Reports

Source and Deposition of Clay Minerals in Peorian Loess

Loess is one of the most remarkable of the Pleistocene deposits. It is associated with and covers to varying depths and extent most of the major sheets of glacial drift. The origin of loess, however, has been debated. Scheidig (*1*) lists some 20 hypotheses that have been advanced at one time or another to explain its presence and distribution. Chamberlain (*2*) has advanced the most widely accepted theory to explain the origin of loess in the upper Mississippi Valley. He considered the loess as a wind deposit emanating from the flood plains of the major Pleistocene rivers. His concept was that proloess materials were deposited from glacial melt waters on the flood plains of the rivers. After drying, these materials were picked up by strong winds and redeposited as loess on the adjacent uplands.

Chamberlain's theory implies that the mineralogy of the unaltered loess and that of the associated unaltered tills should be similar, including the clay minerals. Studies of clay minerals (*3–5*), however, have shown that the principal type of clay in calcareous Peorian loess in Illinois, Kansas, Nebraska, Iowa, and Missouri is montmorillonite, whereas, illite and some chlorite are the principal clay minerals in tills of Wisconsin age over a broad area (*3, 6, 7*). Some explanations given to account for this difference in mineralogy follow: (i) the montmorillonite clay now found in Peorian loess resulted from weathering of the illite and chlorite in the calcareous material after deposition; (ii) the clay and silt minerals of Wisconsin age weathered to form montmorillonite before and/or during transport; and (iii) the montmorillonite was differentially picked up by the silt particles from the river flood plains, thus concentrating this type of clay in Peorian loess.

On the basis of studies of clay mineral in soils developed entirely from tills of Wisconsin age, explanations i and ii above were considered unlikely. For instance, Beavers *et al.* (*3*) found that only small amounts of montmorillonite (maximum 10 percent) had formed in soils developed from Tazewell and Cary age tills and that no montmorillonite had formed in calcareous tills of the same age. Similar results were found by Bidwell and Page (*6*). Explanation iii cannot be ruled out, although I believe that the bulk of the sediments carried by the Illinois and Wabash rivers during the time of deposition of Peorian loess were of Wisconsin age and that illite was the principal clay mineral in the sediments. The influence of local flood-plain clay sediments is indicated by the tendency of illite clay to concentrate in calcareous Peorian loess in Illinois (5 to 20 percent) near the major rivers (*3, 5*).

I postulate that the bulk of the clay minerals in Peorian loess did not come from local flood plains but that these minerals were carried in by strong winds from widely scattered sources throughout the central United States. The problem is essentially one of deposition of the fine clay. I suggest the following as a possible mechanism that may account for the deposition of fine clays carried from afar, along with local flood plain silts. The air-borne clay minerals were electrostatically attracted and adsorbed onto the larger silt-sized particles that were blown from local flood plains, and then the clays and silts were deposited together.

Charge spectrometer studies of quartz and standard clay minerals, as well as of clays and silts from Peorian loess, show that these materials have a tendency to take on strong electrostatic charges (*5*). It is well established that dust storms are highly electrified, the friction of the particles providing a source of electricity. Boning (*8*) advanced the theory that a part of the charge developed in dust clouds was the result of friction between particles of different sizes. That particles of silt and clay minerals have different electrostatic charges is suggested not only by the fact that the two kinds of particles are different in size but also by the fact that their crystalline structure and dielectric properties are different.

Dallavalle (*9*) states: "Fine dust particles may be swept upward by turbulent wind and kept in motion by it so that the effect of gravity is nullified." Even today, Illinois receives clay from western storms that occasionally cause the sun to appear hazy. When these fine air-borne clays are brought down by snow or rain, they fall in sufficient concentrations to cover clean surfaces with buff-colored clay particles. We also know that fine clay-size material from bomb blasts and volcanoes is carried long distances by wind, even across continents and oceans.

A unique property of loess is its unstratified nature. Thin sections of Peorian loess adjacent to the Wabash, Mississippi, and Illinois rivers show that the materials possess a fine porous fabric with the larger silt-sized grains connected with intergranular braces of a light ocher color consisting of very fine silt with clay minerals evenly disseminated throughout. A homogeneous and unstratified deposit would not be expected to result from the normal settling of silts and clays. Here again it appears that some mechanism other than the normal settling forces was operative and that the silt and clay did not settle independently.

The electrostatic adsorption and deposition of fine clay by local flood plain silts could explain the distribution of the montmorillonitic type of clay throughout the Peorian loess area as well as the unstratified nature of the loess deposit.

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References and Notes

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Artifact in Spectrophotometry Caused by Fluorescence

Recent publications (*1*) have called attention to the possible occurrence of artifacts in difference spectra. These false readings, which generally appear as

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distorted curves with lowered extinctions, were found to occur when readings were made in the presence of backgrounds of high optical density in spectrophotometers which contain single monochromators and which are equipped with sensitive photodetector units. The explanation offered is that, under such conditions, the inherent stray light represents a major portion of the emergent total light (*2*). In attempts to eliminate such errors, recourse was made to a double-monochromator instrument that produces light of greater optical purity.

We should like to report another cause of distorted spectra which occurs in the low ultraviolet region even with double-monochromator spectrophotometers. An example of this type of distortion is illustrated in Fig. 1. Curve *A* is the absorption spectrum of 5×10^{-5} *M* fumarate. Curves *B* and *C* were obtained with the same concentration of fumarate in the presence of 0.4 mg and 2 mg of albumin per milliliter, respectively, read against reference cuvettes containing the same concentration of protein. These curves demonstrate the supression of the fumarate absorption in the region of high background density. The background densities at which distortions occur can be estimated from absorption curves of dilute solutions of protein. Serum albumin at a concentration of 0.1 mg/ml with a 1-cm light path has an optical density of approximately 0.11 at 280 mμ; at 250 mμ there is a minimum density of about 0.05, and at lower wavelengths the density increases rapidly, having a value of 0.2 at 240 mμ, 1.1 at 230 mμ, and 2.0 at 220 mμ. The apparent decreases in optical density at lower wavelengths in curves *B* and *C* of Fig. 1 show the presence of light which is not absorbed by fumarate and which becomes a major component of the emergent light when the background density reaches about 3.

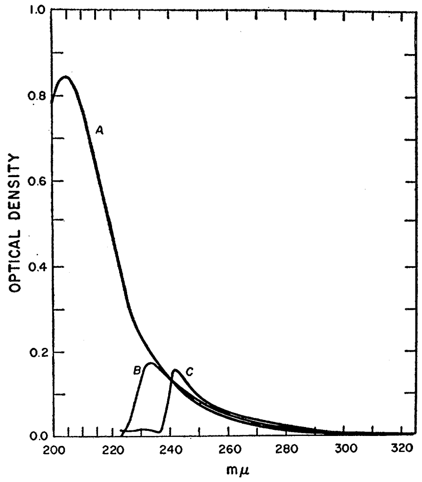

Fig. 1. Effect of protein on the absorption curve of fumarate. Curve *A*, absorption spectrum of $5 \times 10^{-5} M$ fumarate, *p*H 7.4, measured in a model 14 Cary recording spectrophotometer. Curves *B* and *C* are the apparent absorption curves of $5 \times 10^{-5} M$ fumarate in the presence of 0.4 and 2.0 mg of serum albumin per milliliter, respectively.

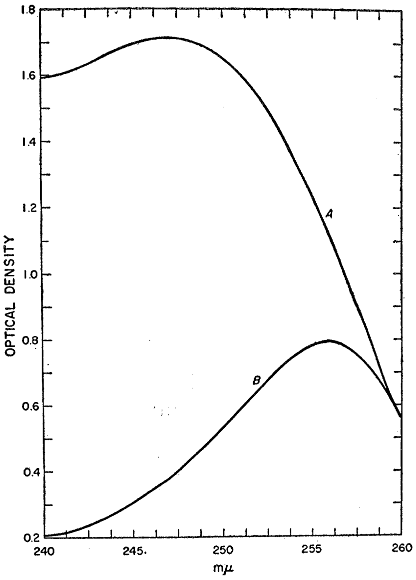

Fig. 2. Fluorescence of silica cuvettes. Five thicknesses of lens paper were placed in the reference beam of a Cary recording spectrophotometer, and the apparent absorption spectrum of a Corning filter No. 7740 was recorded (curve *A*). Curve *B* was then obtained by interposing a silica cuvette between the monochromator and the filter. Placing the cuvette between the filter and the photomultiplier tube did not alter curve *A*.

The amount of unselected light reaching the photodetector is far greater than is to be expected from the stray light component of the double monochromator. That this unselected light is caused by fluorescence is demonstrated in Fig. 2. A neutral filter, lens paper, was placed in the reference compartment of the spectrophotometer to simulate a high optical density (approximately 4), and a Pyrex filter was placed in the other compartment. The apparent Pyrex spectrum was recorded (Fig. 2, curve *A*); this curve indicates practically total absorption below 250 mμ. Curve *B* was then obtained by inserting a silica cuvette between the light source and the Pyrex filter. It is apparent that the exciting light has been partially converted by the cuvette to light of a wavelength which penetrates the Pyrex filter. Essentially the same increase in transmission was found when a cuvette containing a high concentration of protein, which absorbs essentially all of the incident light, was interposed between the monochromator and the Pyrex filter. The fluorescent light in this case is produced predominantly by the protein. Protein fluorescence can be demonstrated with cuvettes made of Corning fused silica; these cuvettes yield only traces of fluorescent light when they are irradiated at wavelengths of 240 mμ or higher; when protein is added to such a cell, a large amount of emergent light is found to pass through a Pyrex filter.

The fluorescence of cuvettes in ordinary use is sufficient to cause significant errors in extinctions at wavelengths below 260 mμ in the presence of high background densities. Theoretically, such errors can be avoided in either of two ways: by using nonfluorescing cuvettes or by filtering the emergent beam. In biological experimentation the first alternative is often not adequate, for the background materials frequently used (for example, protein) exhibit high absorbance and fluorescence.

When the samples themselves generate large amounts of fluorescence, the use of monochromators free from stray light does not eliminate artifacts. A second monochromator, when placed between the cell and the photodetector, would serve to eliminate stray light present in the incident beam and, in addition, fluorescence generated in the cuvette. By this device errors due to fluorescence in double monochromators could also be reduced.

Note added in proof: Since submission of this communication, an article by M. V. Buell and R. E. Hansen has appeared (*3*) describing a spectrophotometer using a "solar blind" photomultiplier tube, which does not respond to wavelengths greater than 280 mμ. This device should eliminate artifacts of the type described above except in cases in which light below 280 mμ is emitted by the samples.

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References and Notes

1. A. H. Mehler, *Science* 120, 1043 (1954); I. Fridovich *et al., ibid.* 125, 1141 (1957).
2. The effect of stray light usually encountered is to minimize extinctions, for the materials investigated absorb the selected wavelengths but not the stray light. However, if the absorption spectrum of a compound is low in a selected region of the spectrum and high in the region of stray light, false peaks will be produced when the spectrum is measured over a high background density. This phenomenon has been demonstrated with the enzymatic oxidation product of 3-hydroxyanthranilate, which has a large, broad absorption with a maximum at 360 mμ. In the presence of protein, additional absorption appears in the regions of protein absorption.
3. M. V. Buell and R. E. Hansen, *Science* 126, 842 (1957).

4 September 1957