References and Notes

1. G. W. Moore, "Speleothem—a new cave term." *Natl. Speleological Soc. News* 10, No. 6, 2 (1952).
2. D. M. Black, "Origin and development of 'positive' water catchment basins, Carlsbad Caverns, N.M." *Natl. Speleological Soc. Bull.* 13, 28 (1951).

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25 November 1955

Some Potassium-Argon Ages for Western Canada

Recent deep exploratory drilling has provided core samples of the Pre-Cambrian basement rocks that underlie the plains of western Canada. A number of these samples (*1*) contain potassium-bearing minerals in sufficient quantity to permit age determinations to be made by the potassium-argon method. Table 1 gives the ages determined for 15 core samples from Alberta and Saskatchewan. The ages of two outcrop samples from the Marian River area of the Northwest Territories are also given.

The basis of selection of core samples was high potassium content and lack of evidence of hydrothermal alteration or weathering. All of the samples are of granitic composition. Samples 1268, 1290, 1291, and 1292 are alkali granites. Sample 1295 is an alkali rhyolite. The remaining samples are calc-alkali granites and adamellites. Potash feldspar supplies the greater part of the potassium content of the rocks. The mica content is generally less than 5 percent. In only three samples—1268, 1433, and 1434—does the mica content exceed 10 percent.

Potassium-argon ages are calculated from the formula

$$t = \frac{1}{(1+R)\lambda_\beta} \cdot \ln \left\{ 1 + \frac{1+R}{R} \cdot \frac{A^{40}}{K^{40}} \right\}$$

where, in the absence of loss of argon from the minerals, R is the branching ratio, defined as the rate of orbital electron capture divided by the rate of beta-particle emission. Two values of R have been reported from argon measurements on dated feldspars, $R = 0.089$ (*2*) and $R = 0.085 \pm 0.005$ (*3*). However, it has now been verified at several laboratories that micas give consistently higher potassium-argon ages than do feldspars from the same deposits, indicating the probable loss of argon from feldspars. If the loss from feldspars is nearly constant, the afore-mentioned values for R can be used in the equation to determine the approximate ages of feldspars. This was the procedure adopted for this preliminary report.

For λ_β, the transformation constant for beta emission, a value of 0.503×10^{-9} yr^{-1} has been obtained from 11 of the most recent counting experiments (*4*).

K^{40} is the mass of potassium-40 per gram of sample. It was calculated from the potassium analyses by assuming Nier's value of 0.0119 percent for the isotopic abundance of potassium-40 (*5*). Total potassium was determined by gravimetric analysis as the chloroplatinate, following decomposition of the sample by the J. Lawrence Smith method. Potassium was corrected for rubidium content, which was determined by flame spectrophotometer.

A^{40} is the mass of radiogenic argon-40 present per gram of sample, as determined by a procedure that has already been described (*4*). At least two determinations were made on all samples except 1295, 1436, and 1437. All argon samples were analyzed by mass spectrometer and corrected for contamination by atmospheric argon. This correction was generally less than 10 percent. The error placed on the potassium-argon ages has been calculated by using an estimated mean probable error of 10 percent in the A^{40}/K^{40} ratio. The agreement between individual analyses was generally more accurate than this.

The determination of potassium-argon ages of core samples from Alberta was undertaken in order to extend Pre-Cambrian geochronology to a previously inaccessible area. In view of the subsequent discovery of the leakage of argon from potash feldspar, the reported ages must be regarded as tentative. Their value is that they represent the minimum ages of the rocks concerned. Also, the agreement of a number of the ages from western Alberta may indicate the existence there of a Pre-Cambrian terrain somewhat younger than the previously dated Churchill province of northern Saskatchewan (*6*). Further age determinations on biotite separated from these samples will be required to confirm the age of the Pre-Cambrian of this area.

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Table 1. Potassium-argon ages for some core samples from western Canada.

Toronto No.	Location (lat. N. and long. W.)	Sample depth (ft)	A^{40}* wt. (% × 10^{-5})	K_2O wt. (%)	A^{40}/K^{40}	Age (10^6 yr)
1290	Imperial Bistcho Lake (59°52′, 118°19′)	6,120	4.58 ± 0.02	5.12	0.089	1350 ± 90
1291	Imperial Lutose Creek (59°20′, 117°20′)	4,525	3.97 ± 0.12	5.11	0.077	1210 ± 80
1434	Imperial Loon Lake (56°28′, 115°20′)	4,980	5.62 ± 0.80	4.33	0.129	1730 ± 120
1293	Shell B. A. Whitelaw (56°06′, 118°12′)	7,492	4.90 ± 0.40	4.60	0.106	1520 ± 100
1292	Imperial Tangent (55°56′, 117°36′)	7,596	8.23 ± 0.70	8.17	0.100	1460 ± 100
1266	Shell Reno (55°58′, 116°31′)	6,768	4.73 ± 0.03	5.96	0.079	1220 ± 90
1294	Imperial Clairmont (55°16′, 118°37′)	11,700	4.77 ± 0.07	5.15	0.092	1380 ± 90
1270	Bear Biltmore (56°32′, 112°35′)	2,855	8.12 ± 0.10	6.13	0.134	1770 ± 120
1289	Bear Biltmore (56°32′, 112°35′)	2,857	7.48 ± 0.30	6.45	0.115	1600 ± 110
1267	Bear Vampire (56°34′, 111°50′)	2,302	6.20 ± 0.05	7.09	0.087	1310 ± 90
1432	Alberta Govt. Salt Well No. 2 (56°40′, 111°15′)	789	5.10 ± 0.30	6.08	0.083	1270 ± 80
1433	Imperial Grosmont (54°49′, 113°29′)	6,405	1.88 ± 0.40	6.09	0.030	570 ± 50†
1268	Imperial Ardrossan (53°33′, 113°03′)	7,800	4.70 ± 0.02	6.19	0.075	1180 ± 80
1269	Imperial Leduc No. 530 (53°19′, 113°45′)	8,985	3.38 ± 0.12	3.73	0.088	1330 ± 90
1295	Tide Water Crown Johnson Lake (50°11′, 106°14′)	7,785	5.15	5.03	0.101	1470 ± 100
1436	Marian River Area, NWT TXG 51 Claim (63°24′, 116°40′)		5.77	4.85	0.118	1630 ± 110
1437	Marian River Area, NWT FG 1 Claim (63°27′, 116°33′)		2.97	5.07	0.078	1220 ± 80

* Uncertainty shown is standard deviation of individual measurements.
† Anomalously low result believed to be in error.

References and Notes

1. Samples for this study were supplied by Imperial Oil Limited, Pacific Petroleums Limited, Shell Oil Company, and Tide Water Associated Oil Company. The research was aided by fellowships awarded by Standard Oil Company to

H. A. Shillibeer and by Imperial Oil Limited to R. A. Burwash. The assistance of the members of the Geophysical Laboratory, University of Toronto, and the Rock Analysis Laboratory, University of Minnesota, is gratefully acknowledged.
2. H. A. Shillibeer *et al.*, *Phys. Rev.* 94, 1793 (1954).
3. G. J. Wasserburg and R. J. Hayden, *Geochim. et Cosmochim. Acta* 7, 51 (1955).
4. H. A. Shillibeer and R. D. Russell, *Can. J. Phys.* 32, 681 (1954).
5. A. O. Nier, *Phys. Rev.* 77, 789 (1950).
6. J. T. Wilson, *Trans. Can. Inst. Mining Met.* 52, 231 (1949); C. B. Collins *et al.*, *Bull. Geol. Soc. Amer.* 65, 1 (1954).

28 November 1955

"Whirling Behavior" in Dogs as Related to Early Experience

In the course of 3 years of experimentation on the relationship of early experience in dogs (Scottish terriers) to their later behavior, there has appeared an interesting phenomenon that is worth reporting separately (*1*). This is the occurrence of "whirling fits" in a number of dogs that were restricted during early life.

Restriction is imposed by rearing the experimental animals from 1 to 8 or 10 months of age in isolation cages (one dog per cage) that are so constructed that the dog inside each can never see any more than the floor of the cage above or the ceiling of the room. By means of a small side compartment adjoining the living space and separated from it by a sliding panel, feeding and cleaning can be accomplished without exposing the restricted animal to the outside environment. After the period of restriction is over, the experimental "Scotties" are compared by means of psychological tests with their littermates which have been reared normally as pets in homes.

Many striking differences have appeared between the normal and the restricted dogs in all phases of behavior, including intelligence, activity, emotionality, and social behavior. These are reported in full elsewhere (*2*). More bizarre than any of these effects of early restriction are the afore-mentioned whirling fits. These have appeared in eight out of eleven severely restricted animals. The three exceptions, while highly active and excitable, have not, to our knowledge, shown the extreme behavior discussed here.

Whirling can be described as follows: very rapid, jerky running in a tight circle; shrill, agonized yelping; barking and snarling; and tail snapping and tail biting. The syndrome may last from 1 to 10 minutes. It is usually heralded by certain characteristic signs. The dog suddenly becomes motionless, cocking its head up and back, as if looking at its own tail. It begins to growl viciously, and its eyes take on a glazed expression. These signs may continue for a minute or two, increasing in intensity until the full-blown fit occurs. To all appearances, whirling does not seem to be under voluntary control but to be "driven." The dog does not seem to be able to control its behavior and cannot usually be distracted even by fairly intense stimuli.

Whatever its nature and causes, whirling is a peculiar and striking form of behavior that is worth further investigation. Several points concerning it should be noted. In the first place, it seems to vary in degree, with respect to both intensity and duration.

Second, although many of the fits appear to occur spontaneously (in that the immediate causes are not known), they usually seem to be set off by some change in the stimulus-environment. This change may be anything from the mere introduction of a food dish into the cage to electric shock or restraint in a harness for a period of time.

Third, all the dogs showing whirling fits shared, to some degree, a common ancestry. All were descendants of three Scotties purchased from Hamilton Station, Bar Harbor, Maine, and bred, within themselves and to outside dogs, for several generations. However, the three animals not showing this behavior were also related to this strain. Consequently, it is difficult to make any obvious inferences concerning the possible genetic origin of the trait.

Fourth, all dogs showing whirling have had a background of severe restriction in early life. None of their normal littermates have shown such behavior. At the same time, since the three exceptions have also undergone restriction, this kind of early experience is not a sufficient condition for the appearance of the symptoms, although it may be a necessary one.

In view of the foregoing points, it is difficult to know what ultimate factors predisposed some animals to whirling fits. Diet is a possible explanation, although it could not be the only cause, since all the animals in the laboratory were fed the same amount and type of ration made up according to the specifications of several experts in dog care. All dogs received, during a typical week, meat (liver, Pard, hamburger), dog biscuits, Purina Dog Chow, vegetables, codliver oil, and milk while they were puppies. The restricted animals showed appetites as good or better than normals. At the same time, we cannot rule out the possibility that this diet might have been inadequate for dogs raised in severe restriction, even though it appeared to be adequate for dogs living in normal environments.

The possibility that whirling was caused by a specific irritation in the tail —thus causing the circling and tail snapping—is unlikely. It does not seem reasonable to suppose that such extreme behavior could be set off so easily and set off only under special conditions involving a change in the sensory environment. When tail injuries did occur, they appeared definitely to be the result rather than the cause of whirling. Consequently, we are inclined to feel that the behavior is central and not peripheral in origin.

Finally, it must be mentioned that the dogs were constantly checked for signs of worms and distemper by examination of their feces and by noting any decline in appetite. There was no evidence of ill health among any of the experimental dogs during their period of restriction. After removal from restriction, they were examined more carefully by a veterinarian, with negative results.

Accordingly, there are considerable grounds for supposing that whirling is dependent, at least partly, on the conditions of restriction imposed during early life. Whether or not it can properly be described as epileptiform is a moot point. None of the parasympathetic components of true seizures were ever observed in the dogs. On the other hand, the gross features of its expression would suggest that it is essentially a related phenomenon.

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References and Notes

1. The observations reported here are part of a project of the McGill Psychological Laboratory supported by a grant-in-aid from the Rockefeller Foundation. The behavior described in the article has been filmed, and the film will soon be available.
2. R. Melzack, *J. Comp. Physiol. Psychol.* 47, 166 (1954); W. R. Thompson and Woodburn Heron, *ibid.* 47, 77 (1954) and *Can. J. Psychol.* 8, 17 (1954).

1 November 1955

Action of Some Centrally Acting Drugs on Ion Transport in Red Cells

Stimulation of excitable tissue is known to be followed by a decrease in membrane potential, which is accompanied by an increased permeability of the tissue to sodium and potassium (*1*). Thus, the cell, on stimulation, loses potassium and gains sodium. During recovery, sodium is removed from the cell and potassium is replaced. The recovery process depends on the active transport of one or both cations, since the movement is against the concentration gradient.

When human blood is refrigerated, the