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CARBONATE PETROGRAPHY OF MIDDLE AND UPPER ORDOVICIAN ROCKS IN THE CENTRAL BASIN OF TENNESSEE

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ABSTRACT

The purpose of this paper is to characterize the carbonate petrography of various Middle and Upper Ordovician formations in the Central Basin of Tennessee.

About 250 hand samples from three formations at three different locations were collected for the study. Examination by acetate peels was found to be satisfactory except to determine optical properties. It was necessary to use X-ray methods to obtain optical data. By these means sets of characteristics for the Bigby-Cannon Limestone, the Catheys Formation, and the Leipers Formation have been established. Certain rock types common to all three formations are recognized, described and photographed for future reference. Some minor reinterpretations of the geologic history of these three formations are proposed for consideration.

INTRODUCTION

The results of the carbonate petrography of the Bigby-Cannon Limestone, the Catheys Formation and the Leipers Formation are presented here. These formations present many lithostratigraphic problems because they are so similar in appearance on outcrop. Three outcrop sections were studied, two (D1 and D4) in Davidson County 5.5 miles apart and one (P1) in Putnam County 65 miles to the east. The Bigby-Cannon Limestone crops out at sections D1 and P1, the Catheys at D1 and P1, and the Leipers at D4 and P1. Section D1 is 88.23 feet thick and is represented by 78 hand samples. Section D4 is 41.11 feet thick and is represented by 31 hand samples. Section P1 is 319.28 feet thick and is represented by 126 hand samples. Due to time limitations, only these three sections were sampled, but the work is being continued by N. K. Moore and Dr. L. P. Alberstadt of Vanderbilt University.

Outcrop sections were selected based upon completeness of formational exposure and carefully measured. Second, an oriented hand sample was taken on the average of every 12 to 18 inches of outcrop or wherever a change in lithology occurred. Third, each hand sample was slabbed, polished, varnished, etched, and an acetate peel taken of the etched surface. The lithostratigraphy was described from the nearly 250 acetate peels. Acetate peels are ideal for the study of carbonate rocks in that a perfect imprint of the etched surface is made, and in that their transparency permits microscopic and photographic examination. They cannot be used for optical mineralogy however, and must be supplemented by spot chemical tests and X-ray determinations. They are easy to prepare—a real advantage. For each peel the size and character of fossil material, calcite, dolomite, and non-carbonate detritus were described. Photographs were made of many of the peels to show characteristic rock types.

In addition each sample was fitted into a simple classification of carbonate rocks derived from the classification of Folk (1959). This classification was designed to be used both in the field and in laboratory examinations to simplify description of measured sections for litho- and biostratigraphic work.

Bigby-Cannon Limestone

The Bigby-Cannon Limestone was defined by Wilson (1949) as two intertonguing facies, one the Bigby-Cannon Limestone facies and the other the Cannon Limestone facies. The Bigby is the western facies and the Cannon the eastern. In addition there is a third facies, the Dove-colored facies, that occurs as discontinuous lentils throughout the eastern half of the formation. "The Bigby-facies is blue-gray in color when fresh, usually weathering to a brownish-gray. . . . This facies is commonly massive-bedded, but the horizontal bedding planes are often difficult to distinguish because of prevalence of irregular oblique planes and more regular cross-bedding planes. The horizontal bedding planes separate strata that average between 1 and 3 feet in thickness. The texture is coarse granular, being composed of ground fragments of bryozoa, brachiopods, etc., and crystalline grains of calcite that are about the same size as the organic fragments." (Wilson, 1949, p. 115.)

"The typical Cannon facies is a uniformly bedded fine- to medium-grained blue limestone occurring in strata that range up to several feet in thickness but averaging about one foot. . . . The Cannon facies is moderately free from silt. The silt that is present occurs as thin partings. . . . Chert may be a common feature in the upper 20 to 30 feet of the Cannon facies, as it was on both the Bigby and Dove-colored facies." (Wilson, 1949, pp. 126-127.)

The Dove-colored facies is light gray weathering to white. It is usually a very pure limestone, but where clayey impurities are disseminated weathering results in yellow to buff discoloration. . . . Bedding varies from an inch to several feet, but averages about one foot. Bedding is uniform, and although the limestone is usually pure, thin partings of silt and clay are often interbedded. The limestone is very fine-grained, dense, and brittle, breaking with a characteristic conchoidal fracture. . . . A common feature is the occurrence of specks and vertical stringers of clear calcite resembling the "birdseye" limestone as described in New York. . . ." (Wilson, 1949, p. 122.)

Three main rock types were found in the Bigby-Cannon Limestone. The Bigby is a coarsely crystalline, brownish-gray (5YR4/1) limestone, unevenly bedded (sometimes crossbedded, phosphatic and higly fossiliferous. It was found only at the D1 section. Beds range from 2 to 13 inches in thickness. Many fossils are silicified with large bryozoans and brachiopods the most conspicuous. Acetate peels indicated that recrystallization is common. The rocks are generally faintly lami--nated, with fragmented fossils of algae, "pellets?", ostracodes and pelmatazoans. Internal structure of the fossils is well preserved. The laminations are caused by the concentration and alignment of the "pellets?", that are stained brown and are probable phosphatized fossil fragments. They range in size from .175 to .525mm and are ovoid. The origin of the "pellets?" is unknown, but it is probably metasomatic replacement of bryozoan pore fillings and other fossil fragments. In this study the Bigby rocks are recognized to be clean, phospatic biosparites, primarily faintly laminated and either well or poorly sorted.

The Cannon type is a dense, finely-crystalline limestone, nodular and evenly bedded, with beds 2 to 4 inches thick and medium gray (N5) in color. The rock types represented are silty biomicrosparites, well to poorly sorted. Some parts of the units are brownish gray (5YR4/1) in color and phosphatic. Chert nodules are common in the lowest 30 feet of the P1 Section. The percentage of detritus increases upwards, due in part to shaly partings. Acetate peels exhibit a normal matrix of micrite to microspar with algae, ostracodes, and pelmatazoan plates. The larger fossils are algae, brachiopods, and bryozoans. Generally, recrystallization has destroyed the internal structure of the fossils. A high silt content appears to obscure the registration of fossil fragments on acetate peels of these strata. The silty texture probably reflects both insoluble and silt-sized carbonate material. Insoluble residues of the Cannon facies determined by N. K. Moore (personal communcation) at the type section average approximately 3 percent by weight; the Bigby averages about 5 percent by weight at the D1 section. This rock type occurs only at the P1 section.

The Dove-colored rock type is a dense, clean, cryptocrystalline limestone, evenly bedded, about 3 to 8 inches thick, with "stringers" and "eyes" of sparry calcite and is very light gray (N7) in color. This rock type was found only at the P1 section. Folk (1959) refers to this rock type as a dismicrite.

Catheys Formation

The Catheys Formation is divided by Wilson (1949) into six major facies: the Shaly facies, Laminated Siltstone facies, Pale-colored facies, Granular facies, Clayey Dove-colored and Nodular facies. These facies are not geographically restricted in the Basin, nor are they restricted to any particular horizon. However, the Shaly facies is generally at the base of the formation in the western part of the Basin, and the Laminated Siltstone facies is observed or occurs at the base in the eastern Central Basin. The Nodular facies is considered to be the "typical" Catheys facies. Where the *Constellaria* beds form the base of the formation, the strata are of the Shaly facies. The Granular facies is similar to the Bigby facies, the Clayey Dove-colored facies is similar to the Dove colored facies of the Bigby-Cannon Limestone. These facies are similar to the Dove-colored facies of the Bigby-Cannon Limestone, and are randomly interbedded and intertongued as far as is now known. Wilson (1949, p. 156) attributes the range in thickness of the Cathey's (from 65 feet in the west to 175 feet in the east) to pre-Leipers erosion.

Three main rock types were observed in the Catheys Formation. The silty, nodular, shaly limestone rock type is found at Section D1 and at section P1. Beds are 2 to 4 inches in thickness, with many 2 to 4 inch shale partings. The rocks are medium to coarse crystalline and medium gray (N5) in color and fossiliferous. This rock type is not comparable to any of the Bigby-Cannon Limestone rock types seen. Acetate peels show that the common fossils are large brachiopods, bryozoans, and corals, with numerous smaller ostracodes, algae and pelmatazoan plates. Sorting is moderate to poor. The coarser rocks are silty biosparies, and the medium crystalline rocks are silty biomicrosparites. Silt is mostly concentrated in patches, but some beds have silt disseminated throughout. Dolomitization is common and sometimes is accompanied by recrystallization.

The coarsely crystalline, phosphatic rock type occurs at sections D1 and P1. This second rock type has massive and uneven bedding, ranging from 2 inches to 2 feet in thickness with some shale partings. The color is brownish gray (5YR4/1) and fossils are abundant. The Bigby facies is similar to this phosphatic rock type of the Catheys, but the Catheys rocks generally have more non-carbonate detritus and less phosphatic "pellets?". As in the Bigby facies these rocks are phosphatic biosparites, but are more silty: insoluble residues average about 14% and are as high as 24.7%. They are classed as silty, faintly laminated, well to poorly sorted biosparites. The amount of phosphate decreases from bottom to top of the section. Some fossils are visible. In acetate peels the most obvious characteristic is the high "pellet?" content, although not as high as that of the Bigby facies. Generally a faintly laminated aspect is detectable. There are some large brachiopods and bryozoans, but well sorted fragments of ostracodes, algae, and pelmatazoans predominate. All of these rocks have a relatively high silt content with the silt (and some dolomite) occurring in large patches. In places recrystallization obscures the internal structure of the fossils.

The third rock type at section P1 is a dense, finely crystalline silty limestone. Bedding is even and commonly laminated. Silicified fossils are abundant. The color is medium gray (N5). This rock type is similar to the Cannon except that the Cannon does not appear fossiliferous and is not nearly so silty. These are silty biomicrosparites and are well to poorly sorted. Acetate peels of these units show the silt is concentrated in patches. A few larger brachiopods and bryozoans occur among numerous algae, ostracodes, and pelmatazoans. There are some "pellets?" These rocks may be what Wilson calls the Pale-colored facies. At section

D1 there is a fourth, but minor, rock type. It is very light-gray (N8) laminated calcisiltite. It is cryptocrystalline and extremely silty with stringers of spar that acetate peels show to be worm burrows. There is some similarity between this rock type and the Dove-colored rock type, but they can be easily distinguished.

Leipers Formation

The Leipers Formation is 0 to 175 feet thick and is not known to be completely exposed at any location according to Wilson. Wilson's description of the lithology of the Leipers is essentially the same as for the Catheys Formation. The two formations are virtually indistinguishable in the field on the basis of lithology alone.

The Leipers Formation observed in the course of this study also has three main rock types. The first occurs at sections D4 and P1. It is characterized by thin, 2 to 4 inch-thick evenly-bedded, fine- to medium-crystalline, silty limestones. Their color is medium gray (N5) weathering to yellowish brown (10YR4/2) because of high ferroan dolomite content. This rock type is similar to the Cannon rock type. These rocks are classed as silty biomicrosparites. The Leipers rocks are more silty than the Cannon rocks, but on outcrop look very much like the third Catheys rock type.

The second rock type is also found at section D4 and consists of a complex series of alternating subunits of (1) silty biomicrosparites, finely crystalline with thin, nodular bedding and shaly partings, and (2) silty biosparies, coarsely crystalline with no shale partings. This unit is unlike all others seen. The fossils are large brachiopods, gastropods, algae and bryozoans with small algae, ostracodes, pelmatazoans, and "pellets?" all with well preserved internal structures. The silty biomicrosparites are poorly sorted and lack the preservation of the internal structure of the fossils, but contain the same fossil types as the biosparites with the exception of the "pellets?". This unit agrees with the description of the Granular facies given by Wilson (1949).

The third rock type occurs at section P1 and is a thinly bedded, nodular, shaly limestone, with fine to medium crystallinity. These units are similar to the nodular shaly limestones of the first Catheys rock type. In contrast, the rocks in the Leipers have many algae- and bryozoan-encrusted fossils in silty biomicrosparites. The rocks are silty, and some are faintly laminated. Some fossils are weathered in relief. The color is medium gray (N5) to light brownish gray (5YR4/1) weathering to pale yellowish orange (10YR8/6) due to ferroan dolomite. The base of the unit exhibits large recrystallized domal stromatoporoids from 1 to 2 feet in length. The acetate peels are dolomitic with silty patches scattered throughout. Some large fragments of brachiopods, algae, and bryozoans with poor preservation of internal structure occur in a usual matrix of algae, ostracodes, brachiopods, and pelmatazoan. Sorting is poor.

From these descriptions it is obvious that the lithologies of these formations are quite similar. Photographs can do much to accentuate similarities and differences among the formations. Much more work will have to be done before any deflnite ideas of stratigraphic relations within and between formations emerge. The author would like to suggest that the present designations of formational contacts as either conformable or unconformable be considered as tenative until more detailed bioand lithographic knowledge is obtained and until the biostratigraphy of the type sections of the Richmond, Eden, and Maysville are defined more accurately. At present the Catheys-Leipers contact is considered to be unconformable on the somewhat dubious descriptions of the Eden fauna available in the literature. The lithostratigraphy described in this paper indicates no difference between the Catheys and the Leipers Formations. It may be that faunal changes observed from the Catheys to the Leipers are due to lateral migrations of biotopes and to transgressive and regressive sequences of environments.

Literature Cited

Folk, R. L. (1959) Practical Petrographic Classification of Limestones. *Am. Assoc. Petroleum Geologists Bull. 43,* pp. 1-38.

Wilson, C. W., Jr. (1949) Pre-Chattanooga Stratigraphy in Central Tennessee. Tennessee Division of Geology Bull. 56, p. 407-ff.

ABSTRACTS OF PAPERS PRESENTED AT THE SPRING COLLEGIATE MEETINGS

EASTERN REGION
LEE COLLEGE, CLEVELAND

Trypanosoma theileri in Cattle in Tennessee During the Winter Months. Randolph K. Greaves and Myrtle M. Fleming, Lee College. Blood from 12 cows from the counties of Bradley, Meigs, McMinn, and Polk, Tennessee, was examined for *Trypanosoma theileri* during March, 1971, and 25% infection was found.

The Effects of Social Reinforcement Upon Retroactive Inhibition. Rebecca Wilson, Tennessee Wesleyan College. One way of measuring the effects of reinforcement upon organisms is to measure improvement or decay of performance. This experiment was designed so that the effects of differing kinds of social reinforcement could be assessed in terms of performance on a typical retroactive inhibition experiment. The basic arrangement for the retroactive experiment is as follows:

	Learn	Learn	Recall
Experimental	A	B	A
Control	A	Rest	A

Students were given either neutral, encouraging, or discouraging information concerning their recall lists in both conditions of use and non-use of interpolated material. An analysis of variance test was used to analyze the data. The results showed a high significance between the immediate and delayed recall as well as between the use and nonuse of interpolated material. The interaction of both the immediate and delayed recall with the use or nonuse of interpolated material was significant. The effect of the various kinds of social reinforcement only approached significance.

Preliminary Comparison of Monogenetic Trematodes Found in Lepomis cynellus from Bradley County, Tennessee. Walter R. Walton, Lee College. Three species of monogenetic trema-

todes from *Lepomis cynellus* are described. One belonging to the genus *Cleidodiscus*, one to *Actinocleidus*, and one to*Gyrodactylus*. A brief synopsis of each genus and methods of isolating the different stages within a life cycle are given.

MIDDLE REGION
MARTIN COLLEGE, PULASKI

A Pollution Survey of Shoal Creek in Lawrenceburg, Tennessee. Jacquelene Perry and Susan Nix, Martin College. During January and February 1971, Shoal Creek in Lawrenceburg Tennessee was chosen for a stream survey. The study was to determine whether or not the Murray Ohio Mfg. Co. was damaging Shoal Creek with the effluent which is continuously being dumped into the creek. The tests which were run for the survey were the dissolved oxygen, five day Biological Oxygen Demand, color comparison, chemistry of the stream, bacteria count, residue, and a test for coliforms. The results of our tests indicate that the Murray Ohio Mfg. Co. is polluting Shoal Creek and is destroying at least a portion of the delicate cycle of the creek.

Nuclear Magnetic Resonance Studies of the Benzene-Antimony Chloride Molecular Complex. Mike Smith, David Lipscomb College. N.M.R. spectra of a 2:1 mole ratio molecular complex of antimony chloride and benzene were determined in cyclohexane solution and in the molten state. The proton signal was shifted downfield in every case. This is attributed to the electron attracting ability of antimony chloride.

A Spectroscopic Method Utilizing Characteristic X-Ray Fluorescence. Doug Cantrell, Middle Tennessee State University. The method by which the X-rays are produced is explained including a discussion of the photoelectric effect. The choice of a gamma-emitting source with respect to the photoelectric absorption cross-section and other factors is discussed. Uses, results, advantages, and drawbacks of the method are demonstrated.

X-Ray and Alpha-Particle Gauging of Thin Foils. Alva H. Welch, Jr., Middle Tennessee State University. The experiment consisted of using monochromatic X-rays from ^{57}Co and alpha particles from ^{241}Am to measure the thicknesses of several copper foils. An evaluation of the photoelectric cross section is made by interpreting the X-ray data on the basis of the alpha particle measurements. The theory and advantages of each method are discussed as are the methods by which the data are analyzed.

The Percidae at Walter Hill Dam on Stones River (Rutherford County, Tenn.). James O. Sweeney, Jr., Middle Tennessee State University. Sampling from 3 October to 17 October 1970 yielded 9 species of Percidae: 7 species of *Etheostoma* (darters), *Percina caprodes* (logperch), and *Stizostedion vitreum* (walleye). *Percina caprodes* was by far the most abundant (228). Water temperature varied from 19 to 27 C and pH ranged from 7.5 to 8.5. Observations on *P. caprodes* included shoal-like movements at high temperatures and predation by large game fish.

The Effects of Ultraviolet Radiation on the Antibiotic Characteristics of Some Known Bacteria. Leonard Lee Dunn, Tennessee Technological University. Bacteria were obtained and tested for antibiotic effects against four other known species of bacteria. These test bacteria were then subjected to ultraviolet radiation and again their antibiotic effects were tested. They were then subcultured and their effects were retested. Various changes in the antibiotic effects were found which may have resulted from mutations in the bacterial DNA.

Stream Survey of Pleasant Run. Joe R. Fite, Jr., Martin College. A stream survey of Pleasant Run Creek was conducted from January 14, through February 21, 1971. Pleasant Run is located in Pulaski, Tennessee, and the survey was conducted to determine the amount and types of pollution the business and industries of Pulaski are depositing in this Stream. The tests that were run in this survey are as follows: Chemical, D.O., Content, Survey of Flora and Fauna.

Examination of Two Psychophysiological Principles: Set and Law of Initial Values. Connie G. White and David H. Martin, David Lipscomb College. As a part of a Biological and Chemical Basis of Behavior II class, 10 students acted as experimenters (E) and subjects (S) in a 2-part experiment. The first phase of the experiment investigated the effect of set on the galvanic skin response (GSR). The Ss were divided into 2 random groups of 5 each. One group was told by E that they would receive an electric shock. The second group was told that they would hear and audible aversive tone. Both groups understood that the physiograph (Narco Bio-Systems, desk model 4A) had to be calibrated before any stimulus would be presented. Before calibration began, there was no statistically significant difference between the groups in basal GSR. After calibration was completed and immediately before stimulation, it was found that the basal resistance of the group expecting shock was significantly lower than the basal resistance of the group expecting an aversive tone. Using the Mann-Whitney U test, this difference was shown to be significant at the .008 level. The results show that creating a set in a S by using either or both verbal and nonverbal cues can affect physiological functioning.

The second phase of the experiment investigated Wilder's Law of Initial Values which simply states that an autonomic nervous system response to a stimulus is a function of the prestimulus level. Still recording GSR each S was presented with an aversive tone of 2.8 KHz ranging from 68 to 80 decibels and lasting 1 second. Using the Spearman Rank Correlation Coefficient, the prestimulus level of skin resistance had a .95 positive correlation with the level of skin resistance after the presentation of the aversive tone. Although there have been conflicting findings by other investigaters, the results of this experiment support Wilder's Law of Initial Values.

Using Behavior Modification Techniques to Motivate Juvenile Delinquents to Learn. John Johnson, David Lipscomb College. Based on the well-known fact (Mink and Kaplan)[1] that most children from underprivileged backgrounds do not excel in academic areas, this experiment was designed to motivate boys at a state training school to want to learn. A behavior modification technique (Lovaas)[2] was used by the teacher to motivate a border-line IQ student in this experiment. To motivate one low achieving student, reinforcements were given in recognition of desired behavior. A one-to-one relationship between teacher and student was used so that the teacher could immediately reward the student's work and strengthen desired behavior. In this case, the student was encouraged to learn square root. Basic instructions were given. Some four weeks later the student had learned his work to the extent that he could work all the problems presented to him. It can be concluded that reinforcement of desired behavior did, in fact, motivate the student in a rather dramatic way.

Volunteering as a Function of Field Structure. Mary Ann Morrison and Linda K. Sherwood, David Lipscomb College. The hypothesis that Ss would be influenced in their willingness to volunteer by the willingness of a model who responded prior to the S's response was tested. The manner was similar to Rosenbaum and Blake's (1955) classic experiment. Thirty Ss, ten in isolated situations and twenty in two separate groups of ten each, were approached by one E and asked to participate in an experiment. The first ten were approached on an individual basis with no social stimuli. The second ten were approached after one E, serving as assistant, had been observed to respond positively. The third ten were approached after obserinvg the E respond negatively to the invitation. Contrary to the findings of Rosenbaum and Blake, no statistical significance was found in the ways in which Ss responded in either condition. Possible causes of the failure to confirm their result are presented.

Effect of Advertising on Cola Selection. Eddie Baker, David Lipscomb College. Eleven subjects rank-ordered 5 cola drinks on the basis of taste preference and then again on the basis of actual taste. There was high inter-subject agreement on the first rankings, but very low agreement on the second. Also the two mean rank-orders correlated −.825 indicating a considerable difference in the ranks obtained by the two methods. This was interpreted as evidence for the power of advertising.

[1] Mink, Oscar G. & Bernard A. Kaplan. *America's Problem Youth, Education and Guidance of the Disadvantaged.* Scranton: International Textbook Company, 1970.

[2] Lovaas, O. I., Freitag, G., Kinder, M. I., Rubenstein, B.D., Schaeffer, B., & Simmons, J. Q. Establishment of Social Reinforcers in Schizophrenic Children Using Food. *Journal of Experimental Child Psychology*, 1966, *4*, 109-125.

Honesty: Its Relationship to Religious Attitudes. Charles Floyd and Ricky Smith, David Lipscomb College. The study was conducted with the use of two general psychology classes taught by the same instructor at two different colleges. One college was a religiously affiliated institute while the other was a state supported university. Regular examinations were given to both classes, graded by the experimenters without marking, and then were returned to the subjects for them to grade. Those answers changed by the subjects were recorded and tested for a significant difference in cheating between the two schools. The experimenters later in the quarter gave a religious attitude test to the subjects. The form and many of the questions for this attitude test were taken from the test given by Brown and Lowe on the religious beliefs and personality characteristics of college students. This attitude test was scored and tested for a significant difference using a t-test. The results showed a slight significant difference in the t-test for religious attitudes but failed to show any significant difference on either a t-test or Chi-square Independence test for cheating. Therefore the experimenters concluded there was no difference in religious attitudes and amount of cheating in this study. These results were further supported by results found by Sturgeon in research for a Masters Thesis on the same subject.

Viscosity Correlations for Binary Solutions Containinng Methanol-Water, Methanol-Cyclohexane, and Methanol-Nitrobenzene. Edward A. Shires and Timothy K. Holder, Tennessee Technological University. The kinematic viscosity for two component systems containing methanol as one component and water, cyclohexane, or nitrobenzene as a second component has been measured as a function of temperature and composition. Experimental data for the system methanol-water verified the large deviations reported in the literature for mixture viscosities from viscosities computed using values for the pure components weighted by mole fractions. Data for the methanol-nitrobenzene system show only minor deviations from the mole fraction weighted average of pure component values. For each of the three systems discussed a correlation of kinematic viscosity as a function of temperature and composition has been obtained in the form of a double power series in temperature and composition. In each case, the correlation describes the experimental data in the least squares sense.

NMR Study of Lanthanide Salts Dissolved in Alcohols (Specifically Erbium Chloride in Methanol). Allen L. Neese, David Lipscomb College. The width of the peaks of a Nuclear Magnetic Resonance spectrum can be used to determine the Transverse Relaxation time according to the equation:

$1/T_2 = \pi\Delta_\nu$, where $\Delta\nu$ = the width at ½ height.

The presence of a paramagnetic metal ion in an organic solution will effect the transverse relaxation time such that the effect may be found by the equation:

$$1/T_{2\ \text{paramagnetic}} = 1/T_{2\ \text{solution}} - 1/T_{2\ \text{solvent}}$$

In this study solutions were made from air and water free $ErCl_3$ and methanol. Five concentrations were made ranging from 0.006M to 0.015M salt. These solutions were run with a standard methanol at temperature intervals of 10°C from +50°C to −80°C and the corresponding peak widths at half-height measured. The values of $1/T_{2p}$ were plotted against $10^3/T(°K^{-1})$. The Swift and Connick equations were applied to give, by assuming a coordination number of 4 for erbium, first order rate constants for the erbium-methanol complex of: 10,000 sec^{-1} at −63.5°C, 7,700 sec^{-1} at −73.5°C, and 4,500 sec^{-1} at −80.0°C.

Use of the chemical shifts and further data will possibly allow the determination of the coordination number and the rate constant independently with statistical accuracy.

Products of the Reaction of N-Bromomethylphthalimide with Aniline. Linda Arney, Middle Tennessee State University. N-Bromomethylphthalimide (BMP) has been found to be more reactive toward nucleophilic reagents than most saturated halides. For example, ethers are formed from it by direct reaction with alcohols, alkoxide ions not being required as in typical Williamson syntheses. BMP also reacts with phenols to give products which were once assigned the structures of aryl phthalimido ethers but have recently been shown to be products of a Friedel-Craft type of reaction involving substitution on the benzene ring.

Sach in 1889 allowed BMP to react with aniline, obtaining a yellow product to which he assigned the structure $C_6H_4(CO)_2CH_2NHC_6H_5$. The only evidence for this assignment was the elementary analysis and an analogy to the product obtained from β-phthalimidoethyl bromide. The recent discovery that ring substitution was involved with phenols seemed to warrant an investigation into the structure of the product obtained by Sachs.

BMP was allowed to react with aniline in a 1:2 molar ratio under essentially the same conditions used by Sachs. In addition to a white, high-melting product identified as aniline hydrobromide, there was also obtained a yellow solid. The latter appeared to be the same yellow product obtained by Sachs. An NMR spectrum of this substance could not be conclusively interpreted due to some overlap of peaks, but the aromatic to non-aromatic proton ratio as well as the amine-ring to phthalimido-ring proton ratio seemed to favor the structure assigned by Sachs. This yellow product appears to be reversibly convertible to a white solid which melts a few degrees below the yellow product. The relationship between these two substances is being currently investigated.

WESTERN REGION
JACKSON STATE COMMUNITY COLLEGE, JACKSON

Summary of Neutron Activation Analysis and a Description of an Experiment Performed at Argonne National Laboratory. Bill Glover, Lambuth College. Neutron Activation Analysis is the radiation of a sample with a neutron source and the counting of gamma rays formed in relation to the elements present. The best nuclear reactions are selected by their cross sections. The choice of the best radiation facility will suppress unwanted elements present. The sample prepared is best small in size and it is easiest to work with when dry. The time of irradiation depends on the sensitivity desired, nuclear cross sections, and half-life of the radioisotope produced. The sample is best counted in a gamma ray counter which records the number and energy levels of gamma rays given off. Interpretation of data is done by means of a comparison to standard energies of gamma rays.

We performed an experiment with the use of neutron activation analysis in the quantitative analysis of various grades of aluminum foil in relation to the manganese content. The conclusion of the experiment showed that various locations of bauxite contained very high differences in the manganese content.

A Short Term Limnological Study of Maple's Creek Lake. Bob McClure and John Santangelo, Bethel College. Quantitative determinations were made for free oxygen water hardness, temperature, turbidity and plankton at various depths of the lake at different seasons over a prolonged period. Data are given which indicate stratification and seasonal inversions in the lake as well as descriptions of the limnological methods used.

A Study of the Cicindelidae (Tiger Beetles) in West Tennessee. Michael Mingea and Omar E. Smith, Memphis State University. In the summer of 1970, a study of the *Cicindelidae* was conducted to determine the occurrence and prevalence of tiger beetles in West Tennessee. Temperature readings were recorded and correlated with the habitat of twelve species. There were approximately four hundred specimens collected.

A Preliminary Study of the Effects of Freezing and/or Refrigeration on Storage of Blood Serum. James S. Flanary and Charles J. Biggers, Memphis State University. Researchers often freeze or refrigerate blood serum samples for later protein analysis. This project uses vertical acrylamide gel electrophoretic studies to demonstrate that various freezing and/or refrigeration storage techniques have variable effects on the blood serum proteins. The study suggests a technique that allows a minimum of denaturization of stored samples.

Semigroup: An Extension of Groupoids. Rita Thompson, Siena College. Although mathematics is defined as the systematic treatment of magnitude, relationships, and quantities expressed symbolically, it can also be considered as the gradual extension of several basic concepts. With a certain number of ideas as the foundation, one can easily construct more complex math systems. Similarly, a groupoid serves as the foundation on which loops, semigroups, groups, rings and fields are built. With the addition of several properties, a groupoid may be enlarged to become a more complex algebraic system.

Since groupoids, quasi-groups and loops are relatively new ideas in group theory, they have been chosen as the topic of this paper. The gradual construction of semigroups will be described with particular interest given to the individual properties of each sublevel.

The Measurement of Transference Numbers—A Laboratory Experiment. W. L. Wallace, J. C. Williams and W. H. Zuber, Memphis State University. A modified moving boundary experiment is described which has been successfully used by students to measure transference numbers of several cations. The experiment illustrated the principles of current conduction in solutions, while still giving a high likelyhood of success. Further, the results compare favorably with those in the literature and show that measurement by this method in fact competes with reported values with respect to accuracy and precision.

Mechanism of Pyrithiamine Resistance in Chlamydomonas Eugametos. James Richmond McCarty, Southwestern at Memphis. The basic mechanism of pyrithiamine resistance in *Chlamydomonas eugametos* is reported to be reduced uptake of the anti-metabolite by the mutant strain. Experiments to determine the uptake of thiamine-^{35}S HCl by a resistant mutant contradict this hypothesis. It is proposed that the resistance is due to the mutant splitting the pyrithiamine into separate moieties.

Comparative Study of the Effects of Copper Sulfate and Sodium Chloride Upon the Growing Habits of Planktonic Algea Cultures. Brother David Arnold, Christian Brothers College. The best growing conditions for the four algal cultures were first determined. After this followed a series of tests which dealt with the toxicants, copper sulfate and sodium chloride. The tests were conducted with eleven glass flasks for each of the algal cultures used. Also included in the flasks were the toxicants and growth medium. The flasks were divided into three different groups according to a graduated scale of strength of the toxicant. After a growth period of two weeks with controlled light and temperatures, the experiments were visually inspected. The results indicated that algae can live in a much higher concentration of sodium chloride than copper sulfate.

Biotic Relationship of Pandorina Morum and Pseudomonas Fluorescens. Albert Ciniglio, Christian Brothers College. Little information is available concerning the mutual effects of association between algae and bacteria, and it mostly pertains to the photosynthetic products of algae and to fixation of nitrogen by soil bacteria. The purpose here was to look for evidence of detrimental effects or of mutual contributions of bacteria and algae to survival. Serial dilutions of *Pseudomonas fluorescens* were added with inocula or bacteria-free *Pandorina morum* cultures to Bold's Basal Medium (BBM) plus soil water and 0.8% nutrient broth. These cultures were incubated at 25°C for 15½ hours of daily fluorescent light, and a dark period at 15°C, for three weeks. The algae grew poorly and the series was repeated using 0.08% nutrient broth; again, the algae did not multiply and the bacteria did, suggesting that a bacterial exotoxin or the addition of the nutrient broth interfered with algal growth.

The Effects of Three Broad-Spectrum Antibiotics on Bartonellus bacilliformis. Robert N. Federhofer, Christian Brothers College. *Bartonellus bacilliformis* is a gram-negative bacterium common to Peru. It is pathogenic in man causing Oroya fever, severe anemia and tumors of the skin and mucous membranes. The bacterium is transmitted by the female sandfly (Diptera: *Phlebotomus*); DDT spraying has reduced the incidence of infection in man. The use of broad-spectrum antibiotics is the best means of controlling the disease. Three broad-spectrum antibiotics were selected to determine their effectiveness in killing the bacterium. The cultures with antibiotic were incubated at 25°C, since this temperature has proven most suitable for the growth of *Bartonellus bacilliformis.* The three antibiotics used were: Tetracycline Phosphate (Bristol), Oxytetracycline/HCl (Pfizer) and Streptomycin (Lily). Streptomycin was the most effective of the three, destroying the bacterium in all concentrations tested—as small as 0.09 mg/ml. Oxytetracycline/HCl and Tetracycline Phosphate were effective in concentrations greater than 0.32 mg/ml.

The Effects of Intravenous Perfusion of Thorazine and Sodium Caparsolate on Mouse Lactic Dehydrogenase Determinations. Robert M. Kraus, Christian Brothers College. Normal mouse serum analyzed for lactic dehydrogenase activity was found to be 450±15% International Units. Intravenous perfusion of Thorazine (Smith, Kline and French) and Sodium Caparsolate (Diamond) increases the LDH activity markedly. The sera from the Thorazine and Sodium Caparsolate treated mice was analyzed 72 hours after the injection of the drugs to allow maximum diffusion of LDH from destroyed cells into the bloodstream.

Beard Growth in Relation to Testosterone. Paul Muscari, Christian Brothers College. Applications of one percent testosterone aquaphor gs. 60.0 were applied daily to the entire bearded area of the face. Growth was allowed to continue for seven days before being cut, collected, and weighed. The first week of application yielded 0.3546 grams with a 3.9 percent increase in beard weight. The second week yielded 0.3592 grams with a 5.2 percent increase, and the third week produced 0.3730 grams with an 8.52 percent increase. All were compared to a week of control growth which weighed 0.3412 grams. Since daily activities affect beard growth, a rating scale from 0 to 5 was devised to interpret such things as mental exertion, physical exertion, degree of nervousness, amount of sleep, alcohol consumption, and sexual stimulation. All of these activities stimulate growth except for physical exertion and increased levels of sleep.

Extraction of Plant Pigments, β-Carotene and Lycopene. Patrick Murphy, Christian Brothers College. Spinach leaves, carrot root, and tomato fruit were the sources for the pigments, and the final products were studied by infra-red spectrophotometry. The spinach was crushed in a 2:1 mixture of methanol and ether. The methanol phase removed the water-soluble materials while the ether extracted the organic pigment. The latter was repeatedly washed with water and dried with anhydrous sodium sulfate. Finally the ether was evaporated. The carrot and tomato were treated with similar procedures: each was doubly refluxed and filtered in a 2:1 mixture of methylene chloride and methanol. The filtrates were repeatedly washed with distilled water, dried with anhyrous sodium sulfate, and the methylene chloride then evaporated. The pigment residues were then dissolved in ether before their IR spectra were recorded.

Effects of Isolation-rearing on Mice. Thomas Steffek, Christian Brothers College. The purpose of this experiment was to observe effects of isolation on young mice. Weight increase, behavioral patterns, and performance in a maze, compared to those of a normal (social) group of mice, were observed. Group 1 (2 males, 2 females in one cage) was the control (social) group. Group 2 (4 males) were isolated in separate cages. Water was severely limited and used as a stimulus for the mice to run the maze. It was primarily scheduled for the evening, and later provided in the maze. After 5 weeks, Group 2 showed more increase in weight (12% per week), whereas Group 1 showed only a 6% increase per week. The same amounts of water and constant access to food were supplied to both groups. Behavior also was markedly different in Group 2. They were hyper-active and hyper-sensitive, and also ate more than did Group 1. In maze performance, Group 1 learned about as rapidly as Group 2 in early trials. Further tests are in progress.

Gel Diffusion Determination of Common Antigens in Bartonella Bacilliformis and Other Gram Negative Bacteria. Gene France, Christian Brothers College. The object of Ouchterlony's gel diffusion test is to bring together optimal concentrations of antigens and antibodies to form visible bands of precipitation. The number of bands indicates the number of antigen-antibody systems present. The plate method of Ouchterlony uses samples present as fluids deposited in wells of an agar plate. The antiserum from *Bartonella bacilliformis* produced in mice is placed in the center well; the antigenic suspensions of the other gram negative bacteria are placed in the surrounding wells. The reactants diffuse toward each other and are precipitated in a medium that originally contained neither. Double, three-dimensional diffusion is involved. Separate lines occur where there are optimal concentrations of corresponding antibodies and antigens. The number of lines indicates the minimal number of common antigens that exist between the *Bartonella* and the other bacteria.

Effects of Sodium Fluoride in Drinking Water of Mice. Clark Irven, Christian Brothers College. Fluoridation of public water systems is a controversial issue. Evidence from some pharmacology studies suggests that because of fluoride's high electronegativity, sodium fluoride in amounts well over one part per million (ppm) may cause improper bone formation and a dental disease ((fluorosis) in which the teeth become specked and decalcified. On February 19, 1971, 16 weanling albino mice were distributed 4 per cage (2 males & 2 females). Each cage was provided with a different concentration of sodium fluoride (analytical reagent powder) dissolved in the drinking water: Cage 1—distilled water, 0 ppm; Cage 2—Memphis tap water, 1 ppm; Cage 3—10 ppm; Cage 4—100 ppm. Initial mouse weight averaged 11.66 g; early water consumption averaged 23.6 ml/mouse/week; NaF consumption average (in mg/mousemouse/week), Cage 1—0, Cage 2—0.055, Cage 3—0.547, Cage 4—5.25. Reactions and changes in appearance or behavior were noted visually. After 57 days, average mouse weight now—29.23 g., increase of 17.57; average water consumption of 48.4 ml/mouse/week, increase of 24.8; NaF consumption now averaging (in mg/mouse/week), Cage 1—0, Cage 2—0.094, Cage 3—1.02, Cage 4—10.87. All litters of Cages 1-3 had normal litter offspring. Cage 4 (100 ppm) mother bore only 1 offspring in each of two pregnancies, indicating possible effects of sodium fluoride on reproduction of mice.

Reversion of T4r$_+$ Bacteriophage to Another Mutant Form. Paul Evans, Christian Brothers College. The r mutants of T4 bacteriophage cause rapid lysis of the host *Escherichia coli* (strain B) cells, resulting i- large, clear plaques on agar plates of the proper host cultures. The wild-type T4 phage produces tiny clear plaques, and will infect both strain B and strain K of *E. coli.* By dilution technique it was determined that the original broth suspension of wild-type phage contained 250 x 10^6 particles. When the phage was applied by dilution technique to a supposedly resistant strain of *E. coli,* one plate formed 18 plaques. This leads to the conclusion that the normal mutation rate affects one in every 139,000 T4 particles.

Chronopotentiometry of Human Blood Hemoglobin. J. William Owens, Christian Brothers College. This study was designed to investigate oxidation-reduction properties of human blood hemoglobin. The techniques used in this chronopotentiometric method were first developed by Testa and Reinmuth (Anal. Chem., 32:1512-1514). That study of EDTA complexes suggested a similar chronopotentiometric approach to the protein-porphyrin complex of iron in hemoglobin. To date, results are somewhat inconclusive. Diffused oxygen in the blood has proved to interfere with the electrolysis. The hemoglobin used is actually the diluted plasma portion of whole blood in which some hemolysis had occurred. Perfusion with nitrogen was attempted to drive off the excessive oxygen in the solution, but excessive frothing prevented complete treatment. The result was active electrode interference. However, visual observation of the reduction electrode compartment showed change of the red hemoglobin color to light brown under sustained electrolysis. A thiocyanide test failed to reveal the presence of any free iron. This suggests that the globulin or porphyrin or both have remained intact. A more dilute solution is under investigation to circumvent the frothing.

Fatty Acid Metabolism by Aspergillus as a Means of Differentiating Between Species. James Robert Farrell, Southwestern at Memphis. Two strains of *Aspergillus parasiticus* (2999 and 3000) were grown on even-chain fatty acids to determine if their growth patterns were alike. Ketones were produced when strains were grown on six to twelve carbon atom fatty acids. It is suggested that the difference in growth pattern may be used as the basis for a taxonomic scheme.

Some Nutritional Effects on Maize Dwarf Mosaic Virus Infected Corn Growth and Chlorophyll Concentration. James Robert Farrell, Southwestern at Memphis. A variety of yellow corn was infected with Maize Dwarf Mosaic Virus (MDMV) and grown hydroponically with varying concentrations of nutrients. It was found that those plants grown in solutions containing 10 and 15 times the normal required amount of iron or magnesium showed no visible signs of infection and the chlorophyll concentrations of the leaves proved to be equal or above that of the *uninfected* controls.

Identification of Some Pennate Diatoms from Memphis Waters. W. Kieth Lara, Christian Brothers College. Slides of diatoms from Memphis streams were prepared by incineration of the organic material at 1000°F. The numbers of diatoms and the numbers of species decreased in samples collected closer to the mouth of each stream (except for the Mississippi River). Diatoms were isolated, and pure clonal cultures obtained by spraying the water samples on agar plates. These were then transferred to a broth medium from which more slides were made prior to species identification.