producing toxic effects. Animals immunized with ketene-treated vaccine are highly resistant to doses of living or heat-killed bacilli which are lethal for non-immunized animals.

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THE OROGENIC HISTORY OF CENTRAL UTAH[1]

DURING the course of studies in 1929–1933 by the writer in the Wasatch Plateau, of central Utah, evidence accumulated to suggest that the rocks there classified as the lower part of the Wasatch formation were not really Wasatch (lower Eocene) in age, but older, perhaps still older Eocene. In the summer of 1934 the writer, searching for fossil evidence on the age of these beds, gathered a small collection of bone fragments which, although not exactly identifiable, were pronounced by C. W. Gilmore to be unmistakably dinosaurian. The presence of these fossils suggested a Cretaceous age for the beds containing them. In June, 1935, J. B. Reeside, Jr., and the writer made a somewhat more extended search, which resulted in a much larger volume of better material, from widely scattered localities. This material remains to be studied by Mr. Gilmore, and the limits of its significance can not yet be stated, but it serves clearly to verify the presence of a varied reptilian fauna, including dominantly several types of dinosaurs, at the time when the beds hitherto classified as the lower member of the Wasatch formation in central Utah[2] were deposited. Inasmuch as these strata were laid down considerably later than the major orogenic disturbance in which the rocks of the Wasatch Mountains were folded, the discovery in them of dinosaurian remains necessitates a notable revision of existing concept respecting the place in the geologic time scale of the known physical events, and this note is offered for the purpose of placing the essential facts on record pending the preparation of a fuller account, in which details of revision can be set forth.

In brief, the rocks of central Utah reveal the following sequence of events in late Cretaceous time:

(1) At some time following the deposition of the Price River formation[3] (coarse sandstones and conglomerates of upper Montana age) the rocks of the region were intensely folded and thrust as far east as the western border of the present Wasatch Plateau; this was the major folding of the mass now forming the Wasatch Mountains.

(2) After an epoch of profound and probably rapid erosion, a varied assortment of sediments, ranging from boulder conglomerate through sandstone to red shale and white to gray freshwater limestone, was deposited, attaining a maximum thickness of several thousand feet.

(3) The region was again disturbed, this time more gently, and the rocks of (2) were tilted up and planed off.

(4) Sedimentation again ensued, beginning with coarse boulder conglomerate and passing on to sandstone, shale and local limestone, including some varicolored sediments but in general not the deep reds of the foregoing strata; these are the dinosaur-bearing beds, formerly classified as the lower member of the Wasatch formation.

Other later epochs of disturbance are recognized in the region, but in confinement of this note to the essential facts concerning the older folding they need not be specifically mentioned.

The dinosaur bones are sparse at all known localities except the one discovered in 1934, and in general they are difficult to find; they occur as scattered individual bones and parts of skeletons, many broken before burial. In answer to the question whether they were possibly reworked from older beds it should be pointed out that the fragility of many of the specimens, the presence of large bones in very fine-grained sediments, the wide distribution of the remains in general and the abundance of the material at the best locality, which is many miles from the nearest possible source in older rocks, effectively demonstrate that the fossils are indigenous to the strata in which they are found.

The first disturbance above mentioned, the major compressive movement in the Wasatch Mountain belt, has generally been considered to mark the close of Cretaceous time, and the succeeding sediments have generally been classified as Eocene, although fossil evidence has been meager and difficult to interpret, in notable part suggestive of age older than Eocene but decidedly not conclusive, and in terms of pre-existing classification acceptable as Eocene. In all the rest of the known Rocky Mountain-Great Plains province the latest dinosaurs are found in the Lance and equivalent beds, now classified by many geologists as Cretaceous. There are of course involved here all the ramifications of the celebrated Laramie problem, and geologists familiar with the controversial terms

[1] Published by permission of the director of the U. S. Geological Survey.

[2] Edmund M. Spieker and John B. Reeside, Jr., *Geol. Soc. Am. Bull.*, 36: 448–449, 1925; Edmund M. Spieker, *U. S. Geol. Survey Bull.*, 819: 45–48, 1931.

[3] Spieker and Reeside, *op. cit.*, pp. 445–448; Spieker, *op. cit.*, pp. 39–45; Edmund M. Spieker and John B. Reeside, Jr., *Geol. Soc. Am. Bull.*, 37: 431–433, 1926.

of this issue will see at once a number of possible dispositions of the evidence here announced, but such matters can not be dealt with in this brief note. It should be noted, however, that this discovery puts on record the first area, to the writer's knowledge, in which the relation of the orogenic movements to the dinosaur-bearing strata is unmistakably clear and not subject to the debatable elements of interpretation. Whether the end of the Cretaceous is to be set at the major orogenic disturbance or at the disappearance of the dinosaurs need not be considered here. The relative significance in terms of the physical record of the names Cretaceous and Tertiary is of lesser importance just now than the recognition that the dinosaurs were present some time after the early and more profound folding in this part of the Cordillera and that the beds containing the dinosaurian remains can hardly, by any stretch of imagination, be considered later than the Lance beds of the plains. Final analysis will probably justify the classification of the strata as Cretaceous.

The regional implications of this discovery can not yet be stated with any certainty, but the profundity of the folding and thrusting in the Wasatch Mountains, considered along with the known structural relations to the north, in Idaho, Wyoming and Montana, almost excludes the possibility that the disturbance was merely local, and suggests strongly that we are dealing here with the major orogenic movement in this general belt of the Cordillera.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

PETROLEUM SPRAYS FOR DANDELIONS

THE very general interest shown in a paper read by the authors at the Pittsburgh meetings leads us to publish this preliminary note on our experiments in the control of dandelions with petroleum sprays. Certain of the higher boiling hydrocarbons contained in the groups sold commercially as distillates and kerosene show a remarkably differential action when sprayed on bluegrass (*Poa pratensis*) lawns at the rate of 200 or 300 gallons an acre. Under favorable conditions the dandelions (*Taraxacum officinale*) are slowly but completely killed, while the bluegrass sod is only temporarily affected. In our experiments, sprays applied on September 20, 1933, in rather warm weather, resulted in a 70 per cent. control of dandelions. Sprays applied on June 6, 1934, in the evening of a hot day, resulted in 63 per cent. control. Sprays applied on a hot day in July of the same year were not carefully checked but gave no noticeable control. Sprays applied on October 1, 1934, in frosty weather resulted in controls of 99 to 100 per cent. Sprays applied on May 20, 1935, in distinctly cool weather (60° F.), have given a control of 95 per cent. or better. It is not clear at the present time whether the stage of development of the dandelion plant at the time of applying the spray is the important factor or whether temperature with its effect upon vaporization of the applied material is the more important. We are inclined to think that temperature is at least a major factor, and would recommend spraying only in cool weather. Petroleum sprays will readily adhere to and penetrate the foliage, either wet or dry, of both dandelions and lawn plants so that a period of cool rainy weather in the spring or fall would appear to be a favorable time for applications. Our results to date would favor fall applications, largely because fewer dandelion seedlings develop before the stolons of the bluegrass have spread to fill in the open areas.

The material may be sprayed broadcast over the lawn at the rate of one half gallon per 100 square feet or, where the dandelion plants are more scattered, a spotting method of spraying may be used. Applications in excess of 300 gallons an acre or about three quarts per 100 square feet may injure the grass, and the use of impure distillates showing a yellow coloration has resulted in a complete kill of bluegrass and white clover sod so that only the water-white products should be used, and even among these some appear to be more toxic to bluegrass and less differential in their action than others. This toxicity is reduced by washing the distillates with H_2SO_4 to remove unsaturated hydrocarbons.

The distillate sprays penetrate the leaves of the dandelion and other plants almost instantly and appear to be slowly moved downward through the roots. Injurious effects other than a cessation of growth may not appear for a week or 10 days, and frequently dandelion plants will continue to die for a month after the spray is applied. Under favorable conditions the entire root system of the plant is killed, and apparently the top dies as a result of this injury to the root. Under less favorable conditions only the upper portions of the root may be killed, and the plants may be reestablished by sprout development. The growth of seedlings, however, is under average conditions more serious than sprouting from the roots in the reestablishment of the dandelion plants. Plots sprayed on June 6, 1934, with straw-colored distillate sprays which killed both sod and dandelions, and reseeded with grass, gave an almost solid stand of dandelion seedlings which developed more rapidly than the seedling bluegrass. Adjoining plots which were sprayed