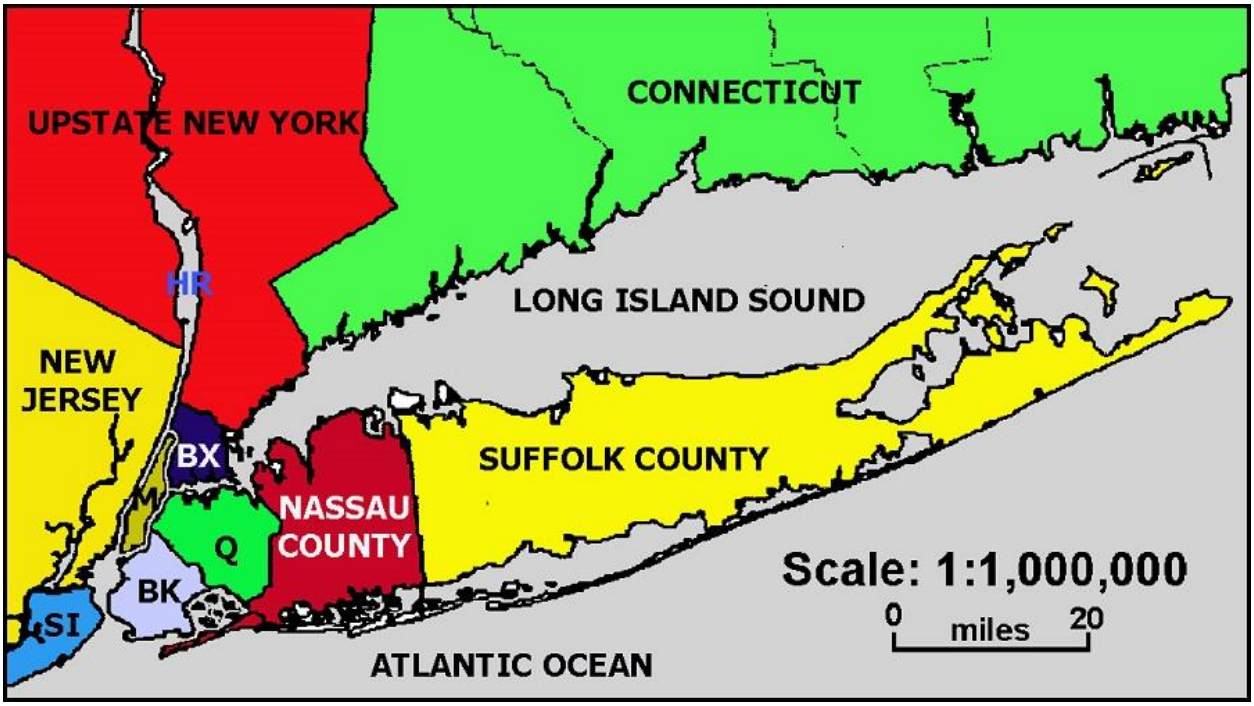
GEOLOGY OF NEW YORK

Authors: David Seidemann and David Leveson, Brooklyn College
Adapted for Hunter College by Shruti Philips



UPSTATE NEW YORK (UNY)	**NEW JERSEY (NJ)**	**HUDSON RIVER (HR)**	**MANHATTAN (M)**	**STATEN ISLAND (SI)**	**BRONX (BX)**
BROOKLYN (BK)	**QUEENS (Q)**	**CONNECTICUT (CT)**	**LONG ISLAND SOUND (LIS)**	**ATLANTIC OCEAN (AC)**	**NASSAU COUNTY (NC)**
SUFFOLK COUNTY(SC)					

WESTCHESTER (W)	NEW JERSEY (NJ)	HUDSON RIVER (HR)	MANHATTAN (M)	STATEN ISLAND (SI)	BRONX (BX)
BROOKLYN (BK)	QUEENS (Q)	CONEY ISLAND (CI)	LONG ISLAND SOUND (LIS)	ROCKAWAY (R)	JAMAICA BAY (JB)
EAST RIVER (ER)	HARLEM RIVER (HR)				

1. **Using both maps above, list the four counties on Long Island from west to east:**

_____

2. **Using both maps above, list the five boroughs of New York City:**

_____

3. **Which is the only borough of N.Y.C. that is part of the mainland of North America?**

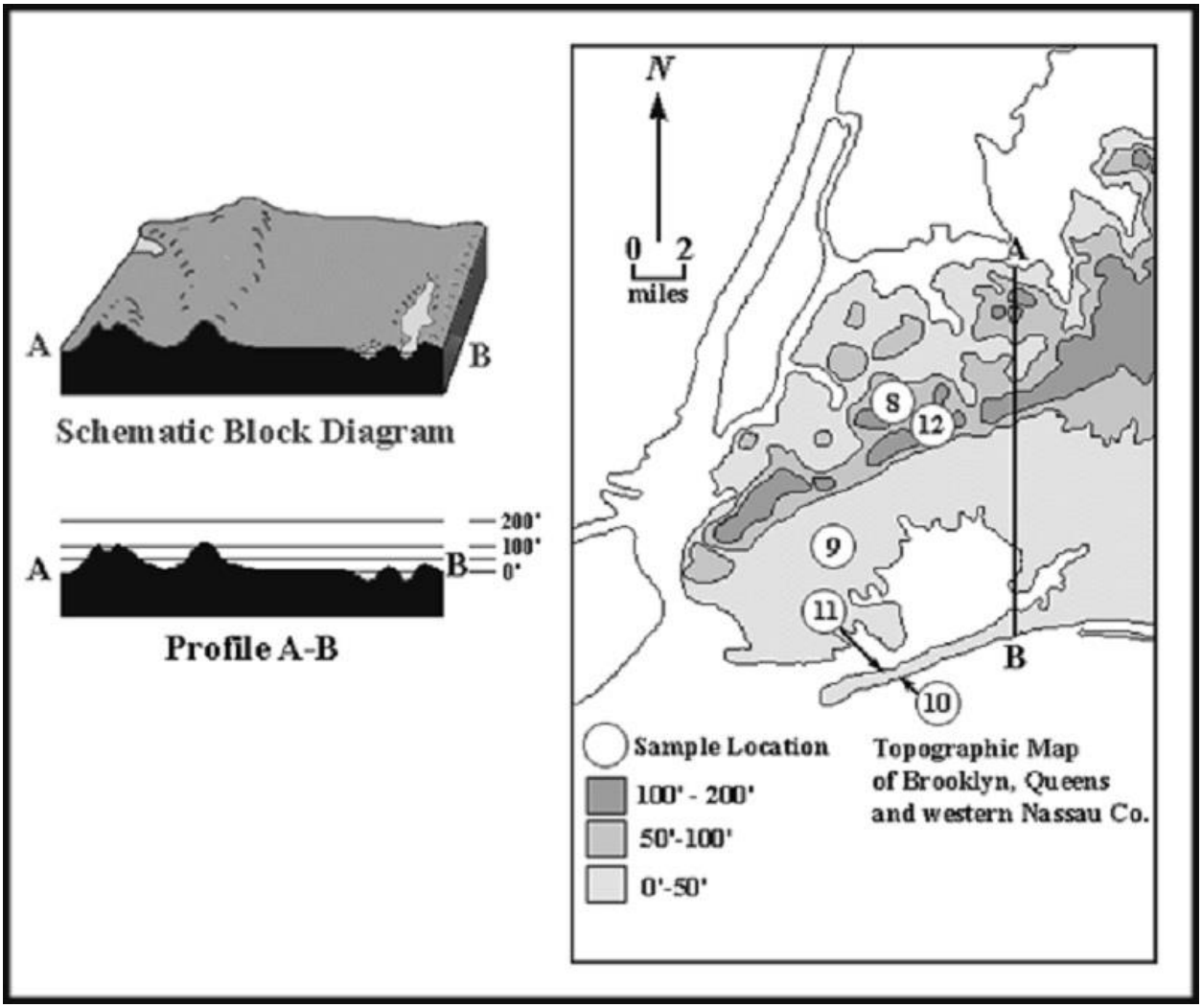
_____

GEOLOGY OF THE PALISADES (NJ), MAHATTAN AND THE BRONX

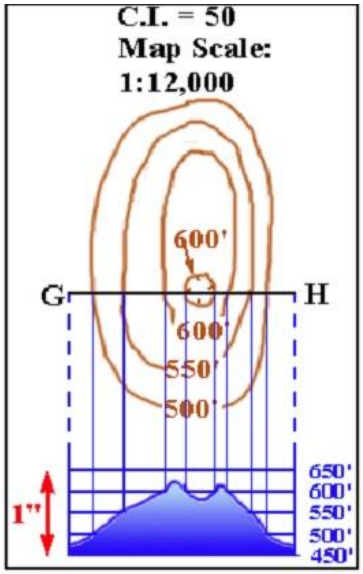
Local Topography

Topography is the description of the configuration of the surface of the land including the sizes and shapes and elevations above sea level of such features as hills, valleys, cliffs and plains. Topography is an expression, by means of physical features, not only of the geology of a country, but to a very large extent of its geological history. If on a map the geology and topography do not fit tightly together either one or the other is wrongly mapped.

The figure below includes a topographic map of **Brooklyn, Queens and western Nassau County,** together with a schematic block diagram that has the north south profile along line A-B as its western face. Profile A-B runs from point A on the north shore of Queens to point B on the south shore of Rockaway. For the sake of clarity, vertical distances in the profile have been exaggerated. On the map, heights above sea level are indicated by the use of shading, as indicated in the legend. Other areas are shown in outline but without their topography.



The figure above: Topographic map of Brooklyn, Queens and western Nassau County. Elevations of land surface are shown by shading, as indicated in the legend. Also shown are a schematic block diagram of western Queens and eastern Nassau County, and a profile along line A-B. Circled numbers indicate locations of sediment samples discussed in the text.



VERTICAL EXAGGERATION

$$V.E. = \frac{\text{HORIZONTAL SCALE}}{\text{VERTICAL SCALE}}$$

$$V.E. = \frac{HS}{VS}$$ both scales have to be in the same units

HS = 1" = 12,000" = 1,000'

VS = 1" = 200'

$$V.E. = \frac{HS}{VS} = \frac{1{,}000'}{200'} = 50$$

What is the **vertical exaggeration** of the profile? (Hint: Vertical exaggeration is horizontal scale (shown in the profile) divided by vertical scale (shown on the map). Before the division is performed, the two scales must be expressed in the same units. Here, the vertical scale is shown in feet, the horizontal scale in miles.) Show your calculations and answer in the space below.

4. The Vertical exaggeration is _____ times.
5. Based on the topographic map of Brooklyn, Queens and western Nassau County, briefly describe and contrast the topography of the northern parts of Brooklyn and Queens as opposed to the southern parts of these two boroughs.

Northern:

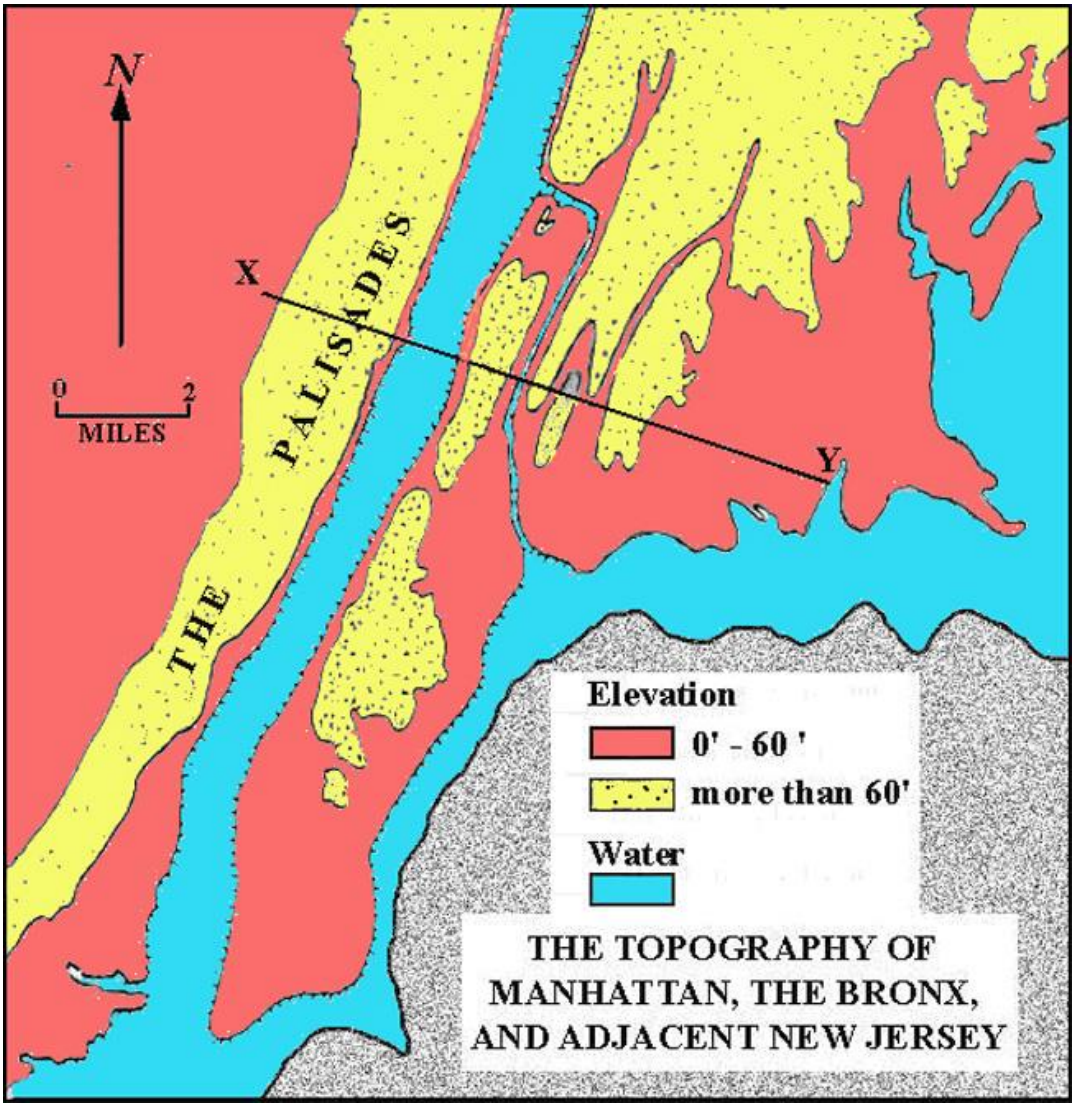
_____

_____

Southern:

_____

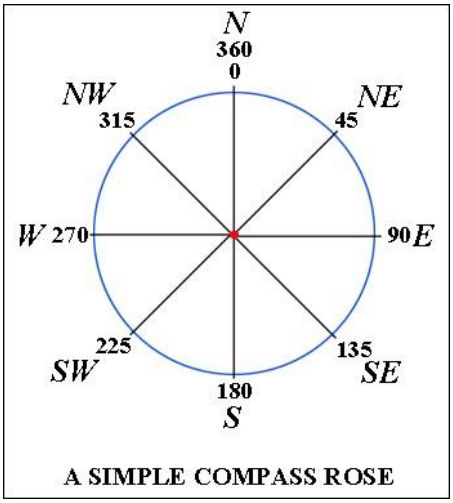
_____



Topographic map of Manhattan, the Bronx, and the Palisades of New Jersey.

The map above is a simple topographic map of **Manhattan, the Bronx, and the Palisades of New Jersey.** Elevations of land surface are shown by patterns indicated in the legend. Waterways are white. Note that with the exception of mid- and lower Manhattan, much of the

region is characterized by a series of **elongated hills (called ridges) and valleys** that are roughly parallel to (a) each other, (b) to the length of Manhattan, and (c) to the Hudson and parts of the Harlem and East Rivers.

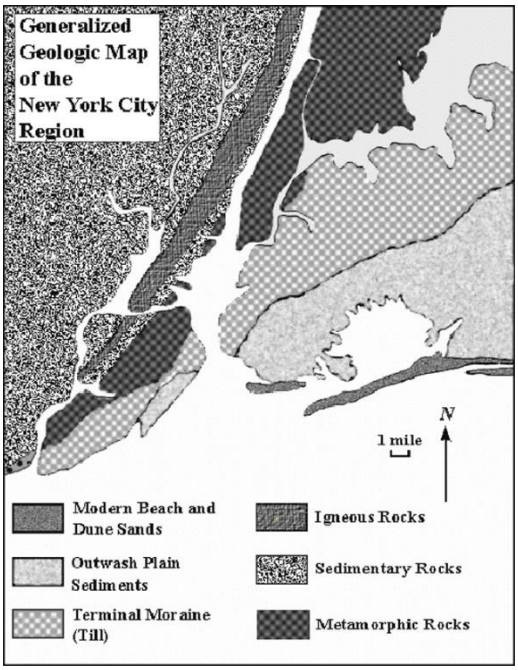


A SIMPLE COMPASS ROSE

6. What is the approximate compass quadrant bearing of these features? _____

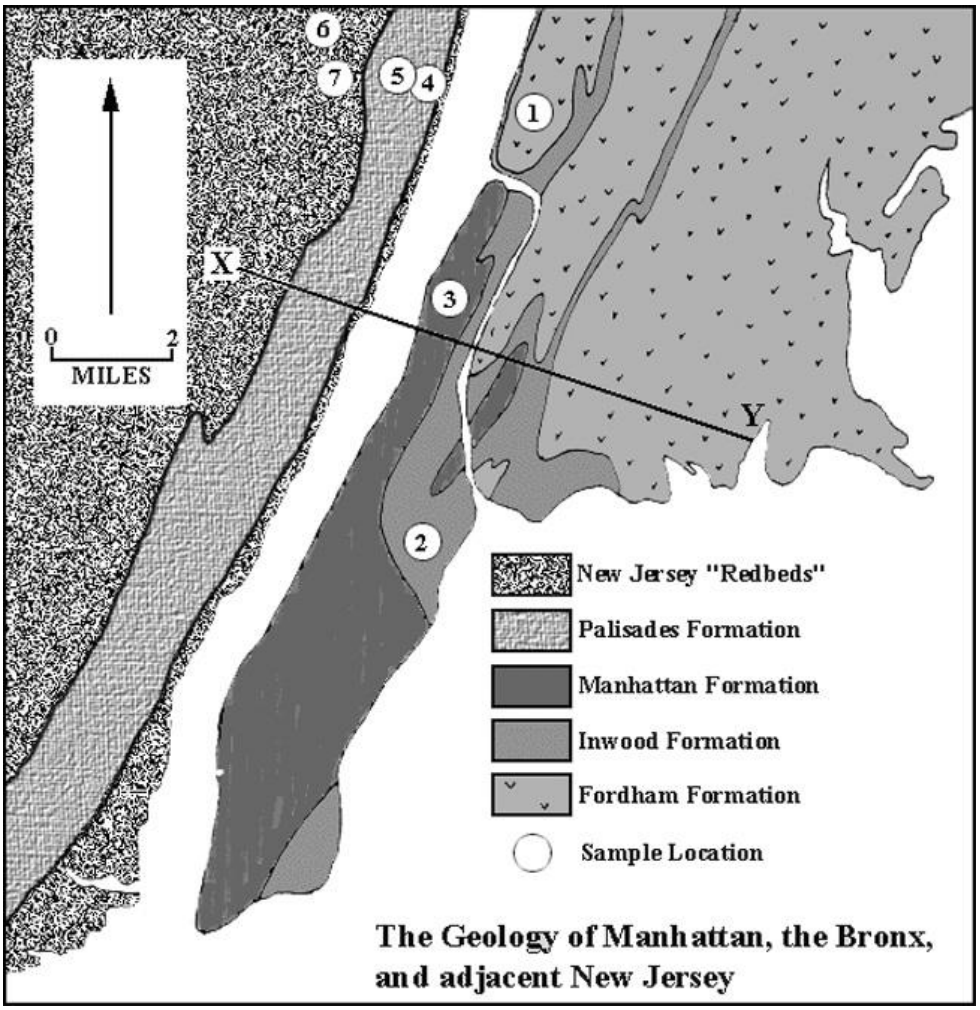
What is their azimuth? _____

Local Geology



Generalized map of the Geology of New York City

The map above is a generalized geologic map of the New York region that shows the distribution of different rock and sediment types that underlies the area. You have been provided with images of these rocks and sediments.



The map above is a more detailed map of Manhattan and the Bronx. It shows the geology of these parts of New York City more accurately than can be depicted on the generalized geologic map. The locations where the rock samples were collected are indicated by circled numbers (samples 1-7). The rocks of samples 6 and 7 occur just to the east and to the west of the Palisades and were collected from both places.

7. Examine samples 1 through 7, and the geological maps above. These maps will allow you to determine the names of each sample. On the table below, identify the rock

formation from which each sample was collected, and indicate whether the sample is a sedimentary (S), igneous (I), or metamorphic (M) rock.

SAMPLE	SPECIFIC ROCK IDENTITY	S, I, M
1		
2		
3		
4		
5		
6		
7		

SAMPLE LOCATION: 1

SAMPLE LOCATION: 2

SAMPLE LOCATION: 3

SAMPLE LOCATION: 4

SAMPLE LOCATION: 5

SAMPLE LOCATION: 6

SAMPLE LOCATION: 7

Origin of topographic features

Our aim is to arrive at an understanding of the **origin of the topographic features of the New York City region** in terms of the materials of which they are composed and/or the geologic processes that created or acted upon them. Manhattan, the Bronx and the Palisades of New Jersey will be considered first.

Manhattan and the Bronx

In these boroughs, bedrock lies at or near the surface of the earth. (Bedrock is the complex but continuous rock mass that forms the outermost part of the crust of the earth and on which rest all loose sediment, soil, water, vegetation, etc.) The bedrock in these two boroughs consists of three major rock types, seen in samples 1, 2 and 3.

SAMPLE LOCATION: 1

SAMPLE LOCATION: 2

SAMPLE LOCATION: 3

8. Which specimen will be the hardest? _____

9. Which specimen will react to hydrochloric acid? _____

10. Which specimen is significantly less resistant to weathering and erosion than the others? Which geological unit is least resistant of the three?

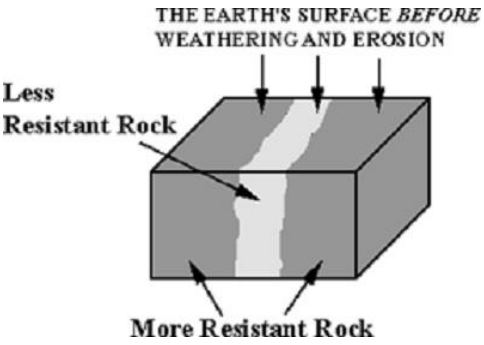
Sample #: _____ Formation: _____

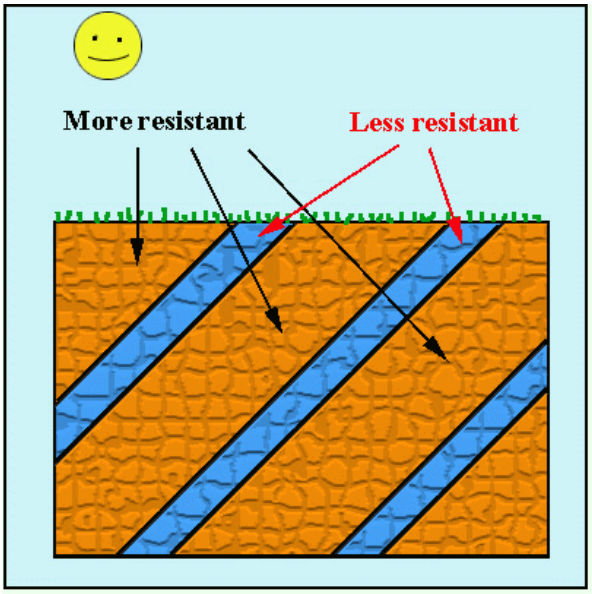
11. Explain why this rock type has low resistance to weathering and erosion.

_____

_____

Imagine flat bedrock that has not yet undergone weathering and erosion. The bedrock consists of two types: one with low resistance to weathering and erosion surrounded by another with high resistance. (see figure below)





Differential Erosion - Erosion that occurs at irregular or varying rates, caused by the differences in the resistance and hardness of surface materials; softer and weaker rocks are rapidly worn away forming topographically low areas called valleys, whereas harder and more resistant rocks remain to form topographically higher areas called ridges, hills, or mountains.

12. After a period of weathering and erosion, how would the elevation of the land surface overlying the low resistance bedrock compare with the elevation of the land surface overlying resistant bedrock?

13. The low resistance bedrock would be higher or lower: _____

14. The landscape feature underlain by the low resistance bedrock would be called a ridge or a valley: _____

To verify your answer, examine the maps above, respectively, the topography and geology of Manhattan, the Bronx and the Palisades.

On the geologic map, look for this pattern. This pattern represents the least resistant rock type out of samples 1, 2, 3.

15. On the topographic map, what pattern represents topographically low areas? Choose between: Red, Yellow, and Blue. _____

16. In northern Manhattan and the western Bronx, is there a general correspondence between the low areas and the areas underlain by the non-resistant rock type? Choose between: Yes or No _____

17. Now, based upon your answers to previous five questions, develop an explanation (hypothesis) for the origin of the topography in the area under consideration.

_____

_____

18. Next, describe the evidence you have uncovered that supports your hypothesis.

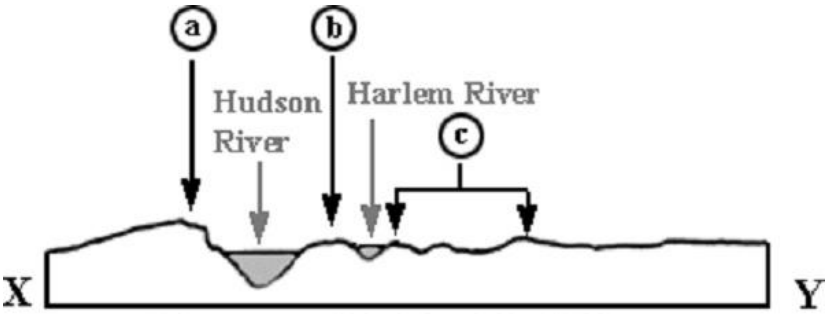
_____

_____

The Palisades

As seen above, an explanation for the topography of Manhattan and the Bronx may be found in variable resistance of bedrock to erosion. A similar control of landscape by variable resistance of bedrock has been proposed for the west bank of the Hudson River. This control is called "differential erosion." There, the Palisades is an elongate ridge that parallels the shore of the river. The east side of the ridge is a sheer cliff that rises hundreds of feet. The west side of the ridge slopes gently downward to the west. The topographic profile X-Y, shown in the figure

below, illustrates the asymmetric character of the Palisades ridge and also shows details of the topography of northern Manhattan and the South Bronx



Topographic Profile X-Y

Topographic profile along X-Y from the topographic and geological maps above.

19. On the profile above, the locations of **the Hudson and Harlem Rivers** are shown. Which letter (a, b or c) indicates the position along the profile of the following three other important features:

The ridge of northern Manhattan _____

The Palisades ridge _____

The ridges and valleys of the southern Bronx _____

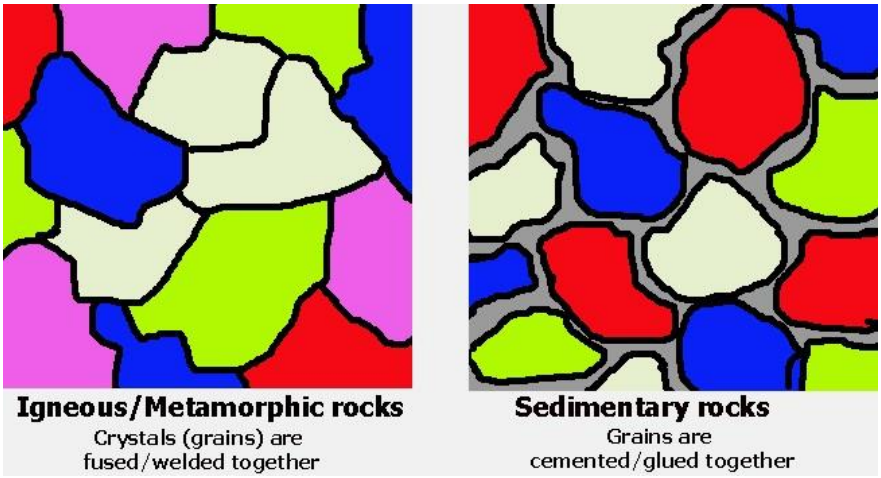
Rock samples 4 and 5 were taken from the Palisades. Rock samples 6 and 7 represent the rocks that occur to the west of the Palisades and are also found in the narrow strip of low land between the foot of the Palisades cliff and the waters of the Hudson River. Testing the resistance to erosion of these four samples with a nail and acid we discover that samples 4 and 5 are hard whereas samples 6 and 7 are soft. None of them react with acid.

SAMPLE LOCATION: 4

SAMPLE LOCATION: 5

SAMPLE LOCATION: 6

SAMPLE LOCATION: 7

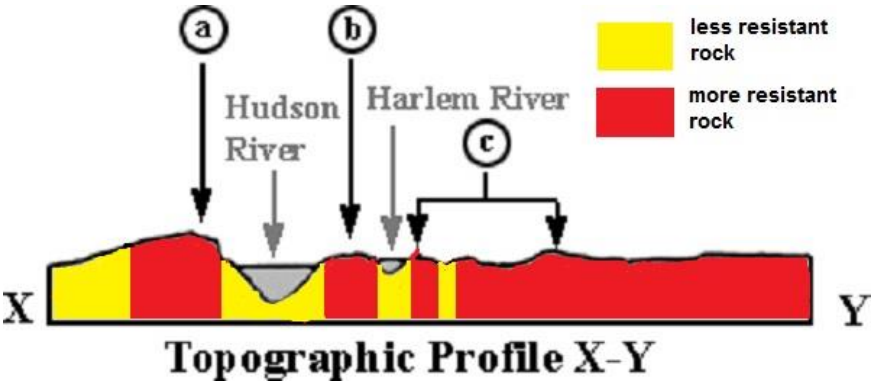


Based on the arrangement of the grains, is sample 6 more or less resistant than samples 4 and 5? _____

Based on the arrangement of the grains, is sample 7 more or less resistant than samples 4 and 5? _____

One can test the hypothesis that '**differential erosion'** is a significant factor in shaping the details of landscape in the areas discussed above by comparing land surface elevation to the character of the underlying bedrock. This may be done using the following procedure.

We can use the topographic **profile X-Y** to see if there is a correspondence between the **topographic map** and the **geological map**. First, we mark the mark the locations of the end of the line (points X and Y) on the edge of the paper. After, we draw strips of red on the edge of the paper to indicate the locations of all bedrock that is relatively resistant to erosion (all patterns on the map except the **New Jersey "Redbeds"** and the **Inwood Formation**). Next, we take the marked edge of the paper and place it along the topographic profile X-Y. Wherever there is a resistant rock present, we made a vertical red stripe from the top to the bottom of the profile

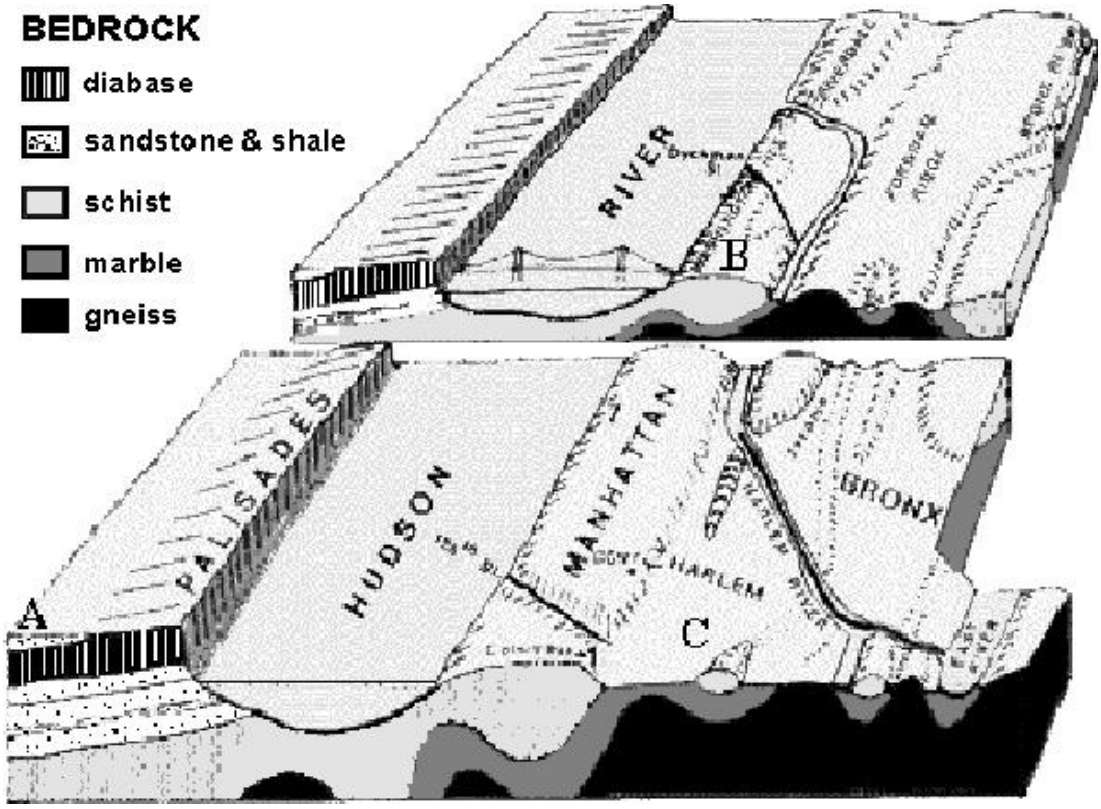


Topographic Profile X-Y

The ridges and valleys on the topographic profile coincide, respectively, with the geological map formations along the geologic cross section (red = more resistant rock and yellow = less resistant rock).

20. Is the hypothesis of differential erosion confirmed or negated? _____

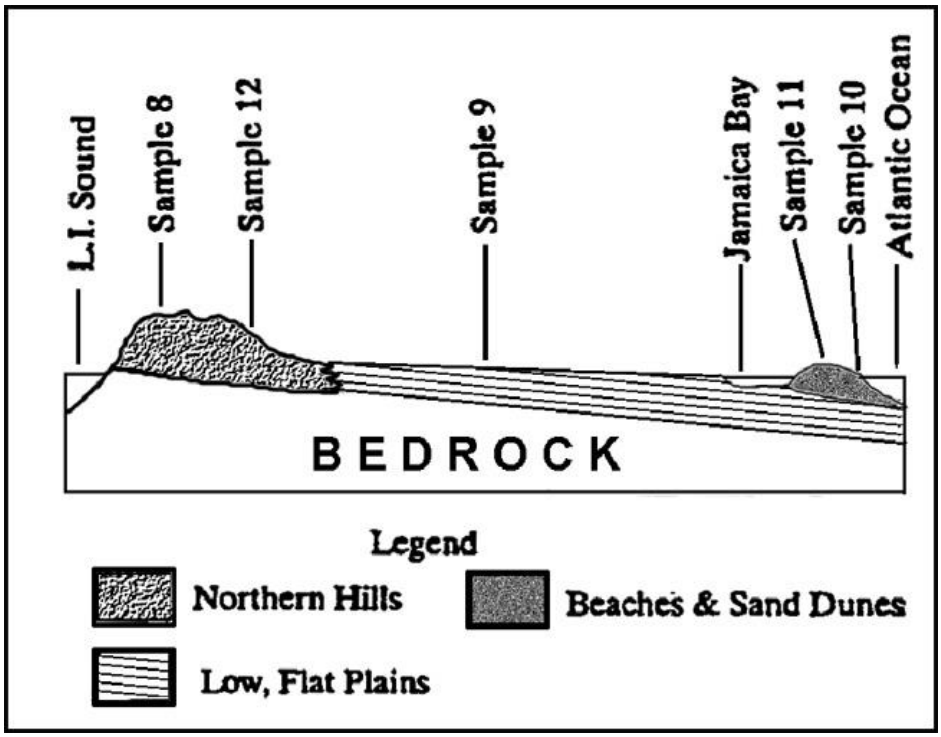
Actually, the rock formations underlying profile X-Y are not vertical layers. As diagrammed in figure below, they vary from inclined planar beds west of the Hudson River to highly contorted beds underlying Manhattan and the Bronx.



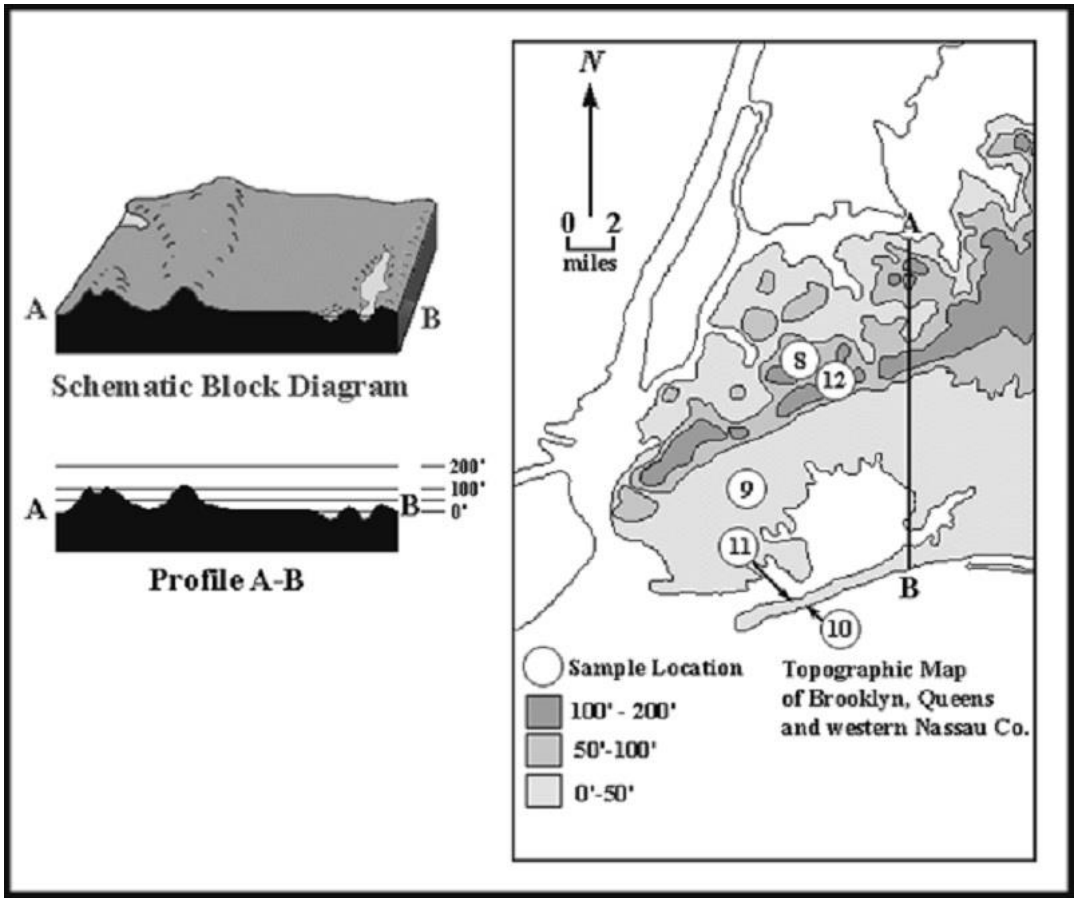
The topography in the Palisades, Manhattan, and the Bronx can be explained by the theory of differential erosion, in fact if we overlay the geologic map on top of the topographic map we can see that there is a correspondence between the two: **soft rocks form lower areas and hard rocks form the higher areas.**

GEOLOGY OF BROOKLYN AND QUEENS

In most areas of Manhattan and the Bronx, bedrock is at or close to the surface of the earth. In Brooklyn and Queens, bedrock is buried by significant thickness of sediment. The depth of the bedrock in these boroughs may be seen in the figure below.



Generalized north-south geologic section and topographic profile across western Long Island (Brooklyn and Queens), showing locations at which samples were collected.



Map showing sample locations.

Because bedrock is not exposed at the surface, hypotheses other than differential erosion of bedrock must be sought to explain the landscape. Three major landscape features occur:

1. Hills that dominate the northern parts of the borough.

2. A low, flat plain that slopes gently southward from the foot of the hills towards the south shore of Long Island.

3. A series of narrow beaches and dunes that run along the south shore.

Describe the sediment samples and note their locations in Figures 2 and 9. In your description, pay special attention to the features that distinguish each type of sediment from the others:

x presence or absence of layering

x general color

x grain size

x uniformity of grain size

x the presence of shells or shell fragments

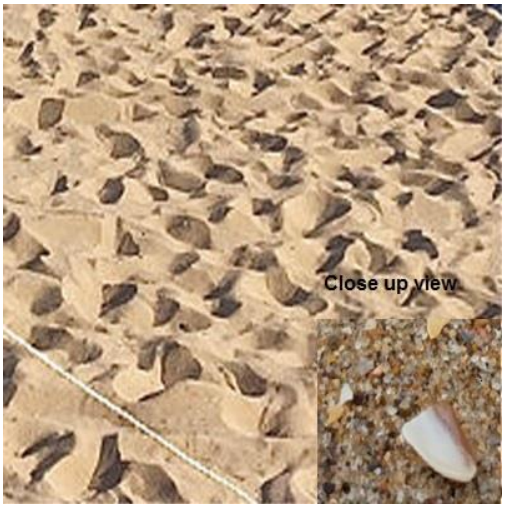
x whether one, several, or many different mineral species are present

21. Use the following table to assemble your data.

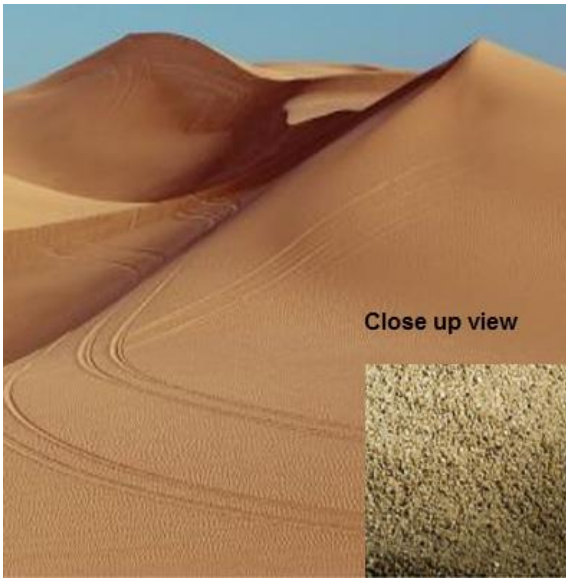
Specimen Location and Number	Layering (Yes/No)	Color	Grain Size	Uniformity of Grain Size (Sorted/Unsorted)	Shells (Yes/No)	Minerals (1,Several, Many)
Hills # _____						
Plain # _____						
Beach # _____						
Dune # _____						

SAMPLE LOCATION : 8

SAMPLE LOCATION : 9



SAMPLE LOCATION : 10



SAMPLE LOCATION : 11

22. Explain the differences between the beach and dune sediment in terms of their origin.

_____

_____

23. What geologic process is most likely to have deposited the sediment out of which the plain is made? Justification?

_____

_____

Boulders (some of them are ten feet in diameter) are found mixed in with the sediment out of which the hills are made. Boulders are also found in Manhattan and the Bronx, resting on bedrock. In those boroughs, some (but not all) of the boulders are found at the very tops of hills.

24. Boulders made of the rock types comprising samples 4, 5, 6 and 7 are also found in the hill sediments. Where, with respect to the Hudson River, is bedrock of the same compositions as samples 4, 5, 6 and 7 found?

_____

_____

The boulders in the hill sediments must represent pieces of bedrock separated from the bedrock and transported to their present sites in the northern hills of Brooklyn and Queens.

25. What geologic agent is capable of moving boulders of this size for several miles? Geologic Agent: **Wind, Flowing Water, or Glacier Gravity**
_____

26. Is this geologic agent at work in this region today? Yes or No
_____

27. Where would you go to determine what evidence is needed to support your hypothesis as to how the boulders were transported?

_____

_____

28. In terms of your hypothesis regarding the transport of boulders, explain the following: **Why is bedrock at or near the surface in Manhattan and the Bronx**?

_____

_____

29. Why are the boulders (and the rest of the sediment mix in which they occur) present in northern Brooklyn and Queens? Why is this area higher and hillier than the area to the south?

_____

_____

30. What is the origin of the flat plain in southern Brooklyn and Queens? Does this theory of origin fit in with your earlier idea as to the agent that deposited the sediment in this area?

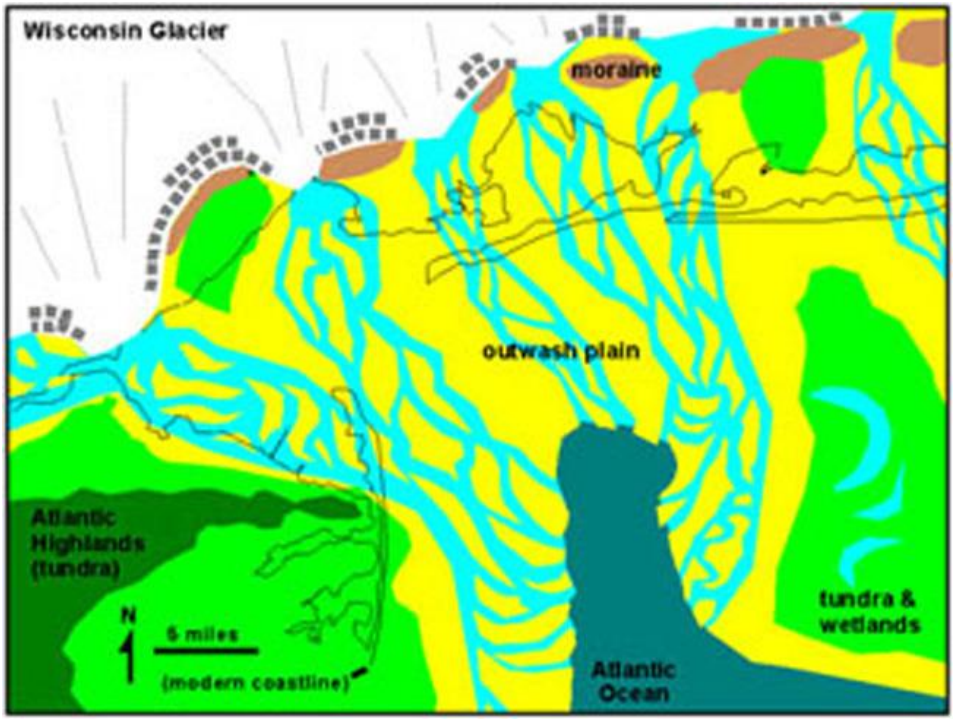
_____

_____

The Wisconsin Ice Sheet, the last of many glacial advances that started at about 90,000 years ago and which stretched down from eastern Canada and advanced as far south as New York City. These glaciers left their marks on the city, depositing rock and debris and accounting for the hilly areas that run straight in the northern part of Brooklyn, Queens, Nassau and Suffolk forming the Ronkonkoma Moraine. During a period of warmth and retreat the glaciers finally begin their final retreat at about 18,000 years ago. In New York City, the Wisconsin Ice Sheet was about 2,000 feet thick (in the Adirondacks it was over 5,000 feet thick and perhaps as much as 10,000 feet thick in Labrador).

Glacial grooves and striations are sets of parallel channels which have been ground out of rock surfaces by boulders (grooves) and pebbles (striations) lodged in the moving sole of a glacier or ice sheet. The weight and pressure made by the colossal thickness of the glacier left its marks on the bedrock surface especially in Manhattan and the Bronx.

As the glacier moves, it behaves like a bulldozer since it will scrape clean the surface that the glacier traveled on; that is why in many parts of Manhattan and the Bronx the bedrock is at the surface and it is complete cleaned and free of top soil.



As the glaciers start to melt all that sediment created the outwash plains of Brooklyn and Queens (soft layers upon layers of unconsolidated sediments made of gravel, sand and silt).

The construction of skyscrapers and subway tunnels is highly dependent on the type of rocks that is underneath the surface and the depth to reach this bedrock. In order to anchor skyscrapers and to dig tunnels we need to have very strong rocks underneath. For this reason in Brooklyn and Queens we don't have skyscrapers and in many parts of these boroughs the subway system has to go above ground.

Conclusion: