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KANSAS GEOLOGY--OVERVIEW AND EXPLORATIONS
(ACTIVITIES FOR TEACHERS)

by

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KANSAS GEOLOGY OVERVIEW AND EXPLORATIONS

Suggested Grade Levels: Junior to Senior High

Introduction

"Go my sons, burn your books, buy yourselves stout shoes. Get away to the mountains, the deserts, and the deepest recesses of the Earth; In this way, and no other, will you gain the true knowledge of things and their properties."

Severinus, 1547

"The more superficial a societies knowledge of the real dimensions of the land it occupies becomes, the more vulnerable the land is to exploitation, to manipulation for short term gain."

Barry Lopez

"Crossing Open Ground"

The need for students to have hands-on exposure to concepts discussed in class is fundamental when dealing with the earth sciences. Finding new ways to do this can be trying, and field trips are not necessarily a novel idea. People have been doing them since Moses was a baby. However, many field trips quickly turn into tours or lectures with little hands-on involvement or exploration. Also, the actual time spent out of the classroom can be all too brief rabbit-hole exercises; popping out out of the room for brief times of frantic activity, then diving for the cover of the classroom. With the Earth as our laboratory we should be able to utilize it much more than is often done.

This unit is a broad introduction to Kansas geology along with specific, systematic methods and exercises for investigating it. It is designed to be used as a laboratory or field emphasis after minerals, rocks, surface processes, and geologic time have been introduced in class. These activities have been 'field' tested and are geared for eighth grade students, but could easily be adapted for a broader audience. The entire unit could take anywhere from four to six weeks, depending on depth of information and scheduling, and would consist of two distinct sections.

Section I would take place in the classroom in preparation for the field experiences. Sending students out in the field without the necessary background and preparation is almost as bad as not sending them out at all.

Section II is the field section which incorporates activities for field work and necessary lab follow-up activities. The sites mentioned, scheduling, and activities presented are the ones I

actually do in my course. However, activities can always be adapted to the time constraints and sites available.

SECTION 1

A. Observations and Inferences

The overall purpose of these lessons is to introduce the concepts of observation and inference, emphasizing the importance of these in field geology.

Objectives: The student should be able to (TSSBAT)

- a) distinguish between an observation and an inference.
- b) list observations and draw inferences based on those observations.

1. BLACK BOX ACTIVITY

Paint a shoebox black. Place any number of different types of items inside the box such as a cork, rubber stopper, ping-pong ball, golf ball, block, pen, etc. Seal the box and set it on the table before class begins. Ask the students to guess what is inside the box. Invariably, someone will say, "give us a clue." Don't give them any clues, but ask for suggestions about how we could determine what was inside the box without opening it. (You may want to ask them how they determined the nature of Christmas presents before Christmas. This may lead to a lengthy discussion of favorite methods for determining the aforementioned presents, but can lead to fruitful conclusions in the long run). Use this as an analogy for determining what is inside the box.

Have a few students come up and shake the box, tip it, or heft it, noting that doing it slowly may reveal some different things than tipping it quickly. (Another way to do this would be to pass the box around the classroom and let each student make an observation.)

Have a student start a list of observations on the board. Only allow those things that are truly observations, not inferences. Some possible observations would be whether something rolls or slides, how heavy or light it is, the number of items in the box (determined by trying to isolate sounds), etc. Do not allow any guesses or inferences such as a guess at the contents. Once there is a pretty good list on the board, have the students start to draw inferences about what might be in the box. These should be based upon their observations. This also could involve common sense as well, as they might try and determine what types of things I as a teacher might have put in there. However, try and have them stick to the observations.

Once the guesses are made, open the box and show them what was inside. Have them react to what was inside and how accurate their observations and guesses were. Impress upon them the idea that their guesses could only be as good as their observations. Have them suggest other ways they may have thought of to better determine what was inside the box. After all the discussion, have each student write down what the difference is between an observation and an inference based upon this activity.

2. DEFINITIONS

Define the following terms and have them compare their own definitions from the previous activity to the ones supplied by you.

OBSERVATION: Describing what you see. Using any of the senses to describe an object or event through careful examination.

INFERENCE: Arriving at a conclusion based upon observations. Deduction.

Quote the following as an example of using inference, or the power of deduction, to come to a conclusion based upon careful observation.

"But do you mean to say," I said, "that without leaving your room you can unravel some knot which other men can make nothing of, although they have seen every detail for themselves?"

"Quite so. I have a kind of intuition that way. Now and again a case turns up which is a little more complex. Then I have to bustle about and see things with my own eyes. You see, I have a lot of special knowledge which I apply to the problem, and which facilitates matters wonderfully. Those rules of deduction are invaluable to me in practical work. Observation with me is second nature. You appeared to be surprised when I told you, on our first meeting, that you had come from Afghanistan."

"You were told, no doubt."

"Nothing of the sort. I knew you came from Afghanistan."

From long habit the train of thoughts ran so swiftly through my mind that I arrived at the conclusion without being conscious of the intermediate steps. There were such steps, however. The train of reasoning ran, 'Here is a gentleman of a medical type, but with the air of a military man. Clearly an army doctor, then. He has just come from the tropics, for his face is dark, and that is not the natural tint of the skin, for his wrists are fair. He has undergone hardship and sickness, as his haggard face says clearly. His left arm has been injured. He holds it in a stiff and unnatural manner. Where in the tropics could an English army doctor have seen much hardship and got his arm wounded? Clearly in Afghanistan. The whole train of thought did not occupy a second. I then remarked that you came from Afghanistan, and you were astonished."

Dr. Watson and Sherlock Holmes
from, "A Study in Scarlet" Sir Arthur Conan Doyle

3. FOSSIL FOOTPRINT ACTIVITY

Make an overhead of the footprints diagram in Appendix A. Show only the top part of the diagram showing the footprints converging, but not yet coming together, being careful not to reveal the rest. Ask the students to make some observations. Be sure they are only observations. Some will want to jump right into deductions or explanations, but stick to the observations. Following are some examples of observations that should be made.

Two sets of tracks; Appear different; One larger than the other (Don't let them infer size of animal here, only size of tracks. Do you know any small animals that leave large tracks?); Large set of tracks get spread out more as they converge

After several observations, ask them to take a guess, or infer, what happened based upon what they see.

After several ideas reveal the middle portion of the diagram, showing the two footprints together. Now ask for observations. The students will be tempted to jump to conclusions and explain things, but ask just for the observations. After the observations, ask for inferences again. The obvious one will be that the two animals got into a fight. Ask them to think of other options related to the observations. Some possibilities might be the following.

The tracks were made by separate animals at different times. They were attracted to the spot by food or water. The tracks were made by animals playing, not fighting.

After several other ideas have been offered, reveal the remainder of the diagram. Ask again for observations. The students will want to jump to conclusions again, but make them stick to the observations. After the observations, ask for the inferences. They will certainly pick up on their main theme of the larger animal fighting and defeating, probably eating, the smaller one. Have them get creative again and think of alternative solutions. Some might be as follows.

The smaller one was a bird and flew away. The smaller one rode away on the back of the larger one, they were playing. The smaller one went into a hole in the ground which has since been filled in.

This diagram affords tremendous opportunity for the powers of observation and illustrates the difference between observation and inference. It also gives the students good practice at coming up with alternative conclusions, or deductions, for the same observations.

As related to field geology, observations are the starting point of our investigation. We must be able to make careful and accurate observations and communicate them to others.

The inferences which we draw will only be as good as the observations we make and the data we collect in the field.

B. KANSAS GEOLOGY

The overall purpose of these lessons is to acquaint the person with various physiography and geologic features of Kansas so they have a framework for understanding the specific geology of their local area in the context of the whole.

Objectives: TSSBAT

- a) Explain the various processes that caused the physiographic regions of Kansas to appear as they do.
- b) Relate the Kansas Timetable and environment of deposition to the geologic and physiographic map.
- c) List and describe the physiographic and geologic region they are located in and will be doing their field work in.

1. GEOLOGIC MAP/TIMETABLE ACTIVITY

a. Distribute colored Kansas Geologic Maps to each person, Appendix B. (These are available in quantity from the Kansas Geological Survey for a small price). The physiographic maps are also in Appendix B and will be used at a later time. Do not confuse these, they look very similar. Begin by having the students make observations about the geologic map. Be sure they are just observations and not interpretations or guesses about why something is that way. Some of the observations might be as follows.

Different colors relate to different systems.

The shape or orientation of some of the sections are patterned or not.

The A to A' line is where the cross section is taken from.

The glacier didn't cover all of Kansas.

There is a ridge and fault beneath the surface of Kansas. (Source of minor earthquakes in KS.)

Layers at the surface in the east are buried in the west. (Rock layers dipping to the west is caused by the uplift of the Ozark dome in Missouri. If you have a geologic map of Missouri this dome structure is readily apparent in the Southeast.)

Next, have the students attempt to infer or hypothesize as to how Kansas formed or some of the reasons behind their observations. Leave it open at this point and be sure to have them explain their reasoning.

b. Distribute the Kansas Geologic Timetables, Appendix C, (also available from the Kansas Geologic Survey) to each student. Read through each of the descriptions for the geologic periods starting with the Precambrian era. Indicate that the Mississippian rocks are the oldest found on the surface in Kansas and relate each description from that point on to the corresponding place where the rocks are exposed in the state. Some things to point out would be as follows.

The period and age of the rocks you will later bestudying in the field.

The way that most of the layers were deposited. (The seas rising and falling, periodically covering Kansas. You may want to introduce the term 'cyclothem', referring to repeating rock units deposited as the ocean came and went across Kansas.)

Anything correct that the students came up with on their own from their hypotheses.

Reasons they could come up with why no Triassic rocks are found in Kansas. (Non-deposition or erosion)

2. SLIDES ILLUSTRATING KANSAS GEOLOGY

For the slides it will be necessary for the students to have their geologic maps, physiographic maps, and timetables for reference. Slides will cover typical surface features and geology. A loaner copy of this suite of slides is available through Dr. William LaShier, School of Education, Curriculum and Instruction, 302 Bailey Hall, University of Kansas, Lawrence, KS 66045 (913/863-4435). A good reference for this is, "Kansas Landscapes: A Geologic Diary", by Frank W. Wilson. This is available from the Kansas Geological Survey. The narrative from the slides is largely taken from that publication. The slide narrative is located in Appendix D.

C. LITHOLOGY

The overall purpose of these lessons is to give the students ways to study the rocks while they are in the field.

Objectives: TSSBAT

- a) Describe a rock sample using appropriate terminology as introduced in this lesson.
- b) List and describe the typical rock types they will be exposed to in the field.
- c) List and describe the possible bedding features or special features rocks may have in the field.

- d) Give the symbols for the various rock types encountered in the field.
- e) Interpret a rock column and match descriptions to the layers in that column.
- f) Describe the relationship between a rock formation and member.

1. ROCK DESCRIPTION ACTIVITY



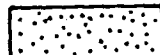
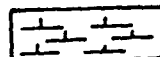
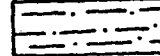
This is a simple activity which illustrates the problems that can arise in trying to describe anything.

Give each group of students a rock sample. All the samples should be the same type of rock and be as nearly identical as possible. Choose ones that do not have fossil samples in them as these will be dealt with at a later time. Have each group come up with a description of the rock sample that they think completely describes it. Give them about 5 minutes. Have each group in turn share their descriptions and begin compiling a master list of what was shared. Use the terminology which they used, don't alter it. There will always be areas of difference. Look at those, and try to come to consensus on what is the best description.

Generate discussion on some of the areas of disagreement and some of the problems groups faced in trying to come up with their description.

2. DESCRIBING LITHOLOGY

The following is information you can share with students concerning describing rocks and rock units in the field. This information could be presented in the form of a checklist, in lecture form, or as a follow-up discussion to the rock description activity. In any case, the information should be included in the students field books as a checklist once they are in the field. This is not an exhaustive list, but is simplified for use by 8th grade students. The list can be changed and modified depending on the level of the student and the rock types that might be studied. Samples of the rock type, slides illustrating terminology, or other visual aides would be useful in describing these terms.

A.	TYPE	SYMBOL
	Limestone	
	Shale	
	Sandstone	
	Limey-Shale	
	Sandy-Shale	

B. **BEDDING:** This refers to the type of layering present in the rock unit studied.

Limestones: Thin, medium, or thick can describe relative thicknesses of the beds studied. **Platy** would be a more specifically used term for thin beds. **Wavy bedded** would refer to horizontal beds that are irregular or 'wavy.' If wavy bedded limestone is diagrammed, the lines should wave. **Crumbly** would refer to rock that fractures easily and come off in small pieces. **Massive** would refer to beds that produce large blocks of stone as they break off.

Shales: **Clumpy-claylike** would be those that are very muddy and have no real distinct layering pattern. To diagram these, the lines would be shorter and spaced further apart. **Fissile** would be those that have very closely spaced, regular breaks. Diagrams for these would be longer lines, layered right atop one another. These are very thin and would break off into thin platy or shingle-like pieces. This is common for many dark black shales.

Sandstones: A special term here would be **cross-bedding**, or when the layering is at angles to each other.

C. **COLOR**

Describe the color or shading of the rock that makes up the unit. This should be a weathered description, one that has been exposed for some time, and a fresh description. The fresh one should be from a freshly broken sample. (Having a rock present which shows very different fresh and weathered colors would be helpful here.)

D. **OTHER**

Mineral Growth: Describe any minerals present, any crystal form shown, or any chert present in the rock units. Be sure to describe, in relative terms, how much is present. Chert would be shown in a diagram as a small triangle within the rock unit.

Nodules: Hardened, separate, rounded pieces found within the rock unit made of different material than the rock unit itself. For example, phosphate nodules commonly found within black, fissile shales.

Concretions: Hardened, separate, rounded pieces found within the rock unit made of the same or similar material as the rock unit itself.

Jointing: Any vertical cracks that may form regularly in the rock units. Note any regular angles made. If movement has occurred across a joint, it is said to be a fault.

3. ROCK COLUMN IN KANSAS

The charts and reference materials used are taken from "The Stratigraphic Succession in Kansas," by Doris Zeller, 1968; University of Kansas Publications. It can be purchased through the Kansas Geological Survey, Lawrence, Kansas. The portion of this book referred to in this section is found in Appendix E.

a. Introductory Activity

Copy and distribute the rock column diagram in Appendix E. (You would actually use that portion of the rock column that is suitable for your area.) Do not distribute the descriptions at this time. Have them make any observations about the diagram that they can. Following are some examples of some possible observations.

The naming becomes more specific from right to left.

The different rock symbols are used indicating type.

There appears to be a pattern.

The sandstones have an unusual 'tongue' shape.

Some of the members are unnamed. (Have students explain any similarities they can among the unnamed members. Notice the unnamed members all have a varied lithology as shown by their symbols.)

b. Classification Scheme

Rocks are named and classified just like organisms are. Any organism will belong to a Kingdom, Phylum, Class, Order, Family, Genus, Species. This identifies the organism, and groups it with other similar organisms at each stage. For rocks there is a similar classification. Rocks are classified by Era, System, Series, Stage, Group, Formation, Member. The member is the most specific designation, while the era is the most broad. Generally, geologists deal with formations and members. The sedimentary rocks of Kansas have been divided into about 170 different formations. Each formation might be broken down into 4 to 10 members.

Look at the diagram.

What system is this in? (Pennsylvanian)

What era would this be a part of? (Not shown on diagram, but it would be the Paleozoic Era)

What series is it? (Upper Pennsylvanian)

What stage is it? (Be careful, this would depend on what unit you are looking at. Answer the rest of these questions for the Oread Limestone. That would make it the Virgilian Stage.)

What group is it? (Shawnee Group)

How many members does the Oread limestone have. (7)

Tell what you can from the names and symbols shown for those members. (Alternate limestone and shale, chert present in the Plattsmouth, the Heebner is a fissile shale, the Plattsmouth is wavy bedded, etc.)

What is the oldest member of the Oread? (Toronto l.s.)

What is the youngest member of the Oread? (Kereford l.s.)

c. Descriptions

Hand out the description sheets for this portion of the rock column. Have students read through the descriptions of each of the members of the Oread Limestone. The descriptions are written in technical, geologic language. Don't get hung up on vocabulary, although a geologic dictionary might be beneficial for your personal use, but concentrate on what can be understood.

Fossils are included in the descriptions as well which is a good way to introduce the next section on paleontology. Another good idea would be to take some slides of one of these member units and compare it to the description as given in the handout. It should be noted that these are general or average descriptions. There will always be local variations, some of which are pointed out in the descriptions.

D. Paleontology

The overall purpose of these lessons is to acquaint the students with various types of fossils they might encounter while on their field trips. Also, to give them practice in identifying unknown fossils.

Objectives: TSSBAT

- a) Describe the relative abundance of fossils present in rock layers.
- b) Identify fossils common to their area by sight from a diagram.
- c) Identify fossils found in the field using their fossil handout sheets.

1. SLAB ACTIVITY

Give each group a limestone slab containing numerous types of fossils. Students should have hand lenses as well so they can see smaller and larger types both. Have them write a description of the different types of fossils they see. Do not give them any help with this. If they are stymied, have them describe by analogy such as, "It looks like....." (For example, a crinoid columnal may look like a wheel with spokes coming out of it, or a fusulinid as a grain of rice). These descriptions will be used later on. Have each group read their descriptions and make sure they are not guessing at naming the fossils. Students are to just describing the fossils or comparing them to something else by analogy.

2. DESCRIBING PALEONTOLOGY

Paleontology refers to a complete description of the fossils present in a rock unit and their relative abundance. This material can be presented in lecture form, as a checklist, or as a discussion based upon the previous activity. The students should have access to this information in their field books as a checklist.

A. ABUNDANCE

Give a relative statement about how many fossils are present. If fossils are very abundant, it would be said to be fossiliferous. If there were only a few, sparse. If none were found in a rock unit, rather than saying none, they should report, none apparent. The reason for this is to acknowledge the fact that only a small portion of the rock unit has been studied.

B. TYPE

As specific a statement as possible should be made as to the types of fossils present. It may only be possible to identify major groups such as Brachiopods or Mollusks. A more specific identification might be possible. It should be emphasized that only what is known should be reported as fact. Guesses or conjecture can be made as to specific types,

but should be recorded as possibilities, not fact. It should also be stated whether the fossils present were actual material, molds or casts. Molds would be impressions left from fossils which have long since decayed. Casts would be other material that has replaced the fossil, but is not original material. If trace fossils are found, such as burrow fills, this should be reported as well.

C. CONDITION

A short statement as to the condition of the fossils should be made. Whether or not the fossils were whole, large broken pieces, or small broken pieces can say a lot about the environment of deposition.

3. FOSSIL HANDOUT SHEETS

Copies should be made of the fossil handout sheets from Appendix F or other suitable sheets obtained for your specific area. They should include common fossils for the area of study.

a. I.D. Activity

Have the students compare their descriptions from the slab activity with the fossil handouts and see if they can match any of them up. Have the students list the ones they think are on the slab. Move around and confirm whether they are correct or not.

Next, hand out various samples which are common to the area of study. Include some whole ones, some pieces, some that are clean, some that are caked in mud, etc. Have a variety of different types and have them go through and try and match them up. These should be keyed by numbers or letters.

b. Common Fossils

Make overheads of the fossil sheets and begin going through the sheets making comments about the types of fossils they will encounter in the field and the ones they just tried to identify. As you go through, after the descriptions, give the number or letter of the fossil that matches the diagram. A resource for fossil identification would be "Ancient Life Found in Kansas Rocks," available from the Kansas Geological Survey.

E. Measurement

The overall purpose of these lessons is to familiarize the students with various methods for taking measurements in the field and for handling the data generated.

Objectives: TSSBAT

- a) Distinguish when estimation or direct measurement should be used.
- b) Describe two methods for making an estimation of a large structure.
- c) Describe the processes and principles related to making a direct measurement on a limestone face.
- d) Describe a Jacobs Staff and line level and how they are used to measure a shale slope.

1. STAIRWAY MEASUREMENT ACTIVITY

Give each group of students a meter stick and tell them to measure a stairway or section of bleachers as accurately as possible in meters. Give them no other instructions than that. When each group is done have them write their answer on the board. When all groups are completed, have them analyze the data. There will be several possible sources of error, some of which are listed below.

A group might have recorded centimeters rather than meters.

A group might have used the inches and feet side of the stick if it is dual scaled. (I can assure you from experience that at least one group will do this no matter how many times you tell them to do the measurements in meters.)

A groups answer may be very different from all the others. The issue of handling bad data will arise at this point. Possible suggestions would be to throw it out, average it in with others, remeasure or describe measurement procedure.

The groups answers may vary in accuracy. Discuss how accurately you can read a meter stick in meters.

After discussing the data, ask the groups to explain how they made the measurement and explain why they used a particular method. Some may have measured each stair and added them up, some may have measured one stair and multiplied by the number of stairs, or some may have measured straight up the wall without measuring the stairs at all. Discuss possible assumptions and sources of error that may be present for each of the methods.

2. MEASUREMENT PRINCIPLES

Making accurate measurements in the field is important in helping to identify the geologic members present in your units of study. Some thicknesses will vary from location to location, but many are consistent over long distances. The following are some things to keep in mind when making measurements in the field.

a. Take all measurements in meters to the closest centimeter. It is not necessary to measure to millimeters. Measurements should be made such as .47 meters for 47 centimeters, 2.98m for 2 meters 98 centimeters, or 3.05m for 3 meters 5 centimeters. Using meters will have both good and bad sides to it. Meters are easier to work with as decimals and graphing it will be easier. However, all the literature is in feet and inches, therefore some conversions will be necessary when back in the lab. This can be good though, as I've found by the end of this unit the students have a much better concept of the metric system and use it more naturally.

b. Measure the thickest portion of the member exposed. Be sure to scan the rock unit and find the places where you have the best chance at measuring the whole member.

c. Find the member contacts as best as possible. These are the planes where one member stops and the next one begins. Often contacts are buried with talus or dirt and some digging must be done. Many times the contacts can be estimated from terrace levels, or breaks in slope. (Given some of these problems it should be obvious now why we don't need to worry about millimeters in our measurements.)

3. MEASUREMENT TECHNIQUES

There are several ways to take measurements in the field. Below are outlined three ways to get measurements in the field.

a. Direct Measurement

The best method, when possible, is direct measurement of the unit. This is easy for vertical limestone faces which can be directly measured, or for shale slopes that are between two limestones that are relatively close together. Be sure to emphasize this method. Once students get into the field, as well as a few teachers I'm afraid, common sense goes out the window. Always take a direct measurement if possible.

b. Estimation

For large walls of limestone or huge hills of shale, a simple way is to estimate the height in meters. A person standing near the wall could be used as a rough measuring stick.

This could work by the reasoning, "John is about 5 feet tall, the wall appears to be about 6 times his height, therefore the wall is about 30 feet."

c. Estimation with Jacobs Staff

A Jacobs Staff is a scaled stick for measuring in the field. A two by two inch board approximately four feet in length works well with junior high sized students. (This comes out to be about 1.22 meters in length) Two by twos are sturdier in the field and less easily lost. Mark off every ten centimeters in bold red marker or paint, and the other centimeter markings in blue marker. This makes it easy to read the scale from a distance.

To estimate thicknesses of rock units using the staff, hold the stick up as a standard length near the member you want to measure. Estimate how many lengths of staff it would take to measure the whole member. One student could hold the staff, while another student steps back to estimate the number of staff lengths. The math can be done later.

For shale slopes, a better way to estimate would be to work your way up the slope with successive measurements. To do this, place the staff at the bottom of the slope. Have one person sight along the top of the vertically held staff into the side of the hill and have them direct another person to stand at that point (sighting to his feet). Then move the staff up to that point and continue making readings until the top of the slope is reached. Be sure to record all your data and add up your measurements at the end.

d. Jacobs Staff and Line Level

If the materials are available, a good way to measure shale slopes is with a Jacobs Staff and line level. You will need a staff, about 5 meters of nylon string, and a line level. To do this, place the staff at the bottom of the slope. Stretch the string out so it intersects the hill at its full length, or if it's a steep slope, stretched from the top of the staff. Attach the level to the string with the clips. When the bubble is centered between the lines, the string is perpendicular from wherever it is on the Staff. Write down your reading and move the stick to where the string intersected the hill and continue to take readings in this fashion. Add up all your readings and you will have the total thickness.

This method works very well, but does take some practice. Try it out before you go into the field. I try and use this method unless the wind or other conditions makes it impossible. When doing large shale slopes, estimation with the staff is best, unless you have a lot of time, because measuring with line levels can get pretty tedious for the students over long distances.

F. Cooperative Groups

The overall purpose of this material is to acquaint the students with the concept of cooperative teams, familiarize them with the responsibilities of the position, and how the teams will work in the field.

Objectives: TSSBAT

- a) List the three positions in the cooperative group.
- b) Describe the responsibilities of each position.
- c) Explain how the positions will rotate once in the field.

1. POSITIONS AND RESPONSIBILITIES

The field work, lab work, and much of the preparatory work is done in the context of cooperative learning groups. This works out very well as roles are clearly defined, and materials are used more efficiently. They work in groups of three, and if there are not the correct number for that to work out, groups of four. I let them choose the group they want to be in for several reasons.

First of all, if students are working with people they want to be with there will be more cooperation with tasks and activities. Secondly, it cuts down on between group interaction and promotes within group interaction. Lastly, the students who routinely might not do anything or cause problems usually group together and it isolates discipline problems. This is strictly my preference though, and I'm certain several good reasons could be found to choose the groups as well. However the groups are chosen though, the cooperative learning scheme is sound.

Have students choose their groups, or assign them at this time. You may want to be aware, if they are choosing groups, of students who may be isolated or not fit in. Try to deal with this before you get to that point and set up something in advance.

2. COOPERATIVE GROUP POSITIONS

Go over the following positions and responsibilities with the groups.

a. Principle Investigator (PI)

Directs the activity

Facilitates discussion

Makes decisions as to who does what within the group

Makes sure safety features are being followed

Is the only person of the group that can ask the instructors questions. (This is very important as it cuts down on the number of people coming to you for help. It makes it more organized and forces the group to verbalize their question and discuss it among themselves before they bring it to you. Many times they resolve their own questions before they get to you.)

b. Materials Manager

Responsible for getting and returning all needed equipment for the investigation

Responsible for correct use of equipment

Responsible for clean up in lab

Responsible for sample bags

c. Reporter Recorder

Responsible for the field book and entering all notes from the field

Makes oral reports in class when needed

Assists the material manager with samples as needed

NOTE: If there is a fourth person in the group, there would be two materials managers and duties divided equally between them.

If someone is absent in the group for that day, then the people left have to take up the slack.

3. ORGANIZATIONAL MATERIALS

Present the following organizational material to the groups.

a. Badges

Make up plastic name tag badges for all the students to identify what position they are on each day. The badges are color coded by teams and students must wear these badges, in plain view, all the time they are in the field. This is important so you can immediately see if someone is spending too much time with the wrong group. Also, it allows you to make sure only the PI is asking you questions and reporting back to the group. It helps as well to know who is supposed to be doing what on any certain day. A common occurrence is for one or more members of the group to not want and be the PI. This way it is easy to see that at least they are switching badges, and hopefully positions, each day.

b. Rotation

The positions rotate on a daily basis. If it is an all day trip, have students change once or twice in the context of that day. The rotation is as follows, and should be recorded in the front of their field books so they can refer to it daily.

Principle Investigator goes to Materials Manager goes to Reporter Recorder goes to
Principle Investigator

G. Preparatory Information

The following items need to be dealt with before students go out of the classroom. You can determine how best to deal with these things, therefore objectives are not provided for this material.

1. FIELD BOOKS, DATA, AND OBSERVATIONS

Field books should be distributed, 1 per group, before any field work is done. This includes even the preparatory field work and could also include the measurement practice done on stairways. The field book will be part of the evaluation at the end of the unit and the students need to know this up front.

To make field books, get manilla folders for each group, punch three holes in them, insert three-hole punched graph paper, and attach with brads. This makes an inexpensive, fairly sturdy book which the students can record data and observations in while doing their field work. (More expensive books can be purchased or obtained, but this has worked as well or better than anything else I've tried). Put enough graph paper in it, you can xerox as much as you need, so they won't have to be refilled.

The front cover can be decorated any way the group wants, within reason, and each group should come up with a team name and color. The colors will be determined by your badges for the cooperative groups, the name can be chosen, again within reason, by the groups themselves. The inside front cover should have the cooperative group positions, responsibilities and rotation so they can refresh their memory as to responsibilities. The inside back cover should have a checklist of what they are to look for in terms of lithology, paleontology, and measurement.

Have students record all information in their field book in ink. This will prevent any needed data from being erased. Also, remind them that this is a field book, so it doesn't have to look 'perfect.' They will probably get dirty, and since rough data from the field is being entered,

mistakes will probably be made. Have them just line through the incorrect information, but not so they can't read it. This information may be needed later whether they think so or not at that point.

It is important, though, that the information should be clearly labelled as to what it represents, dated, and orderly. (Students really struggle with this, and need constant guidance on how to fill in their field book and in fact recording in it at all. One group a few years ago went through a whole day exercise perfectly, yet failed to enter one thing in their field books. They got so wrapped up in the activity, they forgot to write any of it down!).

Be sure to have students write down anything that they think is important. Better to write too much than too little. Don't leave anything to memory, write it down! Encourage them to use their checklists in the back of the field book as they go through the exercises in the field.

2. EQUIPMENT

Listed below is equipment the students have when they go into the field. Not all of this equipment is essential, nor is it necessarily needed to do field geology effectively.

Each person would need:

Hard Hat: Essential, in my mind, from liability standpoint. These can be donated by companies in your town that use hard hats, or perhaps just borrowed from them. They are almost always glad to do it when you tell them what they are for, and also if you ask!

Old Clothes: That people don't mind getting dirty or messed up.

Each group would need:

Jacobs Staff with string and line level

Hand lens

Sample bags and marking pen

Rock Hammer: Needed if you want students to collect samples of limestones, etc., or chip out fossils. Rock hammers are expensive, and advanced planning would be needed to come up with enough for one per group. Grants are sometimes available for program purchases such as these. I obtained mine through a Southwestern Bell Grant.

Safety Glasses: The person using the hammer would be required to wear these.

Field book

Pens: Two, or three if you are a firm believer in Murphy's Law.

3. SAFETY GUIDELINES

Safety needs to be a priority when in the field, just as it does in all situations. If the students are prepared, you have enough supervision, and the students understand what is expected of them, safety almost takes care of itself and there are less discipline problems than if you were in the classroom. Below are guidelines I tell the students before we leave the classroom.

Hard hats are worn at all times while in the field. (In the field is defined by me as off the bus.)

Safety glasses will always be worn by the person using the rock hammer.

Stay with your own cooperative group unless assigned a specific task by the PI.

No throwing anything, regardless of size.

Do not climb any rock faces that are taller than you without permission.

Do not jump off rock ledges of any height.

Stay at least one meter away from all rock overhangs, and don't kick or throw anything down from a ledge or overhang.

Do not overturn large rocks on the ground.

Stay away from snakes, whether they appear harmful or not.

Respect all forms of life.

Apply tick spray as directed before field work is begun.

Check each other for ticks before you get back on the bus.

Report all accidents, no matter how serious, to the instructor.

Stay within the boundaries of the activity. (I always define these before we start).

Have the students sign a sheet with the above written guidelines and turn it in with their permission slips to indicate they understand and agree to follow the safety rules. Also, take a complete first aid kit into the field.

4. PERMISSION SLIPS

Before the students are allowed to go into the field they must have signed permission slips turned in. First, this assures you that the parents are reasonably well informed of what students will be doing in the field. Secondly, you will be prepared to have students treated medically if an emergency should arise. A sample permission slip is included in Appendix G.

5. SUPERVISION

It is good to have at least one adult for every 3 groups of students, or about a 1 to 9 ratio. I tend to use parent volunteers that I train in the geologic techniques and principles, or past students who are still in the area. I have also used students who are still in school and have gotten permission to get out of classes to help with this activity. Never put yourself in the position of being the only adult present when students are doing field work.

SECTION II

A. Measurement and Recording Data Practice

Before going into the field it is essential to practice measurement techniques. No matter how many times you talk about it or demonstrate it to them, by the time they get into the field, all is lost. If they actually do some measurements before going out, and practice taking data, they will be light years ahead, and so will you! The purpose of these activities is to show the students how to do some of these techniques, and give them practice, before they get into the field situations.

Objectives: TSSBAT

- a) Enter all data clearly into their field books, properly dated, and in ink.
- b) Estimate the height of a wall using two techniques.
- c) Measure a hill using estimation.
- d) Measure the height of a hill using a Jacob's Staff and a line level.

1. ESTIMATION ACTIVITY

Have each group go out and give them the task of estimating the height of a fairly large wall of the school or other structure that would be impossible to directly measure. This could be a tree or phone pole as well. Have students record in their data books their estimated measurement, how they arrived at it, and in what situation in the field they would have to use this technique.

2. JACOB'S STAFF ACTIVITY

Make sure the groups are functioning in assigned roles for their cooperative group at this point. Go to a hill near the school if one is available. If not, you could measure the bleachers in the gym with these methods.

- a. Have students hold the staff vertically and sight along the top of the staff, mark the spot sighted by having their partner stand at that point, and the person holding the staff moves up to that point. The process is repeated up the hill or bleachers. At the top, tally up the number of staff heights to calculate the height of the hill. This would be analogous to measuring a shale slope in the field. Have students record all of their data. The PI decides who does what activity in this process and is the only one to direct questions to the instructor. Now is a good time to start instilling this procedure in them.
- b. Students measure the same hill using staffs, line levels, and strings (see Section I, Part E, 3d). Be sure they record all data.

3. PRESENTATION OF DATA

After all the groups have completed their measurements, have groups report their data, through the reporter recorder, to you and fill in a matrix on the board similar to the one below.

	Group						
	1	2	3	4	5	6	7
Estimation of wall							
Staff Estimation(Hill)							
Staff and levels(Hill)							

Once all the data has been filled in, have students comment on any problems they see. Deal with these problems and ask them to try and identify sources of error. Inexperience, wrong methodology, and math errors should all be considered.

B. Field Site 1

The first field site should ideally have at least 3 or 4 distinct units of different lithology and paleontology. For this particular site I take four to five 30 minute segments to complete the study as opposed to one long all day trip. I take the students out in the context of the class period and shuttle them back and forth. This has the added advantage of not interfering with the rest of the school day. This may not be practical for you, but as with all the field work, your own schedules would have to be devised based upon your unique situations.

The purpose of this first site is to introduce students to field work and have them hone their measurement and collecting skills.

Objectives: TSSBAT

- a) Name from bottom to top the members present.
- b) Measure accurately the members with a Jacob's Staff and line level.
- c) Describe the lithology of the members and collect typical rock samples from each member.
- d) Describe the fossils present in the members and collect typical samples.

1. ORIENTATION AND WALK-THROUGH

Before starting, review all safety principles and boundaries for the activity.

Take the students from the bottom of the section to the top, pointing out where the contact points are for each unit. As you walk through the section, explain some of the major lithologic features to give students an idea of the types of things they will be putting in their field books.

For each geologic member, ask students how they would measure it, what equipment they would need, etc. Have students estimate thicknesses of each unit as they go. Use meters to get them used to the units. If any fossils are evident these should be pointed out as well. Do not give the names of the units at this time, or students may just go to the descriptions in their rock column and use that information. Figuring out the outcrop placement in the column is not part of this activity, though, so eventually you'll give students the member names.

Before students get into their groups to begin the activities, instruct them in the safe use of the rock hammer. Remind them always to wear the safety glasses when using it.

2. MEASUREMENT OF UNITS

Review the measurement techniques using staffs and levels, and remind students of the best measurement methods for different units, mentioned during the walk through. Students are to measure each distinct unit. Remind them to put all data into their field books, clearly and in ink.

3. LITHOLOGY DESCRIPTIONS AND COLLECTING

After groups have taken all of their measurements, have them go through the units and describe the lithology using the checklist at the back of their field books. Also have students collect typical samples of the rock. Remind students to take samples they know are from those units, not ones that have fallen from above, and also to get both fresh and weathered samples. Any unusual features should be noted and samples of minerals should be taken as well if possible. The samples should be no larger than fist size and put into bags that are clearly labelled as to which unit they came from. (This is something they will not do unless you emphasize it. They will assume they can remember what rock unit it came from). Have them code the members with numbers or letters.

4. PALEONTOLOGY DESCRIPTIONS AND COLLECTING

Have students carefully examine each member and describe and collect the fossils present. This is one of the things they really enjoy doing, but can get in the way of the other activities. For that reason, it is probably better for this first site that the fossils not be overly abundant. Have students label the fossils the same way they did the rocks. Fossils and rocks should be in

separate bags. Also, have students take no more fossils than is necessary. Emphasize that it is not necessary for them to identify the fossils in the field. They will take them back to the lab and identify them there. Resist the temptation of telling them what each fossil is. Tell them it's a 'nice specimen' and leave it at that.

Before you leave the field, be sure all students are accounted for as well as all equipment!

C. Lab Work for Field Site I

Once back in the room areas need to be available for the groups to put their samples in a quick, orderly way. It is important to have ample lab time after each field trip to compile all the information and prep them for the next field site.

Objectives: TSSBAT

- a) Report thicknesses of the members of site I.
- b) Clean and label, from each member, rock and fossil samples.
- c) Construct a measured section, to scale, for site I.

1. MATRIX OF MEASUREMENTS

Construct a matrix similar to the one made after measuring the hill. It should be something like what is shown below.

	GROUP	1	2	3	4	5	6	7
member C								
member B								
member A								

Ask the students if there appear to be any problems with the data. Discuss the data and try and account for any problems. If there are any true outliers, ask to see the original data the group took in the field. Ask them also to explain how they took the measurement. If the data looks clear and the group seems to know what they were doing you can either leave the data or come up with averages and let everyone use the averages for constructing their measured section.

2. CLEANING AND LABELLING SAMPLES

Each group should have a pan of water, and any materials necessary for cleaning samples (weak acid, toothbrush, etc.). Have them sort out their samples and clean them, separate them into

group by member, and identify any fossils they collected in the field. For this first site, substantial help will be needed in these areas.

Go around to each group while they are doing this and ask them to show you what they got. Correct any obvious errors that come to your attention.

3. MEASURED SECTIONS

A measured section is a visual and written summary of the rock section that has been studied. Have students construct a measured section of site I. This should be on separate graph paper from their field books and should be done by each member of the group. Lithologic and paleontologic information is to be included on the diagrams as well. Depending on the thickness of the units studied, the scales will vary. For this first section you will almost certainly need to set the scales up for them. After this, they can probably do it on their own.

For the data being used, decide whether students should use their own measurements in constructing their sections, or whether averages should be used for the whole class. Also, you should tell the geologic member names at this time so names can be included on the measured section. Typically, I have students label the system, formation, and member names on the stratigraphic section.

A sample measured section is included in Appendix H.

D. Field Site II

The second field site should be one that has the same layers exposed as site I, or layers that have some similarities. The purpose of the field work at this site is to determine if the layers are the same as the ones at site I. If you cannot find suitable sites for this, the activity can still be done, it will just be much more obvious to the students. I use a site which has the same layers exposed, but different lithology and paleontology. The measurements for the units are the same though. This brings up the concept of the same rock members changing over horizontal distances, a concept called a facies change.

Objectives: TSSBAT

- a) Determine which data is important in determining whether two sites correlate or not.
- b) Collect significant data including lithology, paleontology, and measurement.

1. CORRELATION PROBLEM

Present the students with the problem before you get into the field. The problem is to determine whether two sites have the same rock layers exposed or not; do the two sites correlate.

The students determine which information they need to collect, they outline their plan, and begin to collect the data. Hopefully they will go right to their checklists in their field books and begin going through that. If they don't, and appear to be lost, give some direction as to the type of information they would need to make this comparison.

Students will probably try and determine the answer right away in the field, but don't let them! Encourage them to just collect the data and then determine its meaning back in the lab.

Emphasize that they need to get as much data as possible in the time constraints of the activity, and to make sure that everything is clear and labelled.

E. Lab Work for Field Site II

The overall goal of this time in the lab is to come to some type of conclusion, based upon the data collected, as to whether sites I and II are the same geologic members or are different.

Objectives: TSSBAT

- a) Draw a measured section, to scale, for field site II with the appropriate lithologic and paleontologic information included.
- b) Draw a conclusion based upon field data which is supported by that data.
- c) Describe the similarities and differences between sites I and II.

1. MEASURED SECTION

The students should draw a measured section of site II using the same scale as was used for site I. Once it is completed and all the information is filled in, a comparison should be made between the two sites.

2. PROBLEM SHEET

The correlation problem sheet, located in Appendix I, is to be filled out paying particular attention to the unit similarities and differences. The conclusion students draw should be based upon their data and measured sections.

3. ORAL PRESENTATION OF FINDINGS

The reporter recorder should make an oral presentation to the class on their groups findings. They can simply read their correlation problem sheet, or summarize their findings. There should be time for questions from the other groups or from the instructor. Questions should be encouraged related to what their findings of measurement, lithology, or paleontology were and also of their interpretations.

F. Field Site III

The overall purpose of this site is for students to investigate an unknown rock section and attempt to determine which layers they are studying by comparing their findings to the rock column and descriptions.

Objectives: TSSBAT

- a) Determine the number of distinct units present at a site and measure them.
- b) Describe the lithology of the members and collect samples of each.
- c) Describe the paleontology of the members and collect samples of each.

1. STRATIGRAPHY PROBLEM

Explain to the students the overall problem. They are to determine what units are present at the site by investigating in the three areas of measurement, lithology, and paleontology. Remind them of the checklists in their field books to use as a guide.

Encourage students to just collect data without drawing any conclusions at this time. The conclusions will be drawn in the lab when all the data is sorted out. Emphasize that their conclusions will only be as good as their data.

Many groups will struggle with getting started. The first thing they need to do is determine the number of distinct units, or members, present. If this is an extremely difficult section this is one activity you may need to help them with. Again emphasize the importance of labeling all their samples clearly, and writing down as good a descriptions of the layers as possible.

This makes a good all day trip, and is somewhat of a final exam in the field exercise. I actually go to two sites on this trip where the sections overlap and students get to look at 10 or 11 members in sequence between the two sites.

G. Lab Work for Field Site III

The overall goal of this lab session is to pull all the information from site III together and come to a conclusion based upon the data collected in the field.

Objectives: TSSBAT

- a) Present cleaned and labelled lithologic samples of each of the member units of site III.
- b) Present cleaned and labelled paleontologic samples of each of the member units of site III.
- c) Construct a measured section to scale for site III with all the appropriate information included.
- d) Prepare a final report summarizing their conclusions and reasoning related to the members present at site III.

1. CLEANING AND LABELLING SAMPLES

As before, give students the necessary equipment to clean and prepare their rock and fossil samples. I do not require them to label the actual specimen, but just want them grouped so it is obvious which samples go with which member. You could lay down butcher paper on each table, have students sort their cleaned specimens into groups, and then label the paper.

2. MEASURED SECTION

Have students construct the measured section for site III as they have done the others. It may be necessary to change the scale if the section is much larger than the previous ones. They should go ahead and fill in the member names they think go there. Be sure all lithologic and paleontologic information is included.

3. FINAL REPORT

The group should prepare a final report of this site that should include the following:

- a) Final report sheet, found in Appendix J, with the names of the units filled in and reasoning explained.
- b) All their measured sections of site III attached to the final report sheet.

SECTION III

A. Getting Started

As with anything, getting started is half the battle. As we all know, to get something moving you have to overcome inertia. The amount of inertia something has is determined by its mass, and adding a brand new field geology unit to your curriculum may be more inertia than you think you can overcome. On the other hand though, once this massive object is moving, by the same force it tends to keep moving.

1. GETTING ROOM

Finding a place in your curriculum for a new unit may seem to be a Herculean task. In fact, it very well may be. I will not presume to tell you how in fact this can be done in your situation, or even whether it can be done at all. The first thing you must realize though is that if this comes into your curriculum, or anything does, something must go! As I evaluated the things I did during the year I had to make some hard decisions. There were some things which went easily, others hard. The point here is that this decision must be made, and there is no use going any further if you are not willing to cut other things out, or at least tighten them up.

2. GETTING HELP

Some help will more than likely be needed in the area of choosing sites, finding out about local geology, or other technical items. There are several places you can look to for help. First of all, see if there are any other teachers in schools close by who are doing these types of activities. If they are, ask them to fill you in on what they do, where they do it, where they went to for help, etc. It's amazing how many times people are willing to reinvent the wheel, simply because they weren't aware someone was doing something similar close by. When you are doing research, you always do a literature search. When you are adding curriculum, do a similar search of what other teachers are doing in your area and utilize their expertise. Secondly, if no other teachers that you can discover are doing these activities, check out the State Geological Survey. For Kansas, the state survey is located in Lawrence on the University of Kansas Campus. Geologic Surveys often have someone in charge of educational materials or field trips and can help you become acquainted with sites or other information you may need. Lastly, local colleges or universities have geology classes that routinely go into the field. Check with the geology departments at these places to see if they can be of any help.

The expertise is out there somewhere, go find it!

3. GETTING OUT

Like the Nike commercial says, "Just Do It!" There is no substitute for getting out in the field and checking out possible field sites on your own or with others. Sitting behind a desk with a stack of ungraded papers can make the most exciting ideas seem like pipe dreams. Get out, look around, and the possibilities will seem endless.....for they really are.

B. Evaluation

As always, in this type of enterprise, evaluation can be tricky if not downright thorny. I have found that sharing the evaluation scheme below with students at the beginning of the section helps them, and you, to understand how things will be graded. If this is not done that incessant question, "Does this count" or "Is this important", or "Will this be on the test" will always crop up. I have used the following scheme with success. The specifics of how you evaluate will be different, but I would recommend the following areas and percentages.

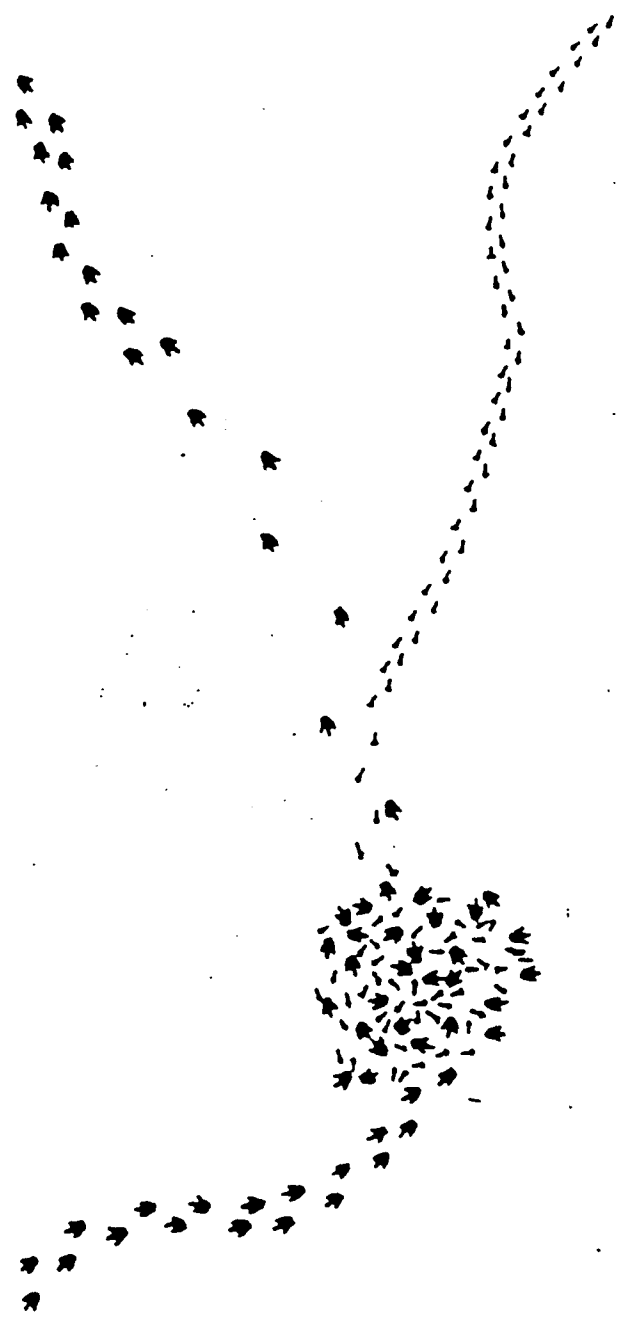
Site I Samples	5%
Site I Measured sections	5%
Site II Measured Sections	10%
Site II Correlation Problem	10%
Site III Samples	10%
Site III Measured Sections	10%
Site III Final Problem	10%
Field Books	15%
Written Test	15%
Cooperation/Participation	10%

The actual points for each item would vary depending on the total points you assign for this unit. This type of breakdown allows for several different forms of evaluation. I would definitely place emphasis on the field books as once they get into the room, that is their link to the outdoors. They need to know this so they can concentrate on taking good notes, making good observations, and clearly recording it. The written test can be any format you deem appropriate. Just be sure the test reflects what you wanted them to know and get from this unit. Explanation questions tend to be more applicable than strict multiple choice. The Cooperative/Participation line item is there for a subjective way to reward groups for being exemplary as well as for disciplinary measures.

I give all the members of the group the same grade except the last two items. I give group grades on the measured sections as a form of quality control. They tend to help each other out more and check each others work.

SECTION IV
Appendixes A-J

APPENDIX A
Footprints diagram

















Kansas Geological Survey

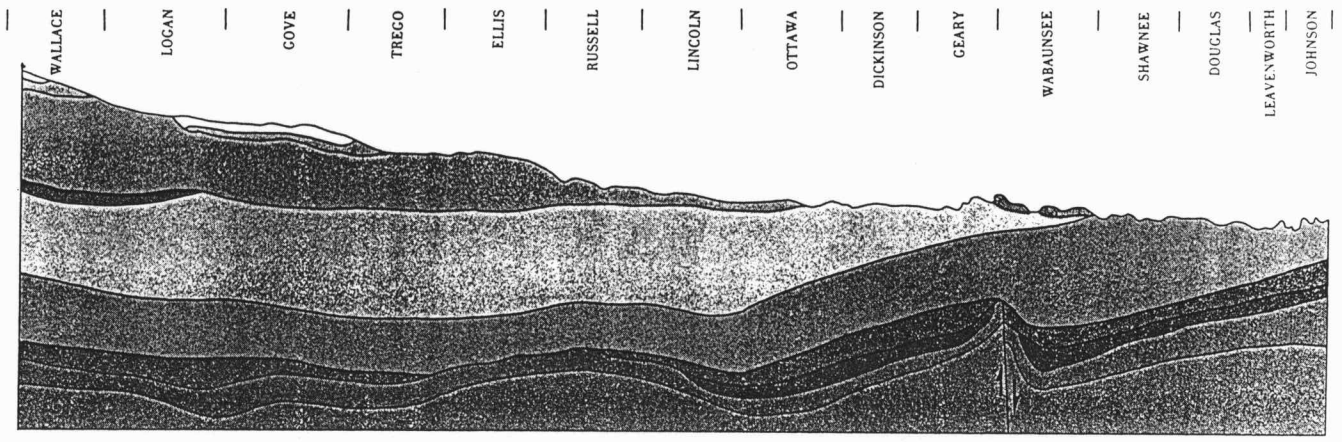
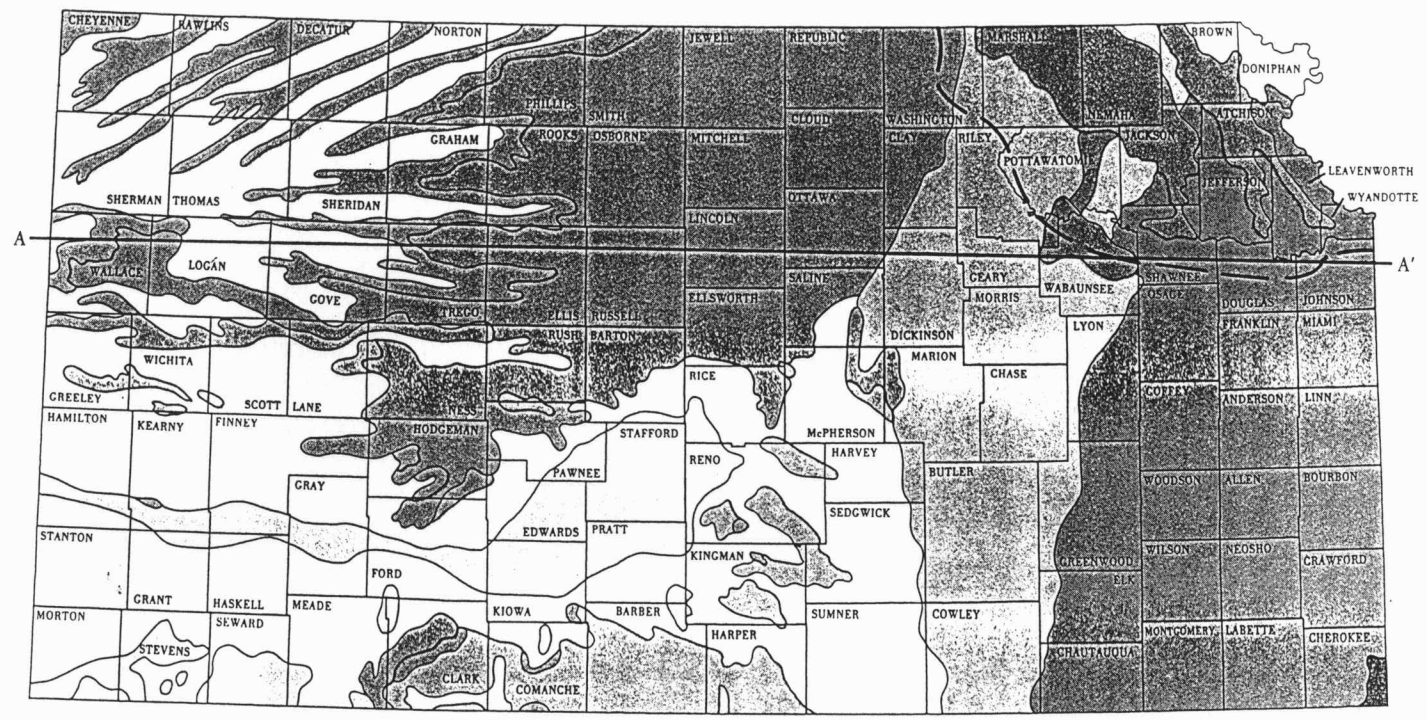
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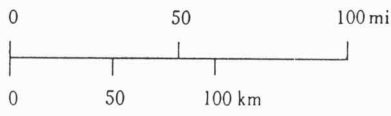
Generalized Geologic Map of Kansas

EXPLANATION

-  QUATERNARY SYSTEM
Loess and river valley deposits
-  Sand dunes
-  Glacial drift deposits
-  Limit of Kansan Glacier
-  TERTIARY SYSTEM
-  CRETACEOUS SYSTEM
-  JURASSIC SYSTEM
-  PERMIAN SYSTEM
-  PENNSYLVANIAN SYSTEM
-  MISSISSIPPIAN SYSTEM
-  SILURIAN-DEVONIAN SYSTEMS
-  CAMBRIAN-ORDOVICIAN SYSTEMS
-  PRECAMBRIAN SYSTEM
-  A—A' Line of cross section








Geologic cross section below I-70



APPENDIX C
Kansas Geologic Timetable

KANSAS GEOLOGIC TIMETABLE

(Not scaled for geologic time or thickness of deposits)

ERAS	PERIODS	EPOCHS	EST. LENGTH (YEARS) *	DESCRIPTION	
CENOZOIC	QUATERNARY	HOLOCENE	10,000+	Early, the land was stable with some erosion. Glaciers moved into the northeast at least twice. Later the climate was dry. Sand dunes were formed by wind in the west. Volcanic ash was blown in from California, New Mexico, and Wyoming.	1.6
		PLEISTOCENE	1,590,000		
	TERTIARY	PLIOCENE	3,700,000	Rocks found are part of the Ogallala Formation (sand, gravel, and porous rock), which contains a large quantity of ground water and occurs only in the western third of the state. No rocks were formed in eastern Kansas.	
		MIOCENE	18,400,000		
		OLIGOCENE	12,900,000		
		EOCENE	21,200,000		
PALEOCENE		8,600,000			
MESOZOIC	CRETACEOUS		77,600,000	Much of the western half was covered by seas. Limestone, sandstone, and chalk formed from sea deposits. Fossils can be found in these rocks, which crop out in central and western Kansas.	66.4
	JURASSIC		64,000,000	Most rock in Kansas is underground in the west. A few small outcrops are found in the southwest corner.	144
	TRIASSIC		37,000,000	No rocks have been found in Kansas.	208
PALEOZOIC	PERMIAN		41,000,000	Much of Kansas was covered by several seas. As they rose and fell, limestone, shale, and chert were deposited. The Flint Hills were formed. When the seas dried up, salt and gypsum were left behind. Salt, now underground, is mined in central Kansas. The Red Hills were formed from deposits of shale, siltstone, sandstone, gypsum, and dolomite.	245
	PENNSYLVANIAN		34,000,000	For much of the period the land was flat. Seas and swamps came and went; coal formed in swamps from dead plants. Shale, limestone, sandstone, chert, and conglomerates were deposited. Two ridges of hills, the Nemaha uplift and the Central Kansas uplift, appeared; both are now buried. Pennsylvanian rocks are found at the surface in eastern Kansas.	286
	MISSISSIPPIAN		40,000,000	Repeated layers of limestone, shale, and sandstone indicate that seas rose and fell. Mississippian rocks are the oldest found at the surface and are in the southeast corner; elsewhere these rocks are only underground.	320
	DEVONIAN		48,000,000	Seas covered Kansas during much of the period. Limestone, shale, and sandstone deposits are only underground.	360
	SILURIAN		30,000,000	Land was uplifted and seas disappeared. Limestone deposits are found only underground.	408
	ORDOVICIAN		67,000,000	Seas covered parts of Kansas during much of the period. Dolomite and sandstone are only underground.	438
	CAMBRIAN		65,000,000	Early, the climate was dry and many rocks eroded. Later, parts of Kansas were covered by seas. Dolomite, sandstone, limestone, and shale are now underground.	505
	PRECAMBRIAN		3,930,000,000	These rocks are the oldest on earth. In Kansas, they are only found deep below the surface and not much is known about them. Many are igneous and metamorphic and have gone through many changes.	570

MILLION YEARS PAST

Eons not shown

* Decade of North American Geology 1983 Geology Time Scale, Geological Society of America

APPENDIX D

SLIDES ILLUSTRATING KANSAS GEOLOGY : The following narrative was developed from the book "Kansas Landscapes: a geologic diary," by Frank W. Wilson. Kansas Geological Survey, 1978.

The suite of slides can be borrowed for a short term loan for in class use, by contacting Dr. William LaShier, Department of Curriculum & Instruction, School of Education, The University of Kansas, Lawrence, Kansas 66045, (913) 864-4435. Many of the slides were taken and loaned for educational uses by Rex Buchanan, Kansas Geological Survey.

1. GENERALIZED PHYSIOGRAPHIC MAP OF KANSAS

The twelve physiographic or landform regions of Kansas are shown. The physiography, or shape the land takes, is strongly influenced by the geology. Have the students try to point out similarities between this map and their Kansas Geologic Map. How has the geology influenced landforms?

2. MISSISSIPPIAN LIMESTONE; CHEROKEE COUNTY

In the extreme Southeast corner of Kansas, a small amount of Mississippian aged limestone is exposed at the surface as part of the Ozark Plateau laps over into Kansas. How old are these rocks according to your geologic timetable? (320 - 360 m.y.) What processes formed them? (Seas rising and falling)

3. SCHEMERHORN CAVE; CHEROKEE COUNTY

Running water can dissolve limestones and caverns may form. This cavern is in Mississippian aged rock in extreme Southeast Kansas. If the roof of a cavern were to collapse, a sinkhole would form. Missouri has many caves made in this way.

4. GALENA MINING; CHEROKEE COUNTY

Galena is the mineral from which lead is obtained. These minerals were place by mineralized water moving through broken rock. Chat piles, or the cherty rock from which the mineral has been removed, are seen in the background. This "chat" is commonly used for railroad beds. What age rocks do these deposits represent? Check geologic map and timetable. (The Galena is mostly in Mississippian aged rocks, but was probably deposited itself at a much later date. The rocks therefore are 320 - 360 m.y. old, while the minerals themselves could only be said to be younger than that.)

5. COAL MINING; CRAWFORD COUNTY

Coal was formed as dead vegetation accumulated at the bottom of swamps and was buried and compressed over long periods of time. This area is known as the Cherokee Lowlands, and the Cherokee Group of rocks found here contains at least 14 coal beds. About what age are these rock layers? (Pennsylvanian, 286 - 320 m.y.)

Steam shovels, such as the one shown, are used to strip the earth away and dig the coal out to load it into trucks. What might be some problems associated with this type of mining? (If left that way, land could not be used for anything. Would need to be 'reclaimed.') What is coal mostly used for in the United States? (Fuel for electric generating plants.)

It should be noted that at the present time there are regulations regarding strip mining, and the land is usually reclaimed in a short amount of time, albeit at a slightly lower elevation!

6. PENNSYLVANIAN SANDSTONE; CHATAUQUA COUNTY

Sandstones are part of the cycle of deposition as the seas came and went over Kansas. In what environment could these rocks have possibly been laid down? (Beach, stream or river channels, or desert environments might be possible answers. These sandstones were probably laid down as ancient deltas deposited sand as streams emptied into the seas.)

The next three slides show evidence of cyclic deposition of rocks known as cyclothems. These were first described in Kansas in the 1930's by R.C. Moore who theorized that each limestone and shale represented a time when the Pennsylvanian sea transgressed and regressed (came and went).

This model begins with a lower limestone, generally thin (from 1- 10 feet thick) that was probably deposited as the sea deepened. Above that is a generally black, fissile (thin and platy) shale, 5 - 10 feet thick. This shale is considered an offshore, marine shale and was probably deposited as the seas reached their maximum depth. Next came an upper limestone that is generally up to 20 feet thick and was deposited as the seas regressed (receded). Then an upper shale was deposited in a non-marine environment. This upper shale is brown to gray, in contrast to the lower dark-gray to black marine shale. Sandstones would have been deposited if a beach environment was present.

(Taken from AESE Field Trip Road Log, 1985, by Rex Buchanon and Jim McCauley. Kansas Geological Survey)

The alternating limestones and shales, due to their differing resistance to weathering and erosion, form an interesting topographic feature. Since the layers all slope gently to the west

and the limestones are more resistant, a series of parallel ridges with steep east faces and gentle west faces occurs. This type of landform is called a "cuesta." This Osage-Cuesta physiographic area is roughly the same as the Pennsylvanian aged rocks in Kansas.

7. OREAD LIMESTONE FORMATION; DOUGLAS COUNTY; CLINTON LAKE SPILLWAY

The layering of the limestones and shales are apparent. The uppermost layer shown is the Plattsmouth limestone which caps many of the hills in Douglas County including Mount Blue, near Eudora, and Mount Oread, which Kansas University sits atop. A thin limestone in the middle of the slope is barely visible, and the black fissile shale is immediately above it. Try to pick out the alternating layers from bottom to top. (Shale slope at bottom, limestone face, gray-brown shale, thin limestone, black, fissile shale, thick limestone at top)

8. OREAD LIMESTONE FORMATION; DOUGLAS COUNTY; CLINTON LAKE SPILLWAY

This is a view from the top of the Oread limestone standing atop the Plattsmouth limestone member. The cycle of deposition can be seen by the terracing effect present.

9. KANWAKA SHALE FORMATION; DOUGLAS COUNTY

The large shale unit shown across the road is the Jackson Park member of the Kanwaka Shale. Limestones can be seen above (Clay Creek) and below (Kereford) this thick shale unit. Red, sandy-shale partings are visible within the shale. Land plant fossils can be found in this layer indicating deposition on land.

10. FLINT HILLS; CHASE COUNTY

The Flint Hills occur just west of the Osage-Cuesta Pennsylvanian area. What aged rocks correlate to the Flint Hills? (Permian aged, 245-286 m.y.) These were formed by the Flint or Chert, the terms are essentially synonymous, being deposited in these rocks making them, and the gravel that comes from them, more resistant to erosion. (Limestone is made commonly from the mineral Calcite with a hardness of 3 on the Mohs hardness scale. Chert is microcrystalline quartz which has a hardness of 7, much more resistant to weathering and erosional processes.) As a result, the Flint Hills are at a higher elevation than the land to the east or west. The absence of trees on the uplands of the Flint Hills has been attributed to the effects of periodic droughts and to lightning-set prairie fires. More recently, fires have been purposely set to burn off the dry grass.

There are three main limestone layers which have abundant chert found in them. The Three Mile Limestone, the Schroyer Limestone, and the Florence Limestone. These form three distinct

terrace levels in the Flint Hills. The prairie landscape and terracing effects can be seen in the slide. Where might trees have a chance for survival on the Flint Hills? (Valley bottoms or other sharp breaks in topography that might protect the trees from fire)

SLIDES 11,12,13 SHOW VIEWS OF LIMESTONE LAYERS CONTAINING CHERT. THE VIEWS ARE PROGRESSIVELY CLOSER.

11. FLORENCE LIMESTONE; RILEY COUNTY

12. FLORENCE LIMESTONE; RILEY COUNTY

Note how some of the chert is random while other chert is organized into bands.

13. THREE MILE LIMESTONE; RILEY COUNTY

14. HUTCHISON SALT; RENO COUNTY

As the seas shrank in size, some of the arms were cut off causing minerals to be deposited as the waters evaporated. Gypsum and salt are two ones left in great abundance in parts of Kansas. The Wellington and McPherson lowlands is the area represented by this. These salt beds are mined near Hutchison and can reach thicknesses of hundreds of feet. What age would these salt beds be from your timetable? (This is still Permian deposition, 245 - 286 m.y.) Because salt is extremely stable where it is deeply buried, national records and documents are stored in deep salt mines near Hutchison.

15. CHEYENNE BOTTOMS; BARTON COUNTY

This is a large sinkhole located in central Kansas which has filled with water. Although this is a freshwater sink, there are other sinkholes near the leading edge of the Hutchison salt, that form salt marshes which look similar to the Cheyenne Bottoms.

16. PERMIAN RED BEDS; CLARK COUNTY

In the later Permian period, thousands of feet of red shales and sandstones were deposited. These layers have been exposed by erosion in the area called the Red Hills.

Beds of light gray gypsum and dolomite are contained at the bottom of the rock outcrop shown.

17. RED HILLS; BARBER COUNTY

The gypsum and dolomite cap the shale hills in this area to make a butte-and-mesa topography. The Indians called these hills the Medicine Hills and the stream that flows from them the

Medicine River. Can you think of any reason why they may have called them this? (Magnesium sulfate, otherwise known as Epsom Salts, and other therapeutic minerals dissolve out of the gypsum and dolomite beds. These natural compounds had healing effects.)

18. TWIN PEAKS; BARBER COUNTY

These are pyramid shaped peaks located in the Red Hills also capped by gypsum and dolomite.

19. LITTLE BASIN; CLARK COUNTY

Near the Red Hills gypsum and salt beds dissolved by groundwater are thought to have formed large sinkholes. This is a cavern whose roof has collapsed causing the ground to 'sink.' About a third of a mile to the west is Big Basin, a sinkhole with a diameter of a mile and a depth of more than 100 feet. Do you think sinkholes are still forming today? (Yes, the same processes that formed these sinkholes are still acting today. In April 1973, a new sink began forming near these called the Seybert sink.) What potential problems could arise from sinkholes? (Settling of land with roads on them This is currently happening on I-70 in Russell county, causing dips or cracks to form in the road. Constant maintenance of this part of the interstate is needed. In extreme cases, where the collapse of land is catastrophic, homes or other structures may end up at the bottom of a large hole.)

The Smoky Hills is the next Physiographic Region. This region is made up of three distinct rock types including the sandstones of the Dakota formation, the Greenhorn Limestone, and the Niobrara Chalk beds. Slides 20 through 25 illustrate this region.

20. DAKOTA FORMATION; ELLSWORTH COUNTY

The easternmost range of hills in the Smoky Hills is capped by the thick sandstones of the Dakota Formation. Outlying hills and buttes here rise above the plains. Coronado heights, north of Lindsborg, is one such hill. It was named this because Coronado, who explored the region in the 1500's looking for the legendary 'Cities of Gold', was said to have climbed this as a vantage point for the surrounding area. How do you think these buttes formed? (Stream erosion) What age rocks are the Dakota sandstones? (Cretaceous period, 66 - 144 m.y.)

21. MUSHROOM ROCKS; ELLSWORTH COUNTY

Huge spheres of the Dakota Sandstone are found in this area at several locations. At Rock City they sit on the ground like huge bowling balls. At Mushroom Rocks State Park they are balanced on natural pedestals of softer rock. Through what process might these have formed?

(Groundwater circulating through sandy rock deposited a limey cement which grew outward in

all directions from fragments acting as a nucleus. As softer, uncemented portions of the sandy rock were weathered away, the spherical, cemented zones remained forming these pedestal structures.)

22. FENCEPOST LIMESTONE; RUSSELL COUNTY

The middle range of hills in the Smoky Hills is capped by the Greenhorn Limestone. Are these rocks older or younger than the Dakota sandstones? (Younger, they are west of the Dakota sandstones.)

At the very top of the Greenhorn Formation is a one-foot-thick layer of rock called the "Fencepost" Limestone. Since lumber was scarce, settlers quarried this limestone and made fenceposts out of it. It is fairly uniform in thickness and slabs could be split off and sawed to proper lengths. When quarried the limestone is relatively soft, but hardens as it is set in place. Most of the original posts remain in good condition even though many generations of wire have come and gone.

23. WILDCAT CANYON; NIOBRARA CHALK; TREGO COUNTY

The westernmost Smoky Hills are made of Niobrara Chalk. What geologic age did these form in? (Still the Cretaceous) Is this formation older or younger than the fencepost limestone? (Younger, it is further west) Chalk is a sediment of the open ocean, composed almost entirely of the remains of microscopic marine plants and animals which floated or swam near the surface of the Cretaceous sea. These organisms were extremely abundant, and as their remains settled to the seafloor they formed a limey ooze that was excellent for preserving the remains of many larger organisms. Given the age of these rocks, what type of fossils might be found here? (Extinct fishes, flying reptiles, Plesiosaurs, Mososaurs, and other ancient forms of life) These chalkbeds are world famous for the abundant vertebrate fossils present.

The canyon shown was cut by stream erosion through the soft chalkbeds.

24. MONUMENT ROCKS; GOVE COUNTY

Well known Cretaceous landmark of the Niobrara Chalk caused by erosion from the ancestral Smoky Hill River.

25. CASTLE ROCK; GOVE COUNTY

Well known Cretaceous landmark also caused by the Smoky Hill River carving its course through the landscape. Why might a rock such as this been important to pioneers going west? (Used as a landmark, as it was by the Butterfield Stageline.)

26. HIGH PLAINS; GOVE COUNTY

During the Tertiary period, see geologic timetable, the Rocky Mountains were being uplifted in the Western United States. As this happened, streams flowed eastward onto Western Kansas and deposited massive amounts of rock, gravel, sand and debris. This caused a buildup of the Western part of the state. Buried under the surface is the Ogallala Formation, the main aquifer for Western Kansas. Right now, water is being removed more quickly from the formation than is being supplied. Over time, what will happen to the Ogallala formation and the farms in Western Kansas if this trend continues? (The aquifer will run dry and farms will have a hard time existing out there, much less raising crops.)

27. POINT OF ROCKS; OGALLALA FORMATION; MORTON COUNTY

The Ogallala has been exposed at several places due to stream erosion.

28. ELEPHANT ROCK; OGALLALA FORMATION; DECATUR COUNTY

A strange rock outcrop formed by erosional processes.

29. SAND DUNES; KEARNEY COUNTY

Sand was deposited by the ancestral Arkansas and Cimmaron Rivers in abundance in Western Kansas. Pleistocene winds swept this sand into dune structures still visible today in parts of Western Kansas. What type of rock would this form over time? (Sandstone)

30. GLACIAL BOULDERS; POTTAWATOMIE COUNTY

During the Pleistocene period in geologic history there were four major advances of continental ice sheets during what is often called the "Great Ice Age." The second one of these covered most of Northeast Kansas. The dashed line showing the furthest advance of this glacier can be seen on the geologic map. It roughly correlates with the location of the present day Kansas River.

The glacial boulders are Sioux quartzite, a metamorphic rock, and are called "erratics" because they were not formed here, but brought down by the glacier and deposited as it receded. The nearest outcrops of this type of rock are in Minnesota and South Dakota.

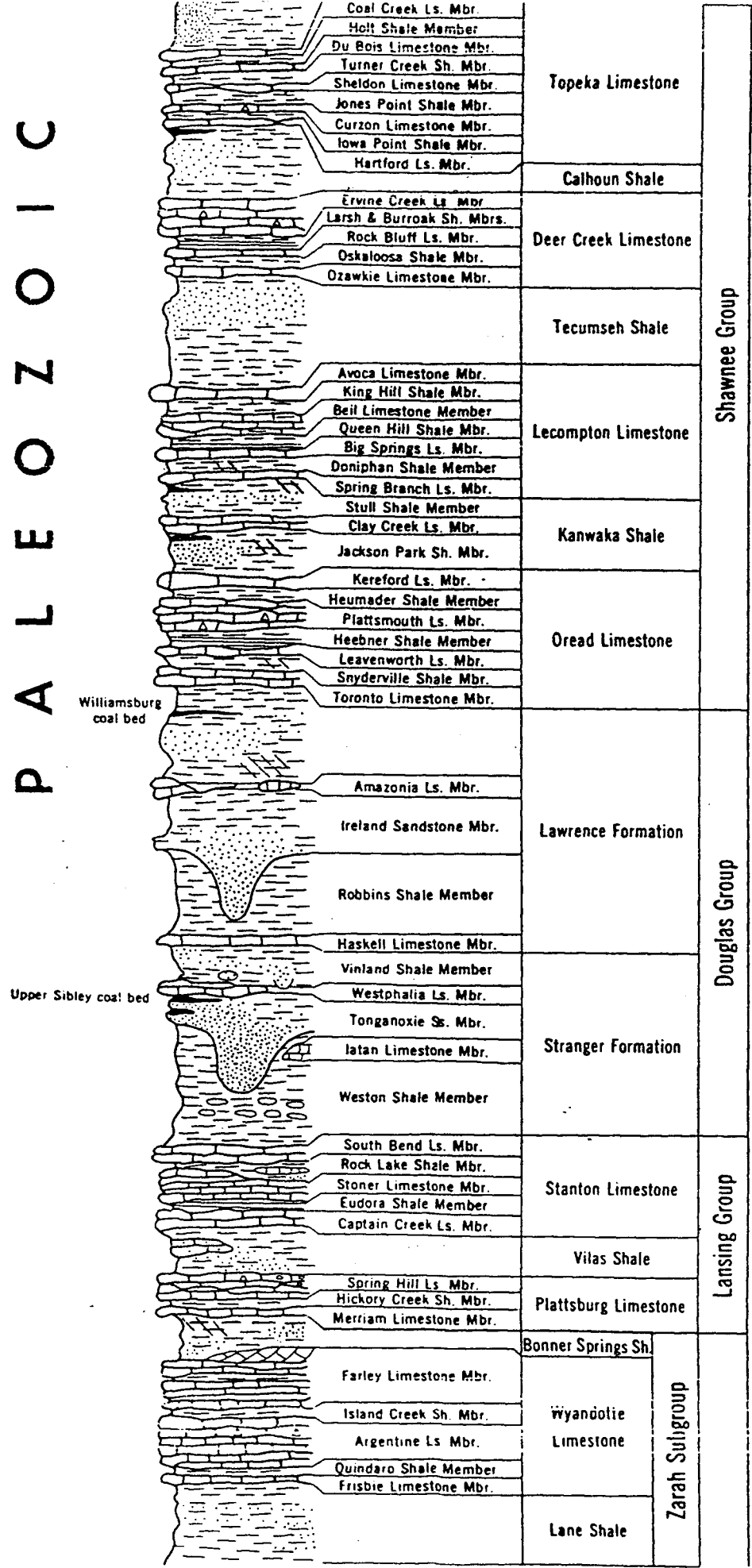
31. GLACIAL ERRATIC; MARSHALL COUNTY

As seen from this picture, the size of boulders moved by a glacier could be quite impressive. Is it possible for glaciers to ever cover Kansas again? (Yes, in fact quite likely. Many scientists feel that we are only in an interglacial warming period at this time, and once again, in the near 'geologic' future, ice may advance over much of the landmasses of the world.)

32. THICK LOESS DEPOSITS; DONIPHAN COUNTY

During the Pleistocene, the winds also picked up silt and deposited it in large quantities in Northeast Kansas as the glaciers retreated. These thick wind-borne silt deposits are called "loess", and can commonly form deposits over a hundred feet thick. Driving on I-70 just west of Kansas City, several loess deposits are exposed.

P A L E O Z O I C



Williamsburg coal bed

Upper Sibley coal bed

VIRGILIAN STAGE

UPPER PENNSYLVANIAN SERIES

PENNSYLVANIAN SYSTEM

MISSOURIAN STAGE

THIS ROCK COLUMN AND THE FOLLOWING DESCRIPTIONS ARE TAKEN FROM ZELLER'S "THE STRATIGRAPHIC SUCCESSION IN KANSAS", 1968. KANSAS GEOLOGICAL SURVEY BULLETIN 189, pp. 32-39.

abundant mollusks, particularly myalinid clams, characterizes the upper part of the Vinland Shale. The thickness of the Vinland ranges from about 2 to 50 feet.

LAWRENCE FORMATION

The Lawrence Formation consists chiefly of gray shale and sandstone, which weathers yellowish-gray, and minor amounts of red shale, coal, gray limestone, and conglomerate. The Lawrence is subdivided into five members, of which the Haskell and Robbins members were formerly included in the underlying Stranger Formation. As redefined, the Lawrence Formation now extends from the base of the Haskell Limestone Member to the base of the overlying Toronto Limestone (O'Connor, 1963). Thickness ranges from 140 feet in northern Kansas to 250 feet in southern Kansas.

HASKELL LIMESTONE MEMBER

The Haskell Limestone Member is a bluish-gray, fine-grained limestone, with a locally developed oölitic facies at the top and base in which pelecypods and gastropods occur. The main part contains algal remains, fusulinids, and brachiopods. This is the most continuous marker bed within the Douglas Group. Thickness ranges from 0 to 12 feet.

ROBBINS SHALE MEMBER

This member consists of gray and yellowish-gray marine shale, which is locally eroded and overlapped by the Ireland Sandstone Member in Franklin County and southern Douglas County. Phosphatic concretions and black fissile shale occur in a zone at the base of the member in the northern part of the outcrop area. Locally a molluscan fauna occurs in the lower beds. The thickness is 0 to 120 feet.

IRELAND SANDSTONE MEMBER

This member consists of shales and siltstones with some coal in the upper part and is typified by lenticular light-buff to brown, thin-bedded, in part cross-bedded, and massive sandstones in the lower part (O'Connor, 1963, fig. 3; Ball, 1964). The sandstone is thickest where it lies discontinuously upon the Robbins Shale Member or older beds. In some places, especially where the Ireland cuts through the Haskell Limestone Member and into the Stranger Formation, a limestone conglomerate is found at the base of the sandstone. The thickness of the Ireland Member ranges from 30 to 120 feet.

AMAZONIA LIMESTONE MEMBER

This member is typically a light-gray, dense, lenticular limestone. Locally it is coquinoïdal or brecciated in appearance. Outcrops are found in Doniphan, Atchison, Franklin, Coffey, and Woodson counties and possibly farther south. Fossils are not abundant generally, but sponges are common locally in the member (Atchison County) and fusulinids occur in southern Kansas. Thickness ranges from 0 to about 14 feet.

An unnamed shale unit comprises the upper part of the Lawrence above the discontinuous Amazonia Limestone Member. It consists primarily of gray, green, and red shale and earthy limestone with minor amounts of siltstone and sandstone, and from Douglas County to Elk County contains the *Williamsburg coal bed*. Fossils are common at the top of this unit in southern Kansas. Thickness ranges from 10 to 60 feet.

SHAWNEE GROUP

The Shawnee Group comprises four limestone and three shale formations. Comparatively thick limestones and a distinctive type of cyclic sequence (Moore, 1935) are characteristic of these rocks. The average thickness is about 325 feet.

OREAD LIMESTONE

The basal formation of the Shawnee Group comprises four limestone members and three shale members, which form a prominent escarpment across the State from Doniphan County, in the north, to Chautauqua County, in the south (Fig. 1). The average thickness in northern and central Kansas outcrops is 52 feet. In southern outcrops the thickness increases to about 100 feet owing mainly to expansion of the interval between the lower two limestone members.

TORONTO LIMESTONE MEMBER

The Toronto Limestone Member is brownish-gray, massive limestone that weathers deep brown. The Toronto is typically developed from Woodson County northward, but it is thinner, sandy, or locally absent in southeastern Kansas. The member is absent also in parts of southern Douglas and western Franklin counties, where a limestone conglomerate occupies its approximate stratigraphic position. Fusulinids, corals, and small brachiopods are the most common fossils. The thickness of the Toronto in northern outcrops ranges from 5 to 12 feet. In southern outcrops it is generally less than 4 feet thick.

SNYDERVILLE SHALE MEMBER

This member contains gray to bluish-gray, red, and green claystone and shale. In northern outcrops, the lower and middle parts are a structureless underclay-like deposit; in southern outcrops, the member becomes more sandy and locally contains sandstone and nodular, argillaceous limestone. Marine fossils, especially *Chonetes*, occur in the uppermost part. The thickness in the northeastern part of the State averages about 12 feet, but in southeastern Kansas it increases to about 75 feet.

LEAVENWORTH LIMESTONE MEMBER

The Leavenworth Limestone Member is a dark bluish-gray, dense, massive limestone occurring in a single bed, which has closely spaced joints. Fusulinids, brachiopods, and gastropods are the most common fossils. The member is absent locally in Franklin County. Almost everywhere along the outcrop its thickness is more than 1 foot and less than 2 feet.

HEEBNER SHALE MEMBER

In many outcrops this member consists of four distinct shale units which are, in ascending order: a thin bed of gray or yellow clay shale, black platy shale, dark bluish-gray shale, and calcareous clay shale. The black platy shale is almost everywhere the thickest part and is commonly less than 3 feet thick. Small brachiopods occur in the calcareous clay shale, conodonts are found in the black shale, and locally there are numerous gastropods and chonetid brachiopods in the thin clay shale at the base of the member. The thickness of the Heebner Shale in outcrops is commonly 5 to 8 feet. It is also a widely distributed subsurface marker identified in radioactivity logs by its intense gamma ray emission.

PLATTSMOUTH LIMESTONE MEMBER

The Plattsmouth is the thickest of the limestone members of the Oread Limestone. Commonly it is light bluish-gray, light-weathering, wavy-bedded, dense limestone. Chert is locally abundant in the northern part of the outcrop. Fossils include fusulinids, corals, bryozoans, brachiopods, and mollusks. The thickness is commonly 15 to 30 feet.

HEUMADER SHALE MEMBER

The Heumader Shale Member is chiefly gray to greenish-gray, clayey to silty shale, which becomes more sandy in southeastern Kansas. Well-preserved mollusks and other fossils are common. The thickness in northeastern Kansas ranges

from 2 to 5 feet and increases to as much as 33 feet in Osage County. It is relatively thick in the southern part of the outcrop area.

KEREFORD LIMESTONE MEMBER

This member is extremely variable in thickness and lithology. Locally it is predominantly light-gray oölitic limestone, even-bedded, dense, blue-gray flaggy limestone, or thick, fine-grained, gray to blue-gray limestone. In northeastern Kansas, upper slabby cross-bedded layers, containing algal and locally land-plant remains, overlie more massive rock that contains fusulinids and other marine invertebrates. In southeastern Kansas, it is locally sandy and contains invertebrate fossils, also. The thickness ranges from 0 to more than 40 feet.

KANWAKA SHALE

In northeastern Kansas, the Kanwaka Shale is divisible into two shale members and a limestone member. In southeastern Kansas, much of the interval between the Oread and Lecompton limestones is occupied by sandstone, sandy shale, and red shale, collectively called the "*Elgin sandstone*." The outcrop thickness ranges from about 40 to 145 feet.

JACKSON PARK SHALE MEMBER

The Jackson Park Shale Member is a bluish-gray to yellowish-brown and red sandy shale and sandstone. Land-plant fossils are more or less abundant. Locally in Douglas County, a thin coal bed and pelecypod-bearing sandy layers occur in the upper part. The thickness ranges from 16 to 52 feet.

CLAY CREEK LIMESTONE MEMBER

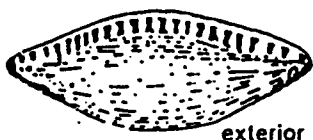
This member is dark-blue to bluish-gray, commonly massive and dense limestone. Fusulinids are locally abundant and other fossils are fairly plentiful. Locally, oölitic, algal, and crinoidal deposits occur in the upper part. The Clay Creek Limestone is persistent in northeastern Kansas at least as far southward as Osage County and is identified in Coffey, Greenwood, and Elk counties as a zone of limestone and fossiliferous, calcareous, sandy shale. The thickness may be as much as 5 feet.

STULL SHALE MEMBER

The Stull Shale Member is a yellowish-brown to red, sandy shale, locally containing one or more coal beds. Sandstone, with somewhat plentiful land plants, occurs in the upper part of the member in northeastern Kansas. The Stull Shale

FOSSILS OF KANSAS

FUSULINID PROTOZOA



exterior



interior

Triticites (FUSULINID) x10

CONULARIID SCYPHOZOA (JELLYFISH)



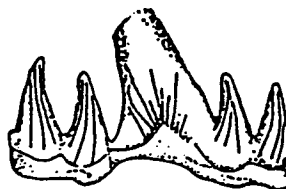
Conularia

ANTHOZOAN (CORAL)

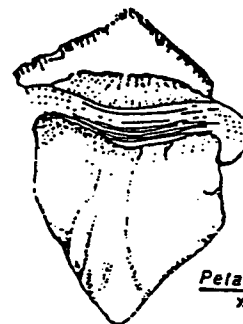


HORN CORAL
(RUGOSE CORAL)

SHARK'S TEETH



Cladodus x1.3

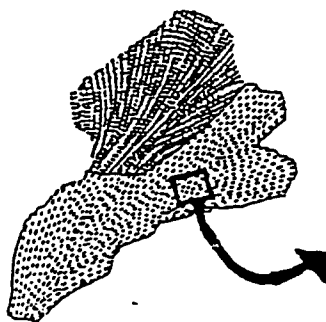


Petalodus
x2

BRYOZOA (MOSS ANIMALS)



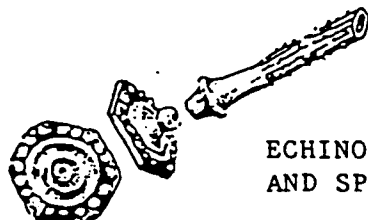
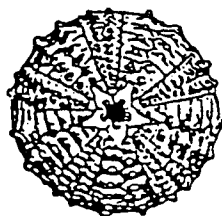
RAMOSE (BRANCHING)
BRYOZOA



LACY BRYOZOA
(FENESTELLID BRYOZOA)



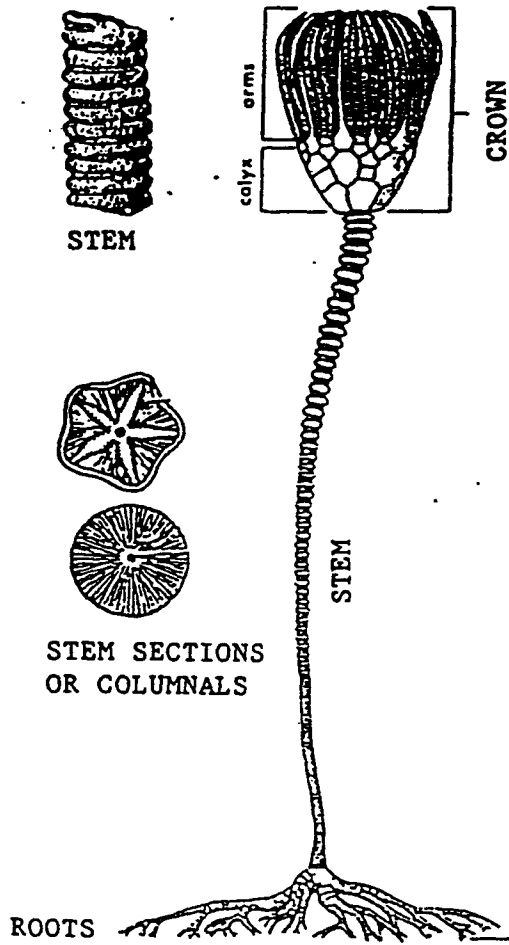
Fenestrellina



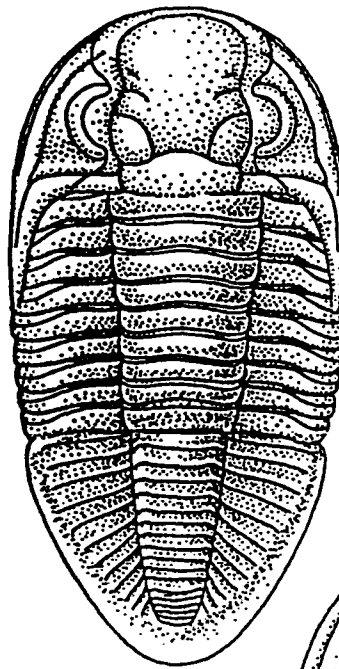
ECHINOID PLATES
AND SPINE

ECHINOID ECHINODERMS (SEA URCHINS)

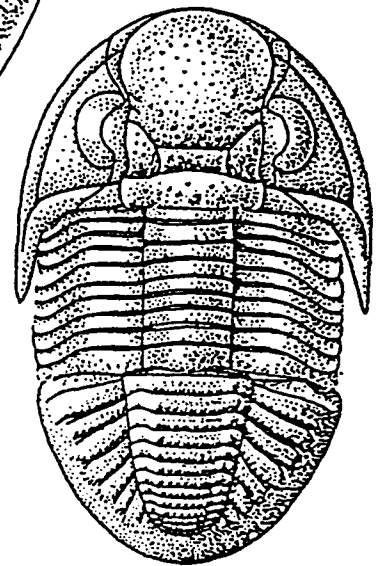
CRINOID ECHINODERMS
(SEA LILLIES)



TRILOBITE ARTHROPODS

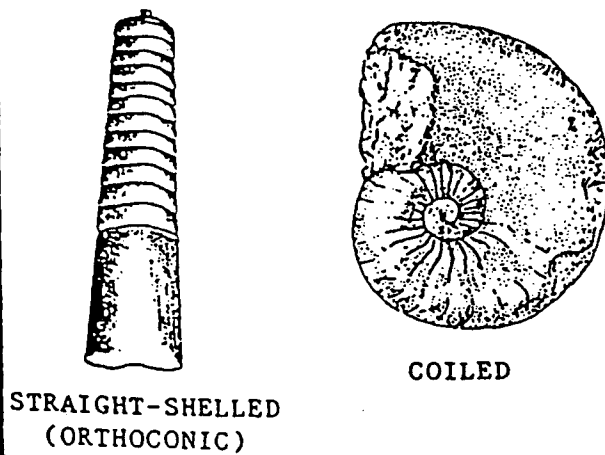


Ameura x6

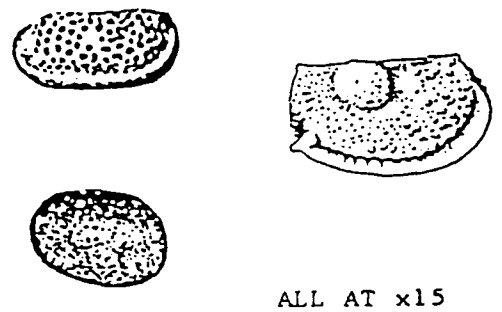


Ditymopyge
x6

CEPHALOPOD MOLLUSCS

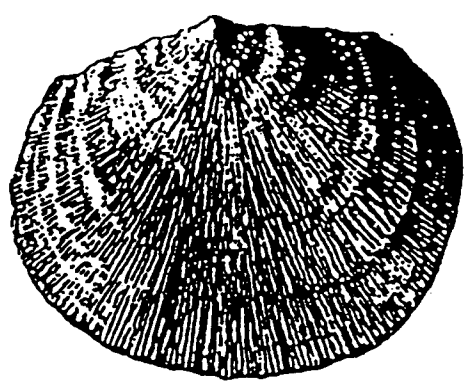


OSTRACODE ARTHROPODS



ALL AT x15

BRACHIOPODS (LAMP SHELLS)



Derbya



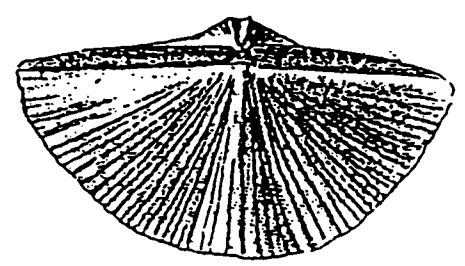
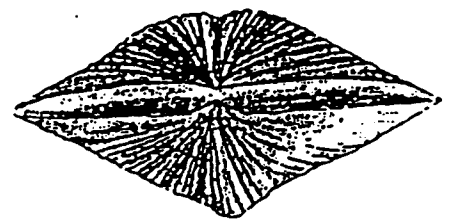
Wellerella



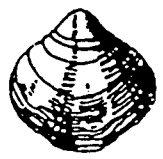
interior



Hustedia x2



Neospirifer



top



side

Composita



side



top

Phricidothyris



top



side

Crurithyris



Chonetinella



Neochonetes



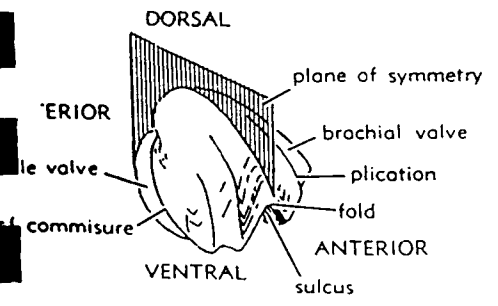
Juresania (A Productid)



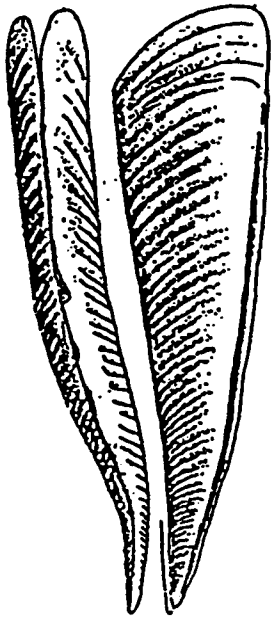
Linoproductus

(A Productid)

Equilateral Symmetry (Brachiopod)



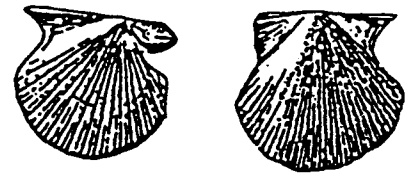
BIVALVE MOLLUSCS (CLAMS)



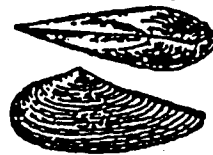
Aviculopinna



Myalina



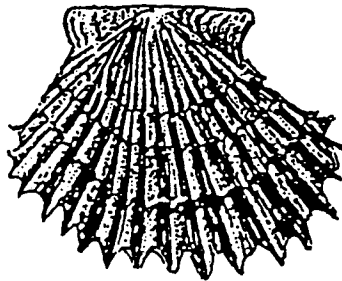
Aviculopecten



Nuculana



Permophorus



Acanthopecten

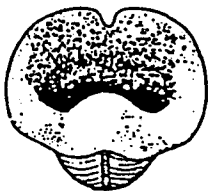


Edmondia



Astartella

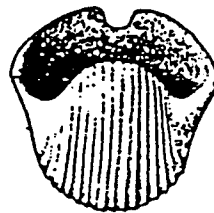
GASTROPOD MOLLUSCS (SNAILS)



Bellerophon x1.5



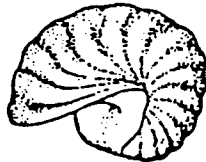
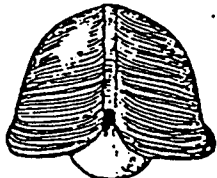
Pharkidonotus x1.5



Euphemites x4



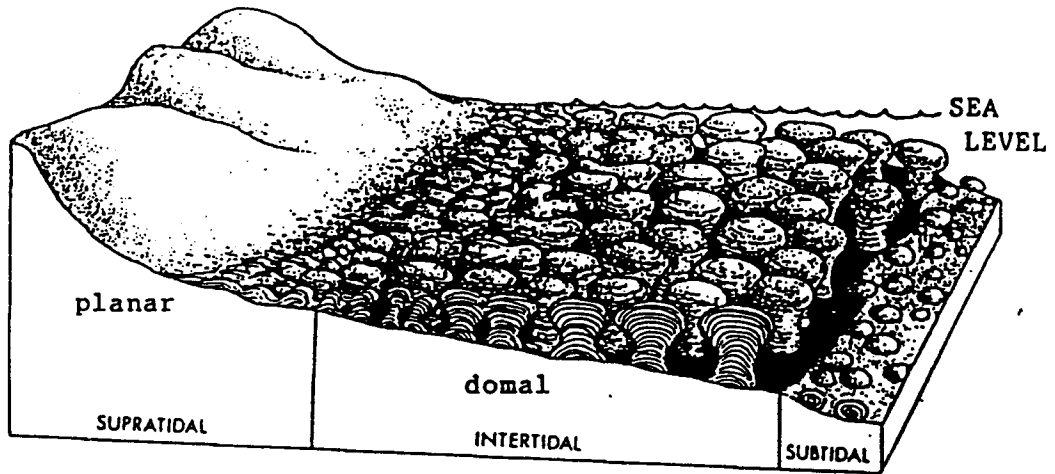
Donaldina x8



Amphiscapha



PLANTS



ALGAL LAMINATED SEDIMENTS (STROMATOLITES)

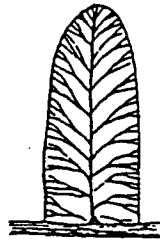


pinnule



pinna

Neuropteris tree fern

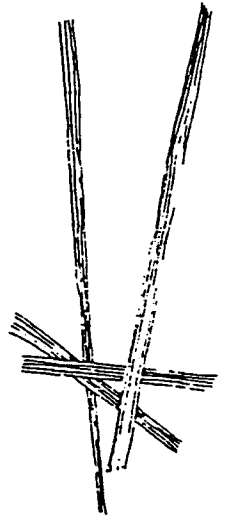


pinnule



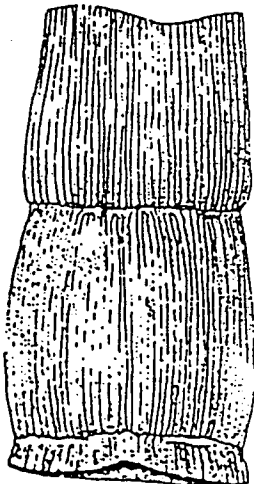
pinna

Pecopteris tree fern



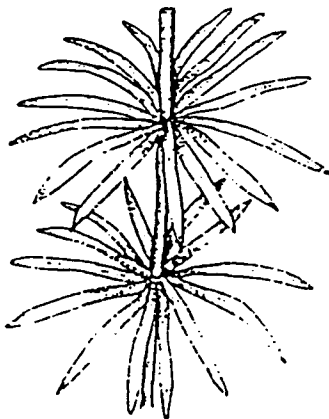
Lepidophylloides

Lycopod
Leaves



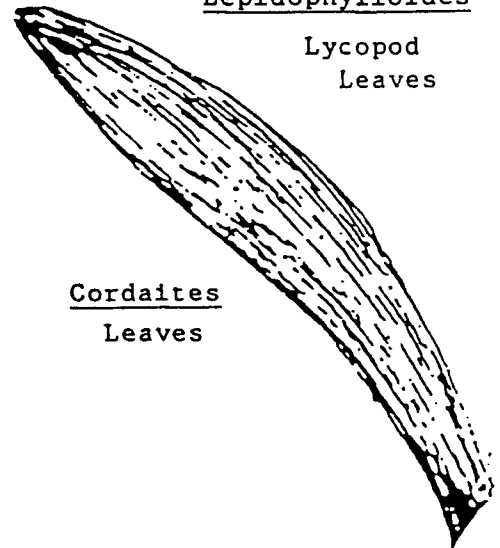
Calamites

Sphenopsid Stems



Annularia

Sphenopsid Leaves



Cordaites
Leaves

APPENDIX G Permission Slip

Dear Parents,

For the next few weeks the eighth grade Earth Science classes will be participating in a field geology study. This will require going to the field to various sites around Eudora and Lawrence. At this time I am planning on taking 4 1-hour trips (within the context of the class period) and 1 all day trip. We will be studying and measuring rock layers along with collecting and labelling rock and fossil samples. The students will be broken into cooperative learning teams which will then prepare reports of their studies.

Every effort will be made to ensure student safety while on these trips, however, all situations and circumstances that arise in the field cannot always be anticipated. Therefore, in the unlikely event your child should need medical attention, we would like your permission for them to participate in these activities and be treated medically by a qualified individual should the need arise.

I am looking forward to a good experience as we investigate, in natural settings, the processes and concepts we have discussed in the classroom. I feel these experiences are tremendously important as we attempt to bring the "Earth" into Earth Science and the "field" into field trip.

If you have any concerns or questions regarding these activities, feel free to contact me at school or home.

Sincerely,

(Your name here)

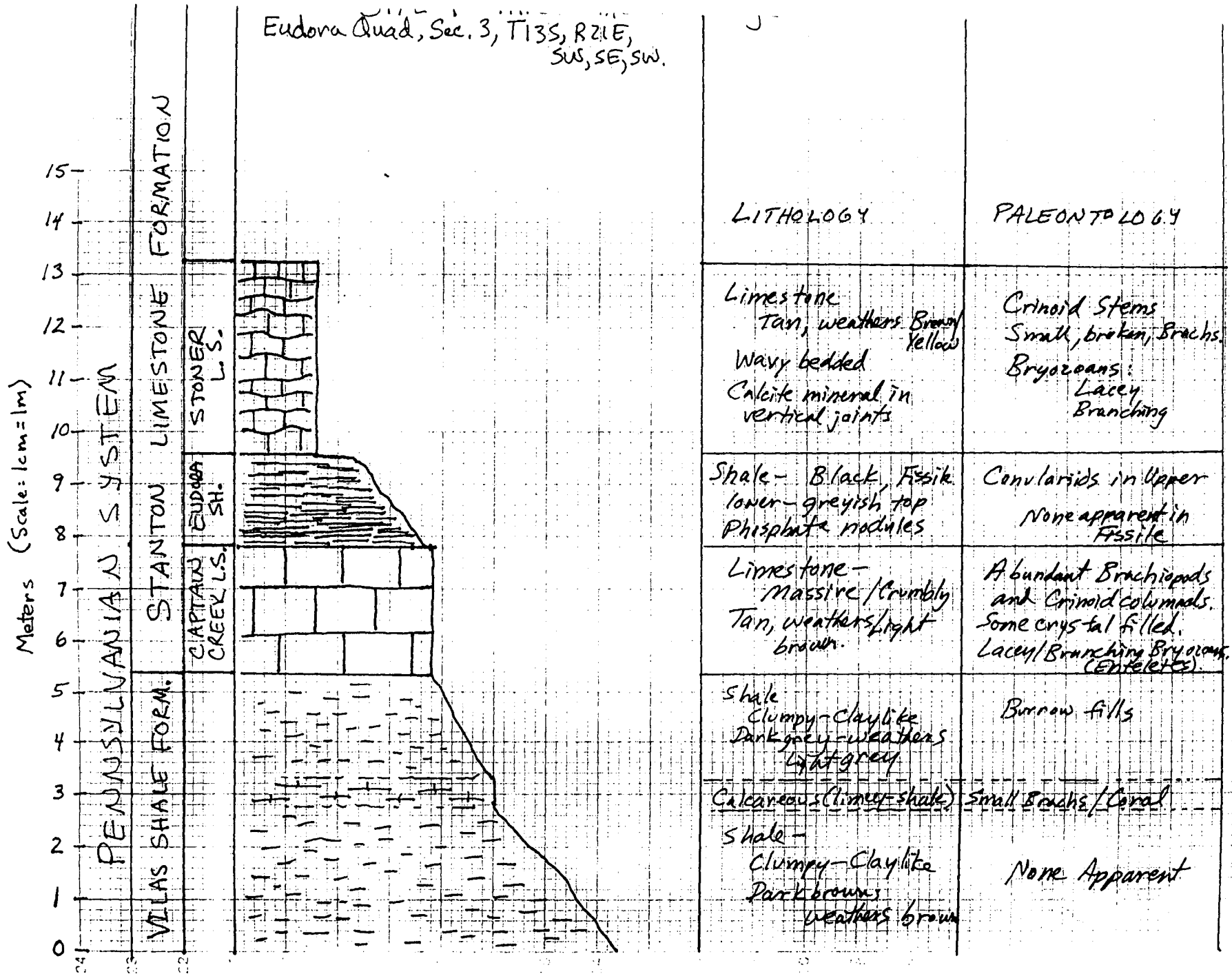
Earth Science Teacher

NAME OF SON/DAUGHTER PARTICIPATING _____

Parents Permission: I give my permission for my son/daughter to participate in the field geology activities and for a qualified individual to treat them medically should the need arise.

(Signature) (Date)

Eudora Quad, Sec. 3, T13S, R21E,
SW, SE, SW.



APPENDIX I

CORRELATION PROBLEM

A measured section for site II should drawn at this time and all the information should be filled in as well.

1. From the data you have gathered from sites I and II, list below what you consider to be the main similarities and differences between these sites. Be as specific as possible.

Similarities:

Differences:

2. From the above information, along with your other data, are the rock members at site II the same as at site I?

Yes _____ No _____

3. Write your main reasons in paragraph form defending why you answered the way you did in # 2.

APPENDIX J

FINAL REPORT

From field site III you were to make a measured section of the members studied. From those, and the data and samples collected, list what you thought the member units were at site III. The lowest layer is number 1, the highest number 10.

Member Name

- 10. _____
- 9. _____
- 8. _____
- 7. _____
- 6. _____
- 5. _____
- 4. _____
- 3. _____
- 2. _____
- 1. _____

In the space below, and on the back of this page if necessary, give at least three main reasons why you chose the ones that you did. Focus on those things that seemed to be outstanding similarities. After that, list any information that didn't seem to fit with your scheme.

SECOND SEMESTER SEQUENCING

I. STRUCTURE OF EARTH/MAPPING

II. MINERALS

III. ROCKS

IV. WEATHERING, EROSION, DEPOSITION

V. GEOLOGIC HISTORY/TIMETABLE

VI. KANSAS GEOLOGY

- A. Surface Features(Slide Show)
- B. Transgression-Regression of Seas
- C. Cyclothem

VII. FIELD GEOLOGY/GEOLOGY INTRODUCTION (Classroom)

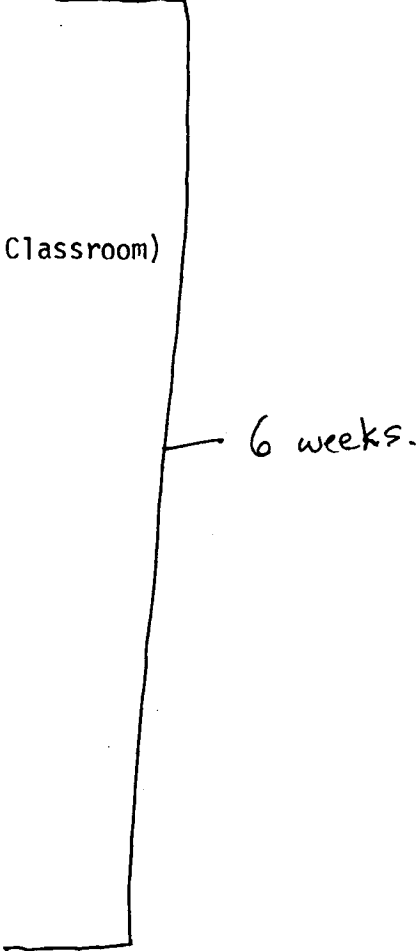
- A. Lithology
- B. Paleontology
- C. Measurement

VIII. FIELD GEOLOGY

- A. Measurement Practice
- B. Field Site I
Lab Work - Field Site I
- C. Field Site II
Lab Work - Field Site II
- D. Field Site III
Lab Work - Field Site III

IX. PLATE TECTONICS

X. VOLCANOES/EARTHQUAKES



6 weeks.