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This report will describe a simple, rapid, and easily accomplished technique for examining lithologic characters of sedimentary rocks and the internal structures of various fossils, as well as the means by which microphotographic records of rock textures and fossils structures can be made. This technique consists of making so-called dry acetate peels, which are impressions of polished and slightly etched rock or fossil surfaces produced by pressing a prepared specimen against a sheet of clear cellulose or frosted acetate after the specimen has been wetted in acetone. When examined by transmitted light, a properly made acetate impression (peel) has the qualities of an expertly cut thin section (except that optical properties discernible by polarized light are not shown by the peel). However, minute textural distinctions are faithfully recorded; these include such features as the laminated or prismatic structure of shells and marks of cleavage planes in minerals.

There is no limitation to the size of the rock surface which may be recorded by an acetate peel, at least within reason. Ordinary thin sections have areal dimensions measured in millimeters, whereas acetate peels having areas of several square inches are made easily.

The facility with which features contained in acetate peels may be recorded photographically should be emphasized because photographs are most easily used for analytical study, for marking features thought to have special significance, and for making comparisons of different peels.

Recent publications (Cuvillier & Sacal, 1951, 1956; Cuvillier, 1952) have indicated the great usefulness of textural features, including nature of fossil remains in various sedimentary rocks, as a basis for correlation of strata and interpretation of sedimentary environments. Acetate peels are especially well adapted to microlithologic studies because they are capable of being made so very easily and quickly. Also, with minimum effort they supply definitive information on the composition (including organic content) and textural nature (including shape and distribution of pore spaces) of rock samples collected in the field and obtained from well cores.

Some limitations are: the absence in peels of characters showing the optical properties of mineral grains. The application of staining techniques allows identification of aragonite, calcite, and dolomite occurring in rocks represented by peel sections.

The fact that acetate peels can be employed like negatives on film for the making of microphotographs adds to their value for purposes of studies of microlithology. It is true that thin sections of rocks can be used similarly for making photographs by projection onto bromide paper; therefore, adaptation for photography is not restricted to peels. If a low-power projection is wanted or rock-texture features observed in a section measuring, say, 3 X 4 or 4 X 5 inches, such a photograph can readily be obtained from a peel, whereas most thin sections of rocks have dimensions of less than a square inch; therefore, an advantage of peels is their larger size.

Peels are specially suited for paleontological studies that require investigation of internal structures (as in the case of most bryozoans,

sponges, stromatoporoids, milleporids, corals, larger foraminifers, calcareous algae, many brachiopods, and other fossils) and determination of microstructural characters of the hard parts themselves. Peels can be prepared much more quickly than thin sections and only an inconsiderable fraction of a fossil is destroyed in sawing a single section through it--most of the specimen is still at hand, permitting comparison of its gross morphological characters with structures revealed by the peel. For determination of internal structure of almost any fossil by the method of serial parallel sections, the use of acetate peels excels, not only because of economy in time and ease of manipulation but because no limit is imposed on closeness of spacing of the serial sections. This is important in the study of small fossils, such as ostracodes and foraminifers, etc.

Notes on preparation of acetate peels from Raymond C. Moore

Five items are required for making a dry acetate peel: (1) means for producing a plane smooth surface on the rock or fossil in the desired place; (2) acid; (3) acetone; (4) a shallow dish or tray, preferably flat-bottomed; and (5) a sheet of acetate, either clear or with a frosted surface.

Preparation of the specimen (rock or fossil) calls for sawing in order to obtain a cut in desired position and to minimize grinding. Ordinarily it is preferable to cut sedimentary rocks in a plane perpendicular to bedding and to record up-and-down directions. This can easily be done when samples are collected in the field. It is necessary to obtain a very smooth near-polished plane surface, for scratches which would be unnoticed in a rock thin section mounted in balsam produce evident blemishes in an acetate peel.

Etching of the smoothed surface of the specimens is undertaken in order to produce microscopic relief reflecting features of rock structure, for when attacked by acid, mineral grains and parts of fossils are dissolved differentially. Weak hydrochloric acid (5 to 10 per cent) is effective for treatment of limestones, but acetic or formic acid may be used instead. Stronger acid and longer etching time are desirable for treatment of dolomitic rocks. Siliceous silts and sandstones can be etched by spreading CaF_2 or NaF_2 mixed with half-and-half acetic and sulphuric acid in proportions to form a creamy paste. A very short time is needed for etching of most carbonate rocks (5 to 30 seconds) but ranges from one to several hours for treatment of highly siliceous rocks. Acid etching of specimens is followed, of course, by brief washing and then drying.

After the rock or fossil surface has been prepared only a few minutes are needed for making an acetate peel. A rectangular shape piece of acetate sheet is cut with dimensions somewhat larger than the surface of the prepared rock specimen and this is placed on a smooth table or piece of plate glass. The thickness of acetate chosen for making peels may range from about 0.05 mm. to 0.5 mm. or even more and no perceptible difference in the quality of impressions is observed. Pieces of a relatively thick acetate sheet resist curling and wrinkling but, being stiff, tend to retain undesirable curvature and are not suitable for mounting under a thin cover glass. An intermediate thickness (0.1 to 0.2 mm.) seems preferable. It is desirable to fasten the acetate down with masking tape to hold it flat. Assigned number and other identification data may be written with wax or graphite pencil along a margin of the acetate sheet.

The smoothed, slightly etched rock surface is immersed in a small quantity of acetone poured into a flat-bottomed dish. The specimen is quickly lifted out of the dish and pressed down firmly on the acetate sheet. A small quantity of acetone (approximately 1 cc.) may be put centrally on the acetate just before the prepared specimen is pressed down, effort being made to expel any air bubbles. All that remains to be done is to allow 2 or 3 minutes before removing the specimen and examining the impression (peel) which has been made in the acetate. Ordinarily the peel can be lifted easily by gently pulling with the fingers. A razor is not needed and its use is avoided.

Probably the first efforts to make peels will be marred by the presence of air bubbles, but a little practice serves to avoid most of this trouble. If a peel is defective and unsatisfactory, it can be thrown away. The prepared

surface of the specimen does not need to be treated again before wetting in acetone and being pressed against another piece of acetate.

When a satisfactory peel has been made, although it has a tendency to bend or curl, it may be examined like a thin section under a lens or with a microscope using transmitted light. It is best to mount the peel between lantern slide glasses, the ordinary 3¼ by 4¼ being satisfactory for most larger peels or 2 X 2 slide glasses for smaller ones; this serves to keep the acetate flat. Mounting the peel between two lantern slide glasses is unsuitable if features of peels are to be studied under a microscope using a 32-mm or higher-power objective because the objective lens cannot be focussed on the peel; a thin cover glass is required. Cover glasses are available with dimensions of 43 X 50 mm., suitable for use with 40 X 50 mm. (2 X 2 in.) lantern slide glasses, and 50 X 75 mm. cover glasses suitable for use with 3¼ by 4¼ lantern slide glasses. The peels may be mounted with narrow strips of Canada balsam or Lakeside 70 cement along borders of the cover glass and outside the area of the peel, the cover glass being pressed down tightly under lead weights for a time after mounting; care is needed because if the peel is embedded in balsam, relief features of the peel disappear. Very thin acetate peels can be mounted in this way satisfactorily and can be observed at high magnifications.

One of the interesting and important aspects of work with acetate peels is the use of peels in conjunction with rock staining, for experiment shows that stains produced on rock sections are transferable to the peels. A rock consisting partly of calcite and partly of dolomite, after differential staining for the purpose of distinguishing these minerals, yields a peel that retains the introduced color distinctions and that provides a photograph in which areas of calcite are readily separated from areas of dolomite. Use of selective stains such as malachite green and alazarine for the purpose of bringing out differences of calcareous rock matrix and structures of organically secreted calcite in fossils has been described (Henbest, 1931) and used with satisfactory results in some paleontological studies, but it has not yet been tested in connection with preparation of acetate peels.

Photographs of peels furnish the best means for comparing characters shown by different peels and for making notations concerning any desired features which are observed; they are ideal for conveying information accurately from one geologist to others. Photography of peels is recommended as routine procedure.

The simplest procedure for photographing acetate peels is to place the peel in a photographic enlarger (preferably the type which can handle negatives 4 by 5 inches or larger). The peel is used as a substitute for a negative film, light being passed through it so as to project a clear image on bromidepaper. The range of magnification obtainable is about X1.5 to X20 although greater enlargement is possible by increasing the distance between lens and paper or by using special lens equipment. Contact prints cannot be made satisfactorily from acetate peels.

When the peel is used as a negative, clear spaces (representing cavities on the rock surface or air bubbles in the acetone) appear as black areas, nearly transparent and highly translucent parts of the peel are recorded by dark gray tones, and most opaque tracts are registered as very light gray to white parts of the photograph. In short, the image is reversed. It is possible to project a peel onto sensitized film instead of photographic paper and then use the film as a negative in place of the peel. This two-step procedure will produce a photograph with clear areas appearing white and dense areas very dark. The two-step prodedure will will permit much greater magnification; a X10 enlargement of the peel on film and another X10 enlargement from the film in printing on bromide paper will produce a photograph with X100 magnification.

The preservation of peels is a simple matter, the most convenient method being to place the peel between two lantern slide cover glasses which can be bound together with tape after the sheets of glass have been pressed firmly together so as to hold the peel flat. Such mounted peels can be numbered, labeled, and filed according to any desired scheme; they may be kept indefinitely.

Photographs of peels are valuable for several types of petrologic analysis. Some of the features which are shown to advantage include: (1) mean size and shape of grains; (2) nature of the dominant and accessory rock constituents, whether clearly zoogenic, phytogenic, or probably inorganic; (3) indication of grain abrasion or evident lack of wear; (4) degree of sorting; (5) orientation of tabular or other special-shape constituents; (6) presence of secondary filling between grains; (7) inter-

penetration of grains, if present; (8) nature and distribution of pore spaces or cavities, with signs of their probable mode of origin; and (9) commonly various special sorts of diagnostic characters. Observation and interpretation of all such features generally furnish a reliable basis for conclusions as to the geological setting in which the studied rock was formed--in shallow current-moved waters, in a very quiet-water environment, adjacent to a reef mass, within a bioherm, etc. No one rock specimen or peel is adequate for reliable stratigraphic interpretation, but studies of a well-selected suite of specimens may provide definitive conclusions.

Wherever sedimentary rocks are found to differ perceptibly in textural features or organic content, or both, and wherever these differences persist laterally for appreciable distances, acetate peels made from selected rock samples are likely to be very helpful in establishing accurate correlations.

In paleontological studies acetate peels can be extremely useful. One advantage of peels as a means of exploring the internal structure of fossils is the fact that only a single cut through the specimen is needed and the severed parts of the fossil can be saved, whereas in making thin sections of small fossils, all or most of the specimen (except the thin section itself) is destroyed. Studies of some fossils requires or is facilitated by making serial sections. These consist of parallel sections at closely spaced intervals. When record is made of the distances between successive sections, structures shown by them can be reconstructed accurately in three dimensions. Thin sections are not suited to study of this sort because they cannot be cut at sufficiently close spacing in most fossils

and it is almost impossible to determine their exact position accurately. The common method, therefore, is to grind a specimen a measured depth below the surface and then to record observed structures by means of a camera lucida; next, the specimen is ground a given distance (as 0.5 mm.) further and another camera lucida drawing made; by repeating these operations a series of sections at determined positions is obtained. Special apparatus for precise control of serial sectioning has been devised (Croft, 1953) and found to be advantageous but it is not required. Acetate peels are ideal ly suited for work of this sort, being substituted for the camera lucida drawings. Photographic enlargements of the peels may be made at a selected uniform scale and if it is desirable to construct a three-dimensional model, tracings on drawing acetate or glass can be prepared and mounted in proper relations to each other. Also, very accurate drawings can be made by marking with waterproof ink on the photographs and then bleaching out the photographic image.

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