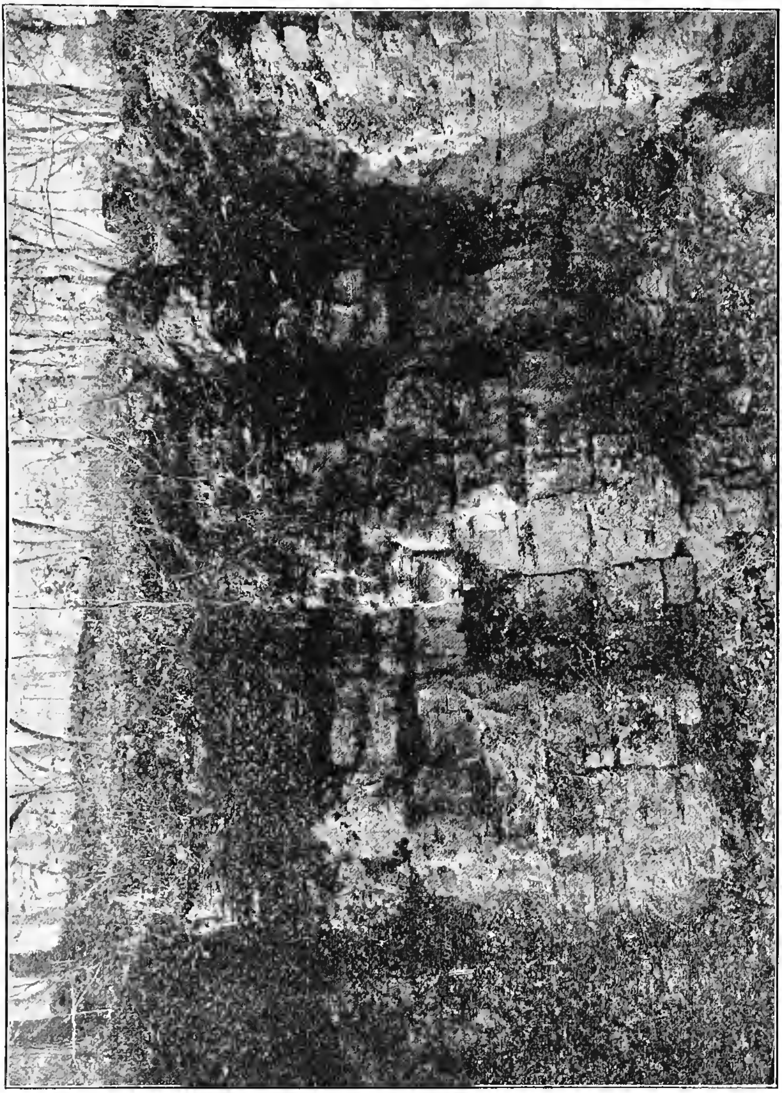
(Plate 21.) The First Calciferous or next country rock, after the First Cambrian limestone, is the surface rock over large areas in thirty or more different counties. Beginning with Benton and Hickory counties, on the west, there are not less than fifty square miles of First Calciferous country in the valley of the Big Buffalo, on the north side of the Osage river, and about an equal area of the same kind of country in the valley of the Little Niangua of Hickory county. And the northeastern one-third of Dallas county is First Calciferous country, except the small Cambrain basin heretofore mentioned, in the valley of the Niangua River, one mile above the mouth of Mill creek.

Excepting the narrow zone of Second and Third Calciferous country which separates the valleys of the Osage and Gasconade between Lebanon and Dixon and the valleys of the Gasconade and Meramec between Rolla and St. Clair (marked by the main line of the St. Louis and San Francisco Railroad) the valley of the Osage between River View and St. Thomas, the valley of the Gasconade between Wright county and Cooper's Hill and the valley of the Meramec from its source to Moselle, are practically all First Calciferous country. In the whole of the plateau occupied mainly by Dent county and in a zone from thirty to sixty miles wide all around it, the highest sedimentary rocks are First Calciferous and St. Thomas sandstone.

Hence we have in Benton, Hickory, Dallas, Wright, Laclede, Camden, Morgan, Cole, Miller, Pulaski, Texas, Phelps, Maries, Osage, Gasconade, Franklin, Crawford, Dent, Shannon, Oregon, Ripley, Carter, Reynolds Iron, Washington, Jefferson, Wayne, Butler, Bollinger, Perry and Ste. Genevieve counties not less than five thousand square miles of First Calciferous country. Now figure up the areas of the surface and sub-drainage zones in which there could have been large concentrations of metallic elements, derived from weathered-out overlying rocks and from the reconstruction of this great country rock, and we have not less than two thousand square miles of good country, distributed among the thirty-one counties mentioned, in which to look for rich fissure and blanket deposits.

(Plate 22.) Add to the above mentioned two thousand square miles of First Calciferous country a possible five hundred square miles of productive Cambrian country, in Madison, St. Francois and sixteen other counties, and then another one thousand square miles of productive Burlington-Keokuk country in Webster, Christian, Greene, Stone, Barry, Lawrence, Dade, Barton, Jasper, Newton and McDonald counties, and you have three thousand five hundred square miles of ore-bear-

Greer Spring, Oregon County.



1st Calciferous, near Greer Spring, Oregon County.

ing country in which profitable mines are now being worked. And I will venture the prediction that when exhaustive search is made and those areas are intelligently explored, billions of mineral wealth will be unearthed. How to proceed in the intelligent development of our mineral resources and thus save the usual waste of energy are the paramount questions with this Geological Survey.

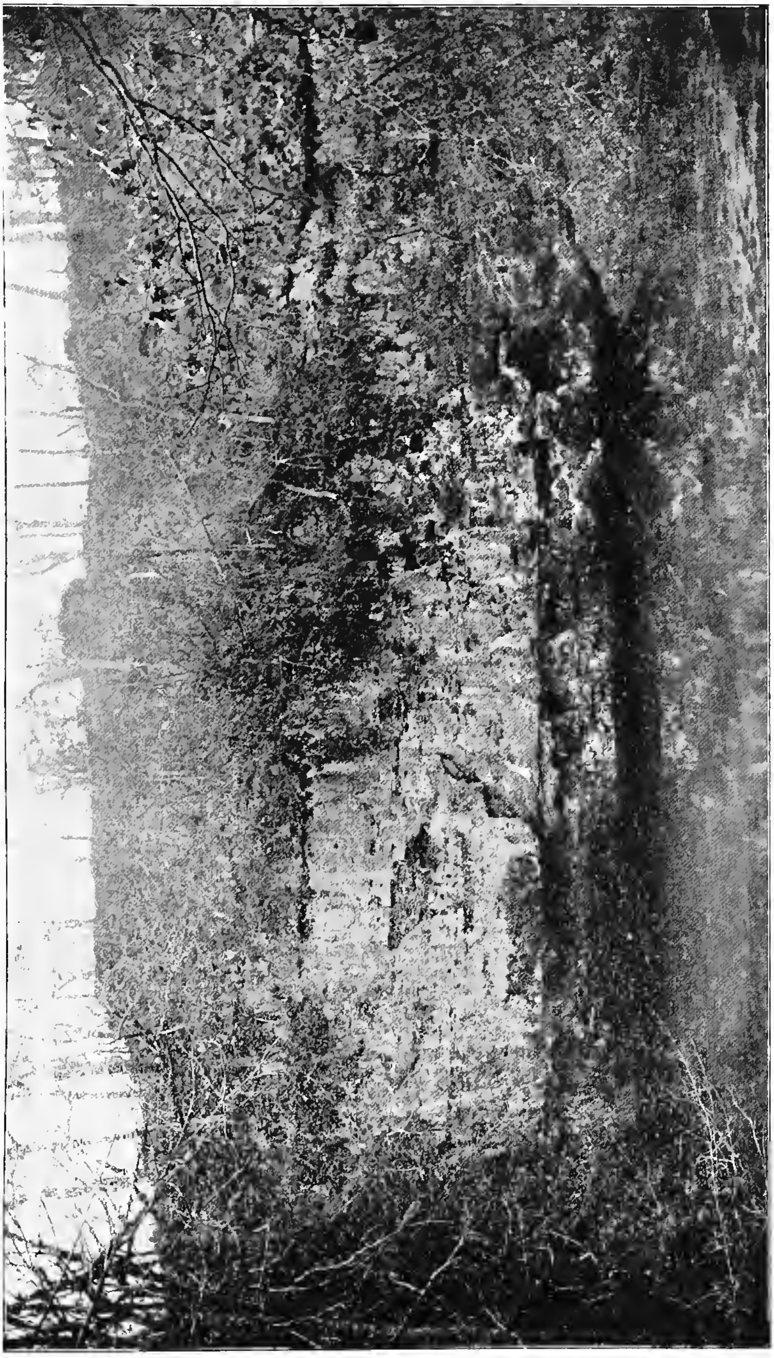
Who the beneficiaries shall be does not concern this Survey, but the exact distribution of our three great country rocks, viz: the First Cambrian, the First Calciferous and the Burlington-Keokuk limestones and the exact zones in them. in which rich ore bodies may reasonably be expected, is one of our chief objectives. The obvious fact that no profitiable mines are now being worked or even have been worked in any other rocks, than the great country rocks above named, suggests that we eliminate everything but them and explore them carefully for duplicate conditions of exposure and structure under which they are known to contain profitable mines.

In eliminating all other country except Cambrian, First Calciferous and Burlington-Keokuk, I want it distinctly understood that I am not posing as an oracle. Neither have I any prejudice in this matter. Nor am I saying that the other rocks are absolutely barren. But I do say frankly that I have explored every county in South Missouri and I have not found what I considered a profitable mine except in Cambrian, First Calciferous or Burlington-Keokuk country. There are hundreds and possibly thousands of mineral prospects and occasionally an old sink or clay blanket that has yielded considerable ore, and some of them are now yielding considerable ore, but I do not know an individual who is much the richer or wiser from having worked them. On the other hand, I know a great many well-to-do people and some few millionaires whose wealth came mainly from mines in one or the other of our three great country rocks.

(Plate 23.) Now without further apology or explanation I will proceed in the delineation of our geological record and when I come to one of the great country rocks, I will dwell on requisite structure and try to indicate its probable productive areas. Before proceeding, however, I beg to call the attention of the reader to the fact, that in a vertical section of our geological record the three great country rocks lie several hundred feet apart. In other words, the First Cambrian limestone (White Lead) lies on the Basal sandstone and under all of the other six or seven hundred feet of Cambrian Beds. The First Calciferous (the rock I am now delineating) lies on top of the Roubidoux sandstone and reaches up four or five hundred feet into the Calciferous group. Therefore, the First Calciferous lies about midway between the First Cambrian and the Burlington-Keokuk limestone.

The First Calciferous is the most siliceous limestone in our whole Calciferous group. For that reason it makes vast quantities of chert and drusy quartz. But the mere fact that our Calciferous group consist of eight members (Four Infusorial sandstones and four Magnesian limestones, in alternate succession) suggests that all of our Calciferous members are siliceous rocks. Those who are familiar with the lithologic characters of the Calciferous of New York will easily understand the difficulty of correlating our whole Calciferous group with the one rock, known as Calciferous in New York, and individualizing our eight distinct members, without a repetition or confusion of terms. The nomenclature I have adopted for this delineation is, however, the one suggested by the facts and is less objectionable than any other. I regard the whole Ordovician division (upper two-thirds) of the Magnesian Lens as the equivalent of the Calciferous of New York. Then, there is no alternative but to describe and name the eight individual members of the group in their natural order of occurrence from oldest to youngest.

In fact all of our magnesian limestones, from the Siliceous cap-rock of the Upper Cambrian upwards, are siliceous limestones or calciferous sandrocks. But the Calciferous of New York comes nearer being a true limestone than a true sandstone. It is nearer a siliceous limestone than a Calciferous sandrock and our four magnesian limestones above the Cam-



Blue Spring, 1st Calciferous, Shannon County.

brian are siliceous limestones rather than calciferous sand-rocks. However, the name, Calciferous is already established and when we have become accustomed to First, Second, Third and Fourth Calciferous that arrangements will seem natural because it is true to nature.

The average thickness of the First Calciferous is somewhere about four hundred feet. In the Meramec Valley in the northwestern part of Washington county and in the southeastern part of Franklin county, it is apparently not less than five hundred feet thick. But there are other localities in which it seems never to have been as much as four hundred feet thick. After having observed it carefully in the thirty-one counties in which it is the surface rock, over large areas, I have concluded that four hundred feet is a conservative estimate of its average thickness, before any portion of it was removed.

In two places, viz: five miles east of Linn Creek in Camden county, and one mile east of Potosi, in Washington county, I have observed that the lime and magnesia had been dissolved out of the First Calciferous and the only residue, a bed of loose sand, remained in place. But the siliceous matter is usually dissolved out first and redeposited in siliceous concretions—chert or drusy quartz. The First Calciferous cherts of one horizon in particular are massive and strongly individualized. They are infallible witnesses to its identity, because they are peculiar to it. (Fig. 1.)

(Plate 24.) The cavernous structure of the First Calciferous is established by Fisher's Cave in Franklin county, the Greer Spring Cave in Oregon county and innumerable other caves in that rock, but more especially by the great boiling or spouting springs which flow out of its open structure. The velocity with which a great volume of cold clear water rises, at the Greer Spring in Oregon county, at the Current River Spring in Carter county, and at the Coppedge Spring in Phelps county, is, indeed, surprising. We tumbled limestone rocks, half as big as a nail keg into the Current River Spring and they were thrown out instantly.

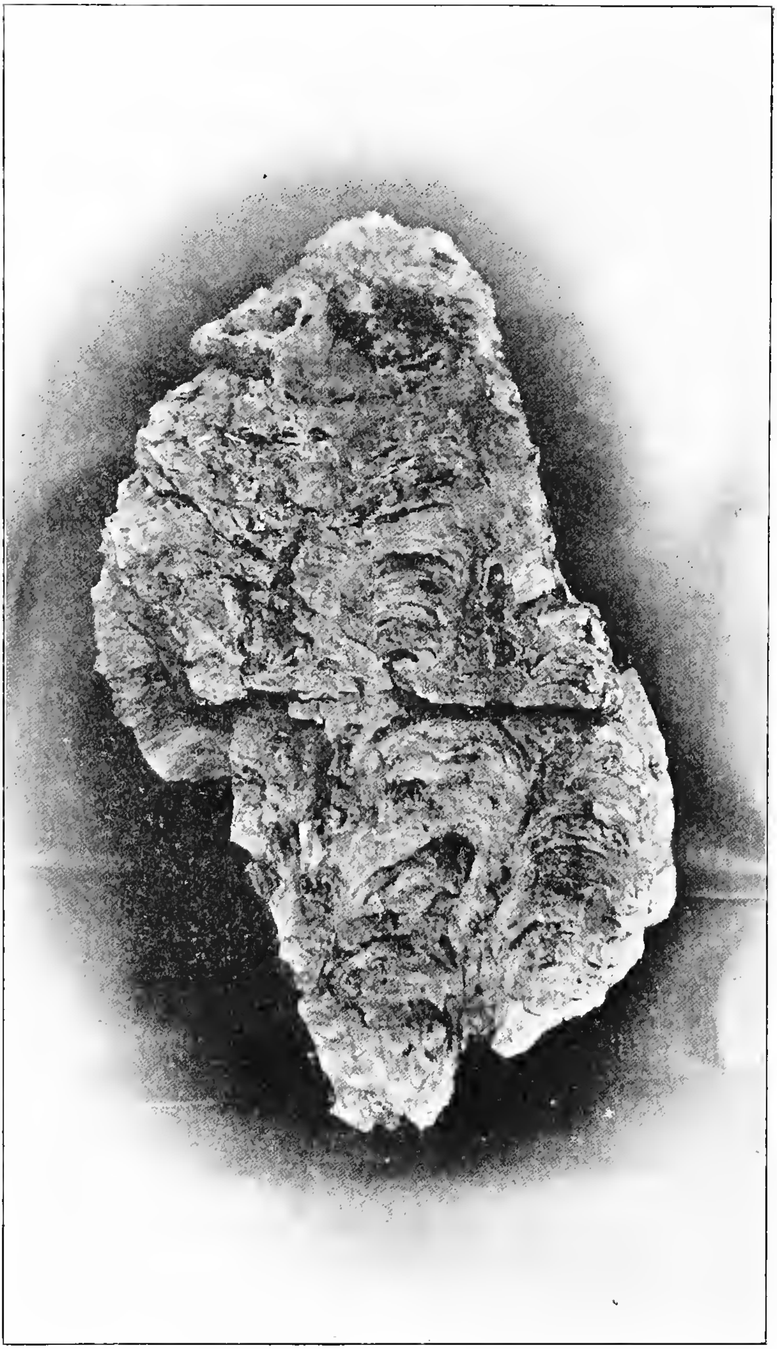


Fig. 1. 1st Calciferous Chert.

Meramec Spring, 1st Calciferous, Phelps Ccunty.

Some of those great Springs which have been credited to the First Calciferous, because it is the only rock in sight are, however, doubtless rising out of the open structure of the Cambrian. The Current River Spring, the Blue Spring in Shannon, the Sweet Spring in Dallas and the Bennett Spring in Laclede county are undoubtedly rising out of the Cambrian. But the only rock in sight is First Calciferous.

The cavernous structure of the First Calciferous is further demonstrated by the great fissure deposits of lead, zinc and copper in the southeastern part of Franklin county. There is no doubt whatever but that this great country rock has had the requisite open structure and the requisite exposure in both surface and sub-drainage zones, to have received numerous rich deposits of metallic ores in each of the thirty-one counties mentioned under this head. Besides the great fissure deposits mentioned, in Franklin and Camden counties, its old sinks and clay blankets have yielded vast quantities of lead, zinc or barite in Jefferson, Washinton, Osage, Miller, Morgan, Camden and Dallas counties.

It is a familiar fact that large quantities of lead and barite have been taken from the clay blankets of the First Calciferous in the south end of Morgan county, from the valley of the Little Niangua in Camden county, from the Valley of the Saline creek and also from the valley of the Tavern creek in Miller county. The valley of the Bois Brule in the southwest part of Cole county has also yielded considerable lead and barite. In the Gasconade valley in Pulaski, Phelps, Maries and Osage counties and in the Third creek country, many rich deposits of lead, zinc or barite, will doubtless be found in the old sinks, clay blankets and vertical fissures of the First Calciferous. In all of those deeply eroded zones, wherein basins and valleys have been cut down, from one to three hundred feet, in the First Calciferous, there are good indications of both fissure and blanket deposits.

(Plate 25.) The main thing now is to get the public mind concentrated on the great country rocks and the kind of structure in each that is known to contain profitable mines. Besides the many fissure and blanket deposits of lead, zinc and barite that have been worked in First Calciferous country all of the iron ore that has ever been mined and smelted in Missouri, except Iron Mountain and Pilot Knob, came from First Calciferous country. And all of the great sink deposits of iron that remain to be exploited are in First Calciferous save one. There is one deposit in Porphyry at the head of the Middle fork of Black river, in Iron county, similar to the deposits that were exploited at Iron Mountain and Pilot Knob. All of the others are in First Calciferous and St. Thomas sandstone and that is virtually the same kind of country.

It is sufficient to say that the floors or borders of all the deeply eroded areas of the interior of the Magnesian Lens in Missouri are First Calciferous country. When we have gotten the exact boundaries, our plan is to publish a geological map of the State, showing the exact areas of the three great country rocks. But I have given, herein so nearly the exact areas of our Cambrian and First Calciferous country and so many landmarks in each that the reader can, by doing a little thinking for himself, make out their boundaries.

Notwithstanding the apparently deep cut tracks of the Missouri and White river, the First Calciferous has been denuded of all overlying rocks only in the deeply eroded valleys and basins of south central and southeastern Missouri. In other words, we have not yet found an exposure of First Calciferous either in the White river basin or in the bluffs of the Missouri river. It is only natural that it should be so, when the Magnesian Lens is dipping in all directions from the most denuded area of our Basal plateau.

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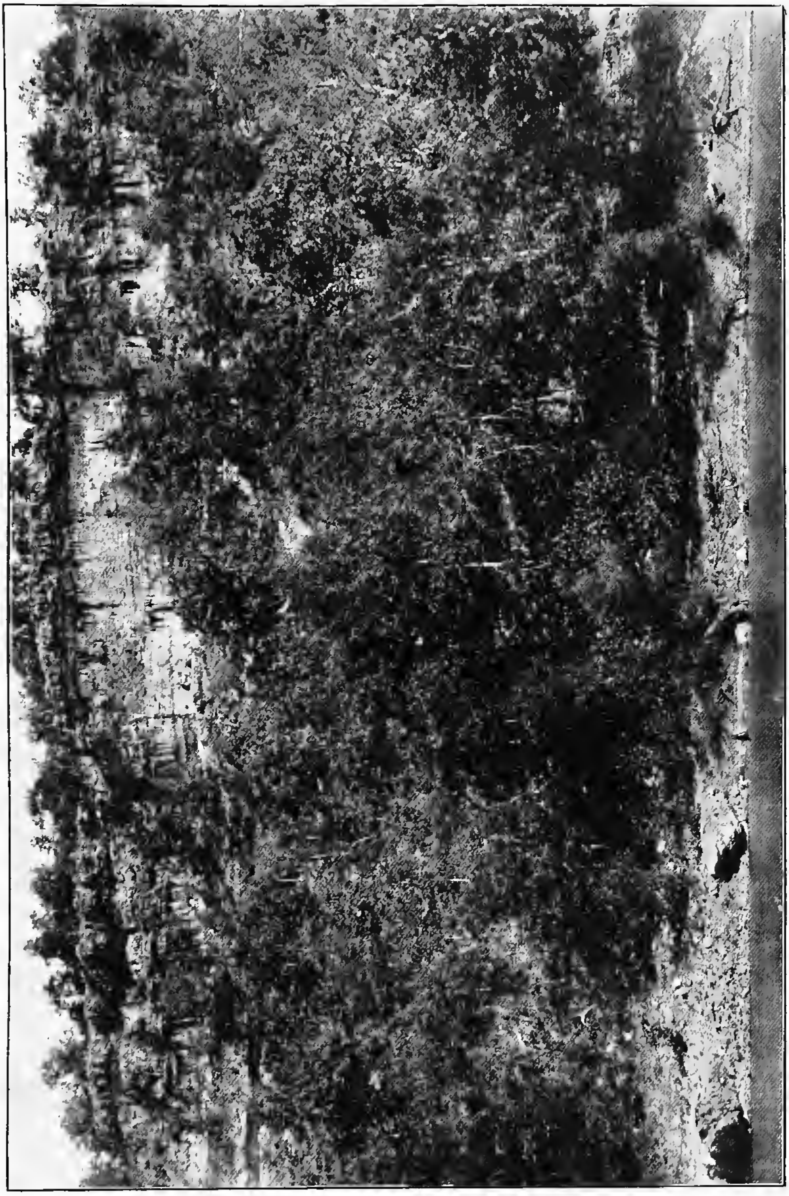
## ST. THOMAS SANDSTONE.

(Plate 26.) The primary fact that each Calciferous member has a basal sandstone suggests that wherever one of those basal sandstones is in place, the overlying Magnesian limestone ought also to be in place. But when we take into ac-



St. Thomas Sandstone, top of cliff, near Riverview, Morgan County.

St. Thomas Sandstone, Castor River, Bollinger County.

count the fact that each one of those Infusorial sandstones is usually a massive quartzite it is not surprising that it should persist, as the surface rock over large areas, long after the overlying member has been decomposed and removed. This is especially true of the St. Thomas sandstone. From River View, in Morgan county, to the Castor River, in Bollinger county, St. Thomas sandstone persists as the surface rock over some very large areas.

The St. Thomas sandstone, named for the thrifty little town of St. Thomas in the south part of Cole county, in which locality it has reached its greatest development, has persisted as the surface rock over more square miles of territory than any other one of our Infusorial sandstones. In the great sandstone plateau of Dent and adjoining counties, the St. Thomas sandstone is the prevailing surface rock. It is the horizon of at least two-thirds of the area of pine forests in southeastern Missouri. Indeed, nearly all of the valuable pine forests in Reynolds, Shannon, Carter, Oregon, Ripley, Butler and Wayne counties are growing on St. Thomas sandstone. While the pine is indigenous to the soils of all these Infusorial sand stones, most of it has been cut from the areas in which the Roubidoux sandstone is the prevailing surface rock and now most of our available pine is growing on the St. Thomas sandstone.

The St. Thomas sandstone persists in an unbroken sheet over the major part of Dent county and as the surface rock on the hills and ridges in the adjoining counties. West of Black river, in Reynolds county, and in the notheastern part of Shannon county the valleys are nearly all in First Calciferous and the tops of the intervening ridges are capped with St. Thomas sandstone and covered with pine forests.

(Plate 27.) As will be shown hereafter the lithologic characters of these Infusorial sandstones and the Magnesian limestones are so radically different that great masses and broken sheets of quartzite are often found well preserved on the floors of basins and valleys, two or three hundred feet below where they were originally deposited. In such areas, the underlying

Magnesian limestone has been dissolved out or decomposed and removed and the massive quartzite from the overlying Infusorial sandstone let down to a relatively lower horizon. For that reason, in ascending a hill, it is sometimes difficult to determine when you have reached the original horizon of the sandstone cap-rock. Obviously so, when the underlying rock has been dissolved out and the quartzite let down all the way from one foot to two or three hundred feet.

At Pay Down, on the Gasconade, the St. Thomas sandstone has not only reached the quartzite stage, but has developed a decidedly oolitic texture. In fact, that feature has been observed in it in several localities. It has suggested to my mind that oolitic texture, in any rock, marks an advanced stage of reconstruction, approaching decomposition. For that reason, I do not regard oolitic texture as concomitant with durability. In other words, were I selecting a rock for a purpose in which durability is a prime consideration, I would not select a rock in which oolitic texture has been developed.

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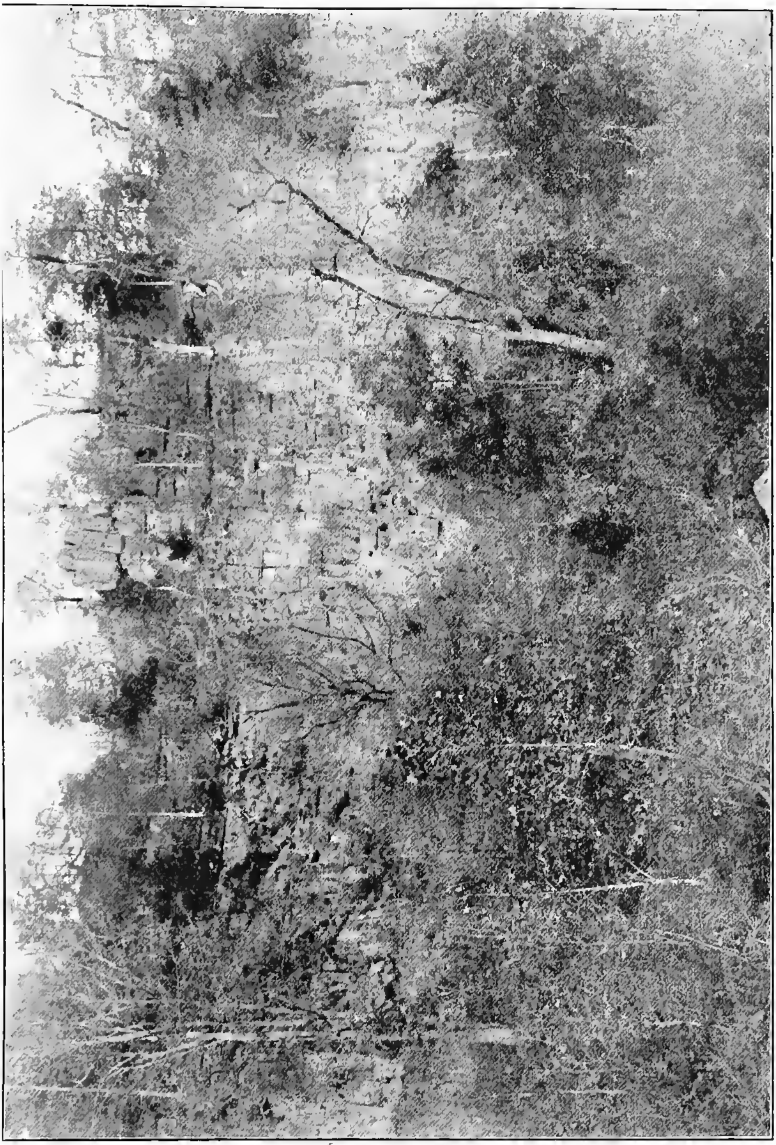
## SECOND CALCIFEROUS.

(Plate 28.) The second Calciferous, with the St. Thomas sandstone for its base, is usually about two hundred feet thick. It is doubtless two hundred and fifty feet thick in some places. Those immense deposits, known as cotton rock, begin with this member. The Second Calciferous is about one-half true limestone and one-half cotton rock. The true limestone yields some excellent building stone, for heavy masonry, but the cotton rock has no economic value.

What has been said about the persistency of the St. Thomas sandstone applies also to the Moreau sandstone. I do not know of a good exposure of Second Calciferous without the Moreau sandstone in place on top of it. Descending the Osage river from Warsaw, the St. Peter sandstone is high up in the river bluffs about the town and the first exposure of Moreau sandstone is in the left bank some two or three miles



2nd Calciferous, Theodosia, Ozark County.

above the mouth of Cole Camp Creek. In the view, opposite the mouth of Cole Camp Creek, we have Second Calciferous below and Third Calciferous above the Moreau sandstone.

The forms of fossil life preserved in the Second Calciferous and especially in its cherts are virtually the same as those found in the First Calciferous and in its cherts. In fact, fossils are rarely ever found in either of these members except in their cherts. But the cherts of either have very pronounced individualities and they are so constant as to be infallible witnesses by which to recognize either rock. (Figure 2.)

Notwithstanding its great thickness and the constancy of its lithologic characters the Second Calciferous is not ore-bearing to a profitable extent and for that reason it is rather monotonous than interesting. So far as we have observed, it is the deepest member of the Calciferous group that is exposed in the White river basin. It is the surface rock over large areas in that region. And it lies in a continuous zone bordering the First Calciferous country on the north in Cole, Miller, Morgan and Benton counties. It also lies in a continuous zone across Howell, Oregon, Ripley and Butler counties, on the south of the pine forest which grows on the St. Thomas sandstone in the region.

Inasmuch as it is the next great rock after the First Calciferous it is only natural that this monotonous mass of magnesian limestone and cotton rock should lie in continuous zones or escarpments around each one of our deeply eroded areas. And for that reason it is the surface rock over thousands of square miles of country which contains many mineral prospects but no profitable mines. The lower and more massive limestones of this member contain a large amount of siliceous matter and make great quantities of chert, but not nearly so much as the First Calciferous under it.

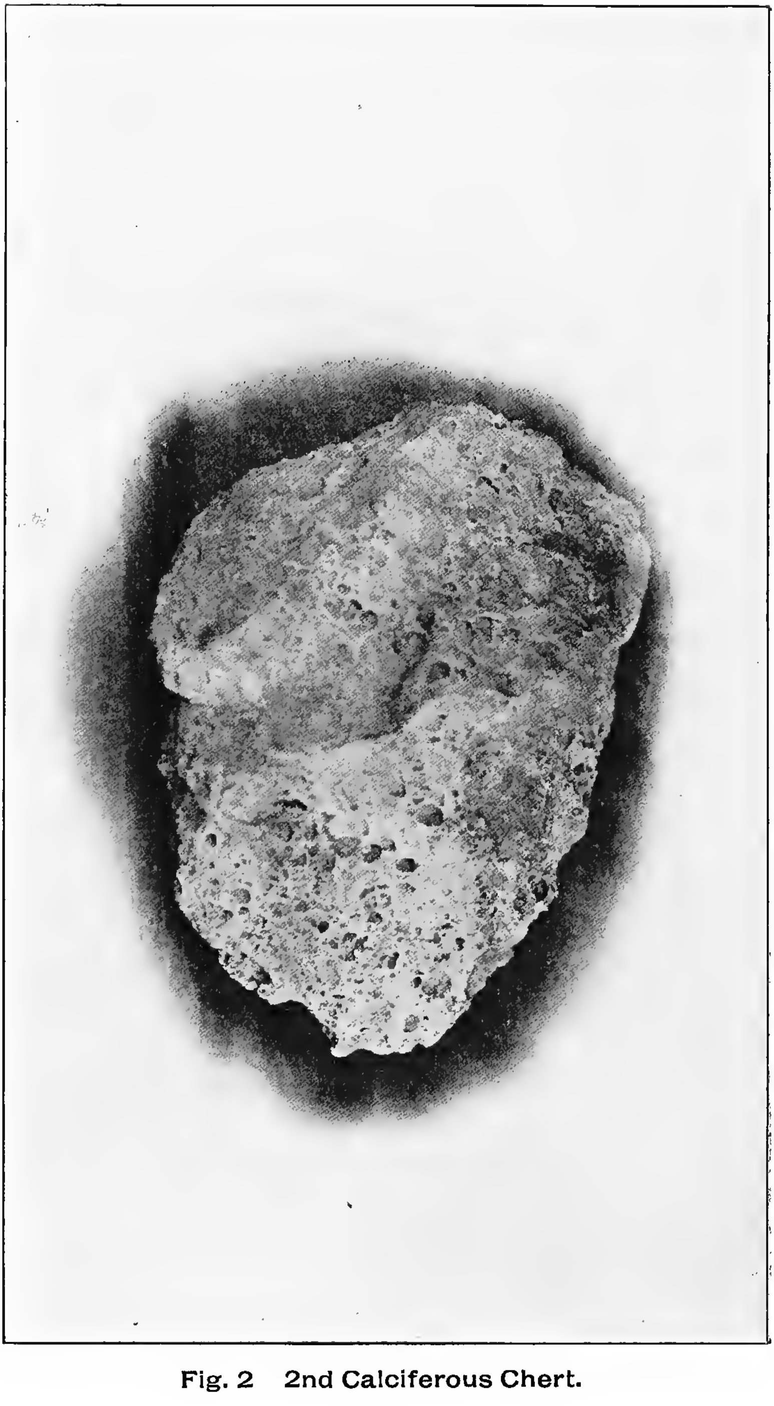


Fig. 2  2nd Calciferous Chert.

Moreau Sandstone, on 2nd Calciferous, Mingo Swamp, Stoddard County.

Moreau Quartzite, Belle City, Stoddard County.

## MOREAU SANDSTONE.

(Plate 29.) The Moreau sandstone, like the St. Thomas and the Roubidoux under it, is very generally a massive quartzite and has persisted as the surface rock over large areas of Second Calciferous country. This third great sandstone of the Calciferous group has been thus named because it has reached its greatest development in the valley of the Moreau, in Cole county. It is, however, as persistent as either one of the other great sandstones of the Magnesian Lens. It is the intensely ripple-marked and glittering Infusorial sandstone which lies at or near the surface about Cole Camp, Buffalo and Lebanon, and supplies the flags and foundation stones for those flourishing towns. It is also the surface rock of a large part of the Burbeuse plateau in Maries and Gasconade counties. About Red Bird and Vichy and Moreau sandstone is exposed in many places.

Along the south side of the Mingo Swamp, in Stoddard county some interesting exposures of Second Calciferous occur, capped with thirty or forty feet of Moreau quartzite. In those places, the quartzite has doubtless shielded and preserved the underlying limestone and cotton rock from decomposition. But in some places the underlying limestones have actually been dissolved out and massive blocks of quartzite from the Moreau are now resting on residuary clay or recent dirft. And that is not an uncommon occurrence in Stoddard County.

(Plate 30.) In one hill, about two miles north of Belle City, the Moreau sandstone is a massive quartzite resting on the true limestone of the Second Calciferous. In another hill, about one mile north of that town, it is a massive quartzite projecting far out beyond its original base and now resting on recent drift. Of course, the underlying limestone was first dissolved out and the space afterwards filled in with recent sediment.

The Moreau sandstone is the surface rock over very much larger areas than is the St. Peter sandstone above it. Obviously, because it is usually a massive quartzite and has not been so generally destroyed by erosion as the St. Peter. The Moreau is in place all around the outside border of the Magnesian Lens, or just within the outside border. It lies about midway between the St. Thomas and St. Peter sandstones and has doubtless been heretofore repeatedly mistaken for one or the other of those rocks. I cannot conceive any other reason why such a persistent and important rock could have been overlooked by geologists.

(Plate 31.) In many places two of those rocks are cropping out of the same hillside, the upper two in one place and the lower two in another. But in no place that I can recall are all three cropping out of the same hillside. Hence, not having differentiated the intervening Calciferous members, the geologist could not possibly distinguish between their basal sandstones, and he would naturally mistake one for the other, because they are all exactly alike in places.

At Gainesville, in Ozark County, the Moreau and St. Peter are exposed in the same hillside and neither one of them is more than five or six feet thick. Both of those rocks are exposed in many places in the White river basin but in no place have I observed either one of them as much as ten feet thick. On the other hand, both of them are exposed along the St. Louis and San Francisco Railroad track, in St. Louis and Franklin counties, and neither is less than forty or fifty feet thick. In short, while all of our Infusorial sandstones vary greatly in thickness they are nevertheless persistent and the Moreau sandstone is not less persistent than any one of the others.

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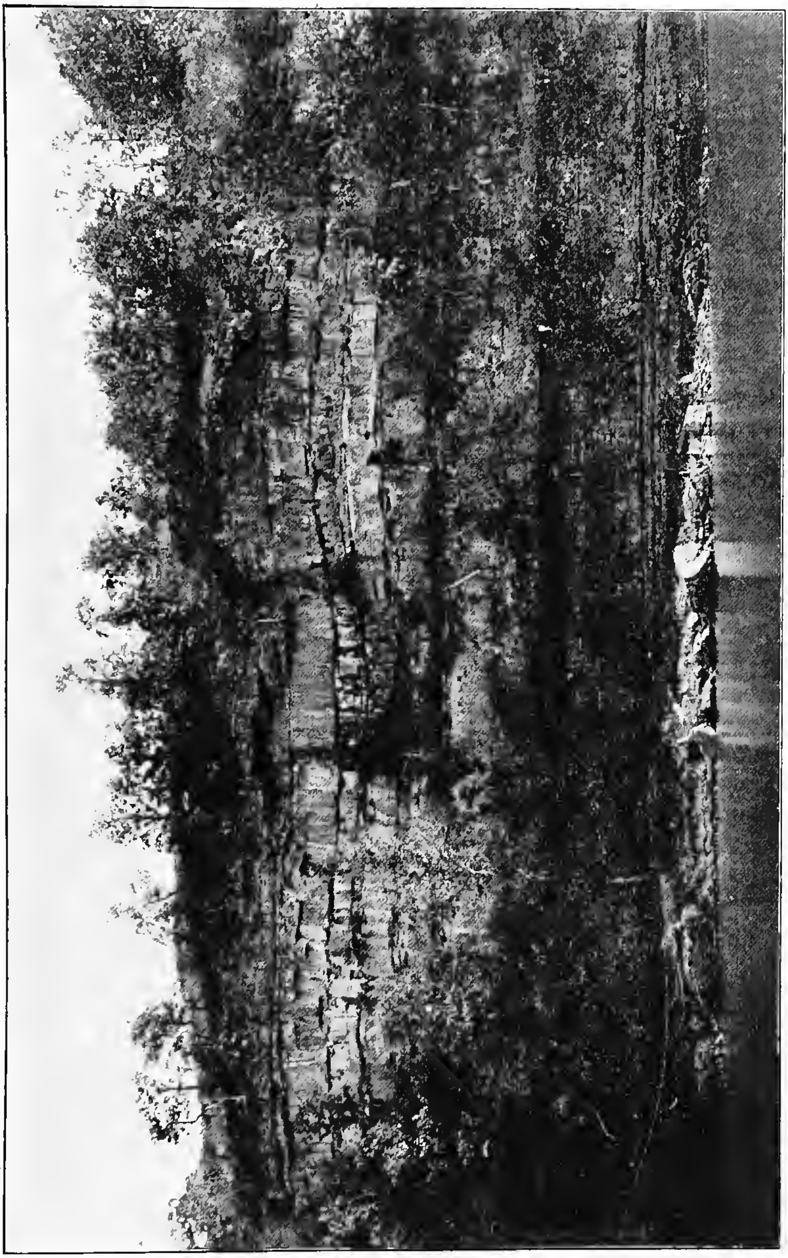
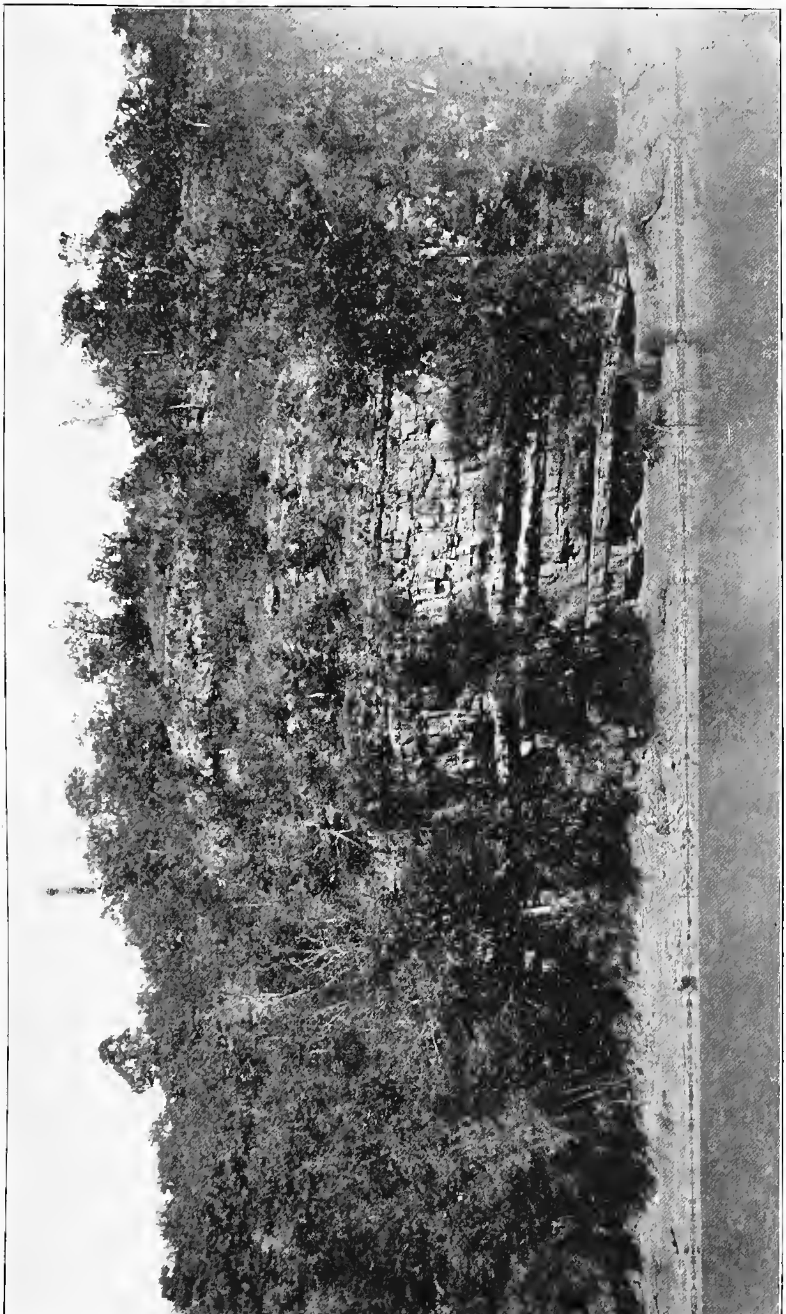
## THIRD CALCIFEROUS.

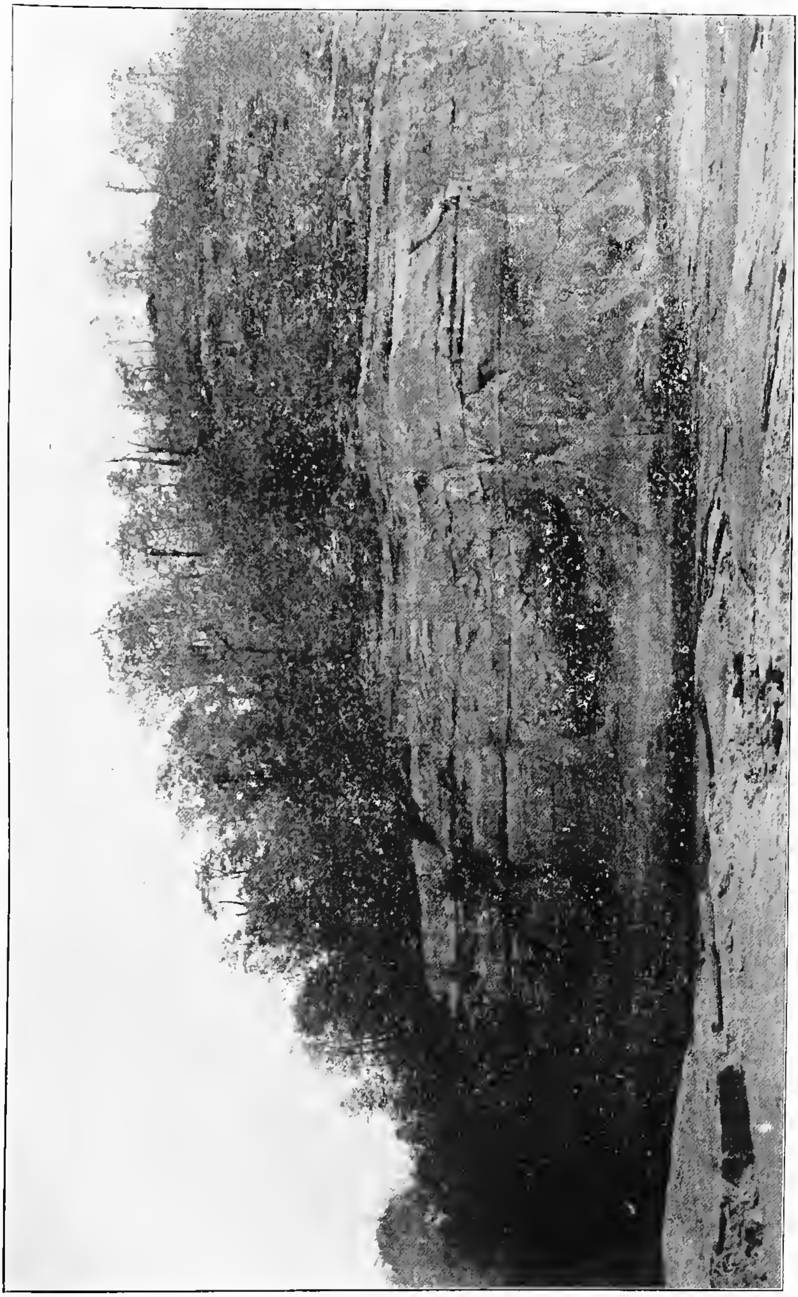
(Plate 32.) Resting on the Moreau sandstone lies the Third Calciferous about three hundred feet thick. It consists of four or five thin beds of true limestone and as many thick



Moreau Sandstone, opposite Cole Camp Creek, Benton County.



Moreau Sandstone, base of 3rd Calciferous, Osage River, Benton County.



St. Peter Sandstone, base of 4th Calciferous, Crystal City.

beds of buff-colored cotton rock. It is approximately one-third true limestone and two-thirds cotton rock. It also makes considerable chert, but not so much as either the First or Second Calciferous. The cherts of all these Calciferous members are more or less oolitic, but the cherts of the Third are more generally oolitic than the others. The cherts of this rock are frequently concentric with regular concretionary structure but most generally foliated and intensely oolitic.

(Figure 3.) Being so very thick and persistent, the Third Calciferous is the surface rock over wide zones around the entire border of the Magnesian Lens. The bluffs of the Missouri river, between Providence and Augusta, are for the most part Third Calciferous. The surface of the White river basin, in Missouri and Arkansas, is made up largely of this rock. It, like the Second Calciferous, is also ore-bearing but its ore bodies are dispersed in clay blankets, old canyons and sinks, and are not generally profitable.

In fact, large concentrations of metallic ores are scarcely to be expected in these rocks, for the reason that relatively thin limestones and thick cotton rocks could not have had at any time the requisite open structure to receive water concentrations. They are as prolific of mineral prospects as any other rocks and have yielded considerable lead and zinc, but no extensive and profitable deposit of ore has been located or developed in any member of the Magnesian Lens above the First Calciferous.

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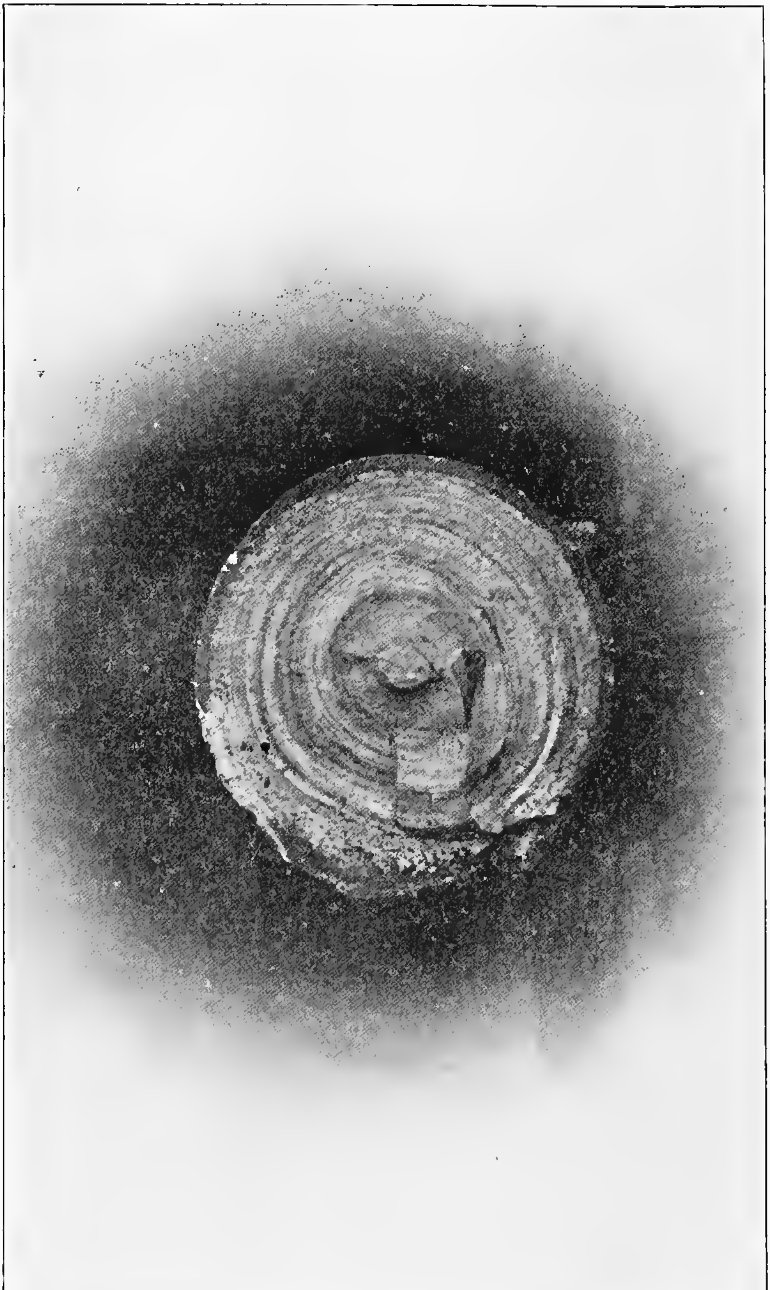
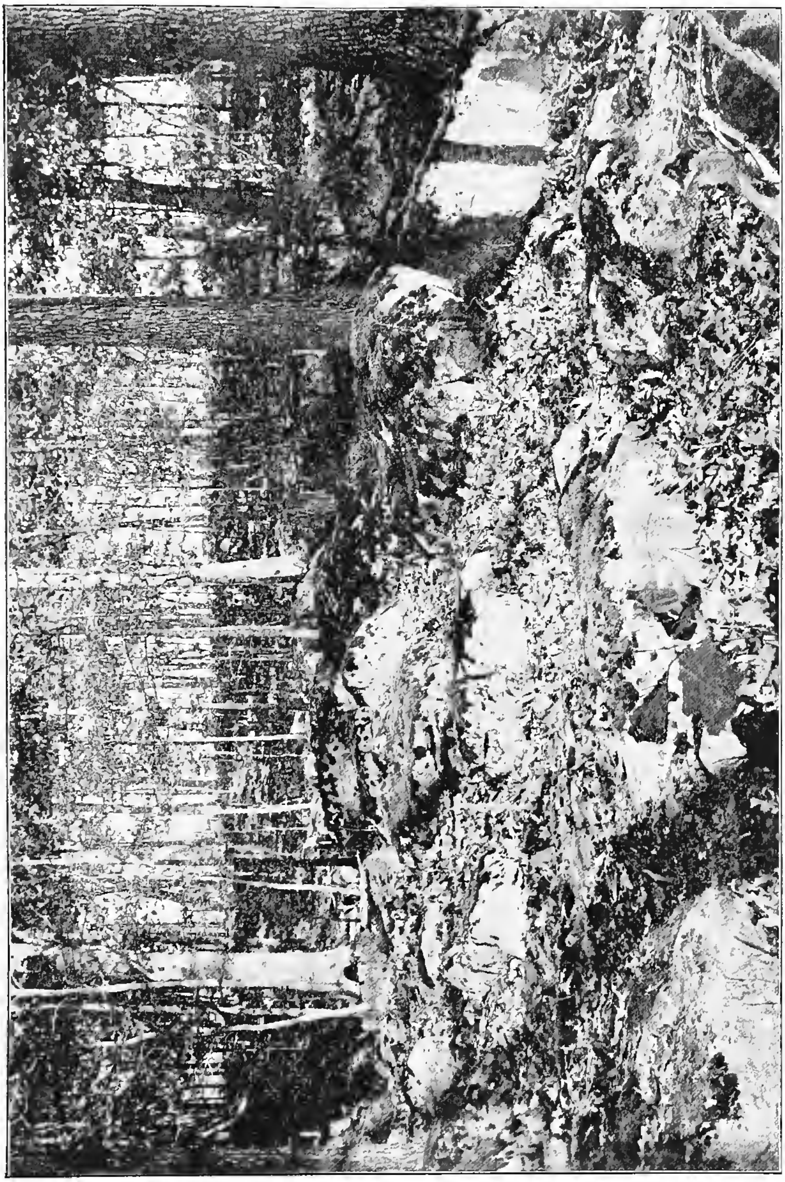
## ST. PETER SANDSTONE.

(Plate 33). The fourth and last Infusorial sandstone of the Calciferous group, long since named the St. Peter sandstone, is one member of the Magnesian Lens with which many people are familiar. It is exposed in many places along the axis of the Ozark Range in Wisconsin, Iowa, Illinois, Missouri and Arkansas. Being more friable and available than the other Infusorial sandstones, it is the rock which yields most of the glass sand in the Mississippi Basin. The most notable



3rd Calciferous Chert.

St. Peter Sandstone, Silica, Jefferson County.



St. Peter Quartzite, near Dexter, Stoddard County.

exposures of St. Peter sandstone in Missouri are at Silex in Lincoln county, near Augusta in St. Charles county, near Pacific in St. Louis county and at Crystal City in Jefferson county.

There are numerous other exposures of St. Peter sandstone in its friable condition, but in localities wherein the overlying rocks have been removed, it, like the other Infusorial sandstones, is very generally a quartzite. In the central zone of the ridge, between the Missouri and the Osage rivers from Jefferson City to Sedalia, isolated patches of St. Peter quartzite persists in most of the high places. In fact, St. Peter quartzite and Burlington-Keokuk cherts are the rocks most frequently encountered in that zone. About Russelville, High Point, Versailles, Florence and thence to Sedalia, St. Peter quartzite and Burlington-Keokuk cherts are very familiar objects.

In the south bluff of Flat Creek, opposite the Sedalia water works, St. Peter sandstone is soft and friable but slightly stained with iron. It occurs also in its friable form near Fairfield, in Benton County, about Hermitage, in Hickory County, and around Bolivar, in Polk County. But it has never been utilized in any of those localities except for building sand.

(Plate 34.) A very beautiful exposure of St. Peter sandstone lies a little to the north and east of Silica, in Jefferson county. It has, however, reached its greatest development in the north bluff of the Missouri River, between Augusta and Matson, where it is now being quarried for the Mississippi Glass Company.

(Plate 35.) But the most remarkable exposure of St. Peter sandstone, that I have observed, is about four miles south and west of Dexter, in Stoddard county. That being a portion of Crowley's ridge, which is made up of small lenses of Tertiary deposits, or reconstructed Cretaceous material, makes the occurrence of St. Peter sandstone the more surprising. But when we reflect that massive quartzites from our Infusorial sandstones are, for good reasons, perhaps the most durable rocks in the world and that Moreau quartzites have persisted in the same county long after the underlying rocks were dissolved out, it is not more strange that the St. Peter quartzites should persist a few miles further south. In the locality mentioned, large areas of surface are covered with blocks of St. Peter quartzite, slightly disrupted, by having been let down in place.

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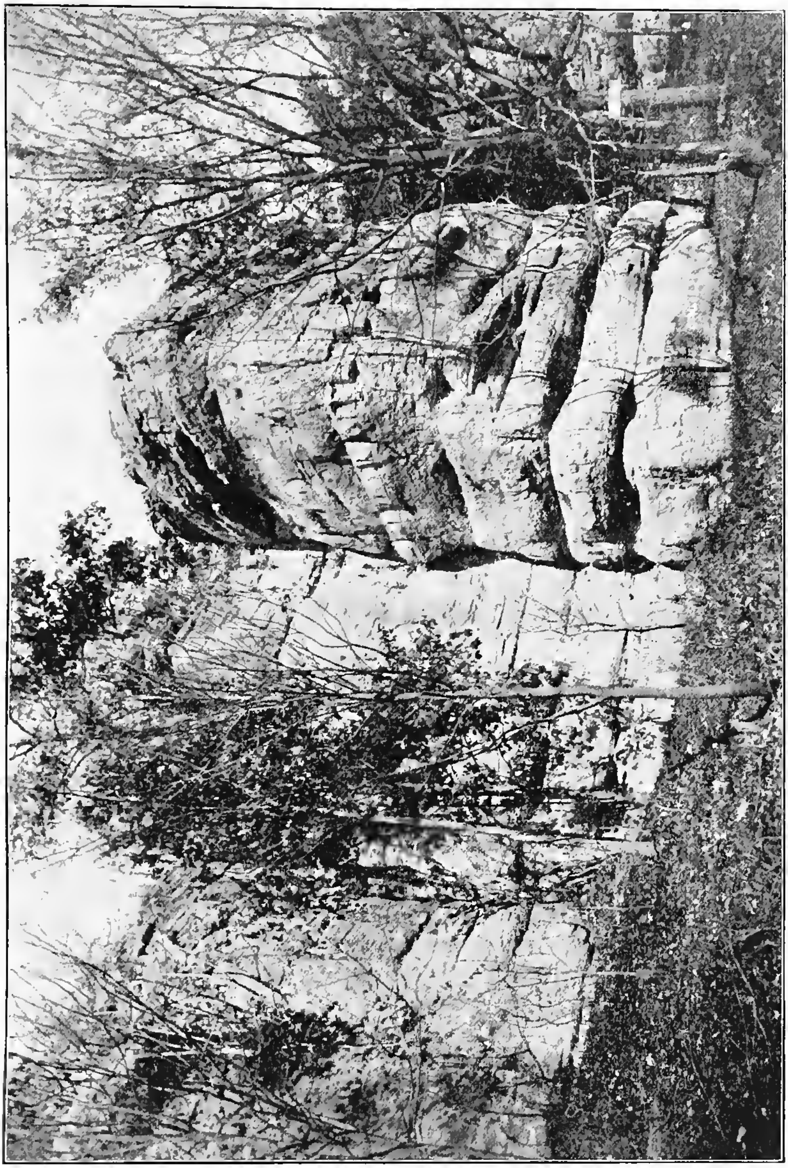
## FOURTH CALCIFEROUS.

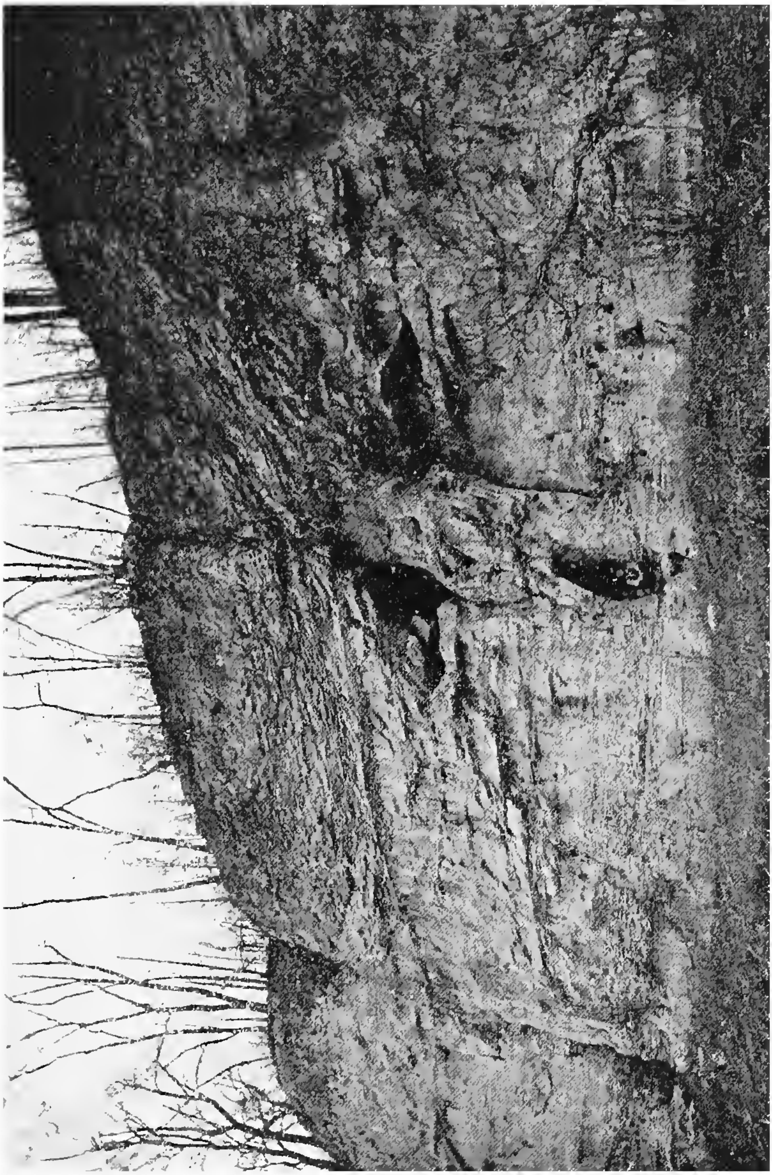
The last member of the Calciferous group and last member of the Magnesian Lens is not so thick as either one of the other Calciferous members. Nor does it cover anything like so much surface. The Fourth Calciferous is, in fact, limited to relatively small areas, or narrow zones, on the northeastern and southwestern borders of the Magnesian Lens. It has perhaps reached its greatest development about Crystal City, in Jefferson county, where it seems to be not less than two hundred feet thick. It is exposed at Matson, in St. Charles county, at Eureka, in St. Louis county, and doubtless in a continuous zone from Matson on the Missouri river to Rush Tower on the Mississippi river. Small areas of it occur also about Perryville, in Perry county.

The Fourth Calciferous is somewhat widely distributed in Polk county east of Bolivar, about Cedar Gap in Wright county, and, in fact, it is present in most of the Bald Knobs of Ozark and Taney counties, north of White river. This member consists of two or three thin beds of true limestone and as many thick beds of cotton rock. It is approximately one-fourth limestone and three-fourths cotton rock. Its proportion of cotton rock is possibly even greater than three-fourths.

In the northeastern zone, in which this rock occurs, its cotton rock has a peculiar purple marking which makes it quite easily recognized. About Eureka, in St. Louis county, the limestone of this member has been quarried somewhat extensively for building stone. In fact, all of the beds of true limestone of the Calciferous group have yielded good building stone in places where the texture and structure were suitable for quarrying.



Black River Limestone, Cape Girardeau.



Trenton Limestone, Hamburg, St. Charles County.

The most remarkable characters of the Fourth Calciferous may, however, be summed up in these facts: 1, It is the last member of the Calciferous group and of the Magnesian Lens. 2, It was doubtless co-extensive with the Magnesian Lens at one time but was decomposed and removed from very large areas before the overlying rocks were deposited. 3, It is the member whose buff-colored cotton rock has never failed to yield a trace of gold. So ends the Magnesian Lens, with a gold-bearing rock.

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## BLACK RIVER LIMESTONE.

(Plate 36.) The next member of our Ordovician Division, after the Calciferous group, is the Black river limestone. On the north side of a fault, hidden by the old river track south of Cape Girardeau, the last three members of the Ordovician occur in rapid succession, proceeding from the Rock Levee to Cape Rock. As suggested by the view, in Plate 36, there are some splendid exposures of Black river limestone in that locality, but this Survey has not recognized that member elsewhere in Missouri. Nor have any fossils been found in those beautiful cliffs. But inasmuch as the Trenton limestone occurs in its full development at the lime quarries, midway between the Rock Levee and Cape Rock, and is cropping out a few miles away to the westward, it is safe to say that those cliffs of fine black limestone along the Rock Levee road, are Black river limestone.

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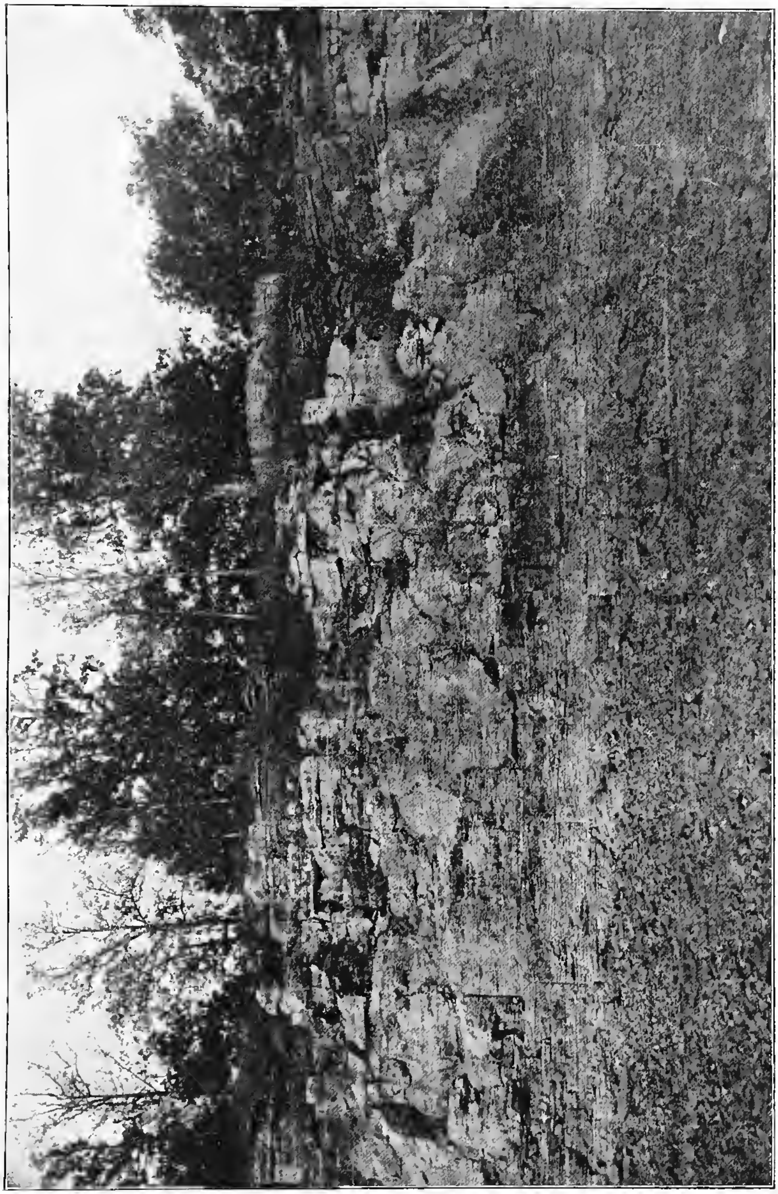
## TRENTON LIMESTONE.

(Plate 37.) On account of the great variety and number of organic forms preserved in its beds, the Trenton limestone is the most interesting member of our Ordovician Division. To my mind, it is the most interesting member of our geological record. Indeed, the Trenton limestone is, in itself, a most wonderful record of the goings on of time. There is always something about a Trenton limestone country that makes it peculiarly attractive. It may not have ocurred to some people that the rocks have much to do with the comforts and pleasures of this life, but when the lover of nature has sought out the primal cause of scenic beauty, he finds that the rocks have much or all to do with it. They have very much to do with the character of the soil.

In the growing season, there is a certain refinement and luxuriance about the vegetation which grows out of Trenton soil that is always refreshing. The creek beds are wider and cleaner than in any other rock, the woods are more beautiful and the towering white cliffs of Trenton limestone, shining out here and there, in the midst of a dense and rich foliage make it all the more charming. To my mind, there are no landscapes more beautiful or refined, than in those Trenton valleys about the mouth of Big River, in Jefferson county, on Charette Creek, in Warren county, or about Spalding Spring, in Ralls county. The inverted Trenton zone, at the latter place is perhaps the greatest geological freak in Missouri.

Notwithstanding the Trenton limestone is admirably adapted for a great ore-bearing country rock and is the greatest country rock in the Ozark Range, in Wisconsin, it has not been submitted to the conditions that would have made it a great ore-bearing rock in Missouri. However, the interesting features of Missouri geology are not all centered in the ore-bearing rocks. The massive white Trenton, including the Orthis bed, is, next to the typical Burlington, the greatest lime rock in Missouri that is now being utilized in the manufacture of lime. Splendid exposures of Trenton limestone occur in Lincoln, St. Charles, St. Louis, Jefferson, Perry and Cape Girardeau counties.

Trenton limestone is also the country rock in whose upward folds or deep-seated arches are found the requisite conditions for commercial supplies of natural gas. In the central zones of its downward folds or inverts are also often found great lenses of coarse sandrock, saturated with crude petroleum. The mere fact that Trenton limestone does exist, under



Cape Rock (Hudson River Beds), Cape Girardeau County.

a considerable depth of argillaceous beds, over a large part of North Missouri, suggests that we may have in certain sharply defined arches and basins, both natural gas and oil in commercial quantities. This Survey has been noting the places where the local structure suggests such deposits and arrangements have been made for exploring some of them.

Please note, it is in the upward folds or arches of the Trenton, where they are covered by several hundred feet of impervious beds, that natural gas is found in paying quantities. On the other hand, it is in sandrock lenses on the floors of troughs or basins in the Trenton that petroleum is usually found. I mean, of course, in the Mississippi Basin and in the latitude of North Missouri.

---

## HUDSON RIVER BEDS.

The Hudson river beds (Lorraine Shales) constitute the closing member of the Ordovician Division. Coming, as they do, immediately after the Trenton limestone whose exposures are limited to the eastern border of the State, between Ralls and Scott counties, inclusive, the Hudson river beds are exposed as surface rocks only in Warren, Franklin,and the eastern border counties.

(Plate 38.) Although somewhat widely distributed the lithologic characters of the Hudson river beds are exceedingly variable. In Cape Girardeau County, for example, the Hudson river beds are made up of thin bedded, fine grained and dark colored, argillaceous limestones. In Pike County, they are mainly harsh, calcareous clay shales, with thin lenses of mudrock, sometimes dispersed and sometimes in regular layers.

The historic "Cape Rock," known to all river men, is one illustration of the Hudson river beds, in their most substantial form. Many beautiful specimens of fossil life are found on the argillaceous bedding planes of the limestone quarried at Cape Rock. The rock is somewhat variable in texture, but usually thin bedded and fine grained. Fossils are seldom found deeply imbedded in the rock, but Crinoids and Star fishes are very abundant in the argillaceous bedding planes. While Cape Rock is widely known to river men, its beautiful and interestnig fauna is perhaps more widely known to paleontologists. And that completes the Ordovician Division in Missouri.

Before leaving this last member of the Ordovician Division, however, I beg to say that the most remarkable clay deposit in Missouri and one of the most remarkable clay deposits in the known world is the Reifsnider clay property, at Warrenton, Warren county. It consists of several hundred acres of Lorraine Shales, in place, altered into a fine white, plastic clay, suitable for almost any ceramic purpose. The original shale bed was about sixty feet thick and has an exposed area of five or six hundred acres. The supply is, therefore, practically inexhaustible.

## CHAPTER V.

# SILURIAN DIVISION.

# SECTION OF SILURIAN.

**Characteristic Fossils.**

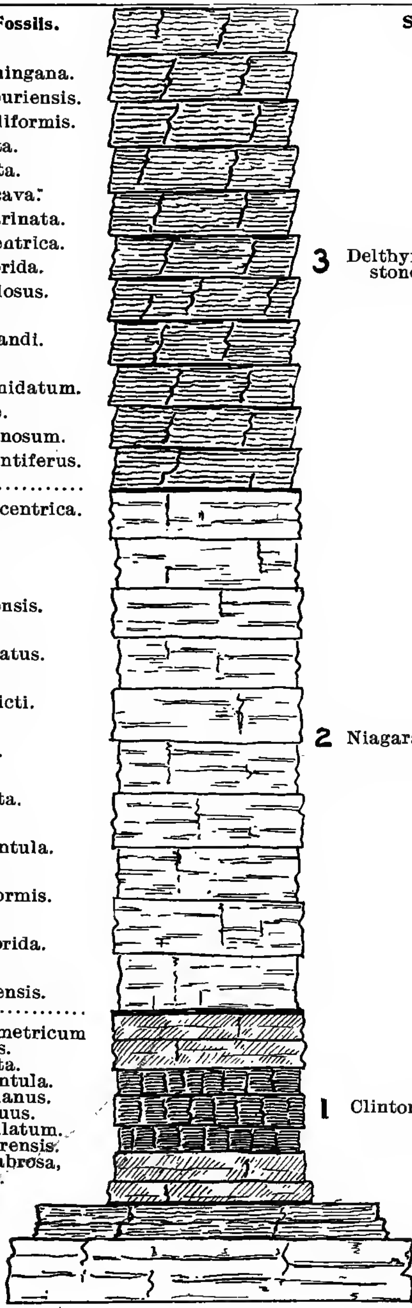
Strepteiasma fanningana.
Striatopora missouriensis.
Edriocrinus pocilliformis.
Atrypa nodostriata.
Atrypina imbricata.
Atrypina subconcava.
Dalmanella subcarinata.
Nucleospira concentrica.
Rhipidomella hybrida.
Spirifer perlamellosus.
Spirifer radiatus.
Uncinulus stricklandi.
Wilsonia saffordi.
Platyceras pyramidatum.
Platyceras spirale.
Platyceras subspinosum.
Dalmanites tridentiferus.

.................................

Stromatopora concentrica.
Favosites forbesi.
Favosites niagarensis.
Halysites catenulatus.
Pisocrinus benedicti.
Pisocrinus gorbyi.
Atrypa nodostriata.
Dalmanella elegantula.
Nucleospira pisiformis.
Rhipidomella hybrida.
Calymena niagarensis.

.................................

Streptelasma geometricum
Pachydictya rudis.
Atrypa nodostriata.
Dalmanella elegantula.
Orthothetes subplanus.
Bellerophon exiguus.
Cyclonema cancellatum.
Platystoma niagarensis.
Pleurotomaria labrosa, var. occidens.



**Subdivisions.**

3 Delthyris Shaly Limestone.

2 Niagara Limestone.

1 Clinton Beds.

Ordovician.

Hudson River & Trenton Limestone.

Niagara Limestone, Burke's Quarry, Mississippi River.

## SILURIAN.

Although our Cambrian and Ordovician Divisions are as well developed as their equivalents in any other geological province of North America, our Silurian rocks are few in number and occur only in isolated deposits. The fact that they are all argillaceous limestones and calcareous shales proves conclusively that they were deposited on the floors of shallow and muddy seas.

---

## CLINTON BEDS.

The First (basal) member of our Silurian Division is the Clinton group of mud-rocks and clay-shales, best developed about the Buffalo Knobs in Pike county. We have not found in Missouri an exposure of the Clinton worth photographing. In fact, its fossils are the only interesting feature about this member. It contains, some new types of small Brachiopods and a few corals hitherto unknown.

The stratigraphic value of the Clinton group is the only value it represents. The fact that it occurs immediately after the Hudson river beds and its fossil characters place it in our Silurian Division, which is relatively small, is about all there is to be said about is. It has no economic value whatever and its area of distribution is perhaps the smallest of any member of our geological record.

---

## NIAGARA LIMESTONE.

(Plate 39.) Resting on the Clinton beds, the same as at Niagara Falls, lies the equivalent of the famous shelf rock of those world-renowned cataracts. The Niagara limestone is the second and most important member of our Silurian Division. It is well developed in Pike and Lincoln counties where it is quarried and used somewhat exensively for building stone. But in that locality it contains too much argillàceous matter to be a desirable rock for either beauty or durability.

In Perry and Cape Girardeau counties, the Niagara limestone is a more crystalline and interesting rock than it is north of the Missouri river. Some very fine samples of red and mottled marble have been quarried from the Niagara limestone, in Cape Girardeau county. If found sufficiently massive, it would doubtless yield good commercial marble. But no effort has, I believe, been made in that direction.

The argillaceous Niagara, in Pike and Lincoln counties, contains many interesting corals. Its Halysites and Favosites are especially interesting. That fact is somewhat difficult to reconcile with the argillaceous character of the rock. The corals suggest that it was deposited in clear water, while the character of the rock itself suggests that it was deposited in muddy water. The corals are there nevertheless, and very abundant.

---

## DELTHYRIS SHALY LIMESTONE.

(Plate 40.) The Delthyris Shaly limestone is the third and last member of our Silurian Division. This member has reached its greatest development in Perry county, about Red Rock Landing and Lithium. For obvious reasons, it is always difficult to find good exposures of thinly laminated or shaly rocks. But the view shown in Plate 40 furnishes a good illustration of the shaly structure of the closing member of our Silurian Division. Besides the structure of the rock, however, which is admirably shown, the view has another interesting feature. That is the narrowest place in the Mississippi river, below St. Louis.

Some indications of rich ore bodies back of Lithium have been reported and some drilling has been done, but the Survey has found that locality the most inhospitable in Perry county

Delthyris Shales, Red Rock Landing, Mississippi River.

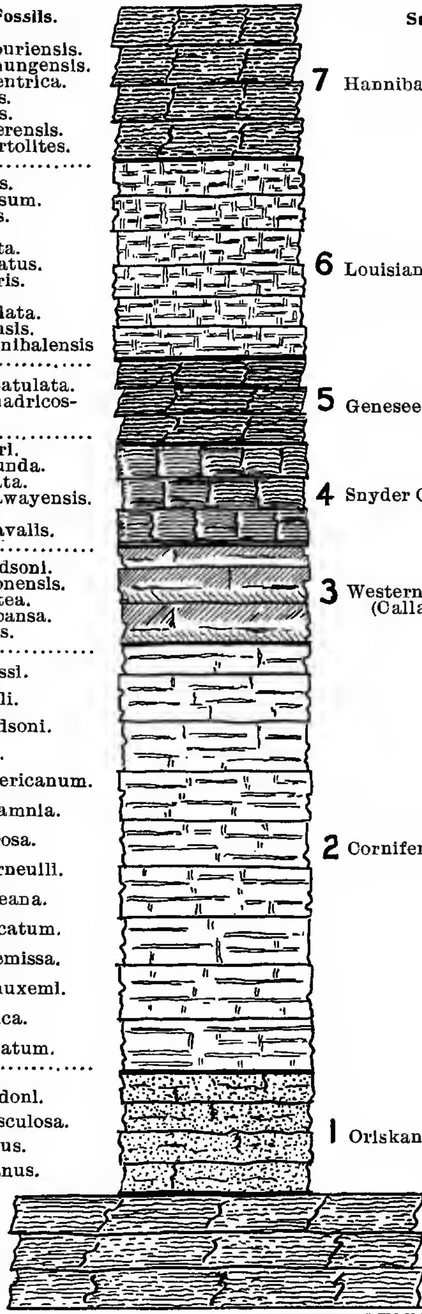
and there is absolutely nothing in sight to suggest rich mineral deposits. The Cambrian and First Calciferous country, in the western part of Perry county, is the only country in that county I would think of exploring for mineral deposits. We have not yet made out the exact areas of Cambrian and First Calciferous in that county, but I have no doubt about their existence and very little doubt but that they are ore-bearing to a profitable extent.

From Perryville to Wittenburg is one of the most delightful drives in Misouri. The road follows a winding ridge nearly all the way and a magnificient landscape lies on either hand. The good old town of Altenburg, about midway between Perryville and Wittenberg, is one of the most hospitable and delightful places in America. Indeed, a prettier country or more hospitable people cannot be found. This Survey feels especially grateful to the people of Perryville, Altenburg and Wittenburg, for courtesies and genuine hospitality. We are not expecting something for nothing but we, like all civilized creatures, appreciate decent treatment when we are at the mercy of the natives.

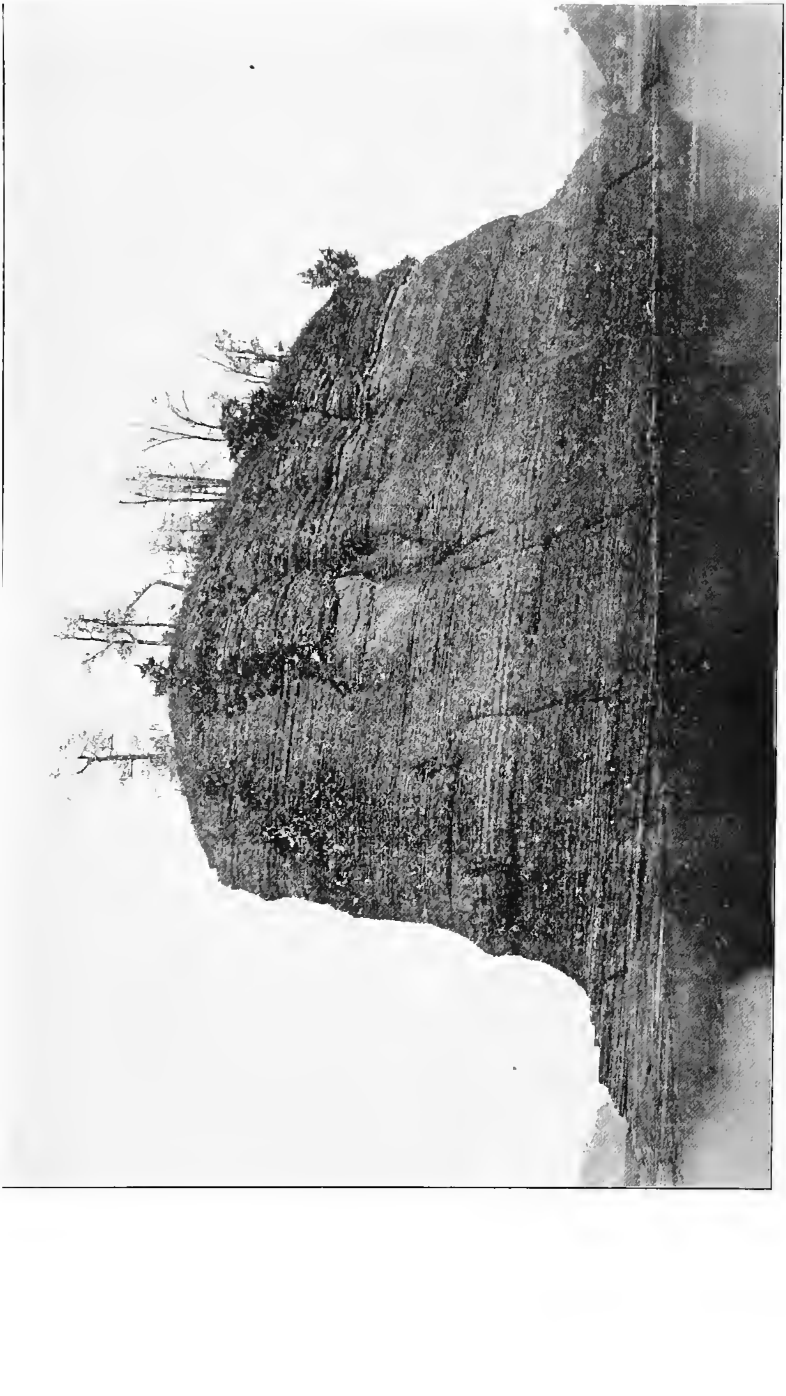
# CHAPTER VI.

# DEVONIAN DIVISION.

# SECTION OF DEVONIAN.



| Characteristic Fossils. | | Subdivisions. |
|---|---|---|
| Scalarituba missouriensis.<br>Orthothetes chemungensis.<br>Productella concentrica.<br>Cardiopsis erectus.<br>Crenipecten laevis.<br>Promacrus websterensis.<br>Tropidodiscus cyrtolites. | 7 | Hannibal Shales. |
| Plumulina gracilis.<br>Conopterium effusum.<br>Palaeacis enormis.<br>Zaphrentis acuta.<br>Ambocoelia minuta.<br>Chonetes geniculatus.<br>Cyrtina acutirostris.<br>Orthothetes lens.<br>Productella pyxidata.<br>Spirifer marionensis.<br>Syringothyris hannibalensis | 6 | Louisiana Limestone. |
| Barroisella subspatulata.<br>Leiorhynchus quadricostatum. | 5 | Genesee Black Shale. |
| Melocrinus gregeri.<br>Acervularia profunda.<br>Atrypa desquamata.<br>Productella callawayensis.<br>Spirifer annae.<br>Stropheodonta navalis. | 4 | Snyder Creek Shales. |
| Acervularia davidsoni.<br>Favosites hamiltonensis.<br>Zaphrentis gigantea.<br>Stromatopora expansa.<br>Atrypa reticularis. | 3 | Western Hamilton (Callaway) Limestone. |
| Alveolites goldfussi.<br>Amplexus yandelli.<br>Acervularia davidsoni.<br>Aulopora serpens.<br>Cystiphyllum americanum.<br>Diphyphyllum stamnia.<br>Pachypora pondrosa.<br>Phillipsastera verneuili.<br>Striatopora linnaeana.<br>Cystiphyllum sulcatum.<br>Stropheodonta demissa.<br>Rhipidomella vanuxemi.<br>Paracyclas elliptica.<br>Gomphoceras lunatum. | 2 | Corniferous Limestone. |
| Megalanteris condoni.<br>Rhipidomella musculosa.<br>Spirifer hemicyclus.<br>Spirifer worthenanus. | 1 | Oriskany Sandstone. |
| | | Delthyris Shaly Limestone. |
| | | Silurian. |



Grand Tower (Corniferous Limestone), Perry County.

## DEVONIAN.

Our Devonian Division consists of seven members, viz: 1, The Oriskany sandstone; 2, The Corniferous limestone; 3. The Western Hamilton beds including the Callaway limestone; 4, The Snyder Creek Shales; 5, The Genesee Black Shales; 6, The Louisiana limestone; 7, The Hannibal Shales. The second, sixth and seventh members of this Division are fairly developed and distributed in Missouri, but they have very little economic vaule, except along the Mississippi river where the Corniferous has yielded some limestone for flux and considerable rough material for river improvement.

## ORISKANY SANDSTONE.

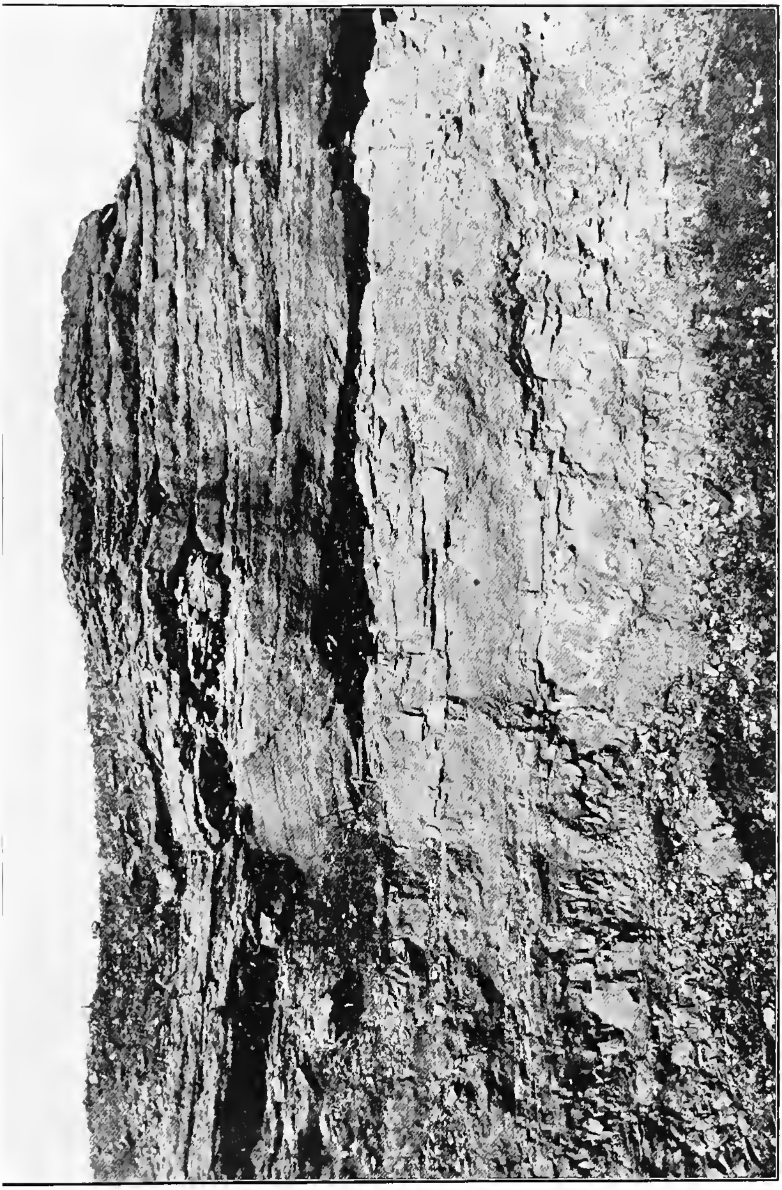
(Plate 41.) The Oriskany sandstone, or first member of our Devonian Division, occurs at the base of the famous Grand Tower in the Mississippi River, about one mile below Wittenberg. It has been reported in other localities in Missouri, but this Survey has not recognized it elsewhere in Missouri than at the base of the Grand Tower and in that immediate locality. The base of the Tower which projects out on the left, as seen in Plate 41, in time of low water, is made up of Delthyris Shaly limestone and Oriskany sandstone. The sandstone is a quartzite and has, therefore, shielded the less substantial Delthyris shales underneath from erosion and thus preserved the foundation of the Tower.

## CORNIFEROUS LIMESTONE.

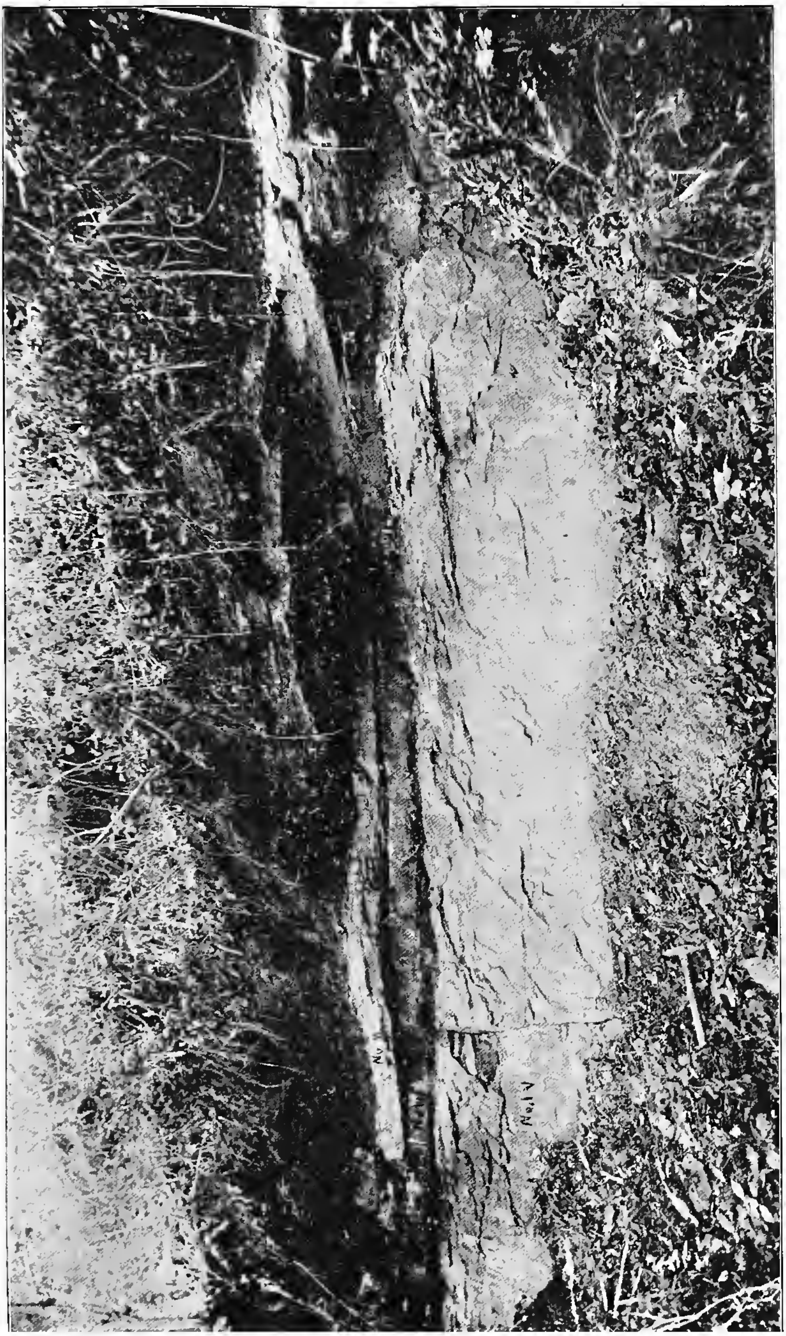
The Corniferous limestone, or second member of our Devonian Division, completes that noble monument, the Grand Tower, above the base, which latter is seen only in time of low water. The view, in Plate 41, was taken from the southwest side and the whole volume of the Mississippi River flows just to the right of the tower. Even in low water, there is an arrow channel between the Tower and the main land on the left in Perry County, Missouri, but there is scarcely any current in it and the whirlpool, in the main river on the east side of the Tower, tends to make a back current, or eddy, on the west side of the Tower. The Grand Tower marks the most picturesque spot in the whole track of the Lower Mississippi. The Tower is not the only interesting object in that locality, but it is the noblest landmark I can recall in any river track in the Mississippi Basin. The view in Plate 41 is looking up stream, of course, and the town of Grand Tower, Illinois, lies across the river to the right.

The Corniferous limestone occurs in many places, in northeastern Missouri. At the village of Sydney, or Shiel, in the northwest corner of Ralls County, the Survey collected some magnificent specimens of Acervularia davidsoni and Favosites hamiltonensis, from the Corniferous beds exposed at that place. Other good exposures occur in Warren and Montgomery counties.

(Plate 42.) The Corniferous limestone has also doubtless an extensive distribution around the northwestern margin of the White River basin. About two miles down the Kansas City and Memphis Railroad track from Cedar Gap, towards Mansfield, there is an interesting exposure of Coniferous lying in contact with the Fourth Calciferous. There is nothing in our geology more suggestive and interesting than contacts like that shown in Plate 42. The second member of the Devonian of Missouri lying in contact with the last member of the Magnesian Lens implies a wonderful story. The Black River limestone, the Trenton limestone, the Hudson River beds and all of the Silurian Division, together with the Oriskany sandstone, were either deposited there and removed before the deposit of the Corniferous, or else they were never deposited in that locality. That is a profound problem which remains to be solved. Complete records with the core-drill is



Corniferous on 4th Calciferous, Cedar Gap.



Snyder Creek Shales, Callaway County.

the only scheme I can conceive for solving such problems. There are doubtless many overlaps on the west side of the Ozark Range which will never be otherwise unfolded.

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## WESTERN HAMILTON BEDS.

In Callaway and adjoining counties are a few local deposits of a fine blue limestone which contains some of the Corals that are common to the Corniferous, but in addition thereto a distinct fauna, which correlates it with the Hamilton of the West. This rock has hitherto been known as the Callaway limestone, but it is undoubtedly the duty of a geological survey to eliminate all provincial names as soon as the rocks have been sufficiently studied to correlate them with their equivalents in other provinces that have been more thoroughly worked.

Although the Hamilton (Callaway) limestone contains an interesting fauna, it has no economic value. It occurs in small lenses, which are dispersed in Callaway and two or three other counties, but is not used for any economic purpose.

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## SNYDER CREEK SHALES.

(Plate 43.) Following immediately after the Hamilton limestone are the Snyder Creek Shales, another Devonian deposit which is limited almost exclusively to Callaway County. Plate 43 shows several important rocks, in their natural order of occurrence, but poorly developed.

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## GENESEE BLACK SHALE.

Under the Louisiana limestone, in Lincoln, Pike and Marion counties, the Genesee Black shales are exposed in many places. This member is also reported in southwest Missouri, but it has not reached a very great development anywhere in the State. It also has an interesting fauna, but no economic value.

## LOUISIANA LIMESTONE.

Next to the Corniferous, the most important and persistent member of our Missouri Devonian is the Louisiana limestone. On account of its exceedingly fine texture, this rock was originally known as the Lithographic limestone. However, after several attempts to locate true lithographic stone in this member, it took the name of Louisiana limestone, after the substantial old river town in Pike County, where it was first studied.

The Louisiana limestone is widely distributed in Lincoln, Pike, Ralls and Marion counties and is fairly well developed in Cooper, Saline and Pettis counties. Indeed, the Louisiana limestone and Hannibal shales are usually present at the base of the Chouteau. The Survey has had this rock tested for native cement, but analysis shows that it consists of 95 per cent. Lime carbonate and only 5 per cent. argillaceous matter.

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## HANNIBAL SHALES.

(Plate 44.) The Hannibal Shales form the closing member of our Devonian Division. This member has no economic value whatever. However, it represents a transition period of muddy seas between the Devonian and the Bed Rocks of the Coal Measures. It is only two or three feet thick, but very persistent between the Louisiana limestone and the Chouteau beds in the Lamine River Valley, in Cooper and Pettis counties.

Hannibal Shales, Hannibal, Marion County.

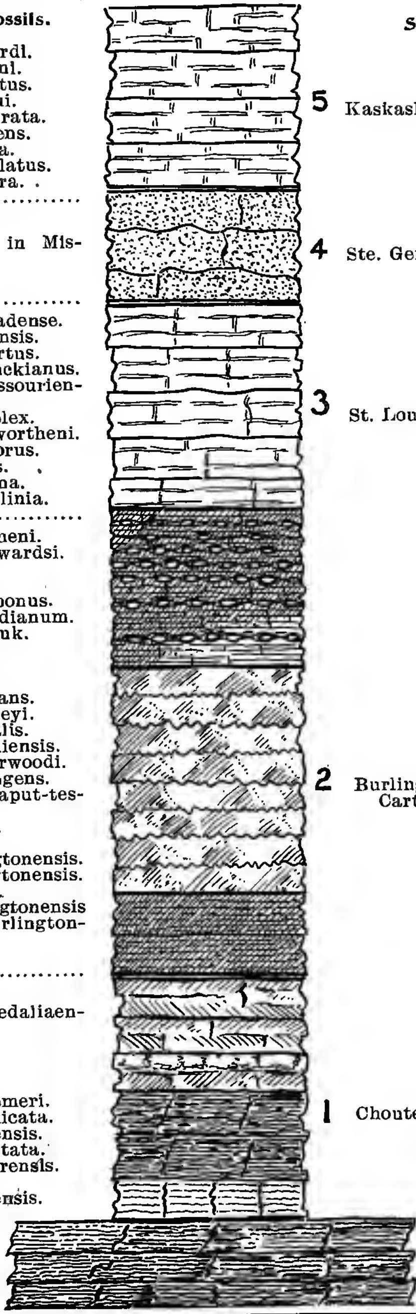
# CHAPTER VII.

# SUBCARBONIFEROUS

OR

# BED-ROCKS OF THE COAL MEASURES.

# SECTION OF SUBCARBONIFEROUS.



| Characteristic Fossils. | | Subdivisions. |
|---|---|---|
| Acrocrinus shumardi.<br>Pentremites godoni.<br>Pentremites sulcatus.<br>Zeacrinus wortheni.<br>Seminula subquadrata.<br>Spirifer increbescens.<br>Spiriferina spinosa.<br>Productus fasciculatus.<br>Reticularia setigera. | 5 | Kaskaskia Limestone. |
| Not fossiliferous in Missouri. | 4 | Ste. Genevieve Sandstone. |
| Lithostrotion canadense.<br>Zaphrentis pallaensis.<br>Granatocrinus curtus.<br>Pentremites koninckianus.<br>Scaphiocrinus missouriensis.<br>Talarocrinus simplex.<br>Archaeocidaris wortheni.<br>Melonites multiporus.<br>Oligoporus parvus.<br>Fenestella banyana.<br>Glyptopora michelinia. | 3 | St. Louis Limestone. |
| Archimedes wortheni.<br>Aviculopecten edwardsi.<br>Spirifer keokuk.<br>Spirifer kelloggi.<br>Chonetes planumbonus.<br>Chonetes shumardianum.<br>Murchisonia keokuk.<br>Griffithides bufo.<br><br>Amplexus blairi.<br>Hadrophyllum glans.<br>Syringopora harveyi.<br>Zaphrentis centralis.<br>Bellerophon sedaliensis.<br>Granatocrinus norwoodi.<br>Camarophoria ringens.<br>Camarophoria caput-testudinis.<br>Acambona prima.<br>Eocidaris blairi.<br>Polypora burlingtonensis.<br>Dielasma burlingtonensis.<br>Dielasma rowleyi.<br>Productus burlingtonensis<br>Rhipidomella burlingtonensis.<br>Spirifer grimesi. | 2 | Burlington-Keokuk or Carthage Limestone. |
| Chonophyllum sedaliaensis.<br>Leptopora typa.<br><br>Schizoblastus roemeri.<br>Ptychospira sexplicata.<br>Pugnax missouriensis.<br>Pugnax striaticostata.<br>Reticularia cooperensis.<br>Spirifer latior.<br>Spirifer missouriensis. | 1 | Chouteau Beds. |
| | | Hannibal Shales. |
| | | Devonian. |

Burlington-Keokuk, on Choteau, mouth of Sac River.

## SUBCARBONIFEROUS (Precarboniferous).

From an economic point of view, at least, our Subcarboniferous Section is far more important and interesting than either the Silurian or Devonian Divisions. That our Subcarboniferous (Bed-Rocks of the Paleozöic Coal Measures) ought to be regarded as a distinct geological period or division, is clearly shown by the absolute unconformity of the Paleozoic Coal Measures with these Bed-Rocks. We have ample proof that a vast deal of folding and erosion had taken place in the Bed-Rocks before the Coal Measures were deposited. And there is very little in common between the Bed-Rocks and the Coal Measures.

Our Paleozoic Coal Measures rest on all of the different members of our Subcarboniferous section and that is about the sum total of their relations. A few fossil genera have persisted throughout the Bed-Rocks and the Coal Measures, but the same may be said of nearly any other two consecutive geological periods. Hence that argument carries no weight. However, Subcarboniferous is an established term in our nomenclature and there seems to be no alternative but to describe the Precarboniferous or Bed-Rocks under one head and the Coal Measures under another.

This section of the geological record consists of five members, viz.: 1, The Argillaceous Chouteau Beds; 2, The Burlington-Keokuk or Carthage limestone; 3, the St. Louis limestone; 4, the Ste. Genevieve sandstone; 5, the Kaskaskia limestone.

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## CHOUTEAU BEDS.

(Plate 45.) The Chouteau, or bottom member of our Subcarboniferous section, has a wide distribution but very little economic value. It seems to have the requisite physical characters for making a good native cement, but for some unaccountable reason that important industry has received very little attention in Missouri. If systematic and exhaustive tests were made, there is very little doubt but that some one of our long list of argillaceous limestones would yield the raw material for a good native cement and a very profitable business.

However, the most important feature about the Chouteau now, is the fact that it forms the impervious floor to the "open ground," or reconstructed channels, in the overlying Burlington-Keokuk—the third great country rock in Missouri. The Chouteau, like the immense beds of cotton rock, in the Second, Third and Fourth Calciferous, is a close structured mud-rock. Either one of them is better adapted for the impervious floor of "open ground," or reconstructed channels, than for receptacles of water concentrations of the metallic ores.

Recalling the Basal sandstones of the First Cambrian and First Calciferous, it is an obvious fact that they were not originally impervious. Those rocks were originally fine-grained and close textured sandrocks. But no purely quartzose sandrock is absolutely impervious. Under the ore-bodies, however, those basal sandstones have absorbed mineral solutions (sulphides) until they have become practically impervious, to a depth of several feet. You could scarcely recognize a specimen of Basal sandstone thus saturated with mineral solutions. The sulphides fill the voids between the once pure quartz grains and give the sandstone the appearance of a mud-rock. But the Chouteau was always an impervious rock, by reason of its intensely argillaceous character.

Between Pittsburg and Weaubleau, in Hickory County, the Survey found several parties drilling and digging in the Chouteau beds, and in the cotton rock of the Third Calciferous, for ore bodies. Again on Weaubleau Creek, in St. Clear County and at Roscoe, people were digging in Chouteau for lead and zinc ores. The nearest that Chouteau ever came to being the country rock or receptacle of a profitable ore body is at Wilson's place, about four miles east of Weaubleau, on the Hermitage road.

At that particular spot, the zinc, held in a fissure of the once overlying Burlington-Keokuk, has been precipitated in the open structure caused by a leaching out of the upper surface of the Chouteau, in the creek bed, which now marks the site of the once overlying fissure. Some rich specimens of zinc sulphide occur in the upper surface of the Chouteau in that creek bed, but they penetrate the Chouteau only a few inches in spots and are not found on either side of the creek bed.

There are large areas of Burlington-Keokuk in the southwestern part of Hickory County, in which profitable ore bodies might be found, if the people would explore its open structure. But they have heretofore wasted their energy on the Chouteau beds and the cotton rocks of the Third Calciferous. The most probable country in Hickory County for profitable ore bodies is in the First Calciferous of the Little Niangua Valley, in the eastern edge of the county.

With few exceptions, the Chouteau occurs in every locality in the State in which the Bed-Rocks of the Coal Measures are exposed. In the exposures of the Burlington-Keokuk, shown in Plates 45, 46 and 47, Chouteau forms the base. In fact, Chouteau is present at the base of the Burlington-Keokuk, at nearly every exposure of the latter named rock, in a wide zone from Marion County to the southwest corner of the State. It is especially well developed in Cooper, Saline and Pettis counties and is constant at the base of the Burlington-Keokuk in the James River and Spring River valleys, in southwest Missouri. In short, the argillaceous Chouteau forms the impervious floor to all of the "open ground," or reconstructed channels in the wall rock, or country rock, of southwest Missouri. And that is its chief function now, in the geology of Missouri.

Our Chouteau beds are the equivalent of the massive oolitic limestone, quarried so extensively at Bedford, Indiana. Our Chouteau is, however, too argillaceous to be oolitic. It carries some fine grained, siliceous layers, or lenses, about Monegaw Springs, in St. Clair County, that are said to be good material for abrasive purposes. But beyond its possibilities as a cement rock, the part it plays as the impervious floor to the "open ground" in the Burlington-Keokuk is now the most interesting thing about our Chouteau.

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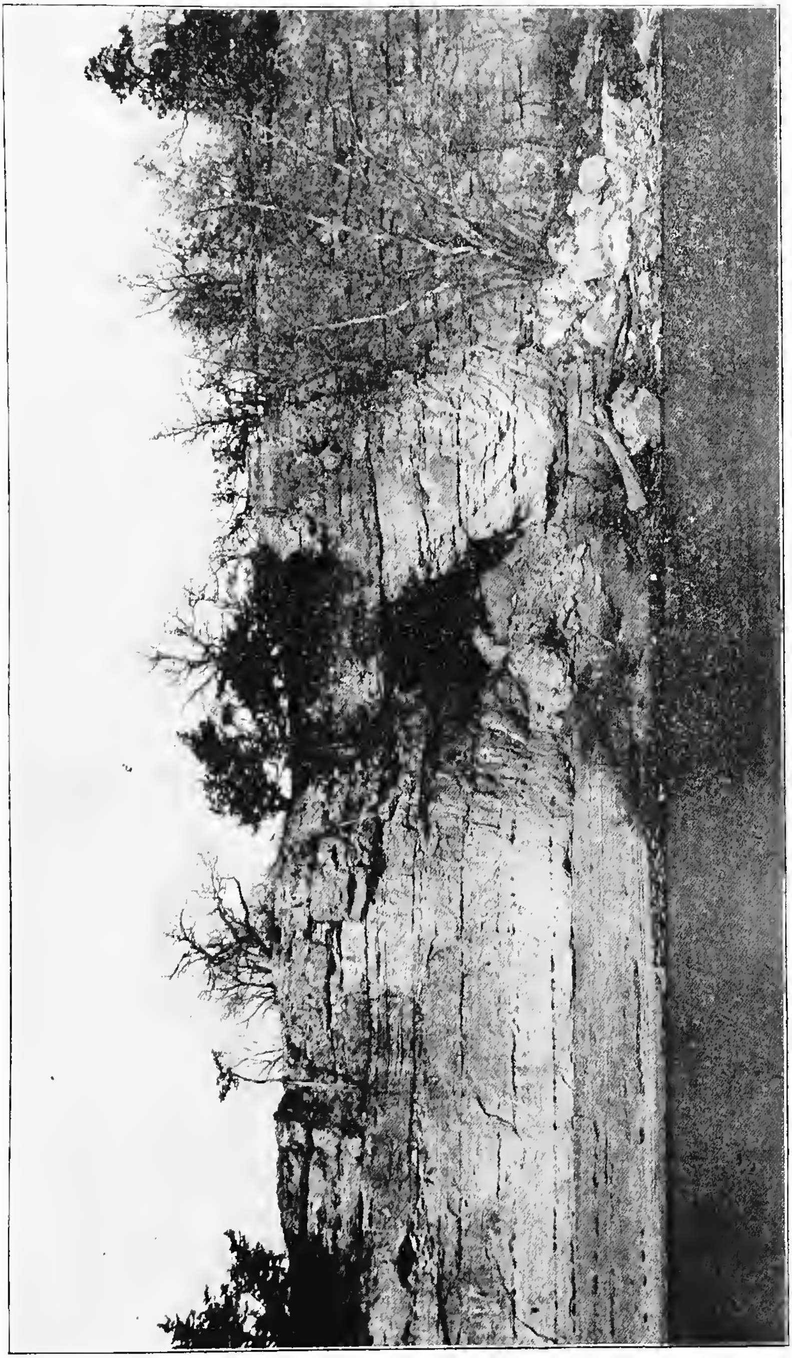
## BURLINGTON-KEOKUK.

(Plate 46.) The Burlington-Keokuk or Carthage limestone is the second member of our Subcarboniferous section and the third great country rock of Missouri. I mean, of course, that it is the third great country rock with reference to age. In its greatest development, the Burlington-Keokuk is possibly two hundred and fifty feet thick, but its average thickness is about one hundred feet. As shown in the sketch of vertical section. it is a three-fold rock. In other words, it consists of three divisions that are radically unlike each other.

This member has been heretofore described as two distinct formations, with certain fossil genera in common. But the Survey has been tracing it and observing it closely from Clark County, in the northeast corner, to McDonald County, in the southwest corner of Missouri. The Geode beds, at the top of the typical Keokuk in Clark County, seem to have their equivalent in the cherty and uncrystalline blue limestone, at the top of the crystalline country rock, in the Spring River Valley. The massive crystalline or middle Burlington-Keokuk is less argillaceous and a little more crystalline at La Grange than at the Des Moines River. Ten miles further south and near Maywood it becomes typical Burlington.

Where it occurs as typical Burlington, its basal member is more argillaceous and darker than its massive middle member. It is quite possible that the alternating characters of the Burlington-Keokuk are due partly to the alternate thickening up and thinning out of its different members. But its alternating lithologic and fossil characters are doubtless due mainly to different physical conditions in different zones at the time the sediment was deposited which produced it.



Rock of Ages (Burlington-Keokuk), Osceola.

This rock has had as wide a distribution as any other member of our geological record. In many localities where the Burlington-Keokuk has been decomposed and removed for thousands of years its cherts persist, as surface rocks, to show that it once existed. It is easy to conceive that a crystalline limestone so widely distributed as the Burlington-Keokuk could have been more crystalline in certain zones and more argillaceous in others. Such alternating physical conditions at the time of its deposit would naturally have produced the alternating lithologic and fossil characters that are now peculiar to it.

Notwithstanding its alternating characters, the Burlington-Keokuk rests on the argillaceous Chouteau, wherever the latter occurs, and reaches continuously from the Des Moines River to the southwest corner of Missouri. Besides the important part it plays as the wall rock, or country rock, of all the profitable ore bodies in southwest Missouri, it is the greatest lime rock in Missouri, because it has the widest distribution and is, therefore, the most available limestone for the manufacture of lime. Furthermore, it yields the finest building stone and more of it than any other limestone in Missouri.

The Carthage limestone has been on the market long enough to have been thoroughly tested, for durability as a building material, as well as constancy of color. For a high grade building stone, there seems to be nothing wanting in that rock, except possibly massive structure. Its stylolite bedding seams, common to that rock wherever it occurs, come rather too close together to admit of massive blocks being produced from its quarries. However, its beds are thicker in some other localities than those in which it is now being quarried.

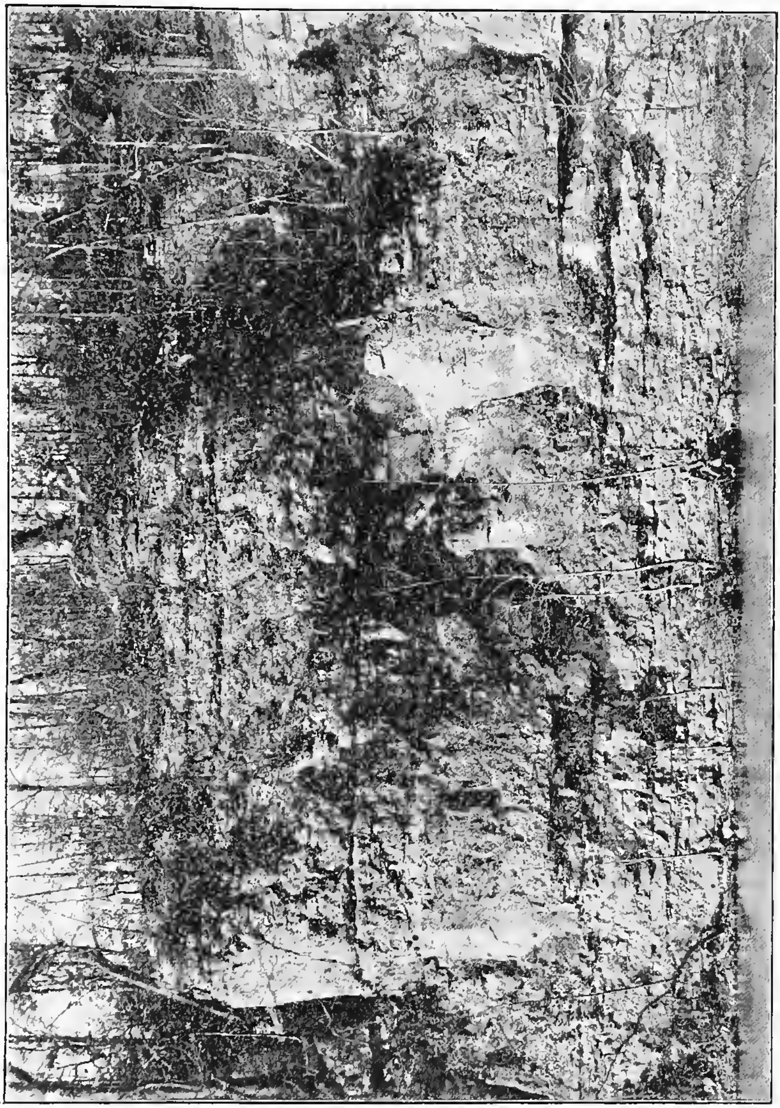
In the Black Water Valley, in Saline County, this rock is well developed in many places. There is a good exposure of typical Carthage limestone in the river bluff at the lower end of the city of Boonville. Another near Troy, in Lincoln County. Between Rocheport and Providence, in Boone County, Burlington-Keokuk forms the river bluffs for many miles and there is little doubt but that a splendid quarry might be developed in that locality.

The Burlington-Keokuk is the famous "Mountain Limestone" and "Encrenital Limestone" of the old geologists. It was well named Encrenital Limestone, because it contains more crinoid relics than any other rock. The products of crinoid relics are invariably crystalline. In fact, most of the commercial marble quarried in the Mississippi Basin is from the massive crystalline beds of the Burlington-Keokuk or Carthage limestone.

The reconstruction of the Burlington-Keokuk, in narrow zones along its numerous lines of fissure, by magnesian water, or mineral solutions, from the Magnesian Lens, is something marvelous. Those reconstruced channels are usually narrow zones coincident with the original joint structure in the country rock. The Face Joint system with a southwest northeast trend, is usually best developed and most of the great fissures and dislocations in the rocks are on that system. But the Head Joint system, with a southeast northwest trend, is sometimes best developed locally.

In the Spring River Valley, in southwest Missouri, fissure development on both systems of primary joints is well illustrated in the different mining camps. At Stott's City, in Lawrence County, for example, the trend of the reconstructed zone is coincident with the head joints in the country rock, or southeast-northwest. In the valley, between Webb City and Carterville, there is reconstructed country on both systems of joints and in that particular locality the areas of "open ground" or reconstructed country are greater than the "Bars," or isolated masses of original country between them.

In the Spring River Valley, the uncrystalline, blue, upper Burlington-Keokuk, has reached its greatest development near the head of Spring River, between Verona and Mt. Vernon, in Lawrence County and about Neosho in Newton County. It occurs, however, in local zones dispersed over the whole valley. Where the Burlington-Keokuk occurs in its full development, the lower section of about one hundred feet is an intensely



Burlington-Keokuk, James River, Green County.

crystalline and cavernous rock. It rests on the argillaceous Chouteau base and is the wall rock or country rock of the ore bodies.

The upper section of about one hundred feet is an uncrystalline, cherty, blue limestone that has no open structure and does not contain any important ore deposits. This upper, uncrystalline and barren limestone bears the provincial name of "Cap-Rock" in the Spring River Valley. In eroded valleys, basins or zones, wherein "Cap-Rock" is gone, it is neither difficult nor expensive to locate "open ground" or reconstructed country. But in other places, where "Cap-Rock" is present in its full development, locating narow zones of reconstructed country under it, is a serious problem. Nor does it necessarily follow that a great ore body will be found when reconstructed country has been located. Indeed, if all of the "open ground" in the Burlington-Keokuk in Missouri had been filled with metallic ores she would have been a prodigy. With her Magnesian Lens, or "mother lode," and her three great country rocks she is already unique.

(Plate 47.) The Valley of the St. James River, in Webster, Greene, Christian and Stone counties, contains many promising spots for future development. The physical conditions in the valley of the James, from its source in Webster County to the north end of Stone County, are practically the same as in the Spring River Valley, except that the uncrystalline "Cap-Rock" either never existed, or has been weathered off, in the James River invert. Hence, the ore bodies may be expected closer to the surface generally. It is always safe to calculate that the ore bodies will stop on the impervious Chouteau. From Ozark to Sparta, the surface indications are very favorable for rich and shallow ore bodies.

There has been considerable wild speculation about the ore bodies extending down, below the country rock, in the Burlington-Keokuk country. The lower crystalline Burlington-Keokuk is the wall rock or country rock of the ore bodies and it rests on the impervious, argillaceous Chouteau. And the Chouteau rests on other argillaceous rocks. Where the churn-drill has pounded a hole down through a body of free ore and loose matrix it would be only natural for pieces of ore to drop down as long as drilling continued in that hole. Moreover, it is a well known fact that the ground does not require casing and it is, therefore, never cased. Hence the churn-drill data, collected in that country, is totally unreliable.

The most significant thing about the ore bodies in the Spring River Invert, that I have observed, is the fact that they are slowly gravitating, with the subdrainage, from northeast to southwest. As the water finds new tracks at lower levels and the more superficial deposits are deserted by the water, by being left above permanent water level, they are exposed to reagents and gradually altered from primary sulphides to secondary oxides and tertiary silicates or carbonates. The metallic value, lost in the alteration of a primary sulphide to an oxide, silicate or carbonate, is carried down and forward with the subdrainage and added to ore bodies that are in process of growth further westwards. This fact is fully demonstrated.

The obvious fact that the trend of subdrainage in the Spring River Invert has been always from northeast to southwest and has never been reversed or materially altered is the best explanation that can be found for the greater concentrations of metallic elements in that zone than in the Osage Basin, to the north of it. The surface and subdrainage lines of the Osage Basin were reversed by the later development of the Rocky Mountains and the conditions in that area of west central Missouri have tended to disperse rather than concentrate the metallic elements. The ore bodies are invariably in process of degradation. But not so in the Spring River Invert.

## ST. LOUIS LIMESTONE.

(Plate 48.) The third member of our pre-Carboniferous sectiton is the St. Louis limestone. It is the Bed-Rock of the Coal Measures in north central and northeast Missouri. It

St. Louis Limestone, Cliff Cave, St. Louis County.

is also the Bed-Rock of the middle invert of the Illinois coal field which extends into Missouri about St. Louis. This rock has reached its greatest development along the Mississippi River front, between the mouth of the Missouri and the mouth of the Meramec. Its cliffs are especially imposing, along the river front, two or three miles south of Jefferson Barracks.

The St. Louis limestone has yielded nearly all of the native stone for rough masonry in St. Louis. The underlying Burlington-Keokuk comes to the surface a few miles west of the city, but the St. Louis limestone, lying close to the surface over nearly the whole area of the city, has naturally yielded the bulk of the material for rough masonry in that city. And it is safe to say that the casual observer does not see more than one-half of the material which enters into the construction of a city.

That the St. Louis limestone was one time widely distributed in Missouri is shown by the occurrence of its ponderous silicified coral, Lithostrotion canadense, in many different localities whence the rock itself has been long since removed. The St. Louis limestone is exposed at the base of the Coal Measures in many places in Clark, Lewis and Knox counties. In Knox County especially there are several exposures of this Bed-Rock deeply marked by the drag of glacial drift across it. Those marks show, of course, the direction in which the glacial drift moved, from northeast to southwest, in that zone.

False bedding is one characteristic of St. Louis limestone which is rather an unusual structure in limestones. Along the old river front, two or three miles below Ste. Genevieve, the false bedding structure in the St. Louis limstone is very prônounced. And at one of the Ste. Genevieve quarries, St. Louis limestone has developed an intensely oolitic texture. The latter character has, however, been developed in a great many of our rocks and suggests an advanced stage towards decomposition rather than an improvement in the texture of any rock.

## STE. GENEVIEVE SANDSTONE.

(Plate 49.) The Ste. Genevieve sandstone or fourth member of our Pre-Carboniferous or Subcarboniferous section is somewhat widely distributed in the eastern part of the State. But it has never been utilized extensively except in the construction of the Eads Bridge, at St. Louis. The view, in Plate 49, was taken at the south end of the old quarry some four miles below Ste. Genevieve, on the old river front. Since the Eads Bridge was built, however, the river has shifted away to new channel to the northeast and left the old quarry two or three miles inland.

The intensely yellowish brown color of the Ste. Genevieve sandstone has doubtless prevented it from becoming a popular building stone. Barring its unpopular color, it is massive, easily quarried and a substantial building material. But it is no longer used except for construction work on the Chester, Perryville and Ste. Genevieve Railroad.

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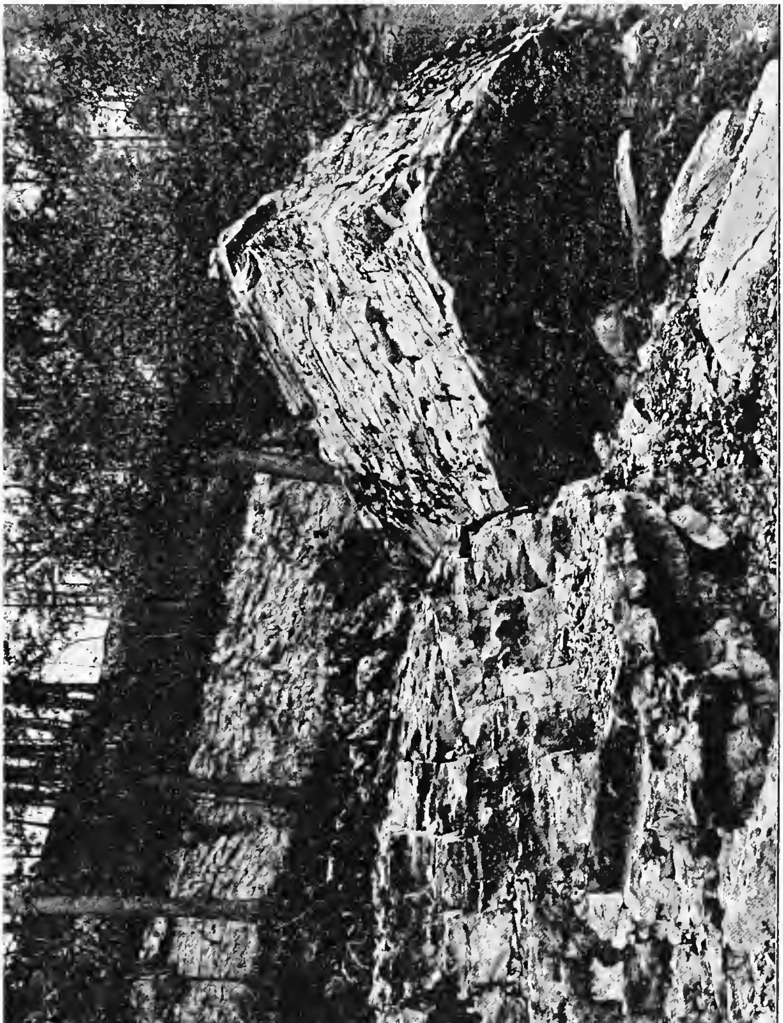
## KASKASKIA LIMESTONE.

(Plate 50.) The Kaskaskia limestone is the fifth and last member of our Subcarboniferous section. The fact that it was one of the Bed-Rocks of our Paleozoic Coal Measures and is not now a Bed-Rock under and portion of our productive coal field is one of its interesting features. Along the river front of Perry County and a portion of Ste. Genevieve County the Basal Sandstone of the Coal Measures rests on Kaskaskia limestone. It is also reported in some small areas in Jasper and Newton counties. But in both of these localities the Coal Measures have been weathered off, or removed by erosion.

Another interesting feature of the Kaskaskia limestone is the recurrence in it of the Bryozoan archimedes. That beautiful organic form seems to have reached its zenith of develop-

Ste. Genevieve Sandstone, Ste. Genevieve County.



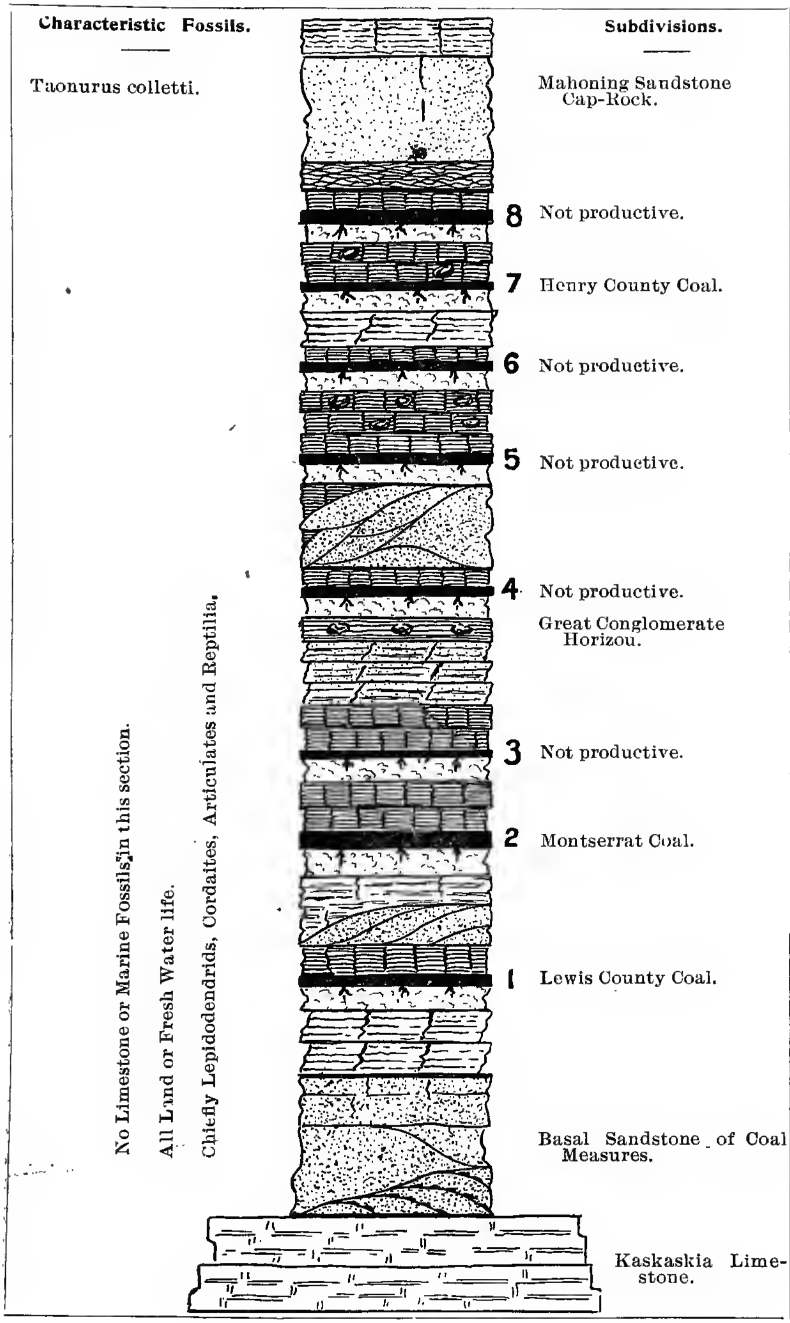
Kaskaskia Limestone, Perry County, near St. Mary's.

ment in the later horizons of the Burlington-Keokuk and to have reappeared at the close of the period of deposit of the Kaskaskia limestone. There is little doubt but that a profitable quarry might be developed in this rock between St. Mary's and Lithium, but it is not being used except for Railroad "ballast." The survey has collected many beautiful specimens of Pentremites and Bryozoa from the Kaskaskia limestone between St. Mary's and Landing Seventy-six, in Perry county.

## CHAPTER VIII.

# LOWER COAL MEASURES.

# SECTION OF LOWER COAL MEASURES.



## PALEOZOIC COAL MEASURES.

Our Paleozoic Coal Measures reach a total depth of about fifteen hundred feet. With the Forest City Lens or Post-Carboniferous section added, they reach the extraordinary depth of about eighteen hundred feet. But there is nothing strange about that, when it is known that our coal field lies in four different parallel zones on the western slope of the Ozark Range. Slope is not a good word to use, in describing the base of our Coal Measures, but it is sometimes hard to think of a word that will convey two or three different aspects of the same thing. If our Coal Measures were removed and the base were left, intact, it would not be a slope, but three great terraces curving around the eastern side of its deepest abyss, like the terraces in the floor of an amphitheatre.

On each terrace in the base lies a zone, in which the Coal Measures are individualized, with reference to depth. To make it plainer, I will say that in the first, or Chariton zone, the depth from surface to bed-rock is nowhere more than three hundred feet; in the second, or Grand River zone, the depth from surface to bed-rock is nowhere more than eight hundred feet; in the third, or Platte River zone, the depth from surface to bed-rock is nowhere more than thirteen hundred feet; in the fourth, or Forest City zone, the depth from surface to bed-rock is nowhere more than eighteen hundred feet. In other words, going westward from the eastern margin, the Coal Measures, in each one of these zones, are from three to five hundred feet thicker than they are in the next zone on the east of it. Moreover, each terrace in the base lies much the lowest in a transverse zone, about coincident with the track of the Missouri River.

The obvious facts in this case are as follows, viz.: The dislocation of three to five hundred feet in the bed-rocks, between the Chariton and Grand River zones, is vividly displayed in the Missouri River bluffs at Miami and White Rock. The town of Miami, in Saline County, rests on the Burlington-Keokuk limestone, in the south bank of the Missouri River. Three miles away, on the opposite side of the river track, in Carroll County, and about equally high above water level in the river, White Rock sandstone quarries are in the great alternating filler which lies on the second horizon of the Middle Coal Measures. The Basal sandstone, all of the Lower Coal Measures and two horizons of the Middle Coal Measures lie between the Burlington-Keokuk bed-rock and the great alternating filler in which the White Rock quarries are situated.

The other two dislocations are not exposed, for the simple reason that they should have been developed and were developed before the rocks now in sight were deposited. One of them lies along the east side of the Platte Valley, the other between the Platte and the Nodaway rivers. Furthermore, the same coal horizon (third of the Middle Coal Measures) worked at Marceline, Brookfield, Trenton and Tom Creek (near Hamilton) lies at about the same depth from the surface. And the floors of all those mines lie practically level. At the Brush Creek Mine, in Jackson County, and in the same zone, the same coal horizon lies about eighty feet deeper in the ground.

At the Randolph Shaft, in Clay County, where the mine was in the Second horizon of the Middle Coal Measures, at a depth of four hundred feet below the top of the Parkville limestone, in the north bluff of the Missouri River, the floor of the mine was rising towards Leavenworth. At Leavenworth, Kansas, where the mines are in the same second horizon of the Middle Coal Measures, the floors of the three mines along the river front are dipping towards Randolph; and yet they are seven hundred feet below the bed of the Missouri River. These are not all of the obvious facts in this case, but I trust they are sufficient.

For different reasons our Coal Measures are differentiated in three sections, viz.: 1, the Lower Coal Measures, embracing the Basal sandstone, eight coal horizons and the Mahoning sandstone for Cap-Rock; 2, the Middle Coal Measures, resting on the Mahoning sandstone and embracing twelve coal horizons, with the Bethany Falls limestone for Cap-Rock; 3, the Upper Coal Measures, resting on the Bethany Falls limestone and embracing nine coal horizons, with the Quitman limestone for Cap-Rock.

Before proceeding to delineate the three sections, however, I will say that the difference in the depths of our four coal zones, from surface to bed-rock, is largely accounted for in the increased thickness of the alternating fillers, between regular coal horizons, in each zone going westwards. For example, the alternating filler in which the White Rock quarries are situated, is usually about twenty feet thick in the Chariton zone; about eighty feet thick in the Grand River zone; about one hundred and fifty feet thick in the Platte River zone.

That one fact shows there was greater subsidence during the Coal period, in the Platte River zone, than in the Chariton zone. Moreover, it effectually knocks out the "oscillation" theory of coal deposit. Inasmuch as the alternating fillers, between coal horizons, clearly represent land sediment carried into the depressed area, to fill it up and thus bring it back to land surface, I cannot discover any sense whatever in the "oscillation" theory.

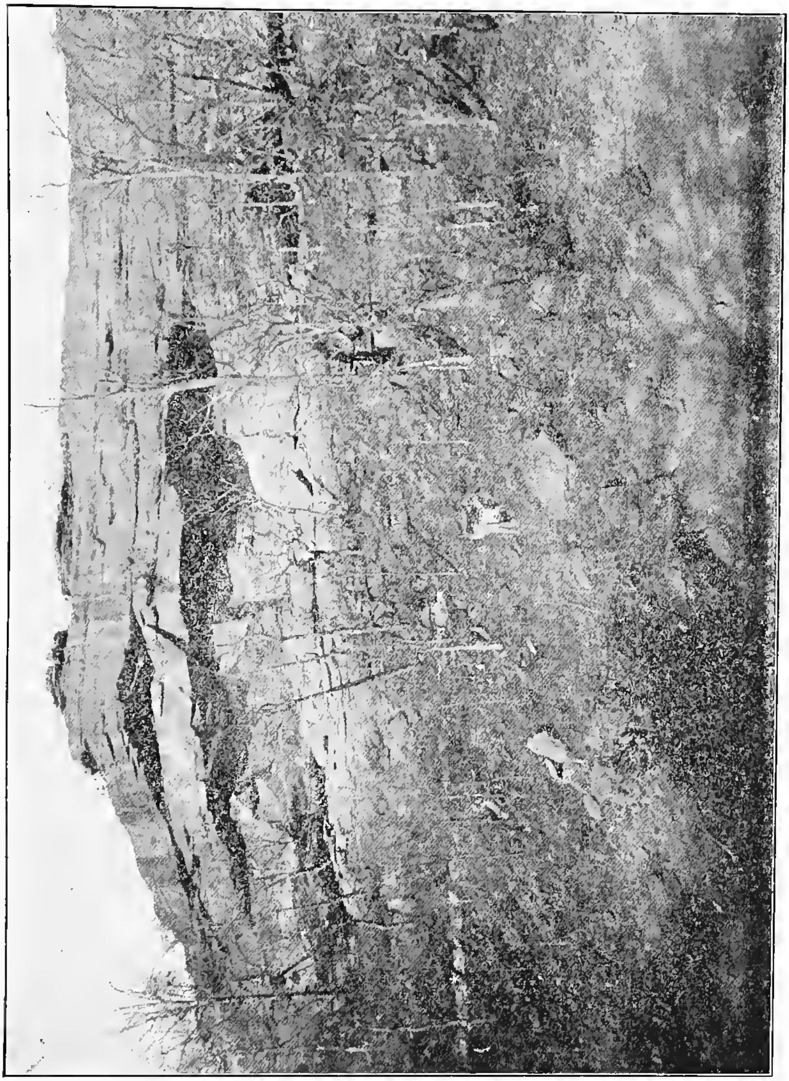
In fact, our thickest coal is in the Chariton zone, where the alternating fillers between coal horizons are the thinnest. Our thinnest coal is in the Platte River zone, where the alternating fillers between horizons are the thickest. That shows the development of the dislocations in the bed-rocks to have been a slow process or an intermittent subsidence of the floor of one great invert, on which each one of the lower members of our Coal Measures was deposited contemporaneously in the different zones.

The facts show that all of the movements in the bed-rocks were downward. The different mass or zones, like the individual blocks in an arch or invert, were gradually readjusting themselves to shorter lines of curvature, as the floor of the whole coal field went down intermittently during the period of coal deposit. The alternating fillers, between regular coal horizons, are made up of land sediment, carried in to fill up the variously depressed area and thus bring it back to land surface; so the cumulative coal forests might grow in the Sunlight and accumulate the requisite plant debris for the coal beds of another coal horizon.

More time and sediment were requried to fill up the deeper depressed zones of one great invert and that explains why our coal beds are thicker in the Chariton or eastern zone. It also explains why the alternating fillers between coal horizons are thickest in the Platte River zone. I do not mention such details in the Forest City zone, because it has not been explored. The cumulative coal forests must have grown in the Sunlight. Their debris must have been preserved from decomposition, by the water in which it was immersed, and have been buried under sediment, one horizon after another, until intermittent subsidence and other requsite conditions of coal deposit had ceased.

## LOWER COAL MEASURES.

(Plate 51.) The Lower Coal Measures rest on the Basal sandstone and are capped by the Mahoning sandstone. In other words, when fully developed, our Lower Coal Measures embrace the Basal sandstone, eight coal horizons and the Mahoning sandstone f r Cap-Rock. The Basal sandstone is, therefore, the first member of our Lower Coal Measure section. In west-central, northeast and southeast Missouri, the Basal sandstone is often found denuded of all overlying beds. In fact, this is true of the Spring River Invert in southwest Missouri. A zone of the Basal sandstone begins somewhere in the north-central portion of Greene County and extends nearly to Aurora, in Lawrence County. It suggests a trough or basin in the Bed-Rocks and a good place to prospect for ore bodies.



Basal Sandstone of Coal Measures, Monegaw Springs, St. Clair County.

Basal Sandstone of Coal Measures, Perry County.

The Basal sandstone at Monegaw Springs, shown in Plate 51, is resting on Burlington-Keokuk. In all southwest Missouri, the Basal sandstone of the Coal Measures is resting on Burlington-Keokuk or Carthage limestone. In Henry, Pettis, Johnson and Saline counties the Basal sandstone is seen in many places resting on Burlington-Keokuk. The reader should not lose sight of the fact that the Burlington-Keokuk is only the second member of the so-called Subcarboniferous section or Bed-Rocks of the Paleozoic Coal Measures. It is safe to say that fully one-third of the whole area of Missouri Coal Measures rests on Burlington-Keokuk.

In north-central and northeast Missouri, the Basal sandstone of the Coal Measures rests on the St. Louis limestone. It also rests on the St. Louis limestone in the vicinity of St. Louis. Along the Wabash Railroad track, between Ferguson and St. Louis, and at several places in the southwestern portion of that city, the Basal sandstone is exposed. Indeed, I can remember when coal was mined immediately south of Tower Grove Park. And the Lower Coal Measure fire clays, mined in that locality, are the basis of a great industry now. Again, it is safe to say that one-third of the whole area of Missouri Coal Measures rests on the St. Louis limestone.

(Plate 52.) In Perry County, where the Big Muddy Invert of the Illinois coal field once extended far into Missouri, the Basal sandstone of the Coal Measures is resting on the Kaskaskia limestone or fifth member of the so-called Subcarboniferous or Bed-rocks of the Coal Measures. The Big Muddy Invert of the Illinois coal field once covered a large portion of Perry and Ste. Genevieve counties. But the Coal Measure rocks have been removed, all except the Basal sandstone, by the letting down of the track of the Mississippi River. Hence we have, along the river front of Perry County, some splendid exposures of the Basal sandstone of the Coal Measures resting on the Kaskaskia limestone.

The magnificent view of the Basal sandstone of the Coal Measures, shown in Plate 52, was taken about four miles above Grand Tower and in Perry County, Missouri. The exposure is opposite Fountain Bluff, Illinois, where the Basal sandstone has reached its greatest development. Under the Basal sandstone, shown in Plate 52, is a splendid exposure of the Kaskaskia limestone, but we could not get both rocks in one photograph. Those Bed-Rocks, standing on the Missouri side, are instructive monuments to show us that the destruction of a vast and valuable area of coal field has been wrought by the slow but inevitable letting down of a great river.

When fully developed, our Lower Coal Measure section embraces the Basal sandstone, eight coal horizons and the Mahoning sandstone for Cap-Rock. That suggests a definition of the term—coal horizon. The Paleozoic soil, or mud, on which the cumulative coal forest grew or rested, is, logically, the first member of a coal horizon. The coal bed, itself, representing the cumulative coal forest which must have grown and flourished in the divine light of our Sun, is logically the second member. The first argillaceous sediment that fell on the sunken mass of forest debris and is now represented by the roof shale or coal slate, as you prefer to call it, is logically the third member. Then, if the conditions of subsistence were such that sufficient sand or fine mud and organic products were precipitated on top of the first argillaceous sediment, to produce a persistent Cap-Rock it is, logically, the fourth member.

A few coal horizons have no persistent cap-rock, but most of them have. In fact, all of the coal horizons in the Middle Coal Measures have limestone cap-rocks, except the second horizon. All of the coal horizons in the Upper Coal Measures have limestone cap-rocks without any exception. And it is well enough to note that they are generally mud-rocks or intensely argillaceous limestones.

The Lower Coal Measure section is easily distinguished from either the Middle or Upper Coal Measures. Its lithologic and fossil characters make it unique. It contains neither limestone rocks nor marine fossils. There are no limestone rocks between the Basal sandstone and the Mahoning sandstone. Only land life and fresh water life are represented in the Lower Coal Measures. When fully developed there are, however, eight productive coal horizons in the Lower Coal Measures. And there are several coal fields, in the Mississippi Basin in which the Lower Coal Measures are thicker than all of our Missouri Coal Measures. But I have already shown that it is not where the Coal Measures are thickest the coal beds are best developed.

In speaking of either coal beds or ore bodies the word, productive, means that the volume and structure of the deposit are such that it may be worked with a profit. For the obvious reason that coal forests grew only in isolated bodies or spots and flourished most where the conditions were most favorable, the same as vegetation grows now, it rarely ever occurs that more than two or three horizons are found productive in one spot. But each and every coal horizon is nevertheless persistent. Indeed, they are the best marked or individualized geological horizons we have and for that reason they ought to be and are persistent. In fact, the members of coal horizons are the only constant rocks in the Coal Measures.

If, in Paleozoic time, when this continent was in process of development, any single paroxysm of contraction had forced the floor of the Appalachian Invert down and thus predetermined the subsidence of a certain coal horizon, in that invert, is there any conceivable reason why it should not have produced the same result in the equivalent of that horizon in the Illinois and Missouri Inverts? That it did, is made conclusive by the obvious fact that the Lower Coal Measures, fully developed, contain exactly eight coal horizons in all three of those great inverts or coal fields. Moreover, the Lower Coal Measures are limited to narrower zones and smaller areas than the Middle Coal Measures.

In the Appalachion coal field, a great conglomerate sheet occurs in the middle of the Lower Coal Measure section. The four upper horizons, between the conglomerate sheet and the Mahoning sandstone, are the productive horizons in eastern Ohio. The four lower horizons, between the Basal sandstone and the conglomerate sheet, are the productive horizons in the southern Tennessee and Alabama coal fields. The fact that none of the four coal horizons under the conglomerate sheet were productive, in eastern Ohio and western Pennsylvania, where the Coal Measures were first studied, gave rise to the so-called "false coal measures" of the old geologists. But it has since transpired that some of the most productive coal beds in the Mississippi Basin are in the first or lowest horizons of the Lower Coal Measures.

The great conglomerate sheet in the middle of the Lower Coal Measure section, in the Appalachian coal field, suggests a further delineation of the Coal Measure rocks. It has already been shown that when a coal horizon has a cap-rock, that horizon consists of four members and they are the only constant rocks in the Coal Measures. The same persistency obtains when a coal horizon has no cap-rock, but in that case, the horizon consists of only three members. Besides those three or four regular members of each individual coal horizon, there are other rocks in the Coal Measures and they have caused all of the confusion among geologists and prospectors. They are the conglomerates, the false bedded sandstones, the sandy shales and the plastic clay-shales, or alternating fillers, between regular coal horizons.

While the members of a regular coal horizon are absolutely persistent and even continuous over large areas, these inconstant, alternating fillers lie in narrow zones, sinuous, of course, but parallel with each other and with some shore line. The reason is apparent, if you think, because they represent land sediment, carried from some eroded land surface into the depressed area. When land sediment is carried into the sea, it is at once assorted. The coarse and heavy materials are precipitated nearest the shore and they form the conglomerates. The next coarsest are carried a little further out and they form the false-bedded sandstones. The next coarsest are carried still further out and they form the sandy shales. Finally, the pure argillaceous matter, remaining suspended in the water longest, is carried out farthest of all and it makes the plastic clay shales.

Every phenomenon in nature is a logical sequence and there can be no question about that. Obviously, when each coal horizon went down, and its coal forests were inundated with muddy water, that sediment would have fallen somewhat evenly over the whole floor. Whatever stems of plants or branches with their foliage were left standing erect, would have been caught in that first fine sediment. The fine sediment would naturally have filled up the spaces under these branches and foliage first and then have settled down on top of them. All of the beautiful impressions of barks, branches and foliage, found in the roof-shale of a coal mine were preserved in that way. They help to make the cleavage planes in the roof-shales.

If the water had afterwards become clear, and it were salt water, that whole area would soon have been colonized by marine life. After having been thus occupied by marine life, during a vast period of time, that whole area would have been covered with organic products. A large portion of these would have been dissolved or ground down into a fine mud, in which some hardy individuals would have been buried and thus preserved as we now find them.

The fossils of animal life, preserved in the argillaceous limestone cap-rocks, like the stems and foliage, preserved in the shales, have undergone various alterations. Yet, while they do not contain the exact materials they contained when planted in the mud, which afterwards made the major part of the rock, they have, in numerous cases, retained their most delicate structure. In many of the older argillaceous limestones, purely siliceous matter has replaced the original materials of the fossils and they are now pure quartz. This is especially true of the corals of the Trenton, the St. Louis limestone and the Chouteau Beds. Their corals and some of their Brachiopods are preserved in quartz. In some cases the fossils are preserved in Iron pyrite and in other cases the pyrite has been altered into limonite and the original structure of the fossils still preserved.

But the depressed area would, in the meantime, have been filled up by organic products and land sediment and thus brought back to land surface before another coal forest could have grown directly over the last. That it was filled up by land sediment, carried in from some eroded land surface and precipitated in narrow zones, according to its lithologic characters, there cannot be any doubt. The different zones, according to their lithologic characters, would have producéd just such rocks as these inconstant, false-beded and alternating fillers between regular coal horizons, that have given the geologists and prospectors so much trouble.

The Lower Coal Measures, or that section of the Coal Measures, embraced between the Basal sandstone and the Mahoning sandstone, represents, in all of its rocks and fossils, the products of land sediment, land life and fresh water life. It is difficult for some people to see it, but when the student or prosepector has learned, by experience, to ignore many of the senseless domas, handed down in the text books, he will find no difficulty about differentiating the Lower Coal Measure section from the Middle or the Upper. It represents the beginning of the long period of coal deposit, when those giant coal plants flourished—the Lepidodendrids and Cordiates. It contains neither limestone rocks nor marine fossils. Articulates and Crustaceans comprise its fauna, Lepidodendrids and Cordiates comprise the major part of its fossil flora.

That it represents an age of low mud-flats, or müd-islands, surrounded by shallow, fresh water lakes, is further demonstrated by the fact that it was the age in which much or most of our iron ores were deposited. The black carbonate, precipitated on the floors of shallow fresh water lakes, by the organic acids derived from the coal forests, has been the source of most of our iron ores. It matters not what alterations the ores may have subsequently undergone, they were originally precipitated in that way and existed in small lenses of black carbonate, dispersed or interbedded with clay shales. These lenses of black carbonate consisted of about equal parts of iron, mud and coal dust, or other organic matter. The concentration of iron having once been started, it is easy to conceive that so abundant a metal could have undergone all of the alterations that other soluble metals have undergone. When the Coal Measures were eroded off in a given area, the iron, like other ores gravitated down into older rocks.

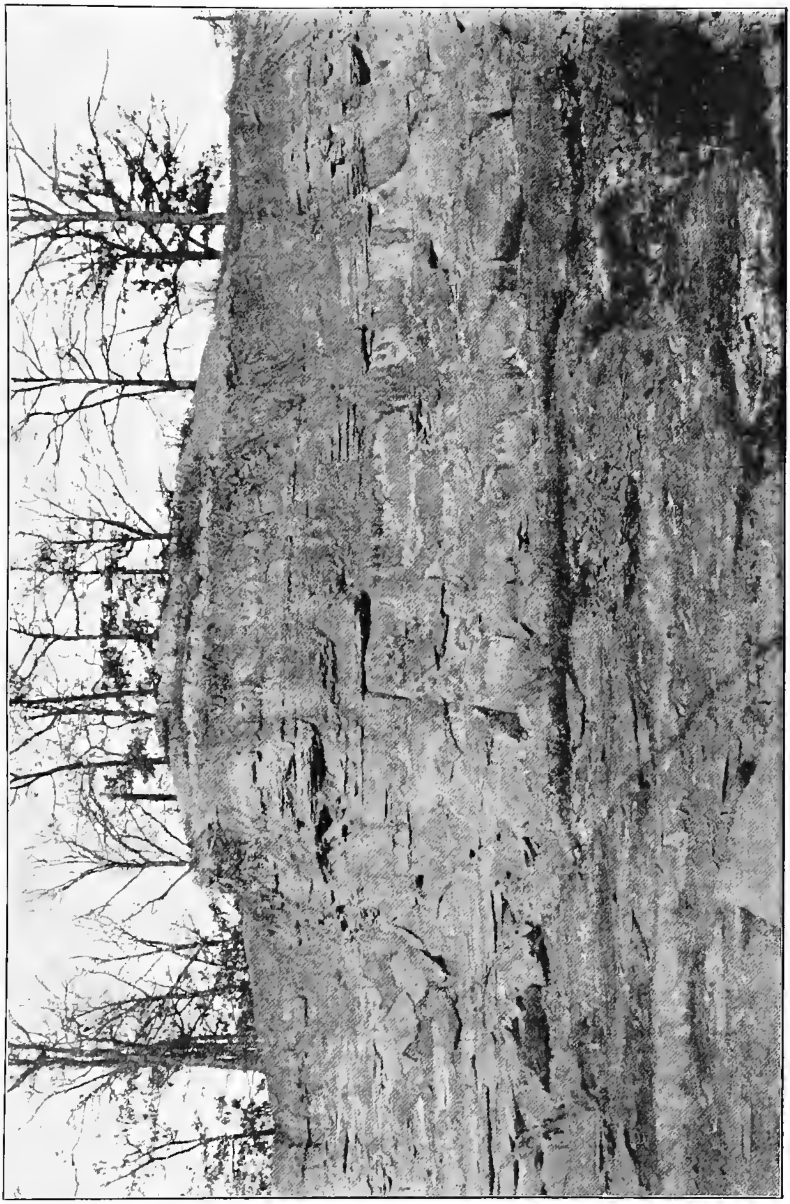
The first horizon of the Lower Coal Measures is productive in a small way about Lewistown and Monticello, in Lewis County. It has also been reported productive in Clark County. But the fact that the Coal Measures have been generally eroded off, in that region, leaving only a small lens of the first horizon, here and there, with glacial drift for roof, there is not much encouragement to look for a profitable mine. The first horizon of the Lower Coal Measures is, however, sufficiently developed in the Grand River zone to be productive in places. In eastern Johnson County, in the west bank of Clear Fork Creek, a little below the Missouri Pacific Railroad bridge, it is supplemented by an immense bed of dark clay-shales and dispersed lenses of black carbonate iron ore. Some millions of tons of iron ore have been concentrated in the creek bed, by the slow but constant dissolving out of the shales. And it furnishes a good illustration of the process by which the concentration of iron ore began. Sir Archibald Geikie mentions similar occurrences of iron ores and shales supplementing coal beds in the coal fields of Scotland.

The second horizon of the Lower Coal Measures has yielded many millions of tons at the Montserrat Mines in eastern Johnson County. Large bodies of that coal still lie untouched, in isolated basins, between Montserrat and Concordia, in Johnson and Lafayette counties. The coal mined in Henry County, south of Grand River, is from one of the upper horizons of the Lower Coal Measures. The Big Muddy coal of Illinois and all of the coal mined in Arkansas and the Indian Territory are from the Lower Coal Measures.

## MAHONING SANDSTONE.

(Plate 53.) The Mahoning sandstone, or Cap-Rock, of the Lower Coal Measures, in its full development, is a threefold rock. In other words, it consists of three distrinct members or divisions, viz: I, Its lower, ferruginous or shaly member; 2, Its middle or massive member; 3, Its upper group of flag-like layers, growing gradually thinner upwards. Its lower or ferruginous member has yielded a vast amount of good iron ore in southeastern Ohio. Its middle or massive member has yielded much good building stone in different states and localities.

About Van Buren and Fort Smith, in Akansas, the three members of the Mahoning sandstone are widely separated by two thick shale beds. And those shales are used in the manufacture of vitrified paving brick. In the Appalachian coal field, the Mahoning sandstone has reached its greatest development. In southwest Missouri, it is in many places the surface rock. It is the only surface rock about Clinton, in Henry County, where it yields all of the native building stone. In the bed of Grand River, a few miles south of Clinton, Taonurus caudigalli are abundant in the Mahoning sandstone. That, of course, is quite an unusual occurence. And there are evidences of a fault, together with other irregular conditions at that particular spot. The first horizon of the Middle Coal Measures is only partially developed but sufficiently to be recognized above the Mahoning sandstone.

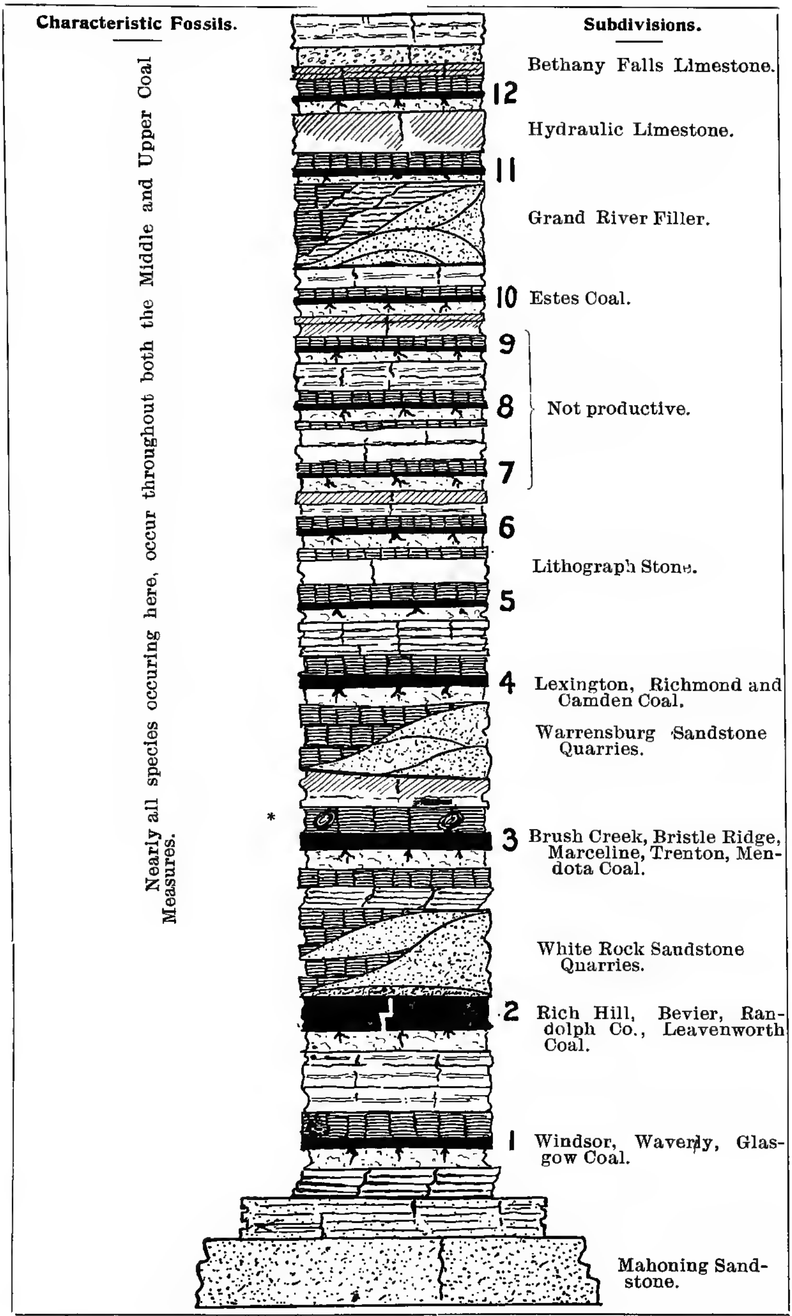


Mahoning Sandstone, Clinton, Henry County.

# CHAPTER IX.

# MIDDLE COAL MEASURES.

## SECTION OF MIDDLE COAL MEASURES.




*NOTE—See page 196.

## MIDDLE COAL MEASURES.

Our Middle Coal Measure section rests on the Mahoning sandstone, embraces twelve coal horizons and has the Bethany Falls limestone for Cap-Rock. In the Middle Coal Measures, three of our most productive coal beds occur. Besides the second horizon of the Lower Coal Measures which has yielded vast quantities of coal about Montserrat, in Johnson County, and the upper horizons of the Lower Coal Measures that are now yielding all of the coal mined in the southern part of Henry County and all of the coal mined in St. Clair County, the second, third and fourth horizons of the Middle Coal Measures are yielding the major part of the commercial coal mined in Misouri.

As already stated, our Middle Coal Measure section embraces twelve distinct and persistent coal horizons, all of which are well defined and doubtless productive somewhere. The first horizon, represented by the lower Windsor coal, in Henry County, the Waverly coal, in Lafayette County, and the only productive coal about Glasgow, in Howard County, is not very productive in Missouri, but it has yielded some excellent coal about Windsor. When fully developed, that horizon has a hard blue limestone cap-rock. But the limestone cap-rock of that horizon is not always present. At Glasgow, in Howard County, the Mahoning sandstone is exposed in the bed of the Missouri River a few hundred yards below the Chicago and Alton Railroad bridge. About one mile north, and near the Wabash Railroad track, the first horizon of the Middle Coal Measures is well developed but the coal is thin. In other words, the under clay, coal, roof-shale and limestone cap-rock are all present, but the coal is thin.

The second horizon of the Middle Coal Measures has yielded and is now yielding most of the coal mined in Missouri

horizon at Leavenworth, Kansas, where it lies seven hundred feet below the bed of the Missouri river.

(Plate 54.) On the second horizon lies the first great alternating filler of the Middle Coal Measures. A cross-section of our coal field, correctly delineated, will show this erratic filler. in the eastern or Chariton zone, varying in thickness between ten and thirty feet; in the second or Grand River zone, between sixty and ninety feet; in the third or Platte River zone, between one hundred and twenty and one hundred and fifty feet. A cross-section of that rock, alone, fixes the greater subsidence of the Bed-rocks of our Coal Measures in the fourth or Forest City zone during the period of coal deposit.

The fact that all of our alternating fillers, between regular coal horizons, lie in sinuous zones, parallel with the curving shore line on the east and are so much thicker on each terrace of the Bed-Rocks, proceeding westwards, accounts largely for the greater depth of our Coal Measures in that direction. It also accounts for thinner coal in the western zones. Obviously, where more sediment and time were required to fill up the more depresed zones and thus bring them back to land surface, there was less time for the accumulation of coal forest debris, which formed the equivalents of the thicker coal beds in the Chariton zone. And here it is well enough to state that the Chariton zone embraces all of our eastern shallow zone, from Putnam and Schuyler counties to Vernon and Barton counties. The big fault in the track of the Missouri River, between Waverly and Brunswick, is the middle section of the dislocation in the Bed-Rocks and Coal Measures, which separates the Chariton and Grand River zones.

White Rock, shown in Plate 54, lies in the north bluff of the Missouri River, in Carroll County. In the south bluff of the Missouri River, at Miami, in Saline County, the Burlington-Keokuk or Carthage limestone (second member of our Subcarboniferous section) lies about level with White Rock on the opposite side of the river. White Rock is simply a massive portion of the first great alternating filler in the Middle Coal

Measures. It represents a narrow zone of nearly pure quartz sand, consolidated into a massive sandrock, which alternates with sandy and plastic clay-shales a short distance westwards. Inasmuch as these fillers, between regular coal horizons, alternate frequently between massive false bedded sandrocks, sandy shales and plastic clay shales, on the same horizon, they have given prospectors and geologists much trouble.

The "old river beds," reported in the midst of the Missouri Coal Measures, do not suggest a very clear conception of the conditions which prevailed during the period of coal deposit. I have an idea that rivers were not much in demand in those days. Especially in the interior of a coal field. One river track, buried under glacial drift, at Mendota, in Putnam County, is the only one I have seen. On the other hand, many old river tracks have doubtless been eroded off the face of the Earth, by the cutting down of other drainage lines.

The second horizon of the Middle Coal Measures has been uncovered in several places, in the floor of the White Rock quarries. Only a few miles away to the westward, the third horizon of the Middle Coal Measures, in its normal development, is resting on the same alternating filler in which the White Rock quarries are situated. The same sandy zone, in which White Rock is situaed lies in the shape of a rainbow, entirely across our coal field. Its outside or eastern edge, marks the dividing line or dislocation between the Chariton and Grand River zones of the Missouri coal field. In this rock, at the Confederate Home, near Higginsville, and in its equivalent at Kansas City, a black bituminous oil occurs in considerable quantities.

Black bituminous oil occurs abundant in many of the sandy zones of this first great filler in the Middle Coal Measures. It is also abundant in some of the sandy zones of other great fillers above the first but not so generally distributed. Efforts have been made to utilize the black bituminous oil found in those fillers between coal horizons, but the only purpose for which it has been used successfully is lubricating farm machinery. It is, however, a low grade lubricant.

To illustrate the alternating character of one of these great fillers, between regular coal horizons, in the Brush Creek Coal Mine, near Kansas City, the first great alternating filler in the Middle Coal Measures, is a false bedded sandrock, about eighty feet thick. At the Randolph Mine, six miles north, it is a plastic clay-shale. In the Riverside Mine, at Leavenworth, Kansas, the roof of the south half is false bedded sandrock. In the north half of the same mine, the roof is sandy and plastic clay-shale. At the Lansing Mine the roof-shale is plastic enough for the manufacture of paving brick. Call to mind, it is the same alternating filler in which the White Rock quarries are situated.

The third horizon of the Middle Coal Measures rests on the first great alternating filler in that section and is one of the most interesting horizons in the whole of our Coal Measures. The coal is not generally so thick in the third as in the second horizon, but it is usually richer and better for domestic use and for the manufacture of gas and coke. The third horizon of the Middle Coal Measures is the productive horizon at Perry, in Ralls County; at Wellsville, in Montgomery County; at Mexico, in Audrain County; at Macon City, in Macon County; at Stahl, in Adair County; at Zola, in Schuyler County; at Mendota and Unionville, in Putnam County; at Marceline and Brookfield, in Linn County; at Trenton, in Grundy County; at Tom Creek, in Caldwell County; at Brush Creek, in Jackson County; at Concordia, in Lafayette County; at Bristle Ridge and Warrensburg, in Johnson County.

This horizon has the full complement of four members: the under-clay, the coal, the roof-shale and a persistent argillaceous limestone cap-rock. The coal is usually in three layers with pronounced cleavages, or partings, between them. And in many places there are parting clays or shales between the bedding planes of the two partings. The three members or layers which make up this coal bed vary greatly in thickness in different localities. That variation and the presence or absence of one or both of the parting clays give this horizon, such a variety of aspects that some people find great difficulty about correlating it in different parts of the coal field. But shale seams, in the midst of coal beds, are essentially erratic or inconstant deposits. They are essentially local deposits. In other words, they are present in one place and entirely absent in another.

Another peculiarity about the third horizon of the Middle Coal Measures is an inconstant shale bed, or "Soapstone," deposited between the roof-shale or slate and the coal. In that case the horizon is sometime difficult to recognize and the roof is apt to be bad. But besides the general character of the coal and its geological relations there are other characteristics usually present by which the horizon may be easily identified. Black concretionary boulders occur in the roof-shale of this horizon and they do not occur in any other horizon of our Coal Measures. When those black concretionary bowlders are broken open with the hammer, or by the frost, they are found to contain Lamellibranchs, Bellerophon, Discina and various other fossils. The beautiful little Lamellibranch, Cardiomorpha missouriensis, is usually abundant in those concretionary bowlders and I do not think it has been found in any other horizon of our Coal Measures. In fact, the third is the most pronounced Lamellibranch horizon of the Middle Coal Measures.

(Plate 55.) On the third horizon rests another alternating filler in a sandy zone of which are situated the Warrensburk Sandstone quarries. This massive deposit of nearly pure quartz sand is consolidated into a thick bed of splendid white sandstone and another thick bed of beautiful blue sandstone on top of it. The white sandstone, at the bottom, is very nearly a pure quartzose sandrock and makes a very durable building stone. The blue sandstone above the white,contains a small quantity of fine coal dust diffused through it and that accounts for the difference in color. The blue stone has, however, been in use many years and has proved quite durable. The massive structure of the deposit permits the use of all economic contrivances for working it and blocks of any size, up to the

Warrensburg Sandstone, Johnson County.

carrying capacity of railroad cars, can be had without delay or serious difficulty.

The fourth horizon of the Middle Coal Measures is productive only in Lafayette, Ray and Clay counties. Some of the oldest coal mines in Missouri were situated in this fourth horizon, along the river front at Lexington and Camden. The coal is not very thick but the quality is good for ordinary purposes and the conditions for long wall mining are very nearly perfect. On account of the excellent mining conditions, this coal is mined with less waste than any other coal bed in Missouri.

The fourth horizon of the Middle Coal Measures, having been mined so long and extensively at lexington and Richmond, is known in the market as Lexinton or Richmond coal. It is best developed at Dover and Richmond and is a fairly good coal bed at Missouri City in Clay County. The same coal bed spreads out over the central portion of Lafayette and occurs in Johnson County, twelve or fourteen inches thick in spots, but is mined only in a small way for local use.

The cap-rock of the fourth horizon is usualy thicker and more crystalline than that of the third. In certain zones, in Johnson County, it is the most crystalline limestone in the Coal Measures and it is the only accumulation of pure Lime carbonate, without magnesia in the State. A successful attempt to demonstrate that this rock, together with some of the coal Measures fireclays in the vicinity of Montserrat, would make a good Portland Cement, resulted in some good Portland cement made from those materials, but the cement factory then contemplated was never built. It seems strange that so safe and profitable a business as the manufacture of cement should have been so long overlooked in a State like Missouri.

After the fourth, none of the eight remaining coal horizons of the Middle Coal Measures are productive in Missouri, except the tenth. At the Woodland Mills, four miles southwest of Laclede, in Linn County on the farm of Mr. Estes, a mine is being worked in a local lens of considerable magnitude in the tenth horizon. The coal is thin but the quality is good. That mine is worked only in a small way for local use.

In sinking the Brush Creek shaft, in Jackson County, the cap-rock of the fifth horizon impresed me as the nearest thing to lithographic stone that I have seen in Missouri. It is a massive cream colored rock, homogeneous in texture, and would doubtless yield good lithographic stone. But as usual, in sinking a shaft for a special purpose, no samples were kept and no test was made of the rock for lithographic purposes. The same rock is exposed, in the river bluff at Lexington, but its texture is coarse and uneven.

There is little else to be said about the rocks of the Middle Coal Measures, above the fourth horizon, until we reach the great alternating filler on the tenth horizon. This third great alternating filler of the Middle Coal Measures is exposed in many places along the tracks of East Grand River and Locust Creek. In fact, this great alternating filler on the tenth horizon of the Middle Coal Measures and the Hydraulic limestone and Bethany Falls limestone, above it, are the prevailing surface rocks in the Grand River zone. That it is an alternating filler is demonstrated by the fact that at the Diamond Brick Works, near Kansas City, it yields the plastic clay shale used in the manufacture of vitrified paving brick. At the Randolph Shaft, six miles north, it is a false bedded sandrock. Along the east branch of Grand River and Locust Creek, in Linn, Grundy and Mercer counties, it alternates between false bedded sandstone, sandy and plastic clay-shales.

The next member of the Middle Coal Measures of any importance is the Hydraulic limestone, so-called, because it has been utilized to some extent in the manufacture of native cement. It is, however, a variable mud-rock and its lithologic character is unreliable.

(Plate 56.) The Cap-Rock and last member of the Middle Coal Measures is the Bethany Falls limestone. Prof. G. C. Broadhead took the picturesque falls in Big Creek, near Bethany, Harrison County, for the typical exposure of that rock and thus named it. It is, however, better developed in other localities. In the valley of the Big Blue, in Jackson County, and in the north bluff of the Missouri River, in Clay

Bethany Falls Limestone, Birmingham, Clay County.

County, the Bethany Falls limestone is better developed than elsewhere in the State. Betwen Randolph and Missouri City, the Bethany Falls limestone lies a little above the Wabash Railroad track and is a very conspicuous landmark.

In the south bank of the Missouri River, about the foot of Wyandotte street, Kansas City, the Bethany Falls limestone is exposed in time of low water. It is also a landmark in Washington Park and many places along the valley of the Big Blue, in Jackson County, where its weathered blocks have been detached and have slipped down the talus slopes and are now lying widely separated from the ladge whence they were detached.

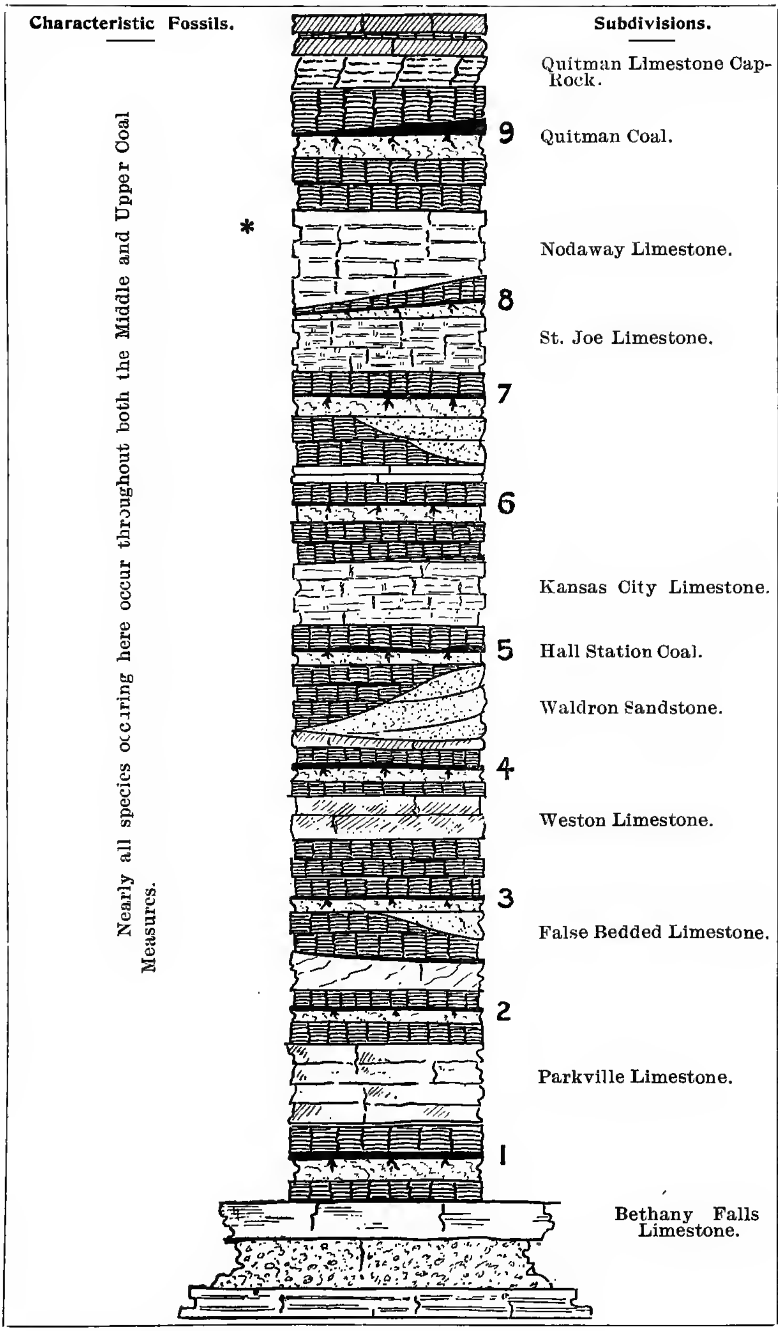
At Kingston and Breckenridge, in Caldwell County, and at Princeton, in Mercer County, the upper member of the Bethany Falls limestone is intensely oolitic. Its texture is very much the same as that of the Bedford limestone of Indiana. The Bethany Falls limestone has not been found sufficiently mas ive and that is the only reason why it should not yield as good building material as the Bedford stone. Some beautiful specimens of oolitic Bethany Falls limestone have recently been sent to this Survey, form the northwestern part of Bates County. From that point to Ravanna in Mercer County, in a sinuous line, is the eastern margin of the Bethany Falls limestone.

It is a part of the plan of this Survey to find the exact eastern and western boundaries of the zone in which the Bethany Falls limestone is the prevailing surface rock and show it, along with the surface areas of other important rocks, in a correct geological map of the State.

# CHAPTER X.

# UPPER COAL MEASURES.

SECTION OF UPPER COAL MEASURES.




*Note—See page 207.

## UPPER COAL MEASURES.

Our Upper Coal Measure section rests on the Bethany Falls limestone and embraces nine coal horizons and the Quitman limestone for Cap-Rock. It is interesting mainly on account of its great number of well preserved fossils. Of the nine well defined coal horizons in the Upper Coal Measures, only one is sufficiently developed to be productive in Missouri. And that is the ninth of the Upper Coal Measures and the twenty-ninth or last horizon of the Paleozoic Coal Measures. It is yielding considerable coal in Nodaway County and has been reported even thicker in Atchison County.

Some small lenses of coal in the Upper Coal Measures have been sometime worked in Platte County, east of Leavenworth. The fifth horizon has yielded some little coal a short distance east of Hall's Station, in Buchanan County, but such local deposits have very little economic value. Outside of its argillaceous limestone cap-rocks, which have yielded large quantities of rough but durable building material, at Kansas City and St. Joseph, our Upper Coal Measure section contains very little of economic value. However, each one of its nine coal horizons represents a short period of emergence, between longer periods of subsidence. And therein lies its most interesting feature. It represents the closing out of the period of coal deposit in Missouri.

The Parkville limestone is the cap-rock of the first horizon of the Upper Coal Measures. It contains some fine specimens of Nautilus, Products punctatus and Bellerophon. It was named the Parkville limestone, because it is there exposed in its full development and is easy of access. From the Perkins Quarry, opposite Kansas City, it is exposed continuously to Parkville. A large mass of it is protruding through the soil, behind the railroad station at Parkville.

On the Parkville limestone, lies another variable filler and then follows the second horizon, with a massive false bedded limestone for its cap-rock. This rock is exposed in the corner of the bluff, at Kansas City, turning from Sixth street towards the Union Station.

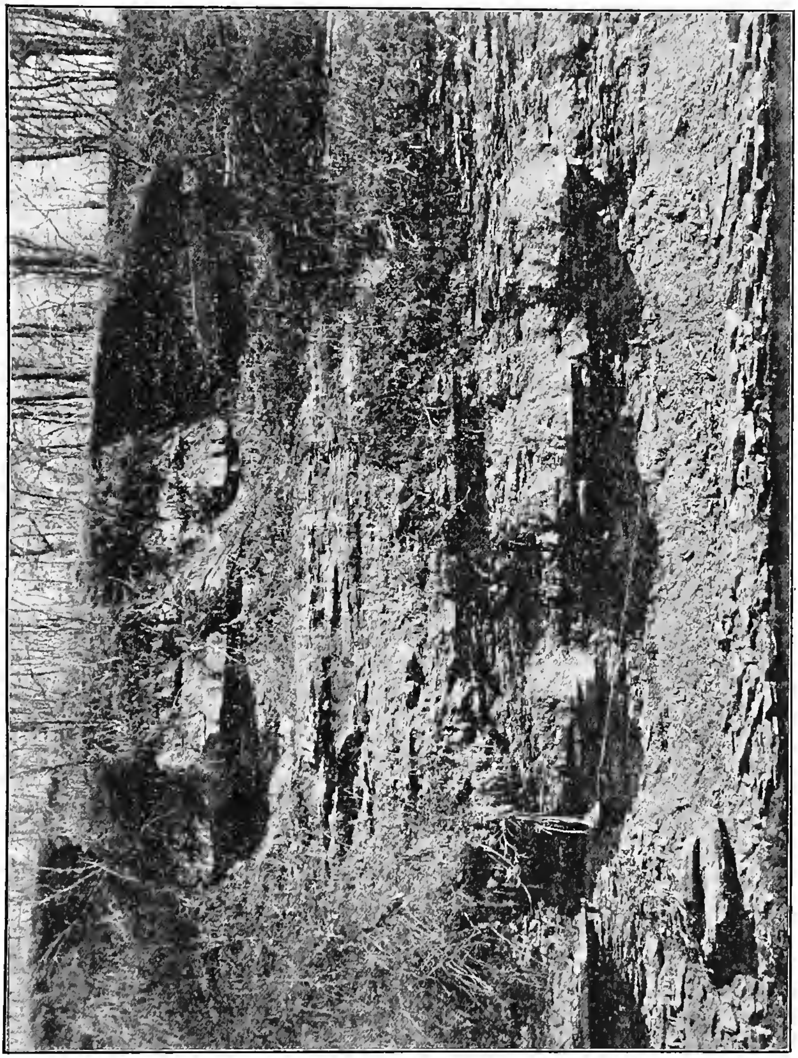
After the massive false bedded limestone, comes another alternating filler and then the third horizon, with the Weston limestone for its cap-rock. North and south of Weston, about level with the Burlington Railroad track, lies a massive argillaceous limestone, abounding in the interesting little fossil, Fusulina cylindrica. This fossil does not differ much in size and form from a grain of wheat. It reminds us of the fact that everything in nature has a function to perform. Indeed, it is surprising but nevertheless true that the most insignificant organisms have been the greatest rock-builders.

Resting on the Weston limestone is another filler and then the fourth horizon follows with a thin bedded argillaceous limestone cap-rock. After that, comes another great alternating filled in which the Waldron sandstone alternates with sandy and plastic shales in other places.

The fifth horizon of our Upper Coal Measures has the Kansas City limestone for cap-rock. It is somewhat more crystalline than most of the cap-rocks of the Upper Coal Measures and has yielded vast quantities of rough but durable building material at Kansas City. It varies between ten and thirty feet in thickness and is the highest rock exposed in the north part of Kansas City. It is exposed in several places between the Midland and Victoria hotels. Also in the top of the bluff facing towards the Upper Station.

After the Kansas City limestone, comes another variable filler and then the sixth horizon with a thin bedded, blue limestone for its cap-rock. That rock is exposed along the Missouri river bluffs, between Weston and Bean Lake, just above the Kansas City limestone. A fine specimen of Orthoceratite was secured at Plattsburg, in this horizon. Between Weston and Amazonia, the Kansas City limestone has the structure and appearance of the Bethany Falls limestone, but

Nodaway Limestone, Brown's Quarry, Holt County.



Quitman Limestone, Quitman, Nodaway County.

its geological relations are sufficient to distinguish it from the Bethany Falls limestone.

Between the sixth and seventh horizons is another filler and on the seventh rests the St. Joe limestone. There is little to be said about it, except that it and the Nodaway limestone above it have yielded most of the native stone that has been used in the biulding of St. Joseph. In the St. Joseph quarries, the St. Joe and Nodaway limestones are apparently one deposit. But a thin shale bed, which separates them in the Blacksnake quarries, thickens up to a hundred feet or more in Corby's Hill, six miles south and east of the Blacksnake quarries.

(Plate 57.) Above the St. Joe limestone, lies the Nodaway limestone, cap-rock of the eightht horizon and the most interesting member of the Upper Coal Measures. It was named the Nodaway limestone, because it has been quarried extensively along the Burlington Railroad track just west of the Nodaway River, in Holt County. Moreover, it is exposed in many places in Nodaway County, at the base of the Quitman coal horizon. The Survey has recognized it at Arkoe, Maitland and Quitman, in Nodaway County and four miles northwest of Rock Port, in Atchison County.

Bryozoa and Fusulina cylindrica are very abundant in the Nodaway limestone. It also contains many fine specimens of Orthoceras, Pinna peracuta, Allorisma subcuneata and Myalina subquadrata. Indeed, it is the most pronounced Lamellibranch horizon in the Upper Coal Measures.

(Plate 58.) Resting on the Nodaway limestone, with a massive argillaceous limestone for its cap-rock, is the Quitman, ninth or last, horizon of the Upped Coal Measures and the twenty-ninth or last horizon of the Paleozoic Coal Measures. The coal in this horizon is productive about Arkoe, in the valley of the Hundred and Two, and at several places in the valley of the Nodaway river. It has been reported three or four feet thick near Tarkio. At the Carpenter Mine, near Quitman, where it reaches a thickness of two and one-half or three feet it is now yielding a considerable quantity of fairly good coal for local use.

There is little else to be said about our Upper Coal Measure section. When systematic search is made for a native cement rock, it will doubtless be found in some one of the cap-rocks of the Upper Coal Measures, or in the Post-Carboniferous section about Forest City.

There is little doubt in my mind but that vast areas of productive coal beds exist, in the lower horizons of the Middle Coal Measures, in north central and northwest Missouri. Of course, they are deep in the ground and relatively thin, but the quality is good and the requisite structure for long-wall mining is better developed in those deep zones than in the shallow eastern zone. For that reason, I have an idea that St. Joseph and other northwestern cities will soon be useing native coal or natural gas.

There are many good reasons for believing that the second horizon of the Middle Coal Measures, worked at Leavenworth, and possibly the third horizon above it, extend continuously up the Platte river valley, to its junction with the Hundred and Two, and thence up the valley of the Hundred and Two into Iowa. I would not expect the coal in either horizon to have an even thickness, all the way from the mouth of the Platte to the Iowa line, but I would evpect local basins of productive coal east of St. Joseph near Bolckow and three or four miles south of Maryville. However, it would require a large investment to develop a profitable mine in any one of those places; because the coal is at least six or seven hundred feet in the ground and the beds are doubtless thin.

The upward fold or arch, in which the gas wells are situated at Iola, Kansas, is fairly well developed in Cass, Ray, Carroll, Caldwell, Livingston, Grundy and Mercer counties. A commercial supply of natural gas will doubtless be found, somewhere in the axis of that fold. And it is possible that petroleum will be found in paying qualtities in the trough, lying to the west of that arch.

The Geological Survey has selected four places in north central and northwest Missouri to explore for coal, petroleum and natural gas. The places selected are: 1, The Platte Valley, in Buchanan County, east of St. Joseph; 2, The Shoal Creek Valley, in Caldwell County, east of Bonanza; 3, The Cream Ridge in Livingston County, about three miles east and north of Chillicothe; 4, The Grand River Valley, in Daviess County, at the railroad junction north of Gallatin.

The purpose of the hole in the Platte Valley is to test the Coal Measures. The purpose of the hole near Bonanza in Caldwell County is to test that basin for both coal and petroleum. The purpose of the hole near Chillicothe is to test the fold or deep-seated Trenton arch for gas. The purpose of the hole near Gallatin is to test that basin for both coal and petroleum. There are other apparently well developed arches and basins in north Missouri, but the above named ones are the most pronounced. And none of them require a hole more than ten or twelve hundred feet deep. Below that depth, core-drilling is very expensive.

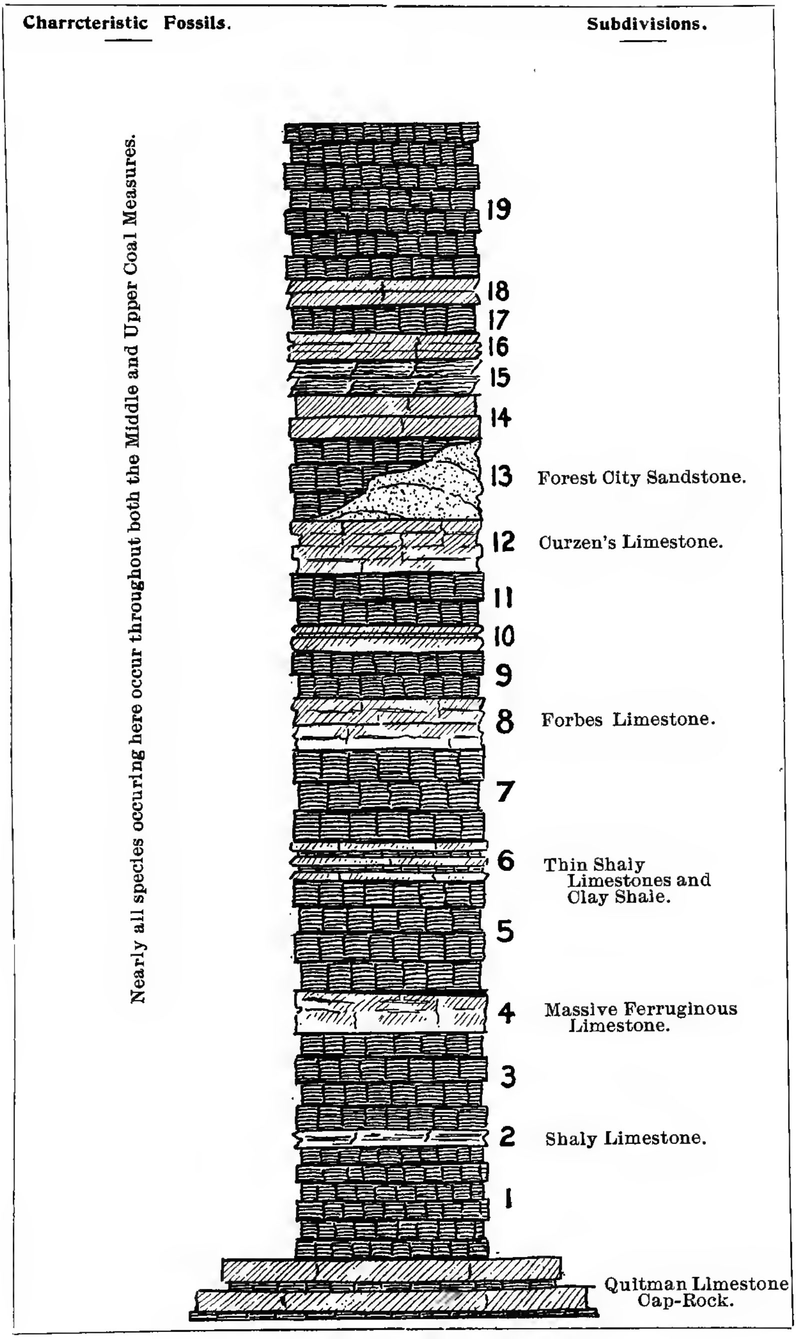
The great superficial fold or arch which deflects the Missouri river, from Amazonia to Atchison, suggests a deep-seated arch in the Trenton limestone. But the Trenton limestone must lie two thousand feet or more form the surface in that fold. The western slope of the superficial arch is very pronounced between Amazonia and the Nodaway River. For that reason, Amazonia is a desirable place to drill for gas, but a hole two thousand or twenty-five hundred feet deep would be required to penetrate the Trenton limestone at that point.

## CHAPTER XI.

# FOREST CITY LENS

## (POST-CARBONIFEROUS).

## SECTION OF FOREST CITY LENS (Post-Carboniferous.)



Post-Carboniferous, Forest City, Holt County.

## FOREST CITY LENS. (Post-Carboniferous.)

(Plate 59.) There is, in the south end of Holt county, Missouri and doubtless extending some distance into Kansas, a great local and superficial lens of mud-rocks and clay-shales, traversed by the Missouri river. Whether that local mass belongs properly in the Permian or not, is an unsettled question among geologists. There is no question whatever but that those mud-rocks and clay-shales represent sediment that was deposited on the floor of a deep abyss, at the close of the Paleozoic Coal Period and after the requisite conditions for coal forest growth had ceased in our coal field. While it does contain many marine fossils and some typical Coal Measure species, it is said to contain typical Permain species and has in it neither roof-shale, coal nor underclay.

Such a thick and absolutely local lens of mud-rocks and clay-shales, as that, shows that after the entire surrounding zones of our coal field had emerged and become permanent land surface, the deepest abyss remained under water and was filled up with organic products and land sediment.

The Forest City Lens, or Post-Carboniferous deposit, is one of the most remarkable geological occurrences in Missouri. On the Missouri side of the river track, about Forest City, that deposit is decidedly local. I am not advised as to its extent in Kansas, but it does not reach exceeding twenty miles in any direction from Forest City, in Missouri. Its beds lie about level, between Forbes and Forest City, and are not less than three hundred feet thick. In fact, it seems to be nearer four hundred feet thick.

It is a monotonous mass of mud-rocks and clay-shales, resting on the Upper Coal Measures. Some of its mud-rocks or argillaceous limestones may prove to be good cement rocks. Beyond that possibility, there seems to be nothing of economic value in it. However, the fact that it represents a deep abyss, which remained under water long after the surrounding country had become dry land, suggests that there may be rock salt, productive coal beds or petroleum in that basin. But a hole two or three thousand feet deep would be required to explore it.

It certainly ought to be explored. But the appropriation for core-drilling is scarcely sufficient for this Survey to undertake an experiment that would necessarily involve so much expense. The four trial holes already mentioned, for gas, coal and petroleum, in north Missouri, and ten or twelve trial holes for disseminated lead, in the Cambrain zones of south Missouri, is all that the Survey can now undertake. If any of those experiments should prove successful, trial holes may be located at other desirable places.

The core-drilling scheme has cost the Survey a vast amount of correspondence and worry, but it is to be hoped that it will prove satisfactory to a majority of the people. It must be apparent to any thinking person that rich ore bodies are not to be expected everywhere. Each ore body represents a concentration of one of the Earth's elements. When nature has concentrated a metallic element into economic bodies, it is only in such places that profitable mines are to be expected. The same may be said of productive coal beds, natural gas and petroleum. The Survey has pointed out the kind of country and strucure in which such deposits are to be expected.

The purpose of the core-drilling scheme is to demonstrate that productive coal beds occur only in the inverts, or basins. in the regular Coal Measures; that petroleum is to be expected only in the downward folds, or basins, in the Trenton limestone; that natural gas is to be expected in commercial quantities only in the upward folds or arches of the Trenton limestone, where it is covered by several hundred feet of argillaceous or impervious beds. In south Missouri, the only ground that can be explored successfully with the core-drill is the Cambrain limestone. It has been shown that the bottom of first Cambrian limestone is the country rock of our disseminated lead deposits. For that reason, the Survey proposes to explore the Cambrian country in south Missouri in as many places as possible.

When the people of Missouri have analyzed this proposition and the energy, that is now being wasted on barren ground, is concentrated on the surface and subdrainage zones of the three great country rocks, for ore bodies, and on the structure indicated for productive coal beds, gas and petroleum, our mineral resources will be developed with some degree of precision. The Geological Survey is not undertaking to guarantee rich deposits at any of the places selected for trial holes, but having studied the country and structure in which rich deposits do occur, we simply propose to drill where such country and structure seem to be duplicated.

Sligo Furnace, 1st Calciferous Country.

St. Joe Lead Mines, Bonne Terre.

Flat River Mines, St. Francois County.

Doe Run Concentrating Works, St. Francois County.

# CHAPTER XII.

## TERTIARY, GLACIAL DRIFT, RIVER LOESS, SOILS AND FORESTRY.

TERTIARY. (Reconstructed Cretaceous.)

Now passing from the Forest City Lens, or Post-Carboniferous of Holt County, to Crowley's ridge, in Stoddard and adjoining counties, we find the Cape Girardeau sandstone, a comparatively recent rock, resting unconformably on the Trenton limestone at Cape Girardeau. At Commerce, a few miles down the river, the Cape Girardeau sandstone, or its equivalent, has developed some massive quartzites which are now lying in the river bank a few rods above the landing.

Lignite beds occur east of Jackson, covered by thick beds of beautiful white clay that is highly plastic and apparently of fine quality. Lignite beds and large deposits of bog iron-ore of apparently Tertiary age occur near Ardeola and Puxico, in Stoddard County. Local lenses of dark colored plastic clay shale occur at Dexter, containing numerous Lamellibranchs and Gasteropods of Tertiary age—probably Miocene. Those beds doubtless represent an extension of the Tertiary or reconstructed Cretaceous of Texas, Louisiana and Arkansas.

This Survey has made very little study of Crowley's ridge, but my impression is that the Magnesian Lens lies close to the surface and forms the base on which are dispersed lenses of reconstructed Cretaceous or Tertiary material. The economic resources of that country consist mainly in its rich soil and luxuriant growth of timber. The timber is being cut at a rapid rate in that country and the time is not far distant when Stoddard will be one of the richest and most productive agricultural counties in Missouri.

The extensive river plains in southeastern Missouri are everywhere covered wiuth rich soil and the country that was once considered worthless swamp lands is being rapidly reclaimed. It is only a question of time when those river plains will be in cultivation and all of that kind of country will be utilized for farming or grazing purposes. For rich agricultural lands, no place in North America offers more inducements than the river plains of southeastern Missouri.

## GLACIAL DRIFT.

Lying almost exclusively north of the Missouri river, and spreading out over nearly all of North Missouri, with its thickest edge to the north and its thinest edge to the south, is a great ragged sheet of Glacial Drift. In Schuyler and Scotland counties, the Glacial Drift is about three hundred feet thick. Farther north and west, it has been reduced by erosion until large zones of the original land surface have been denuded of this burden and the drift lies in widely separated ridges. The Glacial Drift, consists mainly of angular fragments and rounded blocks of granite, gneiss, pegmatite, diabase and red quartzites, dispersed in variable beds of gravel, sand and fine plastic clay.

Fragments of trees that were growing on the original land surface, before the Glacial period, are often found under the drift, and in a fairly well preserved condition. Flint arrow heads, stone axes and other durable relics of Prehistoric Man are also found deeply imbedded or buried in the drift. Valuable pieces of native copper are frequently found, and, I dare say, all of the "lost rocks," in that great sheet of drift, look as if they might have been transported from about Lake Superior.

## PROBABLE EXPLANATION OF THE GLACIAL PERIOD OR ICE AGE.

Assuming, for the sake of brevity, that the first emerged portion of our continent was the floor of a Primordial sargasso sea, the equatorial current of the ocean must have swept around it and have traversed the Arctic Sea. That would have carried equatorial heat far into the Polar region. But the logical sequence of Earth's function is continuous contraction and re-adjustment of her flexible shield to a smaller incandescent center. Contraction means the letting down of her greater inverts first, and that means more land emergence.

If, long after the Coal Period and in comparatively modern time, the emergence of land around the Arctic Sea had stopped the equatorial current from traversing that region, the physical conditions would have been sufficiently altered to have produced the requisite cold. If, then, a vast accumulation of ice had occurred, before sufficient outlets had been cut through the land barriers, a time would have come when the accumulation was so great that the axial motion of the Earth would have thrown it towards the Equator. Sufficient outlets, cut by that process and by subsequent erosion, would have established and maintained the more equable conditions we now enjoy.

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## RIVER LOESS.

In a ragged zone of very irregular width along both sides of the Missouri river and along the west side of the Mississippi, so far as Missouri is concerned, lies a queer deposit of fine plastic loam. This River loess or loam has a light yellowish color and is more fertile along the Missouri River than the heavier brownish colored Loess along the Mississippi. In every other respect, however, they have practically the same characters and seem to have been deposited under the same or similar counditions.

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## OTHER SOILS.

Outside of the river plains and loess zones, the colors and other characters of the Missouri soils, like those of any other country, are predetermined by the decomposing surface rocks. It is a familiar fact that crystalline limestones and pure quartzose sandrocks make yellow soils; and that argillaceous rocks, either sandstone or limestone, make black soils.

Next to the Alluvian drift of the river plains and the light colored loess of the Missouri River, the Cambrain limestone soil is the richest. But on account of the relatively small and rugged areas in which they occur, there is not much Cambrian soil available for cultivation.

The soils whose rock minerals have been derived from the Trenton and Burlington limestones are generally durable and fairly productive. They are the prevailing soils in a wide zone, lying diagonally across the State from southwest to northeast and parallel with the eastern margin of the Coal Measures. They are also the prevailing soils back of the loess in all of the counties fronting on the Mississippi River, from Marion to Cape Girardeau inclusive.

But the largest areas of fertile soils lie in north Missouri and in the northwest half of southwest Missouri. Their rock mineral characters are, for the most part, derived from the argillaceous Glacial drift or Coal Measure cap-rocks. Hence they are usually strong limestone and argillaceous soils. They occur in what were one time, wide, undulating prairies. Soil analysis and adaptability are subjects which this Survey contemplates taking up at an early date.

## FORESTRY.

The Forestry of Missouri is as extensive and varied as the rocks and soils are diversified. But her greatest timber resources lie first in the splendid white oak forests of Crawford, Washington, Iron, Reynolds, Shannon, Carter, Douglas, Oregon, Ripley, Butler and Stoddard counties. Next in her yellow pine forests which grow mainly on the St. Thomas sandstone in Iron, Reynolds, Shannon, Carter, Wayne and Oregon counties. Sweet Gum, Beech, Yellow Poplar and Cypress all flourish on the damp rich soils of the old river plains in several counties in southeastern Missouri.

# CHAPTER XIII.

# CHEMICAL ANALYSIS.

## IRON ORE ANALYSES.

Specular Ores of the Porphyry Region from Iron Mountain, St. Francois County.

Anal. by Dr. Adolph Schmidt.

| | | |
|---|---|---|
| Insoluble siliceous matter | 4.71 | 1.88 |
| Peroxide of iron | 91.45 | 95.04 |
| Protoxide of iron | 2.34 | 2.57 |
| Alumina | 0.93 | 0.75 |
| Lime | 0.45 | 0.15 |
| Magnesia | 0.19 | 0.12 |
| Manganese | 0.00 | 0.00 |
| Sulphur | 0.00 | 0.05 |
| Phosphoric acid | 0.252 | 0.071 |
| Metallic iron | 65.78 | 68.53 |
| Phosphorus | 0.110 | 0.031 |

*Analyses No. 1 is from vein ore. Analyses No. 2 is from surface.

## IRON ORE ANALYSES.

Specular Ore near Tuscumbia, Miller County.

Anal. by Mr. M. S. Cartter.

| | |
|---|---|
| Insoluble | 11.077 |
| Peroxide of Iron | 88.52 |
| Sulphur | trace |
| Phosphorus | trace |
| Metallic Iron | 61.96 |

## ANALYSIS OF LIMONITE ORE.

Thomasville, Oregon County.

Anal. by St. Louis Sampling and Testing Works.

| | |
|---|---|
| Moisture | 12.16 |
| Silica | 2.49 |
| Alumina | 0.78 |
| Sesquioxide of Iron | 84.32 |
| Sulphur | 0.066 |
| Phosphorus | 0.077 |
| Metallic Iron | 59.02 |

## LIMONITES.

Analyses of Limonite from Lamon's bank near West Plains, Howell County.

| | | | | | |
|---|---|---|---|---|---|
| Water | 10.97 | 11.07 | 11.25 | 11.37 | 10.08 |
| Silica | 7.63 | 6.02 | 2.70 | 4.11 | 3.08 |
| Iron | 56.96 | 56.40 | 59.90 | 57.94 | 59.36 |
| Sulphur | 0.05 | 0.049 | 0.037 | 0.063 | 0.72 |
| Phosphorus | 0.104 | 0.115 | 0.087 | 0.118 | 0.57 |

## BROWN HEMATITE.

Warsaw, Benton County.

Anal. by Dr. Litton.

| | |
|---|---|
| Sulphur | 1.05 |
| Silica | 2.11 |
| Iron Peroxide | 88.85 |
| Alumina | 0.87 |
| Water | 10.01 |
| | 102.89 |

## BROWN HEMATITE.

Buffalo, Dallas County.

Anal. by Dr. Litton.

| | |
|---|---|
| Silica | 2.88 |
| Alumina | 0.64 |
| Iron Peroxide | 84.80 |
| Water | 11.62 |
| Sulphur | 0.12 |
| | 100.06 |

## BROWN HEMATITE.

Mouth of Niangua, Camden County.

Anal. by Dr. Litton.

| | |
|---|---|
| Silica | 4.36 |
| Iron Peroxide | 83.27 |
| Alumina | 1.08 |
| Water | 11.11 |
| | 99.82 |

## MANGANESE ORES.

Analyses of ores from (Lindsay's ore bed) Reynolds County.

| | |
|---|---|
| *Silicious matter | 28.81 |
| Iron (as Peroxide) | 4.81 |
| Manganese (as Protoxide) | 50.84 |
| Lime | 6.24 |

*The "Silicious matter" in this ore is Feldspar, containing 71.50 per cent. Silica and 14.85 Alumina. Potash was qualitatively determined only.

## MANGANESE ORES.

Analyses of ores from Hick's bank, near Fredericktown, Madison County.

| | |
|---|---|
| Silicious matter | 56.82 |
| Peroxide of Iron | 18.67 |
| Sesquioxide of Manganese | 14.24 |
| Water | 3.19 |

| | |
|---|---|
| Metallic Iron | 13.07 |
| Metallic Manganese | 9.86 |

## ANALYSIS OF MICROCRYSTALLINE GALENITE.

Mine La Motte. Anal. by Litton.

| | |
|---|---|
| Sulphur | 13.50 |
| Lead | 84.50 |
| Iron | trace |
| Copper | trace |
| Nickel | trace |

## ANALYSIS OF PORPHYRY.

Shannon County.

| | |
|---|---|
| Silicic Acid | 37.27 |
| Ferric Oxide | 42.19 |
| Alumina | 4.29 |
| Calcium Carbonate | 1.74 |
| Magnesium Carbonate | 4.80 |
| Sodium Carbonate | 1.19 |
| Potassium Carbonate | 3.12 |
| Water | 5.38 |
| | 99.98 |

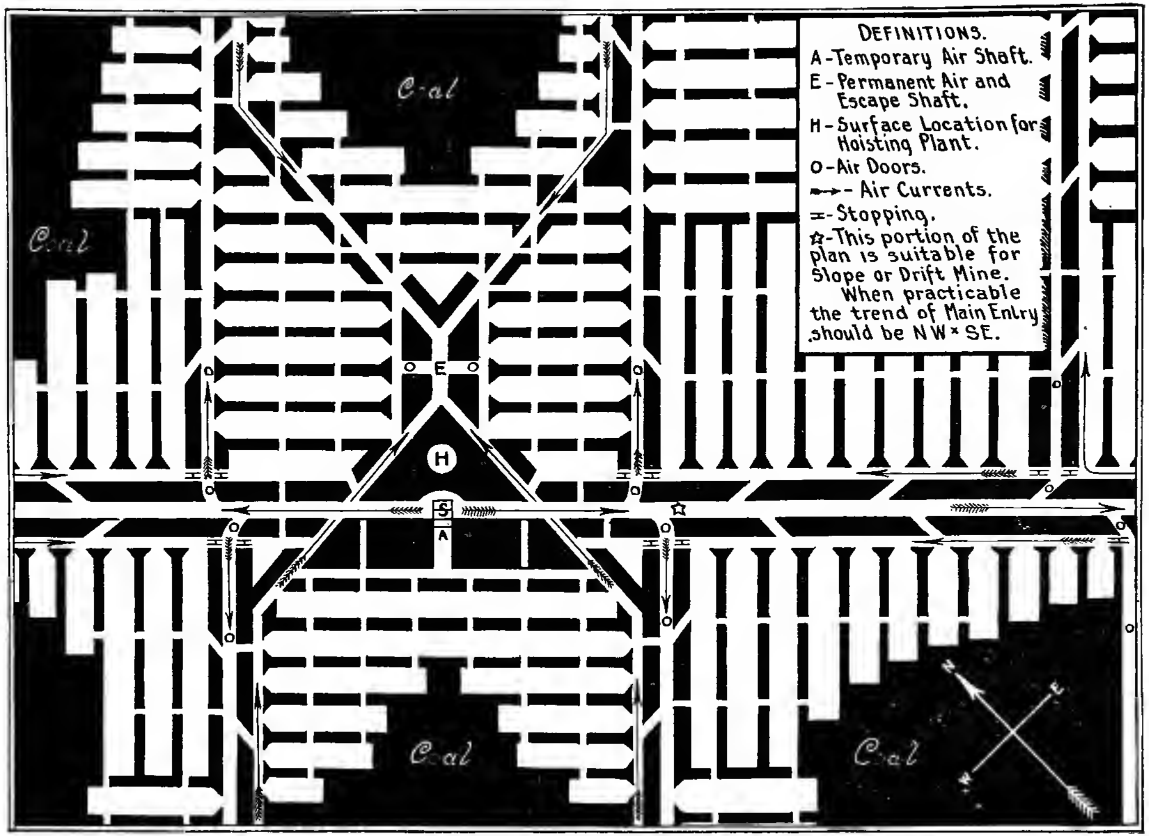


Fig. 4. Plan for Room and Pillar Mine.

## ANALYSIS OF COPPER CARBONATE.

Shannon County.

| | |
|---|---|
| Cupric Oxide | 70.800 |
| Ferric Oxide | 3.463 |
| Calcium Carbonate | 1.035 |
| Magnesium Carbonate | 0.650 |
| Silica | 0.363 |
| Sulphur | 0.876 |
| Carbonic Acid | 16.640 |
| Water | 7.050 |

Per cent. metallic Copper, 56.64.

## ANALYSIS OF FIRST CALCIFEROUS LIMESTONE.

Crawford County. Anal. by Schmidt.

| | |
|---|---|
| Calcium Carbonate | 84.078 |
| Magnesium Carbonate | 12.654 |
| Ferric Oxide | 0.423 |
| Alumina | 0.564 |
| Insoluble Matter | 2.565 |
| | 100.284 |

## ANALYSIS OF FIRST CALCIFEROUS LIMESTONE.

Shannon County. Anal. by Schmidt.

| | |
|---|---|
| Calcium Carbonate | 55.216 |
| Magnesium Carbonate | 42.374 |
| Ferric Oxide and Alumina | 0.916 |
| Insoluble Matter | 1.330 |
| | 99.836 |

## ANALYSIS OF FLINT OR NON-PLASTIC FIRECLAY.

| | |
|---|---|
| Silica | 43.56 |
| Alumina | 41.48 |
| Water | 14.05 |
| Iron Sesquioxide | 0.35 |
| Lime | 0.45 |
| Magnesia | 0.00 |
| Alkalies | 0.20 |

## ANALYSIS OF FLINT OR NON-PLASTIC FIRECLAY.

High Hill, Montgomery County.

| | |
|---|---|
| Silica | 45.12 |
| Alumina | 40.46 |
| Water | 13.34 |
| Iron Sesquioxide | 0.47 |
| Lime | 0.29 |
| Magnesia | trace |
| Alkalies | 0.30 |

## ANALYSIS OF FIRECLAY.

Middle Coal Measures, Vandalia, Audrain County.

| | |
|---|---|
| Silica | 53.77 |
| Alumina | 30.90 |
| Water | 12.68 |
| Iron Sesquioxide | 1.74 |
| Lime | 0.39 |
| Magnesia | 0.32 |
| Alkalies | 0.49 |

Specific gravity, 2.43.

## ANALYSIS OF FIRECLAY.

Middle Coal Measures, Fulton, Callaway County.

| | |
|---|---|
| Silica | 48.30 |
| Alumina | 37.54 |
| Water | 12.76 |
| Iron Sesquioxide | 1.48 |
| Lime | 0.57 |
| Magnesia | 0.00 |
| Alkalies | 0.50 |

Specific gravity, 2.44.

## ANALYSIS OF KAOLIN.

Chilton, Carter County.

| | |
|---|---|
| Silica | 73.82 |
| Alumina | 18.16 |
| Combined Water | 6.16 |
| Iron Sesquioxide | 1.32 |
| Lime | trace |
| Magnesia | 0.21 |
| Alkalies | 0.24 |

## ANALYSIS OF BALL OR BOND-CLAY.

Regina, Jefferson County.

| | |
|---|---|
| Silica | 45.97 |
| Alumina | 36.35 |
| Combined Water | 12.36 |
| Iron Sesquioxide | 1.08 |
| Lime | 1.14 |
| Magnesia | 1.09 |
| Alkalies | 1.84 |

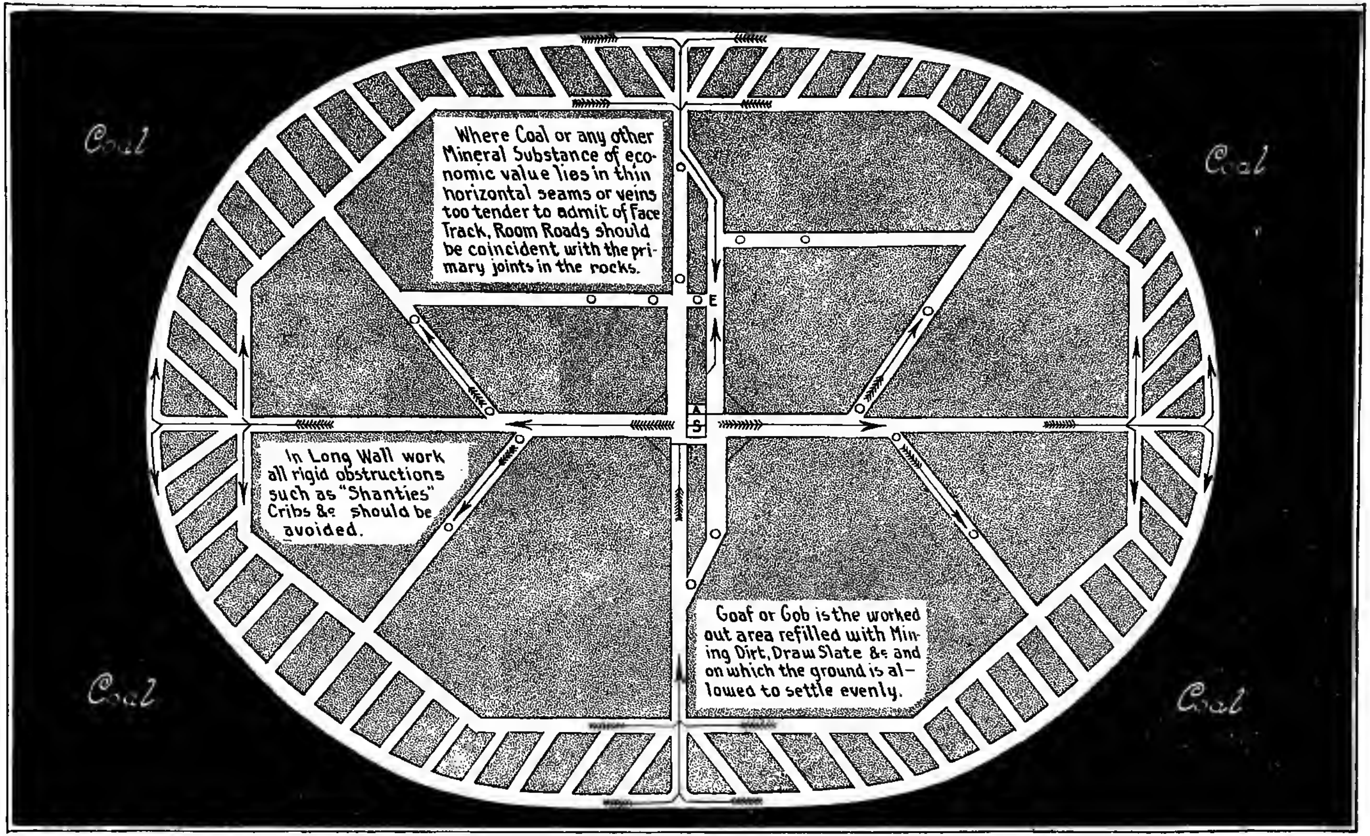


Fig. 5. Plan for Long Wall Mine—with room roads.

## ANALYSIS OF FELDSPAR.

Near Jonca, Ste. Genevieve County.

| | |
|---|---|
| Silica | 64.80 |
| Alumina | 18.00 |
| Potash (trace of Soda) | 15.90 |
| Water | 0.70 |
| Iron, Lime, Magnesia | 0.60 |
| | 100.00 |

## ANALYSIS OF LOESS, FROM BLUFF AT ST. JOSEPH.

Anal. by Dr. Litton.

| | |
|---|---|
| Insoluble Matter | 35.08 |
| Oxides of Alumina and Iron | 5.22 |
| Calcium Carbonate | 58.33 |
| Magnesium Carbonate | 0.77 |
| | 99.40 |

## ANALYSIS OF LOESS FROM BIG MOUND, ST. LOUIS

Anal. by Dr. Litton.

| | |
|---|---|
| Silica | 76.19 |
| Alumina and Iron Peroxide | 16.88 |
| Lime | 2.50 |
| Magnesia | 0.73 |
| Carbonic Acid and Water | 2.68 |
| | 98.98 |

## ANALYSES OF MISSOURI MINERAL WATERS.

Contents are expressed in grains per gallon.

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### BIG SULPHUR SPRING, JEFFERSON COUNTY.

Muriatic Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 0.8177 |
| Calcium Sulphate | 10.8829 |
| Calcium Chloride | 37.6935 |
| Magnesium Chloride | 12.8456 |
| Potassium Bromide | 2.2956 |
| Sodium Chloride | 168.5675 |
| Specific gravity, 1.0031 | Mineral matter, 233.1320 |

### ELK LICK SPRING, SALINE COUNTY.

Muriatic Water. Anal. by Woodward.

| | |
|---|---|
| Silica | 0.3972 |
| Alumina | 0.1168 |
| Calcium Bicarbonate | 27.0537 |
| Calcium Sulphate | 20.6042 |
| Calcium Chloride | 4.5083 |
| Magnesium Chloride | 22.8198 |
| Sodium Chloride | 176.7242 |
| Specific gravity, 1.0033 | Mineral matter, 252.2242 |

### AFTON SPRING, JEFFERSON COUNTY.

Muriatic Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 0.8177 |
| Calcium Sulphate | 33.0658 |
| Calcium Chloride | 27.3583 |
| Magnesium Chloride | 40.4379 |
| Potassium Bromide | 1.7348 |
| Sodium Chloride | 265.8275 |
| Specific gravity, 1.0043 | Mineral matter, 369.2595 |

### BELCHER ARTESIAN WELL, ST. LOUIS COUNTY.

Muriatic Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 0.9346 |
| Oxide of Iron | 0.0584 |
| Calcium Sulphate | 50.1847 |
| Calcium Chloride | 47.4941 |
| Magnesium Chloride | 46.0840 |
| Potassium Chloride | 0.8680 |
| Potassium Bromide | 3.0583 |
| Sodium Chloride | 401.5730 |

Specific gravity, 1.0059 Mineral matter, 550.2551

### AKESION SPRING, SWEET SPRINGS, SALINE COUNTY.

Muriatic Water. Anal. by Woodward.

| | |
|---|---|
| Silica | 0.3154 |
| Alumina | 0.3154 |
| Calcium Bicarbonate | 52.2582 |
| Calcium Sulphate | 55.9339 |
| Calcium Chloride | 85.2176 |
| Magnesium Chloride | 89.5086 |
| Potassium Chloride | 5.3422 |
| Sodium Chloride | 882.7786 |

Specific gravity, 1.0149 Mineral matter, 1171.5531

### GREAT SALT SPRING, SALINE COUNTY.

Muriatic Water. Anal. by Woodward.

| | |
|---|---|
| Silica | 0.3914 |
| Alumina | 0.0993 |
| Calcium Bicarbonate | 23.0752 |
| Calcium Sulphate | 117.7563 |
| Calcium Chloride | 108.2547 |
| Magnesium Chloride | 103.0718 |
| Sodium Chloride | 1388.1556 |

Specific gravity, 1.0219 Mineral matter, 1750.8043

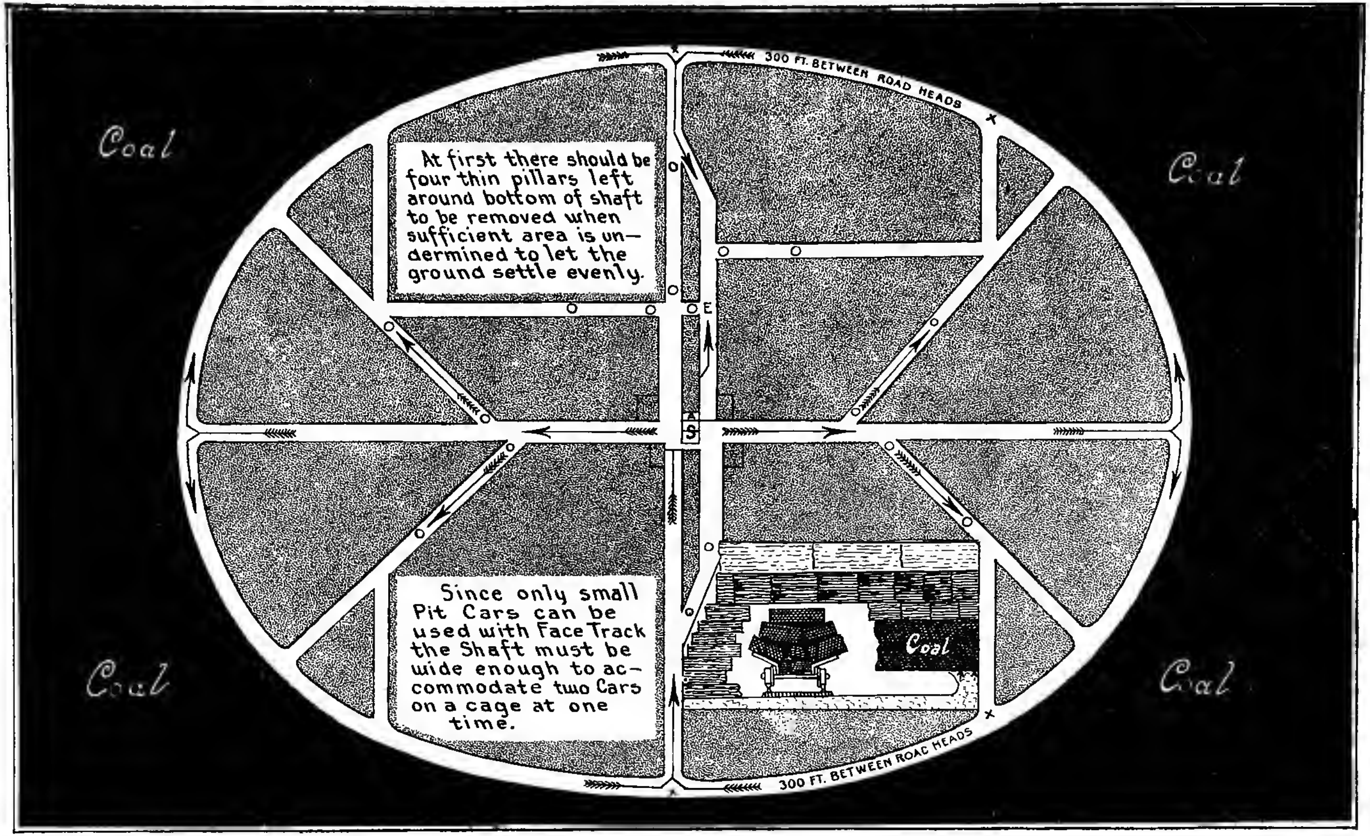


Fig. 6. Plan for Long Wall Mine—with face track.

## NAPTON SPRING, SALINE COUNTY.

Muriatic Water. Anal. by Woodward.

| | |
|---|---|
| Silica | 0.4731 |
| Alumina | 0.1810 |
| Calcium Sulphate | 102.3255 |
| Calcium Chloride | 117.3459 |
| Magnesium Chloride | 83.7611 |
| Potassium Chloride | 9.9901 |
| Sodium Chloride | 1039.0722 |
| Specific gravity, 1.0174 Mineral matter, | 1353.1489 |

## BOLING SPRING, BENTON COUNTY.

Muriatic Water. Anal. by Woodward.

| | |
|---|---|
| Silica | 0.6191 |
| Calcium Bicarbonate | 19.7795 |
| Magnesium Bicarbonate | 7.8157 |
| Calcium Sulphate | 3.9918 |
| Magnesium Chloride | 4.6945 |
| Potassium Chloride | 1.5278 |
| Sodium Chloride | 35.3679 |
| Specific gravity, 1.0005 Mineral matter, | 73.7963 |

## SPALDING SPRING, RALLS COUNTY.

Muriatic Water. Anal. by Woodward and Robertson.

| | |
|---|---|
| Silica | 0.3387 |
| Calcium Bicarbonate | 12.5712 |
| Calcium Sulphate | 96.7200 |
| Magnesium Sulphate | 0.3300 |
| Magnesium Chloride | 48.4300 |
| Potassium Chloride | 8.6600 |
| Sodium Chloride | 533.2613 |
| Specific gravity, 1.0091 Mineral matter, | 700.3112 |

## OLD BLACK, MONEGAW SPRING, ST. CLAIR COUNTY.

Muriatic Water. Anal. by Woodward.

| | |
|---|---|
| Silica | 0.6483 |
| Calcium Bicarbonate | 32.4645 |
| Magnesium Bicarbonate | 7.0916 |
| Calcium Sulphate | 3.1873 |
| Magnesium Chloride | 9.4938 |
| Potassium Chloride | 2.7221 |
| Sodium Chloride | 111.4822 |

Specific gravity, 1.0017 Mineral matter, 167.0898

## GLASGOW MINERAL SPRING, HOWARD COUNTY.

Muriatic Water. Anal. by Robertson.

| | |
|---|---|
| Silica | 0.4439 |
| Alumina | 0.0175 |
| Calcium Sulphate | 71.1345 |
| Calcium Chloride | 47.7500 |
| Magnesium Chloride | 81.9303 |
| Potassium Chloride | 7.1569 |
| Sodium Chloride | 831.4624 |

Specific gravity, 1.0142 Mineral matter, 1084.6278

## SALT SPRING, RANDOLPH COUNTY.

Muriatic Water. Anal. by Woodward.

| | |
|---|---|
| Alumina | 0.1869 |
| Calcium Bicarbonate | 94.8024 |
| Calcium Sulphate | 43.0500 |
| Calcium Chloride | 51.8700 |
| Magnesium Chloride | 84.7100 |
| Potassium Chloride | 6.7300 |
| Sodium Chloride | 777.2792 |

Specific gravity, 1.0106 Mineral matter, 1053.6285

## CLARK'S SPRING, BENTON COUNTY.

Muriatic Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 0.4089 |
| Calcium Bicarbonate | 17.7524 |
| Magnesium Bicarbonate | 6.6704 |
| Calcium Sulphate | 7.3678 |
| Magnesium Chloride | 5.8558 |
| Sodium Chloride | 56.2479 |

Specific gravity, 1.0014 Mineral matter, 94.3032

## PLATTSBURG SPRING, CLINTON COUNTY.

Alkaline Water. Anal. by Woodward.

| | |
|---|---|
| Silica | 1.5596 |
| Alumina | 1.3901 |
| Calcium Bicarbonate | 17.6256 |
| Magnesium Bicarbonate | 3.9805 |
| Sodium Bicarbonate | 0.8400 |
| Sodium Sulphate | 0.2300 |
| Potassium Chloride | 0.5790 |
| Sodium Chloride | 0.5000 |

Specific gravity, 1.0003 Mineral matter, 26.7048

## POST OAK SULPHUR SPRING, JOHNSON COUNTY.

Alkaline Water. Anal. by Woodward.

| | |
|---|---|
| Silica | 0.5783 |
| Calcium Bicarbonate | 11.3664 |
| Magnesium Bicarbonate | 7.5630 |
| Sodium Bicarbonate | 2.8749 |
| Sodium Sulphate | 3.3279 |
| Potassium Chloride | 1.4190 |
| Sodium Chloride | 8.9535 |

Specific gravity, 1.0001 Mineral matter, 33.5797

## WINDSOR SPRING, HENRY COUNTY.

Alkaline Water. Anal. by Woodward.

| | |
|---|---|
| Silica | 0.7009 |
| Alumina | 0.4205 |
| Calcium Bicarbonate | 0.8800 |
| Magnesium Bicarbonate | 0.8933 |
| Sodium Bicarbonate | 2.3267 |
| Potassium Sulphate | 0.8063 |
| Sodium Sulphate | 0.1049 |
| Potassium Chloride | 0.1224 |
| Specific gravity, 1.0000 | Mineral matter, 6.2550 |

## ELECTRIC SPRING, DIXON, HOWELL COUNTY.

Alkaline Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 0.5841 |
| Calcium Bicarbonate | 11.4902 |
| Magnesium Bicarbonate | 8.9753 |
| Sodium Bicarbonate | 3.3654 |
| Sodium Chloride | 0.0481 |
| Specific gravity, 1.0003 | Mineral matter, 24.4631 |

## CLIMAX SPRING, CAMDEN COUNTY.

Alkaline Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 0.7009 |
| Calcium Bicarbonate | 8.4486 |
| Magnesium Bicarbonate | 7.9949 |
| Sodium Bicarbonate | 0.0625 |
| Sodium Chloride | 0.0088 |
| Specific gravity, 1.0002 | Mineral matter, 17.2197 |

## ARTESIAN WELL, NEVADA, VERNON COUNTY.

Alkaline Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 0.8177 |
| Calcium Bicarbonate | 13.7206 |
| Magnesium Bicarbonate | 11.5124 |
| Calcium Sulphate | 4.3690 |
| Sodium Chloride | 45.5951 |

Specific gravity, 1.0014 Mineral matter, 76.0116

## GALBRAITH SPRING, McDONALD COUNTY.

Alkaline Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 0.5841 |
| Calcium Bicarbonate | 6.9563 |
| Magnesium Bicarbonate | 3.0508 |
| Calcium Sulphate | 0.6853 |
| Sodium Chloride | 1.8078 |

Specific gravity, 1.0002 Mineral matter, 14.0854

## ARTESIAN WELL, CLINTON, HENRY COUNTY.

Alkaline Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 0.8177 |
| Calcium Bicarbonate | 16.0778 |
| Magnesium Bicarbonate | 15.6698 |
| Calcium Sulphate | 7.4968 |
| Potassium Chloride | 2.0852 |
| Sodium Chloride | 52.4010 |

Specific gravity, 1.0019 Mineral matter, 94.5483

### LINEVILLE WELL, MERCER COUNTY.

Sulphatic Water. Anal. by Woodward and Robertson.

| | |
|---|---|
| Silica | 0.1168 |
| Alumina | 0.2862 |
| Calcium Sulphate | 1.9000 |
| Magnesium Sulphate | 3.1800 |
| Sodium Sulphate | 180.3000 |
| Potassium Chloride | 1.7400 |
| Sodium Chloride | 15.0700 |

Specific gravity, 1.0034 Mineral matter, 202.5930

### B. B. SPRING, PIKE COUNTY.

Sulphatic Water. Anal. by Woodward and Robertson.

| | |
|---|---|
| Silica | 0.6659 |
| Alumina | 1.6647 |
| Calcium Bicarbonate | 5.1516 |
| Calcium Sulphate | 75.6700 |
| Magnesium Sulphate | 475.5900 |
| Potassium Sulphate | 1.0600 |
| Sodium Sulphate | 7.2100 |
| Sodium Chloride | 2.4500 |

Specific gravity, 1.0068 Mineral matter, 569.4622

### CRYSTAL SPRING, LA MONTE, PETTIS COUNTY.

Sulphatic Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 3.0957 |
| Ferrous Sulphate | 7.8905 |
| Aluminium Sulphate | 10.5561 |
| Calcium Sulphate | 29.8600 |
| Magnesium Sulphate | 9.8481 |
| Sodium Sulphate | 6.0790 |

Specific gravity, 1.0015 Mineral matter, 67.3294

### ALUM WELL, VERSAILLES, MORGAN COUNTY.

Sulphatic Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 2.6869 |
| Ferrous Sulphate | 22.4177 |
| Aluminium Sulphate | 89.8930 |
| Calcium Sulphate | 38.2009 |
| Magnesium Sulphate | 32.6454 |
| Sodium Sulphate | 7.0901 |

Specific gravity, 1.0031 Mineral matter, 192.9340

### REGENT SPRING, CLAY COUNTY.

Saline Chalybeate Water. Anal. by Woodward and Robertson.

| | |
|---|---|
| Silica | 1.1156 |
| Alumina | 0.2978 |
| Ferrous Bicarbonate | 3.4376 |
| Manganous Bicarbonate | 0.9821 |
| Calcium Bicarbonate | 28.8676 |
| Magnesium Bicarbonate | 3.7542 |
| Magnesium Sulphate | 0.3500 |
| Magnesium Chloride | 0.4200 |
| Potassium Chloride | 0.6700 |
| Sodium Chloride | 2.2300 |

Specific gravity, 1.0007 Mineral matter, 42.1274

### SILOAM SPRING, CLAY COUNTY.

Saline Chalybeate Water. Anal. by Woodward and Robertson.

| | |
|---|---|
| Silica | 1.5245 |
| Alumina | 0.0526 |
| Ferrous Bicarbonate | 2.1175 |
| Manganous Bicarbonate | 0.3836 |
| Calcium Bicarbonate | 23.1066 |
| Magnesium Bicarbonate | 2.2769 |
| Magnesium Sulphate | 0.2500 |
| Sodium Sulphate | 1.1700 |
| Potassium Chloride | 0.3400 |
| Sodium Chloride | 0.9000 |

Specific gravity, 1.0008 Mineral matter, 32.2017

### FROST'S SPRING, CLINTON COUNTY.

Saline Chalybeate Water. Anal. by Woodward and Robertson.

| | |
|---|---|
| Silica | 1.5011 |
| Alumina | 0.1810 |
| Ferrous Bicarbonate | 0.0921 |
| Calcium Bicarbonate | 23.5557 |
| Magnesium Bicarbonate | 4.3627 |
| Magnesium Sulphate | 4.7400 |
| Sodium Sulphate | 2.8200 |
| Sodium Chloride | 1.1600 |

Specific gravity, 1.0007 Mineral matter, 38.4126

### REED'S SPRING, LIBERTY, CLAY COUNTY.

Saline Chalybeate Water. Anal. by Woodward and Robertson.

| | |
|---|---|
| Silica | 1.1681 |
| Alumina | 0.3400 |
| Ferrous Bicarbonate | 0.8271 |
| Calcium Bicarbonate | 15.4386 |
| Magnesium Bicarbonate | 2.0166 |
| Magnesium Sulphate | 0.3300 |
| Sodium Sulphate | 0.9100 |
| Potassium Chloride | 0.4700 |
| Sodium Chloride | 0.9700 |

Specific gravity, 1.0005 Mineral matter, 22.4704

### CRYSTAL SPRING, PLATTE COUNTY.

Saline Chalybeate Water. Anal. by Woodward and Robertson.

| | |
|---|---|
| Silica | 1.7406 |
| Alumina | 1.1624 |
| Ferrous Bicarbonate | 0.6752 |
| Calcium Bicarbonate | 17.1008 |
| Magnesium Bicarbonate | 1.4600 |
| Magnesium Sulphate | 2.1400 |
| Sodium Sulphate | 1.3000 |
| Potassium Chloride | 0.5900 |
| Sodium Chloride | 1.0800 |

Specific gravity, 1.0004 Mineral matter, 27.2490

## MAIN SPRING, 9-WONDERS, EL DORADO, CEDAR COUNTY.

Chalybeate Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 1.6355 |
| Ferrous Bicarbonate | 2.5993 |
| Magnesium Bicarbonate | 5.0629 |
| Calcium Sulphate | 6.3832 |
| Magnesium Sulphate | 0.0868 |
| Sodium Sulphate | 4.5541 |
| Sodium Chloride | 0.3369 |
| Specific gravity, 1.0003 | Mineral matter, 20.6587 |

## GREENWOOD SPRING, JACKSON COUNTY.

Chalybeate Water. Anal. by Schweitzer.

| | |
|---|---|
| Ferrous Bicarbonate | 2.3395 |
| Calcium Bicarbonate | 2.5005 |
| Magnesium Bicarbonate | 0.4690 |
| Sodium Bicarbonate | 57.4211 |
| Sodium Silicate | 6.7678 |
| Specific gravity, 1.0012 | Mineral matter, 69.4979 |

## PARK SPRING, EL DORADO SPRINGS, CEDAR COUNTY.

Chalybeate Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 2.2196 |
| Ferrous Bicarbonate | 3.3791 |
| Calcium Bicarbonate | 1.8586 |
| Magnesium Bicarbonate | 1.8549 |
| Sodium Sulphate | 3.1414 |
| Sodium Chloride | 0.4771 |
| Specific gravity, 1.0002 | Mineral matter, 12.9307 |

### RANDOLPH SPA, RANDOLPH COUNTY.

Chalybeate Water. Anal. by Woodward and Robertson.

| | |
|---|---|
| Silica | 0.5491 |
| Alumina | 0.9404 |
| Ferrous Bicarbonate | 7.2427 |
| Calcium Bicarbonate | 33.3983 |
| Magnesium Bicarbonate | 9.7687 |
| Sodium Bicarbonate | 1.9336 |
| Sodium Sulphate | 0.3300 |
| Potassium Chloride | 0.6951 |
| Sodium Chloride | 0.6100 |

Specific gravity, 1.0009 Mineral matter, 54.4679

### LEBANON MAGNETIC WELL, LACLEDE COUNTY.

Chalybeate Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 0.4089 |
| Ferrous Bicarbonate | 0.5198 |
| Calcium Bicarbonate | 6.9278 |
| Magnesium Bicarbonate | 5.9269 |
| Sodium Bicarbonate | 2.8073 |
| Sodium Chloride | 0.0962 |

Specific gravity, 1.0002 Mineral matter, 16.6869

### LITHIUM SPRING, LITHIUM, PERRY COUNTY.

Chalybeate Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 1.6355 |
| Ferrous Bicarbonate | 0.5197 |
| Calcium Bicarbonate | 26.6976 |
| Magnesium Bicarbonate | 13.6017 |
| Sodium Bicarbonate | 0.7668 |
| Sodium Sulphate | 1.3477 |
| Sodium Chloride | 19.5298 |

Specific gravity, 1.0006 Mineral matter, 64.0988

### DENVER SPRING, WORTH COUNTY.

Chalybeate Water. Anal. by Woodward and Robertson.

| | |
|---|---|
| Silica | 1.6005 |
| Alumina | 0.7184 |
| Ferrous Bicarbonate | 0.1855 |
| Calcium Bicarbonate | 45.9705 |
| Calcium Sulphate | 17.4500 |
| Magnesium Sulphate | 9.8000 |
| Sodium Sulphate | 1.1700 |
| Potassium Chloride | 0.5400 |
| Sodium Chloride | 2.8600 |

Specific gravity, 1.0014 Mineral matter, 80.2949

### ELECTRIC SPRING, JOHNSON COUNTY.

Chalybeate Water. Anal. by Woodward.

| | |
|---|---|
| Silica | 1.5645 |
| Alumina | 0.4089 |
| Ferrous Bicarbonate | 0.1428 |
| Calcium Bicarbonate | 27.1180 |
| Magnesium Bicarbonate | 10.6194 |
| Calcium Sulphate | 5.3781 |
| Sodium Sulphate | 7.0954 |
| Sodium Chloride | 0.1058 |

Specific gravity, 1.0002 Mineral matter, 52.4329

### MOORESVILLE SPRING, LIVINGSTON COUNTY.

Chalybeate Water. Anal. by Woodward and Robertson.

| | |
|---|---|
| Silica | 1.5596 |
| Alumina | 0.3095 |
| Ferrous Bicarbonate | 0.0767 |
| Calcium Bicarbonate | 35.5844 |
| Calcium Sulphate | 27.8800 |
| Magnesium Sulphate | 7.1600 |
| Sodium Sulphate | 1.5100 |
| Potassium Chloride | 0.8700 |
| Sodium Chloride | 2.4000 |

Specific gravity, 1.0013 Mineral matter, 77.3502

## PERTLE SPRING, JOHNSON COUNTY.

Chalybeate Water. Anal. by Woodward.

| | |
|---|---|
| Silica | 1.5069 |
| Alumina | 0.2570 |
| Ferrous Bicarbonate | 1.1119 |
| Calcium Bicarbonate | 15.6604 |
| Magnesium Bicarbonate | 6.7583 |
| Sodium Bicarbonate | 5.5508 |
| Sodium Sulphate | 4.5099 |
| Sodium Chloride | 0.1408 |
| Specific gravity, 1.0004 | Mineral matter, 35.4960 |

## LITHIA SPRING, KANSAS CITY, JACKSON COUNTY.

Chalybeate Water. Anal. by Schweitzer.

| | |
|---|---|
| Silica | 1.5420 |
| Alumina | 0.0350 |
| Ferrous Bicarbonate | 0.1910 |
| Calcium Bicarbonate | 23.8589 |
| Magnesium Bicarbonate | 5.9696 |
| Sodium Bicarbonate | 0.2689 |
| Sodium Sulphate | 0.8400 |
| Potassium Chloride | 0.4400 |
| Sodium Chloride | 1.2926 |
| Specific gravity, 1.0004 | Mineral matter, 34.3680 |

# APPENDIX.

# APPENDIX.

OFFICE OF THE MISSOURI GEOLOGICAL SURVEY,
JEFFERSON CITY, MO., August 1, 1900.

During the recent and fatal illness of the late Dr. John A. Gallaher, the accompanying Preliminary Report on the Structural Geology of Missouri went to Press. Numerous changes and additions which would have been made in the body of this Report were not made owing to the fact that the proof was not read by the author and the reading of same was left to persons wholly inexperienced in the matter of "proof-reading." It is to be regretted that Dr. Gallaher's able work in differentiating the Missouri Paleozoic terminated so abruptly and that he did not live to carry out his work in the exhaustive manner he had outlined.

DARLING K. GREGER,
Ass't State Geologist.

OFFICE OF THE STATE GEOLOGIST.
JEFFERSON CITY, MO., July 14, 1900.

Pursuant to the call of the Governor, who is ex-officio President of the Board of Managers of Geology and Mines, a meeting of said Board was held in the Executive reception room at the Capitol on the day aforesaid, and there was present Messrs. O. A. Crandall of Sedalia, G. W. B. Garrett of Lamar and J. R. Edwards of Jefferson City, successor to L. M. Rumsey, deceased. The President of the Board, Governor Stephens, and Dr. John S. Logan of St. Joseph, being absent. On motion, the appointment of a State Geologist was deferred until a full meeting of the Board could be had. It was further ordered by the Board that the cut of the late Dr. Gallaher, procured by his son, be accepted by the Board and placed in the Report of this Board now being printed, and that seven thousand extra pages be purchased for the purposes aforesaid in producing the likeness of the late Dr. Gallaher. On motion, J. R. Edwards was requested to prepare the resolutions of respect on the death of the State Geologist and our worthy associate, Mr. L. M. Rumsey, and together with the sketch of the life of Dr. Gallaher to be printed in the official Report of this Department. Whereupon the following resolutions were submitted and unanimously adopted:

## DEATH OF DR. JOHN A. GALLAHER.

At a meeting of the Board of Managers held at the Capitol in the City of Jefferson, Missouri, on Saturday July 14, 1900, official information was given said Board, that Dr. John A. Gallaher, late State Geologist, had departed this life on the 21st day of June, 1900, and thereupon said Board, for the purpose of expressing its regrets at the death of this noble man and official, unanimously adopted the following resolutions:

Whereas, Almighty God in his infinite wisdom has called from our midst our brother officer, Dr. John A. Gallaher, who for the past three years and more has occupied the position of State Geologist, by appointment from this Board, and called him to labor in other fields; therefore, be it resolved, that in the death of Dr. Gallaher this State has lost one of its most efficient, upright and honorable officials—a man of the strictest integrity and one who has labored faithfully in the performance of the duties of the office to which he had been appointed, and laying aside all personal interest has endeavored to develop the mineral resources of this great State, that she might take her rank in the Union of States, not alone for agriculture and other resourceful interests, but as one of the greatest of mineral producing States. No doubt in his zeal to advance this great interest in a great measure, may be traced the disease that carried him away from us, and made vacant a position not easily filled, and caused a loss to this great State almost irreparable in its nature, and to this Board whose relations with the deceased has been so pleasant and instructive, that it is hard to believe that he shall come before us no more. To a loving and devoted family, no one can tell how deep and sad the affliction, and only those who were so near and dear to him can give an idea of his great loss, and to these the direct and immediate bereaved ones, we extend our heartfelt sympathy in the loss of husband and father. As a further mark of esteem we direct the Secretary to spread upon the records of this Department of the State a copy of these resolutions, as also a sketch of the life of the deceased as given by Dr. John S. Logan, and that the same be given the public press together with a likeness of the deceased, and to be published in the official report of this Department.

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## DEATH OF MR. L. M. RUMSEY.

At a meeting of the Board of Managers of the Bureau of Geology and Mines, the Vice-President of the Board announced the death of Mr. L. M. Rumsey of St. Louis, who has been connected with the Board for nearly four years, one of the most active and efficient officers whose vacancy on the Board is keenly felt throughout the State, but no one feels his loss more keenly than his associates on this Board, for the last three years, and to express their feelings in the death of their associate the folowing resolutions were unanimously adopted:

Whereas, Learning through the public press and through the official announcement of the Vice-President of this Board, of the death of our associate, Mr. L. M. Rumsey, and to express our feelings for his family and our esteem for him as a man, citizen and officer of the Board, we, his associates, have deemed it proper to give expression to this feeling, as follows: Resolved, That in the death of Mr. Rumsey this Board loses the services of a faithful and efficient officer, one who from the day of his appointment has worked faithfully to promote the great mining interests of this State, and to bring into prominence the vast fields of mineral, that for years have lain hidden in the deep recesses of the earth, and labored diligently and earnestly to bring forward every interest connected with the mineral growth of this State, and in his death, this great interest is in a great measure retarded and it will take time to start upon its upward course again. But not only is his death a loss to us, his associates, but the State, for in him it had an official, who has done much to place Missouri on an equal footing, at least, with the other great mining States of the Union. To the family of the deceased, who have been deprived of a loving and devoted husband and parent, we extend our heartfelt sympathy, and as a mark of respect and esteem for our associate, we direct the Secretary of this Board to spread upon its record these resolutions; that a copy of them be given the public press and transmitted to the family of the deceased, and it is further ordered that they be printed in the official report of this Department, that our heartfelt sympathy might be extended to his bereaved and sorrowing family.

Resolved, That these resolutions be spread upon the record of this office and that a copy be furnished for publication and be printed in the report of this Board and a duly certified copy thereof be transmitted to the family of the deceased. And be it further

Resolved, That we extend to the family of the deceased our heartfelt sympathy in this sad hour of their affliction.

On motion, the Board adjourned subject to the call of the President.

O. A. CRANDALL, Vice-President.
J. R. EDWARDS, Sec'y Pro tem.