Land surface processes and landscape dynamics - focus on Sweden
NGEA09, 2017

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What will we do in this module of the course

• A few lectures (as a basis for the project work)

• Project work 2: Phosphorous leaching from agricultural land in Skåne

• Project work 1: Weathering and sustainable forestry in Västra Götaland

  including:

  Excursion to a forest catchment in Västra Götaland, and lecture by HAV (Havs- och Vattenmyndigheten, Göteborg)
Goal for this part of the course

- To understand the Swedish landscape, landforms and its properties (slopes, mineral content, soil type, etc) and how and when it was formed.

- To be able to connect this to environmental issues.

- To understand your roles as physical geographers in this context.
Understanding the landscape – essential when working with environmental issues

- **atmosphere**
  - greenhouse effect
  - temperature
  - shortwave radiation
  - longwave radiation
  - air pollution
  - CO\(_2\) emission

- **hydrosphere**
  - evaporation
  - precipitation
  - runoff

- **biosphere**
  - ecosystem services
  - evapotranspiration
  - nutrient uptake

- **lithosphere**
  - weathering
  - drainage

- **groundwater**

- **wildfires**
  - greenhouse gases,
  - aerosols

- **primary production**
  - decomposition
  - litter

(Borrowed from B. Smith)
Project work 2 – Phosphorous leaching from agriculture

Photo: Cecilia Akselsson
Project work 1 – Weathering and sustainable forestry
Excursion

Photo: Cecilia Akselsson

Photo: Cecilia Akselsson
Litterature

Mc’Knights Physical Geography - A landscape appreciation, by D. Hess

Water´s journey from rain to stream, by H. Grip and A. Rodhe (Vattnets väg från regn till back)

Reports and papers that are handed out during the course

Your own literature search

In Swedish:
Sveriges Nationalatlas: Atlas över Skåne, by T. Germundsson and P. Schlyter

Sveriges Nationalatlas: V. Götaland, by B. Frizell & M. Werner (in English at UB)

Sveriges geologi från urtid till nutid, by M. Lindström m.fl.
Today’s lecture

- Geomorphological processes (introduction)
- Land forms, rocks and soils in Sweden from the different geomorphological processes:
  - Endogene processes
  - Mass movements
  - Glacial erosion processes
  - Fluvial erosion processes
  - Coastal erosion processes
  - Eolian erosion processes
- Soil formation processes
Processes: Endogene and exogene

(From Hess, 2013)
Geomorphological processes and landforms all over the world

**Periglacial processes**
Polygon wedge ice: Svalbard

**Glacial processes**
Esker: Dalarna, Sweden

**Endogene processes**
Volcano, Mexico

**Mass movements, fluvial processes, coastal processes**
Braided channel, New Zealand

**Eeolian processes**
Dunes: Namibia

From Hess, 2013

Photo: Jonas Åkerman
History of the earth

(Modified from Hess, 2013)

[Diagram showing the geological time scale with key events and timescale]

Soils
Younger bedrock
Old bedrock ("urberg")

Photo: Jonas Åkerman
Photo: Cecilia Akselsson
Photo: C. Akselsson
Photo: Jonas Åkerman

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Endogene processes - forms many landforms and rocks

- Driven by plate tectonics

- Creation of mountain ranges, horsts, faults; Volcanism and metamorphism

From Hess, 2013

Photo: Cecilia Akselsson
Three types of rocks with different origin

1. Igneous rocks
   - Plutonic (intrusive)
   - Volcanic (extrusive)

2. Sedimentary rocks

3. Metamorphic rocks
Three main units in Swedish bedrock

- The Baltic/Fennoscandian shield (”urberget”)
- The Caledonides (Kaledoniderna, ”fjällkedjan”)
- Sedimentary bedrock
The baltic/fennoscandian shield

- Formed during precambrium (>545 million years ago)
The Caledonides- Fjällkedjan

-Formed after a collision 500 – 400 million years ago

-Sandstone, quartzite, limestone, shale, amphibolite, gneiss, marble and more...from precambrium to devon

Photo: Cecilia Akselsson
Remains from a collision between Baltica and Laurentia 500-400 million years ago

From Hess, 2013
Sedimentary bedrock

Cambrian to tertiary

Submerged thus protected (Siljanringen); meteorite 360 million years ago

Diabase covering and protecting (e.g. Billingen)

Cambrium, ordovicium, silur, trias, jura, tertiary

Bottom of Baltic sea
Lime in bedrock and soils
The Tornquist zone
Collision 400 million years ago, movements along the zone mainly during the cretaceous and tertiary periods.
Earth quakes along the zone (weak but still....)
A volcano in Skåne: Jällabjer, ca 150 million years old

Photo: Jonas Åkerman
The horsts in Skåne

- Hallandsåsen
- Söderåsen
- Kullen
- Nävlingeåsen
- Linderödsåsen
- Romeleåsen
Hallandsåsen...
The building of a tunnel through Hallandsåsen

- Started 1992
- 1997: Water leakage, tightening required, acrylamide leached, killed fishes, and affected cows
- Further technical problems due to "bad" rock - "Unforeseeable rock conditions"
- Finally opened 13 dec 2015. Cost 10,8 billion SEK (11 time more than predicted)
Clear NW-SE pattern in soils and land use
Exogene processes: Mass wasting and erosion

From Hess, 2013
Mass wasting - Caledonides

(Photo: Cecilia Akselsson)
Mass wasting - Söderåsen
Mass movements move material short distances through gravity. Fast movements can have devastating effects.

*Example: Landslide outside Gothenburg*

*Sydsvenskan, 22 dec 2006*
Erosion (glacial, fluvial, eolian, coastal)

- "Release" of material
- Transport
- Deposition

(From Hess, 2013)
Glacial erosion processes

(Photo: Jonas Åkerman)
The Quaternary period: 2,600,000 – 10,000 years ago
(The age of the earth: 4,600,000,000 years)

- Several ice ages during the quaternary period
- Last one: Weichsel 110,000-10,000 years ago
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<th>Geologisk tid</th>
<th>Istd (Nordeuropa)</th>
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<th>Tidsintervall (eller år sedan periodens början år 2000)</th>
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<td>Mellan</td>
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*(From Wikipedia)*
Pleistocene glaciation – maximum extent

(From Hess, 2013)
Effects of glaciers - processes

- "Release" of material
  - Glacial plucking
  - Glacial abrasion
  - Subglacial meltwater erosion

- Transport
  - Transport at the base of the ice or on the top
  - Melt streams

- Deposition
  - Direct deposition by glacial ice
  - Secondary deposition by melt water
Landforms caused by continental ice sheets

(From Hess, 2013)
Swedish soils and many of the landforms: Formed by the ice ages

(Photograph: Cecilia Akselsson)
The development of the Baltic sea during ice retreat

1. 10,200 BP
2. 9,800 BP
3. 9,500 BP
4. 6,500 BP

Baltiska issjon

Yoldia havet

Ancylus sjön

Litorina havet

(skoltips.wordpress.com)
Highest coast line (högsta kustlinjen)
Soil types in Sweden

- Torv (Mires)
- Lera (Ccay), finmo (silt)
- Grovmo (silt), sand, (sand) grus (gravel)
- Isälvs sediment (glaciofluvial sediments)
- Lerig morän, (clayey till) moränlera (till clay)
- Morän (till)
- Kalt ber/tunt jordtäcke (bare rock/thin soils)
- Glaciär (Glacier)
- Sjö (Lake)
Soil types determinant for land use...
..and hydrological properties, e.g. permeability

SNA, Berg och Jord
Another effect of glacial processes – land uplift

SNA, Berg och Jord
Fluvial processes – contributes more to shaping landforms than all the other external processes together

(From Hess, 2013)
Oversized valley in Rövarekulan

(Photo: Cecilia Akselsson)
Fluvial landforms

Valley shaped by fluvial processes to a V-valley, and reshaped by glaciation to U-shaped valley

Photo: Jonas Åkerman
Soil types in Sweden – red and dark green are fluvial sediments
Coastal processes – reshaping due to wave activities

*Washed tills below highest coastline*
Coastal processes – reshaping due to wave activities

“Raukar” Gotland

(SGU)
Eolian processes

Coastal dunes
Eolian and coastal processes

*Pine plantations along the south coast of Skåne to prevent erosion and transport of sand to agricultural land*

(Photo: Cecilia Akselsson)
The landforms, topographical and hydrological patterns and the soil properties are the results of many different processes acting on different time scales.

Example: (Washed till) “Svallad morän”

- Endogene processes explains mineralogical composition
- Glacial processes have broken down and moved the material
- Coastal processes (below highest coastline) have washed the till

(SGU)
Soils forming processes

Photo: Cecilia Akselsson

(From SGU)
Podzolization

- Positive moisture balance, cool regions (boreal forests in subarctic environments)

- Slow weathering, limited nutrient requirements, acid litter

- Leaching due to high precipitation and lots of acids: Fe and Al oxides and other elements leaches, creates a bleached layer and a layer enriched in the leached elements

Photo: Cecilia Akselsson
National system, Sweden – Iron podsol

- Organic layer
- Light layer, weathered, mostly quarts left
- Reddish layer, enriched in substances from above, e.g. Fe compounds

[Link to MarkInfo map: http://www-markinfo.slu.se/]

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National system, Sweden – Brown forest soil

-No sharp boundaries between layers, mixed by earth worms
National system, Sweden – Transition type

-In between podzol and brown forest soil

(http://www-markinfo.slu.se/)
National system, Sweden – Lithosols

- Thin layer of organic soil horizon/mineral soil (max 10 cm)

MarkInfo
Swedish Survey of Forest Soils (SK) 83-87
Map: Åke Nilsson
(http://www-markinfo.slu.se/)