Technical Papers

The Lake Altus Wave-Cut Surface in the Wichita Mountain Area, Oklahoma

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In the western part of the Wichita mountains of Oklahoma there may be seen an erosion surface, on the granite hills, at an elevation of about 2200 ft above sea level and 500 to 700 ft above the adjacent plains. The best development of this surface occurs on Soldier Mountain and adjacent peaks south of Lake Altus. The surface described here is named from Lake Altus.

Locally the Lake Altus surface is hundreds or even several thousands of feet across, but in general it truncates granite knobs of small mass or encircles, as a platform 50 to 150 ft wide, granite hills of greater mass. The slope of the surface, in the latter instances, is radially outward, in the range 30 ft/mi to somewhat more than 100 ft/mi.

Taylor (*1*) reported and Evans (*2*) described in detail grooves or notches cut by wave action on granites of the Wichita mountains. The grooves are approximately horizontal and perfectly parallel, are associated with narrow but distinctive wave-cut platforms, and are developed inside an old sea cave and between the faces of fractures.

No notches have been found above the erosion surface. Commonly the notches are preserved only within 25 to 50 ft of the modern ground surface on the adjacent plains. Inasmuch as they are present at many different elevations (today controlled by the depth of erosion and the elapsed time since the shale cover was removed), the assumption is that at one time they did exist above the erosion surface.

The notches, the radial-outward slope, the low slope angle, the thin veneer of granite boulders on the slope, and the narrowness of the platform indicate that the Lake Altus surface was cut by wave action.

Wave-cut notches have not been reported from the eastern Wichita mountains. The Lake Altus surface is present, however. It has its best development in the eastern part of the mountains on Elk Mountain, north of Indiahoma. It may be seen on USGS topographic maps of the area (Cache, Cooperton, Saddle Mountain, Snyder sheets). A statistical study of 200 hilltop and 100 random hillside elevations from these four quadrangles indicates a definite accordance between 2200 and 2270 ft and a possible surface between 2400 and 2500 ft. The top of Mount Scott, a flat surface about 700 ft long, fits in the latter interval.

Two similar surfaces at elevations of about 400 to 500 and 900 to 1000 ft above sea level have been studied in the subsurface, north of the western part of the mountains, by means of electric logs and drillers' logs. They also possess radial-outward slopes in the same range of values.

The two surfaces studied from well log data are overlain by coarse arkose and red shales of late Virgil (late Pennsylvanian) to Garber (lower middle Permian) age. The lower surfaces are therefore tentatively dated as late Pennsylvanian and early Permian, respectively. The exposed Lake Altus surface is thought to date from post-Garber, probably middle Permian time.

The sequence of three, perhaps four, surfaces, associated with uncounted wave-cut notches, indicates a late Pennsylvanian and Permian sea advance that may have completely submerged the mountain range. Because the elevation differences among the surfaces is of the order of 2000 ft, subsidence rather than sea-level fluctuation probably accounted for the transgression (*3*).

References

1. C. H. Taylor, *Okla. Geol. Survey Bull.* **20**, 59 (1915).
2. O. F. Evans, *J. Geol.* **37**, 76 (1929).
3. For a detailed description, with figures, see *Shale Shaker* (Okla. City Geol. Soc.), in press.

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Nutritional Studies with the White-Throated Wood Rat (*Neotoma mexicana*)

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In the development of the science of nutrition, the use of different species of animals has greatly facilitated the advancement of knowledge and the discovery of new dietary factors. The cotton rat and the hamster have been particularly useful in the study of dental caries and in virus work. This prompted us to study the white-throated wood rat, *Neotoma mexicana,* as a mammalian species that might have nutritional patterns of unique value for research (*1*). During the course of the experiments several interesting observations were made concerning the behavior of wood rats: (i) the wood rats could be maintained on a commercial rat chow but did not readily accept a purified type of diet containing all the nutrients known to be essential for the albino rat; (ii) the water intake was observed to be unusually high; and (iii) when the commercial chow was supplemented with aminopterin, a folic acid antagonist, the wood rats survived for a longer period than mature albino rats.

The wood rat is indigenous to the arid southwestern United States and Mexico and, in its natural habitat, lives where vegetation affords protection from carnivores and shelter from the elements. It is primarily nocturnal. Flowers, fruits, and leaves are the main items of diet. Animals for our studies were obtained from Colorado through the courtesy of the Fish and Wildlife Service of the Department of the Interior.

The rats were captured in Douglas County, Colorado, around sandstone ledges of an area designated as Daniels Park.

Under laboratory conditions, a commercial stock diet for rats appeared to meet the requirements for maintenance and growth. A purified diet normally used for the albino rat was then tried. The diet had the following percentage composition: casein, 25; starch, 64; salt mixture, 4; and corn oil, 7. In addition, the diet was supplemented with the fat-soluble vitamins and all B-vitamins at levels more than adequate for the albino rat. The wood rats did not adapt themselves to the diet, weight responses were unsatisfactory, and food consumption was only about half of the amount consumed on the stock diet. Since it has been reported that the cotton rat responds to liver concentrate, 1 percent of a liver extract was incorporated in the diet to replace an equivalent amount of starch. The wood rats did not respond to this diet either, and food consumption was low.

Studies have suggested an effect of bulk formers on the life-span of rats (*2*), and since the wood rat normally subsists on a diet that is relatively high in fiber, it was thought that this might be a limiting factor in the diet. One percent of cellulose (Reflux), however, did not improve the acceptability of the diet to the animals. When the animals were given free access to the stock and purified diets either with or without cellulose, they invariably ate the stock diet. The purified diet was also fed in pellet form, but this did not improve its acceptability. In view of Curt Richter's (*3*) interest in the wood rat and his special facilities for activity studies and multiple-choice feeding techniques, a limited number of animals was made available to him. The wood rats drank large quantities of water, much more than would be taken by domesticated Norway rats, but not much more than would be consumed by wild Norway rats. The spontaneous running activity of the wood rats was low as compared with the activity of wild Norway rats. Of several natural foods and synthetic diet materials used in the multiple-choice feeding system, it was apparent that the rats preferred the natural foods.

Since the experiments using a purified diet did not yield quantitative data, it was considered worth while to try adding an antimetabolite to the stock diet. Aminopterin (4-aminopteroylglutamic acid) was used, since it will produce an impairment in erythropoiesis in the mouse, white rat, chicken, and monkey. In the white rat a dose of 50 μg of aminopterin given intraperitoneally daily will produce marked effect within 5 to 6 days (*4*). The daily level of aminopterin selected for these studies with the wood rat was 250 μg per 10 g of food. On the stock diet, without aminopterin, the average hemoglobin value was 13.5 g per 100 ml of blood and the RBC count 7,690,000. The RBC count and hemoglobin values declined to less than half the original value after aminopterin had been fed for 12 to 35 days. The animals declined in weight, and the amount of food consumed was decreased. The hair coat tended to be rough, and the animals developed a general unthrifty appearance, which was correlated with the decrease of RBC and hemoglobin values. From these preliminary studies, however, it is not possible to conclude that folic acid is a dietary essential, since the possibility of a toxic action of aminopterin has not been eliminated. Adult albino rats of the Wistar strain fed the same quantity of aminopterin survived no longer than 2 wk. This suggests that the wood rat has a sensitivity to aminopterin that is less than that of the albino rat.

Information was also obtained on the excretion of some of the B-vitamins when the wood rats were fed the stock diet. The animals were kept in individual, wire-bottom, metabolism cages, and feces and urine were collected quantitatively for 3 successive days. Standard microbiological procedures were used for determining the riboflavin, niacin, and pantothenic acid contents of urine and feces. The results presented in Table 1 are values for nine animals. It is apparent that there was considerable variation among the animals in the excretion of each of the three vitamins. This reflects, at least in part, the variation in food intake and corresponding variations in the amount of vitamins ingested. It is interesting to note that, of the total pantothenic acid excreted, a much higher proportion was excreted via the renal pathway than was the case for niacin and riboflavin. The intake of pantothenic acid was only slightly higher than the rate of excretion, whereas with riboflavin and niacin the

Table 1. Average excretion and range of riboflavin, niacin, and pantothenic acid.

	Feces		Urine		Total excretion	Total intake
	(μg/g)	(μg/24 hr)	(μg/ml)	(μg/24 hr)	(μg/24 hr)	(μg/24 hr)
			Riboflavin			
Average	22.7	37.4	0.51	12.2	50	119
Range	10.8–34.8	16.6–71.3	.1–1.9	4.7–25.5	21–97	98–196
			Niacin			
Average	85.3	132.4	1.5	57.8	190	345
Range	56.0–178.0	78.2–235.5	.1–4.2	11.2–125.4	89–361	144–602
			Pantothenic acid			
Average	18.8	29.4	2.0	68.4	98	93
Range	9.4–31.4	14.7–41.5	.05–3.2	1.2–279.4	16–321	76–151

amount ingested was in the order of twice the amount excreted.

Although the wood rat appears to have several characteristics worthy of further investigation, the difficulties encountered in maintaining the animals under laboratory conditions make it unlikely that they will find widespread use. Not only was there a poor growth response to a purified type of diet, but reproduction under laboratory conditions was unsuccessful, as was also reported by Hall and coworkers (*5*) for the related Florida wood rat, *Neotoma floridana osagensis.*

References and Notes

1. Contribution No. 73 of the McCollum-Pratt Institute. These studies were supported by a grant from the National Institutes of Health, U.S. Public Health Service (HEW).
2. A. J. Carlson and F. Huelzel, *J. Nutrition* **36**, 27 (1948).
3. Acknowledgment is made to Curt Richter of The Johns Hopkins Hospital for his participation in this phase of the study.
4. G. M. Higgins, *Blood* **4**, 1142 (1949).
5. E. R. Hall, University of Kansas, personal communication.

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A Geothermal Measuring Circuit*

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Early in 1949 the U.S. Geological Survey undertook a program of geothermal measurements in drill holes in the Naval Petroleum Reserve in northern Alaska. A multiconductor cable for such measurements was specially designed in the Geological Survey for use in these arctic drill holes. The circuit may be of interest to others making precise temperature measurements at multiple points.

Thermistors were used as the thermal measuring elements because of their high sensitivity: a change in resistance, at room temperature, of −4.4 percent per degree Celsius change in temperature.

The circuit was designed to permit maximum accuracy with a minimum number of conductors in the cable. To achieve this, all the conductors were connected together at the bottom end of the cable (Fig. 1). This assures that each conductor in the cable has the same length and, what is especially important, that each has the same temperature and temperature distribution along its length. One of the conductors was then used as a common return lead for all the circuits. A thermistor was inserted at the desired position in each of the other conductors save one, which was reserved as a test lead. This allows an accurate determination of the circuit resistance for each thermistor circuit with only one conductor for each thermistor and without regard to the nature of the temperature distribution along the cable.

In operation, one terminal of a Wheatstone bridge is connected to the common lead (Fig. 1). The other terminal is connected, through a multipoint selector switch, to the desired thermistor lead. If R_θ is the resistance of the thermistor alone, R_L the thermistor circuit or lead resistance, and R_M the measured resistance value,

$$R_\theta = R_M - R_L. \tag{1}$$

Because all the conductors in the cable are made of the same wire, all have the same temperature coefficients of resistance, α, β, ... Moreover, because of their adjacency and parallelism in the cable, all have the same temperatures and temperature distribution, when equilibrium with their surrounding medium has been attained. If the effective temperature of the cable is t (°C),

$$R_L = R_{L0}(1 + \alpha t + \beta t^2 + \ldots), \tag{2}$$

where R_{L0} is the circuit resistance at 0°C. Since the test lead is one of the conductors, the resistance of the test circuit must also be

$$R_T = R_{T0}(1 + \alpha t + \beta t^2 + \ldots). \tag{3}$$

Therefore,

$$R_L/R_T = R_{L0}/R_{T0}. \tag{4}$$

Since this ratio is independent of temperature, it follows that

$$R_L/R_T = R_{LC}/R_{TC}, \tag{5}$$

where R_{LC} and R_{TC} are the resistances of thermistor circuit and test circuit, respectively, as measured in the laboratory at some convenient calibration temperature t_C prior to the insertion of the thermistors in the cable. From this it follows that

$$R_L = (R_{LC}/R_{TC})R_T \tag{6}$$

and

$$R_\theta = R_M - (R_{LC}/R_{TC})R_T. \tag{7}$$

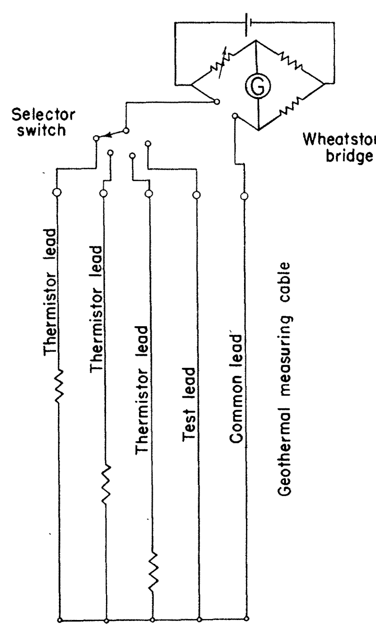

Fig. 1. Diagrammatic wiring circuit for geothermal measuring cable.

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