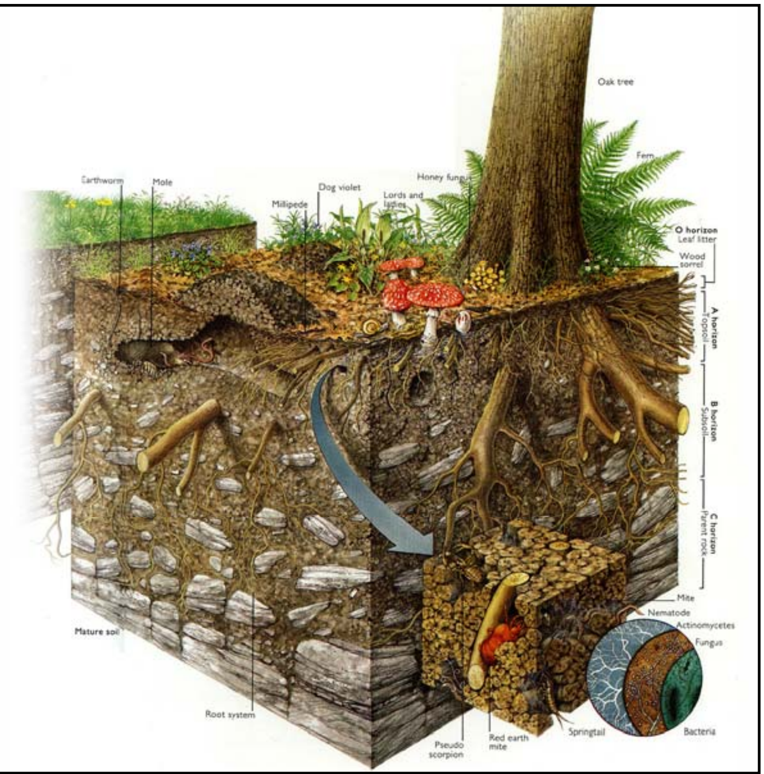
LECTURE TWO

SUSTAINABLE SITE DESIGN

Geology

GOALS and REQUIREMENTS
SITE PLANNING
ECOLOGICAL DESIGN
SUSTAINABILITY
AN EXERCISE



Soil section from Derek Elsom's, *Earth, The Making, Shaping and Workings of a Planet*, 1992

ARCH 2450 SUSTAINABILITY THROUGH ARCHITECTURE

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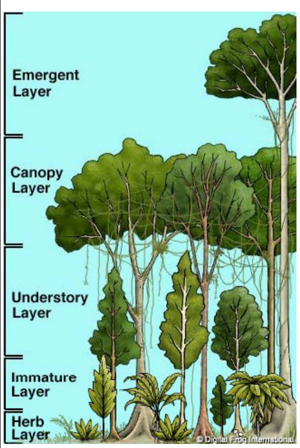
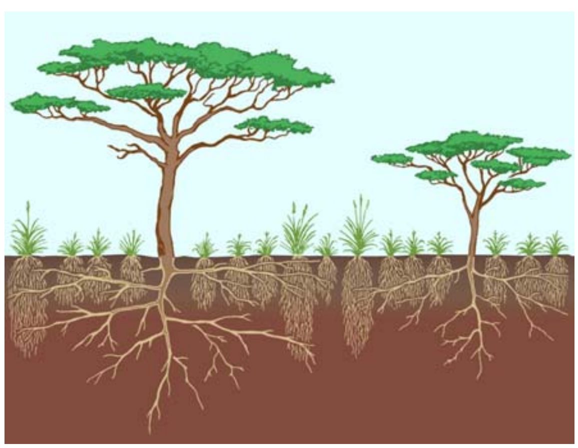
LECTURE TWO

SUSTAINABLE SITE DESIGN

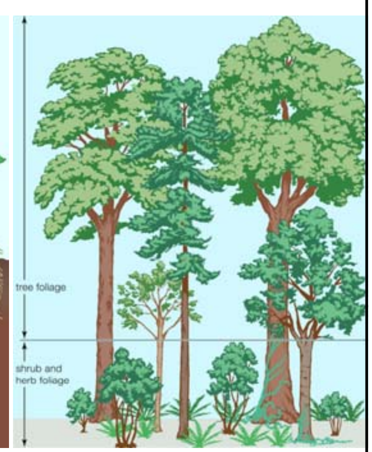
Plant Communities and Soil



Rain Forest



Savannah



Temperate Forest

Natural plant communities are determined by and determine climate and soil.

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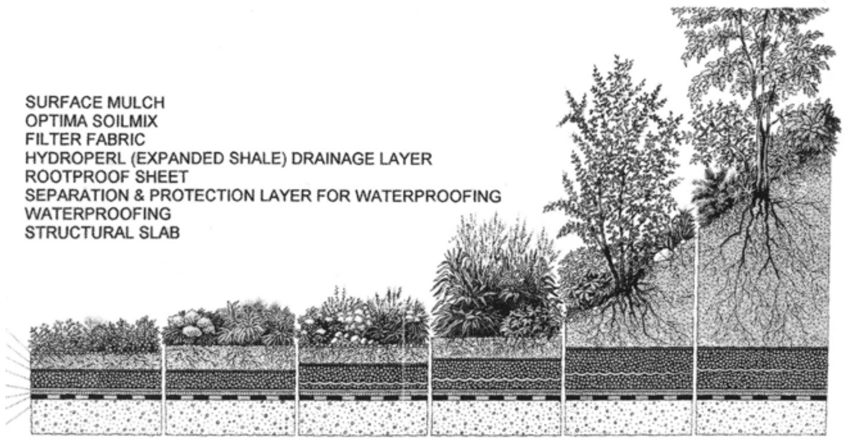
LECTURE TWO

SUSTAINABLE SITE DESIGN

Extensive green roof



Intensive green roof

Green roofs are a microcosm of the larger environment and for diverse plantings a variety of soil depths and types are often required.

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Site Planning

Soils & Geology

Lecture Outline

1. Plant communities and soil
2. Sedimentary, igneous & metamorphic rock
4. organic & inorganic
5. percolation
6. types & layers of soil
7. soil investigations
8. issues affecting bearing capacity
9. NYC geology
10. Accessing USGS maps

Geology

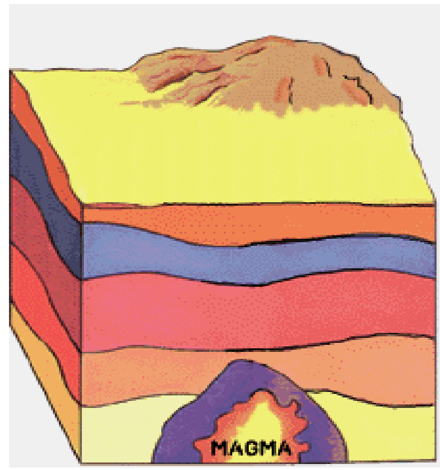
Geology is the scientific study of the structure and composition of the earth's surface

The earth is made up of very complex systems of rock, soil and water.

Geology - Architects

As architects we need to have a basic knowledge of geology to understand the nature of the site characteristics, to design adequate foundations and proper drainage. This knowledge also helps us to plan appropriate changes to the site.

We consult civil engineers for drainage, and structural engineers for building foundations.



Types of Rock

There are three types of rocks:

Sedimentary

Igneous

Metamorphic

Rocks - Sedimentary

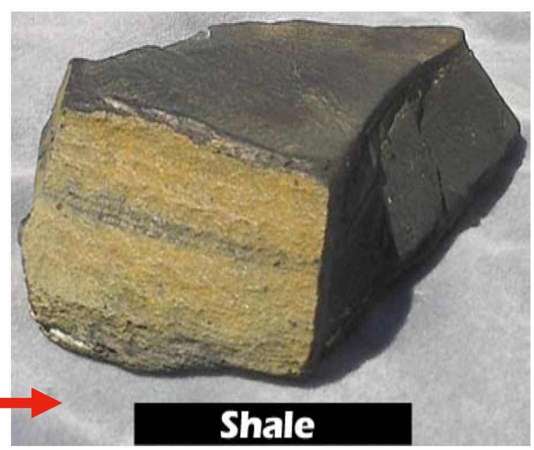
Rocks formed by the deposition of transported sediments. This type of rock is formed by particles which have been transported by streams, ocean currents, ice or wind.

The particles could be sand, dirt, rocks or even skeletons, shells and parts of living creatures. The rock is laid down in layers and the most beautiful is often considered to be limestone.

Rocks – Sedimentary, Contin.

Lithification is the process by which deposited sediments are converted to firm rock. This type of rock covers most of the earths surface.

Examples are
sandstone
shale
limestone



Rocks – Sedimentary, Contin.

Sandstone
- resists weathering
- rugged topography

Shale
- most common
- smooth flowing topography

Limestone
- prone to chemical weathering.

Rocks - Igneous

Igneous rocks are formed when molten rock material cools and solidifies on or beneath the earth's surface. It is hard, dense and strong with very high bearing capacity.

Granite

Rocks - Metamorphic

Rock formed from igneous or sedimentary rock as a result of heat, pressure, and chemical action.

Metamorphism is the process by which igneous or sedimentary rock is converted to metamorphic rock. It occurs mainly in mountainous areas.

Rocks – Metamorphic, Contin.

Foliated – arrangement of minerals in parallel layers along which the rock easily splits into thin flakes or slabs.

Slate
Schist
Gneiss

Rocks – Metamorphic, Contin.

Unfoliated metamophic rocks include:

Quartzite

Marble

Soil

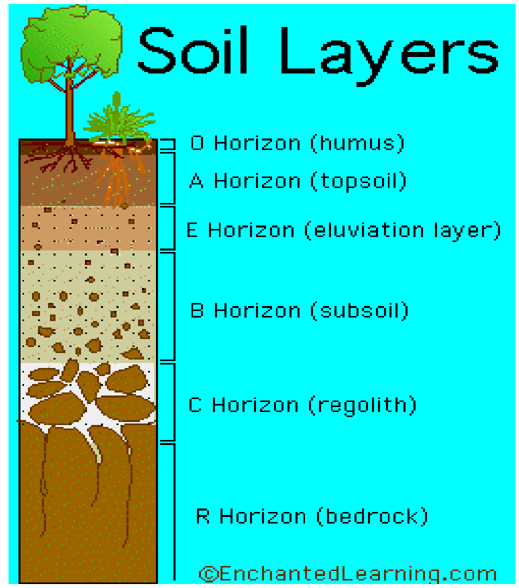
Soil is a natural mineral, formed of decomposed and disintegrated parent rock, that supports plant life.

The properties of soil are affected by a number of factors: the nature of parent rock, climate, topography, age and vegetation.

Soil Horizons

Soil is divided into horizontal layers called horizons.

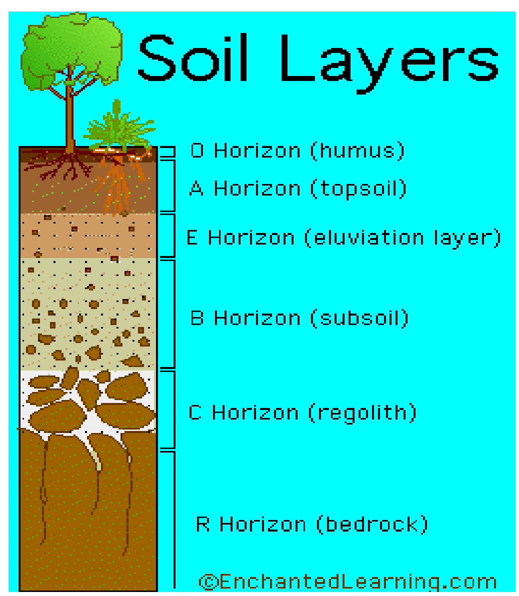
The three main horizon layers are the A, B and C layers.



A Horizon

The layer called topsoil; Seeds germinate and plant roots grow in this dark-colored layer.

It is made up of humus (decomposed organic matter) mixed with mineral particles.

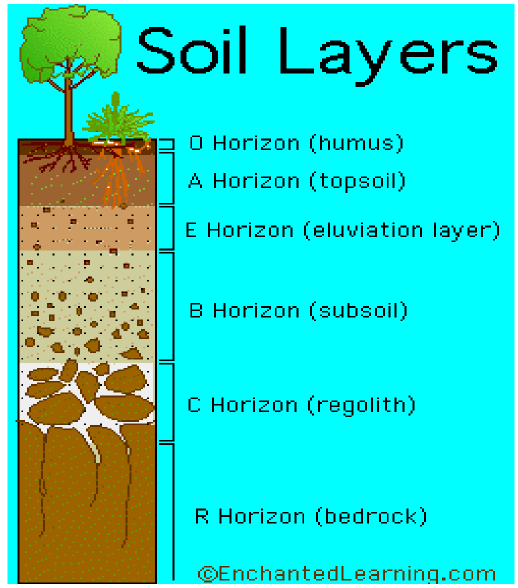


B Horizon

Also called the subsoil

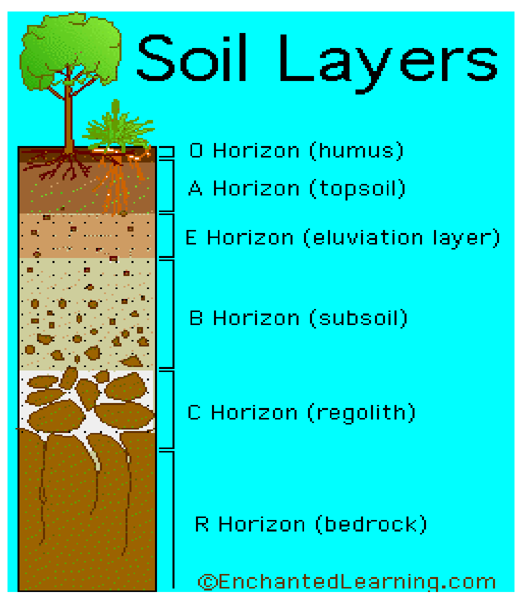
- this layer is beneath the E Horizon and above the C Horizon.

It contains clay and mineral deposits (like iron, aluminum oxides, and calcium carbonate) that it receives from layers above it when mineralized water drips from the soil above.



R Horizon

The unweathered rock (bedrock) layer that is beneath all the other layers.

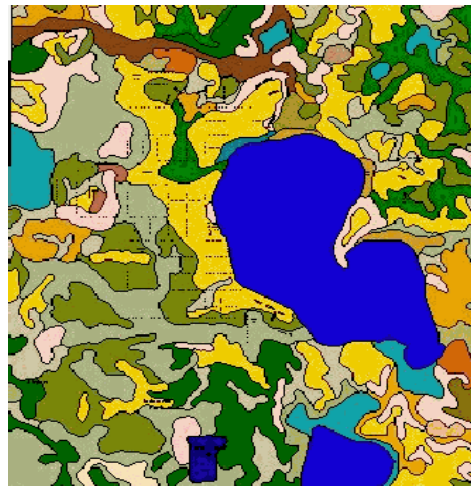


Soil Classifications

There are many different ways of classifying soil based on its uses.

As Architects we are most interested in systems based on particle size since that largely determines 3 important soil qualities:

Drainage
Bearing Capacity
Erodibility

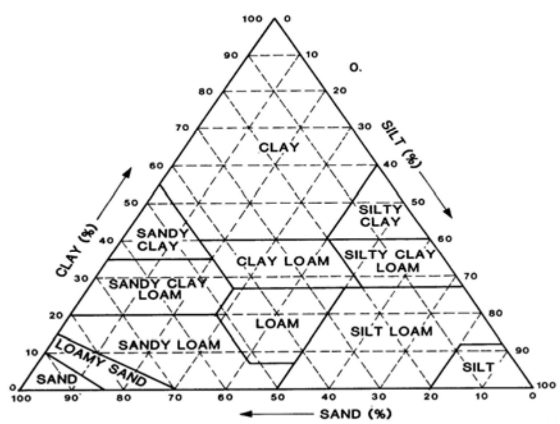


US Department of Agriculture Soil Classifications

- Sand
- Silt
- Clay

- This is too narrow for us so we also look at

- Gravel
- Organic Soils



Sand .002 to .25

Sand is a coarse grained soil whose particles are .002 to .25 inches in diameter

Silt .002 to .00008

Silt is a fine grained soil whose particles are .002 to .00008 inches in diameter

Clay smaller than .00008

Clay is a fine-grained soil whole particles are smaller than .00008 inches in diameter

Gravel larger than .25

Gravel is a coarse grained soil whose particles are larger than .25 inches in diameter.

It has good to excellent drainage characteristics and bearing capacity.

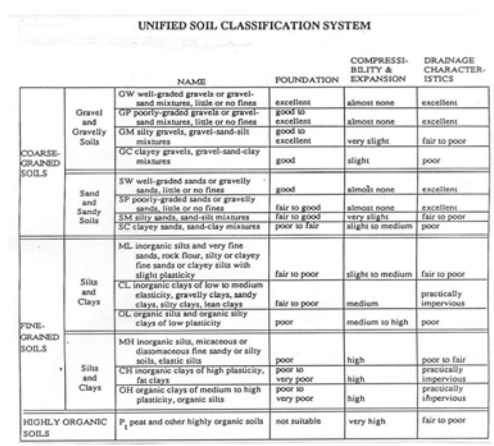
Organic Soils

Organic soils such as peat have poor drainage and very low bearing capacity

Unified Soil Classification System

Soils are divided into various sub-categories

1. coarse grained (gravel and sands)
2. fine grained (very fine sands, silts and clay)
3. highly organic soils, such as, peat, poor drainage and very poor bearing capacity



UNIFIED SOIL CLASSIFICATION SYSTEM

		NAME	FOUNDATION	COMPRESSIBILITY & EXPANSION	DRAINAGE CHARACTERISTICS
COARSE-GRAINED SOILS	Gravel and Gravelly Soils	GW well-graded gravels or gravel-sand mixtures, little or no fines	excellent	almost none	excellent
		GP poorly-graded gravels or gravel-sand mixtures, little or no fines	good to excellent	almost none	excellent
		GM silty gravels, gravel-sand-silt mixtures	good to excellent	very slight	fair to poor
		GC clayey gravels, gravel-sand-clay mixtures	good	slight	poor
	Sand and Sandy Soils	SW well-graded sands or gravelly sands, little or no fines	good	almost none	excellent
		SP poorly-graded sands or gravelly sands, little or no fines	fair to good	almost none	excellent
		SM silty sands, sand-silt mixtures	fair to good	very slight	fair to poor
		SC clayey sands, sand-clay mixtures	poor to fair	slight to medium	poor
FINE-GRAINED SOILS	Silts and Clays	ML inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	fair to poor	slight to medium	fair to poor
		CL inorganic clays of low to medium elasticity, gravelly clays, sandy clays, silty clays, lean clays	fair to poor	medium	practically impervious
		OL organic silts and organic silty clays of low plasticity	poor	medium to high	poor
	Silts and Clays	MH inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	poor	high	poor to fair
		CH inorganic clays of high plasticity, fat clays	poor to very poor	high	practically impervious
		OH organic clays of medium to high plasticity, organic silts	poor to very poor	high	practically impervious
HIGHLY ORGANIC SOILS		P_t peat and other highly organic soils	not suitable	very high	fair to poor

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Soil Investigations

1. Test pit
2. Test boring
3. Soil boring log
4. Research

Test Pit

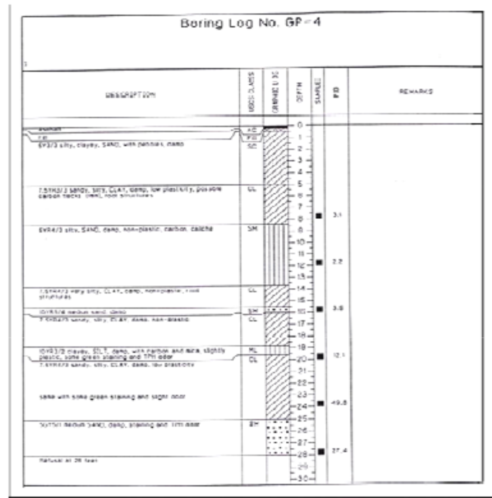
A Test pit is an excavation made to expose the subsurface soils for an in-place examination

Test Boring

Test boring is a hole drilled into the ground, from which samples or undisturbed subsurface soils are obtained for laboratory inspection and testing

Soil Boring Log

A soil boring log is a graphic representation of the soils encountered in a test boring.



Bearing Capacity

Bearing Capacity is the ability of a soil to support a structural load.

TABLE 5-1 Safe Loads on Earth Foundation Beds

MATERIAL	LOAD (lb/ft^2)
Hard rock	80,000
Medium rock	30,000
Hardpan	20,000
Soft rock	16,000
Gravel	12,000
Sand, firm and coarse	8,000
Clay, hard and dry	8,000
Sand, fine and dry	6,000
Ordinary firm clay	4,000
Sand and clay, mixed or in layers	4,000
Sand, wet	4,000
Clay, soft	2,000
Alluvial soil	1,000

Source: J. D. Carpenter, ed., *Handbook of Landscape Architectural Construction* (Washington, D.C.: Landscape Architecture Foundation, 1973), p. 239.

Nature of Soil

Soils vary in their bearing capacities.

Clays and silts have a fair ability to support loads; organic soils are unsuitable.

See chart.

Problems encountered that may result in poor bearing capacity

- Subsidence
- Previous building
- Nature of soil
- Expansive soils
- Seasonal changes

Subsidence

Subsidence is the sinking of the land because of organic fill, or the pumping out of oil, gas or water.

Previous Building

Foundations must rest on undisturbed soil.

If a building was previously on the site, the new foundation must go below the level of the old foundations.

Expansive Soil

Expansive soil Refers to clay which swells when wet and shrinks when dry.

Piers or footings must go below the depth of seasonal change and must be protected from the surrounding expansive soil.

Seasonal Changes

In the winter, soil freezes and expands. In the summer, the soil contracts.

Frost line is the deepest penetration of frost below grade. Foundations must be below this level.

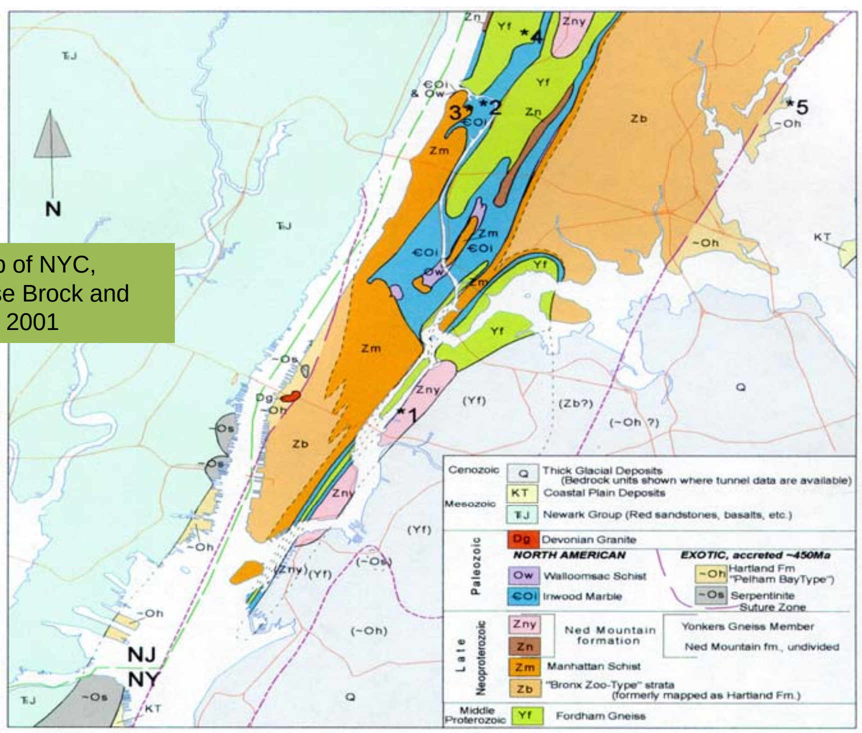
Methods of Overcoming Poor Bearing Capacity

Compaction is the reduction of soil volume by pressure from grading machinery.

Piles rely on the support of friction.

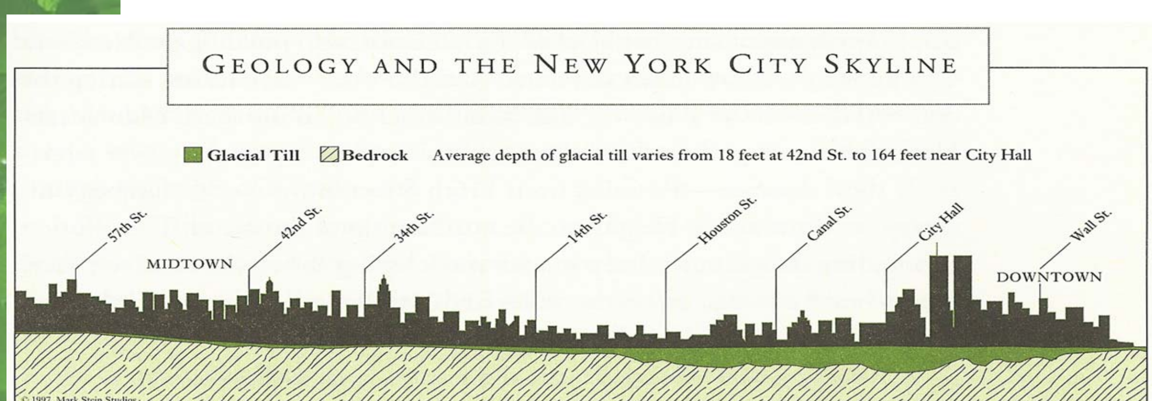
The foundation may go down to bedrock.

Geologic Map of NYC, Pamela Chase Brock and Patrick Brock 2001

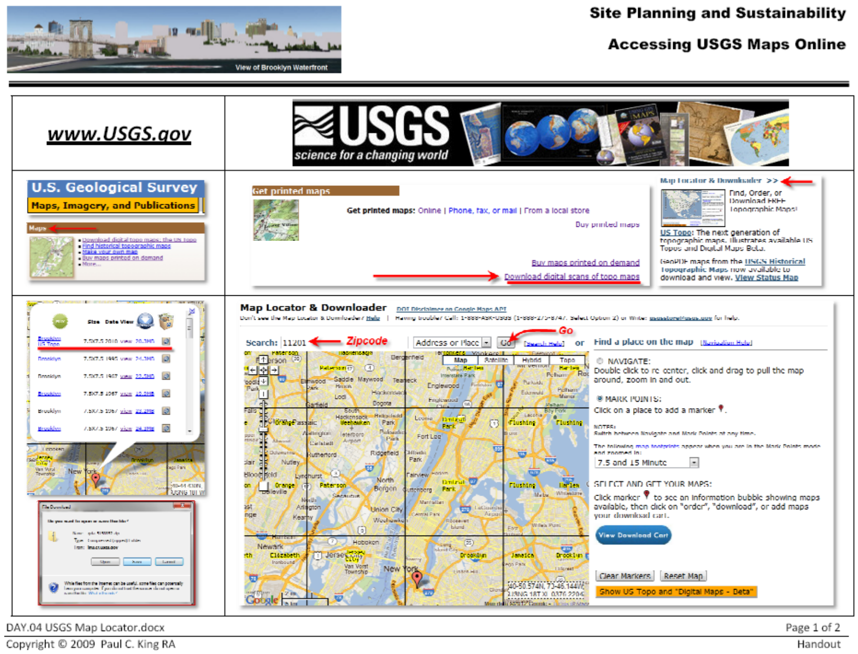


Fordham Gneiss beneath Belvedere Castle, Central Park, image credit Stig Nygaard © 2005

Manhattan Schist, Edgecombe Avenue, image credit John Seitz © 2010



From *Wild New York*, Mittlebach and Crewdson, 1997



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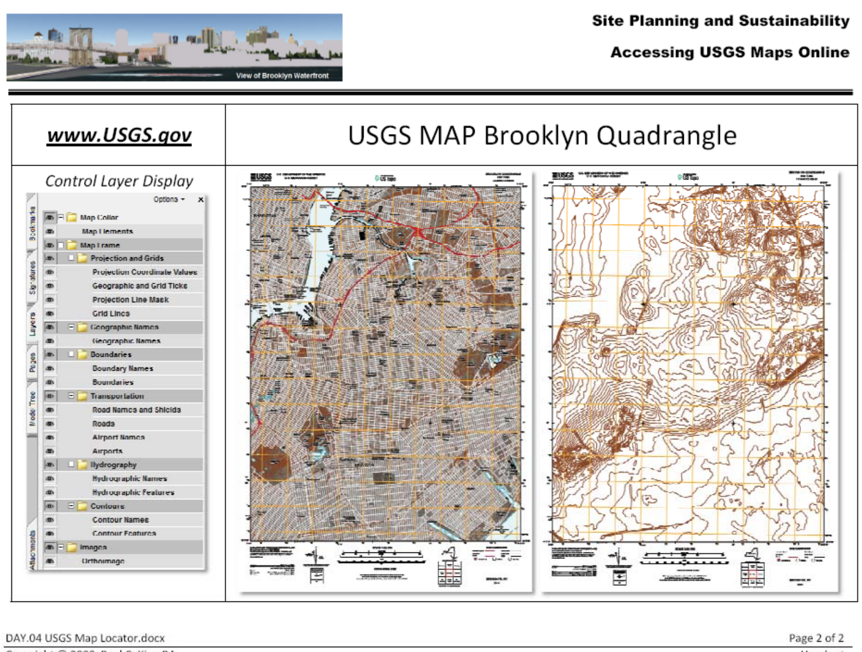

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