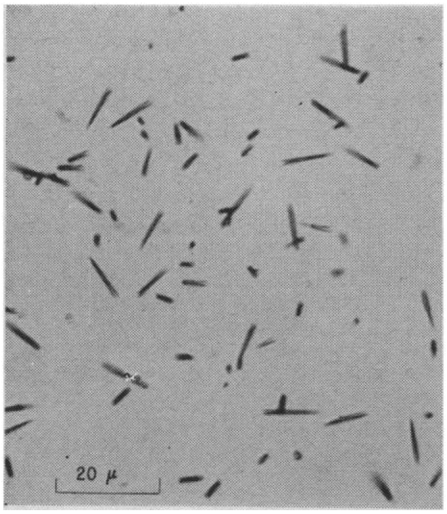

Fig. 1. Fission fragment tracks in Lexan.

taneous fission of Cf^{252}. The sample is then immersed in a suitable chemical reagent, rinsed, dried, and examined in an optical microscope. We find deep pits or tracks on the irradiated portion, but not elsewhere; and the number of pits is equal to the number of incident fission fragments. Alpha particles emitted by the Cf^{252} did not lead to observable pits.

We have produced pits indicating fission fragment tracks in condensation polymers—bisphenolacetone carbonate (Lexan), polyethylene glycol terephthalate (Mylar), cellulose nitrate, cellulose acetate—and in an addition polymer—polymethyl methacrylate (Plexiglas). Successful etching solutions were a mixture of aqua regia and hydrofluoric acid 6:1 for Plexiglas, NaOH in water (specific gravity 1.3) for Lexan resin, and KOH in water (specific gravity 1.4) for the other polymers mentioned.

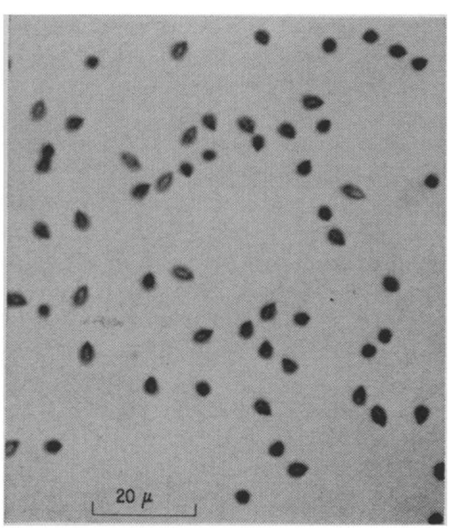

Fig. 2. Fission fragment tracks in cellulose nitrate. Round pits are from fragments crossing normal to the surface; pointed cones correspond to fragments which entered at acute angles.

Generally, tracks lengthen and widen in linear fashion with increased time of solution until some maximum length is reached. Tracks therefore have a conical shape, with the cone angle θ depending on the ratio R of the chemical-attack rate along the damaged material of the track to the general rate of attack of the undamaged material. For large values of R, $\theta (= 2 \csc^{-1} R)$ is small and the pits approach channels in shape and hence accurately define the direction taken by fission fragments.

Figure 1 shows a random array of tracks from a sample of Lexan polycarbonate which was placed close to the source of fission fragments. In Fig. 2 are pits produced in cellulose nitrate under conditions where θ is not small, and therefore the conical form of the pits is evident. Tracks in Lexan have a maximum length of about 20 microns, which is about the estimated range of fission fragments for this material.

Annealed cellulose acetate shows pits of angle intermediate between that of Lexan resin and cellulose nitrate. Cellulose acetate in its usual form gave pits which were ragged and ill-defined. Since this behavior was eliminated by annealing before irradiation, we conclude that internal stresses from processing or molecular alignment or both were responsible for the original behavior. If Lexan resin is annealed for 20 minutes after irradiation, tracks still may be detected above 185°C.

Plastic such as Lexan resin constitutes a simple and useful new type of solid-state detector for observing nuclear events of massive particles. An appreciable amount of a heavy element can be dissolved in the plastic as an organometallic compound (for example triphenylbismuthine). Since alpha particles do not lead to detectable tracks, irradiations may be performed with light particles without obscuring the tracks of interest, those that result from the massive particle interactions (such as fission) produced by irradiation. Plastics have the desirable property generally of being composed of elements of low atomic mass, so that scattering of heavy particles is very much smaller than in nuclear emulsions (*5; 6*).

R. L. Fleischer
P. B. Price

General Electric Research Laboratory, Schenectady, New York

References and Notes

1. E. C. H. Silk and R. S. Barnes, *Phil. Mag.* **4**, 970 (1959).
2. D. A. Young, *Nature* **182**, 375 (1958).
3. P. B. Price and R. M. Walker, *J. Appl. Phys.* **33**, 3407 (1962); ———, *Phys. Rev. Letters* **8**, 217 (1962); **3**, 113 (1962); R. L. Fleischer, P. B. Price, R. M. Walker, *Rev. Sci. Instr.*, in press.
4. R. L. Fleischer and P. B. Price, in preparation.
5. R. L. Fleischer, E. L. Hubbard, P. B. Price, R. M. Walker, in preparation.

6. We thank A. Ghiorso for making possible the Cf^{252} irradiations and R. P. Kambour and R. E. Robertson for helpful discussions. Supported in part by the Air Force Cambridge Research Center.

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Microfossils in Wisconsinan Loess and Till from Western Illinois and Eastern Iowa

Abstract. *Wisconsinan loess from Illinois and Iowa contains a varied assemblage of microfossils including radiolaria, foraminifera, sponge spicules, and opal phytoliths. The foraminifera and radiolaria are derived from Cretaceous rocks occurring on the northern Great Plains. The sponge spicules are from fresh-water sponges living during the epoch of loess deposition. The phytoliths were produced by vegetation growing during deposition. These microfossils are valuable in determining loess and till provenance and in paleoecological reconstruction.*

Loess deposits of Illinois are particularly suited to study and correlation because of their great depth and extensive distribution. The extent and nature of these deposits have been described and correlated by Smith (*1*), Leighton and Willman (*2*), and more recently Frye, Glass, and Willman (*3*). These studies have indicated that the source of Illinois loess may be quite distant and that loess distribution and thickness is closely dependent on drainage-system distribution.

In the course of investigation of Illinois loess, microfossil assemblages composed of radiolaria, foraminifera, sponge spicules, and opal phytoliths have been discovered. These fossils were found in the isolate of less than 2.30 specific gravity, which was obtained by centrifugation of 2.5 to 3.0 g of sample with a nitrobenzene-bromoform mixture. The calcareous foraminifera are buoyant because they are air filled. The yield of fossils from a 3-g sample is often quite small, and it is necessary to use care in removing the fossils from the tube; this is best accomplished by using a dropping pipette or by freezing the tube.

Serial samples from five Wisconsinan loess sections in Illinois and grab samples from one site in Henderson County, Illinois (T11N, R4W, sec. 8, NW ¼, NW ¼, NE ¼) and two in eastern Iowa (Linn County, T83N, R6W, sec. 11, NW ¼, SW ¼, and T86N, R6W, sec. 34, center) were studied. Also, one calcareous Iowan till sample from Jones County, Iowa (T85N, R4W, sec. 36, center) was examined. Sampling sites are represented in Fig. 1. Loess sections *A*, *C*, *D*, and *E* are the Collinsville, Eldred, Sepo, and North Quincy sections of Frye, Glass, and Willman (*3*). Section *B* is equivalent to their Burdick Branch site [see Pleasant Grove section (*3*)]. Sections *C*, *D*, and *E* are important because the blocking of the Ancient Mississippi River near Muscatine, Iowa, and adjustment to its present course along the western boundary of Illinois is recorded in the loess of these sections. Fossil assemblages found in the sections are presented in Fig. 2.

Radiolaria were found in samples at several levels in the sections studied. *Dictyomitra*, a Cretaceous genus, is the most common form; spumellarians are also present. *Dictyomitra* has been reported from Cenomanian deposits in Lyon and Redwood Counties, Minnesota, by Bolin (*4*), from the Pierre shale of Manitoba by Rüst (*5*), and from the Lea Park shale of Alberta by Nauss (*6*) as well as from numerous more distant Cretaceous localities. During the present investigation, radiolaria were also found to be common in samples from Iowan till. Since the upper zone of Peoria Loess was deposited after adjustment of the Illinois River to its modern drainage lines, the occurrence of radiolaria in the upper zone at Sepo and Eldred (Fig. 2) either reflects blow over of silt from the Mississippi Valley or reworking of earlier loess.

Foraminiferal assemblages were found in loess samples from Iowa and from two samples in the lower zone or main body of Peoria Loess in the loess sections studied. The assemblages have been size sorted, and all specimens fall within the 80- to 120-μ range. *Heterohelix globulosa* (Ehrenberg) and *Hedbergella planispira* (Tappan) are the most common species. Juvenile specimens of *Heterohelix moremani* (Cushman) and *Bulimina venusae* Nauss are also present along with a number of rarer juvenile forms too small to be

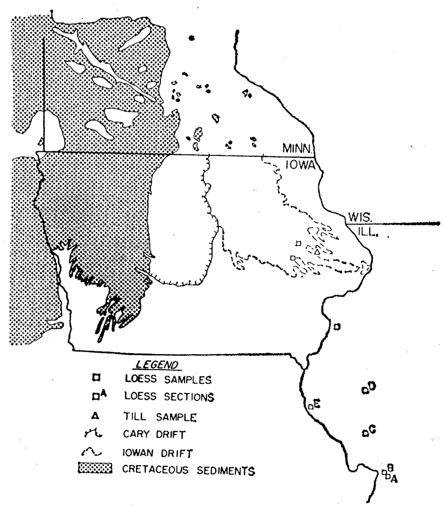

Fig. 1. Location of sampling sites and distribution of Cretaceous sedimentary rocks. Sections: *A*, Collinsville; *B*, Burdick Branch; *C*, Eldred; *D*, Sepo; *E*, North Quincy.

accurately determined. The assemblages resemble those described from the Cenomanian deposits of Minnesota by Bolin (*4*), the Greenhorn limestone of the Great Plains by Tappan (*7*), the Colorado group and Pierre shale by Morrow (*8*) and Loetterle (*9*), and the Lea Park Shale of the Vermilion area, Alberta, by Nauss (*6*). Similar foraminiferal assemblages were also found in Iowan till.

Whole and fragmented opaline monactine sponge spicules ranging from 20 to 100 μ in length also occur in loess (Fig. 2). These spicules are derived from fresh-water Spongillidae.

Graminous opal phytoliths also occur in loess (Fig. 2). Trichomes, fundamental cells, and bulliform cells are most commonly found in the size range 15 to 50 μ. In some specimens there is marked pitting, suggesting dissolution.

Identification of Cretaceous microfossils in loess of Illinois and Iowa, and till of Iowa is definite evidence of the transport of part of these sediments over considerable distances by a combination of ice, water, and wind. Cretaceous rocks to the northwest, possibly as far north as Manitoba, were undoubtedly the sources of these fossils. These fossils show conclusively that the ultimate origin of at least a portion of the silt-sized fraction of the loess came from Cretaceous sediments of the northern Great Plains, a concept which has been recognized by glacial geologists but lacked decisive evidence. Systematic study of abundance and distribution of these fossils may aid in loess correlation. The presence of foraminifera in some samples and their absence in others suggests differences in the *p*H of loess depositional environment and/or differential susceptibility to mechanical attrition. Where foraminiferal tests occur, the remarkably good state of preservation is indicative of the slight extent to which geologic agents have altered the very fine sand fraction.

The occurrences of phytoliths are indicative of conditions favorable to sparse grass growth during loess deposition. The continuous and abundant occurrence of phytoliths throughout the Collinsville and Burdick Branch sections (Fig. 2) is particularly striking in this

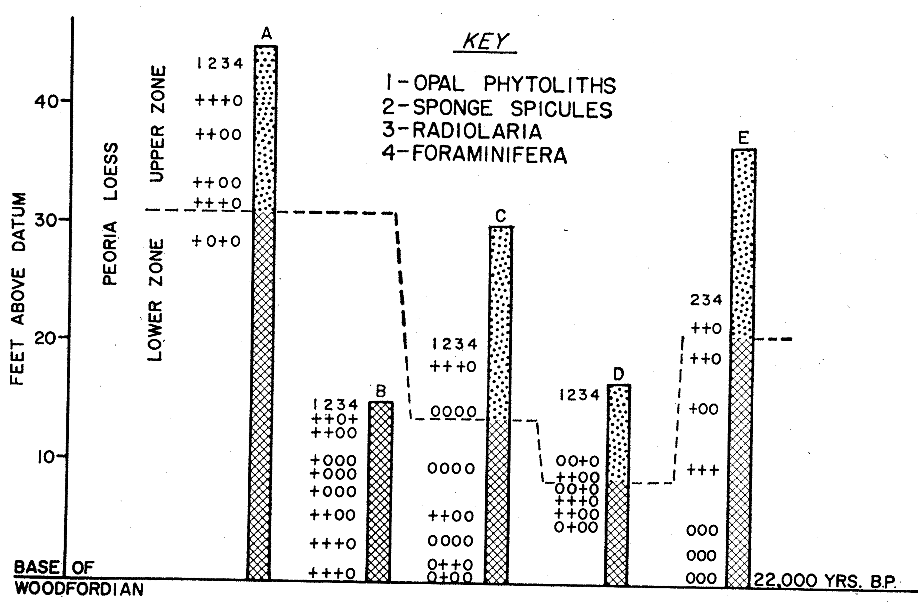

Fig. 2. Distribution of microfossils in loess sections. *A*, Collinsville; *B*, Burdick Branch; *C*, Eldred; *D*, Sepo; *E*, North Quincy. The upper zone and lower zone or main body are the correlations of Frye *et al.* (*3*).

respect, although a portion of these fossils may be derived from either Wisconsinan flora or Tertiary sedimentary rocks (for example, the Ogallala group) of the Missouri River drainage basin. Presence of sponge spicules indicates sponge occupancy of streams not directly influenced by glacial melt waters during much of the period of loess deposition (*10*).

ROBERT L. JONES
Department of Agronomy
W. W. HAY
Department of Geology
A. H. BEAVERS
Department of Agronomy,
University of Illinois, Urbana

References and Notes

1. G. D. Smith, *Illinois Univ. Agr. Expt. Sta. Bull.* **490**, 139 (1942).
2. M. M. Leighton and H. B. Willman, *J. Geol.* **50**, 599 (1950).
3. J. C. Frye, H. D. Glass, H. B. Willman, *Illinois State Geol. Surv. Circ.* **334** (1962).
4. E. J. Bolin, *J. Paleontol.* **30**, 278 (1956).
5. D. Rüst, *Can. Geol. Surv., Contr. Can. Micro-Pal.* **4**, 101 (1892).
6. A. W. Nauss, *J. Paleontol.* **21**, 329 (1947).
7. H. N. Tappan, *ibid.* **14**, 93 (1940).
8. A. L. Morrow, *ibid.* **8**, 186 (1934).
9. G. J. Loetterle, *Nebraska Geol. Surv. Bull.* **12** (1937).
10. Supported by funds from the National Science Foundation (G-16070). Published with approval of the director, Illinois Agricultural Experiment Station. We thank J. C. Frye, H. B. Willman, and H. D. Glass, Illinois State Geological Survey, for loess samples from the Collinsville, Eldred, Sepo, and North Quincy sections.

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Cognitive Factors in the Extinction of the Conditioned Eyelid Response in Humans

Abstract. *Rate of extinction of the conditioned eyelid response in humans is a function of the degree of discriminability of the procedural changes that occur with shift from acquisition to extinction. Extinction is greatly retarded when these changes are minimized or the subject is distracted by another task.*

Experimental extinction of the conditioned eyelid response in human subjects has typically been found to be extremely rapid. Thus, when extinction curves are plotted in terms of the number of previously nonreinforced trials, performance may reach its minimum (asymptotic) level in as few as six to eight trials, with many individuals ceasing to respond after the first nonreinforcement. Questioning of subjects from some of our studies has suggested that a possible factor underlying this rapid extinction might be the subject's recognition of the change in the experimental conditions with shift from acquisition to extinction. Even when not aware of the fact that their eyelids have been conditioned to respond to the conditioned stimulus (CS) most subjects appear to become aware of it when, with the onset of extinction, the unconditioned stimulus (UCS) is suddenly discontinued. Under such conditions the response decrement is probably, in part, a function of some higher order process, some kind of inhibitory set that is more or less immediately adopted by the subject upon recognition of the change. The present report is a preliminary account of a study which shows that the response decrement in extinction is much slower when the change in conditions from acquisition to extinction is reduced and, hence, is more difficult for the subject to recognize.

A number of techniques designed to reduce the difference in the conditions of acquisition and extinction have been employed in previous studies done in our laboratory. McAllister (*1*), after demonstrating that an extended CS–UCS interval of 2500 msec did not lead to conditioning, showed that a conditioned response established with a CS–UCS interval of 500 msec became extinguished when this interval was extended to 2500 msec. He found, furthermore, that extinction under this extended interval proceeded more slowly than when the UCS was discontinued. Subsequent studies (*2*), however, have shown that this relatively slower extinction under the extended CS-UCS interval holds only when the original conditioning is conducted under a partial reinforcement schedule. After 100-percent reinforcement, no difference is obtained in the rate of extinction under the extended CS-UCS interval and the condition of no UCS. Extinction is extremely rapid with both procedures.

In these earlier studies the conditioning procedure that was used involved a CS duration of 550 msec. With the shift to extinction with the extended CS-UCS interval, this duration was increased to 2550 msec. Finding that subjects readily reported noticing this change in the duration of the CS, we decided to try to reduce recognition of the change in conditions from conditioning to extinction by keeping the CS duration constant at 2550 msec for both acquisition and extinction.

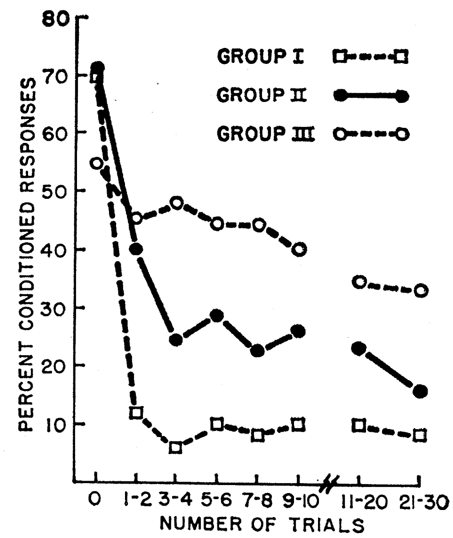

Fig. 1. Percentage of conditioned responses during extinction as a function of number of previous nonreinforced trials.

Three groups were run. In group 1 the UCS was omitted in extinction. In groups 2 and 3 the UCS was continued during extinction but at a CS-UCS interval of 2500 msec. In the case of group 3 a second learning task was introduced into the situation. It was believed that this procedure would decrease still further the likelihood that the subjects would observe the changes in the stimulus events related to extinction. Also, it was presumed that this technique would prevent the subject from recognizing that he was being conditioned.

The learning task used for this purpose was the light-guessing or probability-learning task designed by Estes and Straughan (*3*). The situation involved a centrally placed signal light which, when it came on, was a signal for the subject to anticipate within its duration (2 seconds) which of two small bulbs, one to the left and one to the right of the signal light, would subsequently light up. The subjects were given a set of instructions to the effect that the experiment was concerned with the effects of distraction on performance in a difficult problem-solving situation. They were instructed that their task was to predict which of the two small lamps was going to light up and to signify their prediction by pressing the push button located on the left or right arm of their chair. They were told further that distracting stimuli in the form of a tone and air puff to their eye would be given in between their response of pressing a button and the lighting up of one of the lamps. The