Chapter 1 : Gleanings from outcrops of silurian strata in the Red River Valley [electronic resource] / - CORI

This complete the description of 7 exposures of Silurian strata in the Red River Valley. These present four groups of rocks possessing marked differences in their lithological and palaeontological characters, and may be represented in the following summary: Selkirk Rocks. Exposure 1,2,3 and 4. Condition Comparatively soft. Action of cold acid.

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But the present year brought more leisure for scientific research, better opportunities and greater facilities for thorough examination of these strata. Besides, a personal examination of the various outcrops described in this paper, on which occasions I have had excellent opportunities to examine the rocks in situ, there has also been examined a very large quantity of stone brought to Winnipeg from the quarries and used both for ordinary building purposes and as stone to be "dressed" for ornamental work. The "dressing" of these stones has opened up a treasure-house of fossil wealth. Many of them in the rough are very large, and require to be split up into smaller pieces before being dressed. As these have been opened, some most interesting specimens of primeval life have been revealed. Nearly every day during the present summer the buildings in course of erection have been visited and scarcely has a single visit been made without some information gained regarding the Silurian fossils of these rocks. In placing the results of my investigations before you, I purpose describing groups of outcrops that are somewhat uniform in their lithological and palaeontological characters, and enumerate the fossils found in them. After which to give some conclusions arrived at from the consideration of the whole. The accompanying sketch map represents the location of the seven outcrops described in this paper. A sketch map showing the position of the exposures was on exhibition. The exposure is not very extensive as yet, the quarry being opened but a comparatively short time. As you approach this place from the station you perceive that there is a slight elevation, well defined in the vicinity of the outcrop. Looking at the fact of the rock you observe that the strata are covered with about four feet of loose grift in the southern part, but full then in the northern. In this are numerous boulders, a few gneissoid, but most of them the same material as the solid rock, and of a more or less angular nature. The strata on the east side is quite horizontal, but on the west very much tilted. There appears to be a break through the centre of the quarry, indicating a marked upheaval at one time. This likely took place after the glacial period, for the glacial drift is deposited quite irregularly over the disturbed rock. From the raised appearance of this part it seems as if the apparent mound over the quarry had its origin in this upheaval. Fossils appear after the first layer of rock is removed. No part of the quarry as yet seems more prolific than another. They layers of rock are about 2 feet thick, and exposed to a depth of 12 feet. Neither from personal observation nor from questioning the workmen have I been able to ascertain that certain fossils characterize particular beds. The most casual observer could not fail to observe the fossils on the stones of this place. Remains of Cephalopods Corals and the genus Receptacullites are seen on every side, the last being exceedingly common. The Cephalopods are numerous and large, several 5 to 7 inches in diameter have been observed. The rock from this place is largely used in Winnipeg for ornamental stone. Being comparatively soft it "dresses" readily and takes a good finish and when burnt produces a very white lime. It is of a grayish white color and effervesces strongly on treatment with cold Hydrochloric acid. It presents a peculiar mottled like appearance which adds much to its beauty as an ornamental stone. This strange mixture of brown and white is difficult to account for. In some cases it appears as if its origin might be due to seaweed remains. Often the colored portion approaches the color of yellow ochre and seems strongly impregnated with iron, while the intervening spaces are more or less colored. So marked is this mottled condition that the stone from Selkirk district can be distinguished at once from the rock described in a subsequent part of this paper. Of the various exposures visited this has afforded the best results, and as already remarked the fossils cannot be connected with particular beds but are bound within a thickness of 10 feet. In several of the thick fragments of rock though no lines of stratification can be seen, still in many cases they readily split. When this is done peculiar markings are frequently observed. These appear to be the remains of plant life. Portions of stems can be made, but the whole are in a confused condition and no definite characteristics are discernible. Notwithstanding fossils are numerous in this limestone and in many cases their generic characters easily observed yet we often find the specific comparatively obscure and difficult to identify. Exposure 2 This quarry is about half a mile northwest of No. Here the rock is not so near the surface as in the preceding, but covered with about 20 feet of drift material which renders it more difficult to quarry the stone. The drift is full of large boulders of the same material as the solid rock below. These are taken out and shipped to the city. Only a few feet of the solid rock has been worked, and though many fragments are lying about, yet they do not appear as prolific in fossils as at the rock at the former quarry. The stone is the same as already described in general appearance, but is said to be slightly softer and preferred by stone-dressers. Here the rock is on the bank of the river 5 feet above the water level. About 15 feet of drift overlies the stone. This rock while to a great extent it resembles in external characters that from exposures 1 and 2 seems to be harder, but breaks very readily, and in some cases presents a conchoidal fracture. A large quantity of this stone was quarried during the past winter and conveyed to Selkirk to be used in the erection of the provincial asylum. I had an excellent opportunity of examining this stone on the asylum grounds, where large quantities of it was lying. Whether the fact of its being quarried in winter affected its condition I am not prepared to say, but it certainly possessed some characters differing much from the rock at East Selkirk. The stone-cutters pronounced it a very fine rock to work and much superior to any of the Red River stone they had dressed. Very little could be seen at the quarry. The surface had fallen into the excavation during the spring and covered up the rock, but during several examinations at the public buildings some very fine specimens were obtained. Fossils were very common and peculiar in as much as they were in some cases like those found at Stony Mountain in an entirely different kind of rock, thus forming a sort of transition between the rocks at Selkirk East, 4 miles further down the river, and those of the mountain situated several miles west of it. This is an important point and well worthy the attention of future investigators. Orthis testudinaria, chaetetes lycoperdon and one imperfect specimen of the genus Rhynchonella, common fossils at Stony Mountain, were found at this place. Several masses of a coral apparently of the genus Diphyllum were found here only. Crinoid stems and some fragments of Polyzoa were also observed. I was very much surprised at the results obtained from this outcrop, for I had found none of the above mentioned at either of the East Selkirk exposures, and am inclined to consider this a connecting stratum between those of Stony Mountain and East Selkirk. McCharles, of Winnipeg, had found specimens of the genus Spiferia here, but as the stone containing them was a rounded fragment it may have come from elsewhere, probably the Deronian rocks, supposed to lie west and north of this part. Exposure 4 This is still father south, being about four miles up the river. In this vicinity numerous limestone boulders are found. These are much the same in character as the rocks of the preceding quarries. They are frequently collected by farmers in the neighborhood and used in making lime. No large exposure occurs in any part like those of outcrops 1,2,3, as no stone is quarried at present in this district, but it is evident from the innumerable limestone boulders scattered along the river that rocks in situ are not below the surface. These exposures show that this band of mottled whitish grey rocks extends at least in width for a distance of 8 miles, and that this rock is very uniform in its external character. The following is a list of fossils obtained from the outcrops referred to as Exposures 1,2,3,4. They vary from 5 to 10 inches in diameter. There is scarcely a large stone but shows several specimens. In every case the specific characters are very obscure. Although I have seen innumerable specimens none as yet have been observed that gave the least indication "of a great central cavity," as stated by Billings in his descriptions of this genus. Every one is circular, none less than 5 inches in diameter an usually about lines thick. The external and internal integuments are distinct and the peculiar tubular skeleton very marked. The rhomboidal plates are readily perceived and the rounded protuberance on the lower side easily seen. It is very difficult to get complete specimens out on the rock, as they almost invariably break up owing, no doubt, to their discoidal form and comparative thinness. The species common here is likely Receptaculities Oweni, Hall. In this the laminae numbering 4 to the line are well marked, and present a wave-like appearance. Three distinct crests are shown in one specimen. On the surface above these are several apertures, around which the laurmae presents a series of concentric rings. This wave-like arrangement has been observed on several specimens, and seems to be a characteristic of the species. On the surface are conical elevations, and the whole covered wite stellate markings. Some specimens very large, over a foot, in diameter. A variety of this species with small corallites has been found. The lace-like structure of the corallites and stellate appearance on the surface make it one of the most beautiful corals found in the Selkirk limestone. Zaphrentis, - Common in three forms. Each likely represents a different species. One shows a distinctly quadrilateral outline in a transverse section. Another exhibits a short but expanded cup, while the third is much longer and tapers more gradually to a point. Besides these, two other species of coral seem to be present or allied to Favosites, the other to Syringopora.

Chapter 2 : Ouachita Mountains - Wikipedia

Gleanings from outcrops of silurian strata in the Red River Valley [microform] by Panton, J. Hoyes (James Hoyes), ; Manitoba Historical and Scientific Society Publication date

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries. We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes. Read more about Early Journal Content at http: JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. The geological formations are not as numerous or of such great variety as in many states, and the strata have undergone but little deforma- tion since they were deposited. They are for the most part prac- tically horizontal or have only a gentle dip. Metamorphism has produced little or no change in the rocks, and, except for the deeply buried granite near the eastern borders of the state, there have been no intrusions or extrusions of igneous material. The rocks are chiefly clays, shales, and sandstones belonging to the Cretaceous and Tertiary periods, overlain in most places by the drift deposits of the Pleistocene. The surface features of about two-thirds of the state are therefore those of a gently rolling to rough drift plain. The flat lacustrine plain of the Red River Valley occupies a strip 25 to 35 miles wide along the eastern border, while west and south of the Missouri River the drift mantle is too thin to affect the topog- raphy to any great extent. This large area beyond the Missouri everywhere shows evidence of long-continued erosion, with its numerous stream valleys, buttes, mesas, and badlands. The granite is struck at depths ranging from to feet, and its surface is quite uneven. It is overlain in some places by glacial drift, in others by Cretaceous shale and sandstone, and in the northern portion of the valley by Paleozoic strata. In going from south to north in the valley the granite has been encountered in wells at various depths as follows: Wahpeton, feet; Moorhead, Minnesota, across the river from Fargo, feet; well 7 miles north of Moorhead, feet; Casselton, 20 miles west of Fargo, feet; Grand Forks, feet; East Grand Forks, Minnesota, feet; University, two miles west of Grand Forks, feet; and Grafton, 40 miles north, feet. The well at Rosenfeld, Manitoba, 14 miles north of the international boundary and 1 1 miles west of the Red River, reached the granite or gneiss at 1, feet. The Moorhead well, which was drilled by the city in search of water and gas, is notable on account of the distance it went in the granite, the record being as follows: Two or more of these systems outcrop not far to the north in Manitoba, to the east in Minnesota, and to the south 1 G. The Grafton well passed through, beneath feet of drift and Lake Agassiz silt, feet of Paleozoic strata, including feet of shale and sandstone, which has been referred to the Cambrian, and feet of limestone, sandstone, and shale, which are believed to belong to the Ordovician. The Ordovician appears to thicken rapidly toward the north, for while at Grafton, as stated above, it is feet thick, 60 miles north at Rosenfeld, Manitoba, it has increased to feet, and is overlain by feet of Silurian strata. The Dakota sandstone at Morden rests directly on the Devonian beds. In the Morden well, at a depth of feet, feet of Devonian red and gray shales and a thin layer of porous limestone were penetrated, and strata of this age cover a narrow strip of territory lying just west of the Silurian in Manitoba. It is not unlikely that these Devonian and Silurian strata extend south some distance into North Dakota. In the deep well at the Jamestown asylum 19 feet of limestone was pene- trated at the bottom of the wells, at a depth of 1, feet. The well at LaMoure, about 40 miles southeast of Jamestown, struck a compact gray crystalline limestone with a pinkish tinge at 1, feet, and went 28 feet in this rock, stopping at a depth of 1, feet. The age of the limestone struck in these two wells is not known, though it is probably to be referred to the early Paleozoic. During the later Paleozoic the region does not appear to have been an area of deposition and probably remained above the sea also throughout a large part of the Mesozoic, since rocks belonging to the Triassic, Jurassic, and Lower Cretaceous or

Comanchean are, so far as known, wanting in the state. In the southeastern counties, as well as in South Dakota and elsewhere, the sandstone is the chief source of artesian water. It is a non- marine formation and was deposited either in a large lake or was spread by rivers over their broad flood plains. The Dakota sand- stone underlies the entire state, except a considerable portion of the Red River Valley, where it has been removed by erosion Fig. A rather fine-grained white sandstone, which is doubtless the Dakota, is found in a number of wells in the Red River Valley at depths ranging from to feet, and in several wells the sand- stone was penetrated feet. In southeastern North Dakota outside the valley, the Dakota sandstone is encountered at depths varying from about feet near the western edge of the Red River Valley to 1, feet and over not far west of the James River and near the edge of the Missouri Plateau. The increasing depth of the formation is due both to the westward dip of the Dakota and the rise of the land surface in that direction. The depth of the sandstone at Enderlin is feet; Valley City, about feet; Oakes, feet; Ellendale, 1, feet; and Jamestown, 1, feet. The deep well at Devils Lake, in the northeastern part of the state, struck the sandstone at 1, feet, while at Leeds, 30 miles north- west of Devils Lake, it lies at a depth of 2, feet. The Harvey well, near the center of the state, reached the Dakota at 2, feet, and a deep boring a few miles from Westhope, Bottineau County, entered the sandstone at about 2, feet. Though the well at Mandan reached a depth of 2, feet it failed to strike the Dakota, probably by several hundred feet. As disclosed by the wells which penetrate it, the Dakota forma- tion is a soft white or gray sandstone in beds 10 to 50 feet thick, separated by shale. In the regions where it occurs at the surface the sandstone has yielded an abundance of fossil leaves, the Dakota flora including no less than species of trees and other plants. In northeastern South Dakota wells have encountered to feet of Benton. While the Cretaceous formations have been largely removed by erosion from the Red River Valley, a dark-colored shale overlying a soft sandstone has been encountered in a number of wells in different parts of the valley, and it seems not improbable that this is the Benton shale. In that case this shale underlies the drift over a portion of the valley. This escarpment extends far to the north in Canada, and the formation appears in the Tiger Hills, Riding and Duck mountains, and the Pasquia Hills. In North Dakota the Niobrara occupies a narrow belt extending 30 miles south of the international boundary, the outcrops being found along the Pembina, Tongue, north fork of Park River, and tributaries of these streams, which have cut deep valleys in the escarpment and exposed the Niobrara beneath the Pierre shale. A highly calcareous shale exposed in the valley of the Cheyenne River at Valley City is also probably to be referred to the Niobrara. It contains 45 per cent of carbonate of lime, and lies just below the black and white bands forming the base of the Pierre, as described on a later page. The Niobrara is a light to dark gray, moderately hard calcareous shale. It contains numerous small white specks of lime which give it a finely mottled or speckled appearance, plainly seen on fresh fractures. Where the rock has been weathered it becomes almost white and has a chalky appearance; in fact, in many localities outside the state the formation is a nearly pure chalk. Its lime content, which is the most marked characteristic of the Niobrara, is due almost entirely to the presence of minute Foraminif era which are readily seen under the microscope. The most abundant forms are the two species so common in chalk, Globigerina cretacea and Textularia globulosa. The percentage of lime carbonate in the different layers varies widely, ranging from 30 per cent and less to 75 per cent. Many of the beds are suitable for making natural hydraulic cement and are used for this purpose, while certain layers have almost or quite the composition of a natural Portland cement rock. Wherever the Niobrara formation is exposed in the Pembina Mountains it maintains a fairly uniform character throughout its thickness of feet and more. By far the greater portion of the aggregate thickness is formed of a rather dark bluish-gray speckled rock, which commonly varies in lime carbonate content from 55 to 65 per cent in passing from one layer to another. Generally the more speckled the rock appears the higher it is in lime. Between these thicker beds high in lime carbonate are others much thinner, varying from a few inches to a foot in thickness, which are much lower in lime. Where exposed in northeastern North Dakota the Niobrara strata have yielded a number of vertebrate and invertebrate fossils. Among the latter are Inoceramus labiatus, specimens of Ostrea and Avicula, besides the microscopic forms previously mentioned. The large diving bird, Hesperomis, several species of fishes, Plesiosaurus, and the vertebrae of a crocodile have also been found. The maximum thickness of the Niobrara in the Pembina Moun- tains is feet. At Morden, Manitoba, the formation is feet, and farther north it averages from to feet, but seems to thicken toward the west, for the well at Deloraine, a few miles north of the Turtle Mountains, shows a thickness for the Niobrara of feet. The formation probably has a thickness of at least feet in southern and central North Dakota, since at Valley City the combined thickness of the Benton and Niobrara is about feet. The artesian wells at this place reach the Dakota sand- stone at a depth of approximately feet below the bottom of the Cheyenne Valley, and the calcareous shale, which outcrops in the sides of the valley and is believed to be Niobrara, rises about 80 feet above the well curbs. The thickness of the beds between the top of the Dakota sandstone and the base of the Pierre is thus io A. It also out- crops along the valley of the Missouri River for a distance of over 20 miles north of the South Dakota line, and is brought to the surface in the southwestern corner of the state by the Cedar Creek anticline, which lies mostly in Montana. Throughout the large eastern area it is covered by glacial drift, except where the streams have cut through this mantle and exposed the shale beneath. The Pierre outcrops in many places along the James and Cheyenne rivers and is finely exposed along the South Branch of Park River and other tributaries of the Red River in the region of the Pembina Mountains. The escarpment of the Pembina Mountains is com- posed largely of this shale, which is well shown in the numerous ravines and gorges, while in places the underlying Niobrara is also seen. The base of the Pierre as found in this region is composed of black, jointed, carbonaceous shales which contain many thin layers of yellow or white non-plastic clay, which has much of the con- sistency of cheese. The black and yellow strata present a striking appearance and seem to be characteristic of the base of the Pierre over extensive areas. They appear at frequent intervals for a distance of 30 miles along the Pembina Mountain escarpment and extend at least miles northwestward in Canada, where they have been noted in the Riding and Duck mountains. They are also found miles south of the Pembina Mountains at Valley City. The yellow or white clay seams vary in thickness from 1 to 6 inches, and the interstratified black layers from 8 to 14 inches. The uniformity and extent of some of the yellow seams are remark- able because they have been traced continuously for a distance of 35 miles, and a single clay seam 2 inches thick for 25 miles. The typical Pierre overlying these basal beds is a bluish-gray to dark gray jointed shale of remarkably uniform character, which often weathers into small flaky fragments. The rock commonly shows yellow spots or stains of iron oxide. Many of these are rich in marine shells, including the following: Scaphites nodosus Owen vars. The position of the western boundary of the large Pierre area is known only approximately, since the region is heavily drift- covered and there are practically no outcrops. Not far west of the boundary as represented on the map p. It will be noted that no areas of Fox Hills or Lance are represented on the map along most of the margin of the Pierre shale. These formations are not known to underlie the drift farther north than indicated on the map, and in the absence of information regarding their presence in the central and northern parts of the state they are not mapped in that region. If they are actually absent from that area it would of course mean an unconformity between the Pierre and the overlying Fort Union. The Pierre is the thickest Cretaceous formation in North Dakota, reaching 1, to 1, feet or over. It is not likely that its entire thickness is represented throughout most of the large eastern area, since the formation had undergone great erosion before being covered by the glacial drift and hundreds of feet were doubtless removed in many places. In the latter region the aggregate thickness of these formations ranges from to feet, but they become thicker to the north and northwest, where 1 Identified by Dr. The deepest well in the state, at Max, 30 miles south of Minot, has a depth of about 2, feet, but it passed through drift, some Fort Union, and probably the Lance before entering the Cretaceous shales, and it did not reach the Dakota sandstone. The Deloraine well not far north of the international boundary went through 1, feet of shales, including some Fort Union strata, without reaching the Dakota. The largest of these is along the Missouri River, where the formation is exposed for over 40 miles north of the South Dakota line and extending 5 to 10 miles on either side of the river. A narrow belt of Fox Hills sandstone surrounds the Pierre area in the southwestern corner of the state, and there is a small outcrop near the center of the state. The sandy portion of the formation is a yellow, rusty brown or gray, rather soft sandstone. Cross-bedding is very common, and the formation contains great numbers of large and small ferruginous sandstone concretions and indurated masses and layers, these also exhibiting cross-bedding. The concretions are apparently due to the segregation of the iron in certain portions of the rock, cementing the sand into firm, hard masses, considerably harder than the sandstone in which they are imbedded. These concretionary masses vary in size from an inch and less to 6 and 8 feet. Small, irregular, twisted or stemlike forms are abundant in places.

Chapter 3 : images tagged with 'rock strata' :: Geograph Britain and Ireland

*Gleanings From Outcrops Of Silurian Strata In The Red River Valley, Manitoba () [James Hoyes Panton] on calendrierdelascience.com *FREE* shipping on qualifying offers. This scarce antiquarian book is a facsimile reprint of the original.*

Devonian geology Significant geologic events The union of the paleocontinents of Laurentia and Baltica occurred near the beginning of the Devonian to form a single landmass that has been referred to both as Laurussia and as Euramerica. The northern portion of the combined landmass gave rise to widespread areas of continental desert , playa , and alluvial plain deposits that form one of the earliest documented large areas of nonmarine sedimentation. These terrestrial deposits, known as the Old Red Sandstone , covered much of the then-united areas of North America , Greenland , Scandinavia , and the northern British Isles. They contain remarkable documentation of the colonization of land by vertebrates as well as that of freshwater rivers and lakes by plants and fish. The two latter groups existed prior to this time, but they had their earliest extensive evolutionary radiation during the Devonian. Courtesy of Ernst ten Haaf The areas south of the Old Red Sandstone, including sectors of eastern and western North America, central and southern Europe, and parts of European Russia, were often covered by shallow continental shelf seas with local deeper marine troughs. The continental collision that united these paleocontinents, which began during the Silurian Period , resulted from the closing of the Iapetus Ocean which was the precursor of the Atlantic Ocean and is known as the Iapetus suture. It was marked by a mountain-building event, the Caledonian orogeny , that established a mountain chain stretching from present-day eastern North America through Greenland, western Scandinavia, Scotland , Ireland , and northern England and south to the fringes of western North Africa. Considerable igneous activity was associated with the Caledonian orogenic belt, both intrusive emplacement of magmatic bodies at depth and extrusive volcanic activity at the surface. Sediments derived from erosion of the mountain belt formed locally important strata such as the European deposits laid down during the Lower Devonian and the Catskill Delta in New York state begun in the Middle Devonian. The present-day southern continents of South America, Africa, Australia, and Antarctica and the Indian subcontinent were joined together as the enormous continental mass called Gondwana during the Devonian. Large areas of Asia east of the Ural Mountains were divided into separate landmasses at this point in Earth history. Their distribution is poorly understood, but many of them may have been attached to the margins of Gondwana. Also during the Devonian Period, Gondwana began impinging upon Laurussia. There is evidence that these two landmasses completely fused together during the Late Carboniferous or Early Permian periods. Sea level rose transgressed and fell regressed frequently during the Devonian. Some of these episodes were accompanied by a brief period of deposition of anoxic oxygen-depleted black shales or limestones. Many of these deposits are quite widespread. Some are associated with the extinction of important groups of fossil organisms. Economic significance of Devonian deposits In many countries Devonian rocks have provided building stone, refractory and building brick, glass sands, and abrasive materials. Marble of Devonian age has been quarried in France and Belgium. German medieval castles are mostly clad with Devonian slates. In areas of European Russia and in Saskatchewan, Can. Lodes of tin , zinc , and copper occur in several areas where Devonian rocks have been subject to orogenic mountain-building processes, such as in Devon and Cornwall in England and in central Europe. Since the 19th century, oil and natural gas have been produced from Devonian rocks in New York and Pennsylvania. In the s, oil was found in Devonian sandstones in the Ural-Volga region and later in the Pechora area of northern European Russia. In oil was discovered in an Upper Devonian reef at Leduc, Alta. These rocks occur on all continents both at the surface and as substrata. Subsequent folding has made such rocks common in many ancient fold belts. The standard stages are shown on the table. Stratigraphic boundaries within the Devonian System are correlated using various fossil groups. In Devonian marine deposits, small toothlike conodonts and chambered cephalopod ammonites are especially important, but spores, brachiopods lamp shells , and corals are also useful. In nonmarine deposits, freshwater fish and plant spores are employed for correlation. In the past, considerable difficulty was encountered in correlating the Silurian-Devonian boundary, and serious errors were made. This situation resulted because of the misconception that graptolites became extinct at the boundary. It is now known that these invertebrates range into the Emsian. In areas where graptolites range into the Early Devonian, especially in mainland Europe and Asia, much miscorrelation occurred. Today the base of the graptolite zone of Monograptus uniformis is regarded as marking the base of the Devonian. Occurrence and distribution of Devonian deposits Europe and North America were united approximately along their present continental slope margins during the Devonian Period. The collision of these two landmasses resulted in the Caledonian orogeny. At the close of the Silurian and continuing in the Early Devonian, considerable igneous activity both extrusive and intrusive occurred in the Caledonian mountain belt , which stretched from New England , Nova Scotia , Newfoundland, Scotland, and Scandinavia to eastern Greenland. Radiometric dating of granitic intrusions associated with the Caledonian orogeny yields ages between about million and million years. The igneous activity that produced such intrusions constituted the final stages of subduction and obduction that is, overthrusting of the edge of one lithospheric plate over another at a convergent boundary , leading to the union of the constituent parts of Laurussia. The Caledonian mountains were undergoing active uplift during the Devonian. The Old Red Sandstone deposits appear to be the detritus produced by the erosion of these mountain areas. Clastic material from the belt dominated the European Lower Devonian but was local and limited after that point. In eastern North America similar activity near the Silurian-Devonian boundary was followed by renewed activity during the Middle Devonian that was associated with the Acadian orogeny and the commencement of the Catskill Delta. The easterly derived fan clastics of the latter are increasingly dominant eastward across New York state, and its mostly nonmarine alluvial rocks are best seen in the Catskill Mountains near Albany. Marine Devonian rocks provide evidence that marine waters encircled Laurussia. It is clear that there was probably easterly directed subduction in western North America during the Devonian. Relics of this process are incorporated into the Cordilleran mountain chain as discrete terranes that were accreted to the continent during or after the Devonian. The clearest evidence is from the mid- Famennian Antler orogeny , during which a tectonic event resulted in clastic material being shed eastward. This event is well documented, especially in Nevada. In many areas Devonian rocks have been heavily deformed and folded by subsequent tectonic activity. These fold belts may be distinguished from cratonic areas where sediments remain much as they were when formed. The main fold belts in North America are the Cordillera western mountain ranges, including the Rocky Mountains and the Appalachian belts to the east. In contrast, the Devonian of the Midwestern United States and adjoining areas is flat-lying. In South America the main fold belt is the Andes and sub-Andes; east of this line, the Devonian rocks are little disturbed. In Australia the main fold belt is in the east from Queensland to Tasmania. In Europe the Armorican fold belt stretches eastward from Cornwall and Brittany. To the south of this line from the Pyrenees to Malaysia, Devonian rocks are caught up in the Alpine-Himalayan fold belt. Similarly, the Devonian of the Ural Mountains is disturbed, whereas to the west, on the Russian Platform, and to the east there is less deformation. In all these cases the folding occurred well after the Devonian, but there is evidence that Devonian sedimentation contributed to the oceanic belts that were sites of the mountain building that occurred later. In the regions that have suffered severe deformation, the Devonian sediments are frequently metamorphosed into slates and schists and often lose all the characteristics by which they may be dated. In areas where little change has taken place, all rock lithologies occur, from those characteristic of continental and desert conditions to the varied lithologies associated with continental shelf and deep-sea accumulation. Contemporary igneous activity was widespread in the form of extrusive lavas, submarine pillow lavas, tuffs, agglomerates, and bentonites, as well as igneous intrusions. Extrusive activity is found in both continental and marine environments , whereas plutonic intrusions are usually linked with areas of uplift such as the Caledonian and Acadian belts of Europe and eastern North America. Sediment types A wide range of terrestrial and marine sediments of Devonian age are known internationally, and there is a corresponding variety of sedimentary rock types. Devonian igneous activity was considerable, albeit localized. Laurussia is thought to have been near-tropical and sometimes arid. Playa facies, eolian dunes, and fan breccias are known. Fluviatile sediments, deposited by water under flash-flood conditions, have been identified, and these are correlated to alluvial sediments of broad coastal flats. There are lacustrine deposits of freshwater or supersaline type. Similar facies are known in other continental areas of the Devonian. Similarly, nearshore clastic, prodelta, and delta sandstones and offshore mud facies are comparable to those known in other periods. Devonian sedimentary rocks include the spectacular carbonate reef deposits of Western Australia , Europe, and western Canada, where the reefs are largely formed of stromatoporoids. These marine invertebrates suddenly vanished almost entirely by the end of the Frasnian Age, after which reefs were formed locally of cyanobacterian stromatolites. Other areas have reefs formed by mud mounds, and there are spectacular examples in southern Morocco, southern Algeria, and Mauritania. Also distinctively Devonian is the development of locally extensive black shale deposits. The latter are frequently characterized by distinctive fossils, though rarely of the benthic variety, indicating that they were formed when seafloor oxygen levels were very low. Distinctive condensed pelagic limestones rich in fossil cephalopods occur locally in Europe and the Urals; these form the facies termed Cephalopodenkalk or Knollenkalk in Germany and griotte in France. In former times the latter was worked for marble. Evaporite deposits are widespread, but coals are rare. There is no firm evidence for glacial deposits except in the late Devonian of Brazil. Various types of volcanic rocks have been observed in the areas that were converging island-arc regimes. Some volcanic ash horizons, such as the Tioga Metabentonite of the eastern United States, represent short-term events that are useful for correlation. Europe A line passing from the Bristol Channel eastward to northern Belgium and Germany roughly demarcates the Devonian marine area from the Old Red Sandstone continental deposits to the south. The continental deposits, which characteristically are red-stained with iron oxide, extend also to Greenland, Spitsbergen, Bear Island, and Norway. The rocks of this wide area have a remarkable affinity in both fauna and rock type and are usually considered to have been united in Devonian times. The relationships with the underlying Silurian System are seen in the classic Welsh borderlands, where the Ludlow Bone Bed was taken as the boundary until international agreement placed it somewhat higher. In Wales, southern Ireland, and the Scottish Lowlands , thicknesses of detrital deposits, chiefly sandstones, accumulated to as much as 6, metres 20, feet in places. These sediments are rich in fish and plants, as are the eastern Greenland and Norwegian deposits. Widespread volcanics occur in Scotland. Devonian rocks in Devon and Cornwall are mostly marine, but there are intercalations of terrestrial deposits from the north. In northern Devon, at least 3, metres 12, feet of shales, thin limestones, sandstones, and conglomerates occur. The latter two lithologies are typical of the Hangman Grits and Pickwell Down Sandstones, which are the main terrestrial intercalations. However, in southern Devon, reef limestones occur in Middle Devonian formations, and the Upper Devonian formation locally shows very thin sequences formed on submarine rises and contemporary pillow lavas in basinal areas. In northern Cornwall both the Middle and Upper Devonian formations primarily occur in slate facies. Fossils found in these rocks have permitted detailed correlations with the Belgian and German sequences.

Chapter 4 : Bend Archâ€“Fort Worth Basin - Wikipedia

Gleanings from outcrops of silurian strata in the Red River Valley [electronic resource] / By J. Hoyes (James Hoyes) Panton and Manitoba Historical and.

Bring fact-checked results to the top of your browser search. Completion of the Phanerozoic time scale With the development of the basic principles of faunal succession and correlation and the recognition of facies variability, it was a relatively short step before large areas of Europe began to be placed in the context of a global geologic succession. This was not, however, accomplished in a systematic manner. The German naturalist Alexander von Humboldt had recognized the widespread occurrence of fossil-bearing limestones throughout Europe. Particular to these limestones, which formed large tracts of the Jura Mountains of Switzerland, were certain fossils that closely resembled those known from the Lias and Oolite formations of England, which were then being described by William Smith. By , when the geologist Leopold Buch recognized this rock sequence in southern Germany, the conceptual development of the Jurassic System was complete. The coal-bearing strata of England, known as the Coal Measures , had been exploited for centuries, and their distribution and vertical and lateral variability were the subject of numerous local studies throughout the 17th and early 18th centuries, including those of Smith. Conybeare and William Phillips, in their synthesis of the geology of England and Wales in Conybeare and Phillips coined the term Carboniferous or coal-bearing to apply to the succession of rocks from north-central England that contained the Coal Measures. The unit also included several underlying rock formations extending down into what investigators now consider part of the underlying Devonian System. At the time, however, the approach by Conybeare and Phillips was to encompass in their definition of the Carboniferous all of the associated strata that could be reasonably included in the Coal Measures succession. While doing so, he began to recognize a common sequence of soft limestones, greensands glauconite-bearing sandstones , and related marls in what is today known to be a widespread distribution along coastal regions bordering the North Sea and certain regions of the Baltic. The dominant lithology of this sequence is frequently the soft limestones or chalk beds so well known from the Dover region of southeast England and Calais in nearby France. In Jules Desnoyers of France, studying sediments in the Seine valley, proposed using the term Quaternary to encompass all of these various post-Tertiary formations. At nearly the same time, the important work of Lyell on the faunal succession of the Paris Basin permitted finer-scaled discrimination of this classic Tertiary sequence. In Lyell, using various biostratigraphic evidence, proposed several divisions of the Tertiary System that included the Eocene, Miocene, and Pliocene epochs. By he proposed using the term Pleistocene instead of dividing his Pliocene Epoch into older and newer phases. Beyrich introduced the Oligocene in after having investigated outcrops in Belgium and Germany, while Schimper proposed adding the Paleocene in based on his studies of Paris Basin flora. Based on his earlier work, Friedrich August von Alberti identified in these three distinct lithostratigraphic units, the Bunter Sandstone, the Muschelkalk Limestone, and the Keuper Marls and Clays, as constituting the Trias or Triassic System. Perhaps one of the most intriguing episodes in the development of the geologic time scale concerns the efforts of two British geologists and in large measure their attempts at unraveling the complex geologic history of Wales. Adam Sedgwick and Roderick Impey Murchison began working, in , on the sequence of rocks lying beneath the Old Red Sandstone which had been included in the basal sequence of the Carboniferous, as defined by Conybeare and Phillips, earlier in What started as an earnest collaborative attempt at deciphering the structurally and stratigraphically complicated rock succession in Wales ended in with a presentation outlining two distinct subdivisions of the pre-Carboniferous succession. Working up from the base of the post-Primary rock succession of poorly fossiliferous clastic rocks in northern Wales, Sedgwick identified a sequence of rock units defined primarily by their various lithologies. He designated this succession the Cambrian , after Cambria, the Roman name for Wales. Murchison worked downward in the considerably more fossiliferous pre-Old Red Sandstone rock sequence in southern Wales and was able to identify a succession of strata containing a well-preserved fossil fauna. Murchison named his rock succession the Silurian , after the Roman name for an early Welsh tribe. With it being superseded by the paleontologically based concept of the Silurian, some sort of compromise had to be worked out. The term Ordovician is derived from yet another Roman-named tribe of ancient Wales, the Ordovices. This divisible Silurian, as well as separate lines of evidence gathered by Lapworth in Scotland and Wales, finally enabled the individual character of the Cambrian, Ordovician, and Silurian systems to be resolved. While involved in their work on Welsh stratigraphic successions, Sedgwick and Murchison had the opportunity to compare some rock outcroppings in Devonshire, in southwest England, with similar rocks in Wales. Eventually recognizing that these fossil-bearing sequences represented lateral equivalents in time and perhaps temporally unique strata as well, Sedgwick and Murchison in proposed the Devonian System. During the early s, Murchison traveled with the French paleontologist Edouard de Verneuil and the Latvian-born geologist Alexandr Keyserling to study the rock succession of the eastern Russian platform, the area of Russia west of the Ural Mountains. Near the town of Perm, Murchison and Verneuil identified fossiliferous strata containing both Carboniferous and a younger fauna at that time not recognized elsewhere in Europe or in the British Isles. Whereas the Carboniferous fossils were similar to those they had seen elsewhere mainly from the Coal Measures , the stratigraphically higher fauna appeared somewhat transitional to the Triassic succession of Germany as then understood. Murchison coined the term Permian after the town of Perm to represent this intermediate succession. Furthermore, coal-bearing strata exposed in Pennsylvania greatly resembled the similar coal-bearing strata of the Upper Coal Measures. Lying beneath these coal-bearing rocks of Pennsylvania was a sequence of limestones that could be traced over thousands of square kilometres and that occurred in numerous outcrops along various tributary streams to the Ohio and Mississippi rivers in Indiana, Kentucky, Missouri, Illinois, and Iowa. Eventually the overlying strata, the coal-bearing rocks originally described from Pennsylvania, were formalized as Pennsylvanian in by the paleontologist and stratigrapher Henry Shaler Williams. The North American-defined Mississippian and Pennsylvanian systems were later correlated with presumed European and British successions. Although approximately similar in successional relationship, the Mississippianâ€"Pennsylvanian boundary in North America is now considered slightly younger than the Lowerâ€"Upper Carboniferous boundary in Europe. By the s, with the development of the geologic time scale nearly complete, investigators were beginning to recognize that a number of major paleontologically defined boundaries were common and recurrent regardless of where a succession was studied. By this time rock successions were being defined according to fauna they contained, and the relative time scale, which was being erected, was based on the principle of faunal succession; consequently, any major hiatus or change in faunal character was bound to be interpreted as important. In Sedgwick proposed that all pre-Old Red Sandstone sediments be included in the rock succession designated the Paleozoic Series or Era that contained generally primitive fossil fauna. This subdivision of the generally fossiliferous strata that lay superpositionally above the so-called Primary rocks of many of the early workers resulted in the recognition of three distinct eras. Subsequent subdivision of these eras into specific geologic periods finally provided the hierarchy for describing the relative dating of geologic events. Development of radioactive dating methods and their application As has been seen, the geologic time scale is based on stratified rock assemblages that contain a fossil record. For the most part, these fossils allow various forms of information from the rock succession to be viewed in terms of their relative position in the sequence. Approximately the first 87 percent of Earth history occurred before the evolutionary development of shell-bearing organisms. The result of this mineralogic control on the preservability of organic remains in the rock record is that the geologic time scaleâ€"essentially a measure of biologic changes through timeâ€"takes in only the last 13 percent of Earth history. Although the span of time preceding the Cambrian periodâ€"the Precambrian â€"is nearly devoid of characteristic fossil remains and coincides with some of the primary rocks of certain early workers, it must, nevertheless, be evaluated in its temporal context. Early attempts at calculating the age of the Earth Historically, the subdivision of Precambrian rock sequences and, therefore, Precambrian time had been accomplished on the basis of structural or lithologic grounds. With only minor indications of fossil occurrence mainly in the form of algal stromatolites , no effective method of quantifying this loosely constructed chronology existed until the discovery of radioactivity enabled dating procedures to be applied directly to the rocks in question. The quantification of geologic time remained an elusive matter for most human enquiry into the age of the Earth and its complex physical and biological history. Although Hindu teachings accept a very ancient origin for the Earth, medieval Western concepts of Earth history were based for the most part on a literal interpretation of Old Testament references. Biblical scholars of Renaissance Europe and later considered paternity as a viable method by which the age of the Earth since its creation could be determined. One such attempt was made by Archbishop James Ussher of Ireland, who in determined that the Creation had occurred during the evening of Oct. By his analysis of biblical genealogies, the Earth was not even 6, years old! As previously noted, fundamental to the principle was the premise that various Earth processes of the past operated in much the same way as those processes operate today. The corollary to this was that the rates of the various ancient processes could be considered the same as those of the present day. Therefore, it should be possible to calculate the age of the Earth on the basis of the accumulated record of some process that has occurred at this determinable rate since the Creation. Many independent estimates of the age of the Earth have been proposed, each made using a different method of analysis. These chemical and physical arguments or a combination of both were all flawed to varying degrees because of an incomplete understanding of the processes involved. The notion that all of the salts dissolved in the oceans were the products of leaching from the land was first proposed by the English astronomer and mathematician Edmond Halley in and restated by the Irish geologist John Joly in It was assumed that the ocean was a closed system and that the salinity of the oceans was an ever-changing and ever-increasing condition. Based on these calculations, Joly proposed that the Earth had consolidated and that the oceans had been created between 80 and 90 million years ago. The subsequent recognition that the ocean is not closed and that a continual loss of salts occurs due to sedimentation in certain environments severely limited this novel approach. Equally novel but similarly flawed was the assumption that, if a cumulative measure of all rock successions were compiled and known rates of sediment accumulation were considered, the amount of time elapsed could be calculated. While representing a reasonable approach to the problem, this procedure did not or could not take into account different accumulation rates associated with different environments or the fact that there are many breaks in the stratigraphic record. Even observations made on faunal succession proved that gaps in the record do occur. How long were these gaps? Do they represent periods of nondeposition or periods of deposition followed by periods of erosion? Nevertheless, many attempts using this approach were made. William Thomson later Lord Kelvin applied his thermodynamic principles to the problems of heat flow , and this had implications for predicting the age of a cooling Sun and of a cooling Earth. From an initial estimate of million years for the development of a solid crust around a molten core proposed in , Thomson subsequently revised his estimate of the age of the Earth downward. Using the same criteria, he concluded in that the Earth was between 20 and 40 million years old. His estimate came into question after the discovery of naturally occurring radioactivity by the French physicist Henri Becquerel in and the subsequent recognition by his colleagues, Marie and Pierre Curie , that compounds of radium which occur in uranium minerals produce heat. The Earth was, in effect, not cooling. An absolute age framework for the stratigraphic time scale In his book Radio-activity , Rutherford explained that radioactivity results from the spontaneous disintegration of an unstable element into a lighter element, which may decay further until a stable element is finally created. This process of radioactive decay involves the emission of positively charged particles later to be recognized as helium nuclei and negatively charged ones electrons and in most cases gamma rays a form of electromagnetic radiation as well. This interpretation, the so-called disintegration theory, came to provide the basis for the numerical quantification of geologic time. In Strutt succeeded in analyzing the helium content of a radium-containing rock and determined its age to be 2 billion years. This was the first successful application of a radiometric technique to the study of Earth materials, and it set the stage for a more complete analysis of geologic time. Although faced with problems of helium loss and therefore not quite accurate results, a major scientific breakthrough had been accomplished. Also in the American chemist Bertram B. Boltwood , working with the more stable uraniumâ€”lead system, calculated the numerical ages of 43 minerals. His results, with a range of million to 2. Acceptance of these new ages was slow in coming. Perhaps much to their relief, paleontologists now had sufficient time in which to accommodate faunal change. Researchers in other fields, however, were still conservatively sticking with ages on the order of several hundred million, but were revising their assumed sedimentation rates downward in order to make room for expanded time concepts. In a brilliant contribution to resolving the controversy over the age of the Earth, Arthur Holmes , a student of Strutt, compared the relative paleontologically determined stratigraphic ages of certain specimens with their numerical ages as determined in the laboratory. This analysis provided for the first time the numerical ages for rocks from several Paleozoic geologic periods as well as from the Precambrian. Carboniferous-aged material was determined to be million years, Devonian-aged material million years, Ordovician or Silurian material million years, and Precambrian specimens from 1. As a result of this work, the relative geologic time scale, which had taken nearly years to evolve, could be numerically quantified. No longer did it have merely superpositional significance, it now had absolute temporal significance as well.

DOWNLOAD PDF GLEANINGS FROM OUTCROPS OF SILURIAN STRATA IN THE RED RIVER VALLEY

Chapter 5 : Red River Formation - WikiVisually

Silurian strata immediately underlie the silty material of the Red River Valley, while throughout this region Cretaceous outcrops belonging to a period of much later date occur. Great stretches of arable land here too, lie spread before us, affording ample room for millions of pioneers ready to possess the land.

Assessment unit number also indicates time span of stratigraphic units. Continuous-type accumulations include fractured shale and fractured limestone oil and gas, basin-centered gas, coal bed gas, and tight reservoir gas. They typically cover large areas, have source rocks in close association with these unconventional reservoir rocks, and are mostly gas and in some cases oil charged throughout their extent. The southern and eastern boundaries are defined by county lines that generally follow the Ouachita structural front, although a substantial portion of this structural feature is included near Dallas. The north boundary follows the Texas-Oklahoma State line in the east, where the province includes parts of the Sherman Basin and Muenster Arch. The western boundary trends north-south along county lines defining the junction with the Permian Basin where part of the eastern shelf of the Permian Basin lies in Province Structural elements[edit] Major structural features include the Muenster and Red River Arches to the north, and the Bend and Lampasas Arches along the central part of Province Along the east portion is an area that includes the Eastern Shelf and Concho Arch, collectively known as the Concho Platform. Several faults that cut basement and lower Paleozoic rocks in the southern part of the province are identified at the Ordovician Ellenburger Group stratigraphic level. These faults and associated structures formed during development of the Llano Uplift and Fort Worth Basin with faulting ending by the early Missourian. The basin resembles other basins of the Ouachita structural belt, such as the Black Warrior, Arkoma, Val Verde , and Marfa Basins that formed in front of the advancing Ouachita structural belt as it was thrust onto the margin of North America. Thrusting occurred during a late Paleozoic episode of plate convergence. It is a broad subsurface, north-plunging, positive structure. The arch formed as a hingeline by down-warping of its eastern flank due to subsidence of the Fort Worth Basin during early stages of development of the Ouachita structural belt in the Late Mississippian and west tilting in the late Paleozoic which formed the Midland Basin. There is disagreement on the structural history of the Bend Arch. Flippen suggested it acted as a fulcrum and is a flexure and structural high and that only minor uplift occurred in the area to form an erosional surface on the Chester-age limestones that were deposited directly on top of the Barnett. In contrast, Cloud and Barnes suggested periodic upwarp of the Bend flexure from mid-Ordovician through Early Pennsylvanian time resulted in several unconformities. The sedimentary section in the Fort Worth Basin is underlain by Precambrian granite and diorite. Cambrian rocks include granite conglomerate, sandstones, and shale that are overlain by marine carbonate rocks and shale. No production has been reported from Cambrian rocks. Ellenburger Group carbonate rocks represent a broad epeiric carbonate platform covering most of Texas and central North America during the Early Ordovician. A pronounced drop in sea level sometime between Late Ordovician and earliest Pennsylvanian time, perhaps related to the broad, mid-North American, mid-Carboniferous unconformity, resulted in prolonged platform exposure. This erosional event removed any Silurian and Devonian rocks that may have been present. Provenance of the terrigenous material that constitutes the Barnett Shale was from Ouachita thrust sheets and the reactivation of older structures such as the Muenster Arch. Post-Barnett deposition continued without interruption as a sequence of extremely hard and dense limestones were laid down. These limestones have often been confused with the lower part of the overlying Marble Falls Formation Early Pennsylsvnian , and they have never been formally named, although they are widely referenced in the literature as the "Forestburg Formation. All of the Mississippian-age reef complexes whose bases have been penetrated by boreholes have been found, without exception, to be resting directly upon the underlying Ordovician rocks. But although reef growth began at the same time as Barnett Shale deposition, the reefs did not survive to the end of Barnett time; all known Chappel reefs are immediately overlain by the typical Barnett

Shale facies except for a very few in central Clay County that have been very deeply breached by pre-Atokan erosion. The reef complexes are subdivisible into three constituent facies: The reef cores are porous enough to serve as stratigraphic traps for oil and gas, and they have yielded excellent production in the northern part of the Fort Worth Basin for three-quarters of a century. The reef core, of course, is represented by the egg yolk, and the reef flank debris are represented by the egg white. The inter-reef facies is represented by a black, calcareous, bituminous shale. Where it occurs in Jack County it is typically 30 to 40 feet 9 to 12 meters thick, and it is synonymous with the calcareous basal shale member of the Barnett. Consequently, the proximity of a given borehole to a nearby reef complex can be qualitatively estimated by the degree to which this lower member of the Barnett has been impregnated with calcite. With progressive subsidence of the basin during the Pennsylvanian, the western basin hinge line and carbonate shelf, continued migrating west. Deposition of thick basinal clastic rocks of the Atoka, Strawn, and Canyon Formations occurred at this time. Petroleum production history[edit] Hydrocarbon shows were first encountered in Province during the mid-nineteenth century while drilling water wells. Sporadic exploration began following the Civil War, and the first commercial oil discoveries occurred in the early s. The Ranger field produces from the Atoka-Bend formation, a sandstone-conglomerate reservoir that directly overlies the Barnett formation. Operators drilled more than 1, wildcats in and around the Fort Worth Basin attempting to duplicate the success of Ranger. By , the province reached a mature stage of exploration and development as demonstrated by the high density and distribution of well penetrations and productive wells. A majority of the commercial hydrocarbons consist of oil in Pennsylvanian reservoirs. Province is among the more active drilling areas during the resurgence of domestic drilling, which began after the OPEC oil embargo in It has consistently appeared on the list of the ten most active provinces in terms of wells completed and footage drilled. More than oil wells and 4, gas wells were drilled and completed in this area from to

Chapter 6 : North Dakota Geologic Survey

"Gleanings from outcrops of silurian strata in the Red river valley." By J. Hoyes (James Hoyes) Panton. Abstract. Manitoba Hist. & Sci. Soc. Trans.

Geochronology â€” Geochronology is the science of determining the age of rocks, fossils, and sediments using signatures inherent in the rocks themselves. Absolute geochronology can be accomplished through radioactive isotopes, whereas relative geochronology is provided by such as palaeomagnetism. By combining multiple geochronological indicators the precision of the age can be improved. Biostratigraphy does not directly provide an absolute age determination of a rock, both disciplines work together hand in hand however, to the point where they share the same system of naming rock layers and the time spans utilized to classify layers within a stratum. By measuring the amount of decay of a radioactive isotope with a known half-life. A number of isotopes are used for this purpose. More slowly decaying isotopes are useful for longer periods of time, two or more radiometric methods can be used in concert to achieve more robust results. Some of the commonly used techniques are, Radiocarbon dating and this technique measures the decay of carbon in organic material and can be best applied to samples younger than about 60, years. This technique measures the ratio of two isotopes to the amount of uranium in a mineral or rock. Often applied to the mineral zircon in igneous rocks, this method is one of the two most commonly used for geologic dating. Monazite geochronology is another example of U-Pb dating, employed for dating metamorphism in particular, uranium-lead dating is applied to samples older than about 1 million years. This technique is used to date speleothems, corals, carbonates and its range is from a few years to about , years. These techniques date metamorphic, igneous and volcanic rocks and they are also used to date volcanic ash layers within or overlying paleoanthropologic sites. The younger limit of the method is a few thousand years. Electron spin resonance dating A series of related techniques for determining the age at which a surface was created. Exposure dating uses the concentration of exotic nuclides produced by cosmic rays interacting with Earth materials as a proxy for the age at which a surface, such as an alluvial fan, was created. Burial dating uses the radioactive decay of 2 cosmogenic elements as a proxy for the age at which a sediment was screened by burial from further cosmic rays exposure. Luminescence dating techniques observe light emitted from such as quartz, diamond, feldspar 2. Ordovician â€” The Ordovician is a geologic period and system, the second of six periods of the Paleozoic Era. The Ordovician spans Lapworth recognized that the fauna in the disputed strata were different from those of either the Cambrian or the Silurian periods. It received international sanction in , when it was adopted as a period of the Paleozoic Era by the International Geological Congress. Life continued to flourish during the Ordovician as it did in the earlier Cambrian period, invertebrates, namely molluscs and arthropods, dominated the oceans. The Great Ordovician Biodiversification Event considerably increased the diversity of life, fish, the worlds first true vertebrates, continued to evolve, and those with jaws may have first appeared late in the period. Life had yet to diversify on land, about times as many meteorites struck the Earth during the Ordovician compared with today. The Ordovician Period began with a major extinction called the Cambrianâ€"Ordovician extinction event and it lasted for about 42 million years and ended with the Ordovicianâ€"Silurian extinction event, about The dates given are recent radiometric dates and vary slightly from those found in other sources and this second period of the Paleozoic era created abundant fossils that became major petroleum and gas reservoirs. The boundary chosen for the beginning of both the Ordovician Period and the Tremadocian stage is highly significant and it correlates well with the occurrence of widespread graptolite, conodont, and trilobite species. The base of the Tremadocian allows scientists to relate these species not only to each other and this makes it easier to place many more species in time relative to the beginning of the Ordovician Period. A number of terms have been used to subdivide the Ordovician Period. In , the ICS erected an international system of subdivisions. The corresponding rocks of the Ordovician System are referred to as coming from the Lower, Middle, the Floian corresponds to the lower Arenig, the Arenig continues until the early Darriwilian, subsuming the Dapingian.

The Llanvirn occupies the rest of the Darriwilian, and terminates with it at the base of the Late Ordovician. The Sandbian represents the first half of the Caradoc, the Caradoc ends in the mid-Katian, during the Ordovician, the southern continents were collected into Gondwana. Gondwana started the period in equatorial latitudes and, as the period progressed, drifted toward the South Pole, the small continent Avalonia separated from Gondwana and began to move north towards Baltica and Laurentia, opening the Rheic Ocean between Gondwana and Avalonia 3. Precambrian â€" The Precambrian is the earliest period of Earths history, set before the current Phanerozoic Eon. The Precambrian is a supereon that is subdivided into three eons of the time scale. It spans from the formation of Earth about 4. Relatively little is known about the Precambrian, despite it making up roughly seven-eighths of the Earths history, the Precambrian fossil record is poorer than that of the succeeding Phanerozoic, and fossils from that time are of limited biostratigraphic use. This is because many Precambrian rocks have been metamorphosed, obscuring their origins, while others have been destroyed by erosion. A stable crust was apparently in place by 4, Ma, the term Precambrian is recognized by the International Commission on Stratigraphy as a general term including the Archean and Proterozoic eons. It is still used by geologists and paleontologists for general discussions not requiring the more specific eon names and it was briefly called the Cryptozoic eon. A specific date for the origin of life has not been determined, carbon found in 3. Well-preserved microscopic fossils of bacteria older than 3. Probable fossils million years older have been found in the same area, there is a fairly solid record of bacterial life throughout the remainder of the Precambrian. The oldest fossil evidence from that era of such complex life comes from the Lantian formation of the Ediacarian period, a very diverse collection of soft-bodied forms is found in a variety of locations worldwide and date to between and Ma. These are referred to as Ediacaran or Vendian biota, hard-shelled creatures appeared toward the end of that time span, marking the beginning of the Phanerozoic era. By the middle of the following Cambrian period, a diverse fauna is recorded in the Burgess Shale. The explosion in diversity of lifeforms during the early Cambrian is called the Cambrian explosion of life, while land seems to have been devoid of plants and animals, cyanobacteria and other microbes formed prokaryotic mats that covered terrestrial areas. Evidence of the details of plate motions and other activity in the Precambrian has been poorly preserved. It is generally believed that small proto-continents existed prior to Ma, the supercontinent, known as Rodinia, broke up around Ma. A number of glacial periods have been identified going as far back as the Huronian epoch, one of the best studied is the Sturtian-Varangian glaciation, around â€" Ma, which may have brought glacial conditions all the way to the equator, resulting in a Snowball Earth. The atmosphere of the early Earth is not well understood, most geologists believe it was composed primarily of nitrogen, carbon dioxide, and other relatively inert gases, and was lacking in free oxygen 4. The Cambrian lasted The period was established by Adam Sedgwick, who named it after Cambria, the Latinised form of Cymru, the Welsh name for Wales, as a result, our understanding of the Cambrian biology surpasses that of some later periods. The rapid diversification of lifeforms in the Cambrian, known as the Cambrian explosion, most of the continents were probably dry and rocky due to a lack of vegetation. Shallow seas flanked the margins of several continents created during the breakup of the supercontinent Pannotia, the seas were relatively warm, and polar ice was absent for much of the period. Despite the long recognition of its distinction from younger Ordovician Period rocks and older Supereon Precambrian rocks, the base of the Cambrian lies atop a complex assemblage of trace fossils known as the Treptichnus pedum assemblage. The Cambrian Period followed the Ediacaran Period and was followed by the Ordovician Period, the Cambrian is divided into four epochs and ten ages. Currently only two series and five stages are named and have a GSSP, because the international stratigraphic subdivision is not yet complete, many local subdivisions are still widely used. In some of these subdivisions the Cambrian is divided into three epochs with locally differing names â€" the Early Cambrian, Middle Cambrian and Furongian, rocks of these epochs are referred to as belonging to the Lower, Middle, or Upper Cambrian. Trilobite zones allow biostratigraphic correlation in the Cambrian, each of the local epochs is divided into several stages. The International Commission on Stratigraphy list the Cambrian period as beginning at million years ago, the lower boundary of the Cambrian was originally held to represent the first appearance of complex life, represented by trilobites. The recognition of small shelly fossils before the first trilobites, and Ediacara biota substantially earlier and this formal designation allowed radiometric dates to be obtained from samples across the globe that corresponded to the base of the Cambrian. Early dates of million years ago quickly gained favour, though the used to obtain this number are now considered to be unsuitable. Large, high-velocity rotational movement of Gondwana appears to have occurred in the Early Cambrian, the sea levels fluctuated somewhat, suggesting there were ice ages, associated with pulses of expansion and contraction of a south polar ice cap. In Baltoscandia a Lower Cambrian transgression transformed large swathes of the Sub-Cambrian peneplain into a epicontinental sea, the Earth was generally cold during the early Cambrian, probably due to the ancient continent of Gondwana covering the South Pole and cutting off polar ocean currents 5. Silurian â€" The Silurian is a geologic period and system spanning As with other periods, the rock beds that define the periods start and end are well identified. However, terrestrial life would not greatly diversify and affect the landscape until the Devonian, the Silurian system was first identified by British geologist Sir Roderick Impey Murchison, who was examining fossil-bearing sedimentary rock strata in south Wales in the early s. He named the sequences for a Celtic tribe of Wales, the Silures, inspired by his friend Adam Sedgwick and this naming does not indicate any correlation between the occurrence of the Silurian rocks and the land inhabited by the Silures. As it was first identified, the Silurian series when traced farther afield quickly came to overlap Sedgwicks Cambrian sequence, however, charles Lapworth resolved the conflict by defining a new Ordovician system including the contested beds. An early alternative name for the Silurian was Gotlandian after the strata of the Baltic island of Gotland, the French geologist Joachim Barrande, building on Murchisons work, used the term Silurian in a more comprehensive sense than was justified by subsequent knowledge. He divided the Silurian rocks of Bohemia into eight stages and his interpretation was questioned in by Edward Forbes, and the later stages of Barrande, F, G and H, have since been shown to be Devonian. Despite these modifications in the groupings of the strata, it is recognized that Barrande established Bohemia as a classic ground for the study of the earliest fossils. The epoch is named for the town of Llandovery in Carmarthenshire, the Wenlock, which lasted from It is named after Wenlock Edge in Shropshire, England, during the Wenlock, the oldest known tracheophytes of the genus Cooksonia, appear. The first terrestrial animals also appear in the Wenlock, represented by air-breathing millipedes from Scotland. The Ludlow, lasting from The high sea levels of the Silurian and the flat land resulted in a number of island chains. The southern continents remained united during this period, the melting of icecaps and glaciers contributed to a rise in sea level, recognizable from the fact that Silurian sediments overlie eroded Ordovician sediments, forming an unconformity. The continents of Avalonia, Baltica, and Laurentia drifted together near the equator and this event is the Caledonian orogeny, a spate of mountain building that stretched from New York State through conjoined Europe and Greenland to Norway 6. Devonian â€" The Devonian is a geologic period and system of the Paleozoic, spanning 60 million years from the end of the Silurian, It is named after Devon, England, where rocks from this period were first studied, the first significant adaptive radiation of life on dry land occurred during the Devonian. Free-sporing vascular plants began to spread across dry land, forming extensive forests which covered the continents, by the middle of the Devonian, several groups of plants had evolved leaves and true roots, and by the end of the period the first seed-bearing plants appeared. Various terrestrial arthropods also became well-established, Fish reached substantial diversity during this time, leading the Devonian to often be dubbed the Age of Fish. The first ray-finned and lobe-finned bony fish appeared, while the placodermi began dominating almost every aquatic environment. The ancestors of all four-limbed vertebrates began adapting to walking on land, as their strong pectoral, in the oceans, primitive sharks became more numerous than in the Silurian and Late Ordovician. The first ammonites, species of molluscs, appeared, trilobites, the mollusk-like brachiopods and the great coral reefs, were still common. The Late Devonian extinction which started about million years ago severely affected marine life, killing off all placodermi, and all trilobites, save for a few species of the order Proetida. The palaeogeography was dominated by the supercontinent of Gondwana to the south, the continent of Siberia to the north, while the rock beds that define the start and end of the Devonian period are well identified, the exact dates are uncertain. According to the International Commission on Stratigraphy, the Devonian extends from the end of the Silurian Older literature on the Anglo-Welsh basin divides it into the Downtonian, Dittonian, Breconian and Farlovian stages, in the Late Devonian, by contrast, arid conditions were less prevalent across the world and temperate climates were more common. The Devonian Period is formally broken into Early, Middle and Late subdivisions, the rocks corresponding to those epochs are referred to as belonging to the Lower, Middle and Upper parts of the Devonian System. Early Devonian The Early Devonian lasted from It spanned from Middle Devonian The Middle Devonian comprised two subdivisions, first the Eifelian, which gave way to the Givetian The first tetrapods appeared in the record in the ensuing Famennian subdivision. This lasted until the end of the Devonian,

Chapter 7 : Full text of "The Geology of North Dakota"

Buy Gleanings from Outcrops of Silurian Strata in the Red River Valley, Manitoba () by James Hoyes Panton from Amazon's Fiction Books Store. Everyday low prices on a huge range of new releases and classic fiction.

We make online versions available as a free, public service. As an historical document, Transactions may contain language that is no longer in common use and which may offend some readers. This online version was prepared using Optical Character Recognition software so that spelling and punctuation errors may have occurred inadvertently. If you find any such errors, please inform us, indicating the document name and error. Please direct all inquiries to webmaster mhs. The Paper of the Evening Mr. Panton was then called upon to read his paper, "Gleanings from the Geology of the red River Valley", which follows: Tonight for a short time, we purpose directing your attention to the Book of Nature, and from the fragmentary leaves of the geological records glean something about the rocks beneath our city, and the loose material which overlies them. Rocks may exist in two forms, the solid, which is represented here some fifty feet below the surface, and the pulverized, which, mingled with decomposing vegetable matter, forms the soil of our fields. The solid form is fixed, and has not been removed from its present position since deposited, while the pulverized has in most cases been derived from rocks at a distance. These have been ground down and transported by agencies to which reference will be made afterwards. To say something regarding the nature of these rocks, as they form the foundation on this city, is our object in appearing before you tonight. The geology of our great North West, like our vast plains and immense rivers, is on a magnificent scale. To the eye of the geologist a grand vision appears, as he contemplated the marvelous panorama that rolls before him, portraying the geological features of the country lying between the Laurentian rocks to our east, and the lofty mountains to the west. The former, representatives of the first rocks to triumph over the universal waters of primeval days and the latter belonging to a period near the summit of the geological series. Between these great natural boundaries, we see stretching before us, the three vast prairie steppes of the North West, rising in succession above each other and distinguished by characteristic physical features. First Prairie Steppe Known as the Red River Valley, is 52 miles wide at the international boundary line, widening to the north, with an elevation of feet above sea level and embracing an area of square miles or over 4,, acres. The last of our country to emerge from water, it has received a rich compensation in the drainage of the North West for countless years, a rich alluvial deposit to which the eyes of the world are turned with astonishment at its almost inexhaustible fertility. In this rich valley abundant harvests are reaped upon fields which have been sown for fifty successive years with wheat, and as yet show no indication of less productive power. Since our geological gleanings are to refer more particularly to this deposit, as it occurs beneath and around Winnipeg, we shall not dwell at present upon an area fraught with a great future to the inhabitants of Manitoba. Second Prairie Steppe Following upon the first, the Second steppe appears with an elevation of feet, miles wide at its southern limit and narrowing slightly towards the north. Within this vast area, are square miles of land, more rolling in its character than the preceding district, but also containing vast stretches of prairie land. The deposits here differ from those of the first steppe, both regarding age and nature. Silurian strata immediately underlie the silty material of the Red River Valley, while throughout this region Cretaceous outcrops belonging to a period of much later date occur. Great stretches of arable land here too, lie spread before us, affording ample room for millions of pioneers ready to possess the land. In the prolific fields of these extensive acres, industry and economy cannot fail to meet with enviable success to those who are now joining in the advancing tide of settlers across their boundless plains. Third Prairie Steppe Crossing our plains we finally reach the third great table land of the North West, miles wide on the forty-ninth parallel with an elevation of feet. It embraces an area of , square miles. In this immense area lie our vast coal fields, so extensive that the term Lignite Tertiary Plateaus has been applied to all the region. Nearly all of the coal exposures referred to as occurring in the North West, are found in this district. As further investigations are made concerning the nature and extent of this coal bearing strata, it will be found that plenty of fuel will be supplied with but little difficulty to the future occupants of the treeless prairie land to the east. Besides the great coal deposits of incalculable value, vast stretches of heavily wooded districts, belts of arable land and rich pasturage areas, occur throughout the region. As this great scene sweeps before us, showing in succession these marked natural steps, each full of interest sufficient to supply material for a long paper, we can perceive what an attractive country this is to the enthusiastic student of nature. The rich ores of the Laurentian rocks eastward, just being unearthed are attracting thousands to seek the hitherto hidden treasures of that place. The lands of almost exhaustless fertility in the Red River Valley are rapidly being occupied. The rolling districts of the second plateau with drier and warmer soil, are eagerly sought after by the practical agriculturalist. While the third steppe with an inexhaustible store of fuel, will not be less attractive as a supply to the inhabitants of woodless districts. But our work is confined to a narrower limit and our attention must be confined more particularly to some remarks on the geology of places less remote than those interesting regions to which reference has been made. In order to enable him to locate his homestead, so we have been looking around for geological landmarks, which will enable us to ascertain our position in the series of geological strata. Our rich alluvial soil has supplied some information, but it was not until was had ascertained the depth and nature of drift material below us, and the character of the rock over which it has been spread ages long receded into the past, that we have been able to open the stony records at the proper place, and ascertain our relation to the past. These are grouped into Formations known by certain names, which are often taken from the locality where the formation is well represented, as Trenton, Hudson River, Devonian, or it may be from the nature of the rock, as Red Sandstone Gypsiferous, etc. The formations have their characteristic fossils, consequently when we find these we can arrive at a pretty sure conclusion regarding when and how the formation was deposited, as well as the nature of the deposit. Another important fact concerning the formations is that they always occupy the same positions relative to each other. For example, if we represent the formations by 1,2,3,4 etc. Some may not be represented in certain localities, there may be no 4,6,7, but if we find 3,2,5,1, they will occupy the position 1,2,3,5. From this it will be readily understood that as soon as we obtain a few characteristic fossils in the neighborhood of a place we can, with considerable certainty, make out the position of the rock in the geological series. Andrews, and at the C. These outcrops, no doubt, belong to the same rock as that which is found some 50 feet below the surface at Winnipeg. The characters of the deposits at Stony Mountain are closely allied to those of the Hudson river formation in other localities, while the buff-colored magnesian limestones of the Red River Valley are likely representatives of the upper part of the Trenton limestone. Both formations belong to what is commonly known as the Lower Silurian Series. Fossils of the Silurian Age Before a stratum of rock can be formed, in most cases it is necessary that the place upon which it is laid be beneath a body of water, especially when the rock contains the remains of marine organisms. Now, since we have some good stratum pf Silurian rock some 50 feet below the surface, cropping out west and north of us, we may assume that at one time this part of the country has been submerged and raised again from the waters which covered it. On an examination of the rocks at any of the outcrops referred to, you are almost certain to find some traces of primeval life some bear a close resemblance to shells of our own day, some not unlike the backbone of fish, while others are readily recognized as corals. All these peculiar remains are traces of animals, which occupied the waters when the site of Winnipeg was the floor of the ocean. These creatures dying their bodies became entombed in the muddy bottoms, afterwards petrified and as fossils have come into our possession, serving as keys to unlock the hidden secrets of the past. As these animals, now known only by fragments of rock resemble those found in salt water at the present time we at once infer, that the waters which covered this place in those early days were of a briny nature. Pursuing the same line of thought we can readily assume that in those days the climate was much different from the present. For as already mentioned among the inhabitants of our early sea were corals, a group of animals that can exist only in waters which have a mean temperature of 66 degrees. The wedge shaped fossils, which usually show a series of rings with a sort of rod running through their center are called Orthoceratites, they vary in size from a few inches to three feet in length. They are the remains of animals, which lived in shells consisting of many chambers, the last being occupied by the animal, a representative of the cuttle fish family. Many of the shells found are readily identified as belonging to both groups of mollusks, those with univalve and bivalve shells. Among the fossils of our rocks are some of wormlike form. They vary from one to several inches in length. These are the stems of what are known as stone lilies. The stone lily is what remains of an organism, which flourished in the seas of the past. Attached to the sea bottom by the expanded base of a jointed stem and surmounted by a flowerlike expansion, it bore some resemblance to a cloud lily, especially when the tentacles of the animal were folded in. They seem to have been very numerous, for large portions of rock are found made up almost entirely of this crinoid stems, not uncommonly called Encrinites. It is a rare thing to find a complete form, though at almost every outcrop innumerable fragments of stems are found. We have now to call your attention to a fossil not common here, but some fragments have been found. This Peculiar Fossil Not unlike a butterfly with expanded wings, is only a fragment, and represents the tail of the organism. Fragments of this nature are common, but complete forms, such as the specimens before you, are very rare. This fossil belongs to a type of very unique organisms common in the Silurian seas. From the trilobed appearance of the animal it has received the name Trilobite. These creatures seem to have been able to curl themselves up, either for protection or to enable them to sink more rapidly. So complete has the process of replacement gone on in some of these trilobite fossils that in many cases the structure of the eye is accurately preserved as can be seen by examining the specimens before you, which show all the parts very distinctly. Some peculiar, tiny saw-shaped markings also occur on the rocks of the Hudson River formation; these are known as Grapolites. Upon the tooth-like projections small cups were situated, each of which contained a small organism of very simply structure. A whole colony of these creatures were located upon the axis and with their tiny tentacles were able to whip food into their rudimentary mouths. These fossils occur in a variety of forms, some with a single row of tooth-like projections, others within a double. Many are not unlike a leaf and a few consist of many axes radiating from a common centre. The Grapolites and Trilobites are of especial interest in determining the age of a deposit. As yet none have been found in strata above the Lower Carboniferous, consequently when we find them on the surface we know at once that we are below the coal measures, and as far as coal is concerned we will seek for it in vain. Coal may appear above these fossils, but it has not been found below them. The animals to which reference has been made were among the leading types then in existence; for at that period in creation no insects, no fishes, no birds, in short, none of the higher animals had as yet made their appearance. Life was confined chiefly to the sea, and of a very rudimentary nature. The only plants were seaweeds, and, as noted, the animal kingdom was but scantily represented, the genera and species were limited, but the individuals were very numerous. Up to this time stillness was a leading feature in nature. No sound was heard except the lashing of the waves unimpeded in their course across the bleak and solitary rocks. The continent, like its species, was submarine in its mode of existence. It was outlined, but not till long periods had passed, during which great physical disturbances took place, was the present form brought into existence. Such was the dumb state of affairs when the rocky foundation of our ambitious city was laid. The presence of boulders in this so-called drift material, of the same composition as rocks north and east of us, and the salty nature of much of the water found in some wells would seem to indicate that our soil has been derived from other sources than the disintegration of the rock beneath, and that much of our clay is an alluvial deposit brought here in past ages from districts quite remote from Winnipeg. From an interview with Mr. Piper, known as having an extensive experience in well boring throughout the city, we have learned that the average nature of a vertical section of the deposits, overlying the solid rock here is as follows: Surface mould, one to four feet, dark color and exceedingly fertile. Dark gray clay, thirty to fifty feet, with boulders scattered throughout, some of them four feet in diameter, and chiefly gneissoid, and no doubt derived from Laurentian rocks. Light colored clay, one to three feet, containing many small stones. Hard pan, two to ten feet, a very solid and compact form of clay. Sand, gravel and boulders, five to twenty-five feet.

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Gleanings from outcrops of silurian strata in the Red River Valley By: Panton, J. Hoyes (James Hoyes), Published: () "Gleanings from outcrops of silurian strata in the Red river valley." By: Panton, J. Hoyes (James Hoyes), Published: () Waveney Valley studies: gleanings from local history.

Structural Geology The Williston Basin, compared to many basins worldwide, is a structurally simple basin. It is roughly circular, deepest in its center, and the strata become both shallower and thinner towards its margins. It is a large basin, covering approximately , square miles over parts of North Dakota, South Dakota, and Montana and parts of the adjacent Canadian provinces of Saskatchewan and Manitoba. The basins deepest point is thought to be near Williston, ND where the Precambrian surface is more than 16, feet below the surface. The earliest rocks are difficult to study because the Lower Phanerozoic and Precambrian rocks are not exposed at the surface in North Dakota and only a few wells have penetrated these rocks. Our present understanding of the early geologic history of the basin is pieced together from outcrops in adjacent states and provinces, from seismic data, and from the limited well data. The Superior Craton is Archean in age and consists mainly of granites and greenstones that were emplaced between 2. Rocks of the Wyoming Province are gneissic, or banded to lenticular feldspar and quartz-rich rocks, and are approximately the same age as rocks from the Superior Craton. Between these two cratons, under most of western North Dakota, lies the Trans-Hudson orogen, which is composed of oceanic material from an early rifting event within the Superior Craton. Green et al, Rocks from the island-arc complexes are between 1. Structural elements in the vicinity of the Williston Basin Modified from Green et al, The internal structural geology of the two provinces and the orogen can be very complex, as are the structural relationships between them. Our limited ability to either sample the rocks or to seismically image them restricts our ability to determine how the Williston Basin formed. The early structural history of the basin has had an impact on later Phanerozoic deposition, but the extent of that impact is not always known. Although subsurface data is limited, in Beaver Lodge Field on the Nesson anticline, it can be demonstrated from well control that within a few miles, there are hundreds of feet of topographic relief on the Precambrian surface Fig. The relief on the basement surface is either an erosional remnant of a granite knob or is a horst block formed by movement along vertical to near-vertical faults. Most of the structural deformation during the Phanerozoic Eon in North Dakota probably resulted from the subsidence of the Williston Basin. The main evidences of structural deformation in the basin are folding and faulting. The best evidence of folding in North Dakota is the anticlinal and synclinal structures that were formed. Many other unnamed anticlinal structures exist in the basin, but only some of them have been proven to be oil-producing. The other primary evidence of structural deformation is faulting, and faults are less well documented in North Dakota. Some faults, like those on the west flank of the Cedar Creek anticline Clement, and the Heart River fault Chimney et al. Clement shows faults to be steeply dipping, almost vertical, and reports that faults along the Cedar Creek anticline have undergone recurrent near-vertical and wrench movements. He also reports that the displacement direction along some of these faults changed over time. The inferred faults probably have similar characteristics to the larger faults on the Cedar Creek anticline, that is they dip nearly vertically, may have a component of wrenching, have undergone recurrent movements, and the direction and magnitude of displacement has changed over time. However, it is unlikely that most faults will be proven to exist because the near-vertical dip makes them difficult to intersect or image. Note the relief on the Precambrian surface and the missing Deadwood section over the Precambrian high. Features that are frequently interpreted to be present in the Williston Basin are lineaments. A lineament is the surface expression of a basement block boundary or fault Brown and Brown, The magnitude of individual displacements may not have been great, but the displacement was at least sufficient to have affected local deposition and erosion patterns. These local patterns often control where oil is trapped. Stratigraphy and Petroleum Characteristics Basement Rocks Precambrian Basement is the crust of the earth extending from the base of sedimentary cover down to the Mohorovicic discontinuity, or all Precambrian rocks. Phanerozoic deposition in the Williston Basin began on a surface of weathered basement rocks. The Precambrian is subdivided into two eons. The older is the Archeozoic Eon, from between 4 to 2. The geology of the Precambrian rocks underlying the Williston Basin is complex, consisting of many juxtaposed, fault-bounded lithostructural domains Peterman and Goldich, Green et al suggested that the basement rocks in western North Dakota formed in an orogenic belt, or linear deformed area, called the Trans-Hudson orogen that lies between the Archean Superior and Wyoming Provinces Fig. More recently, Baird and others reported another, previously unknown block under western North Dakota which they named the Dakota block. They interpreted the block to be an Archean continental fragment because of similarities in its reflection geometry to Archean crustal material exposed in the Glennie domain in Canada. In general, basement rocks do not produce oil in North Dakota, but one well in Newporte Field did produce oil from fractured Precambrian rocks. The Cambrian sea transgressed eastward into an embayment on the edge of the Cordilleran shelf Carlson, ; Lochman-Balk, , and deposited siliciclastic sediments, sands and shales, as the dominant sediment type in North Dakota. During Lower Ordovician, carbonate sediments began to be deposited in the center of the basin, which was now formed and had begun to subside LeFever et al. Location of oil and gas wells producing from the Cambrian Deadwood and Ordovician Winnipeg formations. Equivalent strata are thought to have covered a much greater area, once extending at least as far as Nebraska to the south and southeast, but later erosion has removed much of the strata. Deposition was continuous across the Ordovician-Silurian boundary and sedimentation continued at least until Middle Silurian. The top of the sequence is a major erosional unconformity that has removed an unknown amount of strata. All of these formations were deposited in marginal to shallow marine environments. The Black Island Formation has two members Thompson, The lower member is comprised of two lithofacies, a lower red-bed lithofacies containing quartz arenites and "clayshales", and an upper green quartz wacke. The upper member is also comprised of two lithofacies, a quartz arenite and green quartz wackes. The Icebox Formation, an organic-rich green shale, is thought to be a source rock for Lower Paleozoic reservoirs Dow, ; Williams, The Roughlock Formation is predominantly a nodular limestone and is transitional with the overlying Red River Formation LeFever et al, In both areas, production is from Black Island sandstones and natural gas is the dominant hydrocarbon produced. The Red River Formation, the basal unit of the group, has been subdivided into two informal members. The lower member is the lower two-thirds of the formation and is composed of fossiliferous and selectively dolomitized limestones. The upper member includes four dolomitized porosity zones; the "D", "C", "B", and "A" zones, in ascending order Carroll, The upper three zones are capped by anhydrite beds while the "D" zone is not Fig. The anhydrites are widespread, as they are present across most of western North Dakota and eastern Montana, and they are present in the center of the basin Fig. Two depositional models have been proposed to explain the origin of the dolomites and capping anhydritesin the upper Red River Formation. In the first model, the marine waters in the central Williston Basin evaporated to the point that a sabkha developed there Carroll, while in the second model, all deposition occurred in subtidal environments Kendall, The data can be interpreted to fit either model, hence the controversy. Stratigraphy of the upper Red River Formation The letters correspond to informally named porosity zones. Modified from Carroll, In the sabkha model, the "D" zone strata were deposited in a subtidal to intertidal environment and the basal strata of the "C", "B", and "A" zones were deposited in a subtidal environment. The upper strata of the "C", "B", and "A" zones were deposited in a broad supratidal environment, or sabkha Carroll, In this model, a series of marine transgressions deposited subtidal to intertidal sediments during the basal phase of each cycle, were followed by a marine regression. In the cases of the "C", "B", and "A" zones, the regression dried out the basin. Dolomitization in the upper three zones was different - penecontemporaneous with deposition. The anhydrites were deposited in the high-evaporation environment of the sabkha. The sabkha model requires that sabkha progradation continued until the center of the basin was completely filled. In the second model of upper Red River sedimentation, deposition occurred in a subtidal environment. In this model, the dolomites and anhydrites were deposited during periods of basin restriction and increasing water salinity Kendall, The anhydrites were precipitated from the seawater when a high enough water salinity was reached before conditions returned to a more normal marine environment. Another possibility is that the dolomites formed as a result of a later diagenetic event. Most Red River Formation production has been found west of the Nesson anticline, in the deepest parts of the basin, and is associated with structural closures. The Red River Formation is the second most important hydrocarbon producing horizon in North Dakota and produces hydrocarbons in many fields Fig. The Stony Mountain Formation conformably overlies the Red River Formation and is comprised of interbedded calcareous shales and argillaceous limestones. The Stony Mountain Formation is rarely productive, but where it is productive it is always associated with a Red River Formation structure. Production usually comes from the Gunton Member which can have a well developed dolomite porosity. Continuous sedimentation occurred across the Ordovician-Silurian boundary and dolomites and limestones, with thin anhydrite beds near the basin center, were deposited. The Stonewall Formation produces oil and gas from several zones, usually associated with a Red River structure Fig. Interlake Formation Figure Partial distribution of oil and gas wells producing from the Ordovician Red River Formation. Partial distribution of oil and gas wells producing from the Silurian Stonewall Formation. Partial distribution of oil and gas wells producing from the Silurian Interlake Formation. Interlake lithologies are dominated by dolomitic mudstones and dolomites. The formation was exposed from Late Silurian through Early Devonian when karst topography was formed. Various interpretations have been made of Interlake stratigraphy. LoBue informally subdivided the Interlake Formation into three members, and interpreted the formation as a sequence of sublittoral to supralittoral environments. LoBue also recognized paleosols, and interpreted them as periods of prolonged subaerial exposure. Megathan Megathan assigned group status to the Interlake and defined eight formations within it. Megathan interpreted Interlake Group deposition as occurring in a succession of hypersaline lower Interlake to freshwater upper Interlake environments. In contrast, Inden et al Inden et al considered the Interlake to be a formation and interpreted it as a series of low-energy, shallowing-upward cycles deposited in a restricted-marine environment. The upper Interlake Formation is productive along large structures Fig. Salt-plugged porosity degrades reservoir performance in some places whereas fracturing has enhanced performance in other areas. The middle Interlake Formation is productive in two fields in Stark County and the lower Interlake Formation produces from two porosity zones, informally named the Salsbury and the Putnam. These two porosity zones produce on major structures in North Dakota and production can be significant, like that at Stoneview Field on the Nesson anticline. Typically, oil with a significant volume of gas is produced from Interlake reservoirs.

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Chapter 9 : MHS Transactions: Gleanings from the Geology of the Red River Valley

Gleanings from outcrops of silurian strata in the Red River Valley by J. Hoyes Panton 1 edition - first published in Gleanings from the geology of the Red River Valley.

Etymology[edit] Louis R. Harlan claimed that "Ouachita" is composed of the Choctaw words ouac for buffalo and chito for large, together meaning "country of large buffaloes". At one time, herds of buffalo inhabited the lowland areas of the Ouachitas. Wright wrote that "Ouachita" is composed of the Choctaw words owa for hunt and chito for big, together meaning "big hunt far from home". Together with the Ozark Plateaus , the Ouachitas form the U. Interior Highlands , one of few mountainous regions between the Appalachians and Rockies. The maple-leaf oak Quercus acerifolia is found at only four sites worldwide, all of which are in the Ouachitas. Today, there are large populations of white-tailed deer , coyote , and other common temperate forest animals. Though elusive, hundreds of black bear roam the Ouachitas. Several species of salamander are endemic to the Ouachitas and have traits that vary from one locale to another. Subranges[edit] The Athens Piedmont consists of a series of low relief ridges, none exceeding 1, feet. It is located south of the Ouachitas and extends from Arkadelphia, Arkansas to the Arkansas-Oklahoma border. The Caddo, Cossatot, and Missouri mountains are a high, compact group of mountains composed of the weather-resistant Arkansas Novaculite. They are located primarily in Montgomery and Polk counties, Arkansas. The highest natural point is Raspberry Mountain at 2, feet. The headwaters of multiple rivers are found in this area, including the Caddo , Cossatot , and Little Missouri rivers. The highest natural point is Whiskey Peak at 1, feet. The Crystal Mountains are generally taller than the nearby Zig Zag Mountains, achieving elevations over 1, feet. The Fourche Mountains are a long, continuous chain of mountains composed of the weather-resistant Jackfork Sandstone. The highest natural point is Rich Mountain at 2, feet, which intersects the Arkansas-Oklahoma border near Mena, Arkansas. The highest natural point is Mount Magazine at 2, feet, which is also the highest natural point of the Ouachitas and U. The Frontal Ouachita Mountains are structurally quite different from the rest of the Ouachitas and are sometimes considered a separate range. The highest natural point is Trap Mountain at 1, feet. They are so named because of their unique chevron shape when viewed from above, the result of plunging anticlines and synclines. The Zig Zag Mountains are not exceptionally tall, but do reach heights over 1, feet. Vertical strata in the eastern Ouachitas Cluster of Arkansas quartz crystals from the Ouachita Mountains The Ouachitas are formed by a thick succession of highly deformed Paleozoic strata constituting the Ouachita Fold and Thrust Belt, which outcrops for approximately miles in western Arkansas and southeastern Oklahoma. They are unique because metamorphism and volcanism , features that are common in orogenic belts, are notably absent with the exception of some low-grade metamorphism. Due to the high degree of folding and faulting, the Ouachitas are clustered into distinct subranges, with ridges separated by relatively broad valleys. The Ouachitas are also known for novaculite , a variety of chert that has undergone low-grade metamorphism ; particular grades found only in Arkansas are used for making whetstones. History[edit] Cambrian through Mississippian strata of the Ouachitas were deposited in a narrow, two-sided basin called the Ouachita Trough, which formed as part of a Cambrian failed rift system. The Atoka Formation , which was deposited much later during the Pennsylvanian , has the largest areal extent of any of the Paleozoic formations in Arkansas.