topic XIV

What Causes Landscapes?

Time Emphasis: 15 days

TOPIC OUTLINE

INVESTIGATION		A-1a	A-1b	A-1c	A-2a	B-1a	B-1b	B-1c
Estimated Time (Periods)		FT	2	3	2	FT	1	1
A. Landscape characteristics								
A-1 Quantitative observations — *What Are Some Landscape Characteristics That Can Be Observed and Measured?*								
A-1.1 Hill slopes	A-1.11		■	■				
A-1.2 Stream patterns	A-1.21		■	■				
A-1.3 Soil associations	A-1.31	■				■		
A-2 Relationship of characteristics — *How Are Landscape Characteristics Related?*								
A-2.1 Landscape regions	A-2.11		■		■	■		
	A-2.12		■		■	■		
	A-2.13		■					
	A-2.14		■		■	■		
B. Landscape Development								
B-1 Environmental factors — *How Is Landscape Development Influenced by Environmental Factors?*								
B-1.1 Uplifting and leveling forces	B-1.11					■		
	B-1.12		■	■		■		
	B-1.13		■		■	■		
B-1.2 Climate	B-1.21					■	■	
	B-1.22	■	■	■	■	■	■	
	B-1.23					■	■	
	B-1.24		■	■		■		
	B-1.25		■					
	B-1.26							
	B-1.27					■		
B-1.3 Bedrock	B-1.31				■	■		
	B-1.32		■	■	■	■		
	B-1.33		■	■	■	■		
	B-1.34		■	■	■	■		
	B-1.35		■			■		
	B-1.36					■		
B-1.4 Time	B-1.41							
B-1.5 Dynamic equilibrium	B-1.51					■		
B-1.6 Man	B-1.61		■	■		■		
	B-1.62							■
	B-1.63					■		
	B-1.64					■		
	B-1.65							
	B-1.66					■		
	B-1.67			■		■		
	B-1.68							

PROCESS OF INQUIRY OBJECTIVES

		A-1a	A-1b	A-1c	A-2a	B-1a	B-1b	B-1c
Mathematical Skill	PIO-1							■
Measurement Skill	PIO-2	■	■	■	■	■	■	■
Creating Models	PIO-3	■	■	■	■		■	
Analysis of Error	PIO-4	■						
Data Analysis	PIO-5	■				■	■	■

TITLES

Multimedia: Check Multimedia Section of Supplement for reference to this topic.

A-1a	Till Fabric Field Trip
A-1b	Regional Aerial Photo Studies
A-1c	Local Aerial Photo Studies
A-2a	Identifying Landscape Regions
B-1a	Landscape and Soils Field Trip
B-1b	Plotting Evidence of Glaciation
B-1c	Exponential Population Growth

Challenging (1/2 day)

XIV-A-1a: TILL FABRIC FIELD TRIP

QUESTION:

What are some landscape characteristics that can be observed and measured?

MATERIALS:

Magnetic compass, jack knives, shovels, rose diagrams (Supplementary Sheet), clipboards (optional).

SUGGESTED APPROACH:

1. Before leaving on the field trip, ask students to make a list of all evidences they can think of which would indicate direction of ice movement in an area. They probably will not list till fabric without your help. Tell them that tills usually contain elongate pebbles (longer in one axis than the others). These tills are thought to have been smeared out on the surface as the glacier moved past. Ask the students how elongate pebbles would probably come to rest when deposited by this mechanism. Would the long axis point in the direction of movement? Actual research has indicated that most would point in that direction, however, many of them apparently roll into position and are situated at right angles to the first group.

   Next ask how a study of a till could be made to determine direction of ice movement. Students should come up with some form of a till fabric study technique.

2. At the till site, the technique suggested on the student sheet can be used successfully

3. If the technique described is used carefully, a pattern showing a distinct maxima will develop. Sometimes, a secondary maxima will develop at right angles to the first. The first group is inferred to be those pebbles that slid into position; the second group probably rolled into position, usually referred to as "sliders" and "rollers" respectively.

4. Students should work individually or in groups of two. When finished, data should be shared and a direction of glacial movement decided upon. If no pattern develops, discuss possible reasons.

5. Have the students plot direction of movement on a wall map.

PRECAUTIONS:

1. Between 20 and 50 pebbles should be measured before a pattern can be interpreted. Students may have a tendency to infer a direction after only a few pebbles have been measured.

2. Stress the importance of accuracy in the determination of the orientation of the long axis of the pebbles.

TYPICAL RESULTS:

The results should produce a distinctive pattern which should compare to other glacial directional features in the area such as drumlins and glacial scratches on bedrock.

MODIFICATIONS:

1. A till fabric rack can be constructed and used as illustrated in the MacClintock reference.

2. If time is limited, have each student remove only two or three pebbles, and pool the information on one rose diagram when finished.

3. If a field trip is impossible, a large slab of till might be removed from a bank and brought to the classroom where it could be dissected. The orientation of the slab should be measured and recorded at the original site before removal.

REFERENCES:

Paul MacClintock, "A Till Fabric Rack," *The Journal of Geology*, Vol. 67, No. 6, November 1959.

Paul MacClintock and J. Terasmae, "Glacial History of Covey Hill," *The Journal of Geology*, Vol. 68, No. 2, March 1960.

XIV-A-1a: TILL FABRIC FIELD TRIP

QUESTION:

What are some landscape characteristics that can be observed and measured?

INTRODUCTION:

Most areas of New York State exhibit some kind of evidence for previous glaciation, however, not all of this evidence gives any clue as to the direction the ice moved through the area. The glacial geologist is continually looking for new approaches which will help him complete his understanding of the glacial history of his area. One such approach is the "till fabric study" which you will be conducting in an area near your home.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. identify whether or not a soil is a glacial till.
2. state evidence that suggests that a landscape region probably developed under a different climatic environment.

METHOD:

After arriving at the study site, you should:

1. Determine if the layer of material you choose to work with is really a till and not some other form of deposit. If you can uncover a pebble with scratches on its surface, you can use it as proof of "till."
2. Using the shovel, square off a vertical face about 2 or 3 feet in each dimension, measure and record on the bottom of your rose diagram the direction parallel to your working face.
3. Level off a spot at the foot of your vertical working face large enough to support your clipboard in a horizontal position. Position the clipboard so that the bottom of the rose diagram is parallel to the working face.
4. Choosing uniform size till pebbles (1-1½-inch size works best), carefully remove them, without destroying their orientation.
5. Decide which slot on the rose diagram the long axis of the pebble would be most nearly parallel. Make a symbol (I) in that slot. Continue the process for 20-50 pebbles, until it is obvious that you have a distinct pattern developing.

6. After returning to the school you will want to transfer all the individual data to one rose diagram. Be careful to correct for variations in the directions of the working faces.

7. Decide on the direction of ice movement through the area.

Note: Different till fabric results, occurring at two different elevations in the same till bank, has in some instances been used as proof of two glacial advances in the area, each from a different direction.

QUESTIONS:

(A-1.31) 1. Describe the characteristics of the soil in which you conducted your investigation.

2. What was the direction of glacier movement in your area?

3. Do the data indicate the direction of ice movement during the entire time the glacier occupied the area?

4. Is there any evidence that the land surface (e.g., valleys, hills, or mountains) influenced the direction of glacier movement?

5. Were you able to find any other evidence, in the general area of your till fabric study, that would substantiate your results (e.g., glacial striae or long axis of drumlins)?

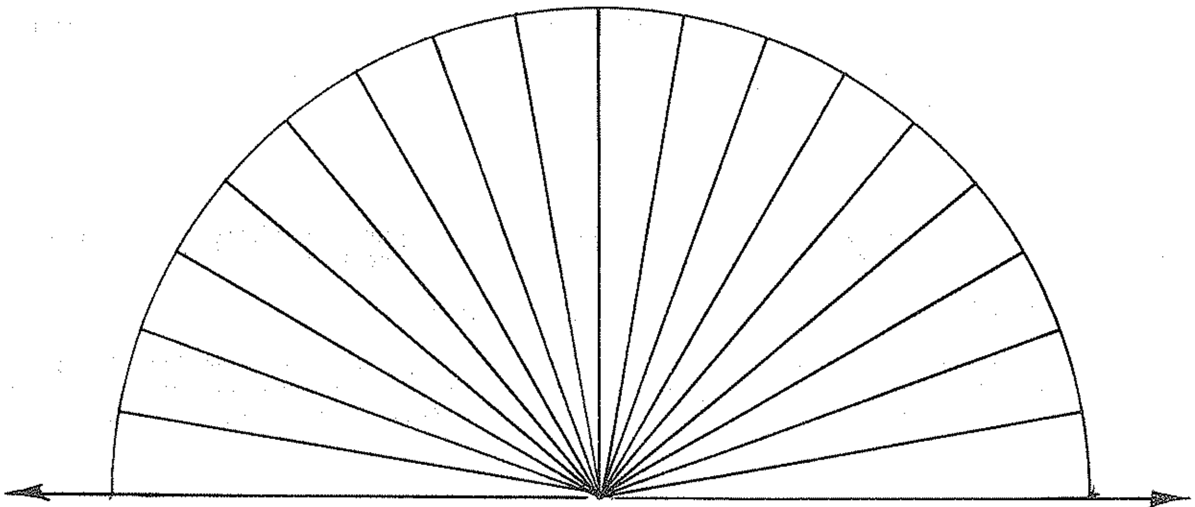
(B-1.22) 6. What evidence can you cite that would suggest that this landscape region may have developed under an extreme glacial climatic condition?

SUPPLEMENTARY SHEET

TILL PEBBLE ORIENTATION

Date ______________________ Location ______________________

Collector ______________________ ______________________



DIRECTION PARALLEL TO WORKING FACE

RECORD DIRECTION HERE: ____________

Total Number of Pebbles _____

NOTES:

Challenging (2)

XIV-A-1b: REGIONAL AERIAL PHOTO STUDIES

QUESTION:

What are some landscape characteristics that can be observed and measured?

MATERIALS:

Each student, or group of two students, should have: stereo viewer, landform map (See Supplementary Sheet #1), and one or more of the aerial photograph sets indicated under Background Information. (For ordering, see Supplementary Sheet #2.) Topographic maps of the same areas are optional.

SUGGESTED APPROACH:

1. Discuss briefly the use of stereoscopes.
2. Allow students to begin work, following the directions on student handout sheet.
3. After completion of the aerial photo study, involve the group in a discussion of their conclusions.

PRECAUTIONS:

1. Individual aerial photos must be ordered several months in advance of the using date to insure receiving them on time. (See the order sheets on Supplementary Sheets.)
2. Students may have trouble using the stereo viewers.
3. Don't contaminate student thought by introducing a lot of geomorphology terms. Most landforms can be recognized and possible origins inferred by the use of common sense and the experiences they have had during this course of study.

MODIFICATIONS:

1. Teachers may wish to use sets of photographs found in stereo atlases, which are available from several suppliers.

BACKGROUND INFORMATION:

Calif. 25. Badwater, Death Valley

Lat 36°15′ N.; long 116°45′ W.
Photographic scale: 1:48,000.
Date flown: Nov. 27, 1948.

Map Reference: U.S. Geol. Survey Furnace Creek, Bennetts Well, Ryan, and Funeral Peak 15-min quadrangles, scale 1:62,500

Features illustrated (set nos. Calif. 25 A-B in southeast corner of photographs). - Badwater, almost the lowest point in the United States, is a spring fed sulfate marsh in the reentrant on the north side of the fan in the center of photograph 25B. The broad white area west of Badwater is subject to flooding and is crusted with rock salt. North of this area, extending to the foot of the gravel fan, is massive rock salt; to the south is rock salt that has been smoothed by flooding. At right is the faulted front of the Black Mountains; the Badwater Turtleback - metasedimentary rocks of Precambrian age - is overlapped at the north by volcanic rocks of Tertiary age.

Calif. 30. Horizontal movement on San Andreas fault

Lat 35°16′N.; Long 119°50′ W.
Photographic scale: 1:20,000
Date flown: July 22, 1957

Map reference: U.S. Geol Survey McKittrick Summit and Painted Rock 7½-min quadrangles, scale 1:24,000

Features illustrated (set nos. Calif. 30 A-B in southeast corner of photographs). - Photographs show offset drainage, well-defined scarps, and trenches in Quaternary deposits along the trace of San Andreas fault and subsidiary faults. The area slopes gently to the southwest to the Carrizo Plain and is crossed by parallel intermittent streams that locally meander. The streams are incised northeast of the trace of the fault.

Fla. 1. Beach ridges, St. Vincent Island

Lat 29°40′N.; long 85°10′W.
Photograph scale: 1:43,000
Date flown: Nov 1, 1942

Map referemce U.S. Geol. Survey Indian Pass and West Pass 7½-min quadrangels, scale 1:24,000

Features illustrated (set nos. Fla. 1 A-B in northeast corner of photographs). - The island is made up entirely of beach ridges and intervening marsh. It has grown southward about 4 miles, during the present sea-level stand. The pattern of ridges suggests that three erosional intervals interrupted the process of island growth (C.A. Kaye, written commun., 1961).

Kans. 2. Flat-lying limestone and shale in the Flint Hills

Lat 39°17′N.; long 96°25′W.
Photographic scale: 1:20,000
Date flown: Sept 18, 1937

Map reference: U.S. Geol. Survey Manhattan sheet, scale 1:250,000

Features illustrated (set nos. Kans. 2 A-B in southeast corner of photographs). - Flat-lying cherty limestone and shale of Permian age in northeast Kansas. The white bands are outcrops of limestone; the wider gray bands are intervening beds of shale. Area is prairie; trees grow only in valleys on the banks of Cedar Creek and its tributaries that are incised below the Flint Hills Upland.

Maine 2. The Horesback along Sunkhaze Stream

Lat 44°57′N,; long 68°25′W.
Photographic scale: 1:24,000
Date flown: May 1, 1956

Map reference: U.S.Geol. Survey Great Pond 15-min quadrangle, scale 1:62,500

Features illustrated (set nos. Maine 2 A-C in northeast corner of photographs). - This gravel ridge - an ice-channel filling or esker - crosses the area from northwest to southeast. It is virtually continuous, as much as 70 feet high, and is bordered by swamps and, locally, by kames. The adjacent rounded hills are of granitic rock.

N. Mex. 8. Normal faults cutting basalt mesa

Lat 35°26′N., long 106°32′W.
Photograph scale: 1:31,680
Date flown: 1935

Map reference: U.S.Geol. Survey Santa Ana Pueblo 7½-min quadrangle, scale 1:24,000

Features illustrated (set nos. N. Mex. 8 A-D in southeast corner of photographs). - The photographs show the eastern half of the Santa Ana mesa near the confluence of Jemez River and Rio Grande (photograph 8A), The basalt flows issued from a north-south trending string of vents, some of which are visible on the west edge of photographs 8C and 8D, and also from a similar line of vents outside the area shown to the east. Numerous north-south-trending faults displace the basalts from a few to 150 feet. The blocks are tilted eastward, and along any one fault of the eastern block has risen relative to the one to the west. The drainage of the mesa has a trellis pattern.

N. Y. 1. Niagara cuesta at Lewiston

County: Niagara
Lat 43°10´N.; long 79°03´W.
Photograph scale: 1:20,000
Date flown: Sept. 25, 1938

Map reference: U.S. Geol. Survey Lewiston 7½-min. quadrangle, scale 1:24,000 (N.Y. only), Toronto sheet, scale 1:250,000
Geology reference: Johnston, R.H., 1964, Ground water in the Niagara Falls area, New York, with emphasis on the water-bearing characteristics of the bedrock: New York Water Resources Comm. Bull. GW-53, 93 p.

Features illustrated (set nos. N.Y. 1 A-B in southeast corner of photographs). - The Niagara River emerges from a narrow gorge cut about 250 feet into a flat upland and enters a broad flat lowland where its channel is wide and its banks are low. The north-facing escarpment separating the upland from the lowlands is the Niagara cuesta, across which the ancestral Niagara river flowed in late-glacial time as a waterfall that has now retreated southward about 6½ miles. The upper part of the escarpment is the massive Lockport Dolomite, underlain by the Rochester Shale and older rocks that erode by sapping. This sapping causes the dolomite cap to be undermined. The lowland north of the escarpment is underlain by Queenston Shale.'

N. Y. 2. Niagara Falls

County: Niagara
Lat 43°05´N.; long 79°04´W.
Photograph scale: 1:24,000
Date flown: May 7, 1963

Map reference: U.S. Geol. Survey Niagara Falls 7½-min quadrangle, scale 1:24,000
Geology reference: Johnston, R.H., 1964, Ground water in the Niagara Falls area, New York, with emphasis on the water-bearing characteristics of the bedrock: New York Water Resources Comm. Bull. GW-53, 93 p.

Features illustrated (set nos. N.Y. 2 A-B in southeast corner of photographs). - Horseshoe Falls and American Falls separated by Goat Island. The falls are about 100 feet high. At the time these photographs were taken, there was considerable ice in the rapids both above and below the falls. The massive Lockport Dolomite forms the lip of the falls and the upper part of the walls of the gorge. Below is the Rochester Shale.

N. Y. 3. Drumlins near Palmyra

County: Wayne
Lat 43°08´N.; long 77°14´W.
Photograph scale: 1:60,000
Date flown: May 6, 1960

Map reference: U.S. Geol. Survey Palmyra and Macedon 15-min quadrangles, scale 1:62,500 Ontario, williamson, Macedon, and Palmyra 7½-min quadrangles, scale 1:24,000
Geology reference: Fairchild, H.L., 1929, New York drumlins: Rochester Acad. Sci. Proc., V. 7, 37 p.

Features illustrated (set nos. N.Y. 3 A-B in northeast corner of photographs). - Ice moving southward from the Ontario basin formed a large drumlin field on the Ontario plain north of the Finger Lakes. The bedrock, concealed beneath drift, is in large part gently dipping shale and dolomite of Silurian age. The drumlins are oval in plan and range in length from less than a quarter of a mile to more than 2 miles. They are commonly three to five times longer than they are wide. The flat-floored valleys between the drumlins are underlain in part by lake deposits and in part by glacial outwash.

N. Y. 4. Potsdam outliers near Hammond

County: St. Lawrence
Lat 44°22´N.; long 75°46´W.
Photograph scale: 1:19,000
Date flown: May 4, 1960

Map reference: U.S. Geol. Survey Muskellunge Lake, Hammond, Redwood, and Chippewa Bay 7½-min quadrangles, scale 1:24,000
Geology reference: New York State Museum and Science Service, Geological Survey, 1962, Geologic map of New York, 1961. Adirondack sheet: New York State Mus. and Sci. Service Geol. Survey Map and Chart Ser. 5, scale 1:250,000

Features illustrated (set nos. N.Y. 4 A-C in northeast corner of photographs). - Broad tables of flat-lying Potsdam Sandstone of Late Cambrian age rise above lowlands underlain by metasedimentary rocks of Precambrian age. The mantle of glacial drift is thin and patchy, and the grain of the metamorphic rocks is clearly expressed by the irregular shapes of the small hills east of Black Creek.

N. Y. 5. Hickory Lake phacolith

County: St. Lawrence
Lat 44°26′N.; long 75°35′W.
Photograph scale: 1:20,000
Date flown: May 4, 1960

Map reference: U.S. Geol Survey Pope Mills 7½-min quadrangle, scale 1:24,000
Geology reference: Buddington, A.F., 1934, Geology and mineral resources of the Hammond, Antwerp, and Lowville quadrangles: New York State Mus. Bull. 296, 251 p.; geol. map, scale 1:62,500

Features illustrated (set nos. N.Y. 5 A-B in northeast corner of photographs). - The oval-shaped area of numerous small roughly concentric ridges in the southern half of photograph 5B is one of Buddington's granite phacoliths. Although the area has been glaciated, the drift is thin and discontinuous. The lowland that surrounds the phacolith (along Birch Creek) is mantled by fine-grained lake sediments of Quaternary age. The surrounding area of more irregular hills is underlain by quartzite, marble, gneiss, and related rocks of the Grenville Series.

N. Dak. 3. Streeter moraine near Alkaline Lake

Lat 46°38′N.; long 99°25′W.
Photograph scale: 1:60,000
Date flown: July 28, 1952

Map reference: U.S. Geol. Survey Jamestown sheet, scale 1:250,000

Features illustrated (set nos. N. Dak. 3 A-B in northeast corner of photographs). - The massive Streeter moraine with many prominent arcuate ridges (southwest quadrant of photograph 3B) was built by southwest-moving glacier ice. In front of it is an outwash plain. Behind the moraine to the northeast is a broad area of collapse moraine deposits with some lakes and multitudes of small irregularly shaped ponds and swamps.

Pa. 2. Strip mines in anthracite coal near Mount Pleasant

Lat 40°42′N.; long 76°20′W.
Photograph scale: 1:20,000
Date flown: Aug. 29, 1958

Map reference: U.S. Geol. Survey Minersville 7½-min quadrangle, scale 1:24,000

Features illustrated (set nos. Pa. 2 A-C in southeast corner of photographs). - The coal beds occur in closely folded synclines; so, in general, the mines outline synclines and the wooded areas anticlines. In the central part of photograph 2B, for example, the east-northeast-trending belt of strip mines just north of the center of the photographs is along a syncline. The adjacent anticline to the south is marked by a strip of woods that passes through the center of the photograph, and the next syncline passes under the large flat-topped heap of coal-mine debris (gray areas east of center of same exposure).

Near the west edge of the photograph the northern syncline is replaced by several minor folds whose axes rise westward. Rocks stratigraphically below the coal beds are brought to the ground surface. The traces of several thrust faults cross the photographs but are not readily apparent.

Pa. 6. Delaware Water Gap

Lat 40°58′N.; long 75°07′W.
Photograph scale: 1:20,000
Date flown: May 6, 1959

Map reference: U.S. Geol. Survey Stroudsburg and Portland 7½-min quadrangles, scale 1:24,000; Delaware Water Gap 15-min quadrangle, scale 1:62,500

Features illustrated (set nos. Pa. 6 A-C in southeast corner of photographs). - Delaware Water Gap is one of the classic water gaps in the Appalachian Highlands, about 1,200 feet deep and less than a mile wide at the top. The nearly flat top of Kittatinny Mountain at the gap was believed by W. M. Davis to be a remnant of his Schooley peneplain preserved on top of the resistant quartzite that can be seen dipping steeply to the northwest. The course of the river through the ridge has been variously attributed to superposition or to structural control related to joints, faults, or plunging folds.

(Puerto Rico)

P. R. 1. Doline or sinkhole karst topography

Lat 18°24´N.; long 66°51´W.
Photograph scale: 1:20,000
Date flown: Feb. 12, 1963

Map reference: U.S. Geol. Survey Camuy 7½-min quadrangle, scale 1:20,000

Features illustrated (set nos. P.R. 1 A-B in northeast corner of photographs). - Intricate karst topography formed in lower Miocene limestone which dips 3°-5° N. Sinkholes are as deep as 60 meters and towers as high as 40 meters. Apparently bare southern and eastern slopes in the southern part of the area are covered by a mat of ferns in contrast to the densely wooded northern and western slopes. Near the southeast corner of photograph 1B a stream appears at the head of an alluviated valley, flows north and then east and disappears in a cave (in woods), flows underground to the north, reappears in another alluviated valley, flows through a small gorge, and finally disappears in a cave that is near the east edge of photograph 1B.

N. Mex. 7. Fine-textured topography on upper Tertiary sediments

Lat 35°47´N.; long 106°07´W.
Photograph scale: 1:54,000
Date flown: May 27, 1954

Map reference: U.S. Geol. Survey Espanola 15-min quadrangle, scale 1:62,500

Features illustrated (set nos. N. Mex. 7 A-B in northeast corner of photographs). - Fine-textured topography with high drainage density formed on the semiconsolidated upper Tertiary rocks (sandstone, conglomerate, siltstone, and clay of the Santa Fe Group). The drainage pattern is largely dendritic, except for the parallel or pinnate pattern in the northeast quadrant of photograph 7B. Mesas near the west edge of the same photograph are capped by basaltic rocks of late Tertiary or Quaternary age. Buckman is near the northwest corner of photograph 7B.

Tex. 4. High Plains escarpment east of Lubbock

Lat 33°35´N.; long 101°13´W.
Photograph scale: 1:63,360
Date flown: Jan. 23, 1954

Map reference: U.S. Geol. Survey Lubbock sheet, scale,1:250,000

Features illustrated (set nos. Tex. 4 A-B in northeast corner of photographs). - Escarpment on the west side of White River (east half of photograph 4A), a tributary of Brazos River. Massive beds of sand cemented by caliche cap the plains and in many places rest directly on sand and gravel (Ogallala Formation of Pliocene age). Triassic sedimentary rocks crop out near White River. Badlands east of the escarpment have a high drainage density compared with the virtually undissected plains to the west where numerous large shallow depressions are as much as half a mile in diameter.

Utah 1. Open pit at Bingham

Lat 40°32´N.; long 112°08´W.
Photograph scale: 1:37,400
Date flown: June 20, 1950

Map reference: U.S. Geol. Survey Bingham Canyon and Lark 7½-min quadrangles, scale 1:1:24,000

Features illustrated (set nos. Utah 1 A-C in southeast corner of photographs). - This great open pit is nearly 1,500 feet deep and 2 miles in diameter. The ore is disseminated pyrite and lesser amounts of copper sulfides in monzonite, quartzite, and limestone.

Utah 9. Badlands near South Caineville mesa

Lat 38°18´N.; long 110°57´W,
Photograph scale: 1:31,680
Date flown: July 12, 1939

Map reference: U.S. Geol. Survey Factory Butte 15-min quadrangle, scale 1:62,500

Features illustrated (set nos. Utah 9 A-B in northeast corner of photographs). - The mesa is capped by the Emery Sandstone Member of the Mancos Shale; the badlands surrounding it are underlain by the Blue Gate Shale Member of the Mancos. Pediments have been formed between the foot of the badlands and the alluvium along Sweetwater Creek (southeast quadrant of photograph 9B).

Utah 14. Cliffs and domes in Navajo Sandstone, Zion National Park

Lat 37°13′N.; long 112°55′W.
Photograph scale: 1:63,360
Date flown: June 16, 1953

Map reference: U.S. Geol. Survey Zion National Park, Zion Canyon Section, scale 1:31,680

Features illustrated (set nos. Utah 14 A-C in southeast corner of photographs). - Flat-lying massive Jurassic sandstones enclose Zion Canyon (northwest quadrant of photograph 14B) and Parunuweap Canyon (south edge of same photograph). Both these narrow canyons are floored with Chinle Shale. The Navajo Sandstone forms the canyon rim and shows conspicuous north-south jointing. The smoother upland away from the canyons is underlain by shales of the Carmel Formation. The Great White Throne, a monolith of Navajo Sandstone, stands just south of the horseshoe bend (Big Bend) in Zion Canyon (northwest quadrant of photograph 14B). Some of the smaller streams that flow in Navajo Sand have meanders that appear to be joint controlled, for example, the stream just southwest of the center of photograph 14B and in the upper part of Parunuweap Canyon (in southeast quadrant).

Wash. 2. Alpine glaciers on Glacier Peak

Lat 48°07′N.; long 121°07′W.
Photograph scale: 1:27,700
Date flown: Oct. 7, 1944

Map reference: U.S. Geol. Survey Glacier Peak 15-min quadrangle, scale 1:62,500

Features illustrated (set nos. Wash. 2 A-C in northeast corner of photographs). - This Pleistocene to Recent andesitic volcano (altitude 10,541 ft.) rises about 6,000 feet above the tops of the adjacent mountains. Glaciers largely conceal the upper slopes of the peak except on its southwest side. The individual glaciers are separated by small arêtes and flow in shallow U-shaped valleys. The glacial dissection of the volcano, although only moderate, is noticeably more advanced than on Mount St. Helens.

Wash 5. Channeled scabland: Cataract in Moses Coulee

Lat 47°30′N.; long 119°45′W.
Photograph scale: 1:73,800
Date flown: Sept. 22, 1952

Map reference: U.S. Geol. Survey Ritzville sheet, scale 1:250,000

Features illustrated (set nos. Wash 5 A-D in southeast corner of photographs). - This great compound cataract (west of center of photograph 5C) includes three recessional gorges that reach back upstream into a broad scabland tract. The cataract to the east started as a double cataract whose members united to leave an island in the gorge below the dry falls. Bretz believes that all three gorges and their cataracts were contemporaneous. To the north the main coulee is a gorge nearly 400 feet deep (northeast quadrant of photograph 5B).

Wyo. 7. Little Dome

Lat 43°25′N.; long 108°52′W.
Photograph scale: 1:23,600
Date flown: Oct. 20, 1948

Map reference: U.S. Geol. Survey Thermopolis sheet, scale 1:250,000

Features illustrated (set nos. Wyo. 7 A-B in southeast corner of photographs). - A small area of Jurassic rocks is exposed in the center of this elongate dome that is largely outward-dipping Cretaceous beds composed of shale and some sandstone. The beds are tightly folded along the southeast-plunging anticlinal axis. The lowlands around the dome are underlain by Cody Shale that is largely concealed by alluvium and terrace deposits.

REFERENCES:

A Descriptive Catalog of Selected Aerial Photographs of Geologic Features in the United States, Geological Survey Professional Paper 590, can be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

XIV-A-1b: REGIONAL AERIAL PHOTO STUDIES

QUESTION:

What are some landscape characteristics that can be observed and measured?

INTRODUCTION:

If the landscape is the result of uplifting and leveling of rock materials at the surface, then you should be able to examine a landscape and say something about (1) the nature of the surface rock, (2) the effect of uplift, and (3) the kinds of leveling processes or agents at work there. You may also be able to say which force, uplifting or leveling, dominates the landscape at present.

In this investigation you will study aerial photos of several different areas in the United States. Describe the landscape in each area observed, and interpret the processes that created the features you observe.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. see a stereo pair of photographs in three dimensions.
2. indicate which processes, uplift or leveling, have been most active in forming the landscape in an area studied by aerial photographs.
3. relate landscapes to the environmental factors which influenced their development.

METHOD:

1. Using the map provided (Supplementary Sheet #1), showing the principle landscape of the United States, find the approximate location of each of the photograph sets that you study.
2. View the photographs provided by your teacher.
3. Answer the following questions about each area:

QUESTIONS:

(A-1.11) 1. What hillslopes with distinctive shapes can you identify?

(A-1.21) 2. What stream patterns are you able to identify?

(A-2.11) 3. Describe the landscape characteristics observed in the photographs.

(A-2.12) 4. Describe any boundaries between landscape regions that you are able to identify.

(A-2.13) 5. Describe the different landscape regions that you observe as you look at various photo sets.

(A-2.14) 6. What landscape regions are you able to identify in the New York State photograph sets?

(B-1.12) 7. Describe evidence of uplifting and leveling forces at work. Which seems to be dominant in each area?

(B-1.13) 8. What effect has crustal uplift or subsidence had on areas where it is evident that it occurred rapidly?

(B-1.22) 9. Describe the areas that appear to have developed under conditions of climatic extremes.

(B-1.24)10. What effect does the balance between weathering and removal of materials have on the steepness of hillslopes? Which photographs illustrate this?

(B-1.25)11. How do hillslopes in dry climates differ from those in wet climates? Which photographs illustrate this?

(B-1.32)12. How can bedrock control the shape and steepness of a hillslope? Which photographs illustrate this?

(B-1.33)13. Describe photograph areas where bedrock resistant to erosion has produced landforms such as plateaus, mountains, and escarpments.

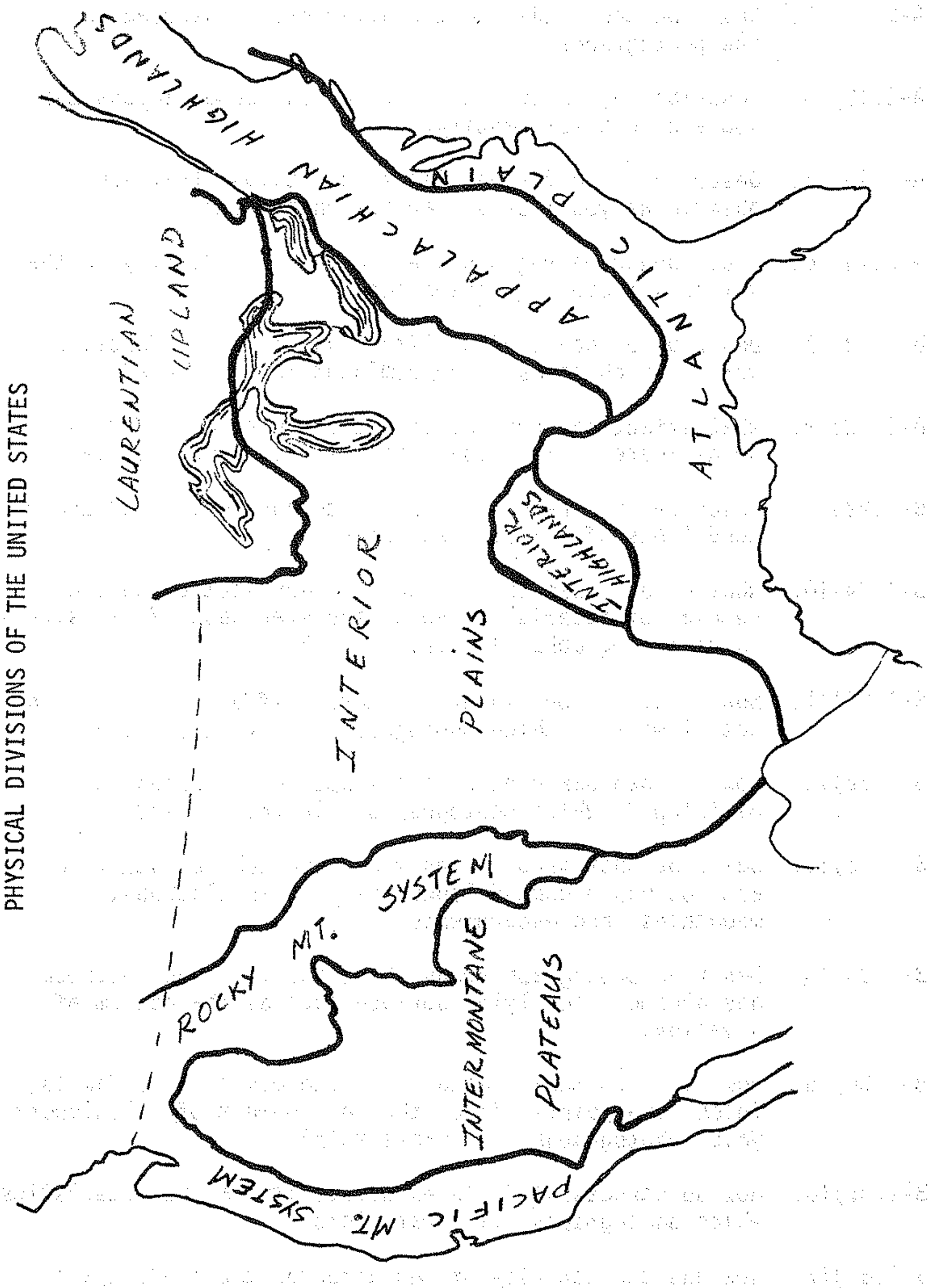
(B-1.33)14. Describe photograph areas where easily eroded bedrock has become a low-lying surface such as the bottom of a valley.

(B-1.34)15. How can structural features in bedrock such as faults, folds, and joints affect the development of hillslopes? Which photographs illustrate this?

(B-1.35)16. How do structural features affect stream characteristics? Which photographs illustrate this?

(B-1.61)17. How has the activity of man affected the landscape in the areas studied?

PHYSICAL DIVISIONS OF THE UNITED STATES



Photograph sets can be ordered by filling out the form below and checking the sets you want.

ORDER FOR AERIAL PHOTOGRAPHS
of
Geologic Features
In the United States

TO: Map Information Office
U.S. Geological Survey
Washington, D.C. 20242

Please send photographs to:

____
____
____
____

Date:	Do Not Write In This Space
Total ordered	
Remittance: $	

Indicate type of paper: double-weight semimatte or single-weight glossy

Prices of contact prints (subject to revision at any time):	1 to 5 each	6 to 100 each	More than 100 each
	$1.00	$0.90	$0.70

SET	PHOTOGRAPHS
California	
25	2 ____
30	2 ____
Florida	
1	2 ____
Kansas	
2	2 ____
Maine	
2	3 ____
New Mexico	
7	2 ____
8	4 ____
New York	
1	2 ____
2	2 ____
3	2 ____
4	3 ____
5	2 ____

SET	PHOTOGRAPHS
North Dakota	
3	2 ____
Pennsylvania	
2	3 ____
6	3 ____
Puerto Rico	
1	2 ____
Texas	
4	2 ____
Utah	
1	3 ____
9	2 ____
14	3 ____
Washington	
2	3 ____
5	4 ____
Wyoming	
7	2 ____

Challenging (3)

XIV-A-1c: LOCAL AERIAL PHOTO STUDIES

QUESTION:

What are some landscape characteristics that can be observed and measured?

MATERIALS:

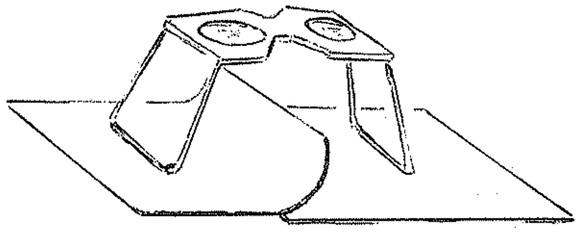
Student stereoscopes, aerial photo stereo-pairs covering the local region around your school. The larger the area covered (more photos) the better. See Background Information.

SUGGESTED APPROACH:

1. Ask students if they think they could find evidence for glaciation in their local area if they had a chance to study the area from an airplane.
2. Ask them if photographs, especially photographs that show elevation, would work even better, since you could take as long as you wanted to study one point on the ground.
3. Indicate to them that to a skilled user, aerial photos tell more, in less time, about an area on the earth than any other type of investigation.
4. Indicate that aerial photo studies are usually used in conjunction with actual field sampling and map studies for maximum understanding of the area studied.
5. A good way to begin is to allow students to study the aerial mozaic of their local area and pick out their home. (This can be accomplished best by having a topographic map of the area on hand for comparison.) Allow each student time to view his home and the surrounding terrian with which he is very familiar. This allows him to associate a hill dimension that he knows, with the way it appears on the photos. This will enable him to better interpret dimensions of landforms in areas foreign to him.
6. Ask the students to choose a series of aerial photos covering a larger area (limited only by time and availability of photos), and identify as many landforms and evidences for glaciation (including direction of movement) as they can. They should keep a written record, including sketches, of the photos studied and the area covered as part of investigation.
7. At the end of the investigation, the students should pool their information, and defend it, if others disagree.

PRECAUTIONS:

1. Students, unable to see with both eyes, will not be able to view the photos stereoscopically.
2. Most students, with practice, *should* be able to see three dimensionally.
3. When the two photos (stereo pair) are positioned flat on the table, only a narrow section can be seen stereoscopically. To view a larger area, you must roll the upper photo back slightly (do not bend sharply) as you continue to move the stereoscope to the left.



4. It takes an earth scientist a long time to develop enough skill to identify landforms from aerial photo studies. This should not be the only objective of this investigation. The students will make inferences and adjust them many times when asked to defend them. This is the kind of thinking process to encourage.

TYPICAL RESULTS:

The students should be able to identify outstanding landforms such as drumlins, kames, and eskers if they are present in your area. They may be able to distinguish a distinct lineation of glacial features indicating direction of glacial movement.

BACKGROUND INFORMATION:

Aerial photos and information can be obtained from:

Eastern Laboratory, Aerial Photography Division
45 South French Broad Avenue
Asheville, North Carolina 28801

The usual approach is to first obtain aerial photo index sheets of your local area. When ordering these, be sure to describe your location as accurately as possible. Include county, state, topographic map name, and latitude-longitude information. These index sheets are mozaics of the individual stereo pairs covering the areas. They are arranged so their individual numbers can be read and subsequent orders for these can be made.

PRICES FOR AERIAL PHOTOGRAPHS
(Effective October 1, 1968)

	CONTACT PRINTS	ENLARGEMENTS - DWSM				PHOTO-INDEXES
Approximate Scale	1" = 1667'	1" = 1320	1" = 1000'	1" = 330' or 1" = 660'	1" = 400'	1" = 1 mile
Paper Size In Inches	9½" X 9½"	14" X 14"	18" X 18"	24" X 24"	40" X 40"	20" X 24"
Quantity 1 - 25	$1.25	$2.50	$2.75	$3.50	$8.00	$2.50 per sheet
Excess over 25	$0.90	$2.00	$2.25	$2.75	$7.00	

NOTE: The 9½" X 9½" size works best for this exercise.

REFERENCES:

Aerial Photographs in Geological Interpretation and Mapping, Geological Survey Professional Paper 373 (can be ordered from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402), $2.50, paper cover.

Wanless, Harold P., *Aerial Stereo Photographs* (available from several suppliers of earth science equipment).

Aerial-Photo Interpretation in Classifying and Mapping Soils, Agricultural Handbook No. 294, issued October 1966. (Available from Government Printing Office, Washington, D.C.) 75¢, paper cover.

A Descriptive Catalog of Selected Aerial Photographs of Geologic Features in the United States, Geologic Survey Professional Paper 590, (can be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402).

XIV-A-1c: LOCAL AERIAL PHOTO STUDIES

QUESTION:

What are some landscape characteristics that can be observed and measured?

INTRODUCTION:

A relatively short time ago, man was unaware that continental glaciation had occurred in North America. When early investigators began suggesting the possibility of a great ice mass covering all of Canada and much of the United States, they were met with much criticism. Today, however, we accept this and continue to gather evidence to help us better understand characteristics such as directions of movement, etc. In this investigation, you will be examining areas near your home for any evidence of glaciation you can find. Try to explain the origin of the various landforms that you see.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. demonstrate three-dimensional viewing of aerial photo stereo-pairs.

2. identify and describe any outstanding landscape features such as drumlins, eskers, moraines, etc., that may be present in your local area.

METHOD:

1. Your teacher will provide you with a stereoscope which will enable you to see aerial photos in three dimensions.

2. Using the aerial mozaic map, locate your home or an area with which you are familiar. Copy down the numbers of the two photographs that cover this area. Ask your teacher for the photographs with these numbers.

3. Study the photographs, using your stereoscope. If you cannot see three dimensionally ask your teacher to check your method.

4. Compare what you have done with the work of other students in the class.

QUESTIONS:

(A-1.11) 1. Describe any hillslopes with distinctive shapes which you think could be measured.

(A-1.21) 2. Describe the pattern of streams in the area studied. Do the patterns observed have measurable characteristics? If so, what?

(B-1.12) 3. Which force, uplifting or leveling, seems to be dominant in your area of study? Why do you think so?

(B-1.22) 4. Describe any evidence that suggests that the landforms you have observed may have developed under conditions of a climatic extreme such as glaciation.

(B-1.24) 5. Describe the balance between weathering and removal of materials that exists in at least one hillslope observed.

(B-1.32) 6. Describe any observable effect that bedrock has had on the shape and steepness of hillslopes studied.

(B-1.33) 7. Describe any areas studied where you think resistant bedrock was responsible for features such as plateaus, mountains, or cliffs.

(B-1.33) 8. Describe any low-lying areas, such as river valleys, where you think bedrock was responsible for the landform development.

(B-1.34) 9. Describe any structural features such as faults and folds for which you can find evidence. (They may or may not be present in the area you have studied.)

(B-1.61)10. Describe any areas studied where it is evident that the activities of man have altered the landscape.

(B-1.67)11. What evidence for environmental conservation and planning can you find in the area studied?

AERIAL PHOTO STUDIES

A skilled earth scientist and aerial photo interpreter can learn a great deal about the basic soil types, rock types, and ground water conditions that exist in an area by a study of aerial stereo photos. This is often accomplished by understanding and recognizing basic landforms. There are only about 36 landforms in the whole world, and, of these, about one-third are rare and not likely to be seen.

Each landform has its own set of characteristics, and aerial photos will exhibit elements of the distinct pattern for each. Black and white aerial photos illustrate six basic elements.

1. Topography - for some landforms this is very definite
2. Drainage - surface drainage pattern
3. Erosion characteristics - gully shapes
4. Black and white tone pattern - produced by near surface conditions
5. Vegetation - cultivated or natural
6. Land use

The following chart contains descriptions of typical glacial landforms which might be found in various regions of New York State.

LAND FORM	BOUNDARY CHARACTERISTICS	TOPOGRAPHIC CHARACTERISTICS	DRAINAGE CHARACTERISTICS	VEGETATIVE CHARACTERISTICS	TONE CHARACTERISTICS	REFERENCES
ESKER	Well-defined curvilinear	1. long, narrow, slightly winding ridges 2. depressions usually occur along the sides 3. usually occur as a single ridge: less commonly, they are found as two or three approximately parallel ridges and, if many miles long, they frequently show a general north-south trend	1. gully form depends upon the size of esker and the type of climate 2. gully spacing and size are related to type and depth of overburden	generally forest covered in humid climates	generally light tones	USGS Professional paper #373, p. 100

Adapted from lecture notes, Prof. D. Belcher, Cornell University

LAND FORM	BOUNDARY CHARACTERISTICS	TOPOGRAPHIC CHARACTERISTICS	DRAINAGE CHARACTERISTICS	VEGETATIVE CHARACTERISTICS	TONE CHARACTERISTICS	REFERENCES
KAMES	1. individuals have a near circular to elliptical outline 2. group has an irregular outline	1. individuals are isolated, conical- to irregularly-shaped mounds with steep sidelsopes 2. size is variable: usually below 50 feet in height and less than 400 feet in largest dimension. Kame groups and terraces may be much wider. Kame moraines are composed of a group of knobs with intervening deep depressions.	1. general absence of integrated surface drainage 2. surface rill erosion often present	usually not cultivated: tree or grass cover is common	crests show light gray to white tones	USGS Professional paper #373, p. 122; Aerial Stereo Photographs (Wanless), p. 19
OUTWASH PLAINS	1. with lowland: fan-shaped transitional zone 2. with highland: distinct-linear boundary	1. near-level, broad tracts with few eroded channels: Type I-level outwash plain 2. many steep-sided, small to large pits, sharply depressed below a near-level surface: Type II - pitted outwash plain	1. abandoned, flat-bottomed, intersecting drainage routes are common 2. there is little surface drainage development	1. semiarid climates: grass-covered 2. subhumid climates: forest covered or cultivated	1. general light tones dotted with small dark areas: such terms as "worm-eaten," "moth-eaten," and "tapioca-like" are used to describe the color pattern of outwash. 2. uniform light tones are common on the elevated, level, cultivated tracts and on valley train deposits 3. dark channel and current markings usually appear as flow patterns when large areas of outwash are viewed	Aerial Stereo Pairs (Wanless), p. 84

Adapted from lecture notes, Prof. D. Belcher, Cornell University

LAND FORM	BOUNDARY CHARACTERISTICS	TOPOGRAPHIC CHARACTERISTICS	DRAINAGE CHARACTERISTICS	VEGETATIVE CHARACTERISTICS	TONE CHARACTERISTICS	REFERENCES
TERRACES	there is a distinct linear boundary	1. the area is flat 2. stair-stepped development between river and upland 3. areal extent of terraces may vary	1. surface drainage is generally absent 2. short, steep, V-shaped gullies are notched into the terrace face 3. slackwater areas border the upland	uniform vegetative pattern	1. light to medium gray with small dark spots 2. broad, light-toned current patterns may be present 3. slackwater areas are dark-toned	
LAKE BEDS	generally insignificant	1. a broad, exceptionally flat surface 2. undulating terrain is rare	1. general absence of surface drainage development 2. relatively large streams may cross the flat area 3. artificial drainage is common in humid areas	areas are heavily cultivated. Large, low swamps may be seen in humid areas	1. uniform, drab, dark gray tones over broad areas 2. locally, dark or mottled tones may be present	
TILL PLAINS	generally insignificant	1. young till plains - drift controlled: broad, gently rolling, little dissected plains 2. young till plains - bedrock controlled: the influence of bedrock is made apparent by the increased angularity of streams; an increase in number and steepness of slope of tributaries; or by solution of underlying rock, as in limestone areas	1. young till plains: channelized runoff is not well established. 2. old till plains: a treelike drainage pattern is well developed. 3. shallow till plains: drainage pattern controlled by characteristics of underlying material.	generally cultivated	1. young till plain - drift controlled: mottled pattern: light islands (high ground) with dark surrounding areas 2. young, thin till deposits on unrelated materials: soil mottling and tone contrast is subdued 3. old till plains: uniform light tones with white-laced gullies or dull, uniform tones without white fringed gullies	USGS Professional paper #373 p. 204; Aerial Stereo Photograph (Wanless), p. 86

Adapted from lecture notes, Prof. D. Belcher, Cornell University

LAND FORM	BOUNDARY CHARACTERISTICS	TOPOGRAPHIC CHARACTERISTICS	DRAINAGE CHARACTERISTICS	VEGETATIVE CHARACTERISTICS	TONE CHARACTERISTICS	REFERENCES
MORAINES	generally insignificant; there may be irregular lines or a transitional zone	1. broad belt of disordered hills, ridges, and irregularly shaped hollows 2. lack of hilltop continuity 3. hills are small, when compared to bedrock forms	1. there is a disordered drainage pattern 2. all types of erosion are common.	generally forested or in pasture: partially tilled land; much swamp growth	heterogenous mixture of light and dark tones	USGS Professional paper #373, pp. 104, 106, 122; Aerial Stereo Photographs (Wanless), p. 17
DRUMLINS	a distinct, linear outline - oval to cigar-shaped	1. a group of parallel, oval to cigar-shaped ridges 2. individual ridges have a smooth, streamlined appearance	surface drainage not developed	cultivated or forest covered	light tones when tilled	Aerial Stereo Photographs (Wanless), p.20

Adapted from lecture notes, Prof. D. Belcher, Cornell University

XIV-A-2a: IDENTIFYING LANDSCAPE REGIONS

QUESTION:

How are landscape characteristics related?

MATERIALS:

Set of topographic maps at a scale of 1:250,000, covering the entire State of New York. See Background Information. (Raised relief maps of N.Y.S. can be used if available.)

Map: Landforms and Bedrock Geology of New York State, 1966. Available from the New York State Museum and Science Service and accompanied by Educational Leaflet No. 20, *Geology of New York, a Short Account*.

Blank map of New York State. See supplementary sheet #2.

SUGGESTED APPROACH:

1. Ask students if, on the basis of their travels in New York State, they could separate the the State into general landform patterns.

2. Ask if they could do this more easily if they could see the entire State from a vantage point many miles high. Indicate that this is possible by using map models of the State that show topography.

3. Use the floor to spread out the individual topographic maps, placing them in their appropriate positions until a mozaic of the entire State is formed. Have students stand back a few feet and try to determine where landform divisions should occur. (These maps can be permanently mounted on the wall, by trimming the borders.)

4. Using their blank maps of New York State, have students sketch in landform boundaries while studying the large map mozaic on the floor. Have them indicate some kind of a descriptive name for each landform determined. Using a blank New York State map drawn on the chalkboard, let the students fill in their landform boundaries. Allow a discussion to develop and boundaries to be changed until the entire class agrees on a map.

5. Pass out copies of *Landform and Bedrock Geology of New York State maps*, and ask the students if they can find any reasons why the landform regions they have identified have developed. Is there any relationship between bedrock geology and landform development?

PRECAUTIONS:

1. Modifications may be necessary in this investigation to obtain the objectives.

2. Because the contour intervals on some of the maps are different, make certain the students are aware of this and consider it when inferring landform boundaries.

3. Students may not divide the State into the same landform regions as is indicated on the landform map of New York State. The fact that they have been able to identify landform differences is much more important than agreeing exactly with another map.

TYPICAL RESULTS:

If students have had some previous work with topographic maps, they should be able to identify some basic landforms. They probably will not identify all that are listed on the landform map of New York State.

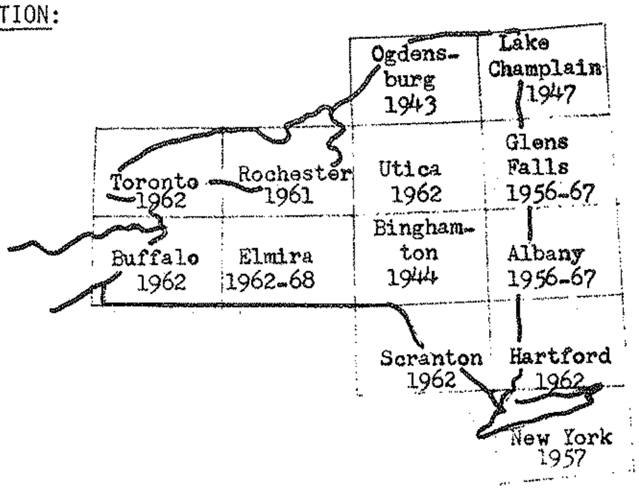
MOFICIATIONS:

1. Have the students start collecting photographs of various areas in New York State a few weeks in advance of the lab. During the lab, they could match these photos with their various landforms. If the teacher has available slides of various parts of the State, they also could be used. Travelogue films of New York State are helpful in observing various landforms.

2. Use raised relief map of New York State to identify landform regions.

3. Take the students on an aerial field trip if facilities are available.

BACKGROUND INFORMATION:



The above maps can be ordered at a cost of $0.75 each from the:

Distribution Section, U.S. Geological Survey
1200 South Eads Street
Arlington, Va. 22202

The scale of the maps is 1:250,000; 1 inch on the map represents about 4 miles on the ground.

NOTE: Prepayment is required, and may be made by money order or check payable to the Geological Survey. Delivery will be expedited by listing maps alphabetically. A discount of 20 percent is allowed on single orders of $20.00 or more.

REFERENCES:

Geology of New York, a Short Account, Educational Leaflet No. 20, pp. 32-35.

XIV-A-2a: IDENTIFYING LEANDSCAPE REGIONS

QUESTION:

How are landscape characteristics related?

INTRODUCTION:

If you have traveled over much of New York State, you have probably observed some different landforms. Some areas are mountainous, others just hilly, and still other areas are low and flat with long stretches of straight highway. You can probably picture in your mind a few different areas of the State and what they look like, but this would not be enough to draw boundaries between these landforms. In order to do this, we need a model of the entire State. In this investigation, you will use such a model.

OBJECTIVES:

When you have finished this investigation, you should be able to:

1. match typical photographs with the various landform regions of New York State.

2. indicate the role that bedrock plays in the development of landforms.

METHOD:

1. Help your teacher assemble the map model of New York State.

2. Stand back far enough so that you can see the entire map system, but stay close enough to see the pattern indicating topography.

3. Study the map and decide where you would draw boundaries between landforms. Try to imagine what the area would look like if you were flying over it in an airplane.

4. Sketch the boundaries that you have decided upon on your blank map of New York State. Label each area with some kind of a descriptive name.

5. Work with the other students at the chalkboard to develop a satisfactory map.

QUESTIONS:

(A-2.11) 1. Which regions of the State have the highest elevation? What landscape region would this be?

(A-2.11) 2. Which areas of the State have the lowest and most level topography? What landscape region would this be?

(A-2.12) 3. How well-defined are the boundaries between landscape regions?

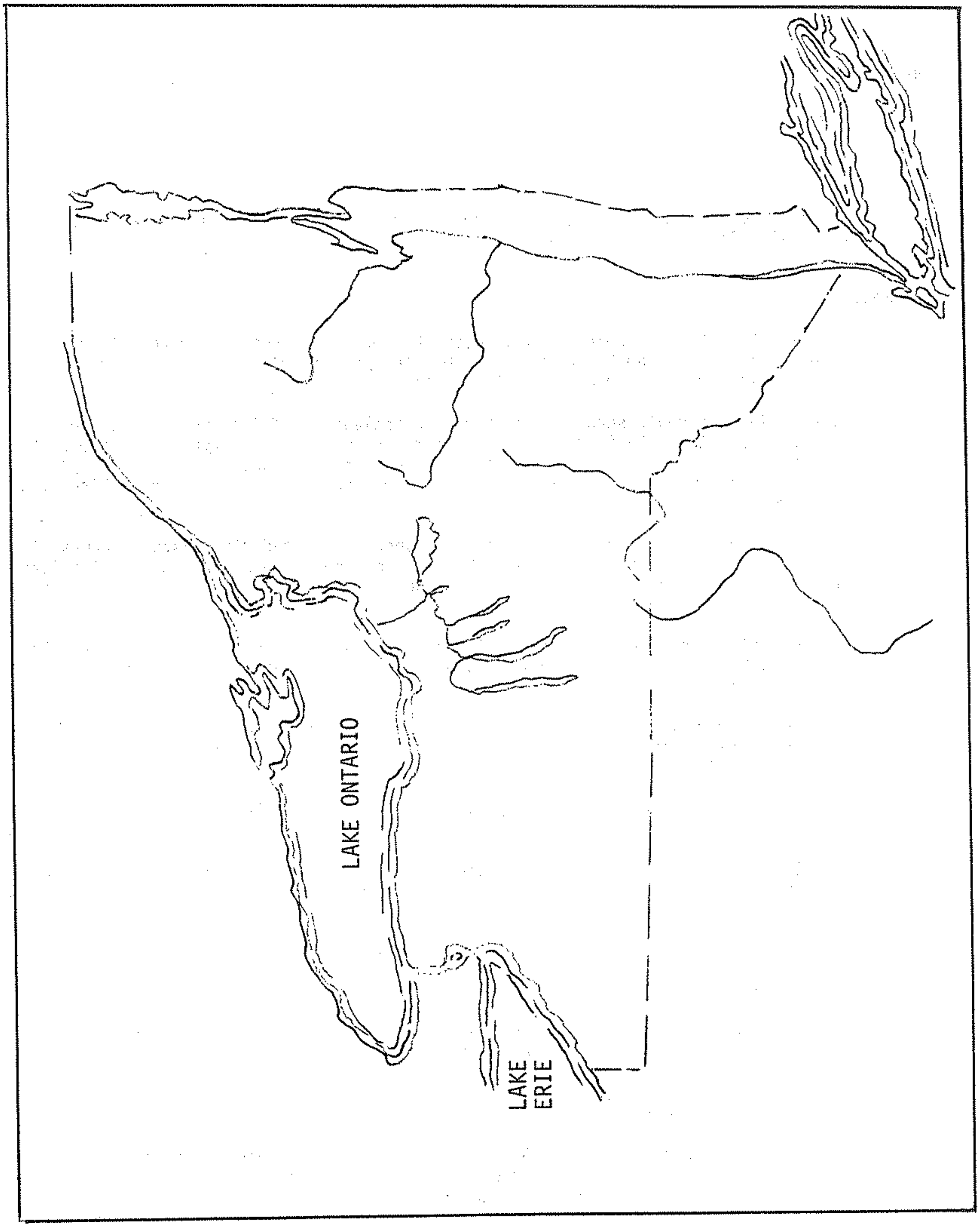
(A-2.14) 4. Describe the distinctive landscape regions that you have been able to identify in New York State.

(B-1.31) 5. Which types of bedrock do you think erode most rapidly? Least rapidly? Describe any relationship between kinds of bedrock and landscape regions identified.

(B-1.33) 6. What relationship can you find between the location of rivers and the bedrock pattern of New York State?

(B-1.13)
(B-1.22) 7. Are there any areas where observed landscape characteristics are not directly related to bedrock type? If so, can you think of any reasons why they might not be related?
(B-1.34)

(B-1.32)
(B-1.34) 8. What are the similarities and differences between the Catskill and Adirondacks in topography and structure?


LAKE ONTARIO
LAKE
ERIE

XIV-B-1a: LANDSCAPE AND SOILS FIELD TRIP

QUESTION:

How is landscape development influenced by environmental factors?

MATERIALS:

Topographic maps of the area to be covered, some form of field notebook for each student, soil auger or shovels. (Optional - hand lens, rock hammers, soil pH testing kits, cameras, etc.)

SUGGESTED APPROACH:

1. The teacher should become familiar with the local area before laying out the route for the field trip. This can be accomplished by studying the references cited and by driving through the proposed area before taking the students.

2. The field trip route should be designed to include the following if possible: traverse of two or more State physiographic regions; two or more bedrock types; and areas where well-drained agricultural soil, forest soil and wet bog-type soil can all be sampled. Permission should always be obtained in advance from property owners before taking students to the premises.

3. At least one preliminary period should be spent with students; discussing what they should look for, how to best record their observations, and, in general, becoming familiar with the region they will be observing. Color slides of various stops can be used to preview the trip.

4. While riding, the teacher should point out as many landform features as possible. Have students keep track of their location on topographic maps. Notes and sketches should be made in the notebooks whenever appropriate.

5. At the soil sampling sites have a few of the students dig a 2- or 3-foot diameter pit a few feet deep so that soil horizons can be easily observed and sampled. The following observations may be made:

   a) Identification of bedrock type under soil sample. This can be done from geologic map information or by observing nearby outcrops.

   b) Identify soils as being either transported or residual. Does the soil contain cobbles that are different from the underlying bedrock type? Can the probable source of this material be inferred?

   c) Identify soils as to the mode of deposition:

      1) horizontal layering - running water

      2) unsorted - containing fine grain material, mixed with larger cobbles, some containing scratches on their surface - (glacial till)

      3) fine grain clays blanketing large areas and containing no cobbles - lake bed deposits

   NOTE: If the three soils sampled are all from the same parent material, the student will be more likely to infer the importance of slope of land (drainage), and vegetative cover on their development.

PRECAUTIONS:

1. Make sure students are aware of the type of clothing they should wear on the field trip.

2. A field trip like this will demand a great deal of teacher planning in order to obtain the desired results; however, once completed, it may be used many times in the future and will represent one of the most rewarding learning experiences of the course.

REFERENCES:

Geologic map of the area (available from New York State Museum and Science Service, Albany, New York)

New York State Geological Association Field Guide Books - refer to listing (Investigation XIII-A-1a)

Glacial geology bulletins of the area (available from the New York State Museum)

Soil survey bulletin of your county. Those produced in recent years are very useful in describing bedrock and soil associations, suggested soil usages, etc.

A soil survey published by the U.S. Department of Agriculture that is still in print may be obtained in one of the following ways:

1) A professional user in the area surveyed can obtain a free copy from the local office of the Soil Conservation Service, from their county agent, or from their congressman.

2) For a time after publication, copies may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

3) Many libraries keep published soil surveys on file for reference.

LIST OF PUBLISHED SOIL SURVEYS IN NEW YORK STATE
AS OF April 1969

1942 Albany and Schenectady
1956 Allegany
*1904 Auburn Area
*1902 Bigflats Area
*1905 Binghamton Area
1932 Broome
1940 Cattaraugus
*1922 Cayuga
*1914 Chautauqua
1932 Chemung
*1918 Chenango
*Clinton
*1923 Columbia
*1916 Cortland
1961 Cortland
*1930 Delaware
*1907 Dutchess
1955 Dutchess
1929 Erie
1958 Franklin
*1922 Genesee
1969 Genesee
*1923 Herkimer Area
*1911 Jefferson
1960 Lewis
*1908 Livingston
1956 Livingston
*1903 Long Island Area
*1902 Lyons Area
*1906 Madison
*1910 Monroe
1938 Monroe
*1908 Montgomery
*1906 Niagara
1947 Niagara
*1913 Oneida
1938 Onondaga
*1910 Ontario
1958 Ontario and Yates
*1912 Orange
1939 Orleans
*1917 Oswego
1940 Otsego
1937 Rensselaer
*1917 Saratoga
*1915 Schoharie
1942 Seneca
1931 Steuben
1925 St. Lawrence
*1928 Suffolk and Nassau
1946 Sullivan
*1903 Syracuse Area
1955 Tioga
*1905 Tompkins
1965 Tompkins
1940 Ulster
*1909 Washington
*1919 Wayne
*1901 Westfield Area
*1919 White Plains Area
1938 Wyoming
1916 Yates

*out of print

XIV-B-1a: LANDSCAPE AND SOILS FIELD TRIP

QUESTION:

How is landscape development influenced by environmental factors?

INTRODUCTION:

The earth scientist uses many tools, such as aerial photos and topographic maps, when making a study of a particular region. But associated with this, he will, whenever possible, do extensive field work. While on these field trips he usually collects samples, makes sketches and photographs, and takes notes that may aid him in drawing inferences about the landscape. During this field trip, you will have an opportunity to do the same.

OBJECTIVES:

When you have finished this investigation, you should be able to:

1. describe the general landforms covered on the field trip.
2. describe in terms of color, degree of wetness, and amount of organic material the three or more soils investigated.
3. infer reasons why the landscapes and soils observed on this trip have their distinctive characteristics.

METHOD:

1. Record descriptions and sketches of the various landforms which you see.
2. Keep track of your location at all times on the map provided for your use.
3. Record the exact location of any evidence for glaciation that you are able to observe.
4. By observing bedrock outcroppings along the highway, attempt to keep track of the type of bedrock which you are passing over.
5. You will probably stop at several locations where soil horizons can be observed and sampled. Record as much information about the soils as you are able and make sketches of what you see.

QUESTIONS:

(A-2.11) (A-2.14) 1. What landscape regions were you able to observe?

(A-2.12) 2. How well defined were the boundaries between landscape regions?

(B-1.11) (B-1.12) 3. Which of the two dominant forces, uplifting or leveling, was dominant in each landscape region observed? How could you tell?

(B-1.13) 4. Describe specific changes in landscape development that you were able to associate with crustal uplift or subsidence.

(B-1.21) (B-1.22) (B-1.23) 5. Has the region you observed undergone any change in climate during the last million years? What evidence can you use to support this? What effect did it have on the landscape development in the area?

(B-1.24) 6. How was the steepness of hillslopes in the areas observed related to weathering and removal of materials?

(B-1.31) 7. What changes in landscape development were you able to observe as you passed over boundaries from one bedrock type to another?

(B-1.32) 8. What changes in hillslope were you able to observe as you passed over boundaries from one bedrock type to another?

(B-1.33) 9. What effect does a layer of very resistant bedrock have on landscape development? Describe some of the landforms that may be found in regions having a resistant layer like this.

(B-1.33) 10. Describe the landforms that may be observed in areas underlain by weak bedrock (rock that erodes quickly).

(B-1.34) 11. If your teacher pointed out any structural features such as faults, folds, and joints, describe what effect they had on landscape development.

(B-1.35) 12. Describe any associations between stream characteristics and bedrock type that you were able to observe.

(B-1.51) 13. Describe the environmental factors that are responsible for the landscape development in each region visited. What effect would a change in one or more of these factors have on the landscape observed?

(A-1.31) 14. Describe the various soil associations and their characteristics that you observed on this field trip.

(B-1.27) 15. What effect would a change in climate have on these soil associations?

(B-1.36) 16. Describe any associations between bedrock type and soils that you were able to observe.

(B-1.61) 17. Describe any landscape alterations that the activities of man have produced which you were able to observe on this field trip.

(B-1.63) 18. What relationships were you able to observe between landscape alterations and man's population density?

(B-1.64) 19. Describe any destructive rapid changes in landscape development that you observed that you could identify as being due to man's activity.

(B-1.66) 20. Describe areas observed on your trip where it was evident that careful planning of natural resource use and development was taking place. Describe areas where it was evident that little planning was being done.

(B-1.67) 21. Describe any areas where man was attempting to reclaim a landscape region after it had been misused.

XIV-B-1b: PLOTTING EVIDENCE OF GLACIATION

QUESTION:

How is landscape development influenced by environmental factors?

MATERIALS:

Four or more contiguous topographic maps of your local area on a bulletin board or wall. Various colored felt tip pens for marking symbols on the map. Reports on the glacial geology of the area, such as the New York State Museum Bulletins.

SUGGESTED APPROACH:

1. Mount four or more contiguous topographic maps of the local area on a bulletin board or the wall.

2. Let the class mark these maps with appropriate symbols to note the glacial features they have found. Students may devise their own symbols or consult one of the references cited in this investigation for the system used on standard geologic maps. The following features may be considered:

   a) glacial scratches on bedrock surfaces
   b) large erratic boulders (identify possible source area if you can)
   c) till fabric information
   d) drumlins (long axis)
   e) melt water deposits (roughly stratified and sorted sand and gravel)
   f) eskers, kames, kame terraces
   g) knob and kettle topography
   h) outwash plains or valley trains
   i) glacial lake deposits (deltaic gravel deposits, evenly bedded sands, layered lake bottom clays)
   j) abandoned shorelines of glacial lakes (beach ridge sand deposits etc.)
   k) abandoned outlets of glacial lakes
   l) location of indicator stones and indicator fans. Erratic pebbles and boulders, consisting of unusual rock types from source areas of limited extent, indicate the direction of glacial movement. For example, the Monyeregian Hills near Montreal contain unusual types of igneous rocks. Erratics of these rocks occur in New York State and clearly indicate the direction of glacial movement. (See Martens: *Glacial Boulders in Eastern, Central, and Northern New York*, in New York State Museum Bulletin, No. 260, June 1925.)
   m) direction of crescentic and lunate fractures, especially on glaciated exposures of quartzitic sandstone, e.g., Potsdam, Oneida, and Shawangunk sandstones. (See Flint: *Glacial and Pleistocene Geology*, Wiley, 1957.)

PRECAUTIONS:

Students may consider their evidence as the "absolute truth." Their conclusions are inferences. Alternative inferences should be encouraged.

MODIFICATIONS:

1. If students are neat in their plotting of data, the same maps could be used in subsequent years with successive classes adding information to the maps.

2. Further research could be done by student committees; e.g., committees being responsible for locating large erratic boulders, glacial scratches on bedrock, or exposures of till.

REFERENCES:

Glacial and Pleistocene Geology by Richard Foster Flint, Wiley, 1957.

Muller: *Pleistocene Geology of Chautaugua County, New York* (New York State Museum Bulletin No. 392, Part II, Albany, 1963).

MacClintock and Steward: *Pleistocene Geology of the St. Lawrence Lowland* (New York State Museum Bulletin No. 394, Albany, 1965).

Check for professional bulletins covering your local area.

XIV-B-1b: PLOTTING EVIDENCE OF GLACIATION

QUESTION:

How is landscape development influenced by environmental factors?

INTRODUCTION:

When an earth scientist investigates a problem, he must decide on, and follow, an organized approach. Especially important is developing a system whereby much diverse observational data can be illustrated and interpreted as conveniently as possible. In this investigation you will have an opportunity to develop such a system.

OBJECTIVES:

When you have finished this investigation, you should be able to:

1. describe a logical approach to the study of the glacial geology of your region. The description should include:

   a) evidence you would look for
   b) methods of analysis, including the use of topographic maps, aerial photos, and field observation
   c) tabulation of data that you would collect

METHOD:

1. Mount four or more contiguous topographic maps of your local area on the bulletin board.

2. Decide on a system of symbols that can be neatly drawn on the maps to illustrate various forms of evidence for glaciation. New symbols may have to be added to the key as future evidence is collected.

3. Plot the evidence for glaciation that you have found during your studies of local landscapes.

QUESTIONS:

(B-1.21) (B-1.22) 1. What are your interpretations of the evidence that you have collected? In what climatic environment were these landscape features formed?

(B-1.23) 2. Describe the rate of landscape development that probably existed when these features formed compared to the rate of landscape development in the same area now.

3. What other ways can you suggest to illustrate diverse geologic data, instead of using a map?

Easy (1)

XIV-B-1c: EXPONENTIAL POPULATION GROWTH

QUESTION:

How is landscape development influenced by environmental factors?

MATERIALS:

A large number of small uniformly shaped objects (e.g., kernels of corn or dried beans, each group of students will need 2,048 objects to complete the investigation), beaker, stack of paper cups, and graph paper.

SUGGESTED APPROACH:

1. Involve the students in a discussion on human population. Consider such points as:
   a) How long have humans been on the earth?
   b) How do the rate of population growth during early periods of human existence compare with population growth rates of today? Why the change?
   c) If the present doubling period of the world population is about 37 years, how could you best describe, in mathematical terms, the rate of human population growth?
2. Indicate to the student that this investigation represents a model of population growth and will help them to better understand the mathematics of such a growth rate.
3. Provide the students with the necessary materials and handout sheets, and allow them to complete the investigation.
4. When completed, including preparation of the graph which can be done as homework, conduct a discussion during which you may want to consider some of the following:
   a) Are there any limitations concerning the number of people the earth will support?
   b) What limitations will be most critical, i.e., which will limit population growth first?
   c) Are there any areas of the world where these problems are apparent now? If so, is it because of local population densities or is it more widespread?
   d) What factors should be considered in determining an optimal population for the earth? What would you consider an optimal population? Have we reached it yet?
   e) What long-range problems will we face if we overpopulate the earth?

MODIFICATIONS:

1. You may wish to have the students consider the population growth occurring in your own county area as shown under Background Information. For more complete information you may want to obtain the booklet listed under references below or contact your district office director of the Office of Planning Coordination as listed:

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New York, N. Y. 10023
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Central New York	-	Robert C. Hansen State Tower Building 109 S. Warren Street, Room 302 Syracuse, N. Y. 13202 (315) 474-5951 Ext. 291
Western New York	-	Myron J. Elkins General Donovan State Office Building 125 Main Street Buffalo, N. Y. 14203 (716) 842-2393

BACKGROUND INFORMATION:

(See next page.)

REFERENCES:

Demographic Projections for New York State Counties to 2020 A.D., available from the Office of Planning Coordination.

BACKGROUND INFORMATION:

SUMMARY POPULATION PROJECTIONS (in thousands)

COUNTY	1950	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
ALBANY	239	273	285	303	327	352	381	413	446	482	520	562	607	655
ALLEGANY	44	44	46	47	48	49	51	52	54	56	57	59	62	64
BRONX	1,451	1,425	1,522	1,555	1,576	1,591	1,608	1,625	1,639	1,653	1,662	1,672	1,681	1,687
BROOME	185	213	222	231	245	262	280	299	316	335	354	376	400	424
CATTARAUGUS	78	80	82	82	82	83	84	85	87	89	91	94	97	100
CAYUGA	70	74	77	78	80	82	84	87	89	90	93	95	98	101
CHAUTAUQUA	135	145	151	153	157	162	168	174	180	187	194	202	211	220
CHEMUNG	87	99	104	108	113	120	128	135	142	149	157	165	174	183
CHENANGO	39	43	46	47	49	52	54	57	60	62	65	69	72	75
CLINTON	54	73	81	86	90	95	101	107	114	119	125	132	139	147
COLUMBIA	43	47	49	51	53	55	57	60	63	65	68	71	74	77
CORTLAND	37	41	44	46	48	50	53	57	61	65	70	75	81	88
DELAWARE	44	44	43	42	42	42	43	43	44	44	45	45	46	47
DUTCHESS	137	176	210	240	275	318	370	432	504	589	685	800	935	1,092
ERIE	899	1,065	1,083	1,102	1,150	1,211	1,282	1,353	1,419	1,485	1,550	1,625	1,709	1,794
ESSEX	35	35	36	36	36	37	38	39	39	40	41	41	42	43
FRANKLIN	45	45	45	45	45	46	48	51	53	56	59	62	66	70
FULTON	51	51	51	51	50	51	52	54	55	56	57	58	60	62
GENESEE	48	54	57	60	62	66	70	75	79	83	87	92	97	102
GREENE	29	31	33	33	34	36	37	39	40	42	44	45	47	49
HAMILTON	4	4	4	4	4	4	4	4	4	4	4	4	4	4
HERKIMER	61	66	68	69	71	74	76	79	81	84	86	89	92	95
JEFFERSON	86	88	89	87	86	85	87	89	90	92	93	95	97	99
KINGS	2,738	2,627	2,704	2,725	2,697	2,671	2,649	2,626	2,606	2,583	2,554	2,529	2,506	2,478
LEWIS	23	23	24	24	24	24	24	24	24	24	24	24	24	24
LIVINGSTON	40	44	48	50	52	55	59	62	66	70	74	79	84	90
MADISON	46	55	57	61	68	75	84	93	102	111	122	135	149	163
MONROE	488	586	644	699	751	807	867	927	988	1,052	1,112	1,178	1,247	1,318
MONTGOMERY	60	57	57	56	55	54	54	54	54	53	53	53	54	54
NASSAU	673	1,300	1,387	1,444	1,511	1,597	1,679	1,743	1,791	1,836	1,879	1,928	1,977	2,021
NEW YORK	1,960	1,698	1,564	1,540	1,506	1,478	1,450	1,424	1,395	1,368	1,335	1,297	1,258	1,217
NIAGARA	190	242	241	248	256	272	291	310	327	346	366	391	418	445
ONEIDA	223	264	280	295	311	332	354	377	399	422	447	474	503	534
ONONDAGA	342	423	457	491	527	568	614	661	709	758	808	863	923	985
ONTARIO	60	68	73	76	80	85	90	95	100	105	110	116	122	128
ORANGE	152	184	223	268	324	394	459	534	620	718	827	927	1,038	1,159
ORLEANS	30	34	37	39	40	43	45	47	49	51	53	56	58	60
OSWEGO	77	86	93	99	107	118	129	141	152	164	178	194	211	229
OTSEGO	51	52	54	54	56	58	61	64	67	71	75	80	86	92
PUTNAM	20	32	42	53	67	82	100	121	145	169	196	225	256	287
QUEENS	1,551	1,810	1,946	2,047	2,120	2,181	2,233	2,270	2,301	2,332	2,354	2,378	2,401	2,421
RENSSELAER	133	143	153	163	174	186	200	214	229	245	262	280	301	322
RICHMOND	192	222	260	296	335	381	434	493	545	602	663	730	795	863
ROCKLAND	89	137	182	231	266	307	354	408	462	518	578	647	726	814
ST. LAWRENCE	99	111	120	126	134	143	154	165	176	188	200	215	230	245
SARATOGA	75	89	99	108	117	128	140	154	168	183	199	218	238	260
SCHENECTADY	142	153	161	165	172	182	192	202	211	221	231	243	256	269
SCHOHARIE	23	23	23	23	23	23	24	24	24	25	26	27	28	28
SCHUYLER	14	15	15	16	16	17	17	18	19	19	20	21	21	22
SENECA	29	32	34	34	35	36	38	39	40	41	42	42	43	44
STEUBEN	91	98	100	102	104	107	110	114	117	120	123	126	129	133
SUFFOLK	276	667	910	1,155	1,380	1,663	2,022	2,463	2,974	3,383	3,751	4,096	4,427	4,720
SULLIVAN	41	45	48	49	50	52	53	55	57	58	59	61	63	65
TIOGA	30	38	43	47	51	56	62	67	73	79	85	91	98	104
TOMPKINS	59	66	75	82	89	96	105	116	127	138	151	164	179	195
ULSTER	93	119	136	149	160	172	187	203	220	237	255	275	297	319
WARREN	39	44	47	49	52	55	58	61	64	67	71	75	79	83
WASHINGTON	47	48	49	48	49	50	52	55	57	60	63	67	71	75
WAYNE	57	68	73	79	85	93	102	113	123	134	147	161	176	193
WESTCHESTER	626	809	856	947	1,044	1,138	1,242	1,351	1,440	1,534	1,632	1,738	1,852	1,969
WYOMING	33	35	36	36	37	37	38	39	41	43	45	47	49	51
YATES	18	19	19	19	19	19	20	21	22	23	24	25	27	29
NEW YORK STATE	**14,830**	**16,782**	**17,794**	**18,751**	**19,668**	**20,757**	**22,004**	**23,356**	**24,744**	**26,079**	**27,402**	**28,803**	**30,288**	**31,783**

XIV-B-1c: EXPONENTIAL POPULATION GROWTH

QUESTION:

How is landscape development influenced by environmental factors?

INTRODUCTION:

Man is now beginning to realize that he is facing an environmental crisis. Many of the hastily made and poorly planned changes that he has inflicted on his environment are now backfiring and making him pay both in financial terms and in more humanistic terms , such as mental and physical health.

Whenever environmental problems are investigated, it is usually found that the basic causes are the products of man himself, namely his advanced technology and his increasing population density.

In this investigation you are going to investigate the mathematical nature of man's population growth.

OBJECTIVES:

When you have finished this investigation, you should be able to:

1. describe the mathematical nature of man's population growth in the past.
2. extrapolate into the future what the world population will be for any given time, if the present growth rate continues.

METHOD:

1. Place a glass beaker on your desk with two objects in it. This will represent the earth which will hold only a finite population.
2. Place a number of paper cups in a row on your desk (10 should be enough).
3. In the first cup, place two of the objects. In the second cup, place twice as many as in the first cup (4). Record on the outside of the cups the number of objects that have been placed in each cup.
4. In cups 3 through 10, double the number of objects that are in the previous cup (i.e., cup number 3 will contain 8 and cup number 4 will contain 16). Record the amount in each cup on the outside.

5. Take the beaker with the two objects in it and determine the beaker's height. What is the approximate volume in percent that is without objects? Record this on the table at 0 time.

6. In 35 seconds, add the contents of cup 1 (i.e., 2 objects) to the beaker and record in the table the total population and the approximate percent of the volume of the beaker that is without objects.

7. At 35-second intervals, add the contents of cups 2 through 10 and fill in the table.

Time	Population	% Volume without	Time	Population	% Volume without
0			6		
1			7		
2			8		
3			9		
4			10		
5					

8. Graph your results, total population versus time.

QUESTIONS:

1. Describe the mathematical nature of the population growth of the objects in the beaker.

(B-1.62) 2. Man's population on the earth is thought to have had a slow start with doubling periods as long as 1 million years. The present world population is thought to be doubling at a rate of every 37 years. How would the mathematical nature of this growth rate compare to your investigation?

3. The present world population is about 4 1/2 billion people. If the earth's radius is about 6400 km. and about 3/4 of its surface is covered with water, what is the present density of human population in terms of number of people per square kilometer? (Area of a sphere = $4\pi r^2$)

4. Assuming a continuation of the present population growth rate, what will the density per square kilometer be 37 years from now? 111 years? 1,110 years?

5. Is space the only limiting factor in determining maximum human population? If not, describe others.

XIV-B-1b: PLOTTING EVIDENCE OF GLACIATION

QUESTION:

How is landscape development influenced by environmental factors?

INTRODUCTION:

When an earth scientist investigates a problem, he must decide on, and follow, an organized approach. Especially important is developing a system whereby much diverse observational data can be illustrated and interpreted as conveniently as possible. In this investigation you will have an opportunity to develop such a system.

OBJECTIVES:

When you have finished this investigation, you should be able to:

1. describe a logical approach to the study of the glacial geology of your region. The description should include:

   a) evidence you would look for
   b) methods of analysis, including the use of topographic maps, aerial photos, and field observation
   c) tabulation of data that you would collect

METHOD:

1. Mount four or more contiguous topographic maps of your local area on the bulletin board.

2. Decide on a system of symbols that can be neatly drawn on the maps to illustrate various forms of evidence for glaciation. New symbols may have to be added to the key as future evidence is collected.

3. Plot the evidence for glaciation that you have found during your studies of local landscapes.

QUESTIONS:

(B-1.21) (B-1.22) 1. What are your interpretations of the evidence that you have collected? In what climatic environment were these landscape features formed?

(B-1.23) 2. Describe the rate of landscape development that probably existed when these features formed compared to the rate of landscape development in the same area now.

3. What other ways can you suggest to illustrate diverse geologic data, instead of using a map?

Easy (1)

XIV-B-1c: EXPONENTIAL POPULATION GROWTH

QUESTION:

How is landscape development influenced by environmental factors?

MATERIALS:

A large number of small uniformly shaped objects (e.g., kernels of corn or dried beans, each group of students will need 2,048 objects to complete the investigation), beaker, stack of paper cups, and graph paper.

SUGGESTED APPROACH:

1. Involve the students in a discussion on human population. Consider such points as:

   a) How long have humans been on the earth?

   b) How do the rate of population growth during early periods of human existence compare with population growth rates of today? Why the change?

   c) If the present doubling period of the world population is about 37 years, how could you best describe, in mathematical terms, the rate of human population growth?

2. Indicate to the student that this investigation represents a model of population growth and will help them to better understand the mathematics of such a growth rate.

3. Provide the students with the necessary materials and handout sheets, and allow them to complete the investigation.

4. When completed, including preparation of the graph which can be done as homework, conduct a discussion during which you may want to consider some of the following:

   a) Are there any limitations concerning the number of people the earth will support?

   b) What limitations will be most critical, i.e., which will limit population growth first?

   c) Are there any areas of the world where these problems are apparent now? If so, is it because of local population densities or is it more widespread?

   d) What factors should be considered in determining an optimal population for the earth? What would you consider an optimal population? Have we reached it yet?

   e) What long-range problems will we face if we overpopulate the earth?

MODIFICATIONS:

1. You may wish to have the students consider the population growth occurring in your own county area as shown under Background Information. For more complete information you may want to obtain the booklet listed under references below or contact your district office director of the Office of Planning Coordination as listed:

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BACKGROUND INFORMATION:

(See next page.)

REFERENCES:

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ERIE	899	1,065	1,083	1,102	1,150	1,211	1,282	1,353	1,419	1,485	1,550	1,625	1,709	1,794
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FRANKLIN	45	45	45	45	45	46	48	51	53	56	59	62	66	70
FULTON	51	51	51	51	50	51	52	54	55	56	57	58	60	62
GENESEE	48	54	57	60	62	66	70	75	79	83	87	92	97	102
GREENE	29	31	33	33	34	36	37	39	40	42	44	45	47	49
HAMILTON	4	4	4	4	4	4	4	4	4	4	4	4	4	4
HERKIMER	61	66	68	69	71	74	76	79	81	84	86	89	92	95
JEFFERSON	86	88	89	87	86	85	87	89	90	92	93	95	97	99
KINGS	2,738	2,627	2,704	2,725	2,697	2,671	2,649	2,626	2,606	2,583	2,554	2,529	2,506	2,478
LEWIS	23	23	24	24	24	24	24	24	24	24	24	24	24	24
LIVINGSTON	40	44	48	50	52	55	59	62	66	70	74	79	84	90
MADISON	46	55	57	61	68	75	84	93	102	111	122	135	149	163
MONROE	488	586	644	699	751	807	867	927	988	1,052	1,112	1,178	1,247	1,318
MONTGOMERY	60	57	57	56	55	54	54	54	54	53	53	53	54	54
NASSAU	673	1,300	1,387	1,444	1,511	1,597	1,679	1,743	1,791	1,836	1,879	1,928	1,977	2,021
NEW YORK	1,960	1,698	1,564	1,540	1,506	1,478	1,450	1,424	1,395	1,368	1,335	1,297	1,258	1,217
NIAGARA	190	242	241	248	256	272	291	310	327	346	366	391	418	445
ONEIDA	223	264	280	295	311	332	354	377	399	422	447	474	503	534
ONONDAGA	342	423	457	491	527	568	614	661	709	758	808	863	923	985
ONTARIO	60	68	73	76	80	85	90	95	100	105	110	116	122	128
ORANGE	152	184	223	268	324	394	459	534	620	718	827	927	1,038	1,159
ORLEANS	30	34	37	39	40	43	45	47	49	51	53	56	58	60
OSWEGO	77	86	93	99	107	118	129	141	152	164	178	194	211	229
OTSEGO	51	52	54	54	56	58	61	64	67	71	75	80	86	92
PUTNAM	20	32	42	53	67	82	100	121	145	169	196	225	256	287
QUEENS	1,551	1,810	1,946	2,047	2,120	2,181	2,233	2,270	2,301	2,332	2,354	2,378	2,401	2,421
RENSSELAER	133	143	153	163	174	186	200	214	229	245	262	280	301	322
RICHMOND	192	222	260	296	335	381	434	493	545	602	663	730	795	863
ROCKLAND	89	137	182	231	266	307	354	408	462	518	578	647	726	814
ST. LAWRENCE	99	111	120	126	134	143	154	165	176	188	200	215	230	245
SARATOGA	75	89	99	108	117	128	140	154	168	183	199	218	238	260
SCHENECTADY	142	153	161	165	172	182	192	202	211	221	231	243	256	269
SCHOHARIE	23	23	23	23	23	23	24	24	24	25	26	27	28	28
SCHUYLER	14	15	15	16	16	17	17	18	19	19	20	21	21	22
SENECA	29	32	34	34	35	36	38	39	40	41	42	42	43	44
STEUBEN	91	98	100	102	104	107	110	114	117	120	123	126	129	133
SUFFOLK	276	667	910	1,155	1,380	1,663	2,022	2,463	2,974	3,383	3,751	4,096	4,427	4,720
SULLIVAN	41	45	48	49	50	52	53	55	57	58	59	61	63	65
TIOGA	30	38	43	47	51	56	62	67	73	79	85	91	98	104
TOMPKINS	59	66	75	82	89	96	105	116	127	138	151	164	179	195
ULSTER	93	119	136	149	160	172	187	203	220	237	255	275	297	319
WARREN	39	44	47	49	52	55	58	61	64	67	71	75	79	83
WASHINGTON	47	48	49	48	49	50	52	55	57	60	63	67	71	75
WAYNE	57	68	73	79	85	93	102	113	123	134	147	161	176	193
WESTCHESTER	626	809	856	947	1,044	1,138	1,242	1,351	1,440	1,534	1,632	1,738	1,852	1,969
WYOMING	33	35	36	36	37	37	38	39	41	43	45	47	49	51
YATES	18	19	19	19	19	19	20	21	22	23	24	25	27	29
NEW YORK STATE	**14,830**	**16,782**	**17,794**	**18,761**	**19,866**	**20,767**	**22,004**	**23,355**	**24,744**	**26,079**	**27,402**	**28,803**	**30,288**	**31,783**

XIV-B-1c: EXPONENTIAL POPULATION GROWTH

QUESTION:

How is landscape development influenced by environmental factors?

INTRODUCTION:

Man is now beginning to realize that he is facing an environmental crisis. Many of the hastily made and poorly planned changes that he has inflicted on his environment are now backfiring and making him pay both in financial terms and in more humanistic terms , such as mental and physical health.

Whenever environmental problems are investigated, it is usually found that the basic causes are the products of man himself, namely his advanced technology and his increasing population density.

In this investigation you are going to investigate the mathematical nature of man's population growth.

OBJECTIVES:

When you have finished this investigation, you should be able to:

1. describe the mathematical nature of man's population growth in the past.
2. extrapolate into the future what the world population will be for any given time, if the present growth rate continues.

METHOD:

1. Place a glass beaker on your desk with two objects in it. This will represent the earth which will hold only a finite population.
2. Place a number of paper cups in a row on your desk (10 should be enough).
3. In the first cup, place two of the objects. In the second cup, place twice as many as in the first cup (4). Record on the outside of the cups the number of objects that have been placed in each cup.
4. In cups 3 through 10, double the number of objects that are in the previous cup (i.e., cup number 3 will contain 8 and cup number 4 will contain 16). Record the amount in each cup on the outside.

5. Take the beaker with the two objects in it and determine the beaker's height. What is the approximate volume in percent that is without objects? Record this on the table at 0 time.

6. In 35 seconds, add the contents of cup 1 (i.e., 2 objects) to the beaker and record in the table the total population and the approximate percent of the volume of the beaker that is without objects.

7. At 35-second intervals, add the contents of cups 2 through 10 and fill in the table.

Time	Population	% Volume without	Time	Population	% Volume without
0			6		
1			7		
2			8		
3			9		
4			10		
5					

8. Graph your results, total population versus time.

QUESTIONS:

1. Describe the mathematical nature of the population growth of the objects in the beaker.

(B-1.62) 2. Man's population on the earth is thought to have had a slow start with doubling periods as long as 1 million years. The present world population is thought to be doubling at a rate of every 37 years. How would the mathematical nature of this growth rate compare to your investigation?

3. The present world population is about 4 1/2 billion people. If the earth's radius is about 6400 km. and about 3/4 of its surface is covered with water, what is the present density of human population in terms of number of people per square kilometer? (Area of a sphere = $4\pi r^2$)

4. Assuming a continuation of the present population growth rate, what will the density per square kilometer be 37 years from now? 111 years? 1,110 years?

5. Is space the only limiting factor in determining maximum human population? If not, describe others.

INVESTIGATIONS INVENTORY

(An asterisk indicates investigations that must have special reference materials ordered in advance. Check the "MATERIALS:" listing for these labs for specific items)

— I-A-1a Shoebox Observations
— I-A-1b Puddle Observations
— I-A-2a Classification
— I-B-1a Density
— I-B-1b Variable Density of Water
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— *LTI #1 Weather Long-Term Investigation
— *LTI #2 Earthquake Long-Term Investigation
— LTI #3 Sun's Patch Watch
— LTI #4 Air pollution Long-Term Investigation
— LTI #5 - #19
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— FE #1 School Building and Grounds
— FE #2 Pit
— FE #3 Stream
— *FE #4 Cemetery
— *FE #5 Beach
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— II-A-1a Sunspot Analysis
— II-C-1a Roadside Pollutants
— II-C-1b Air Pollution - Human Mortality
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— III-A-1a Earth's Shape
— III-A-2a Earth's Circumference
— III-A-2b Roundness and Smoothness
— III-A-3a Ocean Bottom Profile
— III-B-1a Locating Positions
— III-B-2a Temperature Field
— III-B-2b Contour Mapping
— *III-B-2c Earth's Magnetic Field
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— IV-A-1a Celestial Observations
— IV-A-1b Moon's Path
— IV-A-1c Sun's Path Analysis
— IV-D-1a Planet Phases
— IV-C-1b Heliocentric and Geocentric Models
— IV-D-1c Solar Diameter
— IV-D-2a Orbits
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— V-A-1a Electromagnetic Spectrum
— V-A-2a Heat Transfer
— V-B-1a Changes in State
— V-B-1b Energy Absorption
— V-C-1a Specific Heat
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— VI-A-1a Angle of Insolation
— VI-A-1b Solar Altitude Observations
— VI-A-1c Duration of Insolation
— VI-A-1d Land Water Temperatures
— VI-B-1a Terrestrial Radiation
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— *VII-A-1a Weather Watch Analysis
— *VII-B-1a The Synoptic Weather Map
— VII-C-1a Evaporation
— VII-C-1b Vapor Pressure
— VII-C-3a Adiabatic Cooling and Cloud Formation
— VII-C-3b Dew Point-Cumulus Cloud Formation
— VII-C-4a Air-Water Interaction
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— VIII-A-1a Soil Water Movement
— VIII-A-3a Stream Pollution
— VIII-A-3b Water Purification
— VIII-B-1a The Local Water Budget
— VIII-B-2a Stream Hydrograph
— VIII-C-1a Climate of an Imaginary Continent
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— IX-A-1a Soil Formation
— IX-A-1b Reaction Rate and Particle Size
— IX-A-1c Rock Abrasion
— IX-B-1a Nature of Sand
— IX-B-2a Stream Flow
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— X-A-1a Deposition of Sediments
— X-A-1b Stream Table
— X-A-1c Density Currents
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— XI-A-1a Rock Properties
— XI-B-2a Properties of Minerals
— XI-B-2b Structure of Minerals
— XI-C-1a Formation of Sedimentary Rocks
— XI-C-2a Formation of Nonsedimentary Rocks
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— *XII-A-1a Evidence of Crustal Movement
— XII-A-2a Earthquake Watch Analysis
— *XII-A-2b James Hall's Field Trip
— XII-A-2c The spreading Sea Floor
— XII-B-2a Location of an Epicenter
— XII-D-1a Field Trip Through the Mountains
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— *XIII-A-1a Geologic History of New York State
— *XIII-A-1b Geology of the Grand Canyon
— XIII-B-1a Footprint Puzzle
— XIII-C-1a Geologic Time Line
— XIII-C-1b Correlating Rock Outcrops
— XIII-C-2a Radioactive Decay
— XIII-C-1a Variation Within A Species
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— XIV-A-1a Till Fabric Field Trip
— *XIV-A-1b Regional Aerial Photo Studies
— *XIV-A-1c Local Aerial Photo Studies
— *XIV-A-2a Identifying Landscape Regions
— *XIV-B-1a Landscape and Soils Field Trip
— XIV-B-1b Plotting Evidence of Glaciation
— XIV-B-1c Exponential Population Growth
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