same principle applies to the water in soils. On freezing a soil, ice forms in the large pores or, in some instances, ice segregates as lenses. The exchangeable cations surrounding the soil particle are crowded in a film of unfrozen water on the surface. In this unfrozen film the conditions for electro-osmosis are satisfied; there is an excess of cations over anions near a solid surface.

The following describes our experimental method to investigate the occurrence of electro-osmosis in frozen soils. A rectangular slab of soil was frozen between two brass plates in a refrigerated room at − 30° C. Freezing a soil rapidly at low temperatures has the advantage in that little water movement occurs during freezing. The frozen slabs of soil were cut to size and placed in 'Lucite' cells (1 cm × 5 cm × 5 cm). Electrodes (1 cm × 5 cm) were frozen to the sides of the sample. A thermistor was used to record the temperature, while an electrical potential gradient of 1 V/cm was applied across the frozen soil.

Table 1. INITIAL AND FINAL WATER CONTENTS (WEIGHT OF WATER PER WEIGHT OF CLAY × 100 PER CENT) AFTER THE FROZEN SAMPLE WAS EXPOSED TO AN ELECTRICAL GRADIENT OF 1 V/CM FOR 24 H

Soil	Temperature (° C)	Initial water content	Final water content Within 1 cm from anode	Final water content Within 1 cm from cathode
Wyoming bentonite	− 2·0° C	341	275	456
	− 1·5° C	265	134	310
New Hampshire silt	− 1·5° C	30	27	32
	− 1·0° C	28	21	40

Water was transported in the frozen soil towards the cathode. The initial and final water contents (unfrozen water and ice) of two soils after electro-osmosis are presented in Table 1. Initially, the film of unfrozen water is in equilibrium with ice in the sample, but when the unfrozen water is transported from the anode regions, the film of unfrozen water is depleted. It is replenished by the melting of ice in that region. In the final state all ice is removed from the anode region and large bodies of ice are formed in the vicinity of the cathode. Shrinkage cracks form at the anode.

The experimental results show that a considerable amount of unfrozen water can be transported in frozen soil under an electrical gradient. For unfrozen soils the migration of water under electrical and temperature gradients has been related. One expects this also to be valid for frozen soils. The amount and mobility of unfrozen water are such that they can be of practical significance in redistributing moisture under temperature gradients in perennial frozen ground.

P. HOEKSTRA
E. CHAMBERLAIN

U.S. Army Cold Regions Research and
Engineering Laboratory,
Hanover, New Hampshire.

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Silcretes of Central Australia

THE widespread occurrence in central Australia of silcrete which there caps numerous mesas and forms extensive stony pavements on the dissection slopes below them has long awaited a satisfactory explanation. A recent recording[1] of the nature and disposition of certain lateritic and desertic soils, taken in conjunction with the location of major drainage divides and the pattern of endoreic streams to the Lake Eyre depression[2], throws new light on the problem and indicates the following sequence of pedologic and geomorphic events : (1) A regional development of Lateritic Red Earths occurred across what is now the watershed of eastern and northern Queensland. The lateritic weathering was accompanied by the usual loss of silica in the drainage water, one part going to the Pacific Ocean and the Gulf of Carpentaria and the other to the precursors of the present-day ephemeral and endoreic streams, the Georgina, Diamantina, Barcoo Rivers and Cooper's Creek, the courses of which then extended up to 200 miles further south-west. (2) The silica which moved south-westerly was deposited in a large array of rocks and softer deposits of widely different chronology, including variably weathered sandstones, shales and quartzites, and calcareous, gypseous, saline and alunitic formations. To-day these materials are to be found beneath the silcrete caps of the mesas, and the later group at least indicate aridity and/or restricted drainage at the time of their deposition. (3) The large, gently sloping silcrete surface so formed was disrupted and eroded following the development of the down-warped Lake Eyre basin. This depression and its compensating upwarp to the west and south caused differences in elevation of the order of 1,000 ft. with the lowest point below sea-level. This provided a new, internal, and very low base level for erosion and caused rejuvenation and down-cutting of the streams coming from the north-east and reversal of the drainage in the silcrete area to the west and south of the newly formed depression. The combination of earth movement and erosion caused the break-up of the extensive silicified surface into numerous mesas and associated larger areas of fragmented silcrete represented to-day by the pavement on the Stony Desert Tableland Soils.

There thus appears to be in Australia a continental example of absolute accumulation of silica. The distant edge of the silcrete area is about 900 miles from the original source, that is, the Lateric Red Earth tableland from which the Great Dividing Range has also since been sculptured. So far as is known, this genetic linking of the two now dismembered landscapes with once active processes of release and deposition of silica is on a uniquely large scale.

C. G. STEPHENS

C.S.I.R.O., Division of Soils,
Adelaide, South Australia.

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PSYCHOLOGY

Stereoscopic Shadow-images

THE following simple arrangement makes it possible to project, in stereoscopic depth, three-dimensional objects such as wire models of molecular or crystal structures. Small models may be presented enlarged in three dimensions, magnifications of ten or more times being possible. The optical arrangement consists of nothing but a pair of small bright light sources, separated horizontally by a few inches. The sources are placed behind 'Polaroid filters', set at orientations differing by 90°. The point polarized sources give a pair of shadow images of an object, such as a wire model, placed between them and a silver screen. Alternatively, back-projection with a ground-glass screen can be used; but the screen must not de-polarize the light. When the shadows are viewed through crossed 'Polaroid' glasses, they are fused by the brain to form a single stereoscopic shadow-image lying in space.

There is no problem in explaining this effect. The point sources cast shadows on the screen which are flat projections from slightly different positions. The shadows have the disparity of retinal images for eyes placed at the sources. The observer's brain fuses the two disparate shadows into a single stereoscopic shadow, looking incredibly like a real, but jet black, object. It lies in space either in front of or behind the screen, depending on which eye accepts which shadow. By using polaroids oriented at 45° from horizontal, the stereo shadow-image may be placed before or behind the screen simply by reversing the spectacles.

Suitable light sources are miniature filament, 12-V, 100-W tungsten-iodine lamps. The filaments should be oriented vertically, to give maximum horizontal resolution, which is important for giving maximum information of depth through disparity.

Magnification of the normal x- and y-axes is given simply by the ratio of the distance of the object from the lights to the object from the screen. Magnification in depth (z-axis) can be controlled by the horizontal separation of the lamps. In practice a magnification of at least times 10 may be given; but the apparent size of the three-dimensional shadow-image is generally less than might be expected, because of perceptual size constancy.

When the object appears to be in space before the screen it looks smaller than when behind it, though the physical size is of course identical with either orientation of the polaroids. A further perceptual effect is most marked: when the observer moves his head, the stereo shadow-image appears to move with him, to slide across the screen, and rotate to follow the observer as though continuously aimed at him. This is because there is no motion parallax although the image lies perceptually in three dimensions: this corresponds to a normal object rotating to keep the same aspect to the observer though he moves. So he sees movement though his retinal images remain unchanged. When the observer moves away from the screen, the shadow-object does not shrink or lose its depth as might be expected; the reduced angle of convergence of the eyes evidently re-scales the retinal disparity mechanism, so that a given disparity between the retinal images gives greater visual depth. This is indeed fortunate, for the shadow-image appears very similar over a wide range of distance, and so it can be used with effect in a large lecture hall for demonstrating suitable objects. They may be moved or touched by the demonstrator, which makes this a technique having advantages over photographic stereo projection. It is also a useful tool for investigating perception of depth while the observer is moving, and can form the basis of simulators for experiments on the guiding of aircraft and space vehicles.

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R. L. Gregory

Psychological Laboratory,
University of Cambridge.

Retroactive Interference in Short-term Memory

In investigating short-term memory (a term generally used to cover the period of from one to sixty seconds) an important question is whether or not retention is influenced by factors known to be important in long-term memory. One such factor is retroactive interference. Broadbent[1] has asserted that retention depends on the duration of the delay rather than the nature of any activity during the delay. But he rests his case on evidence that retention is impaired by increasing the delay while keeping the activity as constant as possible. Direct evidence that variation of the intervening activity is ineffective has been lacking, but Baddeley and Dale[2] have shown that in minimal paired-associate learning[3] meaningful similarity fails to affect performance significantly, and this supports Broadbent's contention.

Recently Wickelgren[4] has produced evidence suggesting that acoustic similarity does affect retroactive interference in short-term memory. His technique was to present rapidly (2/sec rate) four letters which had to be remembered, then eight which were to be copied down. Immediately the eight had been copied the subjects had to write out the first four from memory. The crucial variable was the similarity of the eight letters which had to be copied to the four which were being remembered. The letters used were taken from two groups *F L M H S X* and *B C D G P T V* (*Z*). Conrad[5] has shown that within each group acoustic confusions are common, whereas between the groups they are rare. (*Z* does not confuse with *B C*, etc., in English; but with its American pronunciation it is obviously similar to the others and Wickelgren added it.) Wickelgren's results indicate that when the letters to be copied came from the same group as those being remembered, memory was poorer than when they came from the other group. They are not clear-cut, however, since he had to introduce repetition. To illustrate this: if *B C D G* were to be remembered and similar letters had to be copied, the only four letters available were *P T V Z*, so subjects were required to write each twice. With the '*F*' sub-group the problem was even more acute since there were only two spare letters.

The experiment reported here was carried out in order to confirm Wickelgren's findings. To avoid the problems already outlined here the subjects were given three letters to remember and six to copy down. The six always consisted of three different letters each repeated once. For this experiment the '*B*' group was pruned to *B C D G P V*. Forty trials were run, 10 with '*F*' letters to be remembered and '*F*' letters copied; 10 with '*F*' letters to be remembered and '*B*' letters copied; 10 with '*B*' letters to be remembered and '*F*' letters copied; and 10 with '*B*' to be remembered and '*B*' copied. Two series of trials were used. The first was prepared by randomizing the order of the 40 trials. The second was derived from the first by keeping the messages to be remembered constant and altering the messages to be copied, so changing *F–F* to *F–B*, *F–B* to *F–F* and so on. Any influence of order of presentation was in this way controlled. All items were read out by the experimenter in time with a metronome beating at a 2/sec rate. A pause of one beat separated the memory message from the copy message. Ten seconds separated the end of one copy message from the beginning of the next memory message. Subjects were tested in two groups of 17. They wrote out all messages on a specially prepared form. An invigilator checked that they put down the copy message before the memory one.

Performance was scored by counting the number of letters in each memory message which were correctly recalled in both substance and position. The results showed a mean score of 59·4 per cent when the copied message came from a different group of letters to the memory message but only 38·7 per cent when the copied message came from the same group. The individual records of 31 of the 34 showed this effect; its statistical significance is, therefore, extremely high ($P < 0{\cdot}001$). Thus Wickelgren's observation is confirmed and we must conclude that the principle of retroactive interference does apply to short-term memory. The form of the similarity which affects performance, however, would seem to differ from that which influences interference in long-term memory. Meaningful similarity is unimportant over these short periods, but similar-sounding items cause interference. Presumably the basis of coding for normal verbal learning with repeated presentations and with opportunity for rehearsal differs from that used for short-term storage following a single presentation.

H. C. A. Dale

Applied Psychology Research Unit,
Medical Research Council,
15 Chaucer Road,
Cambridge.

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